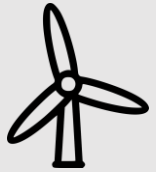
Decarbonizing the U.S. Energy Systems

Presentation to B.U. Advisory Committee on Socially Responsible Investing

Prof. Peter Fox-Penner
Questrom School of Business
Director, Institute for Sustainable Energy
February 25, 2021

Shoutout to the ISE Team for Their Help

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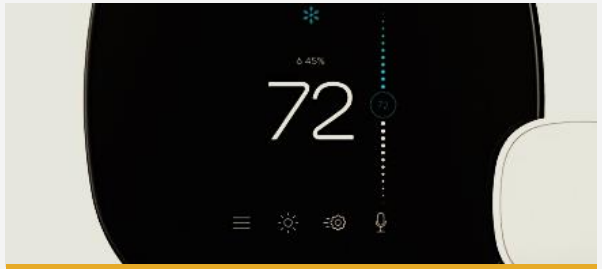
Energy & Climate Policy in Advanced Economies



Maximize Energy Efficiency

Electrify Transportation and Heat or Use Clean Fuels

Convert Industrial Process to Electricity or Clean Fuel

Much Larger Grid

Meeting all Societal Goals:

Affordable, Equitable, Reliable, Financially Viable

JOINT INFRASTRUCTURE

Electrolysis

Clean Gen Fuels

Clean Fuels, Including Delivery Networks

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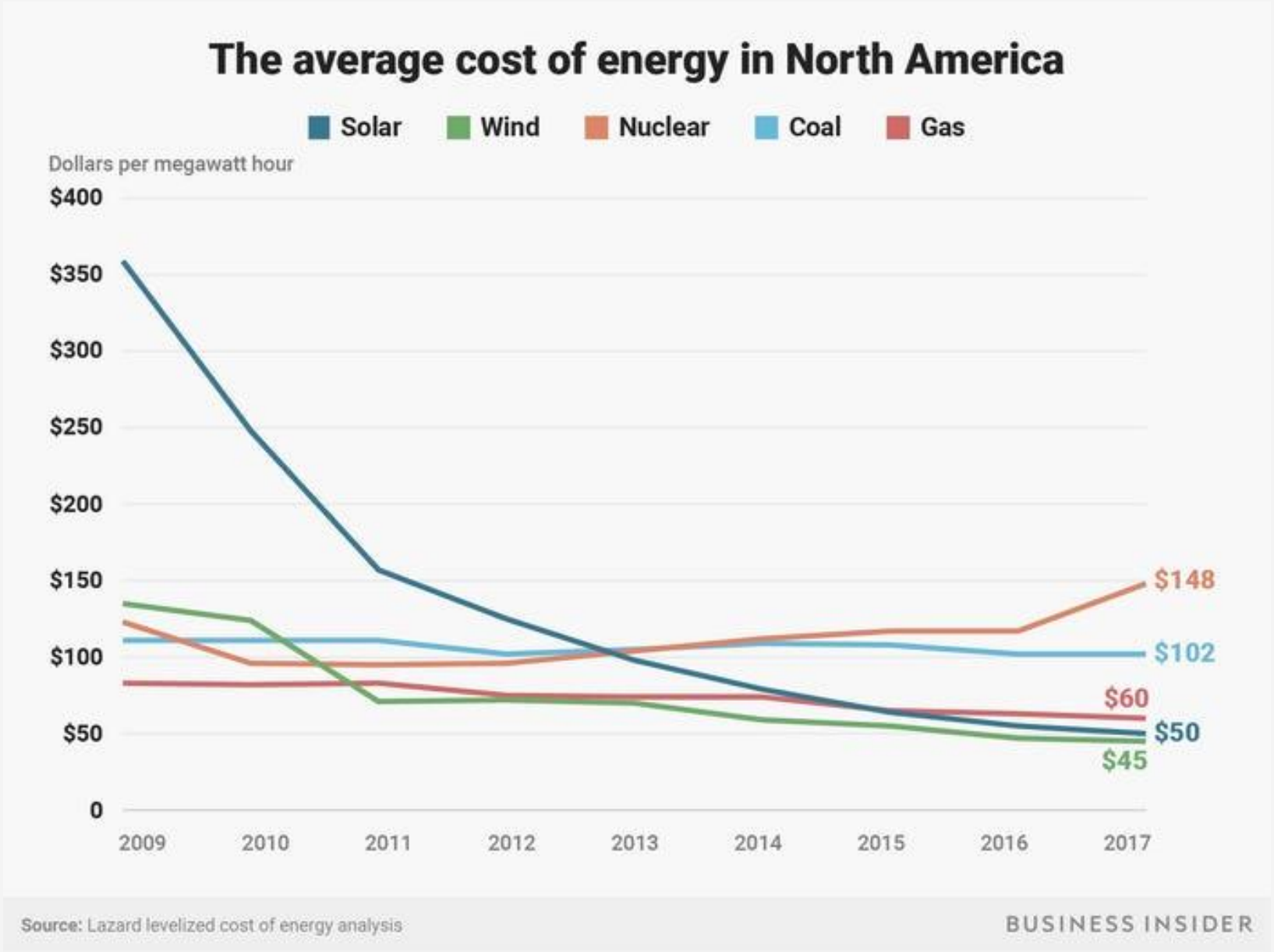
1. Carbon-Free Electricity Supply



