Risky Business Reports

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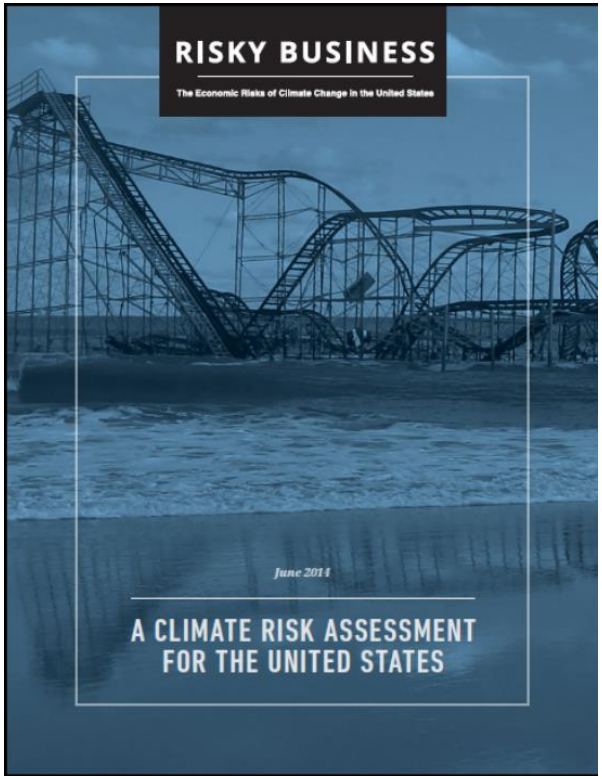

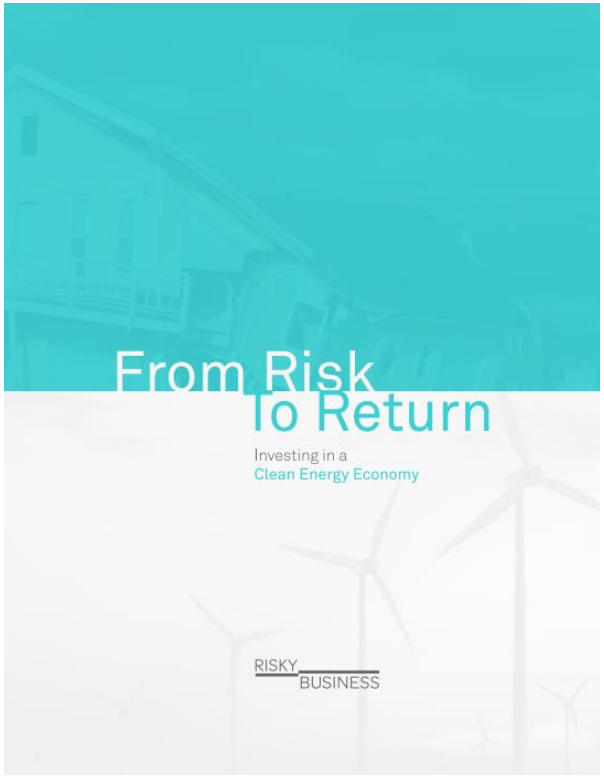

Karl Hausker

WORLD RESOURCES INSTITUTE

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Analytic Approach

- Applies the PATHWAYS model, a detailed stock accounting, technology adoption, and cost model for the US energy system developed by Energy & Environmental Economics (E3)
  - Analyzes technology and cost scenarios.
    - Not a macroeconomic model
  - Uses 2015 Reference Case from EIA Annual Energy Outlook
    - Meet demand for end-use services
    - Capital stock turnover at end of normal lifetime
  - Explores four pathways that each reduce CO_2 emissions 80% by 2050 with different technology mixes
  - National projections plus results for 9 US Census regions, reflecting resource differences
- Beyond modeling:
  - In-depth discussions of implementation issues
  - Case studies on early steps to clean energy transition

