

# Home Energy Rating Variability Study: A Comparison in New Single-family Homes

September 30, 2018

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Prepared for the U.S. Department of Energy

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## Summary

The addition of the *Energy Rating Index* (ERI) in the International Energy Conservation Code (IECC) marked the first time that an energy rating had been incorporated directly into a national model code. The ERI differs from traditional compliance paths in that code compliance, and related home performance, is determined by comparing a home's energy rating to a specified target rating for each climate. The incorporation of the ERI also brought important questions related to code implementation, many centering on the expected consistency of the approach, as well as the roles and responsibilities of those working to implement and verify codes at the state and local levels. The U.S. Department of Energy (DOE) Building Energy Codes Program therefore commissioned a study in attempt to better understand how home energy ratings might function as a code compliance mechanism, and to address the question of variability that could be expected if enlisting the HERS Index<sup>1</sup> for the purpose of demonstrating code compliance via the ERI path.

### Methodology

DOE engaged the regional energy efficiency organizations (REEOs) to collect data, targeting new single-family homes across U.S. climates, as represented by the respective REEO regions. In order to ensure objectivity of the results, the study was conducted as a blind effort, with raters unaware that multiple ratings were being conducted on the same home. Highlights of the Methodology include:

- Each study identified a homebuilder who was willing to participate in the study, providing a house at the final inspection stage of construction
- Multiple RESNET-certified HERS Raters (typically 4-6 per home) were commissioned to perform a plan review and field inspection based on RESNET protocol—each was provided construction documentation for the home and conducted onsite verification
- Ratings were conducted over a four to six day period to assure consistent field conditions and that there would be no overlap of raters onsite
- REEO staff coordinated the individual home assessments and provided quality control, monitoring site procedures and noting observations
- Each home received a preliminary HERS Index and Building Summary Report

### Results

In total, 56 total ratings were gathered across 11 homes. The average rating variability observed for an individual home was approximately 13 points. More information on the range of scores observed and their expected impact on residential energy use is outlined in the Key Outputs section.

Beyond the overall ratings and energy use projections, several inconsistencies were noted amongst additional data points, including many efficiency measures known to have a significant impact on residential energy consumption. Notably, home size and geometry, HVAC equipment, and utility rates, among others. A wide range of software packages and versions were also employed for calculating the energy ratings.

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<sup>1</sup> The HERS Index was chosen as the focal point of the study based on its use within several state codes and the incorporation of RESNET Standard 301 into the IECC.

The results of the study provide insight on the range of potential variability that might be expected under the ERI path and how home energy ratings might function as a code compliance mechanism. It also raises many important questions that are not yet addressed. For example:

- What portion of variability is due to human subjectivity compared to that which is inherent to the selected software or underlying calculation methodology?
- What are the primary drivers of variability sensitivity, including key attributes and inputs with the most significant effect on rating variance and projected energy use?
- What is the effect of variability on home energy performance (i.e., actual energy use)?
- What level of variability is acceptable to industry and affected stakeholders?
- What range of variability will ensure equitable energy use compared to traditional prescriptive and performance-based code compliance paths?

These require further investigation and should be expanded as part of future research efforts.

## Background

### An Introduction to Home Energy Ratings

The Home Energy Rating System (HERS) is an index used to measure home energy efficiency developed and administered by the Residential Energy Services Network (RESNET)<sup>2</sup>. The system is widely used for inspecting and calculating a home's energy performance, including for many above-code programs such as the ENERGY STAR for New Homes program. HERS can be used in both new construction and existing home applications. A HERS Index Score is intended to communicate home's energy performance in an easy and simple manner, portraying the basic energy efficiency characteristics of the home, including heating, cooling and watering heating, and other loads contributing to the cost of owning and operating the home.

Key features accounted in the HERS Index Score include:

- Exterior walls (both above and below grade)
- Floors over unconditioned spaces (e.g., garages or cellars)
- Ceilings and roofs
- Attics and foundations
- Windows and doors
- Vents and ductwork
- HVAC and water heating systems (and controls)
- Envelope air tightness
- Heating and cooling distribution system tightness

A certified Home Energy Rater (HERS Rater) assesses the energy efficiency of a home, assigning it a relative performance score. To calculate a home's HERS Index Score, a certified RESNET HERS Rater does an energy rating on a home and compares the data against a reference home, which is a modeled home design to the same geometry and specified characteristics as the actual home. As the projected energy usage of the home decreases, so does the HERS Index – approximately one point for every one percent improvement over a baseline index of 100. According to RESNET, a home with a HERS Index Score of 70 is 30 percent *more* energy efficiency than the RESNET Reference Home. Similarly, a home with a HERS Index Score of 130 is 30 percent *less* energy efficiency than the same Reference Home<sup>3</sup>.

### Home Energy Ratings in the International Energy Conservation Code

The HERS Index is widely recognized amongst the residential design, construction and code compliance community, and several states have incorporated a HERS compliance option within their codes as part of the state adoption process. These compliance options typically take the form of requiring a HERS Index Score that must be met (or exceeded) in lieu of traditional prescriptive or performance-based compliance paths. In more recent years, the HERS Index has also been incorporated directly into the model energy code for low-rise residential buildings, the International Energy Conservation Code (IECC). The 2015 IECC introduced a new performance path via (an added) Section R406, known as the *Energy Rating Index*, or ERI.

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<sup>2</sup> <http://www.hersindex.com/understanding>

<sup>3</sup> <https://www.resnet.us/hers-index>

## Residential Energy Services Network (RESNET)

The Residential Energy Services Network, or RESNET, is a non-profit organization that serves as the membership and credentialing body for RESNET-certified home energy raters, and as the development body administering the industry standards backing the HERS Index, most notably ANSI/RESNET/ICC Standard 301, the Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using an Energy Rating Index. This Standard is a joint publication of the American National Standards Institute (ANSI), RESNET, and the International Code Council (ICC), and serves as the technical basis for performing and calculating a HERS Score.

Learn more about RESNET at [www.resnet.us](http://www.resnet.us).

## Regional Energy Efficiency Organizations (REEOs)

The Regional Energy Efficiency Organizations (REEOs) are non-profit organizations with the shared goal of connecting key market stakeholders and best practices to leverage the power and benefits of energy efficiency across the United States. The REEO network is comprised of six individual organizations representing various regions of the country:

- Midwest Energy Efficiency Alliance (MEEA)
- Northeast Energy Efficiency Partnership (NEEP)
- Northwest Energy Efficiency Alliance (NEEA)
- South-Central Partnership for Energy Efficiency as a Resource (SPEER)
- Southeast Energy Efficiency Alliance (SEEA)
- Southwest Energy Efficiency Project (SWEEP)

Each REEO is an independent non-profit organization working together to provide a mix of programs and tools to help advance energy efficiency as a resource. In addition to working within their specific regions, the REEOs also collaborate on areas of common interest, including policy, technical assistance programs and communications.

Learn more about the REEO network at <http://www.neep.org/network/regional-energy-efficiency-organizations-network>.

## U.S. Department of Energy

The U.S. Department of Energy (DOE) Building Energy Codes Program is directed by federal statute to perform several functions related to building energy codes for residential and commercial buildings. As part of its directives, DOE is required to review updated editions of the model energy codes, including the International Energy Conservation Code (IECC), and issue a *determination*<sup>4</sup> as to whether the updated edition will result in increased energy efficiency in residential buildings. DOE is also directed to participate in industry model code review and consensus processes, providing technical support and conducting analysis to review the technical and economic basis of code updates. In addition, DOE is directed to provide technical assistance to states implementing building energy efficiency codes.

Learn more about the DOE Building Energy Codes Program at [www.energycodes.gov/about](http://www.energycodes.gov/about).

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<sup>4</sup> <https://www.energycodes.gov/development/determinations>

## Study Purpose

The addition of the *Energy Rating Index* in the 2015 International Energy Conservation Code (IECC) marked the first time that an energy rating had been incorporated into a national model code. While a number of states have incorporated alternative paths built around energy ratings at the state level, this was the first time that a rating option was incorporated within the model code directly as an alternative compliance path. While the HERS Index was not originally specified within the ERI path, the connection was made more explicit when ANSI/RESNET/ICC Standard 301 was incorporated by reference in the 2018 IECC.

Many stakeholders played a role in establishing the ERI and multiple variations were considered as part of the code development process administered by the International Code Council (ICC). The IECC ultimately settled on a relatively simplistic approach by which a home must achieve an ERI at or below (better) than a specified threshold targets for each climate zone in addition to meeting the mandatory requirements of the IECC as well as the prescriptive envelope requirements of the 2009 IECC<sup>5</sup>. In establishing these targets, interested and affected parties provided thorough testimony and analysis supporting the specified thresholds, which vary by only one point between most climate zones, and by a range of just five points across all climates.

The U.S. Department of Energy (DOE) Building Energy Codes Program is directed by statute to perform several activities related to building codes. These include participation in industry processes to review and update building codes, such as the IECC, and providing technical assistance to states implementing building energy codes.<sup>6</sup> The ERI path is fundamentally different from traditional compliance paths in that home performance is determined by comparing a home's energy rating (i.e., ERI) to targets specified in the IECC. There is significant interest in understanding how the ERI will impact residential energy efficiency, how it will function as a compliance path, and what assistance will be needed by states and local code jurisdictions working to implement new editions of the IECC.

DOE therefore commissioned a study in attempt to better understand how home energy ratings might function as a code compliance mechanism. Specifically, to address the question of variability that could be expected when enlisting the HERS Index for the purpose of demonstrating code compliance via the ERI path. Data on HERS ratings for new homes was collected by the REEOs across their respective regions, aggregated and reported. The intent of the study was to provide insight to raters, the code compliance community, and other affected stakeholders for general awareness and to aid ongoing quality assurance efforts. In this initial study, DOE desired objective data and key outputs of the HERS rating process, and specifically did not attempt to understand the *why* behind the ratings, such as isolating or quantifying specific inputs and variables that may be the cause of variability. Consistency and replicability of the rating process is crucial to the ERI path, and to ensure that households can expect equitable levels of energy performance regardless of compliance path.

## Methodology

The purpose of the study was to increase understanding of how home energy ratings might function as a code compliance mechanism, including the level of variability that could be expected when enlisting the HERS Index for the purpose of demonstrating code compliance via the ERI path. The REEOs sampled 11

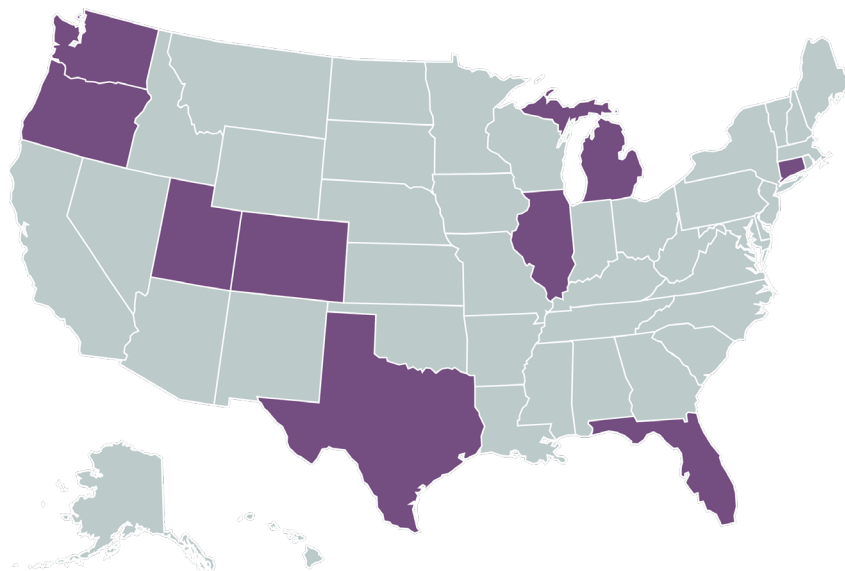
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<sup>5</sup> As outlined in Table 402.1.2 or 402.1.4 of the 2009 IECC

<sup>6</sup> <https://www.energycodes.gov/about/statutory-requirements>



homes<sup>7</sup> across each of their 6 regions for a total of 56 individual ratings. Each home was assessed by 4 to 6 different local RESNET-certified raters. The methodology required a blind study where individual raters were not made aware they were evaluating the same home. This was crucial to ensure objectivity and replicate conditions that could be present when employing the ERI path.



