Energy+Environmental Economics

Decarbonizing Buildings

Michigan Council on Climate Solutions

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Agenda

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+ Decarbonized Gasses
+ Electrification
+ Concluding Thoughts

About E3

Technical & Strategic Consulting for ***the Clean Energy Transition***

Expertise in engineering, economics, mathematics & public policy

75 full-time consultants with a wide variety of backgrounds


San Francisco


New York

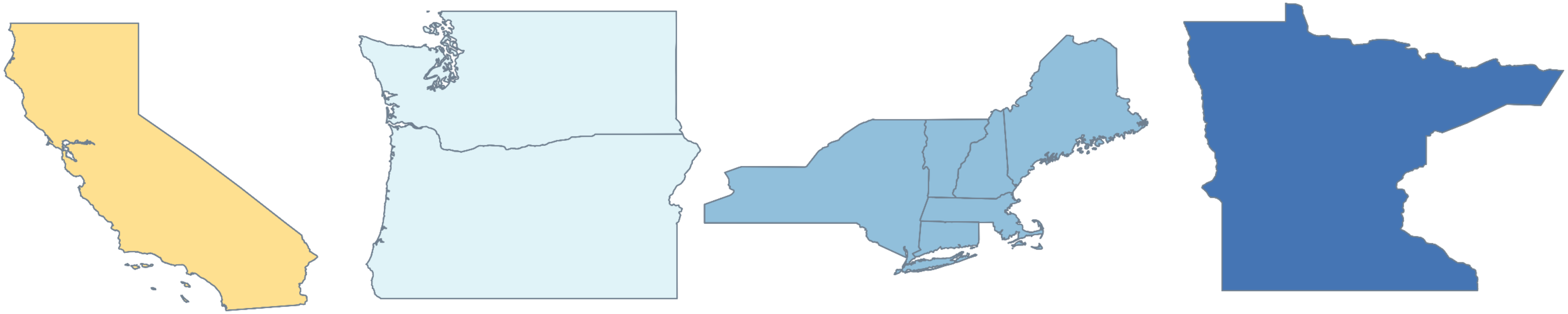

Boston


Calgary

250+ projects per year across a diverse client base

- Advisory and bid evaluation services to the State of South Carolina for the potential sale of Santee Cooper (~$9 billion valuation)
- Integrated Resource Planning for the CA Public Utilities Commission (CPUC) to achieve state clean energy targets (SB100)
- Evaluation of gas peaker replacement and/or hybridization with energy storage in New York City and Long Island
- Price and revenue projections and due diligence for GIP acquisition of NRG renewables portfolio (~$1.4 billion)
- Multiple studies on costs and feasibility of high renewables integration and low-carbon transition pathways from 2020-2050
- Reliability analysis of closing coastal gas-fired power plants and assessment of alternatives (transmission, storage, etc.)

E3 has examined building decarbonization pathways in distinct settings



	California	Northwest	Northeast	Minnesota
Cold Day Temp	35F	10F	-5F	-20F or lower
Heating Fuels	Mostly Gas	Gas and Electric	Gas and Fuel Oil	Mostly Gas
Electric Peak	Summer	Winter	Summer	Summer

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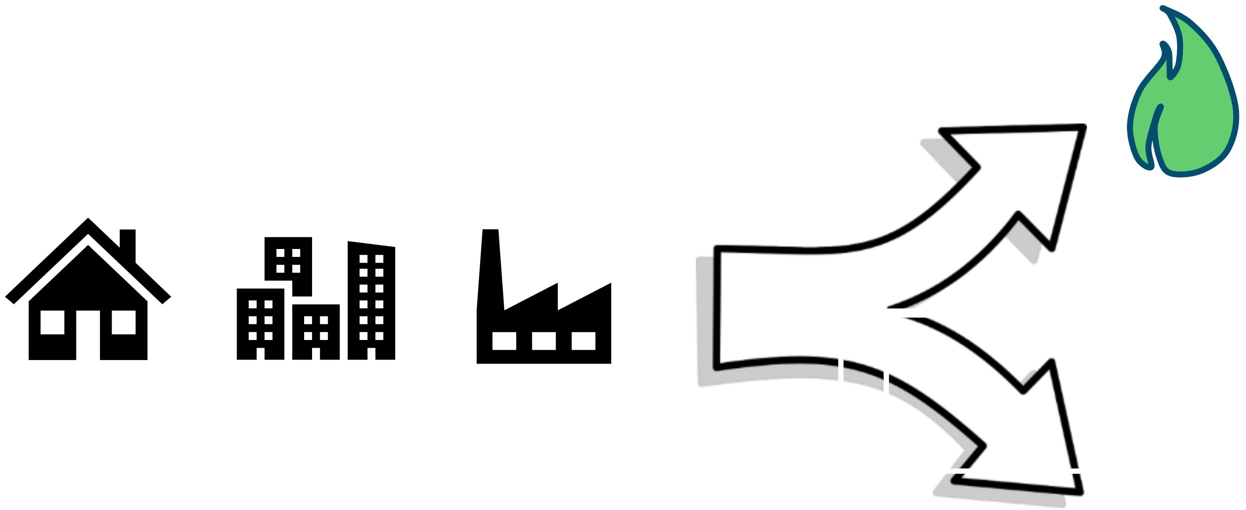
Building Decarbonization Pathways

How will we heat our buildings?



