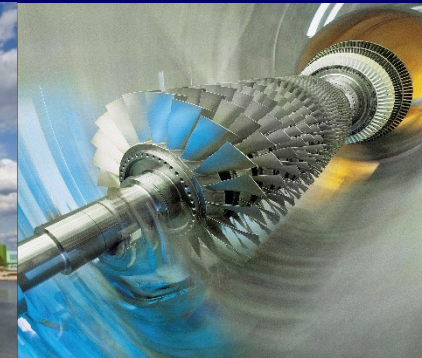


U.S. DEPARTMENT OF
ENERGY

Office of
Fossil Energy



***Southern States Energy
Board
and
Virginia Coal and Energy
Alliance***

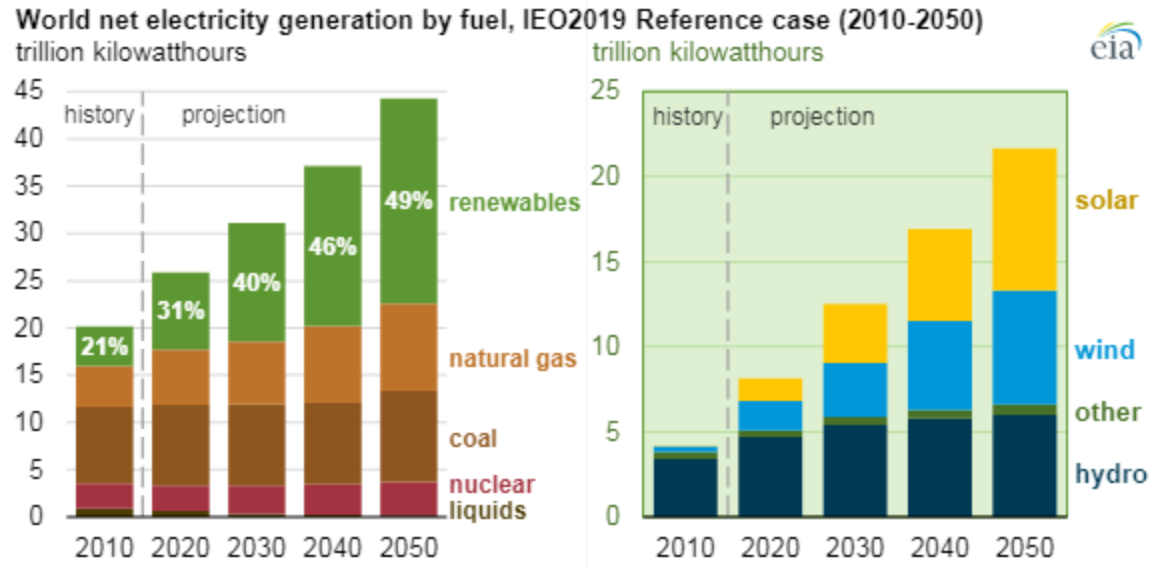
May 18, 2020

Steven Winberg
Assistant Secretary
Office of Fossil energy

The future of coal in the 21st Century depends on four pathways

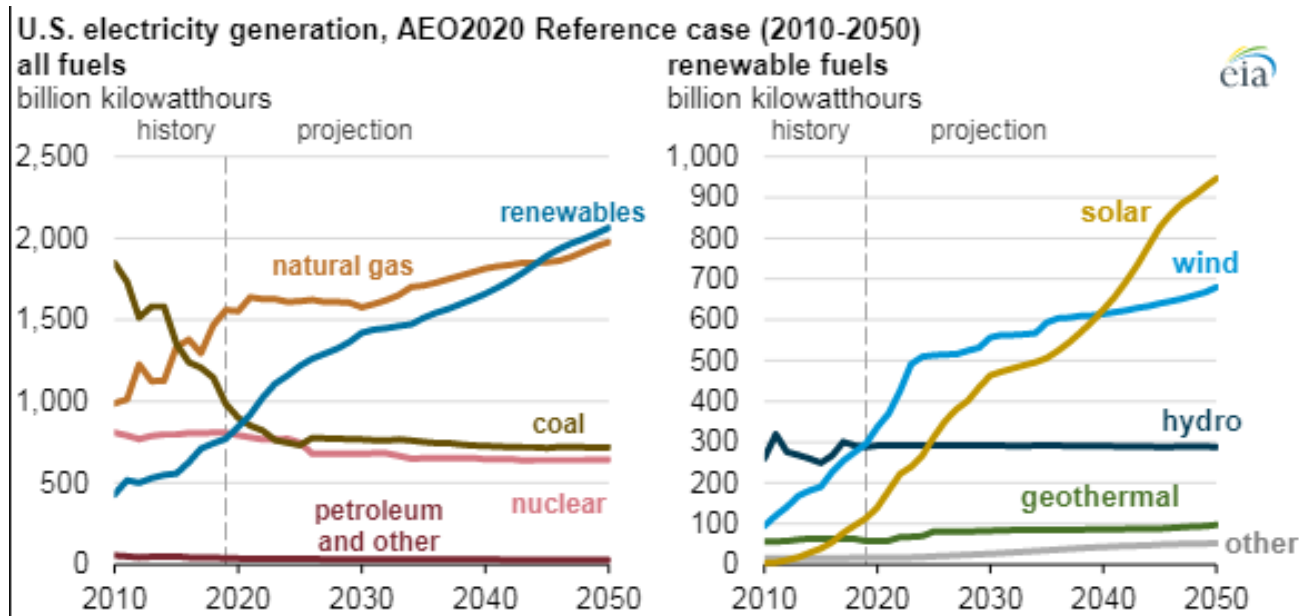
- *Developing Coal FIRST Power Plants of the Future*
- *Advancing Carbon Capture, Utilization and Storage*
- *Expanding Coal's Value Chain – Commercial Products, Advanced Materials, Rare Earth Elements, and Critical Minerals*
