



# HERS Points for HVAC Design & Installation: One Step Closer

2018 ENERGY STAR Certified Homes Stakeholder Meeting  
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September 7<sup>th</sup>, 2018

ENERGY STAR. The simple choice for energy efficiency.



## Vacation!





## Agenda

- Introduction
- Where Are We Now?
- Standard 310 Overview
- Potential HERS Impact
- Field Testing
- Questions

A photograph of a house under construction. The image shows the wooden frame of the roof and the lower walls. A green semi-transparent overlay covers the middle portion of the image, containing the word "Introduction" in white text. The background is a clear blue sky with some white clouds. In the foreground, there is a dirt area with some construction materials, including a blue tarp and a red skid steer loader.

# Introduction



## Installation defects in HVAC systems are commonplace

- Improper airflow.
- Incorrect refrigerant charge.

Study Author	State	Existing or New Home?	Sample Size	Average Airflow	Airflow w/in 10% of 400/ton	Energy Savings Potential	Notes	
Blasnik et al. 1995a	NV	New	30	35%	5%	59%	17%	Est @ 67% combined charge/air flow correction benefits
Blasnik et al. 1995b	CA	New	10				0%	Est @ 67% combined charge/air flow correction benefits
Blasnik et al. 1996	AZ	New	22	18%	4%	78%	21%	Est @ 67% combined charge/air flow correction benefits
Hammarlund et al. 1992	CA	New	12				12%	Lab test of TXV; 8% loss @20% overchg; 2% loss @20% underchg
Neme et al. 1997	MD	New	66	31%	61%	8%	12%	Lab test of Orifice; 13% loss @20% overchg; 21% loss @ 20% underchg
Palani et al. 1992	n.a.	n.a.	n.a.					Single family results
Parker et al. 1997	FL	n.a.	n.a.					Multi-family results
Proctor & Pernick 1992	CA	Existing	175	44%	33%	23%		Charge measured in 22 systems in 13 homes
Proctor 1991	CA	Existing	15	44%				Results from PG&E Model Energy Communities Program
Proctor et al. 1995a	CA	Existing	30	11%	33%	56%		Fresno homes
Rodriguez et al. 1995	n.a.	n.a.	n.a.				13%	Est @ 67% combined charge/air flow correction benefits
Rodriguez et al. 1995	n.a.	n.a.	n.a.				5%	Lab test of TXV EER; 5% loss at both 20% overchg & 20% underchg
VEIC/PEG 1997	NJ	n.a.	n.a.				15%	Lab test of Orifice EER; 7% loss @20% overchg, 22% loss @ 20% underchg
Average					28%	33%	41%	12%



## Installation defects in HVAC systems are commonplace

- Airflow is impacted by the installation:
  - Fan-speed setting
  - Components attached to the system (like the filter)
  - Duct system installed
- Refrigerant charge is impacted by the installation:
  - Length of refrigerant line
  - Change in height between indoor and outdoor sections



## The RESNET Working Group

- ACCA initiated a proposal that RESNET include an evaluation of HVAC design and installation in the HERS index.
- EPA is leading a diverse working group to draft a standard that will accomplish this.

Jim Bergman, Measure Quick	Laurel Elam, RESNET	Brian Mount, Tempo Air
Tommy Blair, AE	Philip Fairey, FSEC	Dave Roberts, NREL
Michael Brown, ICF	Dean Gamble, EPA	Dennis Stroer, CalcsPlus
Greg Cobb, Inglenook Financial	Dan Granback, EI	Iain Walker, LBNL
Wes Davis, ACCA	James Jackson, Emerson	Dan Wildenhaus, TRC
Brett Dillon, IBS Advisors	Rob Minnick, Minnick's Inc.	Jon Winkler, NREL



## Guiding Principles

- Take a 'carrot' rather than a 'stick' approach.
- Reward incremental improvement by HVAC professionals and Raters.
- Rely upon procedures that:
  - Can be performed by both HVAC professionals and Raters.
  - Favor consistency over breadth.
  - Provide value in and of themselves.





