From Risk to Return

Investing in a Clean Energy Economy

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Outline

- Goals of Study
- Analytic Approach
- Three Pillars of the Clean Energy Transition
- Four Pathways
- Report Findings
- Implementation Challenges
- Policy and the Role of Business

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From Risk to Return: Investing in a Clean Energy Economy

- Takes the next step after 2014 ***Risky Business*** report, turning to the long-term **management and reduction** of climate risk.
- Co-chairs engaged WRI to lead this study
- Seriously addressing climate change requires a transition to a clean energy economy that reduce CO_2 (and other GHG) emissions by at least **80 percent by 2050** in the U.S. and across all major economies.
- *From Risk to Return* finds that this transition is **technically and economically achievable using commercial or near-commercial technology**.

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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
  - Deploys commercial and near-commercial technologies
  - 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
  - Exploration of potential impact of autonomous vehicles
  - Case studies on early steps to clean energy transition

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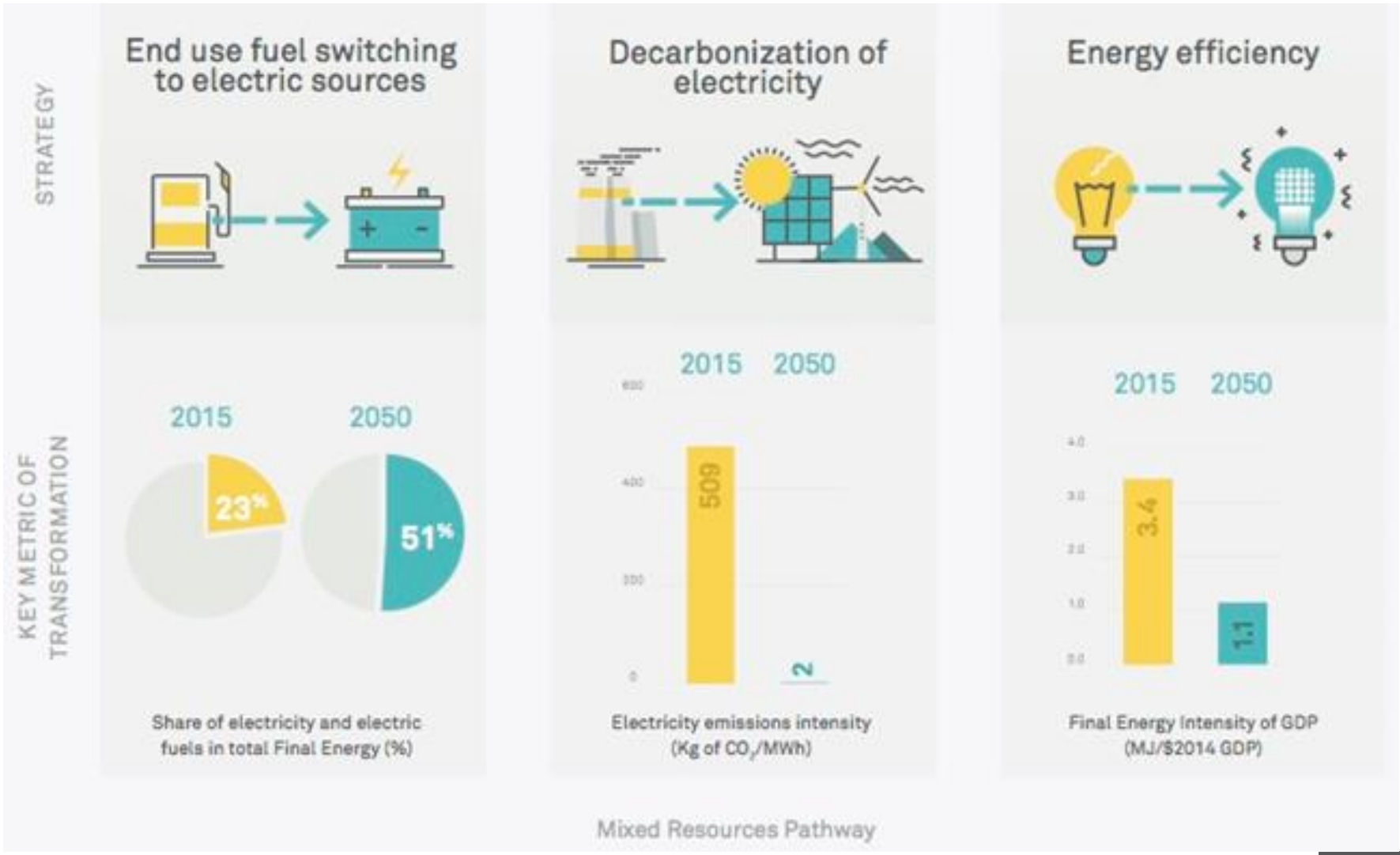
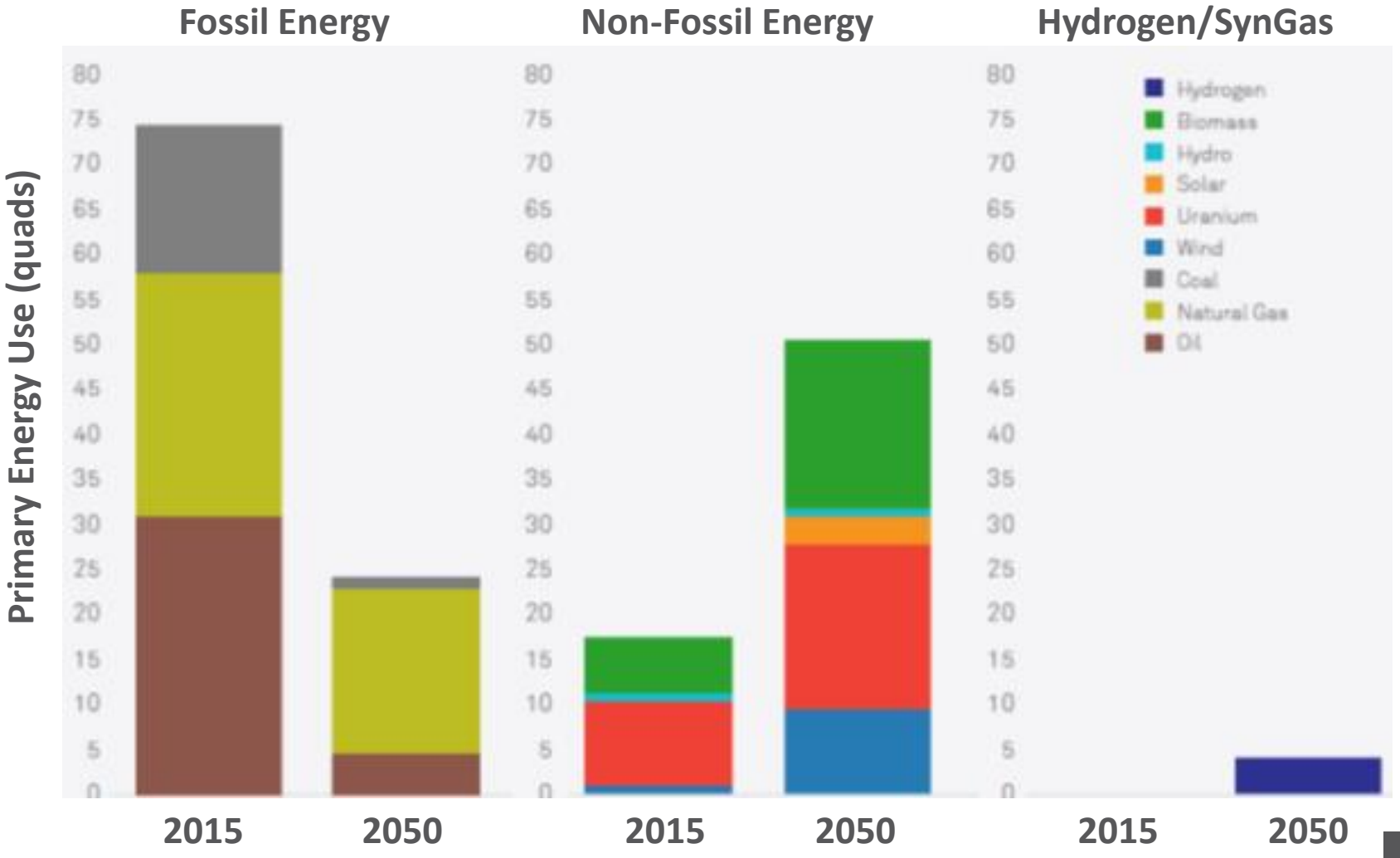
Three Pillars: Strategies and Metrics



Primary Energy Use in 2015 and 2050



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Four Pathways

- This report examines **four different pathways** to accomplish this transition, each with different mixes of technologies, chiefly in electricity and transportation:
  - Mixed Resources Pathway
  - High Renewables Pathway
  - High Nuclear Pathway
  - High CCS Pathway

- Under all of the pathways, the transition requires up-front capital investments that:
  - Achieve both **carbon reductions** and **fuel savings** that grow steadily over time
  - Are consistent with **normal capital stock turnover**