- *Coal Exports*

Outlook for Global Energy Consumption to 2050



Outlook for U.S. Coal-Fired Power Generation

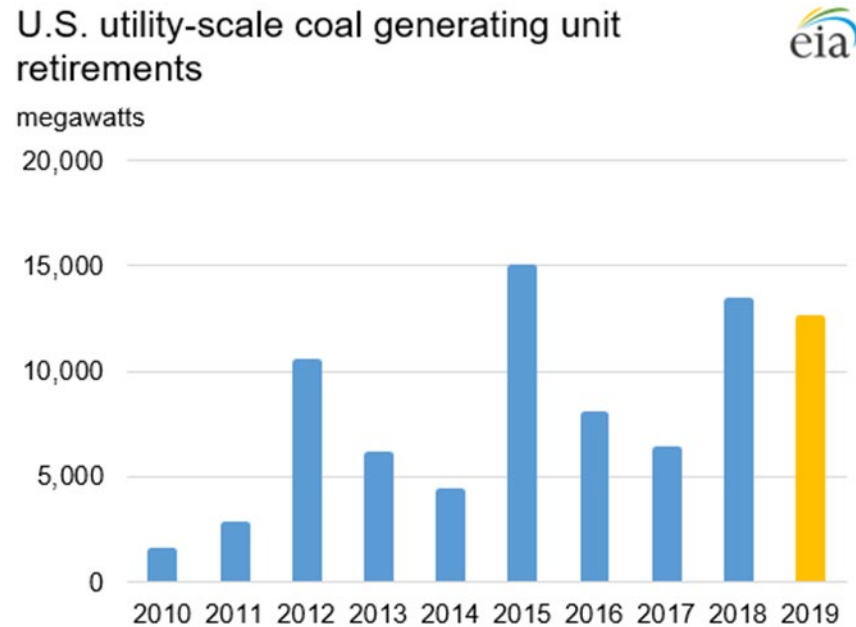
Coal's share of U.S. power generation declines over the next 30 years



Source: U.S. Energy Information Administration, Annual Energy Outlook 2020

Coal Plants Retiring

Coal plant retirements over the past decade have reduced coal-unit capacity by more than 78,000 MW



Data for 2019 are preliminary. Megawatts represent summer capacity of generating units.

