Long-Term Decarbonization Scenarios

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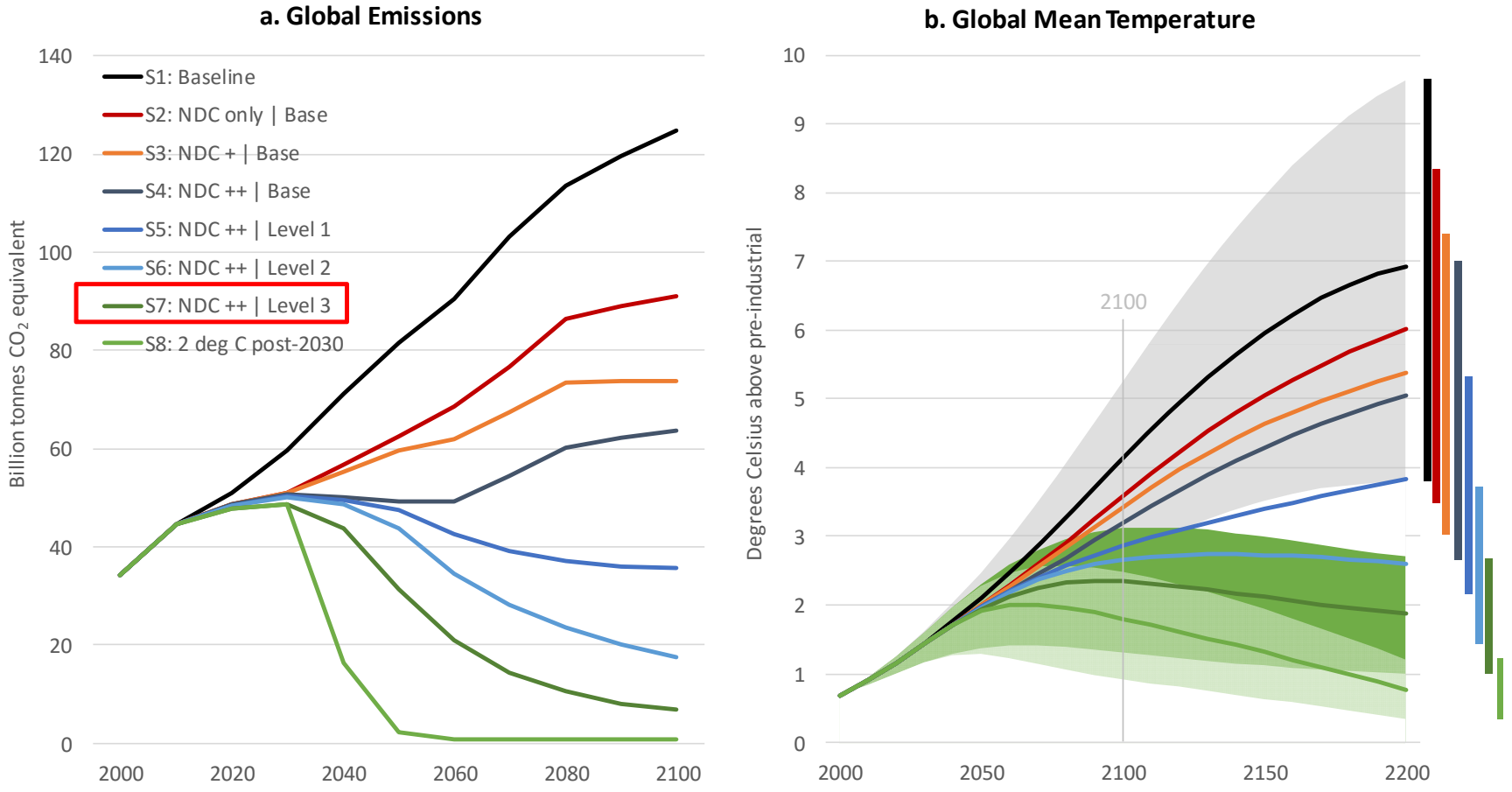
Overview

- "Paris and Beyond" scenarios
- Global pathway for non-electric emissions reductions
- Detailed look at decarbonization in US
- Role of electrification

“Paris and Beyond” scenarios in EPRI’s MERGE analysis



From “The Paris Agreement and Next Steps in Limiting Global Warming”, Rose et al (2016), Climatic Change, under review

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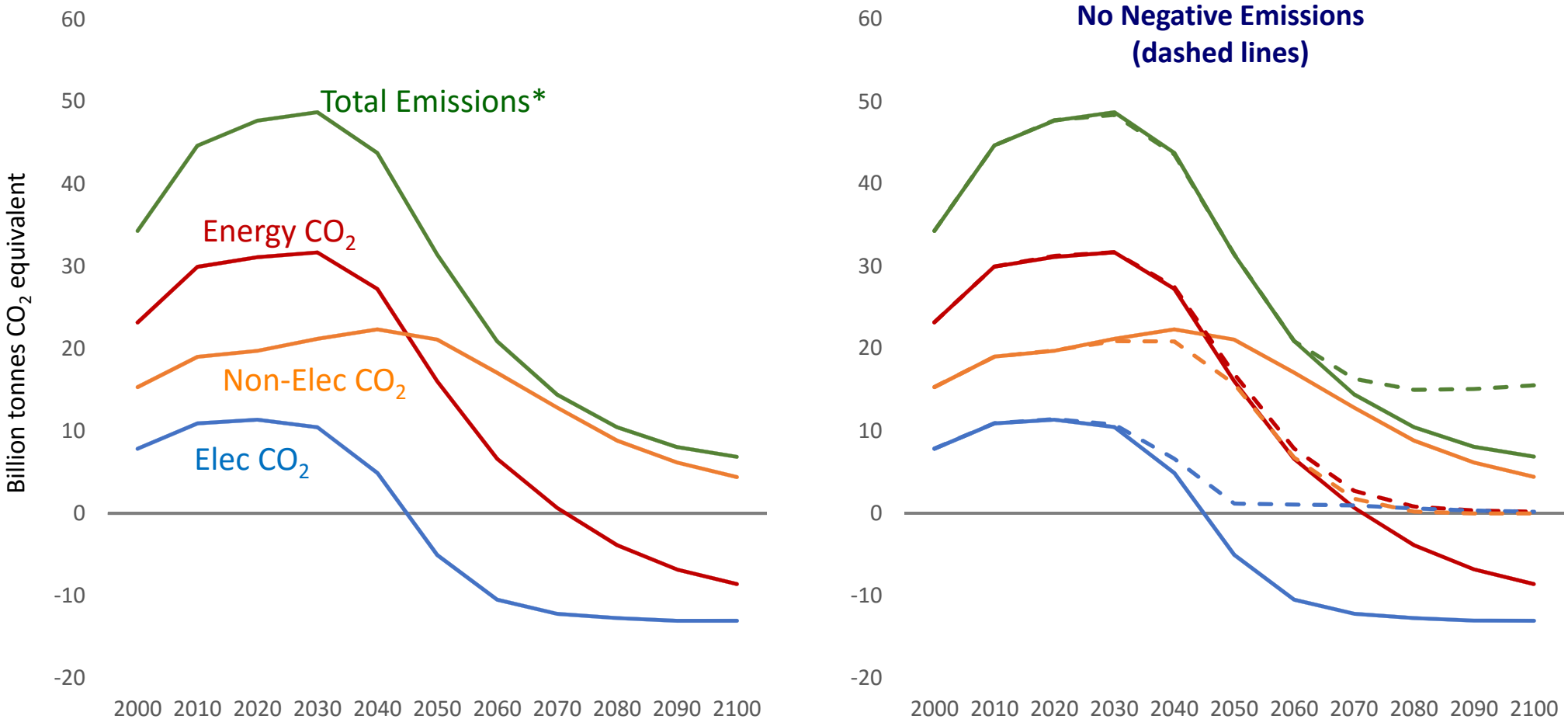
Global Emissions in Ambitious Post-Paris Scenario