Decarbonized gas
Renewable natural gas or hydrogen

- **Potential Advantages: repurposes existing infrastructure, minimal consumer disruption**
- **Potential Drawbacks: cost, not commercial at scale**, can require extensive utility infrastructure retrofits

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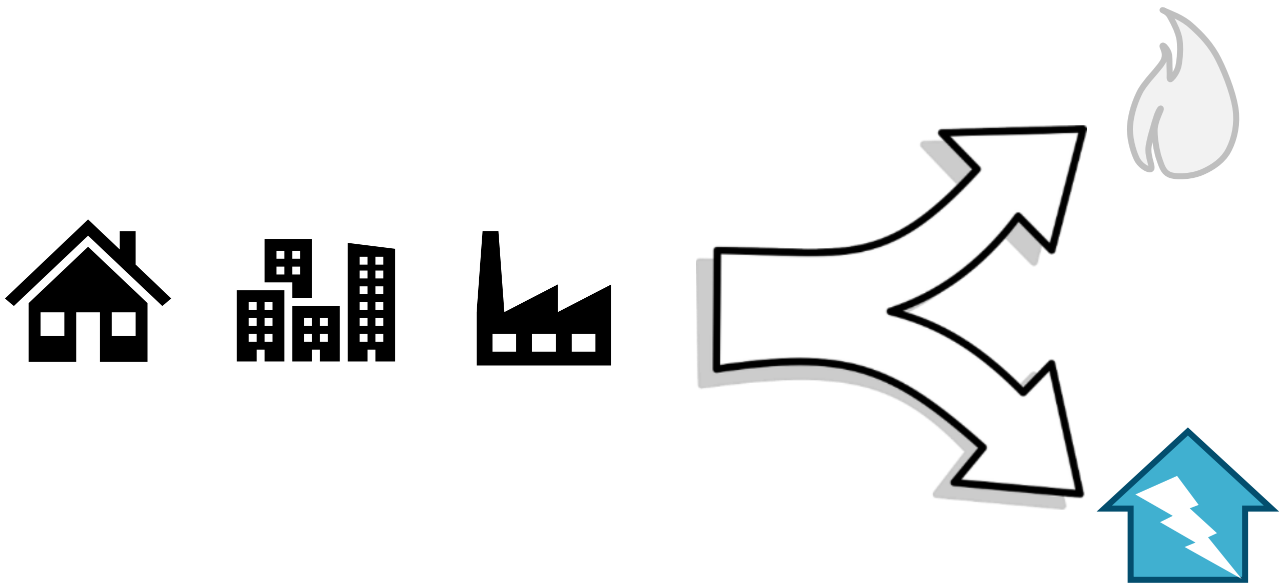
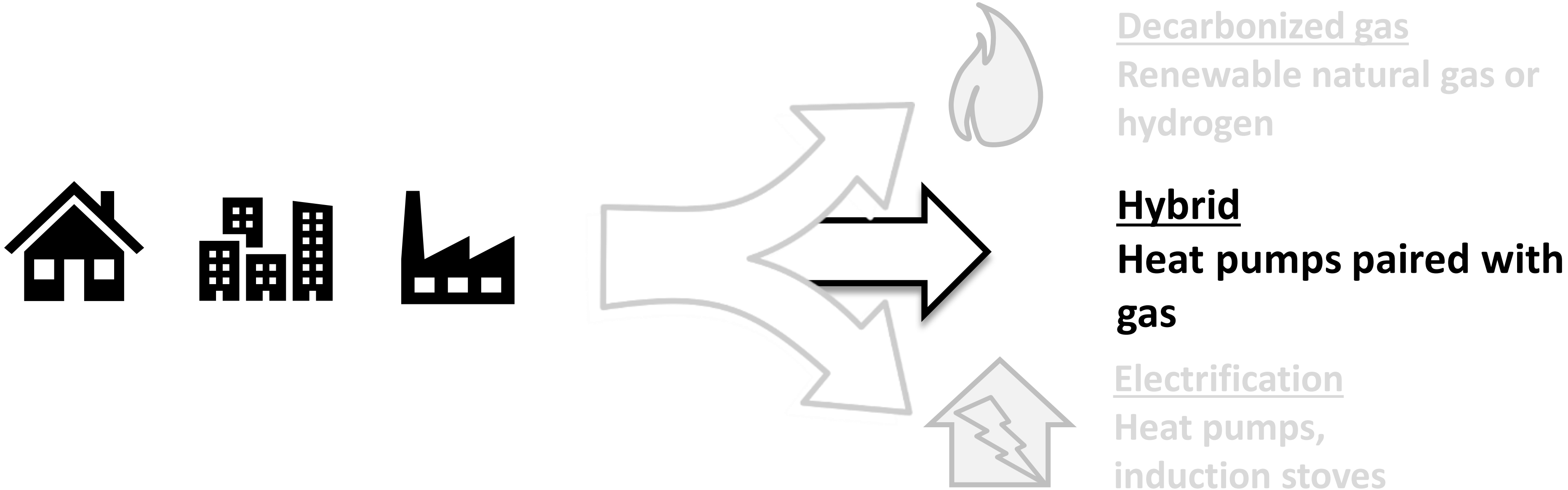


