

2021 Q4

Emerging Technology Quarterly Newsletter

WHAT'S NEW:



Despite another challenging year due to COVID-19, the alliance remained resilient and NEEA staff wrapped up several long-term Emerging Technology projects. In fact, this quarter resulted in the culmination of several years of work on new television testing standards.

First, the Consumer Technology Association (CTA) released the CTA-2037C test procedure, based on test methodology developed by NEEA. And, in December ENERGY STAR® released the updated Version 9 TV specification.

In addition, the Emerging Technology team accomplished the following in 2021:

- Worked with several partners to complete testing on freshwater recirculatory pumps, confirming significant energy savings;
- Completed significant testing of electric and natural gas heat pumps;
- Published the Version 9.0 draft of the Advanced Water Heating Specification;
- Coordinated with the U.S. Department of Energy's (U.S. DOE) Partnership for Advanced Window Systems collaborative; and
- Completed additional testing on paired washers and dryers to better understand real-world performance.

The Emerging Tech team looks forward to continuing its work in 2022. Please reach out with any questions or suggestions on NEEA's emerging technology work. We'd love to hear from you.

~ **Eric Olson**, Manager, Emerging Technology & Product Management ~

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Product Summary & Readiness Levels

	PRODUCT	PROGRAM*	FUEL TYPE	SECTOR	ELECTRIC SAVINGS POTENTIAL**	PRODUCT PERFORMANCE*	MARKET/COMMERCIAL*	PROGRAM READINESS*
Products	Paired Washer-Dryer	RPP			TBD	3	5	5
	Smart Thermostats	N/A			12	3	5	4
	Ultra-High Definition TVs	RPP			57	4	5	5
	Clothes Dryer Balls	RPP			TBD	1	5	1
HVAC	Heat Pump Rating Representativeness	VSHP			TBD	3	5	4
	Very High Efficiency Dedicated Outside Air Systems	VHE DOAS			85	4	3	2
	Variable-Capacity Split System Heat Pumps	N/A			330	4	5	4
	Variable Refrigerant Flow (VRF) System	N/A			TBD	4	4	2
Envelope	Window Attachments	Window Attachments			35	3	5	4
	High-Performance Windows	RNC			60	3	2	2
Lighting	Luminaire Level Lighting Controls	LLLC			75	4	4	3
	LLLC with HVAC Control	LLLC			358	3	2	3
	Circadian Lighting for Residential Homes/Facilities	LLLC			TBD	1	1	1
Water Heating	Combination Hot Water and Space Heat	N/A			130	1-4	1-3	2
	Central Commercial Heat Pump Water Heater	HPWH			50	3	3	3
	Split System Heat Pump Water Heater	HPWH			50	3	3	3
	Integrated Commercial Heat Pump Water Heater	HPWH			50	3	3	4
Motors	Extended Motor Products	XMP			125	3	2	4
	Power Drive Systems	N/A			TBD	4	3	4
Other	Machine Learning (ML) Building Controls	N/A			TBD	1	2	2

* **Program Acronyms Defined:** Retail Product Portfolio (RPP); Ductless Heat Pumps (DHP); Variable Speed Heat Pumps (VSHP); Very High Efficiency Dedicated Outdoor Air Systems (VHE DOAS); Residential New Construction (RNC); Luminaire Level Lighting Controls (LLLC); Heat Pump Water Heater (HPWH); Efficient Gas Water Heaters (EGWH); Extended Motor Products (XMP)

** Technical **electric savings potential** for the region in aMW
* **Readiness Level Definitions** provided on page 21; **Rating Scale** 1=low 5=high

Fuel Type Symbols: Electric Gas

Sector Symbols: Residential Commercial Industrial



Paired Washer-Dryer

Product Description: Residential appliances for washing and drying clothes.

