Electric Reliability Under Deep Decarbonization: *New England Case Study*

9th Annual EPRI-IEA Challenges in Decarbonization Workshop

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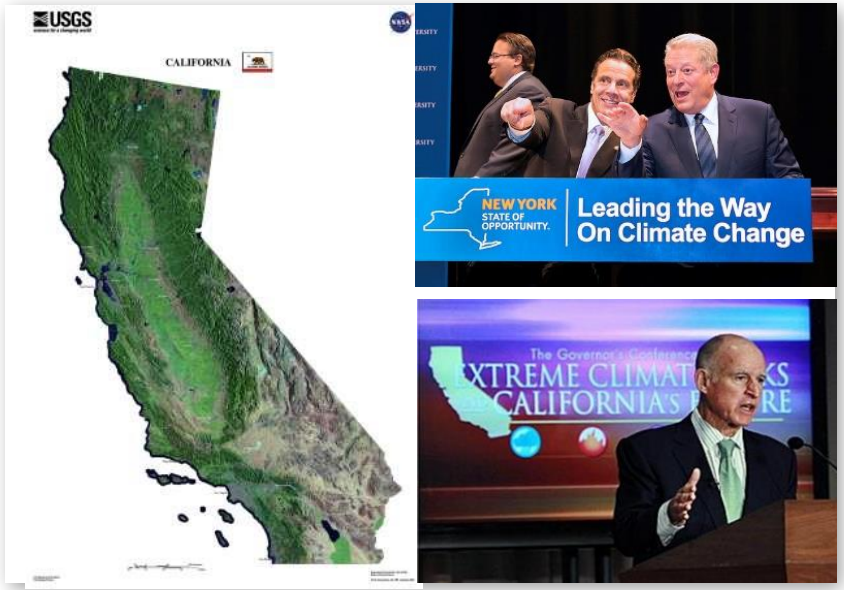
Energy+Environmental Economics

E3 Has Worked with a Wide Range of Clients to Understand the Challenges of Deep Carbon Reductions and High Renewable Penetration

- **United Nations** Deep Decarbonization Pathways Project
- **California:**
  - Carbon Reduction Pathways studies
  - Landmark 2014 study of 50% RPS goal for PG&E, SDG&E, SCE, LADWP, SMUD, CAISO
  - 100% RPS studies for LADWP, SMUD, Calpine, The Nature Conservancy
  - Support for California CPUC IRP process
- Deep carbon reduction and 100% renewables planning in a **diverse group of regions:**
  - **New York:** NYSERDA, NYPSC
  - **Hawaii:** HECO
  - **Canada:** Nova Scotia Power, Atlantic provinces
  - **Upper Midwest:** Xcel Energy
  - **Pacific NW & Desert SW:** numerous utilities
- [Today: Case study on deep decarbonization in New England, sponsored by Calpine]



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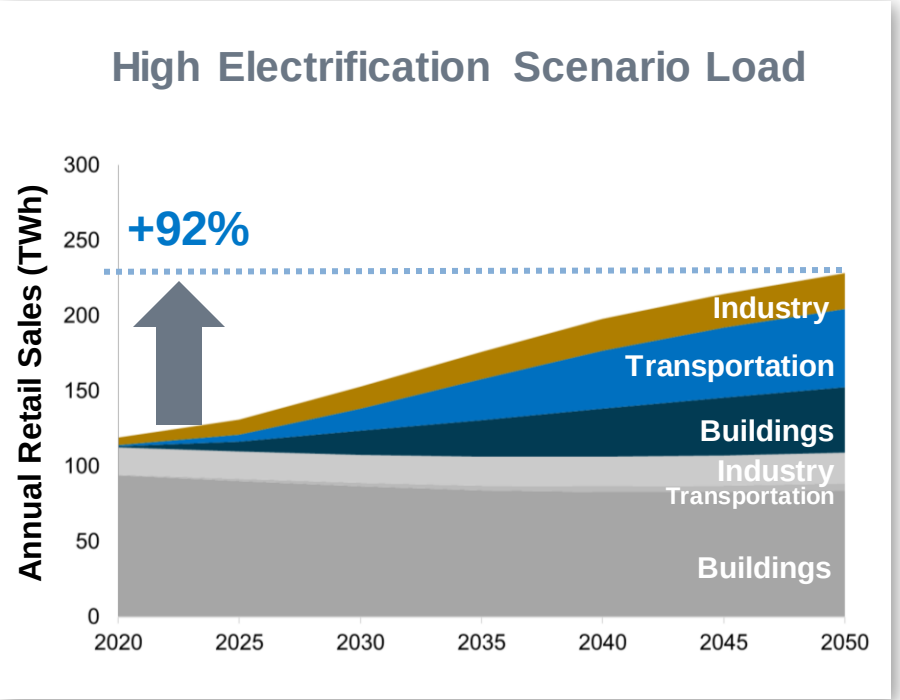
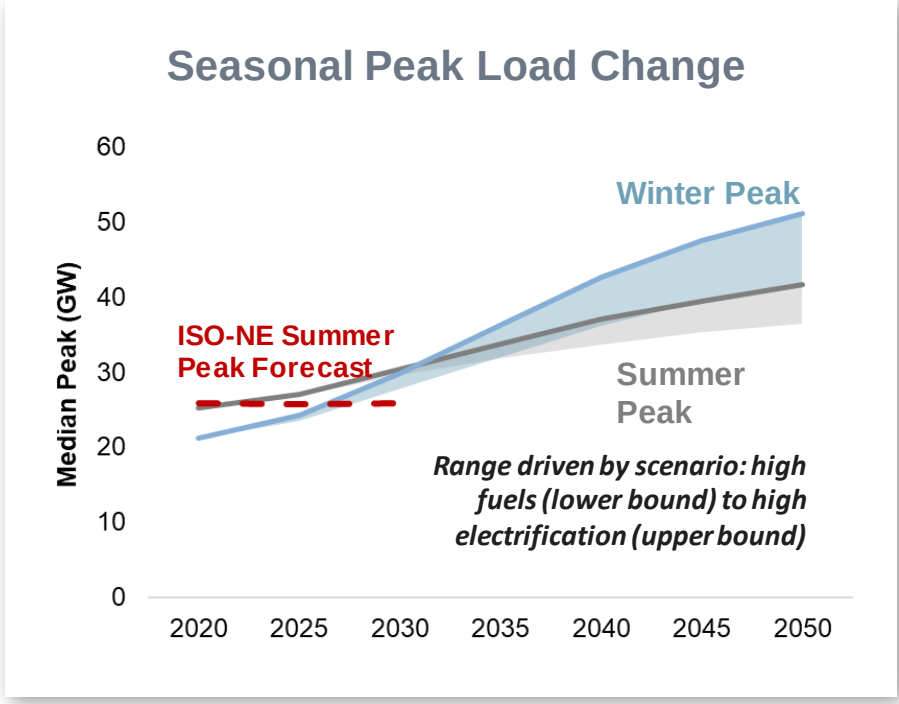
Electricity Demand Grows and Shifts Significantly Under Deep Decarbonization