* *Excludes LU/LUC/F*

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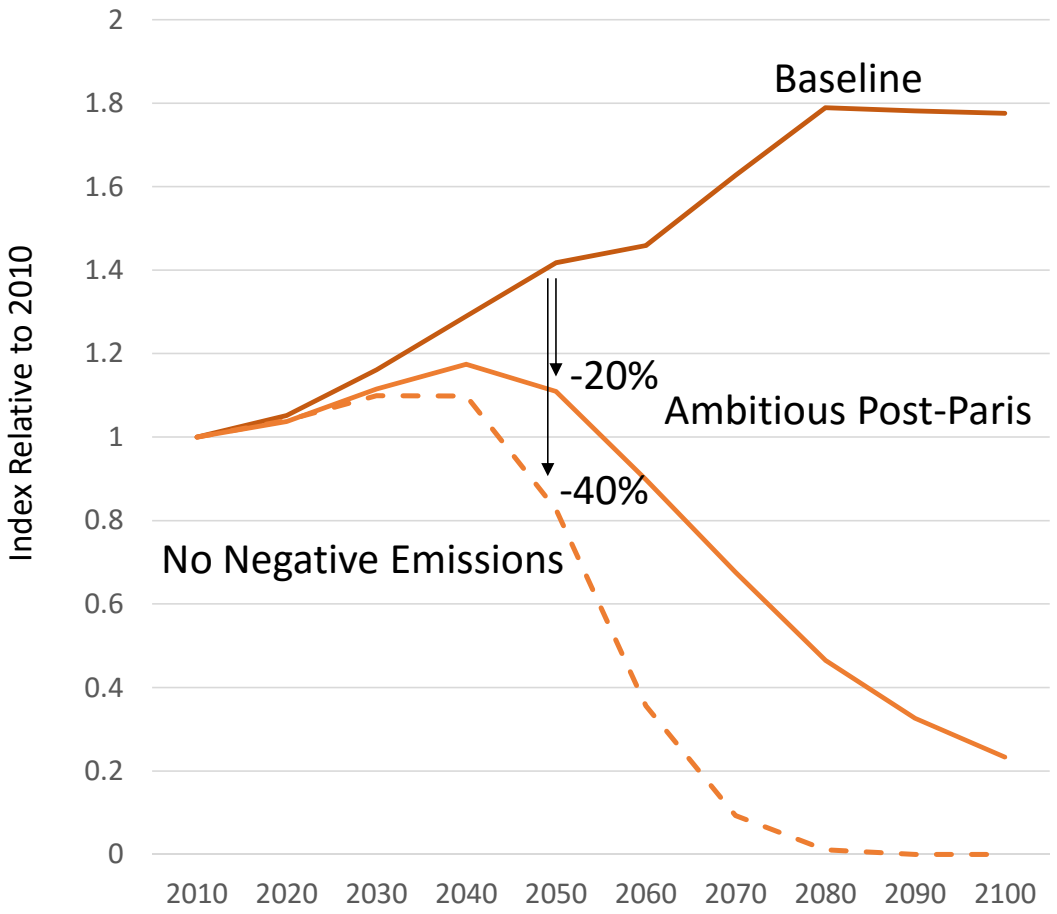
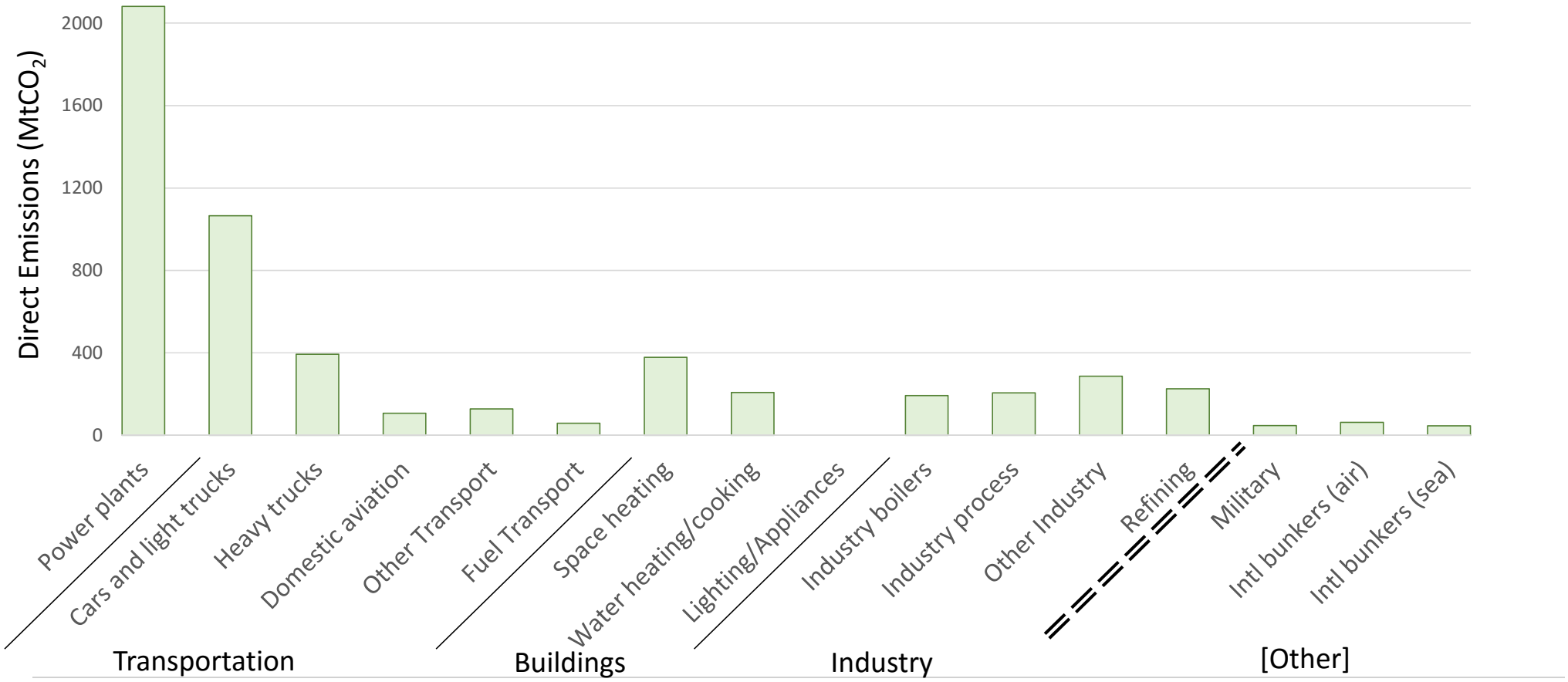
Global Non-Electric Emissions: 20-40% below BAU by 2050