Source: U.S. Energy Information Administration

Coal FIRST: The Future of Power Generation

(Flexible, Innovative, Resilient, Small, Transformative)

- Provides a **zero or near zero CO₂ emissions**
- Provides **low cost power generation**; economically competitive
- Uses advanced materials and processes; **maximizes efficiency**
- **Meets IEA solution for CO₂ emissions** -- carbon capture
- **Only** zero or near zero CO₂ emissions power plant **R&D effort in the world**
- Potential to **revive the US coal industry**; provide a source of **high value exports**
- Provides stability and reliability to the grid of the future, and offer both **“firm and flexible” operations**

Per International Energy Agency (IEA), coal will be the largest source of electricity production in the world by 2040, and likely beyond

**Near-Zero Emissions
Secure, Stable,
Reliable Power**

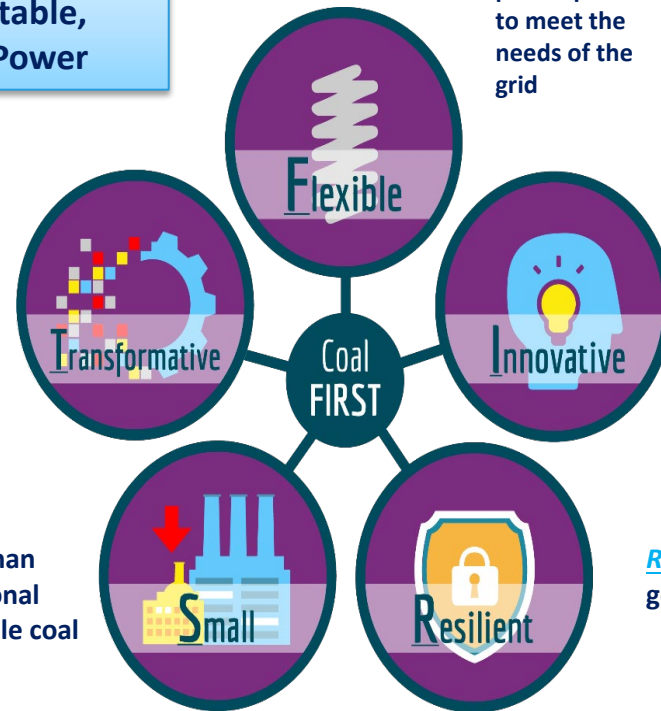
Transforms how coal technologies are designed and manufactured