Project Objectives: Measure the total energy required to wash and dry the same “real-world” load of laundry in matched washers and dryers, including compact washers with heat pump dryers, and front- and top-load washers with electric and natural gas heated dryers. This testing is leveraging previous NEEA work on both clothes washers and dryers. The testing also seeks to inform NEEA staff whether the previously established “real-world” load should be revised with an industry standard ANSI/AHAM HLD-1-2010 textile load, with 100% cotton textiles, to increase industry acceptance and to better ensure reproducibility.

Project Update: The [“Perfect Pairings?”](#) report is now available on [neea.org](#). Lab testing and analysis revealed that the energy use information available from manufacturer-reported U.S. DOE ratings generally underestimates the energy use of washer-dryer pairs, when tested under more realistic conditions, by 30–60% for electric washer-dryer pairs and 35–80% for natural gas pairs. Analysis continues on updating NEEA’s dryer test procedure with a final report due in April 2022.

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Product Readiness Levels:

Product	5	Comm/Market	5	Program	5
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Smart Thermostats

Product Description: Residential thermostats that control various heating and cooling equipment, utilize weather and occupancy data to better manage the systems, and engage homeowners to more closely manage energy use and comfort.

Project Objective: Develop a method to estimate energy savings for smart thermostats based on performance metrics. This will enable Northwest utilities to quickly screen new products for inclusion in Qualified Products Lists (QPLs) and to estimate energy savings.

Project Status: Completed. The [final report](#) is available for download on [neea.org](#). Some of the key findings revealed that the smart thermostat installation resulted in statistically significant energy savings, and major home and life changes occurring in a similar time frame to the thermostat installation also significantly impact energy use/savings.

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Product	3	Comm/Market	5	Program	4
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Ultra-High Definition (UHD) TVs

Product Description: 4K ultra-high definition UHD TVs with various forms of advanced display technologies.

Project Objectives:

- Update U.S. DOE TV test procedure and International Electrotechnical Commission (IEC) test clip to 1) adequately address existing features such as Automatic Brightness Control (ABC) and Motion Detection Dimming (MDD) to prevent gaming of test results by manufacturers; and 2) incorporate emerging technologies such as ultra-high definition UHD, true and upscaled high dynamic range (HDR), increasing panel brightness, and stand-by power.
- Update ENERGY STAR specification to address issues with ABC/MDD, address new energy-consuming features such as UHD, and to account for the U.S. DOE test procedure and IEC test clip updates.
- Conduct retail testing of up to 150 TVs using updated draft test clips and draft test procedure. Use data analysis results to inform final test clip, final test procedure and future ENERGY STAR specification.

Project Update: ENERGY STAR released Version 9 of the Final Draft Specification for televisions. The Final Draft includes changes in response to the Limited Topic Proposal request for feedback on High Contrast Ratio (HCR) capabilities and energy use and updates to align with CTA-2037C: "Determination of Television Set Power Consumption" test procedure, which is incorporated by reference.

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Product	4	Comm/Market	5	Program	5
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Clothes Dryer Balls

Product Description: Clothes dryer accessories that claim to reduce drying time by increasing separation of clothes in the dryer drum.

Project Objective: Understand the effectiveness of different dryer balls at reducing the drying time in residential clothes dryers. This lab study will identify whether the use of two different types of dryer balls will reduce drying time. The first type is 100% wool dryer balls; the second is a rubber/plastic composite with the brand name EcoEgg. This preliminary testing will determine whether larger-scale testing will be pursued.

Project Update: This phase of the project is complete. Preliminary lab testing reveals that the wool dryer balls saved an average of 4.2% energy and 1.8% cycle time; the composite dryer balls saved an average of 3.3% energy and 1.4% cycle time. Additional testing will be performed in Q1 of 2022 to complete the final analysis.

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Product	4	Comm/Market	5	Program	1
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Very High Efficiency Dedicated Outside Air Systems (VHE DOAS)

Product Description: Energy 350, one of NEEA's energy efficiency engineering consultant partners, was able to negotiate an upgrade to its office HVAC system. Through involvement of the building owner, the equipment manufacturer, the distributor, the contractor and NEEA staff, Energy 350 specified a new system that exactly follows NEEA's VHE DOAS system requirements.