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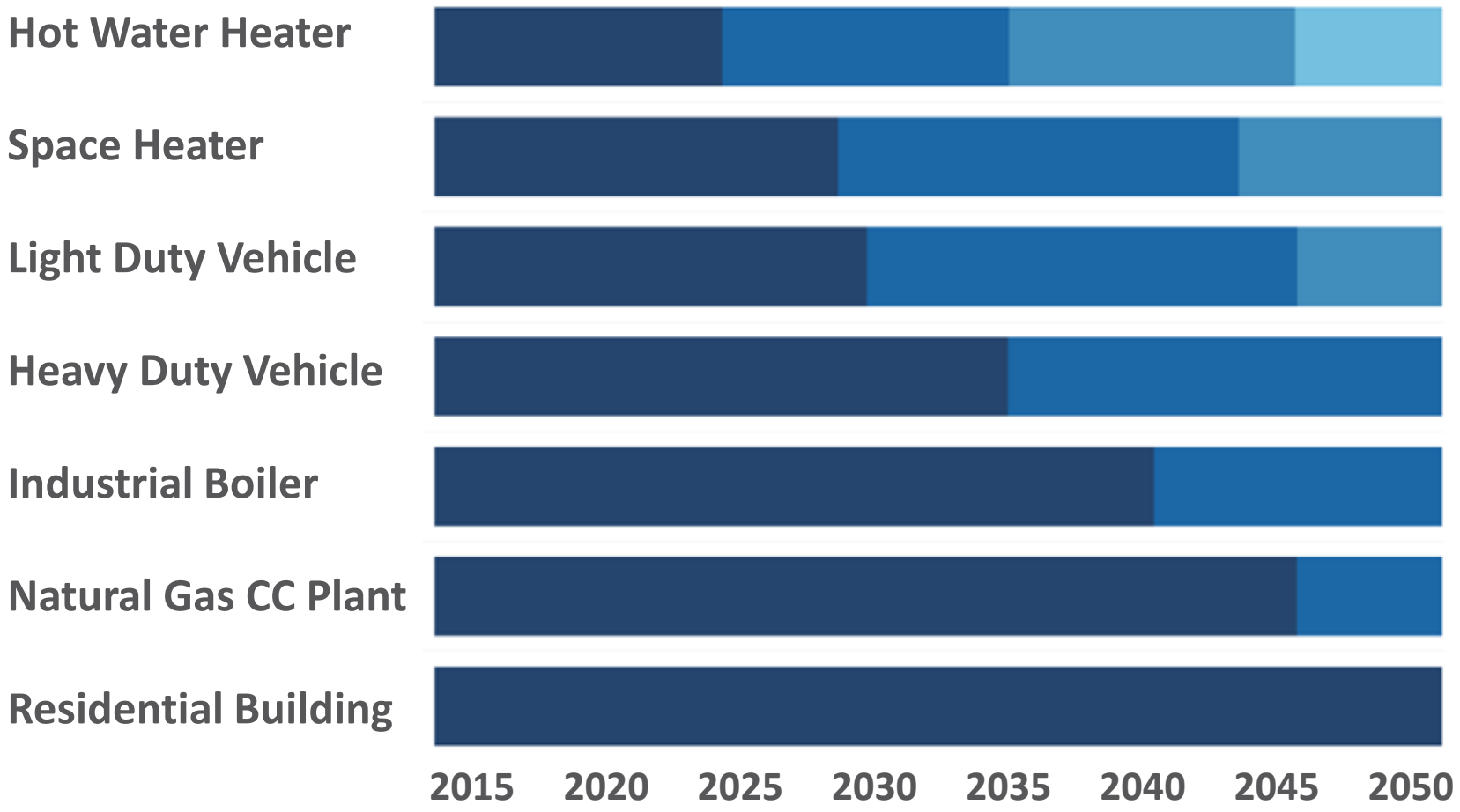
Seize Every Opportunity