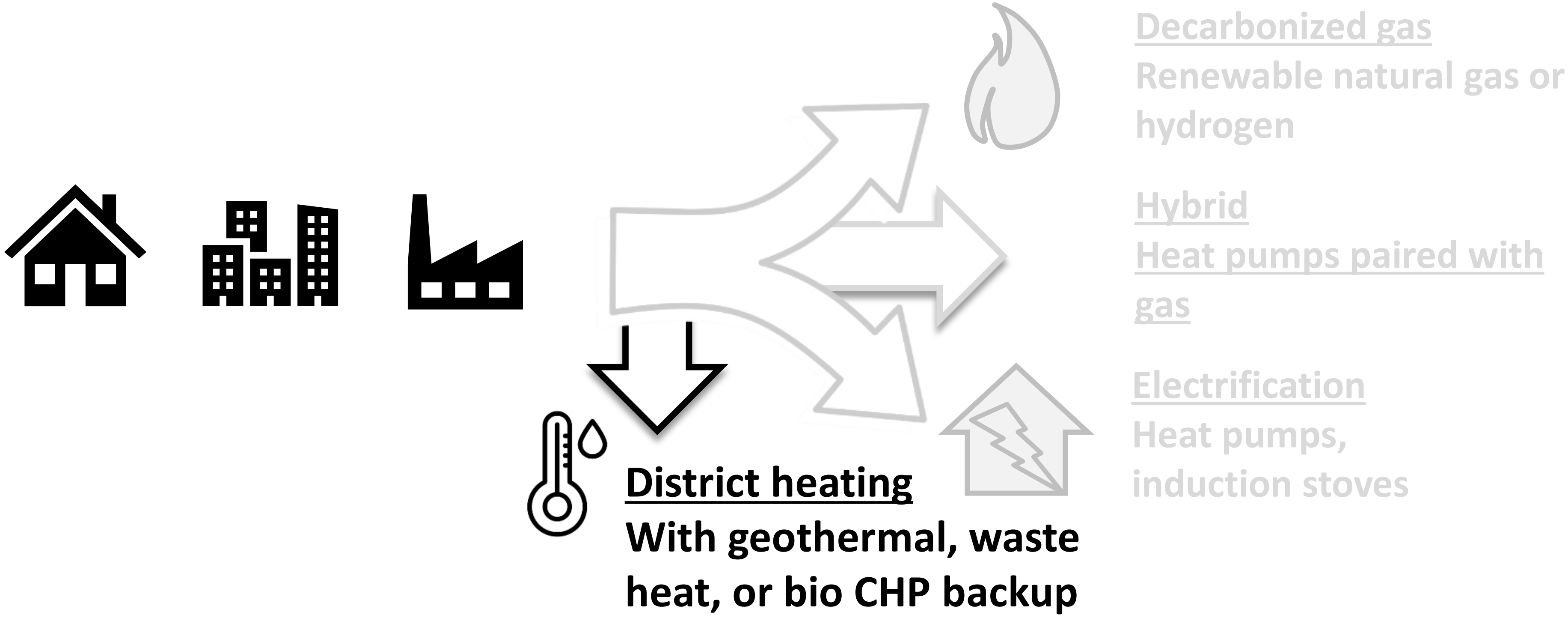
- Potential Advantages: **commercially available** products, **complementary to decarbonized electricity**, assists with climate adaptation
- Potential Drawbacks: requires building retrofits, **upfront consumer costs**, electric peak load impacts, potential for **stranded assets** and **workforce reductions**

How will we heat our buildings?



- **Potential Advantages**: **utilizes existing infrastructure**, reduces demand for more expensive varieties of decarbonized gas, **mitigates grid impacts**
- **Potential Drawbacks**: this approach is **not well studied** in the U.S., though it is **an emerging strategy in Europe**

How will we heat our buildings?



- **Potential Advantages**: multiple input sources enable a diversified decarbonization approach
- **Potential Drawbacks**: partly requires new infrastructure, expansion is **not well studied** in the U.S., though it is **an emerging strategy in Europe and being explored in MA**