Project Objective: Utilize this upgraded HVAC system as a showcase system that would accommodate in-depth system tours for NEEA staff, NEEA's utility funders and potential VHE DOAS market actors.

The new system will also provide ongoing, detailed data monitoring, including:

- Energy, indoor air temperature, relative humidity, CO2 and heat recovery ventilator performance
- Data analysis and energy savings comparing the previous system to the new VHE DOAS replacement system

Project Status: The VHE DOAS at Energy 350's offices is running well, and the project team is looking forward to receiving some winter energy monitoring data. The system's cost analysis is complete, demonstrating what cost is achievable in cubic feet per minute (CFM) on the low end of a major renovation project.

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Product	4	Comm/Market	4	Program	2
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Field Validation of Variable Refrigerant Flow (VRF) System Performance in Cold Climates

Product Description: NEEA staff are partnering with the Northeast Energy Efficiency Partnerships (NEEP) to integrate NEEA's VHE DOAS into a DOE-funded project that aims to validate VRF performance in cold climates.

Project Objectives: Measure in situ cold climate performance of rated VRFs. Study will include measurement of energy use and refrigerant leakage.

Project Status: NEEP completed its cold climate VRF specification as "ENERGY STAR Plus," with products meeting the ENERGY STAR cold climate specification, plus additional requirements and reported performance data and will be available on NEEP's [website](#). The benefit of additional performance data is particularly useful below the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) reporting limit of 17°F. This specification has been submitted to ENERGY STAR for its consideration.

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Product Readiness Levels:

Product	4	Comm/Market	4	Program	2
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Variable-Capacity Split-System Heat Pumps

Product Description: A split-system heat pump based on the successful inverter-driven technology found in ductless heat pumps.

Project Objectives:

- Conduct a detailed product assessment of variable-capacity (inverter-driven) central forced air heat pumps. This includes but is not limited to cost, capacity, coefficient of performance (COP), controls, demand capabilities and remote data collection.
- Develop an analysis tool that calculates the lowest levelized cost of heating and cooling for families of heat pumps based on COP, climate, capacity, cost and demand pricing of power.

Project Status: This project, including the following activities, is complete: Tool development, creation of market assessment database, NEEA Product Council Webinars (February 9 and October 26, 2021), cost data collection, calibration of tool, defining of archetypes, Efficiency Exchange webinar (March 2021), analysis, draft report produced, final tool completion.

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Product	3	Comm/Market	5	Program	4
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Heat Pump Rating Representativeness

Product Description: Heat pumps that can vary their speed to meet heating and cooling demands, enabling the heat pump to operate across a wider ambient temperature range and to have superior performance under low load conditions.

Project Description: This research aims to determine the representativeness of different heat pump test procedures through observation of heat pump performance in a controlled field installation and comparison with corresponding laboratory test results. NEEA will investigate the heat pump test procedures prevalent in North America (CSA EXP07 and DOE Appendix M1) and identify which method more accurately represents energy use. Additionally, key conditions and sequences (e.g., defrost, variation of compressor speed at part load) affecting instantaneous power demand and overall energy use will be investigated.

Project Objectives:

- Identify how well Appendix M1 represents field performance.
- Identify how well CSA EXP07 represents field performance.
- Identify essential pieces of information that need to be captured by any heat pump test procedure in order to accurately represent heat pump performance (e.g., any controls sequences that are particularly impactful to performance).
- Determine critical performance indicators that could effectively be used to differentiate efficient equipment in a qualified products list in advance of modified test procedures being widely available.

Project Status: Completed to date: Scope of work defined, secured funder commitments, RFP issued, selected contractor.

