Grid Planning for Building Electrification

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

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ESIG DER Working Group

Grid Planning for Building Electrification Task Force

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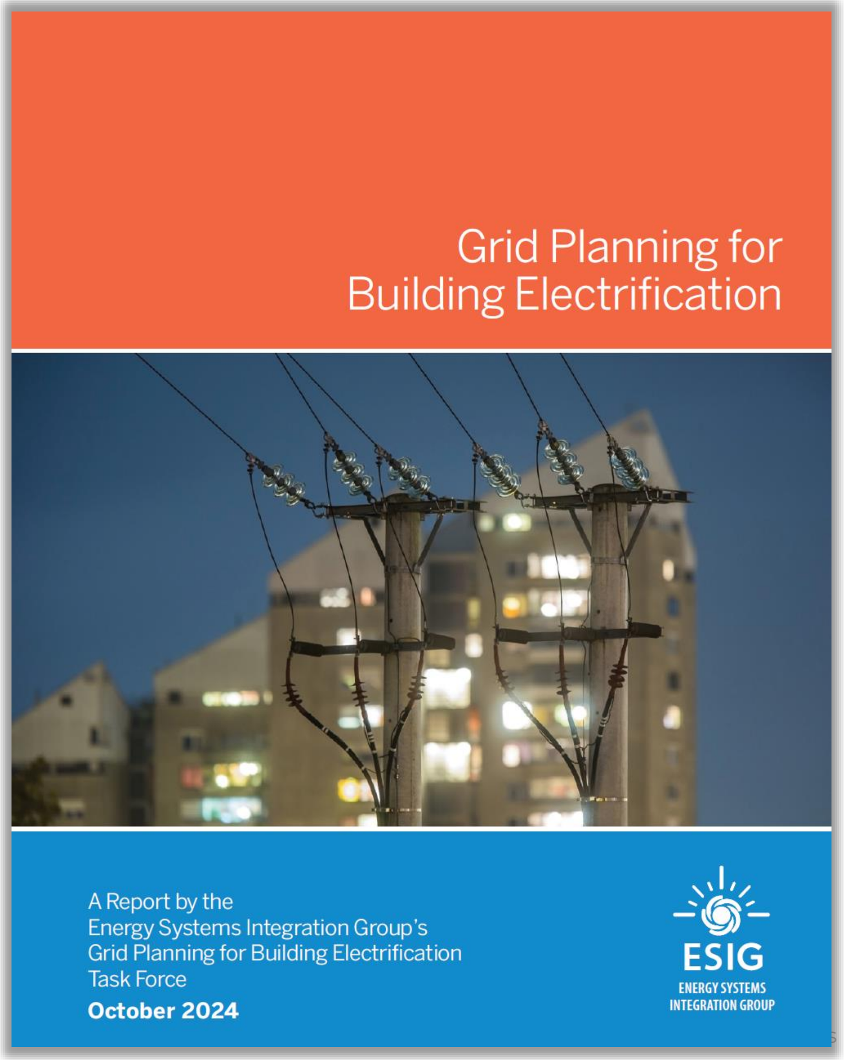
https://www.esig.energy/grid-planning-for-building-electrification/



Agenda

- What is building electrification?
- Challenges presented by building electrification
- Solutions
  - Improve Load forecasting
  - Modernize Planning Approaches
  - Use Energy Efficiency and Demand Management
  - Touch the grid once using a coordinated approach

What is Building Electrification?

Residential & Commercial Sector Electrification

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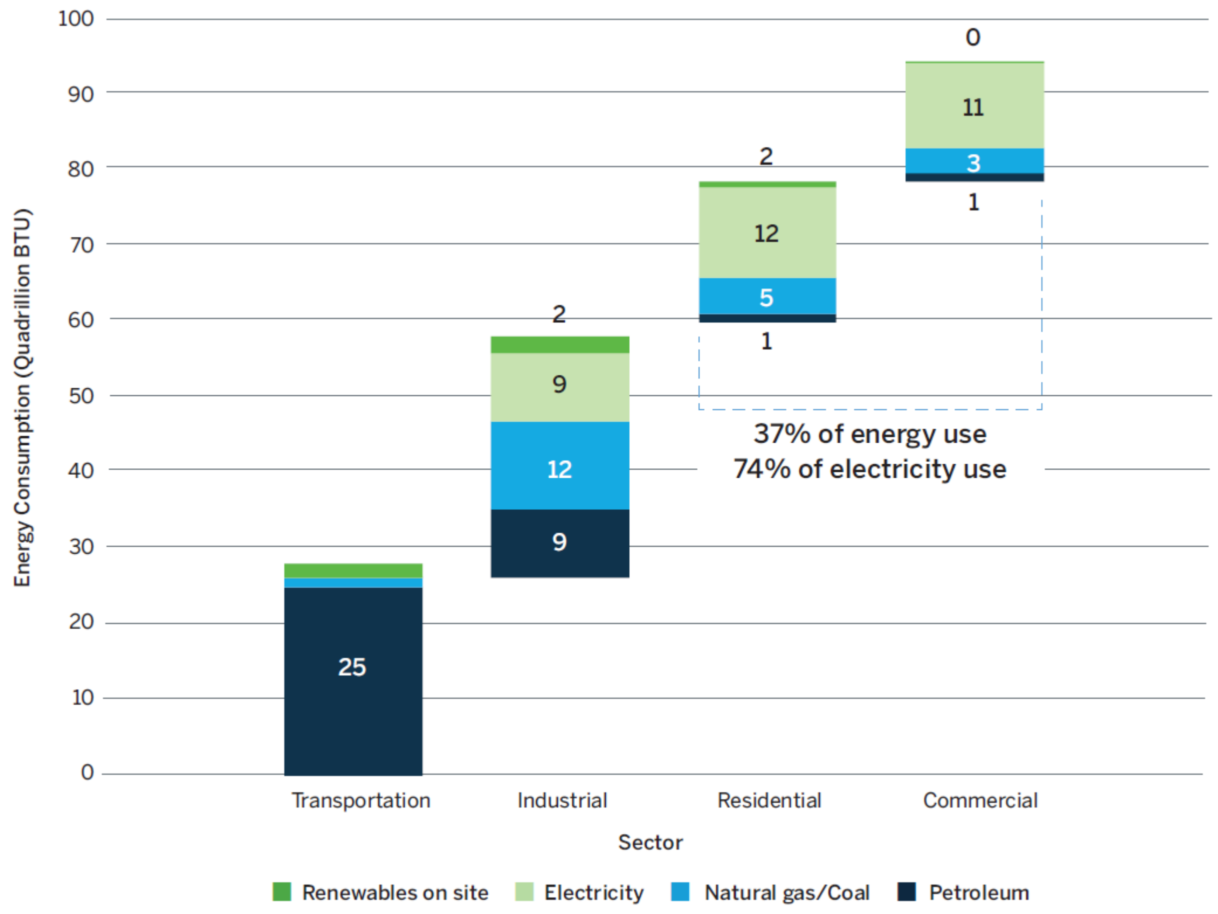
Energy Consumption by Sector of the US Economy, 2023



