



2019 Hot Water Forum

Hilton Downtown Nashville • Nashville, Tennessee • March 11–13

PROGRAM

Monday, March 11

4:00–7:00 pm Registration

5:30–7:30 pm Reception

Tuesday, March 12

7:30 am–5:00 pm Registration

8:00–9:00 am Breakfast/Visit Displays

9:00–10:30 am Welcome, Introductions, and Plenary Panel

Welcome: **Steve Nadel**, American Council for an Energy-Efficient Economy

Introductions: **Chris Perry**, American Council for an Energy-Efficient Economy

Welcome from Platinum Sponsors: **Joshua Green**, A.O. Smith
Karen Meyers, Rheem Manufacturing

Plenary Panel: Hot Water Perspectives from the South

We kick off this year's forum highlighting our move from the Pacific Northwest by featuring experts in the water heating industry in southern states. Join us for a discussion on current successful water heating technologies, policies, and programs. These experts also will discuss the barriers and challenges for implementing energy-efficient water heating technologies in homes and commercial buildings.

Moderator: **Lauren Westmoreland**, Southeast Energy Efficiency Alliance

Panelists: **Carlos Colon**, Florida Solar Energy Center
Shon Richey, Southern Company
Mike Barcik, Southface Institute

10:30–11:00 am Networking Break

11:00 am–12:30 pm

Breakout Sessions

Track A. Technologies

1A. Commercial Applications of Gas Heat Pump Water Heaters

This session will cover a wide range of demonstration and pilot projects concerning commercial applications of gas-fired heat pump water heaters (GHPWHs), including qualitative and quantitative performance results. The presenters also will share innovative applications of GHPWHs—both vapor absorption and vapor compression types—for restaurants, laundry facilities, multifamily housing, and fitness centers with installations in Tennessee, California, Oregon, and Ontario.

Moderator: **Paul Glanville**, Gas Technology Institute

Performance of Commercial-Sized GHPWHs at a Commercial Laundry Facility

Presenter: **Chris Keinath**, Stone Mountain Technology

Demonstration of Pre-Commercial GHPWHs for Hot Water and Air-Conditioning at Full Service Restaurants

Presenter: **Isaac Mahderekal**, Gas Technology Institute

Results from a Cold-Climate Gas-Fired Absorption Heat Pump Multifamily Pilot

Presenter: **Paoyun Liu**, Enbridge

Track B. System Design

1B. Are Showerhead and Aerator Savings Tapped Out? The Current and Future Market for Low-Flow Fixtures

Utilities and programs like the EPA's WaterSense have long encouraged consumers to purchase lower-flow fixtures to reduce water and energy consumption related to hot water use in homes. However as we move toward lower and lower flow rates, behavioral factors and dynamics in hot water delivery may be affecting the ability of lower-flow fixtures to really save water and energy. This session will review the current state of technology and future trends related to low-flow showerheads and faucets and bring a panel of experts to discuss the variability around low-flow showerhead and faucet savings, now and in the future.

Moderator: **Sarah Widder**, Cadeo Group

Market Research on Hot Water

Presenters: **Bretnie Eschenbach**, Cadeo Group

Jonah Hessels, Cadeo Group

Flow Rates for Faucets, Showers, and Tub/Shower Values

Presenter: **Gary Klein**, Gary Klein and Associates

Update on WaterSense and Specification Changes for Showerheads and Faucets

Presenter: **Olga Cano**, US Environmental Protection Agency

Track C. Sectors

1C. Heat Recovery for Hot Water Systems

Drain Water Heat Recovery (DWHR) technologies come in a wide variety of shapes and sizes to serve different applications, whether distributed or centralized in buildings including industrial, commercial, and both multi-family and single-family residential. This presentation details a number of different types of DWHR systems along with their design considerations and benefits.

Moderator: **Harvey Sachs**, American Council for an Energy-Efficient Economy

Drain Water Heat Recovery: Applications and Case Studies

Presenter: **Rod Buchalter**, RenewABILITY Energy Inc.

