# Decarbonization Pathways for Minnesota's Natural Gas Sector

## Mitigating Winter Peak Load with GSHPs and Demand Response

Presented at the 2025 ACEEE Energy Efficiency as a Resource Conference

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# About Synapse

- Founded in 1996 by Bruce Biewald and Jean Ann Ramey
- Leader for public interest and government clients in providing rigorous analysis of the electric power and natural gas sectors
- Staff of 40+ includes experts in energy, economic, and environmental topics
- We assist clients with analyzing costs, energy savings, rate and bill impacts, energy system impacts, emissions, relating to future of gas and building decarbonization pathways

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# Overview

## Scenario development

- Decarbonization pathways for Minnesota’s natural gas sector

## Methodology

- Estimate electric peak impacts from electrification

## Study results

- Electric peak impacts and associated costs

## Sensitivity analysis

- High GSHP adoption
- Demand response

## Conclusions

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# Project Background

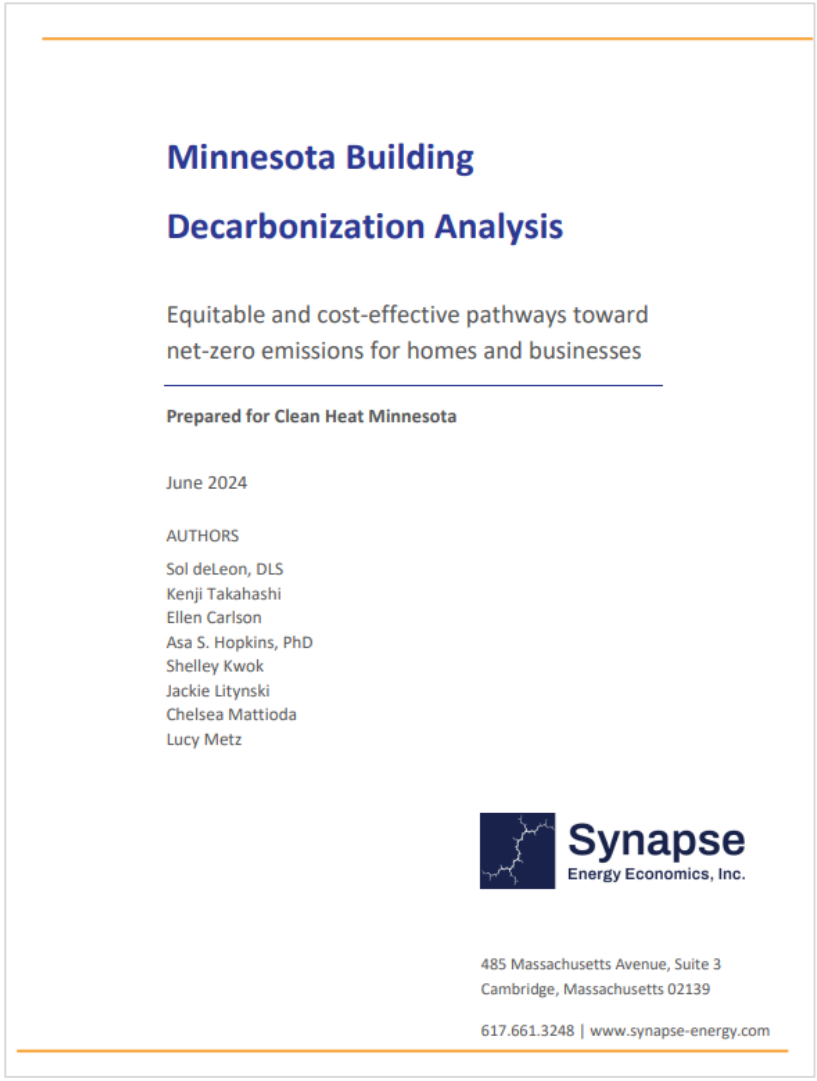
Minnesota set statutory targets to achieve net zero emissions by 2050

- Building sector decarbonization identified as a key strategy for meeting these goals.
- The majority of Minnesota buildings heat with natural gas.
- Recent legislation: gas utilities file innovation plans to reduce emissions.(1)

