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FHA and Fannie Mae offer loans for home energy improvements

The FHA's PowerSaver program allows eligible owners to borrow up to $25,000 at fixed rates for as long as 20 years to finance energy-conservation retrofits. Fannie Mae has an energy-improvement mortgage add-on program.

May 01, 2011 | By Kenneth R. Harney

Reporting from Washington — If you've been looking for a way to pay for energy improvements to your house, two little-publicized new mortgage programs could provide the cash you need.

Both the Federal Housing Administration and mortgage investor Fannie Mae recently have launched options in the energy conservation arena. Here's a quick overview, with some pros and cons:

The FHA's PowerSaver program allows eligible owners to borrow up to $25,000 at fixed rates between 5% and 7% for as long as 20 years to finance high-efficiency windows and doors, heating and ventilating systems, solar panels, geothermal systems, insulation and duct sealing, among other retrofits.

Although PowerSaver is officially a pilot program, Shaun Donovan, secretary of Housing and Urban Development, estimates that 30,000 such loans will be closed in the next two years. It eventually could become a major national program for residential energy upgrades, with total loans extending into the millions, he said.

One important element in the program is energy audits. Although they won't be mandatory, most participating lenders are expected to encourage owners to sign up for an energy efficiency analysis by a certified specialist. The audit should pinpoint where your house is leaky or otherwise inefficient in energy use, and should recommend the specific types of upgrades or additions that could help cut your bills and reduce greenhouse emissions.

The FHA will insure loans to cover the improvements up to the $25,000 maximum under the following guidelines:

•The house must be your principal residence, detached and single-family only. No rentals, no investor homes, no second homes.

•You'll need to demonstrate that you are a solid credit risk. Minimum FICO credit scores of 660 are required, plus your total household monthly debt-to-income ratio cannot exceed 45%.

•Houses with negative equity will not qualify. You'll need some level of equity in the property; there is no mandatory minimum stake, but the combined primary mortgage debt plus the PowerSaver second lien cannot exceed 100% of the appraised market value of the house. You could, for example, have a 10% equity position in a $200,000 home, and still qualify for up to $20,000 in a PowerSaver.

•Lenders are likely to take an extra hard look at all your income and asset documentation because, unlike other FHA-insured mortgages, PowerSaver will cover only 90% of the lender's loss or insurance claim in the event of a default.

Eighteen lenders around the country have signed up so far to participate, including giant Quicken Loans — a Top 10 national mortgage originator — and local players such as California-based Sun West Mortgage, Seattle's HomeStreet Bank, the Bank of Colorado, Stonegate Mortgage in the Midwest, Pennsylvania-based AFC First Financial Corp. and the University of Virginia Community Credit Union. A spokesman for Quicken Loans said the company hoped to offer PowerSaver in as many as 34 states during the pilot period.

Some pros and cons of PowerSaver: The biggest plus is its low fixed interest rate and long term — especially in comparison with most homeowners' alternative options such as bank home equity loans and lines of credit, which typically cost more and may have less favorable payback terms.

The main potential drawbacks center on the program permitting total household mortgage debt loads of up to 100% of market value. Some borrowers could encounter payment problems if they experience even slight income declines. If property values in the area decrease, the loans could put owners into negative equity territory.

Fannie Mae's "energy improvement" mortgage add-on program is significantly different from the FHA's. Rather than a separate loan to finance the energy retrofits, Fannie folds the cost of the improvements — capped at up to 10% of the estimated market value of the home following the energy-efficiency enhancements — into the mortgage amount itself.

In effect, Fannie's program, which is available through participating lenders nationwide, allows you to buy an existing house and improve its energy usage significantly with one mortgage at current market rates. Most single-family properties are eligible for the program, except for manufactured houses and cooperative units.

Be aware that Fannie requires an audit by a certified Home Energy Rating Systems expert upfront to justify the proposed modifications to the house as truly cost-efficient. The audit must be paid for by the borrower, but Fannie will credit an extra $250 through the lenders to partially defray this expense.

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RE-CONSIDERING THE ECONOMICS OF PV POWER

MICHAEL LIEBREICH, JENNY CHASE AND MORGAN BAZILIAN

5 SEPTEMBER 2012

Bloomberg NEW ENERGY FINANCE

FULL PAPER

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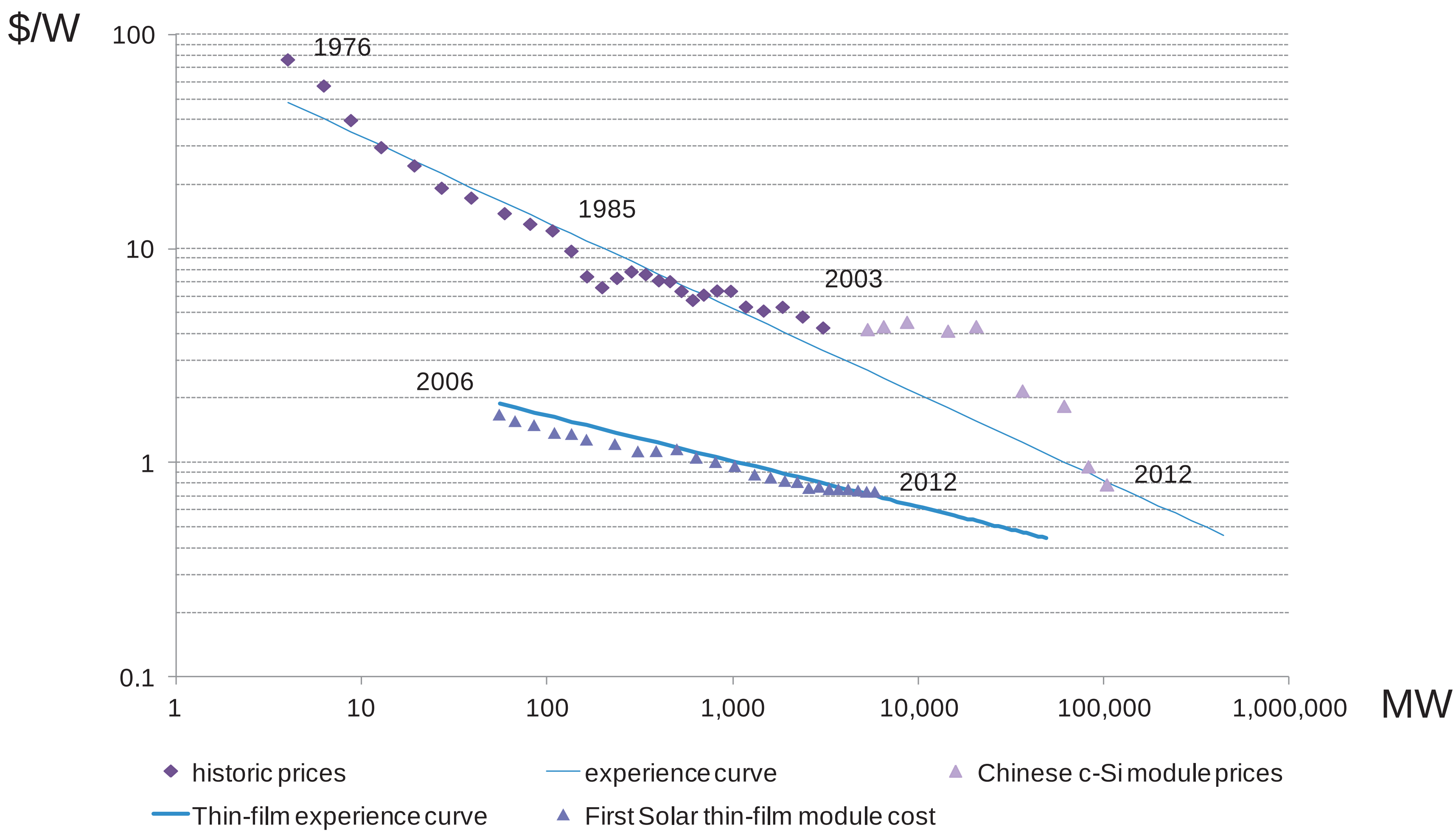
A COMMON MISUNDERSTANDING – IS PV EXPENSIVE?

- Not any more
- Most published benchmarks, especially those used by governments to set incentive regimes, are historical and do not take into account the rapid reduction in global costs
- These cost reductions have been mainly due to a reduction in module prices, which follow a global experience curve. Since the global market switched from undersupply to oversupply and fell back to the experience curve in the past three years, prices have fallen 75%
- Locally, some prices have dropped more slowly as installers, developers, and distributors take profit and work on economies of scale
- At international prices, we are at ‘socket parity’ at significant regions of the world, but this terminology can be misleading and is not necessarily helpful
- This confusion is a policymaking challenge.

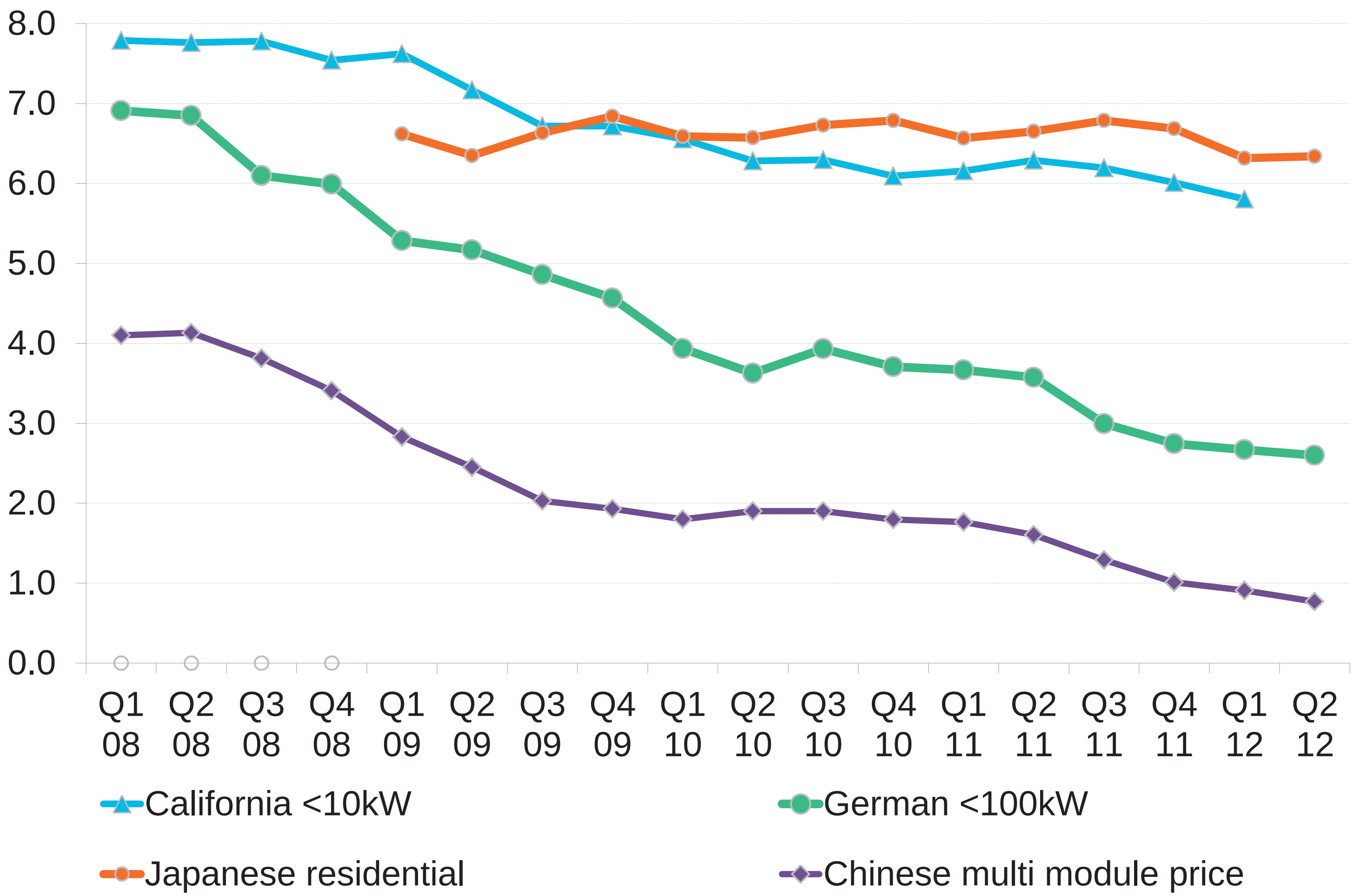
PV EXPERIENCE CURVE, 1976-2012 ($/W)



Note: learning rate crystalline silicon calculated at 24.3% 1976-2003 (2004-2008 are clearly value-based). FSLR calculated at 13.7%, 2006- May 2012. Prices inflation indexed.

Source: Paul Maycock, Bloomberg New Energy Finance

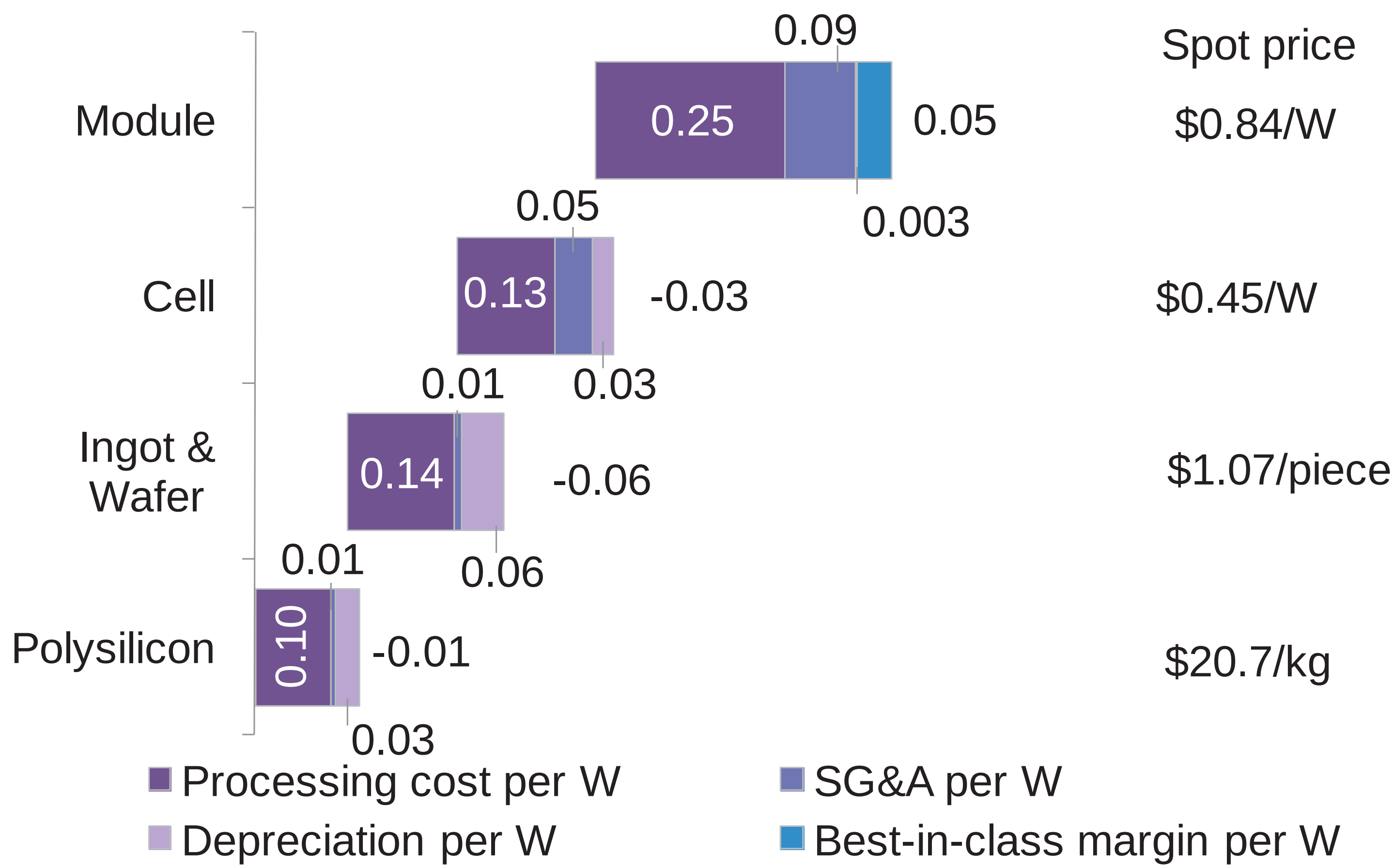
SYSTEM PRICING BENCHMARKS GLOBALLY, AS OF Q2 2012 ($/W)



Note: BSW-Solar publishes an average price for German systems below 100kW, minus VAT. This is shown above in dollars at the rate for the quarter, plus 19% VAT.Japanese data converted to dollars at exchange rate at the time.

Source: BSW-Solar, California Solar Initiative, Japan PV Energy Association, Bloomberg New Energy Finance

CHINESE MULTICRYSTALLINE SILICON MODULE PRICE BUILD-UP, AUGUST 2012 ($/W)

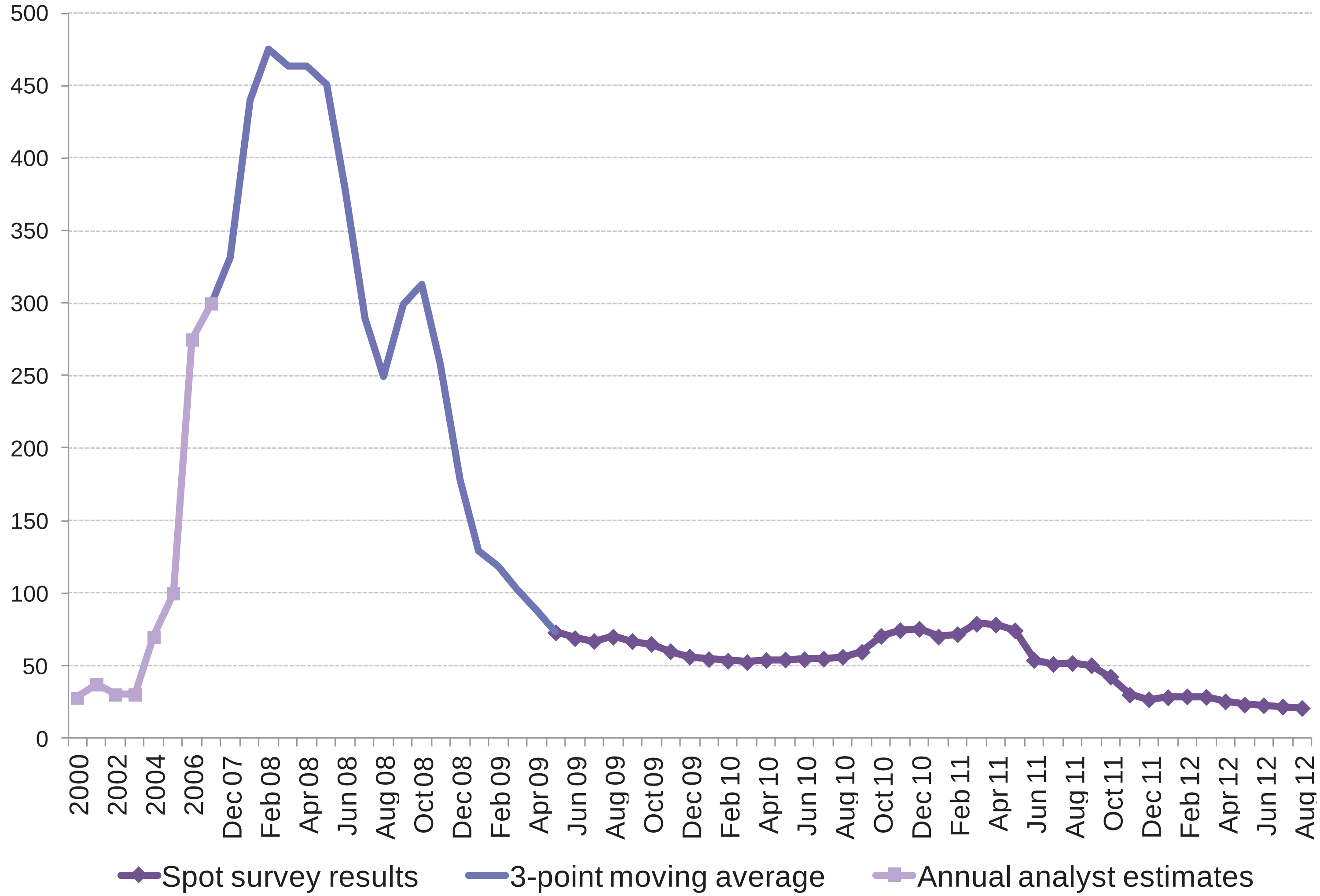


Many parts of the manufacturing chain not currently profitable, although we expect a period of stable prices rather than a rise

Note: Assumes 5.9g of silicon per W of wafer. Processing cost based on SEC filings of quoted companies, publically available reports, various discussions and analyst estimates. SG&A represents sales, general, administration and R&D.

Source: Bloomberg New Energy Finance

SPOT PRICES OF SOLAR-GRADE SILICON, YEAR 2000 – AUGUST 2012 ($/KG)



Note: Annual data 2000-07 from various industry sources. Data November 2007–May 2009 based on a 3-point moving average of actual spot deals. Consistent monthly data collection using the Spot Price Index began in May 2009.

Source: Bloomberg New Energy Finance

LEVELISED COST OF ENERGY – A GOOD METRIC?

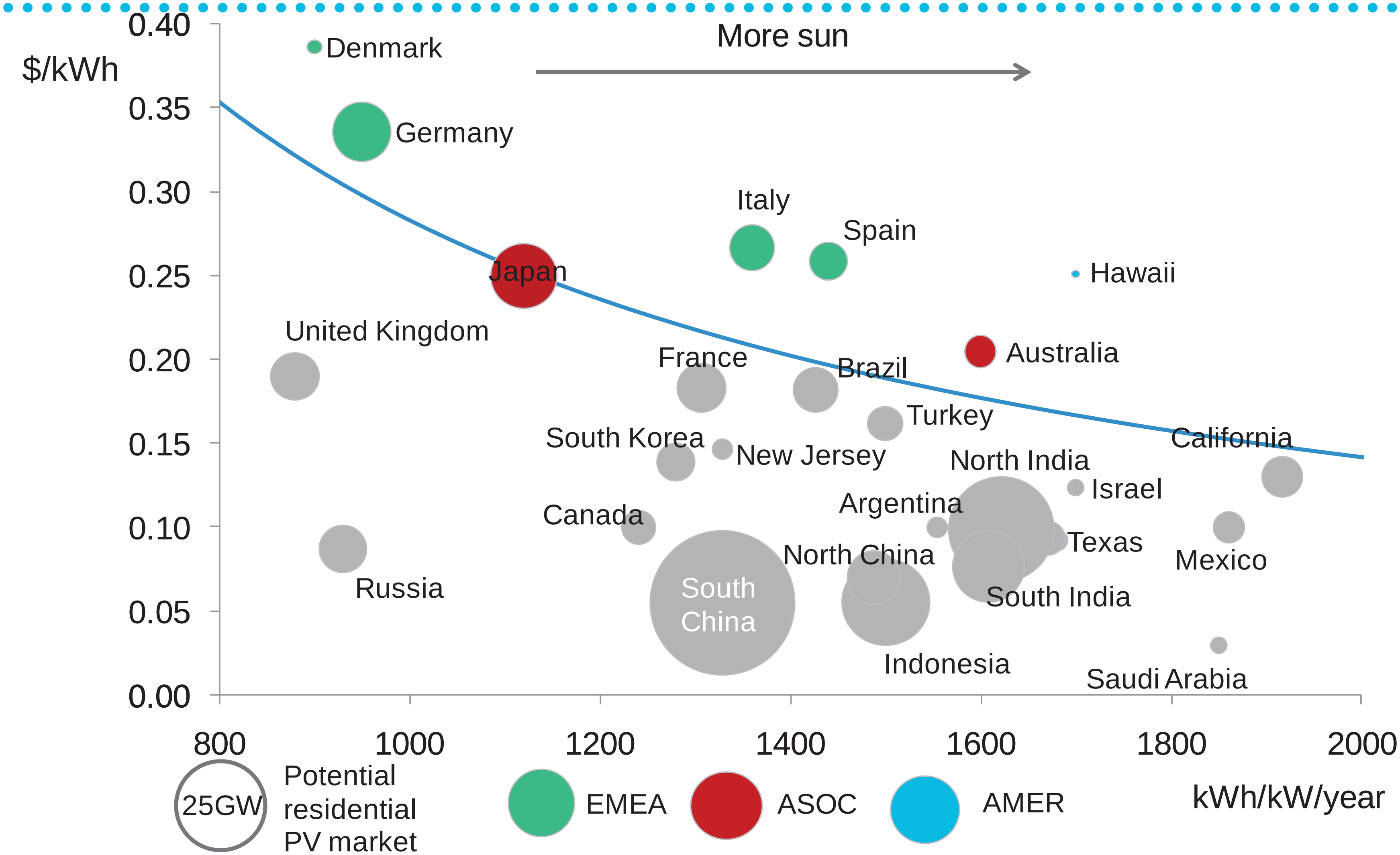
Depends on capex (assumptions vary) but also

- Cost of capital – what return does the owner require?
- Insolation – where is the plant and how sunny is it?
- Almost useless to give a LCOE figure without these assumptions

COMPARING LCOE WITH THE RIGHT COST OF ENERGY

- It is even more difficult to compare LCOE with the right electricity cost metric for any market. It is not applicable to compare cost of PV generation from a rooftop system with the wholesale cost of power, since the avoided cost to a homeowner is much higher (including taxes and transmission fees).
- However, it may also not be applicable to directly compare retail price with LCOE (as in the next few slides)
- In a power grid, the value of electricity generated depends on time of generation and reliability of generation – a much more complex calculation
- ‘Grid parity’ is imprecise – ‘socket parity’ may be better but still the real value of PV generation is complex to calculate

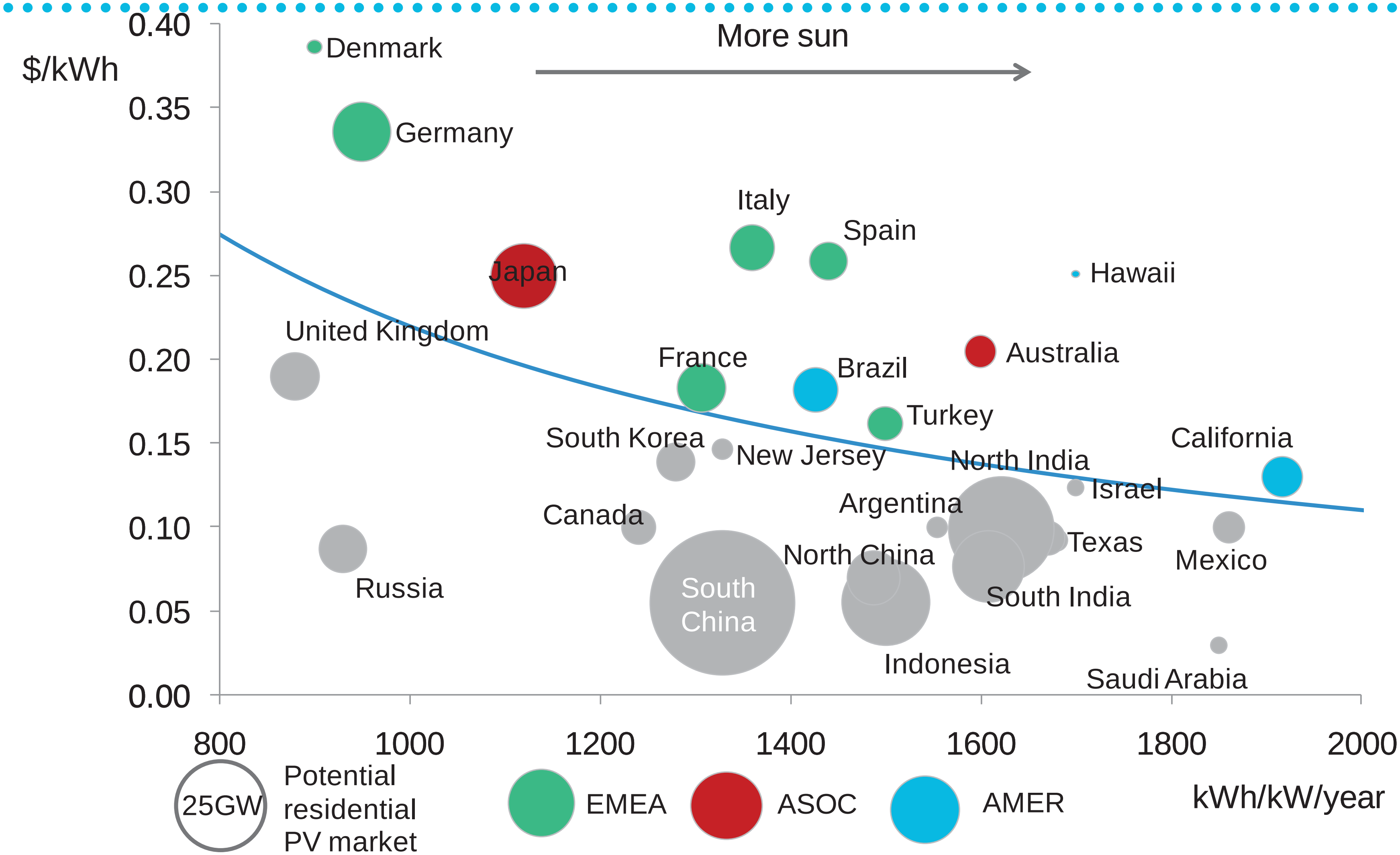
RESIDENTIAL ELECTRICITY PRICE 2012, INSOLATION, RESIDENTIAL PV LCOE 2012



Note: LCOE based on 6% weighted average cost of capital, 0.7%/year module degradation, 1% capex as O&M annually. $3.01/W capex assumed for 2012

Source: Eurostat, grid operators, Bloomberg New Energy Finance

RESIDENTIAL ELECTRICITY PRICE 2012, INSOLATION, RESIDENTIAL PV LCOE 2015



Note: LCOE based on 6% weighted average cost of capital, 0.7%/year module degradation, 1% capex as O&M annually. $2.34/W capex assumed for 2015

Source: Eurostat, grid operators, Bloomberg New Energy Finance

SUMMARY

- Solar got cheap
- Current metrics for analysing the cost and value of PV are often confusing, and the real value is much more complex to calculate
- Current policy-making is inadequate to ensure intelligent integration of cheap solar into a complex power grid
- This paper, ‘Re-considering the economics of photovoltaic power’ lays out the issues under discussion.

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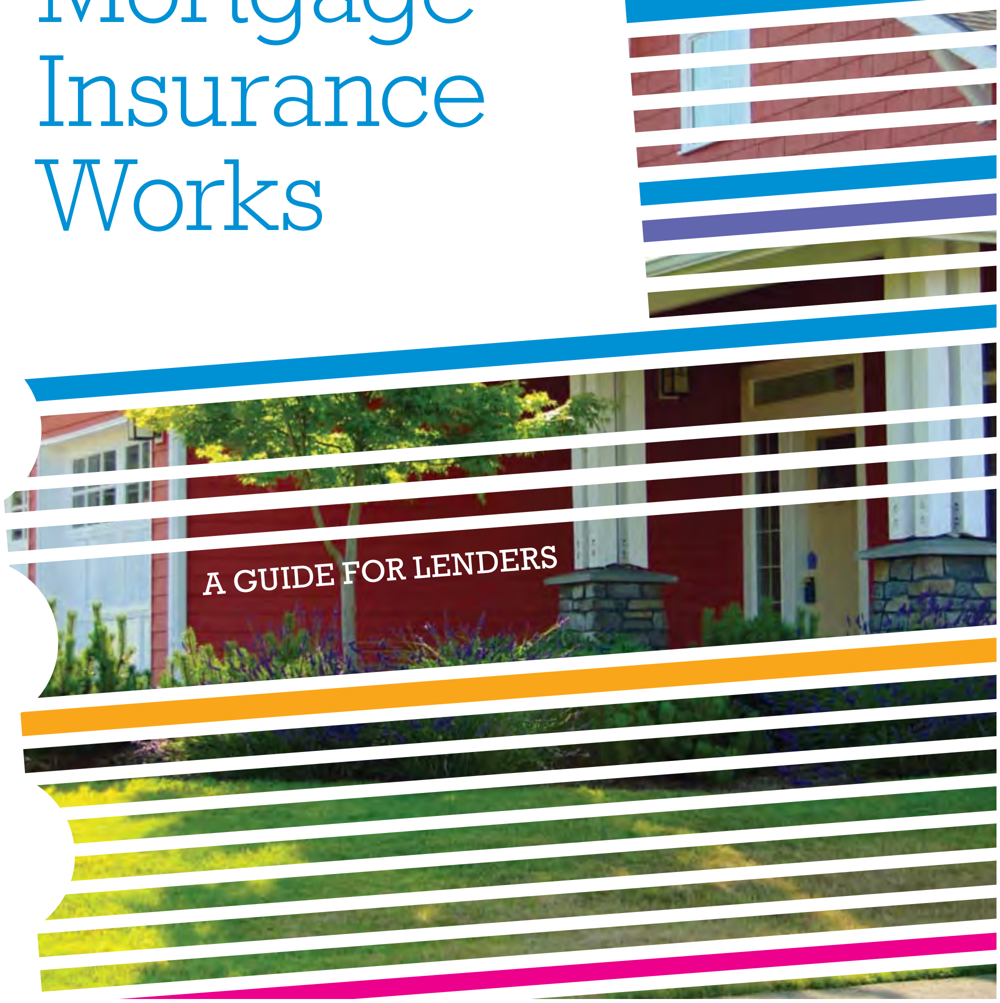
RE-CONSIDERING THE ECONOMICS OF PV POWER

MICHAEL LIEBREICH, MORGAN BAZILIAN, JENNY CHASE

MGIC

How Mortgage Insurance Works



A GUIDE FOR LENDERS

What Is Mortgage Insurance?

- **It's a financial guaranty that reduces the loss to the lender or investor in the event the borrowers do not repay their mortgage**
- **It's also called MI, private MI or PMI**

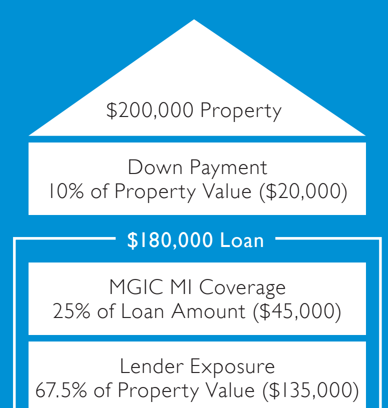
By using MI to reduce risk, the quality of the mortgage as an asset is enhanced. It becomes a safer investment for lenders who keep their loans in portfolio and for investors looking for secure purchases. Even if the borrowers fail to repay, the lender/investor will not suffer a complete loss, but rather, share the loss with the mortgage insurer. →

How Does MI Work?

For example:

Consider borrowers who purchase a $200,000 property with a fixed-rate mortgage.

They make a 10% down payment and are required to use MI to finance a $180,000 mortgage.



Typically on a 90% LTV, fixed-rate mortgage, investors require 25% MI coverage. This means that, in the event of a claim, MGIC is responsible for paying 25% of the outstanding balance, leaving the lender at risk for 67.5%.

On an uninsured loan, the lender is at risk for the entire loan balance.

If, down the road, these borrowers fail to repay their mortgage, the lender or investor files a claim based on the unpaid loan balance, delinquent interest and foreclosure costs.

(See MGIC's Default Servicing Guide for details).

MGIC will elect one of three claim settlement options:

- Payment of Percentage Guaranty – MGIC applies the amount of coverage to the total claim amount. The title of the property remains with the lender.
- Payment of Loss on Sale – If MGIC authorizes the sale of the property prior to settling the claim, the lender or investor is paid the agreed-upon amount.
- Acquisition of Property – MGIC could opt to acquire title to the property, eliminating any potential loss for the lender. The claim settlement paid equals the total claim amount.

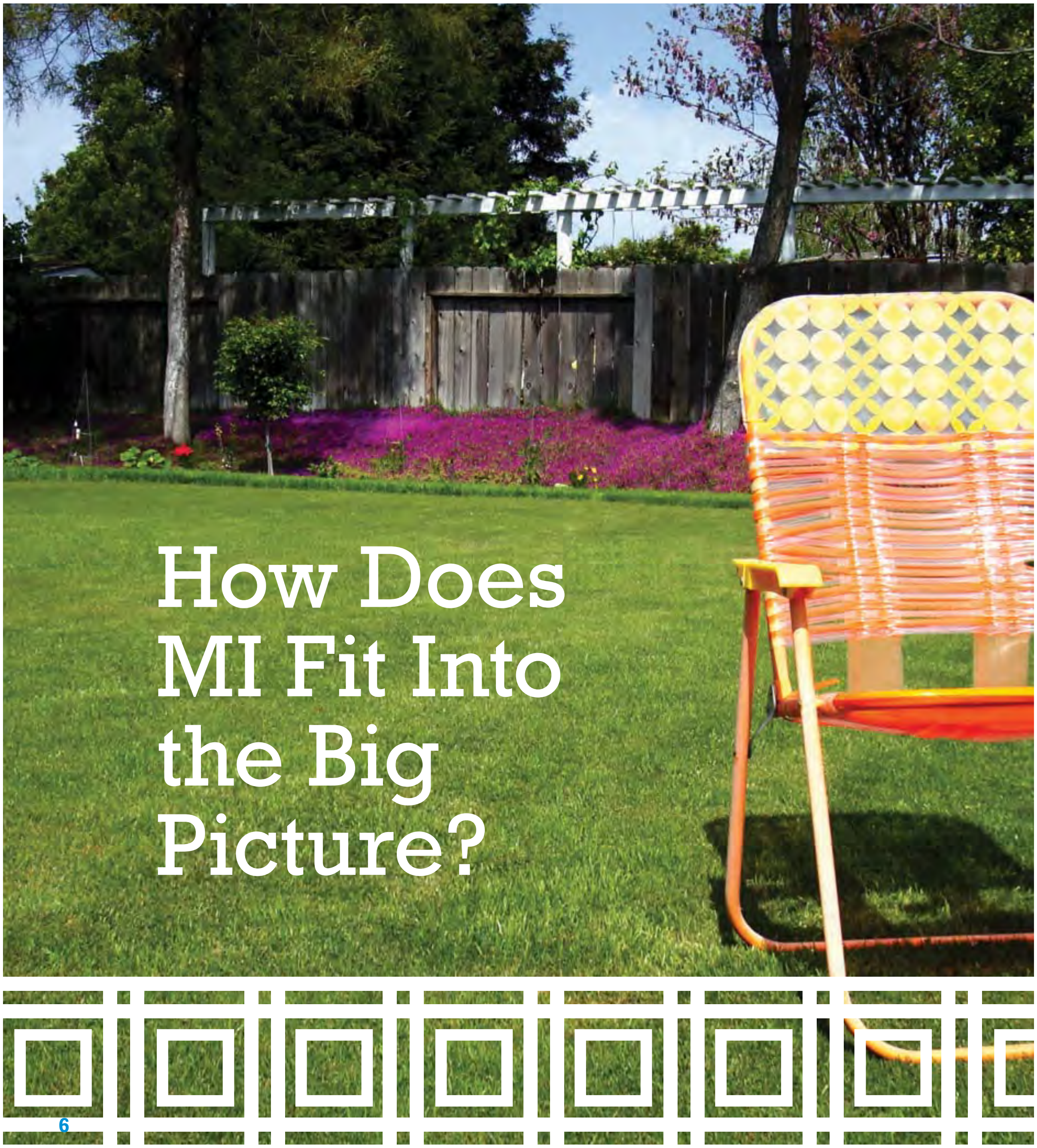
1 2 3

RESOURCES

Calculate MGIC MI premiums and check MI eligibility at www.mgic.com/ratefinder; access rate cards at www.mgic.com/rates.

Compare MGIC MI premium programs and non-MI programs for your borrowers at www.mgic.com/mgiccalculators.

See the MGIC Default Servicing Guide at www.mgic.com/dsguide.



How Does MI Fit Into the Big Picture?

Investors like Fannie Mae and Freddie Mac purchase mortgages from lenders, who in turn use those funds to originate more mortgages.

Investors have set parameters that loans must meet before they are purchased. One such parameter is that the mortgage has a loan-to-value ratio of at least 80%, meaning that the borrowers have made a 20% down payment.

Historically, that 20% down payment has been a difficult hurdle to clear for many consumers. MI was created to help more consumers afford homeownership — to lift them over that hurdle. →

Mortgage insurance can come into play during several stages of the mortgage cycle. It's most commonly ordered during the origination process:

- By the loan originator while taking the loan application
- By the processor while completing the loan file or
- By an investor on warehoused loans

Later on in the cycle, MI serves as the passkey for low-down-payment loans for delivery into the Secondary Market, where the funds from their sale become available to fund new mortgages.

From origination through Secondary Market delivery, MI helps keep the mortgage cycle rolling along.

How Can My Borrowers Benefit From MI?

Borrowers probably do not consider themselves a potential default risk, so they may be skeptical or reluctant about MI. By offering MI as a finance option, you can overcome their doubts by showing them the opportunities that financing with MI can create for them. ➔

Increased buying power.

Say your borrowers have saved $20,000. They could use that cash to put 20% down on a $100,000 home OR they could make a smaller down payment on a more expensive home — for example, 10% down on a $200,000 home.

Expanded cash-flow options.

Using MI to finance their mortgage, your borrowers could elect to put less money down and still have funds for home-related purchases and repairs or investments. For example, rather than putting 20% down ($40,000) on a $200,000 home, they may decide to put down 10% ($20,000) and use the other $20,000 to remodel. ➔

Lower monthly payments.

MGIC rewards borrowers with credit scores of 760-plus with our lowest borrower-paid, credit-tiered monthly MI rates. That translates to monthly MI costs and monthly mortgage payments that are significantly less than FHA financing.

Secure, competitive, predictable monthly payments.

A fixed-rate mortgage with MI provides borrowers with a locked-in monthly payment that will not increase and that will be reduced when MI coverage is cancelled.

Mortgage insurance may be cancelled.

On most loans with MI, coverage must automatically be cancelled by the lender when the loan reaches 78% of original value through amortization. MI also may be cancelled when extra payments bring the loan below 80% of original value.

When your borrowers are ready to cancel, they should contact their loan servicer for a full description of cancellation requirements.

RESOURCES

Prepare your borrowers for homeownership with MGIC's Buyers Ed, an online, Fannie- and Freddie-approved homebuyer education and certification program. Register for your Buyers Ed Lender Code at www.mgic.com/buyersed.

For detailed information about cancelling MI, go to www.mgic.com > MI Servicing > Cancelling MI coverage.

How Do My Borrowers Qualify for MI?

Loan files are underwritten for MI just as they are for lender or investor compliance.

– Underwriting for MI can occur simultaneously with the lender's evaluation or independently of it

– Files can be underwritten manually by the mortgage insurer's underwriting staff or electronically by the insurer's own automated underwriting system →

Generally, the principles of the mortgage industry's Four Cs apply: The borrowers' Credit, Capacity, Capital and Collateral are evaluated, as represented by the information on their loan application and on the documentation gathered to measure, support and substantiate their financial standing and the property's value.

The Four Cs

Credit

The borrowers' willingness to repay the loan, based on their prior use of credit

Capacity

The borrowers' ability to repay, based on the amount and stability of income

Capital

The amount of the investment in the property from savings and other sources

Collateral

Whether the property's value and marketability provide adequate security for the loan

Qualifying With Quality in Mind

As mortgage professionals, our shared goal is to qualify as many borrowers as possible without compromising the assets of the lender or the investor and, above all, without compromising the borrowers' ability to successfully maintain homeownership.

By carefully reviewing the borrowers' Credit, Capacity, Capital and Collateral, MGIC can piece together a comprehensive picture of risk.

The presence of a high-risk factor in any one of these categories doesn't necessarily threaten successful homeownership. But when a number of interrelated high-risk characteristics are present without sufficient offsets or compensating factors, their cumulative effect increases the likelihood of default.

RESOURCES

See our Underwriting Guide and guideline summaries at www.mgic.com/guides.

Order MGIC MI online via the Loan Center: login at www.mgic.com; details at www.mgic.com/loancenter.

How Is MI Paid For?

MGIC offers both lender-paid and borrower-paid MI premium plans.

Borrower-Paid MI

MGIC borrower-paid premium plans incorporate credit scores to tier premiums. Under these plans:

- Borrowers with better credit ratings receive lower MI premium rates
- Those with weaker credit ratings receive higher rates

Monthly Premiums

Borrower-paid monthly MI remains the mortgage industry's preferred MI product because it's easy to execute.

MGIC credit-tiered, borrower-paid monthly MI most often works out to be the best option for borrowers with high-quality credit — even over FHA financing. ➔

Advantages of conventional financing with MGIC monthly borrower-paid MI over FHA include:

- No upfront premium
- Lower loan amount (because there is no upfront premium to finance)
- A lower monthly mortgage payment
- Greater equity
- The chance to cancel MI sooner

A no-premium-due-at-closing option reduces closing costs. Borrowers pay the premiums as part of their monthly mortgage payment.

Monthly premiums are cancellable after an acceptable LTV level has been reached. When they are cancelled, the monthly mortgage payment is reduced by the amount of the MI premium.

Single Premiums

Borrowers pay a one-time, single payment up front at closing or finance it into the loan amount (check investor guidelines.) A third party, such as a builder or a seller, can also pay Single Premiums.

Split Premiums

MGIC Split Premiums give your borrowers the option of paying part of the MI premium up front in order to reduce the monthly MI premium paid along with their mortgage payment. Borrowers can choose the initial premium rate, which is a percentage of the loan amount.

A third party, such as a builder or a seller, may be eligible to pay the initial premium.

Lender-Paid MI

MGIC lender-paid MI rate programs provide a "no MI" option for borrowers.

Lender-paid premiums are usually built into the mortgage interest rate or the origination fee.

For example, in exchange for paying the mortgage insurance premium, the lender may charge the borrowers a mortgage interest rate of 4.5% rather than 4.25%. Or the lender may recoup MI costs by charging an origination fee.

The Cost of MI

The cost of MI is based on

- The MI premium plan
- The mortgage loan program (fixed, adjustable, etc.)
- Loan term
- Whether the MI premium is refundable or nonrefundable
- Loan-to-value (LTV)
- The amount of MI coverage, as determined by the lender or investor
- Loan amount
- The borrowers' credit scores
- Whether there are any adjustments to the premium to compensate for additional risk, such as a loan for a refinance

Your company will guide you regarding the premium plans you may use, as well as any other criteria that will need to be met.

RESOURCES

Calculate MGIC MI premiums and check MI eligibility online at www.mgic.com/ratefinder; access rate cards at www.mgic.com/rates.

Compare MGIC MI premium programs and non-MI programs for your borrowers at www.mgic.com/mgiccalculators.

MI Gives You an Extra Advantage

By understanding how MI works and offering it as a mortgage finance option, you create opportunities for your borrowers and yourself. With MI you can:

- Structure safe, high-LTV loans
- Possibly save your borrowers thousands in MI costs, compared to financing with FHA
- Broaden your customer base
- Enhance your role as Trusted Advisor and differentiate yourself from your competition by:
  - Broadening the options you provide your borrowers
  - Notifying them when they may be able to cancel MI and reduce their monthly mortgage payment

RESOURCES

For more information about mortgage insurance:

- Contact your MGIC Account Manager, www.mgic.com/directory
- Sign up for our free, online MI Basics class at www.mgic.com/training.

Mortgage Guaranty Insurance Corporation
MGIC Plaza, Milwaukee, Wisconsin 53202 • www.mgic.com

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Re-considering the Economics of Photovoltaic Power

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Abstract: We briefly consider the recent dramatic reductions in the underlying costs and market prices of solar photovoltaic (PV) systems, and their implications for decision-makers. In many cases, current PV costs and the associated market and technological shifts witnessed in the industry have not been fully noted by decision-makers. The perception persists that PV is prohibitively expensive, and still has not reached „competitiveness". We find that the commonly used analytical comparators for PV *vis a vis* other power generation options may add further confusion. In order to help dispel existing misconceptions, we provide some level of transparency on the assumptions, inputs and parameters in calculations relating to the economics of PV. The paper is aimed at informing policy makers, utility decision-makers, investors and advisory services, in particular in high-growth developing countries, as they weigh the suite of power generation options available to them.

Keywords: Photovoltaics; Energy economics; Energy policy

1. Introduction

In this paper we seek to provide a measure of clarity and transparency to discussions regarding the present status and future potential of PV system economics. In particular, we review a broad and recent range of academic, government and industry literature in order to highlight the key drivers and uncertainties of future PV costs, prices and potential, and establish reasonable estimates of these for decision makers.

Whilst recent dramatic changes in the underlying costs, industry structure and market prices of solar PV technology are receiving growing attention amongst key stakeholders, it remains challenging to gain a coherent picture of the shifts occurring across the industry value chain around the world. Reasons include: the rapidity of cost and price changes, the complexity of the PV supply chain, which involves a large number of manufacturing processes, the balance of system (BOS) and installation costs associated with complete PV systems, the choice of different distribution channels, and differences between regional markets within which PV is being deployed. Adding to these complexities is the wide range of policy support mechanisms that have been utilised to facilitate PV deployment in different jurisdictions. In a number of countries these policies have become increasingly politically controversial within wider debates on public subsidies and climate change action. As such, the quality of reporting and information on the PV industry economics can vary widely.

PV power generation has long been acknowledged as a clean energy technology with vast potential, assuming its economics can be significantly improved. It draws upon the planet‟s most abundant and widely distributed renewable energy resource – the sun. The technology is inherently elegant – the direct conversion of sunlight to electricity without any moving parts or environmental emissions during operation. It is also well proven; PV systems have now been in use for some fifty years in specialised applications, and for grid connected systems for more than twenty years. Despite these highly attractive benefits and proven technical feasibility, the high costs of PV in comparison with other electricity generation options have until now prevented widespread commercial deployment. Much of the deployment to date has been driven by significant policy support such as through PV feed-in tariffs (FiTs), which have been available in around 50 countries over recent years (REN 21, 2011).

Historically, PV technologies were widely associated with a range of technical challenges including the performance limitations of BOS components (e.g., batteries, mounting structures, and inverters), lack of scale in manufacturing, perceived inadequate supply of raw materials, as well as economic barriers - in particular high upfront capital costs. While the industry was in its infancy - as recently as five years ago global cumulative installation was about 16 GW - this characterisation had merit (EPIA, 2011a). Now, with rapid cost reductions, a changing electricity industry context with regard to energy security and climate change concerns, increasing costs for some generation alternatives and a growing appreciation of the appropriate comparative metrics, PV‟s competitiveness is changing rapidly. As an example, large drops in solar module prices have helped spur record levels of deployment, which increased 54 percent over the previous year to 28.7 GW in 2011. This is ten times the new build level of 2007.

At least some of the confusion over the economics of PV has stemmed from the way PV costs (and prices) are generally analysed and presented. Primarily, this has been done using three related metrics, namely: the price-per-watt (peak) capital cost of PV modules (typically expressed as $[1]/W), the levelized cost of electricity (LCOE) (typically expressed as $/kWh), and the concept of „grid parity‟. Each of these metrics can be calculated in a number of ways and depend on a wide range of assumptions that span technical, economic, commercial and policy considerations. Transparency is often lacking in published data and methodologies. Importantly, the usefulness of these three metrics varies dramatically according to audience and purpose. As an example, the price-per-watt metric has the virtue of simplicity and availability of data, but has the disadvantages that module costs do not translate automatically into full installed system costs, different technologies have different relationships between average and peak daily yields, and there is always the question of whether costs quoted are manufacturers‟ underlying costs versus wholesale costs or retail price[2].

LCOE and „grid parity‟ are of special relevance to government stakeholders but require a wider set of assumptions. They vary widely based on geography and on the financial return requirements of investors, and do not allow for robust single-point estimates. Instead, sensitivities are normally required (yet rarely presented), as are explicit descriptions of system boundaries. The financial case for PV depends on the financing arrangements and terms available, as well as estimates of likely electricity prices over the system lifetime. And often the distinction between wholesale and retail prices is not made clearly. Further, the capabilities of key decision makers

[1] We use the symbol $ to mean US dollars.
[2] There are further potential complexities between cost and price – in one common definition of these terms, for a seller price is what you sell a product or service for, and cost is what you paid for it. For a buyer, price is often used to mean what you pay for a good or service while cost includes ongoing expenditure over its life. Clearly there are considerable opportunities for confusion.

vary greatly in different PV market segments, spanning utility investors for large-scale PV farms to home owners contemplating whether to install roof-top PV systems. There is, thus, a clear requirement for greater transparency in presenting metrics so that they can be usefully compared or used in further analysis.

The aim of this paper is two-fold: first, we attempt to highlight some of the issues that are most critical for decision-makers using the common metrics. Second, we aim to inform policy and investment decision-makers about the best estimates of current costs of PV. This short paper does not address the more general power system issues which need to be dealt with in order to achieve significant PV deployment (e.g., integration, ancillary service provision, or power storage), or does it address the context or impetus behind the drive for increased renewable energy usage (e.g., climate change, or energy security).

The remainder of the paper begins with Section 2, in which a narrative of the dramatic shifts the PV industry has experienced in recent years is presented. Section 3 previews the cost of PV power as described in the literature and compares this to updated estimates. In section 4 we highlight the sensitivity of the LCOE metric to input parameters and assumptions. Section 5 considers complexities surrounding the concept of PV „grid parity". Section 6 suggests cause for optimism in the PV industry and briefly discusses policy implications. Section 7 concludes.

2. A dramatic shift

From 2004 to Q3 2008, the price of PV modules remained approximately flat at $3.50-$4.00/W, despite manufacturers making continuous improvements in technology and scale to reduce their costs. Much of this can be attributed to the fact that the German, and then Spanish, tariff incentives allowed project developers to buy the technology at this price, coupled with a shortage of polysilicon that constrained production and prevented effective pricing competition. The 18 largest quoted solar companies followed by Bloomberg made average operating margins of 14.6%-16.3% from 2005 to 2008[3].

Consequently, both polysilicon companies and downstream manufacturers expanded rapidly. When the Spanish incentive regime ended abruptly at the end of September 2008, global demand stayed roughly flat at 7.7 GW in 2009, from 6.7 GW in 2008, while polysilicon availability increased at least 32%; enough to make 8.5 GW of modules, with an additional 1.6GW of thin film production. As a consequence of this sudden need to compete on price, wafer and module makers gave up some of their margins, and the price fell rapidly from $4.00/W in 2008 to $2.00/W in 2009. The ability of manufacturers to drop their prices by 50%, and still make a positive operating margin, was due to the reductions in costs achieved over the previous four years, driven by scale and advances in wafer, cell and module manufacturing processes, as well as to improved performance resulting from better cell efficiencies and lower electrical conversion losses (Wesoff, 2012).

Since 2004, regardless of module prices, system prices have fallen steadily as installers achieved lower installation and maintenance costs due to better racking systems (IPCC, 2012), and falling BOS costs (Bony et al., 2010). In addition, financing costs have fallen, due, in part, to an improved understanding ofand comfort with, PV deployment risk (NEA et al., 2005; WEF, 2011). It is important to highlight the impacts of recent excess production capacity. In such situations,

[3] Much of the data and graphs in this paper were provided by Bloomberg New Energy Finance (BNEF) and are not otherwise disclosed to the public.

prices can fall to the level of marginal production costs, or even below - the Coalition for American Solar Manufacturing, claimed that, "Chinese manufacturers are illegally dumping crystalline silicon solar cells into the U.S. market and are receiving illegal subsidies" and brought a case resulting in US import tariffs being levelled on China modules in 2012 (Bradsher and Wald, 2012). Regardless of the subsidy situation, there is at least 50 GW of cell and module capacity globally, and an estimated 26-35 GW of demand, for 2012. The implications for future PV pricing are potentially significant, as industry participants fail or consolidate (Sarasin, 2011). In Germany alone, two major solar companies have announced bankruptcy between December 2011 and end of April 2012 (Q-cells and Solon). US firm First Solar closed its European operations in April 2012, and the media has focused on the high profile US based thin film start-up Solyndra bankruptcy in August 2011.

For the first time, in late 2011, factory-gate prices for crystalline-silicon (c-Si) PV modules fell below the $1.00/W[4] mark (Bloomberg, 2012); moving towards the benchmark of $1.00/W installed cost for PV systems, which is often regarded in the PV industry as marking the achievement of grid parity for PV (Lushetsky, 2010; U.S. DOE, 2010, 2012; Yang, 2010; Laird, 2011)[5]. These reductions have taken many stakeholders, including industry participants, by surprise. Many policy makers and potential PV buyers have the perspective that that solar PV is still far too costly on an unsubsidized basis to compete with conventional generation options, and this confusion is exacerbated by the solar industry positions, which, when consulted by policy-makers and regulators, have generally recommended high tariffs. Some have argued that prices are currently below sustainable levels and might even have to rise slightly as the industry consolidates and seeks to return to profitability (e.g., Mints, 2012b); however technological advancements, process improvements, and changes in the structure of the industry suggest that further price reductions are likely to occur in coming years.

3. Price per watt

The most fundamental metric for considering the costs of PV is the price-per-watt of the modules. PV module factory prices (Figure 1) have historically decreased at a rate (price experience factor) of 15-24%[6][7] (IEA, 2010; Zweibel, 2010; IPCC, 2012); the higher figure refers to an inflation-indexed calculation. If one assumed a $3.00/W average 2003 price, experience curves would suggest prices might have fallen to $1.01/W by early 2012[8]. However, primarily because of silicon shortages, module prices temporarily increased to $3.88/W in 2008 before declining to below $2.00/W by December 2009 in some instances. They then fell a further 14% in 2010 (REN 21, 2011). As of April 2012, the factory-gate selling price (ex-VAT) of modules from 'bankable' or "tier 1" manufacturers was $0.85/W for Chinese multicrystalline silicon modules, $1.01/W for non-Chinese monocrystalline silicon modules, with thin film modules and those from less well-

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[4] Throughout the text, W is synonymous with W_p (watt-peak), which is defined as the DC watts output of a solar module as measured under specified laboratory illumination conditions (Green, 1998). We do not discuss the varying affects of temperature on different cell technologies on PV performance.

[5] There is still at least another $1.00/W or so BOS and installation costs.

[6] This means that the price reduced by 15-24% for each doubling of cumulative sales.

[7] Production costs vary among the different PV module technologies but these cost differentials are less significant at the system level; they are expected to converge in the long-term (IEA, 2010).

[8] The anticipated experience curve is represented by the linear regression fit in Figure 1. Note, however, that in reality the data points between around 2003 and 2010 were not on that line, for the most part due to the cost impact of silicon shortages.

known suppliers even cheaper. Depending on the market, distributors of these modules can take a considerable margin, buying at the factory-gate price and selling at the highest price the market can support ('value-based pricing').

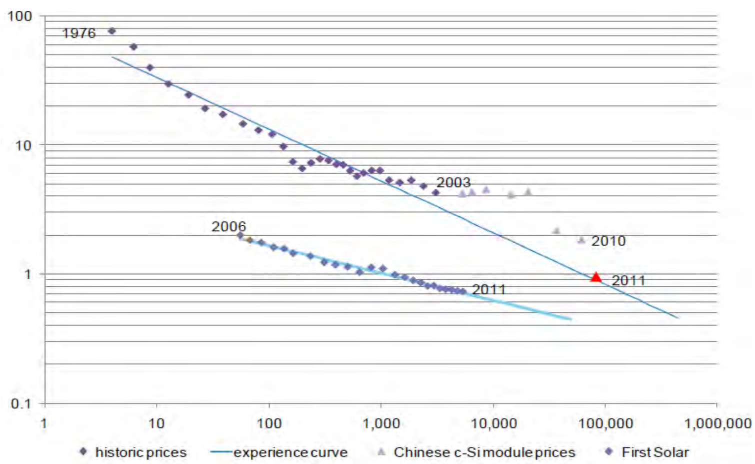

Figure 1: PV module experience curve 1976-2011 (BNEF, 2012a).

A closer look at one type of module (Chinese c-Si) shows the dramatic change in the price curve since 2008 (Figure 2). Historically, modules had a share of around 60% of the total PV system cost (Wang et al., 2011), but due to the extraordinary decline in module prices since 2008, its share in the total installed system cost has since decreased (Hoium, 2011). BOS components are now the majority share of the total capital cost-per-watt and therefore represent one of the main potential sources of further PV system cost reductions (Farrell, 2011a).

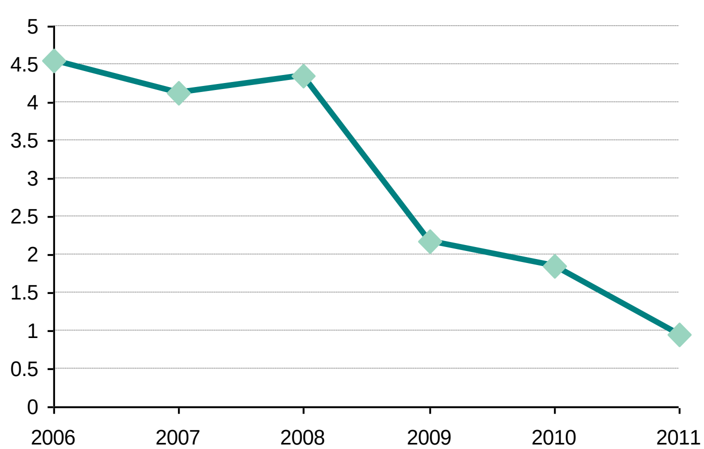

Figure 2: Chinese c-Si PV module prices ($/W): Note the change in the slope of the curve since 2008.

In order to provide further granularity, Figure 3 shows a typical breakdown of a Chinese multicrystalline silicon module in April 2012. (This price is nearly $0.10/W lower that than that of international multicrystalline silicon modules, mainly due to significantly lower processing costs per watt of ingot and wafer, cell and module.)

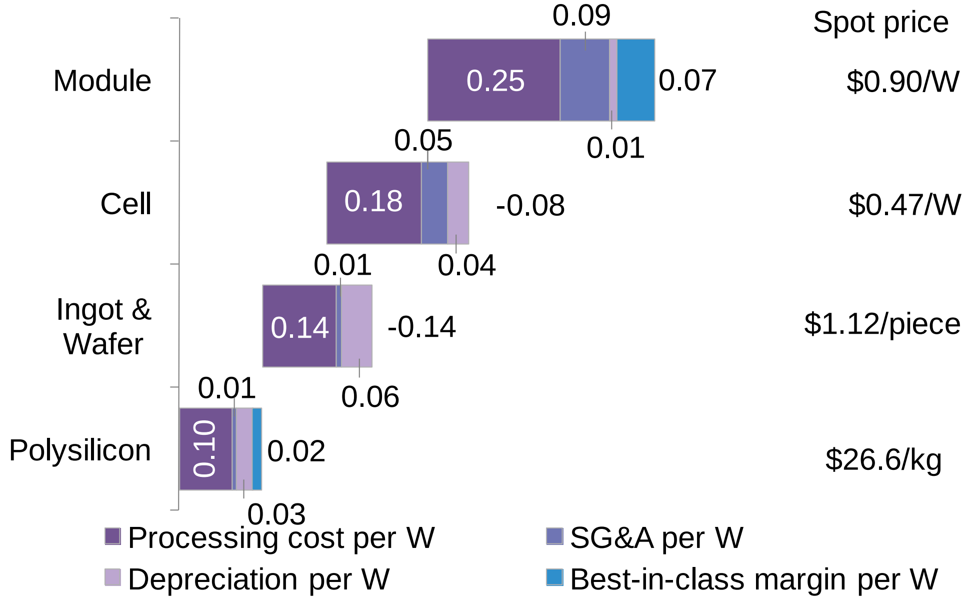

Figure 3 Chinese multicrystalline silicon module cost build-up (assuming 6.0g of silicon per watt of wafer), April 2012 (BNEF, 2012a).

Silicon costs, making up about 20% of the total module cost today, have had a significant impact on PV cost declines as they dropped from temporary highs of more than $450/kg in 2008 to currently (Q1, 2012) less than $27/kg (see Figure 4, and Fessler, 2012).

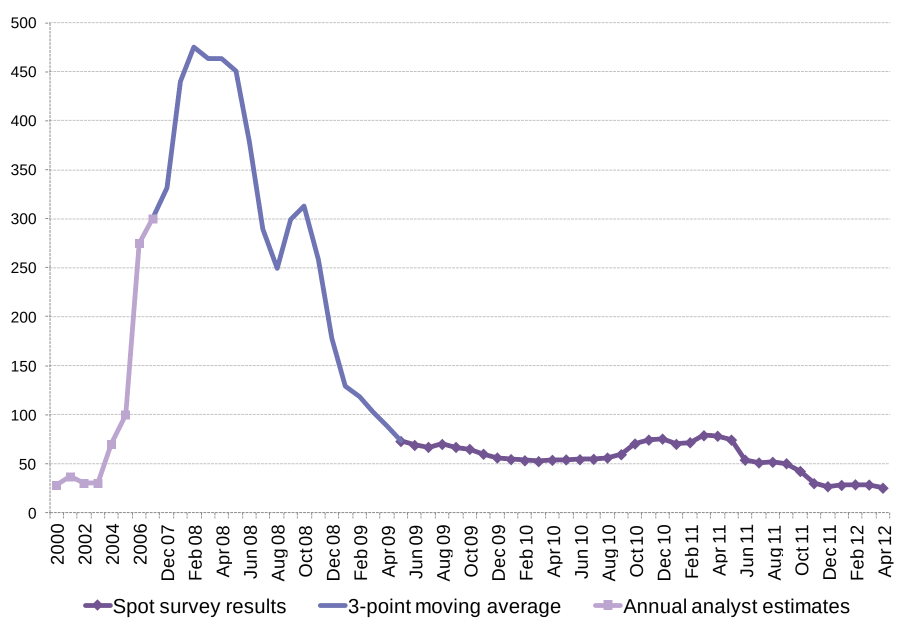

Figure 4: Spot price of solar-grade silicon ($/kg) (BNEF, 2012a).

On average, prices of wafers dropped from just below $1.00/W in 2009 to $0.35/W in Q1 2012, and those of cells declined from $1.30/W in 2009 to $0.55/W in Q1 2012. The BOS components experienced a 19% to 22% learning rate (IPCC, 2012). The price of its single largest component, the inverter, dropped from an average of $0.29/W in 2007 to under $0.20/W in some cases in Q1 2012 (IPCC, 2012; BNEF, 2012). Note the price difference in scale: inverters for a residential system currently still cost around $0.29, while those for commercial and utility scale systems cost $0.19/W and $0.18/W, respectively. According to Bony et al. (2010) the average cost of BOS (including installation) in 2010 ranged from $1.6/W for a ground-mounted system to $1.85/W for a rooftop system. The BOS cost for a 10 MW, fixed tilt, multi c-Si project in the US is reported to be $1.43/W and for a 10 MW, fixed tilt, CdTe project $1.54/W (Greentech Media, 2011). These examples show how many descriptors one needs to cite in order to provide full transparency in any presentation of this seemingly simple metric.

Our discussion so far has focused on crystalline and multicrystalline products, however the thin film PV industry raised its market share from 6% in 2005 to 20% in 2009 (IPCC, 2012). Its share was subsequently reduced to 13% in 2010 and further to 11% in 2011 (REN 21, 2011; Shiao, 2012). Thin film production increased by a record 63% to reach 2.3 GW in 2010. *PVxchange* module retail spot market reports March 2012 thin film module prices between $0.79/W for CdS/CdTe to $0.92/W for a-Si/µ-Si modules (pvXchange, 2012). Modules from First Solar, based on cadmium telluride (CdTe) and making up the bulk of global thin film shipments, have been successful due to a low cost position, but have also come under pressure in 2012 as crystalline silicon prices dropped.

4. Levelized Costs

If keeping up with fast-paced PV equipment cost and price changes is challenging, even more care is required in interpreting levelized cost of electricity calculations. There is a large literature on this subject (see e.g., Pollard, 1979; Rosenblum, 1983; Pouris, 1987; Landis, 1988; Thornton and Brown, 1992; Roth and Ambs, 2004; NEA et al., 2005; Canada et al., 2005; Moore, 2005; Simons et al., 2007; Bazilian and Roques, 2008; Bishop and Amaratunga, 2008; Myers et al., 2010; Singh and Singh, 2010; Yang, 2010; Zweibel, 2010; IEA et al., 2010; Ramadhan and Naseeb, 2011; Branker et al., 2011; Wang et al., 2011; Darling et al., 2011; Eldada, 2011; Timilsina et al., 2012; Mandhana, 2012). While the economic feasibility of a particular energy generation project is typically evaluated by metrics, such as ROI or IRR, the LCOE is most commonly used by policy makers as a long term guide to the competitiveness of technologies[9]. LCOE analysis considers costs distributed over the project lifetime and as such supposedly provides a more accurate economic picture, which system operators prefer over a simple capital cost-per-watt calculation[10]. A particularly important extension is that LCOE requires an estimate

[9]Long Run Marginal Cost (LRMC) is another metric used to calculate economic feasibility of a PV project. Many utilities use LRMC instead of LCOE. For an example of the use of LRMC, please refer to Simhauser (2010). What tool is used depends on the time horizon and perspective of the potential decision-maker. The differences between short-run and long-run marginal costs are covered in NEA et al. (2005).

[10]Useful references for recent, more elaborate work on LCOE calculation methods and/or analysis include: NEA et al. (2005); Lazard (2008); IEA et al. (2010); Singh and Singh (2010); Zweibel (2010); Branker et al. (2011); Darling et al. (2011); Wang et al. (2011).

of long-term PV system performance – a very context-specific outcome, driven by factors including solar insulation at the site, component technologies and specifications, overall system design and installation, and maintenance.

The LCOE for PV c-Si has declined by nearly 50% from an average of $0.32/kWh early 2009 to $0.17/kWh early 2012, while that for PV thin film experienced a drop from $0.23/kWh to $0.16/kWh in the same period. According to BNEF, the current (Q1, 2012) levelized cost ranges from $0.11/kWh to $0.25/kWh. Since the sharp drop in module costs in 2008, the literature on LCOE estimations for PV has grown substantially – we present some of it here. Under a range of financing assumptions and locations, the U.S. DOE estimated a PV LCOE of approximately $0.10/kWh to $0.18/kWh[11] for utility-scale, $0.16/kWh-$0.31/kWh for commercial systems and $0.16/kWh-$0.25/kWh for residential PV systems (NREL, 2009). The U.S. Energy Information Administration"s (EIA) estimates range from $0.16/kWh to $0.32/kWh. Zweibel (2010) calculates a cost of PV electricity in the U.S. Southwest of $0.15/kWh. Running the Solar Advisor Model (SAM), Wang et al. (2011) obtain a LCOE of $0.11/kWh. Calculating LCOE for PV based on input parameter distributions feeding a Monte Carlo simulation, Darling et al. (2011) find an average LCOE of $0.09/kWh, $0.10/kWh and $0.07/kWh for Boston, Chicago and Sacramento, respectively. The US DOE Solar Program"s Technology Plan aims at making PV-generated power cost-competitive with market prices in the USA by 2015. Their energy cost targets are $0.08-$0.10/kWh for residential, $0.06-$0.08/kWh for commercial and $0.05-$0.07/kWh for utility-scale solar PV (Asplund, 2008; IPCC, 2012). Branker et al. (2011) estimate a PV LCOE range for Ontario, Canada, of $0.10/kWh-$0.15/kWh[12]. LCOE estimates for PV in Africa by Gielen (2012) range from $0.20/kWh to $0.51/kWh. Schmidt et al. (2012) estimate PV LCOEs for six developing countries ranging from approximately $0.20-$0.35/kWh in 2010. In general, the LCOE range found in the literature extends from around $0.10/kWh to $0.30/kWh for most contexts.

Despite the substantial drop in PV costs, many commentators continue to note that PV-generated power is prohibitively expensive unless heavily supported by subsidies or enhanced prices (see e.g., Asplund, 2008; IEA et al., 2010; Singh and Singh, 2010; IPCC, 2012; Lomborg, 2012; Neubacher, 2012; Timilsina et al., 2012). Outdated numbers are still widely disemminated to governments, regulators and investors. Yang (2010), for example, calculates PV with a levelized cost of $0.49/kWh. Timilsina et al. (2012) find that the minimum values of LCOE for PV are $0.19/kWh. This sort of data often contrasts sharply with prices submitted in response to Dutch auctions for solar projects around the world, where developers bid to supply solar power at the lowest price. As an example, $0.12/kWh was bid in the Peru tender in August 2011, $0.11/kWh in China in September 2010 and $0.15/kWh in India in April 2012. At the end of March 2012, both SCE and PG&E in the US filed advice letters asking for approval of contracts: of the winning bids for 11 contracts, 9 were for PV, with the highest executed contract price of $0.09/kWh[13] (PG&E, 2012; SCE, 2012). In interpreting these auction results it is important to note that their results may reflect the impact of fiscal incentives and not be directly comparable to LCOEs. In addition, it is not always clear if the backers of these projects intend to make normal

[11] Note that some LCOE figures from the US quoted in this paper may be post-Federal tax rebates and may also include local capex rebates in some cases.
[12] The majority of estimates (presented here and) found in the literature are for the North American region. See Branker et al. (2011) for a comprehensive summary of LCOE estimates from various sources in North America.
[13] While this is the highest clearing price and individual contract prices could be even lower, note that federal tax credits likely make these prices look lower than they would otherwise be.

financial returns. As we will discuss, the fossil fuel or nuclear generation costs that are often used in comparisons may not be equivalent, for a wide range of reasons.

Standard definitions have been proposed for the LCOE method, such as those by IEA (NEA et al., 2005) or NREL (System Advisor Model (SAM)[14] and Levelized Cost of Energy Calculator[15]). Nevertheless, as discussed by Branker et al. (2011), the method "is deceptively straightforward and there is lack of clarity of reporting assumptions, justifications showing understanding of the assumptions and degree of completeness, which produces widely varying results". Darling et al. (2011) suggest using input parameter distributions rather than single numbers in order to obtain a LCOE *distribution*, rather than a single number, as a means of increasing transparency by reflecting cost uncertainty associated with solar projects. Other, more sophisticated methods exist (see e.g., Bazilian and Roques, 2008), but LCOE persists as a widely-used metric[16].

There is ample variation in the underlying LCOE assumptions found in the literature (Queen‟s University, 2011). For example, the capital cost for PV systems in the more current literature can range from $5.00/W[17] to $2.00/W[18]. While PV modules are generally warranted for 25 or more years (Zweibel, 2010), research suggests that a 40 year lifetime has been demonstrated and that 50 years may be within reach with today‟s crystalline technology (IEA, 2010). O&M costs for a utility-scale PV plant can range from $10/kW/year to $30/kW/year; this range may be partly due to differences in the scope of services provided under an O&M contract. (see e.g., Lazard, 2008; Darling et al., 2011; NREL, 2011). The Weighted Average Cost of Capital (WACC)[19] is normally used as a discount rate to determine the net present value of the PV power generation cost[20] but it can vary widely with the type of project owner, the nature and stability of regulatory regimes, and regional differences in cost of capital.

BNEF (on behalf of WEF (2011)) identify the most important determining factors of the levelized cost as being capital costs, capacity factor, cost of equity, and cost of debt. Sensitivity results presented by IEA et al. (2010) draw similar conclusions (see Figure 5), showing that levelized costs of power generated by PV exhibit a particularly high sensitivity to load factor variations, followed by variations in construction costs and discount rate. Singh and Singh (2010) analyze the impact of the choice of loan method on LCOE, identifying the loan repayment method as one high-impact assumption. The results of a rank correlation analysis undertaken by Darling et al.

[14]https://sam.nrel.gov/.

[15]http://www.nrel.gov/analysis/tech_lcoe.html.

[16]LCOE is especially problematic for fossil fuel based generators as assumptions have to be made around future costs of fuel, and costs of associated volatility and uncertainty. Methodologies such as Real Options are beyond the scope of this paper, but are very useful in providing better understanding decision-making in power markets.

[17]Stuart (2011) reports $5.60/W on the high-end for a 5 to 20 MW system between 2008 and 2010. The summary of recent solar PV installed system costs compiled by Branker et al. (2011) ranges from $3.52/W to $5.02/W for utility-scale PV. See Goodrich et al. (2012) for a comprehensive study on residential, commercial and utility-scale PV systems in the US. Barbose and Wiser (2011) report installed costs in 2011 for large-scale PV projects in the range of $3.80/W to $4.40/W.

[18] Figures as low as $1.80/W are appearing (the reputed installed cost in India for 5MW projects according to EPC data from AnSol and SunEdison).

[19] See NEA et al. (2005) for a discussion of technology specific discount rates. For references on the cost of capital, see e.g., Ogier et al. (2004) or Pratt and Grabowski (2010).

[20] Note that this assumption is location and time-dependent as it includes prior assumptions on figures, including real risk free debt, debt risk premium, real and nominal cost of debt, equity risk premium, equity beta, real pre- and post-tax cost of equity, etc. Analyses in the literature abstracting from financing issues often assume 5% and 10% discount rates.

(2011) indicate that financial uncertainties (e.g., variation of discount rate) are a major determining factor of LCOE, followed by system performance (including geographical insolation variation), which equally represents a major contributor to the uncertainty in LCOE.

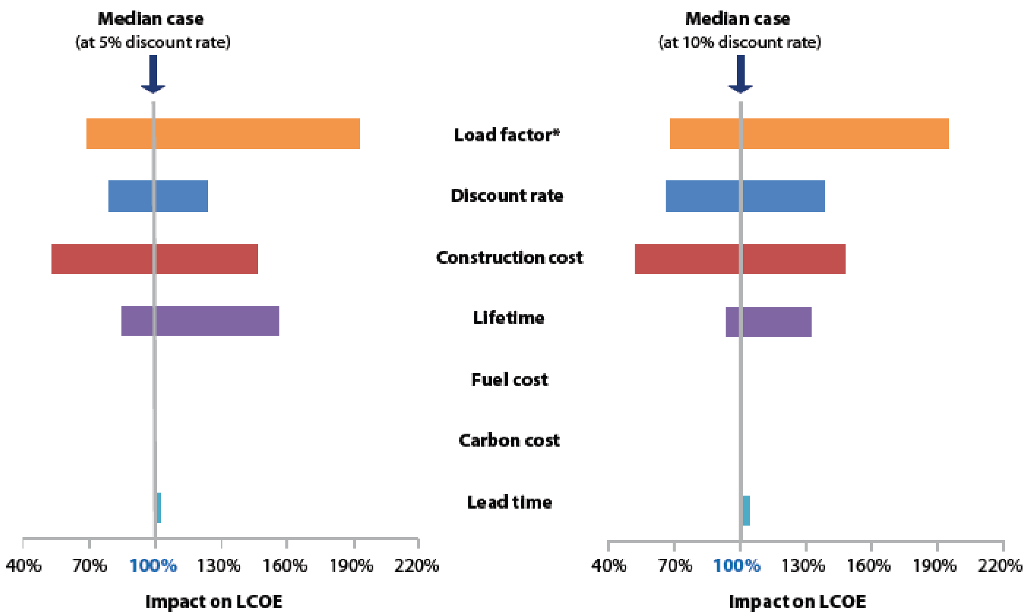

Figure 5: Tornado graph PV LCOE (IEA et al., 2010).

4.1. Power system comparisons

In addition to the complexities of providing clear PV LCOE figures, significant discrepancies between the underlying characteristics and economics of different power generating technologies, as well as of the markets they serve, make it difficult to directly compare project-by-project on a levelized basis. As an example, the Emirates Solar Industry Association (ESIA, 2012) show that based on current market rates, the LCOE from solar PV in typical MENA climates is estimated to be \$0.15/kWh. At this level, PV is cheaper on a simple LCOE basis than open-cycle peaking units at gas prices higher than \$5.00/MMBtu[21]. PV has, in fact, already replaced some peaking plants. In 2009, the California Energy Commission (CEC) rejected a contract for a new plant in San Diego in favour of a PV solar system that would lower the cost of electricity for ratepayers (Ahn and Arce, 2009). The key challenge lies in establishing the underlying place of different technologies within the power dispatch curve, and in the differing ways in which the resulting economics flow through into wholesale and retail electricity prices.

The primary focus within the electricity industry is on what value a particular technology brings to a power system. This can depend on the nature of demand, the network, and the mix of existing generation and its operating rules. Rapidly dispatchable peaking plant has a particularly high value for electricity networks with infrequent periods of very high demand. PV generation, in some locations, matches periods of higher demand and hence can be of high value, but its output

[21] That might appear as a surprising result given the significant investments underway in gas-fired peaking plant around the world including very sunny regions.

is generally variable and only somewhat predictable – a considerable disadvantage in an industry where supply must precisely meet demand (and losses) at all times and locations within the grid (IEA et al., 2010; Joskow, 2010; MacGill, 2010). The coherence of underlying economics and commercial returns for different technologies within an electrical grid adds further complexity for investment analysis, as italso depends on electricity market design and the design of any supporting PV policies.

