WINTER PEAK WHEN SPACE HEATING GOES ELECTRIC

A grid load and a life-safety envelope that collide at winter peak

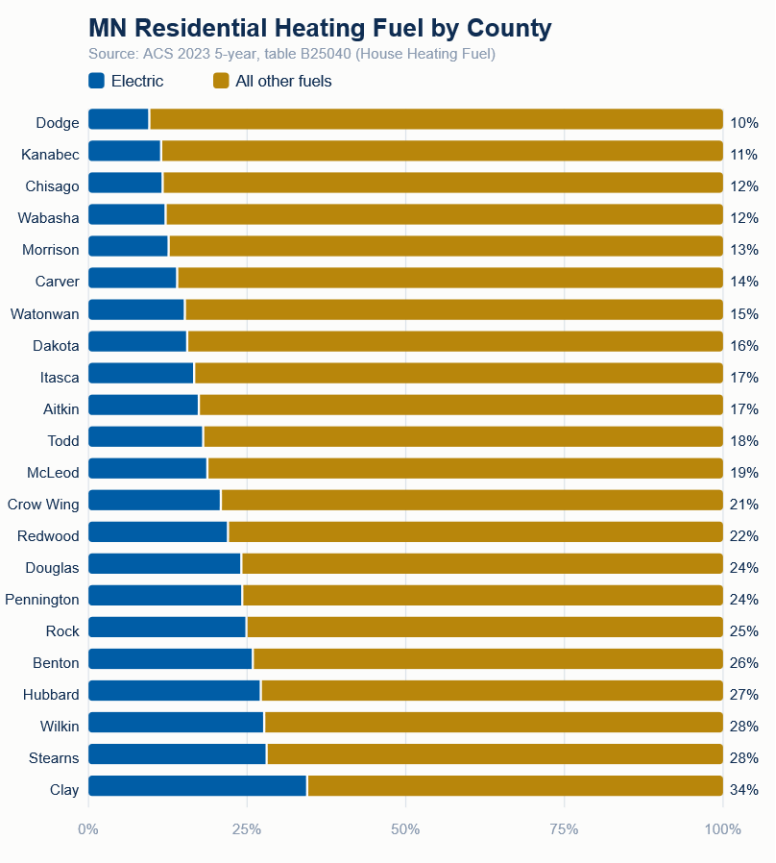
What electrifying heat does to winter risk, the levers that manage it, and the tools you can use.

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Heating isn't on the system yet

- Heating is the biggest energy use in cold-climate homes and most buildings.
- Across the Midwest, most of it runs on natural gas, propane, or fuel oil
- Most utilities here hit their yearly peak in summer, and designed their systems around it
- Electrifying heat moves the largest load onto a system that was never planned for it
- Cold/very cold climate residential heating peaks are **4x** existing cooling peaks
  - Loads are twice as big & equipment is half as efficient



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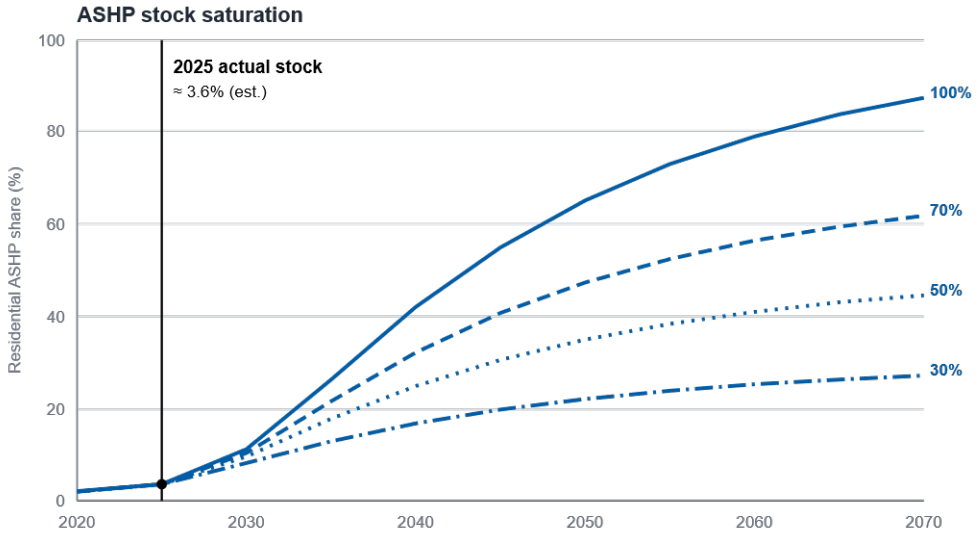
Winter-peak stress: onset and location