For Clean Heat Minnesota, Synapse analyzed decarbonization pathways for Minnesota's natural gas distribution sector, consistent with GHG emission reduction goals

**Read the full report:**

Synapse, 2024. *Minnesota Building Decarbonization Analysis: Equitable and cost-effective pathways toward net-zero emissions for homes and businesses*




*(1) Minn. Stat. §§ 216B.2427 Natural Gas Utility Innovation Plans, https://www.revisor.mn.gov/statutes/cite/216B.2427*

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# Project Background

## Study Objective:

To help identify the most **feasible, equitable, and cost-effective** pathways for reducing emissions from Minnesota's **natural gas distribution sector**, consistent with GHG emission reduction goals.

## Question:

How do different approaches to building decarbonization impact the grid?

## Approach:

Synapse used our in-house modeling tools to analyze two "book-end" scenarios for achieving emissions reductions.

***Analysis components***

| | | |
|---|---|---|
| Building sector | Customer bill impacts | Environmental and health externalities |
| Gas utility sector | Electric peak load impacts | Equipment costs |

*Focus of this presentation*

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# “Book-end” scenarios to illustrate potential pathways to decarbonization

| | Full Electrification | Electrification + Alternative Fuels |
|---|---|---|
| **Primary heating equipment** | • All-electric ASHP with electric resistance backup: 91%<br>• Dual-fuel ASHP with gas backup: 0%<br>• GSHP: 5% | • All-electric ASHP with electric resistance backup: 71%<br>• Dual-fuel ASHP with gas backup: 16%<br>• GSHP: 3% |
| **Renewable natural gas (RNG)** | • None | • RNG blended into natural gas system starting in 2025, fully replaces natural gas by 2050 to serve remaining gas consumption |
| **Water heating, cooking, and drying equipment** | • HPWH and efficient electric appliances replace fossil-fuel-based equipment. | • Most households that stay on gas system keep gas for other end-uses<br>• Other fuels: same as Full Electrification |
| **Early replacements** | • Before-end-of-life equipment replacements phased in from 2045–2050 to eliminate fossil fuel systems | • None explicitly modeled |

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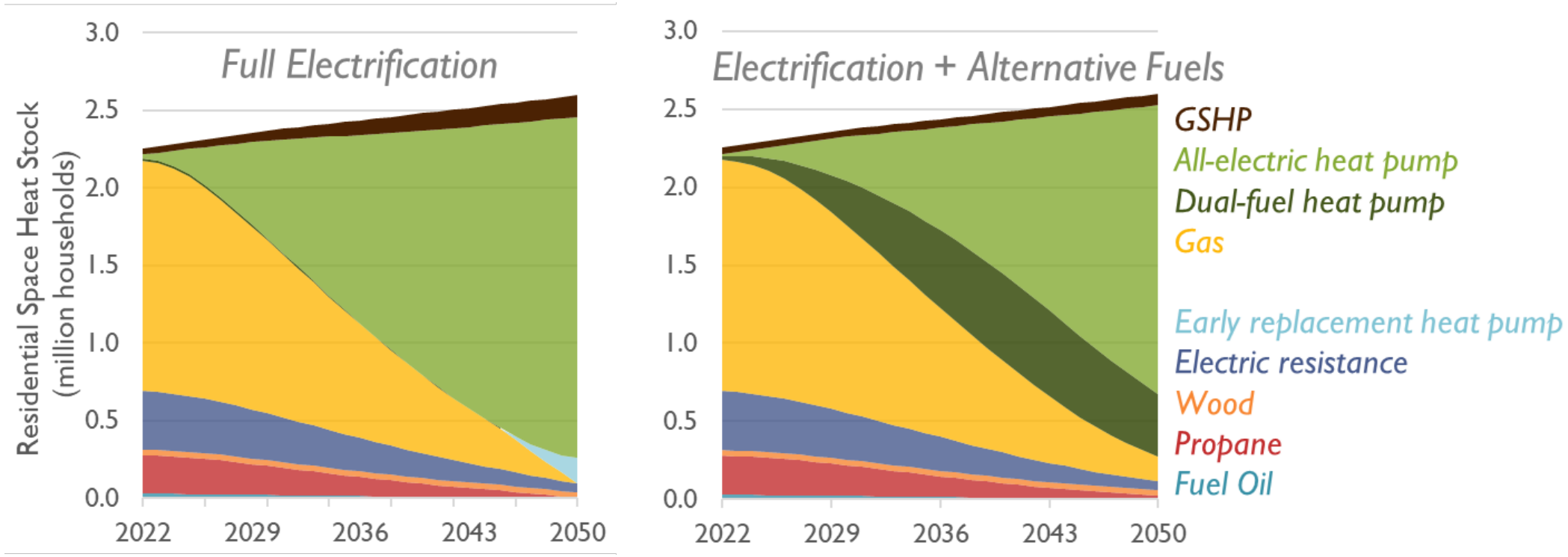
# Building Stock