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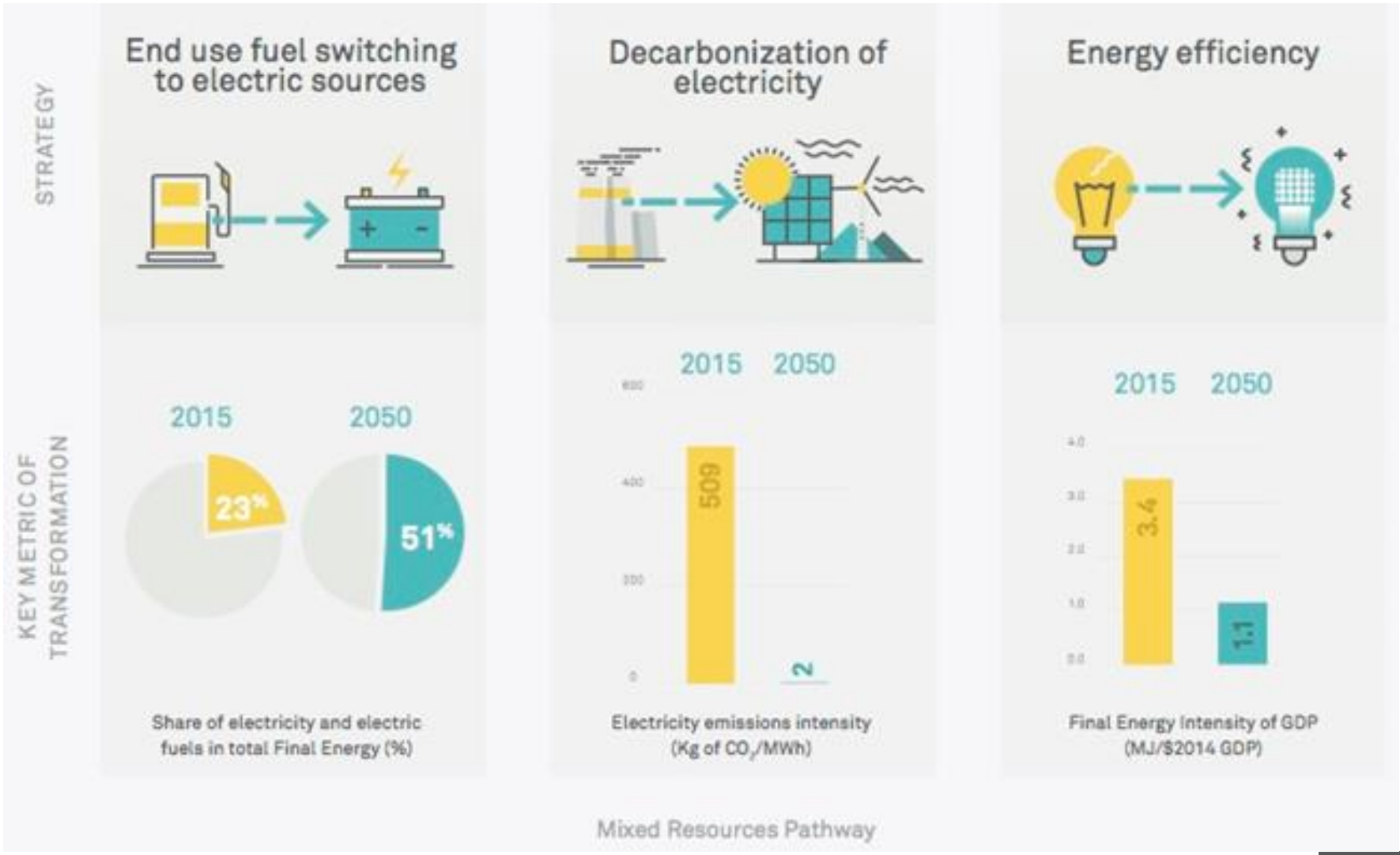
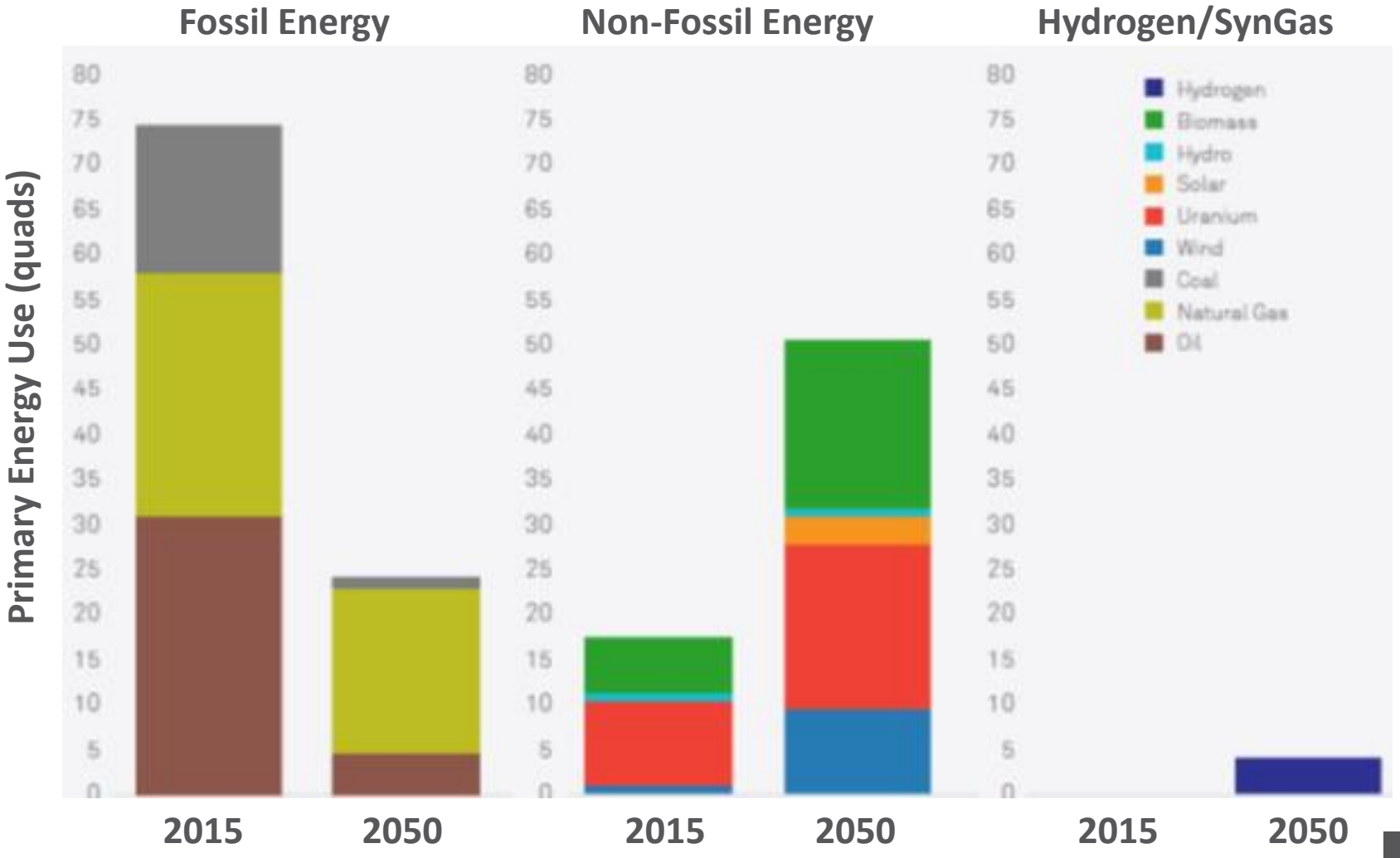
Three Pillars: Strategies and Metrics