Smaller than conventional utility-scale coal plants

Flexible coal plant operations to meet the needs of the grid

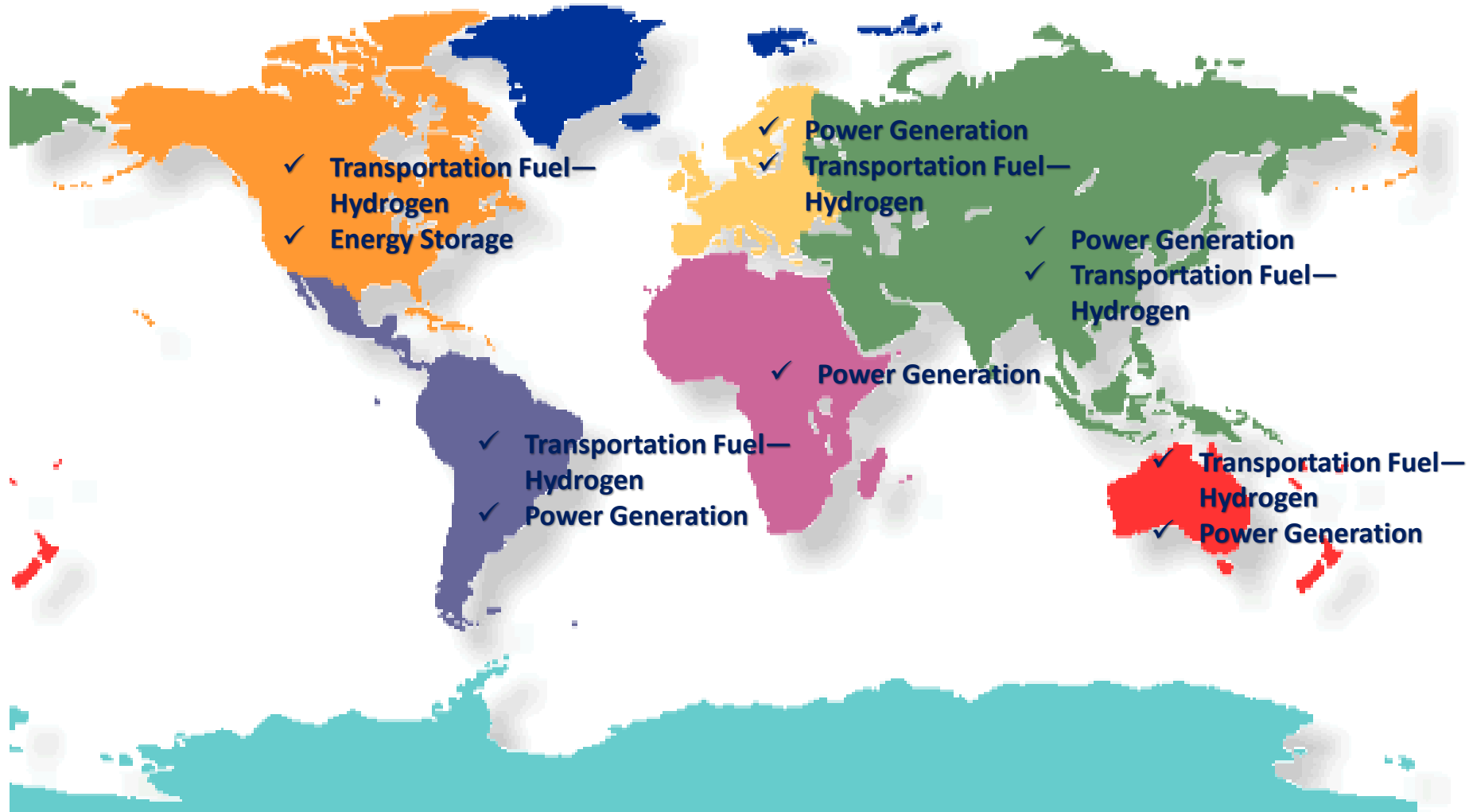
Innovative and cutting-edge components; improved efficiency and near-zero emissions

Resilient power generation



Coal FIRST Adapts to the Needs of Tomorrow

Coal FIRST will deliver advanced technologies that serve as building blocks to meet the variety of evolving energy needs across the globe.

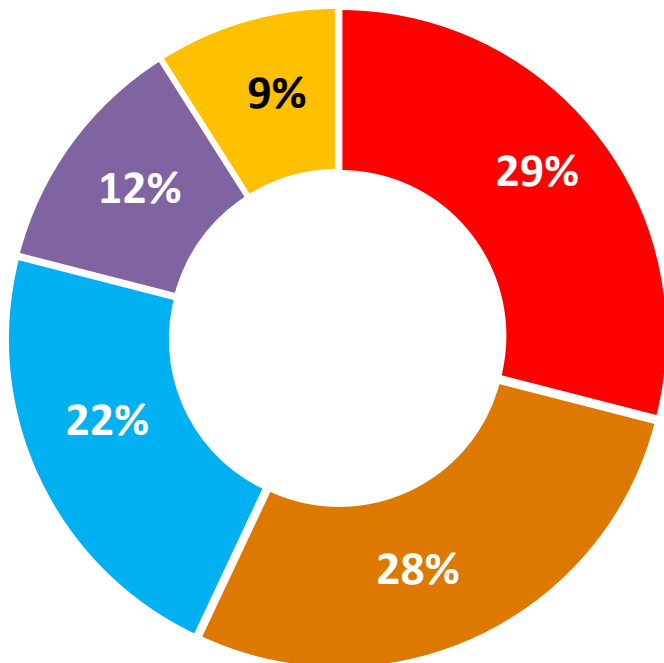


Accomplishments & Next Steps

- **September 2019** – 13 Conceptual FEED Study designs completed
- **April 2020** – 7 Pre-FEED Studies to be completed
- **September 2020** – Two technology Front End Engineering and Design (FEED) Study awards
- **September 2020** – Critical components awards to advance other Coal FIRST designs.
- **Anticipated September 2023** – FEED Study designs and critical components study completed