**Residential space heating stock by equipment fuel type**




- By 2050, only 0.2% of homes are still connected to the gas system in the Full Electrification scenario, compared to 21% in the Electrification + Alternative Fuels scenario
- By 2050, annual electricity consumption roughly doubles under both scenarios

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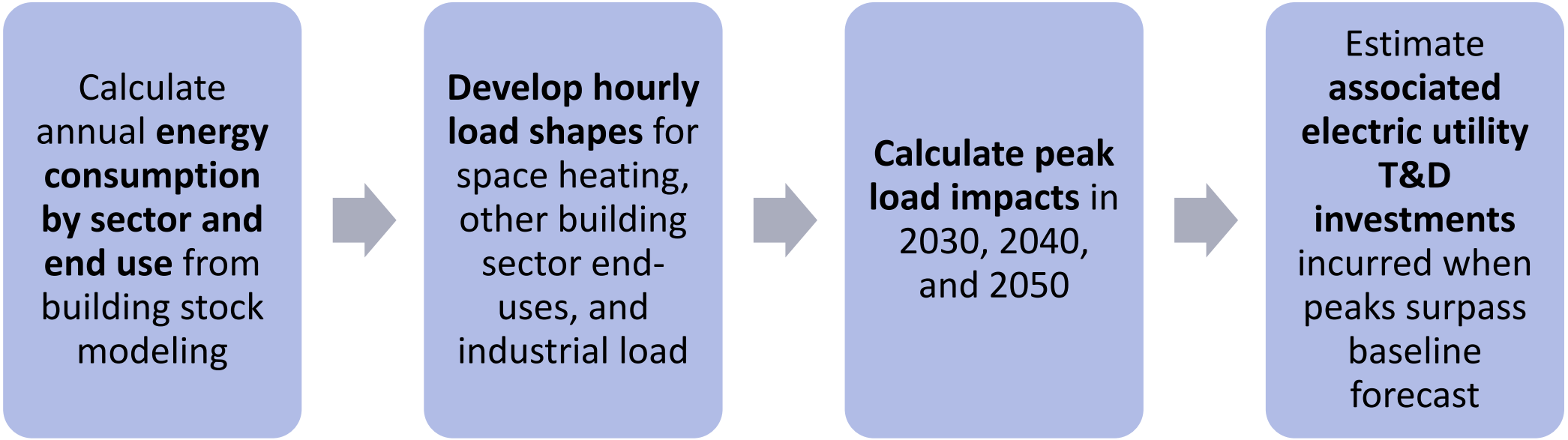
# Peak Load Impact Analysis for Electrification

We developed peak load projections across entire residential, commercial & industrial sectors

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# Peak Load Impact Analysis for Electrification: Space Heating

Hourly end-use loads estimated using NREL's End-Use Load Profiles (EULP) from ResStock & ComStock.