Normal Capital Stock Turnover: 2015-2050



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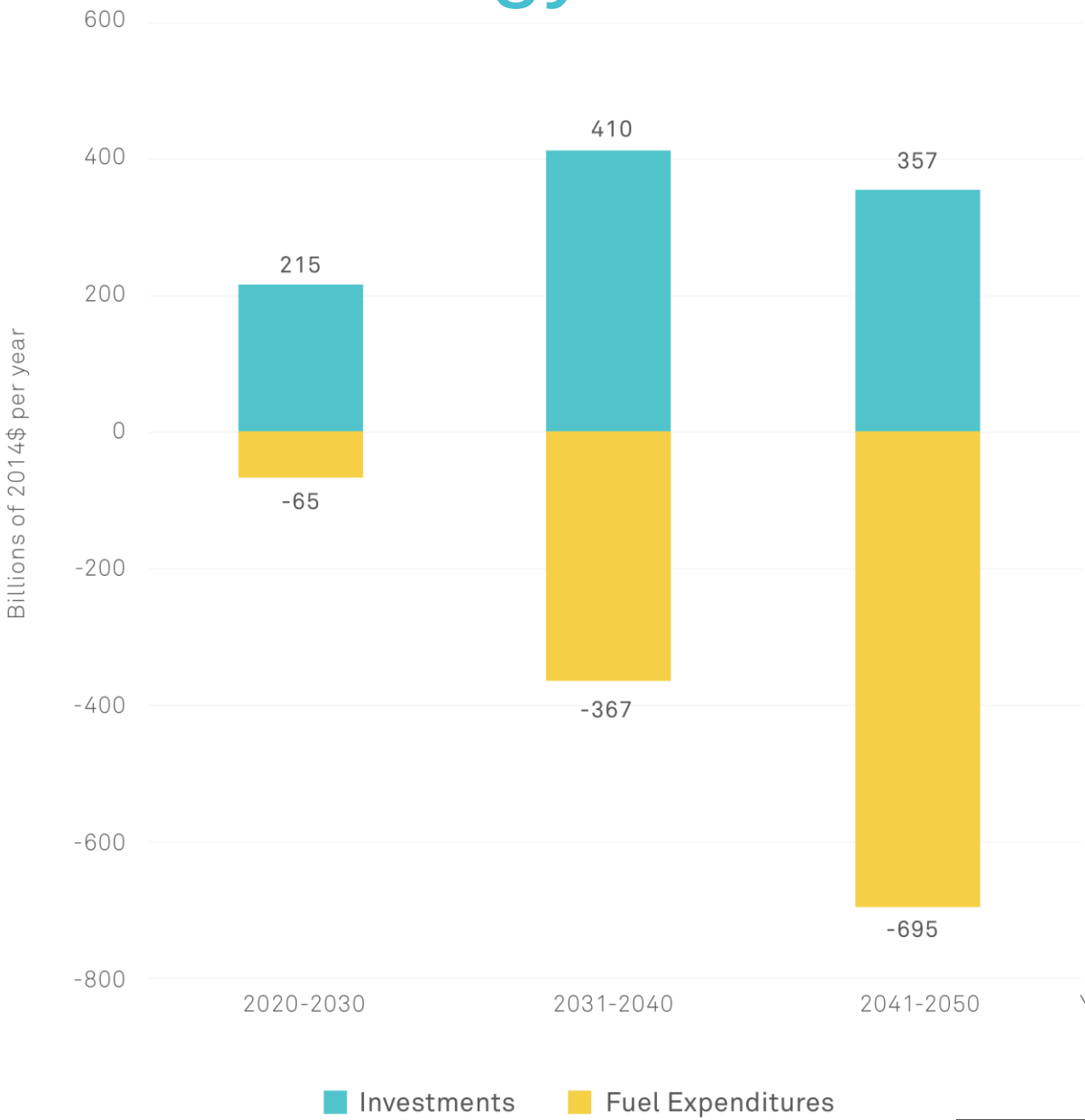
Investing in Clean Energy