Even at comparable levelized costs and with commercially proven technologies, differing risk profiles of different technologies also have a large impact on the viability of the project (NEA et al., 2005). The perceived risk of a technology is directly related to how, and at what costs of capital, projects are financed. Similarly, uncertainty in future fuel and electricity prices impacts differently on the profitability of different technologies (Bazilian and Roques, 2008). While gas-fired technologies, for instance, are particularly sensitive to fuel prices and price volatility (since fuel costs constitute the majority of generation costs), capital-intensive renewables, such as PV, are more sensitive to electricity prices, risk adjusted interest rates, maintenance costs and insolation levels[22].

5. Moving beyond grid-parity

The confusion surrounding the concept of grid parity is perhaps even more significant than either of the other two metrics we have highlighted, yet it remains a cornerstone of PV-related messaging. A new wave of discussions about grid parity has been set off by the recent non-linear price drops (See e.g., Parkinson, n.d.; Yang, 2010; Breyer and Gerlach, 2010; Baillie, 2011; Branker et al., 2011; Hickman, 2011; Seba, 2011; Farrell, 2011b; Shanan, 2012; Trabish, 2012; Carus, 2012; Goffri, 2012; Mints, 2012a). Depending on the scale of the PV project, grid parity normally refers to the LCOE of PV by comparison with alternative means of wholesale electricity provision – often an inappropriate metric as discussed previously. While for large-scale PV, these alternatives may indeed be assessed as alternative wholesale generation projects utilising different technologies, for small-scale domestic or commercial PV systems, the appropriate alternative should be the purchase of electricity at a relevant residential or commercial tariff. The latter case is where grid parity actually took its name – such PV applications are not competing against wholesale generation but, instead, the delivered price of electricity through the grid. Grid parity is not a term that is used for other generation technologies except those that are potentially deployed at small customer premises such as, for example, domestic-sized fuel cells.

As noted with LCOE, however, behind the relatively simple concept of grid parity lies considerable complexity and ambiguity. A particular challenge is the disconnect that is often seen within an electricity industry between underlying economic value, and the actual price for electricity at different points of the supply chain. For example, in wholesale electricity markets the price generally varies over time and by location, and is subject to a range of uncertainties related to the cost of ancillary services, transmission congestion, short-term load regulation, longer-term unit commitment, and contingency management. The competitiveness of large-scale PV in such markets by comparison with other generation options can then depend in large part on how well its intermittent production matches these prices by comparison with other, often dispatchable, plants, what short-term ancillary service implications it poses, and the ability to forecast future production. By contrast, the prices in many retail electricity markets are better

[22] For a detailed discussion of methodologies incorporating risk into cost calculations, see NEA et al. (2005).

described as „schedules of fees" involving flat or relatively simple Time-Of-Use (ToU) tariffs that often smear energy and network costs for end-users, and smear overall costs across customer classes through simple accumulation metering and regulated pricing regimes (Elliston et al., 2010). The competitiveness of PV then depends in large part on its LCOE in particular contexts by comparison with the relevant tariffs that system owners and operators would otherwise be paying (Hoke and Komor, 2012)[23]. Additional complexities include the likely trajectory of future retail tariffs (and potentially underlying changes), and the potential challenges of financing small-scale installations by often poorly informed and relatively unmotivated energy users.

Contrary to the view that the arrival of grid parity is still decades away, numerous studies have concluded that solar PV grid parity has already been achieved in a number of countries/regions (see e.g., Breyer and Gerlach, 2010; Zweibel, 2010; Branker et al., 2011; Darling et al., 2011). This discrepancy is not difficult to understand, given the definitional issues we have presented. As mentioned, it is often difficult to ascertain whether the term refers to grid parity, also known as „busbar parity" (i.e., competitiveness with wholesale prices), or „socket parity" (i.e., competitiveness with electricity user prices). Calculations by Bhandari and Stadler (2009) suggested that grid parity of wholesale electricity in Germany will occur around 2013-2014. Branker et al. (2011) find that for Canada, PV grid parity is already a reality (under specific circumstances). Breyer and Gerlach (2010) estimate that grid parity of large industrial segments would start between 2011 and 2013 and occur at the same time in Europe, the Americas and Asia. Similarly, EPIA (2011) forecasts that „dynamic" grid parity[24] could occur around the year 2013 in the commercial segment in Italy, after which it would spread out across the rest of Europe to reach all types of installations and market segments by 2020.

Figure 6 presents data around when certain countries reached and will reach grid parity. It shows, for example, that countries with higher electricity prices, such as Germany, Denmark, Italy, Spain and parts of Australia have already reached socket parity, defined here as the point where a household can make 5% or more return on investment in a PV system just by using the energy generated to replace household energy consumption, while countries like Japan, France, Brazil or Turkey are expected to reach it by 2015[25]. Such a „busy" and non-intuitive graphic serves to demonstrate how difficult a concept it is to communicate – and this places PV at a disadvantage at a time when the industry is seeking to send clear messages on competitiveness in its political communications and government affairs.

[23] Note that although competitiveness is evaluated prior to build out and installation of PV, it has very little to do with how or when PV is dispatched into a market, if in the wholesale system, or aggregated from distributed generation (if allowed). So, while LCOE represents an average cost, the actual price that PV gets is the spot market price - unless under bilateral contracts, offsets ToU retail prices, or fixed rate prices at the distributed generation level.
[24] In EPIA (2011), „Dynamic grid parity" is defined as "the moment at which, in a particular market segment in a specific country, the present value of the long-term net earnings (considering revenues, savings, cost and depreciation) of the electricity supply from a PV installation is equal to the long-term cost of receiving traditionally produced and supplied power over the grid".
[25] For more detailed information, see Roston (2012).

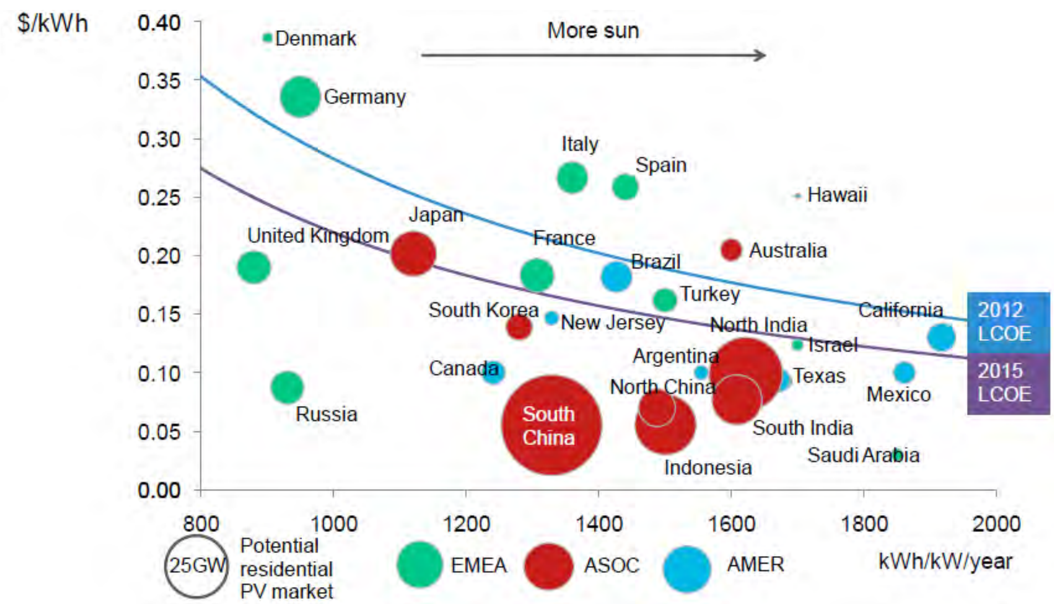

Figure 6: Residential PV price parity (size of bubbles refers to market size) (BNEF, 2012a).
Note: LCOE based on 6% weighted average cost of capital, 0.7%/year module degradation, 1% capex as O&M annually, $3.01/W capex assumed for 2012, $2.00/W for 2015.

6. Cause for optimism

Grid parity is now largely an outdated concept stemming from an industry that has traditionally been used to being an "underdog" of small scale, and constantly fighting for a "level playing field". While the term has served some usefulness as an abstract metric for R&D programmes to strive for, it is not useful in real-world power sector decisions (Mints, 2012b). Since it does not take into account the value of solar PV to the broader electrical industry, and is often used to compare a retail technology against a wholesale price, it implicitly provides a tool for proponents of other technologies to use against PV. Of course standard concepts and practices of assessing commercial viability rely on real data in contracts, financial spreadsheets and bids, remain the norm in transactions – these should replace grid parity in public discourse as well.

Developing countries in particular offer a huge potential market for PV systems. While historically the primary market for PV systems in developing countries has been off-grid applications - mainly individual solar home systems (Hoffmann, 2006; Moner-Girona et al., 2006), a larger market is expected to emerge in the near future for grid-connected PV. For decades, it has been recognised that PV was a good economic alternative in remote (off-grid) industrial applications that rely on diesel power generation, especially to power small electrical loads of up to hundreds of kilowatts (Solarbuzz, 2012). Data from IRENA now indicate that grid-connected PV in Africa has already become competitive with diesel-generated power, with an LCOE between $0.30 and $0.95/kWh, based on size, local diesel subsidies, and pilferage (IRENA, 2012). BNEF (2011) concludes that falling costs in PV technology mean that solar power is already a viable option for electricity generation in the Persian Gulf Region, where it can generate good economic returns by replacing the burning of oil for electricity generation[26].

[26]As long as the unburnt oil is valued at the international selling price, rather than extraction cost.

Similarly, power produced from PV in India is already competitive with power obtained by burning diesel (Pearson, 2012). These and other findings highlight the huge potential of PV in developing countries and indicate that, if not already competitive, PV is rapidly becoming competitive with alternative power generation technologies.

Still, the impacts of decision-makers not understanding the real costs for PV often has led to inefficiencies in, *inter alia*, tariff schemes. If PV power is perceived to be too costly, governments are less likely to take on the financial burden. This was the case in China in 2010, where the anticipated national PV FiT was dropped because solar PV costs were deemed too high[27] (EPIA, 2011b). Other governments introducing new FiT programs are confronted with the challenge of striking the right balance. The Japanese government, for instance, recently adopted a renewable FiT scheme (starting in July 2012) and faced the difficulty of picking an appropriate rate that will stimulate PV investment without overpaying for clean electricity[28] (McCrone and Nakamura, 2012). Alternative mechanisms such as tenders can offer options for addressing the dynamic cost environment, although may have higher risk for development (see e.g., Couture et al., 2010; Elliston et al., 2010; Kreycik et al., 2011). For example, the ACT government recently adopted a reverse auction process for large-scale solar through which developers will be paid their nominated FiT price less the market spot price. This means that as the spot price increases over time, the actual FiT payment will decrease. Collectively ratepayers will pay less FiT throughout the FiT period, although individual households will nonetheless incur higher energy charges as the spot rates increase (ACT Parliamentary Counsel, 2011).

7. Conclusions

The PV industry has seen unprecedented declines in module prices since the second half of 2008. Yet, awareness of the current economics of solar power lags among many commentators, policy makers, energy users and even utilities. The reasons are numerous and include: the very rapid pace of PV price reductions, the persistence of out-of-date data in information still being disseminated (occasionally by those with an interest in clouding the discussion), the misconceptions and ambiguity surrounding many of the metrics and concepts commonly used in the PV industry, and ambiguities regarding underlying PV costs due to the numerous policy support measures that have been put in place over the last decade.

We have presented a large body of academic and industry literature in an attempt to inform policy makers about the current costs and prices of PV, and to lend some clarity to those struggling with understanding the metrics generally used in assessing PV investments. Our main conclusions are that LCOE metrics in the PV industry can be misleading and should therefore be applied with caution as they require careful interpretation and transparency. Furthermore the term „grid parity", the long-sought goal of the PV industry, has become outdated and is generally misleading.

Current PV module prices are considered by some to be below manufacturing cost, and consequently, as unsustainable, in large part because several leading non-Chinese firms in the industry have recently announced losses cutbacks or massive write-downs or filed for bankruptcy (Daily and Steitz, 2011; Daily and Das, 2012; Mints, 2012a, 2012b; Montgomery, 2012; Wesoff,

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[27] The Chinese national PV FiT was subsequently announced in August 2011 (see e.g., Gifford (2011)).
[28] Early 2012 Japan decided that solar will receive JPY 42/kWh for 20 years (Quilter, 2012).

2012)[29]. Ultimately, the shift in prices of solar technology carries major implications for decision makers and policy designers, especially for the design of tariff, fiscal and other supporting policies (see e.g., Ahearn et al., 2011). The challenge is to elegantly transition PV from a highly promising and previously expensive option, to a highly competitive player in electricity industries around the world.

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[29] Perhaps there is an analogy to this in the telecommunications industry that experienced sharp falls in telecoms prices in the early 2000s, resulting in several major bankruptcies. Eventually, though, the excess broadband capacity paved the way for an explosive growth in the internet and communications industries. Similarly, whether prices are sustainable today or not, the abundant capacity in the PV industry may likely be laying the foundation for an enormous increase of PV power.

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Renewable Resource Data Center

PVWatts

PVWatts supports the U.S. Department of Energy's Solar Energy Technologies Program.

NREL's PVWatts™ calculator determines the energy production and cost savings of grid-connected photovoltaic (PV) energy systems throughout the world. It allows homeowners, installers, manufacturers, and researchers to easily develop estimates of the performance of hypothetical PV installations.

The PVWatts calculator works by creating hour-by-hour performance simulations that provide estimated monthly and annual energy production in kilowatts and energy value. Users can select a location and choose to use default values or their own system parameters for size, electric cost, array type, tilt angle, and azimuth angle. In addition, the PVWatts calculator can provide hourly performance data for the selected location.

Using typical meteorological year weather data for the selected location, the PVWatts calculator determines the solar radiation incident of the PV array and the PV cell temperature for each hour of the year. The DC energy for each hour is calculated from the PV system DC rating and the incident solar radiation and then corrected for the PV cell temperature. The AC energy for each hour is calculated by multiplying the DC energy by the overall DC-to-AC derate factor and adjusting for inverter efficiency as a function of load. Hourly values of AC energy are then summed to calculate monthly and annual AC energy production.

The PVWatts calculator is available in two versions. Site Specific Data Calculator (Version 1) allows users to select a location from a map or text list of pre-determined locations throughout the world. Grid Data Calculator (Version 2) allows users to select any location in the United States.

The PVWatts calculator was developed by NREL's Electricity, Resources, and Building Systems Integration Center.

Printable Version

JULY 2012

The Value of Green Labels
in the California Housing Market

An Economic Analysis of the Impact of Green Labeling on the Sales Price of a Home

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EXECUTIVE SUMMARY

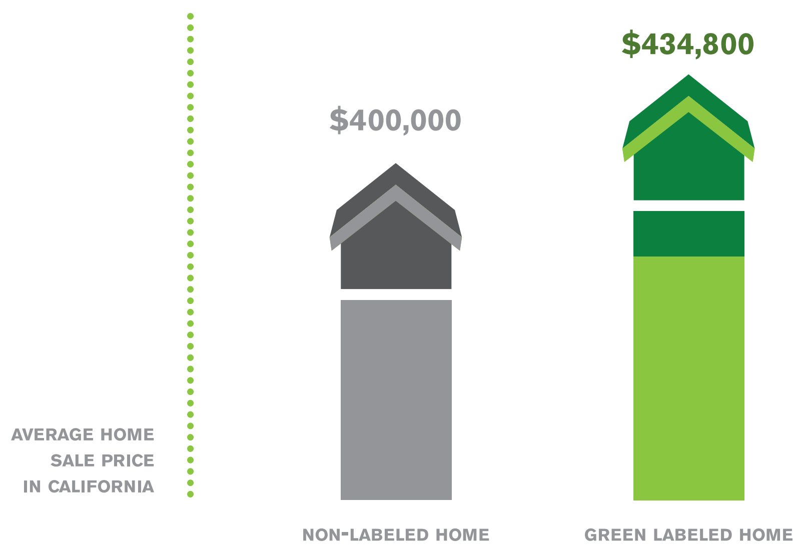
"The Value of Green Labels in the California Housing Market" is the first study to provide statistical evidence that, holding other factors constant, a green label on a single-family home in California provides a market premium compared to a comparable home without the label. The research also indicates that the price premium is influenced by local climate and environmental ideology. To reach these conclusions, researchers conducted an economic analysis of 1.6 million homes sold in California between 2007 and 2012, controlling for other variables known to influence home prices in order to isolate the added value of green home labels.

KEY FINDING: Green Home Labels Add 9 Percent Price Premium

This study, conducted by economists at the University of California, Berkeley and University of California, Los Angeles, finds that California homes labeled by Energy Star, LEED for Homes and GreenPoint Rated sell for 9 percent more (±4%) than comparable, non-labeled homes. Because real estate prices depend on a variety of factors, the study controlled for key variables that influence home prices including location, size, vintage, and the presence of major amenities such as swimming pools, views and air conditioning. Considering that the average sales price of a non-labeled home in California is $400,000, the price premium for a certified green home translates into some $34,800 more than the value of a comparable home nearby.

Green labeled homes sell at higher prices

A green label adds an average **9%** price premium to sale price versus other comparable homes.



GREEN LABELS FOR HOMES

Green home labels such as Energy Star, LEED for Homes, and GreenPoint Rated have been established to verify and communicate to consumers that a home is designed and built to use energy efficiently. Green homes also provide benefits beyond energy savings, such as more comfortable and stable indoor temperatures and more healthful indoor air quality. LEED and GreenPoint Rated homes also feature efficient water use; sustainable, non-toxic building materials; and other features that reduce their impact on the environment, such as proximity to parks, shops and transit.

EXPLAINING THE GREEN PREMIUM

This study yields two key insights into the effect of green labels on property values, and why these effects can be so significant. This is especially important in light of the fact that the added value of a green-labeled home far exceeds both the estimated cost of adding energy efficiency features to a home and the utility-bill savings generated by those improvements. Clearly, other factors are in play in producing this premium:

- The results show that the resale premium associated with a green label varies considerably from region to region in California, and is highest in the areas with hotter climates. It is plausible that residents in these areas value green labels more due to the increased cost of keeping a home cool.
- The premium is also positively correlated to the environmental ideology of the area, as measured by the rate of registration of hybrid vehicles. In line with previous evidence on the private value of green product attributes, this correlation suggests that some homeowners may attribute value to intangible qualities associated with owning a green home, such as pride or perceived status.

RESEARCH METHODOLOGY

The study, conducted by Matthew E. Kahn of UCLA and Nils Kok, visiting scholar at UC Berkeley and affiliated with Maastricht University in the Netherlands, examined all of the 1.6 million single-family homes sold between 2007 and 2012 in California. Of those homes, 4,321 were certified under Energy Star Version 2, GreenPoint Rated, or LEED for Homes. Seventy percent of the homes with a green label that were sold during this time period were new construction. The economic approach used, called "hedonic pricing analysis," controlled for a large number of variables that affect real estate pricing, such as vintage, size, location (by zip code) and the presence of major amenities (e.g., pools, views, and air conditioning). The findings of this study echo the results of previous research in the commercial real estate sector, which has found that green labels positively affect rents, vacancy rates and transaction prices for commercial space in office buildings.

1. INTRODUCTION

Increased awareness of energy efficiency and its importance in the built environment have turned public attention to more efficient, “green” building. Indeed, previous research has documented that the inventory of certified green *commercial* space in the U.S. has increased dramatically since the introduction of rating schemes that attest to the energy efficiency or sustainability of commercial buildings (based on criteria published by the public and private institutions administering the rating schemes). Importantly, tenants and investors value the “green” features in such buildings. There is empirical evidence that “green” labels affect the financial performance of commercial office space: Piet Eichholtz *et al.* (2010) study commercial office buildings certified under the LEED program of the US Green Building Council (USGBC) and the Energy Star program of the EPA, documenting that these labels positively affect rents, vacancy rates and transaction prices.

Of course, private homeowners may be different from tenants and investors in commercial buildings, especially in the absence of standardized, publicly available information on the energy efficiency of homes. But in recent years, there has been an increase in the number of homes certified as energy efficient or sustainable based on national standards such as Energy Star and LEED and local standards such as GreenPoint Rated in California. By obtaining verification from a third party that these homes are designed and built to use energy and other resources more efficiently than prescribed by building codes, homes with “green” labels are claimed to offer lower operational costs than conventional homes. In addition, it is claimed that owners of such homes enjoy ancillary benefits beyond energy savings, such as greater comfort levels and better indoor environmental quality. If consumers observe and capitalize these amenities, hedonic methods can be used to measure the price premium for such attributes, representing the valuation of the marginal buyer (Patrick L. Bajari and Lanier C. Benkard, 2005, Sherwin Rosen, 1974).

In the European Union, the introduction of energy labels, following the 2003 European Performance of Buildings Directive (EPBD), has provided single-family homebuyers with information about how observationally identical homes differ with respect to thermal efficiency. Presumably, heterogeneity in thermal efficiency affects electricity and gas consumption. The EU energy label seems to be quite effective in resolving the information asymmetry in understanding the energy efficiency of dwellings: Dirk Brounen and Nils Kok (2011) estimate hedonic pricing gradients for recently sold homes in the Netherlands and document that homes receiving an “A” grade in terms of energy efficiency sell for a 10 percent price premium. Conversely, dwellings that are labeled as inefficient transact for substantial discounts relative to otherwise comparable, standard homes.

We are not aware of any large sample studies the United States that have investigated the financial performance of “green” homes. There is some information on the capitalization of solar panels in home prices; one study based in California documents that homes with solar panels sell for roughly 3.5 percent more than comparable homes without solar panels (Samuel R. Dastrup *et al.*, 2012). But unlike findings in previous research on the commercial real estate sector, there is a dearth of systematic evidence on the capitalization of energy efficiency and other sustainability-related amenities in asset prices of the residential building stock, leading to uncertainty among private investors and developers about whether and how much to invest in the construction and redevelopment of more efficient homes.[1]

[1] There are some industry-initiated case studies on the financial performance of “green” homes. An example is a study by the Earth Advantage Institute, which documents for a sample of existing homes in Oregon that those with a sustainable certification sell for 30 percent more than homes without such a designation, based on sales data provided by the Portland Regional Multiple Listing Service. However, the sources of the economic premiums are diverse, not quantified, and not based on rigorous econometric estimations.

This paper is the first to systematically address the impact of labels attesting to energy efficiency and other "green" features of single-family dwellings on the value of these homes as observed in the marketplace, providing evidence on the private returns to the investments in energy-efficient single-family dwellings, an increasingly important topic for the residential market in the U.S.

Using a sample of transactions in California, consisting of some 4,231 buildings certified by the USGBC, EPA, and a statewide rating agency, Build It Green, and a control sample of some 1.6 million non-certified homes, we relate transaction prices of these dwellings to their hedonic characteristics, controlling for geographic location and the time of the sale.

The results indicate the importance of a label attesting to the sustainability of a property in affecting the transaction price of recently constructed homes as observed in the marketplace, suggesting that an otherwise comparable dwelling with a "green" certification will transact for about 9 percent more. The results are robust to the inclusion of a large set of control variables, such as dwelling vintage, size and the presence of amenities, although we cannot control for "unobservables," such as the prestige of the developer and the relative quality of durables installed in the home.

In addition to estimating the average effect, we test whether the price premium is higher for homes located in hotter climates and in electric utility districts featuring higher average residential electricity prices. Presumably, more efficient homes are more valuable in regions where climatic conditions demand more cooling, and where energy prices are higher. In line with evidence on the capitalization of energy efficiency in commercial buildings (Piet Eichholtz *et al.*, in press), our results suggest that a label appears to add more value in hotter climates, where cooling expenses are likely to be a larger part of total housing expenses. This provides some evidence on the rationality of consumers in appropriately capitalizing the benefits of more efficient homes.

We also test whether the price of certified homes is affected by consumer ideology, as measured by the percentage of hybrid registrations in the neighborhood. A desire to be environmentally conscious may increase the value of "green" homes because it is a tangible signal of environmental virtue (Steven E. Sexton and Alison L. Sexton, 2011), and an action a person can take in support of their environmental commitment. The results show that the green premium is positively related to the environmental ideology of the neighborhood; green homes located in areas with a higher fraction of hybrid registrations sell for higher prices. Some homeowners seem to attribute non-financial utility to a green label (and its underlying features), which is in line with previous evidence on the private value of green product attributes (Matthew E. Kahn, 2007).

The remainder of this paper is organized as follows: Section 2 describes the empirical framework and the econometric models. Section 3 discusses the data, which represent a unique combination of dwelling-level transaction data with detailed information on "green" labels that have been assigned to a subsample of the data. In Section 4, we provide the main results of the analysis. Section 5 provides a discussion and policy implications of the findings.

2. METHOD AND EMPIRICAL FRAMEWORK

Consider the determinants of the value of a single-family dwelling at a point in time as a bundle of residential services consumed by the household (John F. Kain and John M. Quigley, 1970). It is well-documented in the urban economics literature that the services available in the neighborhood, such as schools, public transport and other amenities, will explain a large fraction of the variation in price (see, for example, Joseph Gyourko *et al.*, 1999). But of course, the dwelling's square footage, architecture and other structural attributes will also influence its value.

In addition to attributes included in standard asset pricing models explaining home prices, the thermal characteristics and other "sustainability" features of the dwelling may have an impact on the transaction price. These characteristics provide input, which combined with energy inputs, provide comfort (John M. Quigley and Daniel L. Rubinfield, 1989). However, the energy efficiency of homes (and their equipment) is often hard to observe, leading to information asymmetry between the seller and the buyer. In fact, homeowners typically have limited information on the efficiency of their own home; it has been documented that the "energy literacy" of resident households is quite low (Dirk Brounen *et al.*, 2011). Indeed, recent evidence shows that providing feedback to private consumers with respect to their energy consumption is a simple, but effective ''nudge'' to improve their energy efficiency (Hunt Allcott, 2011).

To resolve the information asymmetry in energy efficiency, and also in related "green" attributes, energy labels and green certificates have been introduced in commercial and residential real estate markets. The labels can be viewed as an additional step to enhance the transparency of resource consumption in the real estate sector. Such information provision may enable private investors to take sustainability into account when making housing decisions, reducing ostly economic research (Robert W. Gilmer, 1989). From an economic perspective, the labels should have financial utility for prospective homeowners, as the savings resulting from purchasing a more efficient home may result in lower operating costs during the economic life, or less exposure to utility cost escalation over time.[2] In addition, similar to a high quality "view," various attributes of homes, such as durability or thermal comfort, may not provide a direct cash flow benefit, but may still be monetized in sales transactions.

To empirically test this hypothesis, we relate the logarithm of the transaction price to the hedonic characteristics of single-family homes, controlling precisely for the variations in the measured and unmeasured characteristics of rated buildings and the nearby control dwellings, by estimating:

$$(1)\ \log(R_{ijt}) = \alpha green_{it} + \beta X_i + \gamma_{jt} + \varepsilon_{ijt}$$

In this formulation, R_{ijt} is the home's sales price commanded by dwelling i in cluster j in quarter t; X_i is the set of hedonic characteristics of building i, and ε_{ijt} is an error term. To control more precisely for locational effects, we include a set of dummy variables, one for each of the j zip codes. These zip-code-fixed effects account for cross-area differences in local public goods such as weather, crime, neighborhood demographics and school quality. To capture the time-variance in local price dynamics, we interact zip-code-fixed effects with year/month indicators; the transaction prices of homes are thus allowed to vary by each month during the time period, in each specific location. This rich set of fixed effects allows for local housing market trends and captures the value of time-varying local public goods, such

[2] For the commercial real estate market, a series of papers that study investor and tenant demand for "green" office space in the U.S. show that buildings with an Energy Star label–indicating that a building belongs to the top 25 percent of the most energy-efficient buildings–or a LEED label have rents that are two to three percent higher as compared to regular office buildings. Transaction prices for energy-efficient office buildings are higher by 13 to 16 percent. Further analyses show that the cross-sectional variation in these premiums has a strong relation to real energy consumption, indicating that tenants and investors in the commercial property sector capitalize energy savings in their investment decisions (Piet Eichholtz *et al.*, 2010; in press).

as crime dynamics or the growth or decline of a nearby employment district. $green_i$ is a dummy variable with a value of one if dwelling i is rated by the EPA, USGBC or Build It Green, and zero otherwise. $\alpha, \beta, \gamma_{jt}$ are estimated coefficients. α is thus the average premium, in percent, estimated for a labeled building relative to those observationally similar buildings in its geographic cluster—the zip code. Standard errors are clustered at the zip code level to control for spatial autocorrelation in prices within zip codes.

In a second set of estimates, we include in equation (1) additional interaction terms where we interact "green" with a vector of locational attributes:

$$(2)\ \log(R_{ijt}) = \alpha_0\, green_{it} + \alpha_1\, N\, green_{it} + \beta X_i + \gamma_{jt} + \varepsilon_{ijt}$$

We estimate equation (2) to study whether the "green label" premium varies with key observables such as climatic conditions and local electricity prices.[3] We posit that green homes will be more valuable in areas that experience more hot days and areas where electricity prices are high. Presumably, the present value of future energy savings is highest in those regions, which should be reflected in the value attributed to the "green" indicator.

A second interaction effect addressed in this study is whether the capitalization effect of green labels is larger in communities that reveal a preference for "green products." A desire to appear environmentally conscious or to act on one's environmental values may increase the financial value of "green" homes because it is a signal of environmental virtue.[4] Our proxy for environmental idealism is the Toyota Prius share of registered vehicles in the zip code (these data are from the year 2007).[5] Last, we test for whether the green home premium differs over the business cycle. The recent sharp recession offers significant variation in demand for real assets, which may affect the willingness to pay for energy efficiency and other green attributes.

Anecdotally, we know that the green homes in our sample are mostly "production homes" and not high-end custom homes—many large residential developers, such as KB Homes, are now constructing Energy Star and GreenPoint Rated homes. But, it is important to note that we do not have further information on the characteristics of the developers of "green" homes and conventional homes. Therefore, we cannot control for the possibility that some developers choose to systematically bundle green attributes with other amenities, such more valuable appliances in green homes or a higher-quality finishing. We assume that such unobservables are not systematically correlated with green labels. Otherwise, we would overestimate the effects of "green" on housing prices.

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[3] In model (2), we replace the zip-code-fixed effects for county fixed effects, as data on Prius registrations, electricity prices and the clustering of green homes is measured at the zip code level. To further control for the quality of the neighborhood and the availability of local public goods, we include a set of demographic variables from the Census bureau, plus distance to the central business district (CBD) and distance to the closest public transportation hub.

[4] This is comparable to private investors' preference for socially responsible investments (Jeroen Derwall *et al.*, 2011).

[5] See Matthew E. Kahn (2007) for a discussion of Prius registrations as proxy for environmentalism.

3. DATA

A. Green Homes: Measurements and Data Sources

In the U.S., there are multiple programs that encourage the development of energy efficient and sustainable dwellings through systems of ratings to designate and publicize exemplary buildings. These labels are asset ratings: snapshots in time that quantify the thermal and other sustainability characteristics of the building and predict its energy performance through energy modeling. They neither measure actual performance, nor take occupant behavior into account. The Energy Star program, jointly sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy, is intended to identify and promote energy-efficient products, appliances, and buildings. The Energy Star label was first offered for residential buildings in 1995.[6]

The Energy Star label is an asset rating touted as a vehicle for reducing operational costs in heating, cooling, and water-delivering in homes, with conservation claims in the range of 20 to 30 percent, or $200 to $400 in annual savings. In addition, it is claimed that the label improves comfort by sealing leaks, reducing indoor humidity and creating a quieter environment. But the Energy Star label is also marketed as a commitment to conservation and environmental stewardship, reducing air pollution.

In a parallel effort, the US Green Building Council, a private non-profit organization, has developed the LEED (Leadership in Energy and Environmental Design) green building rating system to encourage the "adoption of sustainable green building and development practices." Since adoption in 1999, separate standards have been applied to new buildings and to existing structures.

The LEED label requires sustainability performance in areas beyond energy use, and the requirements for certification of LEED buildings are substantially more complex than those for the award of an Energy Star rating. The certification process for homes measures six distinct components of sustainability: sustainable sites, water efficiency, materials and resources, indoor environmental quality, innovation, as well as energy performance. Additional points can be obtained for location and linkages, and awareness and education.[7]

Whereas LEED ratings for commercial (office) space have diffused quite rapidly over the past 10 years (see Nils Kok *et al.*, 2011, for a discussion), the LEED for Homes rating began in pilot form only in 2005, and it was fully balloted as a rating system in January 2008.

It is claimed that LEED-certified dwellings reduce expenses on energy and water, have increased asset values, and that they provide healthier and safer environments for occupants. It is also noted that the award of a LEED designation "demonstrate[s] an owner's commitment to environmental stewardship and social responsibility."

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[6] Under the initial rating system, which lasted until 2006, buildings could receive an Energy Star certification if improvements were made in several key areas of the home, including high-performance windows, tight constructions and ducts, and efficient heating and cooling equipment. An independent third-party verification by a certified Home Energy Rater was required. Homes qualified under Energy Star Version 1 had to meet a predefined energy efficiency score ("HERS") of 86, equating more than 30 percent energy savings as compared to a home built to the 1992 building code. From January 2006 until the end of 2011, homes were qualified under Energy Star Version 2. This version was developed in response to increased mandatory requirements in the national building codes and local regulations, as well as technological progress in construction practices. The updated guidelines included a visual inspection of the insulation installation, a requirement for appropriately sized HVAC systems, and a stronger promotion of incorporating efficient lighting and appliances into qualified homes. An additional "thermal bypass checklist" (TBC) became mandatory in 2007. As of 2012, Energy Star Version 3 has been in place, including further requirements for energy efficiency measures and strict enforcement of checklist completion.

[7] For more information on the rating procedures and measurements for LEED for Homes, see: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147.

In addition to these national programs intended for designating exemplary performance in the energy efficiency and sustainability of (single-family) homes, some labeling initiatives have emerged at the city or state level. In California, the most widely adopted of these is GreenPoint Rated, developed by Build It Green, a non-profit organization whose mission is to promote healthy, energy- and resource-efficient homes in California.

The GreenPoint Rated scheme is comparable to LEED for Homes, including multiple components of "sustainability" in the rating process, with minimum rating requirements for energy, water, indoor air quality, and resource conservation. Importantly, the GreenPoint Rated scheme is available not just for newly constructed homes, but it is applicable to homes of all vintages. The label is marketed as "a recognizable, independent seal of approval that verifies a home has been built or remodeled according to proven green standards." Comparable to other green rating schemes, proponents claim that a GreenPoint rating can improve property values at the time of sale.

B. Data on Homes Prices and Their Determinants

We obtain information on LEED-rated homes and GreenPoint Rated homes using internal documentation provided by the USGBC and Build It Green, respectively. Energy-Star-rated homes are identified by street address in files available from local Energy Star rating agencies. We focus our analysis on the economically most important state of California, covering the 2007–2012 time period.

The number of homes rated by the "green" schemes is still rather limited – 4,921 single-family homes rated with GreenPoint Rated and 489 homes rated with LEED for Homes (as of January 2012). The number of homes that obtained an Energy Star label is claimed to be substantially larger, but we note that data on Energy Star Version 1 has not been documented, and information on homes certified under Energy Star Version 2 is not stored in a central database at the federal level. Therefore, we have to rely on information provided by consultants who conduct Energy Star inspections. We obtained details on 4,938 single-family dwellings that have been labeled under the Energy Star Version 2 program.

We matched the addresses of the buildings rated in these three programs as of January 2012 to the single-family residential dwellings identified in the archives maintained by DataQuick. The DataQuick service and the data files maintained by DataQuick are advertised as a "robust national property database and analytic expertise to deliver innovative solutions for any company participating in the real estate market."[8] Our initial match yielded 8,243 certified single-family dwellings for which an assessed value or transaction price, and dwelling characteristics could be identified in the DataQuick files; of those homes, 4,231 transacted during the sample period.[9]

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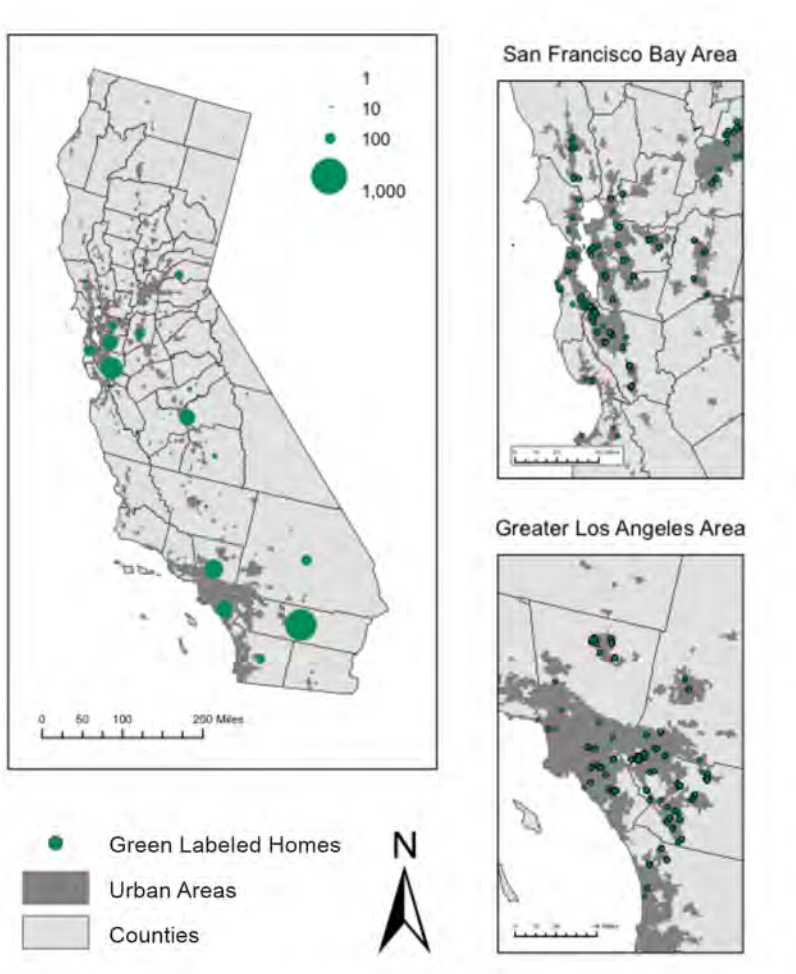
[8] DataQuick maintains an extensive micro database of approximately 120 million properties and 250 million property transactions. The data has been extensively used in previous academic studies. See, for example, Raphael W. Bostic and Kwan Ok Lee (2008) and Fernando Ferreira *et al.* (2010).

[9] We were not able to match the remaining 2,105 certified properties to the DataQuick files. Reasons for the missing observations include, for example, properties that were still under construction, and incomplete information on certified properties.

Figure 1 shows the geographic distribution of the certified homes in our sample. There is a clustering of "green" rated homes in certain areas, such as the Los Angeles region and the San Francisco region. The geographic distribution is correlated with higher incomes (e.g., in the San Francisco Bay Area), but also with higher levels of construction activity in recent years (e.g., in the Central Valley). As shown by the maps, in the case of Los Angeles, many of the "green label" homes are built in the hotter eastern part of the metropolitan area. It is important to note that there is little new construction in older, richer cities such as Berkeley and Santa Monica (Matthew E. Kahn, 2011). This means that it is likely to be the case that there will be few single-family "green homes" built in such areas.

FIGURE 1. Certified Homes in California (2007-2012)



Sources: Build It Green, EPA, and USGBC

To investigate the effect of energy efficiency and sustainability on values of dwellings as observed in the market, we also collect information on all non-certified single-family dwellings that transacted during the same time period, in the same geography. In total, there are nearly 1.6 million dwellings in our sample of green buildings and control buildings with hedonic and financial data.

Besides basic hedonic characteristics, such as vintage, size and presence of amenities, we also have information on the time of sale. Clearly, during the time period that we study, many homes in our geography were sold due to financial distress (i.e., foreclosure or mortgage delinquency). This, of course, has implications for the transaction value of homes (John Y. Campbell *et al.*, 2011). We therefore create an indicator for a "distressed" sale, based on information provided by DataQuick.

We also collect data on environmental ideology, proxied by the registration share of Prius vehicles in each zip code.[10] Local climatic conditions are assessed by the total annual cooling degree days at the nearest weather station (measured by the longitude and latitude of each dwelling and each weather station) during the year of sale.[11] Information on electricity prices is collected at the zip code level.[12]

C. Descriptive Statistics

Table 1 summarizes the information available on the samples of certified and non-certified dwellings. The table reports the means and standard deviations for a number of hedonic characteristics of green buildings and control buildings, including their size, quality, and number of bedrooms, as well as indexes for building renovation, the presence of on-site amenities (such as a garage or carport, swimming pool, or presence of cooling equipment), and the presence of a "good" view.[13]

Simple, non-parametric comparisons between the samples of certified and non-certified homes show that transaction prices of "green" homes are higher by about $45,000, but of course, this ignores any observable differences between the two samples. Indeed, green homes are much younger—70 percent of the dwellings in the green sample have been constructed during the last five years.

More than two-thirds of the stock of "green" homes are those certified by Energy Star, but there is substantial overlap among the green certifications—about 20 percent of the green homes have multiple labels.

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[10] We calculate the Toyota Prius share of registered vehicles from zip code totals of year 2007 automobile registration data (purchased from R.L. Polk).

[11] Data retrieved from http://www.ncdc.noaa.gov/cdo-web/.

[12] Data retrieved from http://www.energy.ca.gov/maps/serviceareas/electric_service_areas.html. We thank the California Energy Commission for providing a list containing each zip code in California and the corresponding local electric utility provider.

[13] DataQuick classifies the presence and type of view from the property. A "good" view includes the presence of a canyon, water, park, bluff, river, lake or creek.

4. RESULTS

Table 2 presents the results of a basic regression model relating transaction prices of single-family dwellings to their observable characteristics and a "green" rating. Zip-code-fixed effects account for cross-area differences in local public goods, such as weather, crime, neighborhood demographics and school quality. The analysis is based upon more than 1.6 million observations on rated and unrated dwellings. Results are presented for ordinary least squares regression models, with errors clustered at the zip code level. Coefficients for the individual location clusters and the time-fixed effects are not presented.

Column 1 reports a basic model, including some hedonic features: dwelling size in thousands of square feet, the number of bed and bathrooms, and the presence of a garage or carport. We also include zip-year/month fixed effects. The model explains about 85 percent of the variation in the natural logarithm of home prices.

Larger homes command higher prices; 1,000 square feet increase in total dwelling size (corresponding to an increase of about 50 percent in the size of typical home) leads to a 31 percent higher transaction price. Controlling for dwelling size, an additional bathroom adds about 10 percent to the value of a home, and a garage yields about 6 percent, on average.

In column 2, we add a vector of vintage indicators to the model. Relative to homes constructed more than 50 years ago (the omitted variable), recently developed homes fetch significantly higher prices. The relation between vintage and price is negative, but homes constructed during the 1960-1980 period seem to transact at prices similar to very old ("historic") homes. Renovation of dwellings is capitalized in the selling prices, although the effect is small; prices of renovated homes are just one percent higher.[14]

Column 3 includes a selection of dwelling amenities in the model. The results show that homes that were sold as "distressed," for example following mortgage default, transact at a discount of 16 percent, on average. The presence of a swimming pool, cooling system or a "view" contributes significantly to home prices.

Importantly, holding all hedonic characteristics of the dwellings constant, column 4 shows that a single-family dwelling with a LEED, GreenPoint Rated or Energy Star certificate transacts at a premium of 12 percent, on average. This result holds while controlling specifically for all the observable characteristics of dwellings in our sample. The "green" premium is quite close to what has been documented for properties certified as efficient under the European energy labeling scheme. A sample of 32,000 homes classified with an energy label "A" transacted for about 10 percent more as compared to standard homes (Dirk Brounen and Nils Kok, 2011). In the commercial property market, "green" premiums have been documented to be slightly higher – about 16 percent (Piet Eichholtz, *et al.*, 2010).

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[14] We replace the original "birth year" of a home with the renovation date in the analysis, so that vintage better reflects the "true" state of the home. This may explain the low economic significance of the renovation indicator.

A. Robustness Checks

In Table 3, the green rating is disaggregated into three components: an Energy Star label, a LEED certification, and a GreenPoint Rated label. The (unreported) coefficients of the other variables are unaffected when the green rating is disaggregated into these component categories. The estimated coefficient for the Energy Star rating indicates a premium of 14.5 percent. The GreenPoint Rated and LEED rating are associated with insignificantly higher transaction prices. Energy efficiency is an important underlying determinant of the increased values for "green" certified dwellings.[15] But of course, sample sizes for homes certified under the alternative rating schemes are quite limited, and just a small fraction of those homes transacted over the past years. An alternative explanation for the lack of significant results for the GreenPoint Rated and LEED schemes is the still limited recognition of those "brands" in the marketplace.[16]

The downturn in housing markets and the subsequent decrease in transaction prices may also have an impact on the willingness to pay for more efficient, green homes. It has been documented that prices are more procyclical for durables and luxuries as compared to prices of necessities and nondurables (see Mark Bils and Peter J. Klenow, 1998). To control for the time-variation in the value attributed to "green," we include interaction terms of year-fixed effects and the green indicator in column 4. When interaction terms of year-fixed effects are included in the model (the years 2007 and 2012 are omitted due to the lack of a sufficient number of observations in those years), we document substantial variation in the premium for green dwellings over the sample period. In the first years of the sample, labeled homes sold for a discount, albeit insignificantly (which may be related to the lack of demand for newly constructed homes during that time period), whereas the premium is large and significant in later years. The parallel with the business cycle suggests that, among private homeowners, demand for "green" is lower in recessions, but increases as the economy accelerates. This is contrasting evidence for the commercial market: It has been documented that green-certified office buildings experienced rental decreases similar to conventional office buildings during the most recent downturn in the economy (Eichholtz *et al.*, in press).

As noted in Table 1, most homes certified by one of three rating schemes have been constructed quite recently – some 70 percent of the green homes were constructed less than six years ago. Recognizing this point, we seek a similar control sample of non-certified single-family transactions, restricting the analysis to dwellings that are five years old or younger.[17]

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[15] The fundamental energy efficiency requirement is identical across the three different labeling schemes, and the mechanisms for verification are almost entirely similar. The three labels require design for 15 percent energy savings beyond building code requirements and all schemes require various on-site verifications to confirm the delivered home was built to that standard. GreenPoint Rated and LEED offer the highest number of credits for exceeding that minimum requirement. Energy Star rated homes are thus not necessarily better energy performers as compared to the other rating schemes.

[16] The Energy Star label is recognized by more than 80 percent of U.S. households, and 44 percent of households report they knowingly purchased an Energy Star labeled product in the past 12 months (see http://www.cee1.org/eval/00-new-eval-es.php3). Energy Star is one of the most widely recognized brands in the U.S. While similar data is not available for GreenPoint Rated or LEED, both were introduced as building labels much more recently, and do not benefit from near ubiquitous cobranding in consumer products.

[17] Quite clearly, this paper mostly deals with labeled developer homes rather than existing homes that went through the labeling process. As noted in Section 2, this raises the possibility of a "developer effect" in explaining the price variation between "green" and conventional homes. More information on the identity of developers of labeled and non-labeled homes would allow us to further disentangle this effect, but we have information on the developers of green homes only. About one third of the homes in the labeled sample have been constructed by KB Homes. Regressions that exclude homes constructed by KB Homes lead to similar results, with the green premium decreasing to about 6 percent.

Table 4 presents the results of this simple robustness check. Control variables, location-fixed effects and time-fixed effects are again omitted. The results presented in Table 4 are not consistently different from the results in Table 3, but the green premium is slightly lower: On average, green-rated homes that were constructed during the last five years transact at a premium of some 9 percent. The Energy Star label is significantly different from zero. We note that the estimated coefficient for the LEED rating indicates a premium of some 10 percent in transaction prices, but this is not statistically significant at conventional levels.

B. Testing for Heterogeneity in "Green Label" Capitalization

As demonstrated in the statistical models reported in Tables 2–4, there is a statistically significant and rather large premium in the market value for green-certified homes. The statistical analysis does not identify the source of this premium, or the extent to which the signal about energy efficiency is important relative to the other potential signals provided by a building of sufficient quality to earn a label. Of course, the estimates provide a common percentage premium in value for all rated dwellings. But the value of green certification may be influenced by factors related to the location of homes: Figure 1 suggests that the distribution of green-rated dwellings is not random within urban areas in California, and this may affect the geographic variation in the value increment estimated for green-certified homes. For example, non-financial utility attributed to "green" certification may be higher for environmentally conscious households (comparable to the choice for solar panels, see Samuel R. Dastrup *et al.*, 2012, for a discussion) or in areas where such homes are clustered (This peer effect is referred to as "conspicuous conservation" in a recent paper by Steven E. Sexton and Alison L. Sexton, 2011).

But, the financial utility of more efficient homes may also be affected by other factors related to the location of a dwelling. The financial benefits of a more efficient home should increase with the temperature of a given location, keeping all other things constant. (Presumably, more energy is needed for the heating of dwellings in areas with more heating degree days, and more energy is needed for the cooling of buildings in areas with more cooling degree days.) To test this hypothesis, we interact the green indicator with information on cooling degree days for each dwelling in the transaction year, based on the nearest weather station in the database of the National Oceanic and Atmospheric Administration (NOAA). Similarly, in areas with higher electricity costs, the return on energy efficiency should be higher. We therefore interact the climate variable with information on the retail price of electricity in the electric utility service area.

Table 5 presents a set of models that include a proxy for ideology, green home density, climatic conditions and local electricity prices. In this part of the analysis, we seek to (at least partially) distinguish the effects of the energy-saving aspect of the rating from other, intangible effects of the label itself. The results in column 1 show that more efficient homes located in hotter climates (e.g., the Central Valley) are more valuable as compared to labeled homes constructed in more moderate climates (e.g., the coastal region). At the mean temperature level (6,680 cooling degree days), the green premium equals about 10 percent. But for every 1000 cooling degree day increase, the premium for certified homes increases by 1.3 percent, keeping all other things constant. **This result suggests that private homeowners living in areas where cooling loads are higher are willing to pay more for the energy efficiency of their dwellings.**[18]

[18] While we do not have household level data on electricity consumption, the "rebound effect" would predict that such homeowners might respond to the relatively lower price of achieving "cooling" by lowering their thermostat. In such a case, the actual energy performance of the buildings would not necessarily be lower, because of this behavioral response.

In column 2, we add an interaction of climatic conditions with local electricity prices. (In models 2-4, we control for location using county-fixed effects.) Presumably, energy savings are more valuable if the price of electricity per kWh is higher. **However, our results do not show a difference in the capitalization of energy savings between consumers paying high rates** (the maximum rate in our sample equals 0.27 cent/kWh) **and those paying lower rates** (the minimum rate in our sample equals 0.07 cent/kWh). This may be because the true driver of consumer behavior is their overall energy outlay rather than the unit cost per kWh.

In Column 3, we include the share of Prius registrations for each zip code in the sample, interacted with the indicator for green certification. Quite clearly, the capitalization of "green" varies substantially by heterogeneity in environmental idealism: **In areas with higher concentrations of hybrid vehicle registrations, the value attributed to the green certification is higher.** These results on the larger capitalization effect of green homes in more environmentally conscious communities are consistent with empirical work on solar panels (Samuel R. Dastrup, *et al.*, 2012) and theoretical work on the higher likelihood for the private provision of public goods by environmentalists (Matthew J. Kotchen, 2006).

In column 4, we include a variable for the "density" of green homes in a given street and zip code, and built by the same developer. One could argue that in areas with a larger fraction of green homes, there is a higher value attributed to such amenity by the local residents. Households who purchase a home on this street know that their neighbors also will be living in a "green" home and this will create a type of Tiebout sorting as those who want to live near other environmentalists will be willing to pay more to live there. In this sense, the "green label" density acts as a co-ordination device. However, competition in the share of green homes in a given neighborhood may also negatively affect the willingness to pay for "green," as such feature is becoming a commodity (see Andrea Chegut *et al.*, 2011, for a discussion).

When including the density indicator, the point estimate for green certification does not change significantly, but the coefficient on green home density is pointing to a negative relation between the intensity of local green development and the transaction increment paid for green homes. This finding is not significant, but the sign of the coefficient is in line with evidence on green building competition in the UK. As more labeled homes are constructed, the *marginal* effect relative to other green homes becomes smaller, even though the *average* effect, relative to non-green homes, remains positive.

5. DISCUSSION AND CONCLUSIONS

A. Costs and Benefits of Green Homes

The economic significance of the "green" premium documented for labeled homes is quite substantial. **Considering that the average transaction price of a non-labeled home equals $400,000 (see Table 1), the incremental value of 9 percent for a certified dwelling translates into some $34,800 more than the value of a comparable dwelling nearby.**

Of course, this raises the issue of relative input costs. The increment in construction costs of more efficient, "green" homes is open to popular debate, and there is a lack of consistent and systematic evidence. Anecdotally, a recent industry report shows that estimated cost to reach a *modeled* energy efficiency level of 15 percent above California's 2008 energy code is between $1,600 and $2,400 for a typical 2,000 sq. ft. dwelling, depending on the climate zone. To reach a *modeled* energy efficiency level of some 35 percent above the 2008 code, estimated costs range from $4,100 to $10,000 for a typical 2,000 sq. ft. dwelling, again depending on the climate zone.[19] (Some of these costs are offset by incentives, and it is estimated that about one-third of the costs could be compensated for by rebates.) These admittedly rough estimates suggest that the capitalization of energy efficiency features in the transaction price (about $35,000) far exceeds the input cost for the developer (about $10,000, at most).

From the perspective of a homeowner, the benefits of purchasing a labeled home, or of "greening" an existing dwelling, include direct cost savings during tenure in the home. Indeed, we document some consumer rationality in pricing the benefits of more efficient homes, as reflected in the positive relation between cooling degree days in a given geography and the premium rewarded to a certified home. Presumably, the capitalization of the label should at least reflect the present value of future energy savings. Considering that the typical utility bill for single-family homes in California equals approximately $200 per month, and savings in a more efficient home are expected to yield a 30 percent reduction in energy costs, the annual dollar value of savings for a typical consumer is some $720. Compared to the increment for green-labeled homes documented in this paper, that implies a simple payback period of some 48 years.

Quite clearly, there are other (unobservable) features of green homes that add value for consumers. This may include savings on resources other than energy, such as water, but the financial materiality of these savings is relatively small. However, **there are also other, intangible benefits of more efficient homes, such as better insulation, reducing draft, and more advanced ventilation systems, which enhance indoor air quality. These ancillary benefits may be appealing to consumers through the comfort and health benefits they provide.**

The results documented in this paper also show that the premium in transaction price associated with a green label varies considerably across geographies. **The premium is positively related to the environmental ideology of the neighborhood.** In line with previous evidence on the private value of green product attributes, some homeowners seem to attribute non-financial utility to a green label (and its underlying features), explaining part of the premium paid for green homes.

[19] Source: Gabel Associates, LLC. (2008). "Codes and Standards: Title 24 Energy-Efficient Local Ordinances."

B. Conclusion

Buildings are among the largest consumers of natural resources, and increasing their energy efficiency can thus play a significant role towards achieving cost savings for private consumers and corporate organizations, and can be an important step in realizing global carbon reduction goals. With these objectives in mind, an ongoing effort has sought to certify buildings that have been constructed more efficiently. Considering the lack of "energy literacy" among private consumers, if homebuyers are unaware of a building's steady state (modeled) energy consumption, then they will most likely not appropriately capitalize energy savings in more efficient dwellings.

Comparable to evidence documented for the commercial sector in the U.S., and for the residential sector in Europe, the results in this paper provide the first evidence on the importance of publicly providing information about the energy efficiency and "sustainability" of structures in affecting consumer choice. Green homes transact for significantly higher prices as compared to other recently constructed homes that lack sustainability attributes. This is important information for residential developers and for private homeowners: Energy efficiency and other green features are capitalized in the selling price of homes.

We note that the green homes in our sample are not high-end, custom homes, but rather "production homes" built by large developers. From the developer's perspective, there are likely to be economies of scale from producing green homes in the same geographic area. If green communities command a price premium and developers enjoy cost savings from producing multiple homes featuring similar attributes, then for-profit developers will be increasingly likely to build such complexes. This has implications for the green premium, as the marginal effect relative to other green homes becomes smaller.

The findings in this paper also have some implications for policy makers. Information on the energy efficiency of homes in the U.S. residential market is currently provided just for exemplary dwellings.[20] **The mandatory disclosure of such information for all homes could further consumers' understanding of the energy efficiency of their (prospective) residence, thereby reducing the information asymmetry that is presumably an important explanation for the energy-efficiency gap.** An effective and cheap market signal may trigger investments in the efficiency of the building stock, with positive externality effects as a result.

Of course, we cannot disentangle the energy savings required to obtain a label from the unobserved effects of the label itself, which could serve as a signaling measure of environmental ideology and other non-financial benefits from occupying a green home. Future research should incorporate the *realized* energy consumption in green homes and conventional homes to further disentangle these effects. Reselling of green-labeled homes will also offer an opportunity to further study the value persistence of certified homes, unraveling the effect of developer quality on the green premium documented in this paper.

It also important to note that this paper focuses just on the market for owner-occupied single-family dwellings. While this represents an important fraction of the housing market, the market for rental housing has been growing considerably over the course of the housing crisis, and represents the majority of the housing stock in large U.S. metropolitan areas such as New York and San Francisco. Addressing the signaling effect of "green" labels for tenants in multi-family buildings should thus be part of a future research agenda.

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[20] At the time of writing, the City and County of San Francisco's Office of the Assessor-Recorder is beginning to record and publish the presence or absence of green labels in the county property database. Their stated objective is to increase the incentive to make green upgrades in new and existing properties by using transparency to increase market actors' ability to act upon label information.

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TABLE 1. Comparison of Green-Labeled Buildings and Nearby Control Buildings (standard deviations in parentheses)

	RATED BUILDINGS	CONTROL BUILDINGS
Sample Size	4,321	1,600,558
Sales Price	445.29	400.51
(thousands of dollars)	(416.58)	(380.47)
Assessed Value	425.95	355.21
(thousands of dollars)	(376.86)	(347.34)
Dwelling Size	2.06	1.80
(thousands of sq. ft.)	(0.69)	(0.86)
Lot Size	8.40	16.94
(thousands of sq. ft.)	(14.01)	(41.23)
Age	1.68	32.23
(years)	(9.49)	(24.39)
VINTAGE:		
Vintage < 6 years	0.70	0.18
(percent)	(0.46)	(0.38)
Vintage > 5 years < 11	0.00	0.08
(percent)	(0.02)	(0.28)
Vintage >10 years < 21	0.00	0.11
(percent)	(0.00)	(0.31)
Vintage > 20 years < 31	0.00	0.14
(percent)	(0.02)	(0.35)
Vintage > 30 years < 41	0.00	0.12
(percent)	(0.02)	(0.33)
Vintage > 40 years < 51	0.00	0.09
(percent)	(0.02)	(0.29)
Vintage > 50 years	0.01	0.20
(percent)	(0.08)	(0.40)
Renovated Building	0.04	0.12
(percent)	(0.19)	(0.33)
Garage	0.15	0.61
(number)	(0.55)	(0.94)
Number of Bedrooms	2.64	2.96
(percent)	(1.63)	(1.18)
Number of Bathrooms	2.03	2.11
(percent)	(1.26)	(0.94)
GREEN LABEL		
Energy Star	0.68	-
(percent)	(0.47)	-
GreenPoint Rated	0.47	-
(percent)	(0.50)	-
LEED for Homes	0.03	0.49
(percent)	(0.16)	(0.50)
Multiple Certifications	0.17	0.39
(percent)	(0.38)	(0.49)
Distressed Sale	0.08	0.11
(1 = yes)	(0.26)	(0.31)
Cooling Equipment	0.45	0.02
(1 = yes)	(0.50)	(0.15)
Swimming Pool	0.01	0.42
(1 = yes)	(0.09)	(0.41)
View	0.00	6.37
(1 = yes)	(0.02)	(4.34)
Prius Registration Share	0.45	14.94
(percent x100)	(0.38)	(1.37)
Cooling Degree Days Per Year	6.86	
(thousands)	(3.86)	
Electricity Price	15.06	
(cents/kWh)	(0.84)	

	RATED BUILDINGS	CONTROL BUILDINGS
TRANSACTION YEAR		
2007	0.01	0.13
(percent)	(0.09)	(0.34)
2008	0.04	0.19
(percent)	(0.20)	(0.39)
2009	0.15	0.23
(percent)	(0.36)	(0.42)
2010	0.55	0.21
(percent)	(0.50)	(0.41)
2011	0.23	0.21
(percent)	(0.42)	(0.41)
2012	0.01	0.02
(percent)	(0.08)	(0.14)

TABLE 2. Regression Results
Dwelling Characteristics, Amenities, and Sales Prices
(California, 2007 - 2012)

	(1)	(2)	(3)	(4)
Green Rating				0.118***
(1 = yes)				[0.023]
Dwelling Size	0.309***	0.289***	0.273***	0.273***
(thousands of sq. ft.)	[0.008]	[0.008]	[0.007]	[0.007]
Number of Bathrooms	0.095***	0.070***	0.066***	0.066***
	[0.005]	[0.005]	[0.005]	[0.005]
Number of Bedrooms	0.015***	0.019***	0.022***	0.022***
	[0.003]	[0.003]	[0.003]	[0.003]
Number of Garages	0.059***	0.062***	0.058***	0.058***
	[0.005]	[0.005]	[0.005]	[0.005]
AGE#				
New Construction		0.248***	0.190***	0.186***
(1 = yes)		[0.017]	[0.016]	[0.016]
1 – 2 years		0.259***	0.209***	0.206***
(1 = yes)		[0.015]	[0.015]	[0.015]
2 – 3 years		0.239***	0.223***	0.221***
(1 = yes)		[0.015]	[0.015]	[0.015]
3 – 4 years		0.207***	0.219***	0.219***
(1 = yes)		[0.014]	[0.014]	[0.014]
4 – 5 years		0.195***	0.213***	0.213***
(1 = yes)		[0.014]	[0.014]	[0.014]
5 – 6 years		0.186***	0.203***	0.203***
(1 = yes)		[0.014]	[0.014]	[0.014]
6 – 10 years		0.191***	0.193***	0.193***
(1 = yes)		[0.014]	[0.014]	[0.014]
10 – 20 years		0.158***	0.149***	0.149***
(1 = yes)		[0.012]	[0.012]	[0.012]
20 – 30 years		0.072***	0.064***	0.064***
(1 = yes)		[0.011]	[0.011]	[0.011]
30 – 40 years		0.009	0.001	0.001
(1 = yes)		[0.010]	[0.010]	[0.010]
40 – 50 years		0.007	-0.002	-0.002
(1 = yes)		[0.008]	[0.007]	[0.007]
Renovated		0.012**	0.011**	0.011**
(1 = yes)		[0.005]	[0.005]	[0.005]
Distressed Sale			-0.161***	-0.161***
(1 = yes)			[0.003]	[0.003]
View			0.063***	0.063***
(1 = yes)			[0.011]	[0.011]
Swimming Pool			0.086***	0.086***
(1 = yes)			[0.005]	[0.005]
Cooling Systems			0.060***	0.060***
(1 = yes)			[0.008]	[0.008]
TIME-ZIP-FIXED EFFECTS	Y	Y	Y	Y
Constant	11.743***	11.651***	11.795***	11.681***
	[0.203]	[0.177]	[0.161]	[0.163]
N	1,609,879	1,609,879	1,609,879	1,609,879
R^2	0.849	0.854	0.864	0.864
Adj R^2	0.856	0.861	0.871	0.871

Notes:

Omitted variable: vintage > 50 years

Regressions include: fixed effects by quarter year, 2007I–2012I, interacted with fixed effects by zip code. (Coefficients are not reported.)

Standard errors, clustered at the zip code level, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

TABLE 3. Regression Results
Green Labeling Schemes and Sales Prices
(Energy Star, GreenPoint Rated and LEED for Homes)

	(1)	(2)	(3)	(4)
Energy Star	0.145***			
(1 = yes)	[0.027]			
GreenPoint Rated		0.024		
(1 = yes)		[0.024]		
LEED for Homes			0.077	
(1 = yes)			[0.082]	
Green*Year 2008				-0.011
(1 = yes)				[0.057]
Green*Year 2009				0.052
(1 = yes)				[0.033]
Green*Year 2010				0.144***
(1 = yes)				[0.024]
Green*Year 2011				0.131***
(1 = yes)				[0.029]
Time-ZIP-Fixed Effects	Y	Y	Y	Y
Control Variables	Y	Y	Y	Y
Constant	11.759***	11.778***	11.795***	11.668***
	[0.162]	[0.162]	[0.161]	[0.165]
N	1,609,879	1,609,879	1,609,879	1,609,879
R^2	0.871	0.871	0.871	0.871
Adj R^2	0.864	0.864	0.864	0.864

Notes:

Regressions include: fixed effects by quarter year, 2007I–2012I, interacted with fixed effects by zip code; as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)

Standard errors, clustered at the zip code level, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

TABLE 4. Regression Results
Robustness Check: Recently Constructed Homes#

	(1)	(2)	(3)	(4)
Green Rating	0.087***			
(1 = yes)	[0.018]			
Energy Star		0.112***		
(1 = yes)		[0.017]		
GreenPoint Rated			-0.016	
(1 = yes)			[0.026]	
LEED for Homes				0.097
(1 = yes)				[0.074]
Time-ZIP-Fixed Effects	Y	Y	Y	Y
Control Variables	Y	Y	Y	Y
Constant	12.044***	12.059***	12.119***	12.114***
	[0.245]	[0.240]	[0.222]	[0.223]
N	314,759	314,759	314,759	314,759
R^2	0.884	0.884	0.883	0.883
Adj R^2	0.899	0.899	0.899	0.899

Notes:

Sample restricted to dwellings constructed during the 2007-2012 period.

Regressions include: fixed effects by quarter year, 2007I–2012I, interacted with fixed effects by zip code; as well as vintage (ranging from 1–5 years), amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)

Standard errors, clustered at the zip code level, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

TABLE 5. Regression Results
Green Labels, Climatic Conditions, Electricity Costs, and Sales Prices#

	(1)##	(2)###	(2)###	(3)###
Green Rating	-0.013	0.098*	-0.057	0.082**
(1 = yes)	[0.026]	[0.054]	[0.039]	[0.033]
Green Rating*Cooling Degree Days	0.014***	0.006		
	[0.003]	[0.075]		
Green Rating*Cooling Degree Days*Electricity Price		-0.001		
		[0.005]		
Green Rating*Prius Registration			21.957***	
			[5.355]	
Green Rating*Green Density				-0.002
				[0.001]
Distance to Closest Rail Station		-0.004***	-0.004***	-0.004***
(in kilometers)		[0.001]	[0.001]	[0.001]
Distance to CBD		-0.001	-0.001	-0.001
(in kilometers)		[0.001]	[0.001]	[0.001]
Time-ZIP-fixed Effects	Y	N	N	N
Time-FIPS-Fixed Effects	N	Y	Y	Y
Control Variables	Y	Y	Y	Y
Constant	12.055***	12.494***	12.378***	12.759***
	[0.023]	[0.067]	[0.161]	[0.240]
N	323,840	238,939	242,678	286,325
R^2	0.877	0.758	0.758	0.747
Adj R^2	0.893	0.760	0.761	0.749

Notes:

Sample restricted to dwellings constructed during the 2007-2012 period.

Regression in column 1 includes fixed effects by quarter year, 2007I–2012I, interacted with fixed effects by zip code; as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)

Regressions in columns 2 - 4 include fixed effects by quarter year, 2007I–2012I interacted with fixed effects by Census tract; the following Census variables at the zip code level: percentage of the population with at least some college education, percentage blacks, and percentage Hispanics, percentage in age categories 18-64, > 64; as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)

Standard errors, clustered at the zip code level, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

RESNET
Residential Energy Services Network

2006 Mortgage Industry National Home Energy Rating Systems Standards

This document was developed by RESNET and the National Association of State Energy Officials.

Setting the STANDARD for QUALITY

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2006 Mortgage Industry National Home Energy Rating Systems Standards

These consensus Standards were developed by the Residential Energy Services Network (RESNET) as amended in accordance with Chapter 5 of these Standards and adopted by the RESNET Board of Directors on July 30, 2012

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Chapter One
RESNET Standards

100 RESNET NATIONAL STANDARD FOR HOME ENERGY RATINGS

101 GENERAL PROVISIONS

101.1 Purpose

The purpose of these standards is to ensure that accurate and consistent home energy ratings are performed by accredited home energy rating Providers through their Raters nationwide; to increase the credibility of the rating Providers with the mortgage finance industry, federal government, state governments, local governments, utility companies, and the private sector; and to promote voluntary participation in an objective, cost-effective, sustainable home energy rating process.

Leaders in both the public and private sectors have identified the need for an accreditation process for home energy rating Providers. This accreditation process may be used by these stakeholders to accept home energy ratings and to assure accurate, independent information upon which the mortgage industry may accept home energy ratings for the purposes of issuing energy efficient mortgage, or similar, products; a state may recognize the home energy ratings as a compliance method for state building energy codes; as qualification for public and private sector energy programs designed to reach specific energy saving goals; and as a way to provide housing markets the ability to differentiate residences based on their energy efficiency. These home energy rating Standards have been developed to satisfy the above purposes.

101.1.1 Relationship to State Law. These Standards specifically recognize the authority of states that have laws requiring certification or licensing of home energy rating Providers. To the extent that state laws differ from these Standards, state laws shall govern.

101.2 Scope

This document sets out the procedures for the accreditation of home energy rating Providers and technical standards by which home energy ratings shall be conducted so their results will be acceptable to all public and private sector industries that may require an objective, cost-effective, sustainable home energy rating process.

102 ACCREDITATION CRITERIA

102.1 Minimum Standards for Home Energy Rating Provider Accreditation

An accredited Home Energy Rating Provider is responsible for insuring that all of the ratings issued by the Provider comply with all of the criteria by which the Provider was accredited.

Home Energy Rating Providers shall be accredited in accordance with the Accreditation Process specified in Chapter 9 of these Standards. A Home Energy Rating Provider must specifically meet the following minimum standards for Accreditation.

102.1.1 A written Quality Assurance Process that conforms to Chapter 9 of these Standards and any specific QA requirements for other Provider categories that may apply to a particular organization.

102.1.1.1 Have a QA Designee that oversees the Provider’s compliance with Chapter 9 of these Standards and any specific QA requirements for other Provider categories that may apply to a particular organization.

102.1.2 Rater Certification Standards. Certification and recertification of energy raters shall be made by Home Energy Rating Providers, which shall include the following provisions:

102.1.2.1 A Home Energy Rating Provider shall provide documentation that their Raters meet the Rater certification provisions contained in Chapter Two of these standards.

102.1.2.2 Performance evaluation of ability to perform accurate ratings.

102.1.2.2.1 In order for a Rater Candidate to be certified as a Home Energy Rater, they must satisfactorily complete two (2) supervised ratings as part of Rater training and a minimum of three (3) probationary ratings within twelve (12) months of successfully passing the National Core Rater Test. A maximum of one (1) of the three probationary ratings may be completed as a projected rating from plans, with the remaining two (2) being confirmed ratings.

102.1.2.2.2 For certified Home Energy Raters who are new to a Rating Provider, as part of Rating Provider’s due diligence process, it is a recommended best practice that Providers require a minimum of three (3) probationary ratings with the new Rater to confirm their skills as a Rater.

102.1.2.3 Professional Development for Raters. Raters shall complete one of the below three options:

102.1.2.3.1 Complete 18 hours of professional development every three years. The 18 hours shall include completion of 18 hours of refresher course(s) offered by a RESNET Accredited Training Provider.

102.1.2.3.1.1 Course(s) shall be approved by the RESNET Training and Education Committee annually;

102.1.2.3.1.2 The Training and Education Committee shall identify areas of Importance;

102.1.2.3.1.3 Instructor shall be required to pass an exam.

OR

102.1.2.3.2 Documentation of 18 hours of attendance at a RESNET Conference in three (3) years would fulfill this requirement.

OR

102.1.2.3.3 Pass the Rater Test every three years.

102.1.2.4 Rater Testing. All certified Raters must take the national home energy rater test administered by RESNET by January 1, 2008.

102.1.2.5 Recertification of Raters no less than every three years.

102.1.2.6 Rater Agreements. As a condition of Rater certification, each Provider shall ensure that a certified Rater who has met the requirements of Chapter 2, Rater Training Requirements, has entered into a written agreement with the Provider to provide home energy rating, field verification, and diagnostic services in compliance with these standards. A copy of the Rater written agreement shall be provided to RESNET with the Provider's accreditation application and within 60 days of making changes to the agreement. The written agreement shall at a minimum require Raters to:

102.1.2.6.1 Provide home energy rating and field verification services in compliance with these standards;

102.1.2.6.2 Provide accurate and fair ratings, field verification and diagnostic testing;

102.1.2.6.3 Comply with the RESNET Code of Ethics. The "RESNET Code of Ethics" is posted on the RESNET website. The Code of Ethics shall be attached to the written agreement. An unexecuted copy of the written agreement shall be provided to RESNET with a Home Energy Rating Provider accreditation application and within 60 days of making changes to the agreement.

102.1.3 A Home Energy Rating Provider shall provide documentation with its accreditation application that the energy rating software used to produce energy ratings is properly licensed.

102.1.4 Minimum Standards for Home Energy Rating Provider's Operation Policies and Procedures must be written and provide for the following:

102.1.4.1 Ratings from plans. If the home energy rating Provider's program provides for ratings by from plans, the rating be labeled as from plans. Such ratings may be used to demonstrate energy code compliance or programmatic qualification but must be confirmed through a field inspection upon completion of construction.

102.1.4.2 Field inspection of all homes.

102.1.4.3 Blower Door Test completed on all homes claiming credit for reduced air infiltration.

102.1.4.4 Duct testing completed on all homes claiming credit for reduced air distribution system leakage.

102.1.4.5 When applicable, improvement analysis given to home owner.

102.1.4.5.1 Recommended improvements with the cost basis supplied for each recommendation by the home energy rating software program, home energy rating Provider or the Rater receiving quotes.

102.1.4.5.2 Estimated energy and cost savings of improvements based upon assumptions contained in the home energy rating Provider program.

102.1.4.6 Written conflict of interest provisions that prohibits undisclosed conflicts of interest but allows waiver with advanced disclosure. The" Home Energy Rating Standard Disclosure" form adopted by the RESNET Board of Directors shall be completed for each home that receives a home energy rating and shall be provided to the rating client and made available to the home owner/buyer. Each form shall include, at a minimum, the name of the community/subdivision, city, and state where the home is located. Each form shall accurately reflect the proper disclosure for the home that it is rated (i.e. it should, reflect the Rater's involvement with the home at the time the final rating is issued. For the purpose of completing this disclosure, "Rater's employer" includes any affiliate entities. Recognizing that a number of different relationships may occur between the Rater or the Rater's employer and the rating client and/or homeowner and/or the marketplace in general, the rating Provider shall ensure that all disclosures are adequately addressed by the Provider's QUALITY assurance plan, in accordance with the relevant QUALITY assurance provisions of the standards.

102.1.4.7 Written Rater discipline procedures that includes progressive discipline involving Probation - Suspension – Termination.

102.1.4.7.2 Rating/Tax Credit Verification Recordkeeping. Providers and/or their certified Raters shall maintain records for each rating/tax credit verification.

102.1.4.7.2.1 The QUALITY assurance record for each home shall contain at a minimum the electronic copy of the building file.

102.1.4.7.2.2 The record for each rating/tax credit verification shall be maintained for a minimum of three years.

102.1.4.8 Rater Registry. The Provider shall maintain a registry of all of its certified Raters. The Provider will also keep on file the names and contact information for all, including company name, mailing address, voice phone number, fax number, and email address. Upon request, the Provider shall provide to RESNET its registry of certified Raters.

102.1.4.9 Complaint Response System. Each Provider shall have a system for receiving complaints. The Provider shall respond to and resolve complaints related to ratings and field verification and diagnostic testing services and reports. Providers shall ensure that Raters inform purchasers and recipients of ratings and field verifications about the complaint system. Each Provider shall retain records of complaints received and responses to complaints for a minimum of three years after the date of the complaint.

102.1.4.10 All Home Energy Rating Providers shall maintain an electronic database of information for each home rated or verified for the tax credit. The minimum content of the database is:

102.1.4.10.1 A unique file reference with ID number;

102.1.4.10.2 Date of on-site inspection;

102.1.4.10.3 Raters name;

102.1.4.10.4 Tool name and version;

102.1.4.10.5 Identification of climate data used for the rating;

102.1.4.10.6 Type of rating, either projected or confirmed;

102.1.4.10.7 Use of rating:

102.1.4.10.7.1 Time of sale rating;

102.1.4.10.7.2 Pre-home improvement rating;

102.1.4.10.7.3 Post home improvement rating; or

102.1.4.10.7.4 Information only rating;

102.1.4.10.8 Address of Rated Home;

102.1.4.10.9 Home type;

102.1.4.10.10 Floor area of conditioned space;

102.1.4.10.11 Fuel types used by building heating, cooling and water heating systems;

102.1.4.10.12 Minimum rated feature energy efficiency data used to determine the rating;

102.1.4.10.13 In the four categories of heating, cooling, water heating and all other uses, the:

102.1.4.10.13.1 Estimated annual purchased energy consumption in total;

102.1.4.10.13.2 Estimated annual purchased energy consumption by fuel;

102.1.4.10.13.3 Estimated annual energy costs in total; and

102.1.4.10.13.4 Estimated annual energy cost by fuel.

102.1.4.10.14 Estimated total annual energy cost for all uses;

102.1.4.10.15 Rating score of the Rated Home on 0-100 points scale and 1-5+ stars category;

102.1.4.10.16 To the extent allowed by state statute, all HERS Providers shall for 10% or for 500 of the homes rated annually, whichever is less, maintain a database of the following:

102.1.4.10.16.1 Homeowners authorization for the release of consumption information by utility companies;

102.1.4.10.16.2 Climate data site used for energy estimation;

102.1.4.10.16.3 Any energy efficiency improvements made to the home and date of completion.

102.1.4.11 Site data collection manual. All HERS Providers shall provide Raters with a manual containing procedures for the on-site collection of data that are at a minimum shall include the on-site inspection procedures for minimum rated features for new and existing homes provided in appendix A.

103 RATING SOFTWARE

103.1 For the purposes of conducting Home Energy Ratings, as defined in these Standards, Providers shall be required to use the most current version of one of the RESNET approved rating software programs contained in the “National Registry of Accredited Rating Software Programs” posted on the RESNET website.

103.2 Rating Software Changes. Should changes that affect the calculated results of the home energy rating occur in the engineering algorithms of a RESNET approved home energy rating software program, Providers shall be required to do the following:

103.2.1 Transition period. On announcement of a new software version release, Providers have a maximum of 60 days to begin all new ratings with the new version.

103.2.2 This requirement only applies to changes mandated by the technical standard or otherwise affecting the calculations of the rating score or projected energy savings.

103.2.3 Persistence. Once a projected rating has been made on a property, the version of the rating software that was used initially may be used for the final rating on that property. Providers, at their option, may update to the latest software version for in-process ratings.

104 RATINGS PROVIDED FOR THIRD-PARTY ENERGY EFFICIENCY PROGRAMS

104.1 See Appendix B for definition of Third Party Energy Efficiency Program (EEP)

104.2 When working with EEP's, Home Energy Raters may be required to perform tests, inspections, verifications and reporting that require skills related to energy efficiency not specific to Home Energy Ratings as defined in these Standards and/or are required to become a Certified Home Energy Rater. However, it is the responsibility of Certified Home Energy Raters to perform all of the stipulated tests, inspections, verifications and reporting related to energy efficiency required by the EEP when agreeing to work with their program, including proper completion of any and all checklists, certificates, or other documentation. Where a Rater does not possess the proper skill or knowledge of a particular test, inspection, verification or reporting requirement, they shall be responsible for obtaining sufficient training from the EEP, or trainer approved by the EEP, to properly fulfill the requirement. An exception may be made in cases where portions of an EEP's testing, inspection, verification or reporting process are completed by another company or individual who holds the required training or certifications.

104.3 See Section 906 for QA Requirements for EEP's

Chapter Two
RESNET Standards

200 RESNET NATIONAL STANDARD FOR RATER TRAINING AND CERTIFICATION

201 GENERAL PROVISIONS

201.1 Purpose

The provisions of this document are intended to establish national Rater training and certification standards which an accredited home energy rating Provider shall follow in certifying home energy Raters. This enhances the goal of producing nationally uniform energy efficiency ratings for residential buildings.

201.1.1 Relationship to other Standards. These standards are a companion document to the "National Accreditation Procedures for Home Energy Rating Systems" as promulgated and maintained by the National Association of State Energy Officials (NASEO) and the Residential Energy Services Network (RESNET) and the "National Home Energy Rating Technical Guidelines" as promulgated and maintained by NASEO. Both guidelines are recognized by the mortgage industry.

201.1.2 Relationship to State Law. These standards specifically recognize the authority of each state that has a state law which requires certification or licensing of home energy rating Providers. To the extent that such state laws differ from these standards, state law shall govern.

201.2 Scope

These standards apply to the training and certification of energy Raters who will be accepted by nationally accredited home energy rating Providers. An energy rating identifies the energy features and estimates the energy performance of a home and does not identify structural or health and safety problems of a home.

202 DEFINITIONS AND ACRONYMS

See Appendix B.

