



Technologies to Include in Utility Programs:

Modern Storm Windows and Smart Diagnostic Tools for Quality HVAC Installation & Maintenance

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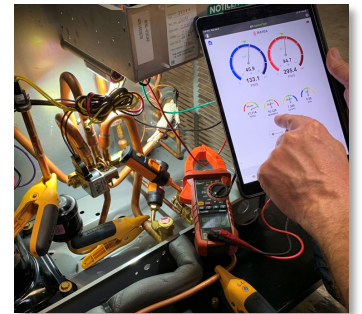


Goal of DOE Technology Campaigns

The **Storm Window and Insulating Panel Campaign (SWIP)** and the **Smart Tools for Efficient HVAC Performance Campaign (STEP)** are two DOE-sponsored, PNNL-managed residential energy efficiency technology campaigns that:

- Aim to increase adoption of new or underutilized technologies such as modern storm windows and smart HVAC diagnostic tools,
- Provide technical support for and recognize the successes of key stakeholders, and
- Seek to partner with program implementers to increase the impact of their utility programs by adding these technologies

We look forward to collaborating with you!



Storm Window and Insulating Panel Campaign



STORM WINDOW & INSULATING PANEL
CAMPAIGN

A collaborative initiative to accelerate the adoption of modern low-emissivity (low-e) storm windows and insulating window panels, delivering affordable energy savings and comfort in buildings where full window replacement is not feasible.

Campaign Partners



Mission

Leave no poor-performing window uncovered

Main Goals

Increasing the use of modern storm windows in weatherization and utility energy efficiency programs



Images Courtesy of Larson Manufacturing and DOE

Check out the [SWIP Campaign website!](#)

Residential Storm Window Opportunity

>50% U.S. homes have inefficient windows (e.g., single pane or clear glass double pane) and only 2% of homes replace their windows each year

OPTIONS:

Energy Efficient
Window Replacement

OR

Energy Efficient Window
Attachments

There are great options for window replacement, but what do you do when:

- Window replacement is impractical or *cost prohibitive*?
- Window replacement is not allowed or desired in *historic buildings*?

Storm window attachments are a cost-effective alternative...

1/3 of the cost of full window replacement

Windows make up
8%
of a home's exterior
but account for
45%
of energy loss



Most household heat is lost through the windows and roof.

What are Low-E Storm Window Attachments?



How Low-E Storm Windows Work

- Air seals prime window, reducing air leakage
- “Dead air space” improves thermal performance
 - Reduces conduction and convective losses across prime window
- Low-E glass reflects radiant heat 35% more effectively than clear glass
- Panels with coatings reduce solar heat gain, particularly effective in southern climate zones

Past Field Demonstrations

2012–2013 Philadelphia MF field study (DOE, NAHB, QuantaPanel)

- 2 large 3-story buildings (101 apartments)
- Replaced old clear storm windows over single pane with new low-e storm windows
- Energy Savings: 20% heating, 9% cooling
- Air leakage reduced by 10%



2011–2013 Atlanta field study (DOE, Larson, QuantaPanel)

- 10 older homes with single-pane windows
- Energy Savings: ~15% heating, 2–30% cooling
- Air leakage reduced by 17% (3.7 cfm₅₀)

2014–2015 Lab Home field test, low-e interior & exterior panels (DOE, PNNL, NEEA, BPA, Larson, QuantaPanel)

- Manufactured homes with metal-framed double-pane clear glass windows
- Energy Savings: 11% heating, 8% cooling



