Tri-Mode Heat Pump Market and Technology Assessment

NEEA Product Council Presentation

June 16, 2026

TRCCOMPANIES.COM

Member of WSP

Tri-Mode Heat Pump Market and Technology Assessment

Tri-Mode Heat Pump System Definition

Tri-mode heat pumps integrate space heating, cooling, and domestic hot water (DHW) into a single system.

Market and Technical Assessment

Assessment evaluates technical readiness, market conditions, and potential to support residential decarbonization goals.

Strategic Insights and Recommendations

Findings identify constraints and opportunities for advancing tri-mode heat pump adoption in NEEA territory.

Introduction

Study Purpose

Assess tri-mode heat pump technology and markets for residential heating, cooling, and hot water applications.

Research Methodology

Used market surveys, expert interviews, and literature reviews to evaluate technology maturity and barriers.

Key Research Questions

Explored barriers to adoption, suitable market segments, and potential cost and energy savings.

What Are Tri-Mode Heat Pumps?

Technology Overview

Tri-Mode System Functions

Tri-mode heat pumps provide space heating, cooling, and DHW from one system, optimizing energy use and space.

System Architectures

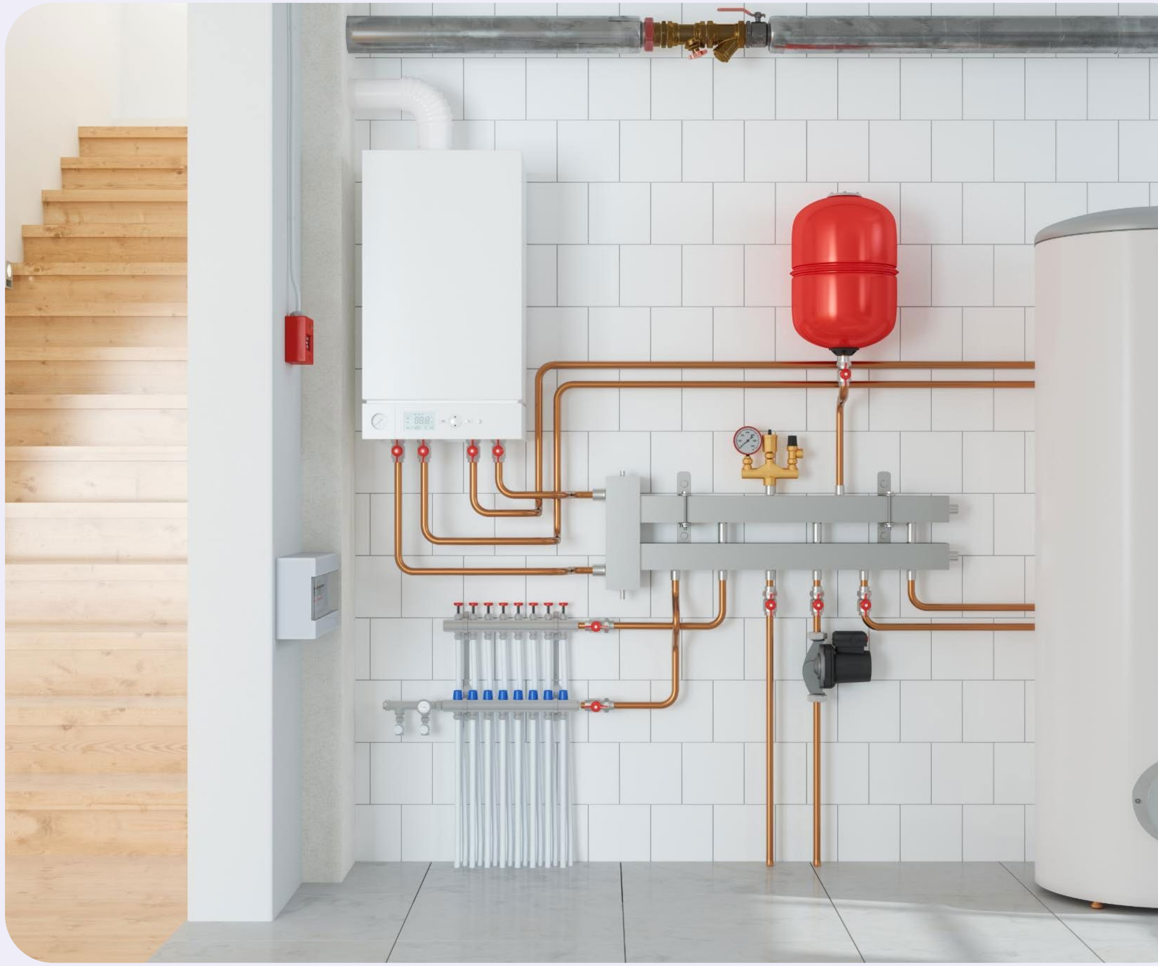
Various architectures include multiple types of both Air-to-Water (AWHP) and Air-to-Air (ATAHP), each offering unique features.