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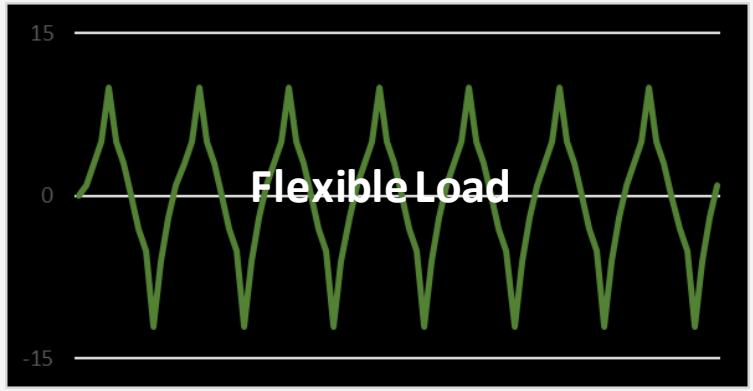
Supply Side of a Carbon-Free Big Grid



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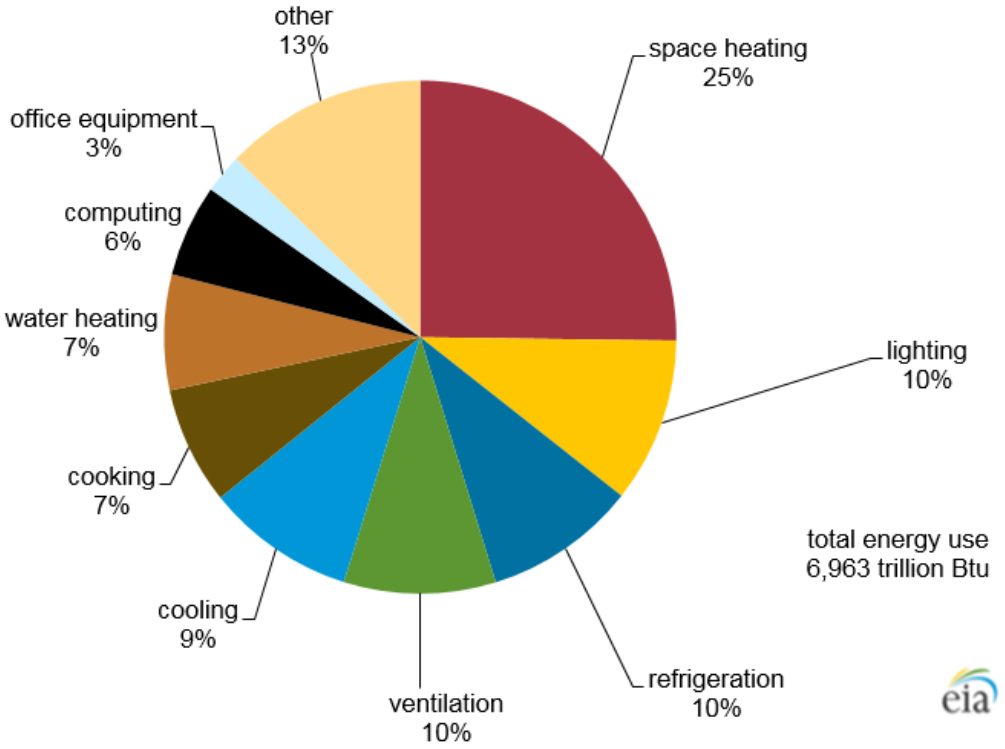
Big Grid Challenges Are Large