The Modern Storm Window Advantage

Field demonstrated, year-round energy savings & benefits

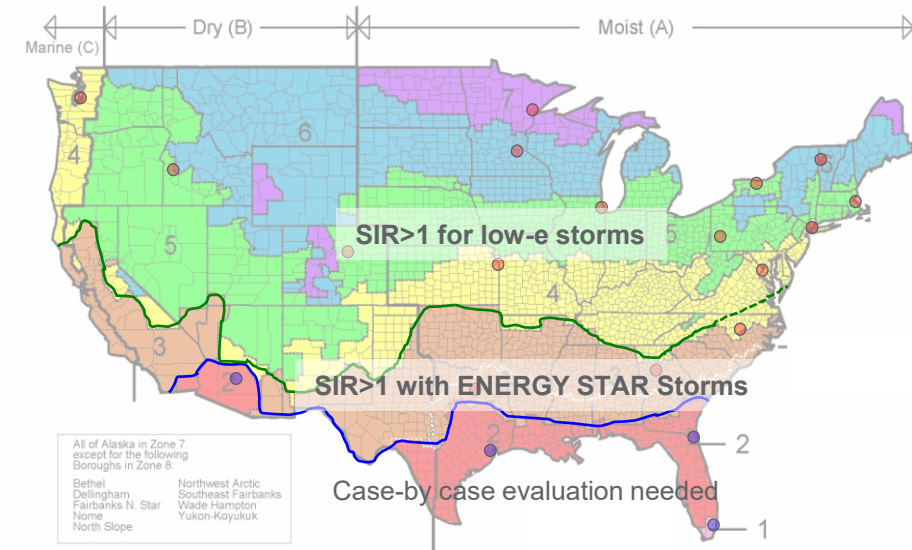
- 10–30% year-round savings in annual heating and cooling energy use in homes with single-pane or double-pane clear glass windows
- Other benefits of added comfort, operability, acoustic improvements, and aesthetic appeal

Widely applicable and available

- More than half of U.S. homes have single-pane windows or double-pane clear glass windows
- Energy rated by [Attachment Energy Rating Council \(AERC\)](#) and highest performing storm windows have [ENERGY STAR](#) label—all available through big box retailers and/or custom orders nationwide
- Most manufacturers estimate 20-year lifetime

Affordable and “Easy” Installation

- Similar energy savings to double-pane replacements at a fraction of the cost
- Savings to Investment Ratio (SIR) meets Weatherization Assistance Program requirements in most climate zones (simple payback of 4–14 years)
- Installation is easy for contractors or as a DIY project



Advancing Modern Storm Window Adoption

Low-E Storm Window Savings Potential Over a Single-Pane Wood-Framed Window

Climate Zone	Average Gas Heating Savings (therms/window)	Average Electric Cooling Savings (kWh/window)
7	30.3	1.0
6	24.0	5.4
5	18.6	6.8
4	13.6	15.2
3	7.6	34.1
2	4.7	49.4
1	- *	58.0