**Figure:** Data collection locations across states and regions

## General Protocol

The protocol implemented was as follows. Each REEO:

1. Identified a homebuilder who was willing to participate in the study and able to provide a single-family house ready to receive a final blower door and duct blaster test.
2. Hired four to six RESNET-certified HERS Raters, each from a different company to perform a plan review and field inspection (based on RESNET protocol).
3. Received a projected HERS Index and relevant input documentation from each of the raters.
4. Aggregated the collection of data and reported findings.

## House Selection

The houses selected for the study were new single-family homes. Each home was recently completed, or close to completion, and ready for final inspection and testing (based on the requirements identified in the IECC). For each region, the respective REEO selected two homes in separate states, and targeted 4-6 ratings per home.

It is important to note that homes were targeted across multiple states and therefore their codes and related energy efficiency requirements varied. Homes were not screened based on the applicable code

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<sup>7</sup> An additional home in Malta, NY also participated in the study, but for diagnostic testing only and did not receive projected HERS Indices.

or evaluated for the purposes of determining compliance (e.g., whether mandatory code measures were met, prescriptive requirements, etc.). It's also important to highlight that the study sought data on the consistency of multiple ratings on a *single* home and not whether the resulting ratings complied with the code (via the ERI targets specified in the IECC).

### Communication Protocol

A REEO staff member or a contractor coordinated raters hired to provide the projected HERS Index. Each REEO generally conducted the following activities:

- Delivery of supporting documentation (i.e., available plans, specifications, and similar information depicting the energy efficiency characteristics of the home)
- Coordinating the ratings and site activities
- Arranging payment
- Other administrative aspects (e.g., email communication, responding to inquiries, etc.)

When initially contacted, raters were generally informed that the builder was considering using a HERS score as a marketing tool or as a means of complying with code, where applicable. They were told that the builder desired to know what HERS Score the home achieved, but that a *confirmed* rating was not necessary for the home.

Prior to the onsite assessment, all raters were provided the same information and documentation (e.g., house plans, window schedules, insulation values and other default or non-observable information). This information was intended to provide a consistent collection of information about a given home to all applicable raters and to aid in the calculation of the HERS Score. If an individual rater made further inquiries about the home or related documentation, responses were provided only to the rater who asked the question.

One thing to note is that a HERS Rater would often be involved throughout the design and construction process in order to verify all inputs required for a confirmed rating. In this case, the limited time window did not allow for verification of items that were already in place and no longer visible, such as wall cavity insulation. While this approach ensured that inspections could be completed quickly for the purposes of the study, it left less opportunity for discovery and interaction that would ideally be part of the rating process. However, in all cases, required information that was not directly observable was provided to all raters in order to maintain consistency amongst variables for a given home.

### On-Site Assessments

To ensure consistent field conditions and maintain study objectivity (blindness), ratings were conducted over two-week period, at maximum, with no overlap of raters on the project site. A member of the REEO staff or a hired contractor met each rater at the subject house, answered questions and monitored the onsite data collection.

## Rating Documentation

The following was generally requested to accompany each rating:

- An informational Home Energy Rating Certificate<sup>8</sup>
- Building Summary
- Performance Report

In some cases, not all requested documentation was provided by the rater. In other cases, raters provided additional documentation, such as AHRI certificates. For houses assessed in Florida, the EnergyGauge Input Summary Report was provided by all raters upon completion of the projected HERS Index.<sup>9</sup>

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<sup>8</sup> The Home Energy Rating Certificates received had a draft watermark printed on the document; “NOT CERTIFIED. For certification this rating must be registered.” This indicated that the rating was not uploaded to the RESNET database as a confirmed rating.

<sup>9</sup> The Florida energy code requires the use of EnergyGauge software for calculating code compliance.

## Key Outputs: Reported HERS Index and Annual Energy Usage

The study encompassed 11 homes across 9 states that are geographically dispersed across the U.S. for a total of 56 individual ratings. Each home received a minimum of at least 4 ratings, with some homes receiving up to 6 ratings. The outputs targeted include the projected *HERS Score* and *annual energy usage* for each home. These are commonly calculated by HERS Raters and are of primary interest to the homeowner or prospective home buyers.

**Table:** Projected HERS Index by Home and Location

Location	HERS Index						
Seattle, WA	76	71	79	75	74	-	-
Portland, OR	83	82	86	86	88	-	-
Orlando, FL	70	74	71	59	-	-	-
Tallahassee, FL	71	62	72	74	-	-	-
Dallas-Fort Worth, TX	78	71	79	67	65	64	64
Austin, TX	69	64	55	75	64	-	-
Denver, CO	67	70	79	68	99	-	-
Salt Lake City, UT	42	51	43	50	-	-	-
Chicago, IL	44	42	51	44	49	40	40
Grand Rapids, MI <sup>10</sup>	65	60	58	60	-	-	-
Derby, CT <sup>11</sup>	(w/o PV)	N/A	55	43	N/A	50	45
	(w/PV)	19	N/A	N/A	28	30	22

The variability of ratings assigned to a particular home ranged from a low of 6 points (Portland) to a high of 32 points (Denver). A majority of homes (7 of the 11) experienced variability of 10 or more points. Average variability across all homes studied was approximately 13 points.

In terms of projected annual energy usage (MMBtu), similar trends are observed. Variability ranges from a low of 6.3 MMBtu in Salt Lake City to a high of 98 MMBtu in Denver<sup>12</sup>. Average variability across all homes studied was 36 MMBtu.

Additional information on each home, including the more detailed inputs and data points provided by individual raters, is outlined in the Appendix.

<sup>10</sup> The Grand Rapids home was not at the typical point of construction for a certified HERS rating. The home was insulated, had drywall installed and finished, and was relatively air sealed. However, the finished flooring, lighting, water heater, air conditioner, thermostat, toilets, and appliances were not installed. More information about the home is listed in the Appendix.

<sup>11</sup> The Derby, CT home had a PV system and several raters chose to evaluate the home either with or without the PV contribution (and in some cases chose to evaluate both scenarios)

**Table:** Projected Annual Energy Usage by Home and Location

Location <sup>13</sup>	Projected Annual Energy Usage (MMBtu)					
Seattle, WA	55.01	82.37	83.17	69.80	64.57	
Portland, OR	52.99	55.69	46.26	47.36	54.98	
Dallas-Fort Worth, TX	97.1	89	66	84.5	53.4	78.6
Austin, TX	68.5	50.3	49.4	58.8	62.1	
Denver, CO	141.4	157.4	121.7	105.4	203.4	
Salt Lake City, UT	39.0	44.5	41.8	45.3		
Chicago, IL	61.4	80.2	92.2	83.0	77.3	55.4
Grand Rapids, MI <sup>14</sup>	93.2	60.8	85.0	79.0		
Derby, CT (w/o PV)	28.4	80.2	44.2	59.3	60.9	

## Conclusion

The current study sought an understanding of what variability might be experienced if enlisting the HERS Index for the purpose of demonstrating compliance with the Energy Rating Index (ERI) path of the IECC. The study included eleven homes across each region of the U.S., as represented by the regional energy efficiency organizations (REEOs), and a total of 56 individual ratings. Average observed per-house variability in the study was approximately 13 points. Variability between the maximum and minimum ratings for an individual home ranged from as little as 6 points to as much as 32 points. Similarly, projected annual energy consumption from a low of 6.3 MMBtu to a high of 98 MMBtu, and averaging 36 MMBtu of variability for an individual home.

While the study deliberately did not evaluate the causation of variability or sensitivity of individual variables, it did record data on many of the inputs and assumptions used by raters in establishing the respective HERS Scores. These data points include many notable attributes that are generally considered to have a significant impact on energy use in single-family homes, such as:

- Envelope and duct tightness
- Envelope insulation levels and installation quality
- Total window area and orientation
- Percentage of high-efficacy lighting
- Appliance and equipment efficiency
- Mechanical ventilation

Several of these additional data points were noted as inconsistent, including some attributes that were directly observable by the rater (e.g., roof color) or provided as part of the home's construction documents (e.g., wall insulation R-value). A wide range of software was also noted, with the average home being rated using three different versions of software. One home was rated with five different

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<sup>13</sup> For houses assessed in Florida, the EnergyGauge Input Summary Report and the informational Home Energy Rating Certificate did not include projected annual energy usage measured in MMBtu.

<sup>14</sup>The Grand Rapids home was not at the typical point of construction for a certified HERS rating. The home was insulated, had drywall installed and finished and was relatively air sealed. However, the finished flooring, lighting, water heater, air conditioner, thermostat, toilets, and appliances were not installed. More information about the home is listed in the appendix.

versions of REM/Rate software amongst six raters. It is unclear to what extent this may contribute to the overall variability for each home. Additional information on these additional data points is presented in the appendix, organized by the respective regions represented in the study.

While the study attempts to assess basic levels of ERI variability, it is based on a relatively small sample of homes, and should not be considered statistically representative. However, it does provide a preliminary sampling of results and raises many important questions for further inquiry. The level of variability observed in the study is notable in comparison to the ERI targets established in the IECC, which typically vary by only one point between climate zones and by five points across all climates.

Looking to the future, there is a need for additional inquiry to more comprehensively assess:

- What portion of variability is due to human subjectivity compared to that which is inherent to the selected software or underlying calculation methodology?
- What are the primary drivers of variability (sensitivity), including key attributes and inputs with the most significant effect on rating variance and related energy use?
- What is the effect of variability on home energy performance (i.e., actual energy use)?
- What level of variability is acceptable to industry and affected stakeholders?
- What range of variability will ensure equitable energy use compared to traditional prescriptive and performance-based code compliance paths?

These questions and others are critical to ensuring the quality and consistency of home energy ratings, as well equitable performance of homes demonstrating code compliance via an ERI.

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## Northwest Region: Seattle, WA and Portland, OR

**Project Team:** Northwest Energy Efficiency Alliance (NEEA)

**Summary:** For houses assessed in WA and OR, NEEA collected the following information from email communication and documents, on-site observations, the RemRate™ and informational Home Energy Rating Certificate.