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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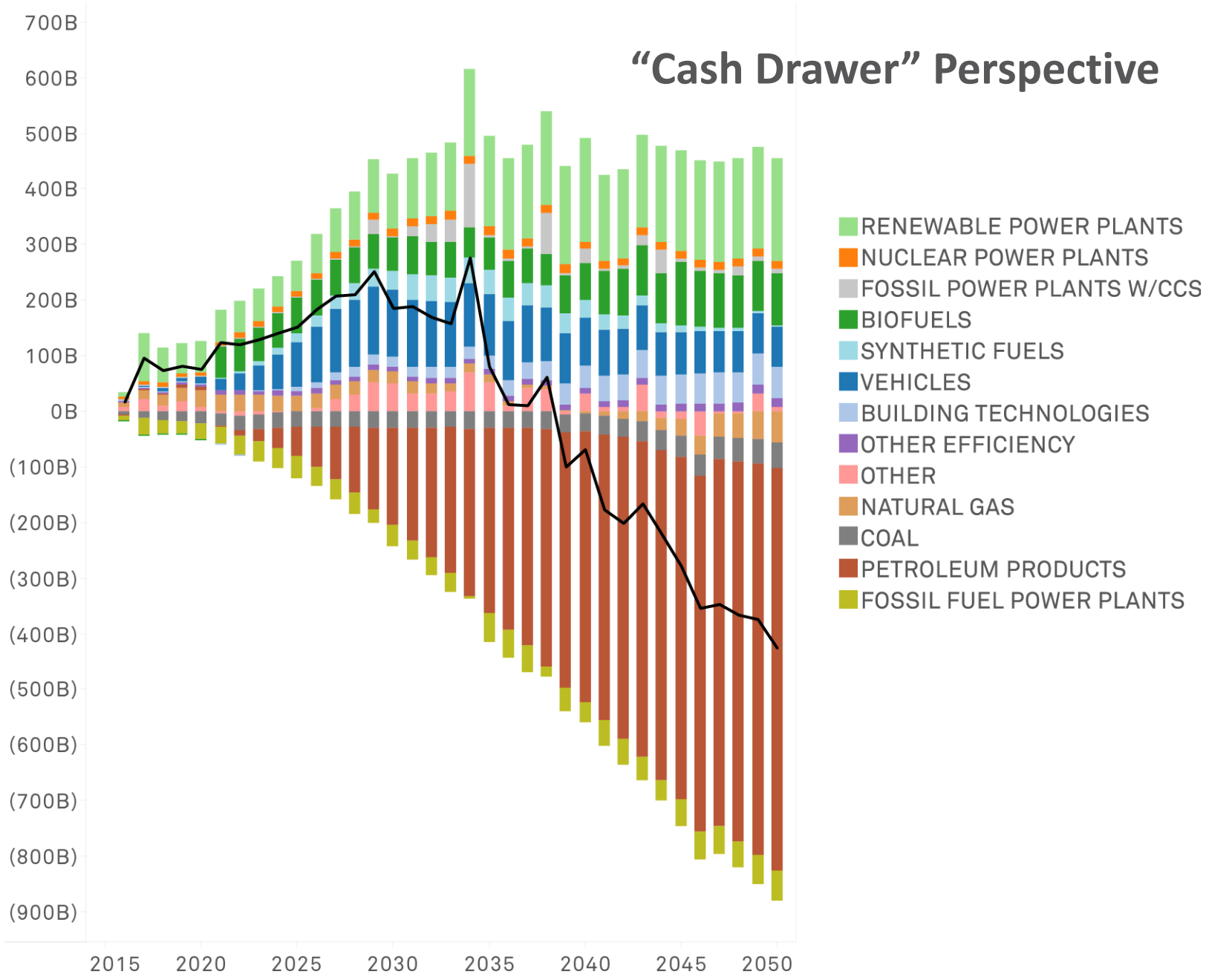
As-Spent Costs and Savings