Environmental and Efficiency Benefits

Use of low GWP refrigerants, thermal energy storage, and heat recovery enhances environmental benefits and system efficiency.

Implementation Challenges

System complexity and control strategies vary, impacting installation, performance, and market readiness of tri-mode heat pumps.



Value Propositions of Tri-Mode Heat Pumps

Grid and Utility Benefits

Thermal energy storage supports load shifting and demand management, reducing reliance on electric resistance heating and lowering peak demand.

Enhanced Comfort

Faster water heating than unitary heat pump water heaters while avoiding noise and local cooling effects. Hydronic distribution may improve comfort in poorly insulated homes.

Increased Resilience and Safety

Stored thermal energy boosts resilience during power outages and AWHP monobloc designs reduce refrigerant risks by confining refrigerant outdoors.

Avoid Costly Electrical Upgrades

Tri-mode heat pumps typically don’t require a new circuit to the water tank location and require less amperage than typical separate HP systems which may eliminate the need for a panel or service upgrade.

Space Savings

In retrofits, tri-mode systems can free up significant space that would otherwise be occupied by multiple systems.

Monobloc (AWHP)

Tri-Mode System Types

System Architecture

Outdoor unit heats or cools a water loop supplying the indoor unit. The water contained in the water loop can be mixed with antifreeze (glycol).