### General Observations

NEEA's project team observed each rater's on-site process, noting their overall workflow, data collection methods, and specific areas of emphasis or deviation. The observations were as follows:

1. Some rating companies sent two field representatives to the site while others utilized just one rater to perform the work. Generally, the larger companies provided two field representatives and employed scheduling/job management software.
2. One rating company utilized an outside subcontractor to deliver performance testing services.
3. Raters generally completed the field visit in one and a half to two hours while one of the raters took nearly three hours to complete testing and inspections.
4. At the Portland site, raters noted a disconnected supply duct at the downstairs powder room. This was noted at different points in the inspection and testing processes. Some discovered the disconnected duct upon initial walkthrough and test set up, while others did not until after their duct test had been completed (requiring them to re-test). One rater did not note the disconnected duct.
5. One rater declined to perform a duct test after discovering the disconnected duct, noting that he would use a stand-in value in the energy model, per RESNET allowances. This rater noted that he typically notifies the builder and allows them time to repair such issues prior to testing.
6. There were slight variations in how building performance tests were set up and performed, notably the configuration of interior doors, baseline pressure measurements, and taping of duct registers and the dryer vent termination. None of the raters were observed performing multiple pressure blower door tests.
7. Some raters performed Combustion Appliance Zone (CAZ) and Zonal Pressure Relief (ZPR) tests while others did not.
8. There was variation in how insulation and air sealing inspections were performed, or what assumptions were made for unobservable areas. Some raters utilized the insulation certificate and/or historical knowledge of the subcontractors' work. Some performed detailed visual inspection of the crawlspace and attic areas, documenting areas where improvements were needed. Others looked only just inside the attic/crawlspace hatch, noting insulation depth to estimate R-value.
9. There was some variation in methods for testing and inspecting ventilation systems. Some raters performed detailed inspections and noted whether the home's ventilation system met code or ASHRAE standards while others performed airflow tests on the home's exhaust fans.



10. There were variations in how raters assessed showerhead and faucet aerator flow rates. Some noted the manufacturer's stamp for rated flow while others took flow measurements. At the Portland site, several raters did not make note of fixture flow rates.
11. Raters performing work at the Portland site invoiced from \$300 to \$660 for their services. Average cost for these services was \$427.
12. Raters performing work at the Lake Stevens site invoiced from \$550-\$1500 for their services. Average cost for these services was \$923.

#### Overview – Portland, OR

Rater	HERS Index	REM/Rate Version	Cost of Rating	Weather Location	Conditioned Area (sq. ft)	Volume (cu ft)
A	83	15.3	\$660	Portland, OR	1,405	12,767
B	82	15.3	\$300	Portland, OR	1,422	13,290
C	86	15.3	\$300	Portland, OR	1,405	11,942
D	86	15.3	\$325	Portland, OR	1,405	12,786
E	88	15.3	\$550	Portland, OR	1,443	14,144

#### Overview – Lake Stevens, WA

Rater	HERS Index	REM/Rate Version	Cost of Rating	Weather Location	Conditioned Area (sq. ft)	Volume (cu ft)
F	76	15.3	\$1,045	Seattle, WA	2,921	27,691
G	71	15.3	\$1,500	Snohomish CO AP, WA	2,921	24,742
H	79	15.3	\$750	Whidbey Island, WA	2,921	24,829
I	75	15.3	\$550	Seattle, WA	3,004	26,954
J	74	15.3	\$770	Seattle, WA	2,990	25,561

#### Key Inputs – Portland, OR

Rater	HERS Index	Bedrooms (count)	Shell Area (sq ft)	2012 IECC UA	Primary Heat Source	DHW Source
A	83	3	4,401	299.3	42k Gas Furnace 93% AFUE; 19k Gas Fireplace 70.6% AFUE	0.62 EF Gas Storage
B	82	3	4,398	294.2	100k Gas Furnace 93% AFUE	0.62 EF Gas Storage
C	86	3	4,244	266.6	100k Gas Furnace 93% AFUE	0.62 EF Gas Storage
D	86	3	3,739	245.0	100k Gas Furnace 95% AFUE	0.59 EF Gas Storage
E	88	3	4,390	316.4	100k Gas Furnace 93% AFUE	0.62 EF Gas Storage

Key Inputs – Lake Stevens, WA

Rater	HERS Index	Bedrooms (count)	Shell Area (sq. ft)	2012 IECC UA	Primary Heat Source	DHW Source
F	76	4	6,096	391.3	68.4k Gas Furnace 95% AFUE	0.93 EF Gas Tankless
G	71	5	7,107	461.2	68k Gas Furnace 95% AFUE	0.91 EF Gas Tankless
H	79	5	6,182	397.3	30k Gas Furnace 90% AFUE	0.58 EF Gas Storage
I	75	5	6,911	397.3	100k Gas Furnace 95% AFUE	0.93 EF Gas Tankless
J	74	4	6,809	413.9	72k Gas Furnace 95% AFUE	0.91 EF Gas Tankless

Estimated Annual Energy Use – Portland, OR

Rater	HERS Index	EUI (kBtu/sf)	Total (MMbtu)	Heating (kWh)	Heating (Therms)	DHW (Therms)	Lighting & Appliance (kWh)	Appliance (Therms)
A	83	37.7	53.0	265.4	323.6	160.6	4865.8	30.7
B	82	39.2	55.7	317.4	340.8	171.1	4543.6	30.7
C	86	32.9	46.3	180.5	256.8	160.1	4950.3	30.7
D	86	33.7	47.4	255.6	241.1	183.9	5835.3	30.7
E	88	38.1	55.0	118.5	331.2	171.1	5615.2	30.7

Estimated Annual Energy - Lake Stevens, WA

Rater	HERS Index	EUI (kBtu/sf)	Total (MMbtu)	Heating (kWh)	Heating (Therms)	DHW (Therms)	Lighting & Appliance (kWh)	Appliance (Therms)
F	76	18.8	55.0	353.5	387.7	128.7	11139.6	0.0
G	71	28.2	82.4	966.9	590.0	130.4	6962.9	80.1
H	79	28.5	83.2	1111.8	514.2	257.1	7183.5	36.1
I	75	23.2	69.8	978.2	489.8	142.7	9047.1	36.1
J	74	21.6	64.6	649.9	491.6	125.7	9041.7	0.0

## Southeast Region: Orlando and Tallahassee, FL

**Project Team:** Southeast Energy Efficiency Alliance (SEEA)

**Summary:** For houses assessed in Florida, SEEA collected the following information from email communication and documents, on-site observations, the EnergyGauge™ Input Summary Report and informational Home Energy Rating Certificate.

### Orlando House Description

The house is located in a suburban city of Orlando, FL and is constructed on an infill lot on an established street of houses built during the post-World War II era. The house is a single-story on slab, concrete masonry unit (CMU) construction with a two-car garage. All the equipment is located in a small utility room adjacent to the garage. The ceilings are 10 feet tall in the whole house except for the foyer and the front office (15 feet). Attic insulation is spray foam and is installed at the roofline. The home's heating, cooling, hot water and cooking range are all electric. SEEA noted that a majority, if not all, of the lamps in the house were incandescent.

### Additional Observations – Orlando

Rater	A	B	C	D
<b>Time On-site</b>	2 hours	1.5 hours	1.5 hours	2 hours
<b>Rater Personnel</b>	2	1	3	1
<b>Performed Blower Door Test</b>	Yes	Yes	Yes	Yes
<b>Blower Door Test Location</b>	Garage entry	Garage entry	Garage entry	Garage entry
<b>Sealed Registers During Blower Door Test</b>	(Most)	Yes	Yes	Yes
<b>Performed Duct Leakage Test</b>	Yes	Yes	Yes	Yes
<b>Checked Attic Insulation</b>	Yes	Yes	Yes	No
<b>Photos of Nameplates</b>	Yes	No	Yes	Yes
<b>Counted Light Bulbs</b>	No	No	Yes	No

### HERS Rating Certificate and Input Summary, Utility Rates

Rater	HERS Index	Utility Rate (cents/kWh)	Annual Energy Use (Kwh/year)	Annual Energy Cost
<b>A</b>	70	13.17	11,993	\$1,373
<b>B</b>	74	11.18	13,114	\$1,501
<b>C</b>	71	11.26	11,958	\$1,369
<b>D</b>	59	8.73	10,387	\$1,189

Note: Energy Gauge v5.1 does not include the individual costs in kWh for heating, cooling, hot water and lights and appliances in the reports SEEA received from HERS raters.

## Input Summary: Project and Climate

Rater	Bedrooms (count)	Occupants (count)	Conditioned Area (sq. ft)
A	3	4	2,399
B	4	5	2,399
C	3	4	2,399
D	3	1	2,399

## Input Summary: Envelope

### Infiltration

Rater	Conditioned Volume (cu. ft)	CFM50	ACH50
A	23,990	919.9	2.3006
B	25,443.8	1064.7	2.5108
C	25,189.5	869	2.0699
D	23,990	966.5	2.4171

### Exterior Walls

Rater	Gross Wall Area (sq. ft)	Net Wall Area (sq. ft)	R-Value	Door Area (sq. ft)
A	2,539	2,052	5	45
B	2,546	2,049	4.1	45
C	2,523	2,038	14	45
D	2,585.51	2095.3	14.5	45.3

Note: The building input summary does not include wall grading, therefore, it has not been included in the report.

### Windows

Rater	Area (sq ft)	Area Facing West (sq ft)	U Factor	SHGC	Shade-Summer
A	441	85	0.27-0.65	0.20-0.26	Drapes/Blinds, exterior 50% screening
B	451	77.2	0.27-0.55	0.20-0.25	Drapes/Blinds
C	440	77.3	0.27-0.65	0.2-0.25	Drapes/Blinds
D	444.9	80.9	0.33-0.55	0.21-0.25	Drapes/Blinds

### Ceiling and Roof

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Ceiling Insulation (R-value)	Deck Insulation (R-value)	Attic Type
A	2,638	2,599	1	20	Unvented
B	2,399	2,599	0	20	Unvented
C	2,399	2,599	0	20	Unvented
D	2,399	2,683	1	20	Unvented

## Input Summary: Mechanical

### Mechanical Equipment

Rater	Cooling Capacity (kBtu/hr)	Total Air Flow (CFM)	Heating Set Point (Deg F)	Cooling Set Point (Deg F)	Heating Capacity (kBtu/hr)	Heating Efficiency (HSPF)	Cooling Efficiency (SEER)
A	42	1,260	70	75	42	8.5	14.5
B	42	1,260	70	75	42	8.2	15
C	42	1,200	70	75	42	8.5	14.5
D	42	1,260	70	75	42	8.5	14.5

### Duct System Inputs

Rater	Duct Surface Area (sq. ft)		Total Leakage (cfm25)	Leakage to the Outside (cfm25)	Location of Ducts	AHU Location
	Supply	Return				
A	479.8	119.95	163.5	10.3	Attic	Main
B	479.8	252.5	252.5	28	Main	Main
C	479.8	119.95	N/A	19	Attic	Main
D	479.8	119.95	N/A	35	Main	Main

## Input Summary: Appliances and Lighting

Rater	Ceiling Fans (count)	Exterior Lamps (count)	Interior Lamps (count)	Refrigerator (KwH/year)	Dishwasher (KwH/year)	Range Oven (fuel)
A	2	19	44	691	270	Electric
B	0	11	14	423	142	Electric
C	5	18	37	705	270	Electric
D	N/A	18	37	N/A	N/A	N/A

## Tallahassee House: Description

The house is located in a suburb of Tallahassee, FL. The house is a single-story on slab, stick construction (2x4 walls), with a two-car garage. The air handle unit is located in the attic and the tankless water heater is located on the exterior of the house. The ceilings are 9 feet tall, with the exception of the entry, dining room and the vaulted ceiling in the great room and kitchen. The house is run mainly by electricity with the exception of a natural gas cooking range and a tankless propane water heater. SEEA noted that a majority of the lamps in this house were compact fluorescent (CFL) or LEDs.

