Future Energy Systems Center

April 26, 2023

Interim Project Update:
Project overview and introduction

System impacts of decarbonization pathways for space heating in cold climates



Project Team

Research leads



Prof. Christopher Knittel, Sloan School



Dr. Dharik Mallapragada, MITEI



Dr. Raanan Miller, MITEI



Prof. Saurabh Amin, Civil & Environmental Eng.



Prof. Les Norford Architecture



Dr. Audun Botterud, LIDS



Dr. Tim Schittekatte, MITEI

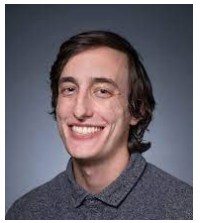


Dr. Pablo Duenas-Martinez, MITEI

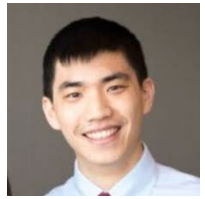
Postdoctoral associates and graduate students



Dr. Rahman Khorramfar, postdoc, MITEI, CEE



Morgan Santoni-Colvin, Grad. student, IDSS/ MITEI



Stephen Lee, Grad. student, Computer Science



Graham Turk, Grad. Student, IDSS/MITEI



Nicolas Morell PhD Student, Universidad Pontificia Comillas

Project alumni

Karen Tapia-Ahumada - Research Scientist
Jonte Dancker - Visiting student
Jameson McBride – TPP' 22
Tony Lee - TPP'22

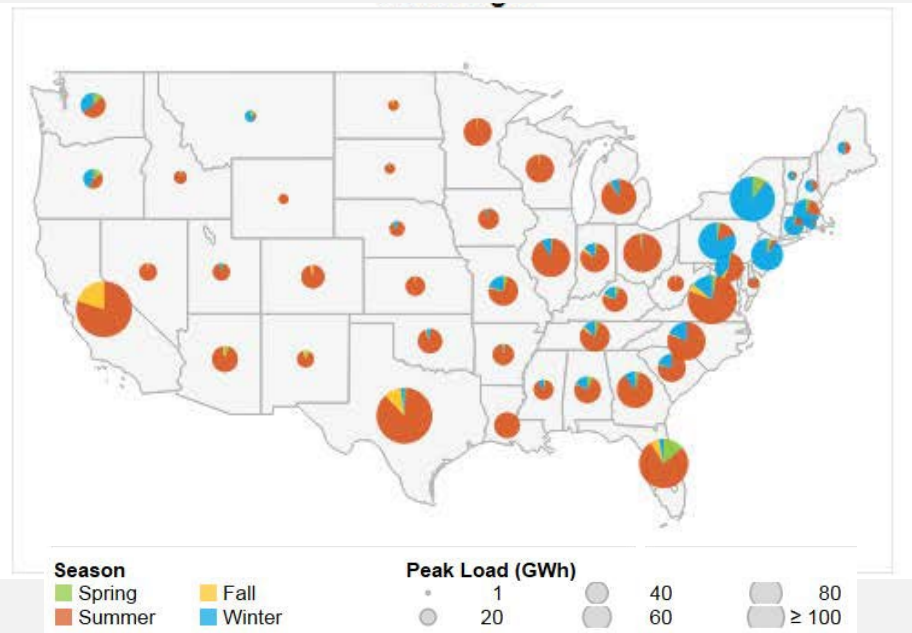
Project motivation and objectives

Motivation

- Buildings accounted for 28% of final energy use and 13% of U.S. GHG emissions in 2021[1]

- Electrification is the leading strategy for decarbonizing buildings, but adoption at scale faces barriers related to many factors including costs and infrastructure impacts

2050 demand peak load magnitude and timing under high electrification scenario (Figure ES-4)[2]



Objectives

1. What are demand-side effects of heat electrification under various penetration and technology adoption scenarios?

2. How does heat electrification impact distribution networks, and what are the implications of tariff design and DER deployment?