In-Scope

HVAC | Water Heating | Clothes Drying | Cooking

Out of Scope

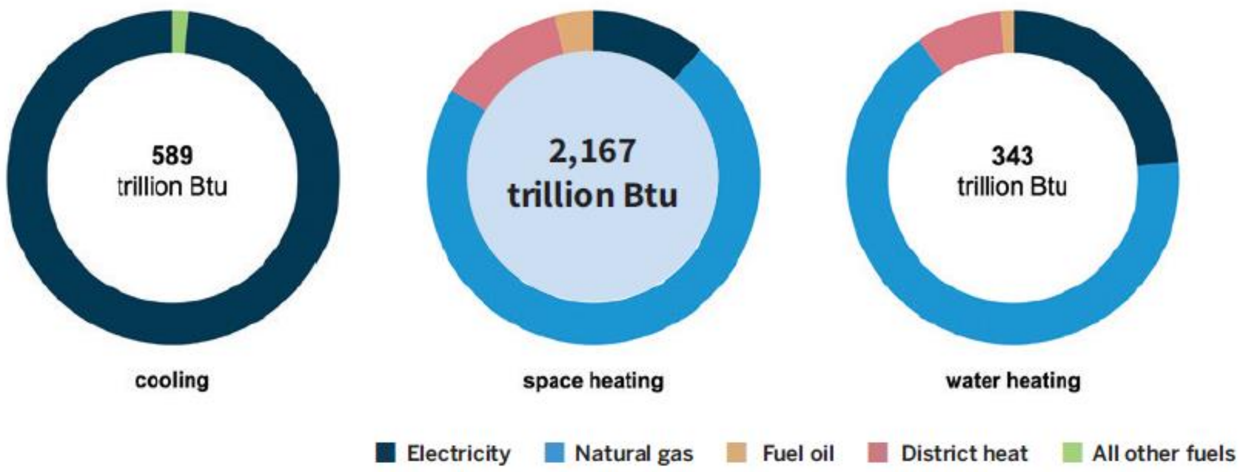
Data Centers | Industrial | DER Ecosystem | Hydrogen

Image source: ESIG, Data via EIA

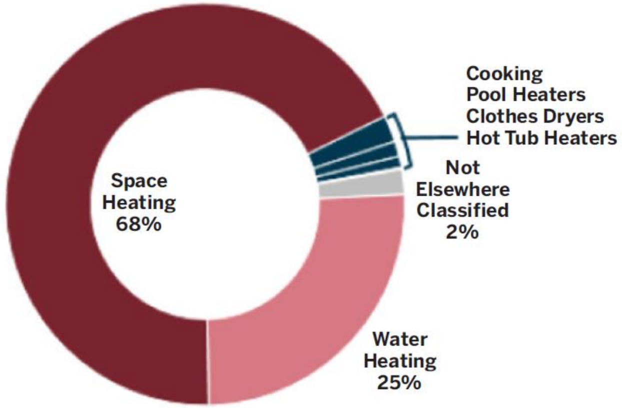
What is Building Electrification?

Mostly Heat Pumps for Space Heating

Commercial Energy Consumption by Fuel and End Use



Residential Natural Gas Consumption by End Use



Heat Pump Technology

- An air conditioner that can run in reverse.
- Transfers heat from one place to another
- Comes in many shapes, sources, and sizes
- Can be used in commercial and residential spaces and for water heating

Image sources: EIA 2023

What is Building Electrification?

Building Electrification can affect all regions

Different regions across the country are at different levels of electrification. Transitioning the non-electric energy consumption to electricity could have dramatic effects on the electricity sector.

