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Electrification: it's great, but how far should we go?

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Electricity is a great fuel

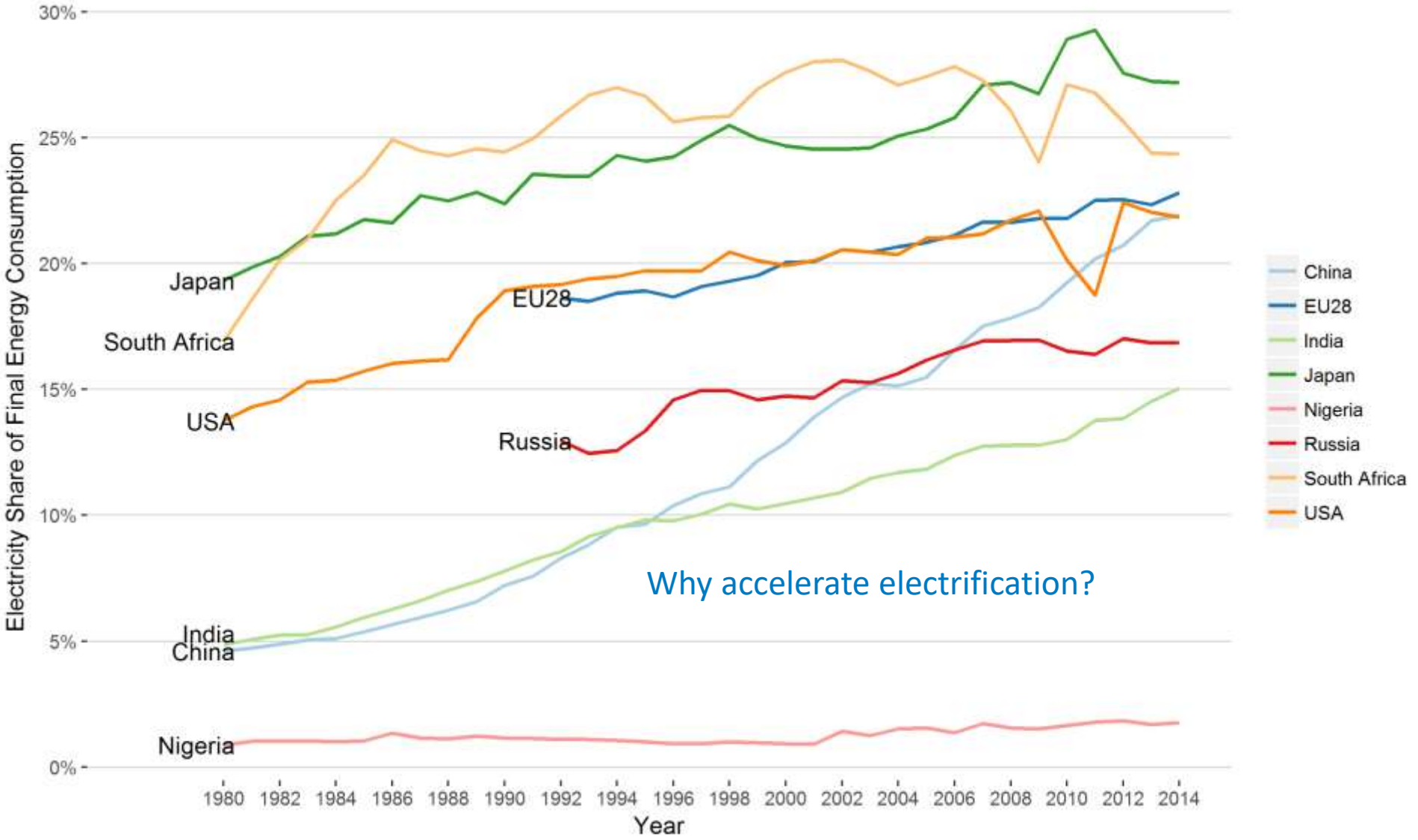
