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LOW-CARBON HEAT SOLUTIONS FOR HEAVY INDUSTRY: SOURCES, OPTIONS, AND COSTS TODAY

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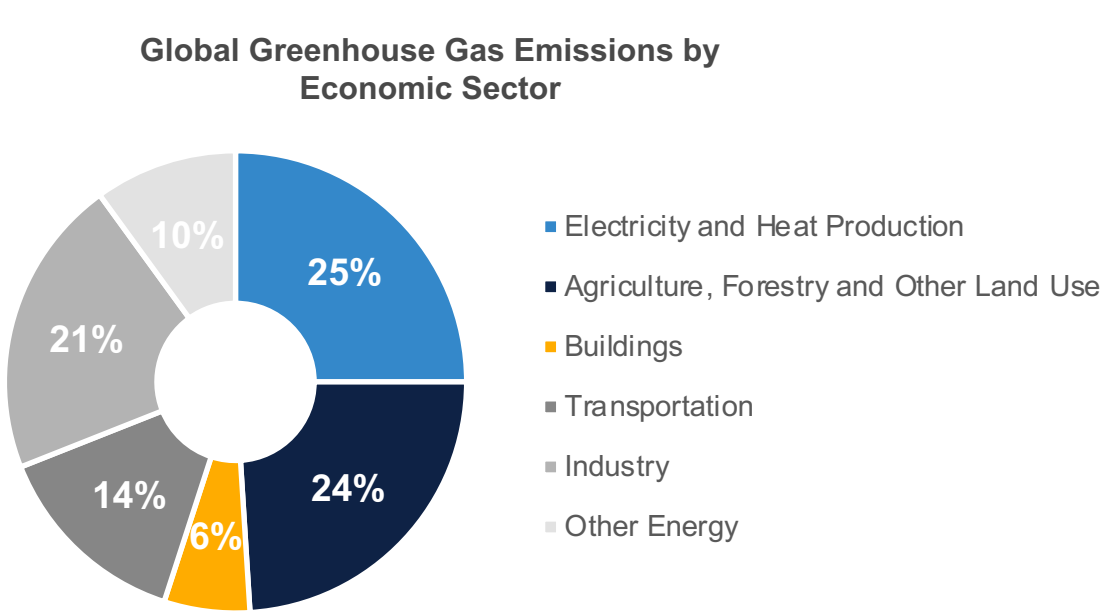
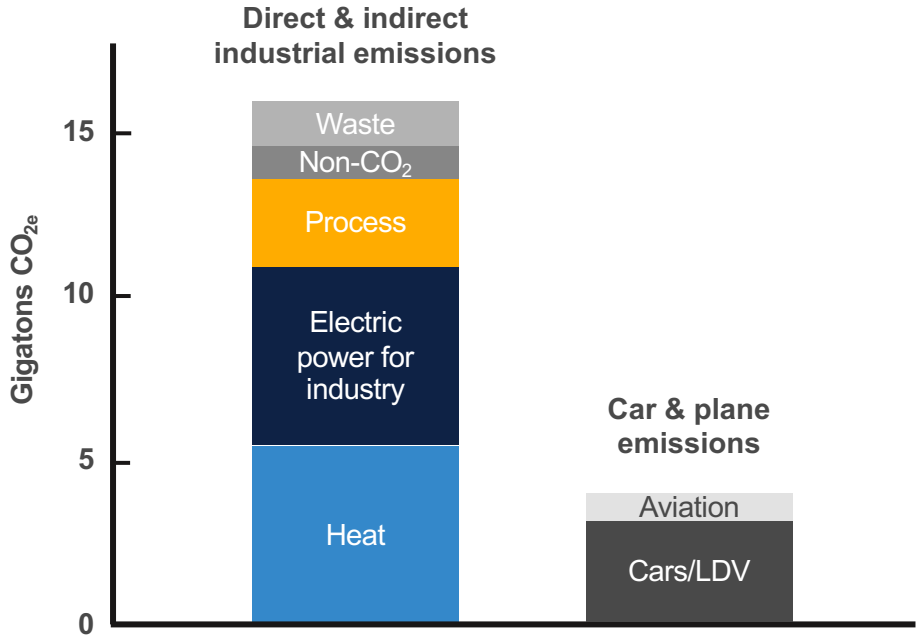
Industrial heat emissions: ~10% global emissions

Can't make key climate goals without solutions



EPA 2016



IPCC (2014); IEA (2017, 2019)

Industry emits more than transportation
Heat for industry emits more than cars & planes combined

Key findings for low-C industrial heat

Findings

- Industrial heat produces a large fraction of global GHG emissions – about 10%
- Few options exist today, and data & scholarship on this topic are scarce
- All options today face substantial technical, operational & economic challenges
- Most alternatives today cost significantly more than today's fuels and processes. Using them would add to wholesale production costs significantly.
- Many options appear to cost more than CCS applied to heat production or full facilities
- Low-C hydrogen appears most versatile and cost competitive for many sectors
- Special policy options may be needed to decarbonize industrial heat

