



**Better Buildings Residential Network
Peer Exchange Call Series:**
How Quality Installation Impacts Equipment
March 26, 2020

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers:
 - **Dean Gamble**, U.S. Environmental Protection Agency (EPA)
 - **David Lis**, Northeast Energy Efficiency Partnerships (NEEP)
 - **Christopher Boyce**, Emerson Climate Technologies
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- One-on-One brainstorming conversations

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming Calls (2nd & 4th Thursdays):

- Apr 09: How Hot Is It? – Preparing for Summer Cooling Season
- May 14: How is the Coronavirus Impacting Energy Efficiency Businesses?
- May 28: Is the Smart Home Delivering on Its Promises?

Peer Exchange Call summaries are posted on the Better Buildings [website](#) a few weeks after the call

For more information or to join, for no cost, email

bbresidentialnetwork@ee.doe.gov, or go to energy.gov/eere/bbrn & click Join



Dean Gamble
U.S. Environmental Protection Agency



How Bad Installation Can Negate Good Equipment

Better Buildings Residential Network Peer Exchange Call

Dean Gamble

March 26, 2020



Introduction

HVAC installation defects are common



HVAC installation defects are common

- Improper airflow:
 - Average airflow ~20% below target. Blasnik et al. (1995)
 - Average airflow 14% below design. Proctor (1997)
 - Measured airflow ranging from 130 - 510 CFM / ton. Parker (1997)
 - 70% of units had airflow < 350 CFM / ton. Neme et al. (1999)
 - Improper airflow in 44% of systems. Mowris et al. (2004)

HVAC installation defects are common

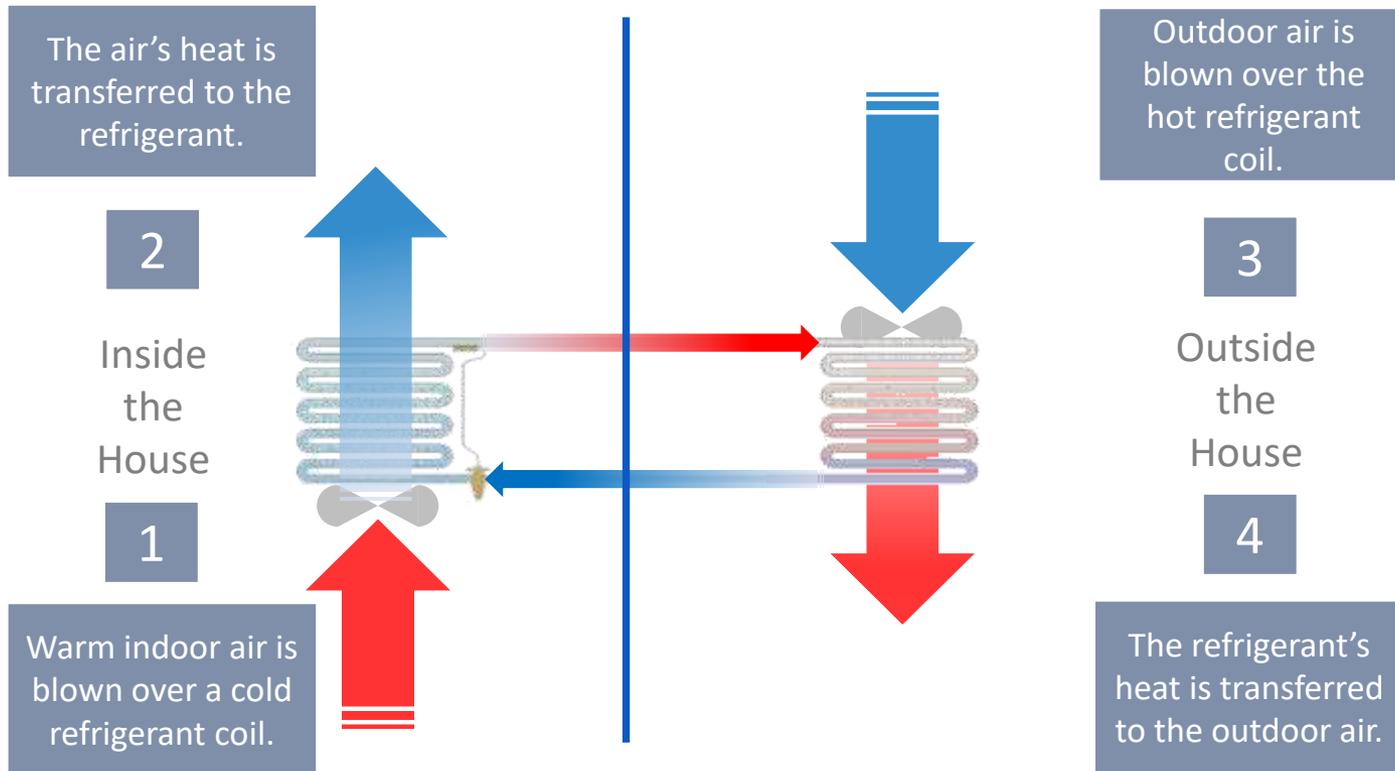
- Incorrect refrigerant charge:
 - In 57% of systems. Downey/Proctor (2002)
 - In 62% of systems. Proctor (2004)
 - In 72% of systems. Mowris et al. (2004)
 - In 82% of systems. Proctor (1997)

HVAC installation defects are common

Study Author	State	Existing or New Home?	Sample Size	Average Airflow	Airflow <350 cfm	Airflow w/in 10% of 400/ton	Energy Savings Potential	Notes
Blasnik et al. 1995a	NV	New	30	345	50%		8%	Est @ 33% combined charge/air flow correction benefits
Blasnik et al. 1995b	CA	New	10	319	90%			
Blasnik et al. 1996	AZ	New	22	344	64%	29%	10%	Est @ 33% combined charge/air flow correction benefits
Hammarlund et al. 1992	CA	New	12			30%	10%	Single family results
Hammarlund et al. 1992	CA	New	66		76%	14%	12%	Multi-family results
Neme et al. 1997	MD	New	25	340				Average for non-participant homes
Palani et al. 1992	n.a.	n.a.	n.a.				4%	Lab test of EER degradation at 25% reduction in air flow
Parker et al. 1997	FL	Both	27	270	89%	7%	10%	Field measurements of flow; lab test of effic loss
Proctor & Pernick 1992	CA	Existing	175		44%			Random sample from PG&E Model Energy Communities Dev
Proctor 1991	CA	Existing	15			33%		Two-thirds SCE Coach
Proctor et al. 1995a	CA	Existing	30	300	80%	11%		Lab test of
Rodriguez et al. 1995	n.a.	n.a.	n.a.				2%	Lab test of
Rodriguez et al. 1995	n.a.	n.a.	n.a.				10%	Lab test of
VEIC/PEG 1997	NJ	New	52	372		30%	7%	Est @ 33%
Average				327	70%	22%	8%	

Study Author	State	Existing or New Homes?	Sample Size	Charge correct to mfg spec	% over charge	% under charge	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				8%	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
Farzad & O'Neal 1993	n.a.	n.a.	n.a.				5%	Lab test of TXV; 8% loss @20% overchg; 2% loss @20% underchg
Farzad & O'Neal 1993	n.a.	n.a.	n.a.				17%	Lab test of Orifice; 13% loss @20% overchg; 21% loss @ 20% underchg
Hammarlund et al. 1992	CA	New	12				12%	Single family results
Hammarlund et al. 1992	CA	New	66	31%	61%	8%	12%	Multi-family results
Katz 1997	NC/SC	New	22	14%	64%	23%		Charge measured in 22 systems in 13 homes
Proctor & Pernick 1992	CA	Existing	175	44%	33%	23%		Results from PG&E Model Energy Communities Program
Proctor 1991	CA	Existing	15	44%				Fresno homes
Proctor et al. 1995a	CA	Existing	30	11%	33%	56%		
Proctor et al. 1997a	NJ	New	52				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
Rodriguez et al. 1995	n.a.	n.a.	n.a.				15%	Lab test of Orifice EER; 7% loss @20% overchg, 22% loss @ 20% underchg
Average				28%	33%	41%	12%	

HVAC installation defects are common



A photograph of a modern, two-story house with a gabled roof and a central window. The house is surrounded by a well-maintained lawn and a concrete walkway leading to the front door. A teal semi-transparent banner is overlaid across the middle of the image, containing white text.

Overview of Std 310: Grading the Installation of HVAC Systems

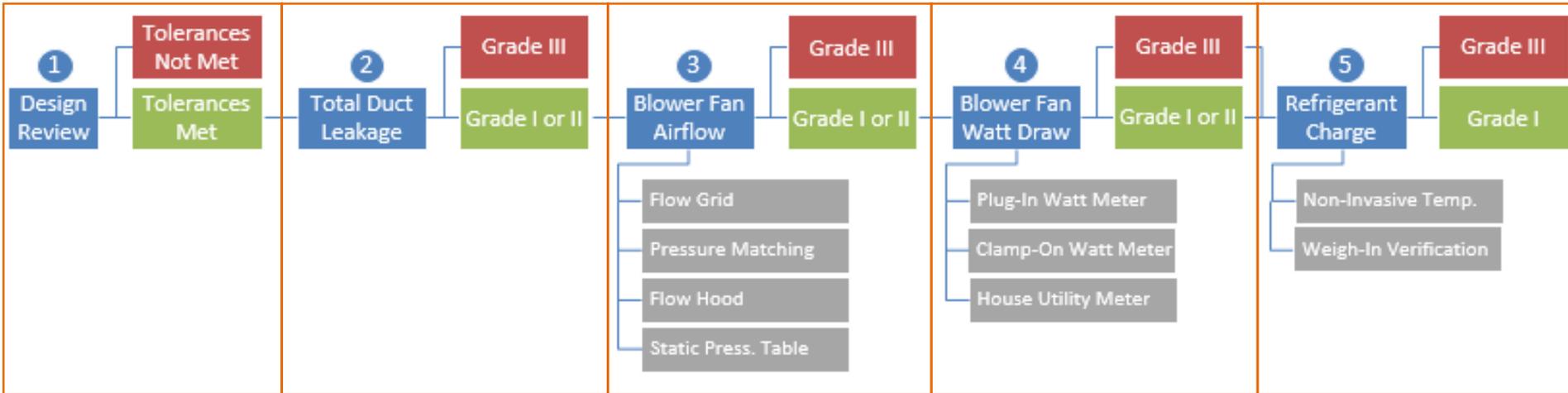
RESNET/ACCA Std. 310: Grading Concept

- Integrate into a standard HERS/ERI rating process.
 - Completed by home energy raters.
 - Primarily, but not exclusively, applicable to new construction industry
- Follow RESNET's insulation quality-installation model:
 - Grade III: The default. No assessment. No penalty and no credit.
 - Grade II: Assessment completed and the system is ok. Partial credit.
 - Grade I: Assessment completed and the system is very good. Full credit.
- Use tasks that California's code requires as a starting point.