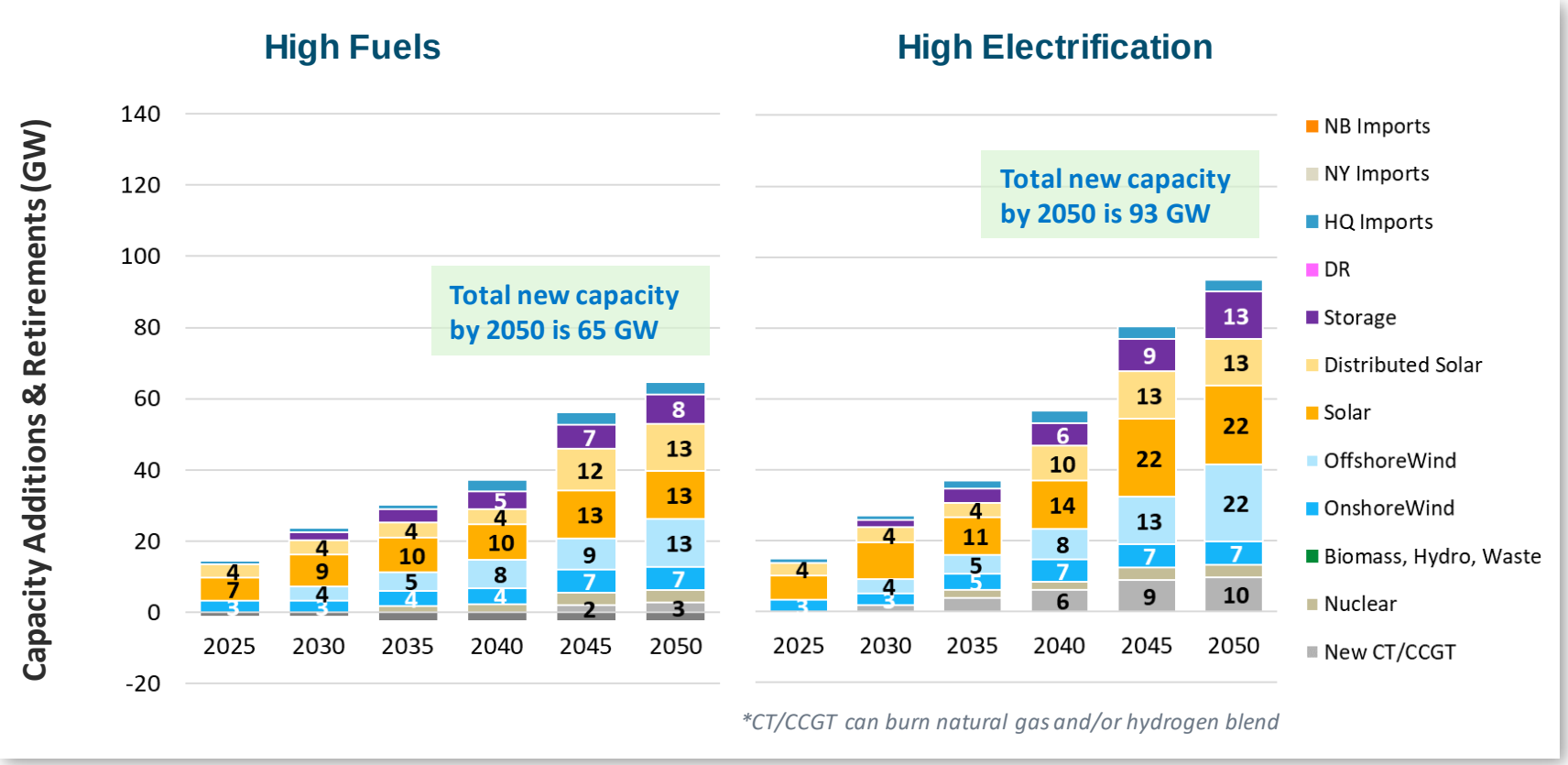
- Electricity demand grows significantly, particularly due to space heating and light-duty vehicles, compared to reference load demand (BAU)
- Electricity demand simultaneously becomes winter peaking in the mid 2030's due to new space heating demand