## Additional Observations

	Rater E	Rater F	Rater G	Rater H
<b>Time On-Site</b>	1 hour	1 hour	1.5 hours	2 hours
<b>Rater Personnel</b>	1	1	2	3
<b>Blower Door Test Location</b>	N/A	N/A	N/A	Screened porch entry
<b>Sealed Registers during Blower Door Test</b>	Yes	Yes	Yes	No
<b>Performed Total Duct Leakage Test</b>	Yes	Yes	Yes	Yes
<b>Checked Attic Insulation</b>	Yes	Yes	Yes	No
<b>Took Photos of Nameplates</b>	No	No	Yes	No
<b>Counted Light Bulbs</b>	No	No	Yes	No

## HERS Rating Certificate and Input Summary, Utility Rates

Rater	HERS Index	Electricity Rate (cents/kWh)	Annual electricity use (KwH/year)	Annual natural gas use (therms/year)	Annual LPG use (gal/year)	Annual total energy cost
E	71	11.45	N/A	N/A	N/A <sup>15</sup>	\$1,532
F	62	11.42	8,210	0	117	\$1,466
G	72	N/A	10,179	117	0	\$1,165
H	74	N/A	8,974	131	31	\$1,027

Note: Energy Gauge v5.1 does not include the individual costs in kWh for heating, cooling, hot water and lights and appliances in the reports SEEA received from HERS raters.

## Input Summary: Project and Climate

All raters consistently listed the same project and climate information.

<sup>15</sup> The rater did not provide a draft HERS Certificate, but instead an excel document. In the excel document provided, the rater indicated that there was a propane tankless water heater, but did not provide a separation of energy usage.

## Input Summary: Envelope

### Infiltration Inputs

Rater	Conditioned Area (sq. ft)	Conditioned Volume (cu. ft)	CFM50	ACH50
E	2,152	19,368	1,784	5.5266
F	2,152	22,165.6	2,586	7
G	2,152	21,520	1,858.5	5.1816
H	2,152	20,444	2,242	6.5799

### Exterior Wall Inputs

Rater	Gross Wall Area (sq. ft)	Net Wall Area (sq. ft)	R-value	Door area (sq. ft)
E	2,037	1,731	13	46
F	1,998	1,661	13	40
G	1,957.30	1604.97	13	40
H	2,049.5	1,704.9	13	20

Note: The building input summary does not include wall grading, therefore, it has not been included in the report.

### Window Inputs

Rater	Area (sq. ft)	Area Facing West (sq. ft)	U-factor	SHGC	Shade-Summer
E	261	0	0.34	0.3	Drapes/Blinds, exterior 50% screening
F	297	0	0.34-0.59	0.26-0.34	Drapes/Blinds
G	312.33	0	0.35	0.26	Drapes/Blinds
H	324.6	114	0.34-0.4	0.26-0.31	Drapes/Blinds

### Ceiling and Roof Details

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Ceiling Insulation (R-value)	Deck Insulation (R-value)	Attic Type
E	2,152	2,407	38	0	Vented
F	2,352	2,407	38	0	Vented
G	2,152	2,407	38	0	Vented
H	2,152	2,407	38	0	Vented

## Input Summary: Mechanical

### Mechanical Equipment

Rater	Cooling Capacity (kBtu/hr)	Total Air Flow (CFM)	Heating Set Point (Deg F)	Cooling Set Point (Deg F)	Heating Capacity (kBtu/hr)	Heating Efficiency (HSPF)	Cooling Efficiency (SEER)
E	28	1,545	70	75	28	9	15
F	48.5	1,455	70	75	29.8	9	16
G	48.5	1,455	70	75	29.8	9	16
H	48.5	1,455	70	75	45	9	16

### Duct System Inputs

Rater	Duct Surface Area (sq. ft)		Total Leakage (cfm25)	Leakage to the Outside (cfm25)	Location of Ducts	AHU Location
	Supply	Return				
E	430.4	107.6	N/A	142.7	Attic	Main
F	475.1	88	N/A	N/A	Main	Main
G	430.4	107.6	258	150	Attic	Attic
H	500	107.6	198	198	Attic	Attic

## Input Summary: Appliances and Lighting

Rater	Ceiling Fans (count)	Exterior Lamps (count)	Interior Lamps (count)	Refrigerator (KwH/year)	Dishwasher (KwH/year)	Range Oven (fuel)
E	5	8	37	691	372	Electric
F	0	100	200	615	270	Gas
G	5	18	37	N/A	N/A	N/A
H	N/A	18	37	N/A	N/A	N/A



## South-central Region: Dallas-Fort Worth and Austin, TX

### Dallas-Fort Worth House Description

SPEER obtained permission from a homebuilder to use one of their spec homes in the Dallas-Fort Worth metropolitan area. The home was 2404 square feet with four bedrooms and three bathrooms. The raters were told to assume grade 1 wall insulation installation, and were given the following data regarding the envelope, HVAC and water heating: southern orientation, exterior sheathing 7/16" OSB, R15 blown in blanket fiberglass in walls, R38 blown fiberglass in attic (R19 under HVAC walkways and vaulted ceilings), windows - SHGC .25 and U-factor .35, ducts R8/R6 supply/return, radiant barrier, heat pump HSPF 8.2, water heater EF .88, and 14 SEER 5 ton AC. The home's heating, cooling, and hot water were all electric. All appliances except for the range were electric. All of the ducts in the home were located in unconditioned space.

### Additional Observations

	Rater A	Rater B	Rater C	Rater D	Rater E	Rater F
<b>Time On-Site</b>	2.5 hours	1.3 hours	1 hour	2.5 hours	1 hour	55 minutes
<b>Rater Personnel</b>	1	1	2	1	1	1
<b>Location blower Door Test</b>	Garage entry	Garage entry	Garage entry	Back porch entry	Garage entry	Garage entry
<b>Sealed Registers During Blower Door Test</b>	No	No	No	No	Yes	No
<b>Performed Total Duct Leakage Test</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Performed Duct Leakage to Outside Test</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Took Photos of Nameplates</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Counted Bulbs</b>	No	No	No	Yes	No	No
<b>Other</b>		Used different duct insulation values than provided.	Used different insulation grading value than provided.			

## HERS Ratings and Home Size

Rater	HERS Index	REM/Rate Version	Cost of Rating	Conditioned Area (sq. ft)	Conditioned Volume (cu. ft)
A	78	14.6.1	\$550	2404	25,242
B	71	14.6.2.1	\$350	2404	23,752
C	79	15.1	\$450	2404	24,047
D	67	14.6.4	\$500	2360	23,506
E	65	15.2	\$573	2292	21,708
F	64	14.6.1	\$375	2402	27,405

## Estimated Annual Energy Cost

Rater	MMBtu	Service Fee	Total Cost
A	97.1	\$174	\$1,765
B	89	\$60	\$2,119
C	66	\$489	\$2,672
D	84.5	\$72	\$2,379
E	53.4	\$60	\$2,402
F	78.6	\$81	\$1,569

## Energy Cost/MMBtu

Rater	Heating	Cooling	Hot Water	Lighting & Appliance
A	\$0.05	\$0.03	\$0.05	\$0.07
B	\$0.06	\$0.04	\$0.11	\$0.11
C	\$0.11	\$0.12	\$0.11	\$0.11
D	\$0.07	\$0.05	\$0.14	\$0.13
E	\$0.15	\$0.15	\$0.15	\$0.15
F	\$0.05	\$0.04	\$0.09	\$0.08

## Input Summary: Envelope

### Wall Details

Rater	Conditioned Area (sq. ft)	Uo Value	Continuous Insulation (R-value)	Insulation Grade
A	2173	0.078	0	1
B	2310	0.074	.5	1
C	2614.7	0.082	0	2
D	2476	0.079	0	1
E	2463	0.070	.4	1
F	2671	0.059	3	1

## Window Details

Rater	Area (sq. ft)	Area Facing West (sq. ft)	Shade – Winter	Shade – Summer
A	307	204	None	None
B	341	16	None	None
C	306.9	16	None	None
D	300.8	182.8	None	Some
E	273	16	None	Some
F	279	16	None	None

## Ceiling and Roof Details

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Continuous Insulation (R-value)	Cavity Insulation (R-value)	Cavity Depth (in)
A	2404	2468	19	R-19	5.5
B	2493	3020	25	R-13	3.5
C	2485	2485	20.7	R-17.3	5.5
D	2444	2444	25	R-13	3.5
E	2323	2323	N/A	R-30	10
F	2404	3005	25	R-13	3.5

## Input Summary: Mechanical

### Mechanical Details

Rater	Tons	Heating Set Point (deg F)	Cooling Set Point (deg F)	Heating Efficiency (HSPF)	Cooling Efficiency (SEER)	Water Heater (EF)
A	5	68	78	8.2	14	0.95
B	5	70	75	8.2	14	0.95
C	5	72	75	8.2	14	0.95
D	5	68	78	8.2	14	0.88
E	5	72	75	8.2	14	0.86
F	3	68	78	8.2	14	0.88

## Duct Details

Rater	Returns (count)	Duct Surface Area (sq. ft)		Total Leakage (CFM25)	Leakage to the Outside (CFM25)	Location
		Supply	Return			
A	6	649.1	601	96	3.99	100% Unconditioned
B	5	649.1	601	186	7.74	100% Unconditioned
C	2	649.1	240.4	271	11.27	100% Unconditioned
D	4	637.2	472	216	9.15	100% Conditioned
E	1	356.2	66	183.36	8	100% Conditioned
F	4	649.1	480.8	75	3.12	80% Unconditioned 20% Conditioned

## Infiltration and Ventilation Details

Rater	Rate (CFM)	Hours	Fan Watts	ACH50
A	52	24	275	3.82
B	130	9	120	4.56
C	161	9.2	681	4.41
D	130	9.5	250	4.2
E	56	24	100	5
F	75	24	19.9	3.7

## Lighting and Appliance Details

Rater	Ceiling Fan (CFM/W)	Dishwasher (EF)	High Efficacy Lighting	
			Interior	Exterior
A	29	0.46	100%	100%
B	127.4	0.84	100%	100%
C	0	275 kWh/yr	0%	0%
D	70.4	260 kWh/yr	100%	0%
E	100	0.71	75%	100%
F	70.4	0.46	100%	100%

## Austin House Description

SPEER obtained permission from a homebuilder to use one of their spec homes in the Austin metropolitan area. The home was 1629 square feet with three bedrooms and two bathrooms. The given R-value for vertical surfaces was R-13 and for roof surfaces was R-25. The home uses gas for heating, water heating and the kitchen range, all other uses are electric. The house has a silver reflective metal roof.