RESNET/ACCA Std. 310: Guiding Principles

- Take a 'carrot' rather than a 'stick' approach.
- Reward incremental improvement.
- Include procedures applicable to both Rater and HVAC professionals.
- Ensure the procedures provide value in and of themselves.

RESNET/ACCA Std. 310: Standard for Grading the Installation of HVAC Systems





Task 1: Design Review



Task 1: Evaluate the design

1. Rater collects design documentation for the dwelling with the HVAC system being tested.
2. Rater reviews design documentation for completeness and compares it to the dwelling. Key features must fall within defined tolerances. For example:

Floor Area	Indoor Design Temps	Insulation Levels
Window Area	Outdoor Design Temps	Infiltration Rate
# Occupants	Window SHGC	Ventilation Rate

3. If tolerances are met, proceed to next task. Otherwise stop here.



Task 2: Total Duct Leakage



Task 2: Evaluate total duct leakage

1. Rater measures total duct leakage according to Std. 380, evaluates the results, and assigns a grade:

Grade	Test Stage	# Returns	Total Leakage Limit (CFM per 100 ft ² or Total CFM)
I	Rough-In	< 3	4 or 40 total
		≥ 3	6 or 60 total
	Final	< 3	8 or 80 total
		≥ 3	12 or 120 total
II	Rough-In	< 3	6 or 60 total
		≥ 3	8 or 80 total
	Final	< 3	10 or 100 total
		≥ 3	14 or 140 total
III	N/A	N/A	No Limit

2. If Grade I or II is achieved, proceed to next task. Otherwise stop here. 19



Task 3: Blower Fan Airflow



Task 3: Evaluate Blower Fan Airflow

- Raters measure the total volumetric airflow going through the blower fan using one of four test methods:
 - A. Flow Hood
 - B. Flow Grid
 - C. Pressure Matching
 - D. OEM Static Pressure Table
- This is just one or two measurements for most systems. It is not measuring the airflow from each register and summing those.
- The result is compared to the design airflow. The closer the better. This difference is used to assign Grade I, II, or III.
- If Grade I or II is achieved, proceed to next task. Otherwise stop here.



Task 4: Blower Fan Watt Draw



Task 4: Evaluate Blower Fan Watt Draw

- Raters evaluate the watt draw of the blower fan using one of three test methods:
 - A. Plug-In Watt Meter
 - B. Clamp-On Watt Meter
 - C. Utility Meter
- The airflow and watt draw is used to calculate fan efficiency. The more efficient, the better. This is used to assign Grade I, II, or III.
- Regardless of grade, you can proceed to next task.



Task 5: Refrigerant Charge



Task 5: Evaluate Refrigerant Charge

- Raters evaluate the refrigerant charge of the system using one of two test methods:
 - A. Non-Invasive Method
 - B. Weigh-In Verification Method

Task 5: Evaluate Refrigerant Charge

A. Non-Invasive Method

- 'Non-invasive' means no gauges connected to refrigerant system.
- Instead, the temperature of the air and refrigerant lines are used.
- Triage systems into two bins:
 - Grade I – Charge is okay
 - Grade III – Charge is not okay



Refrigerant Gauges
Not Connected



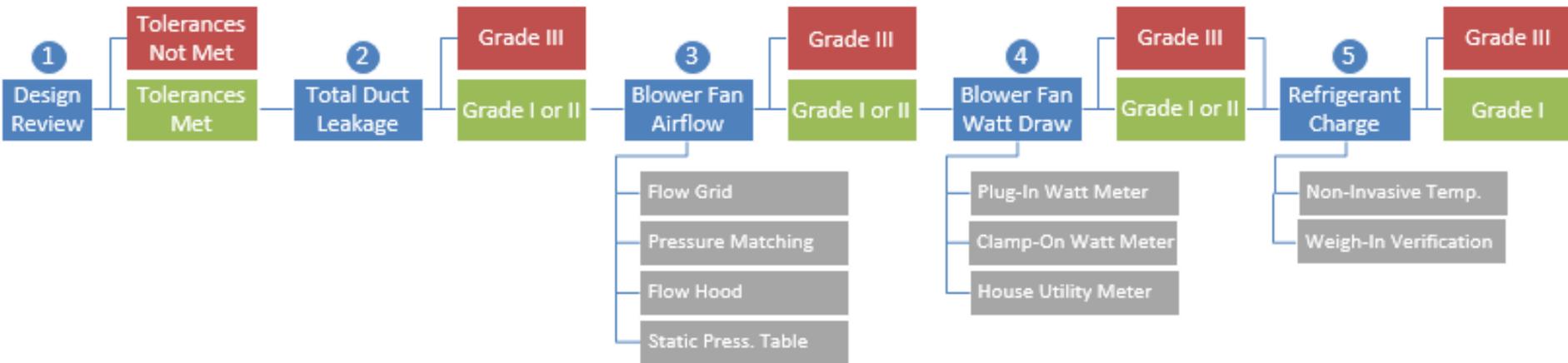
Temperature Sensors
Used Instead

Task 5: Evaluate Refrigerant Charge

B. Weigh-In Verification Method

- The weigh-in verification method can be used year-round and it must be used for:
 - Extreme outdoor conditions.
 - Mini/multi-split systems.
- This method is primarily a document review rather than a performance test.

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

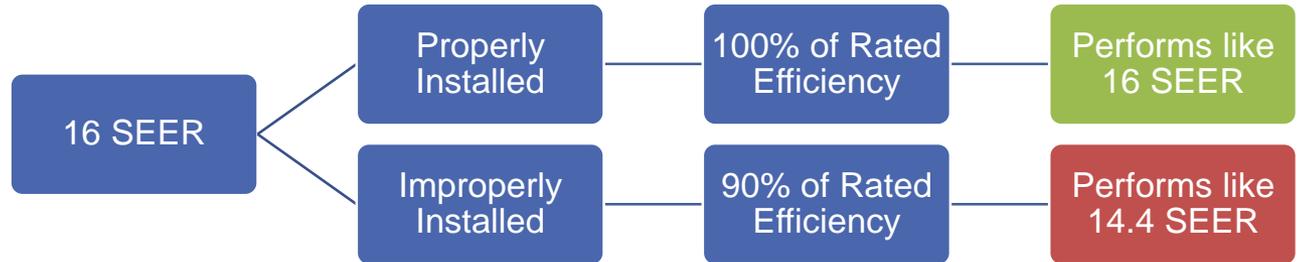




Benefits

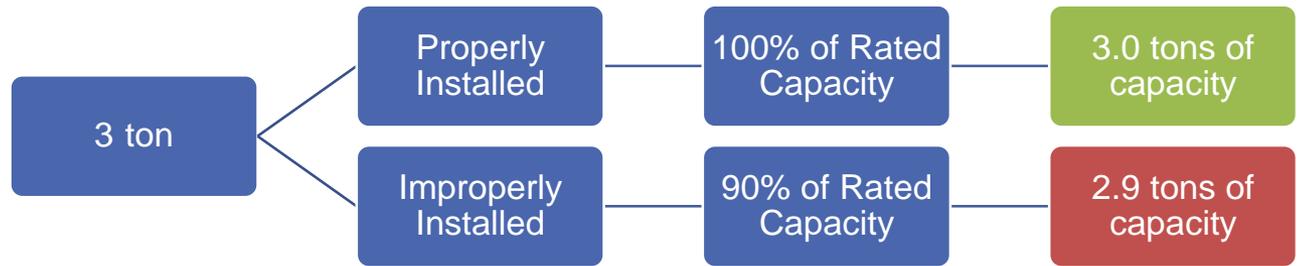
Properly-installed HVAC maintains efficiency

- Rewarded with better efficiency and a better HERS / ERI rating.



Properly-installed HVAC maintains capacity

- Rewarded with better comfort and durability.



HVAC grading benefits for..

- Builders – Energy ratings, tax credit, comfort, durability.
- Utility Programs – Energy and demand benefits.
- HVAC Manufacturers – Rewarded for features that ease installation.
- Raters – Valuable new service for any energy rated home.
- ENERGY STAR Certified Homes – Extra credit for program requirements, lower compliance cost.

A photograph of a modern, two-story house with a gabled roof and a teal overlay. The house features a central window in the gable and a dormer window on the right. A concrete walkway leads to the front door, flanked by green bushes and a lawn. The text "Alternative Compliance Paths" is written in white on the teal background.

Alternative Compliance Paths

Alternative Compliance Paths

- Primary goal of Std. 310 is to define a method for Raters to assess HVAC design and installation.
- However, the standard also includes a framework for two alternative compliance paths:
 - On-board diagnostics that directly provide data to Raters.
 - Third-party verifiers that collect and provide data in lieu of Raters, with oversight outside of RESNET.



Summary

Summary

- Installation defects impact the efficiency & capacity of HVAC systems.
- Standard 310 will be a new standard for evaluating the design and installation quality of HVAC systems.
- The standard is primarily designed for home energy raters, but includes a framework for two alternative compliance paths.
- This will allow homes to earn HERS/ERI points for properly installed HVAC systems.
- To read the second public draft of Standard 310, visit: www.resnet.us/about/standards/resnet-ansi/draft-pds-02-bsr-resnet-acca-310-20xx/
- The standard should be finalized and available for use by the end of this year.