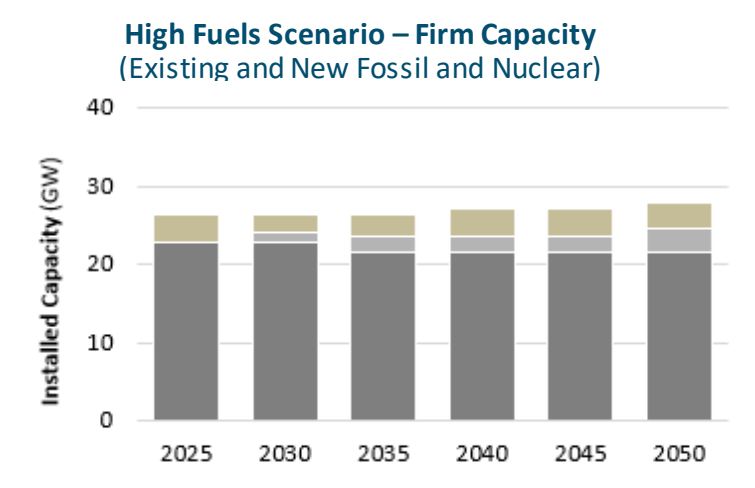
Significant Additions of New Renewable Energy

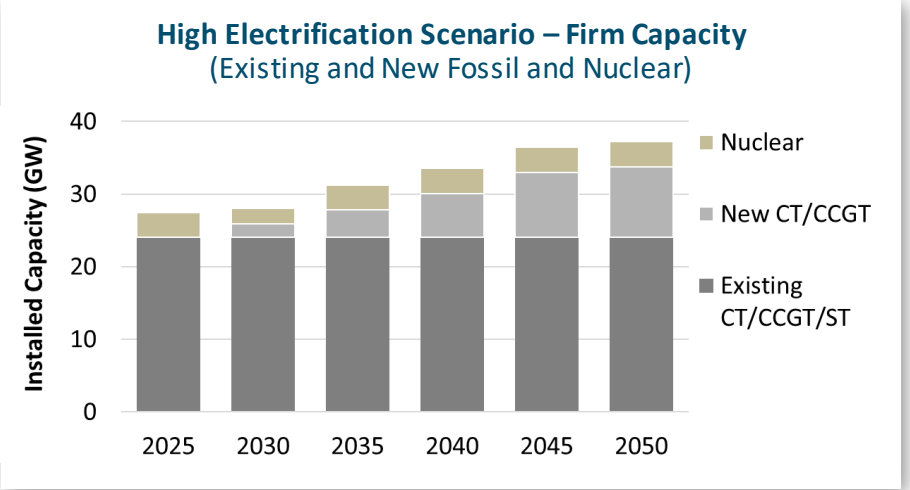
- New capacity additions are dominated by renewables and energy storage, particularly offshore wind and solar
- Land use constraints require significant quantities of offshore wind
- Battery storage helps balance day-to-day supply and demand

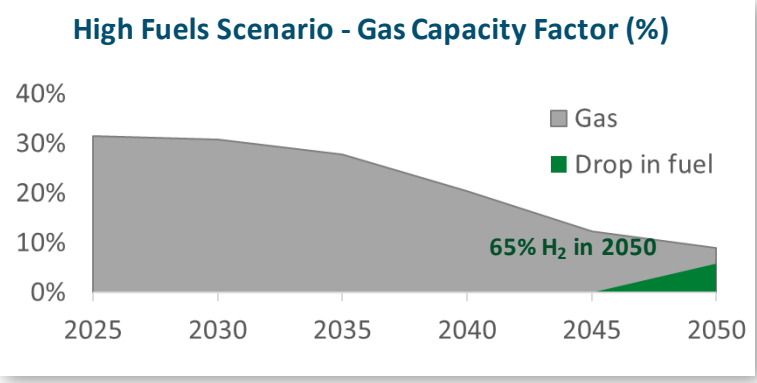


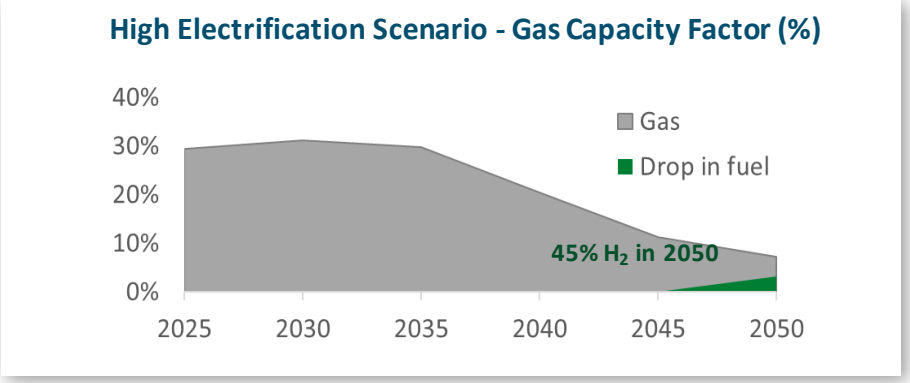
Role of Firm Generation

- Significant quantities of gas and oil resources are retained for reliability, but capacity factors decline substantially. Very limited quantities of gas are burned by 2050.
- In the future, firm generation can be provided by combustion-based generation, nuclear, or emerging long-duration storage technologies
  - Low-carbon firm generation may be achieved through reliance on zero-carbon fuels (hydrogen or biogas), nuclear, or by coupling generation with carbon-capture and storage