## Grading Concept

- Follow the insulation quality-installation model:
  - Grade III: The default. No QI is done. No penalty and no credit.
  - Grade II: Rater reviews key design parameters for accuracy and takes accurate measurements of key installation parameters. The resulting values indicate that the system is not great, but not terrible.
  - Grade I: Rater duplicates the tasks in Grade II, but the resulting values indicate that the system is pretty top-notch.

A photograph of a house under construction. The image shows the wooden frame of the roof and the lower walls. A green semi-transparent overlay covers the middle portion of the image, containing the text "Where Are We Now?". The background is a clear blue sky with some white clouds. In the foreground, there is a dirt area with some construction materials, including a blue tarp and a red skid steer loader.

# Where Are We Now?



## Status Update

- Two major parts:
  - Standard 310: Standard for Grading the Installation of HVAC Systems
    - Brand new standard.
    - Covers all the things that the Rater will do.
  - Standard 301: Standard for the Calculation and Labeling..
    - Updated so that Standard 310 impacts the HERS index.



## Status Update

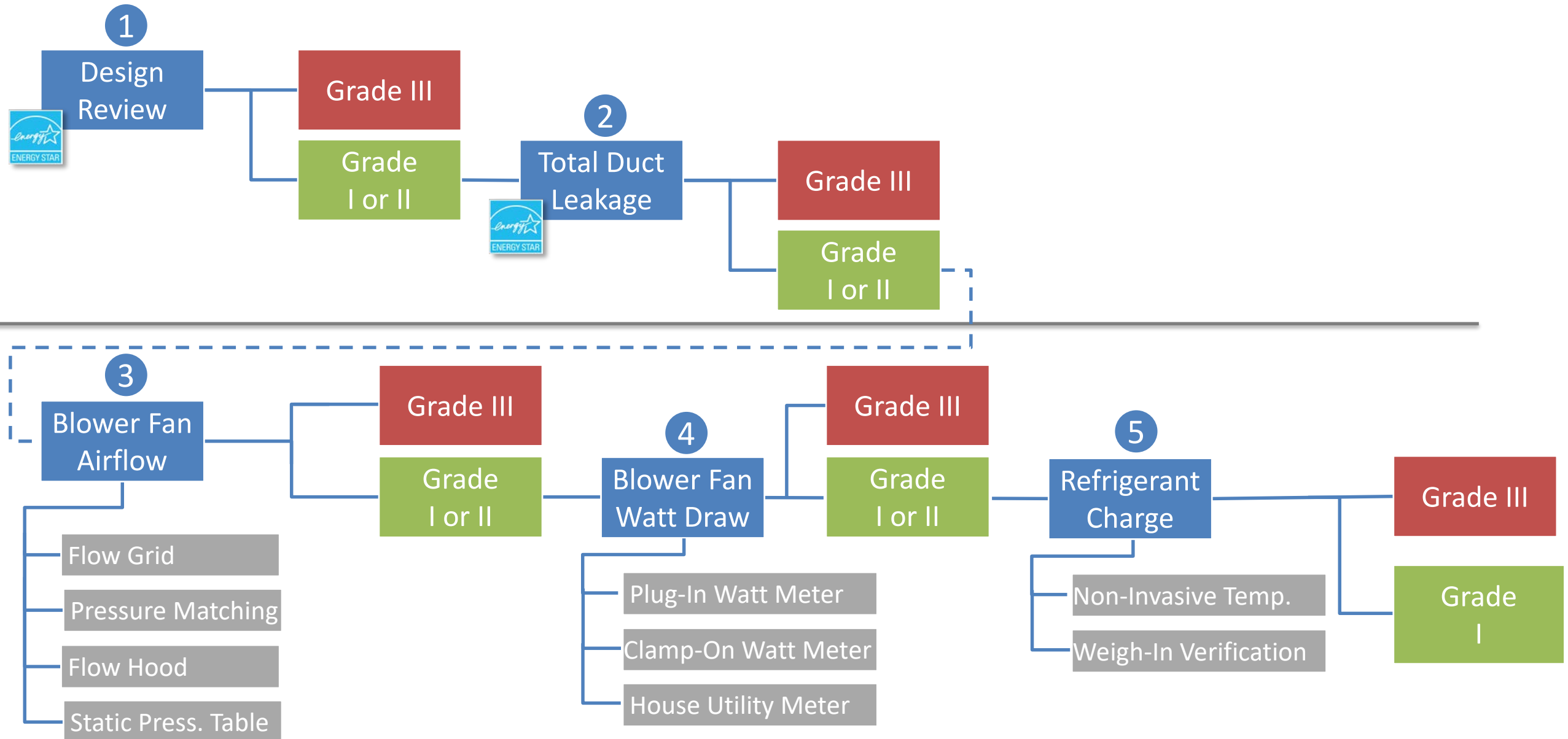
- Working Group is currently reviewing a draft of Std. 310, hoping for approval soon.
- Then:
  - Finalize draft standard.
  - Go through public comment process and committee approvals.
  - Setting up implementation date.
  - Rater training.
  - Software updates.