Laboratory Experimentation and Modeling of Installation Slope Impacts on Drain Water Heat Recovery Effectiveness

Presenter: **Peter Grant**, Frontier Energy

PIRANHA—Zero Carbon Energy-Efficient Hot Water for Buildings

Presenter: **Lynn Mueller**, SHARC Energy Systems Inc.

Track D. Programs, Policies, and Climate Goals

1D. Water Heaters in Zero Net Energy Applications

Builders and policymakers are increasingly looking to design and promote zero-energy buildings, defined by the Department of Energy as “an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.” Efficient equipment and technologies that take advantage of renewable sources of energy are necessary to help achieve these lofty ambitions. The session will provide different examples of water heater technologies and applications that can help support zero energy building objectives.

Moderator: **Jennifer Amann**, American Council for an Energy-Efficient Economy

A Near-ZNE Commercial Building with Swimming Pool Heating Using CHP

Presenter: **Joe Yenshiun Shiau**, SoCalGas

Natural Gas Solid Oxide Fuel Cell for Zero Net Energy and Hot Water in Residential Applications

Presenter: **Alejandra Hormaza Mejia**, University of California-Irvine

Smart Plumbing and Controls Enable Zero Energy Buildings

Presenter: **Scott Campbell**, ACT Inc. D'MAND KONTROLS

12:30–1:30 pm

Networking Lunch and Displays

1:30–3:00 pm

Breakout Sessions

Track A. Technologies

2A. CTA 2045—How We Got Here and Where We Are Going

Thermal storage is one of the key tools to leverage for an ever-increasing renewable grid. This session will provide the fundamentals on the key elements of demand response methods for electric water heaters (resistance and heat pump water heaters), and will explore how this technology implemented is, share the results of a large-scale pilot (over 275 controlled water heaters) and examine next steps.

Moderator: **Geoff Wickes**, Northwest Energy Alliance

High-level Understanding of CTA 2045, Minimum Command Set and Current Status of CTA 2045

Presenter: **Chuck Thomas**, Electric Power Research Institute

Open Standards: Why They Matter and How to Implement Them (CTA-2045, OADR)

Presenter: **Tristan de Frondeville**, SkyCentrics

600 CTA 2045 DR Events in 220 Days—What Were the Results and Where Do We Go from Here?

Presenter: **Conrad Eustis**, Portland General Electric

Track B. System Design

2B. Solar Thermal, Integrated Thermal, and PV, Plus a Touch of History

Using the sun to heat water just makes sense! This session will provide a brief history of the interaction between solar energy and hot water and then examine two specific case studies. The first looks at solar thermal systems in a low-income multifamily building and office building. The second reviews an innovative technology that maximizes both thermal and photovoltaic solar energy collection on demand.

Moderator: **Larry Weingarten**, Consultant

A Brief History of Solar and Water Heating

Presenter: **Larry Weingarten**, Consultant

Evacuated Tubes Solar Thermal Field Testing in a Low-Income Multifamily Apartment with Integration to a Commercial Building

Presenter: **Joe Yenshiun Shiau**, SoCalGas

Hybrid PV/T-HP Solar Hot Water System Design and Economics

Presenter: **Albert Nunez**, Capital Sun Group and SunDrum Solar

Track C. Sectors

2C. Heat Pump Water Heaters (HPWH) in Commercial Applications

Heat pump water heaters have started to make a splash in the residential sector; however the growth of this technology to address the unique needs of commercial customers has lagged behind. Recently manufacturers and programs have started to develop more products and further explore opportunities for this technology to address these higher-use customers. This session will provide updates on new products, field tests, and experiences that can help establish a path forward for both gas and electric commercial heat pump water heaters, while highlighting some of the market barriers and challenges still to be addressed. Introduction to

Moderator: **Ben Larson**, Ecotope

Introduction to Large Scale Heat Pump Water Heaters

Presenter: **Brian Culler**, Colmac WaterHeat

Applications of Commercial Gas Heat Pump Water Heaters in the Northwest

Presenters: **Jeff Rigotti**, Northwest Energy Efficiency Alliance

Jordan Pratt, Energy 350

Heat Pumps Go Commercial

Presenter: **Bill Hosken**, A.O. Smith

Track D. Programs, Policies, and Climate Goals

2D. Innovative Programs: Where Are We Today?