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2017

Total Emissions in 2017 = 6,673 million metric tons (MMT) of CO₂ equivalent.

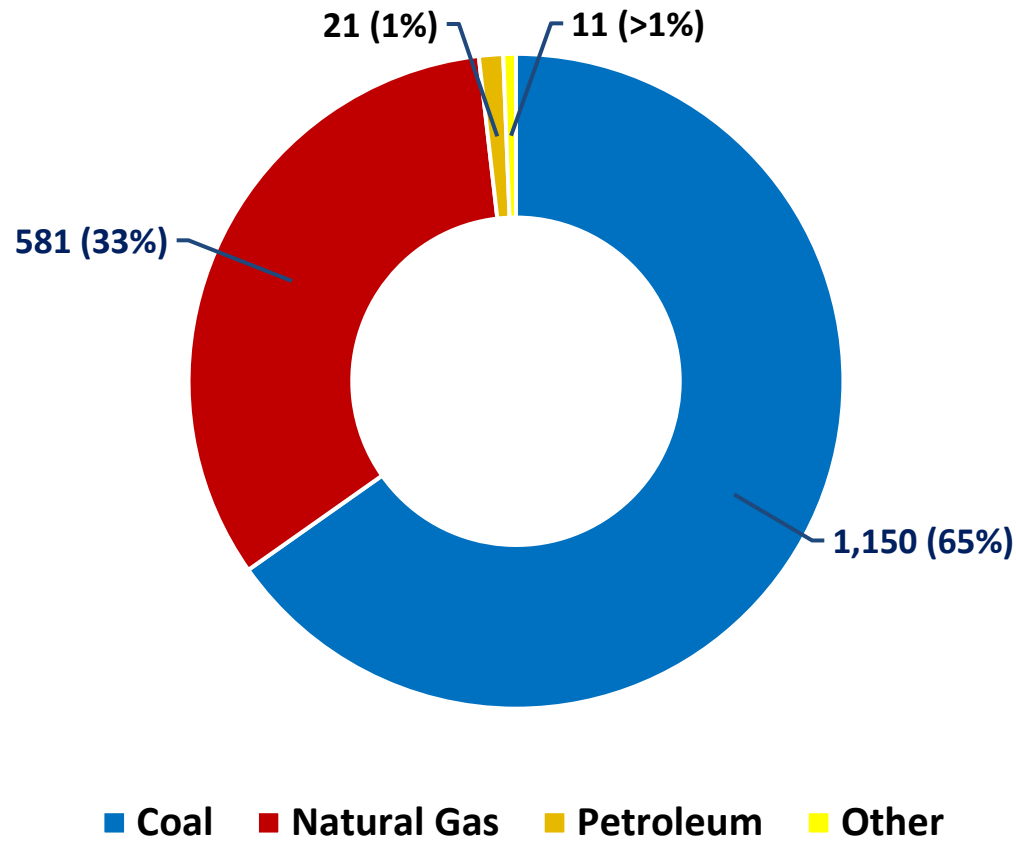


- Transportation (29%)
- Electricity (28%)
- Industry (22%)
- Commercial and Residential (12%)
- Agriculture (9%)

Source: International Energy Agency

Total GHG Emissions from Power Generation by Source (2018)