Transportability

Zero Point-of-use Emissions

Flexibility and Controllability

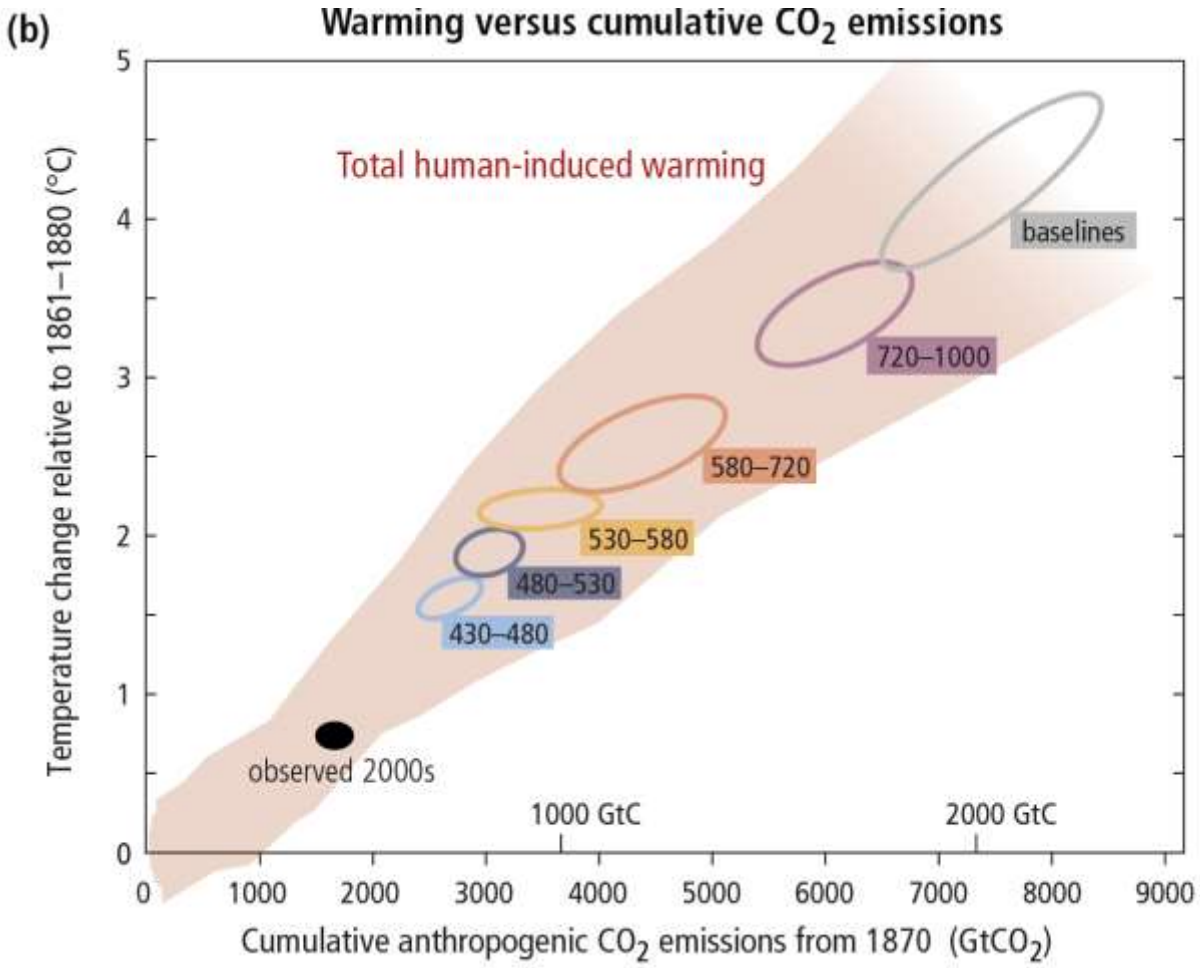
Storability

Electrification – everybody's doing it



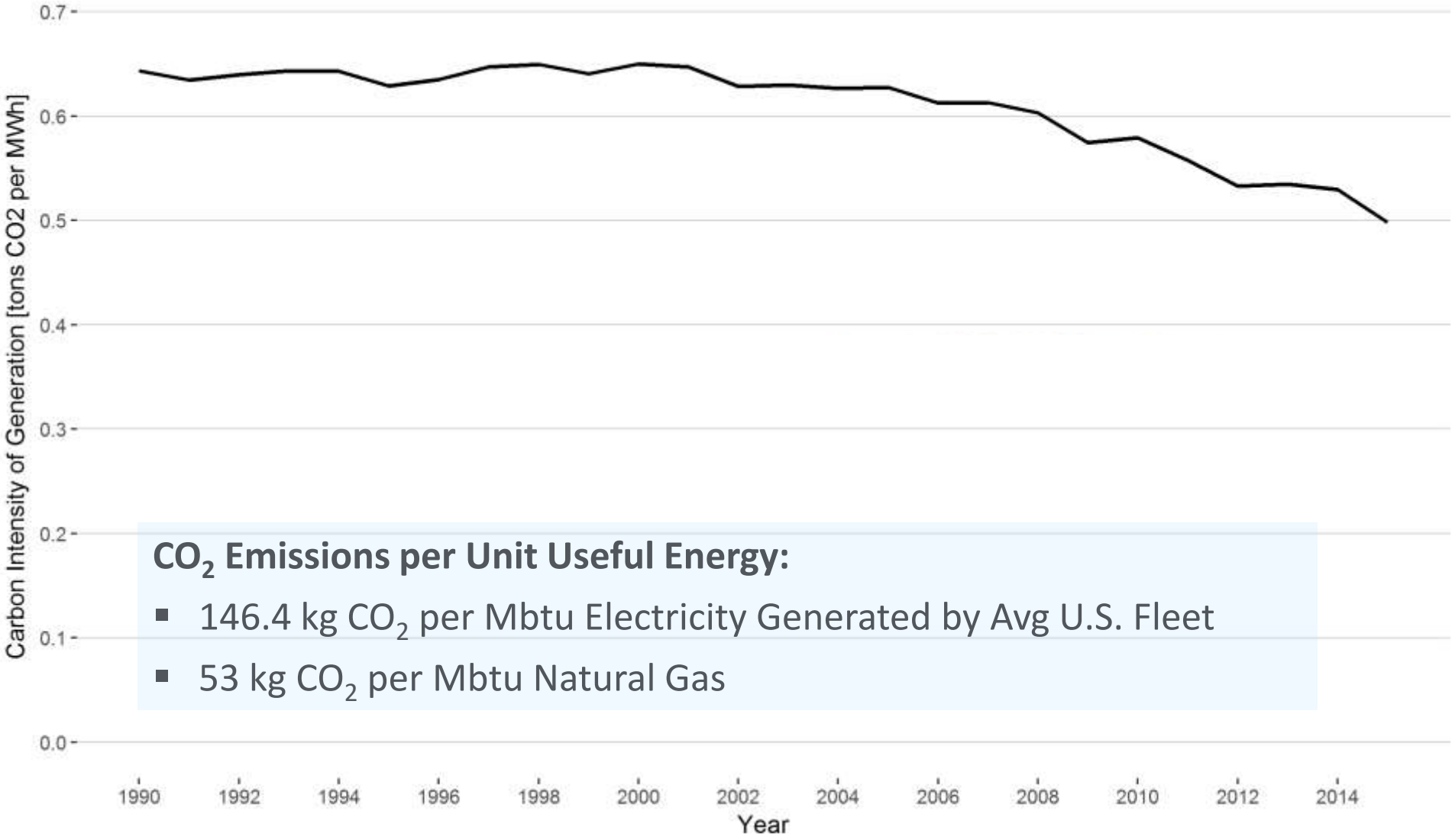
Why accelerate electrification?