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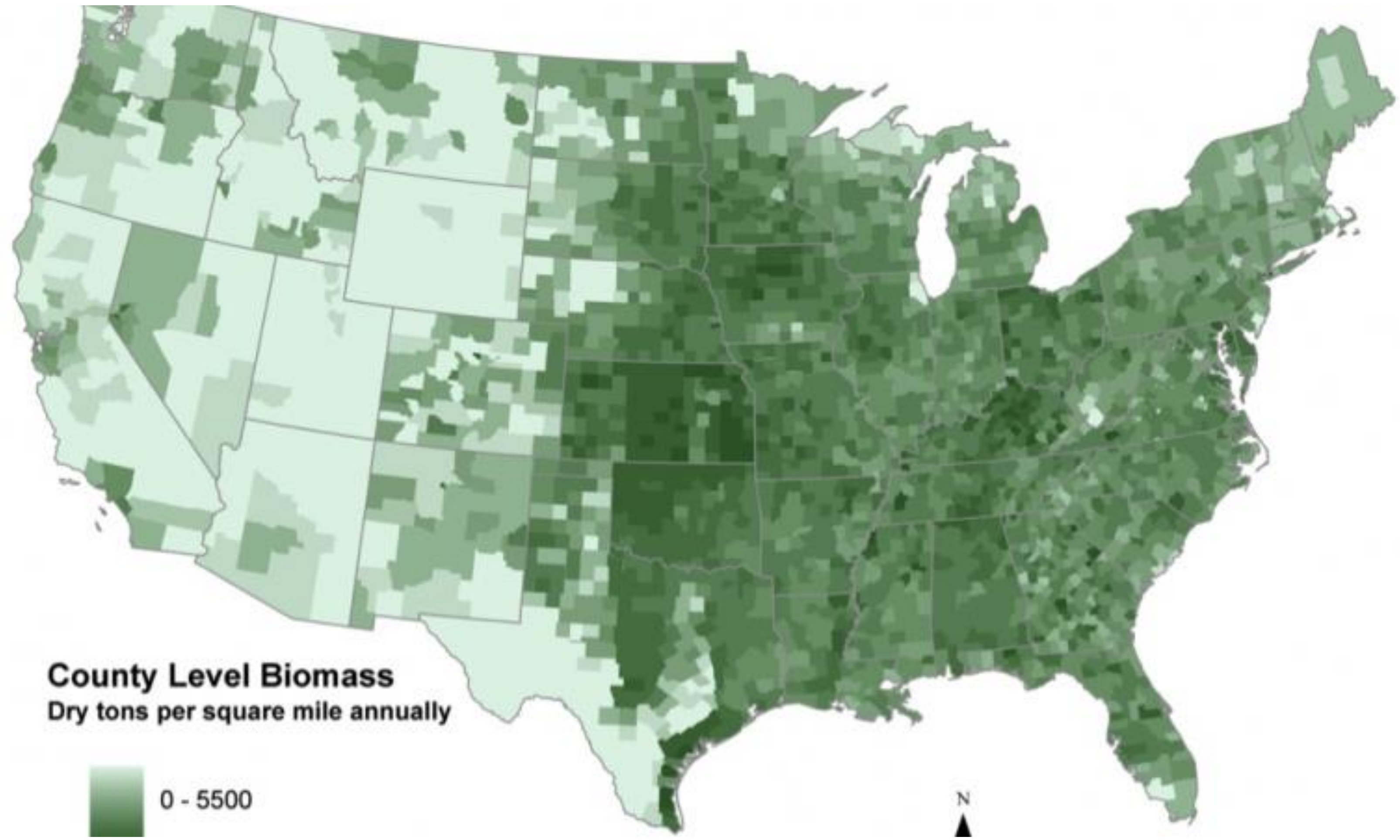
Decarbonized Gasses

Biomethane is the lowest cost-form of decarbonized gas, but is limited in quantity

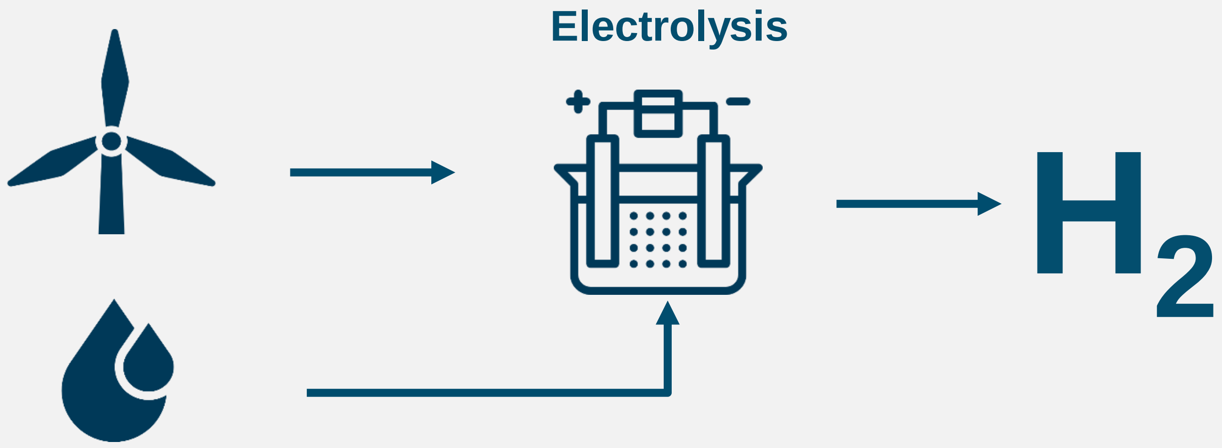


Source: US DOE Billion Ton Report (2016)

- **Biomethane can be produced from wastes**
  - Forests
  - Agriculture
  - Landfill
  - Manure
- **And from purpose grown energy grows**
  - Lifecycle and indirect emissions impacts are important considerations for purpose-grown crops
  - Potential to use lands currently devoted to ethanol for alternative energy crops