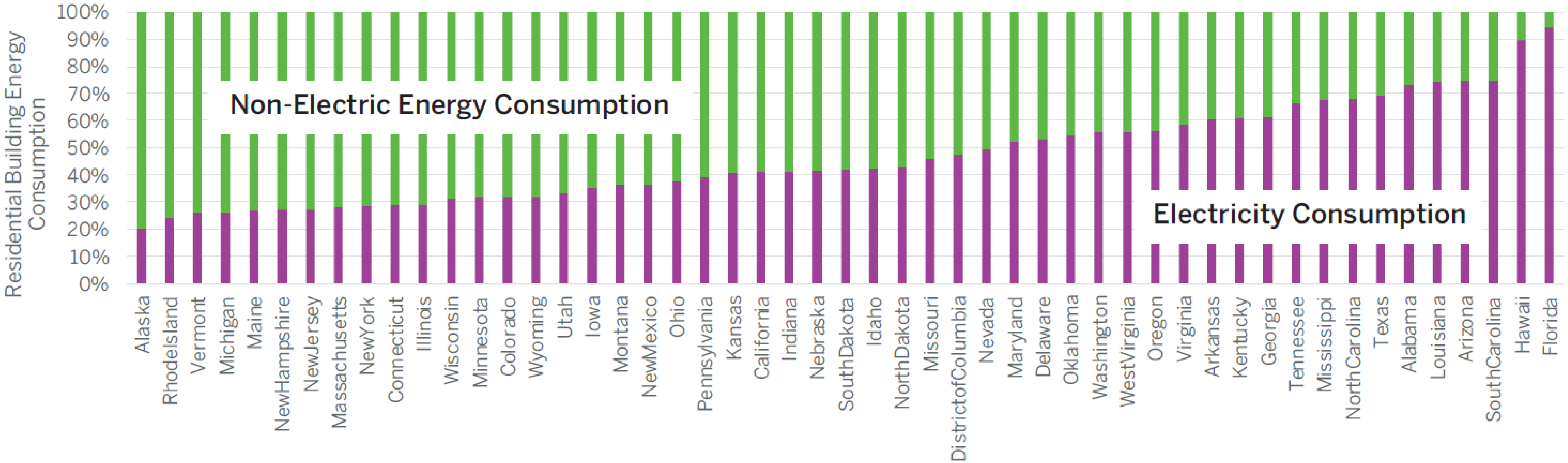
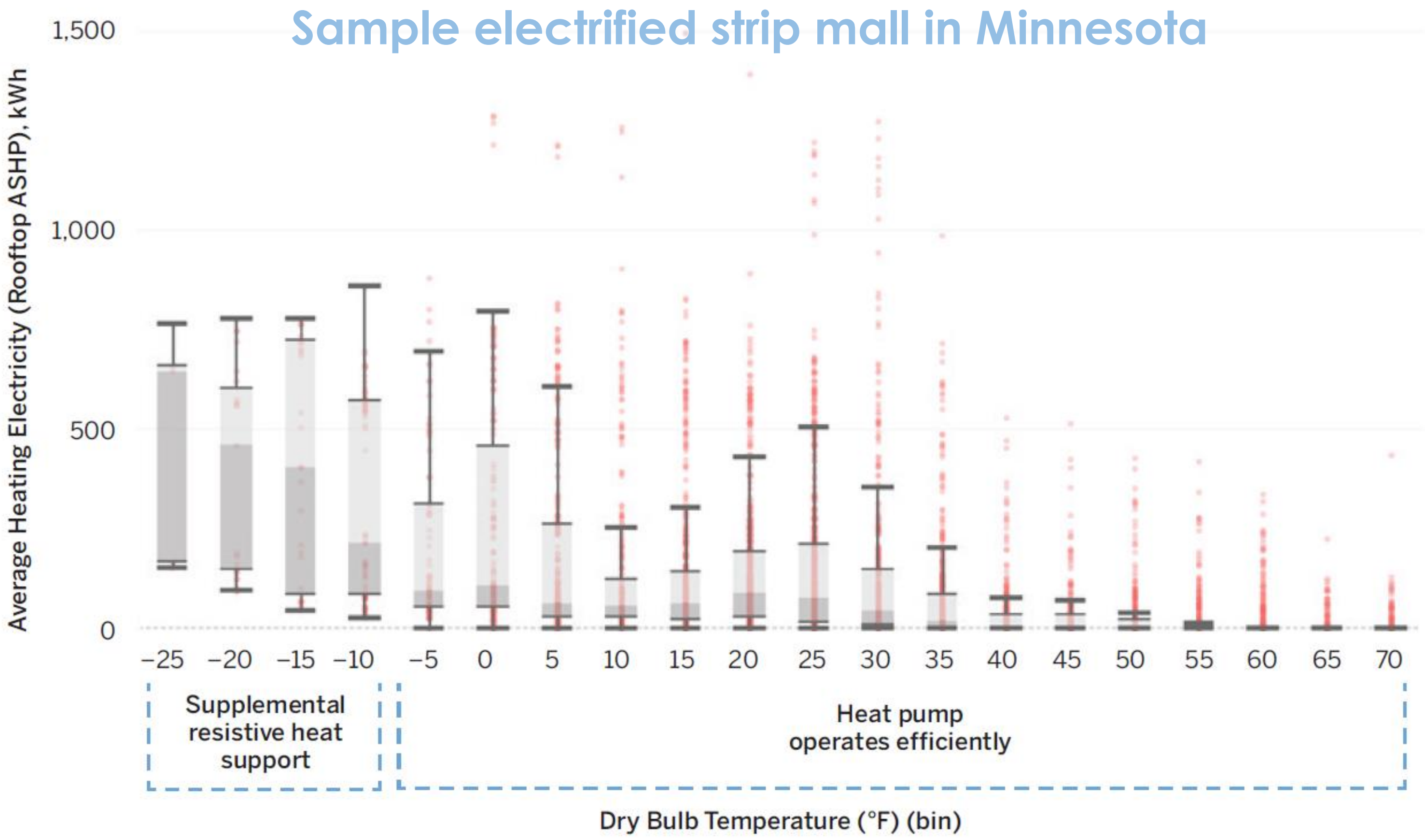


Image source: ESIG, Data via EIA

Increasing Weather Dependence

Nonlinear electric demand under very cold temps. As heating demands increase, heat pumps can rely on supplemental resistive heating support.



Source: National Renewable Energy Laboratory ComStock AMY 2018, release 2024.1, 2024. Single retail strip mall in MN with measure 1: Heat Pump RTU and weather for Wadena, MN (170331-1.parquet, G270110_2018.csv).