Primary Energy Use in 2015 and 2050



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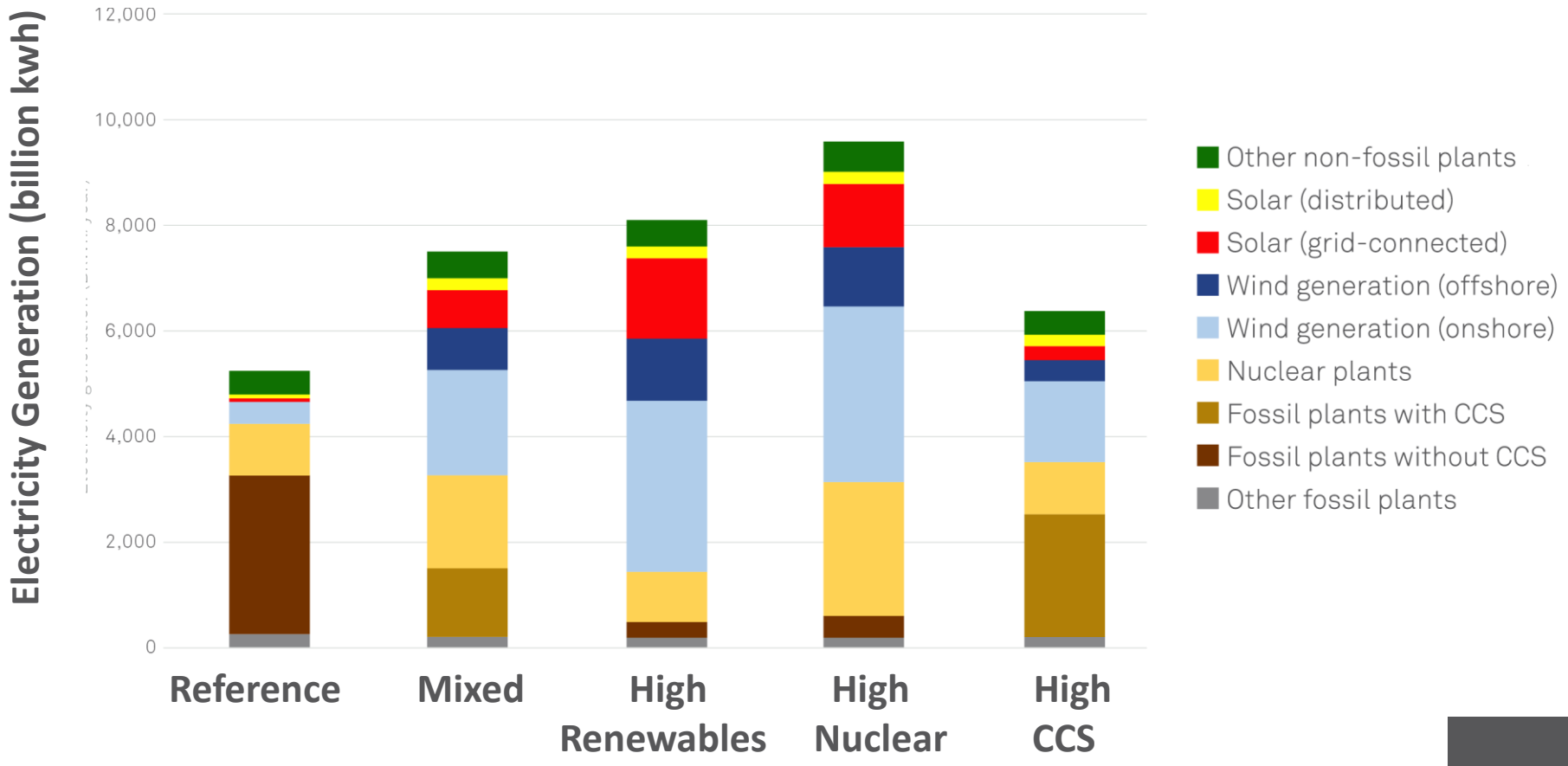
Power Generation in 2050