- Ambitious scenarios have 100%+ reduction in electric sector emissions by 2050
- Meanwhile, non-electric emissions are reduced by 20%, or 40% if negative emissions are not allowed
- Reductions are achieved through:
  - Efficiency improvements (beyond baseline)
  - Electrification (beyond baseline)
  - Other low- or zero-carbon end-use fuel (e.g. bioenergy, hydrogen)
  - CCS in some cases
- Modeling is challenging due to heterogeneity of applications

Where's the carbon in the US economy?



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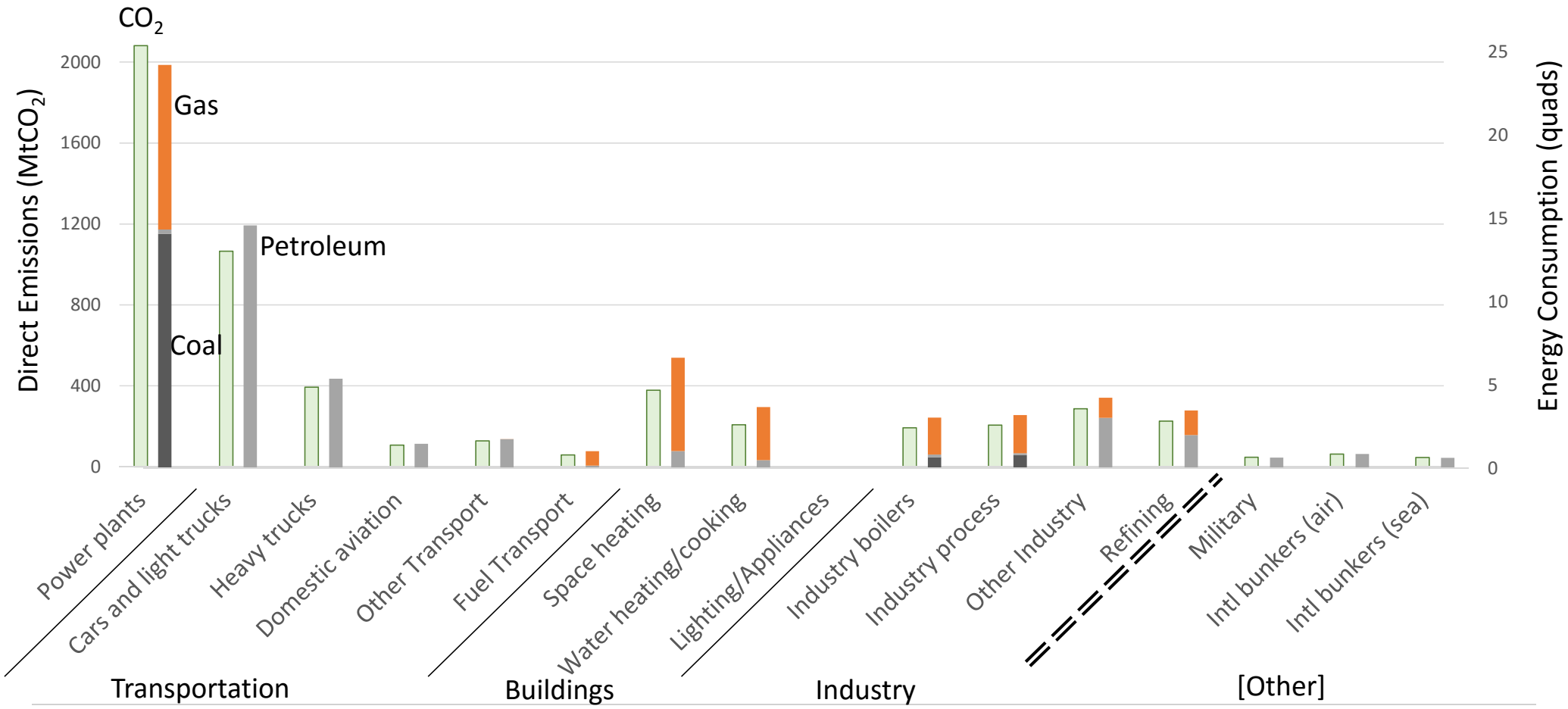
US Direct CO_2 emissions + Fossil Fuel Consumption