Low C Heat: Applications & Sources

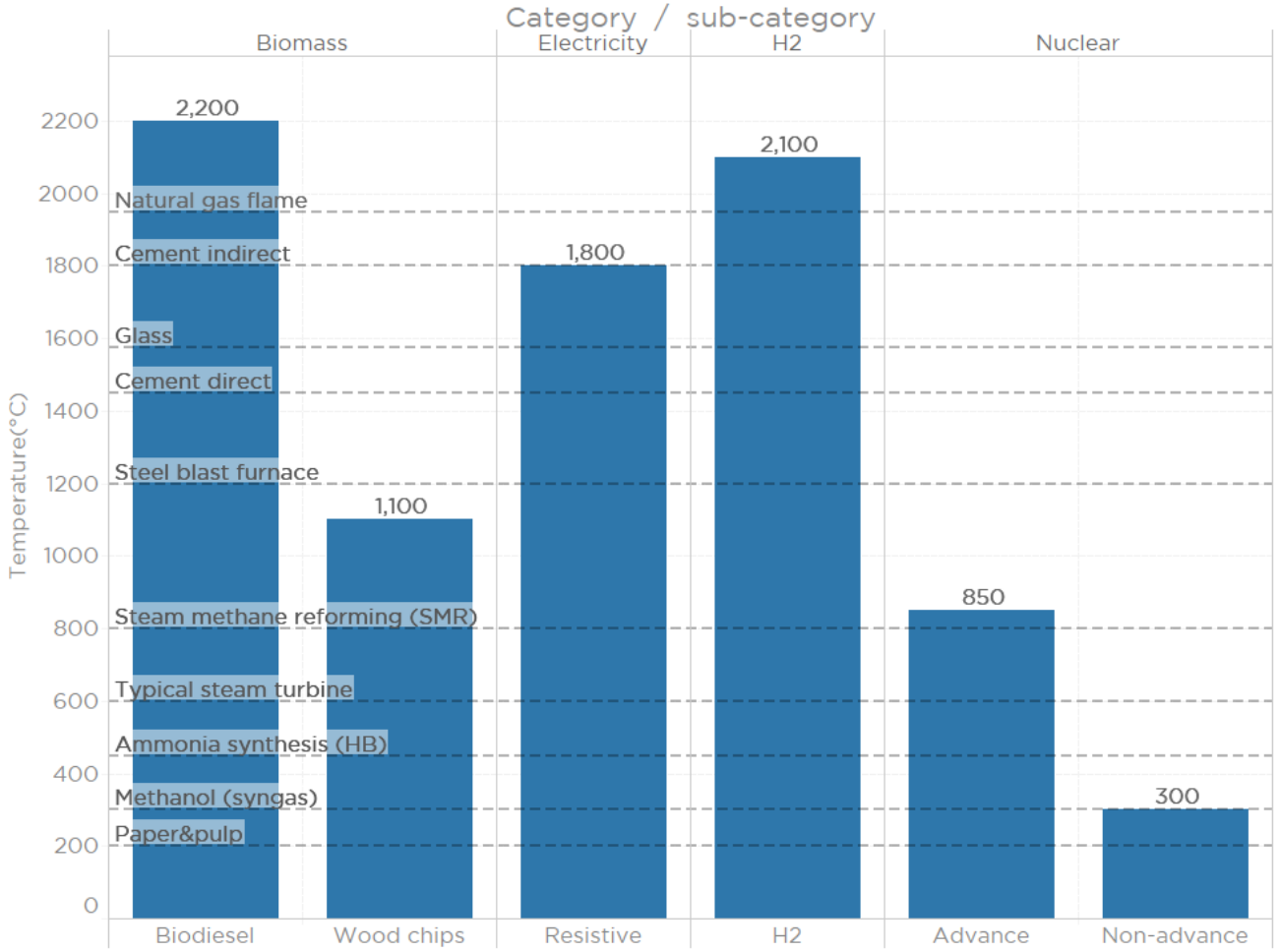
Not that many options for high-quality, large volume heat

Hydrogen
- Green: electrolysis of water from zero-C power
- Blue: From natural gas, with CCS (90%)
- Gray: From natural gas, but not low-C

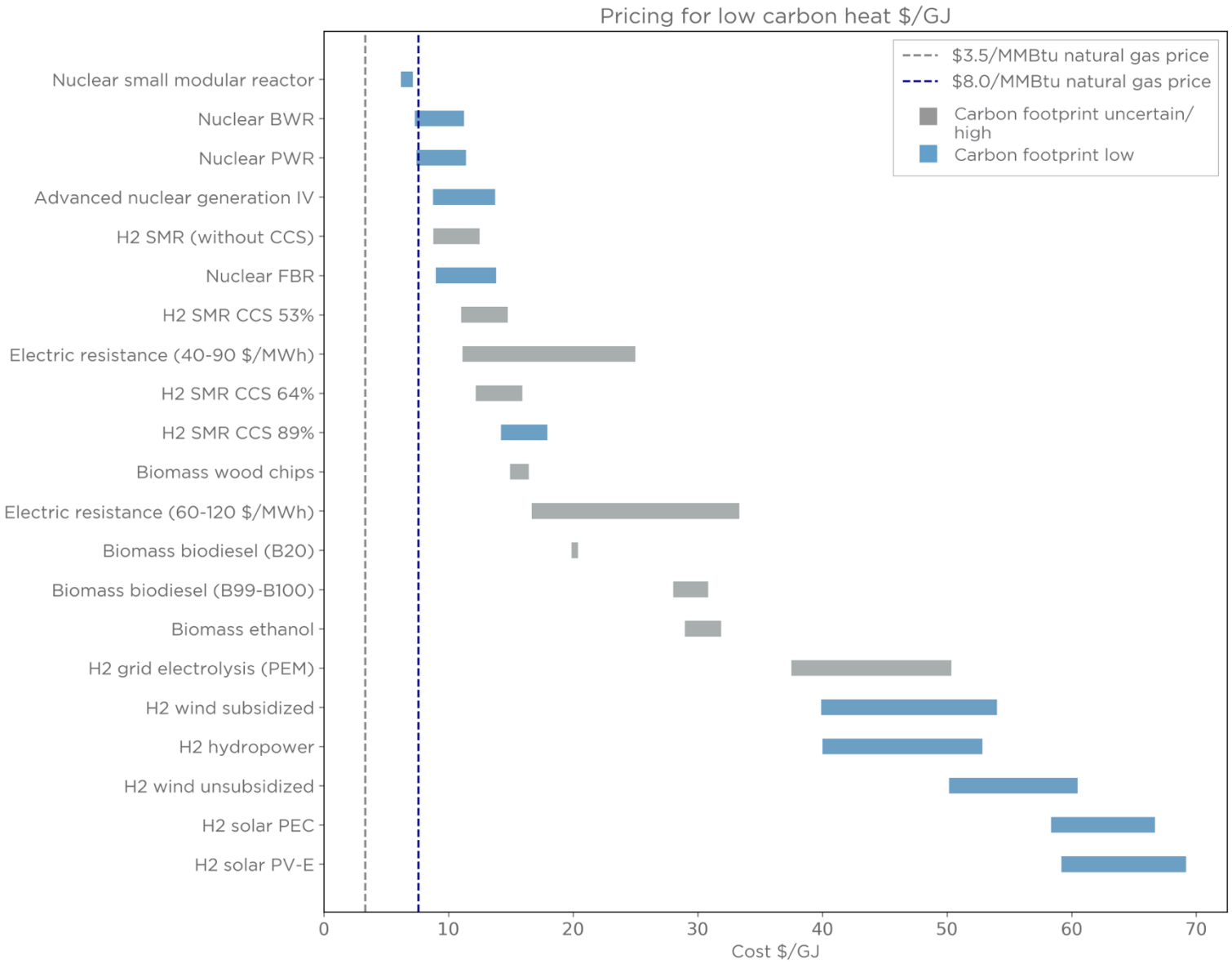
Electricity
- Must be zero-C supply & 90% capacity
- Radiant & resistive heating most mature