203 TRAINING AND EDUCATION COMMITTEE

203.1 RESNET Training and Education Committee

203.1.1 Committee membership. The Training and Education Committee shall be chaired by a member of the RESNET Board of Directors. The Chair shall be approved by the RESNET Board. Nominations of Committee members shall be made by the Chair to the RESNET Board for approval.

203.1.2 Responsibilities. The RESNET Training and Education Committee shall review and approve the following:

203.1.2..1 Core competency examination questions;

203.1.2..2 Time limits for the core examination;

203.1.2..3 Passing scores for the core examination; and

203.1.2..4 Annual accreditation fee.

204 ACCREDITED TRAINING PROVIDERS

204.1 Requirements for Accredited Home Energy Training Providers

204.1.1 Duties and Responsibilities. In order to maintain their accreditation in good standing, all Training Providers shall fully discharge the following duties and responsibilities. Failure to properly discharge all of these duties and responsibilities shall constitute grounds for disciplinary action in accordance with Section 212 of this Standard.

204.1.1.1 Hold the national core competency questions of the national test administered by RESNET in the strictest confidence.

204.1.1.2 Maintain a record, for a period of three years, of all training materials and trainee data, including:

204.1.1.2.1 Historical records of all training schedules and curricula,

204.1.1.2.2 Historical records of all training attendance records,

204.1.1.2.3 Historical records of all examinations and individual examination results,

204.1.1.2.4 Historical records of all certifications issued to any individuals,

204.1.1.2.5 Copies of the most up-to-date instructor presentation materials, training manuals, user manuals, course handouts and any other training materials use for training purposes,

204.1.1.2.6 Copies of all current policies, standards, guidelines and procedures in use by the Training Provider.

204.1.1.3 Maintain acceptable accounting practices, suitable to satisfy the requirements of independent audit procedures.

204.1.1.4 Maintain up-to-date training materials and courseware and provide for adequate training facilities.

204.1.1.5 Maintain certified trainers, who have been certified by RESNET by passing the National Rater Trainer Competency Test, and who satisfy the minimum trainer competencies in accordance with Section 206.1 of this chapter.

204.1.2 Privileges and rights. All accredited Training Providers in good standing shall have certain privileges and rights, as follows:

204.1.2.1 The privilege to display the accreditation seal of the National Accreditation Body on any publications, displays, presentations or marketing materials published, authorized for publication or otherwise issued by the Training Provider.

204.1.2.2 The privilege to make and use any trademarked, copyrighted or otherwise restricted materials other than the national core test developed by RESNET for marketing Rater Training Courses or Training Providers or for recruiting Rater trainees, instructors or trainers.

204.1.2.3 Copies of all current policies, standards, guidelines and procedures in use by the Training Provider.

204.1.2.4 The right to present evidence, arguments and a vigorous defense in any action brought under these standards by any party against a Training Provider.

205 HOME ENERGY RATINGS

205.1 Home Energy Rating Knowledge Base and Skills Set

205.1.1 The following comprise a list of knowledge base and skills are necessary for home energy ratings. Training Providers shall use a certified trainer who has successfully passed the RESNET National Rater Training Competency Test and that their training curricula are sufficiently comprehensive to effectively teach these materials to prospective Home Energy Raters (See Section 6.1). Prospective Home Energy Raters, to become certified, shall demonstrate proficiency through passing the RESNET national core test and other training Provider written examinations and observations.

205.1.1.1 Building Energy Performance.

205.1.1.1.1 Basic energy principles.

205.1.1.1.1.1 Energy terminology, units and conversions.

205.1.1.1.1.2 Heat transfer principles

205.1.1.1.1.2.1 Conduction

205.1.1.1.1.2.1.1 R-values & U-values

205.1.1.1.1.2.1.2 UA concepts

205.1.1.1.1.2.1.3 Parallel paths

205.1.1.1.1.2.2 Convection

205.1.1.1.1.2.2.1 Film coefficients

205.1.1.1.1.2.2.2 Buoyancy

205.1.1.1.1.2.2.3 Forced air flows

205.1.1.1.1.2.3 Radiation

205.1.1.1.1.2.3.1 Solar (absorptance + reflectance + transmittance = 1.0)

205.1.1.1.1.2.3.2 Far infrared (emittance = absorptance)

205.1.1.1.1.3 Moisture Principles

205.1.1.1.1.3.1 Properties

205.1.1.1.1.3.1.1 Dew point

205.1.1.1.1.3.1.2 Relative Humidity

205.1.1.1.1.3.1.3 Evaporation & condensation

205.1.1.1.1.3.2 Transport Mechanisms

205.1.1.1.1.3.2.1 Rain and ground water

205.1.1.1.1.3.2.2 Capillary action

205.1.1.1.1.3.2.3 Air transported

205.1.1.1.1.3.2.4 Vapor Diffusion

205.1.1.1.1.3.2.5 Evaporation and condensation

205.1.1.1.1.3.3 Impacts

205.1.1.1.1.3.3.1 Indoor Air Quality (IAQ)

205.1.1.1.1.3.3.2 Material and building durability

205.1.1.1.1.3.3.3 Human comfort

205.1.1.1.1.3.3.4 Energy use

205.1.1.1.1.4 Air flow in buildings

205.1.1.1.1.4.1 Pressure differentials and measurement techniques

205.1.1.1.1.4.2 Mechanisms and drivers

205.1.1.1.1.4.3 Energy and comfort implications

205.1.1.1.1.4.4 Health & safety issues

205.1.1.1.2 Heating, cooling, ventilation and hot water systems

205.1.1.1.2.1 System types

205.1.1.1.2.1.1 Direct-fired systems

205.1.1.1.2.1.2 Condensing systems

205.1.1.1.2.1.3 Heat pumps and air conditioning systems

205.1.1.1.2.1.3.1 Air Source

205.1.1.1.2.1.3.2 Ground Source

205.1.1.1.2.1.4 Hydronic systems

205.1.1.1.2.1.5 Combo systems

205.1.1.1.2.1.6 Ductless systems

205.1.1.1.2.1.7 Solar thermal systems

205.1.1.1.2.2 Efficiency

205.1.1.1.2.2.1 Measures of efficiency

205.1.1.1.2.2.2 Determination of efficiency (nameplate, age-based defaults, etc.)

205.1.1.1.2.3 Sizing & design

205.1.1.1.2.3.1 Impacts on energy use

205.1.1.1.2.3.2 Impacts on humidity control

205.1.1.1.2.4 Controls

205.1.1.1.2.4.1 Standard thermostats

205.1.1.1.2.4.2 Programmable thermostats

205.1.1.1.2.4.3 Multi-zone

205.1.1.1.2.5 Distribution systems

205.1.1.1.2.5.1 Duct types

205.1.1.1.2.5.2 Restricted returns

205.1.1.1.2.5.2.1 Closed interior doors

205.1.1.1.2.5.2.2 Return ducts and grills

205.1.1.1.2.5.3 Leakage

205.1.1.1.2.6 Fresh air ventilation

205.1.1.1.2.6.1 Supply, exhaust and balanced flow systems

205.1.1.1.2.6.2 Heat exchange systems

205.1.1.1.2.6.3 Energy/enthalpy exchange systems

205.1.1.1.2.6.4 Exchanger efficiency, fan power and duty cycle characteristics

205.1.1.1.2.7 Renewable energy systems

205.1.1.1.2.7.1 Active and passive space heating systems

205.1.1.1.2.7.2 Solar hot water systems

205.1.1.1.2.7.3 Photovoltaic systems

205.1.1.1.2.7.4 Wind generation

205.1.1.1.3 Diagnostic testing procedures

205.1.1.1.3.1 Building air tightness

205.1.1.1.3.1.1 Multipoint pressure testing

205.1.1.1.3.1.2 C, n, □p and R2

205.1.1.1.3.2 Air distribution system air tightness

205.1.1.1.3.2.1 Pressure pan threshold tests

205.1.1.1.3.2.2 Duct air leakage measurements

205.1.1.1.3.2.2.1 cfm25_total

205.1.1.1.3.2.2.2 cfm25 out

205.1.1.1.3.2.3 Pressure measurements

205.1.1.1.3.2.3.1 Operational (by home and its equipment)

205.1.1.1.3.2.3.2 Imposed (by blower door, etc.)

205.1.1.1.3.2.4 Air heat and moisture measurements

205.1.1.1.3.2.4.1 Airflows

205.1.1.1.3.2.4.2 Temperatures

205.1.1.1.3.2.4.3 Relative humidity

205.1.2 Identifying minimum rated features as defined in the National Home Energy Rating Technical Guidelines:

205.1.2.1 Identify basic home construction types; ramifications of these for energy usage.

205.1.2.2 Produce a scaled and dimensioned sketch of a home.

205.1.2.3 Identification of insulation defects and ability to account for them in energy analysis tool inputs.

205.1.2.4 Identify and document the features of the rated home in accordance with the requirements of Section B.5. and Appendix A of the National Home Energy Rating Technical Guidelines.

205.1.2.5 Identifying potential building problems

205.1.2.5.1 Health and safety concerns

205.1.2.5.2 Building durability issues

205.1.2.5.3 Potential comfort problems

205.1.2.5.4 Possible elevated energy use

205.1.2.6 Rating Procedures

205.1.2.6.1 Understanding construction documents

205.1.2.6.1.1 Building drawings

205.1.2.6.1.2 Specifications

205.1.2.6.2 Field data collection (including photo documentation)

205.1.2.6.2.1 Physical measurements

205.1.2.6.2.1.1 Completing scaled sketches

205.1.2.6.2.1.2 Measuring building dimensions

205.1.2.6.2.1.3 Determining building orientations

205.1.2.6.2.1.4 Measuring window overhang lengths and heights

205.1.2.6.2.1.5 Determining roof slopes, gable heights, etc.

205.1.2.6.2.1.6 Calculating gross and net areas and volumes.

205.1.2.6.2.2 Energy feature documentation

205.1.2.6.2.2.1 Energy Analysis (Software) tool data requirements

205.1.2.6.2.2.2 Developing and using field inspection forms

205.1.2.6.2.2.3 Organizing data entry procedures

205.1.2.6.2.3 Characterizing envelope features

205.1.2.6.2.3.1 Determining wall types

205.1.2.6.2.3.2 Determining window and door types and characteristics

205.1.2.6.2.3.3 Determining envelope insulation types, thickness, thermal characteristics and weighted average thermal values

205.1.2.6.2.3.4 Determining duct system characteristics (duct types, insulation value, location with respect to the thermal and air barrier)

205.1.2.6.2.4 Equipment efficiencies determination

205.1.2.6.2.4.1 Nameplate data

205.1.2.6.2.4.2 ARI and GAMA guides

205.1.2.6.2.4.3 Age-based defaults

205.1.2.6.2.4.4 In situ measurements

205.1.2.6.2.5 Performance testing

205.1.2.6.2.5.1 Envelope leakage

205.1.2.6.2.5.2 Air distribution system leakage

205.1.2.6.3 Local climate impacts

205.1.2.6.3.1 Major US climate zones

205.1.2.6.3.2 97.5% and 2.5% design conditions

205.1.2.6.3.3 Cooling and heating design trade-offs

205.1.2.6.4 Utility prices

205.1.2.6.4.1 Revenue-based pricing

205.1.2.6.4.2 Reliable sources

205.1.2.6.5 Reports

205.1.2.6.5.1 Minimum reporting requirements

205.1.2.6.5.2 Improvement analysis

205.1.2.6.5.3 Projected and confirmed ratings

205.1.2.7 Operating Procedures and Office Administration

205.1.2.7.1 National guidelines and standards

205.1.2.7.1.1 Accreditation Procedures

205.1.2.7.1.2 Technical Guidelines

205.1.2.7.1.3 Training & Certification Standards

205.1.2.7.2 Understanding the Reference home and rating method

205.1.2.7.2.1 Reference Home as defined in B.2 of the National Home Energy Rating Technical Guidelines ("Twin" home concept): "The reference home is the geometric twin of the rated home, configured to a standard set of thermal performance characteristics, from which the energy budget, that is the basis for comparison, is derived."

205.1.2.7.2.2 HERS Score computation using the Normalized Modified Loads Rating Method

205.1.2.7.3 Uses of a Rating

205.1.2.7.3.1 Builder assistance

205.1.2.7.3.1.1 Cost effective building design assistance

205.1.2.7.3.1.2 Quality assurance assistance

205.1.2.7.3.1.3 Marketing

205.1.2.7.3.2 Program qualifications

205.1.2.7.3.2.1 EPA ENERGY STAR®

205.1.2.7.3.2.2 Utility

205.1.2.7.3.2.3 Other

205.1.2.7.3.3 Financing advantages

205.1.2.7.3.3.1 Energy Efficient Mortgages (EEM)

205.1.2.7.3.3.2 Energy Improvement Mortgages (EIM)

205.1.2.7.3.4 Energy Code compliance

205.1.2.7.3.5 Added appraisal value

205.1.2.7.3.6 Consumer education

205.1.2.7.4 Understanding real estate, financing and economic terminology

205.1.2.7.5 Dealing with clients

205.1.2.7.5.1 Understanding the business aspects of being a energy Rater

205.1.2.7.5.2 Cultivating builder, banker and real estate partners.

205.1.2.7.5.3 Knowing who the customer is.

205.1.2.7.5.4 Providing excellent service.

205.1.2.7.6 Ethics and disclosure

205.2 Rating Field Inspector Knowledge and Skills Set

205.2.1 The following comprise a list of knowledge base and skills necessary to be certified as a Rating Field Inspector:

205.2.1.1 Completion of Rating Field Inspector training by a RESNET accredited Rater Training Provider.

205.2.1.2 A rating Field Inspector candidate has the option of challenging the classroom training by passing the RESNET National Rating Field Inspector Test.

205.2.1.3 A Rating Field Inspector shall pass the National Field Inspector Test administered by RESNET. A candidate who passes the test must still comply with the training field testing requirement.

205.2.1.4 Upon passing the RESNET National Rating Field Inspector Test, the Rating Field Inspection candidate shall complete five probationary inspections, including basic performance tests under the direct supervision of a certified rater who has accurately completed twenty five (25) confirmed ratings. The rater's Quality Assurance Designeeshall certify that the rater has completed ratings on 25 houses and the files do not have substantial errors detected through quality assurance review process.

205.3 Senior Certified Rater Knowledge and Skills Set

205.3.1 The following comprise a list of knowledge base and skills necessary to be certified as a Senior Certified Rater:

205.3.1.1 Experience as a certified energy Rater for a period of at least one year.

205.3.1.2 Documentation having accurately completed ratings and performance tests of a minimum of 25 homes.

205.3.1.3 Certification in a minimum of two Rater Specialty Certifications.

205.3.1.4 Demonstrate the ability to complete a rating and all required performance testing, without the use of any reference material, in the presence of a Rater trainer or Quality Assurance Designee.

205.3.1.5 Passing the National Senior Rater Test administered by RESNET.

205.3.2 A National Senior Rater must also publicly demonstrate before a jury of 5, approved by the Technical Committee and composed of at least 3 of his/her peers and at least one Certified Trainer and at least one Quality Assurance Designee, that he or she is competent in all areas by passing an oral exam, designed to determine if the National Senior Rater candidate can successfully diagnose and discuss in detail the building science phenomena that underlie a complex home energy rating case study, approved by the Training and Certification Committee.

205.4 Rater Specialty Certification

205.4.1 RESNET will formally recognize Raters' optional specialty certification(s) by independent programs in closely related fields of building performance, above and beyond RESNET's Rater certification. In order to be recognized by RESNET the program must submit an application developed by the RESNET Training and Education Committee. The RESNET Training and Education Committee will select programs based upon the following criteria:

205.4.1.1 The organization offering the certification shall have a credible reputation.

205.4.1.2 The training and certification is conducted by competent and qualified instructors in the prescribed field of instruction.

205.4.1.3 The organization offering the certification shall have a credible training and testing process as part of their certification.

205.4.1.4 The organization shall have clear, effective, and documented independent quality assurance procedures.

205.4.1.5 The organization shall have a clear, effective and documented discipline process.

206 MINIMUM COMPETENCIES

206.1 Minimum Rater Trainer Competencies

206.1.1 A Rater Training Provider shall maintain certified trainers demonstrating the following skills:

206.1.1.1 Mastery of the Home Energy Rating System knowledge base and skills set given by Section 205.1 of this chapter. The certified trainers shall demonstrate these skills by passing the RESNET National Rater Training Competency Test.

206.1.1.2 Ability to communicate effectively with adults in a training setting. This shall be demonstrated through completion of, at a minimum, a sixteen (16) hour RESNET approved adult education program.

> **206.1.1.2.1** Rater trainers that are currently certified have three (3) years from the effective date of this amendment to complete this training requirement.

206.1.1.3 Understanding of the purposes and benefits of home energy ratings and ability to communicate these to students.
206.1.1.4 Understanding the basics of energy efficient mortgages, energy improvements mortgages and related products and ability to communicate these to students.

206.1.2 Minimum Rater Competencies. A Certified Rater shall pass examinations comprising, at a minimum, the national core test administered by RESNET and complete a minimum of two ratings in the presence of a trainer. This examination may either follow training or it may be taken as a challenge examination. Specifically, a Certified Rater shall demonstrate the following skills:

206.1.2.1 Ability to accurately gather from building drawings and specification or from field inspections and product specification and nameplate information and/or determine through field performance testing all input data required by home energy rating software to produce accurate and fair home energy ratings in accordance with the National Home Energy Rating Technical Guidelines.

206.1.2.2 Understanding of the purposes and benefits of home energy ratings and ability to communicate these to potential customers.

206.1.2.3 Understanding the basics of energy efficient mortgages, energy improvement mortgages and related products and ability to communicate these to potential customers.

207 CERTIFIED TRAINING

207.1 Minimum Certified Training Requirements

207.1.1 The curriculum shall be designed to ensure that the Rater trainee is proficient as a Home Energy Rater as defined by Section 206.1.2, Minimum Rater Competencies, as given above.

207.1.2 Successful completion of Rater training requires that the Rater trainee pass a written examination comprising, at a minimum, the RESNET National Core Competency Test administered by RESNET and complete a minimum of two ratings in the presence of a trainer.

207.1.3 Rater certification by an Accredited Rating Provider shall be achieved within 1 year of successful completion of Rater training or training certification shall be null and void.

208 EXAMINATIONS

208.1 Certified Rater Trainer

208.1.1 Written examination. Examinations may be given at completion of classroom training or may be given in the form of a “challenge” exam to individuals who have not undergone classroom training.

208.1.1.1 National core competency test. RESNET shall directly administer the National Rater Training Competency Test to prospective Rater trainers seeking certification. The Rater training Provider seeking accreditation shall submit the names of certified Rater trainers it intends to use; and RESNET will verify whether they have passed the RESNET National Rater Training Competency Test.

208.1.1.1.1 RESNET National Rater Training Competency Test.

208.1.1.1.2 Overseen by a proctor. A proctor is an individual designated by RESNET to oversee the written National Rater Training Competency examination.

208.1.1.1.3 Time limited

208.1.2 Rater Candidates.

208.1.2.1 Written examination. Examinations may be given at completion of classroom training or may be given in the form of a "challenge" exam to individuals who have not undergone classroom training.

208.1.2.1.1 RESNET National Rater Training Competency Test

208.1.2.1.2 Open book (& student notes)

208.1.2.1.3 Overseen by a proctor. A proctor is an individual designated by the Accredited Training Provider to oversee the written examination.

208.1.2.1.4 Time limited

209 PROFESSIONAL DEVELOPMENT FOR RATER TRAINERS

209.1 Rater Trainers annually shall complete a two hour RESNET roundtable on current information and complete one of the following activities:

209.1.1 Document 12 hours of attendance at the RESNET Conference or

209.1.2 Complete 12 hours of RESNET approved CEU's, or

209.1.3 Instruct a minimum of ten (10) rater certification classes.

209.2 A person that is both a Rater Trainer and Quality Assurance Designee shall have to complete both the two hour RESNET roundtable for a Rater Trainer and the two hour roundtable for Quality Assurance Designees (see Section 904.7.3). Rater Trainers and QA Designees selecting the conference or CEU option need only comply with the 12 hour requirement one time, i.e. 12 hours is not required for each position.

210 PROVIDER ACCREDITATION CRITERIA

210.1 Minimum Standards for Rater Training Provider Accreditation
Rater Training Providers shall be accredited in accordance with the Accreditation Process specified in Chapter 9 of these Standards. A Rating Training Provider must specifically meet the following minimum standards for Accreditation:

210.1.1.1 Application Procedure.

210.1.1.1.1 Applicants shall demonstrate that their training meets the criteria established through this Standard. Documentation shall include:

210.1.1.1.1.1 Training curriculum

210.1.1.1.1.2 Training materials and manuals

210.1.1.1.1.3 Examination materials

210.1.1.1.1.4 Facilities description

210.1.1.1.1.5 Organization description

210.1.1.1.1.6 Principals and staff qualifications (detailed resumes)

211 RECIPROCITY

211.1 Nationally accredited Home Energy Rating Providers shall accept certified training provided by an accredited Training Provider as meeting the core competencies for a Home Energy Rater. Accredited Home Energy Rating Providers may add additional training requirements needed to address their specific program, climate, software or administrative requirements.

Chapter Three
RESNET Standards

300 NATIONAL ENERGY RATING TECHNICAL STANDARDS

301 GENERAL PROVISIONS

301.1 Purpose

The provisions of this document are intended to establish national residential energy rating Standards, consistent with the provisions of the Energy Policy Act of 1992, which any provider of home energy ratings may follow to produce uniform energy ratings for residential buildings.

301.1.1 Relationship to Other Standards. This Chapter is a companion Chapter to the "National Accreditation Procedures for Home Energy Rating Systems"(Chapter 1 of this Standard) and "National Rater Training and Certifying Standard (Chapter 2 of this Standard), as promulgated and maintained by the Residential Energy Services Network (RESNET) and recognized by the mortgage industry.

301.1.2 Relationship to State Law. These Standards specifically recognize the authority of each state that has a state law or regulation requiring certification, or licensing of home energy rating systems. To the extent that such state laws or regulations differ from these Standards, state law or regulation shall govern.

301.2 Scope

301.2.1 Application of Standards
These Standards apply to existing or proposed, site-constructed or manufactured, single- and multi-family residential buildings three stories or less in height excepting hotels and motels.

302 DEFINITIONS AND ACRONYMS

See Appendix B.

303 TECHNICAL REQUIREMENTS

303.1 Rating Procedures

303.1.1 To determine the energy rating of a home, all HERS providers shall–

303.1.1.1 If rating an existing home, visit the home to collect the data needed to calculate the rating;

303.1.1.2 If rating a new, to-be-built home, follow the procedures set forth in Section 303.7 and 303.8 of these Standards to collect the data needed to calculate the rating;

303.1.1.3 Use the collected data to estimate the annual purchased energy consumption for heating, cooling and water heating, lighting and appliances for both the Rated Home and the Reference Home as defined in Section 303.4 of these Standards.

303.1.1.4 If the energy efficiency rating is conducted to evaluate proposed energy conserving improvements to the home, calculate additional estimates of annual purchased energy consumption with the home reconfigured to include those improvements sufficient to consider interactions among improvement options.

303.1.1.5 If the Rated Home includes On-site Power Production (OPP), then OPP shall be calculated as the gross electric power produced minus the Equivalent Electric Power of any purchased fuels used to produce the electric power. The HERS Reference Home shall not include On-site Power Production.

For example, assume 1000 kWh (3413 kBtu or 3.413 MBtu) of gross electrical power is produced using 60 therms (6 MBtu) of natural gas to operate a high-efficiency fuel cell system. Using these assumptions, OPP = 3.413 MBtu - (6 MBtu * 0.4) = 1.0 MBtu.

303.1.2 Estimates completed by all HERS providers under Sections 303.1.1.3, 303.1.1.4 and 303.1.1.5 of this Standard must be–

303.1.2.1 Based on the minimum rated features set forth in Section 303.8 of these Standards.

303.1.2.2 Conducted using the standard operating assumptions established in Section 303.5 of these Standards.

303.1.2.3 Conducted using rating tool that has been certified for accuracy under Chapter 1, Section 102.2 of these Standards ("National Accreditation Procedures for Home Energy Rating Systems").

303.1.3 All HERS providers shall compare the estimates provided under Section 303.1.1 of this Standard to determine the energy rating of the home and, if applicable, the energy rating of the home with proposed conservation measures and On-site Power Production installed.

303.2 Rating Determination

303.2.1 HERS Index. The rating Index shall be a numerical integer value that is based on a linear scale constructed such that the HERS Reference Home has an Index value of 100 and a home that uses no net purchased energy has an Index value of 0 (zero). Each integer value on the scale shall represent a 1% change in the total energy use of the Rated home relative to the total energy use of the Reference home. Except in states or territories whose laws or regulations require a specific alternative method, which shall control, equations 1 and 2 shall be used in a 2 step process to calculate the HERS Index for the Rated Home, as follows:

Step (1) Calculate the individual normalized Modified End Use Loads (nMEUL) for heating, cooling, and hot water using equation 1:

$$nMEUL = REUL * (nEC\_x / EC\_r) \quad \text{(Eq. 1)}$$

where:

nMEUL = normalized Modified End Use Loads (for heating, cooling, or hot water) as computed using accredited simulation tools.

REUL = Reference Home End Use Loads (for heating, cooling or hot water) as computed using accredited simulation tools.

nEC_x = normalized Energy Consumption for Rated Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using accredited simulation tools.

EC_r = estimated Energy Consumption for Reference Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using accredited simulation tools.

and where:

$$nEC\_x = (a * EEC\_x - b)*(EC\_x * EC\_r * DSE\_r) / (EEC\_x * REUL)$$

where:

EC_x = estimated Energy Consumption for the Rated Home's end uses (for heating, including auxiliary electric consumption, cooling or hot water) as computed using accredited simulation tools.

EEC_x = Equipment Efficiency Coefficient for the Rated Home's equipment, such that EEC_x equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that EEC_x equals 1.0 / MEPR for AFUE, COP or EF ratings, or such that EEC_x equals 3.413 / MEPR for HSPF, EER or SEER ratings.

DSE_r = REUL/EC_r * EEC_r

For simplified system performance methods, DSE_r equals 0.80 for heating and cooling systems and 1.00 for hot water systems [see Table 303.4.1(1)]. However, for detailed modeling of heating and cooling systems, DSE_r may be less than 0.80 as a result of part load performance degradation, coil air flow degradation, improper system charge and auxiliary resistance heating for heat pumps. Except as otherwise provided by these Standards, where detailed systems modeling is employed, it must be applied equally to both the Reference and the Rated Homes.

EEC_r = Equipment Efficiency Coefficient for the Reference Home's equipment, such that EEC_r equals the energy consumption per unit load in like units as the load, and as derived from the Manufacturer's Equipment Performance Rating (MEPR) such that EEC_r equals 1.0 / MEPR for AFUE, COP or EF ratings, or such that EEC_r equals 3.413 / MEPR for HSPF, EER or SEER ratings and where the coefficients 'a' and 'b' are as defined by Table 303.2.2 below:

Table 303.2.2. Coefficients 'a' and 'b'

Fuel type and End Use	a	b
Electric space heating	2.2561	0
Fossil fuel* space heating	1.0943	0.4030
Biomass space heating	0.8850	0.4047
Electric air conditioning	3.8090	0
Electric water heating	0.9200	0
Fossil fuel* water heating	1.1877	1.0130

*Such as natural gas, LP, fuel oil

Step (2) Determine the HERS Index using equation 2:

HERS Index = PEfrac * (TnML / TRL) * 100 (Eq. 2)

where:

TnML = $nMEUL_{HEAT} + nMEUL_{COOL} + nMEUL_{HW} + EUL_{LA}$ (MBtu/yr).

TRL = $REUL_{HEAT} + REUL_{COOL} + REUL_{HW} + REUL_{LA}$ (MBtu/yr).

and where:

EUL_{LA} = Rated Home end use loads for lighting, appliances and MELs as defined by Section 303.4.1.7.2, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293 or (therms/yr)/10, as appropriate.

$REUL_{LA}$ = Reference Home end use loads for lighting, appliances and MELs as defined by Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293 or (therms/yr)/10, as appropriate.

and where:

PEfrac = (TEU - OPP) / TEU

TEU = Total energy use of the Rated Home including all rated and non-rated energy features where all fossil fuel site energy uses are converted to Equivalent Electric Energy by multiplying them by the Reference Electricity Production Efficiency of 40%

OPP = On-site Power Production as defined by Section 303.1.1.5

303.3 Rating Report

303.3.1 The Rated Home will be given a star rating between one and five-plus stars, determined by the numerical HERS Index and the corresponding number of stars depicted in Table 303.3.1:

TABLE 303.3.1. HERS Index, Star and Efficiency Scales for Rated Homes

HERS Index Range	Stars	Relative Energy Use (with respect to Reference Home)
=<500 and >401	☆	=<500% and >401%
=<400and >301	☆+	=<400% and >301%
=<300and >251	☆☆	=<300% and >251%
=<250 and >201	☆☆+	=<250% and >201%
=<200 and >151	☆☆☆	=<200% and >151%
=<150 and >101	☆☆☆+	=<150% and >1%
=<100 and >91	☆☆☆☆	=<0% and >-9%
=<90 and >86	☆☆☆☆+	=<-10% and >-14%
=<85 and >71	☆☆☆☆☆	=<-15% and >-29%
=<70 and >=0	☆☆☆☆☆+	=<-30% and >=-100%

303.3.2 For each rating conducted under this part, a report shall be prepared containing, at a minimum, the following information:

303.3.2.1 The numerical rating Index determined in accordance with Section 303.2.1 of these Standards;

303.3.2.2 The star rating determined in accordance with Section 303.3.1 of these Standards, except that all plus (+) ratings other than 5+ are optional;

303.3.2.3 The estimated annual purchased energy consumption for space heating, space cooling, domestic hot water, and all other energy use, and the total of these four estimates;

303.3.2.4 The estimated annual energy cost for space heating, space cooling, domestic hot water, and all other energy use, and the total of these four estimates;

303.3.2.5 The unique physical location (full street address or recorded real property identifier) of the Rated home;

303.3.2.6 The name of the individual conducting the rating;

303.3.2.7 The date the rating was conducted;

303.3.2.8 The rating tool (including version number) used to calculate the rating; and

303.3.2.9 The following statement in no less than 8 point font, "The Home Energy Rating Standard Disclosure for this home is available from the rating provider." At a minimum, this will include the Rating Provider's mailing address and phone number.

303.3.3 Economic Cost Effectiveness If ratings are conducted to evaluate energy saving improvements to the home for the purpose of an energy improvement loan or energy efficient mortgage, indicators of economic cost effectiveness shall use present value costs and benefits, which shall be calculated as follows:

LCC_E = P1*(1st Year Energy Costs) **Eqn 303.3.3-1**
LCC_I = P2*(1st Cost of Improvements) **Eqn 303.3.3-2**

where:
LCC_E = Present Value Life Cycle Cost of Energy
LCC_I = Present Value Life Cycle Cost of Improvements
P1 = Ratio of Life Cycle energy costs to the 1st year energy costs
P2 = Ratio of Life Cycle Improvement costs to the first cost of improvements

Present value life cycle energy cost savings shall be calculated as follows:

$LCC_S = LCC_{E,b} – LCC_{E,i}$ **Eqn 303.3.3-3**

where:
LCC_S = Present Value Life Cycle Energy Cost Savings
$LCC_{E,b}$ = Present Value LCC of energy for baseline home configuration
$LCC_{E,i}$ = Present Value LCC of energy for improved home configuration

Standard economic cost effectiveness indicators shall be calculated as follows:

$SIR = (LCC_S) / (LCC_I)$ **Eqn 303.3.3-4**
$NPV = LCC_S - LCC_I$ **Eqn 303.3.3-5**

where:
SIR = Present Value Savings to Investment Ratio
NPV = Net Present Value of Improvements

303.3.3.1 Calculation of P1 and P2. The ratios represented by P1 and P2 shall be calculated in accordance with the following methodology[1]:

P1 = 1/(DR-ER)*(1-((1+ER)/(1+DR))^nAP) **Eqn 303.3.3-6a**
or if DR = ER then
P1 = nAP / (1+DR) **Eqn 303.3.3-6b**

where:
P1 = Ratio of Present Value Life Cycle Energy Costs to the 1st year Energy Costs
DR = Discount Rate as prescribed in section 303.3.3.2
ER = Energy Inflation Rate as prescribed in section 303.3.3.2
nAP = number of years in Analysis Period as prescribed in section 303.3.3.2

$P2 = DnPmt + P2_A + P2_B + P2_C - P2_D$ **Eqn 303.3.3-7**

where:
P2 = Ratio of Life Cycle Improvement costs to the first cost of improvements
DnPmt = Mortgage down payment rate as prescribed in section 303.3.3.2
$P2_A$ = Mortgage cost parameter
$P2_B$ = Operation & Maintenance cost parameter

$P2_C$ = Replacement cost parameter
$P2_D$ = Salvage value cost parameter

$P2_A$ = (1-DnPmt)*(PWFd/PWFi) **Eqn 303.3.3-8a**

where:
PWFd = Present Worth Factor for the discount rate = 1/DR*(1-(1/(1+DR)^nAP))
PWFi = Present Worth Factor for the mortgage rate = 1/MR*(1-(1/(1+MR)^nMP))
DR = Discount Rate as prescribed in section 303.3.3.2
MR = Mortgage interest Rate as prescribed in section 303.3.3.2
nAP = number of years of the Analysis Period as prescribed in section 303.3.3.2
nMP = number of years of the Mortgage Period

$P2_B$ = MFrac*PWinf **Eqn 303.3.3-8b**

where:
MFrac = annual O&M costs as a fraction of first cost of improvements[1]
PWinf = ratio of present worth discount rate to present worth general inflation rate
= 1/(DR-GR)*(1-(((1+GR)/(1+DR))^nAP))
or if DR = GR then
= nAP/(1+DR)
GR = General Inflation Rate as prescribed in section 303.3.3.2

$P2_C$ = Sum {1/((1+(DR-GR))^(Life*i))} for i=1, n **Eqn 303.3.3-8c**

where:
i = the i^{th} replacement of the improvement
Life = the expected service life of the improvement

$P2_D$ = RLFrac / ((1+DR)^nAP) **Eqn 303.3.3-8d**

where:
RLFrac = Remaining Life Fraction following the end of the analysis period

301.1.2.1 Determination of Economic Parameters. The following economic parameter values shall be determined by RESNET in accordance with this Section each January using the latest available specified data and published on the RESNET website.

- General Inflation Rate (GR)
- Discount Rate (DR)

[1] The maintenance fraction includes all incremental costs over and above the operating and maintenance cost of the "standard" measure. Where components of a system have various lifetimes, the longest lifetime may be used and the components with shorter lifetimes may be included as a maintenance cost at the present value of their future maintenance cost. The maintenance fraction may also be used to represent the degradation in performance of a given system. For example, photovoltaic (PV) systems have a performance degradation of about 0.5% per year and this value can be added to the maintenance fraction for PV systems to accurately represent this phenomenon in this cost calculation procedure.

- Mortgage Interest Rate (MR)
- Down Payment Rate (DnPmt)
- Energy Inflation Rate (ER)

The economic parameter values used in the cost effectiveness calculations specified in Section 303.3.3.1 shall be determined as follows:

301.1.2.1.1 General Inflation Rate (GR) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Consumer Price Index for Urban Dwellers (CPI-U) as reported by the U.S. Bureau of Labor Statistics,[2] where ACR shall be calculated as follows:

ACR = ((endVal)/(startVal))^(1.0/((endYr)-(startYr)))-1.0 Eqn 303.3.3-9

where:

ACR = Annual Compound Rate of change
endVal = Value of parameter at end of period
startVal = Value of parameter at start of period
endYr = Year number at end of period
startYr = Year number at start of period

301.1.2.1.2 Discount Rate (DR) shall be equal to the General Inflation Rate plus 2%.

301.1.2.1.3 Mortgage Interest Rate (MR) shall be defaulted to the greater of the 5-year and the 10-year average of simple interest rate for fixed rate, 30-year mortgages computed from the Primary Mortgage Market Survey (PMMS) as reported by Freddie Mac unless the mortgage interest rate is specified by a program or mortgage lender, in which case the specified mortgage interest rate shall be used. The mortgage interest rate used in the cost effectiveness calculation shall be disclosed in reporting results.

301.1.2.1.4 Down Payment Rate (DnPmt) shall be defaulted to 10% of 1st cost of improvements unless the down payment rate is specified by a program or mortgage lender, in which case the specified down payment rate shall be used. The down payment rate used in the cost effectiveness calculation shall be disclosed in reporting results.

301.1.2.1.5 Energy Inflation Rate (ER) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Bureau of Labor Statistics, Table 3A, Housing, Fuels and Utilities, Household Energy Index[3] as calculated using Equation 303.3.3-9.

301.1.2.1.6 Mortgage Period (nMP) shall be defaulted to 30 years unless a mortgage finance period is specified by a program or mortgage lender, in which case the specified mortgage period shall be used. The mortgage period used in the cost effectiveness calculation shall be disclosed in reporting results.

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[2] http://www.bls.gov/CPI/#tables
[3] http://www.bls.gov/cpi/cpi_dr.htm

301.1.2.1.7 Analysis Period (nAP) shall be 30 years.

301.1.2.1.8 Remaining Life Fraction (RLFrac) shall be calculated as follows:

RLFrac = (nAP/Life) – (Integer (nAP/Life)) Eqn. 303.3.3-10

or if Life > nAP

RLFrac = (Life-nAP) / nAP

where:

Life = useful service life of the improvement(s)

301.1.2.1.9 Improvement Costs. The improvement cost for Energy Conservation Measures (ECMs) shall be included on the Economic Cost Effectiveness Report.

301.1.2.1.9.1 For New Homes the improvement costs shall be the full installed cost of the improvement(s) less the full installed cost of the minimum standard or code option less any financial incentives that accrue to the home purchaser.

301.1.2.1.9.2 **For Existing Homes** the improvement costs shall be the full installed cost of the improvement(s) less any financial incentives that accrue to the home purchaser.

301.1.2.1.10 Measure Lifetimes. The ECM service life shall be included on the Economic Cost Effectiveness Report. Appendix C of this standard provides informative guidelines for service lifetimes of a number of general categories of ECMs.

303.3.3.3 The annual energy cost savings for the Rated home shall be estimated by comparing the projected annual energy cost of the Rated home to the projected annual energy cost of a baseline home. For new homes, the most recent HERS Reference home shall be the baseline, except when an alternative reference home is specified by the lender or program underwriter. For existing homes, the unimproved home shall be used as the baseline.

303.3.3.4 The estimated monthly energy cost savings for the Rated home shall be equal to the annual energy cost savings divided by 12.

303.3.3.5 For Fannie Mae energy efficient mortgages the Net Present Value (NPV) of the improvements shall be as calculated by Equation 303.3.3-5.

303.3.3.4 For FHA and Freddie Mac energy mortgages, the present worth of energy savings shall be calculated in accordance with Equation 303.3.3-3 where the baseline home is as specified by the most current HUD Mortgage Letter.

303.3.3.5 Each rating report shall include:

303.3.3.5.1 The estimated monthly energy cost savings for the Rated home;

303.3.3.5.2 The Energy Value for the Rated Home;

303.3.3.5.3 For FHA and Freddie Mac energy mortgages, the present worth of energy savings;

303.3.3.5.4 The weighted lifetime of the measures that was used to determine the present value factor;

303.3.3.5.5 The prevailing mortgage rate (i.e. Assumed Rate) that was used to determine the present value factor;

303.3.3.5.6 The utility rates that were used to determine the estimated annual energy cost savings. The following units shall apply, as applicable to the fuel type(s) used by the Rated home: $ per kWh for electricity, $ per therm for natural gas, and $ per gallon for fuel oil;

303.3.3.5.7 The reference home from which annual energy cost savings were calculated (e.g., 1993 MEC, 2006 IECC, 2006 HERS);

303.3.3.5.8 A reference to the methodology used to calculate the values on the report. Specifically, the report shall reference "Section 303.3.3 of RESNET's 2006 Mortgage Industry National Homes Energy Rating Systems Standards".

3.3.4 If a Projected Rating conducted under Section 303.7.1 of these Standards, the Rating shall be prominently identified as a "Projected Rating."

303.3.5 For each rating conducted under these Standards, the following items are to be prominently displayed on all reports and labels:

303.3.5.1 Date of the rating;

303.3.5.2 Annual estimated energy costs for heating, cooling, water heating and all other uses;

303.3.5.3 Rating Index and;

303.3.5.4 Star rating;

303.3.5.5 At the request of the person for whom the rating is being conducted, as an alternative to reporting the rating Index and star rating, any home achieving a rating Index as defined by EPA Energy Star Homes guidelines, be labeled an ENERGY STAR® Home.

303.4 HERS Reference Home and Rated Home Configuration

303.4.1 Calculation Procedure

303.4.1.1 General. Except as specified by this Section, the HERS Reference Home and Rated Home shall be configured and analyzed using identical methods and techniques.

303.4.1.2 Residence Specifications. The HERS Reference Home and Rated Home shall be configured and analyzed as specified by Table 303.4.1(1).

Table 303.4.1(1) Specifications for the HERS Reference and Rated Homes

Building Component	**HERS Reference Home**	**Rated Home**
Above-grade walls:	Type: wood frame Gross area: same as Rated Home U-Factor: from Table 303.4.1(2) Solar absorptance = 0.75 Emittance = 0.90	Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home
Conditioned Basement walls:	Type: same as Rated Home Gross area: same as Rated Home U-Factor: from Table 303.4.1(2) with the insulation layer on the interior side of walls	Same as Rated Home Same as Rated Home Same as Rated Home
Floors over unconditioned spaces:	Type: wood frame Gross area: same as Rated Home U-Factor: from Table 303.4.1(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Ceilings:	Type: wood frame Gross area: same as Rated Home U-Factor: from Table 303.4.1(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Roofs:	Type: composition shingle on wood sheathing Gross area: same as Rated Home Solar absorptance = 0.75 Emittance = 0.90	Same as Rated Home Same as Rated Home Values from Table 303.4.1.(4) shall be used to determine solar absorptance except where test data are provided for roof surface in accordance with ASTM methods E-903, C-1549, E-1918, or CRRC Method # 1. Emittance values provided by the roofing manufacturer in accordance with ASTM C-1371 shall be used when available. In cases where the appropriate data are not known, same as the Reference Home.
Attics:	Type: vented with aperture = 1ft^2 per 300 ft^2 ceiling area	Same as Rated Home
Foundations:	Type: same as Rated Home Gross Area: same as Rated Home U-Factor / R-value: from Table 303.4.1(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Crawlspaces:	Type: vented with net free vent	Same as the Rated Home, but

Table 303.4.1(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
	aperture = 1ft^2 per 150 ft^2 of crawlspace floor area. U-factor: from Table 303.4.1(2) for floors over unconditioned spaces.	not less net free ventilation area than the Reference Home unless an approved ground cover in accordance with IRC 408.1 is used, in which case, the same net free ventilation area as the Rated Home down to a minimum net free vent area of 1ft^2 per 1,500 ft^2 of crawlspace floor area. Same as Rated Home
Doors:	Area: 40 ft^2 Orientation: North U-factor: same as fenestration from Table 303.4.1(2)	Same as Rated Home Same as Rated Home Same as Rated Home
Glazing: [a]	Total area [b] =18% of conditioned floor area Orientation: equally distributed to four (4) cardinal compass orientations (N,E,S,&W) U-factor: from Table 303.4.1(2) SHGC: from Table 303.4.1(2) Interior shade coefficient: Summer = 0.70 Winter = 0.85 External shading: none	Same as Rated Home Same as Rated Home Same as Rated Home Same as Rated Home Same as HERS Reference Home [c] Same as Rated Home
Skylights	None	Same as Rated Home
Thermally isolated sunrooms	None	Same as Rated Home
Air exchange rate	Specific Leakage Area (SLA) [d] = 0.00048 (assuming no energy recovery)	For residences that are not tested, the same as the HERS Reference Home For residences without mechanical ventilation systems that are tested in accordance with ASHRAE Standard 119, Section 5.1, the measured air exchange rate [e] but not less than 0.35 ach For residences with mechanical ventilation systems that are tested in accordance with ASHRAE

Table 303.4.1(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
		Standard 119, Section 5.1, the measured air exchange rate [e] combined with the mechanical ventilation rate,[f] which shall not be less than 0.01 x CFA + 7.5 x (Nbr+1) cfm
Mechanical ventilation:	None, except where a mechanical ventilation system is specified by the Rated Home, in which case:	Same as Rated Home
	Annual vent fan energy use: kWh/yr = 0.03942*CFA + 29.565*(N_{br}+1) (per dwelling unit) where: CFA = conditioned floor area N_{br} = number of bedrooms	Same as Rated Home
Internal gains:	As specified by Table 303.4.1(3)	Same as HERS Reference Home, except as provided by Section 303.4.1.7.2
Internal mass:	An internal mass for furniture and contents of 8 pounds per square foot of floor area	Same as HERS Reference Home, plus any additional mass specifically designed as a Thermal Storage Element [g] but not integral to the building envelope or structure
Structural mass:	For masonry floor slabs, 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air	Same as Rated Home
	For masonry basement walls, same as Rated Home, but with insulation required by Table 303.4.1(2) located on the interior side of the walls	Same as Rated Home
	For other walls, for ceilings, floors, and interior walls, wood frame construction	Same as Rated Home
Heating systems [h],[i]	Fuel type: same as Rated Home	Same as Rated Home [i]
	Efficiencies:	
	Electric: air source heat pump with prevailing federal minimum efficiency	Same as Rated Home

Table 303.4.1(1) Specifications for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
	Non-electric furnaces: natural gas furnace with prevailing federal minimum efficiency Non-electric boilers: natural gas boiler with prevailing federal minimum efficiency Capacity: sized in accordance with Section 303.5.1.4 of this Standard.	Same as Rated Home Same as Rated Home Same as Rated Home
Cooling systems [h],[k]	Fuel type: Electric Efficiency: in accordance with prevailing federal minimum standards Capacity: sized in accordance with Section 303.5.1.4 of this Standard.	Same as Rated Home [k] Same as Rated Home Same as Rated Home
Service water heating systems [h] [m]	Fuel type: same as Rated Home Efficiency: in accordance with prevailing federal minimum standards Use (gal/day): $30*N_{du} + 10*N_{br}$ where N_{du} = number of dwelling units Tank temperature: 120 F	Same as Rated Home [m] Same as Rated Home Same as HERS Reference Home Same as HERS Reference Home
Thermal distribution systems:	A thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.	As specified by Table 303.4.1(4), except when tested in accordance with ASHRAE Standard 152-2004[n], and then either calculated through hourly simulation or calculated in accordance with ASHRAE Standard 152-2004
Thermostat	Type: manual Temperature setpoints: cooling temperature set point = 78 F; heating temperature set point = 68 F	Type: Same as Rated Home Temperature setpoints: same as the HERS Reference Home, except as required by Section 303.5.1.2

Table 303.4.1(1) Notes:

(a) Glazing shall be defined as sunlight-transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight-transmitting fenestration assemblies in walls bounding conditioned basements.

For doors where the sunlight-transmitting opening is less than 50% of the door area, the glazing area is the sunlight transmitting opening area shall be used. For all other doors, the glazing area is the rough frame opening area for the door, including the door and the frame.

(b)For homes with conditioned basements and for multi-family attached homes the following formula shall be used to determine total window area:
AF = 0.18 x AFL x FA x F

where:

AF = Total fenestration area
AFL = Total floor area of directly conditioned space
FA = (Above-grade thermal boundary gross wall area) / (above-grade boundary wall area + 0.5 x below-grade boundary wall area)
F = 1- 0.44* (Common Wall Area) / (above-grade thermal boundary wall area + common wall area)

and where:

Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions
Above-grade thermal boundary wall is any portion of a thermal boundary wall not in contact with soil.

Below-grade boundary wall is any portion of a thermal boundary wall in soil contact

Common wall is the total wall area of walls adjacent to another conditioned living unit, not including foundation walls.

(c) For fenestrations facing within 15 degrees of due south that are directly coupled to thermal storage mass, the winter interior shade coefficient shall be permitted to increase to 0.95 in the Rated Home.

(d)Where Leakage Area (L) is defined in accordance with Section 5.1 of ASHRAE Standard 119 and where SLA = L / CFA (where L and CFA are in the same units).
Either hourly calculations using the procedures given in the 2001 ASHRAE Handbook of Fundamentals, Chapter 26, page 26.21, equation 40 (Sherman-Grimsrud model) or calculations yielding equivalent results shall be used to determine the energy loads resulting from air exchange.

(e) Tested envelope leakage shall be determined and documented by a Certified Rater using the on-site inspection protocol as specified in Appendix A under “Blower Door Test.” Either hourly calculations using the procedures given in the 2001 ASHRAE Handbook of Fundamentals, Chapter 26, page 26.21, equation 40 (Sherman-Grimsrud model) or calculations yielding equivalent results shall be used to determine the energy loads resulting from air exchange.

(f) The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with equation 43 of 2001 ASHRAE Handbook of Fundamentals page 26.24 in combination with the" Whole-house Ventilation" provisions of 2001 ASHRAE Handbook of Fundamentals, page 26.19 for intermittent mechanical ventilation.

(g)Thermal storage element shall mean a component not normally part of the floors, walls, or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees of due south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

(h)For a Rated Home with multiple heating, cooling, or water heating systems using different fuel types, the applicable system capacities and fuel types shall be weighted in accordance with the loads distribution (as calculated by accepted engineering practice for that equipment and fuel type) of the subject multiple systems. For the HERS Reference Home, the prevailing federal minimum efficiency shall be assumed except that the efficiencies given in Table 303.4.1(1)(a) below will be assumed when:

1) A type of device not covered by NAECA is found in the Rated Home;

2) The Rated Home is heated by electricity using a device other than an air source heat pump; or

3) The Rated Home does not contain one or more of the required HVAC equipment systems.

Table 303.4.1(1)(a). Default HERS Reference Home Heating and Cooling Equipment Efficiencies [i] [k] [m] [n]

Rated Home Fuel	Function	Reference Home Device
Electric	Heating	7.7 HSPF air source heat pump
Non-electric warm air furnace or space heater	Heating	78% AFUE gas furnace
Non-electric boiler	Heating	80% AFUE gas boiler
Any type	Cooling	13 SEER electric air conditioner
Biomass System [1]	Heating	63% Efficiency

Table 303.4.1(1)(a) Notes:

(1)Biomass fuel systems should not be included in ratings when they are considered "supplemental systems", i.e. where an automatic system, sized to meet the load of the house exists. Biomass systems should only be included in the rating in those situations where the automatic heating system is not large enough to meet the load of the house, and a biomass fuel system is in place to meet the balance of the load, or where there is only a biomass fuel system in place. In the situation where there are two systems that together meet the load, the biomass system shall be assigned only that part of the load that cannot be met by the automatic system.

(i) For a Rated Home without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the HERS Reference Home and Rated Home. For electric heating systems, the prevailing federal minimum efficiency air-source heat pump shall be selected.

(k)For a Rated Home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the HERS Reference Home and the Rated Home.

(m) For a Rated Home with an Instantaneous Water Heater, a 40-gallon storage-type water heater with the prevailing federal minimum efficiency and with the same fuel as the proposed water heater shall be assumed for the HERS Reference Home. The Energy Factor of the Instantaneous Water Heater in the Rated Home shall be reduced automatically by the Rating Software to 92% of the value recorded by the Rater (from manufacturer's documentation or AHRI Directory of Certified Product Performance). For a Rated Home without a proposed water heater, a 40-gallon storage-type water heater with the prevailing federal minimum efficiency with the same fuel as the predominant heating fuel type shall be assumed for both the Rated and HERS Reference Homes.

(n)Tested duct leakage shall be determined and documented by a Certified Rater using the on-site inspection protocol as specified in Appendix A under "Air leakage (ducts)".

Table 303.4.1(2). Component Heat Transfer Characteristics for HERS Reference Home [a]

Climate Zone [b]	Fenestration and Opaque Door U-Factor	Glazed Fenestration Assembly SHGC	Ceiling U-Factor	Frame Wall U-Factor	Floor Over Unconditioned Space U-Factor	Basement Wall U-Factor [c]	Slab-on-Grade [d,e] R-Value & Depth
1	1.20	0.40	0.035	0.082	0.064	0.360	0
2	0.75	0.40	0.035	0.082	0.064	0.360	0
3	0.65	0.40	0.035	0.082	0.047	0.360	0
4 except Marine	0.40	0.55	0.030	0.082	0.047	0.059	10, 2 ft.
5 and Marine 4	0.35	0.55	0.030	0.060	0.033	0.059	10, 2 ft.
6	0.35	0.55	0.026	0.060	0.033	0.059	10, 4 ft.
7 and 8	0.35	0.55	0.026	0.057	0.033	0.059	10, 4 ft.

Table 303.4.1(2). Component Heat Transfer Characteristics for HERS Reference Home [(a)]

Climate Zone [(b)]	Fenestration and Opaque Door U-Factor	Glazed Fenestration Assembly SHGC	Ceiling U-Factor	Frame Wall U-Factor	Floor Over Unconditioned Space U-Factor	Basement Wall U-Factor [(c)]	Slab-on-Grade [(d,e)] R-Value & Depth

Notes:

a Non-fenestration U-Factors shall be obtained from measurement, calculation, or an approved source.

b. Climates zones shall be as specified by the 2004 Supplement to the International Energy Conservation Code.

c. For basements where the conditioned space boundary comprises the basement walls.

d. R-5 shall be added to the required R-value for slabs with embedded heating.

e. Insulation shall extend downward from the top of the slab vertically to the depth indicated.

Table 303.4.1(3). Internal Gains for HERS Reference Homes [(a)]

End Use / Component	**Sensible Gains (Btu/day)**			**Latent Gains (Btu/day)**		
	a	**b**	**c**	**a**	**b**	**c**
Residual MELs		7.27			0.38	
Interior lighting	4,253	7.48				
Refrigerator	5,955		168			
TVs	3,861		645			
Range/Oven (elec) [(b)]	2,228		262	248		29
Range/Oven (gas) [(b)]	3,934		470	1,020		122
Clothes Dryer (elec) [(b)]	661		188	73		21
Clothes Dryer (gas) [(b)]	685		194	85		24
Dish Washer	219		87	219		87
Clothes Washer	95		26	11		3
Gen water use	-1227		-409	1,245		415
Occupants [(c)]			3716			2,884

Notes for Table 303.4.1(3)

(a) Table values are coefficients for the following general equation:
Gains = a + b*CFA + c*Nbr
where CFA = Conditioned Floor Area and Nbr = Number of bedrooms.

(b) For Rated Homes with electric appliance use (elec) values and for Rated homes with natural gas-fired appliance use (gas) values

(c) Software tools shall use either the occupant gains provided above or similar temperature dependent values generated by the software where number of occupants equals the number of bedrooms and occupants are present in home 16.5 hours per day.

Table 303.4.1(4). Default Distribution System Efficiencies for Inspected Systems [a]

Distribution System Configuration and Condition:	Forced Air Systems	Hydronic Systems [b]
Distribution system components located in unconditioned space	0.80	0.95
Distribution systems entirely located in conditioned space [c]	0.88	1.00
Proposed "reduced leakage" with entire air distribution system located in the conditioned space [d]	0.96	
Proposed "reduced leakage" air distribution system with components located in the unconditioned space[d]	0.88	
"Ductless" systems [e]	1.00	

Table 303.4.1(4) Notes:

(a) Default values given by this table are for distribution systems as rated, which meet minimum IECC 2000 requirements for duct system insulation.

(b) Hydronic Systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed loop piping and that do not depend on ducted, forced air flows to maintain space temperatures.

(c) Entire system in conditioned space shall mean that no component of the distribution system, including the air handler unit or boiler, is located outside of the conditioned space boundary.

(d) Proposed "reduced leakage" shall mean substantially leak free to be leakage of not greater than 3 cfm to outdoors per 100 square feet of conditioned floor area and not greater than 9 cfm total air leakage per 100 square feet of conditioned floor area at a pressure differential of 25 Pascal across the entire system, including the manufacturer's air handler enclosure. Total air leakage of not greater than 3 cfm per 100 square feet of conditioned floor area at a pressure difference of 25 Pascal across the entire system, including the manufacturer's air handler enclosure, shall be deemed to meet this requirement without measurement of air leakage to outdoors. This rated condition shall be specified as the required performance in the construction documents and requires confirmation through field-testing of installed systems as documented by a Certified Rater.

(e) Ductless systems may have forced airflow across a coil but shall not have any ducted airflows external to the manufacturer's air handler enclosure.

Table 303.4.1(5).

Default Solar Absorptance for Various Roofing Surfaces	
Roof Materials	**Absorptance**
White Composition Shingles	0.80
White Tile (including concrete)	0.60
White Metal	0.50

Default Solar Absorptance for Various Roofing Surfaces	
All others	0.92

303.4.1.3 All enclosure elements shall use framing fractions that are consistent with and representative of reality. Default enclosure framing fractions are provided by Table 303.4.1.3.

Table 303.4.1.3. Default Framing Fractions for Enclosure Elements

Enclosure Element	Frame Spacing (in o.c.)	Default Frame Fraction (% area)
Walls (standard):		
@16" o.c.	16	23%
@24" o.c.	24	20%
Walls (advanced):		
@16" o.c.	16	19%
@24" o.c.	24	16%
Structural.Insulated.Panels	48	10%
Floors (standard):		
@16" o.c.	16	13%
@24" o.c.	24	10%
Floors (advanced):		
@16" o.c.	16	11%
@24" o.c.	24	8%
Ceilings (standard trusses):		
@16" o.c.	16	14%
@24" o.c.	24	11%
Ceilings (advanced trusses – "raised heel"):		
@16" o.c.	16	10%
@24" o.c.	24	7%
Ceilings (conventional framing):		
@16" o.c.	16	13%
@24" o.c.	24	9%

303.4.1.4 Insulation Inspections: All enclosure elements for the Rated Home shall have their insulation assessed in accordance with this Standard. Installed cavity insulation shall be rated as Grade I, II, or III in accordance with the on-site inspection procedures of Appendix A.

303.4.1.4.1 The HERS Reference Home enclosure elements shall be modeled assuming Grade I insulation. Default values for Rated Home insulation that is not inspected according to the procedures of Appendix A shall be in accordance with the requirements of Grade III as given in Section 303.4.1.4.2 and shall be recorded as “not inspected” in the rating information.

Exceptions:

(a) Modular and manufactured housing using IPIA (In-Plant Inspection Agent) inspections may be substituted for the HERS inspection. However, housing manufacturer shall include RESNET insulation inspection details and requirements in their "DAPIA" (Design Approval Primary Inspection Agency) packages submitted to HUD which are used by IPIA's for their factory inspections.

(b) Structural Insulated Panels (SIP's), Insulated Concrete Forms (ICF's), and other similar insulated manufactured assemblies. Note that manufacturer's claims of "equivalent" R-values based on reduced air leakage or other secondary effects may not be used; only the thermal resistance values for the actual materials as found in ASHRAE Fundamentals may be used.

(c) A RESNET-approved, third-party audited installer certification program may be substituted under the conditions specified in the RESNET approval process.

303.4.1.4.2 Insulation Assessment: Insulated surfaces categorized as "Grade I" shall be modeled such that the insulation R-value within the cavity is considered at its measured (for loose fill) or labeled value, including other adjustments such as compression, and cavity fill versus continuous, for the insulated surface area (not including framing or other structural materials which shall be accounted for separately). Insulated surfaces categorized as "Grade II" shall be modeled such that there is no insulation R-value for 2% of the insulated surface area and its measured or labeled value, including other adjustments such as compression and cavity fill versus continuous, for the remainder of the insulated surface area (not including framing or other structural materials). Insulated surfaces categorized as "Grade III" shall be modeled such that there is no insulation R-value for 5% of the insulated surface area and its measured or labeled value, including other adjustments such as compression and cavity fill versus continuous, for the remainder of the insulated surface area (not including framing or other structural materials). Other building materials, including framing, sheathing, and air films shall be assigned aged or settled -values according to ASHRAE Fundamentals. In addition, the following accepted conventions shall be used in modeling Rated Home insulation enclosures:

303.4.1.4.2.1 Insulation that does not cover framing members shall not be modeled as if it covers the framing. Insulated surfaces that have continuous insulation (i.e. rigid foam, fibrous batts, loose fill, or sprayed insulation) covering the framing members shall be assessed and modeled according to Section 303.4.1.4 and combined with the cavity insulation, framing and other materials to determine the overall assembly R-value.

303.4.1.4.2.2 Compression: for modeling purposes, the base R-value of fibrous insulation that is compressed to less than its full rated thickness in a completely enclosed cavity shall be assessed according to the manufacturer's documentation; in the absence of such documentation, use R-value correction factor (CF) for Compressed Batt or Blanket from Manual J, 8th edition Table A5-1, Section 7-d.

303.4.1.4.2.3 Where large areas of insulation that is missing, or has a different R-value from the rest of an assembly exist, these areas shall be modeled with the appropriate R-value and assembly description separately from the rest of the assembly. Insulation R-values may not be averaged according to coverage area. For example, if 50 square feet of a wall area has no cavity fill insulation at all, that 50 square feet shall be recorded as a separate building component with no cavity insulation, but with the existing structural components.

303.4.1.4.2.4 Steel framing in insulated assemblies: calculations for the overall thermal properties of steel-framed walls, ceilings and floors shall be based on the "Thermal Design Guide for Exterior Walls, Publication RG-9405, American Iron and Steel Institute; the "Zone Method" from 2001 ASHRAE Handbook of Fundamentals (P 25.10-11); or equivalent.

303.4.1.5 Renewable energy systems, using solar, wind or other renewable energy sources, which offset the energy consumption requirements of the Rated Home, shall not be included in the Reference Home.

303.4.1.6 For non-electric warm furnaces and non-electric boilers, the values in Table 303.4.1.5 shall be used for auxiliary electric (Eae) in the Reference Home.

Table 303.4.1.5

System Type	EAE
Oil boiler	330
Gas boiler	170
Oil furnace	439 + 5.5*Capacity (kBtu/h)
Gas furnace	149 + 10.3*Capacity (kBtu/h)

303.4.1.7 Lighting, Appliances and Miscellaneous Electric Loads (MELs)

303.4.1.7.1 HERS Reference Home. Lighting, appliance and miscellaneous electric loads in the HERS Reference Home shall be determined in accordance with the values provided in Table 303.4.1.7.1(1) and Table 303.4.1.7.1(2), as appropriate, and equation 3:

kWh (or therms) per year = a + b*CFA + c*Nbr (Eq. 3)

where:

'a', 'b', and 'c' are values provided in Table 303.4.1.7.1(1) and Table 303.4.1.7.1(2)

CFA = conditioned floor area

Nbr = number of bedrooms

303.4.1.7.1.1 Electric Reference Homes. Where the Rated Home has electric appliances, the HERS Reference Home lighting, appliance and miscellaneous loads shall be determined in accordance with the values given in Tables 303.4.1.7.1(1).

Table 303.4.1.7.1(1). Lighting, Appliance and Miscellaneous Electric Loads (kWh/yr) in electric HERS Reference Homes

End Use Component[(a)]	Equation Coefficients		
	a	b	c
Residual MELs		0.91	
Interior lighting	455	0.80	
Exterior lighting	100	0.05	
Refrigerator	637		18
Televisions	413		69
Range/Oven	331		39
Clothes Dryer	524		149
Dish Washer	78		31
Clothes Washer	38		10

Table 303.4.1.7.1(1) Notes:

(a) For homes with garages, an additional 100 kWh per year shall be added to the HERS Reference home for garage lighting.

303.4.1.7.1.2 Reference Homes with Natural Gas Appliances. Where the Rated Home is equipped with natural gas cooking or clothes drying appliances, the Reference Home cooking and clothes drying loads defined above in Table 303.4.1.7(1) shall be replaced by the natural gas and electric appliance loads provided below in Table 303.4.1.7(2), as applicable.

Table 303.4.1.7(2). Natural Gas Appliance Loads (therms/yr) for HERS Reference Homes with gas appliances

End Use Component[(a)]	Equation Coefficients		
	a	b	c
Range/Oven (therms)	22.6		2.7
Range/Oven (kWh)	22.6		2.7
Clothes Dryer (therms)	18.8		5.3
Clothes Dryer (kWh)	41		11.7

Table 303.4.1.7(2) Notes:

(a) Both the natural gas and the electric components shall be included in determining the HERS Reference Home annual energy use for the above appliances.

303.4.1.7.1.3 Garage Lighting. Where the Rated Home includes an enclosed garage, 100 kWh/yr shall be added to the energy use of the Reference Home to account for garage lighting.

303.4.1.7.1.4 Mechanical Ventilation. Where mechanical ventilation is provided in the Rated home, $REUL_{LA}$ shall be modified for the Reference Home by adding [0.03942*CFA + 29.565*(N_{br}+1)] kWh/yr for ventilation fan operation, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

303.4.1.7.1.5 Ceiling Fans. Where ceiling fans are included in the Rated Home they shall also be included in the Reference Home in accordance with the provisions of Section 303.4.1.7.2.11 of this Standard.

303.4.1.7.2 Rated Homes. For Rated homes, the following procedures shall be used to determine lighting, appliance and residual miscellaneous electric load energy consumption.

303.4.1.7.2.1 Residual MELs. Residual miscellaneous electric loads in the Rated Home shall be the same as in the HERS Reference Home and shall be calculated as 0.91*CFA, where CFA is the conditioned floor area.

303.4.1.7.2.2 Interior Lighting. Interior lighting in the Rated home is calculated using equation 5:

$$kWh/yr = 0.8*[(4 - 3*qFF_{IL})/3.7]*(445 + 0.8*CFA) + 0.2*(455 + 0.8*CFA) \quad \text{(Eq. 5)}$$

where:

CFA = Conditioned floor area

qFF_{IL} = the ratio of the Qualifying interior Light Fixtures to all interior light fixtures in Qualifying interior Light Fixture Locations.

For rating purposes, the Rated Home shall not have qFF_{IL} less than 0.10 (10%).

(Informative Note: When qFF_{IL} = 0.10 (10%), the above equation reduces to the standard interior lighting equation of: kWh/yr = 455 + 0.8*CFA.)

For the purpose of adjusting the annual interior lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{IL}, which shall be calculated as the annual interior lighting energy use derived by the procedures in this section minus the annual interior lighting energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For Interior lighting, internal gains in the Rated home shall be modified by 100% of the interior lighting ΔEUL_{IL} converted to Btu/day as follows: $\Delta EUL_{IL} * 10^6 / 365$.

303.4.1.7.2.3 Exterior Lighting. Exterior lighting in the Rated home shall be determined using equation 6:

$$kWh/yr = (100 + 0.05*CFA)*(1-FF_{EL}) + 0.25*(100 + 0 .05*CFA)*FF_{EL} \quad \text{(Eq. 6)}$$

where

CFA = Conditioned floor area

FF_{EL} = Fraction of exterior fixtures that are Qualifying Light Fixtures

For the purpose of adjusting the annual exterior lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{EL}, which shall be calculated as the annual exterior lighting energy use derived by the procedures in this section minus the annual exterior lighting energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

Internal gains in the Rated Home shall not be modified as a result of reductions in exterior lighting energy use.

303.4.1.7.2.4 Garage Lighting. For Rated homes with garages, garage lighting in the Rated home shall be determined using equation 7:

$$kWh = 100*(1-FF_{GL}) + 25*FF_{GL} \quad \text{(Eq. 7)}$$

where:

FF_{GL} = Fraction of garage fixtures that are Qualifying Light Fixtures

For the purpose of adjusting the annual garage lighting energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{GL}, which shall be calculated as the annual garage lighting energy use derived by the procedures in this section minus the annual garage lighting energy use derived for the HERS Reference Home in Section 303.4.1.7.1 (i.e. 100 kWh/yr), converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

Internal gains in the Rated Home shall not be modified as a result of reductions in garage lighting energy use.

303.4.1.7.2.5 Refrigerators. Refrigerator energy use for the Rated Home shall be determined from either Refrigerator Energy Guide Labels or from age-based defaults provided in Table 303.4.1.7.2.5(1).

Table 303.4.1.7.2.5(1) Age-based Refrigerator Defaults

Refrigerator/Freezer Type	Annual kWh Equation
Single-door refrigerator only	(13.5*AV + 299)*VR
Single-door refrigerator/freezer	(13.5*AV + 299)*VR
Refrigerator with top freezer	(16.0*AV + 355)*VR
with TDI	(17.6*AV + 391)*VR
Refrigerator with side-by-side freezer	(11.8*AV + 501)*VR
with TDI	(16.3*AV + 527)*VR
Refrigerator with bottom freezer	(16.6*AV + 367)*VR
Upright freezer only manual defrost	(10.3*AV + 264)*VR
Upright freezer only auto defrost	(14.0*AV + 391)*VR
Chest freezer only	(11.0*AV + 160)*VR
where: AV = Adjusted Volume = (refrigerator compartment volume) + 1.63*(freezer compartment volume) TDI = Through the door ice VR = Vintage Ratio from Table 303.4.1.7.2.5(2)	

Table 303.4.1.7.2.5(2) Age-based Vintage Ratios

Refrigerator Vintage	Vintage Ratio
1972 or before	2.50
1980	1.82
1984	1.64
1988	1.39
1990	1.30
1993	1.00
2001 forward	0.77

For the purposes of determining adjusted volume (AV), the following defaults may be used:

Table 303.4.1.7.2.5(3) Default Adjusted Volume Equations

Model Type	Default Equation
Single door refrigerator only	AV = 1.00 * nominal volume
Single door refrigerator/freezer	AV = 1.01 * nominal volume
Bottom Freezer	AV = 1.19 * nominal volume
Top Freezer	AV = 1.16 * nominal volume
Side by Side	AV = 1.24 * nominal volume
Freezer only	AV = 1.73 * nominal volume

For the purpose of adjusting the annual refrigerator energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{FRIG}, which shall be calculated as the annual refrigerator energy use derived by the procedures in this section minus the annual refrigerator energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For refrigerator energy use, internal gains in the Rated home shall be modified by 100% of the refrigerator ΔEUL_{FRIG} converted to Btu/day as follows: $\Delta EUL_{FRIG} * 10^6 / 365$. Internal gains shall not be modified for refrigerators located in unconditioned spaces (e.g. unconditioned garages, etc.)

303.4.1.7.2.6 Televisions. Television energy use in the Rated Home shall be the same as television energy use in the HERS Reference Home and shall be calculated as TVkWh/yr = 413 + 69*Nbr, where Nbr is the number of bedrooms in the Rated Home.

303.4.1.7.2.7 Range/Oven. Range/Oven (cooking) energy use for the Rated Home shall be determined as follows:

1) For electric cooking:
   kWh/yr = BEF * OEF * (331 + 39*Nbr) (Eq. 12a)
2) For natural gas cooking:
   Therms/yr = OEF*(22.6 + 2.7*Nbr) (Eq. 12b)

plus:
   kWh/yr = 22.6 + 2.7*Nbr (Eq. 12c)

where:
   BEF= Burner Energy Factor = 0.91 for induction ranges and 1.0 otherwise.

OEF = Oven Energy Factor = 0.95 for convection types and 1.0 otherwise
Nbr = Number of bedrooms

For the purpose of adjusting the annual Range/Oven energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{RO}, which shall be calculated as the annual Range/Oven energy use derived by the procedures in this section minus the annual Range/Oven energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For Range/Oven energy use, internal gains in the Rated Home shall be modified by 80% of the Range/Oven ΔEUL_{RO} converted to Btu/day as follows: $\Delta EUL_{RO} * 10^6 / 365$. Of this total amount, internal gains shall be apportioned as follows, depending on fuel type:

a) For electric Range/Ovens, 90% sensible internal gains and 10% latent internal gains
b) For gas Range/Ovens, 80% sensible internal gains and 20% latent internal gains.

303.4.1.7.2.8 Clothes Dryers. Clothes Dryer energy use for the Rated Home shall be determined by the following equation.

kWh/yr = 12.5*(164+46.5*Nbr)*FU/EFdry*(CAPw/MEF - LER/392)/(0.2184*(CAPw*4.08+0.24)) **(Eq. 13)**

where:

Nbr = Number of bedrooms in home
FU = Field Utilization factor =1.18 for timer controls **or** 1.04 for moisture sensing
EFdry = Efficiency Factor of clothes dryer (lbs dry clothes/kWh) from the CEC database [4] or use following electric clothes dryer default: 3.01
CAPw = Capacity of clothes washer (ft^3) from the manufacturer's data or the CEC database **or** the EPA Energy Star website [5] **or** use default of 2.874 ft^3
MEF[6] = Modified Energy Factor of clothes washer from Energy Guide Label **or** use default of 0.817
LER[37] = Labeled Energy Rating of clothes washer (kWh/yr) from Energy Guide Label **or** use default of 704

For natural gas clothes dryers the following equations shall be used:

Therms/yr = (result of Eq. 13)*3412*(1-0.07)*(3.01/EFdry-g)/100000 (Eq. 13a)
kWh/yr = (result of Eq. 13)*0.07*(3.01/EFdry-g) (Eq. 13b)

[4] http://www.energy.ca.gov/appliances/database/excel_based_files/
[5] http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers
[6] This value must be determined from the energy rating for clothes washer as it determines the amount of moisture remaining in the clothes after the washer cycle is completed.

where:

EFdry-g = Efficiency Factor for gas clothes dryer from the CEC database[1] or use the following gas clothes dryer default: 2.67.

For the purpose of adjusting the annual Clothes Dryer energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{CD}, which shall be calculated as the annual Clothes Dryer energy use derived by the procedures in this section minus the annual Clothes Dryer energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For Clothes Dryer energy use, total internal gains in the Rated Home shall be modified by 15% of the Cloths Dryer ΔEUL_{CD} converted to Btu/day as follows: $\Delta EUL_{CD} * 10^6 / 365$. Of this total amount, 90% shall be apportioned to sensible internal gains and 10% to latent internal gains. Internal gains shall not be modified for Clothes Dryers located in unconditioned spaces (e.g. unconditioned garages, etc.)

303.4.1.7.2.9 Dishwashers. Dishwasher energy use for the Rated Home shall be determined using the following equation.

$$\text{kWh/yr} = [(86.3 + 47.73/EF)/215]*dWcpy \qquad \textbf{(Eq. 14a)}$$

where:

EF = Labeled dishwasher energy factor

or

EF = 215/(labeled kWh/year)

dWcpy = (88.4 + 34.9*Nbr)*12/dWcap

where:

dWcap = Dishwasher place setting capacity; Default = 12 settings for standard sized dishwashers and 8 place settings for compact dishwashers

And the change (Δ) in daily hot water use (GPD – gallons per day) for dishwashers shall be calculated as follows:[7]

$$\Delta GPD_{DW} = [(88.4+34.9*Nbr)*8.16 - (88.4+34.9*Nbr)*12/dWcap*(4.6415*(1/EF) - 1.9295)]/365 \qquad \textbf{(Eq. 14b)}$$

For the purpose of adjusting the annual Dishwasher energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{DW}, which shall be calculated as the annual Dishwasher energy use derived by the procedures in this section minus the annual Clothes Dishwasher energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

[7] http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dishwasher.xls

For the purpose of adjusting the daily hot water use for calculating the rating, the daily hot water use change shall be 'ΔGPD_{DW}' as calculated above.

For Dishwasher energy use, total internal gains in the Rated Home shall be modified by 60% of the Dishwasher ΔEUL_{DW} converted to Btu/day as follows: $\Delta EUL_{DW} * 10^6$ / 365. Of this total amount, 50% shall be apportioned to sensible internal gains and 50% to latent internal gains.

303.4.1.7.2.10 Clothes Washers. Clothes Washer annual energy use and daily hot water use for the Rated Home shall be determined as follows:

Annual energy use shall be calculated using the following equation:

kWh/yr = ((LER/392)-((LER*($/kWh)-AGC)/(21.9825*($/kWh) - ($/therm))/392)*21.9825)*ACY **(Eq. 15a)**

where:
- LER = Label Energy Rating (kWh/yr) from Energy Guide Label
- $/kWh = Electric Rate from Energy Guide Label
- AGC = Annual Gas Cost from Energy Guide Label
- $/therm = Gas Rate from Energy Guide Label
- ACY = Adjusted Cycles per Year

and where:
- ACY = NCY * ((3.0*2.08+1.59)/(CAPw*2.08+1.59))
  - where:
    - NCY = (3.0/2.847) * (164 + Nbr*45.6)
    - CAPw = washer capacity in cubic feet from the manufacturer's data or the CEC database[8] **or** the EPA Energy Star website [9] **or** use default of 2.874 ft^3

And daily hot water use shall be calculated as follows:

DHWgpd = 120.5* therms/cyc * ACY / 365 **(Eq. 15b)**

where:
- therms/cyc = (LER * $/kWh - AGC) / (21.9825 * $/kWh - $/therm) / 392

For the purpose of adjusting the annual Clothes Washer energy consumption for calculating the rating, EUL_{LA} shall be adjusted by ΔEUL_{CW}, which shall be calculated as the annual Clothes Washer energy use derived by the procedures in this section minus the annual Clothes Washer energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 **or** (therms/yr) / 10, whichever is applicable.

For the purpose of adjusting the daily hot water use for calculating the rating, the daily hot water use change shall be calculated as the daily hot water use derived by the

[8] http://www.energy.ca.gov/appliances/database/excel_based_files/
[9] http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

procedures in this section minus 7.94 gallons per day for the reference standard clothes washer.

For Clothes Washer energy use, total internal gains in the Rated Home shall be modified by 30% of the Clothes Washer ΔEUL_{CW} converted to Btu/day as follows: $\Delta EUL_{CW} * 10^6 / 365$. Of this total amount, 90% shall be apportioned to sensible internal gains and 10% to latent internal gains. Internal gains shall not be modified for Clothes Washers located in unconditioned spaces (e.g. unconditioned garages, etc.)

Rating and label data on clothes washer may be found at the following web sites:

EPA: www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers
CEC: www.energy.ca.gov/appliances/database/excel_based_files/Clothes_Washers/

303.4.1.7.2.11 Ceiling Fans. If ceiling fans are included in the Rated home, they shall also be included in the Reference home. The number of bedrooms plus one (Nbr+1) ceiling fans shall be assumed in both the Reference Home and the Rated Home. A daily ceiling fan operating schedule equal to 10.5 full-load hours shall be assumed in both the Reference Home and the Rated Home during periods when ceiling fans are operational. Ceiling fans shall be assumed to operate only during the cooling season, which may be estimated to be all months with an average temperature greater than 63 ^oF. The cooling thermostat (but not the heating thermostat) shall be set up by 0.5 ^oF in both the Reference and Rated Home during periods when ceiling fans are assumed to operate.

The Reference Home shall use number of bedrooms plus one (Nbr+1) Standard Ceiling Fans of 42.6 watts each. The Rated Home shall use the Labeled Ceiling Fan Standardized Watts (LCFSW), also multiplied by number of bedrooms plus one (Nbr+1) fans to obtain total ceiling fan wattage for the Rated Home. The Rated Home LCFSW shall be calculated as follows:

LCFSW = (3000cfm) / (cfm/watt as labeled at medium speed)

Where installed ceiling fans in the Rated Home have different values of LCFSW, the average LCFSW shall be used for calculating ceiling fan energy use in the Rated Home.

During periods of fan operation, the fan wattage, at 100% internal gain fraction, shall be added to internal gains for both the Reference and Rated Homes. In addition, annual ceiling fan energy use, in MBtu/yr [(kWh/yr)/293], for both the Rated and Reference homes shall be added to the lighting and appliance end use loads (EUL_{LA} and $REUL_{LA}$, as appropriate) as specified by Equation 2, Section 303.2.1 of this Chapter.

303.4.1.7.2.12 Mechanical Ventilation System Fans. If ventilation fans are present in the Rated Home, EUL_{LA} shall be adjusted by adding total annual kWh energy consumption of the ventilation system in the Rated Home, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293.

303.4.1.8 If the Rated Home includes On-site Power Production, the Purchased Energy Fraction for the Rated Home (see Section 303.2.2) shall be used to determine the impact of the On-site Power Production on the HERS Index.

303.5 Operating Condition Assumptions

303.5.1 All HERS providers shall estimate the annual purchased energy consumption for heating, cooling and hot water for both the Rated Home and the Reference Home using the following assumptions–

303.5.1.1 Where programmable offsets are available in the Rated Home, 2 ^{o}F temperature control point offsets with an 11 p.m. to 5:59 a.m. schedule for heating and a 9 a.m. to 2:59 p.m. schedule for cooling, and with no offsets assumed for the Reference Home;

303.5.1.2 When calculating annual purchased energy for cooling, internal latent gains assumed as 0.20 times sensible internal heat gains;

303.5.1.3 The climatologically most representative TMY or equivalent climate data, which may be interpolated between climate sites if interpolation is established or approved by the accrediting body and consistent for all HERS providers operating within a state.

303.5.1.4 Manufacturer's Equipment Performance Ratings (e.g., HSPF, SEER, AFUE) shall be corrected for local climate conditions and mis-sizing of equipment. To determine equipment mis-sizing, the capacity of heating and cooling vapor compression equipment shall be calculated in accordance with ACCA Manual J, Eighth Edition, ASHRAE 2001 Handbook of Fundamentals, or an equivalent computation procedure, using the following assumptions:

303.5.1.4.1 HERS Reference Home:

303.5.1.4.1.1 Indoor temperatures shall be 75 F for cooling and 70 F for heating.

303.5.1.4.1.2 Outdoor temperatures shall be the 99.0% and 1.0% design temperatures as published in the ASHRAE Handbook of Fundamentals for the city where the home is located or the most representative city for which design temperature data are available.