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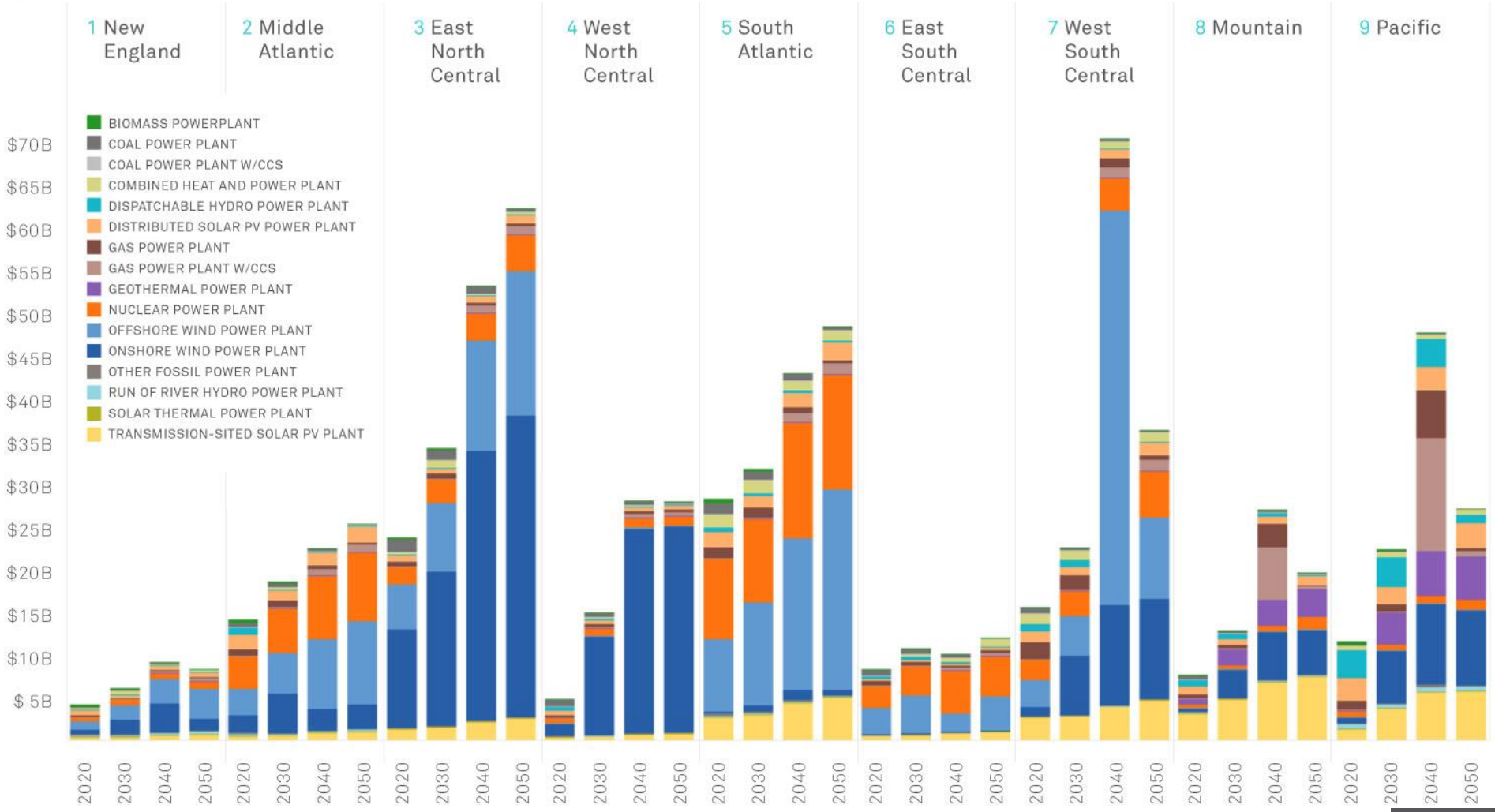