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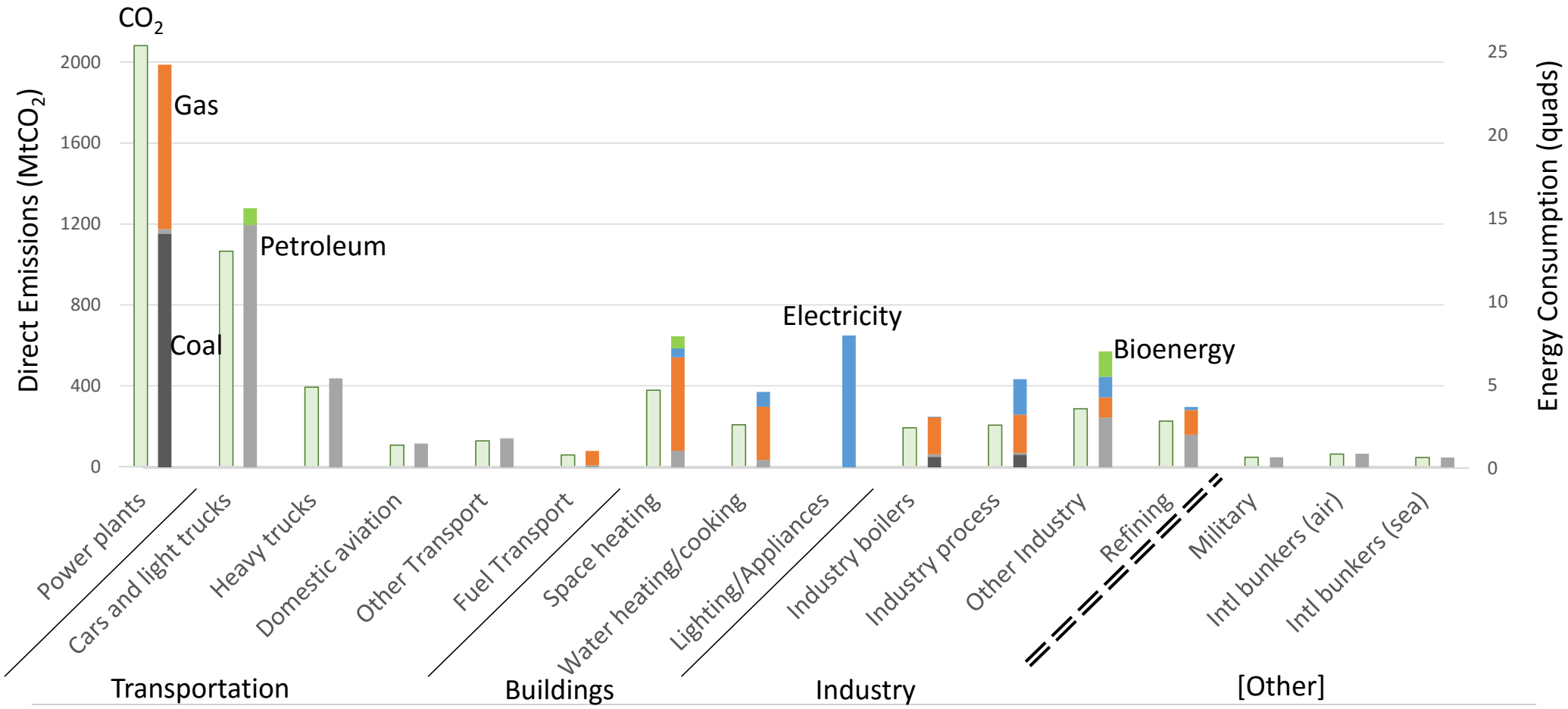
US Direct CO_2 emissions + All Fuel Consumption



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Reducing carbon emissions through electrification

- In nearly every case, replacing fossil fuels with electricity at the end-use results in lower overall carbon emissions
  - Leverage will only increase with tighter constraints on power sector CO2
- Key questions:
  - What are the costs?
  - How much fossil use can be cost-effectively replaced by electricity even without a carbon price?
  - For the remainder, how does carbon pricing change the equation, i.e. how does electrification compare with other mitigation options?
  - In either case, how do we think about adoption and diffusion in the context of consumer behavior?