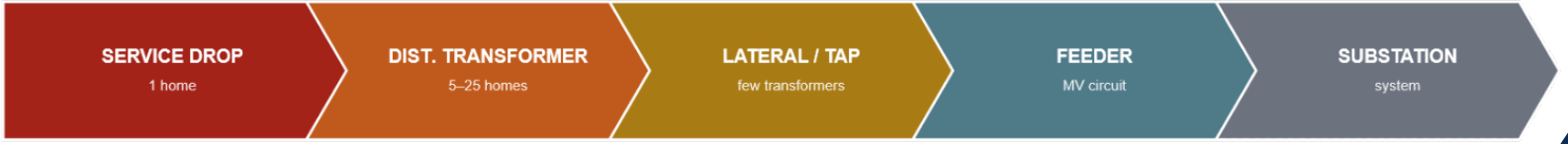
When

- Cold climate ASHP shipments are accelerating
- Still a great deal of uncertainty when they show up on the grid

Where

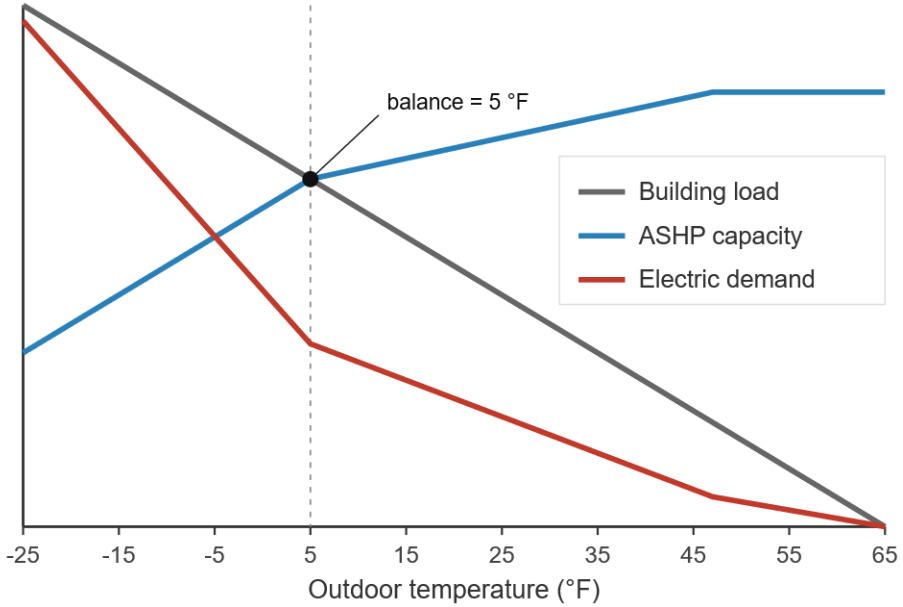
- Changes propagate from the bottom up





Challenges of heat pumps in cold weather

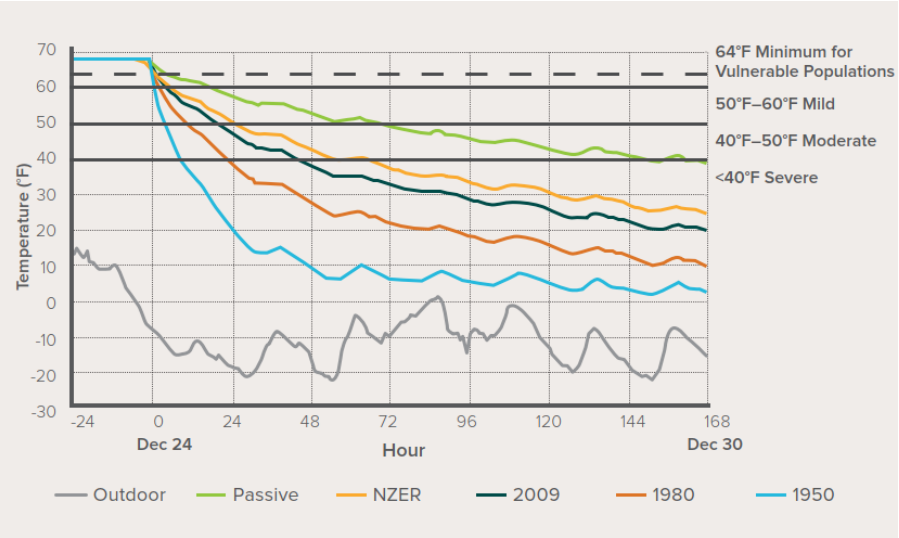
- On the coldest days, almost every home needs heat at the same time
- Heat pumps make less heat when it is colder and need more electricity for each unit they do make
- As temperature drops, electricity use climbs faster than the need for heat
- The problem is set by the coldest hours, not an average winter day
  - Design conditions or cold snaps?