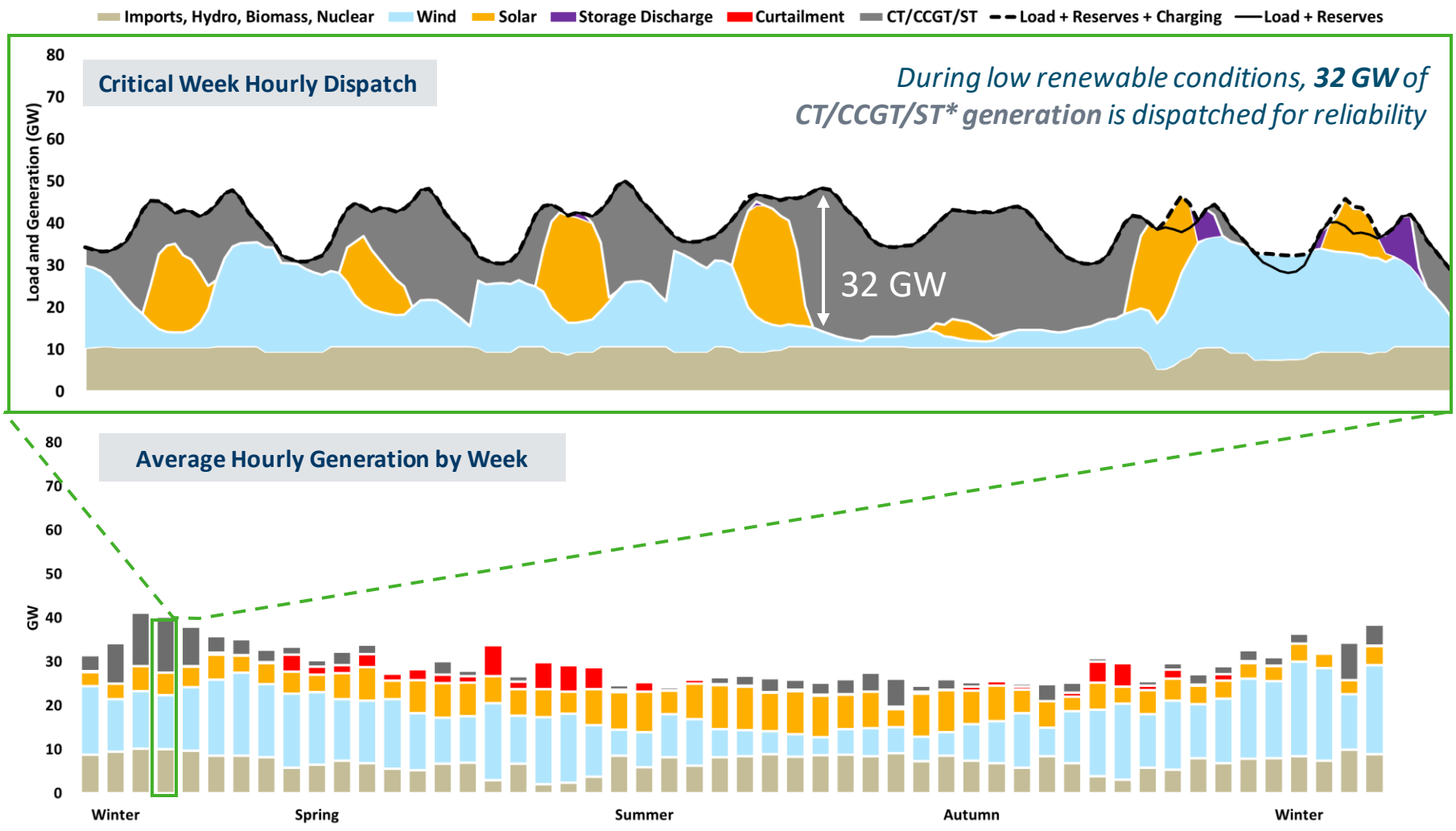








Critical Week Dispatch



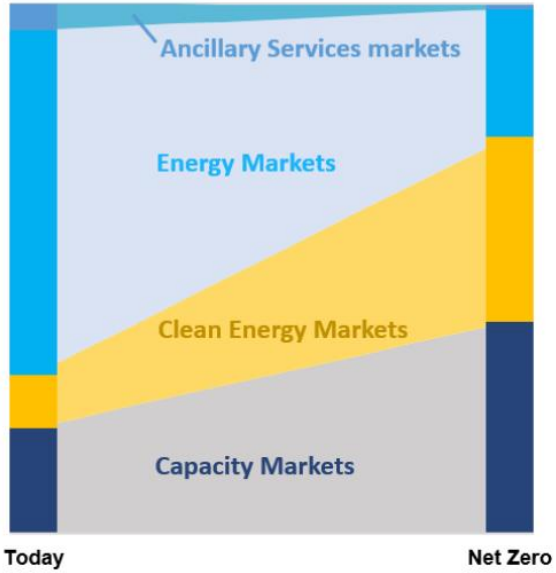
High Electrification Base Case

** Could represent natural gas, hydrogen, or other zero-carbon fuel blend burned in CT/CCGT, or dispatchable long-duration storage if viable technology emerges. More generally, this could represent any firm capacity, e.g. nuclear SMRs and Gas with CCS could also play this role.*