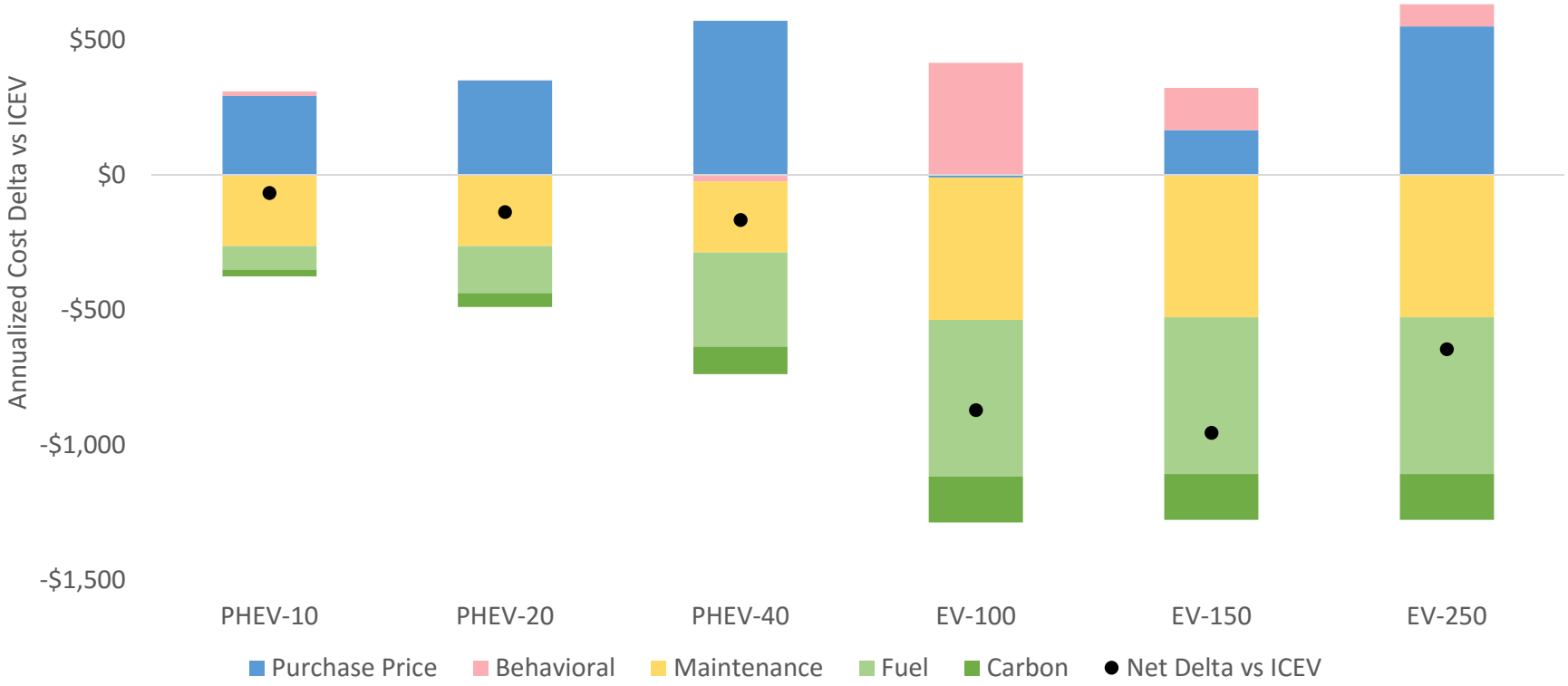
Light-Duty Vehicles

- Currently EVs and PHEVs have a very small market share but may be on the cusp of much more widespread deployment
  - Certain consumer groups may find EV/PHEVs more or less attractive based on usage patterns and technology attitudes (from ORNL):
    - Urban / Suburban / Rural
    - Low / Medium / High annual mileage
    - Early Adopter / Early Majority / Late Majority
- We model the economic trade-offs among alternative vehicles in each region / consumer group based on these “behavioral cost” differences and retail fuel prices

Electric Vehicle Cost Delta vs Conventional Vehicle

- EPRI assumptions about vehicle costs for 2030 (no incentives)
- ORNL estimates of behavioral costs
- current fuel prices + $100/tCO$_2$

Median consumer type



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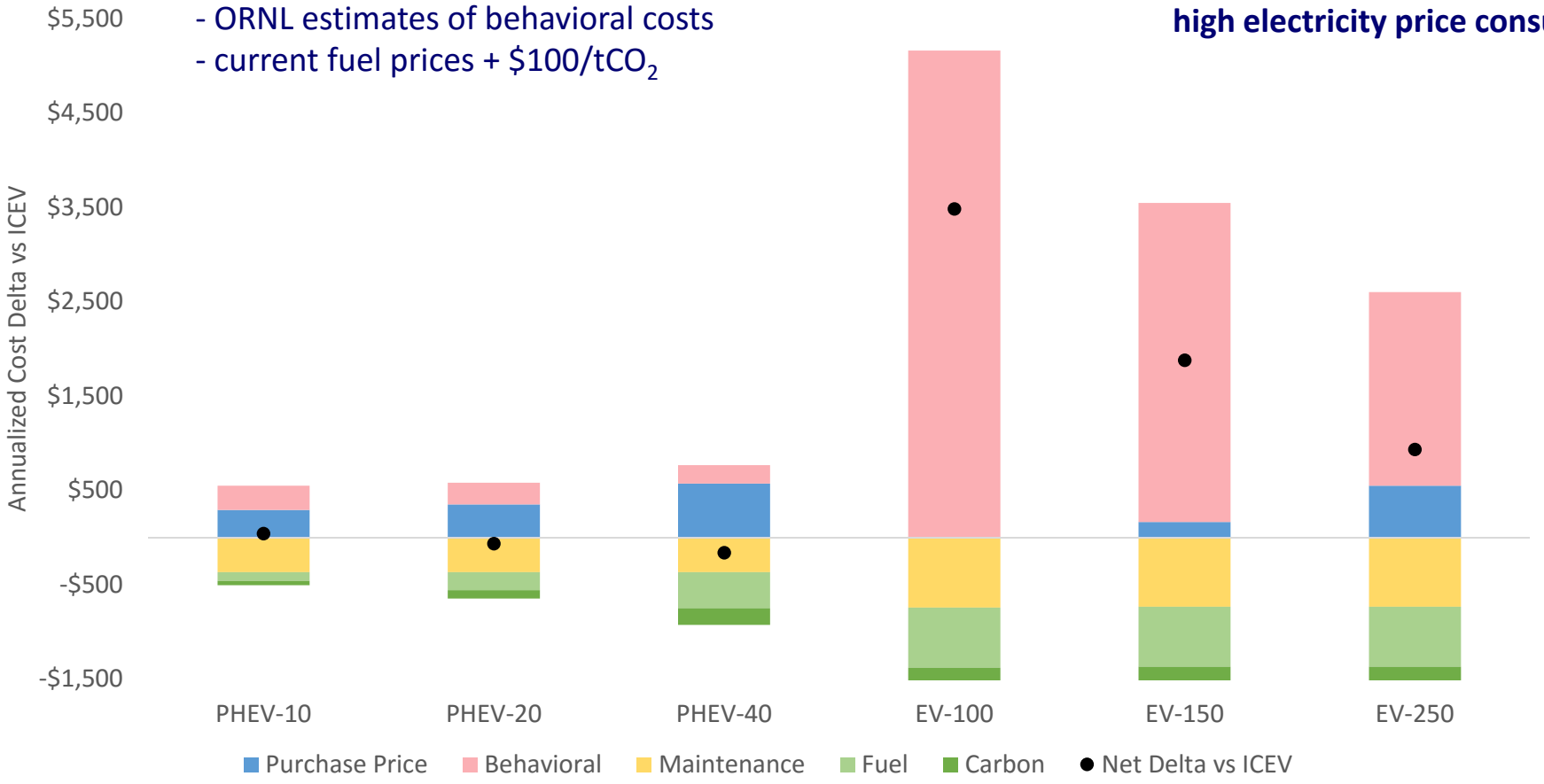
Electric vehicles may not work for all consumer types

- EPRI assumptions about vehicle costs for 2030 (no incentives)
- ORNL estimates of behavioral costs
- current fuel prices + $100/tCO$_2$