## Additional Observations

	<b>Rater G</b>	<b>Rater H</b>	<b>Rater I</b>	<b>Rater J</b>	<b>Rater K</b>
<b>Time On-Site</b>	1.75 hours	3.25 hours	1.75 hours	1.25 hours	1.75 hours
<b>Rater Personnel</b>	1	2	2	1	1
<b>Performed Blower Door Test</b>	Yes	Yes	Yes	Yes	Yes
<b>Performed Total Duct Leakage Test</b>	Yes	Yes	No	No	Yes
<b>Took Photos of Nameplates</b>	Yes	Yes	Yes	Yes	Yes
<b>Counted Light Bulbs</b>	Yes	Yes	No	No	Yes
<b>Other</b>	Measured all exterior walls of house to make sure they matched plans.		Used light bulb information from plans. Provided efficiency rebate information.	Removed vent in bedroom to see if ducts were sealed.	Used central air return for duct leakage test.

## HERS Ratings and Home Size

<b>Rater</b>	<b>HERS Index</b>	<b>REM/Rate Version</b>	<b>Cost of Rating</b>	<b>Conditioned Area (sq. ft)</b>	<b>Conditioned Volume (cu. ft)</b>
<b>G</b>	69	14.6.4	\$400	1,629	22,653
<b>H</b>	64	15.3	\$400	1,635	20,825
<b>I</b>	55	15.3	\$600	1,643	19,716
<b>J</b>	75	15.3	\$500	1,635	14,715
<b>K</b>	64	14.6.1	\$500	1,630	14,886

### Estimated Annual Energy Cost

Rater	MMBtu	Service Fee	Total Cost
G	68.5	\$237	\$1,162
H	50.3	\$72	\$1,096
I	49.4	\$324	\$997
J	58.8	\$120	\$992
K	62.1	\$361	\$1,342

### Energy Cost by Use

Rater	Heat	Cooling	Hot Water	Lighting & Appliance
G	\$202	\$237	\$92	\$394
H	\$106	\$237	\$39	\$642
I	\$135	\$34	\$26	\$478
J	\$100	\$219	\$38	\$515
K	\$90	\$256	\$50	\$585

### Input Summary: Envelope

#### Wall Details

Rater	Area (sq. ft)	Uo Value	Cavity Insulation (R-Value)	Insulation Grade
G	1809	0.085	13	1
H	2045	0.084	13.5	1
I	2393	0.071	19	1
J	1809	0.071	13	1
K	2009.5	0.097	Path Layers	N/A

#### Window Details

Rater	Area (sq. ft)	Area Facing West (sq. ft)	Shade – Winter	Shade – Summer
G	380.6	80.2	None	None
H	379.2	113.1	Varied	Varied
I	337	32	Varied	Varied
J	372	126	Varied	Varied
K	341.72	92.24	None	None

## Ceiling and Roof Details

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Continuous Insulation (R-value)	Cavity Insulation (R-value)	Cavity Depth (in.)
G	1629	1922	0	25	7
H	1963	1963	3.7	23.2	5.5
I	1643	2053.75	3	35	6.1
J	1635	2043.75	5	25	3.5
K	1630	1745	7	Path Layers	Path Layers

## Input Summary: Mechanical

### Mechanical Details

Rater	Tons	Heating Set Point (deg F)	Cooling Set Point (deg F)	Heating Efficiency (HSPF)	Cooling Efficiency (SEER)	Water Heater (EF)
G	2.5	68	78	95	15	0.85
H	2.9	70	75	95	16	0.96
I	3	68	78	94	16	0.83
J	3	68	78	80	14	0.97
K	2.9	68	78	95	16	0.99

### Duct Details

Rater	Returns (count)	Duct Surface Area (sq. ft)		Total Leakage (CFM25)	Leakage to the Outside (CFM25)	Location
		Supply	Return			
G	1	439.8	81.5	149	9.15	Conditioned
H	4	441.5	327	63	3.85	Conditioned
I	1	443.6	82.2	N/A	N/A	Conditioned
J	1	441.5	81.8	N/A	N/A	Conditioned
K	4	440.1	326	159	9.75	Conditioned

### Infiltration and Ventilation Details

Rater	Rate (CFM)	Hours	Fan Watts	ACH50
G	N/A	N/A	N/A	1.96
H	108	10	250	1.36
I	130	16.2	75	1.29
J	53	24	150	5
K	69	2	244.8	1.98

## Lighting and Appliance Details

Rater	Ceiling Fan (CFM/W)	Dishwasher (EF)	High Efficacy Lighting	
			Interior	Exterior
<b>G</b>	0	0.80	30%	0%
<b>H</b>	115	0	80%	100%
<b>I</b>	N/A	N/A	N/A	N/A
<b>J</b>	0	0.46	100%	0%
<b>K</b>	70.4	0	86%	100%



## Southwest Region: Denver, CO and Salt Lake City, UT

### Denver House Description

SWEEP obtained permission from a homebuilder to utilize one of their spec homes located southeast of the Denver Metropolitan area. The construction of the home was complete, and a PDF file of the house plans was given to SWEEP in addition to HVAC and building envelope specifications. The home was listed as 4262 square feet from the plans. It had three bedrooms and two and a one-half bathrooms. The raters were told to assume the home was constructed under 2009 IECC construction practices in an area with no energy code inspections. Raters received the plans before arriving on-site and performing the rating.

At the time of the rating the clothes washer, dryer and refrigerator were not installed. The garage lighting was 100% LED lighting, a fluorescent light in a closet and all of the remaining lights were incandescent light bulbs. The above grade wall assembly consisted of 2x6 studs 16oc with fiberglass batt insulation in the cavity. This house has a gas furnace, electric AC unit and standard tank gas water heater. All appliances except for the range and one oven were electric. The dryer was not plumbed for natural gas and no refrigerator or washer and dryer were installed.

### Additional Observations

	Rater A	Rater B	Rater C	Rater D	Rater E
<b>Time On-Site</b>	1.75 hours	1.5 hours	4.5 hours	2.5 hours	3 hours
<b>Rater Personnel</b>	1	1	1	1	2
<b>Bedroom (count)</b>	5	5	5	3	4
<b>Performed Blower Door Test</b>	Yes	Yes	Yes	Yes	Yes
<b>Sealed Registers During Blower Door Test</b>	No	No	No	No	No
<b>Performed Total Duct Leakage Test</b>	No	No	Yes	Yes	Yes
<b>Performed Duct Leakage to Outside</b>	No	No	Yes	Yes	No
<b>Took Photos of Name plates</b>	No	Yes	Yes	Yes	Yes
<b>Counted Light Bulbs</b>	No	Yes	Yes	Yes	Yes
<b>Other</b>	Retrotec Blower door	Retrotec Blower door	Retrotec Blower door, Used infrared Camera	Minneapolis (TEC) Blower door	Retrotec Blower door, Used infrared Camera

## HERS Ratings and Home Size

Rater	HERS Index	REM/Rate Version	Cost of Rating	Conditioned Area (sq. ft)	Conditioned Volume (cu. ft)
A	67	15.3	\$625	4,267	42,670
B	70	15.1	\$925	4,260	44,300
C	79	14.6.4	\$1,500	4,251	33,087
D	68	14.6.4	\$500	3,931	42,455
E	99	15.3	\$1,220	4,264	46,009

## Estimated Annual Energy Cost

Rater	MMBtu	Service Fee	Total Cost
A	141.4	\$120	\$1626
B	157.4	\$50	\$2411
C	121.7	\$0	\$2714
D	105.4	\$0	\$2294
E	203.4	\$120	\$2944

## Energy Cost/MMBtu

Rater	Heat	Cooling	Hot Water	Lighting & Appliance
A	\$406	\$95	\$99	\$906
B	\$993	\$127	\$165	\$1076
C	\$1077	\$129	\$222	\$1286
D	\$838	\$94	\$164	\$1198
E	\$1208	\$188	\$131	\$1297

## Wall Details

Rater	Area (sq. ft)	Uo Value	Insulation Grade	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)
A	4,250	0.061	1	0	19
B	3,862	0.060	1	0	19
C	2,853	0.069	3	0	20
D	3,270	0.063	1	0	18
E	2,187	0.072	3	0	19

## Window Details

Rater	Area (sq. ft)	Area Facing West (sq. ft)	Shade – Winter	Shade – Summer
A	451	296	0.85	0.70
B	423	266	0.85	0.70
C	242	148	0.85	0.70
D	412	299	0.85	0.70
E	374	267	0.85	0.70

### Door Details

Rater	Opaque Area (sq. ft)	Uo Value	Opaque Area (R-value)
A	40	0.155	5.5
B	18	0.329	2.1
C	45	0.311	2.28
D	40	0.184	4.5
E	48	0.447	1.3

### Ceiling and Roof Details

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Cont. Insulation (R-Value)	Cavity insulation (R-Value)	Cavity Depth (in.)	Insulation Grade	Uo
A	2,255	2,255	0	38	11.3	1	0.027
B	2,467	2,908	8	20	5.78	1	0.027
C	2,157	2,697	10	27	8.58	3	0.040
D	2,109	2,363	25	13	7.64	1	0.026
E	2,330	2,497	13	25	7.08	2	0.028

### Mechanical Details

Rater	Systems (count)	Tons Cooling	Heating Set Point (deg F)	Cooling Set Point (deg F)	Heating Efficiency (AFUE)	Cooling Efficiency (SEER)	Water Heating (EF)
A	3	3	68	78	93.0	13.5	0.62
B	3	3	68	76	93.0	13	0.62
C	3	4	68	78	93.0	13	0.62
D	3	3	68	76	93.0	13	0.62
E	4	3	68	78	93.0	13	0.62

### Duct Details

Rater	Returns (count)	Duct Surface Area (sq. ft)		Total Leakage (CFM25)	Leakage to the Outside (CFM25)	Location
		Supply	Return			
A	5	864	800	Did not test	Did not test	100% conditioned
B	8	863	799	Did not test	Did not test	90% conditioned 10% unconditioned
C	9	861	797	Could not get test pressure	Could not get test pressure	93% conditioned 7% unconditioned
D	8	796	590	Could not get test pressure	Could not get test pressure	90% conditioned 10% unconditioned
E	7	864	800	Could not get test pressure	Could not get test pressure	100% Conditioned

### Lighting and Appliance Details

Rater	Ceiling Fan (CFM/Watt)	Refrigerator (kWh/year)	Dishwasher (EF)	High Efficacy Lighting	
				Interior	Exterior
A	None	637	0.46	10%	0%
B	80	430	270 kWh/yr.	5%	0%
C	75	691	270 kWh/yr.	10%	0%
D	None	775	270 kWh/yr.	0%	50%
E	None	0	270 kWh/yr.	0%	100%

### Infiltration and Ventilation Details

Rater	Rate (CFM)	Hours	Fan Watts	ACH50
A	None	24	None	3.52
B	None	24	None	3.33
C	None	24	None	4.30
D	None	24	None	3.24
E	None	24	None	2.86

## Salt Lake City House Description

The Salt Lake City home was completed in July 2016 and is 2,100 square feet in size, with 1,050 square feet on the main level and a 1,050 square foot basement. The home was built to Passive House standards and includes a ductless heating and cooling system. The home also has an extremely airtight envelope, high insulation values, and advanced windows and doors. At the time of the assessments, the home was finished and unoccupied.

The home is served by a ductless “two headed” mini-split heat pump and an HRV. Two raters reported two mechanical systems in the home and one rater reported three systems (perhaps due to their counting the heat pump system as two units). SWEEP was informed that the lighting in the home was 100% LED.