Increasing Weather Dependence

Winter events often last longer, changing the stress profile on grid equipment

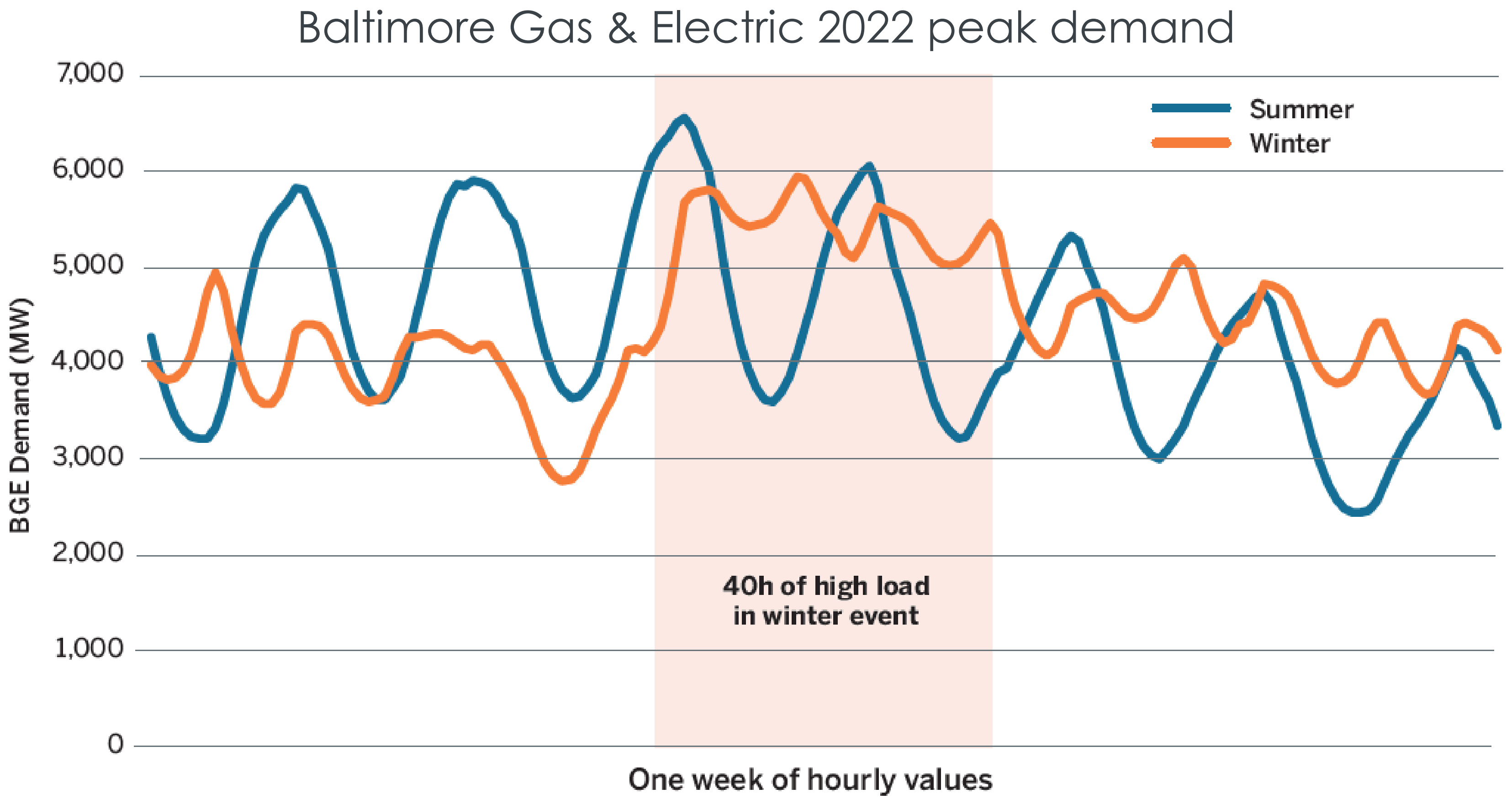


Image source: ESIG, Data via EIA930

Perceived Far Future Impacts

Perceived far future impacts as adoption of electric heating unfolds.