303.5.1.4.1.3 Infiltration rate in air changes per hour (ach) shall be:

(a) For summer: 1.2 * nL * W
(b) For winter: 1.6 * nL * W
(c) Where: nL = 0.48
(d) W = Weather factor from W Tables in ASHRAE Standard 136

303.5.1.4.1.4 Mechanical ventilation shall be zero.

303.5.1.4.1.5 All windows shall have blinds/draperies that are positioned in a manner that gives an Internal Shade Coefficient (ISC) of 0.70 in the summer and an ISC of 0.85

in the winter. These values are represented in ACCA Manual J Eighth Edition as "dark closed blinds" in the summer and "dark, fully drawn roller shades" in the winter.

303.5.1.4.1.6 Internal heat gains shall be 1,600 Btu/hr sensible for appliances plus 230 Btu/hr sensible and 200 Btu/hr latent per occupant, with the number of occupants equal to the number of bedrooms plus one.

303.5.1.4.1.7 Heat pump equipment shall be sized to equal the larger of the heating and cooling season calculations in accordance with these procedures.

303.5.1.4.1.8 Systems shall be smaller than the size calculated using this procedure plus 100 Btu/hr.

303.5.1.4.2 The Rated Home:

303.5.1.4.2.1 Indoor temperatures shall be 75 F for cooling and 70 F for heating.

303.5.1.4.2.2 Outdoor temperatures shall be the 99.0% and 1.0% design temperatures as published in the ASHRAE Handbook of Fundamentals for the city where the home is located or the most representative city for which design temperature data are available.

303.5.1.4.2.3 Infiltration rate shall be either the measured envelope leakage area converted to equivalent natural air changes per hour (ach,nat) or the default value derived above for the Reference Home modified as follows:

(a) For summer: either 1.2 * ach,nat or 1.2 * nL * W
(b) For winter: either 1.6 * ach,nat or 1.6 * nL * W
(c) Where: nL = 0.48
(d) W = Weather factor from W Tables in ASHRAE Standard 136

303.5.1.4.2.4 Mechanical ventilation shall only be included for systems that are controlled to run every hour or every time the HVAC system operates. Standard bathroom and kitchen ventilation may not be considered as ventilation for sizing purposes.

303.5.1.4.2.5 Combined infiltration and ventilation may not be less than the ventilation rates required by ASHRAE Standard 62.2-2004, nor greater than nL * W * 1.2 in summer and nL * W * 1.6 in winter.

303.5.1.4.2.6 Windows shall include observed blinds/draperies. For new homes, all windows shall assume blinds/draperies that are positioned in a manner that gives an Internal Shade Coefficient (ISC) of 0.70 in the summer and an ISC of 0.85 in the winter. (These values are represented in ACCA Manual J Eighth Edition as "dark closed blinds" in the summer and "dark fully drawn roller shades" in the winter.)

303.5.1.4.2.7 Internal heat gains shall be 1,600 Btu/hr sensible plus 230 Btu/hr sensible and 200 Btu/hr latent per occupant, with the number of occupants equal to the number of bedrooms plus one.

303.5.1.4.2.8 Heat pump equipment shall be sized to equal the larger of the heating and cooling season calculations in accordance with these procedures.

303.5.1.4.2.9 To the degree that the installed equipment for the Rated Home exceeds properly sized equipment in accordance with the above procedures, the manufacturer's equipment performance rating shall be reduced accordingly.

303.5.1.5 For heat pumps and air conditioners where a detailed, hourly HVAC simulation is used to separately model the compressor and evaporator energy (including part-load performance), the back-up heating energy, the distribution fan or blower energy and crank case heating energy, the Manufacturer's Equipment Performance Rating (HSPF and SEER) shall be modified as follows to represent the performance of the compressor and evaporator components alone: HSPF, corr = HSPF, mfg / 0.582 and SEER, corr = SEER, mfg / 0.941. The energy uses of all components (i.e. compressor and distribution fan/blower; and crank case heater) shall then be added together to obtain the total energy uses for heating and cooling.

303.5.1.6 For ground-loop and ground-water heat pumps, the Auxiliary Electric Consumption shall be determined as follows:

GSHP Auxiliary Electric Power (Watts) = $GSHP_{pump} - GSHP_{intp} + GSHP_{fanEPS}$

Where:

$GSHP_{pump}$ in watts is the observed pump nameplate data (Volts *Amps), shall be added for all periods of heat pump operation. Amps may be taken from nameplate as Run Load Amps (RLA) or Full Load Amps (FLA). Alternatively, pumping energy that is measured on-site with a watt-hour meter, or using measured V*A may be substituted. Such measured pumping energy may be further adjusted for on-site measured duty cycle during heat pump operation, when pumping is intermittent during continuous heat pump operation.

GSHPintp in watts is the estimated pump power required to overcome the internal resistance of the ground-water heat exchanger under AHRI test conditions. GSHPintp = W/ton * rated cooling btu/h / 12,000. W/ton shall be 30 for ground loop (closed loop) systems and 15 for ground water (open loop) heat pump systems.

$GSHP_{fanESP}$: If ducts are attached to the system to deliver heating or cooling, the external fan energy in watts, $GSHP_{fanESP}$ = (air flow in CFM * 0.2 Watts/CFM), shall be added for all periods of heat pump operation. If the design airflow is unknown, the default air flow in CFM shall be (400 * rated cooling btu/h / 12,000), where 400 is the air flow in CFM per nominal ton (12 kbtu/h) of capacity. Note that for the purposes of calculating an adjusted equipment efficiency, $GSHP_{fanESP}$ shall also be added to the rated heating capacity, and subtracted from the rated cooling capacity of the equipment. For that adjustment, $GSHP_{fanESP}$ shall be converted into Btu/h by Btu/h = $GSHP_{fanESP}$ * 3.412.

For the purpose of a projected rating only, if $GSHP_{pump}$ cannot be determined, the following adjustments may be made to the rated efficiency of the GSHP:

Adjusted EER (closed loop) = 0.0000315*EER^3 - 0.0111*EER^2 + 0.959*EER
Adjusted EER (open loop) = 0.00005*EER^3 - 0.0145*EER^2 + 0.93*EER
Adjusted COP (closed loop) = 0.000416*COP^3 - 0.041*COP^2 + 1.0086*COP
Adjusted COP (open loop) = 0.00067*COP^3 - 0.0531*COP^2 + 0.976*COP

303.5.1.7 Natural ventilation shall be assumed in both the Reference and Rated Homes during hours when natural ventilation will reduce annual cooling energy use.

303.5.1.8 When a whole-house fan is present in the Rated Home, it shall operate during hours of favorable outdoor conditions, and no whole-house fan shall be assumed in the Reference Home. The fan energy associated with the whole-house fan shall be included in the normalized Energy Consumption for the Rated Home's cooling end-use (nEC_x).

303.5.1.9 Local residential energy or utility rates that–
(a) Are revenue-based and include customer service and fuel charges;
(b) Are updated at least annually; and
(c) Are confirmed by the accrediting body.

303.6 Standardized Existing Home Retrofit Savings

Standardized energy savings for existing home retrofits shall be determined by comparing a Baseline Home with an Improved Home in accordance with the provisions of this section.

303.6.1 Baseline Home. The Baseline Home model for the purposes of determining the energy savings of an existing home retrofit shall be the original configuration of the existing home, including the full complement of lighting, appliances and residual miscellaneous energy use as specified by Tables 303.4.1.7.1(1) and 303.4.1.7.1(2). The energy use of these end uses in the Baseline Home shall be based on the original home configuration following the provision of Section 303.4.1.7.2.

303.6.1.1 Where multiple appliances of the same type exist in the original configuration of the existing home, the same number of those appliance types shall be included in the Baseline Home model.

303.6.1.2 Where a standard appliance as defined by Tables 303.4.1.7.1(1) and 303.4.1.7.1(2) does not exist in the original configuration of the existing home, the standard default energy use and internal gains as specified by Table 303.4.1(3) for that appliance shall be included in the Baseline Home model.

303.6.2 Improved Home. The improved home model for the purpose of determining the energy savings of an existing home retrofit shall be the existing home's configuration including all energy improvements to the original home and including the full complement of lighting, appliances and residual miscellaneous energy use contained in the home after all energy improvements have been implemented.

303.6.2.1 Where an appliance has been upgraded but the existing appliance is not removed from the existing home property, both the new and existing appliance shall be included in the Improved Home model.[10]

303.6.2.2 Where a standard appliance as defined by Tables 303.4.1.7.1(1) and 303.4.1.7.1(2) does not exist in the improved configuration of the existing home, the standard default energy use and internal gains as specified by Table 303.4.1(3) for that appliance shall be included in the Improved Home model.

303.6.2.3 Improvements in lighting and appliance energy use in the Improved Home model shall be calculated in accordance with Section 303.4.1.7.2.

303.6.3 Standard Operating Conditions.

303.6.3.1 Both the Baseline Home and Improved Home shall be configured and modeled in accordance with the Rated Home specifications of Table 303.4.1(1) except that the Baseline Home shall not violate the input constraints specified in Table 303.6.3(1) below.

Table 303.6.3(1) Baseline Home Input Constraints

Equipment Constraints*	**Minimum Value**
Forced-air furnace, AFUE	72%
Hot water / steam boiler, AFUE	60%
Heat Pump, HSPF	6.5
Heat Pump, SEER	9.0
Central air conditioner, SEER	9.0
Room air conditioner, EER	8.0
Gas-fired storage water heater, EF	0.50
Oil-fired storage water heater, EF	0.45
Electric storage water heater, EF	0.86
Enclosure Constraints (including air film conductances)	**Maximum U-factor**
Wood-frame wall	0.222
Masonry wall	0.250
Wood-frame ceiling with attic (interior to attic space)	0.286
Unfinished roof	0.400
Wood-frame floor	0.222
Single-pane window, wood frame	0.714
Single-pane window, metal frame	0.833

*** Exception:** Where the labeled equipment efficiency exists for the specified piece of existing equipment, the labeled or measured steady state efficiency shall be used in lieu of the these minimum input constraints.

303.6.3.2 Air Distribution Systems

[10] For example, if a refrigerator is upgraded to a more efficient model and the original refrigerator is kept on property for potential use as a second refrigerator; both refrigerators shall be included in the Improved Home energy model.

303.6.3.2.1 In cases where the air distribution system leakage is not measured in the original Baseline Home, the ducts shall be modeled in the spaces in which they are located and the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled in both the Baseline Home and the Improved Home as 0.10 times the conditioned floor area of the home split equally between the supply and return side of the air distribution system with the leakage distributed evenly across the duct system.

Exception: If the air handler unit and a minimum of 75% of its duct system are entirely inside the conditioned space boundary, the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled in both the Baseline Home and the Improved Home as 0.05 times the conditioned floor area of the home split equally between the supply and return side of the air distribution system with the leakage distributed evenly across the duct system.

303.6.3.2.2 In cases where the air distribution system leakage is measured:

303.6.3.2.2.1 For the Baseline Home, the ducts shall be modeled in the spaces in which they are located and the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be modeled as the lesser of the measured air distribution system leakage to outdoors at 25 Pascal pressure difference in the original Baseline Home or 0.24 times the conditioned floor area of the home, either split evenly between the supply and return side of the air distribution system or as measured separately with the leakage distributed evenly across the duct system.

303.6.3.2.2.2 For the Improved Home, the ducts shall be modeled in the spaces in which they are located and the air distribution system leakage to outdoors at 25 Pascal pressure difference shall be set equal to the measured air distribution system leakage to outdoors at 25 Pascal pressure difference in the Improved Home, either split evenly between the supply or return side of the air distribution system or as measured separately with the leakage distributed evenly across the duct system.

303.6.3.3 Both the Baseline Home and the Improved Home shall be subjected to the operating conditions specified by Section 303.5.1.4.2.

303.6.4 Total Energy Savings Calculation.

303.6.4.1 Energy units used in the calculation of energy savings shall be units of Equivalent Electric Energy using the Reference Electricity Production Efficiency for fossil fuels. Equivalent electric energy use shall be calculated using Equation 303.6.4-1.

$$kWh_{eq} = kWh_{elec} + \frac{Btu_{fossil} * 0.40}{3412} \qquad \text{(Eqn. 303.6.4-1)}$$

303.6.4.2 Energy savings shall be calculated as the difference between the whole-house projected equivalent electric energy use of the Baseline Home and the whole-house projected equivalent electric energy use of the Improved Home.

303.6.4.3 The energy savings percentage of the retrofit shall be calculated as the whole-house equivalent electric energy savings as determined by Section 303.6.4.2 above divided by the whole-house equivalent electric energy use of the Baseline Home.

303.7 Projected and Confirmed Ratings

303.7.1 A HERS provider may calculate the Projected Rating of a to-be-built or to-be-improved home based on architectural drawings with material, mechanical and electrical specifications for a to-be-built home, or based on a site audit for a to-be-improved home; and by:

303.7.1.1 Using either the envelope leakage rate specified as the required performance by the construction documents, the site-measured envelope leakage rate, or a default value as specified for the Reference home in Table 303.4.1(1).

303.7.1.2 Using either the distribution system efficiency specified as the required performance by the construction documents, the site-measured distribution system efficiency, or a default distribution system efficiency value from Table 303.4.1(1); and

303.7.1.3 Using the planned location and orientation of the proposed home, or if the proposed orientation is unknown, calculating ratings for the home facing each of the four cardinal directions, north, south, east and west, and using the largest HERS Index as the ”worst case” Projected Rating.

303.7.2 Upon completion of construction and verification of the proposed specifications, all rated features of the home shall be confirmed using site inspections and envelope air leakage rates and distribution system efficiencies derived from on-site diagnostic tests conducted in accordance with Section 303.8.1 of this Standard, and the actual orientation of the home.

303.7.3 Rating tools accredited under Section 303.8 of this Standard must be retested and re-certified if a new version of the tool is released that includes changes to the engineering algorithms.

303.8 Minimum Rated Features

303.8.1 All HERS providers shall calculate the estimated annual purchased energy consumption for heating, cooling, water heating and lighting and appliances set forth in Section 303.1 of this Standard using the energy loss and gain associated with the minimum rated features as set forth in Table 303.8.1(1),

303.8.1.1 For existing homes, the envelope thermal characteristics of building elements 1 through 7 set forth in Table 303.8.1(1) are determined by site observation.

303.8.1.2 If data for the minimum rated features set forth in Section 303.8.1.1 of this Standard cannot be obtained by observation or without destructive disassembly of the home, default values shall be used. The default values are determined from the following sources listed in the preferential order of use:

(a) For manufactured homes, available manufacturer’s data:

(b) Current and historical local building practices; or
(c) Current and historical local building codes.

303.8.1.3 For existing homes, the determination of air leakage and duct leakage values set forth as building elements 10 and 11 in Table 303.8.1(1) are determined by data collected on site using the following procedures listed in preferential order of use:

303.8.1.3.1 Current on-site diagnostic tests conduced in accordance with the requirements set forth in Table 303.4.1(1); or

303.8.1.3.2 Observations of the condition of the building and duct system made by a Certified Rater. Based on these observations, values from Tables 303.4.1(4) shall be used.

303.8.1.3.3 The energy efficiency of the mechanical equipment set forth as building elements 12 through 14 in Table 303.8.1(1) is determined by data collected on site using the following sources listed in preferential order of use:

(a) Current on-site diagnostic test data as corrected using the following equation:

Eff,rated = Eff,listed * Es,measured / Es,listed

where:

Eff,rated = annual efficiency to use as input to the rating
Eff,listed = listed annual efficiency by manufacturer or directory
Es,measured = measured steady state efficiency of system
Es,listed = manufacturer's listed steady state efficiency, under the same operating conditions found during measurement

(b) Name plate data;
(c) Manufacturer’s data sheet; or
(d) Equipment directories.

303.8.1.4 When information on the energy efficiency of mechanical equipment cannot be determined from the sources listed in paragraph 303.8.1.3.3 of this Standard, the values set forth in Tables 303.8.1(2); 303.8.1(3); 303.8.1(4) and 303.8.1(5) shall be used.

303.8.1.5 Any HERS provider may base annual purchased energy consumption estimates for the Rated Home on additional features if the HERS provider’s energy analysis tool is capable of doing so.

Table 303.8.1(1) Minimum Rated Features

Building element	Minimum Rated Feature

Table 303.8.1(1) Minimum Rated Features

Building element	Minimum Rated Feature
1. Floor/Foundation Assembly.	Construction type (slab-on-grade, crawl space; basement), insulation value (edge, under slab, cavity, sheathing), framing material and on-center spacing, insulation installation (Grade I, II, or III), vented or unvented (crawl space), capacitance (if slab or basement receives appreciable solar gain).
2. Walls	Construction type, insulation value (cavity, sheathing), framing material and on-center spacing insulation installation (Grade I, II, or III) capacitance, color (light, medium, or dark).
3. Roof/Ceiling Assembly	Construction type, insulation value (cavity, sheathing), framing material and on-center spacing insulation installation (Grade I, II, or III), framing covered by insulation or exposed, roof color (light, medium, or dark).
4. Rim Joist	Insulation value (cavity, sheathing).
5. Doors	Construction type, insulation value.
6. Windows	Construction type, orientation, U-value (of complete assembly), solar heat gain coefficient, shading.
7. Skylights	Construction type, orientation, tilt, U-value (of complete assembly), heat gain coefficient, shading.
8. Passive Solar System (Direct Gain system)	Solar type, collector type and area, orientation, tilt efficiency, storage tank size, pipe insulation value.
9. Solar Domestic Hot Water Equipment	System type, collector type and area, orientation, tilt, efficiency, storage tank size, pipe insulation value.
10. Air Leakage	Air leakage measurement type (default estimate, blower door test, tracer gas test), volume of conditioned space.
11. Distribution System	System type, location, insulation value (duct and pipe), air leakage measurement type (default estimate, duct pressurization).
12. Heating Equipment	Equipment type, location, efficiency (AFUE, HSPF), auxiliary electric (Eae); power rating of ground fluid circulating pump(s) for ground-loop and ground-water heat pumps.
13. Cooling Equipment	Equipment type, location, efficiency (SEER, COP).
14. Domestic Hot Water Equipment	Equipment type, location, energy factor or seasonal efficiency, extra tank insulation value, pipe insulation value.
15. Control Systems	Thermostat type.

Table 303.8.1(1) Minimum Rated Features

Building element	Minimum Rated Feature
16. Light fixtures	Number of qualifying and non-qualifying light fixtures in qualifying locations (i.e. kitchens, dining rooms, living rooms, family rooms/dens, bathrooms, hallways, stairways, entrances, bedrooms, garage, utility rooms, home offices, and all outdoor fixtures mounted on a building or pole (excluding landscape lighting)).
17. Refrigerator(s)	Total annual energy consumption (kWh) for all units from: California Energy Commission: Appliance Database at http://www.energy.ca.gov/appliances/appliance/index.html or Association of Home Appliance Manufacturers (AHAM) directories
18. Dishwasher(s)	Energy factor (cycles/kWh) for all units from: the Federal Trade Commission's " Dishwasher Energy Data" posted at http://www.ftc.gov/bcp/conline/edcams/eande/appliances/data/2004/dwasher/brand.htm
19. Ceiling Fans	Labeled cfm, Watts and cfm/Watt at medium fan speed from EPA ENERGY STAR ceiling fan label.
20. Mechanical Ventilation System(s)	Equipment type, daily run hours, and wattage (may be listed in the Certified Home Ventilating Products Directory available from the Heating and Ventilation Institute (HVI).
21. On-site Power Generation	Total annual kWh generation and total site fuel used in the production of on-site power generation as derived from manufacturer's performance ratings.

Table 303.8.1(2) Default Solid Fuel Combustion Seasonal Efficiencies for Space Heating

Type	Location	Seasonal Efficiency	Notes
EPA-Listed Stove, Furnace, or Boiler	Conditioned space	Contained in the EPA publication "Certified Wood Heaters" and posted at http://www.epa.gov/compliance/resources/publications/monitoring/programs/woodstoves/certifiedwood.pdf	
EPA-Listed Stove, Furnace or Boiler	Unconditioned space	0.85 of EPA listing	
EPA Stove – Not Listed	Conditioned space	60%	For stoves with documented EPA

Table 303.8.1(2) Default Solid Fuel Combustion Seasonal Efficiencies for Space Heating

Type	Location	Seasonal Efficiency	Notes
			compliance, but not found on EPA's Web site list of certified stoves
EPA Stove – Not Listed	Unconditioned space	50%	For stoves with documented EPA compliance, but not found on EPA's Web site list of certified stoves
EPA-Listed Stove Insert	Enclosed, such as in fireplace	Subtract 10% from listed seasonal efficiency	
Non-EPA Stove	Conditioned space	50%	Not tested or listed by EPA
Non-EPA Stove	Unconditioned space	40%	Not tested or listed by EPA
Biomass Fuel Furnace or Boiler with Distribution System	Conditioned space	50%	Not tested or listed by EPA Distribution system efficiency shall also be considered
Biomass Fuel Furnace or Boiler with Distribution System	Unconditioned space	40%	Not tested or listed by EPA Distribution system efficiency shall also be considered
Biomass Fuel Furnace or Boiler with Distribution System	Outside	30%	Not tested or listed by EPA Distribution system efficiency shall also be considered
Solid Fuel Furnace or Boiler – Independently Tested	Central with ducted or hydronic distribution	0.85 of tested listing	Only permitted with documentation of independent testing lab documentation Distribution system efficiency shall also be considered

Table 303.8.1(3) Default Values for Mechanical System Efficiency (Age-based)*

Mechanical Systems	**Units**	**Pre-1960**	**1960-1969**	**1970-1974**	**1975-1983**	**1984-1987**	**1988-1991**	**1992 to present**
Heating:								
Gas Furnace	AFUE	0.72	0.72	0.72	0.72	0.72	0.76	0.78
Gas Boiler	AFUE	0.60	0.60	0.65	0.65	0.70	0.77	0.80
Oil Furnace or Boiler	AFUE	0.60	0.65	0.72	0.75	0.80	0.80	0.80
Air-Source Heat Pump	HSPF	6.5	6.5	6.5	6.5	6.5	6.80	6.80
Ground-Water Geothermal Heat pump	COP	2.70	2.70	2.70	3.00	3.10	3.20	3.50
Ground-Coupled Geothermal Heat Pump	COP	2.30	2.30	2.30	2.50	2.60	2.70	3.00
Cooling:								
Air-Source Heat Pump	SEER	9.0	9.0	9.0	9.0	9.0	9.40	10.00
Ground-Water Geothermal Heat Pump	EER	10.00	10.00	10.00	13.00	13.00	14.00	16.00
Ground-Coupled Geothermal Heat Pump	EER	8.00	8.00	8.00	11.00	11.00	12.00	14.00
Central Air Conditioner	SEER	9.0	9.0	9.0	9.0	9.0	9.40	10.00
Room Air Conditioner	EER	8.0	8.0	8.0	8.0	8.0	8.10	8.50
Water Heating:								
Storage Gas	EF	0.50	0.50	0.50	0.50	0.55	0.56	0.56
Storage Oil	EF	0.47	0.47	0.47	0.48	0.49	0.54	0.56
Storage Electric	EF	0.86	0.86	0.86	0.86	0.86	0.87	0.88

* **Exception:** Where the labeled equipment efficiency exists for the specific piece of existing equipment, the labeled efficiency shall be used in lieu of these minimum input constraints.

TABLE 303.8.1(4) Default Values for Mechanical System Efficiency (not Age-based)*

	Units	Rating
Heating:		
Gas Wall Heater (Gravity)	AFUE	0.72
Gas Floor Furnace	AFUE	0.72
Gas Water Heater (Space Heating).	AFUE	0.75
Electric Furnace	HSPF	3.413

TABLE 303.8.1(4) Default Values for Mechanical System Efficiency (not Age-based)*

	Units	Rating
Electric Radiant	HSPF	3.413
Heat Pump Water Heater (Space)	HSPF	5.11
Electric Water Heater (Space)	HSPF	2.73
Cooling:		
Electric Evaporative Cooling	EER	30
Gas Absorption Cooler	COP	0.40
Water Heating:		
Heat Pump	COP	2.00
Instantaneous Electric	EF	0.87
Instantaneous Gas	EF	0.75
Solar (Use SRCC Adjustment Procedures)	EF	2.00

* **Exception:** Where the labeled equipment efficiency exists for the specific piece of existing equipment, the labeled efficiency shall be used in lieu of these minimum input constraints.

Table 303.8.1(5) Default EAE Values

System Type	EAE
Oil boiler	330
Gas boiler	170
Oil furnace	439 + 5.5 * Capacity (kBtu/h)
Gas furnace	149 + 10.3 * Capacity (kBtu/h)

303.9 Software Rating Tools

303.9.1 Minimum capabilities. Calculation procedures used to comply with this Standard shall be computer-based rating software tools capable of calculating the annual energy consumption and HERS Index of all building elements that differ between the HERS Reference Home and the Rated Homes and shall include the following capabilities:

303.9.1.1 Compliance with the rating provisions of Section 303.1 of this Standard

303.9.1.2 Computer generation of HERS Index and star ratings in accordance with the provisions of Section 303.2 of this Standard

303.9.1.3 Automated computer generation of the HERS Reference Home using only the input for the Rated Home

303.9.1.4 The software tool shall not allow the user to directly modify the building component characteristics of the HERS Reference Home

303.9.1.5 Calculation of whole-building, single-zone sizing for the heating and cooling equipment in the HERS Reference Home residence in accordance with Section 303.5.1.4 of this Standard.

303.9.1.6 Calculations that account for the indoor and outdoor temperature dependencies and the part-load performance of heating, ventilating, and air conditioning equipment based on climate and equipment sizing

303.9.1.7 Printed rating report in accordance with Section 303.3 of this Standard

303.9.2 Approved tools. Rating software tools shall be accredited by RESNET through compliance with the "RESNET Rating Software Testing and Verification Procedures" posted on the RESNET web site at www.natresnet.org (see also Chapter 1, Section 102.2.1).

303.10 Innovative Design Request

303.10.1 HERS providers can petition RESNET for adjustment to the HERS Index for a Rated Home with features or technologies not addressed by approved software tools and/or this Standard. Innovative Design Requests (IDRs) to RESNET shall include, at a minimum, the following:

303.10.1.1 A Rating generated from approved rating software tool for Rated Home without feature(s) that cannot be modeled in the software tool.

303.10.1.2 Written description of feature(s) not included in Rating generated from software.

303.10.1.3 Manufacturer's technical and/or performance specifications for feature(s) not included in the Rating generated from the approved software tool.

303.10.1.4 Estimated energy impact. Calculations or simulation results estimating the energy impact of feature(s) not included in the Rating generated from an approved software tool and documentation to support the calculation methodology and/or describe the modeling approach used.

303.10.1.5 Estimated adjustment to HERS Index. Calculations shall follow procedures of Sections 303.1 and 303.2.

303.10.2 Upon review of an IDR, RESNET Standing Technical Committee shall request additional supporting documentation for further consideration or provide a recommendation with justification to the Board as follows: a) is approved, b) is denied, or c) is approved with modifications. The RESNET Board of Directors shall accept or reject the recommendation of Technical Committee or request further information from the Technical Committee.

303.10.3 IDRs shall be approved on a case by case basis. RESNET shall assign a unique identifier to each IDR and maintain a database of IDRs. If RESNET approves the IDR, the HERS provider may issue a supplemental report that adjusts the HERS Index as approved.

Chapter Four
RESNET Standards

400 NATIONAL STANDARD FOR BUILDER OPTION PACKAGES

401 BACKGROUND

The following procedures for accrediting Building Option Package (BOP) Providers have been developed and adopted by the Residential Energy Services Network (RESNET). BOPs were developed by the U.S. Environmental Protection Agency (EPA), can be used by builders to demonstrate compliance to the ENERGY STAR® Homes Program standard. The BOPs have been demonstrated to meet the Home Energy Rating score threshold adopted by the Environmental Protection Agency under "worse case" scenarios and involve the same building performance inspection as a home energy rating.

401.1 Purpose

The purpose of this procedure is to ensure that accurate and consistent BOPs are implemented by accredited BOP Providers nationwide to increase the credibility of BOPs and the ENERGY STAR® Homes program

401.2 Scope

401.2.1 This document sets out the procedures for the accreditation of BOP Providers so their results will be acceptable to the housing industry and consumers.

401.2.2 There may be instances in which state laws or regulations will have additional requirements to those specified in this document.

402 DEFINITIONS

See Appendix B.

403 ACCREDITATION CRITERIA

403.1 Minimum Standards for BOP Provider Accreditation

BOP Providers shall be accredited in accordance with the Accreditation Process specified in Chapter 9 of these Standards. A BOP Provider must specifically meet the following minimum standards for Accreditation:

403.1.1 Minimum BOP Inspector Training Standards:

403.1.1.1 A BOP Provider must provide for BOP inspector certification by requiring inspectors to successfully complete a RESNET accredited home energy Rater training courses and to demonstrate competence in completing BOP performance inspections in the field. The following elements must be included in its BOP inspector training:

403.1.1.1.1 Basics of building science

403.1.1.1.2 Thermal resistance of insulating materials

403.1.1.1.3 Space heating/cooling equipment efficiency

403.1.1.1.4 Blower door testing procedures

403.1.1.1.5 Duct leakage and testing procedures

403.1.1.1.6 Determining the efficiency of windows

403.1.1.1.7 Basic principles of BOPs

403.1.1.1.8 BOP Provider's policies and procedures for inspectors

403.1.1.1.9 Quality assurance procedures

403.1.2 Certification Standards

403.1.2.1 Certification and recertification of BOP inspectors shall be through a RESNET accredited home energy Rater training Provider, which shall include the following provisions:

403.1.2.1.1 Initial classroom and/or field training.

403.1.2.1.2 Performance evaluation of ability to perform accurate BOP inspections including passing the national RESNET test.

403.1.2.1.3 Continuing Education - 12 hours of education and training approved by the BOP Provider during the three years of certification. Ten hours of the training shall be training approved by RESNET.

403.1.2.1.4 Recertification of BOP inspectors no less than every three years

403.1.3 Minimum Standards For BOP Provider's Operation Policies and Procedures must be written and provide for the following:

403.1.3.1 Field inspection of all homes for verifying technical specifications.

403.1.3.2 Blower Door Test completed on all homes claiming credit for reduced air infiltration lower than the default value.

403.1.3.3 Duct testing completed on all homes claiming credit for reduced air distribution system leakage lower than the default value.

403.1.3.4 Written BOP inspector discipline procedures that includes progressive discipline involving Probation - Suspension - Termination

403.1.3.5 Quality Assurance by BOP Providers

403.1.3.5.1 BOP Providers that are not already Rating Providers must have a written Quality Assurance Process that conforms to Chapter 9 of these Standards.

403.1.3.5.2 Have a Quality Assurance Designee that oversees the Provider's compliance with the requirement of this Chapter and Chapter 9 of these Standards.

403.1.3.5.3 BOP Inspection Recordkeeping. Providers and/or their certified BOP inspectors shall maintain records for each BOP inspection.

403.1.3.5.3.1 The quality assurance record for each home shall contain at a minimum the electronic copy of the inspection file.

403.1.3.5.3.2 The record for each inspection shall be maintained for a minimum of three years.

403.1.3.5.4 BOP Inspector Registry

403.1.3.5.4.1 The Provider shall maintain a registry of all their certified BOP inspectors. The Provider will also keep on file the names and contact information for all, including company name, mailing address, voice phone number, fax number, and email address. Upon request the Provider shall provide to RESNET its registry of certified Raters.

403.1.3.5.5 Complaint Response System.

403.1.3.5.5.1 Each Provider shall have a system for receiving complaints. The Provider shall respond to and resolve complaints related to BOP inspections and field verification and diagnostic testing services and reports. Providers shall ensure that inspectors inform purchasers and recipients of ratings and field verifications about the complaint system. Each Provider shall retain records of complaints received and responses to complaints for a minimum of three years after the date of the complaint.

403.1.3.6 Knowledge of other EPA methods for labeling a home as ENERGY STAR®.

403.1.3.7 Written conflict of interest provisions that prohibit undisclosed conflicts of interest but allow waiver with advanced disclosure. The "Home Energy Rating Standard Disclosure" form adopted by the RESNET Board of Directors shall be completed for each home that receives a BOP inspection and shall be provided to the rating client and made available to the home owner/buyer. Each form shall include, at a minimum, the name of the community/ subdivision and city and state where the home is located. Each form shall accurately reflect the proper disclosure for the home that it is rated (i.e. it should reflect the

BOP inspector's involvement with the home at the time the final ENERGY STAR® certificate is issued). For the purposes of completing this Disclosure, "Rater's employer" is defined as including any affiliate entities. Recognizing that a number of different relationships may occur between the inspector or the inspector's employer and the rating client and/or homeowner and/or the marketplace in general, the BOP Provider shall ensure that all disclosures are adequately addressed by the Provider's quality assurance plan, in accordance with the relevant Quality Assurance provisions of the Standards.

403.1.4 Technical Requirements for BOPs

403.1.4.1 The BOP Provider can only use BOPs approved by the EPA ENERGY STAR Homes Program.

403.1.4.2 Monthly Energy Savings. For a Fannie Mae energy efficient mortgage, the BOP Provider shall calculate the monthly energy savings that the BOP achieves over the HERS Reference Home in accordance with the provisions of 303.3.3.3.2.2 of Chapter 3 of this standard.

403.1.4.3 Energy Value. For a Fannie Mae energy efficient mortgage, the BOP Provider shall calculate the energy savings value of the BOP in accordance with the provisions of 303.3.3.2.1 of Chapter 3 of this standard.

403.1.4.4 Specialized requirements. Where specific BOPS approved by EPA have technical requirements that are outside the normal range of BOP inspector skills, specialized training shall be provided to inspectors by the BOP Provider to inspect for compliance with those BOPs.

404 SUNSET PROVISION

Chapter 4 of these Standards, and any references to the provisions in Chapter 4 made elsewhere in these Standards, shall sunset on January 1, 2012.

Chapter Five
RESNET Standards

500 REVISION OF STANDARDS

501 REVISIONS AND AMENDMENTS

From time to time it may become necessary to revise or amend the standards set forth in this document. Circumstances that may lead to such revision or amendment include but are not limited to the following:

501.1 Periodic Reviews

To respond to periodic reviews by the promulgating bodies;

501.2 Changes in Law

To respond to changes in law;

501.3 Technical Innovations

To respond to technological innovations; and

501.4 Proposals for Change

To respond to proposals for change from interested parties.

501.4.1 Continuous review of standards

501.4.1.1 RESNET will accept on an on-going proposals to change the standards. RESNET has formed the following standing committees to consider proposals submitted: Quality Assurance and Ethics Committee, Technical Committee, and Training and Education Committee. After considering proposals the appropriate committee can submit proposals to amendment the standard.

501.4.2 Process for submitting proposals to change standards:

501.4.2.1 Proposals to change these standards may be submitted in writing, at any time, to RESNET.

501.4.2.2 All proposals to change that meet the criteria set forth in this section of these procedures shall be accepted for consideration and evaluation.

501.4.2.3 Proposals to change these standards shall include the following:

501.4.2.3.1 Identification of the proposal to change, including the following minimum information:

501.4.2.3.1.1 Proponent(s) full name(s),

501.4.2.3.1.2 Organizational affiliation(s) or representation(s),

501.4.2.3.1.3 Full mailing address(es),

501.4.2.3.1.4 Daytime phone number(s),

501.4.2.3.1.5 Signature of primary proponent, and

501.4.2.3.1.6 Date

501.4.2.3.2 Specific revisions to the standards in a format that clearly identifies the manner in which the standards are to be altered (ie. underline/strikeout format or equivalent). Any proposal to change that does not include proposed alteration(s) shall be rejected and returned to the proponent.

501.4.2.3.3 Substantive reason(s) or justification for each proposed change. The lack of substantive justification for a proposed change may result in the return of the proposals to change to the proponent(s).

501.4.2.3.4 Supporting documentation that may be needed for the reasoned evaluation of the proposal.

501.4.2.4 Proposals to change these standards shall be considered and evaluated at least annually.

501.4.3 Standards Revision Process.

501.4.3.1 Revision to these standards shall occur only after the relevant proposals to change have been subjected to public scrutiny and comment using the following review process:

501.4.3.1.1 RESNET shall appoint a standing Standards Committee. The RESNET Standards Committee shall be responsible for conducting the periodic evaluation and the annual evaluation of proposals to change through a consensus process, whereby both consenting and the non-consenting opinions are documented and incorporated as comments into each report or proposal to change..

501.4.3.1.2 Following initial evaluation by the RESNET Standards Committee, proposals to change shall be posted on the RESNET website for a period of not less than 30 days during which public comment shall be accepted.

501.4.3.1.3 Following the public comment period, the appropriate RESNET Committee shall meet to reconcile public comments with the initial proposed amendment of the RESNET Standards Committee and, if changes are determined necessary, a final set of recommended changes with consensus comments that considers public comments shall be prepared on each proposal for change. The proposed changes to the amendment shall then be forwarded to the RESNET Standards Committee for approval.

501.4.3.1.4 Proposals for change receiving a simple majority support from the RESNET Standards Committee after public comment shall be incorporated into a set of proposed revised amendments that will be submitted to the RESNET Board of Directors for final approval.

501.4.3.1.5 Proposed revisions from the RESNET Standards Committee shall be approved by a simple majority of the RESNET Board of Directors. Rejection of proposals from the RESNET Standards Committee shall require a two-thirds majority of the RESNET Board of Directors. Upon approval by the RESNET Board of Directors, the changes shall be incorporated into a set of revised Standards. If a proposed revision fails to receive either a simple majority vote for approval or a two-thirds majority vote for rejection, it will be referred back to the RESNET Standards Committee for further consideration.

501.4.3.2 The revised accreditation procedures shall be published on the RESNET Web Page not later than the end of September each year in which changes are recommended.

Chapter Six
RESNET Standards

600 RESNET NATIONAL STANDARD FOR SAMPLED RATINGS

601 GENERAL PROVISIONS

601.1 Purpose

Sampling is intended to provide certification that a group of new homes meets a particular threshold such as ENERGY STAR®, energy code compliance, or qualification for an energy efficiency lending program. It is based on pre-analysis of building plans meeting the intended qualification (e.g. a HERS Index threshold), and subsequent random testing and inspections of a sample set of the homes as-built. Certifying a group of homes by sampling entitles the customer to documentation certifying that the homes meet the desired threshold; it does not constitute a confirmed HERS rating on any home.

601.2 Scope

This chapter sets out the procedures for the accreditation of Sampling Providers. Accredited Sampling Providers shall assume all warranties and liabilities associated with the sampling of homes. RESNET does not provide any warranty, either explicit or implied, that sampled homes will meet or exceed the threshold specifications for the sample set. There may be instances in which state laws or regulations differ from these Standards. In such instances, state law or regulation shall take precedence over this standard.

602 DEFINITIONS AND ACRONYMS

See Appendix B.

603 TECHNICAL REQUIREMENTS FOR SAMPLING

603.1 Compliance Requirements

The testing and inspection of homes for minimum rated features shall be conducted in compliance with the procedures for conducting home energy ratings and Builder Option Packages (BOPs) contained in this Standard.

603.2 Homes Eligible to be Sampled

The homes being sampled shall be of the same construction type using the same envelope systems.

603.3 Analysis of Homes

A worst-case analysis shall be performed on each home plan, considering worst-case orientation, all known option packages, and applicable site location(s). If an option or change in the design of the structure is made that differs from those used in the initial analysis in a way that would require more stringent threshold specifications, then that home must be individually rated. At a minimum, a certified Rater shall oversee this process.

603.4 Labeling of Homes

603.4.1 Every home plan within a given sample set shall be assigned the same HERS Index as determined by the threshold specification for that floor plan.

603.4.2 Every home subjected to this sampling Standard shall be provided with a label in accordance with Section 303.3 of these standards, which contains the following statement: "This home has been certified using a sampling protocol in accordance with Chapter 6 of the RESNET Standards (see *http://resnet.us.standards/* . This label shall be located on the electrical panel and the font shall be a minimum of 10 points.

603.5 Sample Set of Homes

Sampling controls may be applied to any sample set of homes within the same subdivision or metropolitan area and climate zone (as specified in the most current edition of the IECC), provided the criteria in Item 603.2 are met and:

603.5.1 Each sample set is made up of homes at the same stage of construction (e.g. pre-drywall, final);

603.5.2 For each stage of construction, each sample set will be comprised of homes eligible for the applicable sampling controls within a 30 calendar day period. For example: a sample set that is defined for a pre-drywall inspection must include homes that are eligible for that pre-drywall inspection within a given 30-day period. If fewer than seven (7) homes are available for that phase of inspection, the sample set must be cut off at the number of homes that are available within that 30-day period. This sample set need not be carried through to final inspection; in fact, a whole new sample set may be defined for the final inspection phase based on the homes available for that phase within a new, 30-day period applied to that phase of tests and inspections.

603.5.3 Each home subject to sampling is required to be part of an identified set of sampling controls for each test or inspection that is sampled;

603.5.4 Each participating subdivision within a metropolitan area is subject to sampling controls on at least one home in any 90 calendar day period;

603.5.5 Each participating subdivision within a metropolitan area must start a minimum of one home in any 90 calendar day period.

603.6 Application of Sampling

The application of the sampling controls in this standard are only required for those tests and inspections that are not conducted on every home. Sampling controls shall be conducted for any tests and inspections not conducted on every home, according to the field testing and inspection requirements of 303.6.2.

603.7 Sampling Controls

603.7.1 A complete set of Sampling Controls shall be performed at a minimum ratio of one (1) test or inspection per seven (7) homes within a given sample set. At a minimum, a certified Rater shall oversee this process.

603.7.2 Sampling Providers may complete the sampling controls collectively on a single home or distribute the tests and inspections across several homes within a given sample set, provided the total number of individual tests and inspections meets or exceeds the minimum ratio set forth in 603.7.1.

603.7.3 To qualify for sampling in a metropolitan area, a builder shall first complete, without any incidence of failure, a complete set of sampling controls on at least seven (7) consecutive homes in that metropolitan area. For this initial phase of testing and inspections, the complete set of sampling controls shall be performed on each of the seven (7) homes.

603.7.3.1 Exception: A builder who has been implementing a sampling process for certifying homes in a specific metropolitan area under the EPA's ENERGY STAR® for Homes program as of January 1, 2008, will be allowed a one time exception to 603.7.3 for that metropolitan area.

603.7.3.2: For each newly started subdivision, sampling may begin only after three (3) consecutive homes have been completed without any incidence of failure.

603.7.4 Having successfully met the requirements of 603.7.3, a Sampling Provider may complete sampling controls for a builder indefinitely until a "failure" occurs or any of the criteria set forth in 603.2 are no longer met.

603.7.5 A complete set of sampling controls, whether performed on a single home or spread across several homes, must be completed whether or not one or more failure(s) are found.

603.7.6 When an "initial failure" occurs, the failed item(s) shall be tested or inspected in two (2) additional homes selected from the same sample set. Testing and/or inspections for any item(s) that may become inaccessible during the construction process, (e.g. wall insulation) must be timed so additional testing and/or inspections can occur on other homes in the sample set before they become inaccessible for inspection or testing.

603.7.7 When an "additional failure" occurs, in one or more of the two (2) additional homes, the failed item(s) shall be tested or inspected in the remaining four (4) homes selected for the same sample set.

603.7.8 Until the failure is corrected in all identified (failed) homes in the sample set, none of the homes shall be deemed to meet the threshold or labeling criteria.

603.8 Multiple "Additional Failures"

Action is required if three (3) "additional failures" occur within a ninety (90) calendar day period. The required action depends on whether those "additional failures" apply to the same failed item or various failed items.

603.8.1 If the multiple "additional failures" all apply to the same failed item, the builder shall submit to 100% inspection of that failed item, for a minimum of seven (7) homes, before resuming sampling of that item. Remaining unrelated sampling controls may be conducted on a sampled basis throughout this process.

603.8.2 If the multiple "additional failures" apply to various failed items, or additional failed items are found during testing and inspection of additional homes, the builder must begin again and complete 603.7.3 at a minimum, before continuing with sampling.

603.8.3 Exception: If a builder conducts a "root cause analysis" on an item or items covered under 603.8.1 or 603.8.2, and submits it in writing to the sampling Provider, sampling may resume as soon as the Provider deems that the solution has been implemented. The "root cause analysis" report shall contain at a minimum:

603.8.3.1 A written description of the problem(s) covered by the analysis;

603.8.3.2 A written explanation of the underlying reason(s) that the problem(s) occurred (e.g. inadequate training of subcontractor(s) or site supervisors, insufficient information or inadequate detail in the plans or specifications, etc);

603.8.3.3 A written description of a clearly defined process to correct the underlying cause(s);

603.8.3.4 A written description of when and how that process has been carried out;

603.8.3.5 A copy of the root cause analysis report shall be kept by the sampling Provider as part of the QA file, for a period of time of three (3) years, consistent with the requirements of 102.1.4.8.2.

603.9 Quality Assurance by Sampling Providers

603.9.1 The Sampling Provider's Rating Provider QA Designee shall be responsible for monitoring compliance with the sampling process and maintaining records in accordance with the requirements of Chapter 9.

603.9.2 In addition to the Quality Assurance requirements specified in Chapter 9 for Home Energy Rating Providers, a Sampling Provider's QUALITY assurance process shall include, at a minimum, the following:

603.9.2.1 All homes that are qualified by the use of sampling shall be considered to be rated homes. QA file review and field monitoring shall be conducted on a percentage of all the homes certified or qualified under sampling, rather than the percentage of tested and inspected homes.

603.9.2.2 The field QA required in Chapter 9 may be conducted on any of the qualified or certified homes within the sample sets, and shall not be limited to the tested and inspected homes.

604 PROVIDER ACCREDITATION CRITERIA

604.1 Minimum Standards for Home Energy Rating Sampling Provider Accreditation
Home Energy Rating Sampling Providers shall be accredited in accordance with the Accreditation Process specified in Chapter 9 of these Standards. A Sampling Provider must specifically meet the following minimum standards for Accreditation.

604.1.1 All Sampling Providers shall be accredited by RESNET as a Home Energy Rating Providers and maintain their accreditation in good standing.

604.1.2 A Sampling Provider's accreditation must be renewed annually by RESNET.

604.1.3 In order to be eligible to be a Sampling Provider, the RESNET accredited rating Provider shall complete a minimum of twenty-five (25) confirmed ratings that have been documented to be accurate by the Rating Provider's Quality assurance designee.

604.1.4 The Sampling Provider shall demonstrate to RESNET a minimum insurance coverage of $1,000,000 in general liability coverage and $1,000,000 in professional liability coverage.

604.1.5 Builders cannot use the sampling standard to certify or qualify homes in which they have a financial interest.

604.2 Responsibilities of Accredited Sampling Providers

604.2.1 Sampling Providers are responsible for ensuring that all of the Sampling inspections conducted and issued by their sampling program are in compliance with all of the criteria by which the system was accredited.

604.2.2 Sampling Providers are responsible for ensuring that the specifications for the minimum rated features for the sampled homes be communicated to the personnel or trades responsible for completing the work.

604.2.3 Minimum Standards For Sampling Provider's Operation Policies and Procedures must be written and provide for the following:

604.2.3.1 Field inspections and tracking of all homes in the sample set for verifying threshold technical specifications and tracking failures and re-inspections;

604.2.3.2 Blower Door Testing completed for sample sets in which the threshold specifications include credit for reduced air infiltration lower than the default value;

604.2.3.3 Duct testing completed for sample sets in which the threshold specifications include credit for reduced air distribution system leakage lower than the default value;

604.2.3.4 Sampling Inspector discipline procedures that include progressive discipline involving Probation - Suspension – Termination.

605 EFFECTIVE DATES

605.1 Quality Assurance
July 1, 2007 – Section 603.9 shall be implemented by all sampling Raters and Providers.

605.2 Effective Date of Standard
January 1, 2008 – The remainder of Chapter 6 shall be implemented by all sampling Raters and Providers

Chapter Seven
RESNET Standards

700 RESNET NATIONAL STANDARD FOR HOME ENERGY AUDITS

701 GENERAL PROVISIONS

701.1 Purpose
The provisions of this standard are intended to define a framework for a home energy audit process. A certified auditor, an accredited Provider and/or a program will apply this standard to improve the energy performance of existing homes through uniform, comprehensive home energy surveys, audits and ratings for existing residential buildings. This standard is intended to encourage investments by building owners that produce the following outcomes:

- Increase the energy efficiency of homes;
- Increase the comfort of homes;
- Increase the durability of homes;
- Reduce the risk that energy improvement recommendations will contribute to health, safety, or building durability problems;
- Reduce waste and pollution, protecting the environment; and
- Ensure that the recommendations are within the community standards (e.g. historic districts, flood zones, subdivision covenance).

And to ensure that throughout the process, energy improvement recommendations are portrayed with reasonable and consistent projections of energy savings.

701.2 National Standard for Home Energy Audits.
There are 3 categories of home performance assessments defined in this standard, listed in order of increasing accuracy and completeness:

1. Home Energy Survey (HES)
    a. On-Line Home Energy Survey
    b. Professional Home Energy Survey
2. Building Performance Audit (BPA)
3. Comprehensive HERS Rating (CHER)

Visual examination and measurement of the home as built are the first steps for any audit process; BPA and CHER exceed HES since they require performance testing. All steps produce a list of recommended improvements, but BPA and CHER include a formalized work scope. A CHER exceeds a BPA only in that a CHER also includes a formal Home Energy Rating.

701.3 Relationship to Other Standards
This Chapter is a companion Chapter to the 2006 RESNET Mortgage Industry National Home Energy Rating System Standard as promulgated and maintained by the Residential Energy Services Network (RESNET) and recognized by the mortgage industry and programs promoting the improved energy performance of buildings.

701.4 Relationship to State Law
This standard specifically recognizes that some state laws or regulations have additional requirements to those specified in this document. To the extent that such state laws or regulations differ from these Standards, state law or regulation shall govern.

701.5 Scope
This Home Energy Audit Standard will address RESNET Providers for each area of home inspection, applicable procedures, types of home inspections, certifications of the inspectors, summary of requirements for each type of inspection, and the reports to accompany each type of inspection.

701.5.1 Application of Standards
This standard applies to existing site-constructed or manufactured, single- or multi-family, residential buildings three stories or less in height.

702 DEFINITIONS AND ACRONYMS

See Appendix B.

703 HOME ENERGY AUDIT PROVIDER ACCREDITATION CRITERIA

703.1 Minimum Standards for Home Energy Audit (HEA) Provider Accreditation
Home Energy Audit Providers shall be accredited in accordance with the Accreditation Process specified in Chapter 9 of these Standards. An HEA Provider shall specifically meet the following minimum standards for Accreditation.

703.1.1 Home Energy Survey Professional and Building Performance Auditor Certification Standard. Home Energy Survey Professionals (HESPs) and Building Performance Auditors (BPAs) shall be certified (and recertified) by RESNET-accredited HEA Providers, who shall abide by the following provisions:

703.1.1.1 HEA Providers shall provide documentation that the HESPs and/or BPAs under their Providership meet the following certification requirements:

703.1.1.1.1 Performance Evaluation. HESPs and BPAs shall pass a performance evaluation of their ability to perform accurate Home Energy Surveys and/or Building Performance Audits in accordance with sections 704 and 705. Each HESP and BPA shall complete a probationary period where close supervision is provided by the HEA Provider's QA Designee (as defined in Chapter 9 of these Standards). The probationary period covers a minimum of three Home Energy Surveys and/or Building Performance Audits (as applicable) after which the QA Designee shall determine if additional training is needed.

703.1.1.1.2 Professional Development for HESPs and BPAs. HESPs and BPAs shall complete one of the below three options:

703.1.1.1.2.1 Complete 18 hours of professional development every three years. The 18 hours shall include completion of 18 hours of refresher course(s) offered by a RESNET Accredited HEA Training Provider; or

703.1.1.1.2.2 Documentation of 18 hours of attendance at a RESNET Conference every three (3) years; or

703.1.1.1.2.3 Pass the HESP online test every three years.

703.1.1.1.3 Testing. All certified HESPs shall pass the national Home Energy Survey Professional (HESP) online test administered by RESNET with a score of at least 75 percent. Each certified BPA shall pass the national Building Performance Auditor (BPA) online test administered by RESNET with a score of at least 80 percent, and pass any additional field evaluations to determine competency to perform building air leakage and duct pressurization tests, and combustion safety procedures as required in Chapter Eight of these Standards.

703.1.1.1.4 Recertification of individuals by the HEA Provider shall occur every three (3) years.

703.1.1.1.5 Agreements. As a condition of certification, each HEA Provider shall ensure that each certified individual enters into a written agreement with the Provider to provide the applicable field verification services in compliance with these Standards. An unexecuted copy of the written agreement shall be provided to RESNET with the Provider's accreditation application, and again within 60 days of making changes to the agreement. The written agreement shall, at a minimum require Auditors to:

703.1.1.1.5.1 Provide audit verification services in compliance with these Standards;

703.1.1.1.5.2 Provide accurate and fair Professional Surveys or Audits; and

703.1.1.1.5.3 Comply with the RESNET Code of Ethics. The RESNET Code of Ethics shall be attached to the written agreement.

703.1.2 Minimum Standards for HEA Provider Operation Policies and Procedures shall be submitted in written form to RESNET for approval, and shall at a minimum provide for the following:

703.1.2.1 Written conflict of interest provisions that prohibit undisclosed conflicts of interest, but may allow waiver with advanced disclosure. The "Standard Disclosure" form adopted by the RESNET Board of Directors shall be completed for each home that receives a Home Energy Survey or Building Performance Audit and shall be provided to the client and made available to the homeowner. Each form shall accurately reflect the proper disclosure for the home that it represents. For the purpose of completing this disclosure, "Auditor's employer" includes any affiliate entities. Recognizing that a number of different relationships may exist among the auditor or the auditor's employer, other contractors that may complete work on the home, and the survey client and/or homeowner, the HEA Provider shall ensure that all disclosures are adequately addressed by the Provider's quality assurance plan, in accordance with the relevant quality assurance provisions of these Standards.

703.1.2.2 Written Auditor discipline procedures that include progressive discipline for probation, suspension, and decertification.

703.1.2.3 In accordance with the minimum requirements set forth in Chapter 9 for quality assurance, a written audit Quality Assurance Plan and designation of a Quality Assurance Designee.

703.1.2.4 Auditor Registry. The HEA Provider shall maintain a registry of all of its certified Auditors. The specified Provider shall also keep on file the names and contact information for all certified Auditors, including company name, mailing address, voice phone number, fax number, and email address. Upon request, the HEA Provider shall provide to RESNET its registry of certified Auditors.

703.1.2.5 Complaint Response Process. Each HEA Provider shall have a publicly accessible system for receiving complaints. HEA Providers shall ensure that Auditors inform clients about the complaint process by publicizing the web address of the complaint resolution process. Each HEA Provider shall retain records of complaints received and responses to complaints for a minimum of three (3) years after the date of the complaint.

703.1.3 Additional HEA Provider Duties Related to Oversight of Building Performance Auditors (BPAs)

703.1.3.1 Certification of Performance Testing Proficiency. The HEA Provider is responsible for certifying that each BPA has successfully completed the following:

703.1.3.1.1 Passing the RESNET BPA online exam in accordance with Section 703.1.1.1.3.

703.1.3.1.1.1 BPA candidates who have NOT previously passed the 50 question RESNET HESP exam shall pass the 50 question BPA exam with a minimum score of 80%.

703.1.3.1.1.2 BPA candidates who have previously taken and passed the 50 question RESNET HESP online exam with a minimum score of 75%, shall pass an abbreviated 25 question BPA exam and pass with a minimum score of 80%.

703.1.3.1.2 BPA candidates shall complete a combined total of twenty (20) hours of RESNET approved training in Pressure Diagnostics, Combustion Appliance Zone (CAZ) Testing and Work Scope Requirements which includes field training and a field proficiency demonstration as defined in the *RESNET Guidelines for Combustion Appliance Testing and Writing Work Scopes* (hereinafter "RESNET interim guidelines") and chapter 8 of these Standards.

704 NATIONAL HOME ENERGY AUDIT PROCEDURES

704.1 Home Energy Survey

The purpose of the Home Energy Survey is to assess the general condition of the home with respect to energy performance. The Home Energy Survey shall include a report that shows a general range of a home's energy efficiency based on minimum specific criteria (e.g. insulation, equipment age, general condition, energy usage and costs) and a lookup matrix based on regional norms and climate, as approved by RESNET. The Home Energy Survey is not required if the homeowner wishes to directly pursue a Building Performance Audit or a Comprehensive HERS Rating. The Home Energy Survey will take one of two forms: a DOE- or RESNET- approved computerized On-Line Home Energy Survey performed by the owner or occupant, or a Professional Home Energy Survey conducted by a certified Home Energy Survey Professional.

704.1.1 On-Line Home Energy Survey. The On-Line Home Energy Survey shall collect substantially the same data and information and shall be subject to the same limitations as the Professional Home Energy Survey. On-line Home Energy Survey software shall be hosted by a RESNET accredited HEA Provider or another organization approved by RESNET and the on-line program report shall be approved by RESNET.

704.1.2 Professional Home Energy Survey. The Professional Home Energy Survey shall include on-site visual inspection of the energy features of the dwelling unit, and documentation of its general condition, including envelope features and ages; equipment types, characteristics and ages; appliance and lighting characteristics; and likely anticipated remediation issues such as moisture or combustion appliance problems. Where available, the Professional Home Energy Survey shall include a review of utility use and billing history. The Home Energy Survey is a visual inspection only and does not include diagnostic testing. Home Energy Survey Professionals may also use home energy survey and labeling software programs approved by RESNET or the U.S. Department of Energy. A homeowner is not required to have a Professional Home Energy Survey prior to having a Building Performance Audit or Comprehensive HERS Rating.

704.1.2.1 The Home Energy Survey Professional (HESP) shall interview the homeowner regarding energy, comfort problems and related durability issues. The HESP shall review the goals listed in 701.1 of these Standard, and provide an explanation of the home energy audit process and potential availability of incentive programs that maybe accessed by the homeowner. The interview shall include, but is not limited to, the following subject areas:

704.1.2.1.1 Comfort complaints, including areas of the home that are too hot or too cold.

704.1.2.1.2 Energy billing concerns.

704.1.2.1.3 Durability issues, including water intrusion, ice damming, etc.

704.1.2.1.4 The potential for the homeowner to follow up with a Building Performance Audit or Comprehensive HERS Rating.

704.1.2.1.5 Interest in potential home energy performance improvements.

704.1.2.2 The HESP shall inform the homeowner of low cost/no cost improvements that can be implemented by the homeowner.

704.1.2.3 The HESP shall request copies of utility bills and/or written permission to obtain past energy use information from the utility supplier(s), for the purpose of estimating generalized end-use consumption (base, heating, and cooling). If the customer declines, the HESP shall explain the reason for the request and the potential effect on the home energy survey.

704.1.2.4 The HESP shall advise the homeowner on where to locate qualified individuals (including the RESNET website) to conduct a Building Performance Audit, a Comprehensive HERS Rating, and/or RESNET Qualified Contractors to complete the work on the home.

704.1.2.5. Minimum Procedures for a Professional Home Energy Survey:

704.1.2.5.1 The Home Energy Survey Professional (HESP) shall complete a RESNET-approved survey form. The survey form will require the HESP to visually review the home to determine, measure or estimate the following features:

704.1.2.5.1.1 R-values and location of wall/ceiling/floor insulation;

704.1.2.5.1.2 Square footage and approximate age of home;

704.1.2.5.1.3 Glazing type(s), frame material(s), and permanently installed shading devices such as screens or applied films;

704.1.2.5.1.4 Type, model number, efficiency (if available), and location of heating/cooling system(s);

704.1.2.5.1.5 Type of ductwork, location and R-value of duct insulation, visual assessment of obvious duct leakage, and any indications of previous duct sealing;

704.1.2.5.1.6 Type of foundation is crawl space, basement, or slab, along with venting and insulation locations;

704.1.2.5.1.7 Type of attic, approximate age, type and color of roofing material and presence and type of venting.

704.1.2.5.1.8 Checklist of common air-leakage sites; indicating likely opportunities for leakage reduction;

704.1.2.5.1.9 Estimated age and efficiency (if available), condition, number and location of major appliances such as dishwashers, refrigerators, freezers and washing machines;

704.1.2.5.1.10 Number, type, and controls of indoor and outdoor light fixtures and portable lamps that are suitable for energy efficient re-lamping;

704.1.2.5.1.11 Durability issues such as visual indications of common moisture problems, including condensation, roof leaks, foundation leaks, ground-water intrusion, ice damming, and plumbing leaks, as well as signs of mold, mildew, insect damage, efflorescence, and stains;

704.1.2.5.1.12 Presence, size, and location of exhaust fans, and determination of whether they are vented to the outdoors;

704.1.2.5.1.13 Number, type, and flow rate of water fixtures (e.g. faucets, showerheads), presence and control of hot water recirculation loop/pump;

704.1.2.5.1.14 Presence and type(s) of combustion equipment; visually identifiable evidence of flame rollout, blocked chimney, rust and corrosion; missing or damaged vent connectors;

704.1.2.5.1.15 Mechanical systems that are likely to cause or contribute to excess infiltration or pressure imbalances, such as attic fans or bedrooms with no return air or transfer grilles.

704.1.2.5.1.16 Any identified potential combustion appliance safety hazards related to energy retrofit work.

704.1.2.5.2 The following elements are outside the scope of a Professional Home Energy Survey:

704.1.2.5.2.1 The use of blower doors, duct leakage test equipment or an infrared camera.

704.1.2.5.2.2 Any other diagnostic testing of the home

704.1.2.5.2.3 Quantification of any levels of air tightness, duct tightness, or ventilation amounts.
704.1.2.5.2.4 Combustion Appliance Zone (CAZ) testing

704.1.2.5.3 Energy savings estimates will only be generalized and presented along with the qualification that a Building Performance Audit or Comprehensive HERS Rating shall be obtained to calculate more detailed energy savings estimates.

704.1.2.6 Minimum Professional Home Energy Survey Report Documentation

704.1.2.6.1 At the completion of the Professional Home Energy Survey the Home Energy Survey Professional shall provide the homeowner a standardized report using a format approved by RESNET, signed and dated by the HESP. The report at a minimum shall provide information to the homeowner that addresses:

704.1.2.6.1.1 All data collected in accordance with Section 704.1.2.5.1, above;

704.1.2.6.1.2 Whole-house solutions overview of how the home works as a system and how to prioritize actions;

704.1.2.6.1.3 The quality of installation of HVAC equipment including general information on proper sizing of equipment, duct sealing, insulation and general condition of the ductwork, and the importance of proper refrigerant charge and air flow;

704.1.2.6.1.4 The quality of the building envelope air sealing and proper levels of insulation;

704.1.2.6.1.5 An overview of potentially appropriate ENERGY STAR or better products and appliances;

704.1.2.6.1.6 Information regarding access to a Building Performance Audit or Comprehensive HERS Rating;

704.1.2.6.1.7 Potential non-energy benefits of improving the energy efficiency of the home including reduction of carbon emissions, improved comfort and air quality;

704.1.2.6.1.8 General statement regarding opportunities to improve the thermal envelope, mechanical equipment, lighting and appliances in the home;

704.1.2.6.1.9 General discussion of observations and concerns regarding combustion appliance operation;

704.1.2.6.1.10 A safety notification form adopted by RESNET that is filled out and presented to the homeowner identifying potential hazards such as lead paint, asbestos, mold, and radon that are outside the scope of the Home Energy Survey. ;

704.1.2.6.1.11. Information on available rebate, financing, and/or tax incentive programs that will help the homeowner

704.1.2.7 Limitations. Unless certified by RESNET as a Building Performance Auditor or Comprehensive HERS Rater, (or another certification that is recognized by RESNET as equivalent), the Home Energy Survey Professional shall not produce a detailed written work scope for improvements as part of a Professional Home Energy Survey.

704.2 Building Performance Audit

The purpose of the Building Performance Audit is to identify building performance deficiencies and provide a work scope sufficient for improvements to be made to the audited home. The Building Performance Audit includes an evaluation, performance testing, computer software analysis using software that is accredited by RESNET or approved by

DOE for this purpose, and reporting of proposed treatments for improvement of an existing home. The evaluation shall include a review of the data collected from any previous energy audit or survey, any further required measurement and performance testing, and combustion appliance testing. The Auditor shall determine the appropriate work scope for the home. A homeowner may elect to go through this process with or without a prior Professional Home Energy Survey. A Building Performance Audit includes all of the provisions of the Professional Home Energy Survey (Section 704.1.2.5), plus the performance of diagnostic testing and reporting requirements as follows:

704.2.1. Evaluate building shell air leakage in CFM50

At a minimum, a single point (50 Pa) blower door depressurization test shall be performed in accordance with the envelope testing protocols contained in chapter 8 of these Standards and the results thereof shall be included in the audit report.

704.2.2. Evaluate duct leakage.

704.2.2.1 The Auditor shall perform a duct leakage test in accordance with the protocols in chapter 8 of these Standards, and/or specify a duct leakage test in accordance with RESNET standards prior to beginning any duct-sealing work.

704.2.3 Conduct CAZ Depressurization, Spillage and CO testing

704.2.3.1 The auditor must perform a worst-case depressurization, spillage, and CO test in accordance with the RESNET interim guidelines.

704.2.4 Prepare a Detailed Retrofit Work Scope

A BPA Report shall include a retrofit work scope in accordance with the RESNET interim guidelines.

704.2.4.1 The work scopes for recommended improvements shall be determined by the Auditor based upon the findings of the assessment and the client's budget and objectives. The recommendations shall be presented to the homeowner in order of priority based on cost effectiveness and priorities for remediation of combustion appliance deficiencies. At a minimum, five (5) of the most cost-effective measures must be recommended regardless of the client's budget.

704.3 Minimum Building Performance Audit Report Documentation

704.3.1 Upon completion of the audit, provide the client with a written record (physical or electronic) of the audit and resulting recommendations within five (5) business days. It shall include:

704.3.1.1 General findings of audit as defined in Section 704.1.2.6

704.3.1.2 General recommendations for improvements

704.3.1.3 The results of the combustion appliance testing.

704.3.1.4 Work scopes for suggested improvements

704.3.1.5 Cost-effectiveness estimates based on analysis

704.3.1.6 Information on where to locate qualified individuals (including the RESNET website) to conduct a Comprehensive HERS Rating and/or RESNET Qualified Contractors or other contractors suitable to complete the work on the home.

704.4 Comprehensive HERS Rating
The Comprehensive HERS Rating is the most in-depth performance audit. It includes evaluation, performance testing, reporting of the proposed work scope for improvement of an existing home in accordance with section 704.2, and a HERS Rating in accordance with Chapter 3 of these Standards. A homeowner is not required to have a Professional Home Energy Survey or Building Performance Audit prior to having a Comprehensive HERS Rating.

705 REQUIRED SKILLS FOR CERTIFICATION

705.1 Minimum skills and knowledge base required to conduct a Professional Home Energy Survey

705.1.1 Basics of heat transfer concepts

705.1.2 Basics of building performance testing

705.1.3 Basics of air distribution leakage

705.1.4 Calculating gross and net areas

705.1.5 Definitions/energy terminology

705.1.6 Basic combustion appliance concerns

705.1.7 Basics of envelope leakage, thermal bypass, thermal bridging

705.1.8 Determining envelope insulation

705.1.8.1 Presence/absence of insulation and when observable, the quality of its installation

705.1.8.2 Recommended levels of insulation by climate zone

705.1.9 HVAC – determining equipment efficiencies from model numbers or default tables

705.1.9.1 HVAC pros/cons, drivers and sensitivities of major system types

705.1.10 Household appliances – estimate efficiency from model numbers or vintage

705.1.11 Energy, power, moisture, heat-conductivity/resistance, and temperature units and key conversion factors

705.1.12 Measuring building dimensions

705.1.13 Identification and documentation of energy survey inspected features of the home

705.1.14 Basics of specifications

705.1.15 Determining window and door efficiency

705.1.16 Determining building orientation and shading characteristics

705.1.17 Defining the thermal boundary, and appropriate recommendations for changing the thermal boundary

705.1.18 Basics of measure interaction, expected life, and bundling for optimal performance considering the house as a system and the emerging need for deep savings.

705.2 Minimum skills and knowledge base required for an individual to conduct a Building Performance Audit

705.2.1 The skills and knowledge required for an individual to conduct a Home Energy Survey in accordance with section 705.1 of these Standards.

705.2.2 Ability to perform building envelope leakage testing in accordance with the envelope testing protocols in chapter 8 of these Standards.

705.2.3 Ability to perform duct leakage testing in accordance with the duct testing protocols contained in chapter 8 of these Standards.

705.2.4 Ability to perform CAZ, spillage, and CO testing in accordance with Worst-Case Depressurization and Combustion Appliance Testing protocols contained in the RESNET interim guidelines.

705.2.5 Understanding of pressure influences and remediation of the following conditions

705.2.5.1 Room and zone pressure imbalances caused by lack of ducted return air or pressure relief mechanisms such as transfer grilles or jumper ducts.

705.2.5.2 CAZ depressurization or combustion appliance spillage caused by return leaks in the CAZ zone, supply leaks outside the house pressure boundary, zonal pressure imbalances, and/or exhaust appliances including other combustion equipment.

705.2.5.3 Pressure differential diagnostics in intermediate buffer zones including (but not limited to) attics, garages, or crawlspaces.

705.2.6 Ability to prepare a detailed work scope in accordance with protocols contained in the RESNET interim guidelines.

705.2.7 Familiarity with local climate conditions, housing stock, and climate specific practices.

705.3 Minimum skills and knowledge base required for an individual to conduct a Comprehensive HERS Rating

705.3.1 The skills and knowledge required for an individual to conduct a Building Performance Audit in accordance with section 705.1 and 705.2 of these Standards;

705.3.2 The Home Energy Rating Knowledge Base and Skills Set found in section 205.1 of these Standards and the Minimum Rater Competencies found in section 206.1.2 of these Standards.

705.3.3 Ability to conduct building simulation and performance analysis and provide HERS Ratings in accordance with the requirements in Chapter 3 and Chapter 8 of these Standards.

706 GENERAL LIMITATIONS AND EXCLUSIONS

706.1 Limitations

706.1.1 The energy use information contained in reports resulting from Professional Home Energy Surveys, Building Performance Audits or Comprehensive HERS Ratings do not constitute any warranty of energy cost or savings.

706.1.2 Surveys, Audits and Ratings that are performed in accordance with these standards:

706.1.2.1 Are not technically exhaustive.

706.1.2.2 Will not identify concealed conditions or latent defects.

706.1.3 Neither the Building Performance Audit nor the Comprehensive HERS Rating is intended to be an inspection of the structural soundness of the home or any other attributes of the home other than the home’s energy features and safety issues related directly to proposed work scopes.

706.1.4 The Professional Home Energy Survey is not applicable to building design and construction features except those listed in section 704.1.2.5.

707 HOME ENERGY AUDIT TRAINING PROVIDER ACCREDITATION

707.1 Requirements for Accredited HEA-Training Providers

707.1.1 Duties and Responsibilities. In order to maintain their accreditation in good standing for providing HESP and/or BPA training courses, all HEA-Training Providers shall fully discharge the following duties and responsibilities.

707.1.1.1 Hold the national core competency questions of the national HESP and BPA test administered by RESNET in the strictest confidence.

707.1.1.2 Submit to RESNET for approval, copies of the HESP and BPA course presentation materials, training manuals, user manuals, course handouts and any other training materials used for training purposes,

707.1.1.3 Submit for approval, **c**opies of all policies, standards, guidelines and procedures to be used by the HEA-Training Provider.

707.1.1.4 Maintain a record, for a period of three years, of all training materials and trainee data, including:

707.1.1.4.1 Historical records of all training schedules and curricula,

707.1.1.4.2 Historical records of all training attendance records,

707.1.1.4.3 Historical records of all examinations and individual examination results,

707.1.1.4.4 Historical records of all certifications issued to any individuals,

707.1.1.4.5 Copies of all current policies, standards, guidelines and procedures in use by the HEA-Training Provider.

707.1.1.5 Maintain acceptable accounting practices, suitable to satisfy the requirements of independent audit procedures.

707.1.1.6 Maintain up-to-date training materials and provide adequate training facilities.

707.1.1.7 Only utilize RESNET Certified BPA Trainers who have at a minimum been certified by RESNET as having passed the 100-question BPA Trainer's Exam with a minimum score of 90%.

707.1.2 Privileges and rights. All accredited HEA-Training Providers in good standing shall have certain privileges and rights, as follows:

707.1.2.1 The privilege to display the accreditation seal of RESNET on any publications, displays, presentations or marketing materials published, authorized for publication or otherwise issued by the HEA-Training Provider.

707.1.2.2 The privilege to make and use RESNET designated trademarked, copyrighted or otherwise restricted materials for marketing both HESP and BPA Training Courses.

707.1.2.3 The right to present evidence, arguments and a vigorous defense in any action brought under these standards by any party against a HEA-Training Provider.

708 MINIMUM HOME ENERGY AUDIT TRAINER COMPETENCIES

708.1 Required HEA Trainer Competencies

708.1.1 To teach either HESP or BPA training curriculum, a HEA-Training Provider shall maintain RESNET Certified HEA Trainer(s) demonstrating the following skills:

708.1.1.1 Mastery of the Home Energy Audit Standards knowledge base and skills set given in this chapter. The trainers shall demonstrate these skills by passing the 100-question RESNET HEA Trainer's Exam with a minimum score of 90%.

708.1.1.2 Ability to communicate effectively the methods, procedures, knowledge and skills to produce accurate and fair Home Energy Audits from building investigation and performance testing and combustion safety in accordance with this Chapter and RESNET interim guidelines.

708.1.1.3 Understanding of the purposes and benefits of home energy surveys and audits and ability to communicate these to students.

708.1.1.4 Understanding the basics of cost-effective energy improvements, preparing a work scope and the ability to communicate these to students.

Chapter Eight
RESNET Standards

Effective Date
This chapter goes into effect on January 3, 2012

800 RESNET Standard for Performance Testing and Work Scope: Enclosure and Air Distribution Leakage Testing

801 Background
This Standard will present a step-by-step approach for how to measure:
- enclosure air leakage for the inspection of low rise, three stories or less, residential and light commercial buildings, and
- duct leakage associated with HVAC systems
- air flows for ventilation systems, and
- work scope and combustion safety procedures

802 Procedures for Building Enclosure Airtightness Testing
The purpose of this test procedure is to determine the airtightness of a building enclosure measured in cubic feet per minute at a 50 Pa pressure difference (*CFM50)*.

802.1 ON-SITE INSPECTION PROTOCOL
There are three acceptable airtightness test procedures:

> **802.1.1** Single-point test: Measuring air leakage one time at a single pressure difference as described in section 802.5
>
> **802.1.2** Multi-point test: Measuring air leakage at multiple induced pressures differences as described in section 802.6
>
> **802.1.3** Repeated single-point test: The test is similar to the single point test, but the test is done multiple times for improved accuracy and estimating uncertainty as described in section 802.7

The building may be tested by applying a positive or negative pressure. Follow all manufacturers' instructions for set up and operation of all equipment. If certain requirements of this standard cannot be met, then all deviations from the standard shall be recorded and reported.

> **Note**: Use caution when deciding how and whether to test homes with potential airborne contaminants (e.g. fireplace ash, mold or asbestos) and refer to local, state and national protocols/standards for methods to deal with these and other contaminants.

802.2 Protocol for Preparing the Building Enclosure for Testing

802.2.1 Doors and windows that are part of the conditioned space boundary shall be closed and latched.

802.2.2 Attached garages: All exterior garage doors and windows shall be closed and latched unless the blower door is installed between the house and the garage, in which case the garage shall be opened to outside by opening at least one exterior garage door.

802.2.3 Crawlspaces: If a crawlspace is inside the conditioned space boundary, interior access doors and hatches between the house and the crawlspace shall be opened and exterior crawlspace access doors, vents and hatches shall be closed. If a crawlspace is outside the conditioned space boundary, interior access doors and hatches shall be closed. For compliance testing purposes, crawl-space vents shall be open.

802.2.4 Attics: If an attic is inside the conditioned space boundary, interior access doors and hatches between the house and the conditioned attic shall be opened; and attic exterior access doors and windows shall be closed. If an attic is outside the conditioned space boundary, interior access doors and hatches shall be closed and exterior access doors, dampers or vents shall be left in their as found position and their position during testing shall be recorded on the test report.

802.2.5 Interior Doors: Shall be open within the Conditioned Space Boundary. See the definition of "Conditioned Space Boundary" for clarification.

802.2.6 Chimney dampers and combustion-air inlets on solid fuel appliances: Dampers shall be closed. Take precautions to prevent ashes or soot from entering the house during testing. Although the general intent of this standard is to test the building in its normal operating condition, it may be necessary to temporarily seal openings to avoid drawing soot or ashes into the house. Any temporary sealing shall be noted in the test report.

802.2.7 Combustion appliance flue gas vents: Shall be left in their normal appliance-off condition.

802.2.8 Fans: Any fan or appliance capable of inducing airflow across the building enclosure shall be turned off including, but not limited to, clothes dryers, attic fans, kitchen and bathroom exhaust fans, outdoor air ventilation fans, air handlers, and crawl space and attic ventilation fans. Continuously operating ventilation systems shall be turned off and the air openings sealed, preferably at the exterior terminations.

802.2.9 Non-motorized dampers which connect the conditioned space to the exterior or to unconditioned spaces: Dampers shall be left as found. If the damper will be forced open or closed by the induced test pressure, that fact shall be reported in the test report. Clothes dryer exhaust openings should not be sealed off even if there is no dryer attached but this fact should be noted in the test report.

802.2.10 Motorized dampers which connect the conditioned space to the exterior (or to unconditioned spaces): The damper shall be placed in its closed position and shall not be further sealed.

802.2.11 Un-dampered or fixed-damper intentional openings between conditioned space and the exterior or unconditioned spaces: Shall be left open or fixed position, however, temporary blocking shall be removed. For example: fixed-damper ducts supplying outdoor air for intermittent ventilation systems (including central-fan-integrated distribution systems) shall be left in their fixed-damper position. *Exception:* Un-dampered supply-air or exhaust-air openings of *continuously operating* mechanical ventilation systems shall be sealed (preferably seal at the exterior of enclosure) and ventilation fans shall be turned off as specified above.

802.2.12 Whole building fan louvers/shutters: Shall be closed. If there is a seasonal cover, install it.

802.2.13 Evaporative coolers: The opening to the exterior shall be placed in its off condition. If there is a seasonal cover, install it.

802.2.14 Operable window trickle-vents and through-the-wall vents: Shall be closed.

802.2.15 Supply registers and return grilles: Shall be left open and uncovered.

802.2.16 Plumbing drains with p-traps: Shall be sealed or filled with water, if empty.

802.2.17 Combustion appliances: Shall remain off during the test.

Maintain the above conditions throughout the test. If during the test, induced pressures affect operable dampers, seasonal covers, etc. then reestablish the set-up and consider reversing direction of fan flow.

After testing is complete, return the building to its as found conditions prior to the test. For example, make sure that any combustion appliance pilots that were on prior to testing remain lit after testing.

802.3 Accuracy Levels for Enclosure Leakage Testing
This standard defines two levels of accuracy:

802.3.1 ***Standard level of accuracy***: level of accuracy that produces test results that can be used in the modeling software or to assess compliance with a performance standard, energy code, or specific program requirement. This is the level of accuracy that is normally attained unless there are adverse testing conditions such as high winds, an extremely leaky building or very large baseline pressure adjustments.

802.3.2 ***Reduced level of accuracy***: during adverse testing conditions or in certain applications where testing time and costs are a factor, a test with a reduced level of accuracy may be used. Such applications may include demonstrating compliance with a performance standard, energy code, or specific program requirement. However, measurements made with a reduced level of accuracy may require surpassing the threshold value by an amount which will account for the added uncertainty as defined in the sections below. RESNET accredited software that uses test results with a reduced level of accuracy shall internally adjust the calculations in accordance with this chapter.

802.4 Installation of the Blower Door Airtightness Testing System

802.4.1 Install the blower door system in an exterior doorway or window that has unrestricted access to the building and no obstructions to airflow within five feet of the fan inlet and two feet of the fan outlet. Avoid installing the system in a doorway or window exposed to the wind.

802.4.1.1 It is permissible to use a doorway or window between the conditioned space and unconditioned space as long as the unconditioned space has an unrestricted air pathway to the outdoors. For example, an attached garage or porch can be used as the unconditioned space; in that case, be sure to open all exterior windows and doors of the unconditioned space to the outdoors.

802.4.2 Install the pressure gauge(s), fans and tubing connections according to equipment manufacturer's instructions.

802.4.3 Record the indoor and outdoor temperatures in degrees F to an accuracy of 10 degrees F.

802.4.4 Record the elevation of the building site with an accuracy of 2000 feet; this may be omitted at elevations less than 5000 feet above sea level.