### HERS Rating and Home Size

Rater	HERS Index (from plans)	HERS Index (in field)	REM/Rate Version	Conditioned Area (sq. ft)	Conditioned Volume (sq. ft)
F	42	44	v15.1	2,096	16,151
G	51	47	v14.6.3	2,063	17,305
H	43	NR	v14.6.4	1,956	15,648
I	50	50	v15.1	1,798	16,182

### Estimated Annual Energy Cost

Rater	MMBtu	Service Fee	Total Cost
F	39	\$153	\$1087
G	44.5	\$153	\$1231
H	41.8	\$101	\$944
I	45.3	\$153	\$1123

### Energy Cost/MMBtu

Rater	Heating	Cooling	Hot Water	Lights/Appliances
F	\$28.64	\$30.80	\$7.13	\$29.25
G	\$19.59	\$10.71	\$24.47	\$29.10
H	\$25.29	\$27.33	\$7.40	\$26.06
I	\$25.87	\$28.70	\$7.42	\$27.36

### Wall Details

Rater	Area (sq. ft)	Uo Value	Insulation Grade	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)
F	1,136	0.025	1	21	22
G	1,141	0.074	1	21	22
H	1,008	0.022	1	24	23
I	N/A	N/A	N/A	N/A	N/A

### Window Details

Rater	Area (sq. ft)	Area Facing West (sq. ft)	Shade – Winter	Shade – Summer
F	207	44	0.85	0.7
G	157	35	0.85	0.7
H	218	45	0.85	0.7
I	N/A	N/A	N/A	N/A

### Door Details

Rater	Opaque Area	Uo Value	R-Value of Opaque Area
F	40	0.891	0.2
G	40	0.149	5.75
H	42	0.187	4.4
I	N/A	N/A	N/A

### Ceiling and Roof Details

Rater	Ceiling Area	Roof Area	Cont. Insulation (R-Value)	Cavity Insulation (R-Value)	Cavity Insulation Grade	Framing Factor
F	1,048	1,310	12	64	1	0.11
G	1,005	1,005	7	69	1	0.11
H	1,079	1,079	7	69	1	0.1412
I	N/A	N/A	N/A	N/A	N/A	N/A

### Mechanical Details

Rater	Systems (count)	Heating Set Point (deg F)	Cooling Set Point (deg F)	Heating Efficiency (HSPF)	Cooling Efficiency (SEER)	Water Heating (EF)
F	2	68	78	9.3	18	0.95
G	2	68	78	9.3	18	0.95
H	3	68	78	N/A	12.5	0.95
I	N/A	N/A	N/A	N/A	N/A	N/A

### Lighting and Appliance Details

Rater	Ceiling Fan (CFM/Watt)	Refrigerator (kWh/year)	Dishwasher (EF)	High Efficacy Lighting	
				Interior	Exterior
F	0	701	0	100%	100%
G	0	701	0.46	100%	100%
H	0	701	0	90%	100%
I	N/A	N/A	N/A	N/A	N/A

### Infiltration and Ventilation

Rater	Rate (CFM)	Hours	Fan Watts	ACH50
F	125	24	126	0.69
G	253	24	166	0.11
H	95	24	126	0.13
I	N/A	N/A	N/A	0.6

## Midwest Region: Chicago, IL and Grand Rapids, MI

### Chicago House Description

The house is a 2,880-sq. ft., two-story craftsman-style with a conditioned basement. This house is certified with EPA Indoor Airplus and Energy Star v. 3.1. At the time of the rating, the home was nearing obtaining a CO and all appliances except for a washer and dryer were installed. The home has a smart thermostat and is mechanically ventilated with an air-cycler.

Below are key features of the house (confirmed by MEEA and the builder), which were compared to the results obtained by the six raters.

### Home Characteristics

<b>General Characteristics</b>	<b>Conditioned Area (sq. ft)</b>	<b>Conditioned Volume (cu. ft)</b>	<b>Stories Above Grade</b>	<b>Bedrooms</b>	<b>Conditioned Basement</b>
	2,880	24,000	2	3	Yes
<b>Structural Characteristics</b>	<b>Slab</b>	<b>Foundation</b>	<b>Above Grade Walls</b>	<b>Sheathing</b>	<b>Roof</b>
	Poured Concrete	Poured Concrete	2x6 plates w/ 2x4 staggered studs at 24" O.C.	Zip System panels wrapped in Tyvek	24" O.C. 2x4 raised heel trusses
<b>Building Thermal Envelope</b>	<b>Slab Insulation</b>	<b>Foundation Wall Insulation</b>	<b>Above Grade Wall Insulation</b>	<b>Attic Insulation (measured)</b>	<b>Windows (U-Factor)</b>
	R-10	R-15 (exterior)	R-21 or R-13.3 + 7.6	R-56	.18-.22
<b>Mechanical Equipment &amp; Ventilation</b>	<b>Gas Furnace Efficiency (AFUE)</b>	<b>Electric AC Efficiency (SEER)</b>	<b>Tankless Water Heater Efficiency (EF)</b>	<b>Air Cycler (CFM)</b>	<b>Air Cycler (Watts)</b>
	96	13.5	0.97	100	139
<b>Lights &amp; Appliances</b>	<b>Refrigerator Efficiency (kwh/yr.)</b>	<b>Dishwasher Efficiency (kwh/yr.)</b>	<b>Washer Efficiency (kwh/yr.)</b>	<b>Dryer Efficiency (EF)</b>	<b>High Efficacy Lighting – Interior/ Exterior</b>
	685	270	704	2.67	98% / 75%



## Additional Observations

Variables	Rater A	Rater B	Rater C	Rater D	Rater E	Rater F
<b>Time On-Site</b>	2 Hours	2 Hours	1.5 Hours	1 Hour	1 Hour	2 Hours
<b>Rater Personnel</b>	1	2	2	2	1	1
<b>Performed Air Leakage Test</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Location of Air Leakage Test</b>	Front Entry	Front Entry	Front Entry	Front Entry	Back Entry	Front Entry
<b>Sealed Registers for Duct Test</b>	Yes	Yes	Could not test	Unable to observe	Yes	Yes
<b>Performed Duct Leakage to Outside Test</b>	Yes	Yes	Could not test	Unable to observe	Yes	Yes
<b>Performed Total Duct Leakage Test</b>	Yes	Yes	Could not test	Unable to observe	Yes	Yes
<b>Noted Equipment Model #s</b>	Yes	Yes	Yes	Unable to observe	Yes	No
<b>Counted Light Bulbs</b>	Yes	No	No	Unable to observe	No	No
<b>Used Infrared Camera</b>	No	No	Yes	Unable to observe	No	No
<b>Notes</b>		Additional staff was a trainee	Rater scheduled HERS provider QC of this rating.	Rater arrived 1 hour before MEEA staff		

Note: Rater C could not conduct a duct pressure test because carpet was being installed in the bedrooms.

## HERS Ratings and Home Size

Rater	HERS Index	REM/Rate Version	Cost of Rating	Conditioned Area (sq. ft)	Conditioned Volume (cu. ft)
<b>A</b>	44	14.6.4	\$900	2,880	25,920
<b>B</b>	42	14.6.4	\$450	3,120	28,704
<b>C</b>	51	15.3	\$450	2,880	24,000
<b>D</b>	44	14.6.4	\$450	2,880	24,000
<b>E</b>	49	15.3	\$700	2,880	24,055
<b>F</b>	40	14.6.3.1	\$900	2,880	25,920

## Estimated Annual Energy Cost

Rater	MMBTU	Service Fee	Energy Cost	Total Cost
A	61.4	\$120	\$1,067	\$1,187
B	80.2	\$349	\$1,373	\$1,722
C	92.2	\$180	\$1,815	\$1,995
D	83.0	\$262	\$1,436	\$1,698
E	77.3	\$312	\$918	\$1,230
F	55.4	\$372	\$809	\$1,181

## Energy Costs by Use

Rater	Heat	Cooling	Hot Water	Lighting & Appliance
A	\$281	\$81	\$64	\$625
B	\$254	\$76	\$80	\$970
C	\$404	\$126	\$88	\$1,197
D	\$224	\$60	\$73	\$1,264
E	\$163	\$122	\$46	\$583
F	\$138	\$52	\$58	\$562

## Foundation Wall Detail

Rater	Area (sq. ft)	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)	Uo Value (Wall Only)	Insulation Grade
A	563.2	15	0	0.064	3
B	594	15	0	0.064	2
C	563.2	15	0	0.066	3
D	576	15	0	0.063	1
E	563.2	15	0	0.064	3
F	545.6	15	0	0.097	1

## Slab Floor Details

Rater	Area (sq. ft)	Continuous Insulation Under Slab (R-value)
A	960	10
B	1040	10
C	960	10
D	960	0
E	960	10
F	960	0

### Rim and Band Joist Details

Rater	Area (sq. ft)	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)	Uo Value (Wall Only)	Insulation Grade
A	256	0	20	0.069	3
B	343	0	20.9	0.045	1
C	298.7	0	21	0.053	1
D	256	0	21	0.054	1
E	298.8	0	21	0.045	1
F	256	0	19	0.048	1

### Above Grade Wall Details

Rater	Area (sq. ft)	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)	Uo Value	Insulation Grade
A	2554.5	0	20.9	0.064	3
B	2706	7.6	13.3	0.051	1
C	2652	7	21	0.039	1
D	2624	7	15	0.046	1
E	2641.9	7	14	0.049	1
F	2557	7.5	13	0.05	1

### Window U-Factor and SHGC Details

Rater	Total Area (sq. ft)	Area Facing West (sq. ft)	U-Factor	SHGC	Shade - Winter	Shade - Summer
A	284.3	63	.19-.22	0.24	0.85	0.7
B	257.5	62.4	.18-.27	.17-.27	0.85	0.7
C	270	77	.19-.22	.24-.27	.85-1	.7-1
D	277	64	0.23	0.17	0.85	0.7
E	254.5	60.9	.18-.22	.24-.27	1	1
F	304.8	69	.18-.22	0.26	0.85	0.7

### Ceiling and Roof Details

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Continuous Insulation (R-value)	Cavity Insulation (R-value)	Cavity Depth (in.)	Uo
A	960	1200	44.1	12.6	3.5	0.017
B	1040	1082	47	13	3.5	0.016
C	960	1200	26	30	7.3	0.019
D	960	1200	47	13	3.5	0.016
E	960	1200	49	11	3.5	0.017
F	960	1689	39	10.5	3.5	0.02

### Mechanical Equipment Details

Rater	Heating Set Point (deg F)	Cooling Set Point (deg F)	Heating Capacity (kBtu/hr)	Cooling Capacity (kBtu/hr)	Heating Eff (AFUE)	Cooling Eff (SEER)	Water Eff (EF)
A	68	78	39	23	96	13.5	0.97
B	68	78	40	24	96.1	13.5	0.96
C	72	75	39	24	96	13	0.97
D	72	75	38	24	96	13	0.92
E	72	75	39	24	96	13	0.97
F	68	78	38.4	36	96	14	0.97

### Duct System Details

Rater	Returns (count)	Supply Duct Surface Area (sq. ft)	Total Duct Leakage (CFM25)	Leakage to Outside (CFM25)	Location
A	5	583.2	12.3	0.49	100% Conditioned
B	8	631.8	6.66	0	100% Conditioned
C	6	583.2	Could not test	Could not test	100% Conditioned
D	7	583.2	7.64	0.87	100% Conditioned
E	6	583.2	6.18	0.42	100% Conditioned
F	4	739.3	6.91	0	33% Conditioned 34% Attic

Note: The builder used Aeroseal® to seal the duct work so at the time of testing the plenum had not been sealed.