ENERGY STAR Residential New Construction

Web & Email:

Single Family: www.energystar.gov/newhomesrequirements
Multifamily: www.energystar.gov/mfnc
Email: energystarhomes@energystar.gov

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David Lis
Northeast Energy Efficiency Partnerships



Getting Residential Air-Source Heat Pumps Right in Cold Climates

- Dave Lis, Director, Technology and Market Solutions
- March 26, 2020
- BBRN Webinar- How Bad Installation Can Negate Good Equipment



Northeast Energy Efficiency Partnerships



Mission

We seek to accelerate regional collaboration to promote advanced energy efficiency and related solutions in homes, buildings, industry, and communities.

Approach

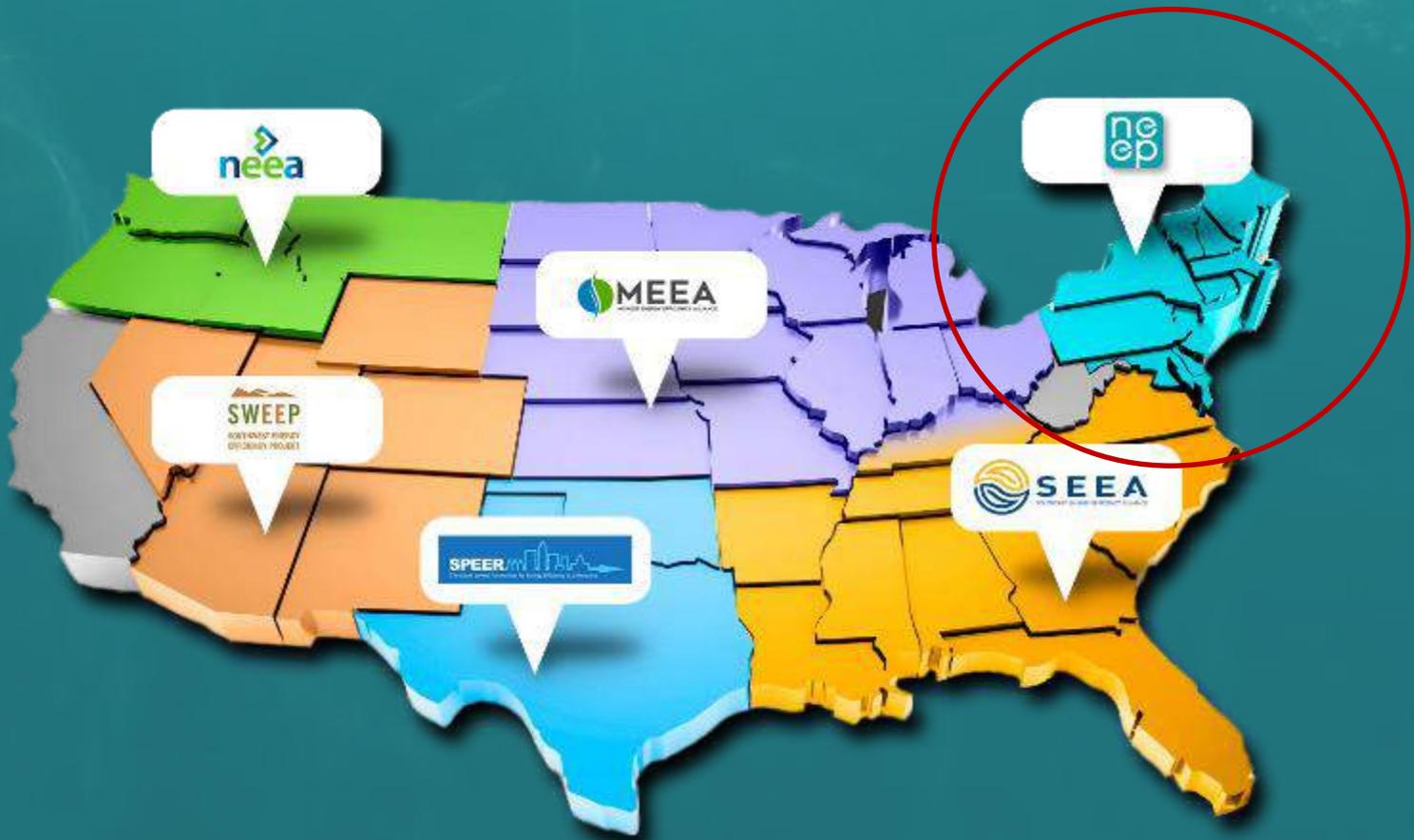
Drive market transformation regionally by fostering collaboration and innovation, developing tools, and disseminating knowledge



“Assist the Northeast and Mid-Atlantic region to reduce building sector energy consumption 3% per year and carbon emissions 40% by 2030 (relative to 2001)”

About NEEP

A Regional Energy Efficiency Organization

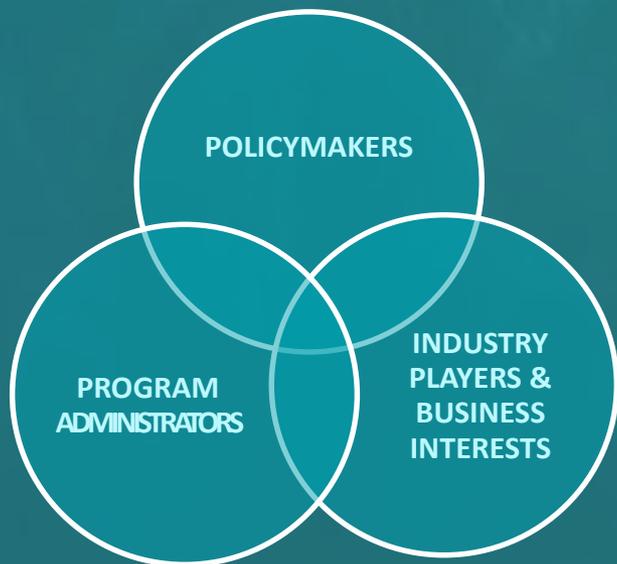


Here's what I'll be covering today

- Quick background on NEEP's regional Air-Source Heat Pump Initiative
- Why we care about design and installation practices
- Overview of NEEP's ASHP Installer Resources
 - Sizing & Selecting
 - Installation



Regional ASHP Market Transformation Strategy



ASHP adoption plays a significant role in our region achieving carbon reduction goals



- Assumed Market shares in 2035 according to NEEP's "Plausibly Optimistic" scenario reflects;
 - **Residential Heat Pumps-**
 - 89% for delivered fuel systems
 - 68% sales share of today's natural gas systems sales

Market Transformation Strategies



- 1. Increase Consumer Education and Awareness**
- 2. Increase Installer/Builder Awareness of, and Confidence in, ASHP through expanded training and education**
- 3. Reduce Upfront Costs of installed systems through robust and aligned promotional programs and the support of alternative business models**
- 4. Mobilize State and Local Policymakers to expand support for ASHPs**
- 5. Promote Advanced Control technologies to allow automated coordination among multiple heating systems**
- 6. Enable the promotion of climate-appropriate ASHPs through Improved Performance Metrics**
- 7. Develop more accurate tools to predict energy, cost and GHG savings associated with ASHP installation through collection and analysis of Real World Performance Data**

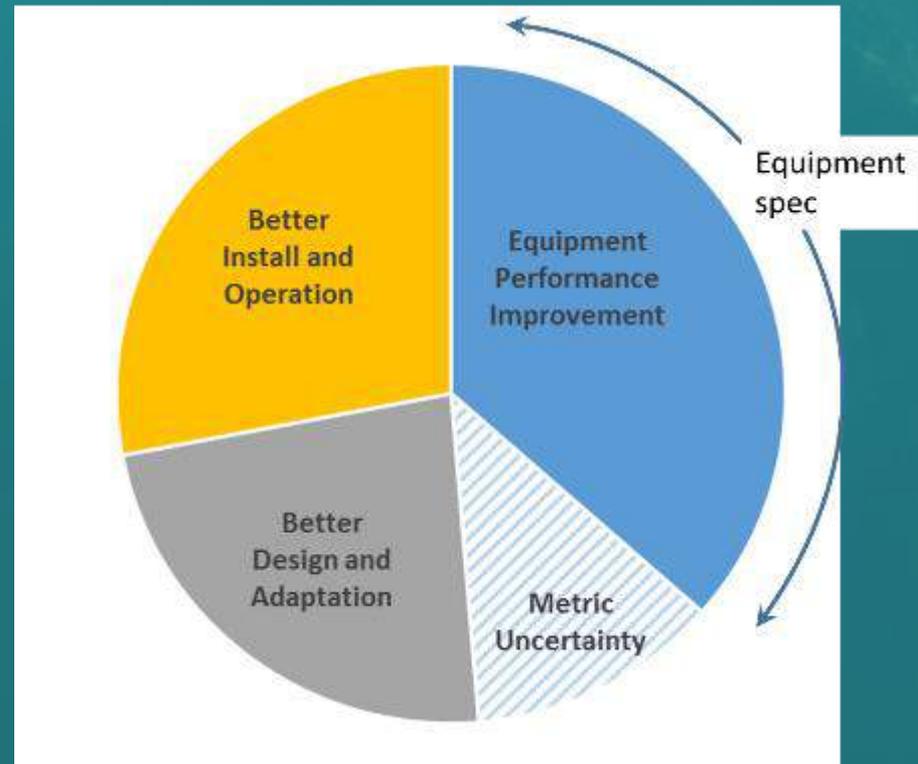
Market Transformation Strategies



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In field performance relies on the design, equipment, and install

- We often focus too heavily on equipment ratings
- Working regionally and with partners outside the region on driving improvements in all areas



Sizing/selecting/installing in cold climates

- Sizing/selection/Installation crucial to system performance
- New systems, new applications challenge longstanding metrics, tools and practices.