Remaining (target dates): The project kickoff is in early January 2022, with the test site setup planned for March 2022, data gathering from June 2022–March 2023, and the final analysis and report in June 2023.

The project has been divided into field testing (Phase 1) and lab testing (Phase 2). Additional funding is needed for Phase 2; multiple sources are currently being sought.

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Product	4	Comm/Market	5	Program	4
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Why Heat Pump Metrics Matter

Product Description: Produces a white paper and associated presentation that represents the evidence and value of better performance ratings for variable speed heat pumps.

Project Objectives: Building off NEEA's previous work helping develop CSA EXP07 load-based and climate specific testing for heat pumps and air conditioners, continue gathering evidence that current heat pump ratings do not accurately reflect real-world performance. Present a case for better ratings and a visual infographic for general audience and program managers that explains why metrics make a difference to customer, utility and product development cycles.

Project Status:

- Final draft report completed Q4 2021.
- Publication (after technical editing) expected Q1 2022.
- Accompanying PowerPoint with easy-to-understand visuals will also be completed in Q1 2022.

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Product Readiness Levels:

Product	4	Comm/Market	5	Program	4
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EXP07 Repeatability Testing and Value Engineering

Product Description: Field and lab testing of variable speed heat pumps under identical conditions to gather data needed to assess the repeatability and reproducibility of heat pump testing procedures.

Project Objective: This project involves co-funded research with AHRI, PG&E, Purdue University and Natural Resources Canada (NRCAN) to evaluate the repeatability and reproducibility of the Canadian Standards Association EXP07 test procedure.

Project Status:

- Round robin lab testing completed.
- Draft report completed in Q4 2021.
- Final report expected Q1 2022.

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Product	4	Comm/Market	5	Program	4
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Window Attachments

Product Description: Products that attach to existing low performance windows to increase their energy performance; includes films, blinds, storm windows, secondary glazing systems, awnings, etc.

Project Objective: Assess the energy savings, product performance and occupant acceptance of low-e surface applied films and suspended film in secondary windows.

Project Update: Stretched film product has been installed at both test sites. This is the fourth product at the Seattle test site and the third of four installed at the Tacoma test site. Due to wrinkling, the product was removed from the Smart Building Center in Seattle and replacement options are being reviewed. Thermal data are being collected from both locations and occupant feedback and sound testing are planned for January 2022, with results anticipated in March 2022.

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Product	3	Comm/Market	5	Program	4
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Primary Triple Pane Windows

Product Description: Primary window using three panes of glass (or film or rigid plastic), two of standard thickness and a center thin pane of glass (or film). The overall thickness and weight are similar to standard double pane windows.

Project Objectives: Identify manufacturing technical needs for production of thin triple pane windows; provide technical assistance on production processes (adapting double glazed equipment or new lines); research motivating factors for increasing production of thin triple pane windows; identify barriers in the supply chain; investigate enhancements in thin triple pane window technology.

Project Update: Q4 2021 research laid the foundation for extensive work in Q1 2022, including building the Partnership for Advanced Window Systems national collaborative. Early 2022 will focus on working with supply chain actors to understand market dynamics and barriers, conducting cost studies to identify cost reduction opportunities, and working with high-volume builders as early adopters to drive sustained demand.

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Product	3	Comm/Market	2	Program	2
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Luminaire Level Lighting Controls (LLLC)

Product Description: Advanced lighting control systems, either with wireless sensors or with luminaire integrated lighting controls, to provide occupancy-sensor and light-level control plus energy metering.

Project Objective: The Next Generation Lighting Systems (NGLS) program’s prior competitions in 2017 and 2018 selected connected lighting for testing installation, commissioning and energy performance in a real-world test location. In 2021, NGLS added a new project studying the installation, color tuning, energy monitoring and occupancy/daylighting performance of the system with the possibility of future studies.

Project Update: NGLS & NEEA continue to collect data from the NEEA office install, and look to have multiple networked lighting controls (NLCs) installed at the Living Lab at Parsons School of Design in New York City in 2022.