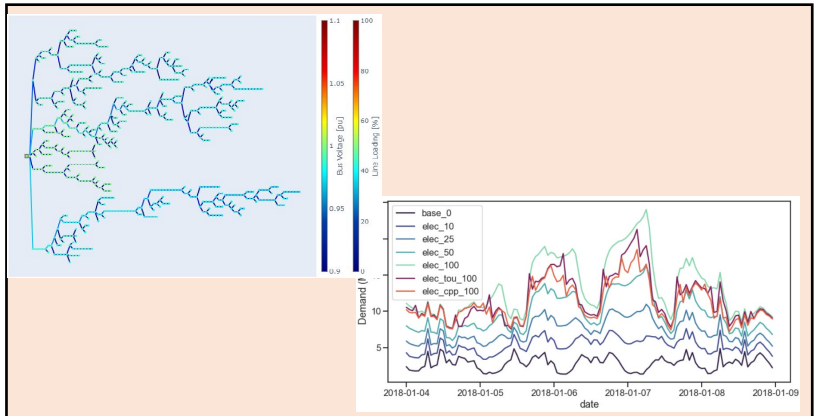
3. What are bulk system impacts of electrification vs. other approaches for heat decarbonization (e.g. synthetic gas, H_2) ?

4. How to account for system resiliency in energy system planning and what does it imply about the cost of alternative decarbonization pathways?

1. https://www.eia.gov/energyexplained/us-energy-facts/images/consumption-by-source-and-sector.pdf
2. Mai et al. 2018. *Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States*

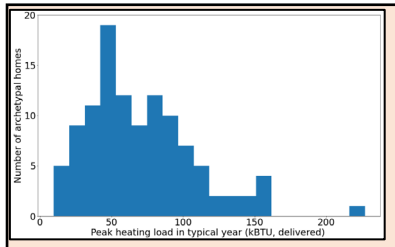
Project workstreams and outputs to date

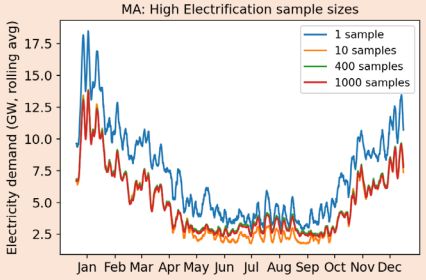
Distribution network analysis



- Characterizing realistic cost of heat pumps installations
- Modeling of electrification impacts on networks
- Retail tariff to encourage shift/curtail demand use away from peak periods

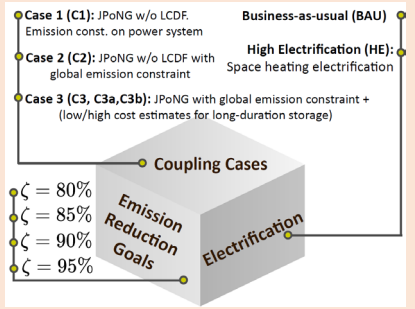
Demand modeling

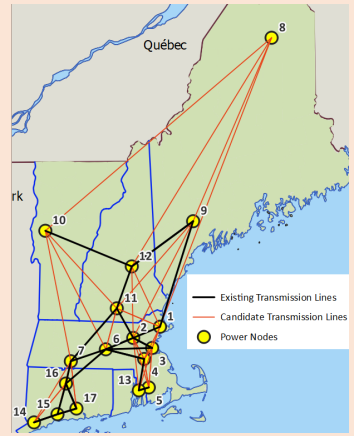




- Bottom-up modeling of building stock to study fleet-level impacts of demand-side measures
- Data-driven modeling to characterize demand patterns at local level*

Bulk energy systems analysis





- Joint gas-electricity infrastructure modeling under emissions, demand and technology scenarios
- Robustness of infrastructure to inter-annual variations in supply & demand*

Project-level key impacts

- **4 publications** submitted for peer-review, multiple conference presentations (AGU, INFORMS etc.)
- Stakeholder engagement and outreach (notable examples)
  - Participated in MA commission on Clean Heat (Jan –Dec 2022)
  - Ongoing discussion w/ ISO-NE about infrastructure planning and demand modeling
  - Retail rates: Boston Globe Op-Ed, Joule Commentary piece, ESIG workshop on market design

* These aspects of the project are still being developed based on among other things, timing of receiving data inputs from utility partners

Summary of research products published to date

- Reforming retail electricity rates to facilitate economy-wide decarbonization

- Impact of Heat Pumps, Rooftop PV, and Hydrogen Blending on Gas-Electricity Distribution Networks in Northeast US
- Clean heat at what cost? Economic optimization of residential space heating in Massachusetts

- Implications of heating electrification on distribution networks and distributed energy resources

- Electric-Gas Infrastructure Planning for Deep Decarbonization of Energy Systems

- Advancing in the implementation of forward-looking incremental network charges: locational granularity, ex-post pricing, and customer response coordination (under review, available on Member website)

- Decarbonized Future Power-Gas Systems Under Large-Scale Electrification of Building Heating in New England (poster available on member website)