The Innovative Programs track will begin with a lay of the water-heating land—taking stock of how programs have evolved over the past several years and looking at some noteworthy strategies that have come to the forefront. Presenters will share results of and findings about the role of voluntary specifications, successes from design efforts, and deployment/delivery tactics that address persistent barriers to the uptake of efficient systems and installation. This session will tee up the remaining three breakouts in the Innovative Program track.

Moderator: **Josh Butzbaugh**, Pacific Northwest National Laboratory

Efficiency Programs: From Good to Great

Presenter: **Alice Rosenberg**, Consortium for Energy Efficiency

The Heat Pump Water Heater Market: What Is Working?

Presenter: **Chris Granda**, Appliance Standards Awareness Project

Mystery Shopping for Water Heaters: Market Mechanics Revealed

Presenter: **Brian Booher**, D+R International

3:00–3:30 pm

Networking Break

3:30–5:00 pm

Breakout Sessions

Track A. Technologies

3A. It's a Tankless Job

Consumers love tankless gas water heaters. Providing endless hot water, this technology offers homeowners a unique value and some utility programs for tankless are enjoying great uptake. Manufacturers claim new technology provides high levels of performance without the need to upgrade to larger gas service lines, significantly reducing installation costs.

Moderator: **Peter Grant**, Frontier Energy

New Gas Tankless Technology and How to Support Trade Ally Uptake

Presenter: **Jeff Rigotti**, Northwest Energy Efficiency Alliance

Recent Lab Testing of Tankless Units: Evaluating Performance and Reliability

Presenter: **Alex Fridlyand**, Gas Technology Institute

Utility Program Successes and Lessons Learned

Presenter: **Kent Crouse**, Cascade Natural Gas

Track B. System Design

3B. Impact of System Design and Water Use on Premise Plumbing Microbiome

Drinking water is not sterile, and our pipes are home to a diverse microbial community. As our fixtures become more efficient and we implement water- and energy-saving measures to reduce the cost of water heating, water is staying in our pipes for longer periods of time. This increased time that water is stagnating in our pipes may lead to the growth and proliferation of opportunistic pathogens such as Legionella Pneumophila, Mycobacterium Avium, and Pseudomonas Aeruginosa. Explore how plumbing design, water heating temperature, water use patterns, and water quality impact the microbial community in buildings.

Moderator: **Jim Lutz**, Hot Water Research

Household Drinking Water is a Source of Clinically Relevant Cystic Fibrosis Opportunistic Bacterial Pathogens

Presenter: **Sarah-Jane Haig**, University of Pittsburgh

Water Stagnation in Premise Plumbing Leads to Predictable Microbiome Responses

Presenter: **Fangqiong Ling**, Washington University - St. Louis

Premise Plumbing Factors Leading to Mycobacterial Growth in the Greater Philadelphia Region

Presenter: **Anurag Mantha**, Virginia Tech

Track C. Sectors

3C. Opportunities in Commercial Kitchens

Food service is one of the highest hot water use industries in the commercial sector and opportunities for improved efficiency abound in the kitchen. This session will highlight recent technologies and strategies for improving efficiency and looking beyond the water heater to different end-use and design considerations that can reduce hot water energy use while maintaining or improving customer satisfaction.

Moderator: **Lydia Ruiz**, SoCal Gas

Water and Energy Savings with Pumped Rinse Dish Machines

Presenter: **Michael Slater**, Frontier Energy

Design Guide for Hot Water Systems in Commercial Food Service

Presenter: **Michael Slater**, Frontier Energy

A Commercial Kitchen Hot Water System Retrofit Case Study

Presenter: **Stephen Walmsley**, SoCalGas

Track D. Programs, Policies, and Climate Goals

3D. Innovative Programs for Engagement Strategies

Efficient water heaters are not going to sell themselves. This session will focus on various program approaches aimed at supporting the purchase and installation of water heaters. From educating contractors, training plumbers, and informing consumers, there are several places along the sales channel where program engagement can help influence decisions and actions. Presenters will share respective examples of how their intervention strategies are designed to deliver impact.