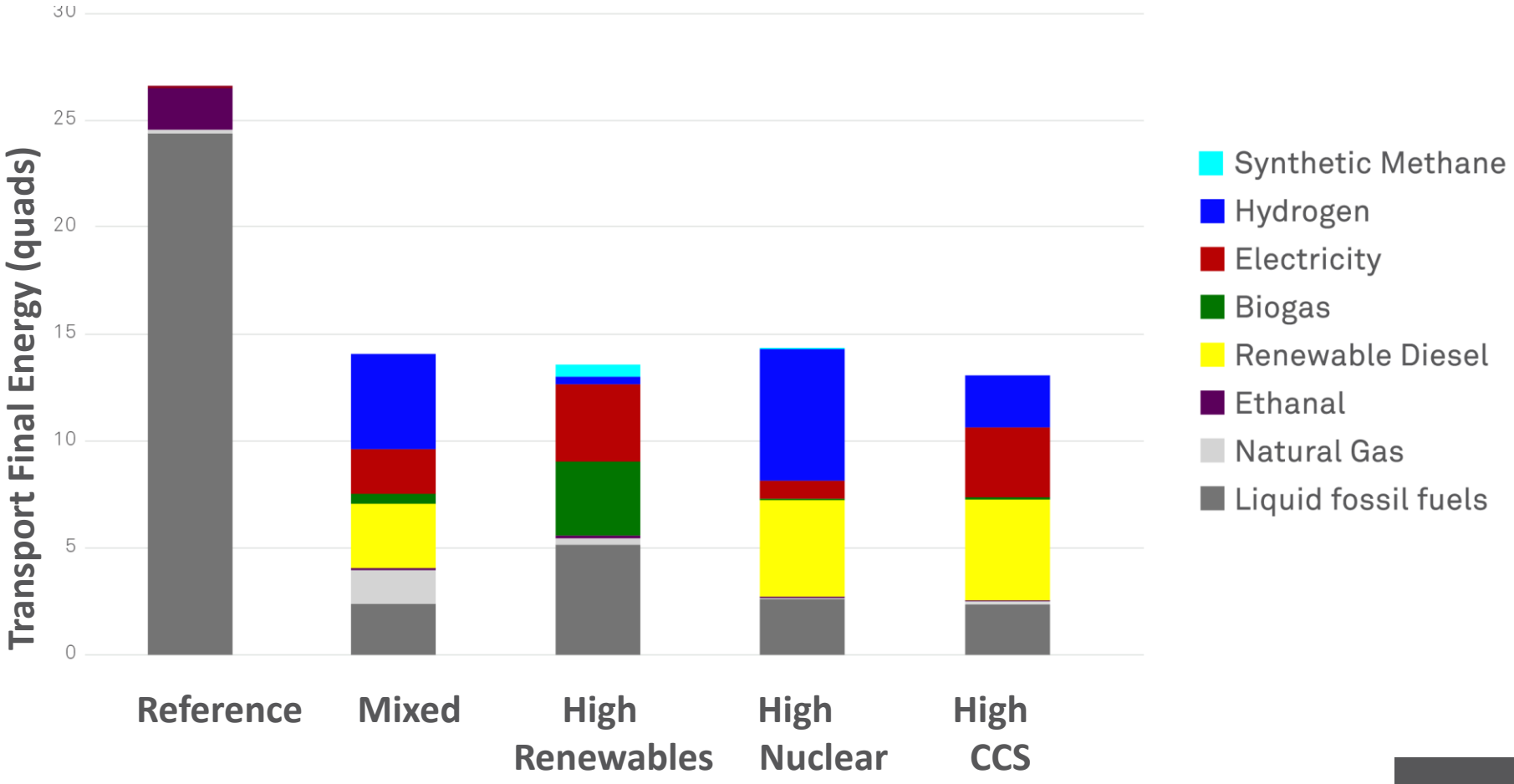
Power Generation Investment by Region



