



## TIP 394: Small Scale Multifamily CO<sup>2</sup> Heat Pump Water Heater Design & Pilot Study

### Context

The largest single energy use in new multifamily buildings in the Pacific Northwest is domestic water heating. The Northwest is seeing a boom in new apartment construction in urban and suburban areas

Traditionally, these buildings have defaulted to in-unit, electric-resistance tanks installed in tiny compartments for water heating. These are relatively inexpensive to install and also inefficient. The integrated heat pump water heaters currently on the market, designed for single family houses, are poor candidates for replacements in these situations because they do not operate well in enclosed compartments. The 2015 edition of the Washington State Energy Code added an optional compliance path for low-rise (three stories or less) multifamily involving central/distributed heat pump water heating. To date, however, no buildings have been built with such a system. Without projects like the one proposed, demonstrating viable alternatives, it is likely this market segment will remain untapped for some time. On the other hand, if this project goes forward, the demonstration buildings will make this code option viable for other states in the Northwest.

### Description

This project will research, design, pilot, verify, and document a heat pump water heating system for small-scale multifamily buildings using CO<sub>2</sub>-based transcritical refrigeration cycles. The project team will conduct a general system design exercise to support specific building construction and create a system sizing tool. The tool will help contractors and designers find the right balance of output capacity and storage. It will draw on existing knowledge of hot water use patterns and will be a web-based application accessible to all users.

With those two tasks complete, the team will write a measurement plan to monitor energy use and install metering equipment in the demonstration buildings. Subsequently, the team will conduct system design optimization based on measurement feedback and write a project report. The project is planned to take two years to complete. System research, design, and building selection/coordination, will take place in the first year. The buildings are anticipated to be occupied toward the end of the first year of the project allowing time for data

collection, verification and documentation in the second year.

The project is organized around three main tasks:

*Task 1-Design Concepts and Sizing Tool.* The project team drafts general design concepts for both central and distributed heat plant systems and creates the optimization sizing tool. This phase also includes recruitment of several buildings into the study.

*Task 2-Specific System Design and Installation.* The team supports developing draft CO<sub>2</sub> heat pump water heating system designs and engineering drawings for specific buildings using the sizing tool. They also review contractor bids, observe installations, and oversee commissioning of systems.

*Task 3-Measurement & Verification and Reporting.* The team writes the measurement and verification plan, installs metering for 6-12 month testing period, and analyzes data.

### Why It Matters

This project will add a remarkably low-energy water heating method to the multifamily market. The CO<sub>2</sub> heat pump system could use 75% less electricity amounting to an energy savings of 1,444 kWh/yr for each unit served. BPA can incentivize this design concept to help reach its regional energy efficiency targets. This technology applies to a wide swath of the multifamily market. It is best suited to small-scale projects (4-40 units) which are common across the BPA service territory in rural and urban areas alike.

### Goals and Objectives

This project intends to create a viable, cost-effective, high-efficiency alternative for water heating in the small multi-family residential market segment.

Ecotope, in partnership with the Northwest Energy Efficiency Alliance (NEEA) and Sanden International, will accomplish this goal by designing, piloting, and verifying air-source, CO<sub>2</sub> heat pump water heaters for domestic water heating in small-scale multifamily buildings

## Deliverables

Project deliverables are listed by the associated task.

Task 1: Component Sizing Tool  
Feasibility Study Report

Task 2: Operational water heating systems in all buildings

Task 3: Measurement and Verification Plan  
Final Project Report

At project closure the principle investigators will present high-level project results, discuss lessons learned, and recommend next steps towards rolling out the design to the broadest possible market

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**Project Start Date:** October 1, 2016

**Project End Date:** September 30, 2018

## Funding

Total Project Cost: \$210,000

BPA Share: \$105,000

BPA FY2017 Budget: \$ 52,500

## Reports, References, Links

## For More Information Contact:

### BPA Project Manager:

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## Related Projects

This project builds on or complements other projects from the Technology Innovation portfolio:

TIP 292-Advanced Heat Pump Water Heater Research

TIP 318-Enhanced Residential Efficiency Analysis Tools for the Pacific Northwest

TIP 338-Application of Combined Space and Water Heat Pump Systems to Existing Homes for Efficiency and Demand Response

TIP 341- Waste Water Heat Pump Design and Pilot Study

### Principal Investigator:

Ben Larson, Ecotope

## Participating Organizations

Ecotope, Inc.

Northwest Energy Efficiency Alliance (NEEA)

Sanden International, Inc.