Base window characteristics: U-value: 0.88, SHGC: 0.61

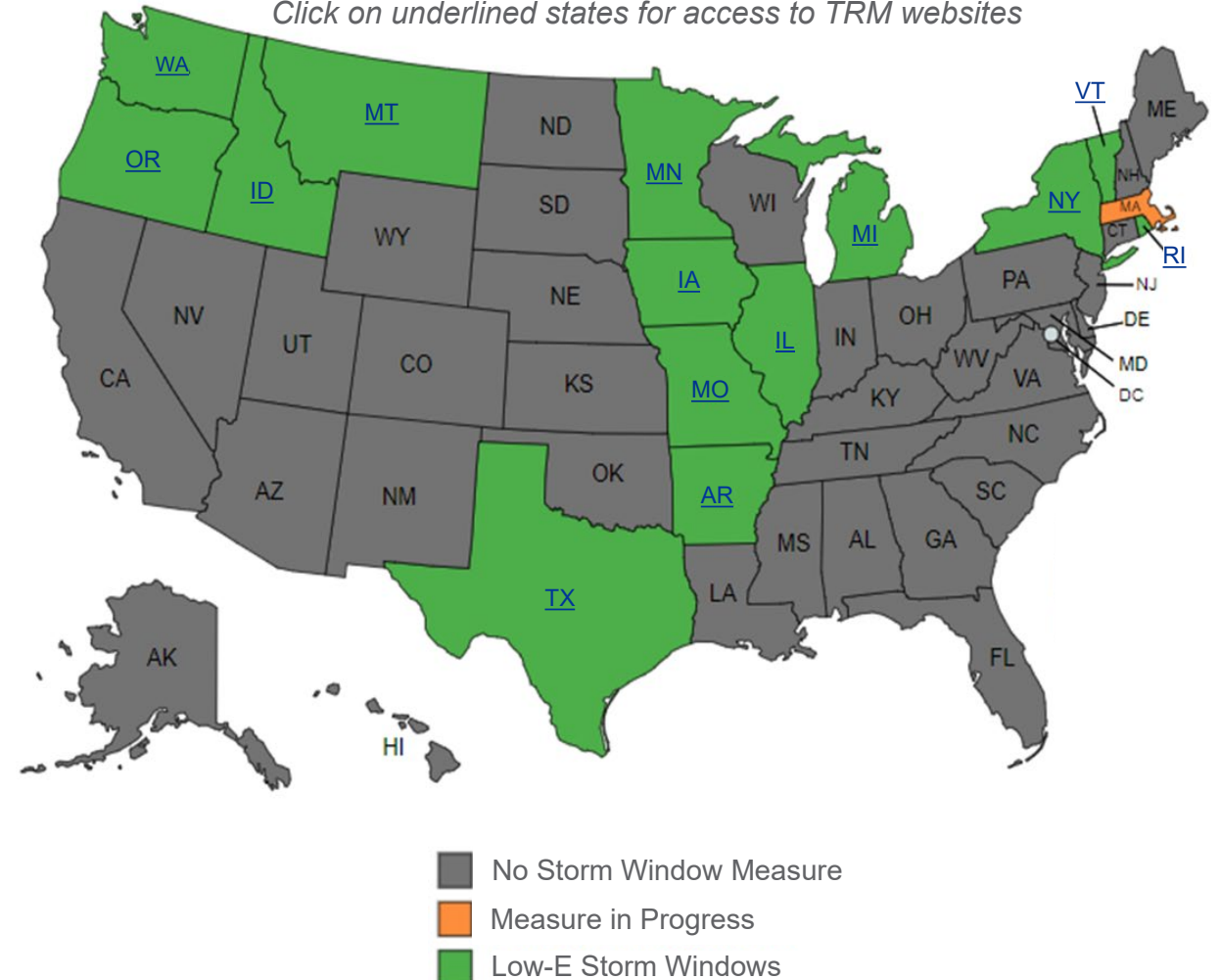
Existing Storm Window Utility Programs

Click on underlined Programs for access to websites

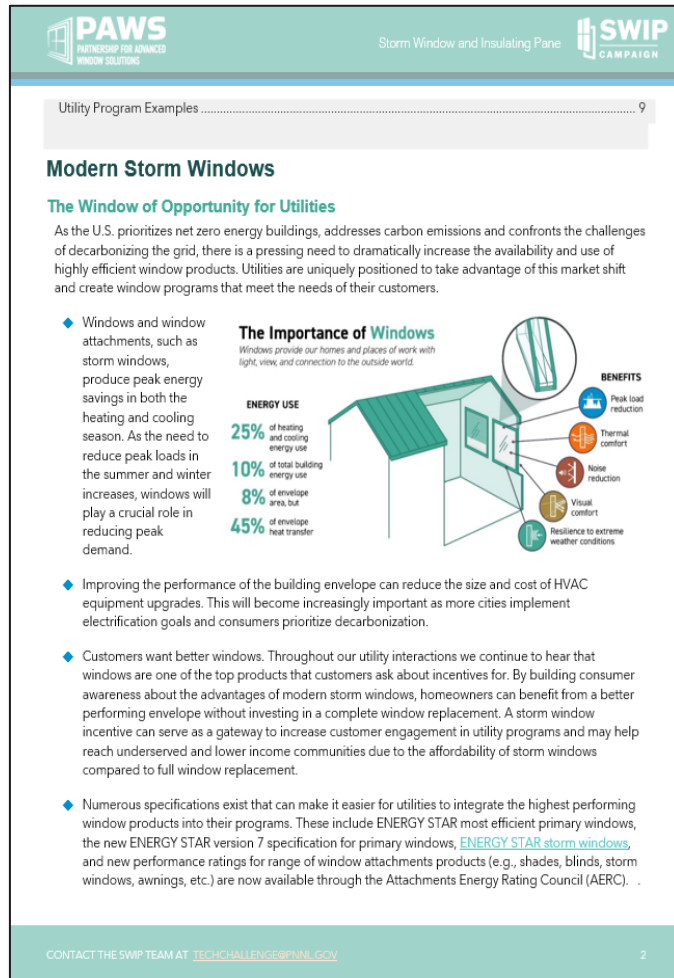
- Avista ([WA](#), [OR](#), [ID](#))
- [PSEG Long Island](#)
- [National Grid Rhode Island](#)
- [NYSERDA, Comfort Home Program](#)
- [XCEL Energy](#) (CO)
- [Benton REA](#) (WA)
- [Chelan PUD](#) (WA)