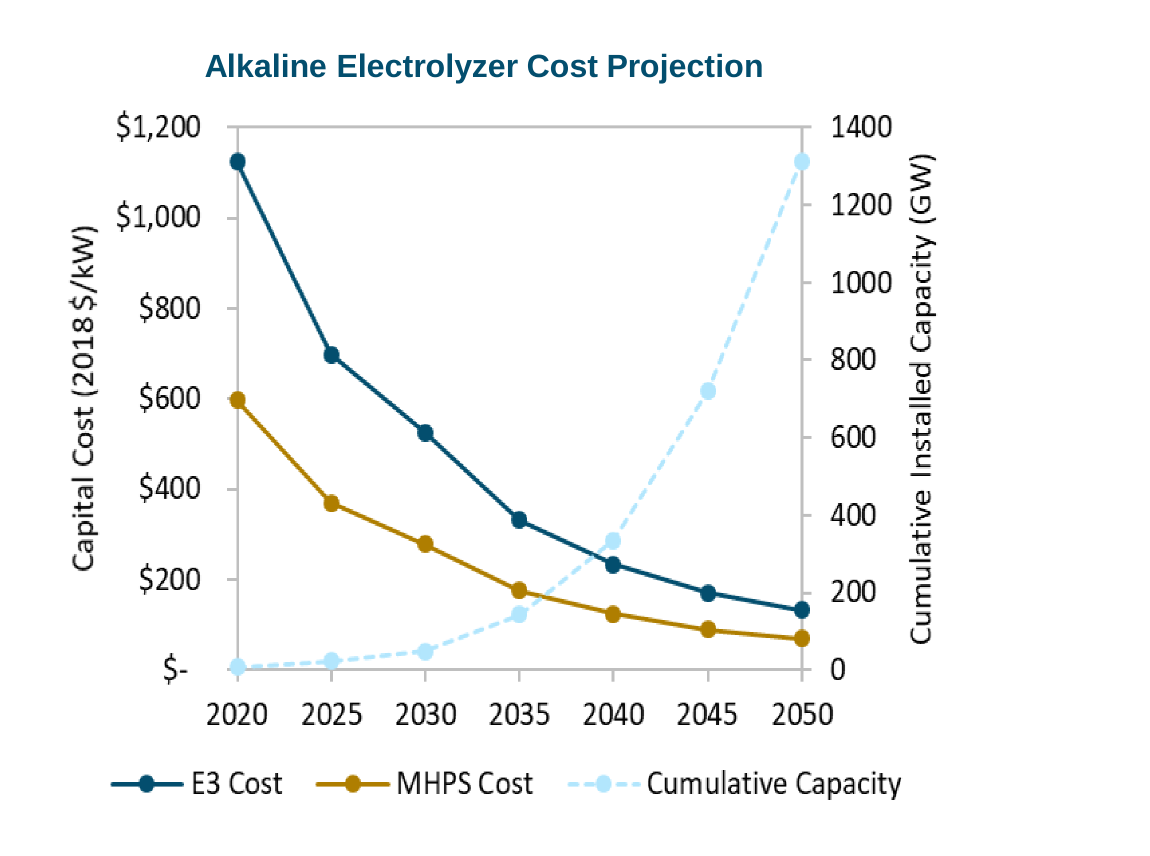
What about hydrogen?