Rural, high mileage, late majority, high electricity price consumer type



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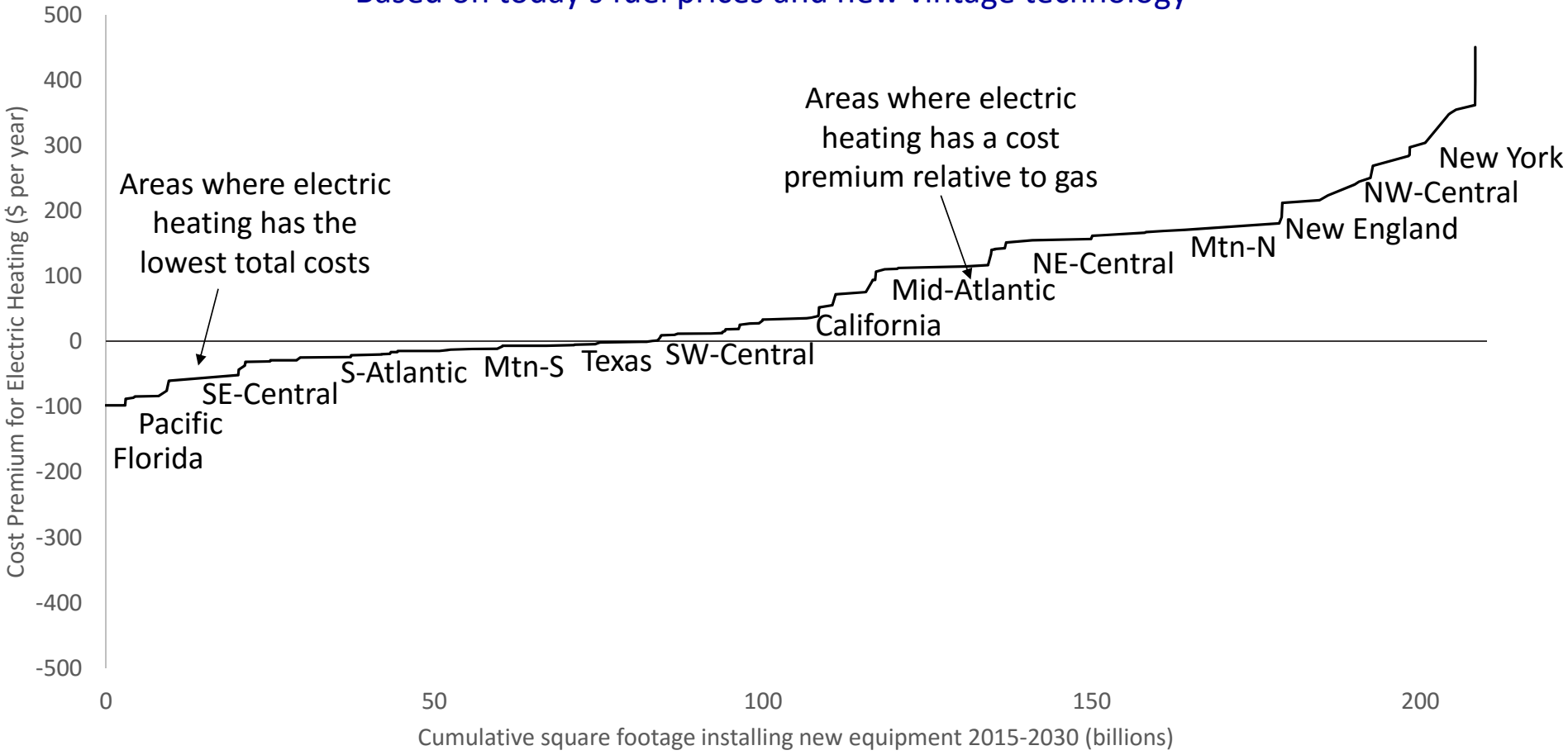
Electric Heating in Buildings

- Currently about 1/4 of residential floorspace in the US has electricity as the main heat source, according to EIA surveys
  - Concentrated in regions with mild climates / favorable relative fuel prices, e.g. Florida and Pacific NW
  - Higher shares in mobile homes and multi-unit buildings
  - Lower share in commercial buildings
- New opportunities for air source heat pump (ASHP) technology
- We model the economic trade-offs for ASHP vs. conventional furnace (+ A/C) in each region / climate zone based on temperature profile and retail fuel prices