Transportation Energy Use in 2050



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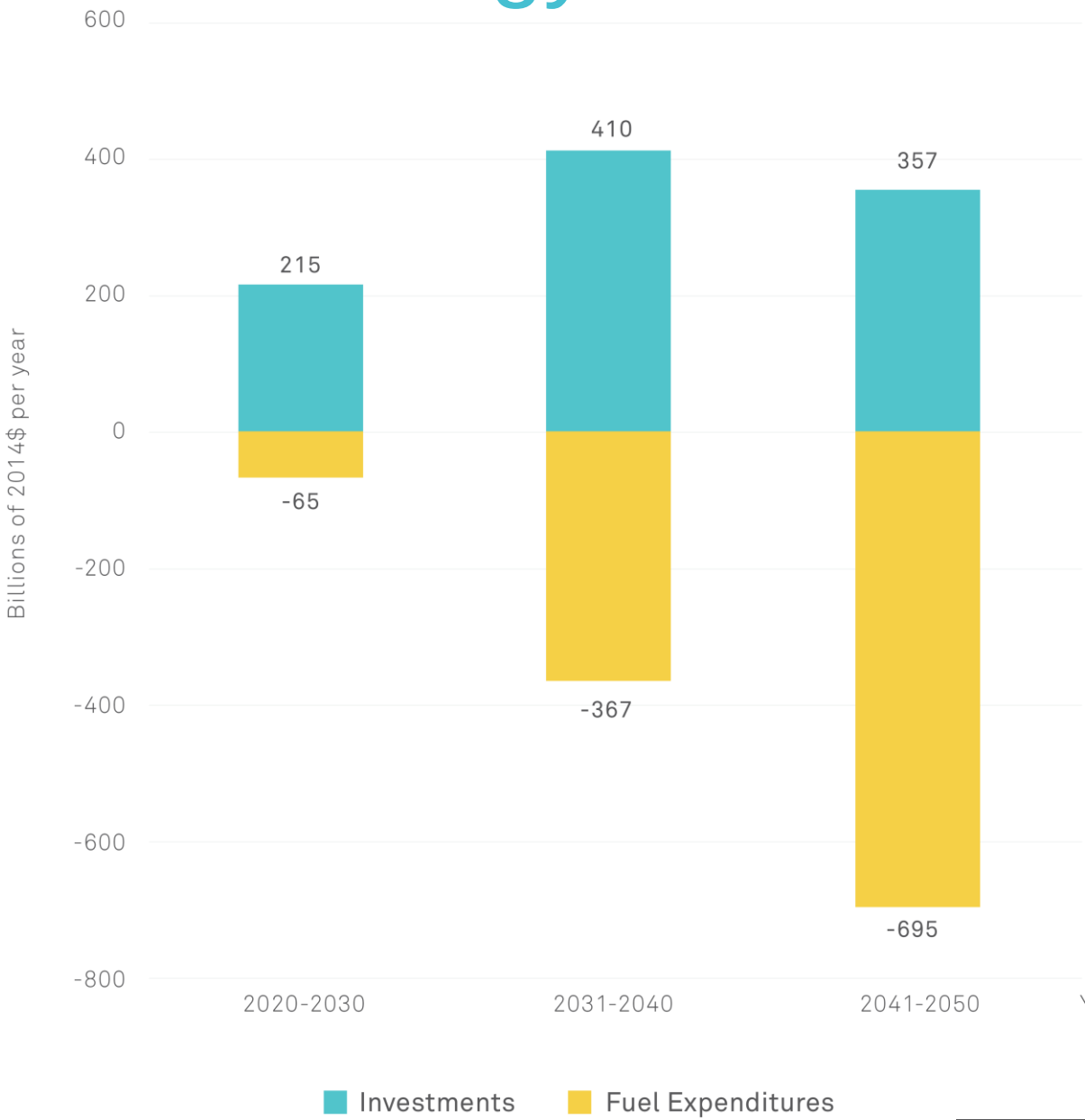
Investing in Clean Energy

Average annual change in investments and fuel expenditures by decade.