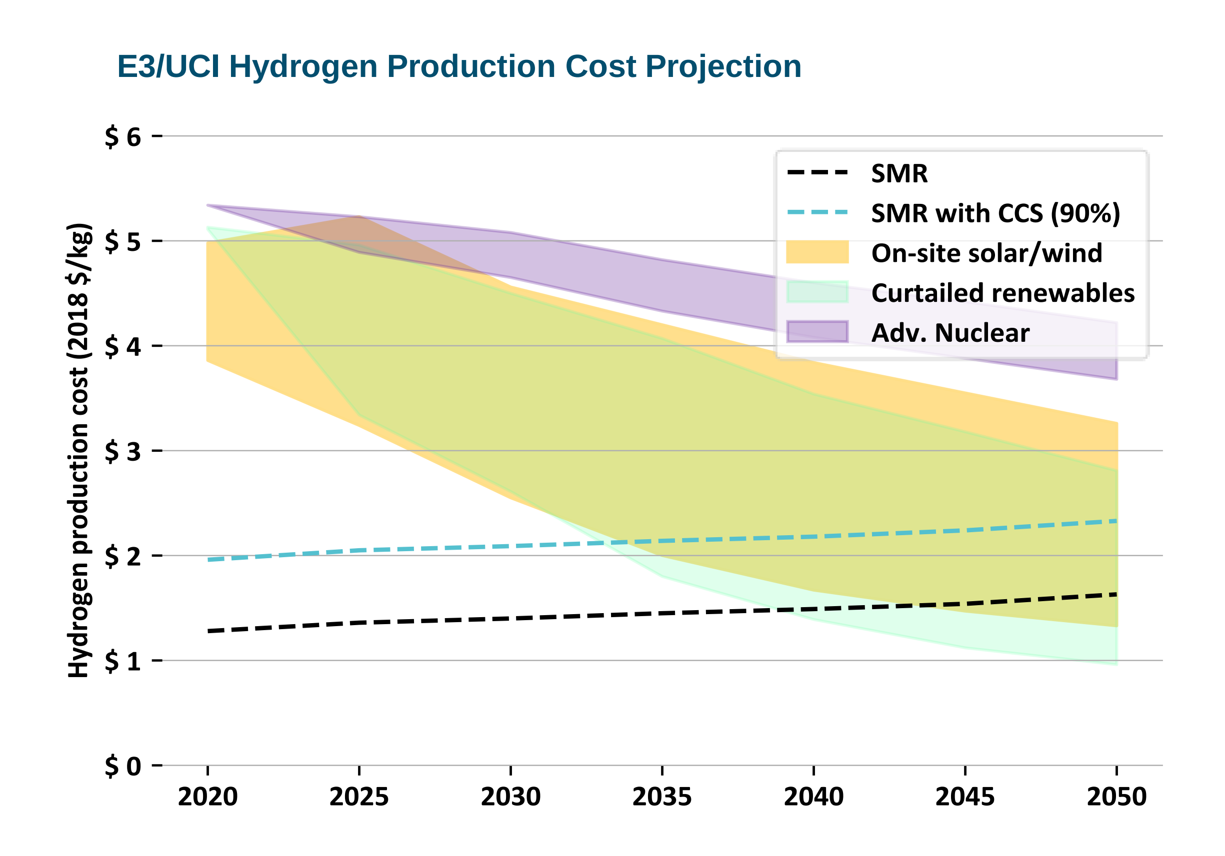
“Green” Hydrogen



“Blue” Hydrogen

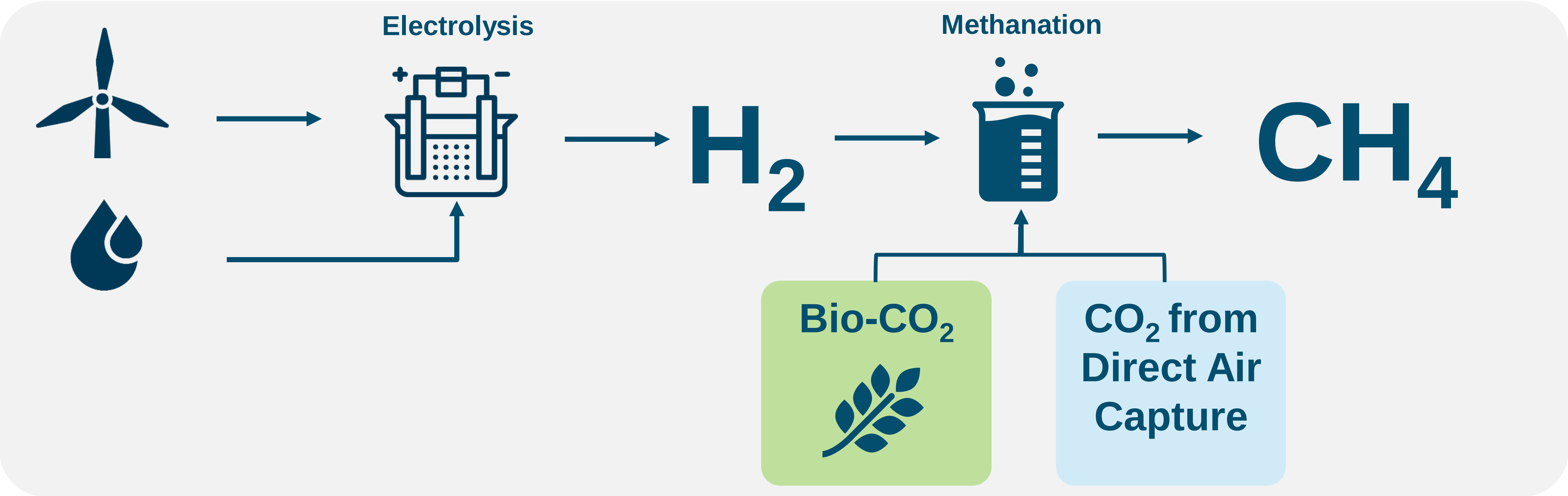
Hydrogen production costs are expected to decline





- E3 recently published a report on potential opportunity for renewable hydrogen in a deeply decarbonized future with Mitsubishi Hitachi Power Systems (MHPS)
- Electrolysis with renewable power may be more economic than SMR with CCS if electrolyzer costs fall with an aggressive learning rate of 25% and curtailed renewables are available at close to zero cost