2. Changing Electricity Use

Decarbonizing Building Energy Use

Commercial Buildings Energy Use



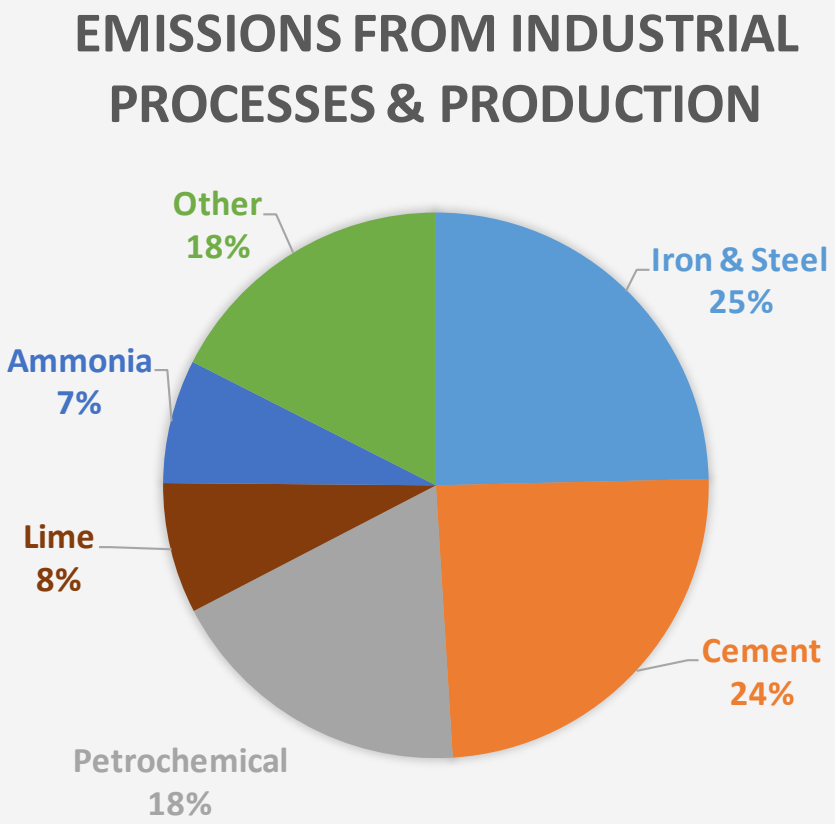
Source: U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey.

- Electrify Heat in 130mm buildings via Heat Pumps
  - Air Source
  - Ground Source (geothermal)
  - District Heating
- Clean non-electric heat from renewable gas, green hydrogen

Challenges:

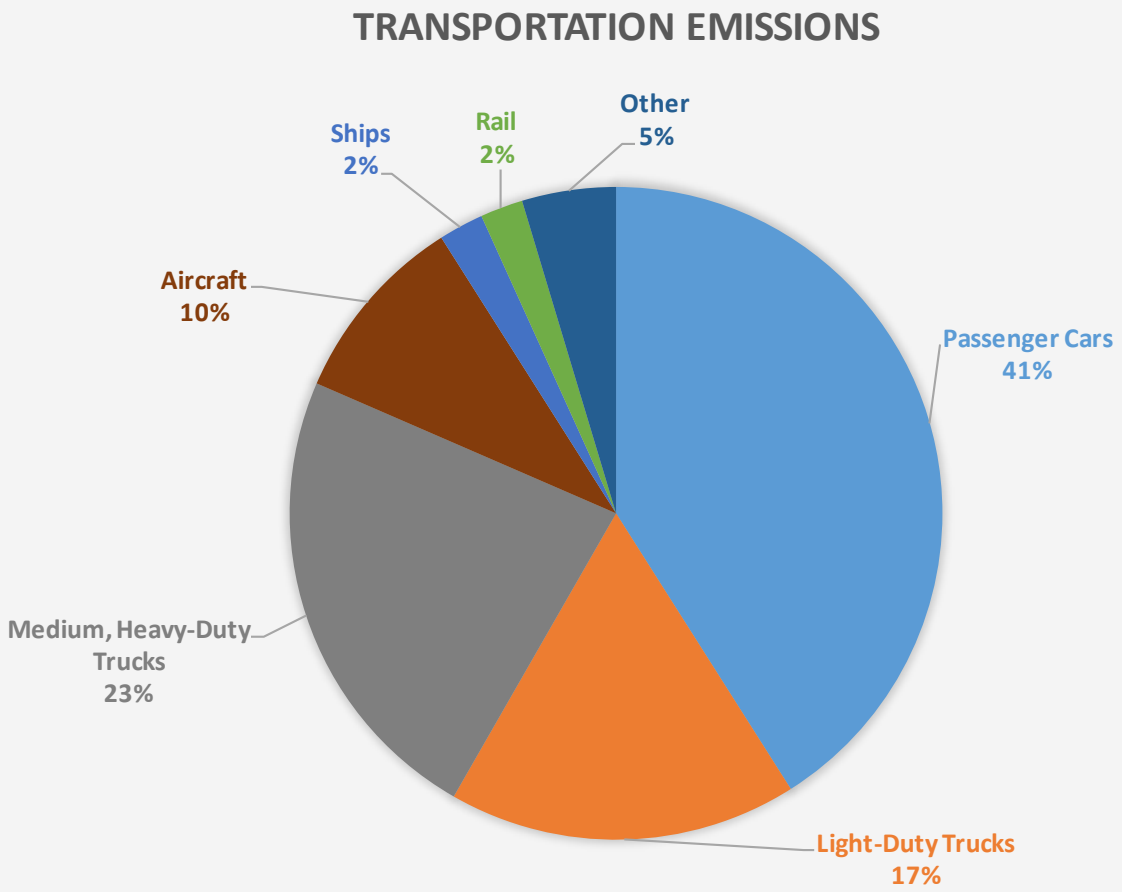
- Policies to promote new & retrofits
- Financing is critical: ~$10Tn