Biomass
- Must be low-C on a life-cycle basis
- Wood chips & biofuels most mature
- Biogas supplies are problematic

Nuclear
- Heat generated by neutrons from decay
- Current processes generate steam
- Adv. Processes could do more

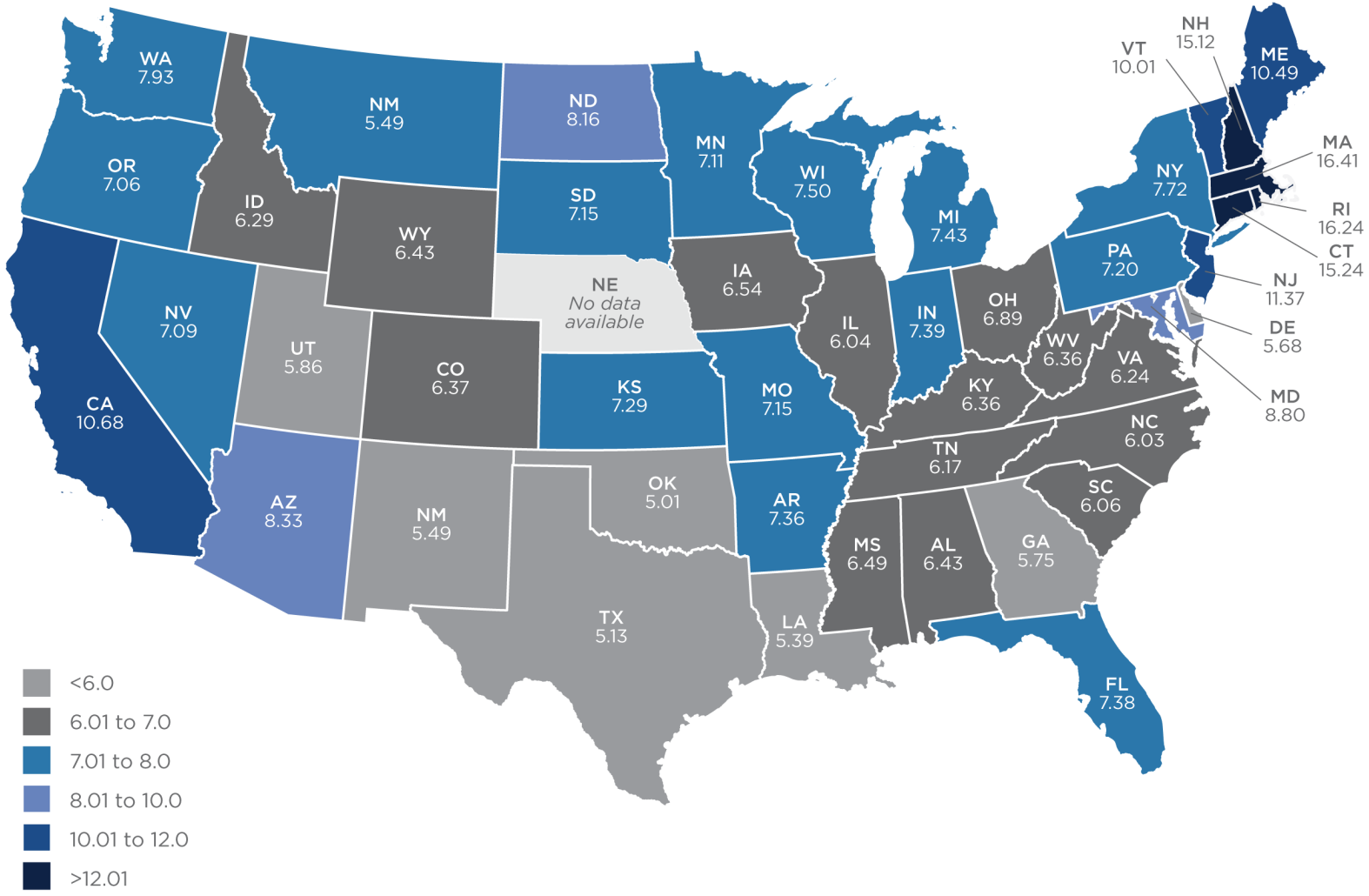


Low-C heat prices: wide range, all more than natural gas

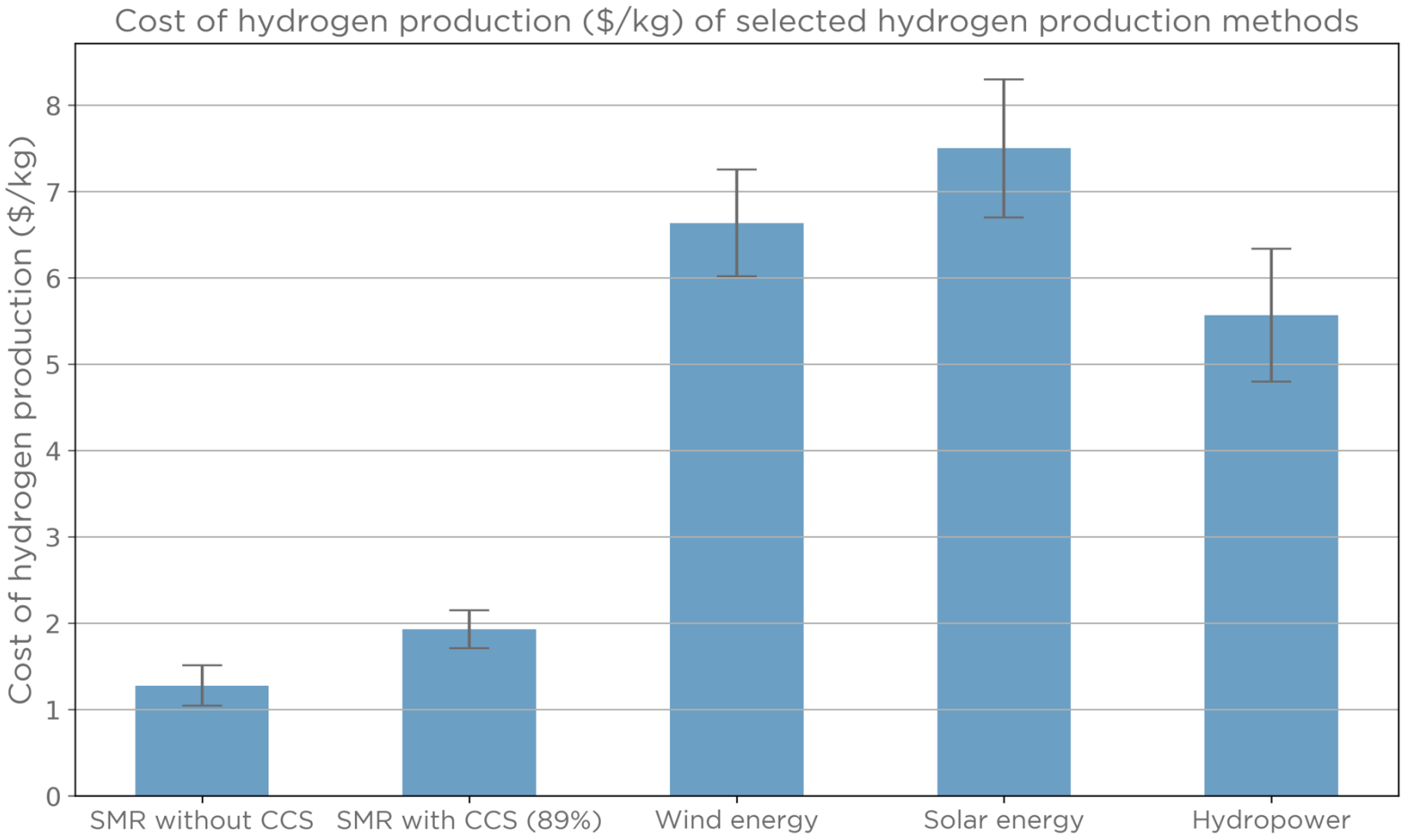


Firm industrial power contracts from investor owned utilities

From $49-117/MWh (median = $69/MWh)