Climate Change



Source: IPCC AR5

Emissions intensity of generation in the U.S. is on the decline



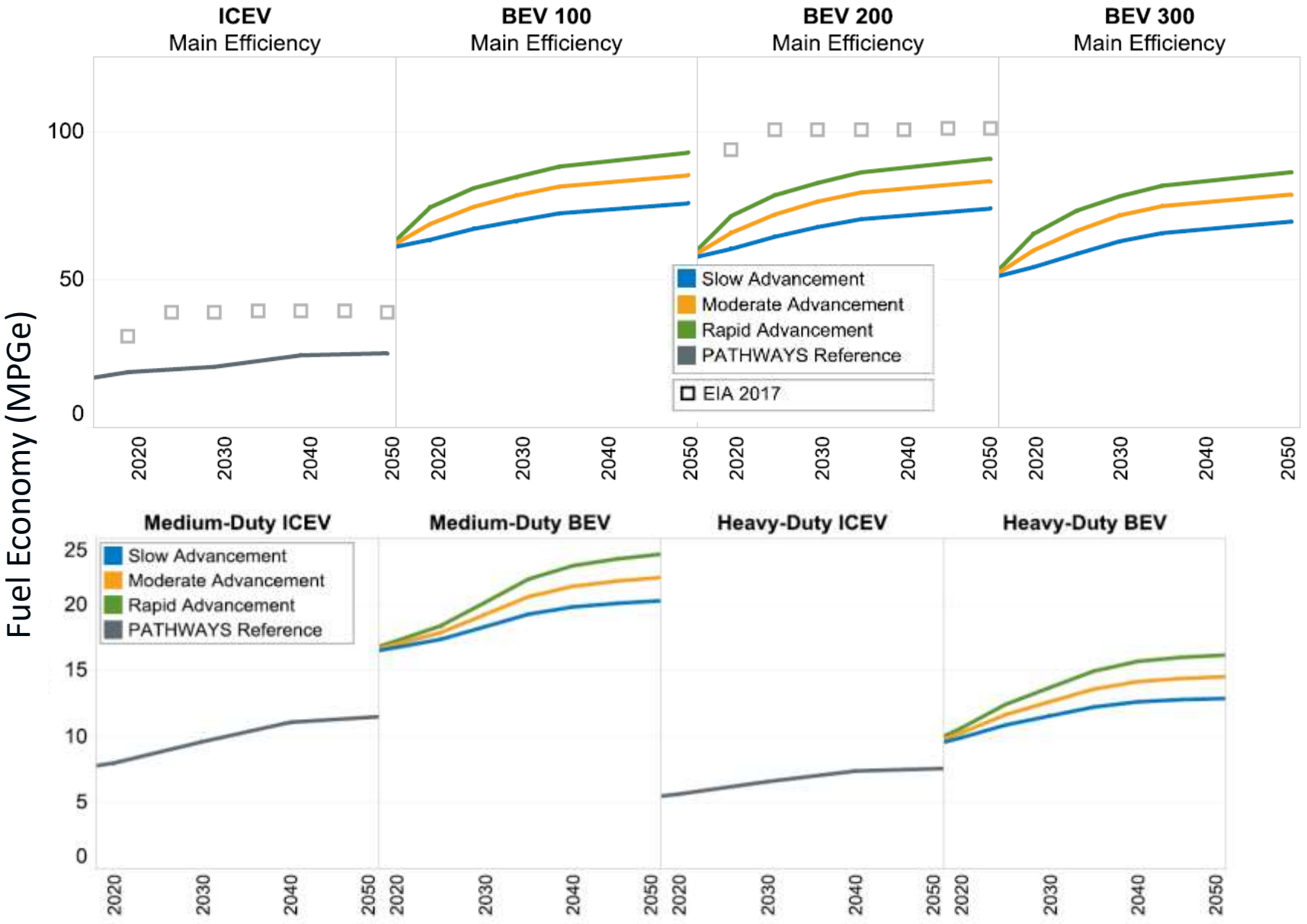
CO_2 Emissions per Unit Useful Energy:

- 146.4 kg CO_2 per Mbtu Electricity Generated by Avg U.S. Fleet
- 53 kg CO_2 per Mbtu Natural Gas