Decarbonizing Industrial Energy Use



- Can focus first on big five: steel, cement, chemicals, lime, ammonia
- Massive R&D -- new technologies, processes, and materials ($30 Bn)
- Policies that promote decarbonization for all industry – carbon tax insufficient
- "Buy green" incentives seem useful
- Industries need public-private collaboratives
- Pre-commercial public funding important

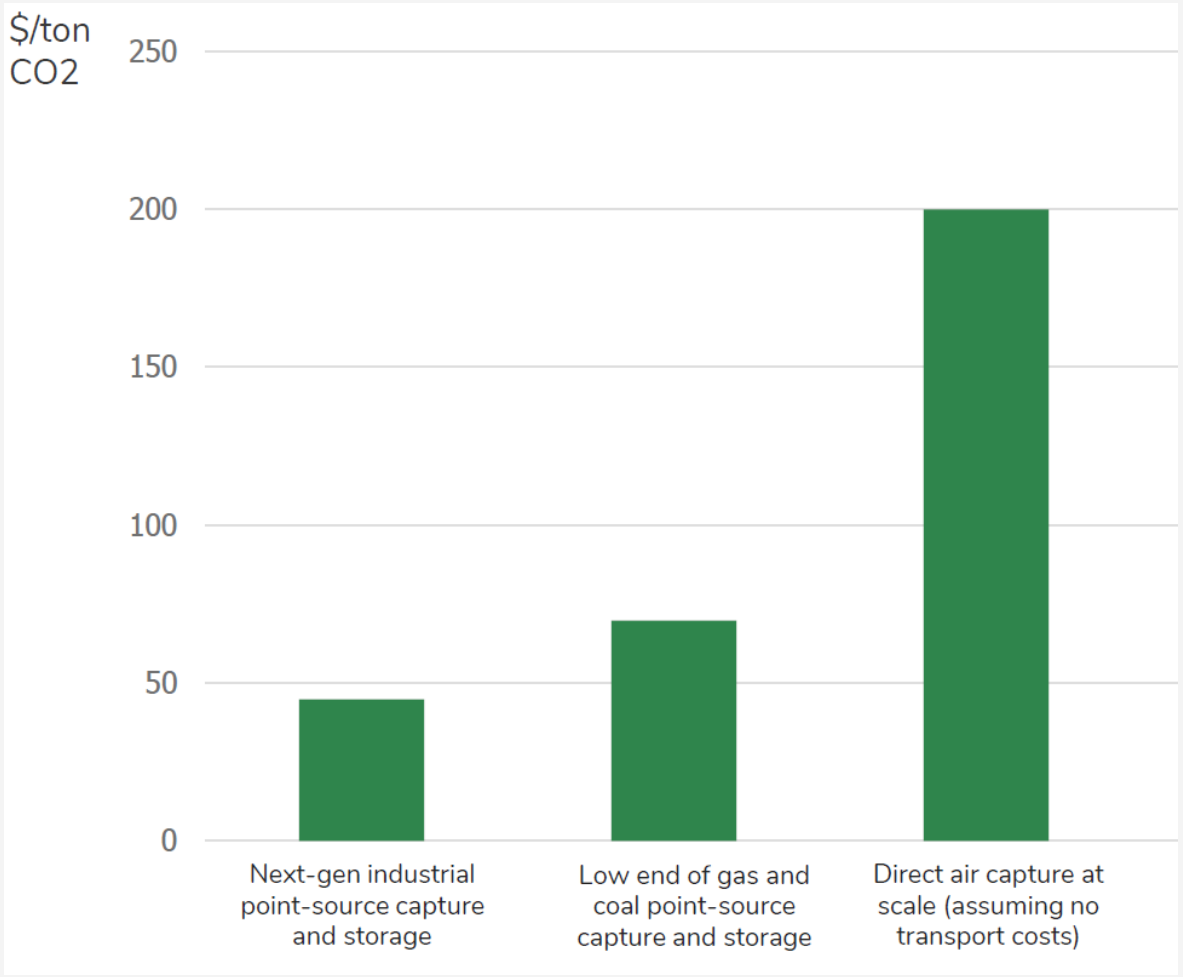
Decarbonizing Transportation

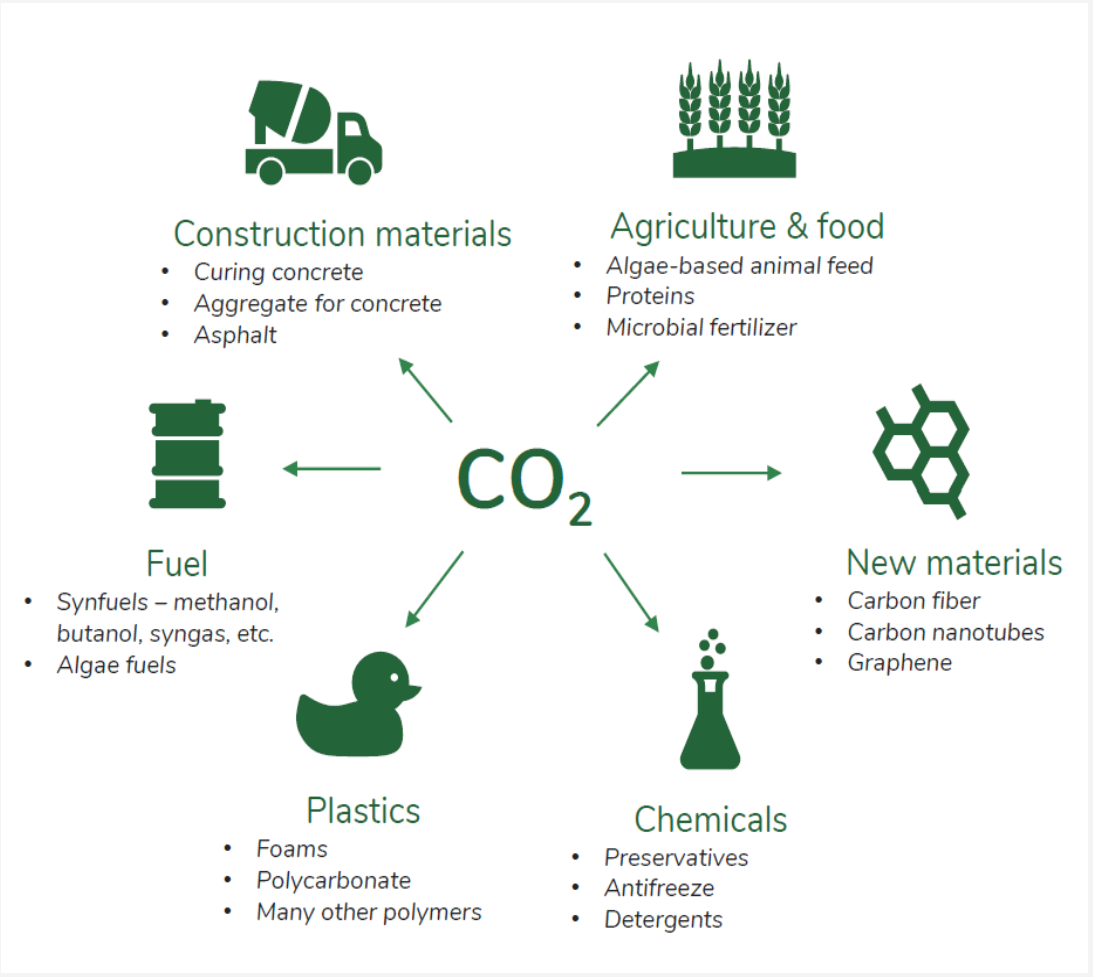


- Passenger car transition to EV and FCVs underway – need public and private infrastructure
- All other forms of transport need R&D, incentives, and requirements:
  - Airlines and trucking: electricity, H_2, biofuels
  - Railroads: electricity likely
  - Ships: electricity, H_2, ammonia

3. Clean Fuel Supplies

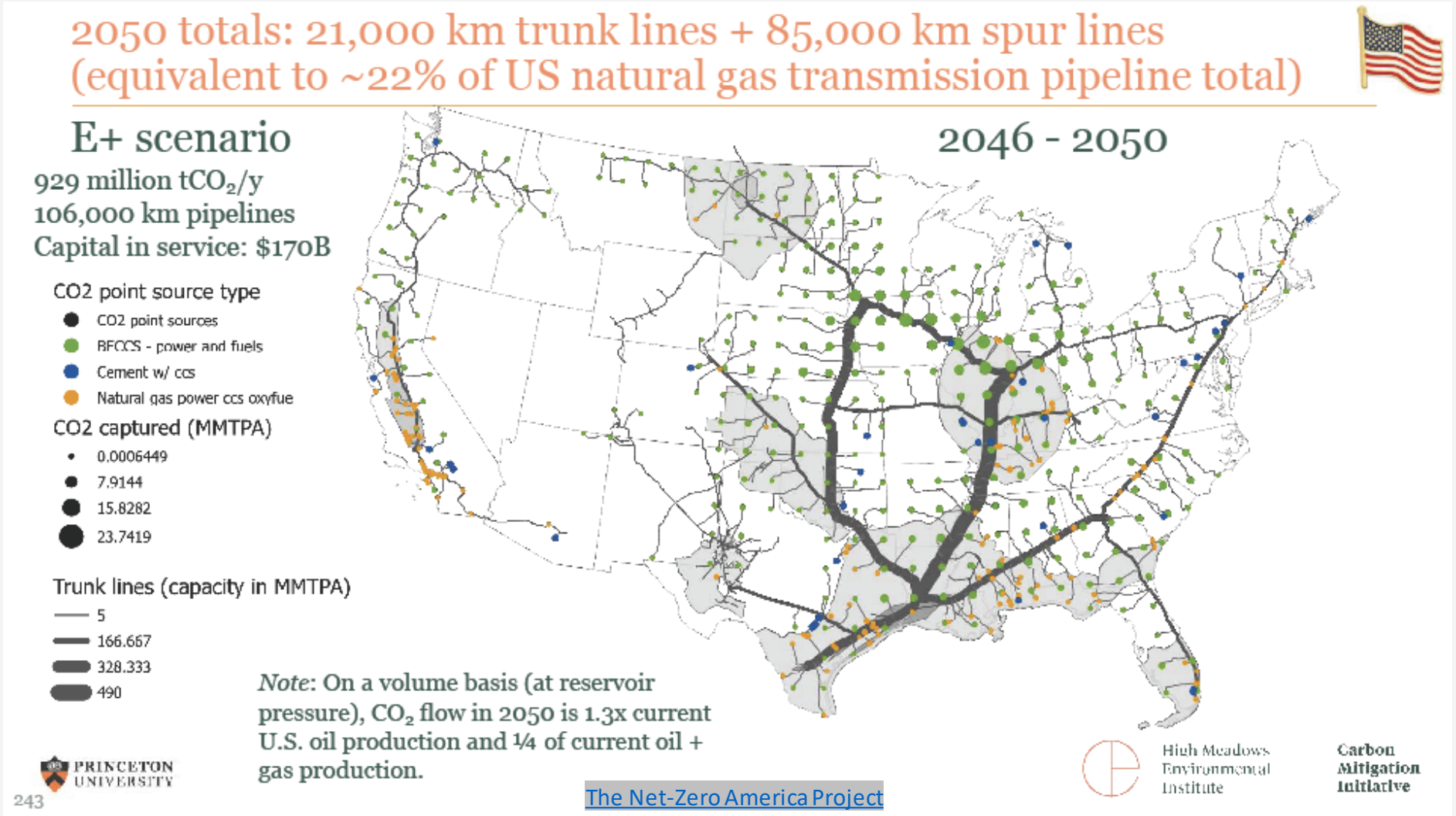
Carbon Capture, Sequestration, and Use





Source: Center for Climate and Energy Solutions report, (2019), McKinsey(2020); Energy Impact Partners