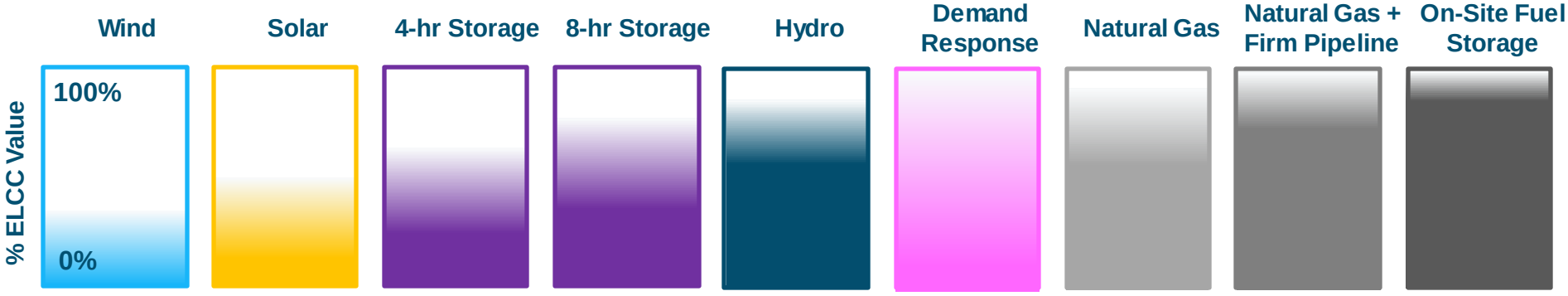
Capacity Accreditation is a Key Emerging Market Design Challenge

- Markets are rapidly moving to more rigorously quantify the reliability/capacity contributions made by renewable, storage, and conventional resources
- This is important because it could become a (or the) driver of resource revenues – the alternative is to have perpetual periods of scarcity coupled with very high prices (which may be politically unpalatable)
- It is important that the reliability risks of all resources are accounted for properly, not just renewable/storage but conventional resource access to firm fuel

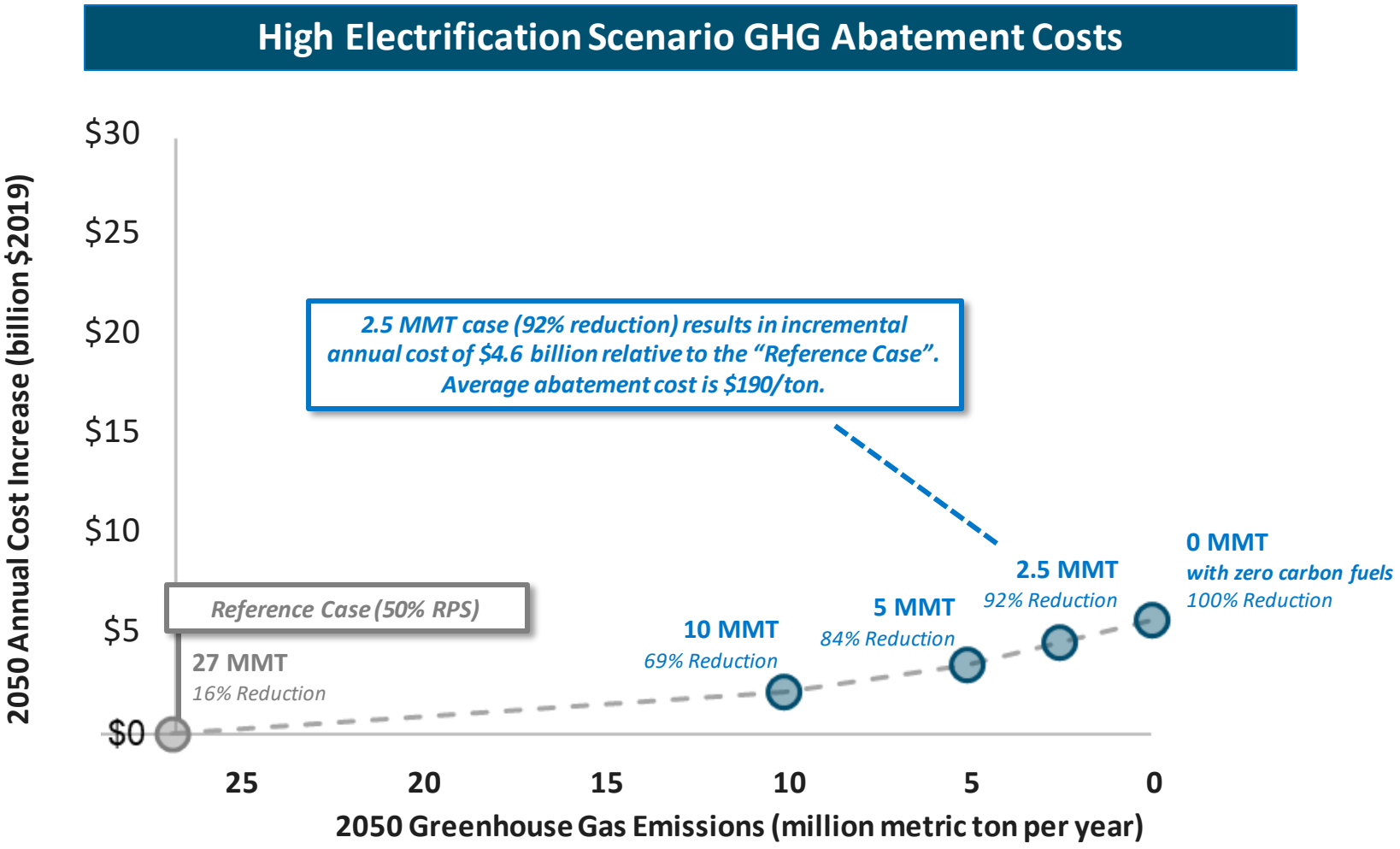
Evolution of Electricity Markets Under Net Zero