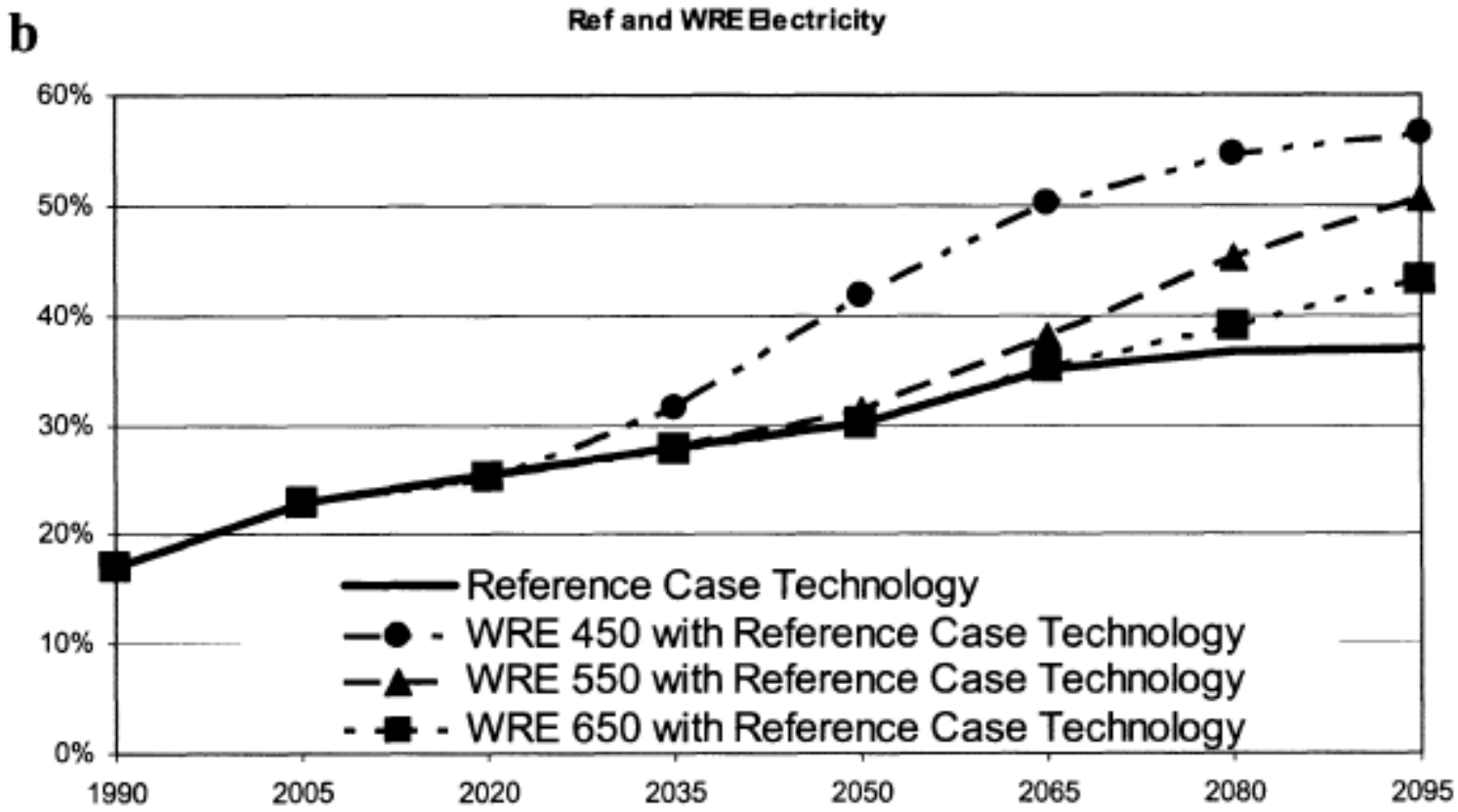
Electric devices are typically much more efficient: space heating

- Typical gas furnace: ~90% efficiency
- Typical heat pump: ~250 to 300+ % efficiency (for heating), and improving

Electric devices are typically much more efficient



Early modeling showed electrification (combined with power-sector decarbonization) is a key component of reducing GHGs