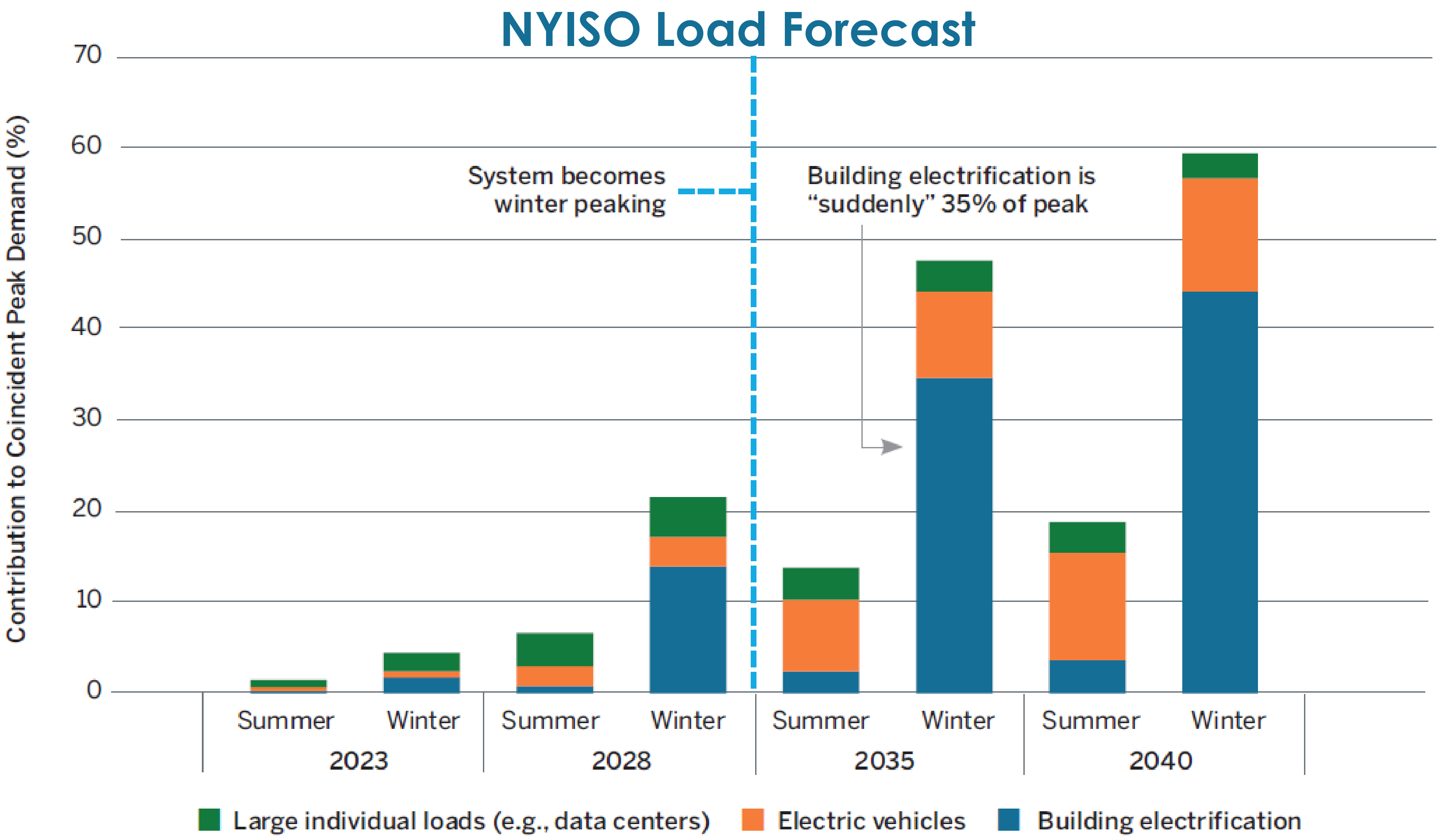


Image source: ESIG Analysis of NYISO 2023 Gold Book.

The Challenge of Building Electrification

Rapid Adoption

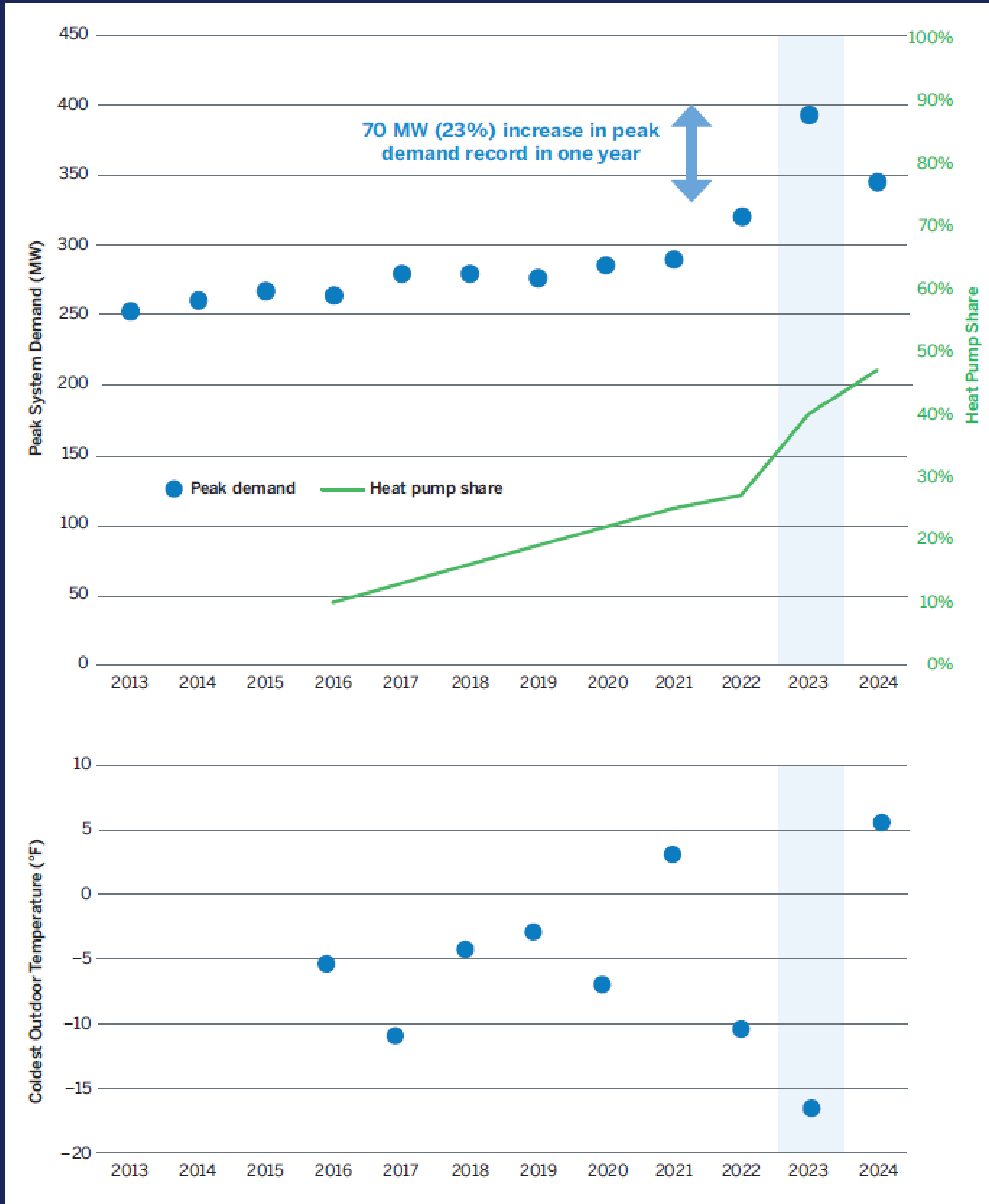
Potential for the Addition of New Loads to Outpace Utility Planning

- Prince Edward Island (PEI) has a program to provide free heat pumps to residents.
  - 7000 new heat pumps installed since 2021.
  - A cold snap in early 2023 led to a 23% year over year demand increase
- Last September, Maine met its goal of installing 100,000 heat pumps in households two years ahead of schedule and is aiming to install another 175,000 by 2027.
- In 2023, heat pumps outsold gas furnaces in the United States for the second year in a row

Image sources: ESIG analysis of various sources.