802.4.5 If ***ACH50***, i.e., air changes per hour @ 50 Pa, will be calculated, record the ***building volume*** (the volume enclosed by the conditioned space boundary)**.**

802.5 Procedure for Conducting a One-Point Airtightness Test (if a multi-point test will be conducted, skip to section 802.6)

802.5.1 Choose and record a ***time averaging period*** of at least 10 seconds to be used for measuring pressures. With the blower door fan sealed and off, measure and record 5, independent, ***average baseline building pressure readings*** with respect to outside to a resolution of 0.1 Pa.

802.5.2 Subtract the smallest baseline measurement from the largest recorded in Step 802.5.1 and record this as the ***baseline range***.

802.5.3 Airtightness tests with a baseline range less than 5.0 Pa, will be considered a ***Standard Level of Accuracy*** Test. Airtightness tests with a baseline range between 5.0 Pa and 10.0 Pa will be considered a ***Reduced Level of Accuracy*** Test and the results will be adjusted using Section 802.8. A one point test cannot be performed under this standard if the baseline range is greater than 10.0 Pa. Record the level of accuracy for the test as ***standard*** or ***reduced***, as appropriate**.** The baseline test may be repeated employing a longer time averaging period in order to meet the desired level of accuracy.

802.5.4 Re-measure the baseline building pressure using the same time averaging period recorded in Step 802.5.1 or use the average of the baseline pressures measured in step 802.5.1. This measurement is defined as the ***Pre-Test Baseline Building Pressure***. If desired for greater accuracy, a longer time averaging period may be used. Record the ***Pre-Test Baseline Building Pressure***.

802.5.5 Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 50 Pa. Induced building pressure shall be defined as the (unadjusted) building pressure minus the pre-test baseline building pressure. If a 50 Pa induced building pressure cannot be achieved because the blower door fan does not have sufficient flow capacity, then achieve the highest induced building pressure possible with the equipment available.

802.5.6 A one-point test may only be performed if the maximum induced building pressure is at least 15 Pa and greater than four times the baseline pressure. If the maximum induced building pressure is less than 15 Pa, recheck that the house set up is correct and determine if any basic repairs are needed prior to further testing or modeling of the building. A multi-point test may be attempted, or multiple fans may be used. If using multiple fans, follow the manufacturer's instruction for measurement procedures.

802.5.7 Measure and record the unadjusted building pressure and nominal (not temperature and altitude corrected) fan flow using the same averaging period used in Step 802.5.4. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration (rings, pressurization or depressurization, etc), fan and manometer models and serial numbers.

802.5.8 Turn off the fan.

802.5.9 If your pressure gauge has the capability to display the induced building pressure (i.e. "baseline adjustment" feature) and adjust the fan flow value to an induced building pressure of 50 Pa (i.e. "@50 Pa" feature), then follow the manometer manufacturer's procedures for calculating the results of a one-point test and record the following values: induced building pressure, nominal CFM50, fan configuration, fan and manometer models and serial numbers. If needed calculate the following values:

- ***induced building pressure*** =
  measured building pressure minus the ***Pre-Test Baseline Building Pressure***

  Note: If a "baseline adjustment" feature of the manometer was used, then the induced building pressure is displayed on the pressure gauge.

- ***nominal CFM50*** = $(50 / \text{induced building pressure})^{0.65}$ x recorded fan flow

  Note: If both a "baseline adjustment" feature and an "@50 Pa" feature were used, the nominal CFM50 is displayed directly on the pressure gauge.

If the altitude is above 5,000 feet or the difference between the inside and outside temperature is more than 30 degrees Fahrenheit then calculate the corrected CFM50 as defined below:

- ***corrected CFM50*** =
  nominal CFM50 x altitude correction factor x temperature correction factor

  where:
  altitude correction factor = 1 + .000006 x altitude, altitude is in feet
  temperature correction factors are listed in Table 802.1

802.6 Procedure for Conducting a Multi-Point Airtightness Test

802.6.1 Equipment that can automatically perform a multi-point test may be used to perform the steps below.

802.6.2 With the blower door fan sealed and off, measure and record the pre-test baseline building pressure reading with respect to outside. This measurement shall be taken over a time-averaging period of at least 10 seconds and shall have a resolution of 0.1 Pa. Record the pre-test baseline building pressure measurement.

802.6.3 Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 60 Pa. If a 60 Pa induced building pressure cannot be achieved because the blower door fan does not have sufficient flow capacity, then adjust the fan to achieve the highest induced building pressure possible.

802.6.4 Measure the ***unadjusted building pressure*** (not baseline adjusted) and nominal fan flow (neither temperature nor altitude corrected) using the same time-averaging period used in Step 802.6.2. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration, fan model and fan serial number. Assure that the fan is being operated according to the manufacturer's instructions.

Note: since both pre- and post-test baseline measurements are required, do not use any baseline-adjustment feature of the manometer. In addition, do not use an "@50 Pa" feature because the nominal fan flow shall be recorded.

802.6.5 Take and record a minimum of 7 additional unadjusted building pressure and nominal fan flow measurements at ***target induced pressures*** which are approximately equally-spaced between 60 Pa (or the highest achievable induced building pressure) and 15 Pa. In very leaky buildings, the low end of this range may be reduced to as little as 4 Pa plus the absolute value of the baseline pressure.

802.6.6 Turn off and seal the blower door fan.

802.6.7 Measure and record the ***post-test baseline building pressure*** reading with respect to outside. This measurement shall be taken over the same time-averaging period used in Step 802.6.2 and shall have a resolution of 0.1 Pa. Record the post-test baseline building pressure measurement.

802.6.8 Enter the recorded test values, temperatures and altitude into software that can perform the necessary calculations in accordance with ASTM E779-10, Section 9.

The software program shall calculate and report: corrected CFM50 and the percent uncertainty in the corrected CFM50, at the 95% confidence level, as defined in ASTM E779-10, Section 9.

Although ACH50 may be reported, this calculation may be omitted if the ACH50 metric is not needed.

Note: To avoid a higher percent uncertainty than desired, the testing technician may choose a larger, time-averaging period and start over at Step 802.6.2.

802.6.9 If the reported uncertainty in the corrected CFM50 is less than or equal to 10.0%, then the airtightness test shall be classified as a ***Standard Level of Accuracy*** test. If the reported uncertainly in the corrected CFM50 is greater than 10.0%, the airtightness test shall be classified as a ***Reduced Level of Accuracy*** test and the results will be adjusted using Section 802.8.

802.7 Procedure for Conducting a Repeated Single Point Test

802.7.1 With the blower door fan sealed and off, measure and record the pre-test baseline building pressure reading with respect to outside. This measurement shall be taken over a time-averaging period of at least 10 seconds and shall have a resolution of 0.1 Pa. Record this value as the pre-test baseline building pressure measurement.

802.7.2 Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 50 Pa. If a 50 Pa induced building pressure can not be achieved because the blower door fan does not have sufficient flow capacity, then achieve the highest induced building pressure possible with the equipment available.

802.7.3 If during any single repeat of this test, the induced building pressure is less than 15 Pa, recheck that the house set up is correct and determine if any basic repairs are needed prior to further testing or modeling of the building. Following any repairs or changes to the set up, the test shall be restarted from the beginning. If you can not reach at least 15 Pa every time, then use the procedures in sections 802.5 or 802.6.

802.7.4 Measure and record the unadjusted building pressure and nominal (not temperature and altitude corrected) fan flow using the same time-averaging period used in Step 802.6.2. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration (rings, pressurization or depressurization, etc), fan model and fan serial number.

Note: If your pressure gauge has the capability to display the induced building pressure (i.e. baseline adjustment feature) and the capability to adjust the fan flow value to an induced building pressure of 50 Pa (i.e. "@50 Pa" feature), then follow the manufacturer's procedures for calculating the results of a one-point test and record the following values: induced building pressure, nominal CFM50, fan configuration, fan model and fan serial number.

802.7.5 Turn off the fan.

802.7.6 Calculate the following values:

- ***induced building pressure*** = unadjusted building pressure (Pa) minus pre-test baseline building pressure (Pa).

  Note: If a baseline adjustment feature was used, then the induced building pressure is displayed on the pressure gauge.

- nominal CFM50 = (50 Pa / Induced building pressure) $^{0.65}$ x nominal fan flow.

  Note: If both a baseline adjustment feature and an "@50 Pa" feature were used, the nominal CFM50 is displayed directly on the pressure gauge.

802.7.7 Repeat Steps 802.7.1 through 802.7.6 until a minimum of 5 nominal CFM50 estimates have been recorded. The same fan configuration shall be used for each repeat.

802.7.8 Calculate the ***Average Nominal CFM50*** by summing the individual nominal CFM50 readings and dividing by the number of readings.

802.7.9 If the altitude is above 5,000 feet or the difference between the inside and outside temperature is more than 30 degrees Fahrenheit then calculate the corrected CFM50 as defined below:

Calculate the ***Average Corrected CFM50*** =

Average Nominal CFM50 x altitude correction factor x temperature correction factor

where:

altitude correction factor = 1 + .000006 x altitude, altitude is in feet

temperature correction factors are listed in Table 802.1

Table 802.1 Temperature Correction Factors for Pressurization and Depressurization Testing- Calculated according to ASTM E779-10

Correction Factors for Pressurization Testing

OUTSIDE TEMP (F)	INSIDE TEMPERATURE (F) 50	55	60	65	70	75	80	85	90
-20	1.062	1.072	1.081	1.090	1.099	1.108	1.117	1.127	1.136
-15	1.056	1.066	1.075	1.084	1.093	1.102	1.111	1.120	1.129
-10	1.051	1.060	1.069	1.078	1.087	1.096	1.105	1.114	1.123
-5	1.045	1.054	1.063	1.072	1.081	1.090	1.099	1.108	1.117
0	1.039	1.048	1.057	1.066	1.075	1.084	1.093	1.102	1.111
5	1.033	1.042	1.051	1.060	1.069	1.078	1.087	1.096	1.105
10	1.028	1.037	1.046	1.055	1.064	1.072	1.081	1.090	1.099
15	1.023	1.031	1.040	1.049	1.058	1.067	1.076	1.084	1.093
20	1.017	1.026	1.035	1.044	1.052	1.061	1.070	1.079	1.087
25	1.012	1.021	1.029	1.038	1.047	1.056	1.064	1.073	1.082
30	1.007	1.015	1.024	1.033	1.041	1.050	1.059	1.067	1.076
35	1.002	1.010	1.019	1.028	1.036	1.045	1.054	1.062	1.071
40	0.997	1.005	1.014	1.023	1.031	1.040	1.048	1.057	1.065
45	0.992	1.000	1.009	1.017	1.026	1.035	1.043	1.051	1.060
50	0.987	0.995	1.004	1.012	1.021	1.029	1.038	1.046	1.055
55	0.982	0.990	0.999	1.008	1.016	1.024	1.033	1.041	1.050
60	0.977	0.986	0.994	1.003	1.011	1.019	1.028	1.036	1.045
65	0.973	0.981	0.989	0.998	1.006	1.015	1.023	1.031	1.040
70	0.968	0.976	0.985	0.993	1.001	1.010	1.018	1.026	1.035
75	0.963	0.972	0.980	0.988	0.997	1.005	1.013	1.022	1.030
80	0.959	0.967	0.976	0.984	0.992	1.000	1.009	1.017	1.025
85	0.955	0.963	0.971	0.979	0.988	0.996	1.004	1.012	1.020
90	0.950	0.958	0.967	0.975	0.983	0.991	0.999	1.008	1.016
95	0.946	0.954	0.962	0.970	0.979	0.987	0.995	1.003	1.011
100	0.942	0.950	0.958	0.966	0.970	0.982	0.990	0.998	1.007
105	0.938	0.946	0.954	0.962	0.970	0.978	0.986	0.994	1.002
110	0.933	0.942	0.950	0.952	0.966	0.974	0.982	0.990	0.998

Correction Factors for Depressurization Testing

OUTSIDE TEMP (F)	INSIDE TEMPERATURE (F) 50	55	60	65	70	75	80	85	90
-20	0.865	0.861	0.857	0.853	0.849	0.845	0.841	0.837	0.833
-15	0.874	0.870	0.866	0.862	0.858	0.854	0.850	0.846	0.842
-10	0.883	0.879	0.874	0.870	0.866	0.862	0.858	0.854	0.850
-5	0.892	0.887	0.883	0.879	0.875	0.871	0.867	0.863	0.859
0	0.900	0.896	0.892	0.887	0.883	0.879	0.875	0.871	0.867
5	0.909	0.905	0.900	0.896	0.892	0.888	0.883	0.879	0.875
10	0.918	0.913	0.909	0.905	0.900	0.896	0.892	0.888	0.884
15	0.927	0.922	0.918	0.913	0.909	0.905	0.900	0.896	0.892
20	0.935	0.931	0.926	0.922	0.917	0.913	0.909	0.905	0.900
25	0.944	0.939	0.935	0.930	0.926	0.922	0.917	0.913	0.909
30	0.952	0.948	0.943	0.939	0.934	0.930	0.926	0.921	0.917
35	0.961	0.956	0.952	0.947	0.943	0.938	0.934	0.930	0.925
40	0.970	0.965	0.960	0.956	0.951	0.947	0.942	0.938	0.934
45	0.978	0.974	0.969	0.964	0.960	0.955	0.951	0.946	0.942
50	0.987	0.982	0.977	0.973	0.968	0.963	0.959	0.955	0.950
55	0.995	0.990	0.986	0.981	0.976	0.972	0.967	0.963	0.958
60	1.004	0.999	0.994	0.989	0.985	0.980	0.976	0.971	0.967
65	1.012	1.008	1.003	0.998	0.993	0.988	0.984	0.979	0.975
70	1.021	1.016	1.011	1.006	1.001	0.997	0.992	0.988	0.983
75	1.029	1.024	1.019	1.015	1.010	1.005	1.000	0.996	0.991
80	1.038	1.033	1.028	1.023	1.018	1.013	1.009	1.004	0.999
85	1.046	1.041	1.036	1.031	1.026	1.022	1.017	1.012	1.008
90	1.055	1.050	1.045	1.040	1.035	1.030	1.025	1.020	1.016
95	1.063	1.058	1.053	1.048	1.043	1.038	1.033	1.028	1.024
100	1.072	1.066	1.061	1.056	1.051	1.046	1.041	1.037	1.032
105	1.080	1.075	1.070	1.064	1.059	1.054	1.050	1.045	1.040
110	1.088	1.083	1.078	1.073	1.068	1.063	1.058	1.053	1.048

802.7.10 Estimate the precision uncertainty using one of the two following methods

802.7.10.1 Standard Statistical Process – Use a calculator or computer to compute the Standard Deviation of the repeated Nominal CFM50 readings. Divide this Standard Deviation by the square root of the number of readings. Multiply the result by the t-statistic in table 802.2 corresponding to the number of readings taken. Convert this result to a percentage of the Average Nominal CFM50.

Table 802.2 Precision Uncertainty: Values of t-statistic

Number of readings	t-statistic
5	2.78
6	2.57
7	2.45
8	2.37
9	2.31

802.7.11 If a software program is used, it shall at a minimum calculate and report:

802.7.11.1 Average CFM50, corrected for altitude and temperature

802.7.11.2 The percent uncertainty in the CFM50, at the 95% confidence level, as calculated in 802.7.10.

802.7.11.3 ACH50 (air changes per hour @ 50 Pa) = (CFM50 x 60) / building volume (in cubic feet). This calculation may be omitted if the ACH50 metric is not needed.

802.7.12 If the reported uncertainty in the CFM50 is less than or equal to 10.0%, then the airtightness test shall be classified as a Standard Level of Accuracy test as defined in section 802.3. If the reported uncertainly in the CFM50 is greater than 10.0%, the airtightness test shall be classified as a Reduced Level of Accuracy test as defined in section 802.3.

802.8 Application of Results

802.8.1 Adjusting CFM50 for Tests with a Reduced Level of Accuracy. When using results classified as having a Reduced Level of Accuracy, an adjustment shall be used in certain situations. The adjustment is done to improve the probability that the tested building meets the required performance threshold. The adjusted CFM50 in these situations is defined as:

adjusted CFM50 = extending factor x corrected CFM50,
where:
For a One-point Test, classified as Reduced Level of Accuracy:
extending factor = 1 + 0.1 x (50 / the induced pressure)

For a Multi-point Test, classified as Reduced Level of Accuracy:
extending factor = 1 + (% uncertainty / 100)

adjusted CFM50 value shall be used when:

- determining whether or not a building meets an airtightness threshold, and
- conducting a Home Energy Rating for the purpose of compliance with any standard, energy code or program.

adjusted CFM50 value shall NOT be used when:

- calculating the expected energy savings from retrofit,
- conducting an energy audit, or
- assessing the relative airtightness of a group of buildings.

802.8.2 Other Leakage Metrics:
ELA may be calculated by: ***ELA*** = 0.055 x CFM50
Where ELA is in square inches

ACH50 = corrected CFM50 x 60 / building volume (in cubic feet)

Specific Leakage Area may be calculated by:
SLA = 0.00694 x ELA/ building floor area (square feet)
Where ELA (Effective Leakage Area) referenced to 4 pa is in square inches

Normalized Leakage Area may be calculated by:
NLA = SLA x $(S)^{0.3}$, where S is the number of stories above grade

802.9 Equipment Accuracy and Requirements
Blower door fans used for building air leakage testing shall measure airflow (after making any necessary air density corrections) with an accuracy of +/- 5%. Pressure gauges shall measure pressure differences with a resolution of 0.1 Pa and have an accuracy of +/- 1% of reading or 0.5Pa, whichever is greater.

Blower door and associated pressure testing instruments shall be tested annually for calibration by the HERS Rating Provider or Certified Rater. The provider shall use a standard for field testing of calibration provided by the equipment manufacturer. Magnehelic Gauges cannot be field tested and shall be recalibrated by the Blower Door manufacturer annually. Field check the fan and flow measuring systems for defects and maintain them according to manufacturers recommendations. The HERS Rating Provider or Certified Rater shall maintain a written log of the annual calibration check to verify all equipment accuracy for a period of three (3) years. These records shall be made available within 3 business days to the RESNET Quality Assurance Administrator upon request.

803 On-site Inspection Procedures for Duct Leakage Testing
The purpose of these test procedures is to make a determination of the amount of leakage of a duct system, either total system leakage or leakage to outside of the conditioned space. Because total duct leakage (to both inside and outside the conditioned space) at 25 Pascals should always be greater than the leakage to outside, the total leakage may be used instead of leakage to outside for determining that a system meets a required threshold. The total leakage value may be entered into software as if it were leakage to the outside for this purpose. However, total leakage should not be substituted for leakage to outside when conducting an energy audit or predicting savings from retrofits, except as indicated. Table 803.1 summarizes the test methods approved for use in the RESNET Standards.

803.1 Air Handler Flow
For the purposes of determining if a total duct leakage test method may be used (see table 803.1), the Air handler flow can be measured in accordance with ASHRAE Standard152-2004, ASTM E1554-2007, or by using the following default values: 400 CFM per ton of air conditioner or heat pump capacity or 200 CFM per 12,000 Btu/h of furnace (output) capacity whichever is greater.

Table 803.1- Duct Leakage Test Methods

Test Method	Test pressure	Conversion to operating pressure	Supply/Return	Notes
Leakage to the Outside Tests				
RESNET Standard Section 803.7	25 Pa	No conversion	Assume ½ supply and ½ return	
ASHRAE 152 Annex B	25 Pa	½ plenum pressure for supply and return individually	Separate	
ASTM E1554-07 Method A: "DeltaQ"	Normal Operation	n/a	Separate	Can be used for energy auditing but not compliance testing. To limit precision errors this test is only allowed in this RESNET Standard if the Building Enclosure Leakage is less than 2500 cfm @ 50 Pa
ASTM E1554 Method B	25 Pa	½ plenum pressure for supply and return individually	Separate	
Total Duct Leakage Tests				The total leakage may be used instead of leakage to outside for compliance testing. It may be used for energy audits or savings estimates if the total leakage is less than 10% of air handler flow**.**
RESNET Standard Section 803.5	25 Pa	No conversion	Assume ½ supply and ½ return	
ASHRAE 152 Annex C	25 Pa	½ plenum pressure or assume 62.5 Pa	Assumes ½ supply and ½ return	2.5% of air handler flow added if testing done without air handler. 2.5% added if testing done without registers/grilles.

803.2 RESNET Simplified Test Procedures

For purposes of this chapter, duct leakage may be measured by either pressurizing or depressurizing the duct system. Tests measure either total leakage or leakage to the outside. Total leakage includes all leaks in the air distribution system and leakage to the outside only refers to leaks to outside the conditioned space. The following text mentions only pressurization, but depressurization may also be used.

Testing of the duct system(s) of a building is accomplished by use of a duct leakage testing device and, when testing leakage to outside, a blower door. For total duct leakage, the duct

leakage tester is attached and used to pressurize the duct system to 25 Pa. This test measures all duct leakage including leakage between the ducts and the conditioned space and leakage between the ducts and any unconditioned space or outside.
When performing a duct leakage to outside test, a blower door is also used to pressurize the building to 25 Pa while the duct leakage tester is used to equalize the pressure inside the duct system with the building pressure induced by the blower door (e.g 25 Pa). Multiple blower doors may be used if the conditioned space can't be uniformly pressurized with a single blower door (for example- a conditioned crawlspace). Because the ducts and the conditioned space of the building are theoretically at the same pressure, little or no air flows through leaks between the ducts and the conditioned space and the duct leakage tester only measures the leakage between the ducts and spaces outside the conditioned space. When ducts are entirely within the conditioned space boundary, 100% of the system is visible at the time of testing and the system is fully ducted (i.e., no building cavities are used to transport air) the ducts do not have to be tested and the ducts may be assumed to have no leakage to outside the conditioned space.

803.2.1 Multifamily Buildings

For multifamily buildings where each unit has its own duct system, each unit may be tested individually using the procedures in this RESNET standard. Each unit should be treated as if it is a single family dwelling. The leakage to outside test is performed using a blower door in the main entry to the unit to pressurize the individual unit with reference to outside. If the main entry door is in an interior hallway then the hallway needs to be well connected to outside through open windows or doors or an exterior window or door (such as to deck or patio) may be used. Similarly, only the ducts in the unit under test are pressurized. For compliance testing, use measured leakage to outside. For energy audits or savings estimates, it may be assumed that the leakage to outside is one-half of this measured leakage. For compliance testing, the total leakage test method may be used instead of leakage to outside.

803.3 Protocol for Preparing the Building and the Duct System for a Duct Leakage Test (Items 803.3.1-803.3.8 are used for both Total and Outside Leakage tests)

803.3.1 Adjust the HVAC system controls so that the air handler fan does not turn on during the test.

803.3.2 Turn off any fans that could change the pressure in either the conditioned space or any spaces containing ducts or air handlers (bathroom fans, clothes dryers, kitchen vent hood, attic fan, etc.).

803.3.2 Turn off all vented combustion appliances if there is a possibility that the space containing the appliance will be depressurized during the test procedure.

803.3.3 Remove all filters from the duct system and air handler cabinet. If the duct leakage testing system is installed at a central return grille, also remove the filter from that grille.

803.3.4 Any intentional openings into the duct system such as combustion air or ventilation ducts shall be left in their normal non-ventilation operating position. Motorized dampers should be closed.

803.3.5 If ducts run through unconditioned spaces such as attics, garages or crawlspaces, open vents, access panels, doors, or windows between those spaces and the outside to eliminate pressure changes due to duct leakage during the test procedure.

803.3.6 Supply registers and return grilles shall be temporarily sealed in some manner so as to allow for the pressurization of the duct system.

803.3.7 Zone and bypass (not balancing) dampers shall be set to the open position to allow uniform pressures throughout the duct system.

Total leakage test only: Fully open at least one door, window or comparable opening between the building and outside to prevent changes in building pressure when the duct leakage testing system is running.

Leakage to the outside test only: All exterior doors and windows between the building and outside shall be closed, and other openings to the outside that may hinder the ability of a blower door fan to pressurize the building to 25 Pa with reference to outside should be closed or covered in some manner. Interior doors shall be open.

803.4 Installation of the Duct Leakage Testing System (used for both total leakage and leakage to outside tests)

803.4.1 Attach the duct leakage tester system to the largest return grille closest to the air handler. Use the manufacturer’s recommended installation procedure that is consistent with the mode (i.e. pressurization vs. depressurization) of the test being performed. Be sure the remaining opening in the return grille is temporarily sealed.

When testing a duct system with 3 or more returns, installation of the duct leakage tester at the air handler cabinet may be a better attachment location.

Document the attachment location of the duct leakage testing system.

803.4.2 Select a location to measure duct pressure. Choose one of the following three locations to measure duct pressure:

- The largest supply register closest to the air handler, or
- The main supply trunk line, or
- The supply plenum can be used if the duct leakage tester is installed at a central return.

Document the duct pressure measurement location.

803.4.3 Insert a pressure probe into the duct system at the chosen measurement location. If measuring at the supply trunk line or supply plenum, you must use a static pressure probe (be sure the probe is pointing into the air stream). If measuring at a supply register, you may use a static pressure probe, or you may simply insert a straight pressure probe or the end of a piece of flexible tubing.

803.4.4 Install the pressure gauge and tubing connections in accordance with the manufacturer's instructions and the test mode (pressurization vs. depressurization) being used. The duct system pressure should be measured with reference to the inside of the building. Turn on and configure the pressure gauge for the test procedure being performed.

803.5 Procedure for Conducting a Total Duct Leakage Test

803.5.1 Select the appropriate range (e.g. flow ring) of the duct leakage testing fan and configure the flow gauge to match the selected range.

803.5.2 Turn on the duct leakage testing fan and increase fan speed until the duct system has been pressurized to 25 Pa (+/- 0.5 Pa). Measure and record the duct pressure reading (0.1 Pa resolution) and the fan flow reading (1 CFM resolution) using a 5 second averaging period. Also record the fan configuration (range), fan and manometer models and serial numbers. Be sure the fan is being operated according to the manufacturer's instructions.

If 25 Pa of duct pressure cannot be achieved because the duct testing fan does not have sufficient flow capacity, then achieve the highest duct pressure possible with the equipment available and record the values above.

> **Note:** If your pressure gauge has the capability to adjust the fan flow value to a duct pressure of 25 Pa (i.e. @25 Pa feature), then follow the manufacturer's procedures for conducting a one-point total leakage test, and record the following values: duct pressure, CFM25 (or fan flow in CFM and pressure in Pa if 25 Pa not achieved), fan configuration, fan and manometer models and serial numbers. If your gauge does not have an @25 feature and the measured duct pressure was not exactly 25 Pa, calculate and record CFM25 as: $\text{CFM25} = (25\text{ Pa}/\text{ duct pressure})^{0.6} \times \text{fan flow}$.

803.5.3 Turn off the duct testing fan.

803.6 Installation of the Blower Door System (used for leakage to outside test only)

803.6.1 Install the blower door system in an exterior doorway that has unrestricted access to the building and no obstructions to air flow within five feet of the fan inlet. The blower door fan should be installed in a configuration that is consistent with the mode of the duct leakage test (i.e. pressurization vs. depressurization).

803.6.2 Install the pressure gauge(s), fan and tubing connections as per manufacturer's instructions.

803.7 Procedure for Conducting a Duct Leakage to Outside Test

803.7.1 With both the blower door and duct leakage fans sealed, measure the baseline building pressure with reference to outside using a 5 second averaging period.

803.7.2 Unseal the blower door fan. Turn on the blower door fan and pressurize the building by 25 Pa (+/- 0.5 Pa) from the measured baseline building pressure (i.e. change the building pressure by 25 Pa). **Note:** If your pressure gauge has the capability to display the induced building pressure (i.e. baseline adjustment feature), then follow the manufacturer's procedures for pressurizing the building by 25 Pa.

803.7.3 With the blower door fan continuing to run, unseal the duct leakage testing fan and select the appropriate range on the duct leakage testing fan. Configure the duct leakage testing system gauge to match the selected range.

803.7.4 Turn on the duct leakage testing fan and increase fan speed until the duct system pressure reads 0.0 (+/- 0.1 Pa). **Note:** The duct system pressure should be measured with reference to the inside of the building.

803.7.5 Re-check the blower door pressure gauge and if necessary, re-adjust the blower door fan to maintain a 25 Pa pressurization. **Note:** If the blower door fan is being operated with a "cruise control" feature, it is not necessary to recheck the blower door pressure gauge.

803.7.6 Return to the duct leakage pressure gauge and if necessary, re-adjust the duct leakage testing fan until the duct system pressure reads 0.0.

803.7.7 Record the following values: building pressure, duct pressure, CFM of flow through the duct testing fan, duct testing fan configuration, duct testing fan and manometer models and serial numbers. Calculate and record CFM25: CFM25 = (25 Pa/ building pressure)$^{.6}$ x duct leakage fan flow.

803.7.8 Turn off both the blower door and duct leakage testing fans.

<u>**Note:**</u> If the blower door system is unable to pressurize the building to 25 Pa because the blower door fan does not have sufficient flow capacity, then you will need to conduct the test at the highest achievable building pressure and adjust the measured duct leakage as described in step 803.7.7.

<u>**Note:**</u> If the duct testing fan was unable to create a pressure difference of zero between the duct system and the building (while the blower door is pressurizing the building to 25 Pa) because the duct testing fan does not have sufficient flow capacity, then the test will need to be performed at a lower building pressure and adjust the measured duct leakage as described in step 803.7.7.

803.8 Application of Results

803.8.1 The results of the total duct leakage test represent the total amount of duct leakage both to the inside and to the outside of the conditioned space and represent the overall leakage of the entire system. The total leakage may be of use in some programs where the total system duct leakage is required.

803.8.2 The duct leakage to the outside test is designed to measure only the duct leakage occurring to the outside of the conditioned space. Many programs use this measurement as the determining factor as to whether a duct system fails or passes.

803.8.3 If rating software requires separate input of supply and return leakage that have not individually been measured you shall assume that ½ of the total measured leakage is in the supply and ½ is in the return.

803.9 Equipment Accuracy and Requirements

Duct testing fans used for determining either total leakage or leakage to outside shall measure airflow with an accuracy of +/-5%. Pressure gauges shall measure pressure differences with a resolution of 0.1 Pa and have an accuracy of +/-1% of the reading or 0.5 Pa, whichever is greater.

Blower doors, duct testers, and associated pressure testing instruments shall be field-tested annually for calibration. The calibration procedure shall follow the equipment manufacturer's recommendations.

The HERS Rating Provider or Certified Rater shall maintain a written log of the annual calibration check to verify all equipment accuracy for a period of three (3) years. These records shall be made available within 3 business days to the RESNET Quality Assurance Administrator upon request.

804 On-site Inspection Procedures for ventilation air flow Testing

The purpose of these test procedures are to measure the air flows through whole house ventilation systems and local exhausts. The test procedures treat the air flows into and out of the grille being measured separately. The Air Flow Resistance method may only be used on systems that do not have multiple branches in the ventilation air duct system. Use of a manometer with manufacturer-installed calibrated ports (common on ERV/HRV equipment) is an acceptable method if the manufacturer's instructions are followed

804.1 Air Flows into Grilles

804.1.1 Powered Flow Hood

A powered flow hood consists of:

- A flow capture device that is to be placed over the grille to be measured. The flow capture element needs to be large enough to cover the whole grille and be airtight.
- A pressure measuring system inside the flow capture element that is designed and installed to measure the static pressure inside the flow capture element.
- A manometer to measure the pressure difference between the inside of the flow capture element and the room.

- An air flow meter to measure the air flow through the air flow capture element. The air flow meter shall measure airflow with an accuracy of +/-5%.
- A variable-speed fan to move air through the flow capture element and the flow meter.

804.1.1.1 Place the flow capture element over the grille to be measured.

804.1.1.2 Turn on the air flow assisting fan and adjust the airflow until zero pressure difference is measured between the flow capture element and the room.

804.1.1.3 Record the air flow through the air flow meter.

804.1.2 Air Flow Resistance

The Air Flow Resistance method measures the pressure difference across a flow capture element with a known air flow resistance. A rectangular user fabricated box can be used if the size of the hole is not greater than half the size of the box in each direction and the distance from the hole to the grill is at least as large as the larger dimension of the hole. User fabricated devices shall be approved by a provider prior to use.

804.1.2.1 Place the flow capture element over the grille to be measured. Ensure there is air tight seal around the grille and the flow device so that all of the air entering the grill goes through the device.

804.1.2.2 Measure the pressure difference (ΔP) between the flow capture element and the room at a corner of the inlet side of the box. The hole in the flow capture device should be sized so that the pressure difference is between 1 and 5 Pa.

804.1.2.3 Calculate the air flow using the manufacturer's calibration of the air flow resistance device.

For user fabricated devices that do not have a manufacturer's calibration, the following equations may be used to calculate the air flow.

Air Flow (cfm) = Open Area$\times 1.07 \times (\Delta P)^{0.5}$; for Area in in^2, ΔP in Pa
Air Flow (L/s) = Open Area$\times 0.078 \times (\Delta P)^{0.5}$; for Area in cm^2, ΔP in Pa

804.2 Air Flows Out of Grilles

804.2.1 Powered Flow Hood

The measurement procedure is the same as for air flow into grilles (Section 804.1.1) but with the fan and flowmeter arranged to have flow out of the grille.

804.2.2 Bag Inflation

The Bag Inflation method requires the use of a bag of a known volume, a method to hold the bag open (typically a lightweight frame of wood, plastic or metal wire), a shutter to start the air flow and a stopwatch.

804.2.2.1 Completely empty the bag of air and place a shutter over its opening.

804.2.2.2 Rapidly withdraw the shutter and start the stopwatch.

804.2.2.3 When the bag is completely full stop the stopwatch.

804.2.2.4 Calculate the airflow by dividing the bag volume by the elapsed time. Calculate the air flow in cfm as 8 X bag volume in gallons/number of seconds

804.2.2.5 Repeat measurement one or more times and average the results.

804.2.2.6 How to Choose a Bag

Plastic thickness. Bags made from thinner material often do not fill uniformly because the air flow from the register blows them about too much. If the bag sides flap a lot and measuring the same register twice gives results that differ by more than 20%, then try a bag with thicker material.

Use the right sized bags. Bags that fill in under two seconds will have increased errors because of resolution issues in timing how fast the bag is filled. Conversely, bags that are too large for a given register flow will have increased leakage around the edges of the bag before it fills completely and may not generate enough pressure to push a bag into its final shape. Aim for a fill time of 2 to 20 seconds.

804.3 Equipment Accuracy Requirements and Specification

The manometer shall measure pressure differences with a resolution of 0.1 Pa and have an accuracy of +/-1% of the reading or 0.5 Pa, whichever is greater.

805 Work Scope and Combustion Safety Procedures

805.1 These protocols shall be followed by RESNET-accredited Raters and Auditors (hereinafter referred to collectively as "Auditors") performing combustion appliance testing or writing work scopes for repairs.

805.2 If the Auditor has been trained and certified in accordance with a RESNET approved "equivalent home performance certification program" or the Building Performance Institute (BPI) Standards, the Auditor may follow protocols in accordance with those equivalent standards.

805.3 RESNET-accredited Training Providers shall train HERS Auditors on these protocols through either field exercise or through simulated conditions. A written exam administered by a RESNET-accredited Trainer is also required, provided by RESNET. The test shall cover the content of these guidelines with a minimum of 25 questions. A minimum score of 80% is required to pass.

805.4 Prior to conducting any test that affects the operating pressures in the home, the Auditor shall inquire whether a person that has environmental sensitivities (asthma, allergies, chemical sensitivity, etc.) is present in the home. If such a person is present, the Auditor shall not perform such tests without written disclosure from the affected party (or responsible adult). The written disclosure shall state (at a minimum) that "during the period of testing, some amount of dust, particles, or soil gases already present in the home may become airborne." Without a signed disclosure, the Auditor shall either reschedule the test for a time when they will not be present, or ask them to leave the home during the testing process. The Auditor shall also inquire as to the presence of pets that may potentially be affected by testing procedures.

806 Gas Leakage Test

806.1 If there is a noticeable odor indicating gas buildup within the home, the occupants and Auditor shall leave the house and the appropriate authorities and utility providers shall be notified from outside the home.

806.2 The Auditor should use a gas detector upon entry into the home to detect the presence of natural gas. If gas is suspected or confirmed, ensure that switches are not operated while exiting and no ignition concerns are present. The audit shall not proceed until the proper authorities have deemed it safe to re-enter the home. If there is no noticeable odor indicating gas buildup within the home, the Auditor shall determine if there are gas leaks in the fittings and connections of natural gas appliances within the home and natural gas/liquid propane supply lines following these protocols.

806.3 Inspect all fittings and joints in supply lines and appliance connectors and confirm suspected leaks with leak-detection fluid. Identify for repair or replacement any kinked, corroded or visibly worn flexible gas lines and any flexible connectors manufactured prior to 1974.

806.4 Equipment needed

- Combustible gas detector capable of measuring 20 ppm
- Leak detection fluid (non-corrosive)

807 Worst Case Depressurization Test

This test procedure measures the pressure in the Combustion Appliance Zone (CAZ) and provides visual evidence of spillage potential.

If there are any vented combustion appliances that use indoor air to vent combustion gases and which are not classified as a category 3 or 4 according to NFPA standard 54, then a worst case depressurization test shall be performed using the following protocol.

807.1 Check the combustion appliance zone for the presence of flammable or explosive material near a combustion source.

807.2 Visually inspect venting system for proper size and horizontal pitch and determine there is no blockage or restriction, leakage, corrosion or other deficiencies that could cause an unsafe condition.

807.2.1 Inspect burners and crossovers for blockage and corrosion.

807.2.2 Inspect furnace heat exchangers for cracks, openings or excessive corrosion.

807.3 Close all the exterior doors and windows of the home.

807.4 Close fireplace damper(s) if fireplace is present.

807.5 Close any interior doors between the CAZ and the remainder of the house, ensuring that all vented appliances and exhaust fans have been turned off.

807.6 Measure the baseline pressure difference between the CAZ with respect to (WRT) outside (ambient) and baseline CO levels. Set the gauge to read pressure and record the baseline pressure.

807.7 Turn on all exhaust fans in the home (kitchen range hood, bath exhaust, clothes dryer, etc.) that exhaust air outside the building envelope.

807.8 Record pressure in CAZ with respect to Outside.

807.9 Turn on the air handler. Record pressure in CAZ with respect to outside. If air handler makes the CAZ more positive (or less negative), turn it off. If the air handler is kept on, close interior doors to any rooms that have no return registers.

807.10 If fireplace is present install blower door and set to exhaust 300 CFM to simulate fireplace in operation.

807.11 Record net change in pressure difference within the CAZ WRT outside between baseline and worst case depressurization conditions. Record the position of doors and conditions of fans and air handler. When the net change in CAZ pressure is lower (more negative) than the limits specified below, the work scope shall specify remediation through pressure balancing, duct sealing, and/or other pressure-relief measures, as applicable.

807.12 Turn on vented combustion appliance with the smallest Btu capacity. Operate appliance for 5 minutes then measure CO levels according to the carbon monoxide test procedure below, and check appliance draft using a smoke pencil at the draft diverter. If the smoke is not fully drawn up the flue, the appliance has spillage under worst case depressurization. Record if there is any spillage and record CO level. When spillage occurs or CO exceeds the limits specified below in section 9, the work scope shall specify remediation, including equipment repair or replacement, and/or building pressure remediation, as applicable. If both spillage and high CO are found during the test, the homeowner should be notified of the conditions and that it needs immediate remediation.

807.13 Turn on all the other combustion appliances, one at a time, within the CAZ and repeat step 1.12 on each of them.

807.14 If spillage or high CO occurs in any appliance(s) under worst case depressurization, retest that appliance(s) under natural conditions.

807.14.1 Turn off the combustion appliances.

807.14.2 Turn off the exhaust fans.

807.14.3 Open the interior doors.

807.14.4 Let the vent cool.

807.14.5 Test CO and spillage under natural conditions. If the test failed under worst-case, but passes under natural conditions, the work scope shall specify building pressure remediation, as applicable.

807.14.6 If an appliance fails under natural conditions, the Auditor shall inform the homeowner of the problem, and the work scope shall specify remediation, including equipment or vent system repair or replacement, as applicable.

CAZ Pressure Limits
-15 Pa for pellet stoves with exhaust fans and sealed vents

-5 Pa for Atmospheric vented oil or gas system (classified as a category 1 or 2 according to NFPA standard 54, such as oil power burner; fan-assisted or induced-draft gas; solid-fuel–burning appliance other than pellet stoves with exhaust fans and sealed vents)

If ambient CO levels exceed 35 ppm at any time, stop any testing and turn the combustion appliances off. Open all the exterior doors and windows. No one should enter the home until the CO levels drop below 35 ppm. The combustion appliance causing the increase in CO levels must be repaired by a qualified technician prior to completing the combustion appliance tests, unless the work scope calls for replacement of the appliance(s).

808 Carbon Monoxide Testing
Test all spaces (including attached garages, crawlspaces, basements) containing combustion appliances for carbon monoxide using the following protocols.

808.1 CO testing of ambient air shall be performed continuously while performing a Worst Case Depressurization Test and/or under natural conditions, as required by paragraph 807.14.

808.2 Equipment used shall:

- Be capable of measuring carbon monoxide (CO) levels from 0 to 2,000 ppm (parts per million)

- Have a resolution of 1 ppm
- Have an accuracy rate of + 5 ppm
- Be calibrated annually by the manufacturer (or using manufacturer's instructions) and evidence of the calibration shall be submitted to the Rating Provider Quality Assurance Designee

808.3 Zero the carbon monoxide meter outside the building away from any combustion outlets or automobile traffic areas.

808.4 Take a measurement of CO levels within the home upon entering to establish a baseline. Do not measure near combustion appliances while they are operating. If ambient CO levels are higher than 35 ppm during normal appliance operation, turn off the appliance, ventilate the space, and evacuate the building. The building may be reentered once ambient CO levels have gone below 35 ppm.

808.5 For atmospherically-vented appliances:

808.5.1 Take a measurement of vent gases upstream of (before they reach) the draft diverter.

808.5.2 Appliance must operate for at least 5 minutes before taking sample.

808.5.3 Take sample during worst-case depressurization test and/or under natural conditions, as required by paragraph 1.14. Record the CO level.

808.6 For direct- or power-vented appliances:

808.6.1 Sample must be taken at vent termination.

808.6.2 Appliance must operate for at least 5 minutes before taking sample.

808.6.3 Take sample during worst-case depressurization test and/or under natural conditions, as required by paragraph 1.14. Record the CO level.

808.7 For LP- or natural gas ovens:

808.7.1 Open a window or door to the outside.

808.7.2 Remove any foil or cooking utensils within the oven.

808.7.3 Verify that the oven is not in self-cleaning mode.

808.7.4 Turn oven on to highest temperature setting.

808.7.5 Close the oven door and begin monitoring the CO levels in the kitchen, 5 feet from the oven at countertop height. Record CO levels.

808.7.6 Measure the CO levels within the oven vent.

808.7.6.1 Samples must be taken while burner is firing.

808.7.6.2 Operate burner for at least 5 minutes while sampling flue gases.

808.7.6.3 If CO levels are higher than 100 ppm, repeat the flue gas sampling until the CO levels stop falling.

808.7.6.4 Record the steady state CO reading in ppm and turn off oven.

808.8 If measured CO levels are higher than 100 ppm (200 for oven), or an appliance fails to meet manufacturer's specifications for CO production (whichever is higher), the work scope shall specify replacement or repair of the appliance, and the homeowner shall be notified of the need for service by a qualified technician.

808.9 If ambient CO levels exceed 35 ppm at any time, stop any testing and turn the combustion appliances off. Open all the exterior doors and windows. No one should enter the home until the CO levels drop below 35 ppm. The combustion appliance causing the increase in CO levels must be repaired by a qualified technician prior to completing the combustion appliance tests, unless the work scope calls for replacement of the appliance(s).

809 Work Scope for Contractors

809.1 Requirements

809.1.1 All work must meet applicable codes and regulations for the jurisdiction.

809.1.2 When air sealing is being performed the work scope shall specify CAZ depressurization testing to be performed at the end of each workday.

809.1.3 The work scope for recommended improvements will be determined by the Auditor and shall be based upon the findings of the assessment, the client's needs and budget, and priorities identified during combustion appliance testing, subject to health and safety requirements.

809.1.4 The work scope shall clearly identify for the client any remedial actions which require prompt attention, affect safety, or require a licensed trade.

809.1.5 The work scope shall provide sufficient specification that the client may obtain reasonably comparable bids from alternative sources for making recommended improvements.

809.1.6 All scopes of work shall include this statement: "**The estimated energy use and savings information contained in the audit report does not constitute a guarantee or warranty of actual energy cost or usage.**"

809.1.7 The work scope shall be developed based on the Auditor's diagnosis and analysis. Emphasis shall be on:

- bringing air distribution system components inside the building enclosure when it is feasible, or sealing and insulating ducts when it is not
- improving airflow and total HVAC system efficiency as applicable
- upgrades to the building enclosure as applicable
- improvements to lighting and appliances as applicable

809.1.8 The scopes shall reflect the "house as a system" approach, recognizing measure interaction. The following statement shall be included whenever a fireplace or combustion appliance is located within the building enclosure:

> "This work scope is not a list of recommendations that may be implemented independently; any exclusions or variations to this scope may increase the risk of flue gas spillage, back-drafting, carbon monoxide production and/or moisture problems within the home."

809.1.9 When specifying equipment replacement, new equipment sizing shall be based on the proposed, upgraded condition of the building enclosure and duct system.

809.1.10 The work scope shall call for post-work combustion appliance testing in accordance with these guidelines when any work affecting enclosure or duct tightness, or building pressures, is specified.

809.2 Work Scope: Carbon Monoxide

809.2.1 The source of the CO must be repaired or replaced and the problem corrected prior to commencing work on other tasks on the work scope, unless remediation of the CO production is specifically related to one or more of those tasks (such as duct repairs that will correct a large negative pressure in the CAZ).

809.2.2 If there are combustion appliances within the building envelope, a carbon monoxide detector should be specified in the main area of each floor according to manufacturer's recommendations, typically in the hallway outside each bedroom area.

809.2.3 If measured CO levels are higher than 100 ppm (200 for oven), or an appliance fails to meet manufacturer's specifications for CO production (whichever is higher), the work scope shall specify replacement or repair of the appliance, and the homeowner shall be notified of the need for service by a qualified technician.

809.3 Work Scope: Worst Case Depressurization

809.3.1 If the results of the Worst Case Depressurization Test indicate the potential for backdrafting by failing the CAZ pressure limits or spillage test, remediation of the failure must be addressed in the work scope, through one or more of the following (as applicable): targeted air- and duct-sealing, room pressure balancing, exhaust fan makeup air, or appliance replacement (with power- or direct-vented equipment). As an alternative, the combustion appliance zone may be isolated by creating a sealed combustion closet containing the combustion appliances that has the proper amount of combustion air supplied to it according to the applicable version of the IRC. Adequate sealing for isolation purposes shall include air sealing and duct sealing (especially of adjacent platform or cavity return ducts) and confirmed by another CAZ depressurization test.

809.3.2 The work scope should specify replacement of atmospheric-vented combustion appliances with high-efficiency sealed combustion, direct vent, or power vented appliances when feasible. If the home has unvented combustion appliances, the /Auditor shall recommend they be disconnected and replaced with vented combustion appliances.

809.3.3 If unvented combustion appliances are not removed or replaced with vented combustion appliances or electric appliances, the work scope shall not specify measures that affect the air tightness of the envelope, including air sealing, duct sealing, sidewall insulation, or window replacements. Duct sealing outside the thermal envelope may be specified in IECC climate zones 1-3.

Auditor Referenced Standards

These referenced standards provide guidance for the Auditor in the performance of their role as an auditor or home energy rater (diagnostic testing, analysis, writing scopes of work).

1. 2006 Mortgage Industry National Home Energy Rating Systems Standards, published by the Residential Energy Services Network, latest version, www.resnet.us

2. ASHRAE/ANSI Standard 119-1998 RA-2004 Air Leakage Performance for Detached Single-Family Residential Buildings, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., www.ashrae.org

3. ASHRAE/ANSI Standard 152-2004 Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., www.ashrae.org

4. ASTM E1998-02(2007) "Standard Guide for Assessing Depressurization-Induced Backdrafting and Spillage from Vented Combustion Appliances", published by ASTM International, www.astm.org

5. ASTM E1827-96(2007) "Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door", published by ASTM International, www.astm.org

6. ASTM E1554-07 "Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization", published by ASTM International, www.astm.org

7. Reflective Insulation, Radiant Barriers and Radiation Control Coatings, published by the Reflective Insulation Manufacturers Association- International, www.rimainternational.org

8. Protocols for Verifying HVAC Systems to the ACCA Quality Installation Standard, published by the Air Conditioning Contractors of America, www.acca.org (currently in draft)

9. Verifying ACCA Manual J® Procedures, published by the Air Conditioning Contractors of America, www.acca.org

10. Verifying ACCA Manual S® Procedures, published by the Air Conditioning Contractors of America, www.acca.org

11. Verifying ACCA Manual D® Procedures, published by the Air Conditioning Contractors of America, www.acca.org

12. NAIMA Fibrous Glass Duct Installation Check List, published by the North American Insulation Manufacturers Association, www.naima.org

13. AHRI Certification Directory, published by the Air-conditioning, Heating and Refrigeration Institute, www.ahridirectory.org

Contractor Work Scope Referenced Standards
These referenced standards should be referenced in the work scope, as applicable to provide guidance for the contractor to perform the work scope.

1. International Residential Code for One- and Two-Family Dwellings- 2006, published by the International Code Council, Inc., www.iccsafe.org

2. International Energy Conservation Code- 2006, published by the International Code Council, Inc., www.iccsafe.org

3. International Mechanical Code- 2006, published by the International Code Council, Inc, www.iccsafe.org

4. International Fuel Gas Code- 2006, published by the International Code Council, Inc., www.iccsafe.org

5. ANSI/ACCA Standard 5 QI-2007 HVAC Quality Installation Specification, published by the Air Conditioning Contractors of America, www.acca.org

6. Manual J, Residential Load Calculation, 8th edition, published by the Air Conditioning Contractors of America, www.acca.org

7. Manual D, Residential Duct Systems,3rd edition, published by the Air Conditioning Contractors of America, www.acca.org

8. Manual S, Residential Equipment Selection, published by the Air Conditioning Contractors of America, www.acca.org

9. Manual RS, Comfort, Air Quality, & Efficiency by Design, published by the Air Conditioning Contractors of America, www.acca.org

10. Manual T, Air Distribution Basics, published by the Air Conditioning Contractors of America, www.acca.org

11. Manual H, Heat Pump Systems, published by the Air Conditioning Contractors of America, www.acca.org

12. Manual G, Selection of Distribution Systems, published by the Air Conditioning Contractors of America, www.acca.org

13. ASHRAE Standard 62.2 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., www.ashrae.org

14. ASHRAE Standard 52.2 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size , published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., www.ashrae.org

15. ASTM Standard C1015-06 “Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation”, published by ASTM International, www.astm.org

16. ASTM Standard C1320-05 “Standard Practice for Installation of Mineral Fiber Batt and Blanket Thermal Insulation for Light Frame Construction”, published by ASTM International, www.astm.org

17. ASTM Standard C727-01 (2007)e1 “Standard Practice for Installation and Use of Reflective Insulation in Building Constructions”, published by ASTM International, www.astm.org

18. ASTM Standard C1158-05 “Standard Practice for Installation and Use of Radiant Barrier Systems in Building Constructions”, published by ASTM International, www.astm.org

19. ASTM Standard E2112-07 “Standard Practice for Installation of Exterior Windows, Doors and Skylights”, published by ASTM International, www.astm.org

20. Flexible Duct Performance and Installation Standards 4th edition, published by the Air Diffusion Council, www.flexibleduct.org

21. Fibrous Glass Duct Construction Standards, 5th edition, published by the North American Insulation Manufacturers Association, www.naima.org

22. FTC Trade Regulation Rule 16 CRF 460, Labeling and Advertising of Home Insulation, published by the Federal Trade Commission, www.ftc.gov

Sample Work Scope Form
(This is informative and does not contain requirements necessary for conformance to these guidelines.)

Work Scope for ___________________________________
All work will be performed according the following checked standards

This work scope is not a list of recommendations that may be implemented independently; any exclusion to this scope may increase the risk of flue gas spillage, back-drafting, carbon monoxide production or moisture problems within the home.

What qualifications are required from contractors/technicians conducting the work:

What work needs to be performed:

Where the work needs to be performed:

How the work is to be performed (referenced Standard(s)):

Chapter Nine
RESNET Standards

900 RESNET NATIONAL STANDARD FOR QUALITY ASSURANCE

901 GENERAL PROVISIONS

901.1 Purpose

RESNET has the responsibility of accrediting Providers. This chapter outlines the quality assurance responsibilities of RESNET and Providers , the role and responsibility of the Quality Assurance and Ethics Committee, the role and responsibility of the Accreditation Committee, the RESNET Accreditation Process for all Providers, the RESNET policies and procedures for Probation, Suspension and Revocation of Provider Accreditation, and the Appeals process for each of these disciplinary actions.

902 DEFINITIONS AND ACRONYMS

See Appendix B.

903 RESNET QUALITY ASSURANCE REVIEW OF ACCREDITED PROVIDERS

903.1 RESNET shall randomly select a limited number of accredited Providers and conduct an annual review of their Quality Assurance records. This QA review may be a review of electronic files submitted to RESNET upon request, an onsite field review, or both. The RESNET Board of Directors shall determine the number of Providers that shall be reviewed on an annual basis and who will provide the quality assurance review.

903.2 Records that may be reviewed may include, but are not limited to:

903.2.1 Rating electronic files

903.2.2 Rating quality assurance records

903.2.3 Complaint files

903.2.4 Rater agreements

903.2.5 Rater registry

903.2.6 Disclosure files

903.2.7 Rating databases;

903.2.8 Interviews with a Provider's QA Designee, Delegates, Raters or Rating Field Inspectors;

903.2.9 "Shadowing" a Provider's Raters or Rating Field Inspectors in the field as they complete data collection, testing and inspections.

903.3 An accredited Rating Provider has the right to challenge the findings of a RESNT Quality Assurance reviewer for cause by submitting, in writing to the RESNET Executive Director, the details of their challenge.

903.4 Significant inconsistencies or errors in electronic records reviewed may result in an onsite review by RESNET.

904 QUALITY ASSURANCE REQUIREMENTS FOR PROVIDERS

904.1 No step in the QA process may be performed by the same individual that performed any part of the testing, inspection or rating of the home being subject to the QA review. In other words, if an individual performed any part of the inspection or rating process on a home, that individual cannot be the QA Designee or Delegate performing any part of the QA process specific to that home. Any ratings performed by a QA Designee that are submitted as part of a Provider's QA Submission to RESNET shall be reviewed for quality assurance by a separate individual who meets the QA Designee requirements established by RESNET.

904.2 Providers are responsible for completing an annual submission of QA results to RESNET. RESNET shall designate the date submissions are due, the content of each submission, and the time frame for which data shall be provided, e.g. January 1st through December 31st. Providers will have at least thirty (30) days from notification until the submission is due.

904.3 Quality Assurance of Providers

904.3.1 RESNET shall develop a Quality Assurance Checklist that is to be used by QA Designees for the purpose of verifying a Provider's compliance with the individual requirements for Providers set forth in the RESNET Standards. The checklist shall consist of items that are to be reviewed during an initial, first-time QA review by a QA Designee new to a Provider as well as items that RESNET has identified as requiring annual verification.

904.3.2 For the first-time QA review completed by a QA Designee new to a Provider, including in the event that a Provider changes QA Designees, every item on the checklist should be checked for compliance, accuracy and completeness. In subsequent years, the list of items to be checked may be shortened to include only those items that RESNET has identified as requiring annual verification.

904.4 Quality Assurance of Raters and Ratings

904.4.1 Review of rating data files

904.4.1.1 The Provider's QA Designee shall be responsible for an annual rating data file review of the greater of one (1) home or ten percent (10%) of each Rater's annual total of homes for which confirmed or sampled ratings were provided. When determining the number of rating data files to review for a Rater, round up to the next whole number when the percentage calculation yields a decimal point, e.g. 101 homes x 10% = 10.1 means that 11 rating data files shall be reviewed.

904.4.1.2 A review of rating data files shall be conducted on an ongoing basis as appropriate for the volume of ratings being completed, and at a minimum quarterly.

904.4.1.3 The rating data file review completed by a QA Designee shall consist of, at a minimum, the following:

> **904.4.1.3.1** Rating data files shall be selected using a nonbiased selection process from the entire pool of files available at the time of the review for each Rater. It may be necessary to first select homes that represent a particular area of interest in the construction process for new and existing homes, geographic location, builder, etc. Once it is ensured that homes from these areas of interest will be included in the QA process, a nonbiased selection process can then be applied such as random selection. Special effort should be taken to make certain that the selected files are as representative as possible of the homes being rated which, in some instances, may require more than the minimum (1) home or ten percent (10%).
>
> **904.4.1.3.2** QA of rating data files does not require that Raters submit data to their Provider and/or QA Designee for every home that is rated. Only data for the homes selected for QA shall be required to be submitted to the QA Designee.
>
> **904.4.1.3.3** For projected ratings created from architectural drawings for Sampled Ratings, confirm that data were accurately entered into the rating software from data collection forms and/or plans, including worst-case analysis;
>
> **904.4.1.3.4** For projected ratings created from architectural drawings, confirm that the Minimum Rated Features and threshold specifications, including worst-case analysis, for each plan are made available for verification in the field (i.e. geometric characteristics, duct leakage and envelope leakage thresholds). In the case of confirmed ratings for homes built from architectural drawings, verify that Minimum Rated Features data from testing and specification findings from the field are accurately entered into the rating software after construction is completed;
>
> **904.4.1.3.5** For confirmed ratings on existing homes, review any field data collection forms or notes to confirm that data were accurately entered into the rating software.
>
> **904.4.1.3.6** Confirm that files, paper and/or electronic, are being maintained by Raters and archived for each rating and/or unique floor plan, including a set of

architectural drawings for projected ratings from plans. These files shall be maintained a minimum of three (3) years;

904.4.2 On-site verification of ratings.

904.4.2.1 For each Rater, the Provider's QA Designee shall be responsible for an annual onsite field evaluation of the greater of one (1) home or one percent (1%) of the Rater's annual total of homes for which confirmed or sampled ratings and diagnostic testing services were provided. When determining the number of onsite evaluations to complete for a Rater, round up to the next whole number when the percentage calculation yields a decimal point, e.g. 101 homes x 1% = 1.01 means that 2 onsite evaluations shall be completed.

904.4.2.2 For Raters utilizing Rating Field Inspectors (RFI's), the QA Designee shall ensure that an annual onsite field evaluation of the greater of one (1) home or one percent (1%) of the RFI's annual total of homes for which data was collected are subject to evaluation. The RFI evaluations may fulfill all or a portion of the Provider's annual onsite QA requirement. When determining the number of onsite evaluations to complete for an RFI, round up to the next whole number when the percentage calculation yields a decimal point, e.g. 101 homes x 1% = 1.01 means that 2 onsite evaluations shall be completed.

904.4.2.3 Onsite inspections shall be conducted on an ongoing basis as appropriate for the volume of ratings being completed, and at a minimum of annually.

904.4.2.4 Where feasible, each home selected for onsite inspections for each Rater shall be randomly selected and/or selected from as many different builders, communities and floor plans as possible.

904.4.2.5 As part of the onsite inspection of ratings, the QA Designee shall ensure that the minimum rated features of a rating are independently confirmed (i.e. confirmation of geometric characteristics, inspection of minimum rated features, and completion of any necessary performance testing) to determine whether the rating and/or diagnostic testing were accurately completed by the Rater, and determine whether information was completely collected and reported as required in 303.1 of Chapter 3 of these Standards.

904.4.2.6 Confirm that HERS Index scores for each home reviewed be no more than three percent (3%) (+/-) variation in the HERS Index from the HERS Index result as determined by the QA Designee. When calculating the HERS Index point variance allowed for a given Index, round down to the nearest whole Index point, with the allowable variance never less than two (2) HERS Index points.

904.4.2.7 Non-compliance of a reviewed rating shall trigger corrective action.

904.4.2.7.1 The rating shall be corrected in order to come into compliance with RESNET technical Standards under the supervision of the QA Designee.

904.4.2.7.2 The QA Designee shall develop and implement a corrective action plan for the Rater of the rating that addresses any underlying problems that led to the non-compliant rating.

904.4.2.7.3 The Provider shall initiate appropriate disciplinary action on the Rater in accordance with the Provider's written Rater disciplinary procedures.

904.4.2.7.4 Multiple instances of non-compliance with 904.4.2.5 shall, at a minimum, trigger an increased rate of file reviews or onsite inspections of homes and additional appropriate disciplinary action in accordance with the Provider's written Rater disciplinary procedures.

904.4.2.8 If a QA Designee is required to complete an onsite QA inspection on at least two (2) homes for a given Rater, the QA Designee may use one centralized – proctored rating QA event, and only one, for review of the Rater in lieu of an independent confirmation of the rating for the home as required for the balance of homes evaluated for the onsite inspection process.

904.4.2.8.1 A centralized proctored rating QA event is defined as a rating that occurs at a house assigned by the QA Designee at which the QA Designee, or their Delegate, must be onsite to ensure that the Rater being reviewed is working completely independently to gather all aspects of the minimum rated features of a home. The Rater being reviewed will not be allowed to communicate by any means with others while gathering information in the home or creating their rating software file and report. The review shall include, but is not limited to, the following:

1. Diagnostic equipment set-up and testing measurements
2. Insulation evaluation and R-value determination
3. Calculations of gross areas, volumes, and square footage of the home
4. Input and creation of the software rating file and reports

904.4.2.8.2 QA under this Section shall adhere to the same variance allowances provided for in Section 904.4.2.5.

904.5 Significant Non-compliance by Providers.

It is the expectation of RESNET that Providers fully comply with all the requirements set forth in these Standards. Discovery of one or more areas of non-compliance via the RESNET QA process, reporting by a QA Designee as part of the Provider's QA process, or in the course of RESNET's research of an ethics or consumer complaint will result in the QA Designee working with a Provider to come back into compliance. However, on occasion, there may be instances where actions by a Provider are truly egregious and, as such, would be deemed to be "significant non-compliance". This Section seeks to define the thresholds when actions by a Provider are deemed to be significant non-compliance, thereby requiring that the QA Designee report the significant non-compliance to RESNET and additional action by RESNET may be taken.

904.5.1 Significant non-compliance by Providers shall include, but not be limited to, the following:

904.5.2.1 Failure to comply with multiple individual requirements, or requirements impacting multiple Raters and/or ratings, for Providers set forth in the RESNET Standards and enumerated in a RESNET Quality Assurance Checklist;

904.5.2.2 Failure of a Provider to comply with the RESNET Standards of Practice, Code of Ethics, or Conflict of Interest Disclosure;

904.5.2.3 Failure to follow a Provider's written Rater disciplinary procedures for known or obvious non-compliance with the RESNET Standards, Standards of Practice, Code of Ethics, or Conflict of Interest Disclosure.

904.5.2 Reporting of significant non-compliance to RESNET.

904.5.2.2 QA Designees must report all significant non-compliance by a Provider to RESNET when it becomes known to the QA Designee so that RESNET may assist the QA Designee in working with a Provider to come back into compliance.

904.5.2.3 Failure of a QA Designee to report significant non-compliance issues may result in actions taken by RESNET as stipulated in Section 905.10.

905 QUALITY ASSURANCE DESIGNEE (QA Designee)

905.1 A Home Energy Rating Provider and BOP Provider shall designate one and only one officer, employee, or contractor to be the Primary Quality Assurance Designee for the organization, responsible for quality assurance within the organization. This does not preclude a Provider from having more than one QA Designee on staff or as a contractor, as may be necessary for business models where QA Designees do Ratings. The Primary QA Designee shall have ultimate responsibility, on behalf of the Provider, for fulfilling the requirements listed in Section 905.8 and who shall be the single point of contact to RESNET regarding all Quality Assurance matters. All QA Designees shall meet each of the minimum requirements to be a QA Designee as stipulated in this Section.

905.2 The designated officer, employee, or contractor responsible for quality assurance shall meet the following minimum requirements:

905.2.1 Previous certification as a Home Energy Rater;

905.2.2 As a certified Home Energy Rater, complete confirmed ratings on a minimum of twenty-five (25) homes prior to becoming a QA Designee;

905.2.3 To be eligible to QA a particular rating type (e.g. sampled, BOP, survey/audit, EEP), a QA Designee must have completed a minimum of five (5) of that rating type;

905.2.4 Passing the RESNET Quality Assurance Designee Test.

905.3 Verification of QA Designee and Delegate Requirements

905.3.1 A QA Designee must confirm that the minimum requirements to be a QA Designee and Delegate, as set forth in this Section 905, have been met.

905.3.2 Five (5) of the twenty-five (25) required confirmed ratings for a QA Designee must be individually reviewed by a QA Designee in accordance with section 904.4.2, three (3) of which may have been included in the annual QA process for a Provider in the previous twenty-four (24) months.

905.4 Professional Development for QA Designees

905.4.1 All QA Designees annually shall complete a two hour RESNET QA Roundtable on current information AND complete one (1) of the following activities:

905.4.1.1 Document 12 hours of attendance at the RESNET Conference; or

905.4.1.2 Complete 12 hours of RESNET approved CEU's; or

905.4.1.3 Documented field QA reviews on a minimum of 25 homes.

905.4.2 A person that is both a Rater Trainer and Quality Assurance Designee shall have to complete both the two hour RESNET roundtable for a Rater Trainer (see Section 209) and the two hour roundtable for Quality Assurance Designees. Rater Trainers and QA Designees selecting the conference or CEU option need only comply with the 12 hour requirement one time, i.e. 12 hours is not required for each position.

905.5 Proof of QA Designee qualifications shall be submitted by Providers with an application for accreditation or with a notification to RESNET of a change to a Provider's QA Designee(s).

905.6 All QA Designees shall have a signed agreement with the Provider to be the Provider's QA Designee.

905.7 Changes to a Provider's QA Designee(s)

905.7.1 If a Provider changes Primary QA Designees or a Provider's Primary QA Designee leaves the organization, is terminated as an outside QA Designee contractor, or is no longer eligible to be the QA Designee, the following steps shall be taken:

905.7.1.1 Within five (5) business days of the Primary QA Designee change, departure, termination, or knowledge of ineligibility, the Provider shall inform RESNET of the change, departure, termination, or ineligibility;

905.7.1.2 In the case of a change in Primary QA Designee as a result of departure, termination, or ineligibility, the Provider shall have forty (40) business days from the date of departure, termination, or knowledge of ineligibility to appoint a replacement Primary QA Designee and notify RESNET of the newly designated officer, employee, or contractor, including proof of qualifications in accordance with 905.2.

905.7.2 If a Provider with multiple QA Designees adds or removes a QA Designee, the Provider shall inform RESENT within five (5) business days of the change.

905.8 Quality Assurance Designee Delegate (QA Delegate)
QA Designee's may have the file review and on-site inspection responsibilities performed by a Quality Assurance Designee Delegate. The QA Designee, however, remains responsible for the accuracy and compliance of the Provider's quality assurance program, including reviews and inspections completed by a QA Delegate.

905.8.1 A QA Delegate must be a certified Home Energy Rater and have completed, on a minimum of twenty-five (25) homes, the portion of the inspection or rating process for which the individual is performing quality assurance tasks. In other words, if the QA Delegate is repeating on-site testing and inspections as part of the QA process, that individual must have at least performed these tasks on a minimum of twenty five (25) homes.

905.8.2 The QA Designee is responsible for ensuring that the QA Delegate maintains their qualifications to be a QA Delegate, i.e. certification as a Rater.

905.9 Responsibilities of a QA Designee. Responsibilities of the QA Designee shall include:

905.9.1 Maintenance of quality assurance files;

905.9.2 Review of ratings conducted during a new Rater's probationary period. Prior to certifying a Rater Candidate, a Provider's QA Designee shall confirm that the Candidate has satisfactorily completed Rater training from a RESNET Certified Training Provider and satisfactorily completed their probationary ratings in accordance with Section 102.1.2.2.

905.9.3 Monitor the accuracy of the QA Delegate's performance of QA tasks by reviewing the results of the QA process for each QA Delegate (i.e. 1% field verification/10% file verification).

905.9.4 Complete annual submission of QA results to RESNET in accordance with Section 904.2;

905.9.5 With the annual QA submissions to RESNET, provide a listing of the QA Designees performing QA tasks on behalf of the Provider and a listing of the QA Delegates who have undertake QA reviews on behalf of a QA Designee;

905.9.6 In accordance with Section 904.3, annually complete the RESNET QA Checklist for Providers;

905.9.7 In accordance with Section 904.4, monitor ratings of all types conducted by certified Raters;

905.9.8 Maintenance of records for all ratings and tax credit verifications.

905.9.8.1 The QA record for each home shall contain at a minimum the information required by Section 904.4.1.3.

905.9.8.2 The record for each rating/tax credit verification shall be maintained for a minimum of three (3) years.

905.9.8.3 Upon RESNET's request, a Provider shall submit to RESNET the number of homes for which ratings/tax credit verifications were provided since the last data submittal. The ratings/tax credit verification shall be identified by type (to include projected and confirmed ratings for new and existing homes and the number of homes verified for tax credits). To the extent RESNET makes this information public; it will do so only in an aggregated form.

905.10 Failure of a QA Designee to Fulfill Their Responsibilities. Failure of a QA Designee to properly fulfill their responsibilities as specified in these Standards may include one or more of the following actions by RESNET:

905.10.1 The QA Designee being placed on probation;

905.10.2 Removal of the QA Designee from the RESNET Directory of qualified QA Designees;

905.10.3 Removal of the QA Designee's credential as a QA Designee;

905.10.4 RESNET no longer recognizing the QA Designee as a Home Energy Rater;

905.10.5 At the Provider's expense, further oversight by RESNET of the QA Designee and the Provider's processes and procedures;

905.10.6 To the extent that the Provider is at fault for the QA Designee's failure to fulfill their responsibilities, the Provider may be subject to probation, suspension or revocation in accordance with Section 911;

905.10.7 The QA Designee may appeal an Action taken by RESNET under this Section using the Appeals procedures stipulated in Section 912 of these Standards.

906 QUALITY ASSURANCE REQUIREMENTS FOR THIRD-PARTY ENERGY EFFICIENCY PROGRAMS

906.1 See Appendix B for definition of Third Party Energy Efficiency Program (EEP).

906.2 The rating data file for each home shall contain at a minimum an electronic copy of the rating software file as it pertains to the EEP and other pertinent required documentation (e.g. checklists, certificates, etc.). The rating data file will clearly identify which EEP the home qualifies under.

906.3 Rating data files and the results of onsite verification of ratings files will be made available by Providers for quality assurance initiatives implemented by EEP's.

906.4 EEP files will be inspected for quality assurance pursuant to section 904.4 and shall include those items related to energy efficiency specific to the EEP that may be in addition to the Home Energy Rating. Significant non-compliance by Providers shall be reported to EEP's when they become known to RESNET.

907 QUALITY ASSURANCE AND ETHICS COMMITTEE

907.1 Committee Membership. The Quality Assurance and Ethics Committee (QA Committee) shall be chaired by a member of the RESNET Board of Directors. The Chair shall be approved by the RESNET Board. Nominations of Committee members shall be made by the Chair to the RESNET Board for approval.

907.2 Committee Responsibilities. The QA Committee shall have the following responsibilities:

> **907.2.1** Oversight of RESNET's rating quality assurance program as defined in this chapter;
>
> **907.2.2** Review and rule on the merits of appeals from the Ethics and Appeals Committee;
>
> **907.2.3** Through the Ethics and Appeals Committee, review and rule on the merits of formal Ethics Complaints received by RESNET;
>
> **907.2.4** Through the Ethics and Appeals Committee, review and rule on the merits of Consumer Complaints received by RESNET;
>
> **907.2.5** Through the Ethics and Appeals Committee, review and rule on the merits of all appeals of non-approval or renewal of an application, probation, suspension, or revocation.

907.3 Ethics and Appeals Committee. The Ethics and Appeals Committee shall have the responsibility of investigating ethics and consumer complaints and hearing appeals of an Application or Renewal Application that has been denied, or if a Provider has been placed on probation, or if a Provider's accreditation has been suspended or revoked. The Committee shall report to the QA Committee.

907.3.1 Committee membership. The Ethics and Appeals Committee shall be composed of five (5) members, none of whom shall also be a member of the Quality Assurance and Ethics Committee.. Nomination of the Committee Chair shall be made by the Quality Assurance and Ethics Committee to the RESNET Board for approval. The Chair of the Ethics and Appeals Committee shall nominate the other members of the Committee to the RESNET Board for approval, two (2) being Home Energy Raters and two (2) being representatives of Provider organizations.

908 ETHICS AND CONSUMER COMPLAINTS

908.1 Filing of Ethics Complaints

908.1.1 Ethics complaints may be filed against an accredited Provider for violating the RESNET Code of Ethics, failing to enforce the Code of Ethics with their certified Raters, or failure to comply with the specific requirements set forth in the RESNET Standards.

908.1.2 An ethics complaint shall document the alleged violation(s). The complaint shall also be specific about which section(s) of the Code of Ethics or the RESNET Standards have been violated. To be considered, the full and complete complaint shall be sent by registered mail, or other method which provides evidence of delivery, to the Executive Director of RESNET and contain the following information:

908.1.2.1 The name of the complainant and contact information;

908.1.2.2 The accredited Provider that is the subject of the complaint;

908.1.2.3 A complete description of the alleged violation(s);

908.1.2.4 A recitation of all the facts documenting the complaint including contact information;

908.1.2.5 Copies of any relevant documents.

908.2 Investigation of Ethics Complaints

908.2.1 The RESNET Executive Director shall assign a case number and forward the ethics complaint to the Ethics and Appeals Committee. The Committee shall consider the documentation contained in 908.1.2 in making a decision whether to proceed or dismiss the complaint.

908.2.2 In cases where the Ethics and Appeals Committee finds the documentation submitted does not meet the minimum standards for an ethics complaint, the complaint may be dismissed. Both parties shall be notified by registered mail, or other method which provides evidence of delivery, of the Ethics and Appeals Committee's finding.

908.2.3 Upon a decision by the Ethics and Appeals Committee that the ethics complaint should proceed to the next step, the RESNET Executive Director shall send a copy of the complaint by registered mail, or other method which provides evidence of delivery, to the subject of the complaint immediately. The respondent has 20 business days to submit a full and complete response to the complaint. All relevant information and documentation shall be included in the response. The response shall be in writing and sent to RESNET by registered mail, or other method which provides evidence of delivery.

908.2.4 Upon receipt of the response, the RESNET Executive Director shall immediately forward the response to the RESNET Ethics and Appeals Committee for consideration and action. Within thirty (30) business days of receiving the ethics complaint, the Ethics and Appeals Committee shall take action on the complaint. The action may include, but is not limited to:

908.2.4.1 Dismissal of complaint;

908.2.4.2 Requirement that the rating Provider take steps to correct the problem;

908.2.4.3 Recommendation to the QA Committee of sanctions under Section 912 (Suspension and Revocation of Accreditation) of this chapter.

908.2.5 All parties to the complaint shall be informed by registered mail, or other method which provides evidence of delivery, of the Ethics and Appeals Committee's action.

908.3 Filing of Consumer Complaints

908.3.1 Consumer Complaints may be filed by consumers who have grievances against RESNET, a Provider accredited by RESNET, or a Rater certified by an accredited Provider.

908.3.2 RESNET shall implement a Consumer Complaint Response Process to address and investigate consumer complaints.

908.4 Complainants shall have the right to appeal the decision of the Ethics and Appeals Committee to the QA Committee and RESNET Board of Directors. The Appeals process shall follow the same process and procedures stated in Section 912.2.2 and 912.2.3 respectively.

908.5 All complaints, responses, and supporting documentation received by RESNET shall be handled in strict confidence by the RESNET staff, the Ethics and Appeals Committee, the QA Committee and the Board of Directors.

909 ACCREDITATON COMMITTEE

909.1 Committee Membership. The Accreditation Committee shall be chaired by a member of the RESNET Board of Directors. The Chair shall be approved by the RESNET Board. Nominations of Committee members shall be made by the Chair to the RESNET Board for approval.

909.2 Committee Responsibilities. The Accreditation Committee shall be responsible for the review and approval of all Applications for Provider accreditation.

910 PROVIDER ACCREDITATION AND RENEWAL PROCESS

910.1 National Registry of Accredited Providers

RESNET shall maintain a national registry of accredited Providers and will post the registry on its web site. The following Provider categories shall have individual registries.

910.1.1 Home Energy Rating Provider

910.1.2 Home Energy Rating Software Provider

910.1.3 Training Provider

910.1.4 Builder Option Package (BOP) Provider

910.1.5 Sampling Provider

910.1.6 Home Energy Survey Provider

910.2 Provider Accreditation Process

910.2.1 An entity seeking accreditation must file with RESNET an application for the specific Provider category for which they seek accreditation. RESNET shall create the applications for each accreditation category.

910.2.2 Confidentiality of Information. Any applicant for a Providerhip who wishes to have certain information in their application treated as confidential in order to limit disclosure shall, at the time of submission, attach a statement specifying the proprietary information and requesting confidentiality.

910.2.3 Review and Notification.

910.2.3.1 RESNET staff action. Within twenty (20) business days of receipt of an application, RESNET staff will review the application to determine whether the applicant and its Raters are eligible for accreditation in accordance with the specific requirements for each Provider category. Upon completion of the review, RESNET staff shall do one of the following:

910.2.3.1.1 Request for additional information. If additional information is required in order to complete the review of the application, the application shall be returned to the applicant along with a written request for additional information. Upon receipt of additional information, RESNET staff shall have twenty (20) business days to take action in accordance with 910.2.3.1.2 or 910.2.3.1.3

910.2.3.1.2 Recommendation for approval. If RESNET staff is satisfied that an application is complete and meets all the requirements for accreditation, they shall make a recommendation to the Accreditation Committee that the application be approved.

910.2.3.1.3 Recommendation for denial. If RESNET staff is not satisfied that an application is worthy of approval for accreditation, they shall make a recommendation to the Accreditation Committee that the application be denied and provide an explanation of the reasons for the recommendation (i.e. incompleteness, failure to meet/comply with a specific accreditation requirement, etc.).

910.2.3.2 Accreditation Committee action. Within fifteen (15) business days of receipt of a recommendation for approval or denial from RESNET staff, the Committee shall do one of the following:

910.2.3.2.1 Request for additional information. If the Committee requires additional information, the application shall be returned to the applicant along with a written request for additional information. Upon receipt of additional information, the Committee shall have twenty (20) business days to render a decision in accordance with 910.2.3.2.2 or 910.2.3.2.3.

910.2.3.2.2 Approve the application.

910.2.3.2.3 Deny the application. If an application is denied, RESNET staff shall inform the applicant in writing of the reasons for denial. Additionally, the applicant shall be informed of their right of appeal under Section 912 of this Chapter.

910.2.3.3 Within ten (10) business days of a decision by the Committee, RESNET staff shall inform the applicant in writing of the status of their application.

910.2.4 For each approved application, RESNET shall issue a unique Accreditation Identification Number (AIN) to the Provider for the Provider category approved and, in accordance with 910.1, the accreditation will be incorporated into the respective national registry of accredited Providers.

910.2.5 Term of accreditation.

910.2.5.1 All Provider accreditations shall be valid for a term of one calendar year and shall be renewed annually on January 1st upon successful completion and approval by RESNET of an application for renewal in accordance with Section 910.3.

910.2.5.2 For fist time applicants approved after September 1st, for any Provider category, initial accreditation is valid through the end of the calendar year, i.e. renewal of the accreditation shall not be required for the calendar year in which the application was approved.

910.3 Accreditation Renewal Process

910.3.1 Accredited Providers must submit an "application for renewal" (renewal application) with RESNET no later than October 1st of each calendar year. By September 1st, RESNET shall send to each Provider a renewal application and reminder of the deadline for submission.

910.3.2 Program element changes. At the time of submitting a renewal application, it is the accredited Provider's responsibility to inform RESNET of any substantive changes in the Provider's operating policies and procedures or other information that affects meeting the minimum accreditation criteria for each Provider category for which it is seeking renewal. Changes will be evaluated by RESNET in the same manner as the original application for accreditation.

910.3.3 Successful renewals. Successful renewals will be posted on the national registry and communicated to the applicant by RESNET.

910.3.4 Late applications.

910.3.4.1 Renewal applications received after the deadline for submission are not guaranteed to be approved prior to the end of the calendar year. Should an accreditation with a late renewal application expire prior to approval, the RESNET Accreditation Committee, at its sole discretion, may grant an extension with a grace period not to exceed twenty (20) business days.

910.3.4.2 Renewal applications not given an extension or not approved prior to the end of the grace period shall be noted as "pending" on the national registry and the applicant will be advised to cease representing themselves as accredited until the application receives approval.

910.3.5 Accreditation not renewed. Accredited Providers that elect not to renew or fail to meet renewal requirements will be removed from the national registry and be so advised in writing. Providers have the right to appeal a non-renewal decision in accordance with Section 912 of this Chapter.

910.3.6 Accreditations in appeal. Provider accreditations that have not been renewed and are under appeal will be noted as "pending" on the national registry until the appeal is resolved. Providers will be advised to cease representing themselves as accredited.