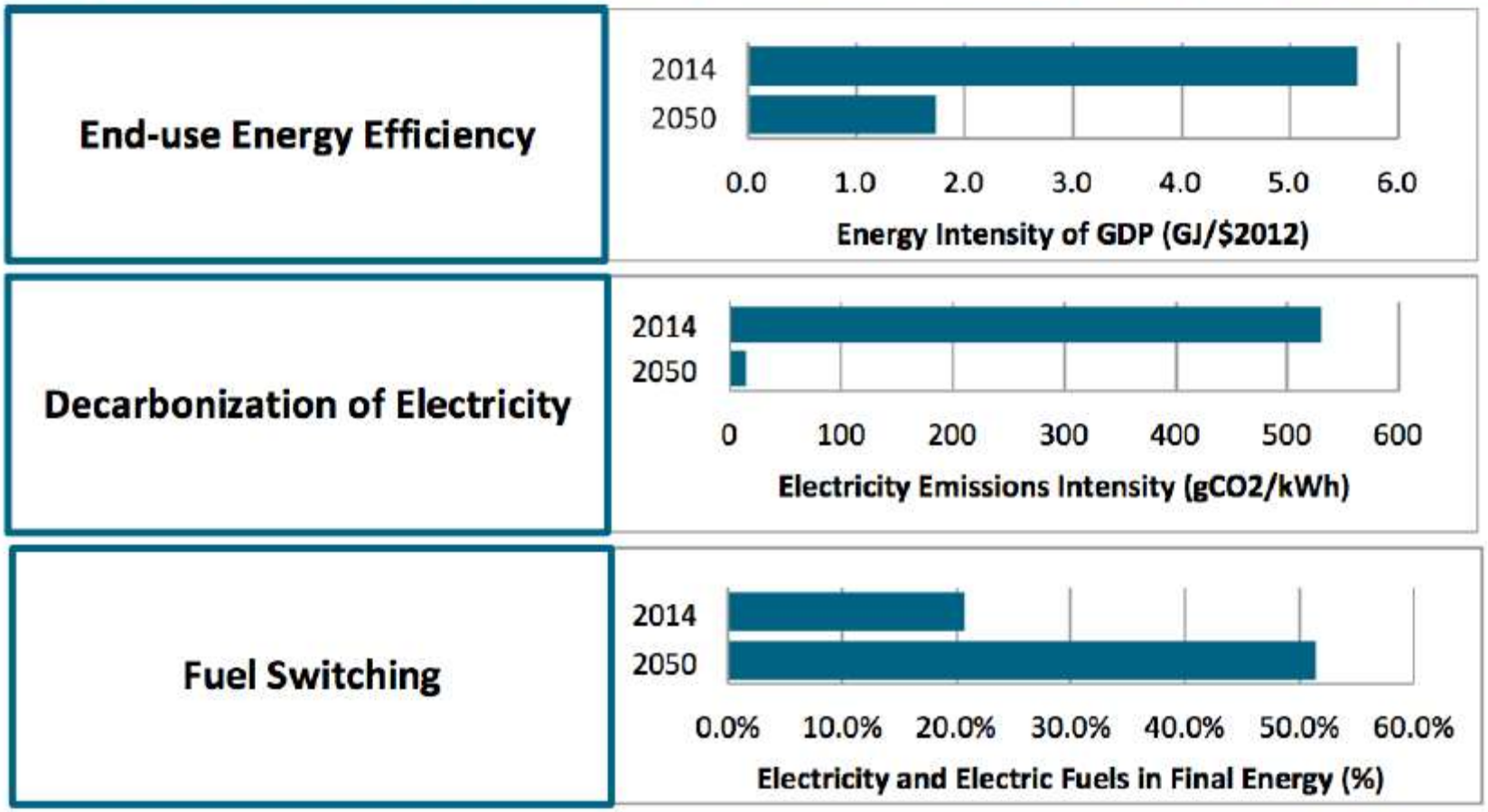


Ratio of US electricity production to total final US energy use under a reference scenario and set of CO_2 stabilization scenarios

Source: Edmonds et al., 2006

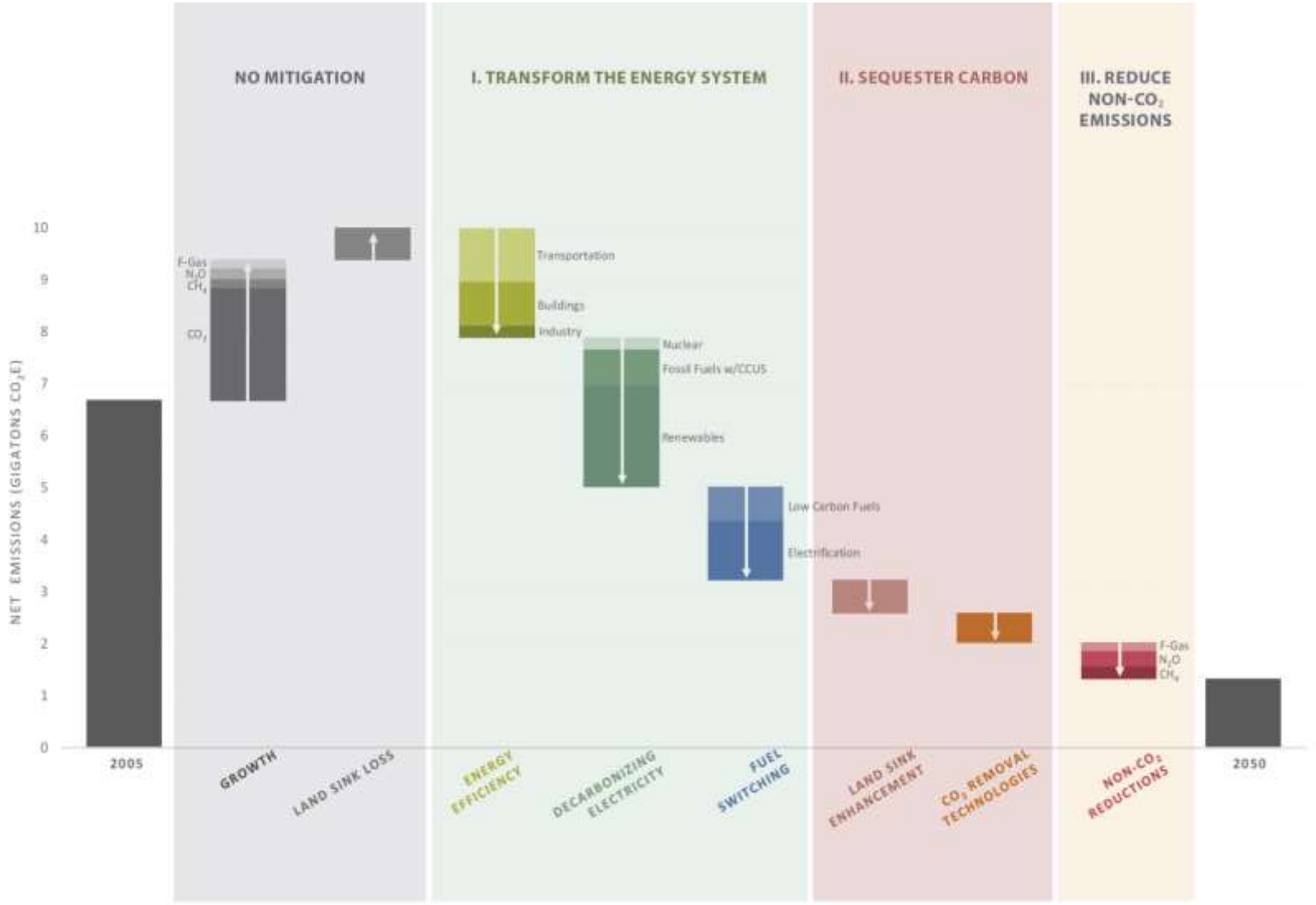
As models have improved, results haven't changed