Modeled diversity comes from stock models — ResStock / ComStock.

Risk concentrates as we remove diversity

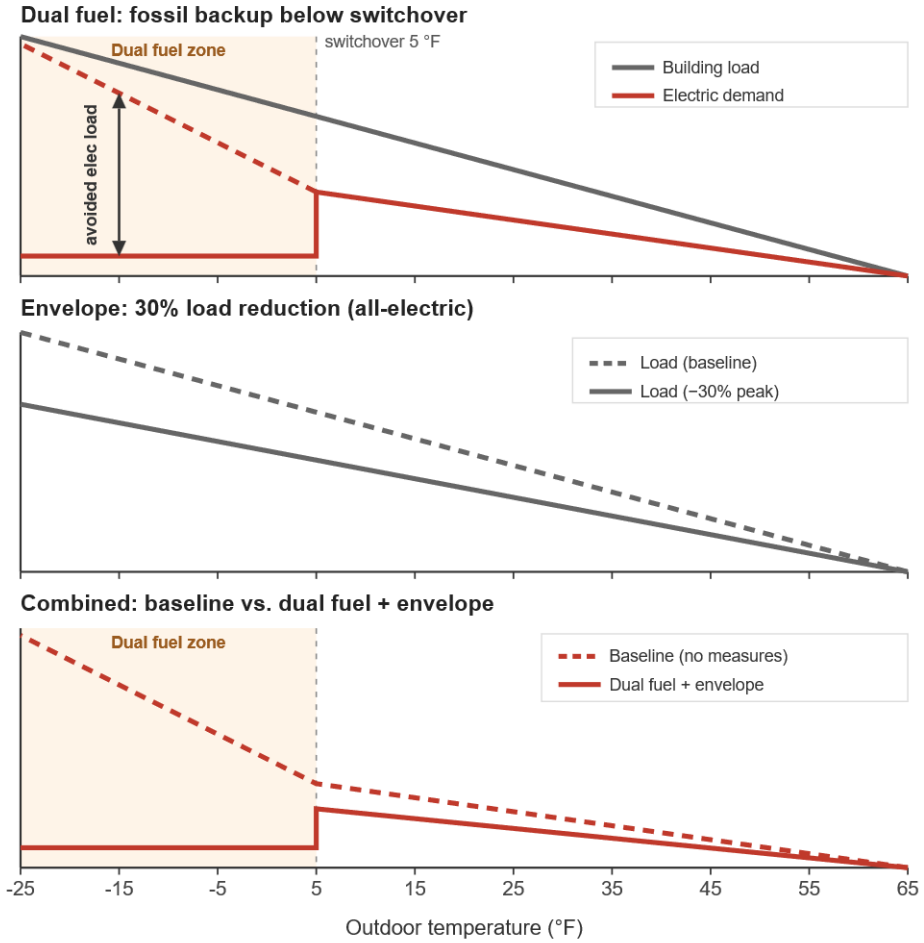
- A gas furnace without a generator also goes dead in a blackout so outage risk is not materially changed
- Today, natural gas, propane, and oil each fail in their own way, on their own day
- Put all heating on electricity and those separate risks become one shared risk, on the same cold night.
- At −20 °F, the cost of losing heat depends on the occupant: comfort for some, a health hazard for the vulnerable
- Most winter outages today are from storm damage
  - During Feb ‘21 polar vortex MPS instructed by SPP to ration power (~10k customers)



RMI (2020), 'A Framework for Considering Resilience in Building Envelope Design.'