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Product	4	Comm/Market	4	Program	3
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Luminaire Level Lighting Controls with HVAC Control

Product Description: Luminaire level lighting controls with additional sensors and supports for HVAC control.

Project Objective: Determine whether additional energy savings are possible from more granulated sensors in every general lighting fixture. Analyze different HVAC control strategies in terms of how the controls look at the information being collected by the lighting sensors.

Project Update: This project remains on hold due to COVID-related recruiting difficulties. Work continues with multiple manufacturers to find a suitable site.

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Product	3	Comm/Market	2	Program	3
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Circadian Lighting for Residential Homes/Facilities

Product Description: Fixtures and bulbs used in residential and commercial assisted living facilities.

Project Objective: Develop and make available an energy-efficient, portable and easy-to-use lighting device that will improve the overall health and well-being of older residents living in a range of housing environments, while reducing lighting energy use in these settings.

Project Update: The Lighting Energy Partnership (LEP), part of the Light and Health Research Center at Mount Sinai Icahn School of Medicine, spoke to the American Lighting Association in November 2021. They are currently seeking collaborators for commercialization.

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Product	1	Comm/Market	1	Program	1
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Combination Hot Water and Space Heat

Product Description: An integrated appliance providing space and water heating. Production options include different refrigerants and water, air and refrigerant working fluids.

- Electric
 - CO2 refrigerant split system — Sanden Eco Runo
- Gas
 - Condensing gas integrated system — NTI, iFLOW
 - Vapor compression heat pump — IntelliChoice, M-TriGen
 - Stirling cycle heat pump — BoostHEAT, ThermoLift, Olvondo technologies
 - Internal combustion engine (ICE) driven heat pump — Tecogen subsidiary Ilios, Blue Mountain Energy
 - Absorption heat pump — Stone Mountain Technologies Inc. (SMTI), Robur, Vicot

Project Objective: Demonstrate the performance and adaptability of these systems to provide space conditioning and domestic water heating systems in existing homes and small commercial applications.

Project Status:

- Electric
 - Eco Runo: Project is complete.
- Gas
 - HeatAmp: NEEA is working with HeatAmp (Swedish firm) to advance and test a cost-effective high performance residential gas heat pump water heater. Design and manufacturing of optimized subsystem and test rigs are complete. Test and evaluations of subsystems are ongoing. HeatAmp is working to identify a North American manufacturing partner.
 - BoostHEAT: BoostHEAT has shifted to manufacturing only the thermal compressor. Further discussions and opportunities are being investigated.
 - Vicot: Currently GTI is working closely working with Homy Building Solutions and Vicot to initiate a test plan, beginning with the Vicot V65 being commissioned in the GTI climate chamber.

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Product	1-4	Comm/Market	1-3	Program	2
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Split-System Heat Pump Water Heaters (HPWHs)

Product Description: Split-system HPWHs separate the heat pump from the water tank. These products offer a heat pump alternative for locations where the integral product doesn't physically fit. While only one split-system product has been available to date, two additional manufacturers are entering the market.

Project Objective: Lab and field test commercially available split-system water heaters to confirm performance and compliance with NEEA's Advanced Water Heating Specification (AWHS).

Project Update: The system was fine-tuned, and corrections were made due to issues stemming from a lack of documentation; the system is functioning much better, resulting in increased customer satisfaction. Additionally, the data feed is working well, and the customer is engaged in findings. Interim findings are anticipated in early 2022, given the delay of proper instrumentation due to pandemic-related supply chain issues.

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Product	3	Comm/Market	3	Program	3
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Integrated Commercial Heat Pump Water Heaters

Product Description: Similar to integrated residential HPWHs. Commercial applications cover a broad range of hot water uses.

Project Objective: Conduct a feasibility study to determine in-field coefficient of performance (COP), resistance heat utilization and success in keeping up with hot water demand.