A photograph of a house under construction, showing the wooden frame and roof structure. The image is overlaid with a green semi-transparent banner that contains the text "Standard 310 Overview". The background shows a clear blue sky with some clouds and a lush green landscape with trees and a small red tractor in the distance.

# Standard 310 Overview



# Std. 310: Standard for Grading the Installation of HVAC Systems





## Std. 310: Evaluating the Design

- ENERGY STAR Partners are already doing this!
- Step 1: Collect design information for the dwelling with the forced-air system under test.
  - Similar data to what's in the ENERGY STAR HVAC Design Report, though slightly expanded.
- Step 2: Rater reviews design information to verify all required information is documented.
- Step 3: Rater reviews key features to compare design information to the home to be rated.
  - Similar to ENERGY STAR Rater Design Review Checklist
  - Key features include design temperatures, conditioned floor area, window area and SHGC, etc.



## Std. 310: Evaluating the Total Duct Leakage

- ENERGY STAR Partners are already doing this!
- Rater measures total duct leakage according to Std. 380, evaluates the results, and assigns a grade:

Grade	Test Stage	# Returns	Total Leakage Limit
I	Rough-In	< 3	4 CFM/100 sqft or 40 CFM
	Rough-In	≥ 3	6 CFM/100 sqft or 60 CFM
	Final	< 3	8 CFM/100 sqft or 80 CFM
	Final	≥ 3	12 CFM/100 sqft or 120 CFM
II	Rough-In	< 3	6 CFM/100 sqft or 60 CFM
	Rough-In	≥ 3	8 CFM/100 sqft or 80 CFM
	Final	< 3	10 CFM/100 sqft or 100 CFM
	Final	≥ 3	14 CFM/100 sqft or 140 CFM
III	N/A	N/A	No Limit

- Then, in the procedure to evaluate Blower Fan airflow:
  - Any test procedure can be used if Grade I duct leakage is achieved.
  - A subset of procedures can be used if Grade II duct leakage is achieved.
  - Airflow testing not permitted if Grade III duct leakage is achieved.





## Std. 310: Evaluating the Blower Fan Volumetric Airflow

1. Pressure Matching
2. Flow Grid
3. Flow Hood
4. OEM Static Pressure Table

## Std. 310: Evaluating the Blower Fan Volumetric Airflow

### #1. Pressure Matching

Pros	Cons
Accurate: +/- 3%	Can't reach high flows for big systems: needs extrapolation
Uses equipment many Raters already own	Need at least one large low air flow resistance return duct
	Requires hole in supply plenum

1. Measure static pressure created in supply plenum during operation of HVAC system.
2. Turn off HVAC system, connect a fan-flowmeter, and block other return air flow paths.
3. Turn HVAC fan back on.
4. Turn on flowmeter fan and adjust to achieve same static pressure in supply plenum.
5. Determine HVAC airflow by recording airflow of flowmeter fan.





## Std. 310: Evaluating the Blower Fan Volumetric Airflow

### #2. Flow Grid

Pros	Cons
Easy/simple for many systems	Multiple filters in single system are hard to deal with
Can work at higher flows	Need to make sure a good seal is achieved around the plate perimeter
	Slightly less accurate +/- 7%
	Requires hole in supply plenum

1. Measure static pressure created in supply plenum during operation of HVAC system.
2. Install calibrated flow grid in filter slot.
3. Measure pressure difference using flow grid. Correct pressure using value measure in Step 1.
4. Determine HVAC airflow by converting corrected pressure to airflow.