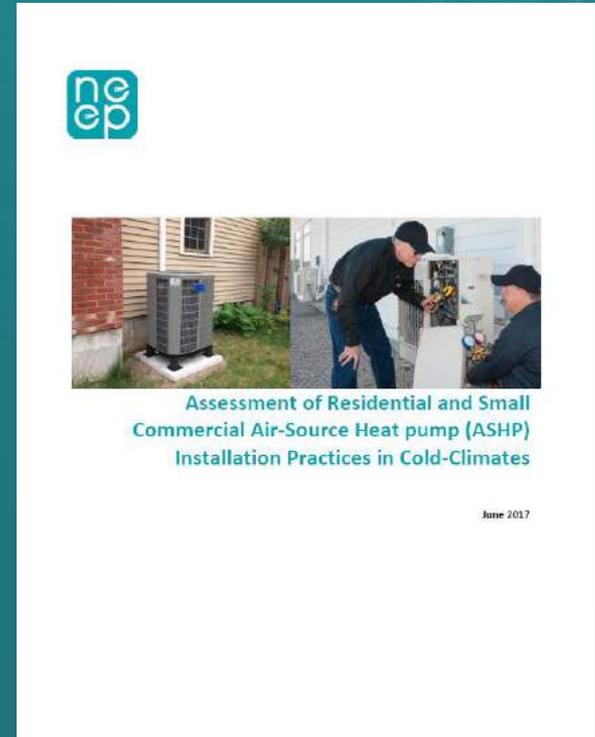


Quantifying the opportunity

- Numerous studies have found significant energy penalties resulting from installation faults
- 2014 NIST Study- “Increases of energy use by 30% due to improper installation practices seem to be plausible.”
- Anecdotal example- difference between MA/RI and VT field performance results

Resource Development process

- With DOE support
- Assessment of Residential and Small Commercial Air-Source Heat pump (ASHP) Installation Practices in Cold-Climates
- Convened Regional Subcommittee



Sizing and Selecting Guide



Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

A companion to NEEP's Guide to Installing Air-Source Heat Pumps in Cold Climates

Introduction

Leading HVAC manufacturers report significant growth in the installation of air-source heat pumps in some of the colder regions of the U.S., including the Northeast.¹ Many of the systems being installed today are “ductless” and variable-capacity. The systems are being installed in a variety of different residential applications, from limited zoned solutions to more comprehensive whole house solutions. System sizing and selection practices have not always kept up with this varied and dynamic landscape of ASHP installations, especially for colder climate installations. System performance, including energy efficiency of the systems, can be negatively impacted by poor sizing and system selection, as is customer comfort. This document was developed to assist installers in sizing and selecting ASHPs for cold climate applications, while maintaining high efficiency, performance, and customer satisfaction. NEEP's Assessment Report – Air-Source Heat Pump Installation Practices in Cold-Climates – provided insight into current sizing and selecting practices and informed the development of this Guide.

There are many types of equipment and a wide variety of common applications for ASHP installations in cold climates. Combinations of single and multi-zone, mini-split, “ductless” or “mini-duct” systems, or more conventional centrally ducted air-handler systems, may be installed in existing or new homes. The purpose may be conventional: provide all the required heating and cooling for a house or a large section of a house, or for a single zone or addition. But it may be less conventional: many mini- and multi-split systems are installed in homes to provide a partial offset to a conventional heating system that uses an expensive or carbon-intensive fuel. When the objective of installing an ASHP is reducing operating costs or emissions, conventional approaches to sizing and selection may need revising. Standard approaches don't fit many of these applications, and may even prevent installers from offering the most cost-effective, optimal solutions to their customers.

This guide is organized into five main application types to allow users to more easily match guidance to their specific installation. The applications are:

Application Sheets

Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

A companion to NEEPS' Guide to Installing Air-Source Heat Pumps in Cold Climates

Heating (or Heating & Cooling) Displacement

Application Description	Customer primarily desires to reduce heating (and/or cooling) cost for overall area of home. Heating is supplemental when the existing heating equipment is intact or near the end of its service life. The main tradeoff is between added cost vs. savings and comfort to ensure cases.
Suggested ASHP System Configuration (Single/Multi-Zone Ductless, Mini-Duct, Centrally Ducted)	For this application, typical configurations are located in a new central living space (for multi-zone), furnace room (mini-duct), hall (for duct) and savings (higher installed cost). In some cases, it may make sense but that is more likely a whole-house.
Suggested Treatment of Existing HVAC System	Left in place, provides heat only as needed in a house or for improved comfort.
Sizing Strategy Overview	Place first zone where heat will come most often (as appropriate) or strategically away from heat to heating load or away from the lowest load design heating load. If adding comfort is desired, cooling capacity for each zone.
Load Calculation	See "Setting Load Calculations Right" to ensure accuracy.
Equipment Selection Considerations	Heating capacity of systems or air source outdoor unit(s) must be sufficient for heating load. Under-sizing equipment for heating should impede through normal operation but under-sizing equipment will reduce operating cost.
Over-sizing Concerns / Tradeoffs	Cooling capacity is mitigated by variable-speed equipment. Cooling capacity is over 130% of design cooling load, look for equipment with a larger turn-down ratio (a lower minimum capacity).

Further Guidance

- Consider floor mount unit serving first floor, especially when heating is the customer priority. Load for effective distribution to individual rooms/bedrooms with low loads, use a register to ensure duct connections are sealed with mastic and insulated to a minimum of R-5. Seal all registers, set control or backdraft damper thermostat to approximately 4°F (lower whenever possible).
- Also note that when a heat pump serves a whole-house thermostat in very tight weather, job weather strategy should include some supplemental heat to prevent the unit and outdoor unit from short cycling.

Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

A companion to NEEPS' Guide to Installing Air-Source Heat Pumps in Cold Climates

Full Heating System Replacement

Application Description	Typically provides HVAC to hydronic or steam distribution, or existing ductwork is leaky, poorly insulated, fully or partially in attic, garage or vented outdoors. Replacing system is decommissioned or partially removed. In some cases, replacement is required to meet code.
Suggested ASHP System Configuration (Single/Multi-Zone Ductless, Mini-Duct, Centrally Ducted)	For this application, typical configuration would include mini-duct configured to serve the entire home. In cases of ducted, a central heat pump system may make sense.
Suggested Treatment of Existing HVAC System	Cutting non-usable ducts are decommissioned or removed. Ducts that are outside conditioned space are sealed and if required are at isolated boundary without. Cutting that are not at the isolated boundary which is not required.
Sizing Strategy Overview	Size for the larger of the estimated heating or cooling load design temperature with 100-115% of the estimated heating load. Or design for auxiliary heat at a balance point of 20°F.
Load Calculation	Use full ACCA Manual J or equivalent.
Equipment Selection Considerations	Heating use manufacturer published performance or data with adequate heating capacity. Cooling may use ASHP to calculate for detailed manufacturer specifications in a separate document.
Over-sizing Concerns / Tradeoffs	Potential cooling capacity is mitigated by variable-speed equipment. Cooling capacity is over 130% of design cooling load, look for equipment with a larger turn-down ratio (a lower minimum capacity) or a larger turn-down ratio (a lower minimum capacity).

Further Guidance

- Consider floor mount unit serving first floor, especially when heating is the customer priority. Avoid oversized loads. For effective distribution to individual rooms/bedrooms with low loads, use a register to ensure duct connections are sealed with mastic and insulated to a minimum of R-5. Thermostatically isolate registers may need separate controls for comfort.
- If existing ducts are sealed, that means that the available indoor unit is matched well with the ducts for an existing zone design, ensure and seal any return bypass and ensure air flow modulates properly with zone.
- When sizing for cooling, whole-house HVAC replacement, total heat pump capacity at design conditions will be smaller than existing heating equipment capacity. Heating load may be reduced because of shell losses.
- Note that measurements of existing central equipment duty cycle at new design conditions can also be used for cooling load.
- Ensure adequate primary or auxiliary heat in basement to prevent freezing pipes in seal and modulate all air.

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Isolated Zone

Application Description	One room or zone that is otherwise thermally isolated from the rest of the house. Includes a bedroom, bathroom, or a room with a fireplace, but not a kitchen or living area.
Suggested ASHP System Configuration (Single/Multi-Zone Ductless, Mini-Duct, Centrally Ducted)	For this application, typical configuration is ductless, single-zone.
Suggested Treatment of Existing HVAC System	Left in place, provides primary heat for home. May not see distribution to isolated zone or inefficient, avoidable if not.
Sizing Strategy Overview	Size for the larger of the estimated heating or cooling load for the heating load if identified as focused on heating or cooling.
Load Calculation	See "Setting Load Calculations Right" to ensure accuracy.
Equipment Selection Considerations	Heating use manufacturer published performance at design conditions with adequate heating capacity. Cooling may use ASHP to calculate for detailed manufacturer specifications in a separate document.
Over-sizing Concerns / Tradeoffs	Potential cooling capacity is mitigated by variable-speed equipment. Cooling capacity is over 100% of design cooling load, look for equipment with a larger turn-down ratio (a lower minimum capacity).

Further Guidance

- Note that an "isolated zone" in a house that is otherwise fully heated by an existing central system may be inefficient and reduce installed cost if useful use is size such a system larger than the actual room or distribution from the central system, and the primary reason for the ASHP is comfort, also account for system before sizing the ASHP unit. Otherwise, it may be beneficial to reduce or remove central system.
- If client need for new system is driven by an existing comfort issue, ensure that any building shell issues (leaks, moisture, existing duct disconnects or leaks, etc.) are addressed before installing new equipment. Seal gaps to be strongly recommended.

Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

A companion to NEEPS' Guide to Installing Air-Source Heat Pumps in Cold Climates

New Construction or Gut Rehab

Application Description	House is well insulated and relatively airtight (new or recently renovated building envelope).
Suggested ASHP System Configuration (Single/Multi-Zone Ductless, Mini-Duct, Centrally Ducted)	For this application, typical configuration could include one or two or more zones, including ductless and/or mini-duct, for a single central air handler. Ductless, when used, are contained entirely within the conditioned boundary of the home. Ductless or very high performance homes may also use only 3/4-ductless and/or mini-duct zones. Large homes that must cover energy code may require more zones and/or central systems.
Suggested Treatment of Existing HVAC System	Follow ACCA Manual J or equivalent load calculations.
Sizing Strategy Overview	Size for the larger of the estimated heating or cooling load. Match system capacity at the design temperature with 100-115% of the estimated heating load, generally without the use of auxiliary heat. Or design for auxiliary heat at a balance point of 20°F or below.
Load Calculation	Use full ACCA Manual J or equivalent.
Equipment Selection Considerations	Heating use manufacturer published performance at design conditions to identify systems with adequate heating capacity. Cooling may use ASHP to calculate for detailed manufacturer specifications in a separate document.
Over-sizing Concerns / Tradeoffs	Potential cooling capacity is mitigated by variable-speed equipment. If minimum speed cooling capacity is over 130% of design cooling load, look for equipment with a higher ratio of heating to cooling capacity or a larger turn-down ratio (a lower minimum capacity), or both.