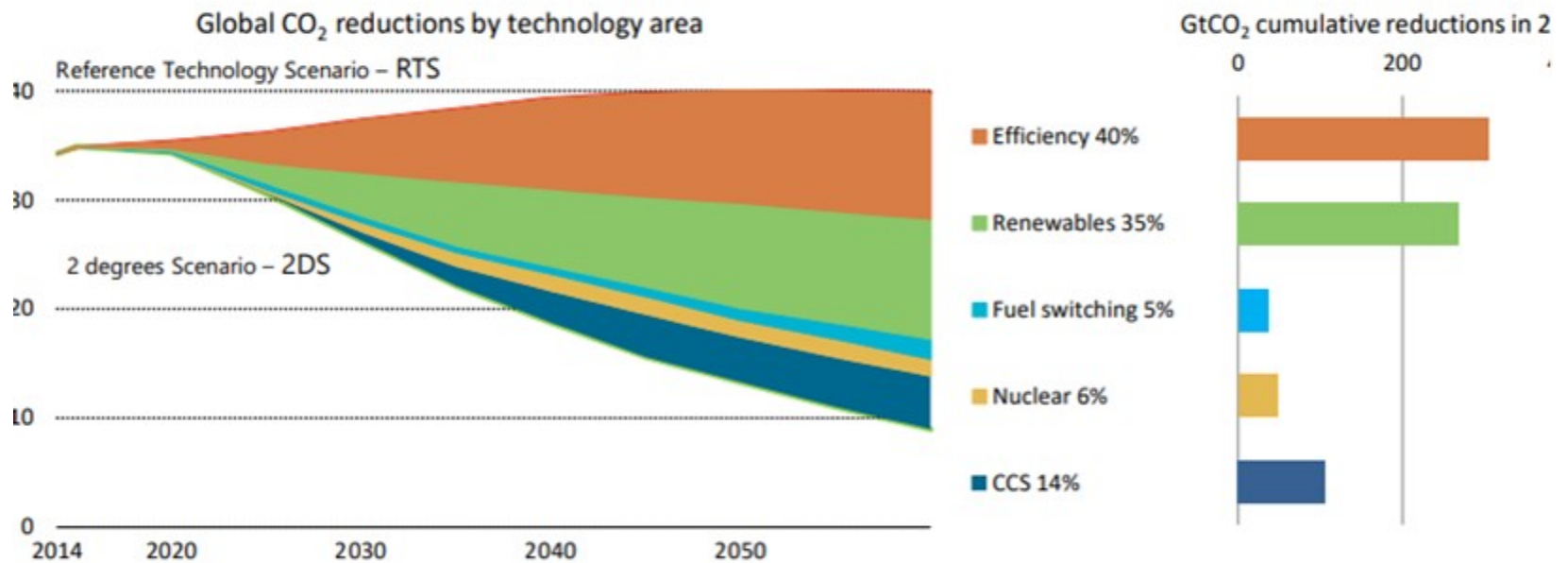
U.S. CO₂ Emissions from Power Generation by Fuel Type (1,763 MMT)