A Growing Number of States with Low-E Storm Window TRM Measures

Click on underlined states for access to TRM websites



SWIP Support for Program Implementers



Utility Program Examples 9

Modern Storm Windows

The Window of Opportunity for Utilities

As the U.S. prioritizes net zero energy buildings, addresses carbon emissions and confronts the challenges of decarbonizing the grid, there is a pressing need to dramatically increase the availability and use of highly efficient window products. Utilities are uniquely positioned to take advantage of this market shift and create window programs that meet the needs of their customers.

- Windows and window attachments, such as storm windows, produce peak energy savings in both the heating and cooling season. As the need to reduce peak loads in the summer and winter increases, windows will play a crucial role in reducing peak demand.

The Importance of Windows
Windows provide our homes and places of work with light, view and connection to the outside world.

ENERGY USE

- 25% of heating and cooling energy use
- 10% of total building energy use
- 8% of envelope area, but
- 45% of envelope heat transfer

BENEFITS

- Peak load reduction
- Thermal comfort
- Noise reduction
- Visual comfort
- Resilience to extreme weather conditions

- Improving the performance of the building envelope can reduce the size and cost of HVAC equipment upgrades. This will become increasingly important as more cities implement electrification goals and consumers prioritize decarbonization.
- Customers want better windows. Throughout our utility interactions we continue to hear that windows are one of the top products that customers ask about incentives for. By building consumer awareness about the advantages of modern storm windows, homeowners can benefit from a better performing envelope without investing in a complete window replacement. A storm window incentive can serve as a gateway to increase customer engagement in utility programs and may help reach underserved and lower income communities due to the affordability of storm windows compared to full window replacement.
- Numerous specifications exist that can make it easier for utilities to integrate the highest performing window products into their programs. These include ENERGY STAR most efficient primary windows, the new ENERGY STAR version 7 specification for primary windows, [ENERGY STAR storm windows](#), and new performance ratings for range of window attachments products (e.g., shades, blinds, storm windows, awnings, etc.) are now available through the Attachments Energy Rating Council (AERC).

CONTACT THE SWIP TEAM AT TECHCHALLENGE@PNL.GOV

Key resource: Storm Window and Insulating Panel Utility Program Playbook

Outlines the technology of modern storm windows and insulating panels and provides guidance for utilities interested in implementing programs to get these products in the hands of consumers, resulting in significant energy savings.

Other support provided by the SWIP Campaign

- Assistance with TRM workpaper submission
- Region specific savings analysis
- Program design ideas
- Marketing support
- Online resources
- Manufacturer connections
- Recognition by the U.S. Dept. of Energy



Smart Tools for Efficient HVAC Performance Campaign



A collaborative initiative to encourage use of smart diagnostic tools among residential HVAC technicians to quickly and easily install/commission new HVAC systems and identify/troubleshoot energy-wasting faults in existing systems.