Further Guidance

- Consider floor mount unit serving first floor, especially in open-plan homes. To avoid overloading ductless units for small individual room loads and for effective air distribution to rooms with low loads (such as bedrooms), use a register to ensure duct connections are sealed with mastic and insulated to a minimum of R-5. Thermostatically isolate areas (such as bonus room, etc.) registers may need separate controls for comfort.
- In extremely tight, low-load buildings, especially in new or near new construction, strategically placed air-handled ductless units may provide adequate comfort for an entire floor, or entire duct system to ensure distribution to smaller rooms. A centrally located, air-handled thermostat control is strongly recommended.

Important concepts

- Address building enclosure issues before sizing/selecting ASHP
 - Reduces heating/cooling costs
 - Reduces needed capacity, cost of system
 - Improved comfort, satisfaction
- Need to go beyond “rule of thumb” Load calculations



Important concepts

- Oversizing is an efficiency killer
 - Increased importance on load calcs
- Size for heating and cooling, rather than “larger of the two”
- Ensure adequate “turn-down”
- Pay special attention to multi-zones
 - turn-down, oversizing
- Generally encourage more, smaller outdoor units

NEEP Cold-Climate Specification/ Product List



NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

Search Products | About Specifications | About ASHP Product | About NEEP | Logout

Brand: All Brands | Model #, ARI #, List # | Ducting Configuration: All Configuration | Heating Capacity (Rated Ther): 0 to 20000 | Heating Capacity (Max Ther): 0 to 20000

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1255 Heat Pumps | Grid View | List View | Download Product List

LG
LSRD
ARI # **20425170**
Outdoor Unit #: LAU120HV3
Indoor Unit #: LAN120HV3
Singlezone Non-Ducted Wall Placement
35,000 Btu/h (10.2 kW)

LG
LNMS RFE
ARI # **204625103**
Outdoor Unit #: LSU240HV3
Indoor Unit #: LSN240HV3
Singlezone Non-Ducted Wall Placement
35,000 Btu/h (10.2 kW)

LG
LNMS RFE
ARI # **204625102**
Outdoor Unit #: LSU240HV3
Indoor Unit #: LSN240HV3
Singlezone Non-Ducted Wall Placement
35,000 Btu/h (10.2 kW)

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

Search Products | About Specifications | About ASHP Product | About NEEP | Logout

Brand: FUJITSU | Model #, ARI #, List # | Ducting Configuration: All Configuration | Heating Capacity (Rated Ther): 0 to 20000 | Heating Capacity (Max Ther): 0 to 20000

1 | 355 Heat Pumps | Grid View | List View | Download Product List

View	Brand Name	ARI # Reference No.	Outdoor Unit Model	Indoor Unit Model(s)	Ducting Config.	HSPF (Region IV)	SEER	CDP at Max Capacity (95°F)	Max Capacity (95°F)	Rated Capacity (94°F)	Rated Capacity (95°F)
	FUJITSU	8912451	42L45HLRF2		Mini-Split	9.5	16.7	2.07	20407	47000	45000
	FUJITSU	202527551	42L48VGLR	42U48VGLS	Mini-Split	10.2	16.6	2.27	26090	52000	48000
	FUJITSU	202125106	42L18VGLR	42U18VGLS	Mini-Split	10.9	21.4	4.31	18120	21000	18000
	FUJITSU	202216444	42L24VGLR	42U24VGLS	Mini-Split	10.8	20	2.05	22800	47000	24000
	FUJITSU	202125108	42L20VGLR	42U20VGLS	Mini-Split	11.5	18.6	2.45	27600	24000	20000
	FUJITSU	202125657	42L26VGLR	42U26VGLS	Mini-Split	11.2	17.3	2.08	24600	26000	26000

LG LGRED
Singlezone Non-Ducted Wall Placement
ARI # **20425170**
Outdoor Unit #: **LAU120HV3**
Indoor Unit #: **LAN120HV3**
Maximum Heating Capacity (Btu/h) @95°: **13,600**
Rated Heating Capacity (Btu/h) @47°: **13,600**
Rated Cooling Capacity (Btu/h) @95°: **12,000**

Information Tables

Brand	LG
Series	LGRED
Ducting Configuration	Singlezone Non-Ducted Wall Placement
ARI #	20425170
Certificate No.	
Outdoor Unit #	LAU120HV3
Indoor Unit #	LAN120HV3
Indoor Unit Type	Mini-Splits
Furnace Unit #	LAU120HV3
SEER	25.5
EER	13.8
HSPF Region IV	12.5
Energy Star	✓
Variable Capacity	✓
Maintenance Capacity (Max 5°F/Max 47°F)	61%
Maintenance Capacity (Max 5°F/Max 17°F)	92%
Maintenance Capacity (Max 5°F/Max 47°F)	100%
Integration	WORKS WITH LG SMART-THING, LG PROPRIETARY HEATER RELAY ACCESSORIES, LG PROPRIETARY PDVCR300 + PDVCR320 DRY CONTACT FOR THIRD PARTY THERMOSTATS, WORKS WITH AMAZON ALEXA AND GOOGLE HOME.
Connectivity	API LICENSING AGREEMENT IS AVAILABLE TO ALLOW OTHERS TO ACCESS CONTROL THROUGH LG Wi-Fi SMART-THING.
Operational Diagnostics	DIAGNOSTICS AVAILABLE THROUGH LG SMART-THING Wi-Fi APP OR LG WIRED CONTROLLER.
Refrigerant(s)	R410A
Pan Heater	
Type	INTEGRATED
Input Power	90 WATTS
Model #	

Performance Specs

Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated	Max
Heating	5°F	70°F	Btu/h	450	-	13,600
			kW	0.19	-	1.37
Heating	17°F	70°F	Btu/h	603	8,360	14,760
			kW	0.2	0.78	1.4
Heating	47°F	70°F	Btu/h	1,023	13,600	22,178
			kW	0.2	0.97	1.25
Cooling	32°F	80°F	Btu/h	1,023	-	13,477
			kW	0.2	-	0.94
Cooling	95°F	80°F	Btu/h	1,023	12,000	13,765
			kW	0.2	0.87	1.14

<https://neep-ashp-prod.herokuapp.com>



Guide To Installing Air-Source Heat Pumps in Cold Climates

A Companion to NEEP's Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates



Introduction

High-quality installations of air-source heat pump (ASHP) systems generate referrals, increase sales, reduce callbacks and improve customer comfort and satisfaction. Installation practices also have a major impact on efficiency and performance of an ASHP system. Efficient ASHPs have seen significant sales growth in colder climates in recent years. The recent generation of cold-climate ASHPs, combined with insights from large-scale installation programs and installers, has led to a better understanding of the full range of practices to ensure maximum system performance and customer satisfaction. This guide provides a list of these best practices, as well as homeowner education and system setup guidance, to help ensure efficient air-source heat pumps and happy customers in cold climates.

Heat pumps should always be installed by licensed, trained professionals. Always follow manufacturer's specification and installation instructions, and all applicable building codes and regulations. All installers should attend a manufacturer's training or preferred installer program.

ASHPs come in a number of configurations, and in some cases the following guidance may be specific to one or more of those system types. There are many variations and terms used, but these guidelines will focus on the following broad categories: "ductless ASHP" refers to any non-ducted cassette type indoor unit (including wall-mount air handlers, floor mounted consoles, in-ceiling cassettes, etc.); "mini-duct ASHP" refers to remote air handlers that are typically designed for compact, concealed-ceiling or short-duct configurations; and "centrally ducted ASHP" refers to whole-house systems with central air handlers. The icons shown here are used below to indicate when guidance is specific to a certain system type. All items without icons are generally applicable to all ASHP configurations.

Applies to:



Ductless ASHP



Mini-Duct ASHP



Centrally ducted ASHP

Installation Best Practices: Categories

- Line Set
- Recommended Tools
- Refrigerant Tubing
- Refrigerant Charge
- Condensate Drain
- Outdoor Unit Installation
- Indoor Unit Installation
- Placement of Indoor Unit
- Ducting Considerations