## Std. 310: Evaluating the Blower Fan Volumetric Airflow

### #3. Flow Hood

Pros	Cons
Accurate: +/- 3%	Can be heavy/unwieldy
Easy to use	Can be sensitive to placement
Does not require hole in supply plenum	Can be expensive
	Will not always fit around air inlet

1. Turn on HVAC system.
2. Connect flow hood to return grille.
3. Turn on flow hood and allow reading to stabilize.
4. Resulting airflow of flow hood determines HVAC airflow.
  - May require additional step to account for back-pressure.
  - For example, some manufacturers require you to test twice – once with a flap open and again with a flap closed.
  - While other manufacturers do this correction automatically without user intervention.





## Std. 310: Evaluating the Blower Fan Volumetric Airflow

### #4. OEM Static Pressure Table

Pros	Cons
Requires only pressures to be measured	Rater required to get OEM Blower Table for installed equipment
Works for all flows	Needs carefully-placed hole in supply-side and return-side, sometimes in equipment housing
Inexpensive equipment	

1. Turn on HVAC system.
2. Measure external static pressure of system's supply side and return side.
3. Determine fan-speed setting through visual inspection.
4. Using blower table information, look up total external static pressure and fan-speed setting to determine airflow.



MOTOR SPEED	TONS AC <sup>1</sup>	EXTERNAL STATIC PRESSURE, (INCHES WATER COLUMN)													
		0.1		0.2		0.3		0.4		0.5		0.6	0.7	0.8	
		CFM	RISE	CFM	RISE	CFM	RISE	CFM	RISE	CFM	RISE	CFM	CFM	CFM	
High	3	1,498	N/A	1,446	N/A	1,368	N/A	1,302	N/A	1,227	N/A	1,145	1,059	954	
Med	2.5	1,223	N/A	1,182	N/A	1,153	30	1,099	31	1,051	32	982	901	813	
Med-Lo	2	983	35	971	35	945	36	919	37	878	39	813	746	659	
Low	1.5	816	42	794	43	758	45	734	46	678	50	637	597	523	



## Std. 310: Evaluating the Blower Fan Watt Draw

1. Portable Watt Meter: Direct Measurement
2. Clamp-On Watt Meter: Direct Measurement
3. Utility Meter: Indirect Measurement