## Lighting and Appliance Details

Rater	High Efficacy Lighting		Dishwasher (kWh/yr.)	Refrigerator (kWh/yr.)	Clothes Washer (kWh/yr.)	Clothes Dryer (EF)
	Interior	Exterior				
<b>A</b>	97.8	75	270	685	704	2.67
<b>B</b>	100	100	270	709	96	3.3
<b>C</b>	75	10	260	749	704	3.01
<b>D</b>	100	100	358	505	704	3.9
<b>E</b>	100	100	467	677	704	2.67
<b>F</b>	100	100	467	691	487	2.67

## Ventilation and Infiltration

Rater	Rate (CFM)	Hours	Fan Watts	CFM/Watt	ACH50
<b>A</b>	51	8	139	0.37	1.05
<b>B</b>	62	24	370	0.17	0.9
<b>C</b>	132	18.8	383	0.34	0.8
<b>D</b>	135	12	135	1.00	1.2
<b>E</b>	120	12	140	0.86	1.1
<b>F</b>	140	10.1	140	1	1.1

## Grand Rapids House Description

The house is a 2,240 square-foot, one story ranch-style home with a finished conditioned basement. This house had a simple design but unfortunately was at the typical point of construction to receive a certified HERS rating. The home did not have the finished flooring, lighting, appliances, or a water heater and air conditioner installed during the time of the rating. In addition, raters were unable to test the duct work because the return duct had not been completely installed. Given the unfinished state of the home, all raters who agreed to rate the home only agreed to do so on the basis of providing a projected rating. MEEA provided details on the missing building components to the raters based on the intention of the builder.

## Home Characteristics

<b>General Characteristics</b>	<b>Conditioned Area (sq. ft)</b>	<b>Conditioned Volume (cu. ft)</b>	<b>Stories Above Grade</b>	<b>Bedrooms</b>	<b>Conditioned Basement</b>
	2,240	20,760	1	4	Yes
<b>Structural Characteristics</b>	<b>Slab</b>	<b>Foundation walls</b>	<b>Above Grade Walls</b>	<b>Sheathing</b>	<b>Roof</b>
	Poured Concrete	8" Concrete Block	2x4 studs @16" OC.	OSB wrapped in Tyvek	16" O.C. 2x4 wooden trusses
<b>Building Thermal Envelope</b>	<b>Slab Insulation</b>	<b>Foundation Wall Insulation</b>	<b>Above Grade Wall Insulation</b>	<b>Attic Insulation</b>	<b>Windows (U-Factor)</b>
	None	R-15 (batt)	R-15 (batt)	R-60 (blown cellulose)	.29, .30, .45
<b>Mechanical Equipment &amp; Ventilation</b>	<b>Gas Furnace Efficiency (AFUE)</b>	<b>Electric AC Efficiency (SEER)</b>	<b>Water Heater Efficiency (EF)</b>	<b>Ventilation (CFM)</b>	<b>Ventilation (Watts)</b>
	95.5	13	.60	NA	NA
<b>Lights &amp; Appliances – not installed, provided by MEEA</b>	<b>Refrigerator Efficiency (kwh/yr.)</b>	<b>Dishwasher Efficiency (kwh/yr.)</b>	<b>Washer Efficiency (kwh/yr.)</b>	<b>Dryer Efficiency (EF)</b>	<b>High Efficacy Lighting – Interior (%)</b>
	582	261	NA	NA	100

Note: MEEA provided each rater with the following information: Slab, foundation, rim, wall and ceiling insulation levels; Appliance information; Air conditioning size and level of efficiency; Hot water heater fuel source, size and level of efficiency; High efficacy lighting percentage.

## Additional Observations

Variables	Rater G	Rater H	Rater I	Rater J	Rater K
<b>Time On-Site</b>	1 Hour	.75 Hours	1.5 Hours	1 Hour	.5 Hours
<b>Rater Personnel</b>	1	2	1	1	1
<b>Performed Air Leakage Test</b>	Yes	Yes	Yes	Yes	No
<b>Location of Air Leakage Test</b>	Front Entry	Side Entry	Front Entry	Front Entry	Did not test
<b>Performed Duct Leakage to Outside Test</b>	Could not test	Could not test	Could not test	Could not test	Could not test
<b>Performed Total Duct Leakage Test</b>	Could not test	Could not test	Could not test	Could not test	Could not test
<b>Noted Window Stickers</b>	Yes	Yes	Yes	Yes	No
<b>Noted Heating Equipment Model #</b>	Yes	Yes	Yes	Yes	No
<b>Asked about Lighting</b>	Yes	No	Yes	Yes	No
<b>Used Infrared Camera</b>	No	No	Yes	No	No
<b>Asked If Home Would Have Whole-House Mechanical Ventilation</b>	Yes	No	Yes	Yes	No
<b>Notes</b>		Rater did not engage MEEA during the rating process	Rater brought an infrared camera gauge insulation grading	Rater explained the rating process in detail to MEEA	Rater wanted to wait conduct final rating when house was closer to completion

## Energy Ratings and Home Size

Rater	HERS Index	REM/Rate Version	Cost of Rating	Conditioned Area (Sq. ft.)	Conditioned Volume (cu. Ft.)	Bedrooms
<b>G</b>	65	14.6.4	\$900	2240	20760	3
<b>H</b>	60	14.6.4	\$500	2240	18700	3
<b>I</b>	58	15.3	\$625	2240	19694	4
<b>J</b>	60	15.3	\$765	2240	17920	4

## Estimated Annual Energy Cost

Rater	MMBTU	Service Fee	Energy Cost	Total Cost
G	93.2	\$120	\$1,385	\$1,505
H	60.8	\$141	\$1,257	\$1,398
I	85.0	\$210	\$1,313	\$1,523
J	79.0	\$60	\$650	\$710

## Foundation Wall Details

Rater	Area (sq. ft)	R-Value	Uo Value (Wall Only)	Insulation Grade
G	1022	15	0.115	3
H	908	15	0.086	1
I	908	15	0.121	2
J	928	15	0.122	3

## Slab Floor Details

Rater	Area (sq. ft)	R-Value (under slab)
G	1,120	0
H	1,120	0
I	1,120	0
J	1,120	0

## Rim and Band Joist Details

Rater	Area (sq. ft)	Continuous Insulation (R-Value)	Cavity insulation (R-Value)	Uo Value (Wall Only)	Insulation Grade
G	136	0	19	0.057	2
H	136	0	19	0.047	1
I	136	0	15	0.063	1
J	136	0	15	0.076	3

## Above Grade Wall Details

Rater	Area (Sq. ft.)	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)	Uo Value	Insulation Grade
G	1,322	0	15	0.092	3
H	1,308	5	15	0.058	3
I	1,268	0	15	0.079	1
J	1,248	0	15	0.092	3



### Window U-Factor and SHGC Details

Rater	Total Area (sq. ft)	Area Facing West (sq. ft)	U-Factor	SHGC	Shade - Winter	Shade - Summer
G	141.9	85.7	.28,.29,.45	0.32	0.85	0.7
H	171	60	.28,.29	.27,.32	1	1
I	162.5	57.5	.29,.45	.32,.59	0.85	0.7
J	121	48	.28,.29	0.32	0.85	0.7

### Ceiling and Roof Details

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Continuous Insulation (R-value)	Cavity Insulation (R-value)	Cavity Depth (in.)	Uo
G	1120	1401	46.5	10.5	3.5	0.017
H	1200	2245	47	13	3.5	0.016
I	1120	1400	46.5	13.5	3.5	0.017
J	1120	1400	47	13	3.5	0.017

### Mechanical Equipment Details

Rater	Heating Set Point (deg F)	Cooling Set Point (deg F)	Heating Capacity (kBtu/hr)	Cooling Capacity (kBtu/hr)	Heating Efficiency (AFUE)	Cooling Efficiency (SEER)	Water Efficiency (EF)
G	N/A	N/A	78	30	95.5	13	0.6
H	68	78	48	24	95.5	13	0.67
I	68	78	80	30	95.5	13	0.67
J	68	78	64	30	94	13	0.62

### Duct Leakage

As indicated previously, the return duct was not installed during the time of the inspection, so raters were unable to test the duct work while on site. All ducts that were installed were in conditioned space.

### Lighting and Appliance Details

Rater	High Efficacy Lighting		Dishwasher (kWh/yr.)	Refrigerator (kWh/yr.)	Clothes Washer (kWh/yr.)	Clothes Dryer (EF)
	Interior	Exterior				
G	100%	100%	261	582	704	2.67
H	50%	50%	269	647	151	2.67
I	100%	100%	260	582	151	2.67
J	100%	100%	260	582	96	3.48

Note: The lighting and appliances were not installed during the time of the field inspections. MEEA told the raters that the home would have 100% LED lights and provided the appliance model numbers for the dishwasher and refrigerator that would be installed. MEEA did not provide model numbers for the clothes washer and dryer.

#### Ventilation and Infiltration Details

Rater	Rate (CFM)	Hours	Fan Watts	CFM/Watt	Cooling Season Strategy	ACH50
<b>G</b>	0	24	0	0.00	Natural Vent.	2.6
<b>H</b>	0	24	0	0.00	None	3.0
<b>I</b>	50	24	15	3.33	Exhaust Only	2.4
<b>J</b>	0	24	0	0.00	Natural Vent.	3.2

Note: Bath fans were installed but were not operational during the field inspections. All raters asked about whether whole house continuous ventilation would be installed in the home, and MEEA said only bath fans would be installed.

All raters tested the total air leakage in the home but obtained slightly different results. Three raters used the front door and one used the side door to conduct the test. Given that the home was not sealed for a final blower door test, Raters A and C taped kitchen exhaust and plumbing penetrations.

## Northeast Region: Derby, CT and Malta, NY

### Derby House Description

The house studied has 2762 square feet of conditioned space; this includes the first floor with two bedrooms and a conditioned basement. The Home is certified Energy Star 3.1. The builder received utility incentives for the energy and renewable energy features. At the time of rating only the dishwasher appliance was installed. The house did not have refrigerator or washer/dryer. The house has an air cycler, smart thermostat and PV array. The entire duct system is installed in conditioned space.