- **Annual change in investments from 2020-2050 would average about $320B per year**
- **Roughly equal to average annual US IT spending over the past decade.**



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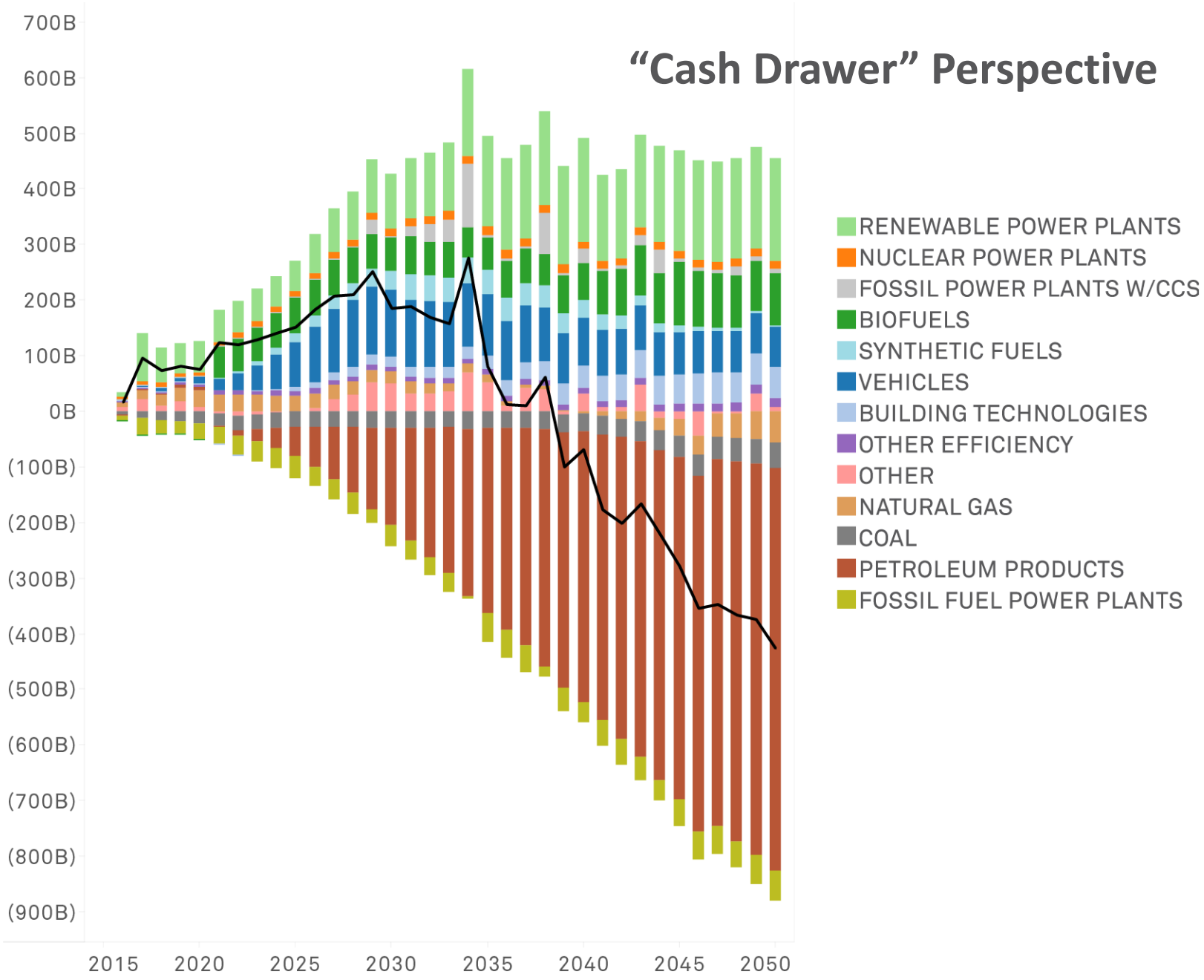
As-Spent Costs and Savings