Moderator: **Jill Reynolds**, Northwest Energy Efficiency Alliance

Contractor Engagement for Training for HPWH Adoption

Presenter: **Alyson Caiola**, United Illuminating

Break Me Off a Piece of That Kit Program: A Comparison of Two Kit Program Delivery Models

Presenter: **Jordan Folks**, Opinion Dynamics

Midstream Models: A Manufacturer's Perspective

Presenter: **Francois Lebrasseur**, A.O. Smith

5:15–6:15 pm Shameless Commerce

Shameless Commerce: Introducing New Products and Services

This session will be anything but the norm. We are offering anyone a few minutes to present the advantages, features, and availability of their new products and services to all forum attendees. The session will be filled with rapid 2.5-minute presentations. Come hear about market innovations and then continue discussing and learning more during the reception.

6:15–7:30 pm Reception

Wednesday, March 13

7:30 am–5:00 pm Registration Open

8:00–9:00 am Breakfast—Visit Displays

9:00–10:30 am Breakout Sessions

Track A. Technologies

4A. Refrigerant-Free and Alternative Refrigerant Heat Pump Water Heaters

Electrically-powered heat pump water heaters available on the market use vapor compression systems with R134a refrigerant, a hydrofluorocarbon (HFC) that has been widely used for decades. HFCs are being phased out in an increasing number of countries due to high direct global warming potential (GWP). This session explores ongoing work to evaluate alternative approaches to electric heat pump water heating, a refrigerant-free system, and low-GWP refrigerants. Low-GWP refrigerants explored are the recently developed hydrofluoroolefins (HFOs) and the natural refrigerant CO₂.

Moderator: **Brian Fricke**, Oak Ridge National Laboratory

Refrigerant-Free Heat Pump Water Heaters

Presenter: **Uttam Ghoshal**, Sheetak Inc.

Maximum Efficiency Heat Pump Water Heater Based on Low-GWP Hydrofluoroolefin Refrigerants

Presenter: **Kashif Nawaz**, Oak Ridge National Laboratory

CO₂ vs. Fluorocarbons: Thermodynamic Comparison of Subcritical and Transcritical Heat Pump Water Heater Efficiency

Presenter: **Kyle Gluesenkamp**, Oak Ridge National Laboratory

Track B. System Design

4B. Designing Hot Water Recirculation Systems

The purpose of domestic hot water (DHW) recirculation systems in large buildings is to provide hot water to the occupants quickly. However circulating water 24/7 comes with a large energy penalty from pipe losses. Additionally, improperly sized re-circ pumps lead to excessive velocities within the pipes and the inherent liability this causes. This session will briefly review the background and recent research on domestic hot water recirculation controls in commercial and multifamily buildings (central systems), as well as options for more efficient DHW delivery in new and existing systems. The session will feature a moderated discussion with a panel of experts about the best design and control approaches for efficient DHW delivery recommendations and best practices.

Moderator: **Sara Widder**, Cadeo Group

Background and Recent Findings on DHW Re-circ Controls in Multifamily and Commercial Buildings

Presenter: **Nate Baker**, Cadeo Group

The Taxonomy of Hot Water Circulation Systems

Presenter: **Gary Klein**, Gary Klein Associates

Track C. Sectors

4C. Residential Combined Space/Water Heating Systems

In this session, presenters will provide research and product development updates on advanced residential combined space/water heating (“combi”) systems. The presentation will include: 1) an introduction to “combi” systems and an overview of test results for multiple sizes and types of “combi” systems using a laboratory-based “Virtual Home” platform; 2) the development and calibration of modeling tools to quantify the performance of different “combi” systems using EnergyPlus; 3) an update from a manufacturer on the design and commercialization of a low-cost, gas-fired heat pump (GHP) installed as a “combi” system; and 4) results from a field demonstration of gas heat pump-driven “combi” systems operating in the Upper Midwest.