Outdoor Unit

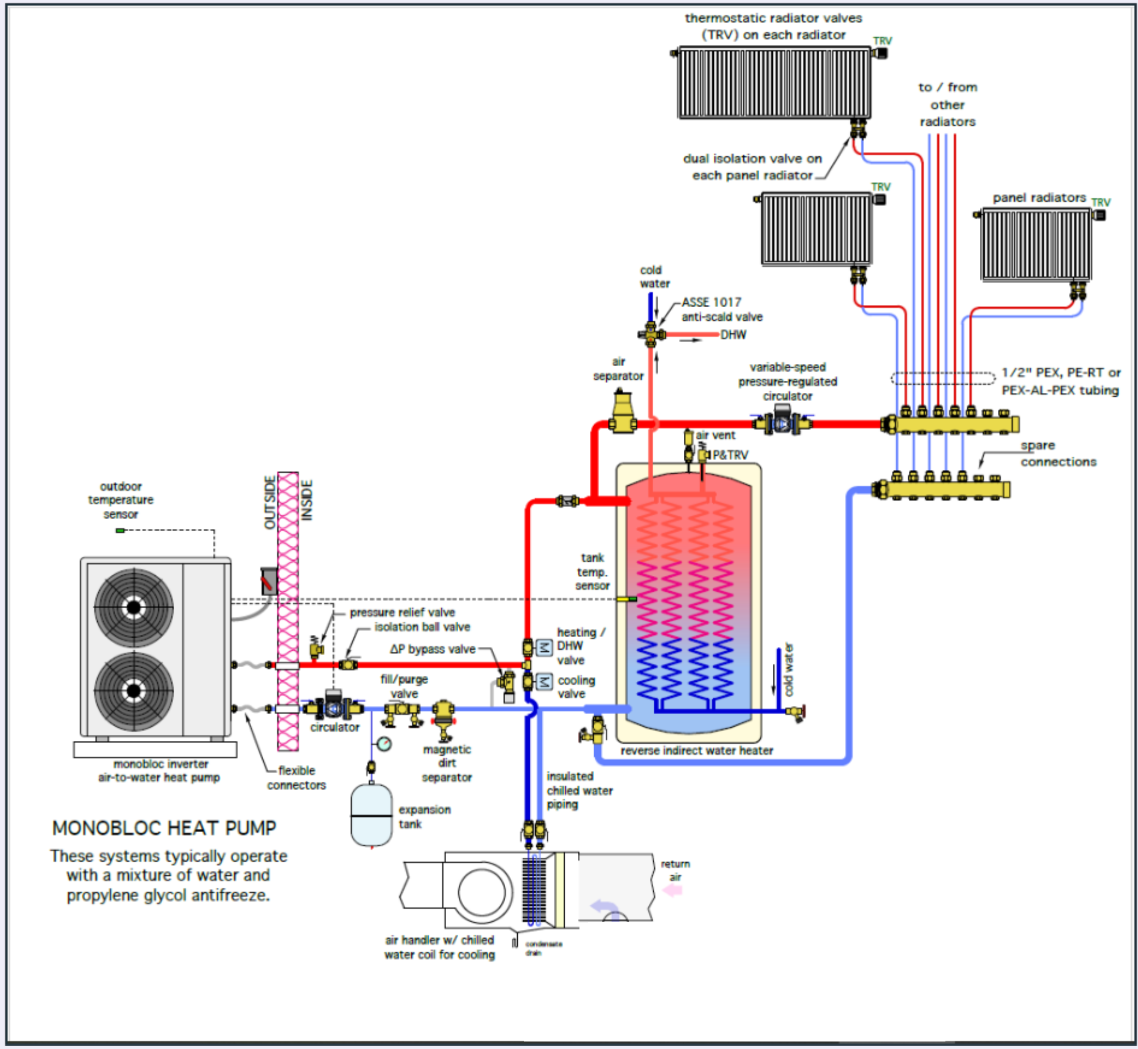
Monobloc unit, meaning all refrigeration cycle components are contained in the outdoor unit. A refrigerant-to-water heat exchanger delivers chilled or heated water.

Indoor Unit

The Hydrobox includes piping and valves which deliver the water to either space conditioning equipment or to an indirect storage tank to heat DHW.

Implementation Challenges

Higher equipment and installation costs. Many available products would require custom design for sizing, component selection, and control strategies increasing installation costs and increasing the risk of issues. Variation in the design and control impacts performance and market readiness.



Refrigerant Split Hydronic (ATAHP)

Tri-Mode System Types

System Architecture

Refrigerant lines run from the outdoor unit to an indoor module with refrigerant to water heat exchanger and valves. Water is pumped from the indoor module to supply space conditioning and indirect DHW tank.