Illustrative ELCC Values

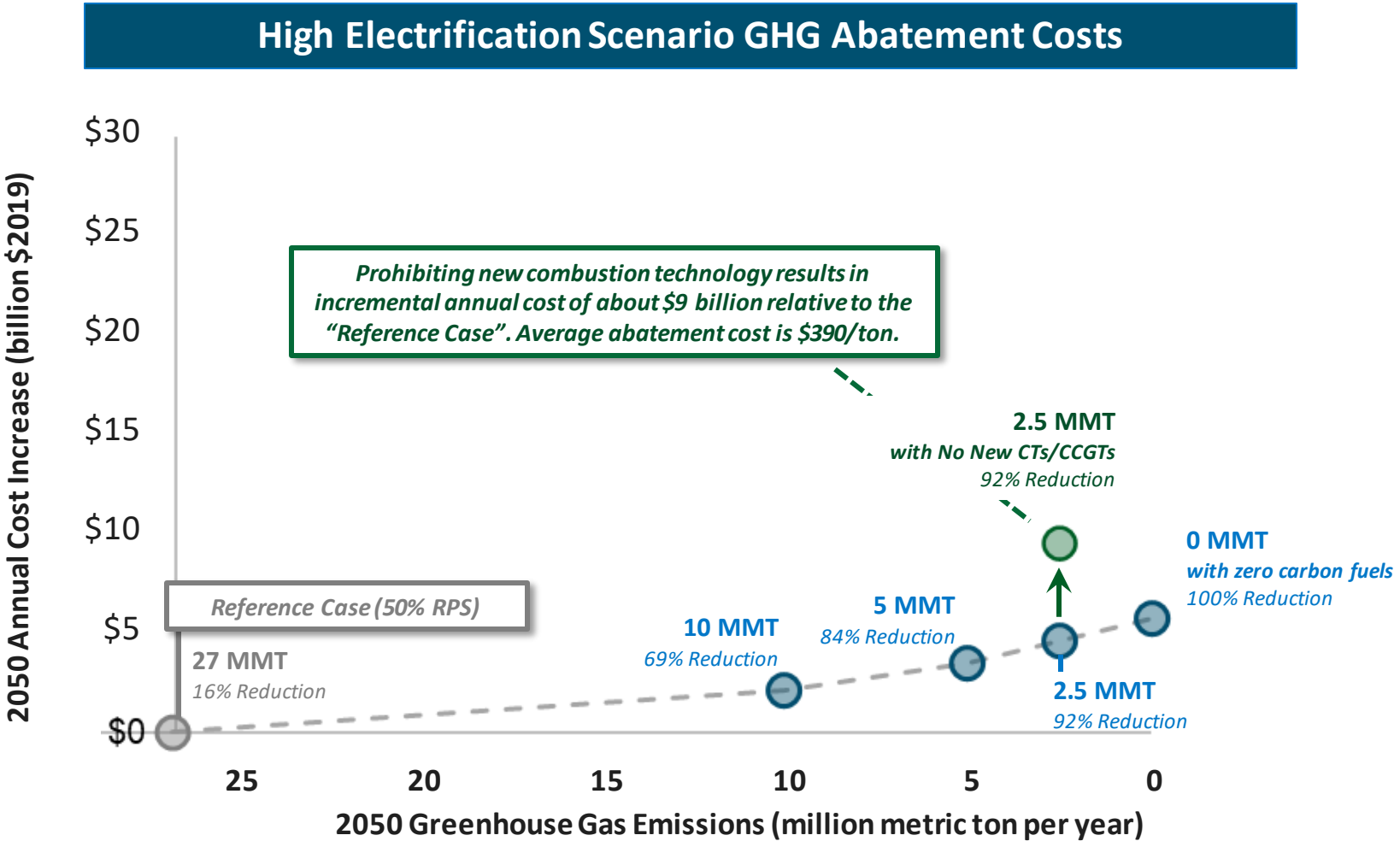


2050 Electricity Sector Abatement Costs under High Electrification Loads



Cost increases are reported relative to the hypothetical Reference Case (50% RPS).
Reductions relative to 2016 emissions of 32 MMT estimated based on EPA SIT database and import emissions for all New England States.