Distribution across US of Electric Heating Cost Premium

Based on today's fuel prices and new vintage technology



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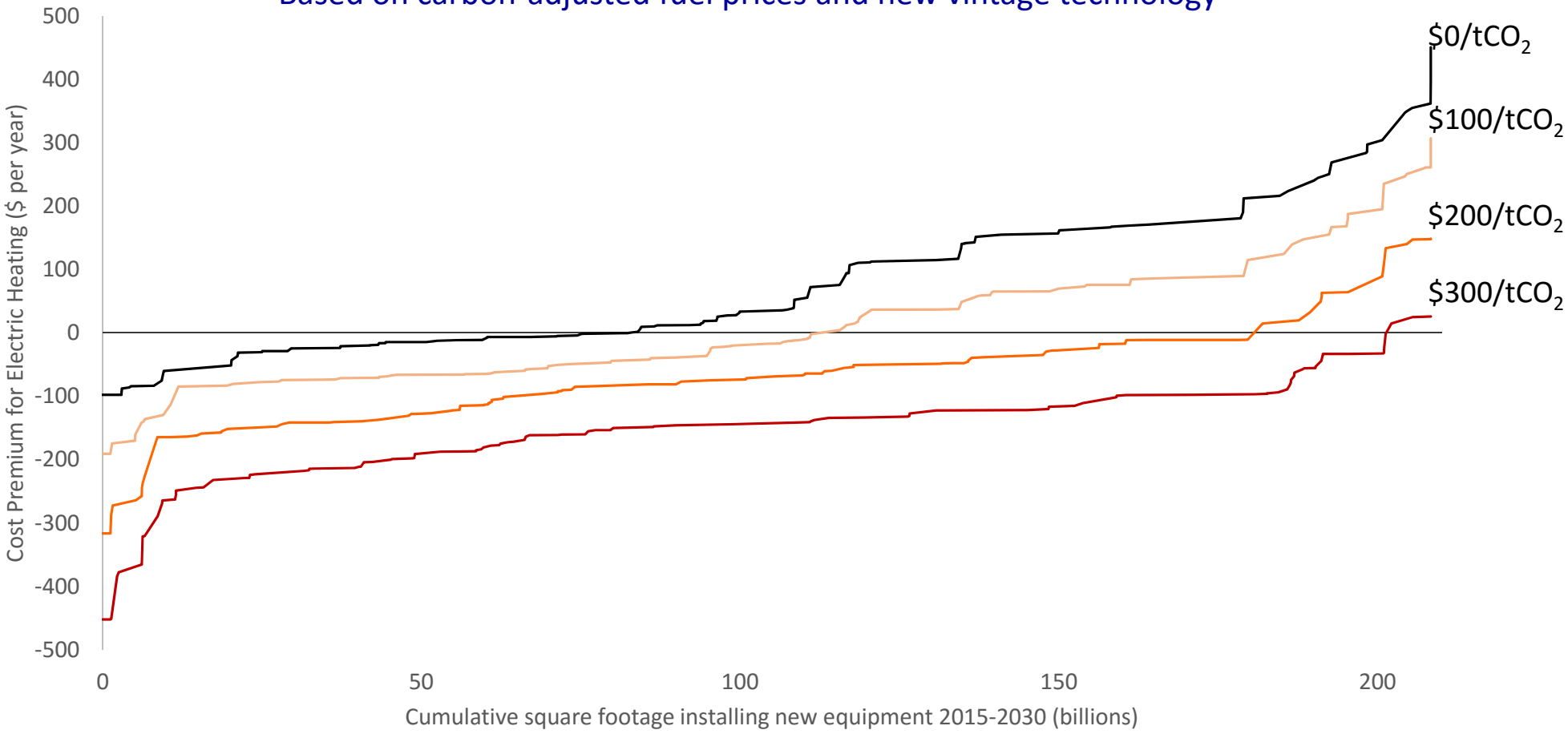
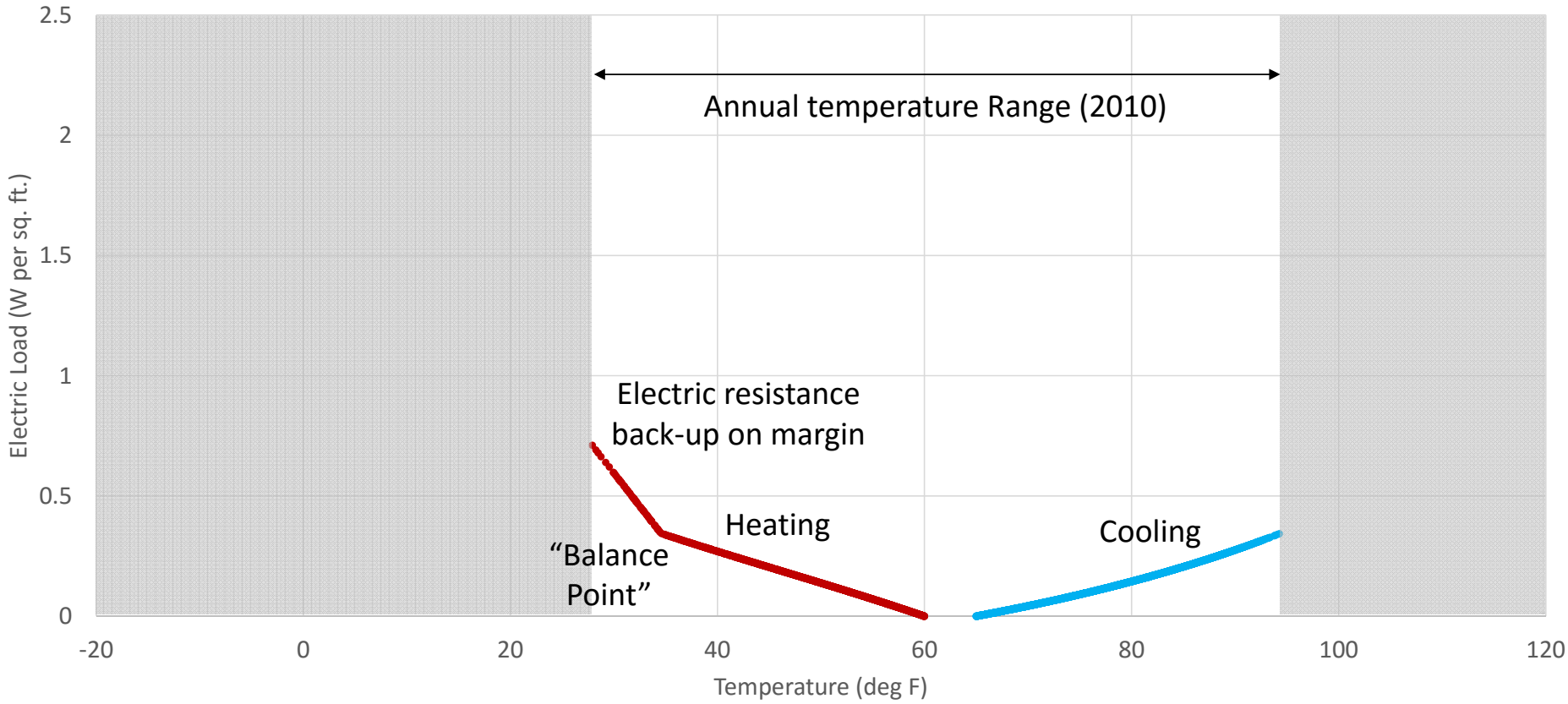
Higher carbon prices → more electric heating in the money