Outdoor Unit

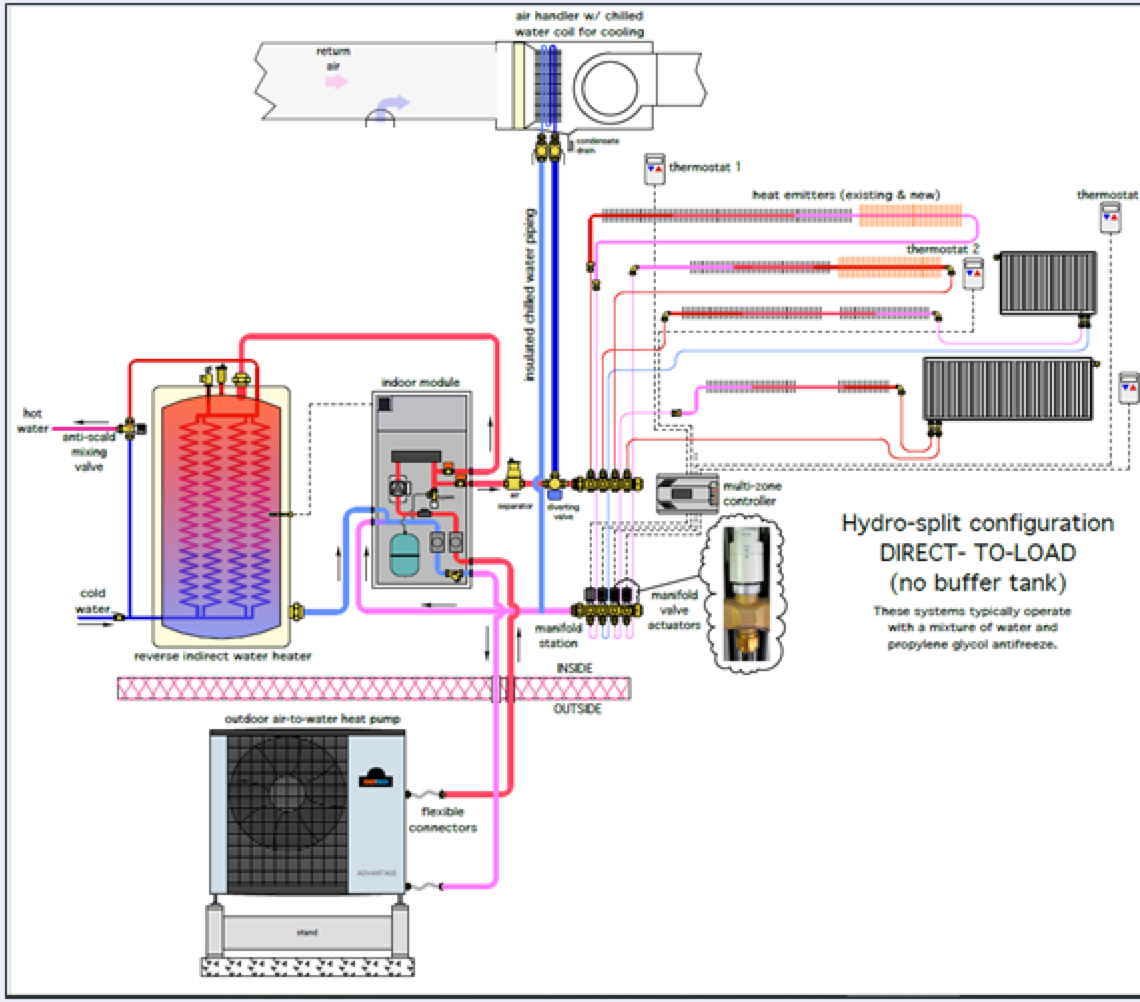
Outdoor unit contains only the compressor and outdoor coil.

Indoor Unit

The indoor unit contains the remainder of the refrigeration cycle components including a refrigerant-to-water heat exchanger, valves, and water pump. The indoor unit supplies chilled or heated water for space conditioning and to an indirect DHW tank.

Implementation Challenges

Higher equipment costs. Some available products may not require custom design. Variation in indirect tank heat transfer performance and controls impact performance.



DX Split Refrigerant (ATAHP)

Tri-Mode System Types

System Architecture

Refrigerant lines run from the outdoor unit to an indoor unit in the form of an air handling unit (AHU) or ductless heads and a separate storage tank to supply DHW. All components from one manufacturer can be installed by the existing workforce at a lower cost.

Outdoor Unit

Outdoor unit contains only the compressor and outdoor coil.

Indoor Units

The indoor units consist of an AHU or ductless heads with refrigerant coil. Refrigerant lines serve a DHW storage tank with refrigerant to water heat exchanger. Some of the products can recover heat from space cooling to heat hot water more efficiently.

Implementation Challenges

Manufacturer hot water tank design and control strategies vary, with a range in equipment costs and performance.

