ORNL/TM-2023/3229

Late-Stage Research Development and Demonstration Sub-activities Updates

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December 2023

OAK RIDGE National Laboratory

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ORNL/TM-2023/3229

Buildings and Transportation Science Division

LATE-STAGE RESEARCH DEVELOPMENT AND DEMONSTRATION SUB-ACTIVITIES UPDATES

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December 2023

Prepared by
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Oak Ridge, TN 37831-6283
managed by
UT-BATTELLE LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

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ABSTRACT

Oak Ridge National Laboratory (ORNL), in collaboration with the Pacific Northwest National Laboratory (PNNL), the National Renewable Energy Laboratory (NREL), the Lawrence Berkeley National Laboratory (LBNL), and the Hummingbird Firm (a specialized consulting firm focused on promoting diversity, equity, and inclusion considerations), has initiated a national initiative known as the Heat Pump (HP) and Heat Pump Water Heater (HPWH) Field Validation Partnership. This effort involves active participation from numerous critical entities involved in research and market transformation within the field.

The ORNL team is responsible for leading Late-Stage Research Development and Demonstration (LSRDD) among the four different topics.

The overall outcomes of this project will be:

- A structured Field Validation Partnership between DOE, the national labs, research, implementation, and market transformation organizations. This will result in unique way to coordinate field validation plans and collect relevant data from around the country into the HP and HPWH Field Validation Database.

- The Field Validation Partnership will result in a continuous stream of information between DOE and the major industry players in the space of HPs and HPWHs. If desired, DOE could use this information to inform roadmaps related to HP and HPWH market adoption and research going forward.

- The structure of this Partnership provides a mechanism for sharing lessons learned directly between Late-Stage RD&D, Building Integration Barriers, Regional Market and Policy and Workforce Development efforts. The result will be training content that is well-reviewed by the Partnership which will lead to a workforce that meets the industry's quality and workforce supply demands.

- The structure of this Partnership also provides an opportunity for regions to share lessons learned on policy and market transformation with each other through the Market and Policy core Committee.

This report includes an update in Late-Stage Research Development and Demonstration.

1. INTRODUCTION

Oak Ridge National Laboratory (ORNL), in collaboration with the Pacific Northwest National Laboratory (PNNL), the National Renewable Energy Laboratory (NREL), the Lawrence Berkeley National Laboratory (LBNL), and the Hummingbird Firm (a specialized consulting firm focused on promoting diversity, equity, and inclusion considerations), has initiated a nationwide partnership for field validation of heat pumps (HP) and heat pump water heaters (HPWH). This initiative involves the active participation of numerous pivotal research and market transformation entities. Figure 1 shows the structure of this partnership. In this project, the ORNL team lead Late-Stage Research Development and Demonstration (LSRDD).

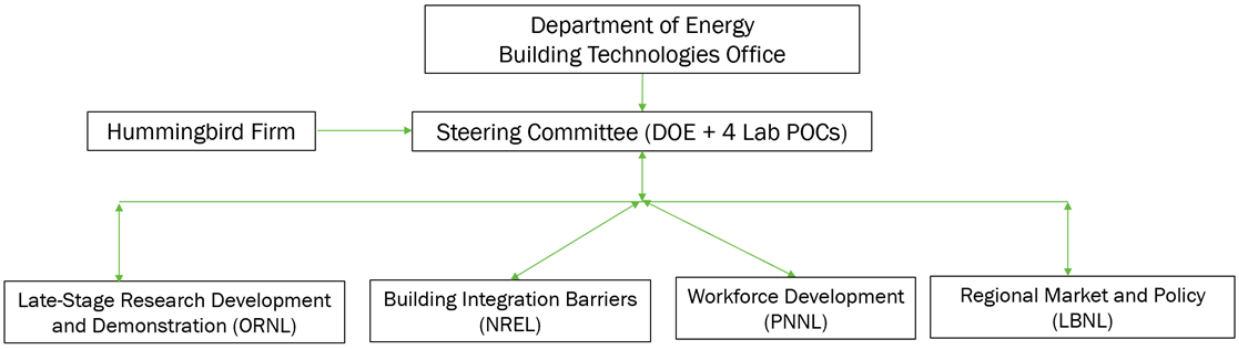

Figure 1. Structure of the partnership

The goal of this project is to establish a Partnership that helps drive adoption of HPs and HPWHs for both residential and commercial buildings. The objectives of this three-year project are to:

- Serve as a national clearinghouse for field test information from all relevant stakeholders
- Identify and inform DOE of remaining gaps and research questions associated with field validation
- Develop and coordinate collaborative efforts among relevant stakeholders throughout the nation
- Work with manufacturers and trade organizations to collect or develop training materials required for quality heat pump installation and maintenance
- Expand and clarify best practices to achieve market transformation in all regions of the U.S.