Convert gas heating profiles to heat pump load profiles

*Based on hourly temperatures and heat pump COP curves*

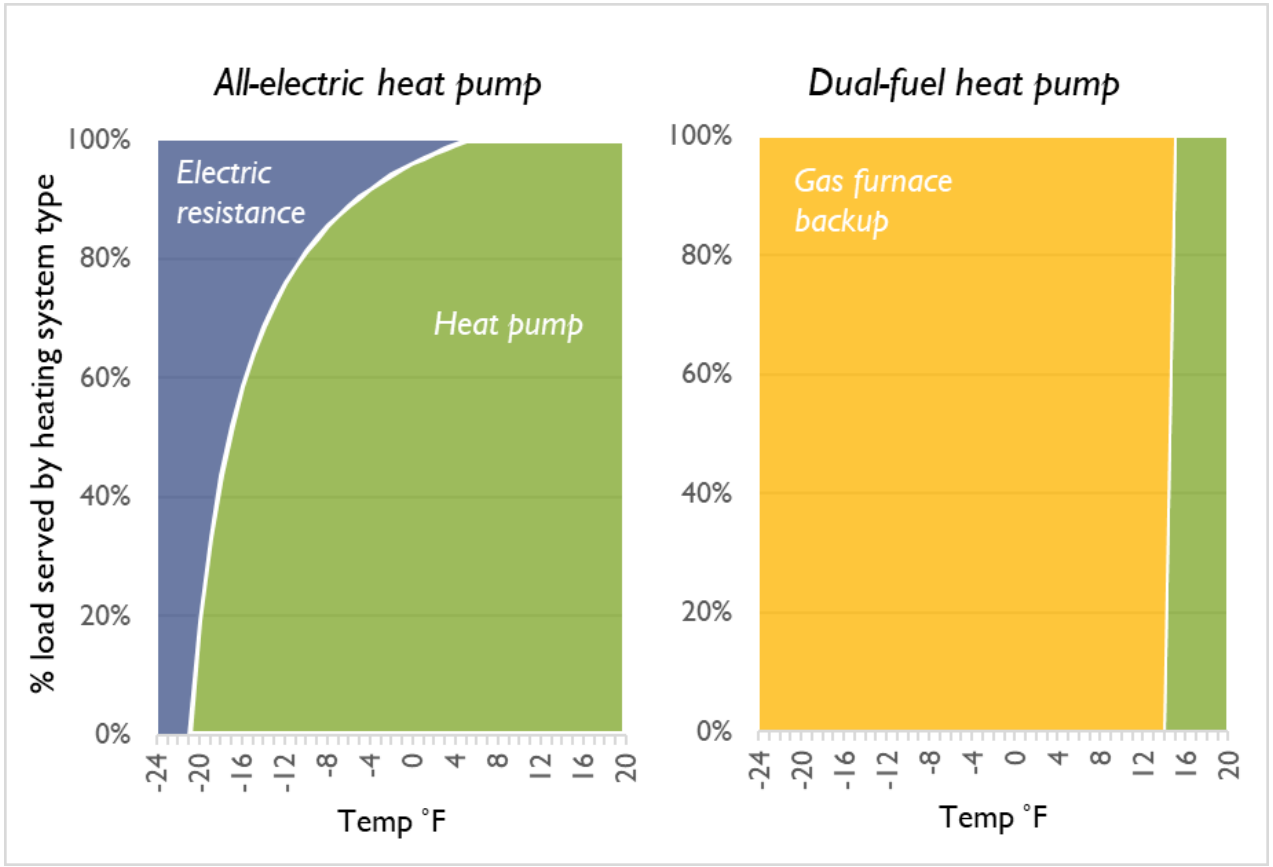
Account for backup heating.

*Dual-fuel ASHP with gas backup: 15°F*

*All-electric ASHP: electric resistance supplements at 5°F*

Develop estimates for extreme weather events

*Heat pumps assumed to be oversized to 120% of design load, meeting demand down to -21°F*