Daikin Europe. (n.d.). *Multi+ indoor unit image*. Retrieved June 12, 2026, from https://www.daikin.eu/en_us/product-group/air-to-air-heat-pumps/multiplus/_jcr_content/root/main_container/content_container/simple_container/twocolumncontainer/column-container-2/image.coreimg.png/1763385300431/multiplus-4-indoor-blue-16-9.png

DX Split VRF (ATAHP)

Tri-Mode System Types

System Architecture

Refrigerant lines run from the outdoor unit to a heat recovery unit. The heat recovery unit, similar to a commercial VRF branch selector box, supplies refrigerant to the indoor units.

Outdoor Unit

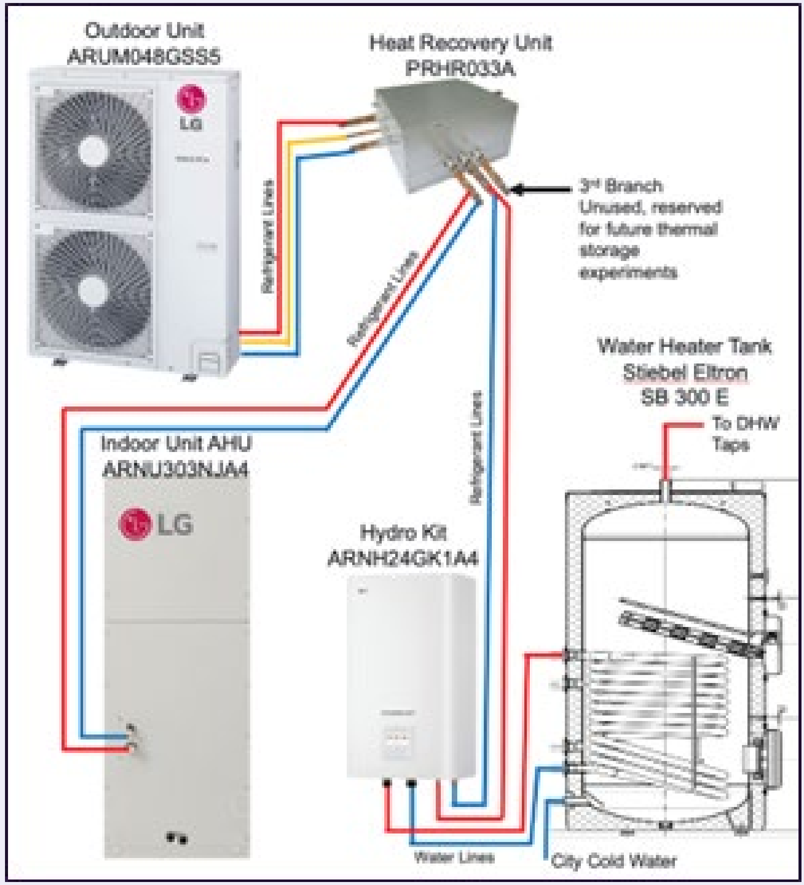
Outdoor unit contains only the variable speed compressor and outdoor coil.

Indoor Units

The indoor units are AHU or ductless heads with a refrigerant coil. For water heating the heat recovery unit supplies refrigerant to a Hydro Kit with refrigerant to water heat exchanger that then supplies hot water to a separate indirect DHW tank. Some products can recover heat from space cooling to heat hot water more efficiently.

Implementation Challenges

High equipment and installation costs. System complexity, installation requirements, and control strategies require specific expertise for installation, limiting workforce and market readiness.



LG Global Business. LG Multi VS with Hydro Kit.

System Type Comparison

Pros and Cons of System Types

Monobloc and Hydro-Split Systems

+ Factory sealed with pre-charged refrigerant reduces leakage and supports low-GWP refrigerants (A2L, A3). Storage tanks can add thermal energy storage.

- Needs glycol in freezing climates and lacks simultaneous DHW and space cooling. Requires skilled installers to properly size and specify system components. Hydronic space conditioning and additional heat exchanger add to system complexity and reduce efficiency. Alternating between space cooling and DHW heating reduces efficiency.