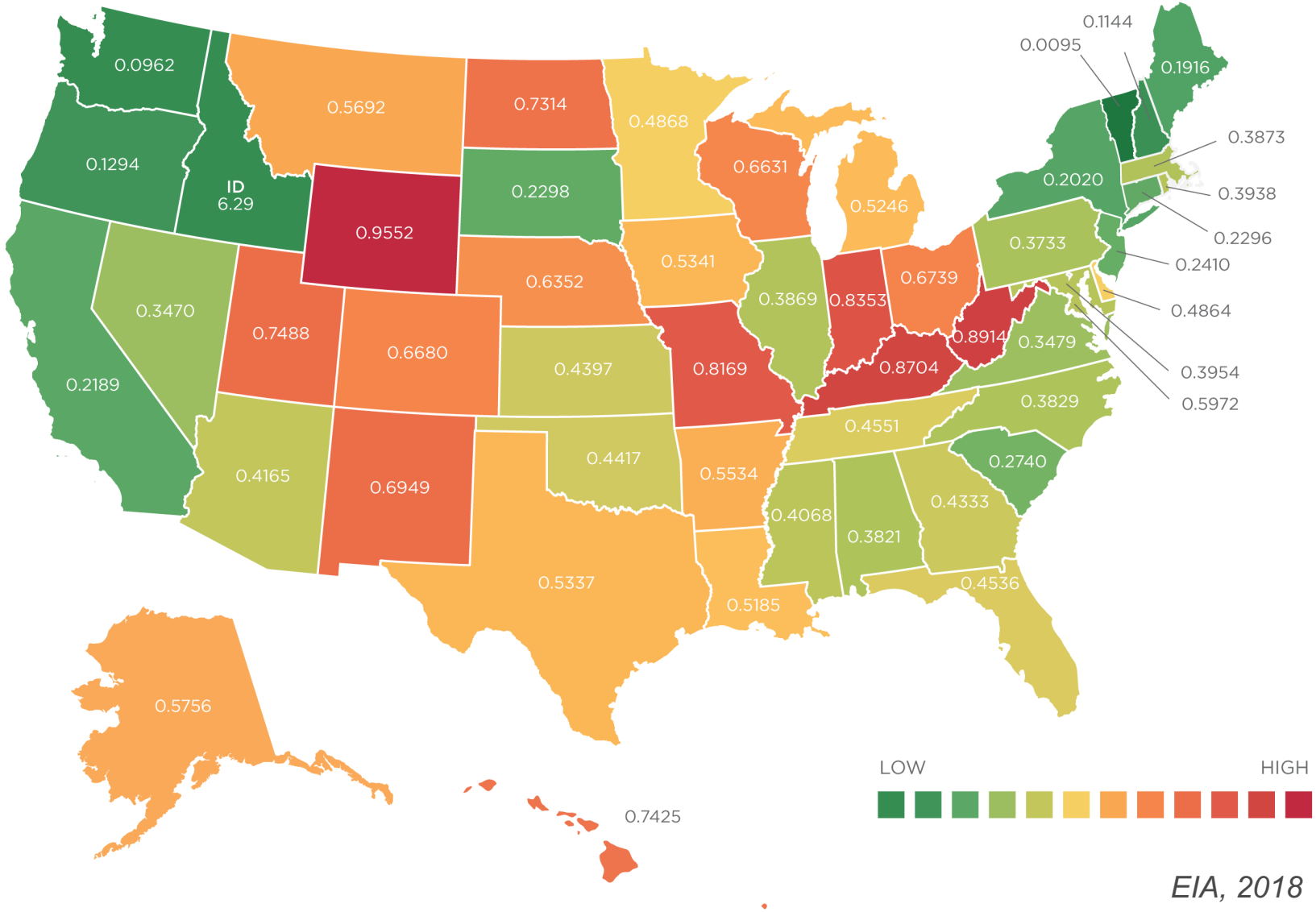


Hydrogen: "Blue" has enormous cost & scale advantages



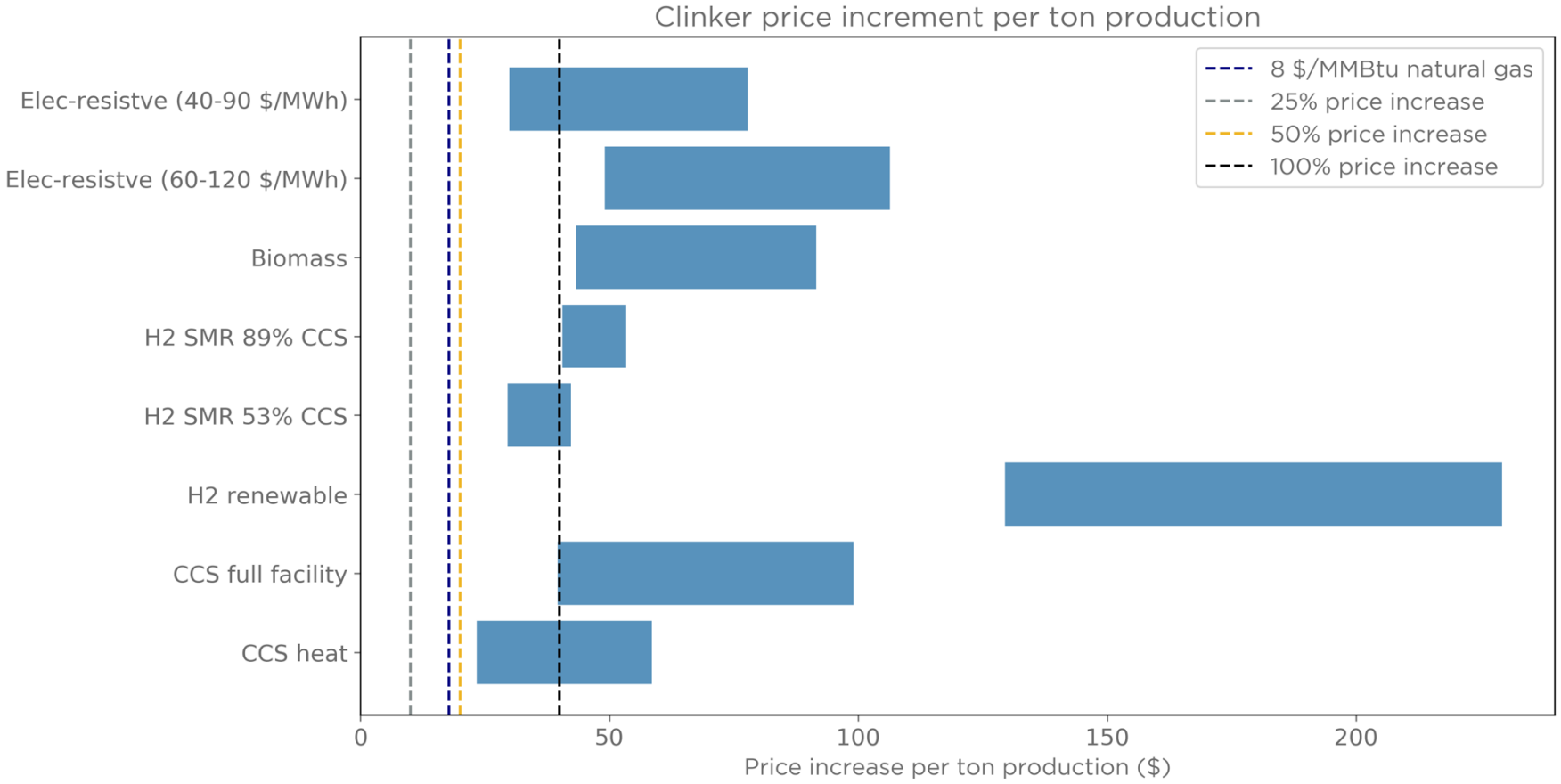
Today's grid is not low-carbon

For electrification to be a low-C heat option, near-zero electricity must be widespread and dispatchable