Campaign Partners

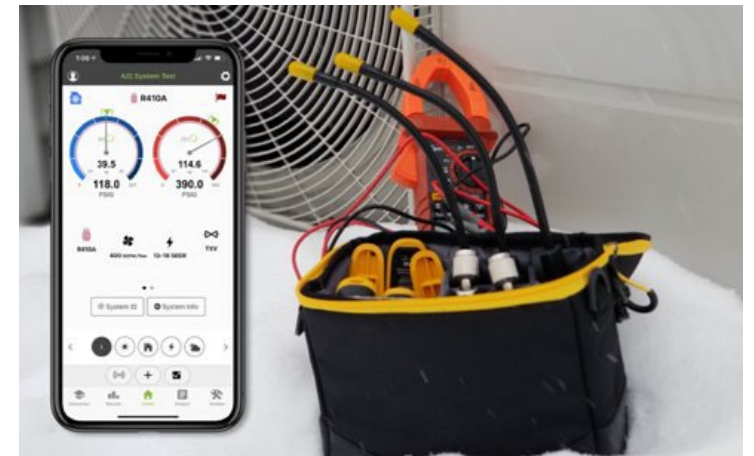


Mission

Eliminate energy-wasting faults in residential HVAC systems

Key Applications

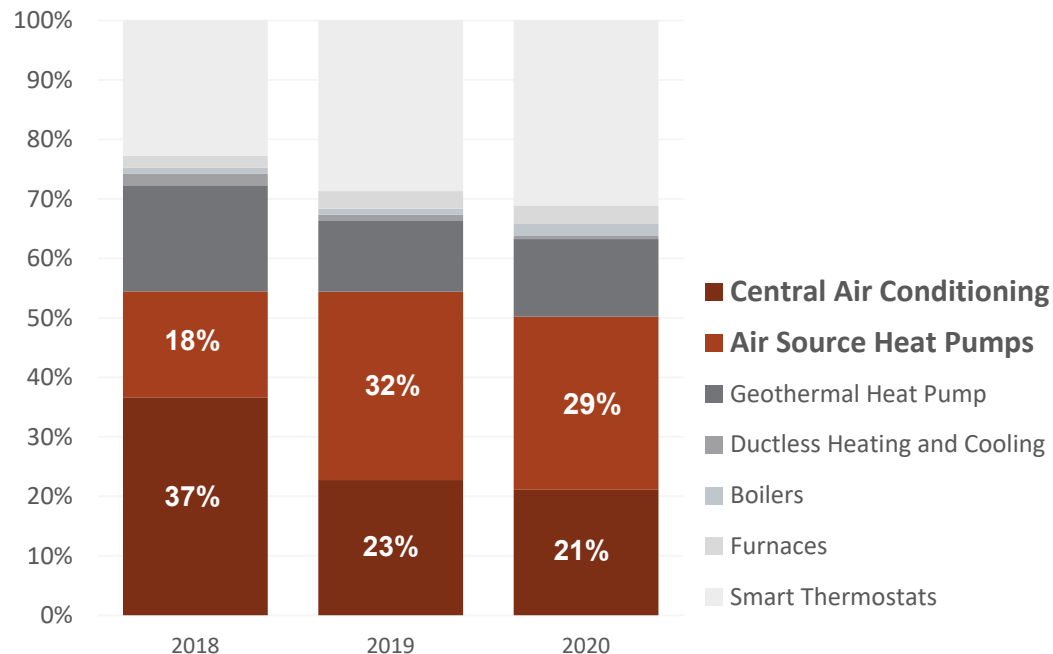
Streamlining verified quality installation and HVAC tune-ups



Check out the [STEP Campaign website!](#)

Residential HVAC Energy Landscape

>40% U.S. residential energy use is attributed to space conditioning, and high efficiency central AC and air source heat pumps are on the rise with decarbonization efforts



ENERGY STAR and Energy Efficient HVAC & Smart Thermostat Promotions by Product Type, 2018-2020

Many utilities incentivize high-efficiency HVAC, but these efficiencies are rarely realized due to installation faults

- DOE report¹ found **70-90% of homes have 1 or more energy-wasting HVAC fault**
- NREL report² found **~9% of energy is wasted nationally due to HVAC installation faults, costing billpayers \$2.5 billion/year**

Utilities can provide quality installation programs to ensure HVAC systems perform as designed...