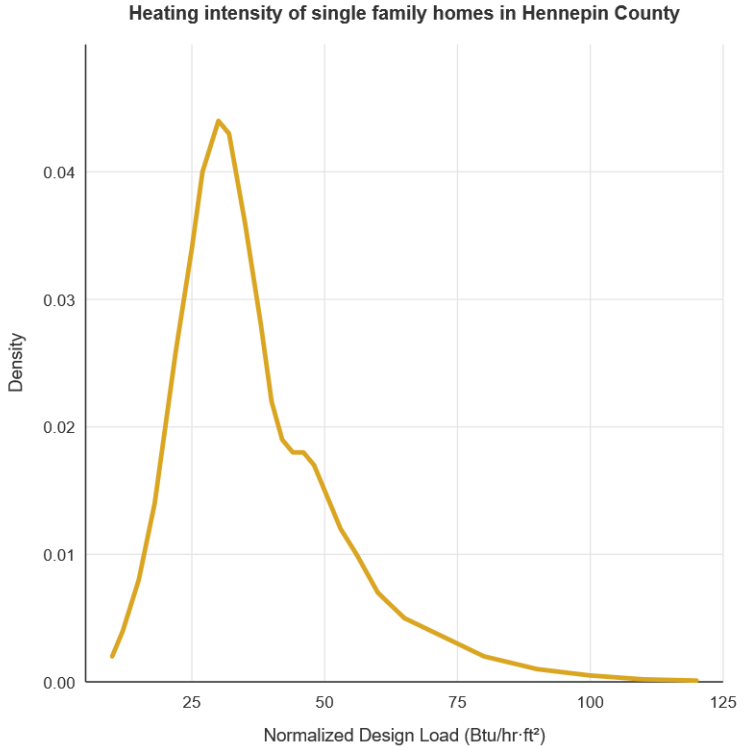
Two levers: dual-fuel and envelope

- Dual fuel heat pumps mitigate peaks by swapping to fossil fuels
  - Heat pump handles mild cold; the fuel takes over deep cold
- Improved building envelopes
  - A tighter, better-insulated home helps twice: a lower peak, and more ride-through during outage
- Combined, winter peak can be managed or partially mitigated
- Sophisticated dual fuel controls may even increase flexibility to respond to winter gric issues



Building Heterogeneity: All buildings are different

- Heating loads are heterogeneous but spatially correlated
  - Clustering introduces an additional, asymmetric grid risk
  - Clustered high loads are the constraint
- Additional load coincidence
  - Heating events last longer and overlap occupancy-driven loads
  - Applies to balance-of-home load and other new electrification loads (appliances, transportation)



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Available Tools

- **Building stock-scale (diversity):** ResStock / ComStock (NLR)
  - Representative building samples
  - 15-min end-use load shapes; electrification & dual-fuel scenarios
  - Pre-run End-Use Load Profiles available by county/state
- **Building → grid bridge:** dsgrid (NLR)
  - Aggregates end-use loads (incl. electrified heat) into bulk-system demand
- **Design load & sizing:** ACCA Manual J & S; ASHRAE 99.6% design conditions
- **Measured: AMI interval data**
  - The only measured diversity & coincident peak in your own

Caveats

- **ccASHP performance is the weak link**
  - Low-temp capacity/COP and backup control
- **Modeled ≠ measured diversity**
  - Models calibrate to aggregate energy and can misrepresent system and feeder peaks
- **National and state samples can misrepresent, especially for rural cold-climate territories**
  - Audit-calibrated local stock models + AMI are the solution
- **Research Grade tools**
  - These stock/grid models reach parameter space conventional tools can't at the cost of being hard to use and not set up for production

ResStock ComStock dsgrid Demand-Side Grid Toolkit

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TAKEAWAYS

Three things to take back

1 Plan for the coldest hours, not an average winter

- Peaks change magnitude, shape, frequency, and season which will challenge existing planning assumptions
- Modeling tools show the diversity and potential range of electrified load
- Local meter data shows where you actually sit and it's a moving target

2 Two levers to shave the deep-cold heating peaks

- Fuel backup caps extreme peaks
- Better envelopes lower it at every temperature and increase outage resiliency

3 Hard-winter know-how already exists across the industry

- Strained peaks, cold snaps, customer safety
- Electrification raises the stakes; utilities get there by building on each other's work