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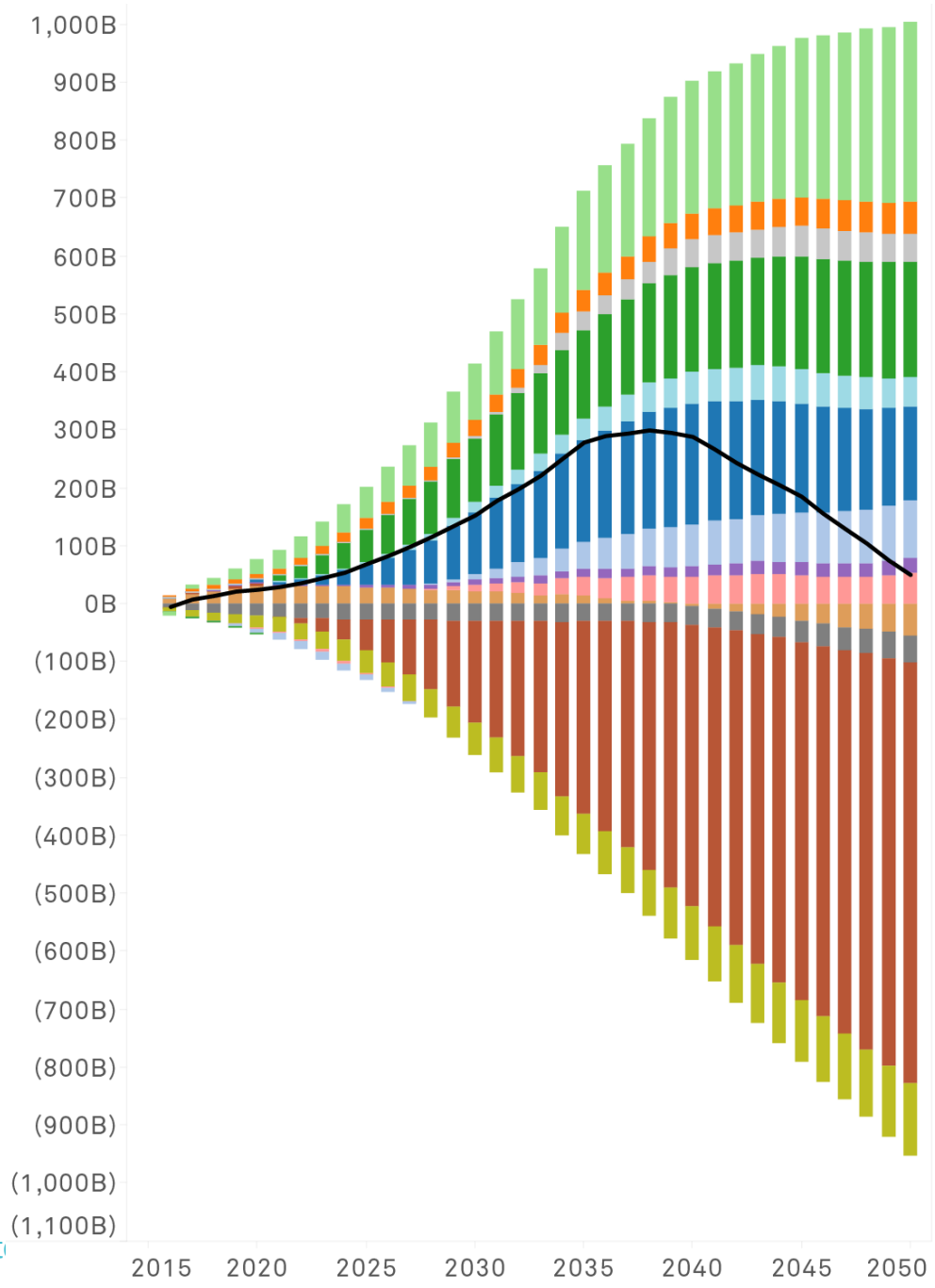
Annualized Costs and Savings

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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Employment Impacts

From a Similar 2015 Study

Gains

- 460,000 additional construction jobs could be created by 2030, with the number rising to 800,000 by 2050

Losses

- Coal mining and oil- and gas-related jobs could decline by more than 130,000 by 2030 and 270,000 by 2050

Overall ~1 million additional jobs by 2050

Source: ICF Incorporated, Economic Analysis of U.S Decarbonization Pathways: Summary of Findings, November 15, 2015.