Moderator: **Paul Glanville**, Gas Technology Institute

Laboratory Results for Advanced Combi Research

Presenter: **Tim Kingston**, Gas Technology Institute

Modeling and Calibrating Combined Space and Water Heating in Residential Applications

Presenter: **Alex Fridlyand**, Gas Technology Institute

Design and Development of Low-Cost GHPs for Residential “Combi” Systems

Presenter: **Chris Keinath**, Stone Mountain Technologies

Results from the Demonstration of GHP “Combi” Systems in the Upper Midwest

Presenter: **Paul Glanville**, Gas Technology Institute

Track D. Programs, Policies, and Climate Goals

4D. Greenhouse Gas Reduction Strategies in the Water Heater Market

As more policymakers identify greenhouse gas reduction as a priority for programs and standards, water heaters are poised to represent a significant opportunity to address these ambitious goals. Improved efficiency, increased uptake of new technologies and refrigerants, and an ability for products to take advantage of renewable energy sources all make water heaters uniquely qualified to be a part of the solution to reducing greenhouse gas emissions. This session will highlight perspectives from utility, manufacturer, and policy viewpoints regarding different paths forward to achieving these shared objectives.

Moderator: **Aaron Winer**, Northwest Energy Efficiency Alliance

The Beneficial Electrification of Water Heating

Presenter: **David Farnsworth**, Regulatory Assistance Project

Northwest Pathways to Deep Decarbonization

Presenter: **Holly Braun**, NW Natural

Decarbonizing Building Heat Loads at Mass Scale with Gas Absorption Heat Pumps

Presenter: **Scott Reed**, Stone Mountain Technologies

10:30–11:00 am

Networking Break

11:00 am–12:30 pm

Breakout Sessions

Track A. Technologies

5A. Unveiling the Retrofit-Ready Heat Pump Water Heater

Witness the unveiling of the Retrofit-Ready Heat Pump Water Heater developed to help California’s gas-fueled homes access the benefits of HPWHs. This “plug and play” technology is designed for easy replacement of gas water heaters, in tight spaces, and with no electrical upgrades required. Presenters will report on the specification development through a collaboration of OEMs, policy, program, and permitting organizations, and on a programmatic framework for demand for HPWHs.

Moderator: **Jim Lutz**, Hot Water Research

The Greenhouse Gas Emission Reduction Goals in California: Implications for Water Heaters in Existing Buildings

Presenter: **Panama Bartholomy**, Building Decarbonization Coalition

Programmatic Framework Development

Presenter: **Ashley Armstrong**, A.O. Smith

Retrofit-Ready HPWH Specification

Presenter: **Ben Larson**, Ecotope, Inc.

Track B. System Design

5B. How Do Plumbing Codes and Guidelines Need to Change to Conserve Water and Improve Quality?

With the drive to conserve water, some have suggested that we are reaching a point where water quality is being compromised. This session will examine places in codes and plumbing guidelines that are in need of revision as water conservation features—particularly those related to the hot water distribution system—gain an increasing foothold in today’s buildings. Results of recent road-mapping efforts to plot a research agenda to address these questions also will be discussed.

Moderator: **William Healy**, National Institute of Standards and Technology

Water Quality, Management, and Systems in the Age of Increased Efficiency

Presenter: **Jonah Schein**, US Environmental Protection Agency

Measurement Science Needs for Safe Sustainable Plumbing: Workshop Findings from Key Stakeholders

Presenter: **Tania Ullah**, National Institute of Standards and Technology

Addressing Today’s Water Use Patterns in Plumbing Codes and Standards

Presenter: **Hugo Aguilar**, International Association of Plumbing and Mechanical Officials

Track C. Sectors

5C. Multifamily Central Heat Pump Applications and Case Studies

In this session, the presenters will review the current state of the shelf of heat pump water heating technologies, discuss what is needed in the market to bring central heat pump water heating to scale, including several case studies and lessons learned with recent installations. Important design considerations with central heat pump systems will be reviewed, and a few design challenges—as well as present solutions to these challenges—will be highlighted. The intent is to highlight key lessons learned in several pilot installations and to showcase some innovative solutions around heat pump water heating. Presentations will center on several pilot heat pump water heating installations located in West coast and Northeast climates.