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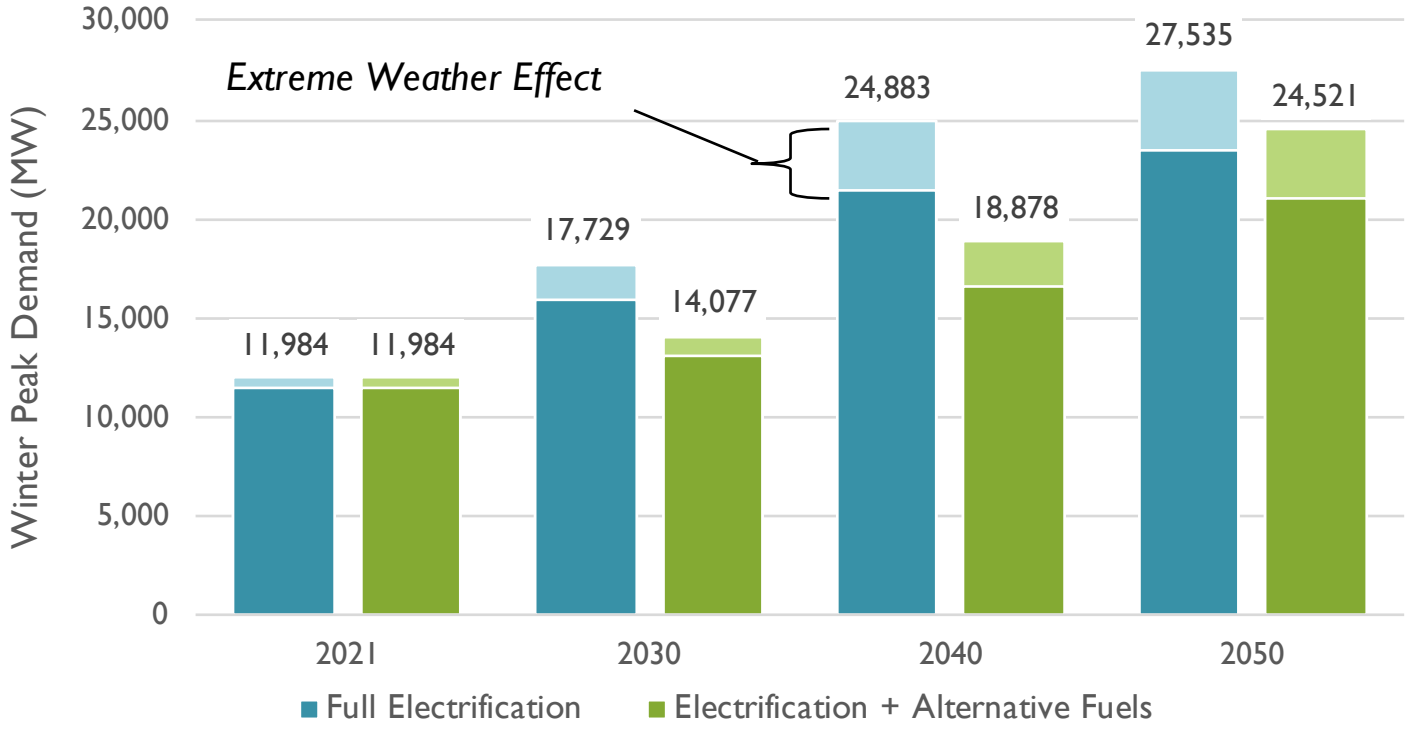
# Significant increase in system-wide electric peak, returning pre-2008 growth rate

**Winter peak load impacts between scenarios for all end uses, including industrial**




## Full Electrification

- Winter peak more than doubles to ~27.5 GW by 2050
- Heating loads more than triple (5.6 GW → 20 GW)
- Cumulative $2.6 billion in T&D investments (PV)

## Electrification + Alternative Fuels

- Winter peak up ~105% by 2050 (3 GW lower)
- Heating loads double (→ 17.5 GW)
- Cumulative $1 billion in T&D investments (PV)