DX Split Refrigerant Systems

+ Avoid freezing risks and improve efficiency with fewer heat exchangers, allow simultaneous DHW and space heating, allow heat recovery from space cooling for more efficient DHW heating. Can be installed by existing residential HVAC workforce.

- More refrigerant in building than typical refrigerant split systems with field-made refrigerant line connections inside building.

Refrigerant Split Hydronic Systems

+ Avoid freezing risks with small amount of refrigerant in building, allow simultaneous DHW and space heating. Storage tanks can add thermal energy storage.

- Need field refrigerant connections and lack simultaneous DHW heating with space cooling. Additional indoor unit increases cost.

DX Split VRF Systems

+ Offer highest flexibility with simultaneous space heating and space cooling via heat recovery, allow heat recovery from space cooling for more efficient DHW heating.

- Have higher refrigerant charge, complex installations require skilled labor, limited optimized control for DHW, additional indoor heat recovery and hydro kit units increases cost

System Type Comparison

Design Considerations

Monobloc and Hydro-Split Systems

- Freeze risk with outdoor water lines
- Complex system sizing and component specification
- Hydronic space conditioning may reduce efficiency and increase cost
- Generally unable to provide two functions simultaneously

Refrigerant Split Hydronic Systems

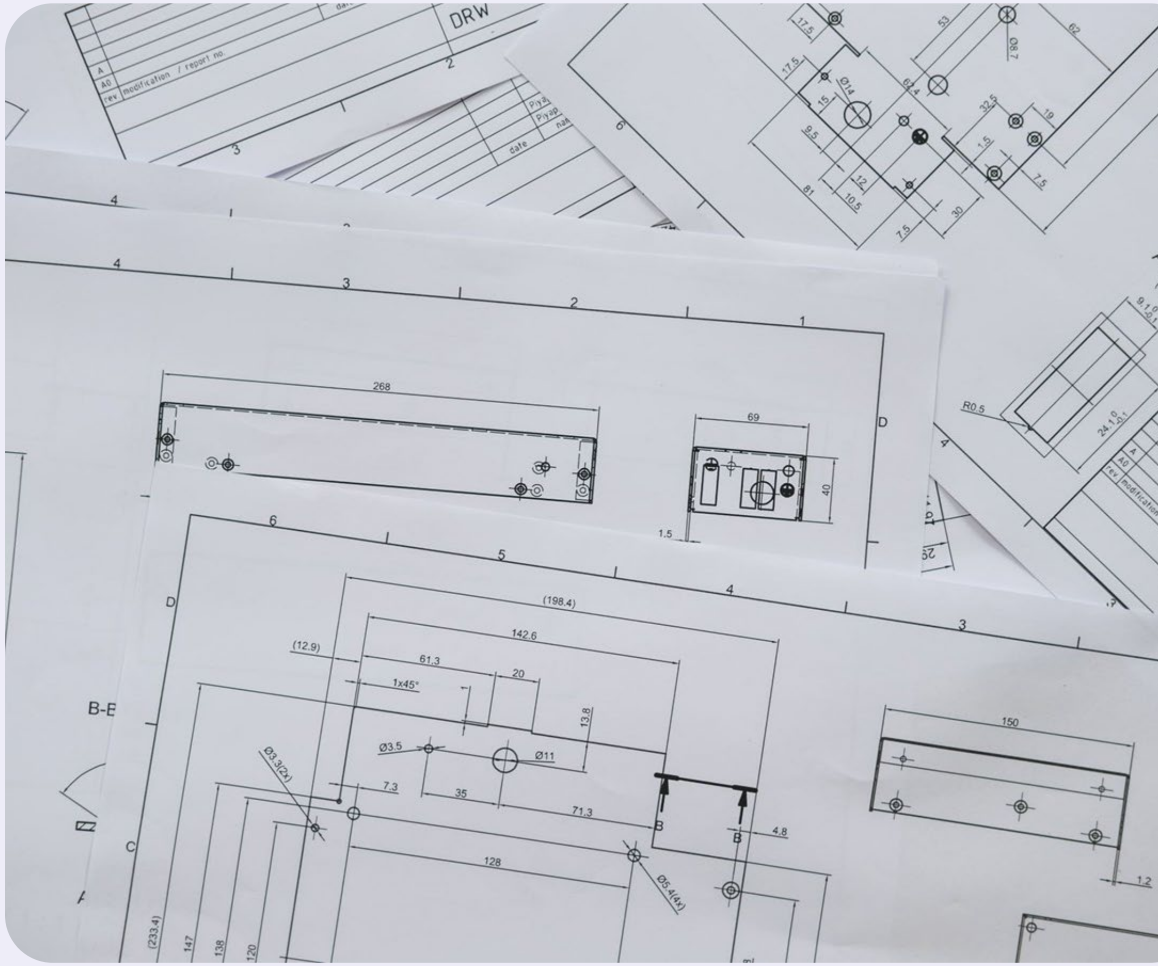
- Hydronic space conditioning may reduce efficiency and increase cost
- Simultaneous DHW heating and space cooling is not possible
- Indoor refrigerant may require safety precautions for flammable refrigerants