CO_2 Pipeline Network



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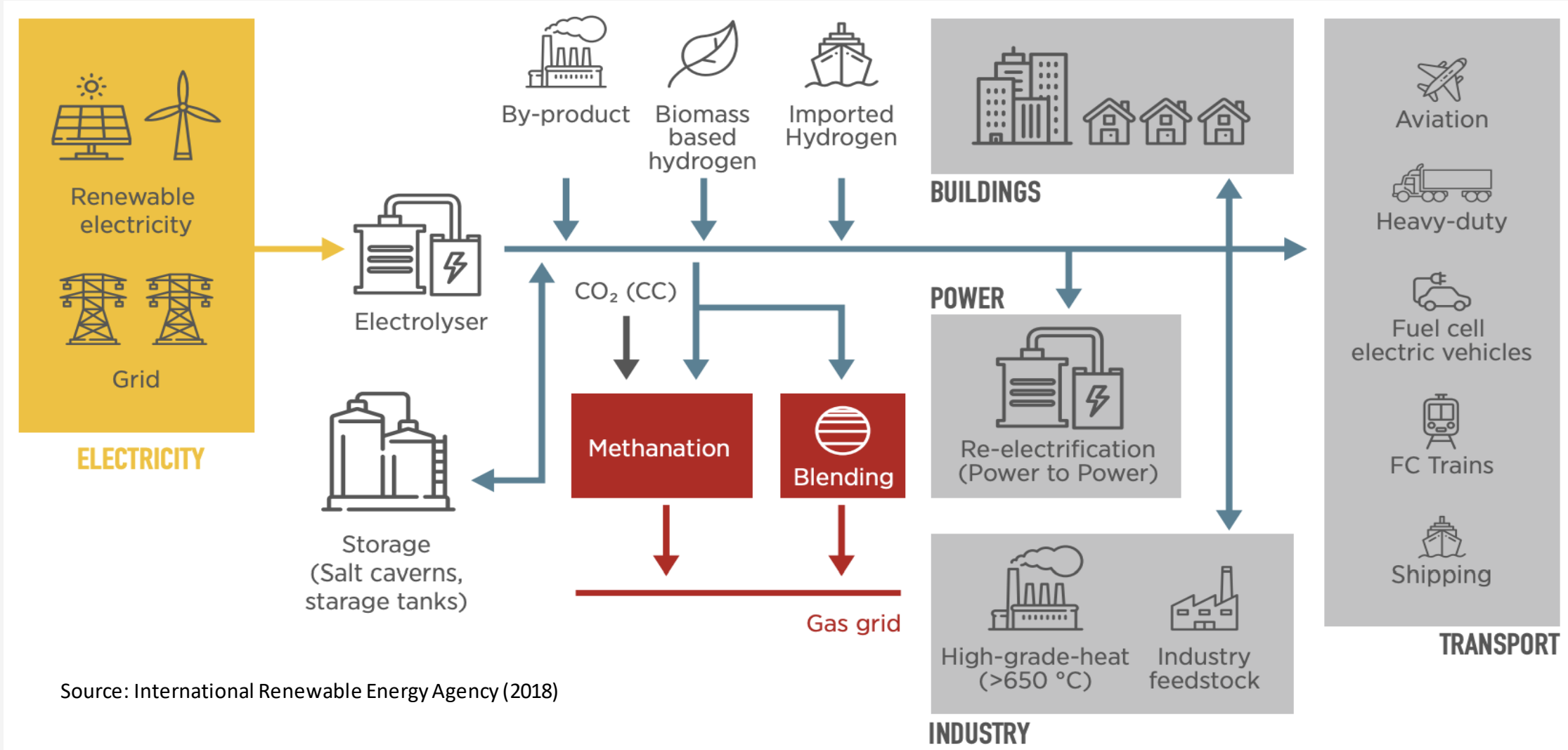
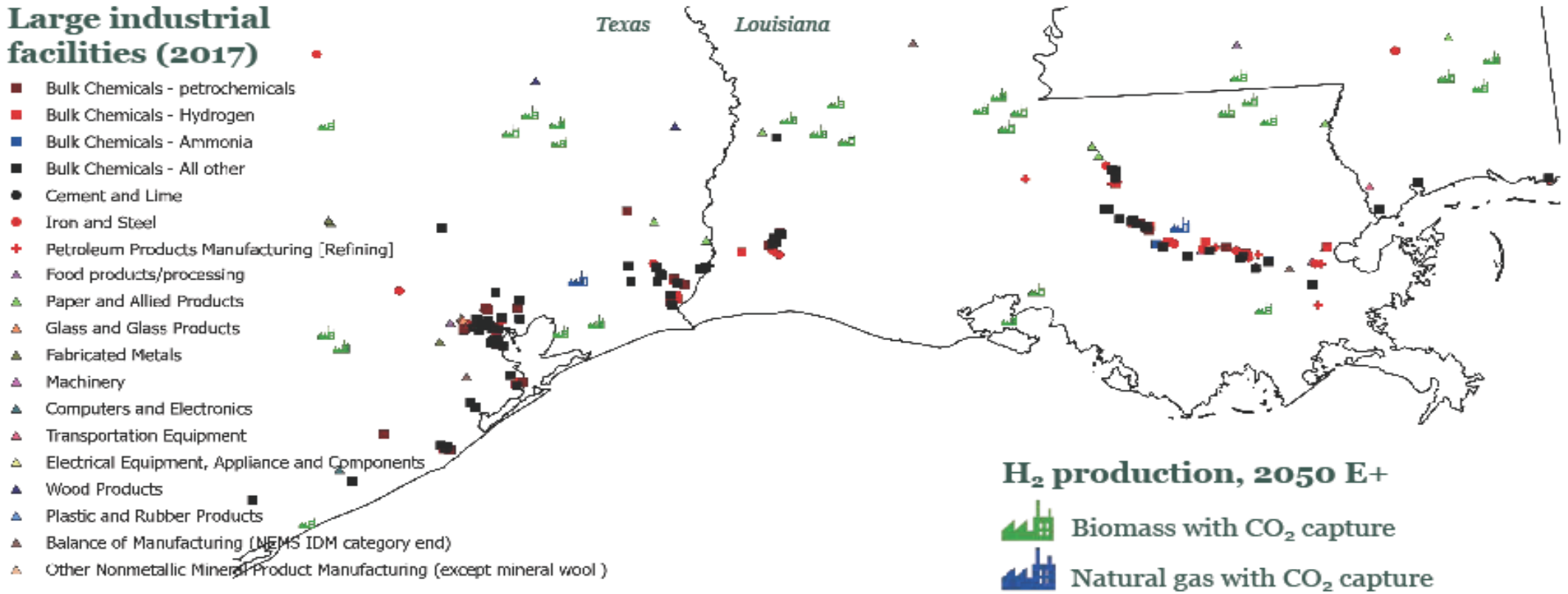
Hydrogen is Versatile, But Must Get Cheaper and Needs Infrastructure



Source: International Renewable Energy Agency (2018)

Notional view of H_2 production and use on the Gulf Coast, 2050



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[The Net-Zero America Project]

High Meadows Environmental Institute

Carbon Mitigation Initiative

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We Can Do This, But It's Not Easy

Rosie the Riveter

- Projections show a net zero energy system achievable by 2050
  - Electric prices and reliability ~ same(!)
  - ~2x+ the size of current grid
  - 500,000 to 1,000,000 net new jobs
  - Large health and env. justice benefits

- The challenges are **technical, policy**, and **fiscal commitment**
  - ~2x to ~3x increase in federal R&D – storage, clean fuels, industrial processes
  - Planning and policies to 2x grid and build H2/RNG/CCS infrastructure
  - $100s of Bn in public funds – unlocking $Tns private capital

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CONFLICT OF INTEREST DISCLOSURE
Dr. Fox-Penner holds equity in Energy Impact Partners, a utility-backed energy investment and innovation firm, EOSE, and consults for Energy Impact Partners and The Brattle Group on energy technologies. Dr. Fox-Penner also conducts research in areas of interest similar to the business interests of Energy Impact Partners and The Brattle Group. The terms of this arrangement have been reviewed by Boston University in accordance with its financial conflicts of interest in research policies.

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