Moderator: **Sean Armstrong**, Redwood Energy

State of the Shelf: Central Heat Pump Water Heating Technology Review and Three Case Studies

Presenter: **Shawn Oram**, Ecotope

Integrated Heat Pump Water Heaters in Multifamily Buildings

Presenters: **Robb Aldrich**, Steven Winter Associates
Jesus Pernia, Eversource Energy

Field Monitoring of Three Different Heat Pump Water Heating System Types in ZNE Multifamily Housing

Presenter: **Sean Armstrong**, Redwood Energy

Track D. Programs, Policies, and Climate Goals

5D. Innovative Programs for Midstream Approaches

For many years, many voluntary programs have shifted increasing focus to retailers, distributors, and those involved in moving water heaters from the manufacturer to the customer. These midstream models work to incentivize the stocking, sale, and availability of high-efficiency models through incentives and education. The presenters will share how they have been designing programs to leverage these midstream opportunities through a variety of unique approaches designed to deliver significant results.

Moderator: **Kyle Booth**, Energy Solutions

Therm Savings with Midstream Programs

Presenter: **Kyle Coumas**, Energy Solutions

Panelists: **Nathan Jutras**, US Environmental Protection Agency
Ryan Crews, Energy Trust of Oregon
Howard Merson, VEIC
Brandon Stepanek, A.O. Smith

12:30–1:30 pm

Networking Lunch

1:30–3:00 pm

Breakout Sessions

Track A. Technologies

6A. Residential Gas Heat Pump Water Heaters—Moving to the Market

Gas heat pump water heaters (GHPWH) are getting close to commercialization. Come to this session to learn the latest on how GHPWHs are performing in the field, why utilities are so engaged with this technology, what is being done to bring them to market, and how you can be involved!

Moderator: **Ryan Kerr**, Gas Technology Institute

Priming the GHPWH Market

Presenter: **Aaron Winer**, Northwest Energy Efficiency Alliance

GHPWHs in California—Field and Laboratory Results

Presenter: **Paul Glanville**, Gas Technology Institute

GHPWHs as a Means to Reduce GHG Emissions

Presenter: **Holly Braun**, Northwest Natural

Track B. System Design

6B. How Low Can We Go? How Close Can We Get?

The panelists will report on the recently completed research project for the California Energy Commission on hot water distribution system performance and designs. The study investigated practical solutions for improving hot water distribution systems, assessed the performance of improved designs, investigated the interactions of low-flow fixtures and different distribution systems, and determined the lowest acceptable flow rates that provide hot water usage performance requirements without degrading distribution efficiency.

Discussion Panelists: **Jim Lutz**, Hot Water Research
Gary Klein, Gary Klein and Associates
Yanda Zhang, ZYD Energy

Track C. Sectors

6C. Uses and Considerations for Residential Smart, Grid-Enabled Water Heaters

Smart, grid-enabled water heaters are the future. They help utilities cut down peak energy demand and help consumers reduce their energy bills. However questions remain: What are the implications of grid-connectivity to the consumer? How effectively can utilities manage water heaters like they would batteries? How should we program these units to optimize occupant energy use? Join this session and hear answers from three experts.

Moderator: **Christopher Perry**, American Council for an Energy-Efficient Economy

Grid-enabled Water Heaters: Balancing Social Acceptability, Safety, and Efficiency

Presenter: **Martin Fassier**, CaSA Connected Appliances Ltd.

Real-World Validation of Power Balancing Services from Packetized Water Heater Virtual Batteries

Presenter: **Kate Desrochers**, Packetized Energy Technologies

Using Machine Learning to Predict Occupant Hot Water Use and Improve HPWH COP

Presenter: **Peter Grant**, Frontier Energy

Track D. Programs, Policies, and Climate Goals

6D. Implications and Considerations from Carbon Reduction Strategies for Water Heaters

Recently, policymakers and stakeholders have proposed a variety of strategies for addressing carbon reduction goals. While these strategies share similar objectives, they result in different trade-offs and considerations, including the role of water heaters in achieving these outcomes. This session will provide an opportunity to hear perspectives on these strategies, consider these tradeoffs, and evaluate the role that water heaters will play as jurisdictions adopt policies aimed at reducing greenhouse gas emissions, including carbon.