DX Split Refrigerant Systems

- Indoor refrigerant may require safety precautions for flammable refrigerants

DX Split VRF Systems

- Indoor refrigerant may require safety precautions for flammable refrigerants
- Additional pipe running between outdoor unit and heat recovery unit is needed
- Complex system design and controls require skilled installers
- Requires skilled contractors likely with previous experience with VRF systems



Global Market Landscape

Adoption Trends, Drivers, and Barriers

Global Adoption Leaders

Europe and Asia lead in heat pump adoption, driven by policies, infrastructure, and contractor expertise.

Key Market Drivers

Regulations, energy efficiency, and low-GWP refrigerant transitions drive market growth globally.

Adoption Barriers

High costs, limited contractor knowledge, product scarcity, and building codes restrict market expansion.

U.S. Market Status

U.S. market is nascent but growing amid electrification and decarbonization initiatives.

Market Adoption Barriers and Potential Solutions

High Installation Costs

Hardware and labor costs are primary barriers, significantly raising installation expenses. Costs should reduce with increased contractor familiarity and expanded product selection. Some systems are already cost-competitive in certain scenarios.

Contractor Knowledge Gaps

Limited installer familiarity increases costs and risks due to added contingencies. Crossover between HVAC and plumbing trades for hydronic systems. Training and workforce development is needed to upskill.

Programs Acceptance of Standardized Testing

Programs can accept the current seasonal ratings for the separate space conditioning and water heating functions. Tri-mode specific testing and rating procedures have been developed and will hopefully be adopted by AHRI and federal minimum efficiency requirements soon.

Low Product Awareness and Availability

Homeowners' low awareness of technology limits sales. Low product availability due to underdeveloped market. These barriers are addressed with program adoption, marketing, and market development.

Restrictive Building Codes

Limitations on flammable and slightly flammable refrigerants add installation complexity and completely eliminate ability to install R290 monobloc systems.

NEEA Market Landscape

Adoption Trends, Drivers, and Barriers

Regional Adoption Potential

Homes with existing hydronic heating and homes in which an electrical upgrade will be avoided are target markets for tri-mode systems.

Key Market Drivers

Regulations focused on decarbonization and energy efficiency, low-GWP refrigerant transitions drive market growth.

Adoption Barriers

High costs, lack of approved standardized testing limits program adoption, lack of a specialized contractor base, smaller number of products available, and building codes restrict market expansion.

Target Markets in the Northwest

High-Potential Target Markets

New mobile, manufactured homes, and existing homes with electric resistance, propane, or oil heating show strong potential for adoption. Existing homes with fuel water heating that can avoid electrical upgrades with tri-mode HP systems can be cost effective as well.

New Construction Opportunities

New single-family and multifamily construction can utilize holistic system designs for optimal efficiency and adoption.

Low-Potential Market Segment

Existing single-family homes with natural gas space heating have lower bill savings and higher retrofit complexity, reducing market potential.