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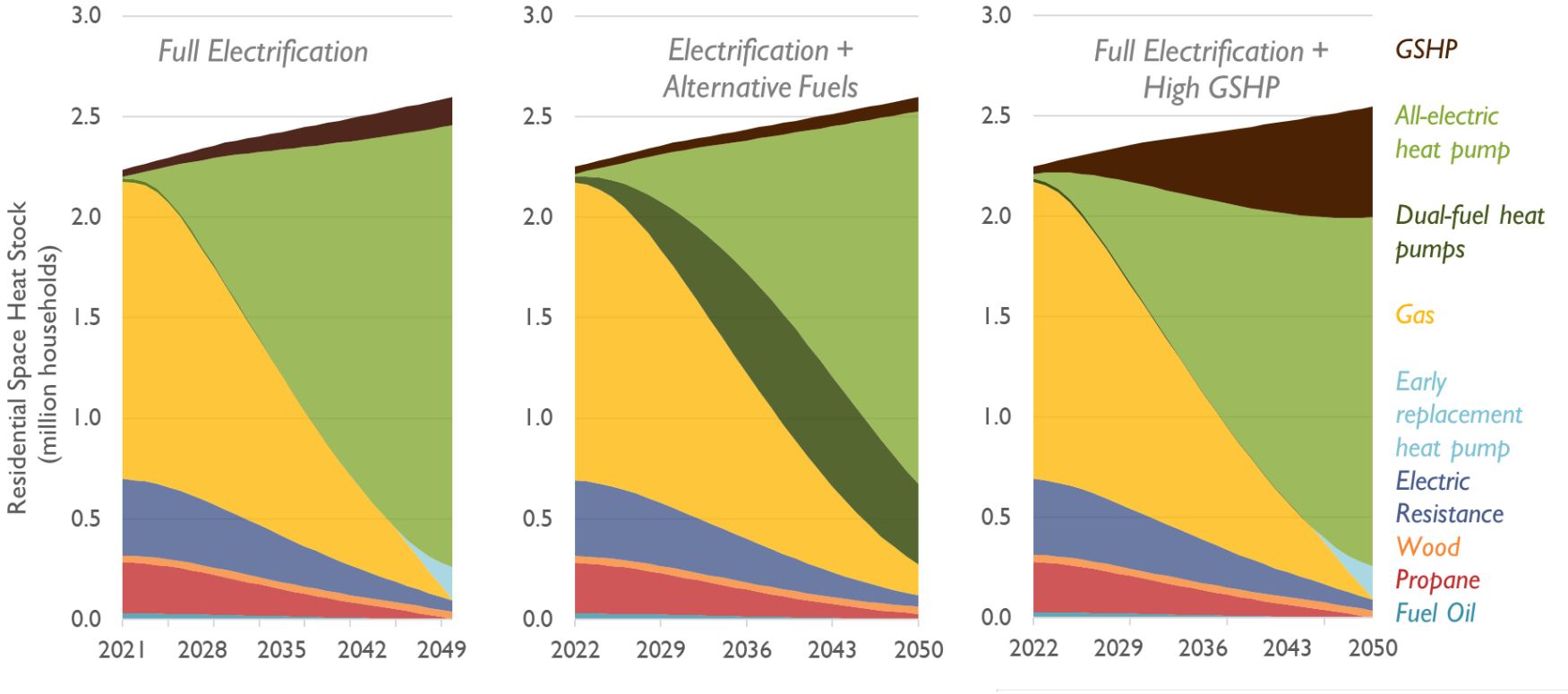
# High GSHP Sensitivity Case

We modeled a new scenario that included a higher GSHP market share and analyzed the impacts of GSHPs on energy consumption, emissions, and cost




**Key assumptions**

- GSHP market share: 25% of heat pump sales
- GSHP COP of 3.4 based on an in-field study in Minnesota[1]

*(1) University of Minnesota. 2016. Residential Ground Source Heat Pump Study. https://mn.gov/commerce-stat/pdfs/card-residential-gound-source-heat-pump-study.pdf*