2050 Electricity Sector Abatement Costs under High Electrification Loads (Cont.)



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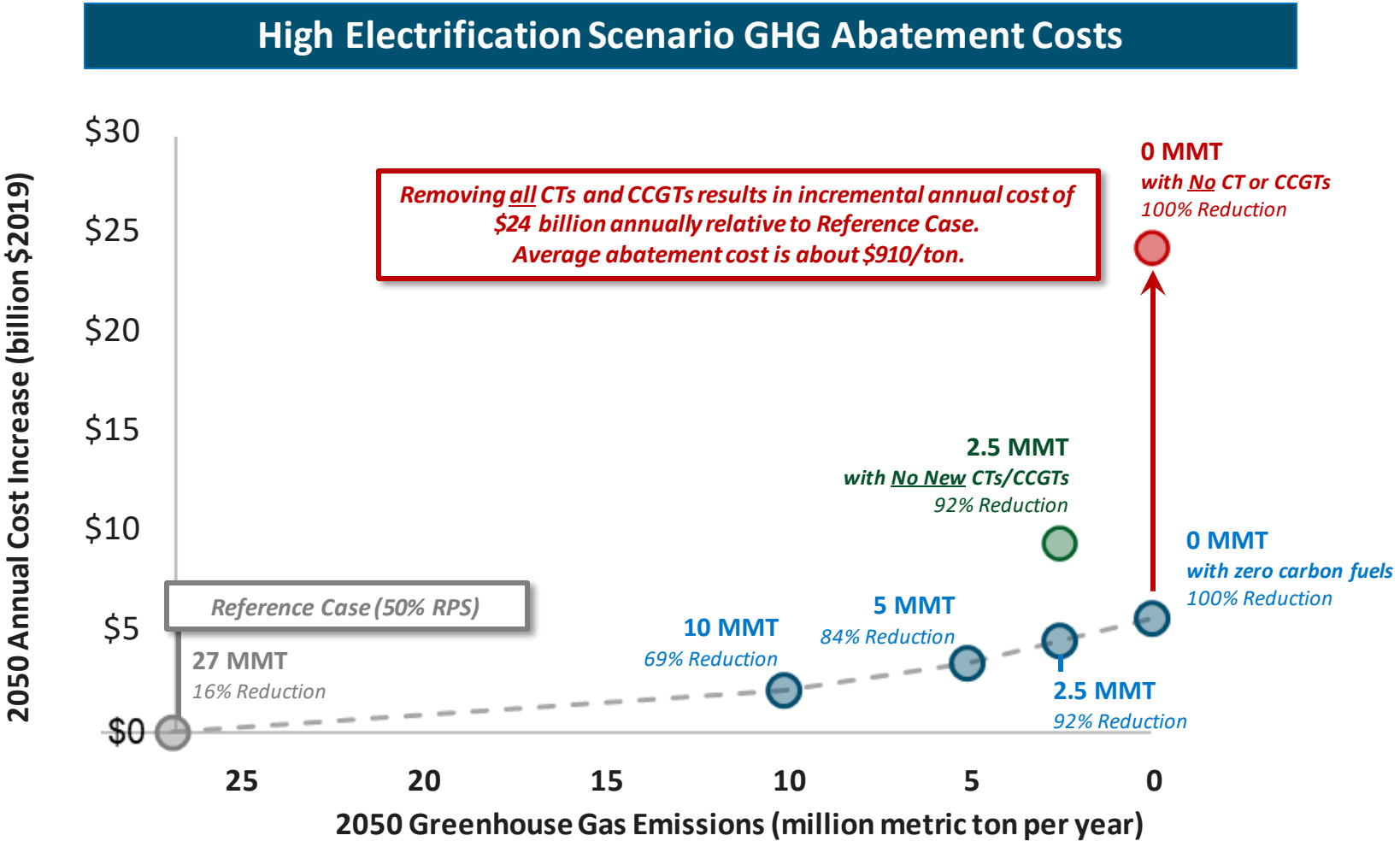

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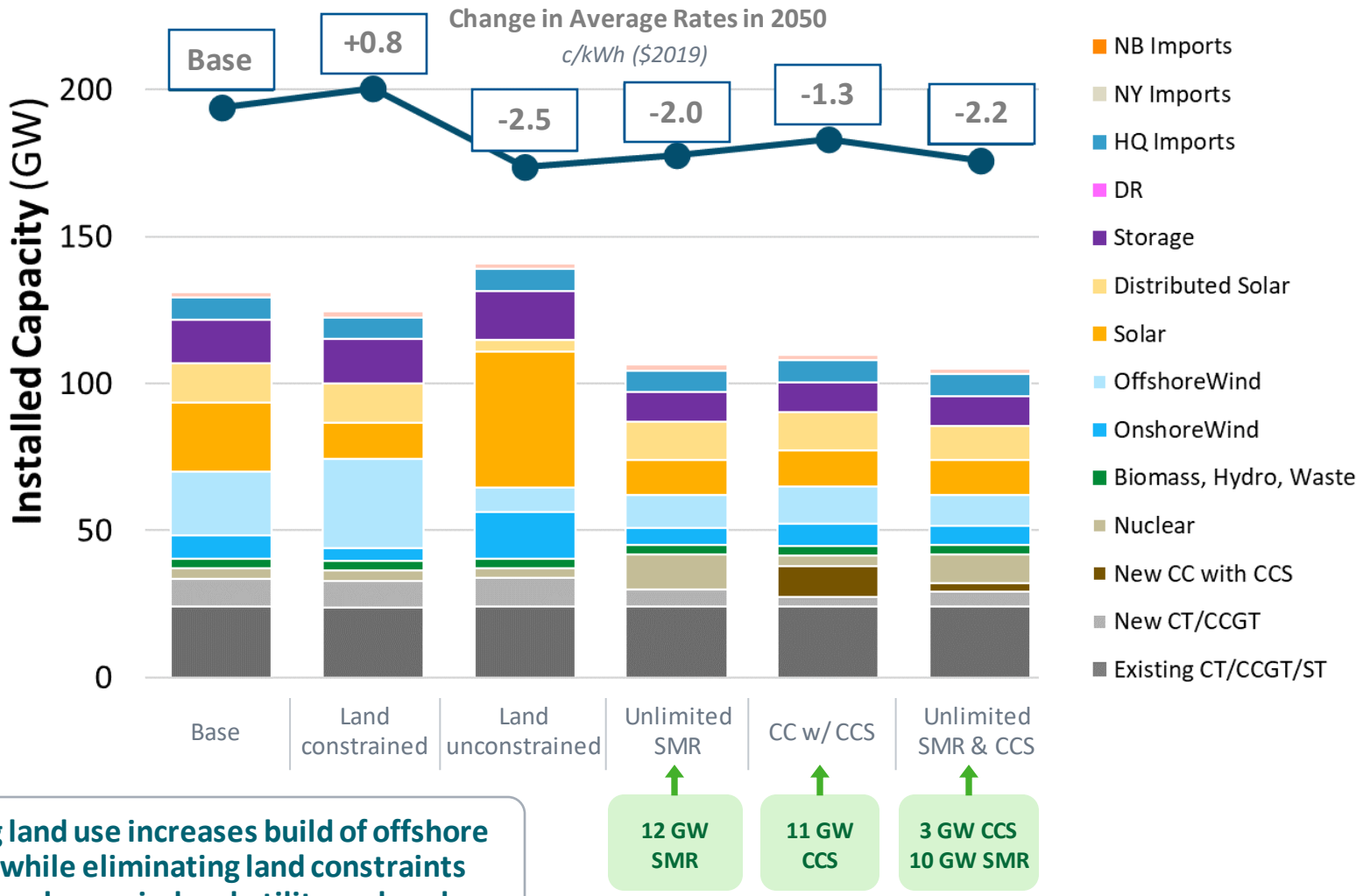
2050 Sensitivity Comparison of Installed Capacity and Rates (High Electrification)