Smart diagnostic tools can help streamline these programs for success

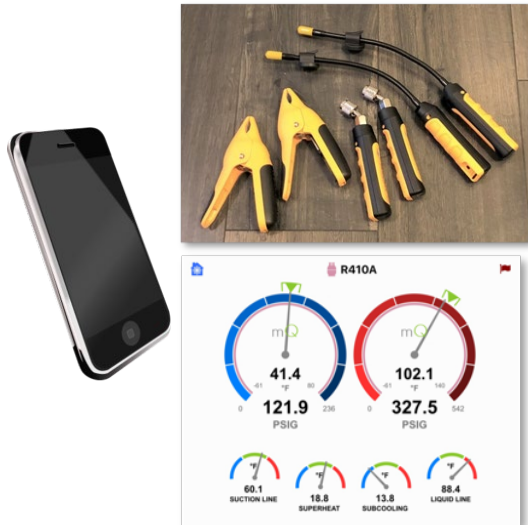
¹ EERE, 2018. Residential HVAC Installation Practices: A Review of Research Findings

² Winkler et al. 2020. Impact of installation faults in air conditioners and heat pumps in single-family homes on U.S. energy usage. Applied Energy, Volume 278

What are Smart Diagnostic Tools?



Traditional HVAC Diagnostics



Smart HVAC Diagnostics

Smart Diagnostic Tools are a collection of wireless probes and a smart diagnostic application on a technician's smartphone or tablet. The probes stream data to the diagnostic application in real time and provide:

- ✓ Performance tests (test-in / test-out)
- ✓ Fault diagnoses
- ✓ Suggestions for corrective actions
- ✓ Improved documentation
- ✓ Streamlined reporting
- ✓ Workflows for utility verified quality installation and maintenance programs

The Smart Diagnostic Tool Advantage for Utility Programs

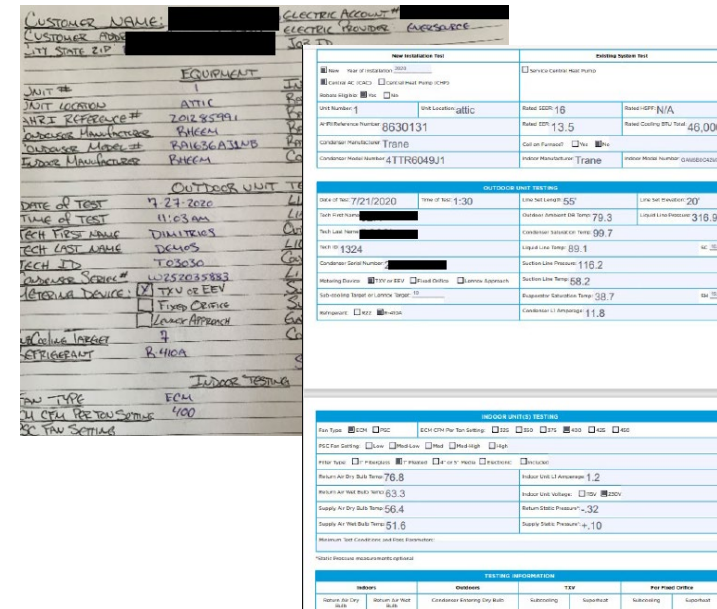
Utility Quality Installation Programs are not novel but were made complicated in the past by

- Manual reporting → extra time for contractors to transcribe, and for utilities/program implementers to review and digitize
- The ability to be “gamed” by contractors inputting measurements known to pass

New Smart Diagnostic Tools streamline implementation of Utility Quality Installation Programs

- Increased transparency and accuracy
 - Probes are directly connected to the system, third party application verifies
 - Measured, not manually written
 - Data is geo-tagged, can verify the address on file
- Everything is digital and reported directly to implementer – can easily review and assist contractors through any issues