Project Update: COVID-19 challenges continue to halt progress on this project. Additional opportunities will be investigated in 2022.

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Product	3	Comm/Market	3	Program	4
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Central Commercial Heat Pump Water Heater

Product Description: Commercial HPWHs used in multifamily buildings with central water heating and a distribution system. Several products are available and new products from major manufacturers are expected soon.

Project Objectives: Test design tools and new HPWHs as efficient electric solutions for central water heating. The results should lead to an updated product specification, test method and potentially a QPL. NEEA staff are supporting a couple of projects in this area, one with the Bonneville Power Administration and one with New Buildings Institute and the California Energy Commission.

Project Update: Work with the Advanced Water Heating Initiative (AWHI) regarding central commercial HPWHs is complete now that a draft of AWHS 8.0 has been published. The Bonneville Power Administration will host the QPL for the central commercial HPWH products, and there are no significant changes.

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Product	3	Comm/Market	3	Program	3
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Heat Pump Water Heater Challenging Installation Research

Product Description: This research is being conducted to better understand the challenges and barriers of HPWH installations and to support NEEA's primary HPWH goal of influencing federal water heating standards.

Product Objective:

- Aid in NEEA's primary HPWH program goal of influencing federal water heating standards.
- Estimate the prevalence of "challenging install scenarios" for HPWHs in the regional housing stock.
- Improve understanding of the ways in which plumbers or installers typically adapt when faced with each scenario.
- Build a better understanding of additional barriers to be addressed, especially in rural and colder climates.

Project Update: A preliminary internal report was produced. The alliance is continuing work with other regions of the U.S. to understand gaps in installation knowledge. Findings will allow the alliance to craft program activities and work with manufacturers to address these areas. External reporting and timing to be determined.

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Product	4	Comm/Market	3	Program	3
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Air-Conditioning, Heating, and Refrigeration Institute (AHRI) 1430 Electric Water Heater Connectivity Standard

Product Description: Hardware and software to make water heaters grid-flexible and controllable.

Project Objective: Support efforts to harmonize connectivity standards among several standards, including AWHS 7.0, ENERGY STAR, California JA13, OpenADR and others.

Project Update: The team, consisting of representatives from ENERGY STAR, U.S. DOE, OpenADR, California Energy Commission (CEC), AWHI, and NEEA, continues meeting biweekly. Work continues on standardizing around CTA 2045B, which is anticipated for publication in Q2 2022.

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Product	3	Comm/Market	3	Program	3
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Heat Pump Technology Identification

Product Description: New or emerging technologies for moving heat from air into water.

Project Objective: Identify new heat pump technologies or approaches that could deliver improved water heating performance in all climates and with any fuel.

Project Update: Portland State University's Engineer and Technology Management Department has identified and interviewed technology researchers. Draft reports for heat pump and duct sealing technologies are complete and will be published in Q1 2022.

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Product	1	Comm/Market	1	Program	1
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Power Drive Systems (PDS) in Constant Load Applications

Product Description: Power drive systems, or the combination of an electric motor, variable speed controls and sensors to provide feedback to the equipment, are fast becoming commonplace due to the dramatic energy-saving potential of reducing motor speed at times of reduced demand. While the market is adopting PDS technology, the benefits of constant load applications have not been adequately documented to justify installation of variable speed technology in a constant load application.

Project Objective: Develop a working technical standard for power drive systems, including an applicable test procedure.

Project Update: The draft standard was produced in October 2021. This document is not yet public — NEEA is coordinating with the National Electrical Manufacturers Association (NEMA) to work through internal procedures to formally adopt the standard. Next steps will include efforts to support NEMA in the rollout of the standard.

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Product	4	Comm/Market	3	Program	4
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Commercial and Industrial Compressor Market Assessment

Product Description: Rotary screw air compressors are positive displacement compressors utilizing two-lobed rotors to reduce air volume and increase pressure. These products typically range from 30 – 200 HP and are used in heavy commercial and industrial applications.