911 PROBATION, SUSPENSION, AND REVOCATION OF ACCREDIATION

911.1 Notification. RESNET shall provide written notification to Providers of any decisions under this section. All notices shall be sent by certified mail, or other method which provides evidence of delivery. All notices shall clarify the procedures being followed, as stipulated in this Standard, and include, where applicable, a statement of the Provider's rights to appeal under Section 912 of this Chapter.

911.2 Probation. If RESNET determines at any time that a Provider has failed to adhere to the accreditation requirements set forth in these Standards, RESNET shall notify the Provider of the specified deficiencies and shall require that specific corrective action, set forth in the notification, be taken within a specified time after the date set forth in such notification. A notice of probation may be appealed under Section 912 of this Chapter.

911.3 Suspension- /Revocation. Any Provider accredited by RESNET may have their accreditation suspended or revoked in any of the following circumstances:

911.3.1 Failure to correct deficiencies. If RESNET determines at any time that an accredited Provider has failed to adhere to the accreditation requirements as established by these Standards and approved as part of the Provider's accreditation, RESNET shall notify the Provider of the specified deficiencies and shall require that specific corrective action, set forth in the notification, be taken not later than twenty (20) business days after the date set forth in such notification.

911.3.1.1 In the event that the deficiencies have not been remedied as stipulated in 911.3.1, RESNET shall have the authority to immediately begin the process of suspension by issuance of a Notice of Suspension Proceedings. Such Suspension Proceedings shall follow the due process procedures contained in 911.3.

911.3.1.2 In the event that the deficiencies have not been remedied within the period set forth in a Notice of Suspension, RESNET shall have the authority to immediately begin the process of revocation by issuance of a Notice of Revocation Proceedings. Such Revocation Proceedings shall follow the due process procedures contained in 911.4.

911.3.2 Acting in such a manner as to impair the objectivity or integrity of the Provider or harm the reputation of RESNET;

911.3.3 Submission of false information to RESNET, or failure to submit to RESNET any material information required to be submitted by the Provider, in accordance with obtaining or maintaining accreditation;

911.3.4 Knowingly or negligently issuing ratings or reports required to be or purported to be completed in accordance with the RESNET Standards which are not;

911.3.5 Misrepresentation by the Provider in advertising or promotional materials of its accreditation status in general or with respect to any service provided by the Provider;

911.3.6 Pursuant to any of the express provisions of sections 910.3.5, non renewal;

911.3.7 Provider goes out of business;

911.3.8 Provider does not re-apply at the end of accreditation period;

911.3.9 Investigated and validated ethics or consumer complaints;

911.3.10 Upon expiration of a Provider's right to appeal a suspension of accreditation pursuant to Section 912 of this Chapter.

911.3.11 Willful misconduct;

911.3.12 Failure to disclose a self-serving interest to clients via the RESNET Home Energy Rating Standard Disclosure form.

911.4 Suspension/Revocation Due Process.
RESNET shall comply with the following due process procedures in considering any suspension or revocation actions against an accredited Provider.

911.4.1 RESNET may, at its discretion, initiate a suspension or revocation action against an accredited Provider by providing the Provider written notice of the action. Such notice shall inform the subject Provider of the entire basis and justification for the action.

911.4.2 Providers have the right to appeal a suspension or revocation action in accordance with Section 912 of this Chapter.

911.4.3 Notifications. Upon the expiration of the notice to appeal period or failure to submit appeal documentation, as stipulated in 912.2.1.1, or the conclusion of the appeals process in which a Provider's appeals are unsuccessful, Providers and their Raters are not allowed to perform ratings, must inform their clients and Raters of their suspended status in writing with a copy of this correspondence sent to RESNET. RESNET will remove the Provider's name from the RESNET website, post their suspended or revoked status on the RESNET website with other Providers and Raters who are under suspension/ revocation, and will, at a minimum, inform the EEP of their suspended/revoked status.

912 APPEALS PROCEDURES FOR NON-APPROVAL OR RENEWAL OF APPLICATIONS, PROBATION, SUSPENSION, OR REVOCATION

912.1 Notification.
RESNET shall provide written notification to the Appellant of any decisions under this section. All notices shall be sent by certified mail, or other method which provides evidence of delivery. All notices shall clarify the procedures being followed, as stipulated in this standard, and include, where applicable, a statement of the Provider's rights to remedy.

912.2 Appeal

912.2.1 Appeals to the RESNET QA Committee's Ethics and Appeals Committee.

912.2.1.1 In the event that an Application or Renewal Application has been denied, or if a Provider has been placed on probation, the Provider shall have the right, for a period of twenty (20) business days after the date of notice, to appeal to the RESNET Ethics and Appeals Committee. If a Provider's accreditation has been suspended or revoked, the Provider shall notify RESNET with five (5) business days after the date of notice of their intent to appeal. The Provider shall then have twenty (20) business days after the date of notice, to submit their appeal documentation, in accordance with 912.2.1.2 and 912.2.1.3, to the RESNET Ethics and Appeals Committee.

912.2.1.2 Appeals shall be in writing and sent by certified mail, or other method which provides evidence of delivery, to RESNET, attention Chairman of the RESNET QA Committee.

912.2.1.3 Appeals shall contain all pertinent and substantive information and arguments that are in contradiction to the proposed non-approval or renewal of an application, probation, suspension, or revocation, including identification of all disputed materials and facts.

912.2.1.4 The appellant Provider may, at the time of noticing its appeal, request a telephonic hearing by the RESNET QA Committee's Ethics and Appeals Committee which gives the appellant the opportunity to provide oral arguments in favor of their appeal. In such an event, the Committee shall, not later than ten (10) business days after the filing of the notice of appeal, notify the appellant Provider of the date of the hearing, which shall be held as expeditiously as possible, but not later than thirty (30) business days after the receipt of the notice of appeal.

912.2.2 Appeals to the RESNET Quality Assurance and Ethics Committee.

912.2.2.1 In the event that a Provider's appeal of its non-approval or renewal of an application, probation, suspension, or revocation is rejected by the Ethics and Appeals Committee, the Provider shall have the right, for a period of twenty (20) business days after the date of the notification of the denial of the appeal, to appeal to the RESNET QA Committee.

912.2.2.2 Appeals shall be in writing and sent by certified mail, or other method which provides evidence of delivery, to RESNET, attention Chairman of the RESNET QA Committee.

912.2.2.3 The appellant Provider may, at the time of noticing its appeal, request a telephonic hearing by the QA Committee which gives the appellant the opportunity to provide oral arguments in favor of their appeal. In such an event, the Committee shall, not later than ten (10) business days after the filing of the notice of appeal, notify the appellant Provider of the date of the hearing, which shall be held as expeditiously as possible, but not later than thirty (30) business days after the receipt of the notice of appeal.

912.2.3 Appeals to the RESNET Board of Directors

912.2.3.1 In the event that a Provider's appeal of its non-approval or renewal of an application, probation, suspension, or revocation is rejected by the QA Committee, the

Provider shall have the right, for a period of twenty (20) business days after the date of the notification of the denial of the appeal, to appeal to the RESNET Board of Directors.

912.2.3.2 Appeals shall be in writing and sent by certified mail, or other method which provides evidence of delivery, to RESNET, attention President of the RESNET Board of Directors.

912.2.3.3 The appellant Provider may, at the time of noticing its appeal, request a telephonic hearing by the RESNET Board which gives the appellant the opportunity to provide oral arguments in favor of their appeal. Within thirty (30) business days, the Board shall render a decision as to whether it chooses to hear the appeal and whether or not there shall be a telephonic hearing for oral arguments. If the Board chooses to hear the appeal, the Board shall, not later than ten (10) business days after the decision to hear the appeal, notify the appellant Provider of the date of the hearing and whether or not the hearing will include oral arguments. The hearing shall be held as expeditiously as possible, but not later than forty (40) business days after notification that the appeal will be heard.

913 EFFECTIVE DATES

913.1 The effective date of these changes to the RESNET Standards shall be January 1, 2011.

913.2 The QA of Low-Volume Raters in accordance with the original provisions of Section 904.6, effective January 1, 2010, shall be allowed until December 31, 2010.

913.3 As of the effective date of these changes to the RESNET Standards, as stipulated in Section 913.1, all individuals who have been qualified as QA Designees or Delegates under the current version of the RESNET Standards shall not be required to meet any new requirements to become a QA Designee as stipulated in Section 905.2.

913.4 As of the effective date of these changes to the RESNET Standards, as stipulated in Section 913.1, any consumer complaints, ethics complaints, and appeals pending before RESNET shall follow the provisions of the RESNET Standards that were in effect as of the date of the filing of the complaint or appeal.

Chapter Ten
RESNET Standards

1000 RESNET STANDARD FOR ENERGYSMART PROJECTS AND ENERGYSMART CONTRACTORS

1001 PURPOSE
This standard defines a framework for designating contractors as RESNET EnergySmart Contractors, defines an EnergySmart Project, and establishes requirements for the final verification and quality assurance review of an EnergySmart Project.

1002 RELATIONSHIP TO STATE LAW
There may be instances in which state laws or regulations differ from these provisions. In such instances, state law or regulation shall take precedence over these provisions.

1003 SCOPE

This document details:

1003.1 Requirements for Contractor Education and Qualification Providers;

1003.2 The process by which a contractor shall receive and maintain designation as a RESNET EnergySmart Contractor;

1003.3 The process by which RESNET EnergySmart Contractors working in partnership with a certified RESNET Comprehensive Home Energy Rating System (CHERS) Rater or Building Performance Auditor (BPA) must complete an EnergySmart Project;

1003.4 The requirements of an EnergySmart Project.

1004 PARTICIPANTS' ROLES AND RESPONSIBILITIES

1004.1 RESNET

Residential Energy Services Network (RESNET) is responsible for the following:

1004.1.1 Accreditation of Contractor Education and Qualification (CEQ) Providers

1004.1.2 Quality Assurance Review of Accredited CEQ Providers

1004.1.3 Quality Assurance Review of Accredited Rating Providers

1004.1.4 Develop a National EnergySmart Contractors test. The competency categories covered on the 50 question multiple-choice test and the percentage of questions devoted to each category are as follows:

1004.1.4.1 Air sealing (10%)

1004.1.4.2 Client communication (6%)

1004.1.4.3 Combustion safety (6%)

1004.1.4.4 Ducts/distribution (10%)

1004.1.4.5 Energy fundamentals (10%)

1004.1.4.6 Ethics (6%)

1004.1.4.7 Health/safety (6%)

1004.1.4.8 Insulation (10%)

1004.1.4.9 Lighting/appliances (4%)

1004.1.4.10 Moisture management (10%)

1004.1.4.11 Structure (6%)

1004.1.4.12 Ventilation (6%)

1004.1.4.13 Heating/AC (10%)

1004.2 Contractor Education and Qualification (CEQ) Provider

1004.2.1 The CEQ Provider must be an accredited RESNET Rating Provider or Home Energy Audit Provider in good standing.

1004.2.2 The CEQ Provider must have a staff member or representative with at least 10 years of residential construction or home improvement contractor experience.

1004.2.3 The CEQ Provider must provide its EnergySmart Contractor Registry to RESNET.

1004.2.4 The CEQ Provider is responsible for the Quality Assurance review of the EnergySmart Contractors.

1004.2.5 The CEQ Provider must have written policies and procedure for designating EnergySmart contractors in accordance with the following provisions:

1004.2.5.1 EnergySmart Contractor course: Develop and provide an initial eight (8) hour RESNET Accredited Qualified EnergySmart Contractor course that covers the following topics:

a. The importance of EnergySmart Contractors

b. The house as a system

c. Building science basics/ building shell fundamentals

d. Energy efficiency concepts

e. Energy related consequences of inefficient construction design and application

f. Introduction on how a Rater/Auditor utilizes air leakage testing, duct leakage testing, and IR technology during energy audits

g. Understanding and completing scopes of work as defined in the RESNET combustion appliance testing and writing work scope contained in Chapter 8 of RESNET Standards

h. Work order, sequences and priority of work, and respect for other contractors

i. Introduction to RESNET Standards and RESNET Code of Ethics

j. Quality Homes (QH) Standard

1004.2.5.2 Continuing Education: Provide at least four (4) hours of Continuing Education (CE) courses per year that are relevant to energy efficiency, home improvement contracting, standards updates, technology updates, new incentive programs, retrofit lessons learned and/or other topics deemed applicable and appropriate by the CEQ Provider.

1004.2.5.3 Delisting: Delist an EnergySmart Contractor that does not renew every three (3) years.

1004.2.5.4 EnergySmart Contractor Agreement: Enter into a written agreement with each EnergySmart Contractor, and send an unexecuted copy of the agreement to RESNET. The agreement shall contain, at a minimum, the following:

a. A written commitment by the EnergySmart Contractor to comply with the guidelines in the RESNET EnergySmart Contractor Pledge and Code of Ethics.

b. A requirement for the EnergySmart Contractor to inform clients about the CEQ Provider's complaint process.

c. A requirement for the EnergySmart Contractor to provide the client with a disclosure statement for jobs not performed to industry standards.

d. A requirement for the EnergySmart Contractor to inform the CEQ Provider within 60 days if EnergySmart Contractor's representative leaves the company or is replaced.

1004.2.5.5 Complaint Resolution Officer: Have signed agreement with a dedicated Complaint Resolution

Officer (CRO) to conduct Non-Compliance Resolution in accordance with Section 1006.5.4. The CEQ Provider shall have sixty (60) days to notify RESNET if the CRO leaves the CEQ Provider, or be subject to suspension of accreditation under provisions of Section 908 of the Mortgage Industry National Home Energy Ratings Standard.

1004.2.5.6 Written EnergySmart Contractor discipline procedures, including:

a. Probation and minimum requirements for duration and corrective action

b. Suspension of certification and minimum requirements for duration and corrective action that at least meet 1006.4.5

c. Termination of certification

1004.2.5.7 EnergySmart Contractor Registry: Maintain an EnergySmart Contractor Registry that contains EnergySmart Contractors' representative's name, company name, mailing address, voice phone number, fax number, and email address.

1004.2.6 Reciprocity with the Air Conditioning Contractors of America (ACCA): RESNET shall recognize contractors trained and designated by ACCA to be EnergySmart Contractors.

1004.3 Complaint Resolution Officer (CRO)

1004.3.1 Shall manage and resolve consumer and Rater/Auditor complaints about EnergySmart Contractors and EnergySmart Contractor or Rater/Auditor complaints about the CEQ Provider.

1004.3.2 Shall submit complaints against the CEQ Provider to RESNET to the attention of the Executive Director.

1004.4 EnergySmart Contractor

1004.4.1 EnergySmart Contractors must be designated as such by a CEQ Provider in accordance with Section 1004.2.5 of this standard[11].

1004.4.2 EnergySmart Contractors must be licensed in the state(s) in which they conduct business if that state requires a license.

1004.4.3 An EnergySmart Contractor company shall assign an employee as its representative. The EnergySmart Contractor's representative shall:

[11] EnergySmart Contractors providing HVAC services must be recognized ACCA QA Program Participants within 90 days of the adoption of this standard.

1004.4.3.1 Take an initial accredited eight (8) hour Qualified Contractor Course from a RESNET accredited CEQ Provider.

1004.4.3.2 Pass the RESNET National EnergySmart Contractors test administered by a CEQ Provider.

1004.4.3.3 Enter into a written agreement with the CEQ Provider in which the EnergySmart Contractor agrees to comply with the program requirements contained in the RESNET Standards and RESNET Code of Ethics.

1004.4.3.4 Complete a minimum of four hours of Continuing Education annually delivered by the CEQ Provider.

1004.4.3.5 Renew with the CEQ Provider not less than every three years. Failure to do so will result in the EnergySmart Contractor being deleted from the CEQ's Registry and from the RESNET Directory.

1004.4.4 Within 60 days of losing their previous representative, the EnergySmart Contractor must notify the CEQ Provider of their new representative.

1004.4.5 Only companies with the EnergySmart Contractor designation from an accredited CEQ Provider are eligible for posting and promotion on the RESNET Directory.

1004.4.6 A company with the EnergySmart Contractor designation must carry a minimum of $1,000,000 in general liability insurance.

1004.4.7 EnergySmart Contractors will install the energy-saving measures from the final, homeowner approved work scope prepared by the Rater/Auditor.

1004.4.8 All EnergySmart Contractors shall have their clients signify that they understand a disclosure statement indicating that all work will or will not meet recognized industry standards.

1004.4.9 All EnergySmart Contractors shall have their clients signify on a disclosure statement that a whole-house audit is recommended.

1004.5 EnergySmart Home Performance Team (EnergySmart Team)

An EnergySmart Team is comprised of the following, as necessary:

1004.5.1 One Project Manager

1004.5.2 A certified CHERS Rater/BPA

1004.5.3 An HVAC contractor who is a recognized ACCA QA Program Participant[12]

[12] EnergySmart Contractors providing HVAC services must be recognized ACCA QA Program Participants within 90 days of the adoption of this standard.

1004.5.4 A RESNET EnergySmart Contractor that specializes in Air Sealing and Insulation who employs at least one senior technician who is an ICAA Certified Insulation Installer or another RESNET recognized quality installation training program.

1004.5.5 Any number of other EnergySmart contractor companies working under the oversight of the Project Manager according to work scope requirements of a certified Rater/Auditor and applicable RESNET Standards of Practice.

1004.5.6 A Final Verifier who is a 3rd party certified HERS Rater/BPA.

1004.6 EnergySmart Project Manager

The ES Team will be led by an EnergySmart Project Manager. The following are the requirements for being the Project Manager:

1004.6.1 Shall be certified as either an EnergySmart Contractor or a Rater/Auditor.

1004.6.2 The EnergySmart Project Manager, if not the Rater/Auditor, shall use a certified RESNET Rater/Auditor for the diagnosis and preparation of energy retrofit recommendation.

1004.6.3 Is an employee of or contractor to the company with whom the homeowner is under contract for the completion of the EnergySmart Project.

1004.6.4 Must ensure that the initial rating or audit is performed on each Project in accordance with the QH Standard.

1004.6.5 Must ensure that preliminary and post-installation combustion safety testing and inspection of all combustion appliances are completed in accordance with the QH Standard.

1004.6.6 Must provide general oversight of all contractors performing work on the EnergySmart Project to ensure proper sequence and compliance with the work scope prepared by the Rater/Auditor, along with ensuring that industry best practices are followed for all work performed.

1004.6.7 Must deliver the initial rating or audit report along with documentation of all work performed to the Final Verifier.

1004.6.8 Must verify that each project has final verification and calculation of estimated projected energy savings conducted by a Final Verifier.

1004.6.9 Must provide all results and EnergySmart Project documentation to the client.

1004.6.10 Must maintain the initial rating or audit report, documentation of all energy-saving retrofits and installations, and the final verification report with all test-out and estimated energy savings results for each individual EnergySmart Project for a period of no less than three years. This documentation must be made available to the HEA, Rating, or CEQ Provider upon request.

1004.6.11 Ensure that all EnergySmart Team participants are eligible to serve on the team.

1004.6.11.1 Eligible HVAC contractors must be listed on the ACCA QA Contractor Registry.

1004.6.11.2 EnergySmart Contractors must be listed on the RESNET Registry.

1004.7 Rating Provider

1004.7.1 The Rating Provider will be responsible for performing Quality Assurance (QA) Review of the Rater Final Verification of an EnergySmart Project.

1004.7.2 The Rating Provider must be RESNET-accredited and in good standing in accordance with RESNET Standards.

1004.7.3 The Rating Provider must be independent of the following:

1004.7.3.1 CHERS Rater or BPA that evaluated the home and prepared the recommendations and work scope.

1004.7.3.2 The EnergySmart Contractors that installed the approved recommended measures.

1004.7.3.3 The independent Rater/Auditor that performed the Final Verification of the EnergySmart Project (the Final Verifier).

1004.7.3.4 Any financial compensation for any of the retrofits performed on the project.

1004.8 Comprehensive Home Energy Rating System (CHERS) Building Performance Auditor (BPA)

The CHERS Rater or BPA is responsible for following the QH Standard procedures to complete the following:

1004.8.1 Conducting the initial, comprehensive evaluation of a home.

1004.8.2 Presenting prioritized energy saving measures recommendations to the homeowner.

1004.8.3 Developing a work scope to be approved by the homeowner.

1004.9 Final Verifier

1004.9.1 The Final Verifier must be an independent certified RESNET CHERS/BPA that does not have a financial interest in any of retrofit work done for the EnergySmart Project, or that is not employed by a company who performs any part of the retrofit work.

1004.9.2 The Final Verifier is responsible for the following:

1004.9.2.1 Must perform applicable combustion appliance testing.

a. Where there are vented combustion appliances that use indoor air to vent combustion gasses, test Worst Case Depressurization in accordance with the QH Standard.

b. Where any space contains combustion appliances, test for Carbon Monoxide in accordance with the QH Standard.

1004.9.2.2 Verification of installed measures. The Final Verifier will review the work scope and signed proposal, and confirm that the installed measures are consistent with selected measures and work scope in accordance with the QH Standard.

1004.9.2.3 Calculation of estimated project energy savings using a RESNET-approved software.

1004.9.2.4 Must report any non-conformance of an EnergySmart Project with respect to combustion safety testing, installed measures, or estimate of projected energy savings to the EnergySmart Contractors' CEQ Provider's Complaint Resolution Officer (CRO) and the Rating Provider's Quality Assurance (QA) designee.

1004.9.2.5 Must report non-conformance of HVAC QA Contractors to the QI Standard to ACCA.

1004.9.2.6 Must maintain Final Verification records, for a period of no less than three years, for every EnergySmart Project for which final verification was performed. These records include:

a. Copy of the work scope and signed proposal,

b. Name and contact information for the Rater/Auditor and EnergySmart Contractors,

c. Completed final verification checklist,

d. Energy simulation software file, and

e. All test-out results.

1005 ENERGYSMART PROJECTS

1005.1 EnergySmart Project

An EnergySmart Project shall employ an EnergySmart Team and comply with the following:

1005.1.1 Follows accepted industry standards and OEM instructions.

1005.1.2 Includes disclosure statements for work performed that does not meet recognized industry standards.

1005.1.3 Verified and validated by a Final Verifier.

1005.1.4 Consists of work performed by either an EnergySmart Contractor or, for work done on HVAC systems or components, the contractor must be a participant in the ACCA QA Recognition Program.

1005.1.5 Is comprised of two or more trades.

1005.1.6 Has an EnergySmart Project Manager that complies with Section 1004.6.

1005.2 EnergySmart Home

A home designated as an EnergySmart Home shall be recognized by RESNET if:

1005.2.1 The project is in compliance with section 1005.1 except for the following:

1005.2.1.1 Must undergo an initial rating or audit that is performed in accordance with QH Standard.

1005.2.1.2 The homeowner is provided an estimate of percentage energy savings and a reduction in estimated energy usage of not less than 30% based upon actual installed measures.

1005.2.1.3 A Final Verifier conducts an independent verification of the project and a calculation of estimated energy savings.

1006 OVERSIGHT

1006.1 RESNET Quality Assurance of CEQ Providers

1006.1.1 RESNET shall select a limited number of CEQ Providers and conduct an annual review of their Quality Assurance records.

1006.1.2 A CEQ Provider shall have the right to challenge the findings of RESNET's quality assurance review.

1006.1.3 CEQ records that must be reviewed include the following:

1006.1.3.1 The CEQ's EnergySmart Contractor Registry

1006.1.3.2 The CEQ's EnergySmart Contractor Agreements

1006.1.3.3 Documentation of CEQ Provider's initial training course and continuing education offerings for EnergySmart Contractors

1006.1.3.4 Documentation of EnergySmart Contractor's Designated Qualification Representative completing required training and testing

1006.1.3.5 Documentation of the Representative's continuing education

1006.1.3.6 The CEQ's EnergySmart Contractor complaint files

1006.1.3.7 Documentation of disciplinary actions

1006.1.4 In the case of an unresolved complaint brought to the RESNET Executive Director, it will be the responsibility of the CEQ to secure the EnergySmart Project files from the EnergySmart Project Manager and present them to RESNET. Failure of the EnergySmart Project Manager to provide adequate records shall result in sanctions up to and including a 60 day suspension of the EnergySmart Contractor designation.

1006.1.5 An on-site review by RESNET may be conducted if there are significant inconsistencies or errors in the reviewed CEQ files.

1006.1.6 Complaints against a CEQ Provider submitted by the CRO to RESNET shall be addressed by the Executive Director. The RESNET Executive Director shall:

1006.1.6.1 Resolve the complaint in forty-five (45) calendar days.

1006.1.6.2 A complaint will be considered resolved once a Complaint Resolution Form has been submitted, signed by the one who files the complaint and the CEQ Provider.

1006.1.6.3 A log of unresolved complaints shall be maintained by the RESNET Executive Director.

1006.1.7 CEQ Providers are subject to Probation, Suspension, and Revocation of Accreditation by RESNET in accordance with Section 911 of these RESNET Standards.

1006.1.7.1 Suspension, and Revocation of Accreditation of a CEQ Provider may result from the following:

a. The provisions described in 911.3.

b. Failure to ensure that the Energy Smart Contractor followed the complaint resolution process in the case of a complaint against the EnergySmart Contractor or failure to follow required disciplinary and corrective action with respect to a contractor.

1006.1.7.2 RESNET shall comply with the due process and appeals procedures contained in Section 912 of these

Standards with respect to disciplinary actions against an accredited CEQ Provider.

1006.2 RESNET Quality Assurance of Rating Providers

1006.2.1 RESNET QA Review of Rating Providers shall be conducted in accordance with Chapter 9 of RESNET Standards and shall include Rating Provider review of EnergySmart Projects.

1006.3 CEQ Provider Quality Assurance of EnergySmart Contractors

1006.3.1 The CEQ Provider shall annually verify that the EnergySmart Contractor's representative is still with the company.

1006.3.2 Respond to complaints against EnergySmart Contractors.

1006.3.3 Follow written EnergySmart Contractor Disciplinary Procedures described in

1006.4 CEQ Provider Complaint Resolution Procedures

1006.4.1 The CEQ Provider must conduct non-compliance resolution when a complaint is received about the work performance of an EnergySmart Contractor from any of the following:

1006.4.1.1 The client

1006.4.1.2 Rater/Auditor

1006.4.1.3 Other EnergySmart Contractor

1006.4.1.4 Final Verifier

1006.4.2 Complaints shall be managed and resolved by the CEQ Provider's Complaint Resolution Officer (CRO) following the CEQ Provider's Complaint Response Process.

1006.4.3 Each CEQ Provider shall retain records of complaints received and responses to complaints for a minimum of three years after the date of the complaint.

1006.4.4 The Complaint Response Process shall include, at a minimum, the following:

1006.4.4.1 Consumer Complaint Form, available for submittal via the RESNET website. (1004.2.3.1) The form will be forwarded to the CEQ Provider to the attention of the CRO.

1006.4.4.2 It is the responsibility of the CEQ Provider to secure the documentation from the EnergySmart Project Manager or Final Verifier for review by the CRO.

1006.4.4.3 The CRO shall evaluate the complaint to determine if the contractor shall be deemed to be in non-compliance. Complaints must:

a. Be related to either structural or major deficiencies (over $500) and must impact the energy efficiency of the home.

b. Include the work contract(s) and copies of checklists denoting unresolved deficiencies.

c. In the event the CRO cannot make a fair evaluation of the complaint based on the information submitted, the consumer shall have the option of hiring an independent Rater/Auditor to visit the site and submit his or her report and findings.

1006.4.4.4 The EnergySmart Contractor Complaint Resolution Process shall consist of the following:

a. The CRO will notify the contractor of the complaint and the contractor shall have forty five (45) calendar days to resolve the complaint.

b. A complaint will be considered resolved once a Complaint Resolution Form has been submitted, signed by both the client and the party against whom the complaint was filed, and the resolution verified by the CRO.

c. If the complaint is not resolved in the allotted time, it will be considered unresolved.

1006.4.4.5 EnergySmart Contractors with three (3) unresolved complaints within a 90 day period or with five or more unresolved complaints at any given time shall have their certification suspended in accordance with the provisions of 1006.4.5.

1006.4.4.6 A log of unresolved complaints shall be maintained by the CEQ Provider and must be made available to RESNET upon request.

1006.4.5 The minimum requirements for suspension of certification procedures are the following:

1006.4.5.1 First Offense: First time an EnergySmart Contractor has three unresolved complaints within a 90 day period or has five outstanding unresolved complaints, the CEQ Provider shall suspend the contractor's certification for a period of not less than 30 days, and:

a. Shall inform RESNET that the contractor's certification has been suspended, and shall request that RESNET remove the contractor from the directory.

b. Shall require the contractor prior to reinstatement to complete two (2) hours of Continuing Education specific to conflict resolution or customer relations, <u>or</u> successfully resolve at least one of the complaints.

c. Shall inform RESNET when the contractor's certification has been reinstated, and shall request that RESNET reinstate the listing on the directory.

1006.4.5.2 Second Offense: Second time an EnergySmart Contractor has three unresolved complaints within a 90 day period or has five outstanding unresolved complaints, the CEQ Provider shall suspend the contractor's certification for a period of not less than 90 days, and:

a. Shall inform RESNET that the contractor's certification has been suspended, and shall request that RESNET remove the contractor from the directory.

b. Shall require the contractor prior to reinstatement to complete three (3) additional hours of Continuing Education <u>and</u> successfully resolve at least one of the complaints.

c. Shall inform RESNET when the contractor's certification has been reinstated, and shall request that RESNET reinstate the listing on the directory.

1006.4.5.3 Third Offense: Third time an EnergySmart Contractor has three unresolved complaints within a 90 day period, or has five (5) outstanding unresolved complaints , the CEQ Provider shall suspend the contractor's certification for a period of not less than twelve (12) months, and:

a. Shall inform RESNET that the contractor's certification has been suspended, and shall request that RESNET remove the contractor from the directory.

b. Shall require the contractor, prior to reinstatement, to complete three (3) additional hours of Continuing Education and successfully resolve at least three of the complaints.

c. Shall inform RESNET when the contractor's certification has been reinstated, and shall request that RESNET reinstate the listing on the directory.

1006.5 Rating Provider Quality Assurance Review of Rater Final Verification of EnergySmart Projects

1006.5.1 The Rating Provider will have a Quality Assurance (QA) Designee that shall perform QA review of a Raters' Final Verification of an EnergySmart Project.

1006.5.2 Quality Assurance File Review (QA File Review)

1006.5.2.1 For each Rater/Auditor that performs Final Verification for an Energy Smart Project the Rating Provider's QA Designee shall annually conduct QA File Review of the Final Verification documentation file(s) for 10% of verified projects or one verified project, whichever is greater,

a. Project documentation file(s) shall include copy of the original work scope and signed proposal, Rater/Auditor and Contractor names and contact information, program sponsor name, completed final verification checklist, energy simulation software file, and all test out results.

b. When the Rating Provider's QA Designee conducts the QA File Review, they shall review at least one project documentation file for each EnergySmart Contractor and EnergySmart Team. The QA Designee shall equitably distribute the QA File Reviews of each individual EnergySmart Contractor's or Team's Projects.

1006.5.2.2 The QA Designee will confirm that each EnergySmart Contractor for the project has been approved by a RESNET-approved CEQ Provider as demonstrated by listing on the RESNET EnergySmart Contractor Directory.

1006.5.2.3 The QA Designee will verify the completion of the Rater Final Verification checklist.

a. There must be consistency between the Final Verification Checklist and final test out results, copy of work scope, and signed proposal.

b. Must include reported results of nonconformance by Final Verification.

1006.5.2.4 The QA Designee will review 10% of the Rater/Auditor Final Verifier energy simulation software file and projected estimated energy savings.

1006.5.3 Quality Assurance Field Review (QA Field Review)

1006.5.3.1 For each Rater/Auditor that performs Final Verification for an EnergySmart Project the QA Designee shall annually conduct QA Field Reviews of EnergySmart Projects at a rate of 1% of verified projects or one project, whichever is greater.

1006.5.3.2 The QA Designee shall confirm the results of the Final Verifier's combustion appliance testing where applicable.

a. Where there are vented combustion appliances that use indoor air to vent combustion gasses, test Worst Case Depressurization in accordance with the QH Standard.

b. Where any spaces contain combustion appliances, test for Carbon Monoxide in accordance with the QH Standard.

1006.5.3.3 The QA Designee shall review the work scope and signed proposal, and shall confirm installed measures are consistent with selected measures and work scope in accordance with the QH Standard.

1006.5.3.4 The QA Designee shall confirm the Final Verifier's Estimate of Project Energy Savings as follows:

a. Calculate an independent estimate of projected energy savings for the EnergySmart Project using the same RESNET-approved software used by the Final Verifier.

b. Compare the Final Verifier's final estimated energy savings against the QA Designee's independent calculation of estimated energy savings.

c. The QA Designee's results must be within 5% of the Final Verifier results.

1006.5.4 Non-Compliance and Resolution

1006.5.4.1 Reporting: Non-compliance of an EnergySmart Project with respect to installed measures or estimate of projected energy savings shall be reported to the CEQ Provider's Compliant Resolution Officer (CRO).

1006.5.4.2 Discipline: Non-compliance of the Final Verifier's Final Verification of an EnergySmart Project with respect to installed measures or estate of projected energy savings shall result in additional action in accordance with the Rating Provider's written Disciplinary Procedures.

1006.5.4.3 Record-Keeping: Rating Providers shall maintain Quality Assurance records for every EnergySmart Project that has received Documentation or On-Site QA Review for a period of no less than three years and that will include the following:

a. Copy of work scope and signed proposal

b. Names and contact information of the Rater/Auditor, ES Contractors, and Final Verifier

c. Program sponsor name

d. Completed final verification checklist

e. All test out results

f. QA Review Results

NATIONAL HOME ENERGY RATING TECHNICAL GUIDELINES

December 28, 2005

Appendix A

ON-SITE INSPECTION PROCEDURES FOR MINIMUM RATED FEATURES

Excerpted from: *Guidelines for Uniformity: Voluntary Procedures for Home Energy Ratings, Version 2.0*, Home Energy Rating Systems Council (HERSC), August 1996.
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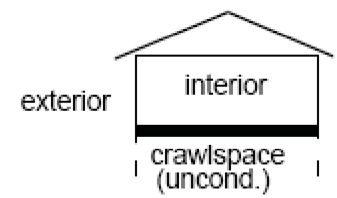
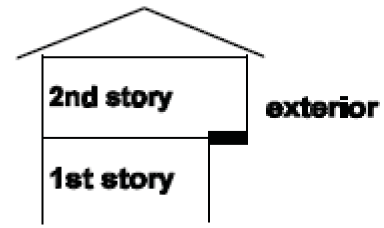
ON-SITE INSPECTION PROCEDURES FOR MINIMUM RATED FEATURES

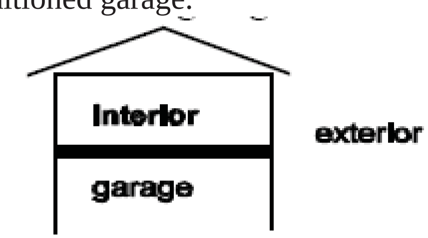
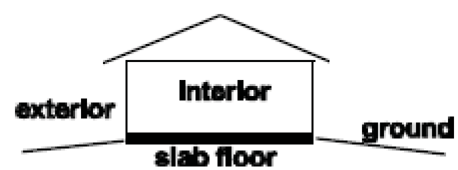
Building Element: Foundation		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Conditioning of space	Determine whether a crawl space or basement is unconditioned, indirectly conditioned or directly conditioned	To determine whether a crawl space or basement is conditioned, assess the insulation placement in the walls or floor/ceiling assembly. A vented crawl space is considered unconditioned regardless of the location or existence of insulation. This is because the ambient temperature of the crawl space is close to the outdoor ambient temperature.  An unvented crawl space or basement may be considered either unconditioned, indirectly conditioned, or fully conditioned, based on the following criteria: *Unconditioned* -Foundation walls are not insulated, floor/ceiling assembly is insulated, and any heating or plumbing distribution systems in the space is insulated. The intention in an unconditioned crawl space or basement is to minimize the heating system losses into the space by means of the distribution and plumbing insulation, and to minimize heat flow through the insulated floor/ceiling assembly. *Conditioned, indirectly* -Foundation walls are not insulated with floor/ceiling assembly insulated and distribution system in the space uninsulated, or foundation walls insulated with floor ceiling assembly insulated or non-insulated and distribution system uninsulated. In an indirectly conditioned crawl space or basement, heating or cooling is unintentionally delivered to the space either through the floor/ceiling assembly or by unintentional losses

		from the heating/cooling system. Indirectly conditioned spaces are typically between the temperature of the outdoor ambient temperature and the indoor conditioned space temperature.

Building Element: Foundation (continued)

Rated Feature	**Task**	**On-Site Inspection Protocol**
Conditioning of space (continued)	Determine whether a crawl space or basement is unconditioned, indirectly conditioned or directly conditioned (continued)	*Conditioned, directly* -Foundation walls insulated or uninsulated and basement or crawl space is intentionally or unintentionally conditioned, by means of a forced air heating or cooling system, hydronic heat, electric resistance, etc. Fully conditioned spaces are typically maintained at the same temperature as the above grade spaces. The distinction between indirectly and directly conditioned basement spaces may be difficult, but is important from a heat transfer perspective. Rater judgment will have to be utilized in many cases. Interview the owner about the temperature in the basement during the heating season, and assess the potential for standby loss from the heating equipment and distribution system, e.g., jacket insulation, leakiness of ducts, insulation on distribution systems, etc.
Construction type	Identify floor over crawl space	A crawl space is typically defined as a foundation condition with a clear vertical dimension 4 feet high or less. Crawl spaces may be vented or unvented. Vented crawl spaces have some form of vent or louver in the crawl space walls, or are constructed in such a manner so that air moves freely from outside the walls to inside the crawl space. Unvented crawl spaces are constructed without any form of vents or louvers in the wall, and are constructed to exclude, to the greatest extent possible, air leakage from outside the walls to inside the crawl space. Crawl spaces may be accessed by a hatchway in the floor of the house or in the wall of the crawl space. To identify a crawl space, look for foundation vents and/or stairs leading up to floor levels from the outside of the building.
	Identify floor over full basement	A full basement has characteristics similar to an unvented crawl space, except that the clear vertical dimension is typically greater than 4 feet. Stairs that lead from the main floor to a below grade space are an indication of a basement in a house, although a house may have a basement with access similar to a crawl space access.

	Identify floor over exterior space	Floor area that borders exterior unenclosed space above grade is considered floor to exterior. For example, in a two story house, the second story may extend horizontally further than the first story, creating some floor area that is exposed to the exterior. 

Building Element: Foundation (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
	Identify floor over unconditioned garage	Identify floors over an unconditioned garage. 
	Identify slab on grade foundation	A slab on grade can be recognized by the absence of either a crawl space or basement. A slab on grade is constructed by pouring a concrete slab directly on the ground as the floor for the house. 
	Identify walkout basement	A walkout basement, if fully conditioned, is typically considered partially slab on grade

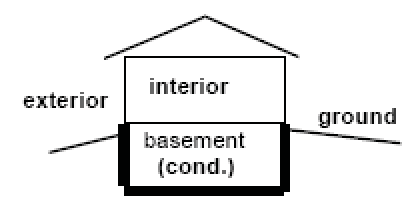
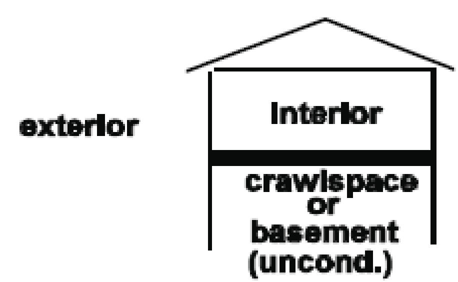
		construction (where the floor level is above grade) and partially a basement (where the floor level is below grade).
Interior surface condition	Determine the inside surface condition of floor (exposed or covered)	*Covered* -If floor is covered with wall-to-wall carpet, consider it covered. Floors with only area rugs are not considered covered. *Exposed* -If the floor has tile, linoleum or wood, consider it exposed.

Building Element: Foundation (continued)

Rated Feature	**Task**	**On-Site Inspection Protocol**
Surface area	Measure floor dimensions	Measure floor dimensions in accordance with ANSI Z765-1996 with the exception of Section 3 Paragraph 6 (floor areas with ceiling heights of less than 5' will be included in finished square footage). For conditioned basements and crawl spaces, find dimensions of basement walls and floor. Divide walls into above and below grade sections. Measure the house or assembly element (window, wall, ceiling, etc.) to the nearest inch, and record the square footage to the nearest square foot. Use exterior measurements; those measurements should start at the exterior finished surface of the outside wall. Openings to the floor below should not be included in the square footage calculation, with the exception of stairways; stairways and associated landings are counted as square footage on both the starting and ending levels. Do not include the "footprint" of protruding chimneys or bay windows. Do include the "footprint" of other protrusions like a cantilever when it includes finished floor area. Do include the square footage of separate finished areas that are connected to the main body of the house by conditioned hallways or stairways. Note to divide basement and crawl space walls into above and below grade.
Thermal mass	Determine presence of thermal mass	Concrete slabs and basement walls when uninsulated or insulated on the exterior can be considered as thermal storage mass when combined with solar gain from south fenestration. Note type of thermal mass: concrete, brick, tile, water.

		South fenestration is defined as fenestration oriented between 45E SE to 45E SW. Slab-on-grade construction in climates with more than 3600 HDD (65) may not be considered solar storage mass unless properly insulated (edge, perimeter, or under slab).

Building Element: Floor of conditioned basement or crawl space

Rated Feature	Task	On-Site Inspection Protocol
Insulation	Determine insulation in walls and floor of conditioned basement or crawl space	If basement or crawl space is determined to be fully conditioned, its walls and floor are considered part of the building envelope. (The floor between the house's ground floor and the basement or crawl space is considered an interior boundary with no associated heat transfer calculated.)  Determine insulation type, thickness and R-value in walls. Wall insulation may be located inside foundation wall (studs and batts, foam under drywall, etc.), integral with foundation wall (insulated cores of block wall, insulating concrete block such as insulating formwork) or outside the foundation wall (rigid foam insulation).
Insulation	Determine amount of floor insulation	

		Use the inspection guidelines under “Walls—Insulation value” to assess “Grade I”, “Grade II”, or “Grade III” installation. Note: in addition to the inspection guidelines under “Walls”, “Grade I” installation for floor insulation also requires that the insulation be installed in complete contact with the subfloor surfaces it is intended to insulate. For loose fill applications, multiply the thickness of the insulation (in inches) by the appropriate R-value per inch based on the insulation type in order to calculate the total existing floor insulation R-value. Floor insulation over unconditioned basements or enclosed (vented or unvented) crawlspaces need not be enclosed to attain a “Grade II” or “Grade I” assessment; floor insulation over ambient conditions does.

Building Element: Slab-on-grade

Rated Feature	**Task**	**On-Site Inspection Protocol**
Perimeter	Determine perimeter of slab foundation	Determine the perimeter of the slab foundation by measuring each dimension to the nearest ½ foot and adding them together.
Insulation	Determine if slab perimeter insulation exists	If present, slab perimeter insulation is usually installed on the outside of the slab and extends both above and below grade. To identify slab perimeter insulation, look for a protective coating above grade as opposed to the usual exposed slab edge at any conditioned space(s). Move a little bit of dirt away from an edge of the slab where conditioned space is located. If present, the rigid insulation around the perimeter of the slab may be seen. However, it may be difficult to visually verify the existence of slab perimeter insulation because of the protective covering which may be installed over the rigid insulation. Slab insulation may also occur between the foundation wall and the slab itself, although this is harder to assess and verify. If the floor has carpeting, a sharp needle may be poked through the carpet near the baseboard on an outside wall. If the needle penetrates beyond the depth of the carpet, there is probably foam insulation between the slab and foundation wall.

		Under slab insulation cannot be assumed to exist unless visually verified by a photograph of construction, at chase way, at sump opening or at plumbing penetrations.

Building Element: Walls

Rated Feature	**Task**	**On-Site Inspection Protocol**
Color	Determine the color of the wall	Identify the color of the wall as light, medium, or dark.
Construction type	Determine the structural system of walls	*Wood framing* -is very common in residential construction. Wood studs are located 16" or 24" on center all along the wall. Knocking on the wall will give a "hollow" sound in the cavities between the studs and a "solid" sound at the stud locations. *Metal framing* -can be found in some newer residential construction. A strong magnet slid against the wall will hold to metal framing. Also check inside the attic at the edges for evidence of metal wall framing. *Masonry walls* - include walls constructed of concrete or brick. A wood framed wall with brick veneer would not be considered a masonry wall. Also note the siding or finish material on the wall. *Foam core walls* - are a sandwich panel consisting of a foam center with outer layers of structural sheathing, gypsum board or outer finish materials. Foam core panels may be structural (load bearing) or non-structural. Non-structural panels are frequently used in post and beam construction. *Log walls* - are typically solid wood walls, using either milled or rough logs or solid timbers. Some homes may have the appearance of solid log walls, yet may actually be wood frame walls with siding that looks like solid logs inside and out. Some log walls are manufactured with insulated cores. Unless manufacturer's documentation is available or visual inspection of insulation type and thickness can be made, assume no added insulation exists in a log wall.

Building Element: Walls (continued)

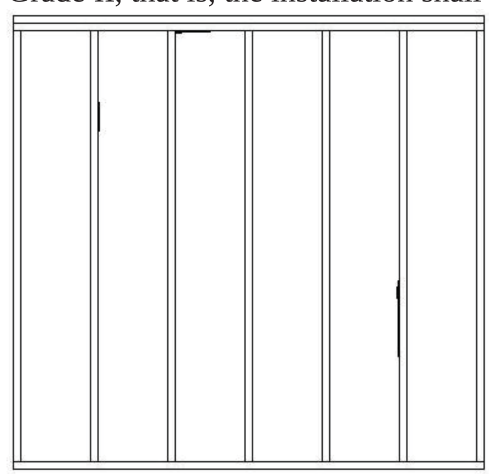
Rated Feature	Task	On-Site Inspection Protocol
Framing members	Determine framing member size for all framed walls exposed to unconditioned space	To determine whether 2x4 or 2x6 framing exists: Measure the width of the window jambs; Subtract the widths of the wall coverings and sheathing materials (approximately .25" to 1.0" for stucco, .5" to .6" for interior sheetrock, and .5" to .75" for other exterior siding materials); Compare the remaining width to 3.5" for a 2x4 wall or 5.5" for a 2x6 wall; If exposed garage walls exist, examine them for reference (although they will not *always* be the same as other walls); If a wall does not come close to the framing width of a 2x4 or 2x6, inspect for foam sheathing on the inside or outside of the walls. In superinsulated construction, "double stud" or "strapped" walls may account for thickness greater than 5.5". For brick veneer walls, assume 4.5" - 5" for brick, airspace and sheathing material. Check the framing member size on all sides of the house. If an addition has been added, be sure to check the walls of the addition separately. If the house has more than one story, check the framing member size for each floor.

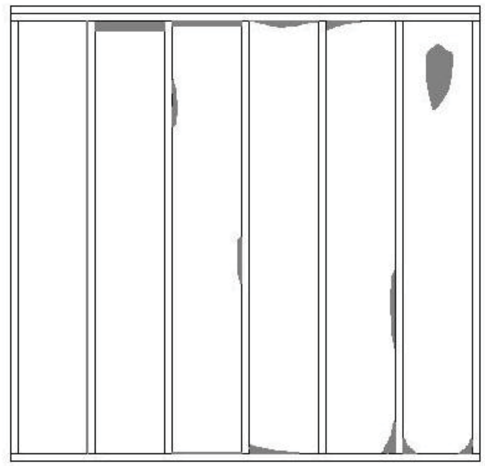
Building Element: Walls (continued)

Rated Feature	Task	On-Site Inspection Protocol
Insulation value	Determine type and thickness of existing	<u>Framed Walls</u> Check at plumbing outlet under sink or, in order of preference, remove cable outlet plate,

	insulation and resultant R-value	telephone plate, electrical switch plates and/or electrical outlet plates on exterior walls. Probe the cavity around the exposed plate with a non-metal device (such as a plastic crochet hook or wooden skewer). Determine type of insulation (fiberglass, cellulose insulation, foam, etc.). Inspect outlets/switch plates on each side of the house to verify that all walls are insulated. Multiply the wall framing member size (in inches) by the R-value per inch. Be sure to use the actual thickness of the insulation when calculating the total insulation R-values. Use 3.5" for 2 x 4 walls and 5.5" for 2 x 6 walls constructed after 1945. Parts of the house that were added later must be checked separately from the original walls. <u>Sheathing</u> Insulated sheathing may exist on walls, but can be difficult to verify. Walls with insulated sheathing may be thicker than walls without insulated sheathing. Visual verification of insulated sheathing may be found in the attic at the top of the wall, exterior wall penetrations, and at the connection between the foundation and the wall.

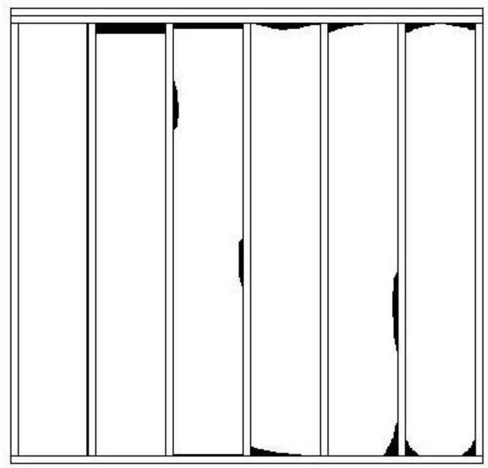
Building Element: Walls (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Insulation Installation	Determine cavity insulation installation characteristics	When it is possible to inspect insulation as installed (i.e., new construction), inspectors shall rate the installation as “Grade I, II, or III” according to the following guidelines, regardless of insulation material or installation process. Note that all insulation installation techniques require proper care to ensure they are completed correctly; if they are not, thermal performance can suffer dramatically. These guidelines apply to cavity fill insulation, continuous rigid insulation, and any other field-installed insulation products. 1. "Grade I" shall be used to describe insulation that is generally installed according to manufacturers instructions and/or industry standards. A "Grade I" installation requires that the insulation material uniformly fills each cavity side-to-side and top-to-bottom, without substantial gaps or voids around obstructions (such as blocking or bridging), and is split, installed, and/or fitted tightly around wiring and other services in the cavity. To inspect, probe in, around, or through the insulation and/or vapor retarder in several places to see whether these requirements are met. Replace or repair the vapor retarder and insulation as necessary. During inspection (typically before drywall is installed), if the exterior sheathing is visible from the building interior through gaps in the cavity insulation material, it is not considered a “Grade I” installation. To attain a rating of "Grade I", wall insulation shall be enclosed on all six sides, and shall be in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity. Exception: the interior sheathing/enclosure material is optional in climate zones 1-3, provided insulation is adequately supported and meets all other requirements. For rim or band joist insulation, use the inspection guidelines under “Walls—Insulation value” to assess “Grade I”, “Grade II”, or “Grade III” installation. Exception: the interior sheathing/enclosure material is optional in all climate zones, provided insulation is adequately supported and meets all other requirements.

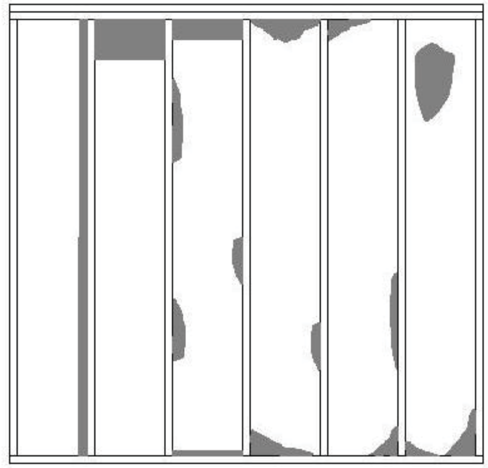
		For exterior applications of rigid insulation, insulation shall be in firm contact with the structural sheathing materials, and tightly fitted at joints to be considered a "Grade I" installation. For faced batt insulation, Grade I can be designated for side-stapled tabs, provided the tabs are stapled neatly (no buckling), and provided the batt is only compressed at the edges of each cavity, to the depth of the tab itself, and provided it meets the other requirements of Grade I. For sprayed or blown-in products, density shall be sufficient that the fill material springs back when compressed slightly with a hand or finger, and provided it meets the other requirements of Grade Interpretation: The following illustrations represent the boundary conditions between Grade I and Grade II, that is, the installation shall be at least this good to be labeled as "Grade I":  Occasional very small gaps are acceptable for "Grade I".

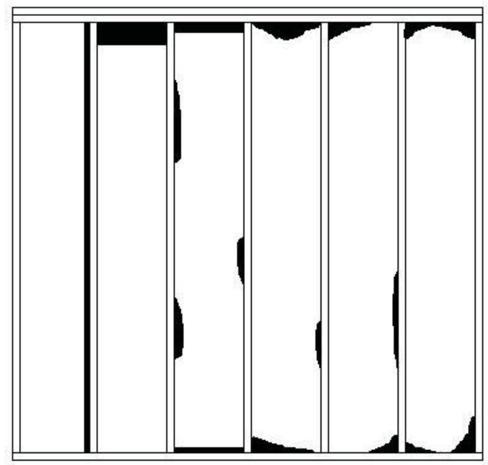
<table>
<tr><td></td><td></td><td>
Compression or incomplete fill amounting to 2% or less, if the empty spaces are less than 30% of the intended fill thickness, are acceptable for “Grade I”.

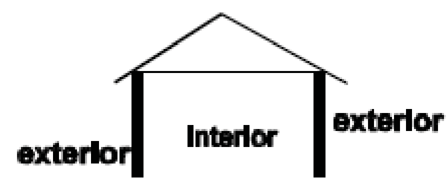
The following standards may be applied as a reference: NAIMA, Recommendations for Installation in Residential and Other Light-Frame Construction—Fiber Glass Home Insulation (PUB # BI402), Recommendations for Installation in Residential and Other Light-Frame Construction—Fiber Glass Loose Fill Insulation (PUB # BI403), CIMA, Technical Bulletin #2 -- Standard Practice for Installing Cellulose Building Insulation, Technical Bulletin #3-- Standard Practice for Installation of Sprayed Cellulosic Wall Cavity Insulation. For other products and materials, manufacturer's installation instructions will apply.

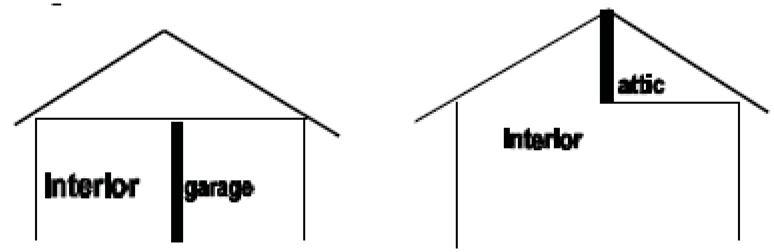
2. "Grade II" shall be used to describe an installation with moderate to frequent installation defects: gaps around wiring, electrical outlets, plumbing and other intrusions; rounded edges or “shoulders”; or incomplete fill amounting to less than 10% of the area with 70% or more of the intended thickness (i.e., 30% compressed); or gaps and spaces running clear through the insulation amounting to no more than 2% of the total surface area covered by the insulation. To attain a rating of "Grade II", wall</td></tr>
</table>

		insulation shall be enclosed on all six sides, and shall be in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity. Interpretation: The following illustrations represent the boundary conditions between Grade II and Grade III, that is, the installation shall be at least this good to be labeled as “Grade II”:  No more than 2% of surface area of insulation missing is acceptable for “Grade II”

		 No more than 10% of surface area of insulation compressed or incomplete fill, by up to 30% (70% or more of intended thickness) is acceptable for “Grade II”. 3. "Grade III" shall be used to describe an installation with substantial gaps and voids, with missing insulation amounting to greater than 2% of the area, but less than 5% of the surface area is intended to occupy. More than 5% missing insulation shall be measured and modeled as separate, uninsulated surfaces according to 3.B.5.p. This designation shall include wall insulation that is not in substantial contact with the sheathing on at least one side of the cavity, or wall insulation in a wall that is open (unsheathed) on one side and exposed to the exterior, ambient conditions or a vented attic or crawlspace. The presence of an air-impermeable barrier such as housewrap will be considered to enclose the building cavities. Interpretation: The following illustration represents the boundary conditions between Grade III and the situation whereby one must measure the uninsulated areas; that is, the installation shall be at least this good to be labeled as “Grade III”:

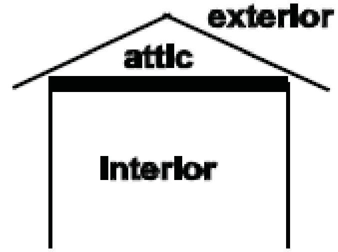
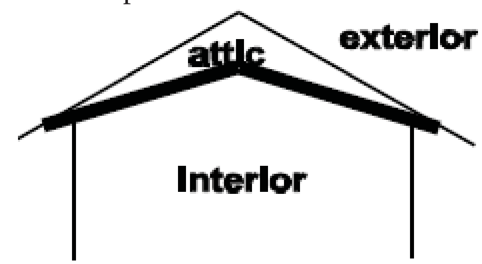
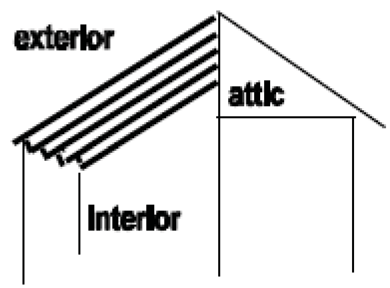
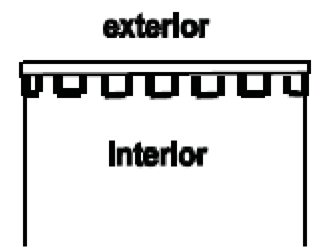
		

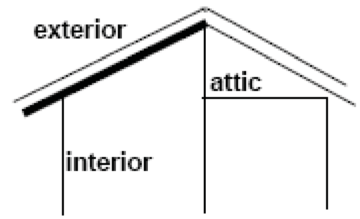
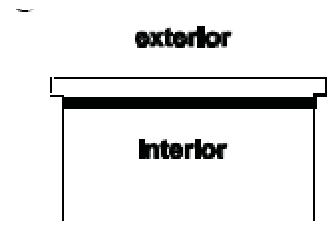
Building Element: Walls (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Location	Determine whether walls border exterior space, attic, garage or crawl space	*Wall to exterior* -Walls border exterior space.  *Wall to enclosed unconditioned space* -Walls that border unconditioned attics, garages and crawl spaces.

		
Surface area	Determine surface area of all walls exposed to unconditioned space	Measure linear perimeter of the walls to the nearest ½ foot. Measure the interior wall height of the walls to the nearest 1/4 foot. Use these measurements to calculate surface area.
Thermal mass	Determine type and thickness of all mass walls	If the dwelling's walls are constructed of concrete, masonry or brick, determine their type and thickness. Solid concrete walls (poured) Measure the thickness of the poured concrete wall in inches. Concrete Masonry Unit Cinder block or uninsulated concrete wall - hollow in the middle. May contain vermiculite or perlite insulation. Check for additional insulation (interior furring, foam board, foam fill). Measure the thickness of the wall in inches.

Building Element: Roof/Ceiling

Rated Feature	Task	On-Site Inspection Protocol
All ceiling areas between conditioned and unconditioned space	Obtain measurements of all ceiling areas	Measure the linear perimeter of the ceiling area to the nearest ½ foot and use these measurements to calculate surface area of the ceiling. If a ceiling area is vaulted, it may be necessary to calculate dimensions geometrically.

		Identify the ceiling as one of the following types. <u>Ceiling to attic</u> If the ceiling has attic space above (even if the ceiling is vaulted, as in a scissor truss) it is considered ceiling to attic. If there is a vaulted ceiling check it's angle against the angle of the roof -- if the ceiling angle is gentler there is attic space above the ceiling. Also check for an attic access, either separate or from an attic over another part of the house.   Framed ceilings fall into two categories: *Roof on exposed beams or rafters* - when you look up from inside the room, you will see exposed beams or rafters.  

Building Element: Roof/Ceiling (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
All ceiling areas between conditioned and unconditioned space (continued)	Determine ceiling construction type (continued)	*Finished framed ceiling* -if the ceiling is framed (has no attic space above it, but you cannot see the rafters because the ceiling is finished with drywall, plaster, paneling, etc.) consider it a finished framed ceiling.  
	Determine the size of the framing members for framed ceilings	Determine the framing member size for framed ceilings exposed to unconditioned spaces. Check the framing by looking for an access through an attic over another part of the house or by looking at the rafters from the outside.
Color	Determine the color of the roof	Identify the color of the roof as light, medium or dark. Also check for a special reflective roof coating.
Construction type	Determine the roof's construction type	Identify the type of roofing surface. Some common types include: Asphalt shingle; Pebble/gravel built-up roof; Tile roof; Wood shingle roof; Rubber roof/roof coating; Metal.
Insulation value	Determine R-value of insulation in attic	Measure the average depth in four places.

Building Element: Ceiling (continued)

Rated Feature	Task	On-Site Inspection Protocol
Insulation value	Determine R-value of insulation in attic	Use the inspection guidelines under “Walls—Insulation value” to assess “Grade I”, “Grade II”, or “Grade III” installation. Note: in addition to the inspection guidelines under “Walls”, “Grade I” installation for ceiling insulation also requires that the insulation be installed in complete contact with the drywall or sheathing surfaces it is intended to insulate. For loose fill applications, be sure to get four readings which accurately reflect the insulation level (the depth should be representative of the entire attic area being examined). Multiply the minimum depth of insulation by its R-value per inch to obtain the total R-value. Insulation in ceilings with attic above need not be enclosed to attain a “Grade II” or “Grade I” assessment. For sealed, unvented attic/roof assemblies, the interior sheathing/enclosure material is optional in climate zones 1-3, provided insulation is adequately supported and meets all other requirements, including full contact with the exterior (roof) sheathing. For ceiling insulation, eave baffles or equivalent construction is required to prevent wind washing to be considered “Grade I”. Note whether the cavity insulation leaves the framing elements exposed, or covers them; if covered, note the thickness that covers the framing.
	Determine the R-value of insulation in framed ceiling	Determine the insulation R-value which exists in the ceiling area (cavity). Use the following method for calculating the overall ceiling R-value: • Determine the type of ceiling insulation present (may be a combination of more than one type); • Multiply the R-value of the material by the depth of the insulation; • If there is no access to the framed ceiling, ask the customer for documentation of insulation or use a default value based on age.

Building Element: Roof Ceiling (Continued)

Rated Feature	Task	On-Site Inspection Protocol
Insulation value	Determine insulation value	The rim joist is the band joist around the perimeter of the floor joists over a basement or crawl space, or between 2 stories of a house. <u>Crawl space or Basement</u> From the basement or crawl space, visually identify and measure the depth of insulation at the rim joist. The insulation used is generally fiberglass batts, often folded in an L-shape and attached to the rim joist. Rigid board insulation may also be found.
Insulation value (continued)	Determine insulation value (continued)	<u>Between Stories</u> Look for access to the area from a garage or a utility access trap door. Visually identify and measure insulation if it exists. If no access can be found, assume insulation exists at the rim joist between stories if: • Insulation was found at the rim joist at the top of the crawl space or basement in the same house; or • Insulation is found in the walls of the same house. Otherwise, assume no rim joist insulation exists.

Building Element: Doors

Rated Feature	Task	On-Site Inspection Protocol
Construction type	Determine construction type of doors	Determine if the exterior door(s) is fiberglass, metal, or wood by making a close inspection of its texture, distinguishing the sound produced when knocking on it, and checking its side view.
Insulation	Determine whether doors are insulated	Judge whether the exterior door(s) is insulated (or not) by its sound, temperature transfer, labeling, or thermal break. *Sound* - Insulated/solid door will sound dull when knocked on. An uninsulated/hollow door

		will sound hollow. *Heat transfer* - Feel the inside and outside of the door with flat palms. Insulated/solid door will less readily transfer heat. The inside will feel warmer in cold outside weather and cooler in hot outside weather than an uninsulated/hollow door.
Insulation (continued)	Determine whether doors are insulated (continued)	*Labeling* - Check the side view of the door at the hinges for a descriptive label. *Thermal break* - Check the side view of metal doors for thermal breaks.
Surface area	Determine surface area of doors	Measure the surface area of the door(s) to the nearest ½ square foot.

Building Element: Windows		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Area	Determine area of windows	Measure the area of the window openings using width times height to the nearest inch. Window openings are measured from the outside edge of the framing and include the frame width.

Building Element: Windows (continued)		
Construction type	Determine window framing and glazing characteristics	<u>Framing Type</u> Examine each window frame in order to determine the type of material used. Open the window and examine it to see whether the frame is made of metal, wood, or vinyl. Tap the frame with fingernail or knuckle to test if it's vinyl or metal. Wood frames are usually thicker than metal. If the window is dual-pane or multiple-pane and is metal framed, determine if a thermal break is present by looking for two separated metal extrusions connected by a rubber spacer. Ask the customer for documentation if you can't tell.

		Some wood windows may have vinyl or aluminum cladding. Check both the inside and outside, since some windows will have vinyl cladding on one side only. <u>Glazing Type</u> Check all windows in the house for number of panes and existence of tint and/or low-e coating. To determine whether the windows are single-paned or multiple-paned: • Look at frame width and spacers; • Look at reflections; • Look at edge thickness. To determine if glazing has a tint or low-e coating: • Check the customer's product literature if available; • Perform a "match test" - there should be one reflection per pane or coating, including low-e and tinting (e.g., a double-paned window with low-e and tint should show 4 reflections); • Compare to glazing samples with and without tinting; • Compare the windows within the space, since tinting is often applied only to certain windows in a house; • Look for a low-e label or etching on the glass.
Orientation	Determine orientation of all windows	Use a compass (adjusting for magnetic deviation) to determine orientation of all windows.
Building Element: Windows (continued)		
Shading	Determine shading of windows	Identify shading by external shade screens, house overhangs/awnings, and shade from trees and other buildings. <u>External Shade Screens</u>

		The most common screen is an insect screen that covers some or all of the window. If it is a full-coverage type screen, assume it is a shade screen. Compare samples of the screen's mesh pattern to those of a window screen sample to determine the type and shading coefficient of the screen. Ask customer for documentation for the shading coefficient (SC) of the screen. If you cannot determine the shading coefficient of the screen, use 36% SC as a default. <u>Projection (Overhang)</u> The shading impact of an overhang can be found by measuring the distance of the projection from the exterior wall surface and the distance (height) between the top of the window and the bottom edge of the overhang. Measure the length of the overhangs over each exterior wall. Measure the height above the window to the bottom edge of the overhang. <u>Exterior Shading</u> *Full (40% SC)* -Consider a 40% SC for an entire side of a house as being roughly equivalent to having a shade screen over a window. For trees and/or bushes to equal this effect, there should be a very dense amount of trees and/or bushes along the entire side of the house that shade both its vertical and horizontal surfaces almost totally. *Partial (70% SC)* -Based on the above definition for full shading, partial shading is considered to be anything in between full and none (no shading). *None (100% SC)* - No shading indicates there may be small plants or shrubs only,

Building Element: Windows (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Solar heat gain factor	Determine solar heat gain factor of glazing	Check product information and consult NFRC guide.
U-value	Determine window U-value	Look for an NFRC label on new windows (it will display full window U-value). If no label can be found but customer has documentation, look up product information in NFRC Certified Products Directory to determine U-value, or consult manufacturer's literature.

Building Element: Skylights		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Area	Determine area of skylights	See windows.
Construction type	Determine framing and glazing characteristics of skylights	See windows.
Orientation	Determine orientation of skylights.	Determine the orientation of the lower edge of the skylight. Use this direction as the orientation of the skylight.
Shading	Determine shading of skylights	See windows.
Solar heat gain coefficient	Determine solar heat gain coefficient of skylights	See windows.
Tilt	Determine tilt of skylights	Measure the tilt of the skylight relative to horizontal. This can be done with a level and angle finder instrument, or geometrically with a protractor (from the ceiling length and heights).
U-value	Determine skylight U-value	See windows.

Building Element: Air leakage		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Blower door test	Determine effective leakage area from a blower door test	Use the testing protocol described in ASHRAE Standard 119 Section 5.1, with the modifications described below: The following protocol shall be followed in preparing the building envelope for testing: 1. Leave all supply registers and return grills open and uncovered. 2. Leave all bathroom and kitchen fans open (i.e., in their normal operating condition). Only a permanently installed back draft damper in its normal condition may impede the flow of air. 3. Leave any combustion air ducts or louvers to the exterior open. (If a homeowner or builder has sealed them off, open them for the test.) 4. Leave any make-up air ducts with in-line dampers (e.g., for large kitchen exhaust fans or combustion air) as-is (unsealed). Only a permanently installed back draft damper or motorized damper, in its normal condition may impede the flow of air. 5. Leave the dryer vent as-is, whether or not the dryer is in place during the test. Only a permanently installed back draft damper in its normal condition may impede the flow of air. 6. Leave open any outside air duct supplying fresh air for intermittent ventilation systems (including a central-fan-integrated distribution system) 7. Operable crawl-space vents, where present, are to be left in the open position. 8. Open all interior doors within the conditioned space, including doors to conditioned basements. (Closet doors may be left closed unless the closet contains windows or access to the attic or crawl space). 9. Leave louvered openings of a whole-house fan as is. (If there is a seasonal cover in place during the test, leave it in place.) 10. Close all doors to the exterior or unconditioned spaces; if any door to the exterior or unconditioned space lacks weather-stripping at testing time, it can be temporarily

		taped off. 11. Close and latch all windows. 12. Close chimney dampers. 13. Either seal or fill with water plumbing drains with p-traps that may be empty. 14. Seal off exterior duct openings to *continuously operating* fresh-air or exhaust-air ventilation systems (preferably at the exterior envelope). 15. Close any adjustable window trickle ventilators and/or adjustable through-the-wall vents. 16. If an evaporative cooler has been supplied with a device used to seal openings to the exterior during the winter, that device should be installed for the test. Use the testing protocol described in ASHRAE Standard 119 Section 5.1. Blower door and associated pressure testing instruments, which include but are not limited to hoses, and Manometers, gauges and fans shall be field tested annually for calibration by the HERS provider or rater. The provider shall use a standard for field testing of calibration provided by the equipment manufacturer. Magnehelic Gauges cannot be field tested and shall be recalibrated by the Blower Door manufacturer annually. Field check the fan and flow measuring systems for defects and maintain them according to manufacturers recommendations The HERS provider shall maintain a written log of the annual calibration check to verify all equipment accuracy for a period of three (3) years. These records shall be made available within 24 hours to a RESNET Quality Assurance Committee member upon request. It is recommended all pressure equipment be field checked for calibration more frequently than is required in these standards, i.e., monthly, quarterly, etc.
Conditioned volume of space	Determine conditioned volume of space	Determine conditioned and indirectly conditioned volume of space by multiplying conditioned floor area by ceiling height. The house may need to be split into different spaces with different ceiling heights and added to each other for both conditioned and indirectly conditioned spaces. For areas with vaulted ceilings, volume must be calculated geometrically.

Estimate	If diagnostic equipment is not used, determine window type and distribution system to estimate leakage	To be determined.
Tracer gas test		To be determined.

Building Element: Heating & Cooling/Distribution System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Air leakage (ducts)	Determine air leakage from ducts	The application of ASHRAE Standard 152 for testing of ducted distribution systems shall be implemented with the following additions and exceptions: 1. Air Handler Fan Flow Measurement using either of the methods specified in Annex A of the standard is preferred. If such measurement is not made, default values of 275 CFM per 12,000 btu/hour of nominal HVAC capacity shall be used. For fossil-fired furnace systems, a default value of 200 CFM for every 12,000 btu/hour of nominal furnace capacity shall be used for heating. 2. Supply and return leakage may be determined by measuring the leakage of each side as in Annex B, or as an alternate the leakage of the entire system may be measured, with the duct pressurization device in the return and the duct-pressure probe in the supply side. The ratio of supply side leakage to return side leakage Q25,s to Q25,r shall be selected separately for heating and cooling based on a worst case determination. The supply side of the system shall be assigned 67% of the leakage and the return shall be assigned 33%, and the overall distribution efficiency determined; then the efficiency with the reverse conditions (67% return and 33% supply) shall be determined, and the lower of the two efficiencies will be applied. 3. Total leakage (Annex C) . The limitation of applicability of Annex C (Section C1) to leakage measurement of 10% or less of air handler air flow shall be based on tested air flow or default air flow, as appropriate according to (1) above. The calculations of 2.5% of air flow in Section C1.1,2, and 3 shall use tested air flow,

		or nominal air flow of 400 CFM per ton. If the register grilles are not installed during the test (C1.2), the 2.5% of fan flow added to the measured leakage may be waived, on condition that a visual inspection, verifying effective sealing of register boot-to-drywall and/or boot-to-subfloor connections, is conducted prior to issuing the final rating.
Insulation	Determine the value of distribution system insulation	Air ducts may be insulated with insulation blankets or rigid insulation board. Inspect the duct or pipe insulation for R-value labeling (printed on the insulation by the manufacturer). If the insulation is not marked with the R-value, identify type and measure the thickness of the insulation to determine R-value. Check for internal insulation by tapping on the exterior and listening to the sound.
Location of air ducts	Determine the location of ducts	Air ducts may be located in the attic, crawl space, basement or in a conditioned area. You must locate and differentiate between supply and return ducts. Ducts may be located in more than one area (e.g., some return ducts in attic and some in conditioned space, etc.).
Type	Identify type of distribution system used to provide space heating and cooling	*Forced air* - a central fan unit connected to ducts which supply heated or cooled air to each room in the home. Forced air systems have supply and return duct work. Supply ducts typically run to each room; return duct work may come from each room or from one or more central locations in the home. *Forced hot water* - heated water is pumped through a series of radiator elements to supply heat. The radiator elements may be conventional radiators, baseboard "fin tube" radiators, cast iron baseboards or radiant hot water panels located at the baseboards or on walls or ceilings. *Hot water radiant system* - heated water is circulated through plastic or metal tubing which is installed in a concrete slab or finished floor or, occasionally, in walls or ceilings. *Unit heater/air conditioner* - heating or cooling is supplied directly from a heating or cooling device located within the space it serves. Window air conditioners and through-the-wall heaters are common examples. Unitary equipment typically has no distribution system.

Building Element: Heating & Cooling/Distribution System (continued)

Rated Feature	Task	On-Site Inspection Protocol
Type (continued)	Identify type of distribution system used to provide space heating and cooling (continued)	*Steam heating* - steam systems utilize a distribution system with cast iron radiators connected to a boiler that creates steam. The steam rises into the radiators through one set of pipes, condenses into water, and drains back to the boiler through another set of pipes. *Electric radiant system* - electric cables are installed in concrete floor slabs or in the ceiling. Electric current is passed through the cables, causing them to heat up, heating the floor or ceiling assembly which radiates the heat to the space. Electric radiant systems may also be comprised of individual radiant panels mounted on the walls or ceilings. *Baseboard electric resistance* - electric elements are installed in baseboard enclosures. Electric current is passed through the electric element to provide heat to the space.

Building Element: Heating and Cooling/Energy Source		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Fuel type	Determine fuels used for heating and cooling	Heating systems may use natural gas, propane, oil, electricity, or some other fuel. Typically the homeowner will know what type of heating fuel is used. Cooling is typically driven by electricity, however some cooling equipment may use natural gas or propane. Look for electric cables and dedicated fuses or circuit breakers for the cooling equipment or gas lines running to the equipment. Note that gas equipment will also have electric cables to power some of the components. Be sure to distinguish between refrigerant lines and possible gas supply lines. *Oil* - look for a large storage tank (typically oblong-shaped) or fill pipes which would indicate a buried tank. Oil is typically supplied to the heating equipment via a 1/4" - 3/8" copper line. A fuel filter may be evident in the line. *Natural gas* - look for a meter connected to piping on the exterior of the home. Piping to the heating equipment is typically done with ½" - 1" iron piping. *Propane* - look for storage tank(s) (typically cylindrical-shaped). Large tanks may be buried with a 12" - 18" cap exposed above grade. Fuel is typically supplied to equipment through 1/4" - 3/8" diameter copper piping. *Electric* - look for large gauge cables running to a central piece of equipment or look at circuit breaker panel for circuits marked for resistance heat circuits (electric resistance or electric radiant systems). *Other fuels* - include coal, wood, processed wood pellets, or other combustible products.

Building Element: Heating and Cooling/Equipment

Rated Feature	Task	On-Site Inspection Protocol
Control system	Identify the control system for the heating and cooling system(s)	Determine the type of control systems. There may be separate controls for the heating and cooling systems. Thermostat controls may be programmable. Note types of features available and/or utilized.
Efficiency	Determine the heating and cooling equipment efficiency	Check nameplate for efficiency rating. If the nameplate is missing, use appropriate directories to determine an appropriate default value. SEER is used to measure the efficiency of central air conditioning and air source heat pump systems. AFUE is used to measure the efficiency of furnaces and boilers. EER is used to determine the efficiency of room air conditioners and ground source heat pumps. Check nameplate for SEER or AFUE rating. EER can be calculated from nameplate information by dividing btu output by watt input.

Building Element: Heating and Cooling/Equipment (continued)

Rated Feature	Task	On-Site Inspection Protocol
Equipment type	Identify type(s) of equipment for heating and/or cooling	*Furnace* - comprised of a combustion chamber and heat exchanger (natural gas, propane or oil) or an electric resistance element (electric) and a fan which forces air across the heat exchanger or resistance element to provide heat in a forced air system. *Fan coil unit* - hot water from a boiler, domestic water heater, or heat pump is circulated through a coil. A fan blows air over the coil to provide heating. This device is used in a forced air system. *Boiler* - this device creates hot water or steam, and can be powered by any fuel type. Can be used with forced air (in conjunction with a fan coil unit), forced hot water, steam, or hot water

		radiant slab systems. *Split system central air source heat pump* - these systems move energy from one location to another using the vapor compression cycle. They are electrically driven, and can provide heating in winter and cooling in summer by reversing the direction of heat flow. Split system heat pumps consist of an outdoor unit and an indoor air handling unit, resembling a furnace. These systems require ductwork for air distribution. Most air source heat pumps incorporate electric resistance supplemental heat in the indoor section. However, some heat pump systems use fossil fuel furnace for supplemental heating. These are known as "dual fuel" or add-on systems. *Single package central air source heat pump* - a single package central heat pump is similar to a split system, except it combines the functions of the indoor and outdoor units into one cabinet, usually mounted on the roof or on the ground. It also requires a separate distribution system. These are uncommon in single-family residences, however they are sometimes found in multi-family dwellings.

Building Element: Heating and Cooling/Equipment (continued)

Rated Feature	**Task**	**On-Site Inspection Protocol**
Equipment type (continued)	Identify type(s) of equipment for heating and/or cooling (continued)	*Ground source heat pumps* - are coupled to the ground through the use of a water well sometimes the same well as used for domestic water (known as "open loop" which water or a water/antifreeze mixture is circulated (known as "closed loop"). Look for 3/4" or larger diameter piping going to and from the heat pump. Circulating pumps may be installed in this piping (closed loop systems) or the pump for the water well may be used for circulating water through the heat pump (open loop). The same piece of equipment can be used in either open or closed loop applications, however given the same piece of equipment, closed loop applications typically have lower efficiency ratings than open loop applications. Ground source heat pumps can also utilize a direct expansion of the refrigerant with copper piping

		buried in the ground. Look for 0.25" - 0.50" copper piping leading from the unit to the outdoors with no outdoor unit. *Split system central air conditioner* - similar to a split system air source heat pump. Consists of an outdoor unit and a coil in the forced air distribution system, usually in a fossil fuel furnace. These systems are electrically powered and provide cooling. *Single packaged central air conditioner* - similar to single packaged air source heat pumps, providing cooling only. *Through-the-wall ductless air source heat pump* - a single packaged air source heat pump designed to be installed without a distribution system. Provides both heating and cooling and is usually installed through an exterior wall. *Window/through-the-wall air conditioner* - a single packaged ductless air conditioner designed to be installed without a distribution system. *Direct evaporative cooler* - is used primarily in very dry climates. Evaporative coolers work by blowing air over a damp pad or by spraying a fine mist of water into the air. Direct evaporative coolers add moisture to the home. *Indirect evaporative cooler* - evaporation takes place on only one side of a heat

Building Element: Heating and Cooling/Equipment (continued)

Rated Feature	Task	On-Site Inspection Protocol
Equipment type (continued)	Identify type(s) of equipment for heating and/or cooling (continued)	*Absorption cooler* - this is a gas air conditioner. Look for a cooling tower, an exhaust pipe, a gas burner to evaporate refrigerant and a heat exchanger similar to an electric air conditioner. *Unitary space heater* - these are fossil fuel burning heaters which have individual controls and no distribution system. They may be equipped with a fan for forcing air circulation over a heat

		exchanger, or they may use simple convective forces. These heaters are typically mounted on outside walls in order to facilitate venting and can use natural gas, kerosene, propane, or other types of fossil fuel.
Location	Determine the location of heating and cooling equipment	Note whether systems are located in conditioned or unconditioned space.