All cases achieve 2.5 MMT/y 2050 GHG electricity sector emissions, consistent with economy-wide "Net Zero"



Limiting land use increases build of offshore wind, while eliminating land constraints favors onshore wind and utility scale solar

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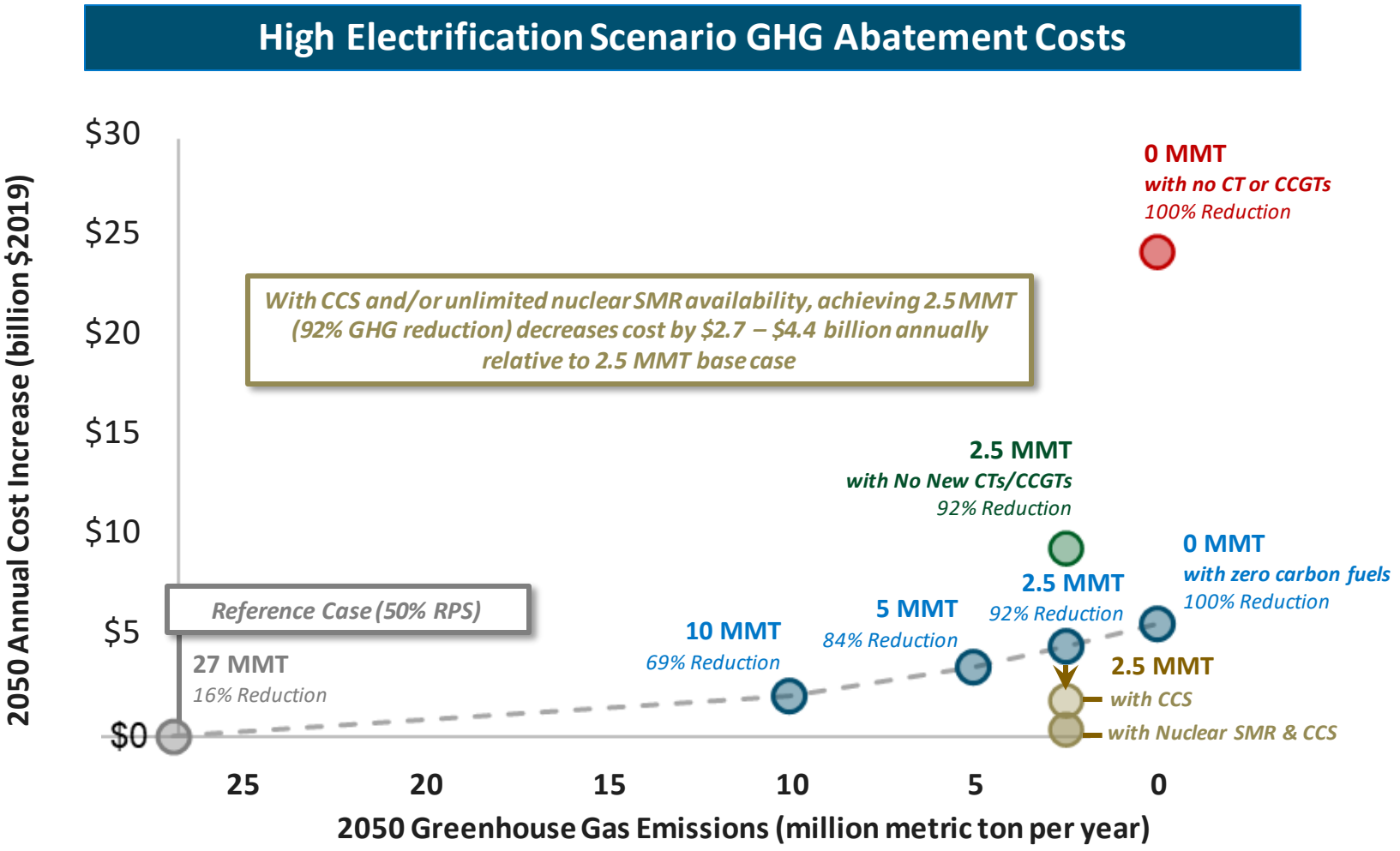

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Thank You!

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