The Q1 milestone in FY 24 is as seen in table 1. Since PNNL, the lead laboratory of this project, will be provided with updates on subcontract status, this report will present the details of the Q1 progress of sub-activities under LSRDD, which is led by the ORNL team.

Table 1. Q1 Milestone

Milestone Name/Description	Criteria	End Date
Subcontract update	Provide update memo to DOE on status of all subcontracts for the Field Validation Partnership.	12/30/2023

2. FORMING LSRDD SUB-ACTIVITY GROUPS

In FY 23, the ORNL team reviewed the existing gaps related to the HP and HPWH. Out of 290 gaps, 55 gaps are under the LSRDD. More than 50% of gaps under the LSRDD are related to the new product considerations as shown in Figure 2.

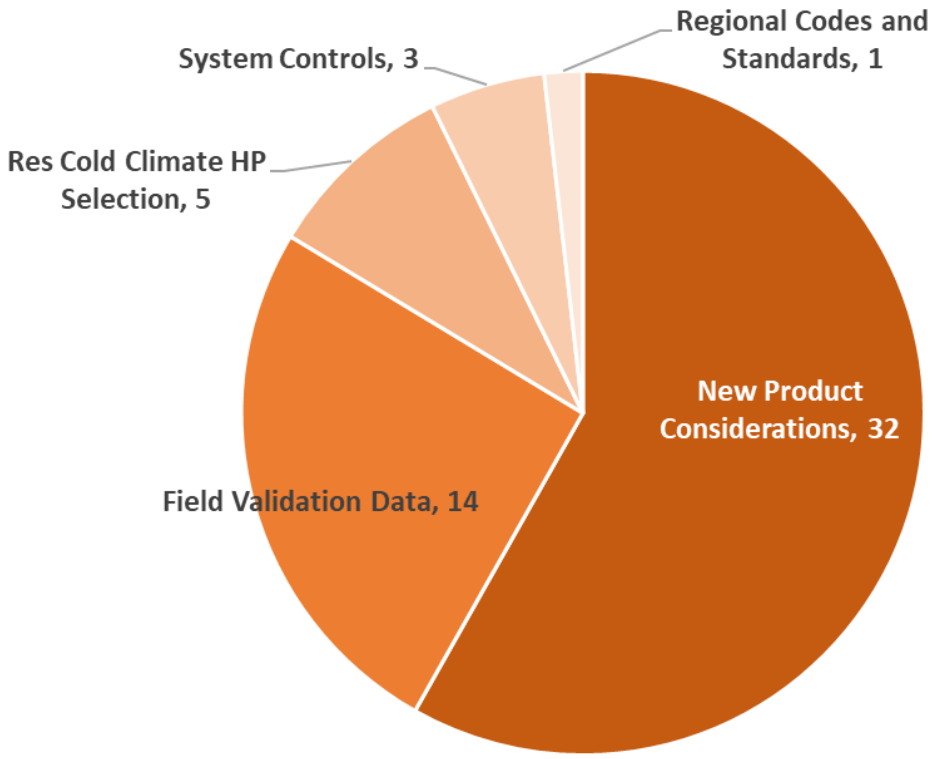

Figure 2. Number of gaps in each subtopic under the LSRDD

To identify the top 5 challenges, the ORNL team and other laboratories initially formed a core committee. In terms of the LSRDD, 54 members are currently working based on their expertise and interests. After forming the core committee, a survey was conducted in May 2023 to identify the top 5 challenges in LSRDD, and 14 members responded. Based on the survey results and internal discussions, the ORNL team identified and consolidated gaps, ultimately selecting the top 5 challenges. The challenges are outlined below.

- HP system price reduction
- HPWH system price reduction
- Lack of field test data/field performance
- HPWH technology development (e.g., CCHP-WH, Improve compressor performance, HPWH space constraints)
- Limited information about the performance characteristics about HPWHs

The ORNL team initiated five sub-activity groups based on these top five challenges. The ORNL team has assigned a lead person for future work on each sub-activity. In FY23 Q4, the ORNL team assigned a maximum of three lead persons per sub-activity, and information about the lead person for each sub-activity is shown in Table 2.