Photos courtesy of Jason Darrow, ICF

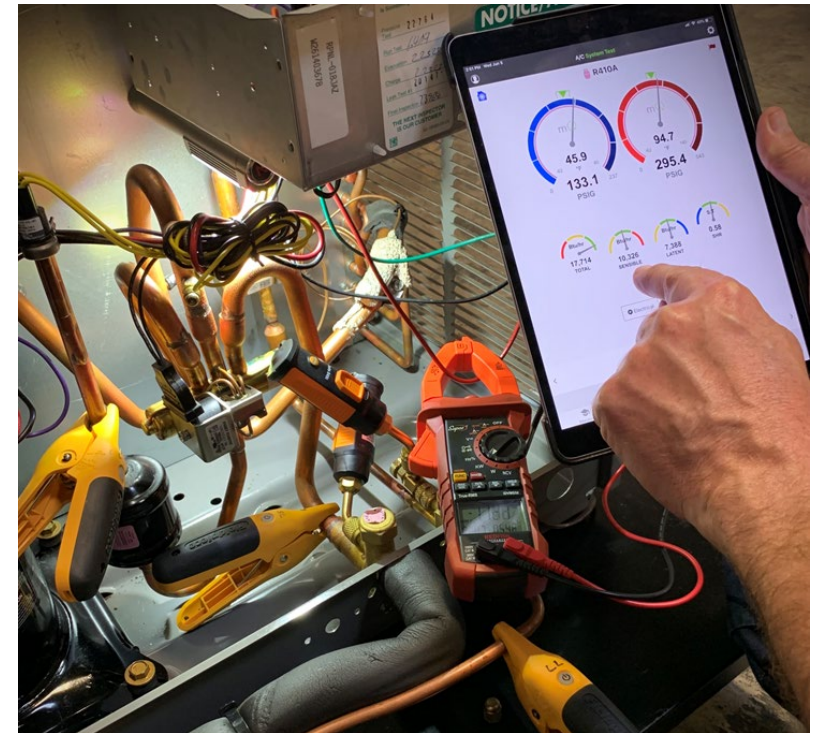


Residential HVAC Opportunity

Smart Diagnostic Tools can drive impact by:

- Optimizing high-efficiency HVAC systems through proper installation and maintenance
- Providing a scalable workforce solution for increased residential energy savings
- Simplifying quality installation and maintenance program execution for HVAC technicians
- Providing customer assurance through traceable and easily understood energy savings

**Savings Potential from Addressing Faults:
0.5 Quad/year; 22 tons of CO₂**



Integrating Smart Diagnostic Tools

Upfront Costs

- Probes (approx. \$1400)
- Diagnostic app subscription/application costs
- Work with diagnostic app developer to design utility workflow

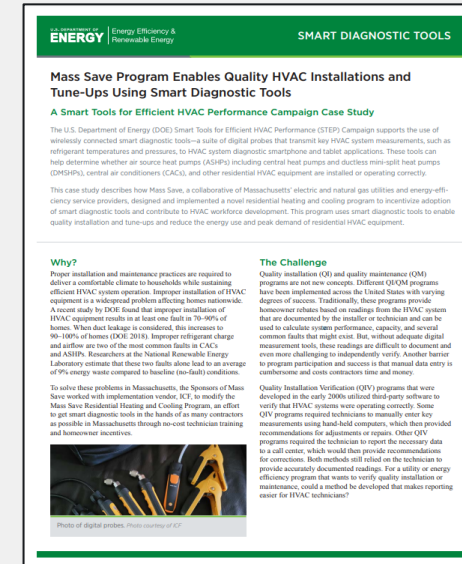
Utility programs can help reduce barriers for contractors

- No-cost training
- Give eligibility to quality installation & maintenance verification jobs, with financial incentives
- Partial reimbursement for the purchase of smart diagnostic tools



Contractor Success with Smart Tools

- ✓ Improved workflow
- ✓ Reduced data entry
- ✓ Diagnostic improvements



Utility Program Case Study

STEP Support for Program Implementers

ENERGY | Energy Efficiency & Renewable Energy

SMART DIAGNOSTIC TOOLS

Smart Tools for Efficient HVAC Performance Campaign

The U.S. Department of Energy (DOE) is working with partners on new collaborative initiatives to support the development and adoption of high-performance heat pumps that operate efficiently and maintain optimal performance over time, delivering comfort, energy savings, and low carbon heating to U.S. homeowners. To that end, DOE is launching a new technology Campaign that promotes the use of smart diagnostic tools that allow HVAC contractors to quickly and easily commission new HVAC systems and identify faults in existing systems. Although Automatic Fault Detection and Diagnostics (AFDD) equipment is available today, it is offered only in a limited number of high-end products that aren't yet cost-effective for most homeowners. Smart Diagnostic Tools address the system performance issue at a much lower cost.