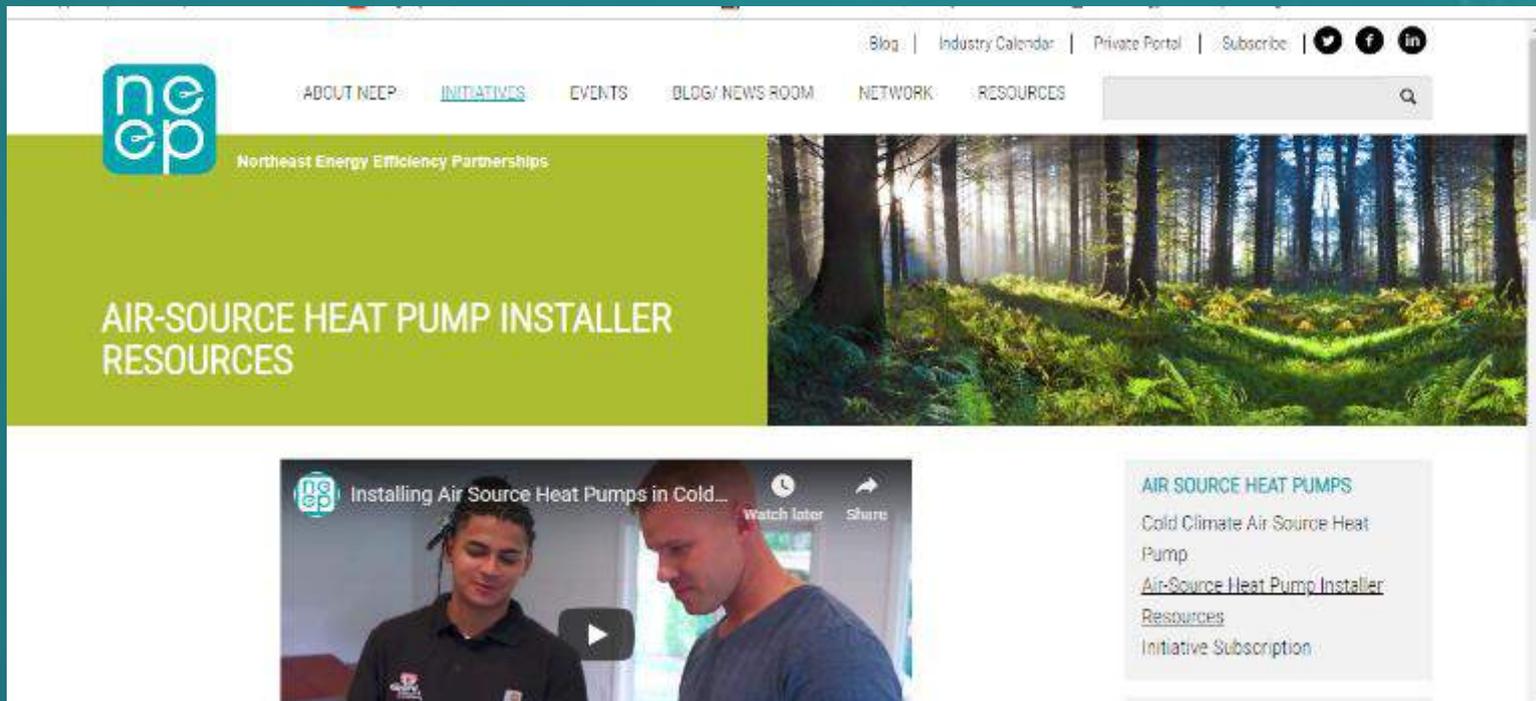
Notable for Cold Climates

- Ensure adequate clearance of outdoor unit above historical average maximum snow depth
- Focus on protecting outdoor unit from eaves/drip/snow
 - De-emphasis on pan heaters
- Ensure adequate clearance of indoor wall unit from the ceiling
- Recommendation of floor-mount / console units
 - For heating-focused applications, lower floors
- Avoid field fabricated flare fittings if possible
 - Gasketed press/crimp designed for the refrigerant and tubing type (e.g., Sporlan Zoom Lock[®], Vulkan LokRing[®]).
- Wall-mounted control shall be installed in a location that will be representative of the space the unit is serving

Video versions now available



Installer Resources



Go to; www.neep.org/ASHPInstallerResources
Spread the word!

Opportunity going forward...

- Improved ASHP Design practices
- Onboard/3rd party diagnostic functionality
 - QI verification, real time performance monitoring
 - Support for ENERGY STAR's QI requirements
- Expanding virtual platforms for training installers

Take-aways

- QI is important across all HVAC, but particularly critical for ASHP adoption in cold climates
- HVAC Industry/stakeholders need to prioritize this
- Help us get the word out.. please share the Resources, contact us if you have suggestions for updates
 - www.neep.org/ASHPIInstallerResources

THANK YOU!

Dave Lis

djlis@neep.org

March 26, 2020

81 Hartwell Avenue, Lexington, MA 02421

P: 781.860.9177 X127

www.neep.org



Christopher Boyce
Emerson Climate Technologies

Sensi Predict Overview



Manage the surprises

Confirm Quality Work

Reduce Callback

Optimize Workforce

Expand Technician Efficiency & Coverage

Eliminate Nuisance Calls

Balance High Volume Call Periods

Create Meaningful Connections with Homeowners

Expand Maintenance Relationships

Increase Close Rate

Manage the surprises

Confirm Quality Work

Reduce Callback

Optimize Workforce

Expand Technician Efficiency & Coverage

Eliminate Nuisance Calls

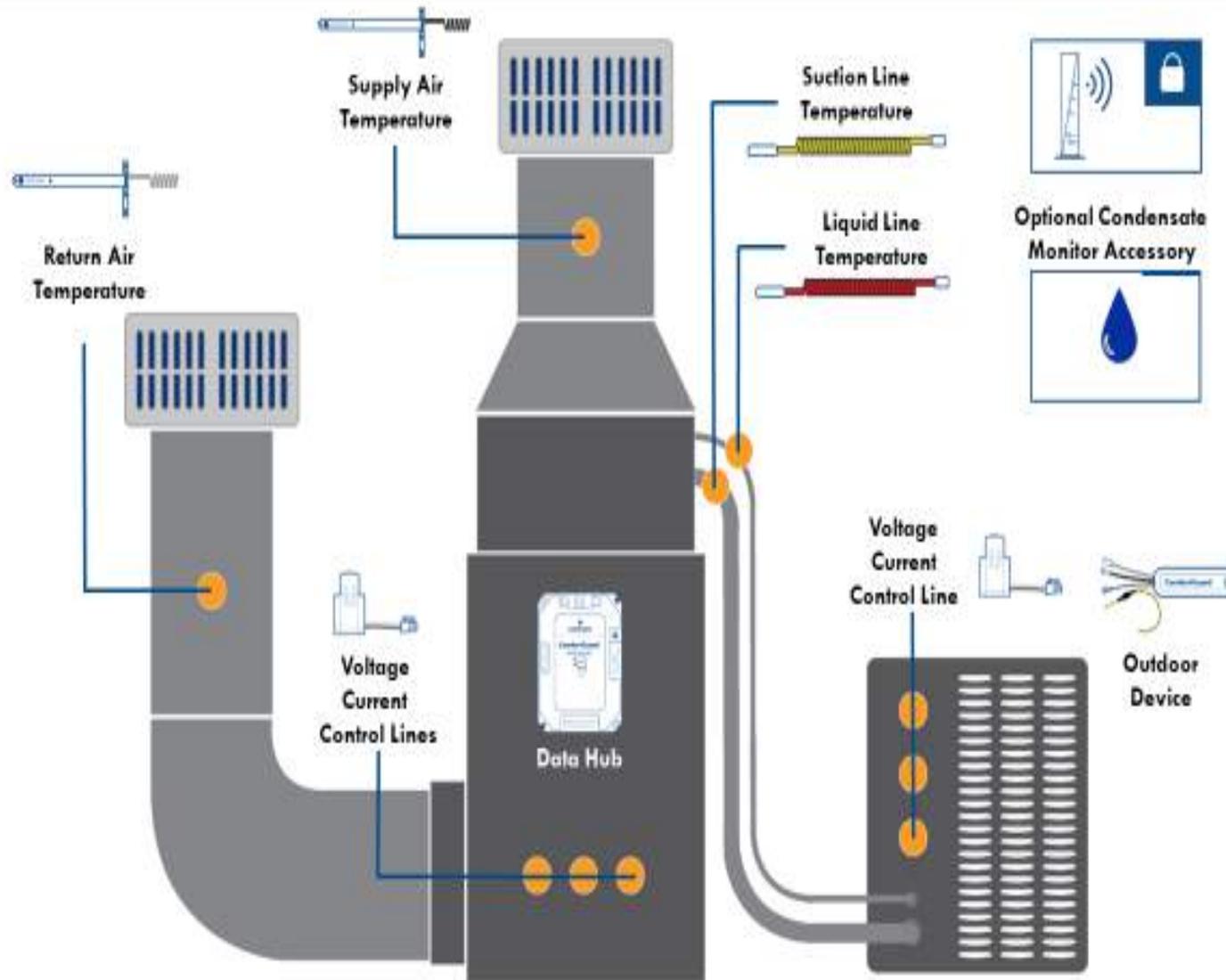
Balance High Volume Call Periods

Create Meaningful Connections with Homeowners

Expand Maintenance Relationships

Increase Close Rate

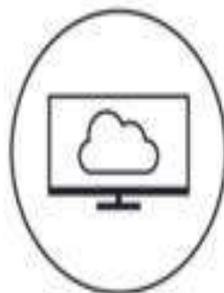
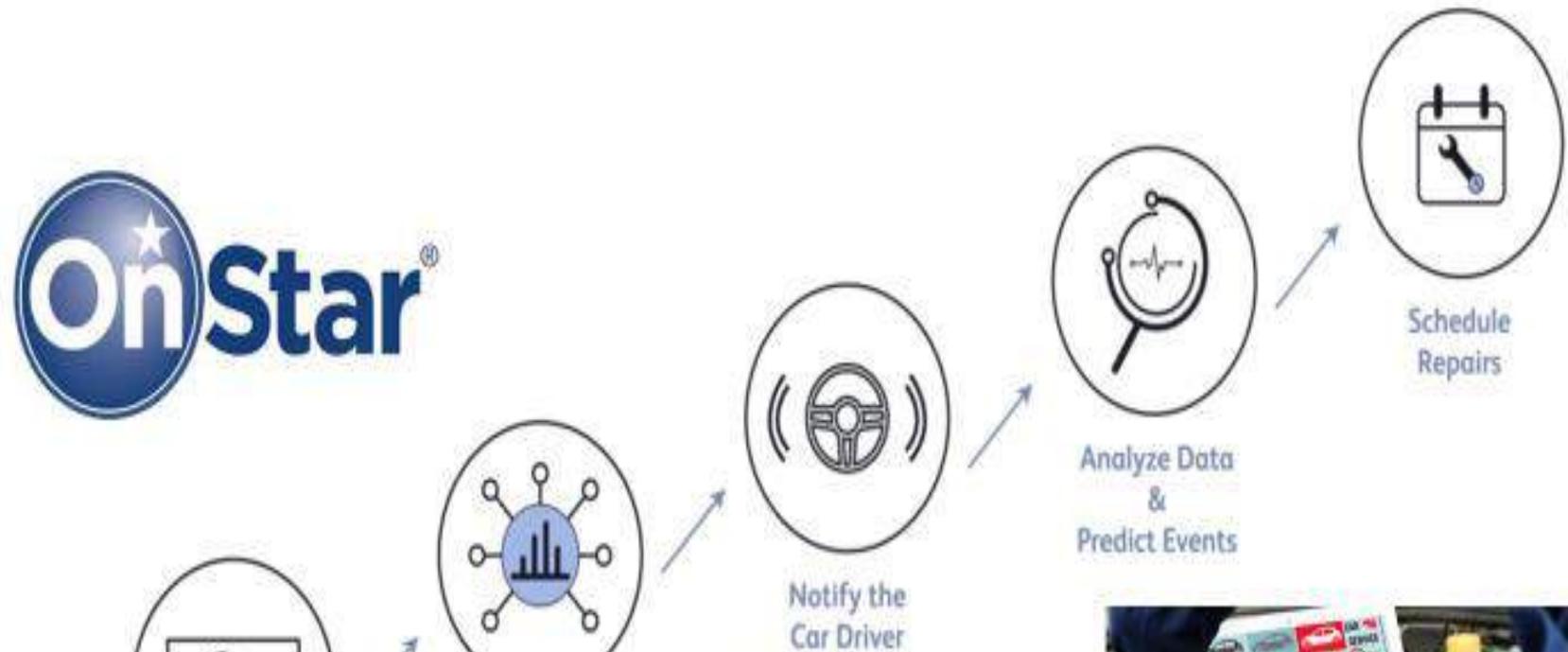
The Product behind the Solution