Figure 11. Indicative Metrics for the Three Main Decarbonization Strategies, Mixed Case Compared to 2014



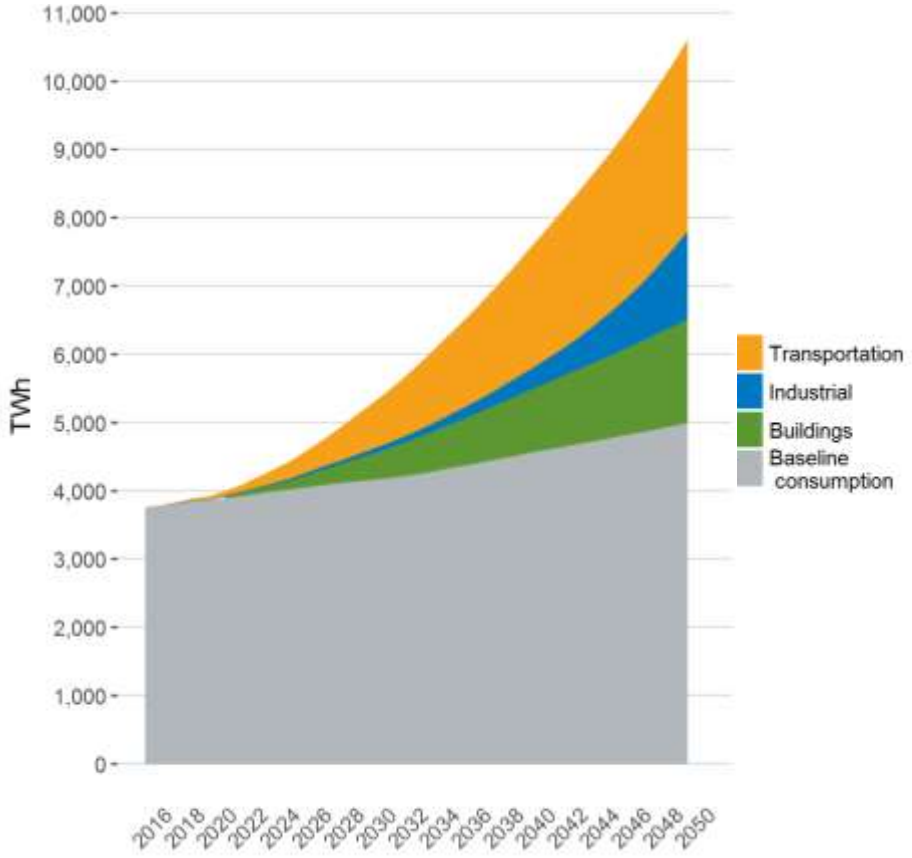
Source: Williams et al., 2014. Deep Decarbonization Pathways Project

U.S. Mid-Century Strategy also identifies electrification as key source of abatement