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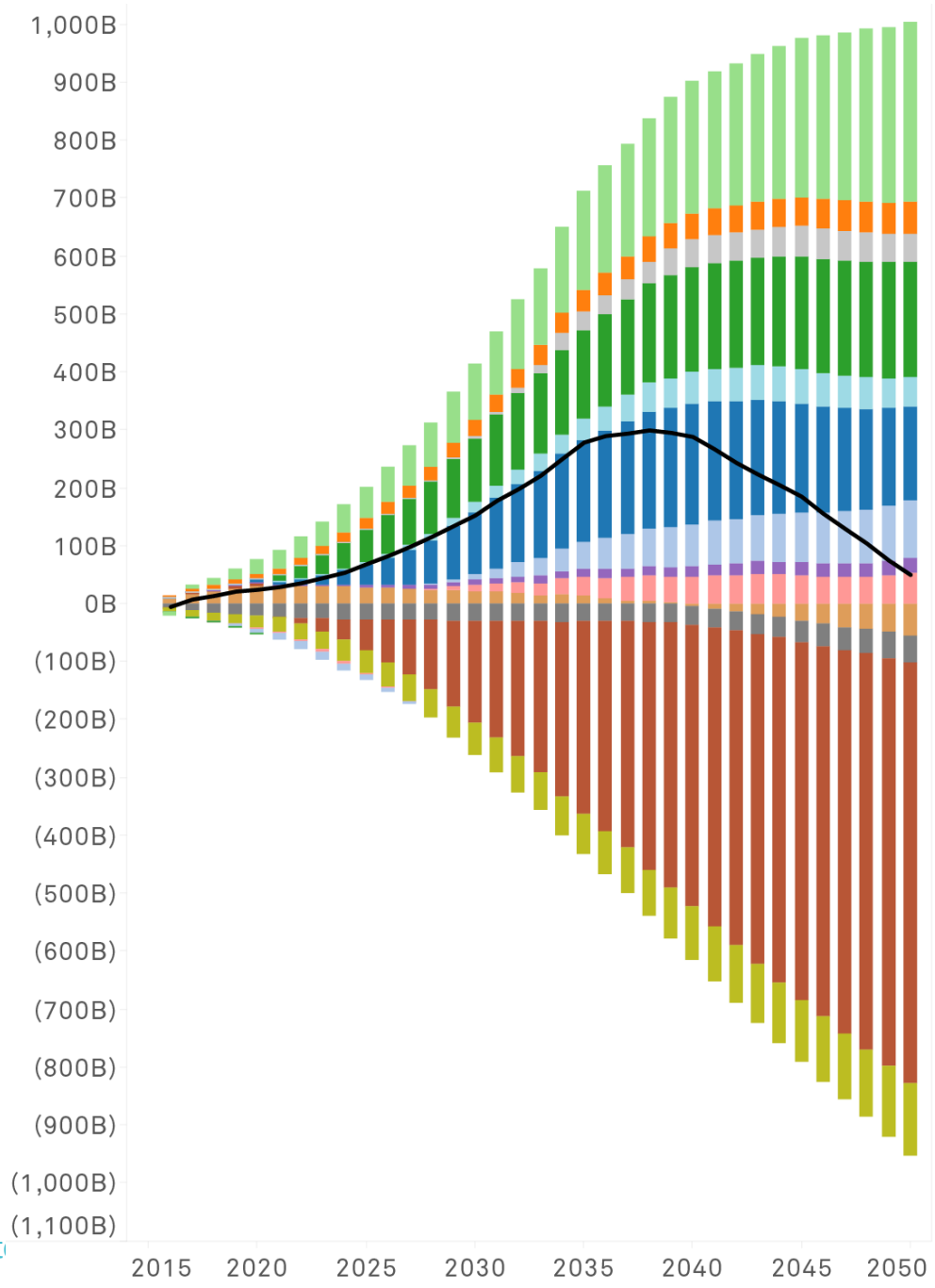
Annualized Costs and Savings

Billions of Dollars (2015$)



Capital cost annualized over lifetime of asset

- RENEWABLE POWER PLANTS
- NUCLEAR POWER PLANTS
- FOSSIL POWER PLANTS W/CCS
- BIOFUELS
- SYNTHETIC FUELS
- VEHICLES
- BUILDING TECHNOLOGIES
- OTHER EFFICIENCY
- OTHER
- NATURAL GAS
- COAL
- PETROLEUM PRODUCTS
- FOSSIL FUEL POWER PLANTS

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Implementation Challenges

- The pace of needed power plant construction would be challenging, but doable.
  - 2-4 X historical rates
- The power grid's transmission and distribution system would require significant expansion and upgrades.
  - Transmission line siting could be a major obstacle
- The shift to electric vehicles would require major physical infrastructure build-out and changes.
  - Focus on Fast Chargers, Workplace, Home, or Battery Swapping?
- Utility business models must change to integrate more variable and distributed resources.
  - Smart grids and smart devices needed to match supply & demand