### Home Characteristics

<b>General Characteristics</b>	<b>Conditioned Area (sq. ft)</b>	<b>Conditioned Volume (cu. ft)</b>	<b>Stories Above Grade</b>	<b>Bedrooms</b>	<b>Conditioned Basement</b>
	2762	23484	1	2	Yes
<b>Structural Characteristics</b>	<b>Slab</b>	<b>Foundation</b>	<b>Above Grade Walls</b>	<b>Sheathing</b>	<b>Roof</b>
	Poured Concrete	Poured Concrete	2 x 6 walls 16" O.C.	Gyp Board, continuous insulation, Tyvek	16" O.C. 2 x 10 wood
<b>Building Thermal Envelope</b>	<b>Slab Insulation</b>	<b>Foundation Wall Insulation</b>	<b>Above Grade Wall Insulation</b>	<b>Attic Insulation (measured)</b>	<b>Window (U-factor)</b>
	R - 10	R - 13	2x6 16" O.C. 2" HDF + R8 FGB + R 6.5 cc	R60 blown cell 18"	0.25
<b>Mechanical Equipment &amp; ventilation</b>	<b>Gas Furnace Efficiency (AFUE)</b>	<b>Electric AC Efficiency (SEER)</b>	<b>Tankless Water Heater Efficiency (EF)</b>	<b>Air Cyclor (CFM)</b>	<b>Air Cyclor (Watts)</b>
	NG 96	16	97		
<b>Lights and Appliances</b>	<b>Refrigerator Efficiency (kwh/yr.)</b>	<b>Dishwasher Efficiency (kwh/yr.)</b>	<b>Washer Efficiency (kwh/yr.)</b>	<b>Dryer Efficiency (EF)</b>	<b>High Efficacy Lighting - Interior (%)</b>
	691	270	2.67	NG	100

*Note: The home has a roof mounted solar system.*

## Additional Observations

Variables	Rater A	Rater B	Rater C	Rater D	Rater E
Time On-Site	1 Hour	4 Hours	3 Hours	3.5 Hours	6 Hours
Rater Personnel	1	1	1	1	1
Performed Blower Door Test	Yes	Yes	Yes	Yes	Yes
Location of Blower Door Test	Front Entry	Front Entry	Front Entry	Front Entry	Front Entry
Sealed registers for Duct Test	Yes	Yes	Yes	Yes	Yes
Performed Duct Leakage Test	Yes	Yes	Yes	Yes	Yes
Performed Total Duct Leakage Test	Yes	Yes	Yes	Yes	Yes
Took Photos of Model #'s	No	Yes	No	No	Yes
Counted Light Bulbs	Yes	Yes	Yes	Yes	Yes
Used Infrared Camera	No	No	No	No	No
Inspected Attic Insulation	No	No	No	No	No
Included PV	Yes	No	No	Yes	Yes
Performed Combustion Testing	No	No	No	No	Yes
Notes		Created SketchUp drawing, modeled REM/Rate on site, traced air leakage	Taped exterior exhaust vents, taped bath exhaust fans, cut open taped dryer vent duct		Spent time speaking with builder regarding details, made observations on moisture issues, traced air leakage

## Ratings and Home Size

Rater	HERS Index	REM/Rate Version	Cost of Rating	Conditioned Area (sq. ft)	Conditioned Volume (cu. ft)
A	19 w/PV	v14.6.3	\$1,200	3058	28285
B	55	v15.3	\$1,200	2635	23106
C	43	v14.6.4	\$1,200	2264	19241
D	28 w/PV	v15.3	\$1,350	2766	23484
E	30 w/PV	v15.3	\$975	2735	28396
	55 w/o PV				

### Estimated Energy Cost

Rater	MMBtu	Service Fee	Total Cost	PV (\$/yr.)
A	28.4	\$375	\$725	(\$1,022)
B	80.2	\$0	\$602	NA
C	44.2	\$485	\$1,609	NA
D	59.3	\$435	\$978	(\$912)
E	60.9	N/A	\$1,309	(\$935)

### Energy Cost

Rater	Heating (\$/Yr.)	Cooling (\$/Yr.)	Hot Water (\$/Yr.)	Lighting & Appliance (\$/Yr.)
A	\$181	\$85	\$82	\$1,024
B	\$449	\$1	\$82	\$71
C	\$138	\$83	\$34	\$898
D	\$426	\$70	\$78	\$880
E	\$705	\$72	\$134	\$960

### Foundation Wall Insulation

Rater	Area (sq. ft)	R-Value	Uo Value (Wall Only)	Insulation Grade
A	4816	31.5	0.043	1
B	3520	6.0	0.988	1
C	2312	17	0.113	1
D	3824	7.5	0.518	1
E	6710	7.5	0.309	1

### Slab Floor Insulation

Rater	Area (sq. ft)	R-Value (under slab)
A	1400	7.5
B	1335	10
C	1383	0
D	1383	0
E	1367	7.5

### Rim and Band Joist Insulation

Rater	Area (Sq. ft.)	Uo Value	Insulation Grade	R-Value
A	132	0.036	1	14.7
B	134	0.049	1	6.5
C	134	0.075	1	14
D	136	0.042	1	6.5
E	136	0.052	3	6.5

### Above Grade Wall Insulation

Rater	Area (sq. ft)	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)	Uo Value	Insulation Grade
A	1254	6.5	19.1	0.045	1
B	1212	6.5	17.1	0.047	1
C	1072	6.5	25.6	0.039	1
D	1548	6.5	20.5	0.047	1
E	1226.6	6.5	19.6	0.048	3

### Window U Value and SHGC

Rater	Total Area (sq. ft)	Area Facing West (sq. ft)	U-Value	SHGC	Shade - Winter	Shade - Summer
A	237.9	64	0.21	0.2	0.85	0.7
B	323.4	73	0.28	0.27	0.85	0.7
C	291.5	64	0.25	0.27	0.85	0.7
D	290.3	74	0.25	0.27	0.85	0.7
E	343.7	93	0.25	0.27	0.85	0.7

### Ceiling and Roof Insulation

Rater	Ceiling Area (sq. ft)	Roof Area (sq. ft)	Continuous Insulation (R-Value)	Cavity Insulation (R-Value)	Cavity Depth (in.)	Uo
A	1400	1750	0	60	12	0.022
B	1335	1668.75	27.8	38	9.5	0.016
C	1383	1728.75	31.5	28.5	7.5	0.017
D	1281	1601.25	35	25	18	0.017
E	1367	1709	36.8	26.3	7.5	0.016

## Mechanical Efficiency

Rater	Heating Set Point (deg F)	Cooling Set Pont (deg F)	Heating Capacity (kBtu/hr.)	Cooling Capacity (kBtu/hr.)	Heating Efficiency (AFUE)	Cooling Efficiency (SEER)	Water Efficiency (EF)
A	68	78	60	36	96	15	0.96
B	68	78	39	18	96	16	0.97
C	68	78	39	18	96	15	0.89
D	68	78	39	18	96	16	0.97
E	68	78	39	18	96	16	0.97

## Duct Leakage

Rater	Returns (count)	Supply Duct Surface Area (sq. ft)	Total Duct Leakage (CFM25)	Leakage to Outside (CFM25)	Location
A	5	567	184	0	100% conditioned
B	4	533.6	230	N/A	100% conditioned
C	N/A	N/A	N/A	N/A	N/A
D	4	462.3	185	0	100% conditioned
E	2	276.9	191	0	100% conditioned

Note: Rater C's report was missing the page that contained this information.

## Lighting and Appliance Efficiency

Rater	High Efficacy Lighting		Dishwasher (kWh/yr.)	Refrigerator (kWh/yr.)	Clothes Washer (kWh/yr.)	Clothes Dryer (EF)
	Interior	Exterior				
A	100%	100%	0	691	704	2.67
B	81%	100%	305	691	704	3.01
C	95%	100%	270	691	96	3.01
D	100%	100%	270	673	704	2.67
E	89.5%	100%	270	673	704	2.67

## Ventilation and Infiltration Details

Rater	Rate (CFM)	Hours	Fan Watts	CFM/Watt	ACH50
A	60	24	40	1.5	1.81
B	74	24	15	4.93	2.22
C	100	11	14.67	6.82	2.06
D	90	13	32	2.81	2.17
E	88	12	10.2	8.63	1.69

## Malta, NY: Identifying a House

Only diagnostic testing (blower door, duct blaster, air flow) was conducted on the New York home and not a full rating. Each rater was provided \$800 for their services.

### Malta, NY House Description

The Malta house is a single-family, detached home. It is a 5000 square foot modern design with two stories above grade, an attached garage, and a conditioned, unfinished basement. The house includes four bedrooms and four full or half bathrooms, a large open floor plan with living room/kitchen area and dining room, plus an office and laundry room. The house uses a natural gas furnace (with a conventional duct system) and water heater, which is located in the basement, as well as an electric central air conditioning system. House is Energy Star 3.1 certified. Building Information:

- Conditioned Area (sq. ft.) - 5000
- Conditioned Volume (cubic ft.) – 44869
- Insulated Shell (sq. ft.) – 9650
- Bedrooms – Four
- House Type – Two Story Single Family Detached
- Foundation Type – Conditioned Basement

### Additional Observations

	Rater A	Rater B	Rater C	Rater D	Rater E
<b>Time Spent On-Site</b>	2.5 hours	1.75 hours	3 hours	2.25 hours	2.75 hours
<b>Raters On-site</b>	1	2	1	3	1
<b>Performed Blower Door Test</b>	Yes				
<b>Location of Blower Door Test</b>	Front Door				
<b>Sealed Registers During Blower Door Test</b>	Yes	No	No	No	No
<b>Performed Total Duct Leakage Test</b>	Yes				
<b>Performed Duct Leakage to Outside Test</b>	Yes				
<b>Other</b>		Ran bath tubs during fan flow test to ensure water in the trap.	Did not tighten blower door frame cams 100%.	Used Retrotec tools (all others used Minneapolis)	<b>Incorrect LTO test:</b> did not reverse blower door fan flow



<b>Performed Fan Flow Test</b>	No (forgot equipment)	Yes (but did not notice 2 <sup>nd</sup> fan in master bath)	No (forgot equipment)	Yes	Yes
<b>Register Taping Strategy</b>	Took off floor grill covers. Closed louvres. Taped unconnected dryer vent.	Taped to outside of grill covers.	<b>Missed seals for several registers.</b> Did not tape fans or dryer vent because this would create “unnatural condition.” Did not close louvres.	Blew smoke through ducts to find poor seals. Sealed additional points (e.g. near air handler)	Did not close louvres.
<b>Duct Testing Cabinet Seal Strategy</b>	Square transition piece pre-taped to cardboard square (sealed rest with duct tape)	Created seal with a combination of duct tape and register seal tape. (Did not remove the air filter.)	Cut the board to fit on-site (connected with duct tape).	Taped around plywood backer (connected with a combo of register tape and painter’s tape).	Register seal tape only.
<b>Duct Testing reference selection</b>	Plenum (test hole pre-drilled)	Closest supply register	Plenum (test hole pre-drilled)	Closest supply register (plenum facing perpendicular to flow)	Plenum (test hole pre-drilled) (plenum facing in the same direction as flow)
<b>Taped Fans (tied in to HRV?)</b>	No	Yes	No	Yes	Yes (but missed one of the fans).
<b>Taped off HRV outside?</b>	No	Yes	No	Yes (did w/ and w/o)	Yes (did w/ and w/o)

## Diagnostic Testing Results

Rater	Envelope Leakage (ACH50)	Duct Leakage to Outside (CFM25)	Duct Total Leakage (CFM25)	Air Flow (CFM)			
				Master Bath	Bath One	Bath Two	Half bath
<b>F</b>	1.43	61	580	36	31	32	30
<b>G</b>	1.36	28	876	20	23	22	25
<b>H</b>	1.56	140	1065	No Fan Test Equipment			
<b>I</b>	0.89	0	606	29	22	24	22
<b>J</b>	1.36	41	637	24	28	25	26