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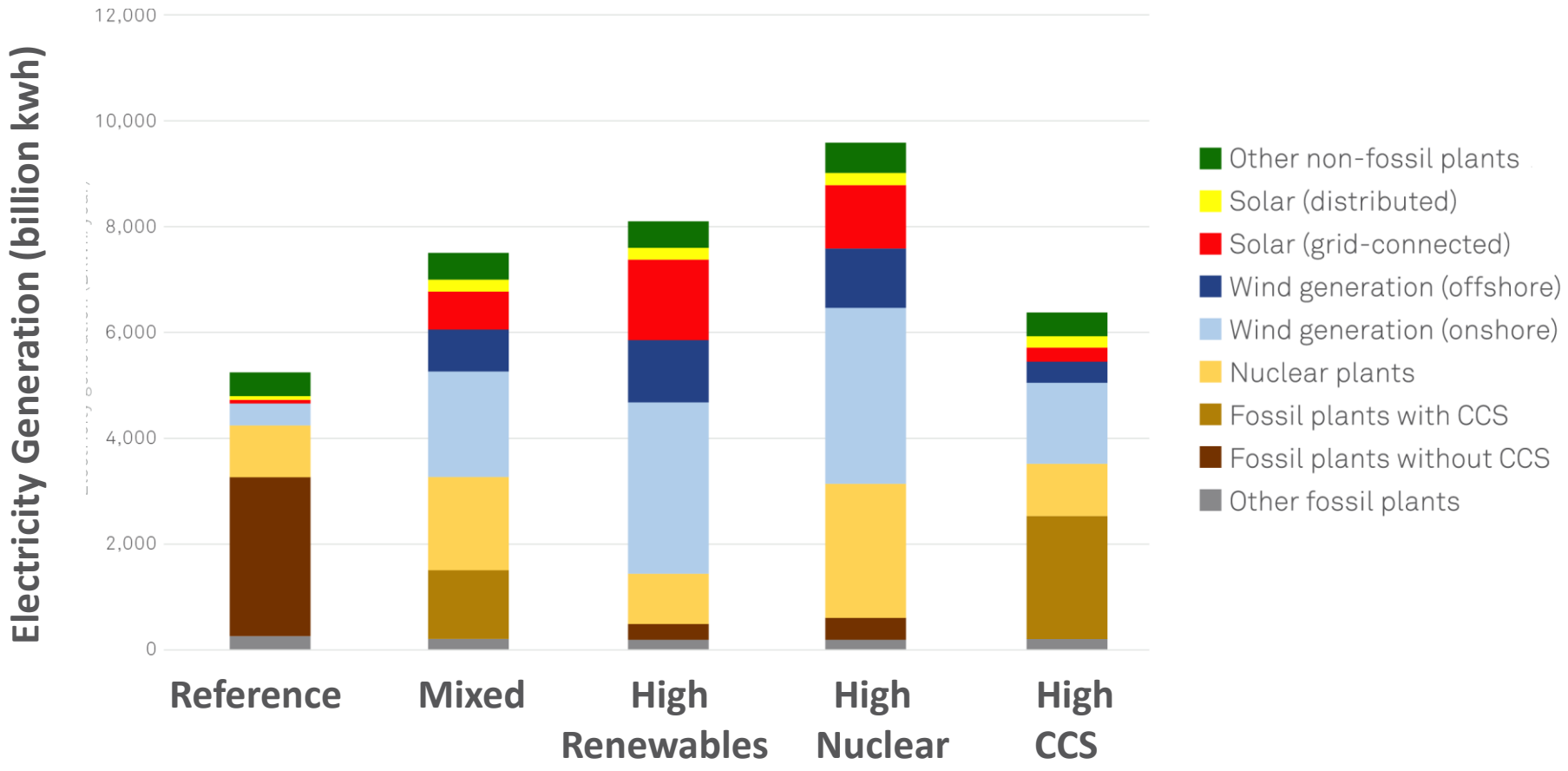
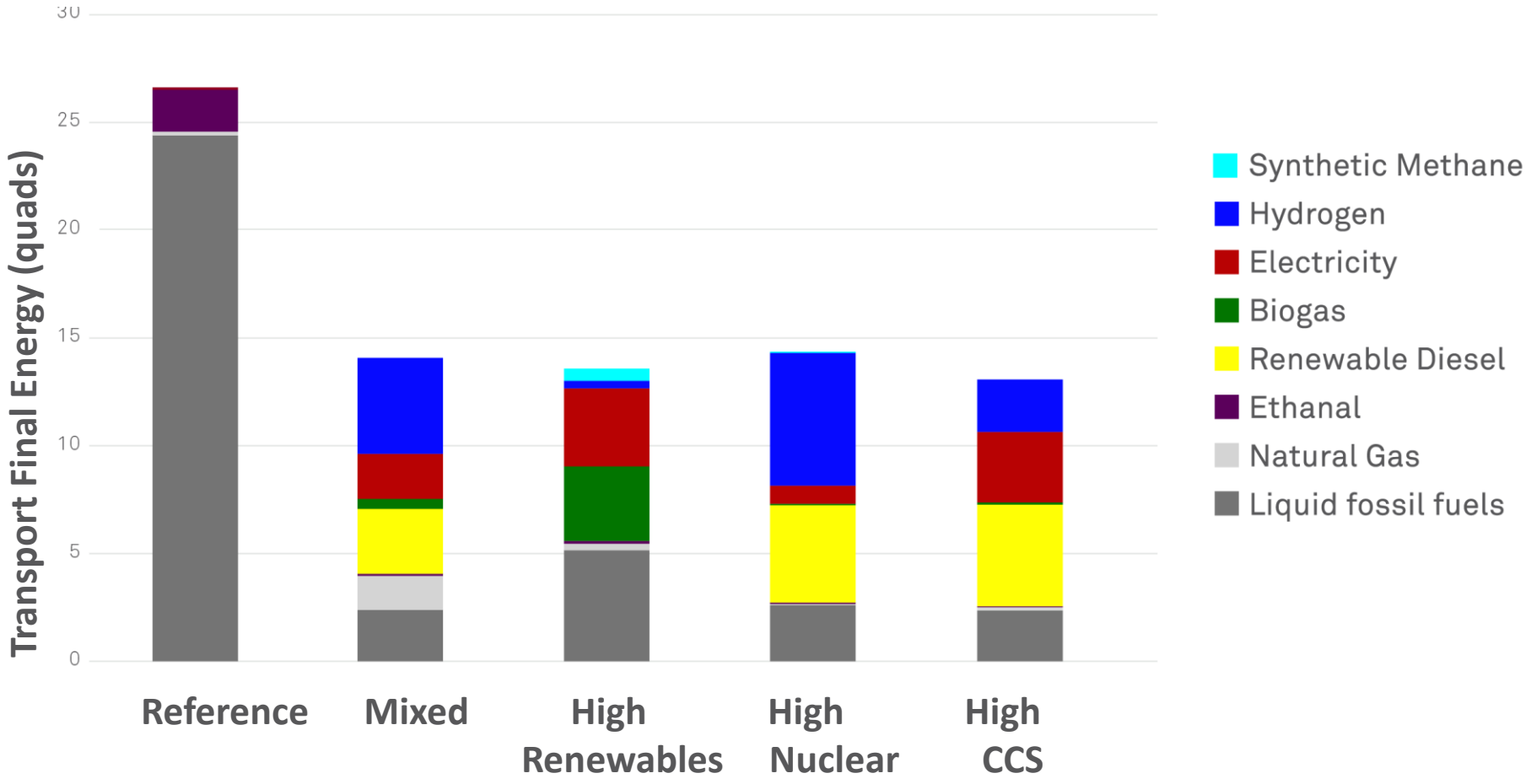
Power Generation in 2050