Based on carbon-adjusted fuel prices and new vintage technology



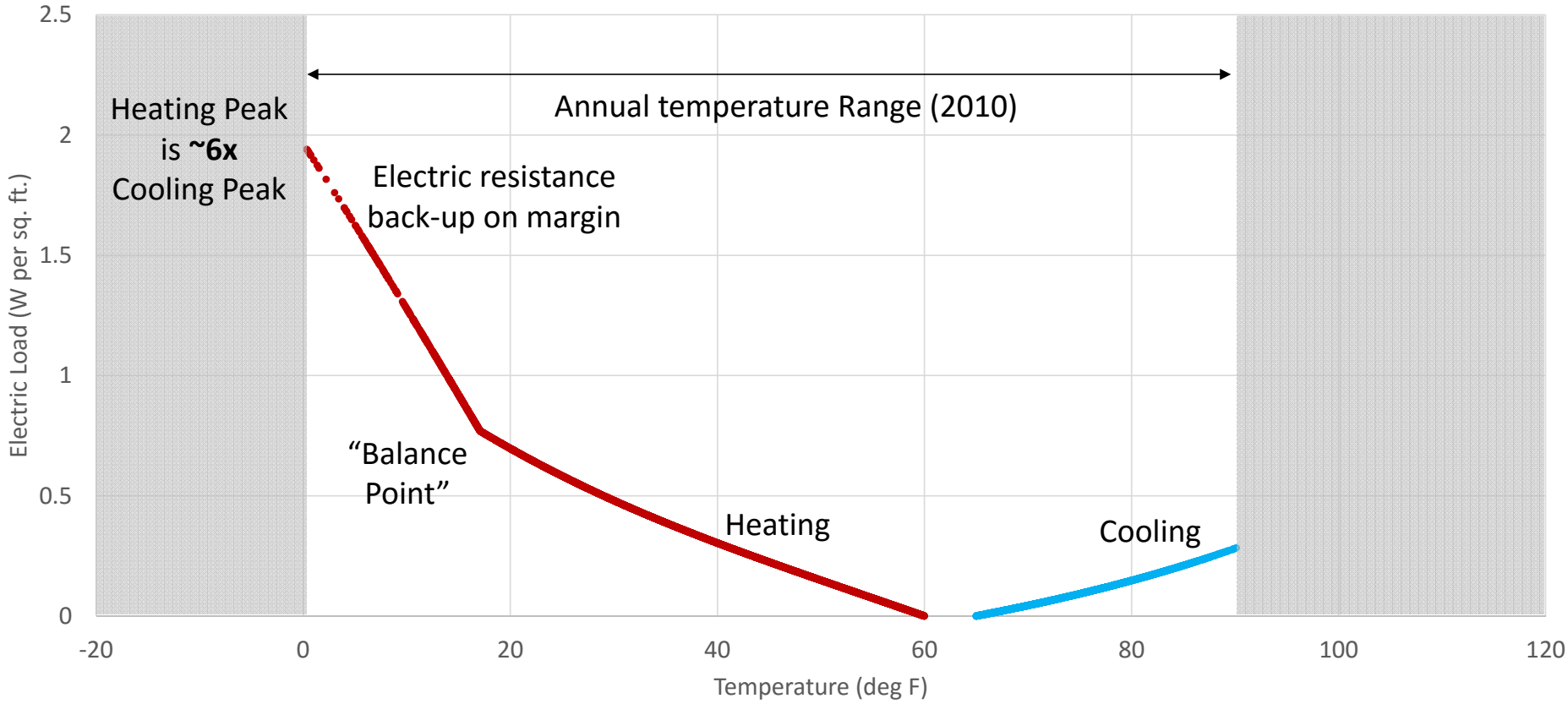
Hourly Building Heating/Cooling Load with ASHP vs Temp

Florida

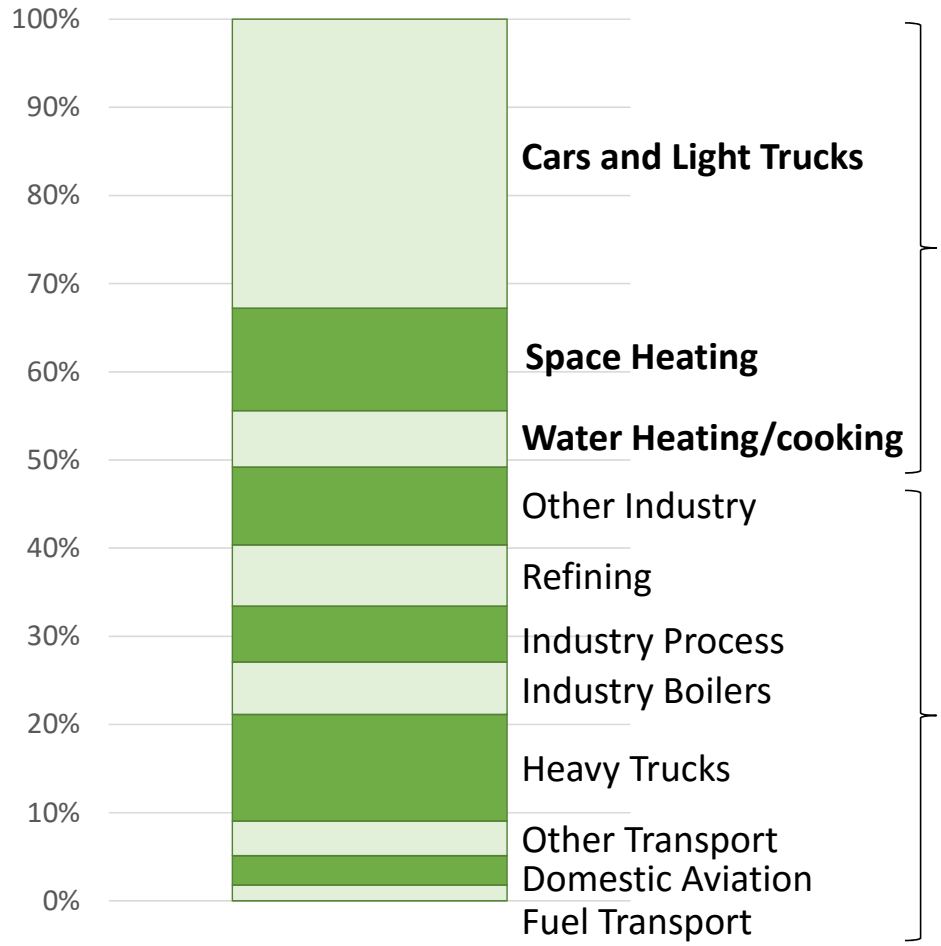


Hourly Building Heating/Cooling Load with ASHP vs Temp

NE-Central (e.g. Chicago)



Non-Electric Energy CO_2 Emissions in US



Half of non-electric emissions are in sectors with clear potential for deep electrification, subject to consumer behavior

Industry and heavy transport: also potential for electrification, but fewer opportunities / more barriers

Key Takeaways

- Energy system decarbonization begins with electric sector
- Non-electric decarbonization rates can depend on negative emissions opportunities in electric sector and elsewhere
- Modeling non-electric emissions is challenging due to heterogeneity and consumer behavior considerations
- Pricing carbon emissions can have small effects relative to other economic factors
- Electrification is a promising decarbonization option, especially in light-duty vehicles and buildings – integrated analysis is needed

Together…Shaping the Future of Electricity