Prince Edward Island

Heat pump impact on system demand



Solutions

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Solutions for Grid Planning for Building Electrification

- Improve Load forecasting
- Modernize Planning Approaches
- Use Energy Efficiency and Demand Management
- Touch the grid once using a coordinated approach

Solutions:

Improve Load Forecasting

Sources of uncertainty change with electrification. Load forecasters are well positioned to communicate the tradeoffs, variables, and key assumptions that drive different outcomes

Best practices in load forecasting:

1. **Expand the Forecast Horizon and Broaden the Factors Considered**
2. **Use Multiple Sources** for forecasts to understand trade-offs, variables, and key assumptions driving forecasts
3. **Consider how buildings are used to establish a clear baseline.**
4. **Consider weather effects.** The weather-sensitivity factors that historically captured building response will change with increased electrification.

Components of Building Electrification Load Forecasts by Forecast Horizon

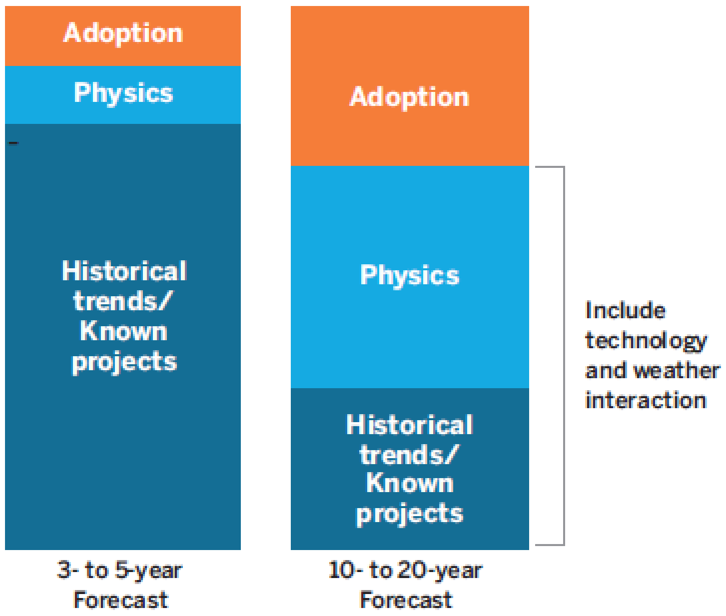


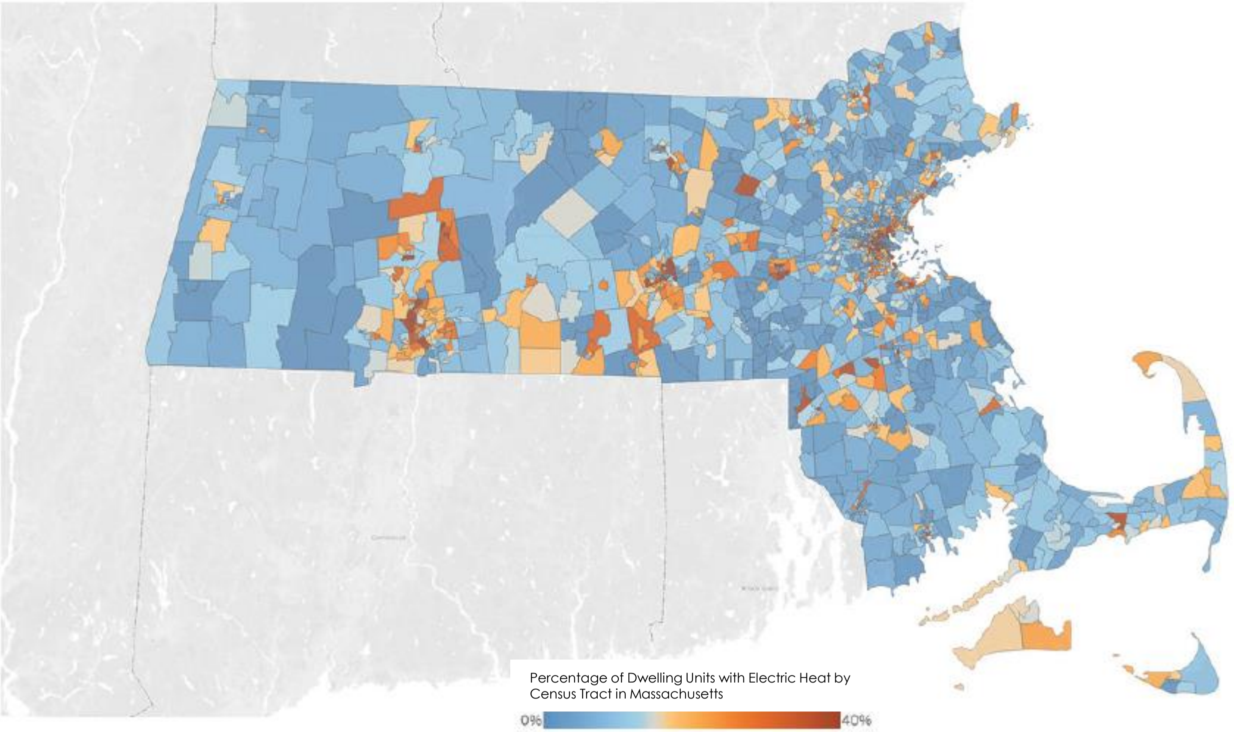
Image sources: ESIG.

Solutions:

Improve Load Forecasting

Consider how buildings are used to establish a clear baseline.

End use changes impact buildings differently.