Moderator: **Alice Rosenberg**, Center for Energy Efficiency

Canada's Energy Efficiency Regulations—An Update

Presenter: **David Villarroel**, Natural Resources Canada

Carbon Footprint and Levelized Cost Comparison of Gas and Electric Water Heaters

Presenter: **Ferit Ucar**, Environmental Defense Fund

Implications of Policy-Driven Residential Electrification for Water Heaters

Presenter: **Rick Murphy**, American Gas Association

3:00–3:30 pm

Networking Break

3:30–5:00 pm

Breakout Sessions

Track A. Technologies

7A. New Concepts for Heat Pump Water Heaters: Split Units and Alternative Refrigerants

Most heat pump water heaters on the market today are packaged units in which the refrigeration system is attached to the water storage tank. Questions often arise on the space heating impacts of these water heaters since the heat pump unit effectively acts as an air conditioner. Recently, products have been introduced that split the heat pump system from the water storage tank, placing the evaporator outdoors, thereby negating space conditioning impacts. Additionally, the units currently available have utilized refrigerants with lower global warming potentials than those typically used in heat pump water heaters. This session will focus on these two concepts for heat pump water heating technology. Focus on the split systems will be on the rating approaches to assess their performance. Information will be supplied to understand how alternative refrigerants can perform as part of a water heating system.

Moderator: **Tania Ullah**, National Institute of Standards in Technology

Challenges in Testing and Rating Split-Unit Water Heaters

Presenter: **William Healy**, National Institute of Standards in Technology

Laboratory Testing of Two Split-Unit Water Heaters: CO₂ and R-410a

Presenter: **Ben Larson**, Ecotope

Propane as an Alternative Refrigerant for Heat Pump Water Heating Technology

Presenter: **Kashif Nawaz**, Oak Ridge National Laboratory

Track B. System Design

7B. National Laboratory Water Heating Research in Tennessee

To Nashville's east and up the road (I-40) a piece, lies "the Secret City" of Oak Ridge. Today it is no secret that Oak Ridge National Laboratory's (ORNL) Building Technologies Research and Integration Center is devoted to the development of technologies that improve the energy efficiency and environmental compatibility of residential and commercial buildings. Water heating is an important part of this mission, and this session explores some current initiatives on water heating at ORNL.

Moderator: **Ayyoub Momen**, Oak Ridge National Laboratory

Virtual Storage: Laboratory and Field Evaluations of Grid-Interactive Water Heaters

Presenter: **Jeff Munk**, Oak Ridge National Laboratory

Semi-Open Sorption Water Heater: Experimental Results and Theory of Operation

Presenter: **Kyle Gluesenkamp**, Oak Ridge National Laboratory

Characterizing the Impact of Modern Dip-Tubes on Hot Water Tank Stratification with Classical Dimensionless Groupings

Presenter: **Joseph Rendall**, Texas A&M and Oak Ridge National Laboratory

Optimization of Water Heater Control Strategy to Maximize UEF and FHR

Presenter: **Ahmad Abuheiba**, Oak Ridge National Laboratory

Track D. Programs, Policies, and Climate Goals

7D. Innovative Programs for Demand Response

Water heaters present not only the opportunity to deliver energy efficiency savings, but also load management savings through connected capabilities. In this session, presenters will talk about how they are incorporating smart devices and water heater technologies to capitalize on demand response opportunities and deliver benefit through these system channels.

Moderator: **Conrad Eustis**, Portland General Electric

Residential Natural Gas Demand Response Program Planning Using Connected Water Heaters

Presenter: **Andrew Nih**, SoCalGas

HPWH Low-Income Demand Response Pilot

Presenter: **Alyse Rodrigues**, United Illuminating

Controlling Load through Water Heaters

Presenter: **Kit Hagen**, Armada Power

Demand Response for the Retrofit Market

Presenter: **James Jackson**, Emerson Climate Technologies