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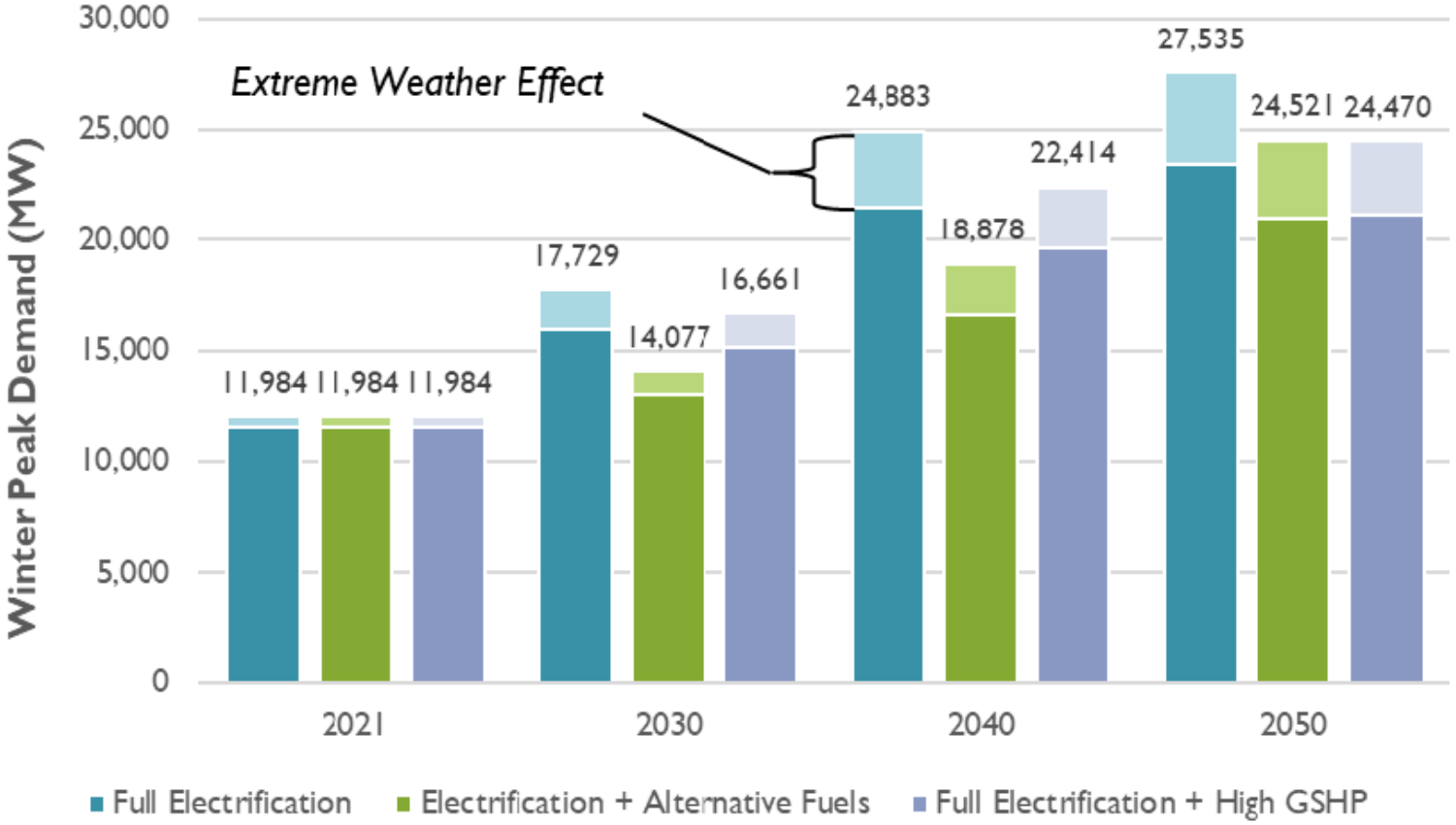
# High GSHP Sensitivity Case

**Winter peak load impacts for all end uses by scenario, including the Full Electrification + High GSHP case**




## High GSHP Sensitivity

- Winter peak 6-10% lower in 2050 than the Full Electrification case
- Cumulative $1.9 billion in net T&D investments (PV), 27% less than Full Electrification