Focus on Early Adoption

Targeting beachhead markets enables early adoption where value is highest and barriers are minimized.

Energy and Cost Savings Potential

Challenges in Savings Quantification

Lack of standardized testing and inconsistent data limit accurate energy and cost savings calculation for tri-mode heat pumps.

Need for Seasonal Performance Metrics

Reliable seasonal metrics are essential for utilities to model savings and develop Technical Resource Manual measures confidently.

Future Standard Implementation

Reassessing savings potential is recommended after implementing CSA C715, a load-based, climate-specific testing standard.

TRM Measures for Tri-Mode DX Split Systems

Development of TRM measures for DX split systems is necessary to evaluate their eligibility for incentive programs.

Market Overview

Key Findings

- The U.S. market is still emerging (ATAHP tri-mode earlier stage)
- AWHP tri-mode products are more available than ATAHP
- Many AWHP systems require multi-OEM integration which adds cost and complexity
- EU and Asia adoption is ahead of the U.S. market

Regional Fits

Key Findings

AWHP

- Best for hydronic heating + forced-air cooling regions
- Leverages existing hydronic & HVAC workforce skills

ATAHP

- Best for ducted forced-air regions
- Can align with typical U.S. HVAC installations

Refrigerant Trends

Key Findings

- Future regulations likely require low-GWP refrigerants
- A2L and A3 refrigerants introduce flammability concerns
- Monobloc AWHP keeps refrigerant outdoors and likely better suited for ultra-low GWP options (e.g., R290)

Adoption Barriers

Key Findings

- Higher upfront cost for whole tri-mode system than single equipment replacement (e.g., HPWH only)
- Limited contractor & homeowner awareness
- Need for design, sizing, and integration upskilling
- Lack of adopted standardized ratings
- Limited product availability (although growing)
- Restrictive building codes

Value Propositions

Key Findings

- Avoids cold air impact from indoor HPWH
- Increases thermal storage and load shifting capability
- Reduces overall refrigerant charge in most scenarios (not VRF)
- Can avoid costly electrical upgrades
- Can provide space savings for smaller retrofits

Cost Comparisons

Key Findings

- Similar cost to separate ASHP + HPWH systems
- More competitive in homes with existing hydronic systems
- Most competitive when tri-mode system avoids electrical upgrades
- Final cost depends heavily on contractor pricing

US Market Potential

Key Findings

- Strongest in new construction markets
- Existing hydronic heating (fuels or electric resistance)
- Homes with limited electrical capacity
- Regions with significant cooling demand

Northwest Market Potential

Member of **WSP**

Key Findings

- New mobile, manufactured homes, and existing homes with electrical resistance, propane, or oil heating
- New single-family and multifamily construction
- Retrofits that avoid electrical panel upgrades
- Early-stage adoption opportunity

Conclusions and Strategic Recommendations

Market Transformation Potential

Under current regulations: ATAHP systems show stronger market transformation potential than water-based systems.

If GWP limits imposed: AWHP systems will likely be solution if GWP limits below roughly 50 GWP are enacted.

Overcoming Adoption Barriers

Targeted incentives, contractor training, and standardized testing can accelerate adoption despite barriers.

Strategic Market Focus

Focusing on defined beachhead markets builds momentum and reduces costs through learning and scale.

Next Steps for NEEA and Stakeholders

Pilot Program Development

Develop pilot programs in targeted beachhead markets to test and refine tri-mode heat pump system architecture fit and adoption strategies.

OEM Collaboration

Collaborate with manufacturers to increase product availability and enhance data transparency.

Standards Advocacy

Advocate for CSA C715 (standardized testing) adoption and development of TRM measures to support regulatory frameworks.

Contractor Training Initiatives

Launch training programs for contractors to build market capability and ensure effective technology deployment.

Q&A and Discussion

Further questions? Reach out.

Christopher Dymond
Cdymond@NEEA.org

Parker Wall
Pwall@trccompanies.com

Dave Vernon
Dvernon@trccompanies.com