Building Element: Domestic Hot Water System		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Efficiency	Determine the Energy Factor or Seasonal Efficiency of the water heater	<u>Storage Water Heater</u> Look for the water heater's rating plate and product literature. Some water heaters will list their EF right on the rating plate. If the water heater is wrapped and there is no accessible information, approximate the age of the unit and use a default efficiency. If accessible, record the Make and Model #. Look up the EF rating of that model in an appropriate efficiency rating directory. If the EF rating is not listed in the directory use a default based on the estimated age of the water heater. <u>Instantaneous Water Heaters</u> Check the unit's nameplate for the RE (Recovery Efficiency). If a gas model, note whether there is a standing pilot light.

Building Element: Domestic Hot Water System (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**

Extra tank insulation value	Determine the insulation value of any exterior wrap	Visually determine if the water heater is wrapped with exterior insulation. If so, measure thickness of the wrap and determine R-value.
Location	Determine location of storage tank	Determine whether water heater is located in conditioned or unconditioned space.
Pipe insulation value	Determine the insulation value of the pipes	Determine whether pipe insulation is installed on all 3/4" or larger, non-recirculating hot water mains. Measure depth of insulation and identify material to determine R-value.
System type	Determine type and heat source of water heater	<u>Storage</u> These water heaters are the most common type. Water is heated in an insulated tank that typically ranges in capacity from 30 to 75 gallons. Storage water heaters may use electric resistance, gas, propane, oil or electric heat pump. *Storage electric* -look for rigid or flexible 240 A/C conduit, UL seal, no vent, no burner or pilot tubing. Thermostats are usually hidden behind metal access doors. Often there is both an upper and a lower thermostat. *Storage gas* -look for a vent connection (top of tank), gas connector and line valve, thermostat, burner and pilot tubing, burner compartment doors, and "AGA" seal rating plate. Most gas water heaters have legs to lift the unit above the floor level to provide combustion air to the burner. *Storage propane* -look for the same features as those listed for gas water heaters. Also, look for a rating plate or tag that states "For Use with LP Gas Only." *Storage oil* -look for features that are similar to a gas water heating storage system. In addition, oil systems are usually furnished with draft regulators which are attached to the vent pipe between the tank and chimney (hinged metal flap with counterweight to allow for variations in flue gas pressure). Vent dampers may also be apparent on the vent pipe. *Storage heat pump* -water heaters remove heat from the air in the room where they are located and then release the heat to the water in the storage tank. Look for the same features as those

		found on electric water heating systems. In addition, there will be a fan, condenser and evaporator. Also, the system may be one single unit, or may be a split system.

Building Element: Domestic Hot Water System (continued)

Rated Feature	**Task**	**On-Site Inspection Protocol**
System type (continued)	Determine type and heat source of water heater (continued)	*Combination DHW/furnace system* - natural gas combo systems use heat drawn from a hot water tank circulating through an air handling module to heat the space. *Geothermal heat pump de-superheaters* - devices which utilize heat pump cycle superheater to heat domestic hot water. Look for insulated lines between air handler unit and storage water heater tank. <u>Instantaneous</u> These water heaters heat water on demand, instead of storing pre-heated water in a large tank. They are usually small units, with storage of no more than 2 gallons, and are often attached to a wall close to the point of use. Instantaneous water heaters may be used in addition to a primary storage water heater to serve fixtures in a distant location of the house, so check for a main storage unit as well. Determine if the instantaneous heater uses gas or electricity. *Instantaneous gas* - look for a connector and line valve, vent connection, thermostat, burner and pilot tubing, and AGA seal. Check whether unit has a pilot light or intermittent ignition device. *Instantaneous electric* - look for the absence of a gas line, vent or pilot light. Look for a UL seal. *Super-heater* - check for this supplementary heat source.

Building element: Solar Domestic Hot Water System

Rated Feature	Task	On-Site Inspection Protocol
Collector	Determine area, orientation, and tilt of collector	Determine the area of the collector. Determine the orientation of the solar collector by taking a compass reading (adjusting for magnetic deviation) in the direction toward which the collector faces. Determine the tilt of the collector. A site selection and angle finder instrument can be used to determine the tilt of the collector. Geometric calculations based on horizontal length and vertical height measurements can also be used.
Efficiency	Determine efficiency of solar system	Look for SRCC label. Check for SRCC system and component name plates. Refer to the Directory of SRCC Certified Solar Collector and Water Heating System Ratings, or other SRCC literature for energy factor (EF) and other performance data.
Extra tank insulation value	Determine the insulation value of any exterior wrap	See Domestic Hot Water, above.
Pipe insulation value	Determine the insulation value of the pipes	Determine the R-value of insulation installed on pipes.
Solar collector type	Identify type of solar collector	Identify the type of solar collector by checking for the SRCC label or manufacturer's information.
Storage tank size and location	Determine the capacity of the storage tank and location	To determine the size of the storage tank refer to documentation or a label indicating the tank capacity. Note if storage is inside or outside of conditioned space.

Building element: Solar Domestic Hot Water System (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
System type	Determine type of solar systems	Identify whether a solar domestic hot water system exists. These systems collect and store solar thermal energy for domestic water heating applications. If a solar water heating system

		exists, determine system type. For systems manufactured after Jan. 1, 1995, system type, energy factor (EF), and other performance characteristics shall be determined from the SRCC label (usually affixed to the solar storage tank) and by referring to SRCC literature. For systems lacking an SRCC label, energy factor and other performance characteristics can be determined using a certified HERS modeling tool, or appropriate default values. Identify as passive or active. Base your evaluation on these criteria: *Passive* - No purchased electrical energy is required for recirculating water through a passive solar collector. Three types of passive systems are integrated collector storage (ICS), thermosiphon systems and self-pumped systems. *Integrated Collector Storage (ICS)* - consists of a single unit which incorporates both collector and water storage. An example is the common "bread box" design. Storage is usually outside the conditioned space. *Thermosiphon* - consists of a flat-plate solar collector and hot water storage tank. Instead of using a pump, circulation of the fluid is achieved by natural convection action. The storage tank must be located above the collector, and is usually outside the conditioned space. *Self-pumped* - circulates fluid from storage to collectors without purchased electrical energy. Photovoltaic and percolating systems are examples of self-pumped systems. The storage tank is usually inside the conditioned space. *Active* -Also known as pumped systems. *Pumped* -purchased electrical energy input is required for operation of pumps or other components. The storage tank is usually inside the conditioned space.

Building Element: Passive Solar Heating System

Rated Feature	Task	On-Site Inspection Protocol
Direct gain	Identify system type and determine solar aperture orientation, aperture area	A solar direct gain system can reduce heating, cooling, and lighting energy requirements through proper sizing, placement, orientation, and/or control of windows, skylights, shading devices, and solar storage mass within the building. To determine aperture area, measure width and height of south-facing glazing and indicate tilt angle. Note glass type(s) (e.g., double glazing) and presence of night insulation (if any). Determine orientation with a compass reading (adjusted for magnetic deviation). Determine the type of thermal mass, its thickness and dimensions. Determine if the mass will be lit by direct solar rays between the hours of 9:00 a.m. and 3:00 p.m. during the winter. Note any trees or other obstructions to solar gain.
Greenhouse or solarium	Identify system type and determine solar aperture orientation, aperture area and information about thermal mass	A greenhouse or solarium creates a South-glazed buffer zone between the house and the exterior and can help heat the living area. They may be used in conjunction with thermal mass (such as bricks or drums filled with water) to store heat and reradiate it at night. See Direct gain, above, for specific inspection items.

Building Element: Passive Solar Heating System (continued)		
Rated Feature	**Task**	**On-Site Inspection Protocol**
Thermal storage mass	Identify system type and determine solar aperture orientation, aperture area and information about thermal mass	Thermal mass systems consist of solar-exposed heavyweight materials with high heat capacitance and relatively high conductance (high thermal diffusivity) such as masonry, brick, concrete, tile, stone, or water placed in the same zones(s) as the solar collection area(s). These elements may be integral with the building or distinct elements within the building. Distinct components: *Trombe wall* -uses a heat storage mass placed between the glass and the space to be heated.

		Measure area of storage mass, determine material, thickness, and capacitance. *Water wall* -replaces the existing wall, or parts of it, with containers that hold water.
Thermosiphon Air Panel (TAP)	Identify system type	*Thermosiphon air panel (TAP)* -has one or more glazing layers of glass or plastic, an air space, an absorber, another air space, and (often) an insulated backing. These are similar in appearance to active flat-plate collectors, often mounted vertically on walls, or ground-mounted, so that the living space is higher than the collector to facilitate convection from the TAP to the house. See Greenhouse, above, for specific inspection items.

Appendix B
GLOSSARY OF TERMS

***Abnormal* -** Some defect exists in the construction and operation of the building enclosure.

ACCA - Air Conditioning Contractors of America

ACCA QA Program - A quality assurance recognition program for HVAC contractors, in which participants (1) attest that they have implemented written policies and procedures in the ANSI/ACCA 5 QI-2010 Standard to effect quality on a consistent basis in the field, (2) complete and submit a detailed HVAC system installation checklist, and (3) have specific elements of the installation validated by a 3rd party Rater for compliance to the EnergyStar New Homes Program requirements. More information can be found at www.acca.org/qa.

***Accreditation Identification Number (AIN)* –** A unique accreditation number assigned to each Provider for each Provider category accreditation.

***Accreditation Committee* –** A Standing Committee of the RESNET organization that is responsible for the review and approval of all Applications for Provider accreditation submitted to RESNET.

Accredited Rating System Provider - A home energy rating Provider accredited through the Mortgage Industry National Home Energy Rating System Standards.

Accredited Rater Training Provider or Training Provider - A home energy Rater training organization accredited by RESNET.

***Acrylic Adhesive Tape* -** Any tape composed of an acrylic nature used as a sealing material primarily for moisture intrusion for house wraps, around windows, and to seal sheets of polyethylene covering the dirt on the floor of a crawl space or a basement

***Additional Failure* –** When additional instances of initial failure(s) are identified in one or more of the other homes in the sample set being tested or inspected.

***Air Barrier* -** Any solid material installed to control air leakage either into or out of the building envelope. The material used shall have an air permeability not to exceed 0.004 cubic feet per minute per square foot under a pressure differential of 0.3 in. water (1.57 psf) (0.02 $L/s.m^2$ @ 75 Pa.) when tested in accordance with ASTM E 2178-01.

***Air Exfiltration* -** Air from the conditioned space leaking outside of the thermal boundary of a structure.

***Air-free Carbon Monoxide* -** A unit of measurement designed to compensate for the excess air to the burner and is only used to express CO levels in a flue gas sample as opposed to ambient air testing. The measurement represents the CO levels with no excess air in the sample or with "perfect" combustion (an unrealistic situation). The measurement incorporates an adjustment to the as-measured CO ppm (parts per million) value to simulate oxygen-free conditions in the sample. (See "as-measured carbon monoxide.")

***Air Infiltration* -** Air from outside the thermal boundary of a structure, which enters the conditioned space.

***Air Leakage Site* -** A specific location in a structure where the air barrier has irregularities in it allowing both air infiltration and exfiltration depending on the interior pressures of the building.

***Air Pressure Boundary* -** Any part of the building shell that offers resistance to air leakage. The most effective Air Pressure Boundary consists of a series of air barriers of interior and/or exterior sheeting material that resists airflow through it. An effective air pressure boundary is nearly airtight.

***Air Wash* -** The movement of air through insulation.

***Annual Fuel Utilization Efficiency* or *AFUE* –** A standardized measure of heating system efficiency, based on the ratio of annual output energy to annual input energy that includes any non-heating season pilot input loss.

***Anomaly (defect)*-** An area of a building where the temperature distribution seen with an infrared imaging system differs by more than 4°F from the temperature distribution expected for the type of construction being viewed, denoting a possible problem area; an inconsistency.

***ANSI* -** American National Standards Institute

***As-measured Carbon Monoxide* -** A direct measurement of carbon monoxide CO in a sample of air or flue gas, usually measured in ppm (parts per million) units. (See "air-free carbon monoxide.")

***ASHRAE* -** American Society of Heating, Refrigerating and Air-Conditioning Engineers

***ASNT* -** American Society for Nondestructive Testing

***ASTM* -** ASTM International, originally known as the American Society for Testing and Materials (ASTM)

***Atmospherically-Vented* -** An appliance using a natural draft venting system.

***Atmospheric Pressure* -** The weight of air and its contained water vapor on the surface of the earth; at sea level, this pressure is 14.7 pounds per square inch.

Auditor An individual who is certified by a RESNET accredited Home Energy Survey Provider to conduct comprehensive home energy audits. Auditors shall be certified as Home Energy Raters by a RESNET accredited Home Energy Rating Provider.

***Auxiliary Electric Consumption* –** The annual auxiliary electrical energy consumption for a fossil fuel fired furnace or boiler in kilowatt-hours per year, derived from the Eae as follows:

> Auxiliary Electric Consumption (kWh/yr) = Eae * (HLH) / 2080) – where: HLH = annual heating load hours seen by the furnace/boiler. Note: If fan power is needed (kW), it is determined by Eae / 2080.

***Back Draft* -** Sustained downdraft during burner operation.

***Base Load* -** An estimate of fuel consumption that does not include cooling or heating fuel consumption.

***Bedroom* –** A room or space 70 square feet or greater, with egress window and closet, used or intended to be used for sleeping. A "den." "library," "home office" with a closet, egress window, and 70 square feet or greater or other similar rooms shall count as a bedroom, but living rooms and foyers shall not.

***Biomass Fuel* –** Non-liquid and non-gaseous combustible substance burned to create energy, such as chunk wood, wood chips, corn husks, etc.

***Biomass System* –** A biomass fuel combustion device and all associated mechanisms, controls, venting, and heat delivery components designed to provide space heating.

***Blackbody* -** An object or surface which absorbs all radiant energy, within a specific spectral band, coming into contact with the surface and does not reflect or transmit any. Thus, the surface has an emissivity of 1.

***Boiler* -** A space heating appliance that heats water with hot combustion gases that pass through a heat exchanger.

***BPI* -** Building Performance Institute

***Building Analyst (BA), Certified* -** An individual who successfully passes the BPI written and field examination requirements for certification in order to evaluate the performance of a home, taking into account systems, physical conditions and other energy and non-energy characteristics of the home.

***Building Performance Auditor* -** A Building Performance Auditor is an individual who is certified by a RESNET accredited Home Energy Audit (HEA) Provider to conduct the evaluation, diagnosis, and testing of an existing home's performance and provides a prioritized work scope for cost-effective energy saving measures and features to the homeowner. As the house is a system, a BPA is competent in building analysis, envelope/shell evaluation and work scope preparation. (1006.1.1.1.1.1)

***Building Envelope* -** The components of a building (walls, ceilings, windows, doors, floors, and foundations) that separate the conditioned space from the unconditioned spaces or conditioned space from outside..

CAZ - See "Combustion appliance zone"

Carbon Monoxide (CO) - An odorless, colorless gas that can cause illness or death.

***Carbon Monoxide Emissions* -** Carbon monoxide (CO) resulting from combustion as
measured in ppm (parts per million. The measurement of CO emissions in flue gas requires a sample to be taken before dilution air enters the venting system. (See "air-free carbon
monoxide" and "as-measured carbon monoxide.")

***CHERS Rater* -** A Comprehensive Home Energy Rating System Rater is an individual who is certified by an accredited HERS Provider to inspect, diagnose and test an existing-home in order to evaluate each of the minimum rated features establish by RESNET, prepare a comprehensive HERS rating according to Chapters One and Three of the RESNET Mortgage Industry National Home Energy Rating Standard (RESNET Standards), and provide a prioritized work scope for the cost-effective energy saving measures and features to the homeowner. In addition to Rater training, a CHERS Rater has completed training on combustion safety diagnostics and retrofit work scope preparation and requirements. (1006.1.1.1.1.2)

***Climate Zone* –** A geographical area defined as having similar long-term climate

***Code Approved HVAC Tape* -** Any tape that is approved by current International Codes (UL181 A or 181 B) used for the air sealing of a heat and air duct system.

***Combustion Appliance Zone (CAZ)* -** A contiguous air volume within a building that contains a combustion appliance; the zone may include, but is not limited to, a mechanical closet, mechanical room, or the main body of a house, as applicable.

***Complain Resolution Officer (CRO)* -** The individual assigned to manage complaint and resolution procedures for the CEQ Provider.

***Comprehensive Home Energy Audit* -** A level of the RESNET Home Energy Audit process defined by this standard to include the evaluation, diagnosis and proposed treatment of an existing home. The Comprehensive Home Energy Audit may be based on a Home Performance Assessment ("Comprehensive Home Performance Energy Audit") or Home Energy Rating ("Comprehensive HERS Audit"), in accordance with the criteria established by this Standard. A homeowner may elect to go through this process with or without a prior Home Energy Survey or Diagnostic Home Energy Survey.

Compression (insulation) - This condition includes but is not limited to batt insulation compressed behind plumbing, heat and air, electrical, and other in cavity obstructions that results in the loss of R-value of the installed insulation. This condition can also occur within a wall cavity without obstructions. See also "Misalignment".

***Conditioned Floor Area (CFA)* –** The finished floor area in square feet of a home that is conditioned by heating or cooling systems, measured in accordance with ANSI Standard Z765-2003 with exceptions as specified in Appendix A of this Standard.

***Conditioned Space* -** Any directly conditioned space or indirectly conditioned space, as defined in this standard.

***Conditioned Space Boundary* –** The continuous planes of the building envelope that comprise the primary thermal and air flow barrier between the directly or indirectly conditioned space and either the outdoors or an adjacent unconditioned space.

Contractor, Certified - A contractor accredited by the Building Performance Institute (BPI) or an equivalent certification organization recognized by the Home Performance with ENERGY STAR® Program to complete specific home performance improvement work.

***Contractor Education and Qualification Provider (CEQ Provider)* -** An organization approved by RESNET in accordance with the requirements of these guidelines to train and prepare individuals to be an EnergySmart Contractor's Designated Qualification Representative and to perform the other duties of a Contractor Education and Qualification Provider established herein.

***COP* –** Coefficient of Performance, which is the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions.

Crawl Space - A shallow unfinished space, beneath the first floor or under the roof of a building allowing access to wiring or plumbing.

***Data Collection* -** The gathering of information on building energy features, energy use history and other relevant building and building operation information.

***Defect* -** See Anomaly

Design Temperature - A high or low outdoor temperature equaled or exceeded 97.5% of the time, used for designing heating and cooling systems.

***Detached One- and Two-Family Dwelling* –** A building with one or two independent dwelling units with an individual or central HVAC system.

***Dewpoint* -** The temperature at which a given air/water vapor mixture is saturated with water vapor (i.e. 100% relative humidity). Consequently, if air is in contact with a surface below this temperature, condensation (dew) will form on the surface.

***Diagnostic Testing* -** The use of building performance-testing equipment (e.g. blower door, duct blaster, flow hood, infrared camera, CO monitor, etc.) to measure, assess and document specific performance characteristics of the building system.

***Dilution Air* -** Air that enters a draft diverter or draft regulator from the room in which the appliance is located.

***Directly Conditioned Space* –** An enclosed space having heating equipment with a capacity exceeding 10 Btu/hr-ft^2, or cooling equipment with a capacity exceeding to 10 Btu/hr-ft^2. An exception is if the heating and cooling equipment is designed and thermostatically controlled to maintain a process environment temperature less than 65 degrees Fahrenheit or greater than 85 degrees Fahrenheit for the whole space the equipment serves.

***Direct Vent Appliance* -** A combustion appliance for which all combustion gases are vented to the outdoors through an exhaust vent pipe and all combustion supply air is vented to the combustion chamber from the outdoors through a separate, dedicated supply-air vent.

***Distribution System Efficiency* –** A system efficiency factor, not included in manufacturer's performance ratings for heating and cooling equipment, that adjusts for the energy losses associated with the delivery of energy from the equipment to the source of the load, such energy losses associated with heat transfer across duct or piping walls and air leakage to or from forced air distribution systems.

Downdraft - Air flow from a chimney or venting system into an enclosed building space.

***Draft* -** A pressure difference that causes combustion gases or air to move through a vent connector, flue, chimney, or combustion chamber.

***Draft Diverter* -** A nonadjustable device built into an appliance or a part of a vent connector that is intended to (1) permit the escape of flue gases in the event of a blockage or backdraft; (2) prevent a downdraft of outdoor air from entering the combustion chamber of an appliance; (3) reduce the effect of the chimney's stack action; and (4) lower the dew point temperature of the flue gas by the infusion of room air.

***Draft Regulator* -** A self-regulating damper attached to a chimney or vent connector for the purpose of controlling draft: A draft regulator can reduce draft; it cannot increase draft.

***Drainage Plane* –** A seamless or overlapping membrane designed to redirect water away from vulnerable building materials.

***EAE* –** The average annual auxiliary electrical energy consumption for a gas furnace or boiler in kilowatt-hours per year as published in the AHRI Consumer's Directory of Certified Efficiency Ratings.

***Emissivity* -** The ability of a surface to emit radiation, measured as the ratio of the energy radiated within a specific spectral band by a surface to that radiated within that same specific spectral band by a blackbody at the same temperature.

Energy Efficiency Rating - An unbiased indication of a home's relative energy efficiency based on consistent inspection procedures, operating assumptions, climate data and calculation methods.

***Energy Analysis Tool* –** A computerized calculation procedure for determining a home's energy efficiency rating and estimating annual purchased energy consumption and cost.

***Energy Efficiency Ratio, or EER* –** the ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

***Energy Efficiency Rating, or Energy Rating* –** See Home Energy Rating.

***Energy Factor, or EF* –**A standardized measure of water heater energy efficiency as determined under Department of Energy Regulations, 10 CFR 430.23(e)(2)(ii).

Energy Saving Measure, or Feature - Any material, component, device, system, construction method, process, or combination thereof that will result in a reduction of energy use.

***EnergySmart Contractor* -** A home improvement contracting company that has been approved by a CEQ Provider to implement energy-saving work scope recommendation prescribed by a certified CHERS Rater or Building Performance Auditor. A home improvement company from any of the trade categories defined on the Directory, who is compliant with the RESNET training, examination and the program requirements contained herein is eligible for designation as EnergySmart and may be listed on the Directory

***EnergySmart Contractor Directory (Directory)* -** A listing of approved EnergySmart Contractors that is posted on the RESNET website.

***EnergySmart Contractor Candidate for Recognition (Candidate)* -** A company with a Designated Qualification Representative who intends to become an EnergySmart Contractor, who shall list itself in the Candidate section, and who shall have 90 days to complete its qualification requirements and receive approval by a CEQ Provider. If the Candidate has not been approved within the time limits, their listing will be removed.

***EnergySmart Contractor Representative (Representative)* -** An individual employed by or a representative of an EnergySmart Candidate, with the necessary level of authority who shall take the required course, pass the RESNET core exam, and otherwise ensure that the contractor, once approved as an EnergySmart Contractor, complies with the terms and conditions of the Directory.

***EnergySmart Improved Home* -** A home that has undergone an EnergySmart Project for which the estimated energy savings calculated by an Independent Rater/Auditor using RESNET-approved software amounts to no less than a 30% reduction in estimated energy usage as a result of the improvements. A home that meets these requirements shall be labeled with the language, "This home is designated as an EnergySmart Home. As such, the estimated energy usage of the home has been reduced by XX%. It is estimated that the improvements to this home will save approximately $XXX per year."

***EnergySmart Project* -** A home performance improvement project with the goal of achieving a 30% reduction in estimated energy usage. The project shall be completed by an EnergySmart Home Performance Team; as such it must involve at least one EnergySmart Contractor and an Independent RESNET Rater/Auditor, one of which acts as the Project Manager, and in which applicable improvement measures are installed by one or more EnergySmart Contractors based upon the assessment and work scope from a RESNET Rater/Auditor. An EnergySmart project shall include Final Verification of the project post-improvement by an Independent Rater/Auditor, who shall calculate the estimated energy savings using RESNET-approved software.

***EnergySmart Project Manager* -** The company or individual with whom the homeowner contracts for the coordinated installation of comprehensive energy-saving retrofits prescribed by a certified Rater/Auditor, and who is responsible for the duties of Project Manager. The EnergySmart Project Manager could be the Rater/Auditor or an EnergySmart Contractor that meets the additional qualification defined in Section 1004.6.

***EnergySmart Home Performance Team (EnergySmart Team)* -** A team consisting of EnergySmart contracting companies and a RESNET certified Rater/Auditor who can collectively prescribe, complete and verify an EnergySmart Home Project.

***EPAct* -** The U.S. Energy Policy Act of 1992.

***Equivalent Electric Energy* –** The amount of electricity that would be produced from site fossil fuel uses when converted to electrical power using the Reference Electricity Production Efficiency.

***Estimated Annual Energy Cost Savings* –** Positive dollar difference between estimated annual energy costs for an improved existing home as compared with the same home in its original condition or for a new home, as compared with the HERS Reference Home, local code or, for the purposes of Fannie Mae mortgages, the RESNET representation of the 1993 Model Energy Code, whichever is applicable.

***Ethics & Appeals Committee* –** A Committee that is responsible for investigating ethics and consumer complaints and hearing a Provider's appeal of its non-approval or renewal of an application, probation, suspension, or revocation.

Evaluation - An analysis of the data collected from any survey or audit, on-site data collection and performance testing, available energy usage records to determine energy use and potential savings from improvements.

Examination - Test administered by an accredited Rater Training Provider from questions developed by Training and Education Committee.

***Excess Air* -** Air supplied to a burner in excess of the amount needed for complete combustion.

***Exposed Wall* –** Walls subjected to heat loss or gain.

***Failed Item* –** A "failed item" constitutes a category of failure, such as insulation installation, duct leakage, prescriptive air sealing requirements, insulation enclosure, eave baffles, mechanical system efficiency, window specifications, etc. For the purpose of follow-up inspections, a "failed item" is not limited to the specific instance in a home but to that category of the minimum rated features as it applies to that home design.

Failure - When one or more of the threshold specifications is not met during the testing and inspection process.

***Fenestration* –** A glazed opening and its associated sash and framing that is installed into a building.

***Fan-assisted Combustion* -** A combustion appliance with an integral fan that draws combustion supply air through the combustion chamber.

Field-of-View (FOV) - The total area of height by width, normally expressed in either degrees or radians, in which an infrared imaging system is capable of displaying, imaging, and recording objects.

Final Verifier - The Final Verifier must be an independent RESNET Rater/Auditor that did not conduct the initial EnergySmart Project rating/audit, or that does not have a financial interest in any of retrofit work done for the EnergySmart Project, or that is not employed by a company who performs any part of the retrofit work

Flame Rollout - A condition in which burner flames discharge from the cabinet of a combustion appliance.

Flashing - sheet material used to cover building joints to prevent bulk water entry

Framing Spacing - The distance from center to center of wall studs, ceiling joists, floor joists and roof rafters.

Furnace - A space heating appliance that heats indoor air with hot combustion gases that pass through a heat exchanger.

Gaps (insulation) - An insulation defect where installed insulation does not completely fill areas of the building enclosure, which allows for conductive and convective heat loss and a reduced R-value of the overall building enclosure.

Heat Exchanger - A device built for heat transfer from one medium to another. The medium may be separated by a solid wall, so that they never mix, or they may be in direct contact. Furnaces contain heat exchangers, of referred to as combustion chambers, made from stamped steel. Air is directed around the exchanger while the combustion process is occurring inside the heat exchanger, allowing the exchange of heat into the air medium, which is then transferred into the home.

Heat Pump - A vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of heat flow may be reversed in order to transfer heat from one location to another using the physical properties of an evaporating and condensing fluid known as a refrigerant. Most commonly, heat pumps draw heat from the air or from the ground moving the heat from a low temperature heat source to a higher temperature heat sink.

Heating Seasonal Performance Factor, or HSPF - A standardized measure of heat pump efficiency, based on the total heating output of a heat pump, in Btu, divided by the total electric energy input, in watt-hours, under test conditions specified by the Air Conditioning and Refrigeration Institute Standard 210/240.

HERS-BESTEST – The Home Energy Ratings System Building Energy Simulation Test published as NREL Report No. NREL/TP-472-7332

***HERS Index* –** A numerical integer value that represents the relative energy use of a Rated Home as compared with the energy use of the HERS Reference Home and where an Index value of 100 represents the energy use of the HERS Reference Home and an Index value of 0 (zero) represents a home that uses zero net purchased energy.

***Home* –** A building with one or more dwelling units that has three or fewer stories above grade, or a single dwelling unit within a building of three or fewer stories above grade.

***Home Energy Assessment* -** Defined by this standard as one of two levels of energy assessment of a home, including Home Energy Survey and Comprehensive Home Energy Audit.

***Home Energy Rater, or HERS Rater or Rater* –** An individual meeting the minimum training requirements for Raters set forth in Chapter 2 of these Standards, documented by an Accredited RESNET Training Provider, and certified by an Accredited Home Energy Rating Provider to inspect a home to evaluate the minimum rated features and complete Home Energy Ratings (see also Rating Field Inspector and Senior Certified Rater).

***Home Energy Rater Candidate, or Rater Candidate* –** An individual who has completed two (2) supervised ratings with a RESNET Accredited Training Provider, passed the National Core Rater Test and is in the process of completing three (3) additional probationary ratings necessary for certification by an Accredited Home Energy Rating Provider as a Home Energy Rater.

***Home Energy Rating, or Rating* -** An unbiased indication of a home's relative energy performance based on consistent inspection procedures, operating assumptions, climate data and calculation methods in accordance with the "National Energy Rating Technical Standards" (Chapter 3 of this Standard). See also "Rating, Confirmed" and "Rating, Projected".

***Home Energy Rating Provider, or HERS Provider, or Rating Provider*-** An organization accredited by RESNET in accordance with section 102 of these Standards that develops, manages, and operates a home energy rating program.

***Home Energy Rating System, or HERS*® -** The procedures, rules and guidelines by which Home Energy Ratings are conducted by accredited Providers (Home Energy Rating, Software, Training, BOP, Sampling, Home Energy Survey), as specified in these Standards.

***Home Energy Survey* -** A level of the RESNET Home Energy Audit process defined by this standard to include one of the following: Diagnostic Home Energy Survey, In-Home Home Energy Survey, , On-Line Home Energy Survey

***Home Energy Survey, Diagnostic* -** A level of the RESNET Home Energy Survey in accordance with this standard, consisting of an In-Home Home Energy Survey and additional diagnostic testing.

***Home Energy Survey, In-Home* -** A level of the RESNET Home Energy Assessment process defined by this standard intended to assess both the general energy performance of the home and the level of the commitment to action on the part of the homeowner. The survey may include data be collected and reported on-line by the homeowner or by a home energy survey professional for the purpose of further analysis and general identification of home performance problems. The intent of the energy survey is to refer homeowners to the next level if it is determined that the home needs further analysis, and the homeowner is motivated to invest in improvements. The On-Line or In-Home Home Energy Survey is not required if the homeowner wishes to directly pursue a Diagnostic Home Energy Survey or Comprehensive Home Energy Audit.

***Home Energy Survey, On-Line* -** A basic energy review of a home using an internet-based tool or software.

***Home Energy Survey Provider* -** An organization accredited by RESNET in accordance with Section 703 of the Mortgage Industry National Home Energy Rating Systems Standards to certify Home Energy Survey Professionals to perform Home Energy Surveys and Auditors to perform Comprehensive Home Energy Audits in accordance with this Standard, and to maintain QUALITY assurance of the Home Energy Survey.

***Home Energy Survey Professional* -** An individual certified by an accredited Home Energy Survey Provider to conduct Home Energy Surveys.

Home Performance Assessment - A detailed evaluation of the condition of a home as a building system, including evaluation of all materials, components, features, systems and subsystems that affect the energy use of the home.

***Home Performance with ENERGY STAR®, or HPwES* -** A national program developed by the Environmental Protection Agency (EPA) and the Department of Energy (DOE), that offers a comprehensive, whole-house approach to improving energy efficiency and comfort of homes, while maintaining or improving safety.

***RESNET Recognized Home Performance Standard* -** Technical standard developed to offer a comprehensive, whole-house approach to improving energy efficiency and comfort of existing homes, while maintaining or improving and durability safety.

House Wrap - A <u>weather-resistant material</u>, intended to serve as an <u>air/moisture barrier</u> if sealed carefully at seams.

***HVAC* –** Heating, Ventilating and Air Conditioning.

IECC - International Energy Conservation Code.

Inches of Water Column (IWC) - A unit of pressure difference; 1 IWC = 250 Pascals (see “Pascal.”)

***Independent Rater/Auditor* -** A RESNET Rater/Auditor who performs Final Verification of an EnergySmart Project in accordance with these sections and is certified by a RESNET-accredited Rating Provider in accordance with RESNET Standards. Independent Rater/Auditors shall be independent of the Auditor/Rater or Contractors(s) who installed the recommended measures, and may receive no financial compensation for any of the retrofits performed on the project.

***Indirectly Conditioned Space* -** A space within a building that is not directly conditioned, but meets one of the following criteria: (1) the area-weighted U-factor of the boundary between it and directly conditioned space exceeds that of the boundary between it and the outdoors or the ground, where U = sum (UA)/sum(A); (2) air to or from directly conditioned spaces is mechanically transferred at a rate exceeding 3 air changes per hour; or (3) any unvented basement or crawl space that contains heating equipment or distribution systems, and for which 50% or more of the floor separating it from conditioned space has no thermal insulation installed.

***Induced combustion* -** See "fan-assisted combustion."

***Industry Accepted Standards for Chapter 10* -** Industry recognized standards that include the following:

ACCA **Air Conditioning Contractors of America (2800 Shirlington Road, Suite 300, Arlington, VA, 22206; tel: 703/575-4477; www.acca.org)**

ACCA 4 QM - 2007 Maintenance of Residential HVAC Systems in One- and Two-Family Dwellings Less Than Three Stories

ACCA 5 QI - 2010 HVAC Quality Installation Specification

ACCA 6 QR - 2007 Standard for Restoring the Cleanliness of HVAC Systems

ACCA 9 QIvp - 2011 HVAC Quality Installation Verification Protocols

ACCA 12 QH-201X Existing Home Evaluation and Performance Improvement

RESNET **Residential Energy Services Network (P.O. Box 4561, Oceanside, CA, 92052-4561; 1-800-836-7057; http://www.resnet.us/)**

Mortgage Industry National Home Energy Rating Standard, 2009

RESNET National Standard for Home Energy Audits, 2005

Rating and Home Energy Survey Ethics and Standards of Practice, 1996

RESNET Standards for Qualified Contractors and Builders, 2010

Infrared Imaging System - An instrument that converts radiation differences associated with surface temperature variations into a two dimensional image by assigning specific colors or tones to the differing temperatures.

Infrared Thermography - The process of using an infrared imaging system to generate thermal images of the surfaces of objects, which can be viewed electronically or printed.

In-Home Home Energy Survey **-** A level of the RESNET Home Energy Assessment process defined by this standard intended to assess both the general energy performance of the home and the level of the commitment to action on the part of the homeowner. The survey may include data be collected and reported on-line by the homeowner or by a home energy survey professional for the purpose of further analysis and general identification of home performance problems. The intent of the energy survey is to refer homeowners to the next level if it is determined that the home needs further analysis, and the homeowner is motivated to invest in improvements. The On-Line or In-Home Home Energy Survey is not required if the homeowner wishes to directly pursue a Diagnostic Home Energy Survey or Comprehensive Home Energy Audit.

Initial Failure **-** When one or more failure(s) are first identified in a home during the sampling process.

Instantaneous Field of View (IFOV) **-** The instantaneous spatial resolutions characteristics of infrared imagers (expressed in angular degrees or radians per side if rectangular and if round, in angular degrees or radians), or the smallest object able to be viewed by the imaging system at a given distance.

Instantaneous Water Heater **-** A water heater that initiates heating based on sensing water flow and has a manufacturer's specified storage capacity of less than 2 gallons.

Internal Gains **–** The heat gains within a home attributable to lights, people, and miscellaneous equipment.

International Energy Conservation Code (IECC) **–** The model code for building energy conservation as promulgated by the International Code Council.

Isolated Combustion Appliance Zone **-** A combustion appliance zone that is not a part of, nor directly connected to, habitable space. It is either outdoors, or is a mechanical room or attached garage that is supplied with outdoor combustion air and separated from habitable space, and which complies with the criteria in Section B.3.2 of this standard.

Knob and Tube Wiring - An early method of electrical wiring in buildings, used from about 1880 to the 1930s. It consisted of single insulated copper conductors run within wall or ceiling cavities, passing through joist and stud drill-holes via protective porcelain insulating *tubes*, and supported on nailed-down porcelain *knob* insulators.

***KBtu* –** 1,000 British Thermal Units (Btu)

***Labeled Ceiling Fan* –** A ceiling fan that has been labeled for efficiency in accordance with EPA guidelines such that the label shows the cfm, cfm/watt and watts of the fan at low, medium and high speeds

***Labeled Ceiling Fan Standardized Watts (LCFSW)* –** The power consumption in watts of a Labeled Ceiling Fan "standardized" to a medium speed air delivery of 3000 cfm.

***Lead Based Paint* -** Paint containing the heavy metal lead, that was used as pigment, to speed drying, increase durability, retain a fresh appearance, and resist moisture that causes corrosion. Although the United States has regulation that prohibits the manufacture or use of lead based paints in residential or applications with direct human exposure, lead paint may still be found in older properties painted prior to the introduction of such regulation introduced in 1978. Paint with significant lead content is still used in industry and by the military.

***Light Fixture* –** A complete lighting unit consisting of a lamp or lamps, and ballasting (when applicable) together with the parts designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply. For built-in valence lighting, strings of low-voltage halogens, and track lights, each individual bulb shall count as a fixture.

***Low-Volume Raters* –** Raters which complete less than twenty five (25) ratings per year or less than fifty (50) ratings over a two year period.

***MBtu* –** One million British thermal units (Btu)

Metropolitan Area - Metropolitan and micropolitan statistical areas as defined by the United States Office of Management and Budget (OMB) and published by the United States Census Bureau at www.census.gov (the most current edition). In areas not included in any defined Metropolitan Area, individual counties may be substituted for the purpose of applying the sampling process.

***Misalignment (insulation)* –** A defect which occurs when installed insulation is not in contact with the air barrier and air intrusion between the insulation and the air barrier seriously compromises the effectiveness of the insulation in framed buildings.

***Model Energy Code: 1993 (MEC '93)* –** The building energy code as promulgated by the Council of American Building Officials (CABO) in 1992 as amended in 1993. The RESNET representation of MEC '93 is the HERS Reference home as defined in the "Mortgage Industry National Home Energy Rating Standards" dated 1999.

***Mechanical Ventilation* -** The active process of supplying or removing air to or from an indoor space by powered equipment such as motor-driven fans and blowers but not by devices such as wind-driven turbine ventilators and mechanically operated windows.

Mechanical Ventilation System – A fan designed to exchange the air in the house with outside air, sized to provide whole-house service per ASHRAE 62.2, and controlled automatically (i.e. not requiring human intervention to turn on and off). The presence of a remote-mounted on-off switch or dedicated circuit breaker labeled "whole house ventilation" (or equivalent) shall not disqualify a system from meeting the requirement of automatic control. The following are three types of mechanical ventilation:

- ***Balanced*** **-** One or more fans that supply outdoor air and exhaust building air at substantially equal rates from the space. This makes heat recovery possible via an air to air heat exchanger.

- ***Exhaust-Only*** **-** One or more fans that remove air from the building, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope.

- ***Supply-Only*** **-** one or more fans that supply outdoor air to the building, causing indoor air to leave by normal leakage paths through the building envelope

Minimum Rated Features **–** The characteristics of the building elements which are the basis for the calculation of end use loads and energy consumption for the purpose of a home energy rating, and which are evaluated by Home Energy Raters in to order collect the data necessary to create a home energy rating using accredited simulation tools.

NFPA **-** National Fire Protection Association

NASEO - National Association of State Energy Officials

National Core Rater Test **-** Computer-based examination developed by the Residential Energy Services Network's (RESNET) Training and Education Committee and administered by RESNET.

National Home Energy Rating Technical Guidelines **-** Voluntary home energy rating system technical guidelines adopted by the National Association of State Energy Officials (NASEO).

National Accreditation Body - The Residential Energy Services Network (RESNET) is the National Accreditation Body for all Providers designated in this Standard.

Natural Draft Venting System **-** A venting system that relies on buoyancy to move combustion gases to the outdoors.

***NIOSH* -** National Institute for Occupational Safety and Health.

***Normal* -**The building shell is functioning as designed.

NREL **–** National Renewable Energy Laboratory.

***On-Line Home Energy Survey* -** A level of the RESNET Home Energy Survey in accordance with this Standard that is a basic energy review of a home using an internet-based tool or software.

***On-site Power Production (OPP)* –** Electric power produced at the site of a Rated Home. OPP shall be the net electrical power production, such that it equals the gross electrical power production minus any purchased fossil fuel energy, converted to its Equivalent Electric Power, used to produce the on-site power.

***OSHA* -** Occupational Safety and Health Administration.

Pascal (Pa) **-** The metric unit of pressure equaling 1 Newton per square meter, or 0.004 inch W.G..

***Performance Testing* -** Testing conducted to evaluate the performance of a system or component using specified performance metrics.

***Polyethylene Sheeting* -** Any sheet material made of polyethylene, often called Visqueen™, used as a moisture barrier either on the walls of a structure built in an extreme northern climate or as a barrier covering the dirt on the floor of a basement or crawl space.

***Power Burner* -** A burner for which air is supplied at a pressure greater than atmospheric pressure; includes most oil-fired burners and gas burners used as replacements for oil burners.

***Power-Vented* -** An appliance that operates with positive static pressure in the vent, and is constructed and installed with a fan or blower to push all the products of combustion directly to the outdoors through independent sealed vents connected directly to the appliance.

***Predicted Depressurization* -** Calculated house depressurization after improvements, accounting for estimated change in house tightness and exhaust fan flow.

Purchased Energy **–** The portion of the total energy requirement of a home purchased from a utility or other energy supplier.

***Purchased Energy Fraction (PEfrac)* –** The fraction of the total energy consumption of the Rated Home that is purchased energy, wherein all site fossil energy uses are converted to their Equivalent Electric Power using the Reference Electricity Production Efficiency of 40%.

***QH Standard* -** BSR/ACCA 12 QH – 201x (*Existing Home Evaluation and Performance Improvement*). A standard that establishes the minimum criteria by which deficiencies in existing residential buildings are identified by audit, improvement opportunities are assessed, scopes of work are finalized, work is performed in accordance with industry recognized procedures, and improvement objectives were met.

***Qualitative (insulation)* -** In relation to insulation inspections, determining general areas of anomalies without assigning temperature values to the patterns.

***Qualifying Light Fixture* –** A light fixture located in a Qualified Light Fixture location and comprised of any of the following components: a) fluorescent hard-wired (i.e. pin-based) lamps with ballast; b) screw-in compact fluorescent bulb(s); or c) light fixture controlled by a photocell and motion sensor.

***Qualifying Light Fixture Locations* –** For the purposes of rating, those light fixtures located in kitchens, dining rooms, living rooms, family rooms/dens, bathrooms, hallways, stairways, entrances, bedrooms, garage, utility rooms, home offices, and all outdoor fixtures mounted on a building or pole. This excludes plug-in lamps, closets, unfinished basements, and landscape lightin*g*.

***Quality Assurance (QA)* –** The planned and systematic processes intended to ensure compliance with current applicable standards in a systematic, reliable fashion.

***Quality Assurance Plan* –** A Provider's written quality assurance processes and procedures as specifically required in Section 904 of these Standards.

***Quality Assurance Designee (QA Designee)* –** An officer, employee, or contractor responsible for quality assurance within a Provider organization, who has met the requirements of section 904.7 of this Chapter and has signed an agreement with the Provider to be the Provider's QA Designee.

***Quality Assurance Designee Delegate (QA Delegate)* –** An individual certified as a Home Energy Rater , appointed by a Quality Assurance Designee to complete a portion of the Quality Assurance process, who has met the requirements of section 904.7.4 of this Chapter.

***Quality Assurance Designee, Primary (Primary QA Designee)* –** The one QA Designee for a Provider who shall have ultimate responsibility, on behalf of the Provider, for fulfilling the Provider's QA requirements/responsibilities and who shall be the single point of contact to RESNET regarding all Quality Assurance matters.

***Quality Assurance & Ethics Committee (QA Committee)* –** A Standing Committee of the RESNET organization that is responsible for the oversight of RESNET's rating quality assurance program, review and ruling on the merits of formal Ethics and Consumer Complaints received by RESNET, and review and rule on the merits of all appeals of non-approval or renewal of an application, probation, suspension, or revocation.

***Quantitative* -** In relation to insulation inspections, determining the total square footage of anomalies of a structure as a percentage of the total surface area of the structure in square feet.

Radon Mitigation - The method(s) for reducing radon entry into attached and detached residential buildings. This practice is intended for use by trained, certified or licensed, or both, or otherwise qualified individuals, following ASTM E 2121-09, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings.

***Radon Testing* -** Typically one of two approaches is used: 1) Approved radon test kit is purchased and used by the person responsible for the building, 2) Certified and/or licensed independent radon tester to perform the required radon test. A short-term test remains in the home for 2 to 90 days, whereas a long-term test remains in your home for more than 90 days.

There are two types of radon testing devices. **Passive** radon testing devices do not need power to function and include; charcoal canisters, alpha-track detectors, charcoal liquid scintillation devices, and electret ion chamber detectors. Both short- and long-term passive devices are generally inexpensive. **Active** radon testing devices require power to function and usually provide hourly readings and an average result for the test period. These include continuous radon monitors and continuous working level monitors, and these tests may cost more. All radon tests should be taken for a minimum of 48 hours. A short term test will yield faster results, but a long-term test will give a better understanding of the home's year round average radon level. Regardless of the approach used if the radon level is confirmed to be 4 picocuries per liter (pCi/L) or higher, the mitigation should occur.

Rated Home - The specific home being evaluated using the rating procedures contained in the National Home Energy Rating Technical Guidelines.

***Rater* –** See Home Energy Rater.

***Rater Candidate* –** See Home Energy Rater Candidate.

***Rater Specialty Certification* –** Professional building performance certification recognized by RESNET as part of a Home Energy Rater's advanced certification.

Rater Trainer, Certified - An individual designated by an Accredited Rater Training Provider to provide instruction and assistance to trainees. A class instructor who has demonstrated, by means of passing the RESNET National Rater Trainer Competency Test, mastery of the building science and rating system and competency necessary to effectively teach Rater training courses.

Rating, Confirmed – An energy rating accomplished using data gathered from an on-site audit inspection and, if required, performance testing of the physical building and its installed systems and equipment.

***Rating Data File* –** The collection of information that makes up a file for Home Energy Ratings projected from plans or confirmed, including take-off forms, field data collection forms, energy simulation software files, RESNET Standard Disclosure Forms, rating certificates, rating reports, QA records (including findings and the resolution of any issues) as well as any documentation required by Third-Party Energy Efficiency Programs (EEP's) such as checklists, copies of labels or third-party certificates,

Rating Field Inspector (RFI) – A Field Inspector is the entry level of Rater certification. A Field Inspector under the direct supervision of a certified home energy Rater may conduct the inspections and necessary basic performance tests (blower door& duct blaster) to produce a home energy rating. This category requires the ability to identify and quantify building components and systems.

***Rating Index* –** See HERS Index.

Rating, ***Projected*** - A rating performed prior to the construction of a new building or prior to implementation of energy-efficiency improvements to an existing building.

***Rating Software* -** A computerized procedure that is accredited by RESNET for the purpose of conducting home energy ratings and calculating the annual energy consumption, annual energy costs and a HERS Index for a home.

***Rating Tool* –** A computerized procedure for calculating a home's energy efficiency rating, annual energy consumption, and annual energy costs.

***Reference Electricity Production Efficiency* –** Electric power production efficiency, including all production and distribution losses, of 40%, approximating the efficiency of a modern, high-efficiency, central power plant. The Reference Electricity Production Efficiency is to be used only to convert site fossil fuel energy uses to an Equivalent Electric Power for the sole purposes of providing home energy rating system credit for On-site Power Production.

Reference Home - A hypothetical home configured in accordance with the specifications set forth in the National Home Energy Rating Technical Guidelines for the purpose of calculating rating scores.

***Refrigerant* -** A compound that absorbs heat when it under goes a phase change, e.g. gas to a liquid. Traditionally, the chlorofluorocarbon (CFC) R-22 was used as a refrigerant for residential air conditioners and heat pumps. Since 1992 time frames have been established for replacing chlorofluorocarbon refrigerants, with non chlorofluorocarbon refrigerants often referred to as R-410A.

The ideal refrigerant has a boiling point somewhat below the target temperature, a high heat of vaporization, a moderate density in liquid form, a relatively high density in gaseous form, and a high critical temperature. Since boiling point and gas density are affected by pressure, refrigerants may be made more suitable for a particular application by choice of operating pressure.

***Refrigerant Charge* -** Quantity of refrigerant in a vapor compression refrigeration/heating system, determined by measuring the discharge and suction pressures/temperatures in the system.

***Registry* -** The database maintained by a CEQ Provider of all EnergySmart Contractors they have approved.

***Relative Humidity (RH)* -** The water vapor pressure in the air expressed as a proportion of the saturated water vapor pressure (ie the highest possible value) at the current air temperature.

RESNET - Residential Energy Services Network

***RESNET Executive Director (Executive Director)* -** A person elected by the Board of Directors of the Residential Energy Services Network (RESNET) to be the Chief Executive Officer of RESNET.

***RESNET National Rater Trainer Competency Test* –** Certification test developed and administered by RESNET to ensure that accredited Rater training Provider' trainers have the requisite knowledge and competence to serve as trainers for prospective certified Rater. The test is based on the national core competency exam developed and maintained by RESNET.

***Return Duct* -** Duct carrying air back (return) to the heating and cooling equipment.

***Room Pressure Differential* -** In many parts of the country, supply air is delivered to individual rooms, but return air is located only or primarily in the central body of the home. The absence of return air in closeable spaces causes positive pressure in the closed rooms and negative pressure in the central zone. These positive and negative pressure differentials create a number of unwanted impacts, which may include; contaminants in the soil (e.g., radon), sewer gases in poorly trapped drain lines, and air contaminants (e.g., pesticides, mold odors, chemicals, auto exhaust, dust) in unconditioned zones such as crawl spaces and garages being drawn into the conditioned living space. Negative pressure can also produce combustion venting problems such as; very high levels of Carbon Monoxide or push the flame out of the combustion chamber in a process referred to as flame rollout. These combustion system impacts can create serious dangers for both home and occupants. In order to alleviate the differentials, "jumper ducts", "transfer grills" or individual returns are installed to alleviate or balance the pressures differential between zones.

***R-Value* –** Thermal resistance value measured in h-ft^2-F/Btu.

***Sample Set* -** A specific group of homes from which one or more individual homes are randomly selected for sampling controls.

Sampling **-** An application of the Home Energy Rating process whereby fewer than 100% of a builder's new homes are randomly inspected and tested in order to evaluate compliance with a set of threshold specifications.

Sampling Controls **-** A collection or set of required tests and inspections performed for a sample set of homes in order to confirm that the threshold specifications have been met. "Sampling controls" may refer to the entire set of tests and inspections, or to a particular phase that constitutes a defined subset of those tests and inspections (e.g. pre-drywall, final, HVAC, windows and orientation, etc).

Sampling Provider **-** An entity, accredited through these standards, that oversees the sampling process and issues the sampling certifications that homes meet a particular set of threshold specifications such as the ENERGY STAR® specifications adopted by the U.S. Environmental Protection Agency.

Seasonal Energy Efficiency Ratio,* or *SEER **-** A standardized measure of air conditioner efficiency based on the total cooling output of an air conditioner in Btu/h, divided by the total electric energy input, in watt-hours, under test conditions specified by the Air Conditioning and Refrigeration Institute Standard 210/240.

Senior Certified Rater **–** A senior Rater is the first category of advanced Rater certification. Senior Certified Raters have demonstrated that they have the increased experience and knowledge base to interpret the findings of a rating and make recommendations on how the home can be improved.

Sensible Heat Ratio (SHR) **-** The sensible heat or cooling load divided by the total heat or cooling load.

Spectral Wavelength **-** The electromagnetic wavelength interval or equivalent over which observations are made when using an infrared imaging system.

Spillage, Spill **-** Combustion gases emerging from an appliance or venting system into the combustion appliance zone during burner operation.

Standard Ceiling Fan **–** The ceiling fan against which Labeled Ceiling Fans are measured for efficiency. At medium fan speed, the Standard Ceiling Fan produces 3000 cfm of air flow and uses 42.6 watts of power.

Standards (HERS Standards) **–** The "Mortgage Industry National Home Energy Rating System Standards", as maintained by the Residential Energy Services Network (RESNET).

Standards Committee **-** A Standing Committee of the RESNET organization that is responsible overseeing the Standards Amendment process.

***Super Heat* –** Heat added to a vapor under pressure, raising the temperature of the vapor above the temperature pressure reference point

Technical Committee - A Standing Committee of the RESNET organization that is responsible for review and oversight of the RESNET Technical Standards (Chapter 3).

Thermal Boundary - The line or boundary where the air barrier and insulation are installed in a building assembly. The air barrier and insulation should be adjacent to one another in a building assembly to prevent airflow from circumventing insulation.

Thermal Boundary Wall - Any wall that separates directly or indirectly conditioned space from unconditioned space or ambient conditions.

Thermal Boundary Wall (Above-Grade) - Any thermal boundary wall, or portion of such wall, not in contact with soil.

***Thermal Expansion Valve (TXV)* -** A component of a vapor compression refrigeration system that varies the amount of refrigerant flow into the evaporator coil based on temperature and pressure, thereby controlling the superheat at the outlet of the evaporator coil**.**

***Thermal Storage Mass* –** Materials or equipment incorporated into a home that will store heat, produced by renewable or non-renewable energy, for release at a later time.

***Thermal bridging* -** Heat conduction through building components, typically framing, that are more conductive than the insulated envelope.

***Thermal Bypass* -** Air movement, air leakage or convection "cell", that circumvents the thermal barrier, is usually hidden and is the result of an incomplete or compromised air barrier.

***Thermal Image* -** A recorded electronic or printed image provided by an infrared imaging system of the thermal surface variations of an object or a surface.

Thermal Resolution, or Noise Equivalent Temperature Difference (NETD) - The minimum temperature difference, typically specified in degrees Centigrade at 30 degrees Centigrade, an infrared imaging system is able to distinguish between two blackbody points on a thermal image.

***Thermogram* -** An infrared picture obtained through the use of an infrared imaging system or other means of recording such images.

***Thermographer, Level I* -** A person who is qualified by training, experience and testing to gather high-quality data and, where pass/fail guidance is provided, to interpret that data. The American Society for Nondestructive Testing (ASNT) defines a Level I as one who can, 1) Perform calibrations, tests, and evaluations for determining the acceptance or rejection of tested items in accordance with specific written instructions, 2) Record test results but have no authority to sign reports for the purpose of signifying satisfactory completion of NDT operations, and 3) Receive instructions or supervision from a Level III or designee.

***Thermography* -** The process of generating and interpreting thermal images.

***Third-Party Energy Efficiency Program, or EEP* -** A national or local program that has set a standard for energy efficiency in building performance and requires a HERS analysis for verification (e.g. ENERGY STAR Qualified Homes, Building America's Builders Challenge, building code, International Code Council, utility companies, etc.)

***Threshold Specifications* -** A set of qualification criteria which are established for a sample set based on worst-case Projected Ratings with consideration of all options, and in worst-case orientation, or a set of prescriptive specifications such as the ENERGY STAR® prescriptive path adopted by the U.S. Environmental Protection Agency.

***Training and Education Committee* -** A Standing Committee of the RESNET organization that is responsible for overseeing RESNET training, RESNET tests, and education and professional development for RESNET Providers and Raters.

***Transfer Duct* -** Properly sized ducting and register grills installed in the wall or door between the central body of a home and an isolated area, in order to reduce room pressure differentials.

***Transfer Grill* -** Properly sized grills installed in the wall or door between the central body of a home and an isolated area, in order to reduce room pressure differentials.

***Typical Meteorological Year, or TMY Data* –** Hourly climate data published by the National Climatic Center, Asheville, NC, based on historical climate data in 216 locations.

***U-factor* -** Coefficient of thermal transmittance (expressed as Btu/h-ft2-oF (W/m2-oC)) of a building envelope component or system, including indoor and outdoor air film transmission coefficients.

***Unconditioned Space* -** Any enclosed space within a building that is neither directly nor indirectly conditioned.

***Unresolved Complaint* -** A complaint deemed by the CEQ Provider to require corrective action by the EnergySmart Contractor.

***Unvented Combustion Appliance* -** Any appliances not used with a duct, chimney, pipe, or other device that carry the combustion pollutants outside the home. These appliances can release large amounts of pollutants directly into a home.

***U-Value* –** Thermal transmittance value measured in Btu/h-ft^2-F.

***Vapor barrier/retarder* -** A material used in the construction process to either slow or stop the movement of moisture, whether in liquid or vapor form, into or out of the building envelope or the wall structure.

***Vapor-Cycle Refrigerant-Based Equipment* -** The most widely used method for air-conditioning of private residences in the United States. System uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere, typically includes four components: a compressor, a condensing coil, an expansion valve (also called a thermal expansion valve), and an evaporator coil.

***Vent Connector* -** The pipe that connects a combustion appliance to a vent or chimney.

Venting System - A passageway or passageways from a combustion appliance to the outdoors through which combustion gases pass.

Voids (insulation) - Areas where no insulation has been installed.

***Wind Wash(ing)* -** Air intrusion between the insulation and the air barrier seriously compromises the effectiveness of the insulation in framed buildings. The long path exfiltration on the cold side of insulation allows moisture from the air to be deposited in the building assembly.

Weather Resistant Barrier (WRB) - Is designed to keep water from entering the building through the walls and is made up of several individual materials: house wrap or building paper (with weather resistive coating), flashings, sealants and tapes. When installed properly, these materials combine to protect the building from rain-induced moisture damage. If the WRB is sealed to block air flow it also contributes to the air barrier system of a home.

***Work Scope* -** A set of written recommendations, including specifications detailing repairs and improvements to be made to a home; a work scope may include pre- and post-work performance testing and acceptance criteria.

Appendix C

(Informative)

General Guidelines for Determining Energy Conservation Measure (ECM) Service Lifetimes and Maintenance Fractions

Improvement Category	ECM Life	Maint. Frac.
Air Sealing, Ducts	20	0
Air Sealing, Envelope	30	0
Attic, Ventilation	30	0
Attic, Radiant Barrier	30	0
Color, Roof Shingles	15	0
Color, Wall Paint	10	0
HVAC, Replacement	15	0
Furnace, Replacement	20	0
Hot Water, Heat Pump	15	0.009
Hot Water, Heat Recovery	15	0
Hot Water, Pipe Insulation	15	0
Hot Water, Tank Wrap	12	0
Hot Water, Solar, Direct	40	0.011
Hot Water, Solar, ICS	40	0.004
Hot Water, Solar, Indirect	40	0.011
Hot Water, Standard System	12	0
Hot Water, Tankless, Gas	12	0.024
Insulation, Block Wall	40	0
Insulation, Ceiling	40	0
Insulation, Frame Wall	40	0
Lighting, High Efficiency	5	0
Pool Pump, High Efficiency	15	0
Refrigerator, Replacement	15	0
Showers, Low Flow	15	0
Window, Replacement	40	0
Window, Film Tinting	15	0
Window, Solar Screen	15	0

Sandia National Laboratories

PV Value™

This spreadsheet tool developed by Sandia National Laboratories and Solar Power Electric™ is intended to help determine the value of a new or existing photovoltaic (PV) system installed on residential and commercial properties. It is designed to be used by real estate appraisers, mortgage underwriters, credit analysts, real property assessors, insurance claims adjusters and PV industry sales staff. For appraisers, the inputs specific to PV in the Residential Green and Energy Efficient Addendum can be used as inputs to PV Value™.

Valuing a PV system is done using an income capitalization approach, which considers the present value of projected future energy production along with estimated operating and maintenance costs that are anticipated to occur during the PV module power production warranty timeframe.

Version 1.1 is now available and can be used on both Microsoft Windows and OS X operating systems. It works with both Excel® 2007 and 2010 for Windows, and Excel® 2011 for Mac. After filling out the form below, you can download the tool and user manual describing how to use the tool and changes made for this version. This information will be used to notify you of updates to PV Value™.

Sandia Labs hosted a webinar describing PV Value™ on December 7, 2011, which can be viewed below. The Interstate Renewable Energy Council hosted a webinar about PV Value™ on April 18, 2012, which can be viewed here.

Updates will be made as necessary, with a new version released on or before July 1, 2013. The current version is 1.1.

Additionally the PV Value™ tool can be accessed at www.pvvalue.com, a web application that is currently in development for 2013. PV Value™ is a trademarked name by Jamie Johnson with Solar Power Electric™.

PV Value™ Tool Download

Please complete the form below to download the PV Value™ tool.

Name *

Email *

State *

Alabama

Zip Code *

User Type *

Residential Appraiser

Submit

PV Value™ Webinar

Click here to download the video.

REVIEW OF SELECTED HOME ENERGY AUDITING TOOLS

In Support of the Development of a National Building Performance Assessment and Rating Program

Prepared for:
The U.S. Department of Energy,
Office of Energy Efficiency and Renewable Energy

Prepared by:
SENTECH, Inc. (now part of SRA International, Inc.)

November 2, 2010

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) is embarking upon an effort to develop a national program to assess the energy performance of houses. The program will provide information to current and prospective homeowners about the energy performance of the house and potential areas of improvement, along with associated cost estimates. As a component of this program, DOE is interested in understanding the variety and characteristics of currently available audit tools that have national validity. Of particular interest is the ability of these tools to accurately analyze residential building performance--regardless of climate, fuel source, architectural style, and building system--with a reasonable level of tool inputs. Additionally, DOE is interested in the ability of these tools to produce reports on estimated fuel consumption and lists of recommended building energy efficiency improvements.

The energy audit tools reviewed in this study include REM/Rate®, BEACON Home Energy Advisor®, EnergyInsights®, Home Energy Tune-uP®, EnergyGauge®, TREAT®, the National Energy Audit Tool (NEAT®), Home Energy Saver™ Professional (HES*Pro*), and RealHomeAnalyzer®. Not included in this study are audit tools under DOE oversight or influence such as, Manufactured Home Energy Audit (MHEA), Home Energy Yardstick, and other specialized tools designed for specialized purposes such as HVAC loads or for localized utility program energy efficiency efforts.

The study is organized by task, including a literature review (of previous related studies), selection of audit tools to review, the creation of audit tool review criteria, audit tool vendor interviews, and compilation and analysis of the data. Information collected regarding audit tools includes names of currently available tools in the marketplace, accuracy, cost, accessibility, ease of use, input and output characteristics, and the purpose and reporting characteristics of each tool.

Findings of the study reveal that no one tool fully captures all the characteristics currently thought to be important to a national home performance assessment program: low cost, universal availability, ease of use with reasonable input requirements, conformance to a universally accepted accuracy standard, and the ability to generate improvement recommendations and associated costs. The audit tools as a population, however, appear to address the potential needs of a national program.

Besides identifying tool deficiencies for application under a national program, this study is expected to assist DOE with:

- developing standards for data inputs, algorithms, and data outputs used by tools in a national program;
- standardizing the method by which home energy improvement measures are prioritized and costed;
- standardizing the benchmark by which home performance is reported; and
- standardizing the type and format of information displayed on home performance reports as well as populated into a national registry database.

2. Introduction

Home energy audit tools are used to evaluate single-family residential buildings in order to identify opportunities for energy efficiency improvements and determine energy performance. These tools vary considerably in how they collect and analyze a home's characteristics and generate energy-efficiency retrofit recommendations. The U.S. Department of Energy (DOE) is undertaking an effort to develop and/or approve the use of uniform and systematic home energy audit tools as one component of DOE's Home Energy Score Program, an overarching program to rate and create recommendations regarding the energy performance of single-family homes. The program's goal is to create a common understanding in the real estate and financial industries of the value of energy efficiency improvements in U.S. housing.

The purpose of this study is to explore widely-used energy audit tools that guide the collection of data by an energy auditor, use the data to generate an analysis of the energy efficiency of a dwelling unit, and generate an understanding of potential improvements to a home to maximize its operational efficiency. Of particular interest is the ability of currently available energy audit tools to accurately analyze residential building attributes, multiple climates, fuel types, and other related factors with a reasonable set of inputs and meaningful outputs (e.g., reports on estimated energy savings, prioritized lists of energy efficiency measures, etc.). The tools in this study were reviewed to gauge how each might impact DOE's development of the Home Energy Score Program.

The next section briefly outlines the key types of energy audit tools. This discussion is followed by a description of the methodology employed in the review of the most widely used audit tools for single-family dwellings. The findings of the tool review are presented next, including tables displaying review criteria and attributes of the reviewed tools followed by recommendations for further study. A summary of the literature search and the corresponding literature references are provided at the end of this report, followed by attachments including the tool vendor questionnaire, sample tool input forms and output reports, and other information referenced in the body of the report.

3. Energy Audit Tool Types

Energy audit tools commonly used by the home performance and weatherization communities (as well as homeowners) to analyze a home and create strategies for energy efficiency improvement or weatherization generally consist of the following types:

- Web-based calculators
- Prioritized lists of measures
- Checklist or survey instruments
- Asset rating tools
- Operational rating and audit tools.

A description of each of these tool types follows with a focus on general category attributes, including:

- Typical tool user
- Tool output and its intended use
- Scope of home analysis by tool (simple vs. comprehensive)

- User expertise required
- Ability of the tool to accept diagnostic inputs (e.g., envelope or duct tightness readings, fan efficiency, etc.)

Web-Based Calculators

Web-based calculators consist of tools commonly offered at little or no cost to perform energy analysis on homes. Groups such as public-service non-profit organizations, utilities, and government agencies are common vendors for these tools. Representative tools from this category include Home Energy Checkup offered through the Alliance to Save Energy, ENERGY STAR® Advisor and Energy Yardstick distributed by the U.S. Environmental Protection Agency (EPA), and Home Energy Saver (HES) hosted on a website developed by the U.S. Department of Energy.

Typical users of these tools are homeowners wishing to identify areas of potential energy improvement in their homes. Output from these web-based tools typically consists of generalized improvement measures or links describing building system improvements so that homeowners gain a general idea of the types of improvements to be further investigated. Home Energy Checkup, billed as an educational tool, presents typical improvements for single-family homes across all eleven climate zones within the United States while noting that actual recommended measures and potential savings will vary. Energy Yardstick analyzes energy bill data, compares usage to other households across the nation, and provides links to the Home Energy Advisor to explore potential improvement measures. The most analytic tool in the group is Home Energy Saver; based on user inputs, the tool presents recommended energy efficiency measures with expected cost savings and payback. A professional version, Home Energy Saver Professional (HES-Pro), is under development and is described later in this report.

These web-based audit tools, while addressing the whole house, are rather simple in scope, as very few characteristics are input and the recommended measures reported are very general in nature. The exception is Home Energy

Saver. This tool directs the user to input more detailed information, such as the number of windows, square footage, desired payback period and level of efficiency improvement. The simple nature of these tools reflects their intended use by a general audience without building science expertise. As such, none of the representative web-based tools, with the exception of HES, accept values from diagnostic equipment (such as from a blower door) because the general public is not expected to have this equipment or data.

Prioritized List of Measures

Prioritized lists of measures exist in electronic software and hardcopy form. Energy efficiency measures are prioritized on the basis of local program initiatives, estimated cost-effectiveness of improvement activities, other factors such as health and safety issues, or a combination thereof. The Florida Weatherization Assistance Program Priority List Assessment and Testing Form (Attachment A) (Ref. 1) offers an example of a form of prioritization based on program goals. This form ranks improvement measures by their order of priority; work will be performed in the same order unless measures are deemed non-applicable for the situation and supporting material provided to back up the judgment. A second example of prioritization is found in the preliminary home improvement specifications developed for the Partnership for Advancing Technology in Housing (PATH) (Ref. 2). Specifications were developed as a function of cost effectiveness as well as technical ability of the improvement contractor. Low-cost, low-skilled activities are advocated over higher cost improvements requiring a more advanced contractor skill set.

Prioritized lists sometimes use inputs from diagnostic tests such as blower door and duct-tightness testing. The Florida example shows inputs for these diagnostic tests. Prioritized lists also vary in the comprehensiveness of an assessment. Some utility energy efficiency programs, for example, have focused primarily upon examining homes for compact fluorescent light bulbs, appliances, and programmable thermostats.

Prioritized lists allow programs and users to:

- Standardize how structures are evaluated and improved,

- Maximize utilization of a wide range of auditor skill sets, and
- Facilitate integration of local program priorities and initiatives such as rebates, health and safety measures, and fuel preferences.

Checklist or Survey Instruments

Checklist or survey instruments typically guide a user to input data collected during a visual energy home "inspection" – a quick audit usually done without diagnostic equipment – onto a data sheet or into a simple software package. Users are not required to possess the more extensive training and experience necessary to conduct the asset and operational ratings and audits described below. Some energy efficiency programs such as those run by utilities and state and local governments then use this data to direct prescriptive improvement measures based on parameters established by each program. For example, if a refrigerator is over 15 years old, a program might prescribe a new refrigerator regardless of condition or actual efficiency of the appliance. The output reports from these tools may also recommend home energy improvement measures either based on prescriptive or calculated measures. Improvement measures recommended may or may not have prioritization assigned to them. Programs that prioritize improvement measures may use varying financial calculations to determine the cost effectiveness of the measure. Expected life of the improvement, material and labor costs, interest rates used to account for the cost of capital, and acceptable payback periods or rates of return all influence how individual improvement measures may be prioritized.

Asset Rating Tools

Asset ratings are energy performance values assigned to a house attributable entirely to the characteristics of the structure, the applicable climate, and a standard set of operating parameters (e.g., for thermostat settings). In other words, individual inhabitant behavior is removed from the calculation. Unlike checklist or survey instruments, asset ratings are more comprehensive and generally require the use of diagnostic tools such as blower doors. Asset ratings allow different houses to be compared using a consistent methodology, which is particularly useful to homebuyers. The best example of an asset rating is found in the automobile industry, where labels are affixed to cars to indicate the gas mileage expected for highway and city driving. Vehicle owners rarely match these values with their own driving because the ratings are calculated using a very precise protocol that an individual's actual driving habits may not mimic. The value in this rating, despite its limitations, is that different cars can be compared using a consistent metric.

The most common example in the housing industry is the Home Energy Rating System (HERS), created by the Residential Energy Services Network (RESNET) originally for new homes but now also used for evaluating the energy performance of existing homes. A HERS index is a number calculated to indicate how a house performs compared to a zero-energy home (with a HERS index of 0) and a home built to the 2004 International Energy Conservation Code (with a HERS index of 100). Currently, ENERGY STAR-labeled homes require a HERS index of 85 or lower.

Operational Rating and Audit Tools

An asset rating, while useful for comparison purposes, is often not very helpful when trying to understand how a home actually functions and where present occupants should make energy efficiency improvements. The rating useful for this purpose is termed an *operational rating*. In addition to operational ratings, energy audits typically evaluate the operational performance of homes to generate a list of possible home energy improvements and energy and cost savings estimates. Comprehensive operational ratings and audits look at the actual energy use of a home as its occupants currently use it. Operational rating and audit tools typically require the use of diagnostic equipment and can use historical utility bill data and occupant operational information obtained from occupant interviews. While extremely useful for current home occupants in determining cost-effective home energy improvements, an operational rating might have limited applicability for future occupants due to highly variable operational behaviors such as thermostat settings, lighting usage, length of showers, and plug loads.

As mentioned above, comprehensive software tools that provide asset ratings, operational ratings/audits, or both, often can be used to guide energy improvement measures. Generally, these types of tools can more accurately determine the benefits of improvements than checklist or survey instruments that produce a list of prescriptive measures and often overestimate energy savings. For example, improving the attic insulation from an R6 to R50 might generate an estimated savings of $200 per year, while increasing the efficiency of a furnace from 80% to 95% efficient might generate $400 of savings per year. It is common for simpler, prescriptive checklist instruments to add up these two measures to report $600 of annual energy bill savings. In reality, these measures influence each other. For example, increasing attic insulation decreases the heating load placed upon the furnace and thereby decreases the benefit realized by upgrading to a higher efficiency system. Many rating and audit tool software tools take this interaction into account and adjust the expected benefits accordingly.

4. Audit Tool Review Methodology

A number of issues complicate the investigation of energy audit tools of potential interest to DOE. The audit tools initially considered for review varied considerably in format, function, availability for review, target audience, and complexity. Therefore, the challenge was to place parameters on the investigation to better review the audit tools and to develop evaluation criteria. To that end, a process was developed that reflects the study's emphasis on identifying industry-accepted tools and key tool attributes that might inform and shape the development of a Home Energy Score Program for Homes pertaining to residential structures.

Accordingly, this study was carried out in six major steps:

- **Literature Investigation.** A cursory investigation of the literature was conducted to identify evaluations of home energy auditing tools in recent years. Another desired result of the literature search was to limit unnecessary duplication of research. In particular, information was sought regarding:

- Audit tools in the marketplace and their corresponding attributes (including tool inputs and reporting characteristics), intended use, marketplace presence, ease of use, and similar factors
- Accuracy of existing tools (e.g., modeled versus actual energy use, or estimated energy savings vs. savings generated by an evaluation tool like DOE's BESTEST)
- Standards impacting audit tool inputs, algorithms, outputs, accuracy, and other properties
- Other relevant literature, including research and information on how existing energy efficiency programs select or approve audit tools.

- **Selection of Energy Audit Tools to Investigate**. This study reviews energy audit tools that exhibit the promise of generating defensible energy savings estimates, can produce prioritized lists of recommended energy efficiency measures, and are widely distributed. The more comprehensive asset rating and operational rating/audit tools met these requirements. As checklist and survey instruments were found to be more custom-tailored for local applications and less tested in the overall marketplace, they were not considered in this study. Web-based calculators and prioritized lists of measures were also not considered, as these tools would likely not satisfy minimum requirements of lenders for energy efficiency project financing.

  In particular, tools recognized by the EPA Home Performance with ENERGY STAR® program, those used in utility-based programs throughout the United States, and those accepted and widely adopted by the Weatherization Assistance Program were evaluated. Excluded were tools developed for a very particular purpose as the Manufactured Home Energy Audit (MHEA). Likewise, other than a cursory description of the software, ENERGY STAR Home Advisor, and Yardstick were also excluded from this review. HES-Pro, however, was included due to added functionality of the tool and its potential to contributing to the Home Energy Score Program.

While many other software packages exist for specific purposes such as calculating heating or cooling loads, determining appropriate ventilation, and serving as an instructional tool, this study restricted tools to those known to be applicable across the majority of climate types within the United States and capable of contributing to the Home Energy Score Program (i.e., whole-house rating and audit tools). The authors recognize and regret the possible omission of other tools also meeting these criteria that were not readily identifiable. The software packages selected for study include the RESNET-accredited tools: REM/Rate®, EnergyGauge®, Energy*Insights*®; tools commercially available and commonly used for energy audits and home performance programs: BEACON Home Energy Advisor®, Home Energy Tune-uP®, TREAT®, and RealHomeAnalyzer®; and other tools, either government-produced or benchmarking applications: HES*Pro*, NEAT®, and Green Energy Compass®. Versions evaluated were the most current at the time of study inception – February, 2010.

- **Definition of Review Criteria.** Prior energy audit tool evaluation studies were examined and a list of questions was developed to query audit tool vendors about their products (Attachment B). Questions regarding the typical purchaser, range or influence of the product, common uses for the tool, input and report characteristics, product costs, ease of use, training and certifications required, and other information of interest to DOE were included. All totaled, 40 review criteria were developed and integrated into a questionnaire.

- **Vendor Interviews**. Vendors were interviewed mainly by telephone to complete the questionnaire. In the cases where vendor representatives could not be reached, the questionnaire was emailed with a request to complete and return the information. In addition, energy audit tool vendors were interviewed at the RESNET 2010 annual conference. Information was collected for all audit tools selected for review but not necessarily for all criteria for each tool. The incomplete responses were not deemed to be critical, given the emphasis on the timeliness of this study. Also, this study considers the attributes of existing audit tools as a whole when making recommendations as to their applicability to the Home Energy Score Program.

- **Review of Selected Audit Tools**. Results from the questionnaires and interviews were compiled into a matrix in order to view the selected energy audit tools by key attributes. This framework allows insight into potential strengths and weaknesses of each tool relative to the goals of the Home Energy Score Program. The review criteria are defined at the end of the matrix presented in the next section. Key attributes were reviewed in light of these issues:

  - ***Cost and accessibility*****.** The Home Energy Score Program, if standardized, needs to be accessible to trade contractors and affordable to consumers, who ultimately bear the cost of the tools through contractor audit and retrofit pricing. Tools that are excessively expensive or require excessive training, certifications, and/or licensing or usage fees are not likely to be good candidate tools for a national program expected to reach millions of homeowners.

  - ***Ease of use*****.** Related to the cost and accessibility of particular tools, the minimum level of skill and experience required to effectively use an audit tool is a key criteria of its application in a national program. In particular, with the current Presidential Administration's focus on green jobs, a tool used for the Home Energy Score Program must not require extensive training or years of experience to accurately operate and produce desired results.

  - ***Applicability to U.S. climate zones*****.** To have the most value to a national program, audit tools that provide the desired outputs for the broadest set of climate zones in the United States would be favored over those tools relevant for a narrow range of climate conditions. Given the current relatively small customer base for audit tools, those tools with adaptability to additional climate zones in the future would also be considered as candidate instruments for the Home Energy Score Program.

- ***Accuracy*.** For estimated energy savings and recommended energy efficiency measures to be deemed credible by trade contractors, lenders, homeowners, energy efficiency program sponsors, and the home performance industry at large, they must approximate real-life conditions before and after a retrofit. Tool accuracy should be evaluated on its ability to emulate the actual energy use of a dwelling, predict energy savings for improvements, estimate or report the “real-world” cost of improvements, and then use cost, energy savings, and interactions between energy efficiency measures to “package” and prioritize home energy improvements. However, limited information is available to ascertain the accuracy of most audit tools in the marketplace today, making review for this criterion difficult at best. Further complicating this review is the lack of industry consensus on the effectiveness of the few standards and instruments currently in use for evaluating the accuracy of audit tools (e.g., DOE’s BESTEST and BESTEST-EX).

- ***Inputs.*** Typically, the lower the number of inputs required by audit tools, the lower the amount of time to collect and enter those inputs, thus reducing audit costs. However, fewer inputs can come at the cost of tool accuracy for a given residence, as tools then rely on generic input defaults. Ideally, a compromise between excessive inputs and inaccurate results lies in affordable yet credible audit tools. Many audit tools also allow the user to expand the level of inputs based, for example, on the number of different building systems to be addressed in the analysis. In reviewing input-related attributes or criteria for individual tools, an attempt was made to consider the nature of the minimum required inputs (i.e., the time to collect the data) in addition to the number of inputs. DOE is also interested in ascertaining common inputs among leading audit tools or a recommended set of minimum audit tool inputs. However, this request came late in the study and, therefore, is not fully explored herein.

- ***Outputs*.** Desirable outputs from audit tools include, at a minimum: estimated energy savings from a future retrofit, prioritized lists of energy efficiency improvements, and estimated costs of those improvements. Desirable outputs from tools used under a labeling program include: a home energy rating (either asset-based or operational rating normalized for "typical" use), a list of recommended or installed home energy improvements, predicted energy savings of improvements, and standardized outputs in predetermined formats for inputting into a national registry or other tools for purposes of further analysis or benchmarking. These types of outputs were examined for each tool reviewed.

- **Findings**. The findings from the above-mentioned review were assessed and compiled for DOE action to establish the role of energy audit tools in a national residential building energy rating program. More specifically, this study attempted to answer questions such as:

  - What is the availability, attributes, costs, and level of adoption of viable existing energy audit tools in the marketplace today?
  - Can existing audit tools be employed under a consistent national home energy performance label, providing defendable ratings and energy savings estimates on retrofit measures? How?
  - Are additional software tools or applications necessary to reach the mass residential market (including key market actors such as home inspectors), either augmenting current tools or filling gaps and deficiencies unmet by existing tools?

  Additional areas of research are identified throughout this study and are also compiled and presented in the Findings section of this report.

5. Findings

Study findings are organized by methodological step. It is important to note that qualitative judgments were made for items where definitive evidence is lacking or where disparate characteristics were compared. A summation of the literature search and findings from the questionnaire follows with a focus on the topics of:

- Cost and availability
- Ease of use
- Applicability to most U.S. climates
- Accuracy
- Inputs
- Outputs or reports.

Summary of the Literature Review

Available Audit Tools – The literature collected and reviewed as part of this study revealed that home energy audit tools primarily are used by the home energy rating community (through RESNET); the DOE-funded Weatherization community; the home performance industry (e.g., through Building Performance Institute (BPI) certification); or utility-, non-profit-, or state/local government-based energy programs. RESNET-accredited tools enjoy some of the widest distribution nationally but are restricted to certified home energy raters (HERS) working under the services of a RESNET-certified Provider. These Providers operate as quality assurance organizations under RESNET and sublicense the tools to energy raters working under the Provider's umbrella. Also important to note is that BPI currently does not require the use of audit or modeling tools to determine estimated energy savings; although, there is movement within the organization to go that way.

Weatherization tools include NEAT®, MHEA®, TREAT®, and a handful of others; some tools listed in the literature are no longer distributed by vendors. NEAT® or TREAT® are used by the majority of the state weatherization assistance programs. These tools are designed to facilitate ease of data entry and produce a report detailing recommended improvement measures that comply with guidelines established by the particular agency, state program, and the national DOE Weatherization Assistance Program in terms of cost and priority.