Consider weather impacts

Simulated Peak Winter Demand in New York in 2035 Under Different Electrification Scenarios

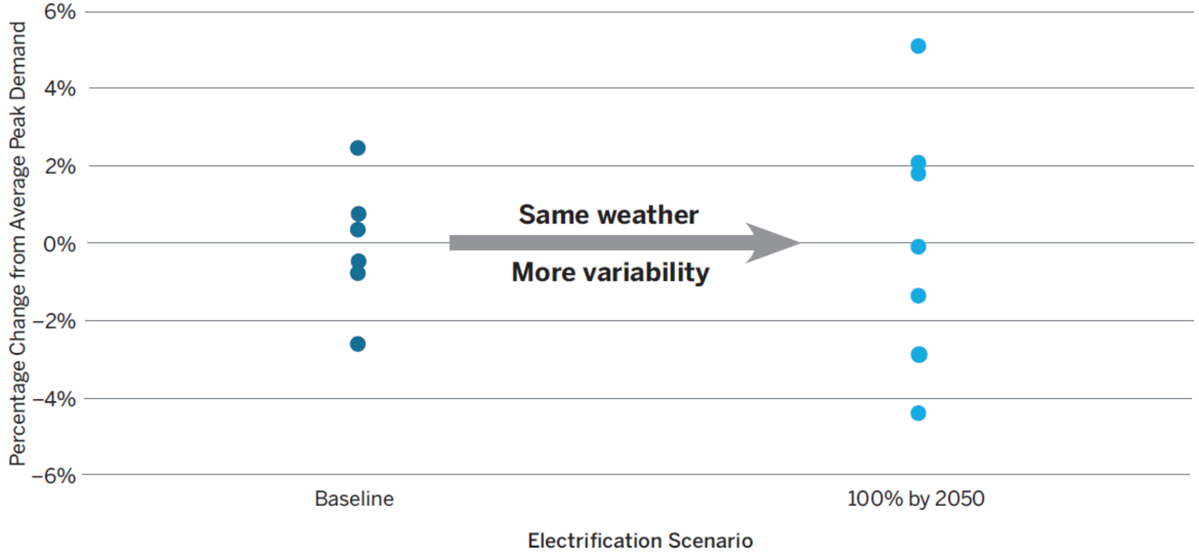


Image sources: (left) Cadeo; data from U.S. Census Bureau (2019)
(right) ESIG; data from Evolved Energy Research and National Renewable Energy Laboratory.

Solutions:

Modernize Planning Approaches

Changing risks and new forecast products prompt new planning approaches, beginning with evaluation of core planning assumptions for long-term suitability.

1. **Reconsider core planning assumptions, including equipment standards**
2. Move beyond a single peak hour
3. **Improve reliability and resilience metrics for an electrified future**
4. Share information across natural gas and electricity

Solutions:

Modernize Planning Approaches | Standards

Reconsider core planning assumptions, including equipment standards

Design conditions
by which standards and plans are made, such as outdoor temperature

Thresholds
that trigger further analysis

Headroom
margin planned for new equipment

Load Diversity
Heterogeneity of load impacts equipment sizing

Solutions:

Modernize Planning Approaches: Reliability and Resilience Metrics

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Rethinking distribution reliability metrics in the context of building electrification

- Reporting on distribution reliability metrics typically exclude “major event days” (MEDs) as defined in IEEE 1366, the standard that defines SAIDI, SAIFI, etc.
- Long-duration winter outages can have a large impact on human health
- Recent work also suggests an equity consideration:
  - High-income households experience proportionately larger losses to consumption during a one-day power interruption,
  - Low-income households experience proportionately larger losses during the longest power interruptions

Indoor Temperature Degradation of Different Types of Buildings in Power Outages During Winter Storms

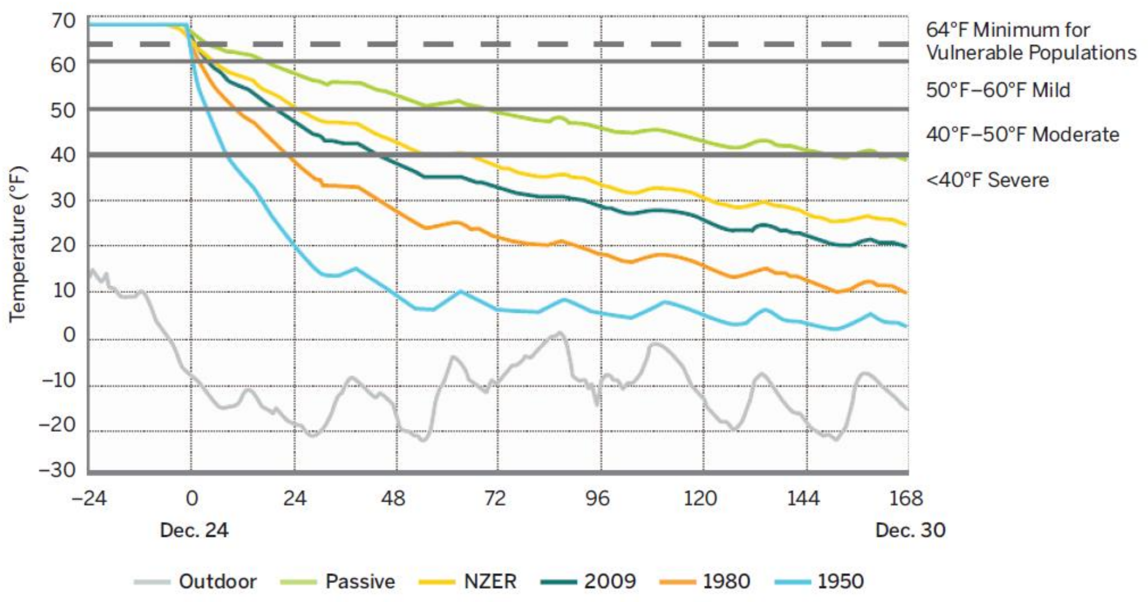

Image sources: Ayyagari, Gartman, and Corvidae (2020); Rocky Mountain Institute.

Solutions:

Energy Efficiency is More Important than Ever

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~~Energy Efficiency~~ "Thermal Resilience" and a whole-systems approach

- **Thermal autonomy** - a building maintains comfortable indoor conditions without grid inputs
- **Passive habitability** - how long a building remains habitable during extended power outages.