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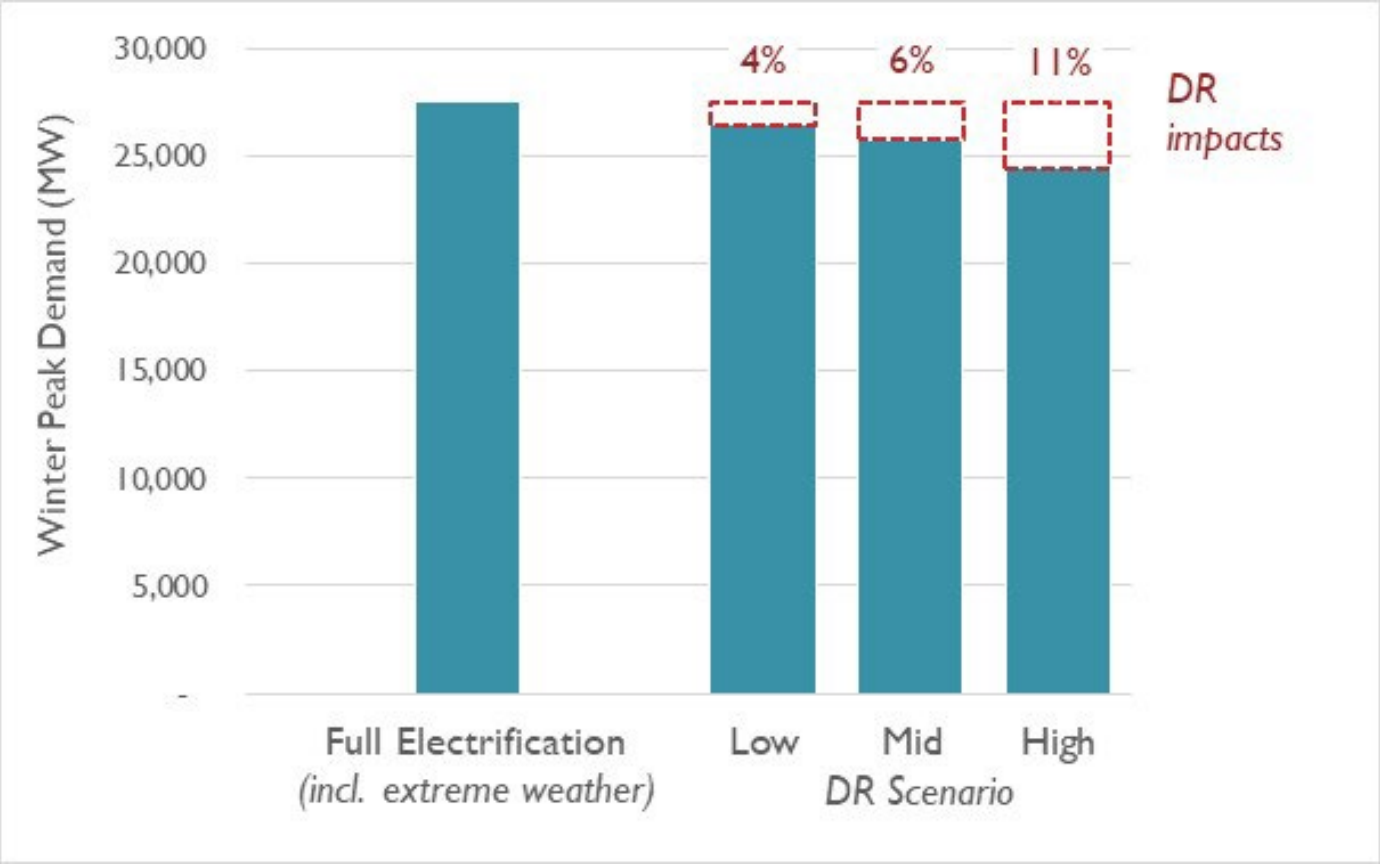
# Demand Response Impacts

**Potential winter peak load reductions from demand response in 2050 for the Full Electrification case**




Methods

- Derived per-participant winter peak savings from DR literature
- Participation rates from 2021 U.S. DOE study(1)
- Applied savings × participation rates (2050)
- Estimated DR reductions for space & water heating

*(1) U.S. DOE. 2021. A National Roadmap for Grid-Interactive Efficient Buildings. https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf*

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# Conclusions

- Under both gas sector decarbonization scenarios, electric loads expected to **more than double by 2050**, switching to winter peaking system.
- **GSHPs** and **demand response** are promising for managing winter peak loads:
  - ***GSHPs*** *could cut winter peak demand by* ***6–10% by 2050***
  - ***Demand response*** *adds another* ***4–11% reduction***
- The study results highlight the need for **proactive, integrated utility planning** across gas and electric systems:
  - *Minimize cost and risk*
  - *Ensure an* ***equitable, reliable, and cost-effective clean energy transition*** *in cold climates*

Read the full report here: https://www.synapse-energy.com/minnesota-building-decarbonization-analysis

Thanks again to Clean Heat Minnesota:

*Citizens Utility Board of Minnesota*
*Comunidades Organizado El Poder y La Acción Latina (COPAL)*
*Fresh Energy*
*Minnesota Center for Environmental Advocacy*
*Sierra Club North Star Chapter*

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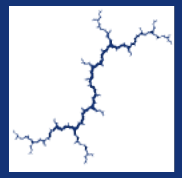
# Thanks!



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