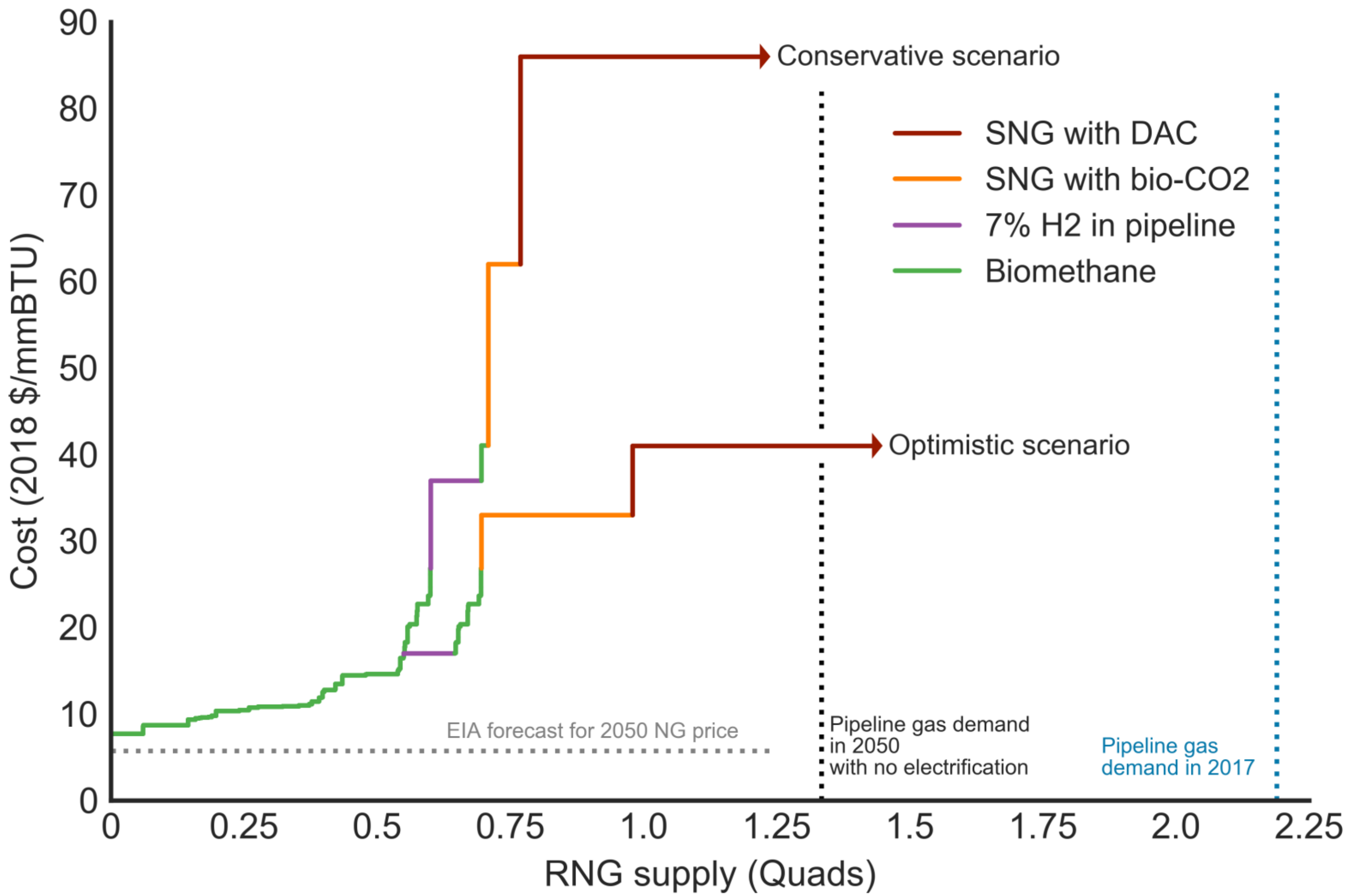
Synthetic Natural Gas (SNG) Production



- SNG production requires a combination of climate neutral hydrogen and climate neutral CO2.
- E3 considers two sources of climate neutral CO2: 1) less costly bio-CO2 from biofuels production, 2) more costly CO2 from direct air capture.

E3 RNG Supply Curve: Conservative vs Optimistic

California Renewable Natural Gas (RNG) Supply Curve, 2050



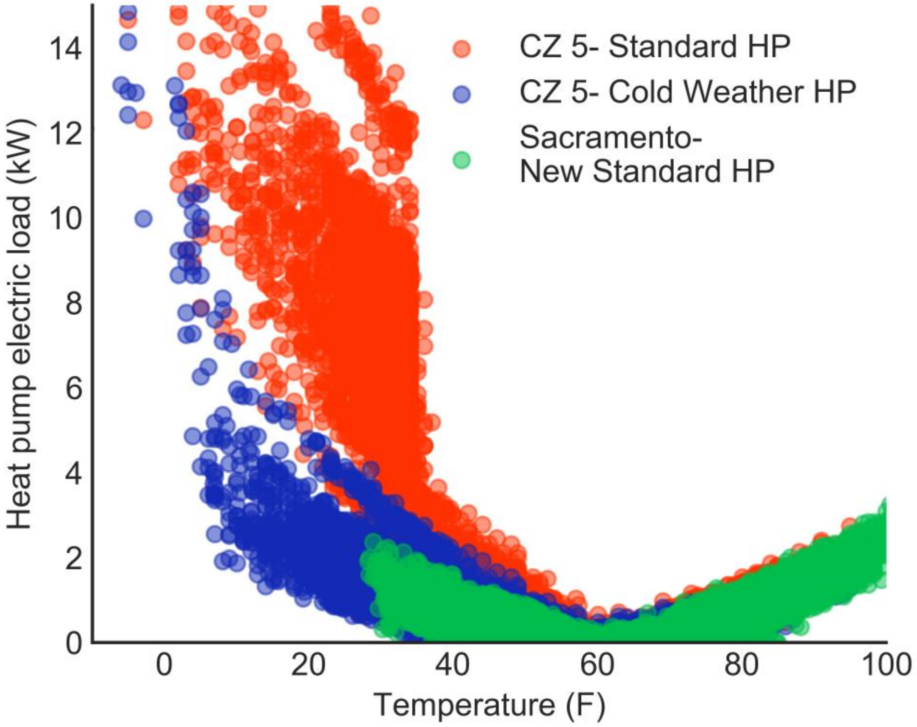
This plot bounds a 'Conservative' and 'Optimistic' set of costs for RNG

The quantities of RNG on the x-axis will be different in MI, but the relative proportions are likely to be similar