Table 2. Lead persons of each LSRDD sub-activity

Sub-activity	Lead Person 1	Lead Person 2	Lead Person 3
HP system price reduction	Bo Shen (ORNL)	Christopher Dymond (NEEA)	
HPWH system price reduction	Noah Gabriel (NBI)	Yeobeom Yoon (ORNL)	
Lack of field test data/field performance	Piljae Im (ORNL)	Abinesh Selvacanabady (PNNL)	Jon Winkler (NREL)
HPWH technology development	Jon Heller (Ecotope)	Joe Wachunas (NBI)	Bethany Sparn (NREL)
Limited information about the performance characteristics about HPWHs	Tom Butcher (BNL)	Joe Rendall (ORNL)	Easwaran Krishnan (ORNL)

The ORNL team reached out to all LSRDD core committee members to establish the sub-activity groups. The sub-activity group members include LSRDD core committee members who expressed interest in participating. Additionally, the lead person of each LSRDD sub-activity reached out to their communities for future work.

3. OBJECTVIES AND OUTCOMES OF LSRDD SUB-ACTIVITY GROUPS

The lead persons of each LSRDD sub-activity groups developed initial objectives, outcomes/outputs, and schedules for each LSRDD sub-activity. The schedule includes both FY24 and FY25. These objectives, outcomes/outputs, and schedules may be revised based on internal discussions within each sub-activity group. Table 3 displays the current objectives, outcomes/outputs, and schedules for each LSRDD sub-activity group. The lead persons of each LSRDD sub-activity group will provide updates every quarter until FY25 Q4. The ORNL team regularly reach out to the lead persons of each LSRDD sub-activity group, and the team attend the sub-activity group meetings to understand the status of work.

Table 3. Objectives, outcomes/outputs, and schedules for each LSRDD sub-activity group

Sub-activity		Description
HP system price reduction	**Key Objective(s)**	1. Understand the cost allocation in the value propagation chain, including manufacturing, distribution, installation, and service. 2. Understand the cost distribution in heat pump unit, i.e., compressor, heat exchangers, fan and blower, expansion devices, electric accessories, control etc. 3. Survey candidate technologies to replace most premium components without degrading the unit performance significantly. 4. Conduct market survey, for various customer bases including low income families, in multiple climate regions. Identify regional solutions with good cost-effectiveness.
	Key Outcome(s)/Output(s)	1. Solutions to remove the deployment barriers, i.e., smooth supply and distribution chains, hold training programs to develop more technical force and support the installation. 2. Identify lower-cost component technologies, and work with component manufacturers to develop system solution and prototype to demonstrate the feasibility. 3. Conduct online seminar to present conclusions of cost distribution and promote low cost solutions.
	Timeline/Schedule	FY24 - Market survey report to summarize cost distribution in heat pump manufacturing, distribution and supply chains FY25 - Technical survey report to identify lower cost component technologies, predict performance results and cost reduction potential.
HPWH system price reduction	**Key Objective(s)**	1. Review the Upfront Costs for Heat Pump Water Heaters (HPWH) Based on Fuel Conversion Type and Climate 2. Analyze the Component Costs Involved in HPWH Installation 3. Identify and Evaluate Cost Reduction Strategies for HPWH Systems 4. Assess the Expected Electrical Infrastructure Savings Resulting from 120-Volt HPWH Installations in Gas Fuel Conversions
	Key Outcome(s)/Output(s)	1. Create memo on current upfront costs for HPWH installations nationally along with identified cost reduction strategies.
	Timeline/Schedule	FY24 - Literature review and stakeholder interviews for identified upfront costs and strategies to reduce them.

		FY25 - Memo on research findings and recommendations
Lack of field test data/field performance	**Key Objective(s)**	1. Review existing field data related to the HP and HPWH in commercial and residential buildings - Search and collect data from public or private databases (from project partners). - Categorize and analyze data (e.g., Location, Building type, Data resolution, Data interval, Level of detail (energy use, COP), Test type) - Identify data gaps in each category. 2. Define use cases for existing and new data: - Determine the specific purposes for which the data is needed to justify its importance. 3. Develop a roadmap to address data gaps: - Utilize potential data sources, including existing data. - Plan to generate new data for high-priority gaps identified in objective #1.
	Key Outcome(s)/Output(s)	1. Create a memo or presentation: Review and analysis of existing dataset and new data needs - Conduct a comprehensive review and analysis of the current dataset. - Identify new data needs. 2. Create a memo or presentation: List of use cases for existing and new data - Document use cases for existing and new data to justify the data needs. 3. Develop a roadmap for a nationwide HP/HPWH database - Create a plan for establishing and/or maintaining a nationwide database. - Prioritize gathering one or two high-priority datasets from the roadmap. : Refine existing dataset - Enhance the existing dataset with detailed metadata and post-processed data. : Use case demonstration
	Timeline/Schedule	FY24 - Review existing field data - Define use cases FY25 - Develop a roadmap for nationwide database - Potentially gather one dataset for high priority.
HPWH technology development	**Key Objective(s)**	1. Expand heat pump product availability. 2. Optimize system design approaches. 3. Reduce cost and form factor. 4. Demonstrate and validate system performance.
	Key Outcome(s)/Output(s)	1. Demonstration projects with detailed EM&V in multiple regions and climate zones.