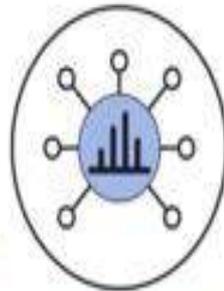
Live Data Sensors

- Supply Air
- Return Air
- Liquid Temp
- Suction Temp
- Indoor Control Lines
- Outdoor Control Lines
- Indoor Current
- Indoor Voltage
- Outdoor Current
- Outdoor Voltage

Automotive Type Predictive Diagnostics comes to HVAC



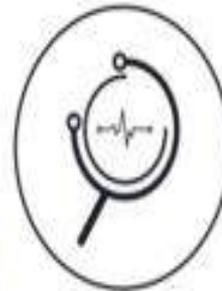
Gather Data



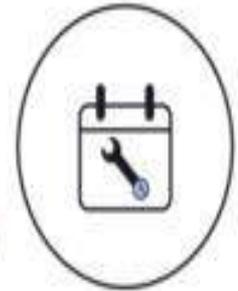
Monitor Data



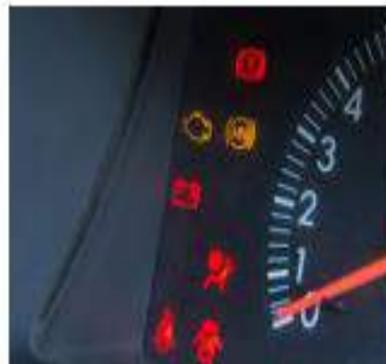
Notify the Car Driver



Analyze Data &
Predict Events



Schedule Repairs



Predictive Diagnostics – Data leads to Action

32 Key Technical Functions of Sensi Predict



Creating the Bond between Contractor & Homeowner

- Ability to Upgrade or Offer Smart Technology
- 24/7 Monitoring
- Real-time Performance Alerts
- Monthly Reports of System Performance/Cost of Operation
- Filter Reminders
- Peace of Mind



SMART MAINTENANCE REPORT

701 Phoenix Drive - Whole Home

Performance Summary

PASS Connectivity	PASS Heating	UNKNOWN Cooling
----------------------	-----------------	--------------------

Estimated Filter Life Remaining

90% This estimate is based on the last filter change date on file. If the estimate is inaccurate, please update the date of the last filter change of the asset.

Connectivity Detail

PASS	Hub and Sensor Status Indoor Hub Wi-Fi Connection: GOOD - Connection Update: 100% Update a few seconds ago - Last Connected Indoor: a few seconds ago - Last Connected Outdoor: a few seconds ago Return Air Sensor: OK Supply Air Sensor: OK Liquid Line Sensor: OK Suction Line Sensor: OK
------	---

Heating Performance Detail

PASS	Gas Furnace Outdoor Temperature: 32.4°F Temperature Split: 43.9°F - GOOD - Last Updated: 4 days ago Indoor Current: 7.44 Amps - GOOD
------	---

Confirm Quality Install with measureQuick

- Reduce Callback
- Tools for technician while on-site for performance confirmation
- Provide Customers an installation report
- Monthly Reports of System Performance



Intelligent Monitoring AND SERVICE FOR TODAY'S TECHNICIANS

SensiPredict™ runs seamlessly with the measureQuick™ operating system allowing for unprecedented connectivity to tools, data, workflows and machine performance benchmarks. Know what's wrong before your truck rolls out the door.

Faster Service with Consistent Outcomes

After repair, use measureQuick to return the system to the functional operation. This assures the equipment is running when your technician leaves as well as the day it was commissioned.



COMMISSION

From configuring and starting new equipment to retro-commissioning old equipment, you'll have the performance data you need to get it done faster and more accurately.



MONITOR

With 32 smart sensors, Sensi Predict keeps the health of your home's HVAC system at your fingertips, alerting technicians, keeping you ahead of problems before they develop.



OPTIMIZE

The effective management of systems requires the ability to identify and implement every possible opportunity for increased system efficiency.

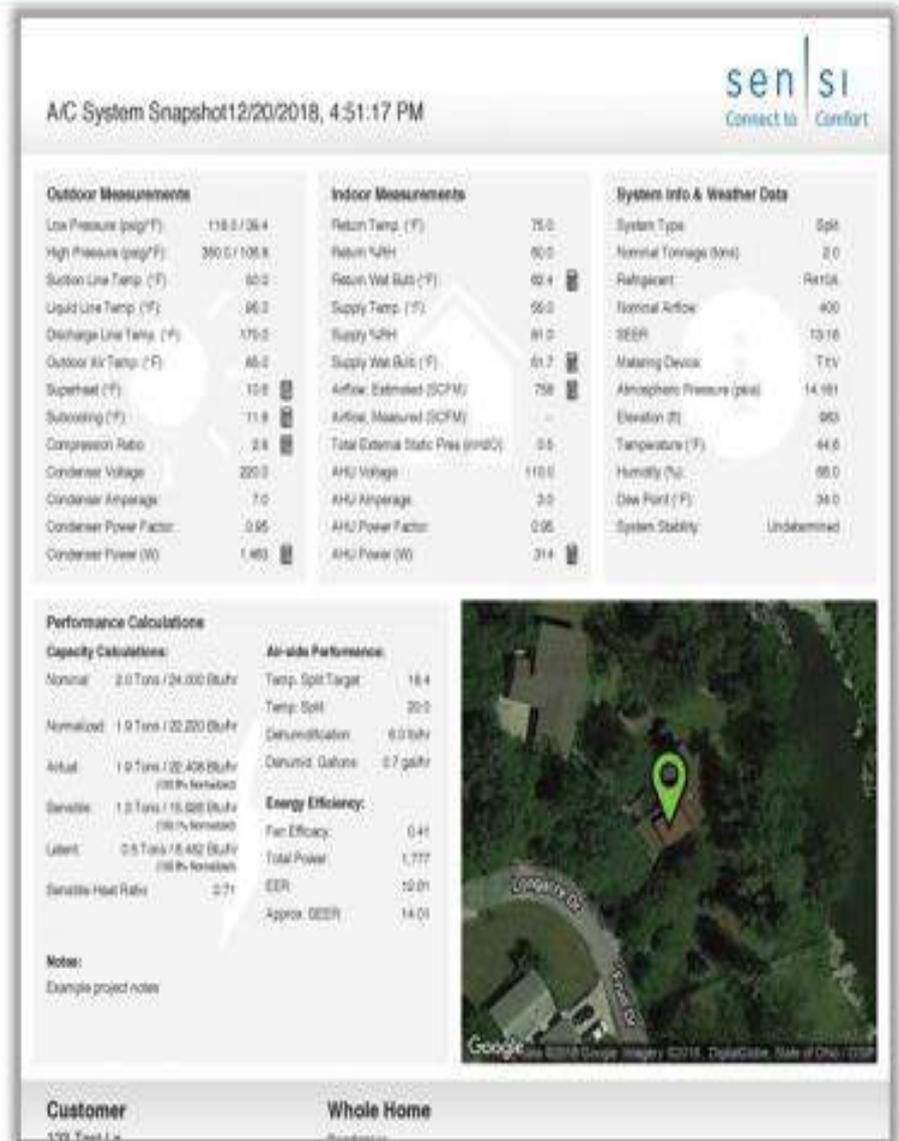


MAINTAIN

Your systems need to run consistently and flawlessly. We're helping to redefine uptime with a smarter approach to ongoing maintenance, planned upgrades and a more sophisticated vision of the future.

Confirm Quality Install with measureQuick

- Utilizes Bluetooth Tools
 - Most comprehensive diagnostic tool
 - Verify SEER & Capacity
 - Works with Sensi Predict
- Sensor Data Live Streams into MQ



Grow Efficiency and Profitability of the Contractor

- Increase Revenue per Truck Roll
- Manage Workflow / Labor
- Verify Repairs & Quality of Installations

Know Before You GO

Sensi Predict
Work Proposal For 35k Revolution Lane

Customer Information

Site Label 35k Revolution Lane	Site Address 10000 Revolution Lane	Location Houston, TX
--	--	--------------------------------

System Information, 35k Rev Lane

System 35k Revolution Lane	Make/Model 35k Revolution Lane	Make/Model 35k Revolution Lane
--------------------------------------	--	--

Performance Check

connectivity OK	timing OK	quality OK	test ok OK
---------------------------	---------------------	----------------------	----------------------

Eliminate Nuisance Calls

System Alerts

Alerts are generated when a system parameter is outside of the normal range.

Alerts are generated when a system parameter is outside of the normal range.

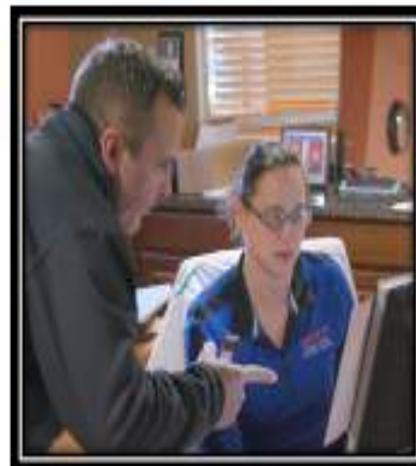
Alerts are generated when a system parameter is outside of the normal range.