Project Objective: Conduct an initial assessment of the air compressor market in the Northwest, including products currently used in the Northwest, a list of available technologies and recommendations for further research into energy savings potential.

Project Update: This project is complete. For questions regarding the results, please contact Shouka Darvishi.

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Product	2	Comm/Market	5	Program	2
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Fans Product Research

Product Description: Stand-alone fans that are not embedded into packaged units.

Project Objective: Provide an initial market assessment and secondary research on the intervention opportunity. Additional scope was added to the project to investigate the use of the fan energy index (FEI) metric by various manufacturers and to investigate which manufacturers are using FEI.

Project Update: This project is complete. For questions regarding the results, please contact Shouka Darvishi.

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Product	3	Comm/Market	2	Program	4
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Machine Learning (ML) Building Controls

Product Description: Applying artificial intelligence (AI) systems to adjust, improve and optimize control of equipment to accommodate changing conditions such as use, occupancy, comfort, air quality, time of use rates and demand response automatically and continually.

Project Objective: Field test one or two products to validate manufacturers' claims.

Project Update: Two buildings have been selected as test sites. BrainBox AI has installed their system and monitoring has begun. Active control should start in 2022 once baseline control options are identified.

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Product	1	Comm/Market	2	Program	2
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	Level 1: Pre-commercial	Level 2: Limited	Level 3: Niche	Level 4: Growing	Level 5: Wide
Supply Chain Maturity & Market Demand	Not commercially available or limited, pre-commercial availability	Commercially available outside of region Requires special order Limited market awareness	Commercially available in Northwest from one manufacturer through standard channels Niche market demand	Commercially available in Northwest from at least two manufacturers Growing market demand	Commercially available from 2+ manufacturers, well developed supply chain across region Wide market demand

PRODUCT PERFORMANCE READINESS

	Level 1: Unvalidated	Level 2: Engineering Validation	Level 3: Lab Validation	Level 4: Limited Field Validation	Level 5: Confirmed
Savings Reliability & Fitness for Use	Manufacturer claims energy savings but not validated by unbiased experts	Concept validated by unbiased expert via technical review and engineering calculations	Independent lab testing of product features and energy use in typical applications with clear baseline established	Lab and small-scale field testing across broader range of applications and systems conditions	Reliable prediction of performance across the range of intended applications; fully evaluable savings via established protocols by regional or national bodies

PROGRAM READINESS

	Level 1: None	Level 2: Exploratory	Level 3: Preliminary Pilots	Level 4: Full-scale Pilots	Level 5: Ready
Cost Effectiveness Knowledge <i>(technical and market potential, product cost at scale, non-energy benefits)</i>	None or very limited	Performance readiness at 2; initial market size calculated (units per year)	Performance readiness at 3; product cost at-scale estimated	Performance readiness at 4; product costs at or trending towards at-scale levels; preliminary estimates of non-energy benefits	Performance readiness at 5; CE calculations based on solid estimates or proven values
Market & Program Knowledge	None or very limited	Preliminary research exposes barriers and/ or similarities to other successfully transformed markets warranting further efforts	Market research illuminates barriers and opportunities to intervene; preliminary logic model developed; small-scale pilots	Formal market characterization underway; larger-scale pilots to test program elements and barrier removal	Formal logic model developed; market characterization and large-scale pilots prove out program design and barrier removal
Risk Assessment <i>(Market, Program, Regulatory)</i>	No risk assessment	Limited risk assessment	Preliminary risk assessment complete - major categories of risk understood	Well-developed risk assessment - no major unresolved risks	Periodic risk assessment process in place



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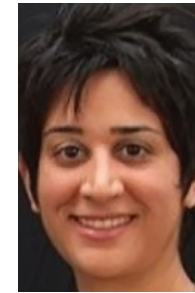
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TOGETHER We Are Transforming the Northwest