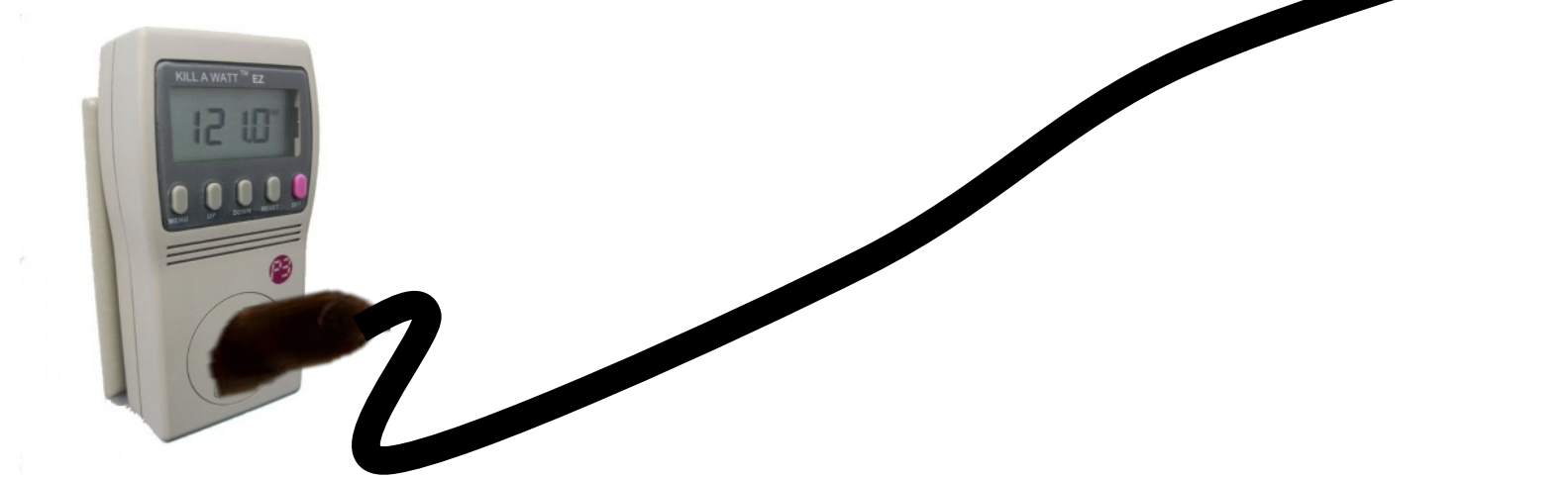


## Std. 310: Evaluating the Blower Fan Watt Draw

### #1. Portable Watt Meter: Direct Measurement

Pros	Cons
Simple	Not usable with hard-wired equipment
Direct measurement of equipment (accurate)	

1. Plug in portable watt meter and blower fan equipment into standard electrical receptacle.
2. Turn on equipment in required mode.
3. Record reading from portable watt meter.





## Std. 310: Evaluating the Blower Fan Watt Draw

### #2. Clamp-on: Direct Measurement

Pros	Cons
Useable with hardwired equipment that has service panel or service disconnect	Requires proper training and safety equipment
Direct measurement of equipment (accurate)	

1. Turn on equipment in required mode.
2. Connect clamp-on watt meter to measure voltage and current at either the service disconnect or through a service panel (not at breaker panel).
3. Record reading from clamp-on watt meter.







## Std. 310: Evaluating the Blower Fan Watt Draw

### #3. Utility Meter: Indirect Measurement

Pros	Cons
Works with all equipment	More steps required (turning off all other circuits)
No new equipment needed	

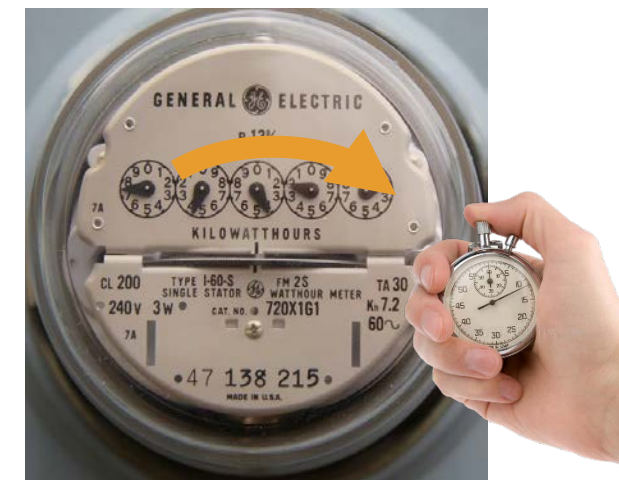
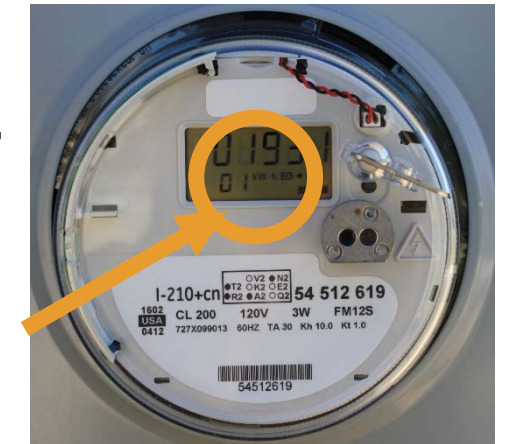
1. Turn off all circuits except air handler's.
2. Turn on equipment in required mode.

#### For a digital utility meter:

1. Record watt draw from utility meter.

#### For an analog utility meter:

1. For 90+ seconds, record the number of meter revolutions and time.
2. Calculate watt draw.





## Std. 310: Evaluating the Refrigerant Charge

1. Non-Invasive Test
2. Weigh-In Verification (only used for select equipment and conditions)

## Std. 310: Evaluating the Refrigerant Charge

### #1. Non-Invasive Test

Pros	Cons
No refrigerant handling certification needed	New procedure to learn
No risk of refrigerant contamination and leaks	Minimum outdoor air temperature required
Less Rater liability	

1. Determine key equipment characteristics.
2. Measure outdoor air and return air temperatures.
3. Calculate target refrigerant line temperatures.
4. Measure refrigerant line temperature.
5. Compare.