Transportation Energy Use in 2050



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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

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Consistent Policy Framework

The private sector has the technical and economic capacity to accomplish – and profit from – this transformation, but that **requires a clear and consistent policy and regulatory framework:**

- Internalize the true costs of carbon emissions, e.g., with a mechanism that puts a price on carbon.
- Avoid subsidizing fossil fuels through tax and other incentives.
- Coordinate and streamline public investment in R&D, infrastructure, education and workforce training
- Lower regulatory and financing barriers
- Require corporate disclosure of material climate-related risks.
- Help workers and communities negatively impacted

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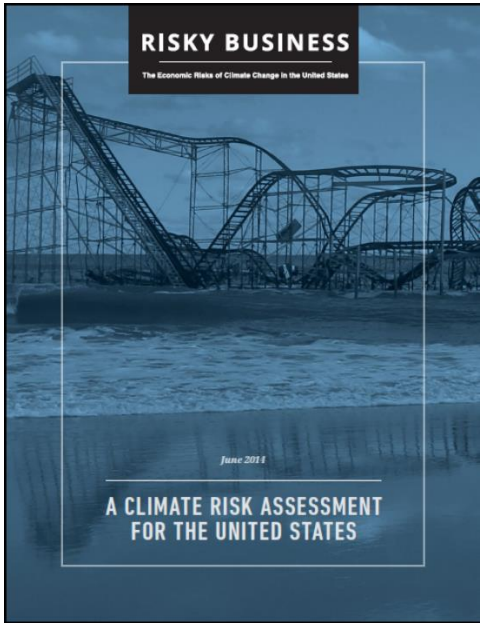
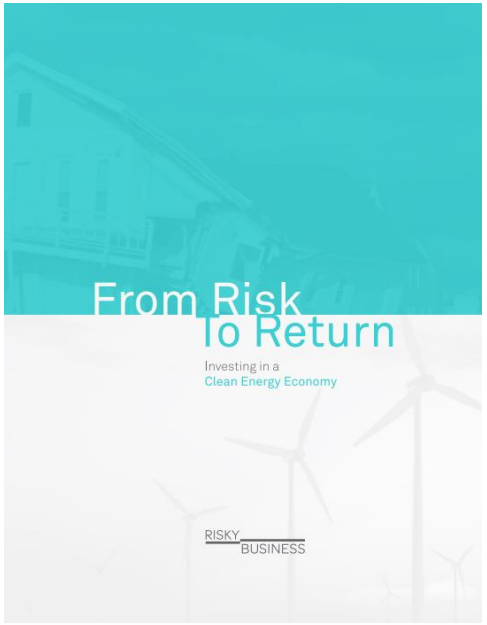
Role of Business

- Include cost of carbon calculation in capital stock decisions
- Factor climate risk into investment decisions
- Disclose the climate risk businesses face
- Engage with government to shape effective policies

Risky Business Reports

Available at:
www.riskybusiness.org





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Extra Slides

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Similarities and Comparisons

- **Similarities**
  - **Demonstrated multiple pathways to a low-carbon economy in 2050**
  - **Energy sector modeling relied on “3 pillars”**
    - **Electrification, electric fuels, and resulting demand growth**
    - **Zero- and low-carbon electricity with roles for renewables, nuclear, and CCS**
    - **Energy efficiency**
- **Differences**
  - **CO2 emissions only vs. all GHG + land sequestration**
  - **Role of Bioenergy with CCS**
  - **Role of Smart Growth**

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Power Generation – 9 Regions