Utility-, non-profit-, and state/local government-based energy efficiency programs develop their own tailored, one-of-a-kind audit tools or rely on proprietary third-party audit tools such as SIMPLE (not evaluated due to being new to market with limited market presence), BEACON Home Energy Advisor®, HomeCheck® (a precursor to RealHomeAnalyzer®), or Home Energy Tune-uP®. These tools are often tailored in some fashion to the individual needs of the utility program; the number and format of the inputs and reports vary considerably. A study by the Energy Trust of Oregon program chronicled the difficulty in using an audit tool as an obstacle to its adoption (Ref. 3).

Audit Tool Accuracy – Information about audit tool accuracy over the broad range of tools is virtually non-existent. Where accuracy is mentioned in available studies, it generally examines a particular tool against only one or two other tools. For example, the 2008 Energy Performance Score report compared REM/Rate® against two versions of Home Energy Saver™ and one other tool (SIMPLE) and found all tools to have issues with the accurate prediction of actual energy usage across a broad range of house types (Ref. 4). It should be noted that this reference has received criticism from the energy modeling community and conclusions from the paper are not widely embraced.

In the literature reviewed, accuracy is addressed more typically in terms of the protocols used to evaluate energy auditing tools. These protocols include BESTEST, BESTEST-EX, and ASHRAE 140 (Refs. 5, 6, 7). As the ASHRAE protocol is primarily used for tools targeting commercial structures, the BESTEST protocols are the standards currently under review for audit tools focused on residential structures. Among other issues, BESTEST is believed by some to frequently overestimate energy savings. In the case of high-performing homes or deep retrofits, the accuracy of BESTEST is particularly debated (Refs. 8, 9). RESNET, as part of its quality assurance procedures, maintains a registry of approved software tools, all of which conform to BESTEST protocols (Refs. 10, 11). BESTEST-EX is a protocol under development to address some of the accuracy issues and to better integrate energy usage data into the algorithms used to generate predicted energy use and potential energy savings. Little publicly-available literature was found on BESTEST-EX.

Information about standards primarily pertains to how audit tools are evaluated. Again, BESTEST, BESTEST-EX, and ASHRAE 140 are the currently available or soon to be available standards relative to energy modeling tools. Otherwise, individual energy efficiency program requirements dictate the specifications for inputs, algorithms, and output in format and data type. For example, NYSERDA in a current Request for Proposal, was very specific in the desired qualities for an energy modeling tool to be used in a *Home Performance with ENERGY STAR* program. NYSERDA has detailed exactly what the tool needs to do, what kind of quality assurance mechanisms are contained within, what the data exchange file should be, and peer review required of the tool. In addition, characteristics of a sample home were provided to proposing vendors to calculate estimated energy savings and generate a recommended list of energy efficiency measures. NYSERDA reviewers would then use this information to gauge the “accuracy” of the proposing vendor’s audit tool (Attachment C.) This approach presumes that the original tool NYSERDA used to develop the results upon which other vendor’s calculations are evaluated is itself extremely accurate. It is more likely that NYSERDA was comfortable with results of its evaluation audit tool based on the combined experience of the organization’s residential energy staff, as opposed to any extensive study as to the accuracy of its tool (beyond perhaps comparing its results with actual post-retrofit utility bills for a single home).

Summary of the Tool Review

Information was obtained from nine vendors with energy audit tools recognized by RESNET-accreditation, DOE Weatherization Assistance Program acceptance, or use by prominent utility, state/local government, and ENERGY STAR programs throughout the nation. As mentioned in the earlier discussion on methodology, tools considered too regionally anchored or restricted by climate zones were eliminated from consideration in this study. Table 1, Table 2, and

Table 3 for RESNET-accredited tools, energy efficiency program tools, and government vendor or other purpose tools respectively detail the information obtained from the vendors, organized by the review criteria defined at the end of the table. Based on review of the information collected about each tool, the following observations were made for each major criterion area studied:

Cost and Availability – NEAT®, HES*Pro*, and TREAT® are the most widely available and used tools in the study; they are available to anyone or, in the case of TREAT, with the means to purchase the tool. The cost for a Single-Family version of TREAT® is $495 with a $200 annual license renewal. NEAT® and HES*Pro* are currently free to the public although HES-Pro was under development and in its beta form when reviewed.

The RESNET-accredited tools have no cost values attributed to them because they are licensed for use through a HERS Provider who charges a license fee. These fees vary considerably depending on the business model of the Provider; for example, a Provider may choose to have a low license fee but charge more for a per-use rating. Additionally, auditors using RESNET-accredited tools must be certified raters and must typically complete a week-long training program offered by HERS Training Providers. It is not unusual for these training programs to cost over $1,500. A caveat is a tool provided by Architectural Energy Corporation called REM/Design® where many of the functions of REM/Rate® are present but is available to everyone and the cost is $327 per computer. REM/Design® was not selected for analysis in this study.

National cost information is not known for utility and state/local government supported tools such as BEACON Home Energy Advisor® and RealHomeAnalyzer®, as subsidy support to auditors and trade contractors by these programs varies considerably. In some areas, users may be less subsidized and therefore carry more of the cost burden.

Home Energy Tune-uP® is offered to certified auditors and home inspectors. Mandatory training consists of a three-day program. Additionally, CMC charges a nominal fee for each report delivered through Tune-uP®.

All in all, the initial costs (including initial licensing and renewal fees, per use fees, and training) of the audit tools examined were not found to be especially prohibitive to the auditor, rater, or trade contractor. These costs were deemed reasonable business expenses. However, if a user was required by program sponsors (utilities, municipalities, states, and others) to obtain a multitude of different audit tools and corresponding training, tool costs would be unacceptable. Tool standardization evolving from the Home Energy Score Program could permit individual users to purchase and use a single "approved" audit tool of their choice.

Ease of Use – The intent of this study was not to obtain every tool under review and model sample houses to evaluate first-hand the ease of use of each tool. While this method would enable the best evaluation of ease of use, time did not permit it. Therefore, a combination of the reviewers' experience with some of the tools, findings from the literature, and the number of inputs required for a report was used to generate a qualitative rating on ease of use for each tool. An ease of use rating correlated solely to number of inputs would potentially mislead the reader; tools with very few inputs might place much of the burden of decision-making or analysis on the auditor, thereby making the tool less friendly.

Tools judged to be most user-friendly include Green Energy Compass® and BEACON Home Energy Advisor®. Green Energy Compass® is not an energy modeling tool. It takes information generated by audit tools to generate a benchmark and energy-use tracking record. Home Energy Tune-uP®, NEAT®, HES*Pro* and Energy*Insights*® were judged to be average in user-friendliness primarily based on user experience and number of inputs. TREAT® and the RESNET-accredited tools were ranked as the most difficult to use. No information concerning RealHomeAnalyzer® was obtained for this draft, but its predecessor, HomeCheck®, was reported as being challenging to use.

BEACON Home Energy Advisor®, being a relative newcomer to the audit tool marketplace, was specifically designed with the goal of ease of use in mind. “Lighter” versions of TREAT® (Surveyor®) for single family, multifamily, and commercial applications are under development but were not specially reviewed under this study. Surveyor® acts as a simplified input interface with TREAT® as the engine. The release dates for these versions are unknown at the time of this writing. The evolution of these easier-to-use audit tools demonstrates the software vendors’ willingness and ability to adapt their tools to the needs of the marketplace, including to an eventual national home energy rating and labeling program.

Applicability to U.S. Climate Zones – All audit tools contained within the matrix are used in the majority of the climate zones for the continental United States and, therefore, would support a national home energy rating and labeling program. EnergyGauge® is most appropriate for the warm-humid climates such as Florida.

Accuracy – Presently, audit tool accuracy is based entirely upon conformance to applicable standards, studies comparing tools to each other, or evaluations of tools against accepted baseline instruments (such as BESTEST.) As the literature identified in this study does not contain any recent comparison of all the tools, the matrix lists the standards, if any, where the tool complies. All of the tools conform to BESTEST or plan to conform to BESTEST-EX with the exception of Green Energy Compass®, which is not a modeling tool. As of this writing, it is assumed that RealHomeAnalyzer® complies with BESTEST but no confirmation has been obtained from the vendor. It should be noted that BESTEST-EX is still under development.

Inputs – The number of inputs necessary to obtain a “typical” report was asked of each vendor (for examples, see Attachment D.) The values range from approximately twenty inputs for Energy*Insights* and TREAT® to a high of approximately 100 for REM/Rate® (considerably less, 33, for Simplified Inputs mode), Home Energy Tune-uP®, EnergyGauge® and NEAT®. BEACON Home Energy Advisor® and HES*Pro* fall in the middle. It is interesting to note that one of the tools reported as difficult to use earlier (TREAT®) also has the fewest inputs. This number of inputs for TREAT® is variable, however, and can be vastly greater depending on the goals set for the tool by its user.

All of the energy auditing tools require some knowledge of building science to effectively gather and enter the necessary information to run analysis. Particularly in cases where deeper retrofits are under consideration or where the inputs are very general in nature, the ability to finesse a tool to better account for improvements which contribute smaller improvement benefits or to adjust inputs to more accurately reflect the "as is" condition is key for accurate modeling. Knowledge of building science as well as an understanding of the "tricks" of the audit tool contributes to more effective improvement recommendations.

If a national home energy rating and labeling program "approves" audit tools (based on various criteria), a user should eventually have a choice of tools from which to select. The user can then base this choice on the level of inputs required of tools, the expertise necessary to achieve accurate results, tool costs, and so forth.

Outputs – With the exception of EnergyGauge®, all the tools can generate home energy improvement recommendations. Green Energy Compass®, NEAT®, and HES*Pro* improvement reports cannot be modified, while the other tools improvement reports have the ability to add comments. Energy Insights, Home Energy Tune-uP®, NEAT® and TREAT® can also accept photos. With the exception of EnergyGauge®, all tools can export data to a file in common database, xml, or csv formats.

A national rating program by definition will require the calculation of a rating or similar benchmark for homes. Tools such as REM/Rate®, Energy*Insights®,* and EnergyGauge® all generate ratings as a requirement for the RESNET-accredited registry of tools for HERS Providers. TREAT® can generate a home energy baseline or label, although TREAT® is no longer on the RESNET-accredited list of software for ratings as the vendor elected not to adapt the changes in the rating system. Most, if not all, the tools reviewed can produce an estimated percent energy savings or before and after estimated energy usage as possible benchmarks.

As mentioned earlier, improvement measures can be prioritized by various energy efficiency programs in a number of different methods. Many, such as the Home Performance with ENERGY STAR and the Weatherization Assistance Program focus partly on health and safety issues with cost effectiveness following as a method of ranking energy efficiency priorities. Some utility-based programs may focus on particular incentives such as appliances through a rebate program. Prioritization of improvement measures can be based upon:

- Health and safety,
- Energy efficiency measures grouped into packages, (e.g., an air-sealing and insulation package),
- Individual or ala carte efficiency measures,
- Cost effectiveness (defined differently by different energy programs),
- Those defined by the program (such as compact fluorescent light bulbs, rebates on appliances, etc.).

The prioritization used in the reported improvement measures by the individual tools reviewed in this study varied as well. Energy Gauge does not currently generate home energy improvement reports and Green Energy Compass® produced a generic improvement report that remains consistent irrespective of the home being analyzed. The general list of improvement measures are used as an educational tool rather than a structure-specific list of energy efficiency recommendations. The recommendations portion of the tool is currently being adapted to produce a list of measures based upon utility bill disaggregation.

Home Energy Tune-uP® lists two groups of recommendations: improvements with a simple payback of 30 years or less, ranked by order of payback; and a second group of improvements that generate more savings than the cost to finance based upon a 15-year loan at 8% interest. Indoor air quality and safety issues are included in the Home Energy Tune-uP® report. Home Energy Tune-uP® uses R.S. Means Repair & Renovation® data as the basis for developing cost of home energy improvement values. The Home Energy Tune-uP software takes into account variations in weather, state codes, labor costs, and fuel prices by reference to the zip code in the address.

The other tools that were reviewed all allowed user input to drive the home energy improvement measures that are analyzed by the tools and then reported. For example, a user may instruct a tool to generate a recommendation to improve attic insulation from R11 to R49 (based on minimum local building codes, recommended ENERGY STAR levels, or some other reasoning.) This recommendation may have little bearing on the cost effectiveness of the measure specified. Energy*Insights*® also permits automatically-generated recommendations for use with utility-based programs that may wish to control the recommendations generated.

Based on the review of how leading energy audit tools generate their respective lists of energy efficiency measures, most tools rely on the user to predetermine what improvements will be analyzed. This predetermination necessitates some level of experience by the user in local building energy codes and industry best practices. For this reason, different energy efficiency improvement recommendations can be made by different users for the same house using the same audit tool. A Home Energy Score Program for homes would benefit from a more consistent set of outputs from audit tools. However, expecting software vendors to enhance their audit tools with local energy code and climate-specific best practices libraries may be too burdensome.

Table 1. Audit Tool Criteria and Attributes Matrix – RESNET Certified

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess attribute	**Energy Gauge**	**REM/Rate**	**Energy *Insights***
General Information			
Vendor	Florida Solar Energy Center	Architectural Energy Corporation	Apogee Interactive
Contact/website	www.energygauge.com	www.remrate.com	www.apogee.net/energyInsights.aspx
Targeted User	Raters	Raters, auditors	Raters, auditors
Highly distributed through U.S. [1]	●	●	●
Primary use:			
Ratings[2]	●	●	●
Code compliance	●	●	○
Audits	○	●	●
Energy[3] tracking/ Benchmarking	○	●	○
Cost	$495	Provider dependent	Sponsor covers cost
Easy to use [4]	○	○	◑
Available for everyone[5]	◑	◑	◑
Upgradeable	●	●	●
Certified algorithm [6]			
BESTEST	●	●	●
BESTEST-EX	○	●	●
Inputs and Modeling			

[1] Reflects the geographic distribution and use in the United States.

[2] A number or ranking reflecting the energy efficiency of the house either from an occupant-blind basis (asset rating) or based on the actual energy use (operational rating).

[3] A tool that can be used to track future energy use and/or compare the structure relative to similar structure/occupant/climate combinations.

[4] A subjective ranking based on the number of inputs required by the tool, personal history of the researchers with the tool, and literature citations.

[5] A subjective ranking based on limitations placed on sale, licensing, or regional availability. Tools available through HERS Providers were ranked as average in availability. Tools available only through regional utility programs were ranked as less available.

[6] Criteria identifies whether a tool has been run through a standardized test, either BESTEST tier 1 & tier 2, or plan to run through BESTEST-EX.

Criteria ● possesses attribute ◐ possesses some of the attribute ○ does not possess attribute	**Energy Gauge**	**REM/Rate**	**Energy *Insights***
Disaggregation of energy use[7]	●	●	●
Normalization of climate/weather	●	●	●
Applicable for all climates[8]	●	●	●
Fuels accepted[9]	E, NG, O, LP	E, NG, O, LP, W	E, NG, O, LP, Other
Calculate interactions between/among measures[10]	●	●	●
Minimum inputs required (approx.)	100	100/33	20
Multiple entries for same building component allowed for:[11]			
Foundations	●	●	●
HVAC zones	●	●	●
Walls	●	●	●
Floors	●	●	●
Ceilings	●	●	●
DHW	●	●	●
Appliances	●	●	●
Accept user-input values:			
Measured inputs[12]	●	●	●
Usage data	○	●	●

[7] Ability of the tool to tease out individual energy-using features of a home and report on their contribution to energy consumption. Typically, baseloads accounting for appliance use, water heating, and plug loads are not broken out. Tools identifying plug loads and with inputs for multiple refrigerators, freezers, window air conditioning units, etc. were ranked highest. Those with an assumed baseload with no opportunity to change the assumptions were ranked lowest.

[8] All tool vendors claim their tools are applicable for all continental-U.S. climates. However, EnergyGauge was primarily designed for use in warm-humid climates.

[9] E=electricity, NG=natural gas, O=oil, LP=propane, C=coal, K=kerosene, W=wood, Ag=agricultural fuels such as corn, S= solar.

[10] The tool algorithm will adjust energy consumption estimates by building element based on the interaction between various elements. For example, increased envelope insulation should reduce the heating and cooling load, thereby minimizing the energy consumption of HVAC.

[11] Tool permits multiple inputs for the same type of building component. For example, does tool allow input for three domestic hot water systems?

[12] Measured inputs describe such values as air infiltration/exfiltration data (blower door), duct tightness, exhaust fan efficiency, etc.

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess attribute	**Energy Gauge**	**REM/Rate**	**Energy *Insights***
Permits detail in billing structure[13]	○	●	◑
Health/safety	○	◑	●
Improvement measure cost data	○	●	●
Plug loads calculated	●	●	●
Reporting and Customization			
Recommendations generated and type[14]	○	● user input	● auto, user input
Exportable data/type[15]	○	● sql, csv	● csv
Reports customizable[16]	○	●	●
Photos allowed	○	○	●
Scope of work generated?[17]	○	◑	◑
Carbon emissions or other metrics used	●	●	●
Asset/Operational rating type			
Asset	●	●	●
Operational	○	○	●
Energy use by fuel	●	●	●
Combined energy units reported (kWh/yr)[18]	○	●	○

[13] Tool permits details ranging from yearly average rates (lowest ranking) to block structure (highest ranking). Seasonal averaging is the middle rank.

[14] Tool recommendations, if generated, consist of either automatically-generated as programmed into the tool, or via user input, either through libraries or conditional lists.

[15] Is data from the tool exportable to other programs or tools and, if so, what file format is generated?

[16] Are reports customizable by the auditor? Tools with report customizable only with comments received an average rank.

[17] It was felt that all tools that generated a recommendation could be altered to produce a scope of work. As they currently exist, however, an adequate scope of work that would enable a contractor to then bid on the project is not generated by any of the tools listed.

[18] Tools often report energy use in terms of kWh/yr and therms if both electricity and natural gas are used. An overall energy consumption value is desired by DOE, such as converting other fuel consumption values to a metric such as kWh/yr.

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess attribute	**Energy Gauge**	**REM/Rate**	**Energy *Insights***
Illustrated on scale[19]	●	●	●
Other Relevant Features			
Estimated input time	>1 Hour	1 Hour	Sponsor dependent
Low level of expertise required[20]	○	◑	◑
Little training necessary[21]	◑	◑	◑
Estimated energy usage compared to actual[22]	◑	◑	◑
Energy savings estimates compared to actual	○	○	○

[19] Asset or operational rating compared to homes with similar characteristics. ENERGY STAR Home Energy Yardstick is an example of such a comparison tool.

[20] Level of expertise ranked purely as a subjective measure based on investigator experience with tools.

[21] Training time of 1 hour or less evaluated as fully meeting the criteria; up to a half-day of training was judged as partially meeting the criteria; and training longer than a half-day was judged as least meeting the criteria.

[22] Subjective evaluation due to the variety of comparison methods. EnergyGauge has performed laboratory comparisons, and EnergyInsight is currently collecting data for this comparison.

Table 2. Audit Tool Criteria and Attributes Matrix – Tools Used by Energy Efficiency Programs

Criteria ● possesses attribute ◐ possesses some of the attribute ○ does not possess attribute	**Home Energy Tune-uP**	**TREAT**	**BEACON HOME ENERGY ADVISOR**	**RealHome Analyzer**
General Information				
Vendor	CMC Energy Services	Performance Systems Development, Inc.	ICF International, Inc.	Conservation Services Group
Contact/website	www.cmcenergy.com	www.TreatSoftware.com	www.icfi.com	www.csgrp.com
Targeted User	Auditors & home inspectors	Auditors	Auditors	Auditors
Highly distributed through U.S. [23]	●	●	◐	●
Primary use:				
Ratings[24]	○	○	○	○
Code compliance	○	○	○	○
Audits	●	●	●	●
Energy[25] tracking/ Benchmarking	○	●	○	○
Cost	$20 per audit	$495	Sponsor covers cost	Contractural with CSG
Easy to use [26]	◐	○	●	◐
Available for everyone[27]	◐	●	○	○
Upgradeable	●	●	●	●
Certified algorithm [28]				

[23] Reflects the geographic distribution and use in the United States.
[24] A number or ranking reflecting the energy efficiency of the house either from an occupant-blind basis (asset rating) or based on the actual energy use (operational rating).
[25] A tool that can be used to track future energy use and/or compare the structure relative to similar structure/occupant/climate combinations.
[26] A subjective ranking based on the number of inputs required by the tool, personal history of the researchers with the tool, and literature citations.
[27] A subjective ranking based on limitations placed on sale, licensing, or regional availability. Tools available through HERS Providers were ranked as average in availability. Tools available only through regional utility programs were ranked as less available.
[28] Criteria identifies whether a tool has been run through a standardized test, either BESTEST tier 1 & tier 2, or plan to run through BESTEST-EX.

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess attribute	**Home Energy Tune-uP**	**TREAT**	**BEACON HOME ENERGY ADVISOR**	**RealHome Analyzer**
BESTEST	●	◑	○	○
BESTEST-EX	●	●	●	●
Inputs and Modeling				
Disaggregation of energy use[29]	○	●	◑	●
Normalization of climate/weather	●	●	●	●
Applicable for all climates[30]	●	●	●	●
Fuels accepted[31]	E, NG, O, LP, C, K, W, Ag, S	E, NG, O, LP, C, K, W, Ag	E, NG, O, LP	E, NG, O, LP, Other
Calculate interactions between/among measures[32]	●	●	●	●
Minimum inputs required (approx.)	80	25	50	25
Multiple entries for same building component allowed for:[33]				
Foundations	●	●	◑	●
HVAC zones	◑	●	◑	●
Walls	●	●	◑	●
Floors	●	●	◑	●
Ceilings	●	●	◑	●

[29] Ability of the tool to tease out individual energy-using features of a home and report on their contribution to energy consumption. Typically, baseloads accounting for appliance use, water heating, and plug loads are not broken out. Tools identifying plug loads and with inputs for multiple refrigerators, freezers, window air conditioning units, etc. were ranked highest. Those with an assumed baseload with no opportunity to change the assumptions were ranked lowest.

[30] All tool vendors claim their tools are applicable for all continental-U.S. climates. However, CMC indicated their tool is most applicable for colder climates.

[31] E=electricity, NG=natural gas, O=oil, LP=propane, C=coal, K=kerosene, W=wood, Ag=agricultural fuels such as corn, S= solar.

[32] The tool algorithm will adjust energy consumption estimates by building element based on the interaction between various elements. For example, increased envelope insulation should reduce the heating and cooling load, thereby minimizing the energy consumption of HVAC.

[33] Tool permits multiple inputs for the same type of building component. For example, does tool allow input for three domestic hot water systems?

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess attribute	**Home Energy Tune-uP**	**TREAT**	**BEACON HOME ENERGY ADVISOR**	**RealHome Analyzer**
DHW	●	○	●	●
Appliances	●	●	●	●
Accept user-input values:				
Measured inputs[34]	●	●	●	●
Usage data	○	●	●	●
Permits detail in billing structure[35]	●	○	○	●
Health/safety	●	●	●	●
Improvement measure cost data	●	●	●	●
Plug loads calculated	◑	●	○	◑
Reporting and Customization				
Recommendations generated and type[36]	● auto	● user input	● user input	● auto, user input
Exportable data/type[37]	● csv	● xml, csv	● xml	● ?
Reports customizable[38]	◑	●	◑	◑
Photos allowed	●	●	○	○
Scope of work generated?[39]	◑	◑	◑	●
Carbon emissions or other metrics used	●	◑	●	●
Asset/Operational rating type				
Asset	○	◑	○	○

[34] Measured inputs describe such values as air infiltration/exfiltration data (blower door), duct tightness, exhaust fan efficiency, etc.

[35] Tool permits details ranging from yearly average rates (lowest ranking) to block structure (highest ranking). Seasonal averaging is the middle rank.

[36] Tool recommendations, if generated, consist of either automatically-generated as programmed into the tool, or via user input, either through libraries or conditional lists.

[37] Is data from the tool exportable to other programs or tools and, if so, what file format is generated?

[38] Are reports customizable by the auditor? Tools with report customizable only with comments received an average rank.

[39] It was felt that all tools that generated a recommendation could be altered to produce a scope of work. As they currently exist, however, an adequate scope of work that would enable a contractor to then bid on the project is not generated by any of the tools listed.

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess attribute	**Home Energy Tune-uP**	**TREAT**	**BEACON HOME ENERGY ADVISOR**	**RealHome Analyzer**
Operational	○	●	●	●
Energy use by fuel	○	●	●	●
Combined energy units reported (kWh/yr)[40]	○	●	○	●
Illustrated on scale[41]	○	○	●	○
Other Relevant Features				
Estimated input time	½ Hour	1 Hour	½ Hour	?
Low level of expertise required [42]	◑	○	○	?
Little training necessary[43]	◑	◑	◑	?
Estimated energy usage compared to actual[44]	●	●	○	●
Energy savings estimates compared to actual	○	●	○	●

[40] Tools often report energy use in terms of kWh/yr and therms if both electricity and natural gas are used. An overall energy consumption value is desired by DOE, such as converting other fuel consumption values to a metric such as kWh/yr.

[41] Asset or operational rating compared to homes with similar characteristics. ENERGY STAR Home Energy Yardstick is an example of such a comparison tool.

[42] Level of expertise ranked purely as a subjective measure based on investigator experience with tools.

[43] Training time of 1 hour or less evaluated as fully meeting the criteria; up to a half-day of training was judged as partially meeting the criteria; and training longer than a half-day was judged as least meeting the criteria.

[44] Subjective evaluation due to the variety of comparison methods. Tune-uP, and TREAT have had analyses performed either under a third-party or as part of a government-subsidized (NYSERDA) research effort.

Table 3. Audit Tool Criteria and Attributes Matrix – Government Vendor or Other Purpose Tools

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess the attribute	**NEAT**	**HES-Pro**	**Green Energy Compass**
General Information			
Vendor	Oak Ridge National Laboratory	Lawrence Berkeley National Laboratory	Performance Systems Development, Inc.
Contact/website	http://weatherization.ornl.gov/assistant.shtm	http://HESPro.lbl.gov	www.psdconsulting.com/greenenergycompass
Targeted User	Weatherization providers	Auditors, home inspectors	Program administrators, auditors, facilities management
Highly distributed through U.S. [45]	●	●	◑
Primary use:			
Ratings[46]	○	●	○
Code compliance	○	○	○
Audits	●	●	○
Energy[47] tracking/ Benchmarking	●	○	●
Cost	free	free	Sponsor covers cost
Easy to use [48]	○	◑	●
Available for everyone[49]	●	●	●
Upgradeable	●	●	●
Certified algorithm [50]			

[45] Reflects the geographic distribution and use in the United States.

[46] A number or ranking reflecting the energy efficiency of the house either from an occupant-blind basis (asset rating) or based on the actual energy use (operational rating).

[47] A tool that can be used to track future energy use and/or compare the structure relative to similar structure/occupant/climate combinations.

[48] A subjective ranking based on the number of inputs required by the tool, personal history of the researchers with the tool, and literature citations.

[49] A subjective ranking based on limitations placed on sale, licensing, or regional availability. Tools available through HERS Providers were ranked as average in availability. Tools available only through regional utility programs were ranked as less available.

Criteria ● possesses attribute ◐ possesses some of the attribute ○ does not possess the attribute	**NEAT**	**HES-Pro**	**Green Energy Compass**
BESTEST	○	◐	○
BESTEST-EX	○	○	○
Inputs and Modeling			
Disaggregation of energy use[51]	○	●	◐
Normalization of climate/weather	●	●	●
Applicable for all climates[52]	●	●	●
Fuels accepted[53]	E, NG, O, LP, C, K, W	E, NG, O, LP	E, NG, O, LP, C, K, W, Ag
Calculate interactions between/among measures[54]	●	●	●
Minimum inputs required (approx.)	100	30	N/A
Multiple entries for same building component allowed for:[55]			
Foundations	●	○	N/A
HVAC zones	●	○	N/A
Walls	●	●	N/A
Floors	●	○	N/A

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[50] Criteria identifies whether a tool has been run through a standardized test, either BESTEST tier 1 & tier 2, or plan to run through BESTEST-EX.

[51] Ability of the tool to tease out individual energy-using features of a home and report on their contribution to energy consumption. Typically, baseloads accounting for appliance use, water heating, and plug loads are not broken out. Tools identifying plug loads and with inputs for multiple refrigerators, freezers, window air conditioning units, etc. were ranked highest. Those with an assumed baseload with no opportunity to change the assumptions were ranked lowest.

[52] All tool vendors claim their tools are applicable for all continental-U.S. climates.

[53] E=electricity, NG=natural gas, O=oil, LP=propane, C=coal, K=kerosene, W=wood, Ag=agricultural fuels such as corn, S= solar.

[54] The tool algorithm will adjust energy consumption estimates by building element based on the interaction between various elements. For example, increased envelope insulation should reduce the heating and cooling load, thereby minimizing the energy consumption of HVAC.

[55] Tool permits multiple inputs for the same type of building component. For example, does tool allow input for three domestic hot water systems?

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess the attribute	**NEAT**	**HES-Pro**	**Green Energy Compass**
Ceilings	●	○	N/A
DHW	●	○	N/A
Appliances	◑	●	●
Accept user-input values:			
Measured inputs[56]	●	◑	N/A
Usage data	●	○	●
Permits detail in billing structure[57]	○	◑	○
Health/safety	●	◑	●
Improvement measure cost data	●	●	●
Plug loads calculated	●	●	◑
Reporting and Customization			
Recommendations generated and type[58]	● user input	● auto	◑ user input
Exportable data/type[59]	● csv	● xml	● xml
Reports customizable[60]	○	○	○
Photos allowed	●	○	●
Scope of work generated?[61]	●	◑	○
Carbon emissions or other metrics used	○	●	●
Asset/Operational rating type			

[56] Measured inputs describe such values as air infiltration/exfiltration data (blower door), duct tightness, exhaust fan efficiency, etc.

[57] Tool permits details ranging from yearly average rates (lowest ranking) to block structure (highest ranking). Seasonal averaging is the middle rank.

[58] Tool recommendations, if generated, consist of either automatically-generated as programmed into the tool, or via user input, either through libraries or conditional lists.

[59] Is data from the tool exportable to other programs or tools and, if so, what file format is generated?

[60] Are reports customizable by the auditor? Tools with report customizable only with comments received an average rank.

[61] It was felt that all tools that generated a recommendation could be altered to produce a scope of work. As they currently exist, however, an adequate scope of work that would enable a contractor to then bid on the project is generated only by NEAT. Green Energy Compass produced only generic recommendations consistent for all homes and was least associated with being able to generate a scope of work.

Criteria ● possesses attribute ◑ possesses some of the attribute ○ does not possess the attribute	**NEAT**	**HES-Pro**	**Green Energy Compass**
Asset	○	○	○
Operational	○	○	●
Energy use by fuel	●	●	●
Combined energy units reported (kWh/yr)[62]	○	○	●
Illustrated on scale[63]	○	●	●
Other Relevant Features			
Estimated input time	>1 Hour	1 Hour	10 Minutes
Low level of expertise required [64]	○	◑	●
Little training necessary[65]	◑	◑	●
Estimated energy usage compared to actual[66]	●	●	●
Energy savings estimates compared to actual	●	○	●

[62] Tools often report energy use in terms of kWh/yr and therms if both electricity and natural gas are used. An overall energy consumption value is desired by DOE, such as converting other fuel consumption values to a metric such as kWh/yr.

[63] Asset or operational rating compared to homes with similar characteristics. ENERGY STAR Home Energy Yardstick is an example of such a comparison tool.

[64] Level of expertise ranked purely as a subjective measure based on investigator experience with tools.

[65] Training time of 1 hour or less evaluated as fully meeting the criteria; up to a half-day of training was judged as partially meeting the criteria; and training longer than a half-day was judged as least meeting the criteria.

[66] Subjective evaluation due to the variety of comparison methods. NEAT, HES-Pro, and Green Energy Compass have had or are currently undergoing analyses performed either under a third-party or as part of a government-subsidized (NYSERDA) research effort.

6. LITERATURE REVIEW

A review of the literature comparing energy auditing and modeling software resulted in few citations, most dating back at least six years. The variety and format for energy auditing and modeling software has changed greatly over the last six to eight years since the last comprehensive reviews of software tools were published. However, the literature describes many of the software packages investigated during this study and reaches conclusions still relevant today.

General Overview of Audit Tools

The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) has a Building Technologies Program that maintains a directory of energy-related software tools including auditing and modeling software (http://apps1.eere.energy.gov/buildings/tools_directory/) (Ref. 12). This directory is not intended to provide a comprehensive review of all features for listed products or to compare and contrast products in similar categories. It does, however, list major features and, in many cases, provides comment regarding strengths and weaknesses of the tool under review. Review database fields include keyword, validation/testing protocol, expertise required to navigate the software, number of users, intended audience, input and output fields required or generated by the tool, computer platform required to operate and programming language used, strengths and weaknesses of the tool, and contact information for the tool vendor including price information. At an elevated hierarchy, the tool reviews can be sorted by subject area such as energy modeling, load calculations, codes and standards conformity, water conservation, and so forth.

The State University of New Jersey Rutgers Center for Energy, Economic and Environmental Policy performed an evaluation of home energy audit tools as part of a comprehensive review of the New Jersey Clean Energy Program (Ref. 13). In this study, only four audit tools were evaluated including Home Energy Checkup, Home Energy Advisor, Home Energy Saver, and a utility-sponsored tool called Home Analyzer. All tools were web-based audit tools designed to provide recommendations or to educate homeowners on energy savings.

Mills (Refs. 14, 15) performed an analysis of multiple energy analysis tools with residential capabilities ranging from web-based tools focused on particular functions such as HVAC load calculations to disk-based, multi-functional software packages. In all, sixty-five programs were evaluated; 50 web-based and 15 disk-based packages. Mills determined that out of the web-based tools, only 21 performed whole-house analysis and out of these, 13 provided open-ended energy calculations, five tools permitted bill disaggregation and only three contained both functions. Of the disk-based tools, six performed whole-house analysis and three performed both open-ended energy calculations and bill disaggregation. Mills noted a wide disparity in intended audience, ease of use, purpose, accuracy of predicted versus actual energy use, number and type of inputs and outputs in all of the tools and presented a matrix as a suggestion for further analysis.

Paradis (Ref. 16) presented an overview of energy analysis tools to help designers select a tool for a particular project. While presenting a mix of tools, the focus of this overview was on commercial structures and multi-family residential for federal audiences. Paradis segmented tools into categories including screening, architectural design, load calculation/HVAC sizing, and economic analysis.

Kim et al. (Ref. 17) performed an overview of energy analysis tools listed within the DOE EERE's Building Energy Software Tools Directory to provide the Texas energy office with a list of tools and associated recommended uses. This study did not assess accuracy or make judgments of tool value; rather the study was an effort to characterize the use of each tool within the directory of potential interest to the energy office.

Audit Tool Accuracy

Stein and Meir (Ref. 7) evaluated HERS ratings and actual billing data for 500 homes in four states. Conclusions were that over large populations, HERS ratings could predict annual energy usage and cost but the accuracy diminished considerably when individual homes were considered for predicted versus actual cost. In particular, a wide disparity was found for older homes. It was further concluded that using actual billing data to calibrate HERS ratings could improve average accuracy over the whole population of rated homes, but does not affect variance.

Hendron, Farrar-Nagy, Anderson, and Judkoff (Ref. 8) also probed the subject of software accuracy as it pertained to the calculated energy savings for high-performance housing as part of the Building America program. Their analysis looked at simulation tools that met the requirements of HERS BESTEST or compared to the International Energy Conservation Code (IECC) and determined that high-performance homes showed vastly different efficiency ratings based upon the energy analysis methodology used. They concluded that high-performance homes required analysis tools with four important features:

- Clearly defined reference home
- Consistent set of operational assumptions that mimicked realistic occupant behavior
- Accurate predicted energy savings modeling
- Reporting process that communicates effectively where energy savings are being realized and to what magnitude.

The paper further states that programs with lower energy-savings expectations, such as *Home Performance with ENERGY STAR*, do not require such accuracy from analytic tools.

A report for Energy Trust of Oregon (Ref. 4) compared the accuracy of four energy modeling software tools over 190 homes in the cities of Portland and Bend, Oregon. REM/Rate®, SIMPLE, and two versions of Home Energy Saver were compared for accuracy of the predicted energy use compared with actual use obtained from billing records. The conclusion was that none of the software was extremely accurate, but SIMPLE performed the best out of the entire population of houses. Recommendations about energy modeling software were:

- Develop energy modeling tools that are more accurate and require less time to input
- Have models better predict and report actual energy usage
- Use standard normalized assumptions for baseloads and plug loads from typical usage patterns (somewhat contradictory to the prior recommendation)
- Produce recommendations for energy improvements based on specific guidelines (to be determined) and be able to model savings of the upgrades.

7. References

The following literature was identified and reviewed as part of this study:

(1) Florida Department of Community Affairs. 2002. Florida Weatherization Assistance Program Priority List Assessment and Testing, Form PLAT-08/02, Division of Housing and Community Development, Tallahassee, FL.

(2) Team IBTS. 2006. PATH 36 Uniform Protocol for Energy-Efficient Remodeling of Existing Housing, C-CHI-00800/CHI-T0001, HUD, Washington, D.C.

(3) Opinion Dynamics Corporation. 2010. Process and Impact Evaluation of the 2007-2008 Energy Trust of Oregon Home Energy Solutions Program Volume 2, Opinion Dynamics Corp., Oakland, CA.

(4) Earth Advantage Institute and Conservation Services Group. 2009. Energy Performance Score 2008 Pilot, Findings & Recommendations Report, Earth Advantage Institute, Portland, OR.

(5) Judkoff, R. and J. Neymark. 2006. Model Validation and Testing: The Methodological Foundation of ASHRAE Standard 140, NREL/CP-550-40360, NREL, Golden, CO.

(6) Judkoff, R. and J. Neymark. 1995. Home Energy Rating System Building Energy Simulation Test (HERS BESTEST) Volume 1, NREL/TP-472-7332a, NREL, Golden, CO.

(7) Stein, J.R., and A. Meier. 2000. Accuracy of Home Energy Rating Systems, Energy (25) 339-354.

(8) Hendron, R., S. Farrar-Nagy, R. Anderson, R. Judkoff, P. Reeves, and E. Hancock. 2003. Calculating Energy Savings in High Performance Residential Buildings Programs, NREL/CP-550-33622, NREL, Golden, CO.

(9) Hendron, R., R. Anderson, C. Christensen, M. Eastment, and P. Reaves. 2004. Development of an Energy Savings Benchmark for all Residential End-Uses, NREL/CP-550-35917, NREL, Golden, CO.

(10) Residential Energy Services Network (RESNET). 2009. National Registry of Accredited Rating Software Programs, RESNET, San Diego, CA.

(11) Residential Energy Services Network (RESNET). 2006. Procedures for Verification of RESNET Accredited HERS Software Tools, RESNET, San Diego, CA.

(12) U.S. Department of Energy (DOE). 2008. Building Energy Software Tools Directory, DOE, Washington, D.C.

(13) New Jersey Clean Energy Program. 2007. New Jersey's Clean Energy Program: Protocols to Measure Resource Savings (Draft), New Jersey Board of Public Utilities Office of Clean Energy, Trenton, NJ.

(14) Mills, E. 2002. Review and Comparison of Web- and Disk-based Tools for Residential Energy Analysis, LBNL-50950, LBNL, Berkeley, CA.

(15) Mills, E. 2004. Inter-comparison of North American Residential Energy Analysis Tools, Energy and Buildings (36)865-880, LBNL, Berkeley, CA.

(16) Paradis, R. 2007. Energy Analysis Tools, Whole Building Design Guide, National Institute of Building Sciences, Washington, D.C.

(17) Kim, H., J. Haberi, and M. Verdict. 2009. Review and Recommendations of Existing Methods and Tools for Building

Energy Analysis, ESL-TR-09-04-01, Southern Energy Efficiency Center, Energy Systems Laboratory, Texas A&M University, College Station, TX.

ATTACHMENTS

Attachment A: Florida Weatherization Program Prioritization of Improvement Measures

Attachment B: Vendor Questionnaire

Attachment A. Florida Weatherization Program Improvement Prioritization List

Weatherization Works in Florida

FLORIDA WEATHERIZATION ASSISTANCE PROGRAM
Priority List Assessment and Testing Form (PLAT-08/02)

ALL BOXES THAT ARE HIGHLIGHTED MUST BE FILLED IN UNLESS THE TESTING PROCEDURE OR THE MEASURE/PRIORITY LIST ITEM DOES NOT APPLY TO THE DWELLING.

TO BE CHECKED IN EACH DATA COLLECTION SECTION:	If Not Applicable:	N/A

CUSTOMER NAME:				PHONE:			
ADDRESS:							
DIRECTIONS:							
JOB NUMBER:				PREVIOUS WX DATE (If applicable):			
INSPECTOR(S):				DATE INSPECTED			
TYPE OF DWELLING	MH	SITE BUILT	OTHER	SQUARE FOOT		NO. OF OCCUPANTS	

PRIORITY LIST SUMMARY

	Priority List	PWOA			Comments
1	Air Sealing / General Heat Waste	N/A	Y	N	
2	Attic and Floor Insulation	N/A	Y	N	
3	Dense-Pack Sidewalls	N/A	Y	N	
4	Solar Window Screens	N/A	Y	N	
5	Smart Thermostat	N/A	Y	N	
6	Compact Fluorescent Lamps	N/A	Y	N	
7	Seal and Insulate Ducts	N/A	Y	N	
8	Refrigerator	N/A	Y	N	
9	Heating and Cooling Systems	N/A	Y	N	
10	Water Heater	N/A	Y	N	

Initial Evaluation for Health & Safety (Section VI of Procedures and Guidelines)

HOUSEHOLD HEALTH

Are there any household occupants health issues that will effect performing blower door testing:	Y	N

CARBON MONOXIDE & GAS TESTING - All combustible appliances and gas lines will be tested first. No weatherization activities will be performed until an unacceptable CO reading on any combustible appliance is corrected.

Appliance	Fuel Type		Location	Unit Type		Venting		Required Monoxor Readings
Primary Heating unit (See note below)	NG	LP		Fixed	Space	Unvented	Vented	Primary heating - pre & post Space heaters - pre & post Cook Stove – 5 - pre Water Heater - 3 - pre
Secondary Unit # 1	NG	LP		Fixed	Space	Unvented	Vented	
Secondary Unit # 2	NG	LP		Fixed	Space	Unvented	Vented	
Cook Stove (See C below)	NG	LP				Unvented	Vented	Final (ambient) 1 for each room with a combustible appliance
Dryer	NG	LP				Unvented	Vented	(Staple CO printouts here)
Water Heater	NG	LP				Unvented	Vented	

1

Note: All combustible appliances must be vented to the outside.*
***(exception - unvented secondary heaters meeting program guidelines)**

Test all GAS Fittings for leaks:	Pass	Fail	**Testing included under stove top and at tank.**	Y	N
Comments:					
If not applicable:	N/A				

Note: – ALL HEATING AND COOLING UNITS DIAGNOSTIC TESTING PROCEDURES AND EVALUATION DATA IS REPORTED UNDER PRIORITY ITEM # 9

COMBUSTIBLE FUEL STOVE REPAIR or REPLACEMENT (Charged to Health & Safety)

Top burner(s) need replacing	Y (1 2 3 4)	N	**Staple photo documentation and technician inspection form here or place in client file.**
Oven burner needs replacing	Y	N	
Stove deteriorated condition warrants replacement:	Y	N	
Comments:			
If not applicable:	N/A		

DETECTORS – (Charged to Health & Safety)

Smoke Detectors	Existing	Y	N	Functioning	Y	N	Install:	Y	N	Location(s):	
CO Detectors	Existing	Y	N	Functioning	Y	N	Install:	Y	N	Location(s):	
Comments:											
If not applicable:	N/A										

POLLUTION SURVEY OF CHEMICALS AND POLLUTANTS:

There	**were**	**were not**	**pollutants stored within the living area**
TYPE	**LOCATION**		
Brought to attention of client for removal or outside storage:	Y	N	
Comments:			
If not applicable:	N/A		

2

ELECTRICAL PANEL

Location		**Name**		**Size**		**Covered**	Y	N
Condition					**Comments:**			

MOLD & MOISTURE EVALUATION (Reference Section III of Procedures and Guidelines)

Existing:	Y	N	**Weatherization measure related**			Y	N	**Postponement of services required**					Y	N
Is venting needed for:			**Stove**	Y	N	**Clothes dryer**	Y	N	**Bathroom**	Y	N	**Whole house**	Y	N
Comments:														
If not applicable:	N/A													

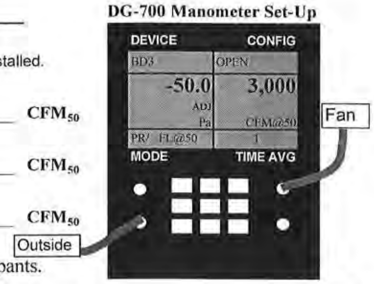
LEAD PAINT EVALUATION – Pre 1978 dwellings (Reference Section III of Procedures and Guidelines)

Visual exterior inspection indicates possible lead paint (deterioration) is existing:											Y	N	N/A	
Visual interior inspection indicates possible lead paint (deterioration) is existing:											Y	N	N/A	
Areas of suspected lead	**Win dows**	Y	N	**Doors**	Y	N	**Walls**	Y	N	**Ceiling**			Y	N
After determining weatherization measure to be addressed, would LSW be required to be performed:													Y	N
Is there flaking paint present				Y	N	**Postponement of services required**							Y	N
Comments:														
If not applicable:	N/A													

3

Diagnostic Testing

DG-700 Manometer Set-Up



Building Tightness Limit (BTL) / Minimum Ventilation Rate (MVR)

Final blower door must be higher than following calculations or ventilation must be installed.

# of Bedrooms Plus 1: ______ X 15= _____ x n factor _____ = _______ CFM_{50}

# of People & Large Pets: ______ X 15= _____ x n factor _____ = _______ CFM_{50}

Building Volume: ________ X .35 / 60= _____ x n factor _____ = _______ CFM_{50}

Note: Smokers count as two occupants. Large or multiple pets count as occupants.

Pre-Wx Blower Door Reading

☐ **Turn off all heating/cooling devices** ☐ **Close all windows** ☐ **Open interior doors**

Outdoor Temp: _______ **Wind:** ___________ **Ring:** _________ **House Pressure:** [PA]

Notes: ____ **Pre-Reading:** [CFM_{50}]

Target Blower Door Reading

If final blower door is not close to target, justification must be provided in Final-Wx Reading notes.

25%		30%		35%				40% beginning @7500cfm50					
Pre	**Target**	**Pre**	**Target**	**Pre**	**Target**	**Pre**	**Target**	**Pre**	**Target**	**Pre**	**Target**	**Pre**	**Target**
3,000	2,250	4,000	2,800	5,000	3,250	6,000	3,900	7,000	4,550	8,000	4,800	9,000	5,400
3,100	2,325	4,100	2,870	5,100	3,315	6,100	3,965	7,100	4,615	8,100	4,860	9,100	5,460
3,200	2,400	4,200	2,940	5,200	3,380	6,200	4,030	7,200	4,680	8,200	4,920	9,200	5,520
3,300	2,475	4,300	3,010	5,300	3,445	6,300	4,095	7,300	4,745	8,300	4,980	9,300	5,580
3,400	2,550	4,400	3,080	5,400	3,510	6,400	4,160	7,400	4,810	8,400	5,040	9,400	5,640
3,500	2,625	4,500	3,150	5,500	3,575	6,500	4,225	7,500	4,500	8,500	5,100	9,500	5,700
3,600	2,700	4,600	3,220	5,600	3,640	6,600	4,290	7,600	4,560	8,600	5,160	9,600	5,760
3,700	2,775	4,700	3,290	5,700	3,705	6,700	4,355	7,700	4,620	8,700	5,220	9,700	5,820
3,800	2,850	4,800	3,360	5,800	3,770	6,800	4,420	7,800	4,680	8,800	5,280	9,800	5,880
3,900	2,925	4,900	3,430	5,900	3,835	6,900	4,485	7,900	4,740	8,900	5,340	9,900	5,940

- Sealing is optional if the Pre-Wx Blower Door reading is below 3,000.
- If the Pre-Wx Blower Door reading is above 9,900 then calculate the target as: Pre-Wx Reading x .6

Target Reading: [CFM_{50}]

Final-Wx Blower Door Reading

☐ **Turn off all heating/cooling devices** ☐ **Close all windows** ☐ **Open interior doors**

Outdoor Temp: _______ **Wind:** ___________ **Ring:** _________ **House Pressure:** [PA]

Notes: ____ **Final-Reading:** [CFM_{50}]

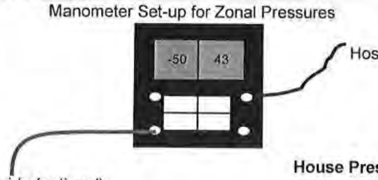
RING REMINDER: All the rings should be left covering the fan while taking the baseline. Then all the rings should be removed to turn on the fan. The rings are for "tight" houses - only put the rings on if the manometer is flashing "Lo" on the screen. To put a ring on, simply reduce the fan speed to zero, and put it on. Then push the "CONFIG" button until the "CONFIG" setting in the top right corner of the manometer matches the ring set-up (For instance, if you are using no rings, it should read "OPEN", if you are using the first ring, it should read "A1").

Each of these tests should be conducted with the blower door depressurizing the house to -50 Pascals WRT Outside. All heating and/or cooling appliances should be turned off prior to any blower door operation.

Zonal Pressures (Zone WRT House)

Manometer Set-up for Zonal Pressures

Any reading under 45 Pa indicates significant air leaks between living space and zone.



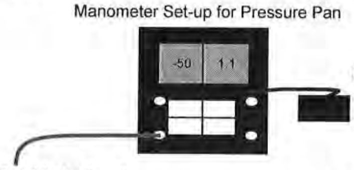
House Pressure: ________ PA

1. Attic 1 ____ Pre-Wx ____ Final-Wx
2. Attic 2 ____ Pre-Wx ____ Final-Wx
3. Crawlspace ____ Pre-Wx ____ Final-Wx
4. Bellyboard ____ Pre-Wx ____ Final-Wx
5. Garage ____ Pre-Wx ____ Final-Wx
6. ________ ____ Pre-Wx ____ Final-Wx
7. ________ ____ Pre-Wx ____ Final-Wx
8. ________ ____ Pre-Wx ____ Final-Wx

Pressure Pan (Duct WRT House) **Zone Pressure Duct Location______**

Manometer Set-up for Pressure Pan

Any reading over 1 Pa indicates need to seal around register and boot using mastic and/or seal/repair duct work.



House Pressure: ________ PA

Returns:

________ **Location** ____ Pre-Wx ____ Final-Wx ________ **Location** ____ Pre-Wx ____ Final-Wx

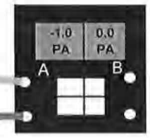
Supplies:

1. ________ Location ____ Pre-Wx ____ Final-Wx
2. ________ Location ____ Pre-Wx ____ Final-Wx
3. ________ Location ____ Pre-Wx ____ Final-Wx
4. ________ Location ____ Pre-Wx ____ Final-Wx
5. ________ Location ____ Pre-Wx ____ Final-Wx
6. ________ Location ____ Pre-Wx ____ Final-Wx
7. ________ Location ____ Pre-Wx ____ Final-Wx
8. ________ Location ____ Pre-Wx ____ Final-Wx
9. ________ Location ____ Pre-Wx ____ Final-Wx
10. ________ Location ____ Pre-Wx ____ Final-Wx

Can't Reach Fifty Factors for Pressure Readings, Multiply by factor to determine Reading if Could get to 50PA

50= 1.0	45= 1.1	40= 1.25	35= 1.42	30= 1.66	25= 2.0	20= 2.5	15= 3.5	10= 5.0	5= 10.0

Combustion Appliance Zone (CAZ) Testing

Open to Zone with Combustion Appliance / Green Hose to Outside	Hose to Zone with Combustion Appliance / Green Hose to Outside
	
Use this setup when you **ARE** located in the Combustion Appliance Zone	Use this setup when you **ARE NOT** located in the Combustion Appliance Zone

a. VISUALLY INSPECT VENTING (of each Combustion Appliance)
b. TURN OFF ALL COMBUSTION APPLIANCES.
c. CLOSE ALL OPERABLE VENTS AND DAMPERS.
d. CHECK DRYER VENT and LINT FILTER
e. CHECK FURNACE FILTER (clean or replace if needed)
f. OPEN ALL INTERIOR DOORS.

NOTE: IF BLOWER DOOR IS SET UP, BE SURE FAN IS COVERED.

1. Setup Manometer and Pressure hoses to measure CAZ (WRT) Outdoors
2. Take Baseline Pressure
3. Turn on all exhaust fans (do not turn on whole-house fans).
4. Close all interior doors to rooms that do not have exhaust fans.
5. If the house has a fireplace that the client uses, turn on the blower door to 300 CFM with Ring B to simulate.

	Appliance 1		Appliance 2		Appliance 3	
	Pre	Post	Pre	Post	Pre	Post
6. Open door, if present, between CAZ and Main Body of house. Record reading.	Pa	Pa	Pa	Pa	Pa	Pa
7. Close door between CAZ and Main Body of house. Record reading. *(If no door, skip to Step number 8)*	Pa	Pa	Pa	Pa	Pa	Pa
8. Turn on Furnace Blower. Check position of interior doors with smoke puffer for worst case. If the smoke blows towards the CAZ, leave the door shut.	Pa	Pa	Pa	Pa	Pa	Pa
9. Open door between CAZ and Main Body of house. Record reading. *(If no door, skip step)*	Pa	Pa	Pa	Pa	Pa	Pa

10. Recreate Worst Case Conditions for each CAZ (Complete this and following steps on each Heating Inspection form)
11. Perform Worst Case Draft and Combustion Tests for each appliance under this worst case condition

* **If Ambient CO gets above 35 ppm, discontinue testing and remove CAZ from worst case conditions.**
* **There should be no spillage after 1 minute of Worst Case and draft should be established after 5 minutes**

Dominant Duct Leakage Test (Main Body WRT outdoors) **Dominant Duct Leakage______PA (Take Baseline First)**

Pressure in Individual Rooms (Room WRT Main body)

Room	Bef	Int	PR	Aft	Room	Bef	Int	PR	Aft	Room	Bef	Int	PR	Aft
1.					4.					7.				
2.					5.					8.				
3.					6.					9.				

6

PRIORITY LIST AND MEASURES (Section IX of Procedures and Guidelines)

IF ANY PRIORITY LIST MEASURE IS NOT APPLICABLE, CHECK APPROPRIATE BOX AND MOVE ON TO THE NEXT MEASURE

PIORITY LIST # 1 - AIR SEALING AND GENERAL HEAT WASTE MEASURES

GENERAL HEAT WASTE MEASURES - REQUIRED

Measure	To Do		Installation / Comments
HVAC Filters	Y	N/A	
Low Flow Showerhead *	Y	N/A	
Faucet Aerator(s) *	Y	N/A	
Water Heater Wrap	Y	N/A	
Water Heater Pipe Insulation.	Y	N/A	
*** Note: Measures may not be applicable if dwelling is on well water.**			

AIR SEALING MEASURES

Measure	To Do		Installation / Comments
Wall Top Plates – attic	Y	N/A	
Caulking	Y	N/A	
Minor Ceiling Repair	Y	N/A	
Minor Wall Repair	Y	N/A	
Minor Floor Repair	Y	N/A	
Threshold	Y	N/A	
Weather-stripping	Y	N/A	

DOORS

Location	Height	Width	Repair		Replace		Either staple photo documentation here or place in client file for second Replacement Door.
Front Door			Y	N	Y	N	
Side or Back Door			Y	N	Y	N	
Comments:							
If not applicable:	N/A						

WINDOWS

Wall Location				Length	Width	Repair		Replace		Either staple photo documentation here or place in client file for third and fourth Replacement Window.
N	S	E	W			Y	N	Y	N	
N	S	E	W			Y	N	Y	N	
N	S	E	W			Y	N	Y	N	
N	S	E	W			Y	N	Y	N	
Comments:										
If not applicable:	N/A									

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PRIORITY LIST # 2 - ATTIC AND FLOOR INSULATION

Before insulation is installed, all by pass areas must be sealed in both the attic and crawl space.

ATTIC – Site Built

Some dwellings are considered as "good year homes" (additions added on to dwelling) thus two data collection spaces.

Location	Area to be insulated	Existing Insulation Type				Existing Thickness		Attic Access Hatch Location		Attic Access Hatch Needs Insulation	
Main Attic	Sq.ft	Cell	Fbrg	Blwn	Roll	In____	R-____	Ceiling	Gable	Y	N
Secondary Attic	Sq.ft	Cell	Fbrg	Blwn	Roll	In____	R-____	Ceiling	Gable	Y	N

Add Insulation to R-30 (South)	Y	N		Add Insulation to R-38 (Central & North)	Y	N

Comments:

	Main Attic		Secondary Attic				Exit through Attic		Air Sealing Req.	
Any Knob & Tube Wiring	Y	N	Y	N		Chimney	Y	N	Y	N
Water Leaks	Y	N	Y	N		Insulation Blocking Required			Y	N

By Pass Inspection areas to be addressed prior to installation of insulation for Air Sealing and Heat Waste.

All items marked **"Y"** must be addressed before insulation is installed.
Specific locations should be indicated below each inspection item or on floor plan drawing.

Exterior Wall Tops		Interior Wall Tops		Wire Chases		Plumbing Chases		HVAC Chases	
Y	N	Y	N	Y	N	Y	N	Y	N
Stairwell/Access Drop		**Closet Drop**		**Soffit Drop**		**Other:**			
Y	N	Y	N	Y	N	Y	N		

Comments:

If not applicable:	N/A

Attic Ventilation

Target Net Free Ventilation Area (NFVA) – calculate square foot of attic space and multiply by .24 =			
	Main Attic	Secondary Attic	*Calculation Notes:*
Sq " of Existing Exhaust (High)			*Finned gable vent = ½ of gross area opening.*
Sq " of Needed Exhaust (High)			*Take ½ of NFVA, subtract Existing Sq " to find amount of needed exhaust*
Check - Total should equal NFVA			
Sq " of Existing Intake (Low)			*Finned gable vent = ½ of gross area opening.*
Sq " of Needed Intake (Low)			*Take ½ of NFVA, subtract Existing Sq " to find amount of needed exhaust*
Check - Total should equal NFVA			
Total of Intake (High) and Exhaust (Low) Check Totals		**This sum should equal or exceed the Target NFVA calculated above.**	
Comments:			
If not applicable:	N/A		

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ATTIC – Manufactured home

Some manufactured homes may have cathedral and one or more flat ceilings thus multiple data collection spaces.											
Location	Area to be insulated		Existing Insulation Type		Existing Thickness		Access Location				
Cathedral Ceiling	Sq.ft		Cell Fbrg	Blwn Roll	In_____	R-Value____	Ceiling	Gable	Roof	Side	
Flat ceiling #1	Sq.ft		Cell Fbrg	Blwn Roll	In_____	R-Value____	Ceiling	Gable	Roof	Side	
Flat ceiling #2	Sq.ft		Cell Fbrg	Blwn Roll	In_____	R-Value____	Ceiling	Gable	Roof	Side	
Kool Seal Roof	Y	N	Square Footage to be coated		Sq.ft						
Comments:											
If not applicable:	N/A										

FLOORS – Site Built

This measure only allowed in the northern and central climate zones.										
	Height		Existing Insulation		Insulation installed w/		Install insulation?		Sq. Ft. to install	
Crawl Space	24" -	24" +	Y	N	Wire stays	Barrier	Y	N	Sq ft.	
Space is	Conditioned	Unconditioned		Exposed Water Lines Insulated			Y	N		
Plumbing Leaks	Y	N	Sub Floor Repair Required	Y	N	Vapor Barrier Exist	Y	N		
Comments:										

By Pass Inspection areas to be addressed prior to installation of insulation for Air Sealing and Heat Waste.									
All items marked **"Y"** must be addressed before insulation is installed. Specific locations should be indicated below each inspection item or on floor plan drawing.									
Exterior Wall Bases		Interior Wall Bases		Wire Chases		Plumbing Chases		HVAC Chases	
Y	N	Y	N	Y	N	Y	N	Y	N
Comments:									
If not applicable:	N/A								

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FLOORS – Manufactured

This measure only allowed in the northern and central climate zones unless there is adequate crawl space clearance.											
	Height		**Existing Insulation**		**Insulation installed w/**		**Install insulation?**		**Sq. Ft. to install**		
Crawl Space	24" -	24" +	Y	N	Fabric	Bellyboard	Y	N	Sq ft.		
Direction of Joists	Longways		Crossway		**Depth of Joists**		2" X 4"		2" X 6"		
Space is	Conditioned	Unconditioned	Skirted		**Exposed Water Lines Insulated**		Y	N			
Plumbing Leaks	Y	N	**Sub Floor Repair Required**		Y	N	**Vapor Barrier Exist**		Y	N	
Belly board requires	**Repair**	**Replacement**			**Install Vapor Barrier**		Y	N			
Comments:											
By Pass Inspection areas to be addressed prior to installation of insulation for Air Sealing and Heat Waste.											
All items marked **"Y"** must be addressed before insulation is installed. Specific locations should be indicated below each inspection item or on floor plan drawing.											
Wire Chases		**Plumbing Chases**		**HVAC Chases**		**Comments**					
Y	N	Y	N	Y	N						
If not applicable:	N/A										

PRIORITY LIST # 3 SIDEWALL INSULATION – Site Built Only

When performing the sidewall inspection process, the answers to some questions may not be possible unless a wall cavity is already exposed or if the agency utilizes an infrared camera.								
SIDEWALLS	**Wall # 1**		**Wall #2**		**Wall # 3**		**Wall # 4**	
Existing insulation	Type ____ R-___		Type ____ R-___		Type ____ R-___		Type ____ R-___	
Are walls weak / require repairs	Y	N	Y	N	Y	N	Y	N
Moisture problems or damage	Y	N	Y	N	Y	N	Y	N
Can sidewalls be blown	Y	N	Y	N	Y	N	Y	N
Exterior wall surface area	Sq.ft.		Sq.ft.		Sq.ft.		Sq.ft.	
Wall area to be insulated (Less Windows/Doors)	Sq.ft.		Sq.ft.		Sq.ft.		Sq.ft.	
Exterior wall composition	Wood	Brick	Masonite Siding		Vinyl Siding		Metal Siding	
Type of Framing	Balloon	Stick	Board/Batten		**Staple documentation to support seeking an insulation contractor for performing dense pack insulation here or place in client file.**			
Width of Cavity	24"	16"	Other					
Infrared camera used to inspect wall cavities	Y	N						
Comments:								
Justification for not addressing this measure:								
If not applicable:	N/A							

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PRIORITY LIST # 4 SOLAR WINDOW SCREENS & FILMS

Orientation	Number of windows to screen/film										Screens: Client informed about reduction of light		Y	N
East	1	2	3	4	5	6	7	8	9	10	Film Type Installed (Fill in)*			
West	1	2	3	4	5	6	7	8	9	10				
South	1	2	3	4	5	6	7	8	9	10				

***Note:** *Site drawing must include landscape surrounding dwelling and include shading percentage. Film only installed on East, South and West windows. Shatter/ storm mitigation film may be installed if a price comparison is performed and approved by state office*

Comments:

If not applicable:	N/A

PRIORITY LIST # 5 SMART THERMOSTAT

Already exists	Y	N	Functioning	Y	N	Client uses it	Y	N	Recommend Install	Y	N
Will tamper proof thermostat cover be installed				Y	N	Client agrees to installation				Y	N
HVAC Contractor inspected existing unit to assure installation is possible				Y	N	Will a new central unit be installed					

Comments:

If not applicable:	N/A

PRIORITY LIST # 6 COMPACT FLUORESCENT LAMPS (CFLs)

Location of Replacement	Bedrooms – 1 2 3 4		Living room		Dining Room		Bathroom		Other:	
Number of bulbs to replace										
Fixture Repairs Needed	Y	N	Y	N	Y	N	Y	N		
Explained to client and provided bulb breakage information for clean up						Y	N			

Replacement Chart:	Incandescent	CFLs	Comments
	40 watts	8-10 watts	
	60 watts	13-18 watts	
	75 watts	18-22 watts	
	100 watts	23-28 watts	
If not applicable:	N/A		

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PRIORITY LIST # 7 SEAL AND INSULATE DUCTS – All Dwellings

All duct work should be performed before any insulation is to be installed.

Location of duct	Attic	Crawl/Belly	Outside Dwelling	Conditioned Space	Unconditioned Space
Type of duct	Sheet Metal	Flex	Duct board	**Other:**	
Condition of duct & boots*	Good condition		Needs repair	Replacement required	No Access
Type of duct system	Trunk	Spider	Other		

** Note: Visual inspection and Pressure Pan Testing must be performed to determine condition & Photo Documentation is required in files for replacing an entire duct system.*

After each of the following, list locations of any repair/replacement activities (reference dwelling site plan).

Duct Insulation	Existing	Repair	Install new	Linear foot needed: ft	

Notes:

Registers	Good Condition	Require cleaning	Replace	

Notes:

Supply and Return ducts	Good Condition	Require cleaning	Replace	

Notes:

Is return adequate for system and dwelling size	Existing size:	Required size:

Notes:

Is supply adequate for system and dwelling size	Existing size:	Required size:

Notes:

Filter size	Sq. inches	**Replace**	Y	N	**Left one more with client**	Y	N
Client instructed on how to install filters	Y	N					

Comments:

If not applicable:	N/A

FYI: Heating = 400cfm per 25,000 Btu output Cooling = 400cfm per 12,000 Btu (TON)

Refer to Duct Sizing Quick Sheet for more info on Duct Sizing

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DUCT SYSTEM QUICK SIZING TABLES

Tons	Air Flow CFM	Flex Duct	Metal RD Round		Equivalent Rectangular Metal Duct Sizes		
	80	6	5				
	120	7	6	or	3.5 x 10		
	160	8	7				
	175	8	8	or	3.5 x 14	(Stud Cavity)	
	200	9	8	or	6 x 8		
	300	10	9	or	8 x 8		
1	**400**	11	10	or	10 x 8	(14 x 8 Panned Joist)	
	500	12	11	or	14 x 8	10 x 10	
4	**600**	13	12	or	16 x 8	12 x 10	
	700	14	13	or	16 x 8	14 x 10	12 x 12
2	**800**	15	13	or	18 x 8	16 x 10	12 x 12
2.5	**1000**	16	14	or	22 x 8	18 x 10	14 x 12
3	**1200**	17	15	or	26 x 8	20 x 10	16 x 12
3.5	**1400**	18	16	or	30 x 8	22 x 10	18 x 12
4	**1600**	20	17	or	32 x 8	24 x 10	20 x 12
	1800	20	18	or		28 x 10	22 x 12
5	**2000**	21	18	or		30 x 10	24 x 12

*Duct Size Calculated at 0.1 inches of available static pressure for each 100 Equivalent Feet of Duct System.

Round Duct Square Inch Equialency	
Size	**SQ. IN.**
5	20
6	28
7	38
8	50
9	64
10	79
12	113
14	154
16	201
18	254
20	314
22	380
24	452
26	531
28	616
30	707

NON - FILTER GRILLE

300 CFM per sq ft Gross Grill area			
Ton	CFM	Gross Sq Ft	Gross Sq inches
1.5	600	2.0	288
2	800	2.7	384
2.5	1000	3.3	480
3	1200	4.0	576
3.5	1400	4.7	672
4	1600	5.3	768

(Doug Garrett Building Performance & Comfort)

FILTER GRILLE

200 CFM per sq ft Gross Grill area			
Ton	CFM	Gross Sq Ft	Gross Sq inches
1.5	600	3	432
2	800	4	576
2.5	1000	5	720
3	1200	6	864
3.5	1400	7	1008
4	1600	8	1152

Common Grille Sizes (GROSS SQUARE INCHES)

16 x 20	16 x 25	20 x 20	20 x 24	20 x 25	20 x 30	24 x 24	24 x 30	30 x 14
320	400	400	480	500	600	576	720	420

GAS FURNACE (2 SQ. IN. PER 1,000 BTU's)	
INPUT BTUS	**SQ IN Ducts Needed Supply and Return**
40,000	80
60,000	120
80,000	160
100,000	200
120,000	240
140,000	280

(DELTA-T INC, Gas Furn & AC CHARTS)

AIR CONDITIONER (6 SQ. IN. PER 1,000 BTU's)	
INPUT BTUS	**SQ IN Ducts Needed Supply and Return**
18,000	108
24,000	144
30,000	180
36,000	216
42,000	252
48,000	288

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Duct Sizing QuickSheet 6/10/2008

PRIORITY LIST # 8 REFRIGERATOR ASSESSMENT

Brand name				**Model number**									
Type	Side by Side	Top Freezer	Bottom Freezer	**Total Cu. Ft**		**Door Hinge**		Left		Right			
Dimensions of space	" - W	" - D	" -H	**Number of household occupants**	1	2	3	4	5	6	7		
Replacement "Options" to be utilized for determining energy efficiency and replacement recommendation													
Option #1* - Metering for a 24 hour period = kWhY usage													
Option #2 *- Metering for a 2 hour period w/o defrost cycle = kWhY usage					**Peak Watts**								
Note: For Option #1 & #2, reference the Priority List for Single Family Dwellings pamphlet, Table 3 chart.													
Option #1 and/or #2 was used and the pamphlet recommended replacement				Y	N								
Option #3 – Enter all required dwelling data in the NEAT and/or MHEA for recommended replacement				Y	N								
Old refrigerator was decommissioned/ removed from the premises				Y	N	**Disposal Fee (BWR charge)**	$						
Comments:													
If not applicable:	N/A												

PRIORITY LIST # 9 HEATING AND COOLING

WINDOW UNITS (Including reverse cycle and/or heat pump)

#	Wall Location (N,S,E,W)	Brand name	BTU output rating	EER or Year Manufactured	Cooling Only	Reverse Cycle	Coils need to be cleaned	
1					Y	Y	Y	N
2					Y	Y	Y	N
3					Y	Y	Y	N
4					Y	Y	Y	N

Unit(s) have a removable filter	Y	N	**Clean**	Y	N	**Dirty**	Y	N	**Replace Filter**	Y	N
Inspection reveals	Base rusted out	Noisy when operating	Vibrates when operating	Doesn't cool	Undersized for space	Over 6 years old	Doesn't work				
Two filters left and changing instructions provided	Y	N	**Maintenance service to be provided**	Y	N						
Replacement(s) recommended	Y	N	**# units to be replaced**	1	2	3	4				
Note: A photo of each unit to be replaced must be included in the client file.											
Reverse cycle or heat pump to be installed to address inadequate existing heating situation	Y	N									
A new unit (cooling or reverse cycle) is to be installed to create a conditioned living space	Y	N									
Notes:											
If not applicable:	N/A										

HEAT PUMP / CENTRAL AIR CONDITIONING

Orientation				Brand name	Model or Serial #	BTU	SEER or Year Manufactured	Disconnect (Designated Breaker)		Refrigerant Line Insulated	
N	S	E	W					Y	N	Y	N
N	S	E	W					Y	N	Y	N

Coil	Clean	Dirty				Filter	Clean	Dirty	Changed	Size	Sq. in.

Two filters left and changing instructions provided	Y	N	Maintenance service to be provided	Y	N

If the visual inspection indicates a need for possible replacement, the NEAT or MHEA must be utilized.
The General House Data Form is used for collecting all of the required data for population.

Audit recommended replacement	Y	N	Pad and tie downs meet existing codes for new unit	Y	N	N/A

Existing duct size compatible with replacement unit	Y	N	Duct inspection performed (Priority #7)	Y	N

Comments:

If not applicable:	N/A	

VENTING HEATING UNIT INSPECTION

If primary unit is unvented, proceed to next data collection section as this section is not applicable	N/A
Unit Description	

1	Location__________ **Type of Fuel** Nat Gas LP Elec Wood **Type of Unit** Forced Air Space Heater			
2	Make__________ Model__________ Serial Number__________			
3	Rated BTU Input __________ Rated BTU Output__________ IF Natural Gas (Clock Meter) within 10% Yes No			
4	Thermostat Location__________ Mercury? Yes No Temp Day_____ Night____ Install Smart Tstat?_____			
5	Gas Leaks? Yes No If Yes, Location of Leak			
6	Visual Inspection of Wiring and Safety Controls OK? Yes No If No List Problem(s)__________			
7	Filter Location __________ Type ________ Missing ___ Clean ___ Dirty ___ Cleaned and Replaced ___ Filter Size ________ X ________ Qty _____ Does Blower Need Cleaning? Yes No Noisy? Yes No			
8	**Is Main Vent / Chimney O.K. ? (circle any problems below)**	Y	N	
	Type, Location, Clearance, Height, Size, Cap, Liner, Mortar, Flashing, Unused flue holes, Thimble, Clean out, Other ________ **Chimney Type** __________ **Chimney Size** ________inches **Chimney Height** ______feet **Liner** Existing Needed N/A **Type**__________ **Liner Size** _____inches **Liner Height** _____feet			
9	**Is Vent Connector from Heating System to Chimney O.K. ? (Circle any problems below)**	Y	N	N/A
	Proper type pipe, Connected properly, Leaky or Corroded, ¼" Rise per Ft, Excessive elbows, Clearance Other__________ **Vent Connector Type** __________ **Vent Connector Size** _____inches **Vent Connector Run** _____feet			
10	Is Clearance from Heating Unit to Combustibles OK? (Ceiling, Walls, Floors)	Y	N	
11	Is Heat Exchanger O.K.?	Y	N	
12	Is this Unit Sealed Combustion ? *(Unit gets Combustion Air from Outdoors)*	Y	N	
13	Is Combustion Air OK? *(More than 50 cubic ft per 1000BTU's or Volume More than BTU's / 20)*	Y	N	
14	If No, How Many SQ Inches Needed? And From Where __________	SQ"		
15	**Pass** ___ **Fail** ___ **If Fail Why**			

Repair or will Replace with :	
If not applicable:	N/A

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All holes that are drilled must be resealed with a Stainless Steel Plug and high temperature caulk.

Heating System Diagnostic Inspection

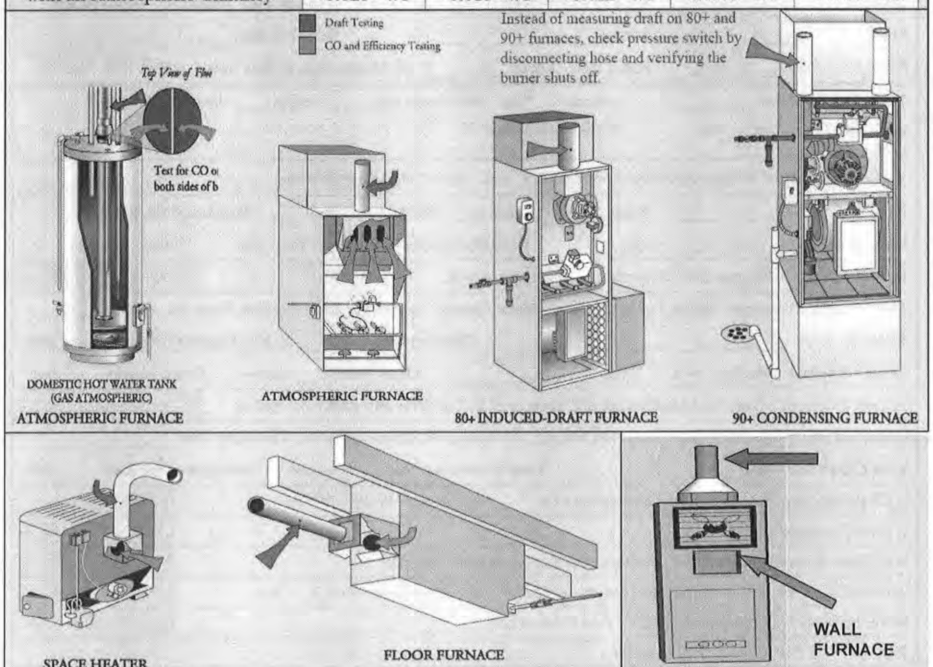
16. From CAZ page, determine worst case draft scenario and recreate conditions (the worst case is the one with the ***most negative*** depressurization of the CAZ. For example -4 PA would be worse than -1 PA).

17. Does the **Draft Inducer** function properly? **Y N N/A** Does the **Pressure Switch** function properly? **Y N N/A**

	PRE Tests	POST Tests
18. **Worst Case Draft** (reference diagrams below for where to test):		
19. **CO - Living Area** (should be less than 9ppm)		
20. **CO - Flue Gases** (should be less than 100ppm)		
21. **Heat Rise** (Air temp at supply minus temp at return)		

Comments:

HEATING UNIT TYPE & VENTING SYSTEM TYPE	Acceptable Draft Reading for Worst Case Draft Test at Listed Outdoor Temperatures (°F)				
	<20	21-40	41-60	61-80	>80
Gas Furnace or Water Heater with an Atmospheric Chimney	-5 Pa -0.020" wc	-4 Pa -0.016" wc	-3 Pa -0.012" wc	-2 Pa -0.008" wc	-1 Pa -0.004" wc



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COMBUSTIBLE HEATING UNITS - VENTED OR UNVENTED

Is an unvented heater being used as primary heating source:		Y	N	**Can it be used as secondary heating source:** (Meets Procedures and Guidelines Requirements)	Y	N
How many unvented units are operating in dwelling	1	2	3	**Have CO readings been completed for any acceptable secondary unvented space heaters**	Y	N
Number to be removed from dwelling to proceed with weatherization activities:	1	2	3	**Will a direct vent heater be installed as the primary heating source:**	Y	N

Cubic foot heated space per heater	**Primary**		**Secondary #1**		**#2**		**#3**	
Installed Vented Heater final CO readings:								
Secondary heater(s) final CO readings:	**#1 -**		**#2 -**					
Comments:				**(Staple CO printouts here)**				
If not applicable:	N/A							

PRIORITY LIST # 10 WATER HEATER

Location	Conditioned Space	Unconditioned	Exterior to dwelling	**Fuel**	Natural	Propane	Elec	
Condition	Good	Rusted	Stained	**Size**	"h	"dia	gallons	**Rated BTU/Watts** /hr
Measured water temperature at sink	Degrees	**Gas line leaks**	Y	N	N/A			
Tank Insulation	Existing	Install	No room	**Water lines insulation**	Existing	Install	**Length**	Lin. Ft.
Pressure relief line plumbed to exterior of dwelling	Y	N	Install					
Replacement recommended	Y	N	**Floor repair required**	Y	N			
Comments:								
Chimney and Venting OK ? Yes No N/A								

WCD Pre	**WCD Final**	**CO Pre**	**CO Final**	**Combustion Air OK?**	**If NO, how much and where from?**
				Y N	
Comments:					
If not applicable:	N/A				

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Attachment B. Vendor Questionnaire

Software Package/Company

Audience	
What is the software focus? (ratings, audits, weatherization)	
How is the software used by your customers?	Primary: Secondary:
Has the software been certified by any organization? If so, which one(s)?	
Is the software being BESTTEST EX tested?	
Is the software used in any utility or state programs? Which ones?	
How widespread is the software being used? # of clients geographic reach	
Modeling	
To what level does the software report usage disaggregation? (heating, cooling, hot water, appliances, lighting, etc.)	
What method is used to model weather?	
Is energy usage weather	

normalized?	
Is there a recognized calculation engine used (e.g. DOE-2) or is it using proprietary algorithms?	
Are there any climate limitations or focus, e.g. better results for cold as compared to hot climates?	
Which fuels can be modeled?	
Does the software perform green house gas calculations (existing usage and improvements)?	
If it calculates GHG impact, what source level is used (e.g. local, regional, national averages)	
Does the software account for interactions from implementation of multiple improvements?	
Inputs	
What are the minimum number of data inputs to get accurate result for usage and improvements?	

Are multiple heating/cooling systems allowed?	
How many of same building component can be input (floors, walls, ceilings)?	
Will the software accept measured inputs, e.g. blower door, duct leakage, etc.?	
Does the software require usage data input?	
How much billing structure flexibility is included – tiers, demand rates, seasonal rates	
Does the software include Health and Safety and/or IAQ info data capture/reporting?	
If so, what information is included?	
Will the software accept user input improvement cost values.	
How does the software deal with plug loads?	
Report/Recommendations	
Will the software allow fuel switching?	
Does the software generate recommendations	

automatically or does it require user input?	
What types of recommendations are included/assessed? Report output/flexibility: Can the report be modified? Can photos be attached?	
Misc	
Have any comparisons been done between calculated and actual energy use? If so, to what level (total, heating, cooling, hot water, lighting, appliance, etc)	
Have energy savings estimates been compared to actual savings?	
What other features of the software make it useful to contractors?	
How long has the software been commercially available?	
What improvements enhancements are planned	

and when are those improvements expected to be released?	
Can data from the software be output to a flat file?	
Additional Features of the software?	
Do you know of any studies doing similar review?	
Who is your competition?	
What can DOE do for you?	
Are you aware of the National Home Rating Program and its Implementation? Due to be release by September.	
What do you think of it?	
How do you believe your company/software would fit into a National Home Rating system?	
What can DOE do to help you? Database Software engine Cost Data Usage info	