Name

State

Save and Add

Assign the Right Tech



Remote Diagnostic / Work Verification

measureQuick

118.8
104.5

How information is delivered to Contractor

Work Management Portal

Sensi Predict

Search

HOME CUSTOMER/SYSTEMS ACTIVATE NEW DEVICE SUPPORT

New Work Proposals Reviewed Work Proposals Connectivity Filter

ID ↑	Account	System	Description	Created	Status
001a377		Helix System	40 - Warning- Refrigerant Temperature is Too Low	04/19/19	New
001a391		Main Floor	204 - Warning - Falling Outdoor Component	04/19/19	New
001a331a		first floor	403 - Warning- Air Conditioner is Not Cooling Effectiv...	04/14/19	New
001a331		first floor	40 - Warning- Refrigerant Temperature is Too Low	04/14/19	New
001a330a		Whole Home	802 - Warning - Furnace Not Operating Properly	04/13/19	New
001a88a8		Kitchen/Den	403 - Warning- Air Conditioner is Not Cooling Effectiv...	04/12/19	New
001a881		Whole Home	204 - Warning - Falling Outdoor Component	04/11/19	New
001a882		Whole stokin home	204 - Warning - Falling Outdoor Component	04/11/19	New
001a6a20		Kitchen/Den	40 - Warning- Refrigerant Temperature is Too Low	04/10/19	New
001a6a1a		Kitchen/Den	204 - Warning - Falling Outdoor Component	04/10/19	New
001a611a		Master Bedroom	403 - Warning- Air Conditioner is Not Cooling Effectiv...	04/09/19	New
001a621a		Ofaloo Main Floor	40 - Warning- Refrigerant Temperature is Too Low	04/09/19	New
001a601a		YAM	403 - Warning- Air Conditioner is Not Cooling Effectiv...	04/09/19	New
001a701a		Main floor	40 - Warning- Refrigerant Temperature is Too Low	04/08/19	New
001a701a		Whole Home	403 - Warning- Air Conditioner is Not Cooling Effectiv...	04/08/19	New
001a701a		Whole Home	40 - Warning- Refrigerant Temperature is Too Low	04/08/19	New
001a701a		Whole Home	204 - Warning - Falling Outdoor Component	04/07/19	New
001a711a		Whole home	204 - Warning - Falling Outdoor Component	04/07/19	New
001a711a		Whole Home	802 - Warning - Furnace Not Operating Properly	04/16/19	New
001a701a		Entire home	204 - Warning - Falling Outdoor Component	04/04/19	New
001a801a		Second floor	403 - Warning- Air Conditioner is Not Cooling Effectiv...	04/03/19	New

Work Proposal Summary

Work Proposal For Jacob Nielson, 1776 West 950 South

Customer

Main Contact

Jacob Nielson
jacobnielson@gmail.com
801-477-0401

Billing Address

100 Sessport Ct.
Olathe, MO 63050

Location

1776 West 950 South
Springville, UT 84663

System Information

Sensi Predict

Name: Whole Home
ICD: 00000902F318033
Install Date:
03/04/2019

Indoor Equipment

Type: Furnace
Make: Tempstar
Model: 88MSA02014-13A3
Input BDTL: 60
Fan Type: PSC
Date Installed:
03/07/2019

Outdoor Equipment

Type: AC
Make: Tempstar
Model: 54A318A05101
Tonnage: 2.5
SER: 11
Refrigerant Type: R-410A
Date Installed:
03/07/2019

Filter Information

12 x 24 x 1
Height Width Depth
Filter last changed on: 06/16/2019

Performance Check



Connectivity

2 days ago



Heating

6 months ago
Temperature Split



Cooling

2 days ago



Filter Life

System Alerts

Code	Severity	Description	Created	Cleared	Status
40	Warning	Refrigerant Temperat...	04/03/2019 06:...	04/03/2019 06:...	New

How information is delivered to the Homeowner

Contractor Branding

- Replaces the some traditional awareness marketing Branded communication
 - Performance reports, Account Portal, Monthly Reports, Alerts
 - Links provide direct access to the contractors

Monthly Report



Real-Time Alert

HALLER ENERGYWISE

Tom, our sensors have detected a warning alert on your system that could lead to breakdown or significant inefficiency. Please review the alert details and recommended action below.

For more information call your contractor at (555) 555-5555.

[Contact contractor](#)

HOUSE NAME: FIRST FLOOR

ALERT AC evaporator coil is excessively cold
Alert 40
Wed Aug 15 2018 12:12 PM

Use only accessories or has already accumulated on your indoor cooling equipment, preventing it from working effectively. Action is required to prevent harm to your equipment and protect your home from possible water.

Homeowner Portal



Sensi Predict™



Questions
And Thank You

SLOPE Platform

A DOE-led collaboration between NREL and 8 EERE technology offices to create a *dynamic, comprehensive energy planning platform* of integrated, localized data for state and local decision makers

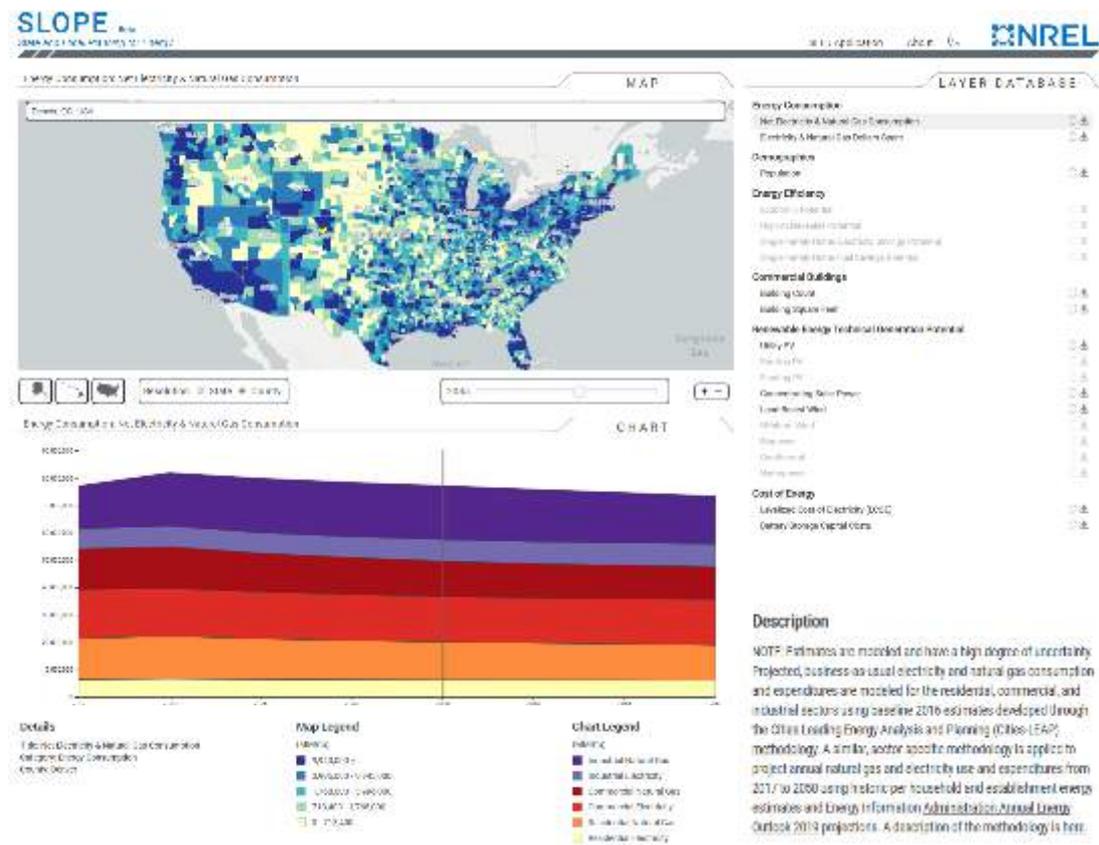
- **Phase I:** Beta version launched (Jan. 2020)
- **Phase II:** Adding transportation and generation mix data; enabling user-saved settings (under development in 2020)

Access the Platform:

<https://gds.nrel.gov/slope>

Comments or Questions?

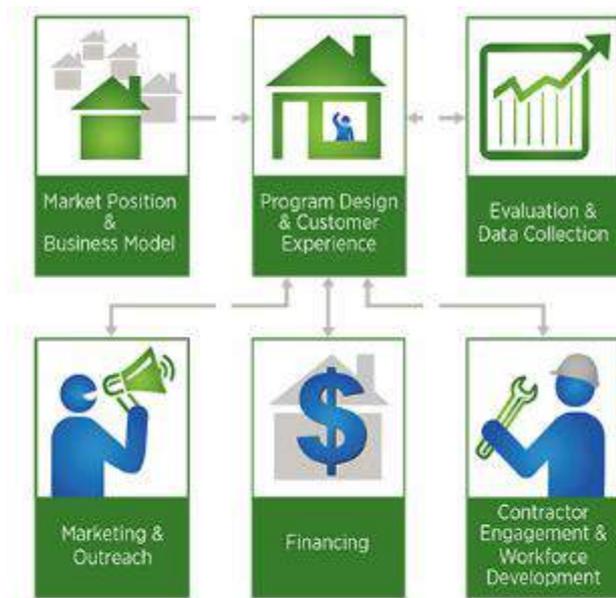
slope@nrel.gov



Explore the Residential Program Solution Center

Resources to help improve your program and reach energy efficiency targets:

- [Handbooks](#) - explain *why* and *how* to implement specific stages of a program.
- [Quick Answers](#) - provide answers and resources for common questions.
- [Proven Practices](#) posts - include lessons learned, examples, and helpful tips from successful programs.
- [Technology Solutions](#) **NEW!** - present resources on advanced technologies, **HVAC & Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.



<https://rpssc.energy.gov>

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Please send any follow-up questions
or future call topic ideas to:
bbresidentialnetwork@ee.doe.gov