		2. Advanced Water Heater Specification with Qualified Product List. 3. Independent lab testing of range of products and design configurations. 4. Active research into simplified designs using unpressurized storage, PCMs, return-to-primary configurations.
	Timeline/Schedule	FY24 - Provide learnings from lab tests for return-to-primary, multipass, and swing tank configurations. FY24-25 - Research and develop prototypes for unpressurized storage and return-to-primary configurations FY24-26 - Bring 3-4 new lowGWP CHPWH products to US market. Demonstrate 8-10 different CHPWH manufactured systems in 3 different climate zones under BENEFIT projects.
Limited information about the performance characteristics about HPWHs	**Key Objective(s)**	1. Review field data to assess the performance of installed HPWHs and identify the necessary data for characterizing HPWHs in both unitary and centralized configurations. 2. Deliver a concise informational resource to the residential buildings community, offering insights into the seasonal efficiency and characteristics of HPWHs.
	Key Outcome(s)/Output(s)	1. A short report reviewing available, published information on basic performance characteristics and a summary of measured in-field performance and building energy use impacts with an emphasis on providing links to key studies and sources. 2. Identify what additional data is needed and recommendations. 3. If data is available: determine the HP and water heating performance.
	Timeline/Schedule	FY24 - Draft a report on the data required to determine performance characteristics and review existing resources. FY25 - Publish/release the final report overviewing the results.

4. PROGRESS OF EACH SUB-ACTIVITY GROUP

Throughout this quarter, the sub-activity leaders focused on forming groups within their sub-activities through discussions with the ORNL team and their internal communities. Additionally, they exchanged ideas and thoughts related to objectives, outcomes, and future tasks in the leadership meeting. Since the sub-activity groups were formed in FY 24 Q1, they plan to have a meeting with all sub-activity members in January. Table 4 illustrates the Q1 progress of each sub-activity group.

Table 4. Q1 progress of each sub-activity group

Sub-activity	Q1 progress
HP system price reduction	- Conduct building energy simulation to assess the performance difference between variable speed HPs and multi-stage HPs to seek cost reduction in compressors
HPWH system price reduction	- The lead person had a meeting with experts in NBI on 12/13 to review objectives and discuss next steps. o In the meeting Noah and Joe decided to reach out to contacts with data on HPWH installation costs, such as Slipstream and PNNL. These data will enable Noah to extract install costs in different territories. An additional next step will be discussing which components can be price-reduced with manufacturers. Noah has already sent an email to Slipstream.
Lack of field test data/field performance	- Three lead persons held a leadership meeting on December 19 to review the overall goals, objectives, and next steps. - We initiated the process to generate a field test data spreadsheet. - We will finalize the spreadsheet format and share it with the 54 LSRDD core committee members. - Through the field test data spreadsheet, we will identify the current status of the existing field dataset.

HPWH technology development	- Commercial HPWH - Formed Commercial HPWH Manufacturer's Action Council to develop areas of collaboration to advance market transformation.
	  o Advanced Water Heater Specification QPL updated with 100+ new products.
	  o PG&E lab testing complete for SanCO2, Colmac, and AO Smith CHPWHs.
	  o Organized panel for ACEEE HWF.
	  o AWHI All-stakeholder 2023 wrap-up meeting on 12/14/23.
	- Residential HPWH - Formed dedicated task group to research in-unit replacements. Kicked off first meeting on 12/20/23.

Limited information about the performance characteristics about HPWHs	- Two lead persons met in November 2023 and discussed the objectives and overall goals. - Identified the people interested in this sub activity. - Initiated consolidation of HPWH experimental studies and identified one dataset corresponds to HPWH field testing. - In discussion to organize the subcommittee meeting (in January 2024) to discuss the literature data sets.

5. CONCLUSIONS

In FY 23, the ORNL team reviewed the existing gaps and identified the top 5 challenges under the LSRDD based on discussions and a Google survey conducted through LSRDD core committee members. After forming five sub-activity groups, the ORNL team assigned a lead person (a maximum of 3) to each sub-activity group. In FY 24 Q1, the lead persons of each sub-activity group provided initial objectives, outcomes/outputs, and schedules for their respective sub-activities. This quarter marks the first after the formation of sub-activity groups and the determination of objectives and key outcomes. During this quarter, most of the sub-activity groups held internal leadership meetings, and they have plans to conduct sub-activity meetings in January.

In FY24 Q2, the ORNL team will provide updates on each sub-activity group.