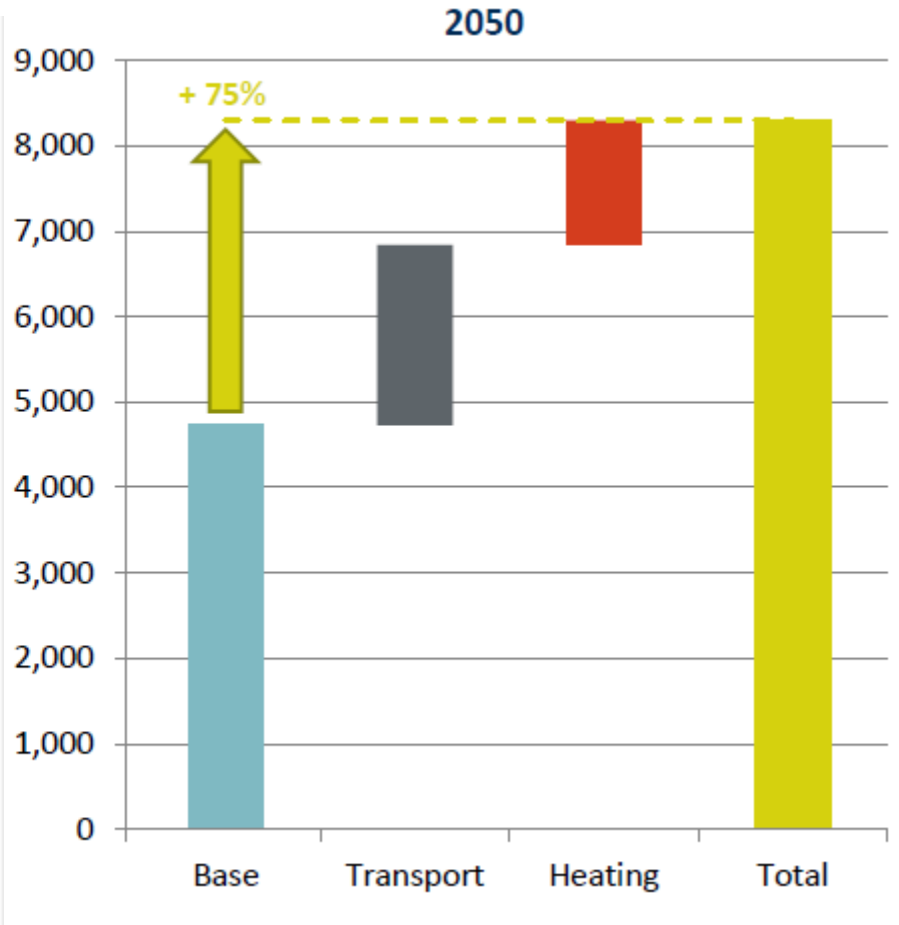


Source: United States Mid-century Strategy for Deep-Decarbonization, 2016

There is a large potential for electrification if pursued aggressively



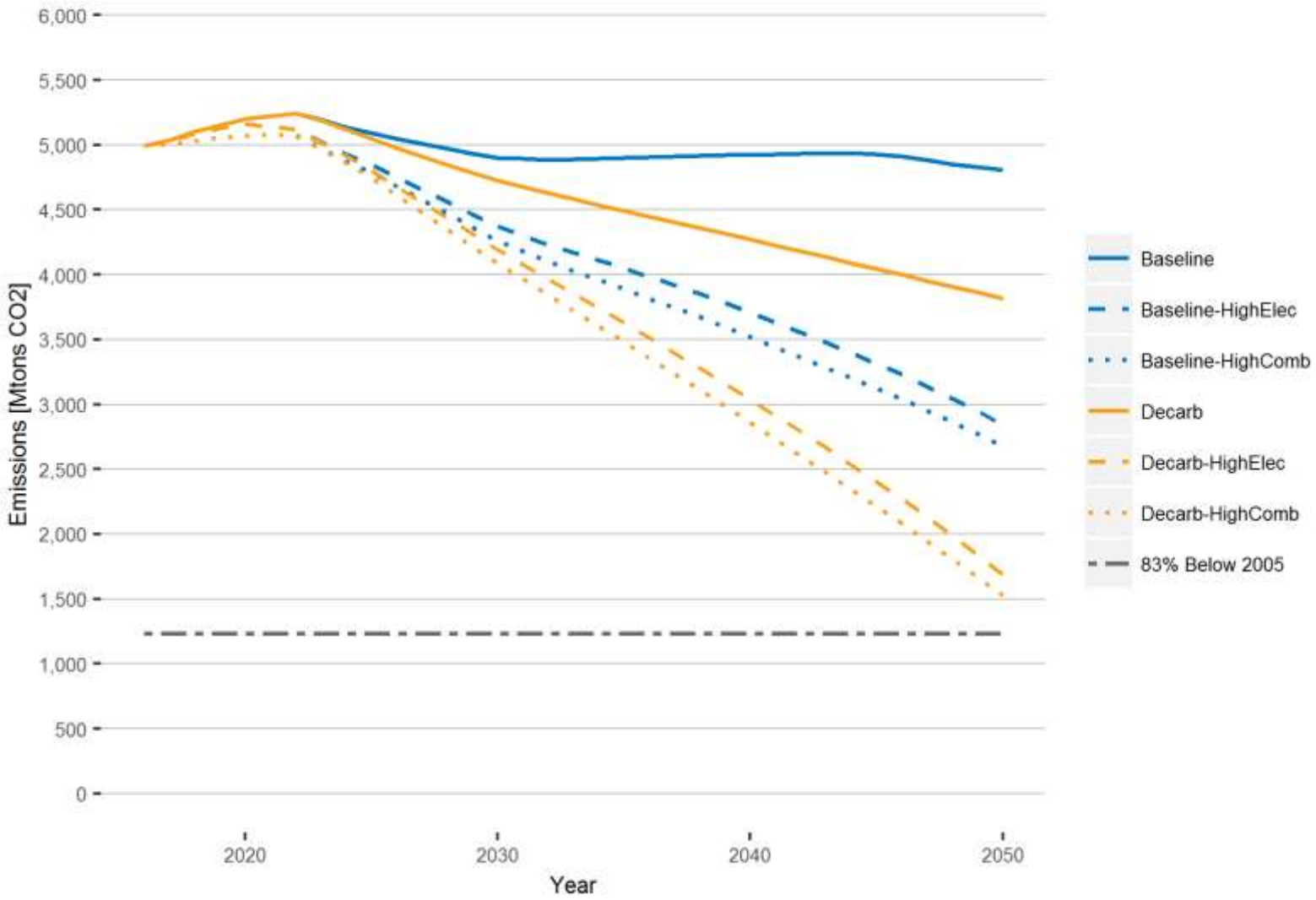
NREL (Steinberg et al., 2017)



Brattle (Weiss et al., 2017)