Electrification

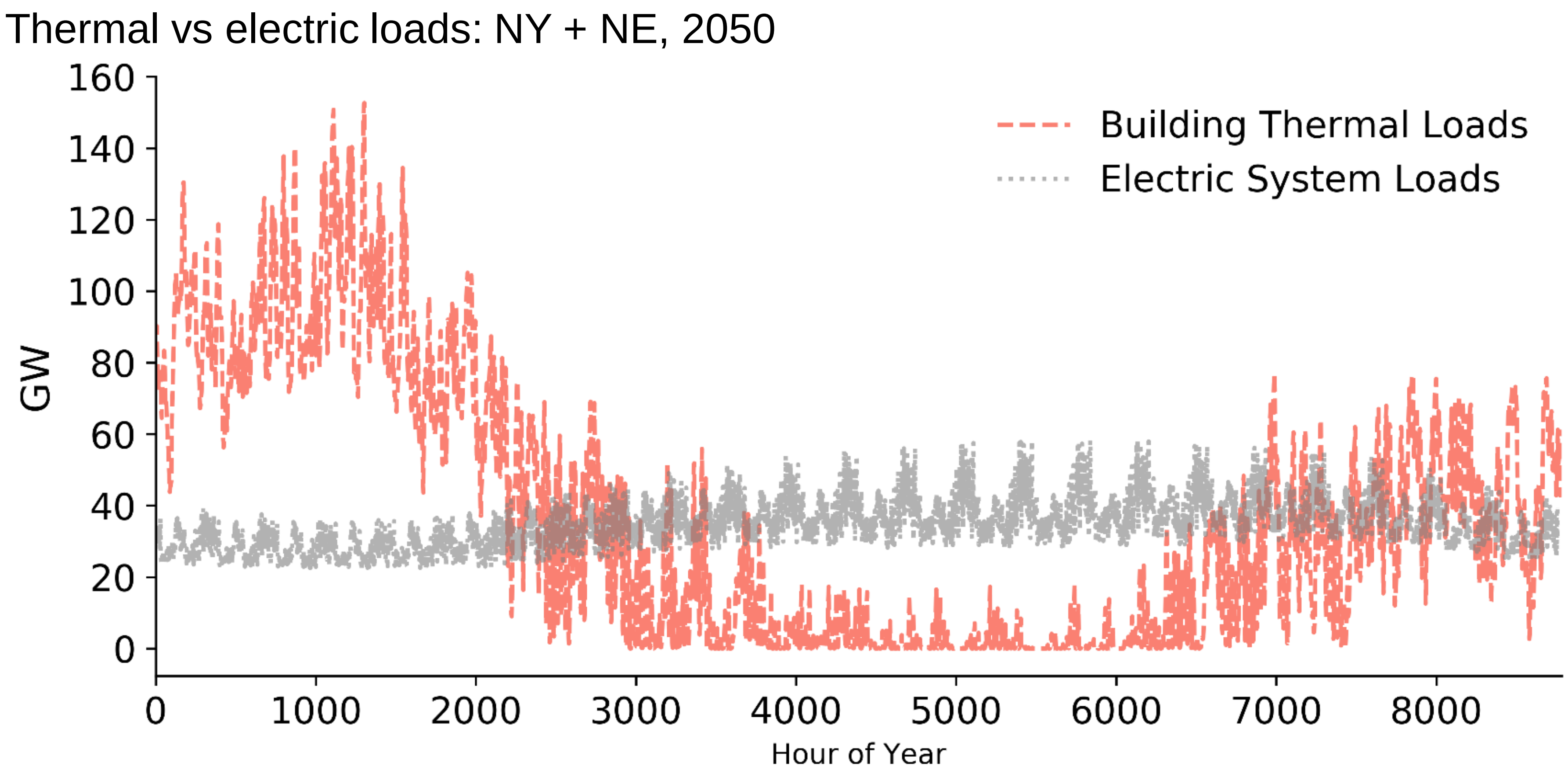
Proposals to electrify heating focus on deployment of air-source heat pumps

ASHP loads for a 2200 ft^2 building



+ **Air-source heat pumps are very efficient on an annual basis, with coefficients of performance (COPs) of 3 or higher possible in Washington today**
+ **However, ASHP COPs fall as the outdoor air temperature drops. This increases the amount of electric load required to keep buildings warm.**
+ **Heat pumps are commonly installed with supplemental heat that is used during the coldest hours of the year.**
  - For all-electric homes, supplemental heat is provided via electric resistance
  - “Cold climate” heat pump models require less supplemental heat than traditional systems. Supplemental heat may not be needed in all cases.

At scale, electrification natural gas end-uses could have large impacts on electricity systems



Potential strategies to mitigate those peaks and open questions

+ **Building shell improvements**
  - What are the trade-offs between investments in buildings vs building a bigger grid?
+ **Continued improvements in the cold-weather performance of heat pumps**
  - How can consumers be incentivized to invest in systems with lower impact on the grid, but that come at a higher private cost?
+ **Ground source heat pumps**
  - Are the electric sector savings sufficiently large to overcome the higher installation costs of these systems?
+ **Hybrid (also called dual fuel) heat pumps**
  - How do the grid benefits of this approach measure against the costs of decarbonized fuels and fuel delivery?
  - Is there a viable business model for fuels (e.g. natural gas, propane, kerosene) to serve purely as backup?
+ **Load flexibility**
  - To what extent (how much, how long) can loads be shiftable?
  - What consumer-side costs will be required to enable those shifts?

Concluding Thoughts

Final Thoughts

+ **Decarbonized gasses can have an important role in decarbonizing buildings end-uses.**
  - However, they are much costlier than natural gas, are likely to be limited in scale and are commercially unproven
+ **Heat pumps can efficiently heat buildings during most hours of the year**
  - But all-electric buildings can cause large electric system impacts during the coldest hours
+ **In cold-climates, lower-cost, lower-risk decarbonization strategies will likely require some combination of decarbonized fuels and electrification**
  - Electrification will likely be a lower cost means to provide heating energy during most hours of the year
  - Decarbonized fuels may have an important role to deliver heat during the coldest hours of the year
+ **Energy efficiency is needed in all cases**