## Std. 310: Evaluating the Refrigerant Charge

### #2. Weigh-In Verification

Pros	Cons
No refrigerant handling certification needed	Requires information from contractor
Works at any outdoor temperature	Not a true performance test



1. Contractor provides:
  1. Weight of refrigerant added / removed
  2. Line length and diameter
  3. Default line length from factory charge (usually 15 feet)
  4. Factory supplied charge
  5. Geotagged photo of scale with weight added / removed
2. Rater then:
  1. Measures line length and diameter
  2. Uses lookup table to determine how much refrigerant should have been added / removed
3. Rater verifies the following:
  1. Deviation between lookup and contractor value within tolerance
  2. Location of geotagged photo matches “in the judgment of the party conducting the evaluation” the location of the equipment

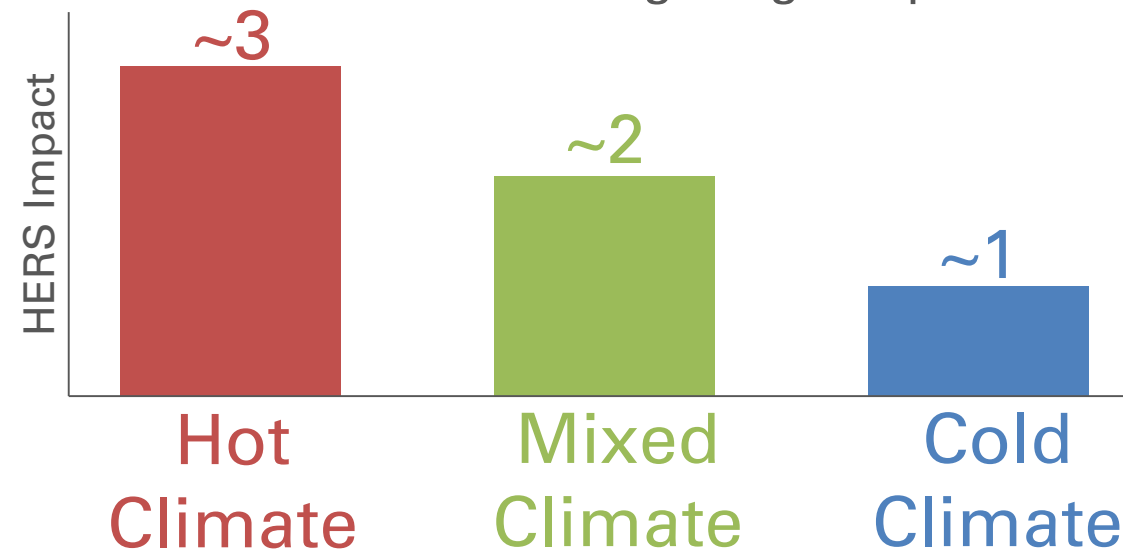


# Potential HERS Impact



## Potential HERS Impact Summary

- For homes where the HVAC design and installation is not assessed, score should be about the same as today.
- For homes where the HVAC design and installation is assessed, impact will be:
  - Dependent on climate
  - Dependent on how efficient the rest of the house is
  - Dependent on how well the system is designed and installed.
- Our goal and prediction is to have the following rough impacts for an ENERGY STAR home:



A photograph of a building under construction, showing the wooden frame and roof structure. The image is overlaid with a semi-transparent green banner that contains the text "Field Testing" in white. The background shows a clear blue sky with scattered white clouds. In the foreground, there is a dirt area with construction materials, including a blue tarp and a red skid steer loader.

# Field Testing

ENERGY STAR. The simple choice for energy efficiency.



## Field Testing

# WE WANT YOU!







## Field Testing: Purpose

- We're still fine-tuning Std 310, but we're far enough along today that we want your help.
- Get key Providers and Raters to road-test the procedures and provide feedback.
- Specific focus is on the new field tests.
- Looking to get feedback like:
  - Were there any obstacles or anything unclear in the procedures?
  - How long did it take to conduct each test?
  - Did different test procedures for the same parameter get similar results?