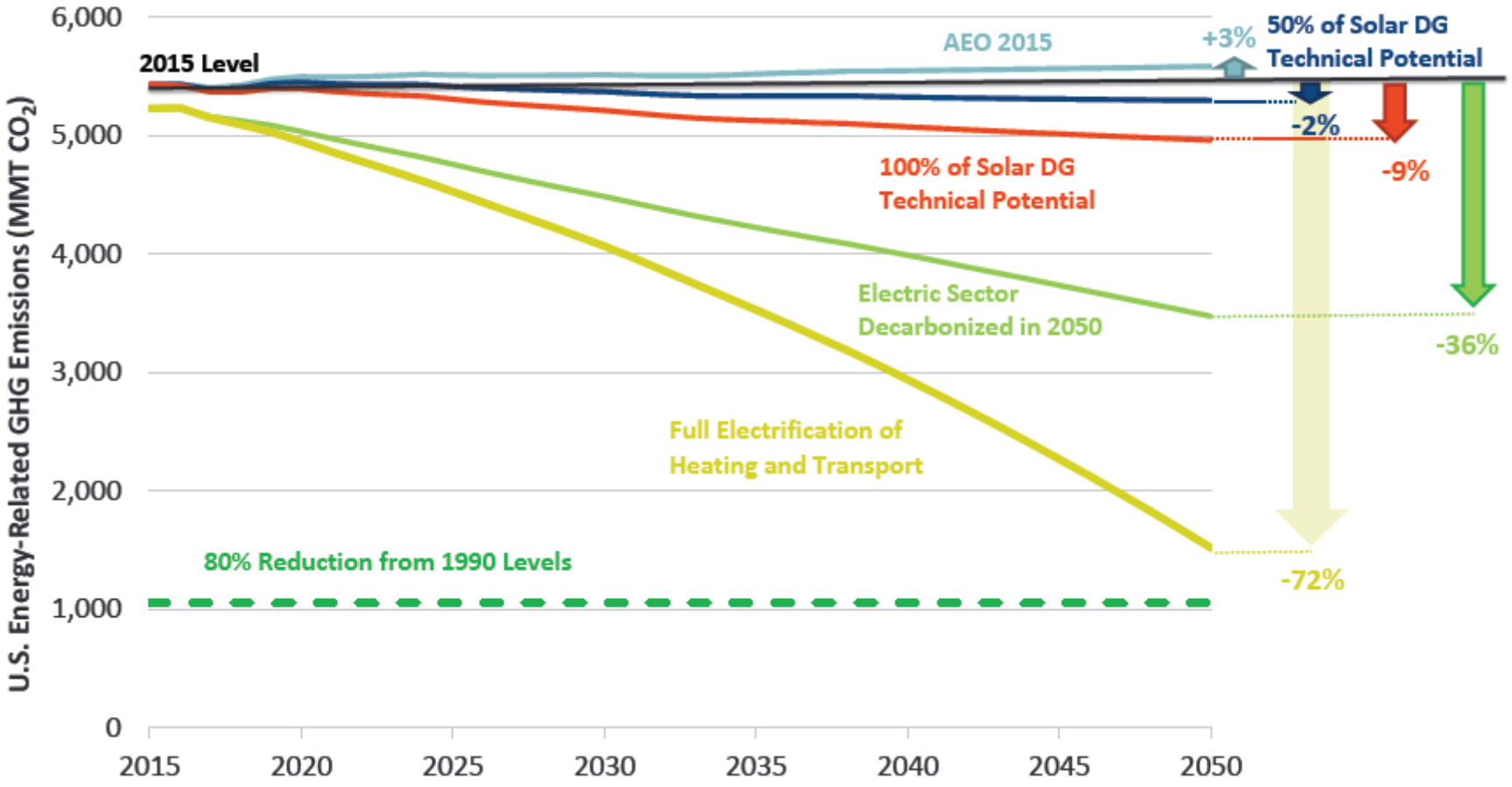
Both studies identify ~a potential doubling of electricity consumption by 2050 under scenarios of aggressive electrification

BUT, electrification and decarbonization, in isolation, are not sufficient to hit aggressive abatement targets



Source: Steinberg et al, 2017

Electrification and decarbonization are not enough on their own



Source: Weiss et al., 2017

What don’t we know:

How much electrification should or will occur?

Drivers of electrification

- Costs and performance (and co-benefits) of electric devices
  - Fuel, technologies, infrastructure
- Tradeoffs between efficiency and electrification
- Evolution of power sector and load
  - Generation mix
  - Electricity markets and customer participation
  - Cost of storage and availability of long-term storage
- Evolution of preferences and behavior
- Policy and regulation, especially GHGs

How will these interact to determine the future level of electrification?

Research Gaps: Data and Integrated Modeling

- Data: lacking comprehensive and detailed projections of:
  1) Cost and performance of electric technologies
  2) Infrastructure costs

  (but these are under development)
- Modeling: lack of integrated bottom-up models that endogenously simulate adoption of end-use devices across demand sectors and simultaneously optimize the evolution of the power sector

Filling the gaps

- Data:
  - It's happening for end-use devices
  - Infrastructure – requires modeling of its own
- Models
  - We're not going to develop the model of everything overnight
  - But, we are making headway: we have great power sector models, decent bottom-up models of load (at least for buildings and transport), and good models of vehicle adoption
  - We need improved adoption models for buildings and industry
  - Then we can integrate the components
  - And what about behavior?

Concluding

- Electrification has many benefits – flexibility, controllability, service quality, environmental and health
- Technical potential for electrification is large
- Climate benefits associated with aggressive electrification could be very large:
  - 75% reduction from 2005 levels (if combined with power sector decarbonization)
- BUT, electrification interacts and competes with a complex array of societal, energy, and climate mitigation pathways
- Next crucial steps in research are to develop data and integrated tools that allow us to explore how these pathways or phenomena interact, and to what degree electrification should be pursued

Thank you!

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