The Smart Tools for Efficient HVAC Performance (STEP) Campaign (Campaign) will serve as a national platform for sharing information and recognizing successes with key stakeholders, including HVAC contractors and installers, energy-efficiency programs, equipment developers, trainers, and others. Space heating and cooling systems account for 44% of energy consumption in U.S. residences. (Energy Information Administration.)

SMART DIAGNOSTIC TOOLS

Quality HVAC Installations and Diagnostic Tools

Performance Campaign Case Study

Efficient HVAC Performance (STEP) Campaign supports the use of digital probes that transmit key HVAC system measurements, such as air diagnostic smartphone and tablet applications. These tools can identify certain heat pumps and ductless mini-split heat pumps residential HVAC equipment are installed or operating correctly.

State of Massachusetts' electric and natural gas utilities and energy-efficient residential heating and cooling program to accelerate adoption of HVAC development. This program uses smart diagnostic tools to enable HVAC contractors to quickly and easily commission new HVAC equipment.

The Challenge

Quality Installation Verification (QIV) and quality maintenance (QM) programs are not new concepts. Different QM/QIV programs have been implemented across the United States with varying degrees of success. Traditionally, these programs provide homeowner rebates based on readings from the HVAC system that are documented by the installer or technician and can be used to validate system performance, capacity, and several common faults that might exist. But, without adequate digital measurement tools, these readings are difficult to document and even more challenging to independently verify. Another barrier to program participation and success is that manual data entry is cumbersome and costs contractor time and money.

Quality Installation Verification (QIV) programs that were developed in the early 2000s utilized third party software to verify that HVAC systems were operating, which then provided recommendations for adjustments or repairs. Other QIV programs required the technician to manually enter key data in a web center, which would then provide recommendations for corrections. Both methods still relied on the technician to provide accurately documented readings. For a utility or energy efficiency program that wants to verify quality installations or performance, could a method be developed that makes reporting easier for HVAC installers?

SMART DIAGNOSTIC TOOLS

Smart Diagnostic Tools for HVAC Contractors

Case Study

Performance Campaign supports the use of wireless key HVAC system measurements such as energy diagnostic smartphone and tablet applications. These tools can help determine if HVAC equipment are installed or operating correctly. Smart Diagnostic Tools address the system performance issue at a much lower cost.

Company

Boucher Energy Systems, Inc.

Established in 1981, Boucher has designed and installed systems for houses ranging from 1,000 to 20,000 square feet—for homes being built from the 1800s to the most modern construction.

Steve Taylor, Installation Manager
Location: Portland, MA
Founded: 1981
Employees: 17
www.boucherenergy.com/

TOOLS USED:

Faloutsos Digital Handheld, FieldScan Job Log System Air Probes and Performance, Tech Digital Handheld, mESUQuick

Tools conveniently synchronize with the diagnostic app, which synthesizes the data to calculate system size, one-time diagnostics, and identify potential faults. The smart diagnostic tools can also remove the need for follow-up and recommend suggested adjustments. These tools check that the HVAC system measurements industry standard tolerances and that the performing optimally.

When in verified, a technician can easily capture data and save it to a cloud file. If there is a problem, the team can more easily troubleshoot by

Case Studies and Fact Sheet



Contractor Demonstration in Colorado, 2022

- Technical resources and support for Utility Program RFPs that could integrate smart tools
- Program design assistance
- Organizing training events for contractors
- Marketing support
- Recognition by the U.S. Dept. of Energy
- Manufacturer connections

Let's work together

Explore partnering with us to help more utilities take advantage of these new efficient technologies.

Support and resources we provide to Program Implementers:

- Assist in adoption of these technologies among contractors via training and case studies
- Provide Utility Playbooks for easier integration of technologies into new and existing programs
- Provide savings calculations and data tailored by region, when available, for program proposals

For more info or to get started, please contact us!

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