## Field Testing: Prerequisites

- To get good feedback we're looking for Raters and Providers who are:
  - Ideally, generally familiar with HVAC system operation
  - Have, or willing to obtain, test equipment
  - Good relationship with HVAC contractor
  - Time and willingness to try out the standard!

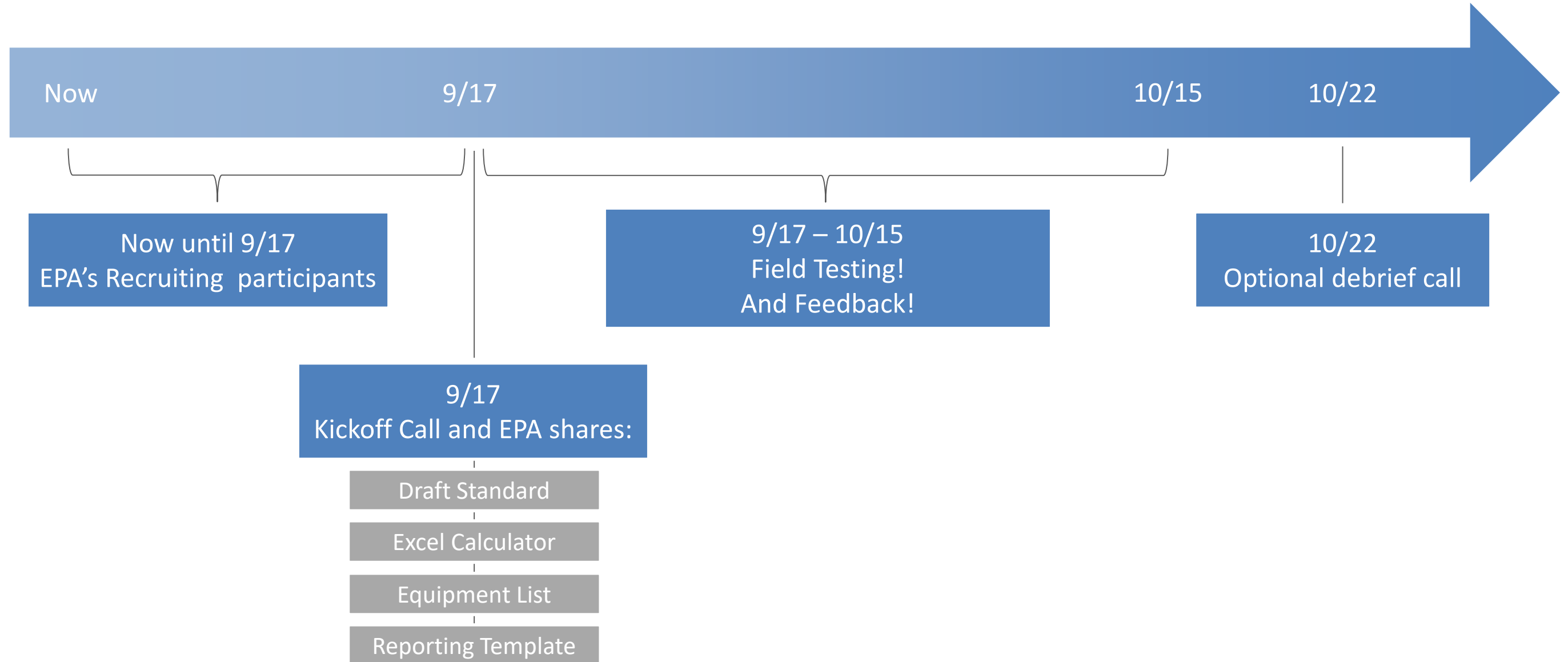


## Field Testing: Logistics

- EPA is recruiting key Raters and Providers starting today
- EPA will send:
  - Invitation to informal kickoff call/webinar
  - Handout with critical information
  - Draft standard
  - Excel calculator to guide tests and help with calculations
  - Reporting template for feedback
- Raters and Providers go out and kick the tires over 4 weeks and report back



## Field Testing: Logistics



A photograph of a house under construction. The image shows the wooden frame of the roof and the lower walls. A large green semi-transparent rectangle is overlaid across the center of the image, containing the word "Questions?". The background shows a blue sky with white clouds and a green landscape with trees and a red tractor in the distance.

**Questions?**