35% by 2035
50% by 2050

Target energy usage intensity improvements on-site at buildings relative to 2005 levels established in the U.S. DOE National Blueprint for the Buildings Sector.

EE impacts both peak and energy requirements

- Consider incentives as part of the planning process, by targeting incentives toward the most impactful upgrades in strategic locations

Solutions:

Touch the Grid Once

1. Invest in future-ready infrastructure—equipment that can support building electrification loads **over the long term** that are appropriate under any future.
2. Upsize equipment **during typical maintenance activities**
3. Planners should **consider the full extent of electrification** when designing grid systems and expand the planning horizon
4. Coordinate grid upgrade programs with **other programs** so that the grid does not create a barrier for building electrification deployment
   - “Touching the grid once” as an economic and equity/access strategy

Solutions:

Touch the Grid Once

Two kinds of grid upgrades:

1. "Future-ready" the grid with opportunistic upgrades:
   - Updated planning criteria
   - Reconsider design standards
     New load factors = different stress on the system
2. Discrete projects requiring upgrades

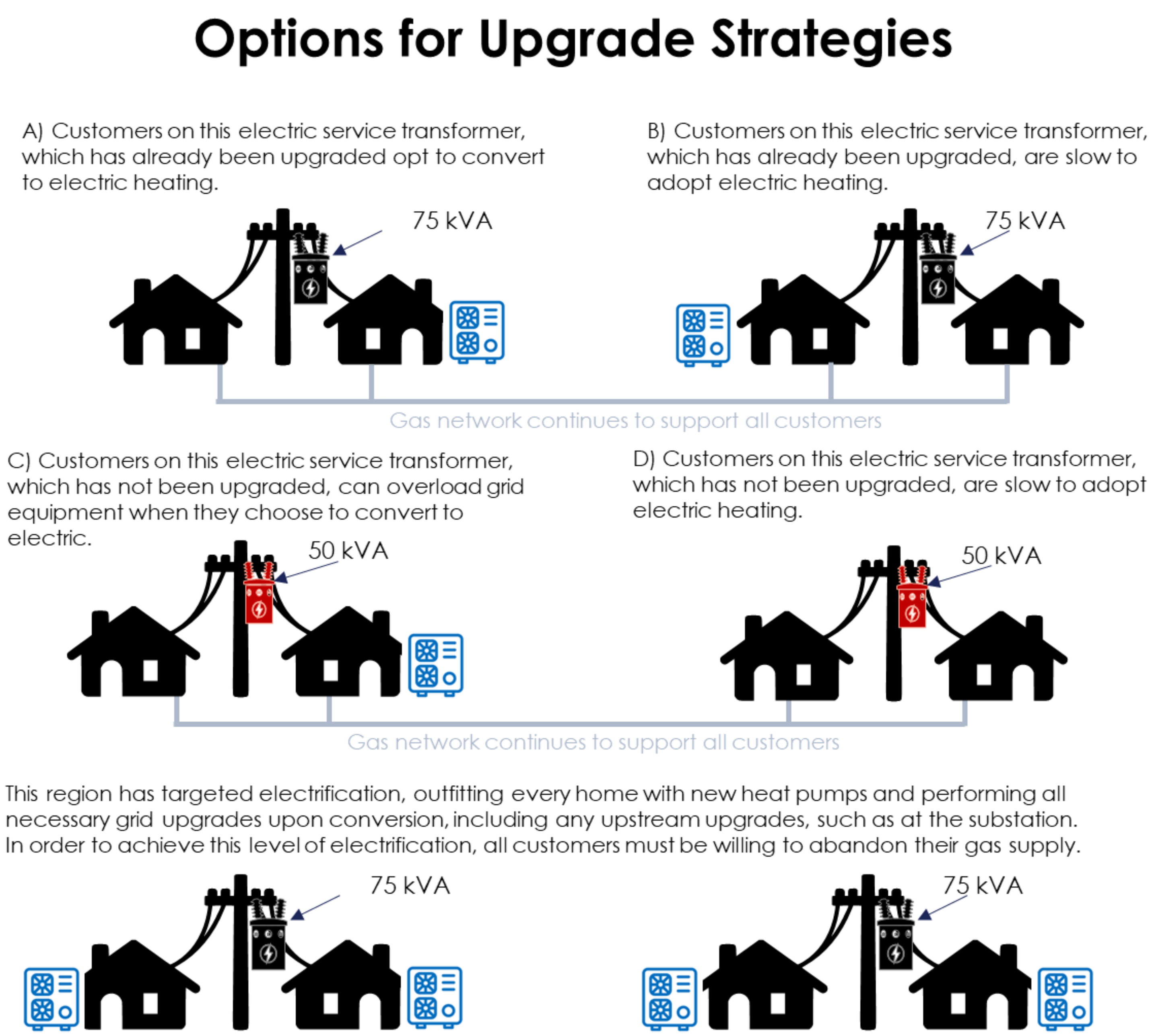

Image sources: ESIG

Bonus Solution:

The Need for Coordinated Planning

The Task Force also identified the need for a holistic perspective and evaluation of tradeoffs across objectives.

Coordinate planning actions:

- Identify mechanisms to supply overall energy needs **across electricity and gas**
- Align **T&D upgrades with resource plans** and customer expectations
- Create **customer programs for grid needs**, such as efficiency incentives
- Develop retail **rates** that encourage electrification and grid interactivity that can be **relied upon by distribution planners**

Next Steps

Start Today:

- Improve Load forecasting
- Modernize Planning Approaches
- Use Energy Efficiency and Demand Management
- Touch the grid once using a coordinated approach

Prioritize based on the area's approach to electrification.

- Maximum financial benefit for customers
- Certainty around electrification requirements
- Specifically targeted buildings
- Equitable solutions
- Mechanisms for fuel switching

Share learnings and research

THANK YOU

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