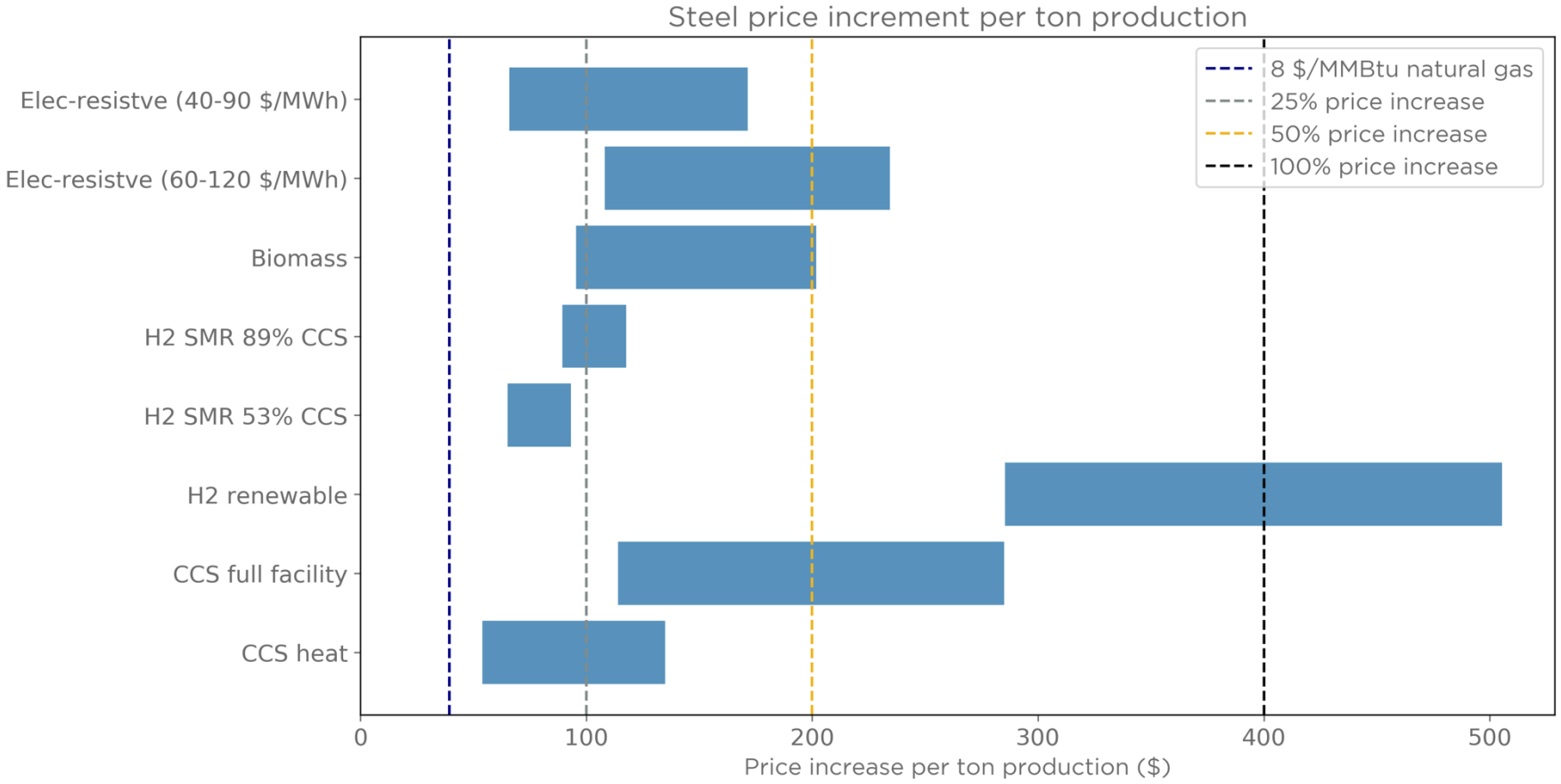


EIA, 2018

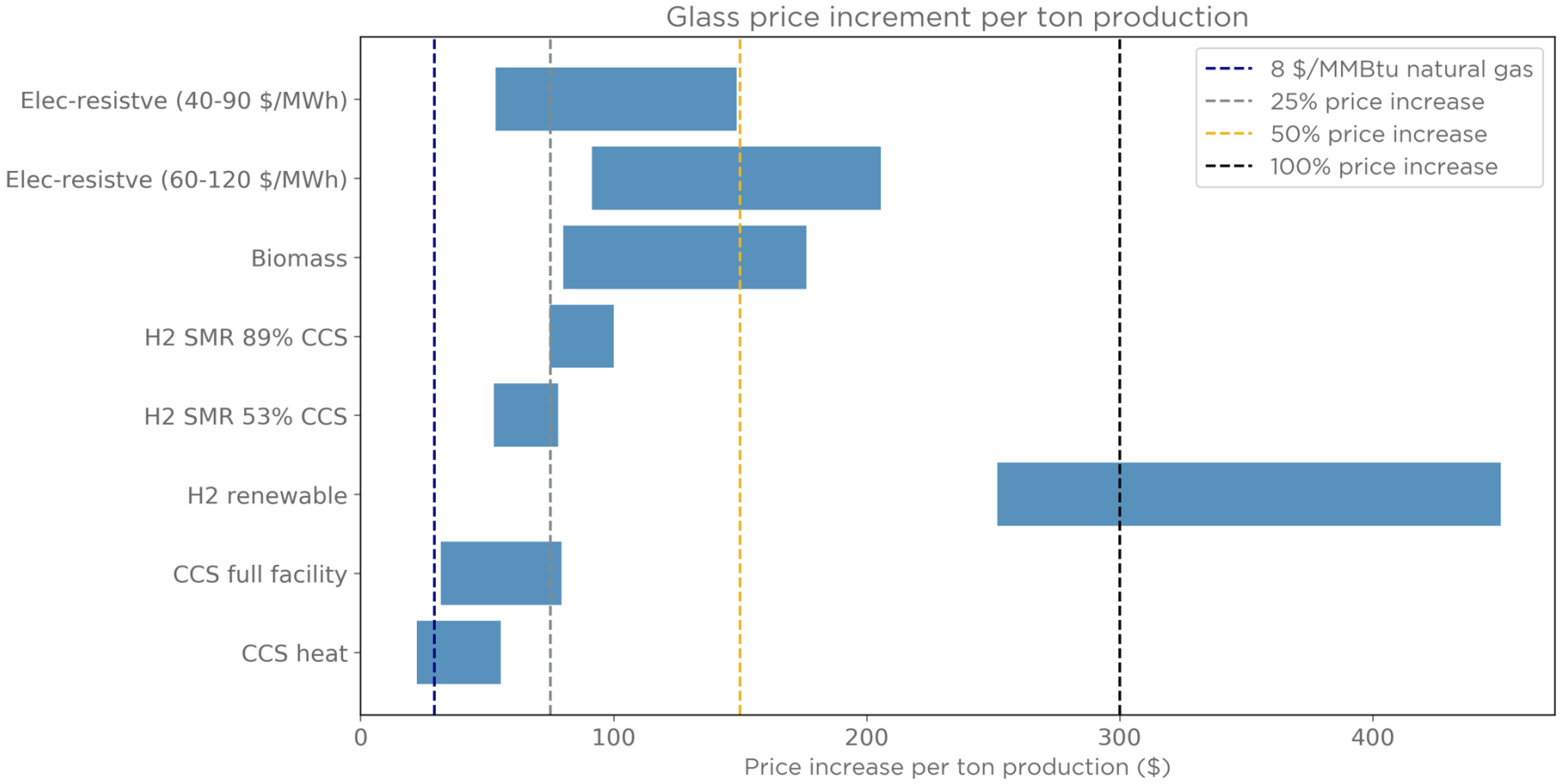
Cement clinker: Low-C heat comparison



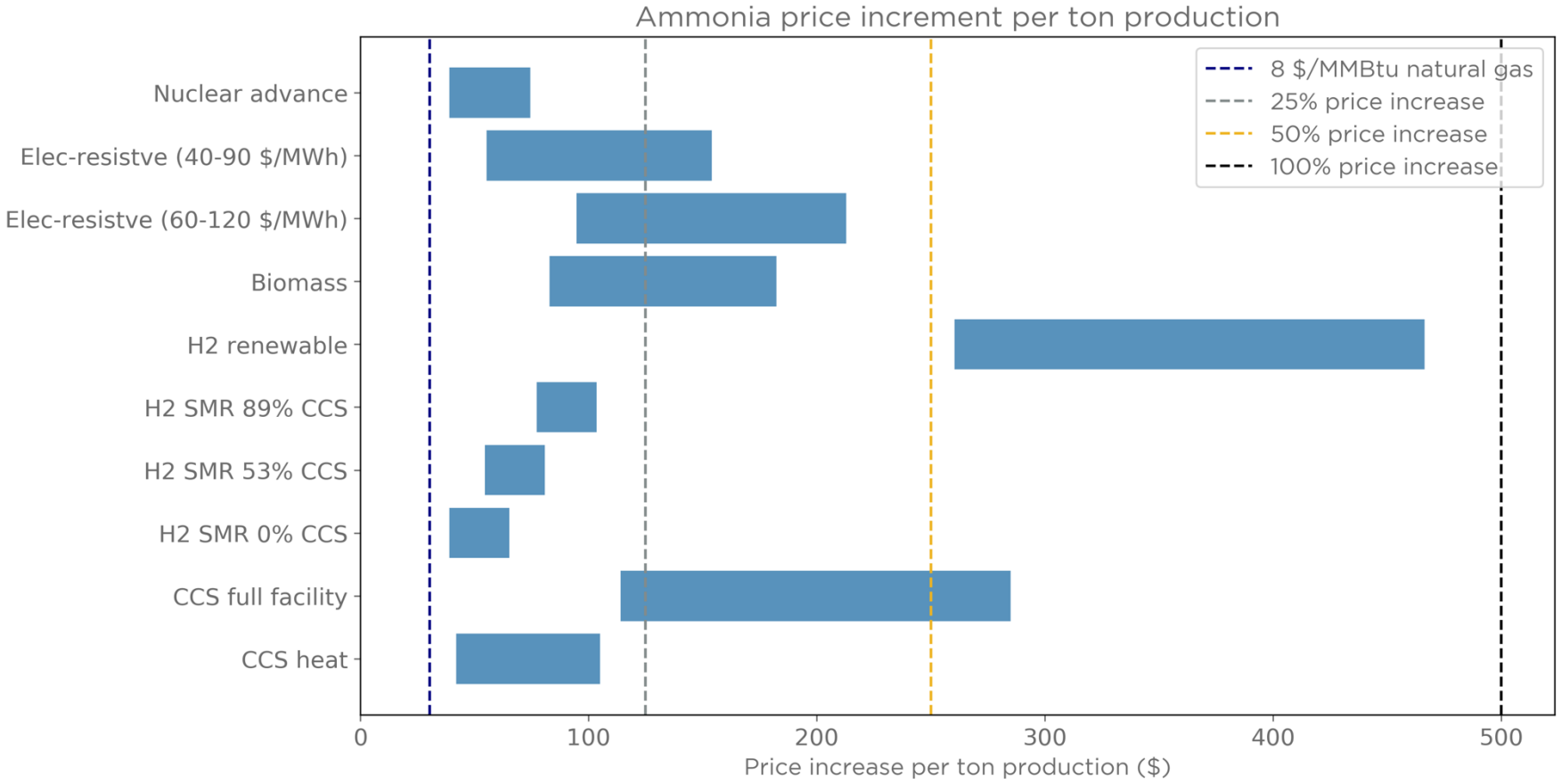
Steel: Low-C heat comparison



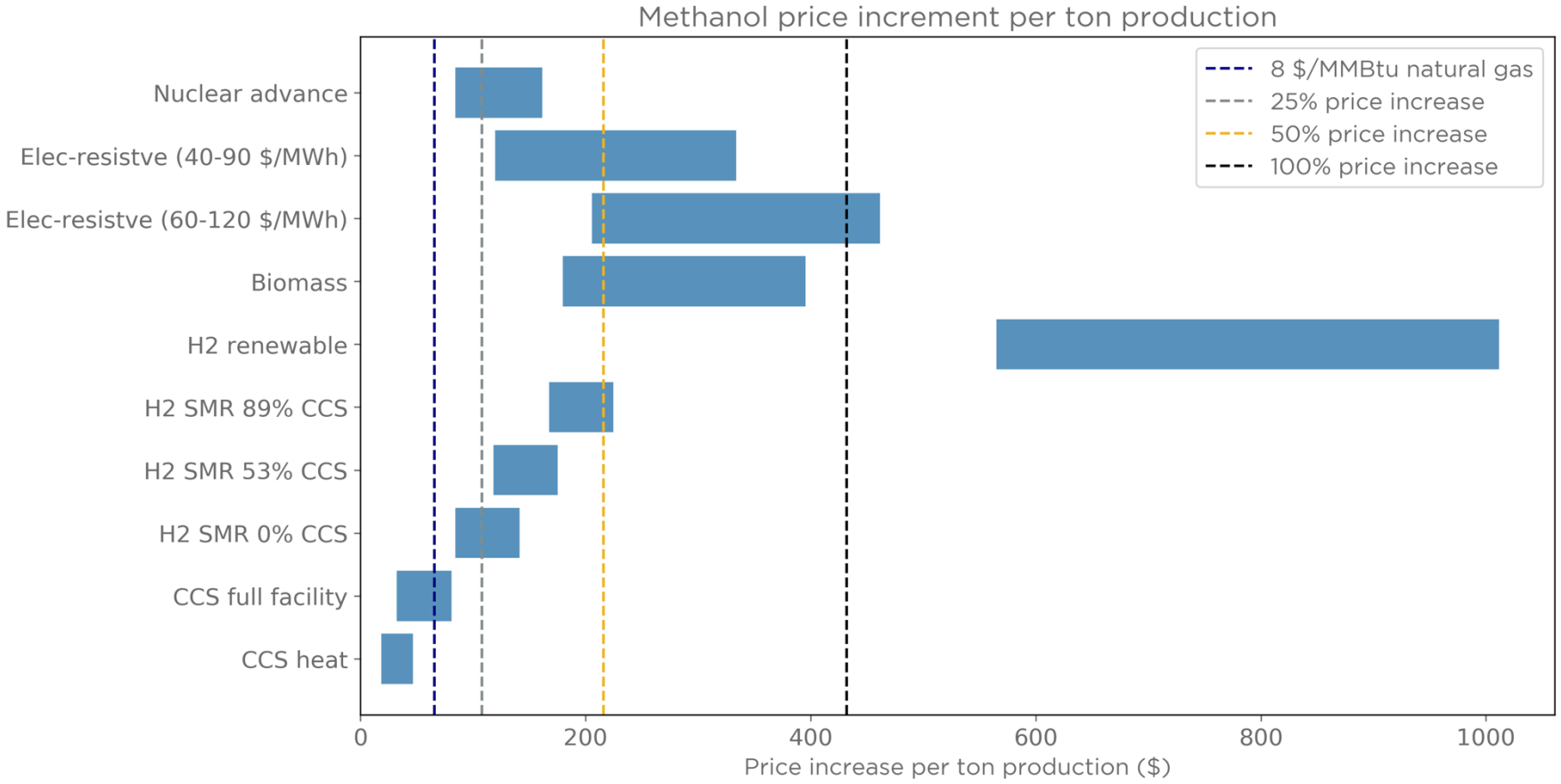
Glass: Low-C heat comparison



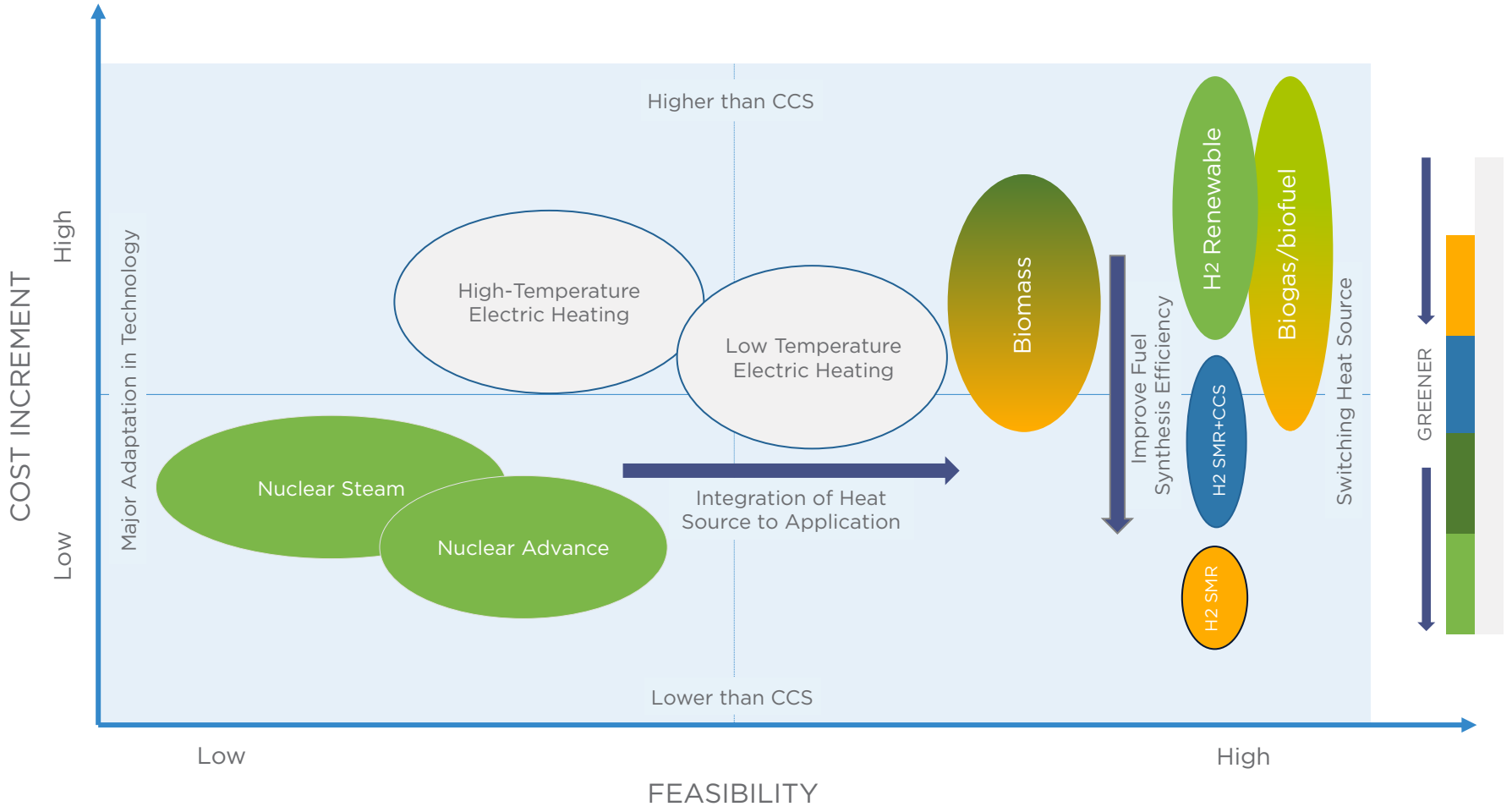
Ammonia: Low-C heat comparison



Methanol: Low-C heat comparison



Innovation is needed to create low-cost, high feasibility low-C heat options



Recommendations for low-C industrial heat

Recommendations

- National & regional governments should begin programs on heat decarbonization
- More and better options are needed. CCUS is likely to prove important.
- Several policies (e.g., gov. procurement) appear both effective and actionable

Innovation is essential and underserved

Much more work is needed on the topic of low-C heat for industry

Thank You

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