Source: EIA

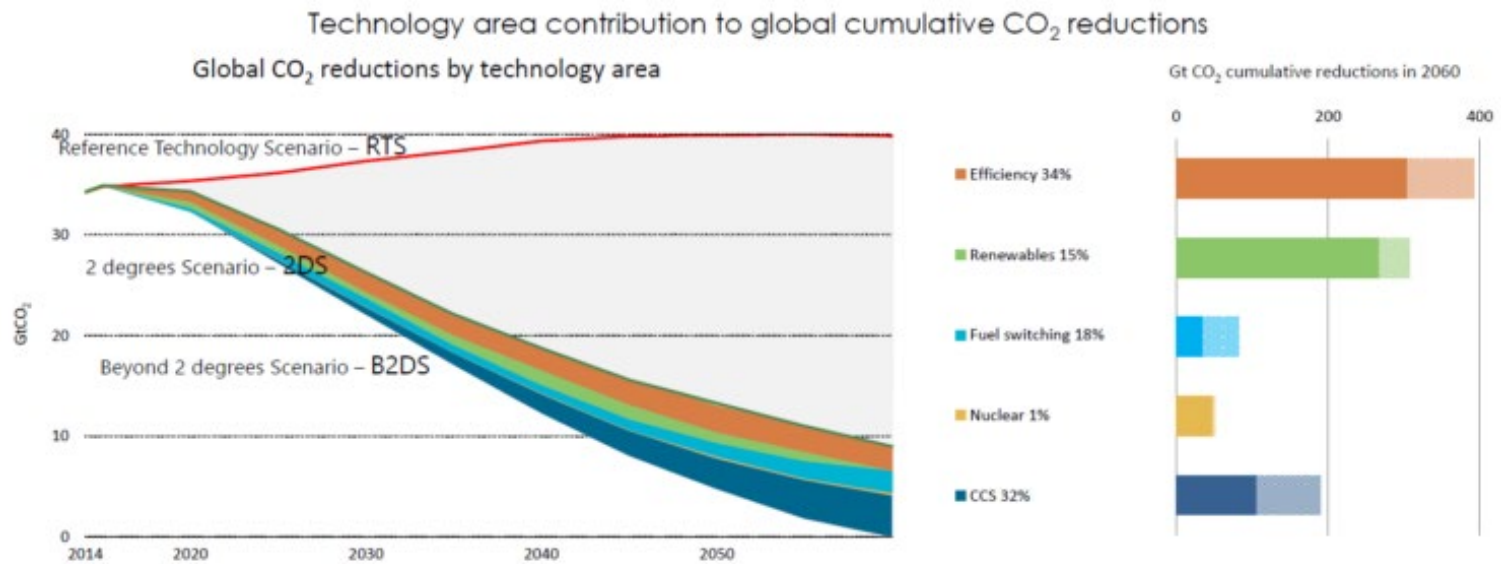
Carbon Capture, Utilization, and Storage

Contribution of various levers to global cumulative CO₂ reductions



Source: IEA

CCUS Provides a Third of CO₂ Reductions in B2D Scenario



Source: IEA

CCUS R&D Program Goals and Challenges

Reduce the cost of capture by 50%

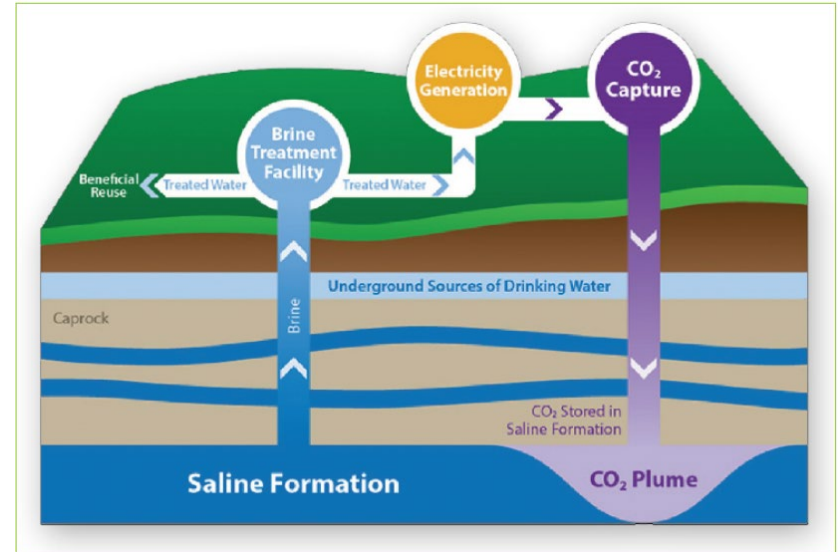
- Capital cost
- Energy penalty
- Integration or process intensification

Develop viable carbon utilization alternatives (\$1T opportunity)

- Reduce Capital cost
- Reduce energy requirements
- Lifecycle assessment better than existing products

Reduce the risk of geologic storage – improve monitoring and simulation

- Higher resolution and quantification (e.g., accurate characterization of faults and fractures)
- Geomechanics (pressure and state of stress)
- Costs/uncertainty/enabling real-time decision making



2012: \$80/tonne

2016: \$60

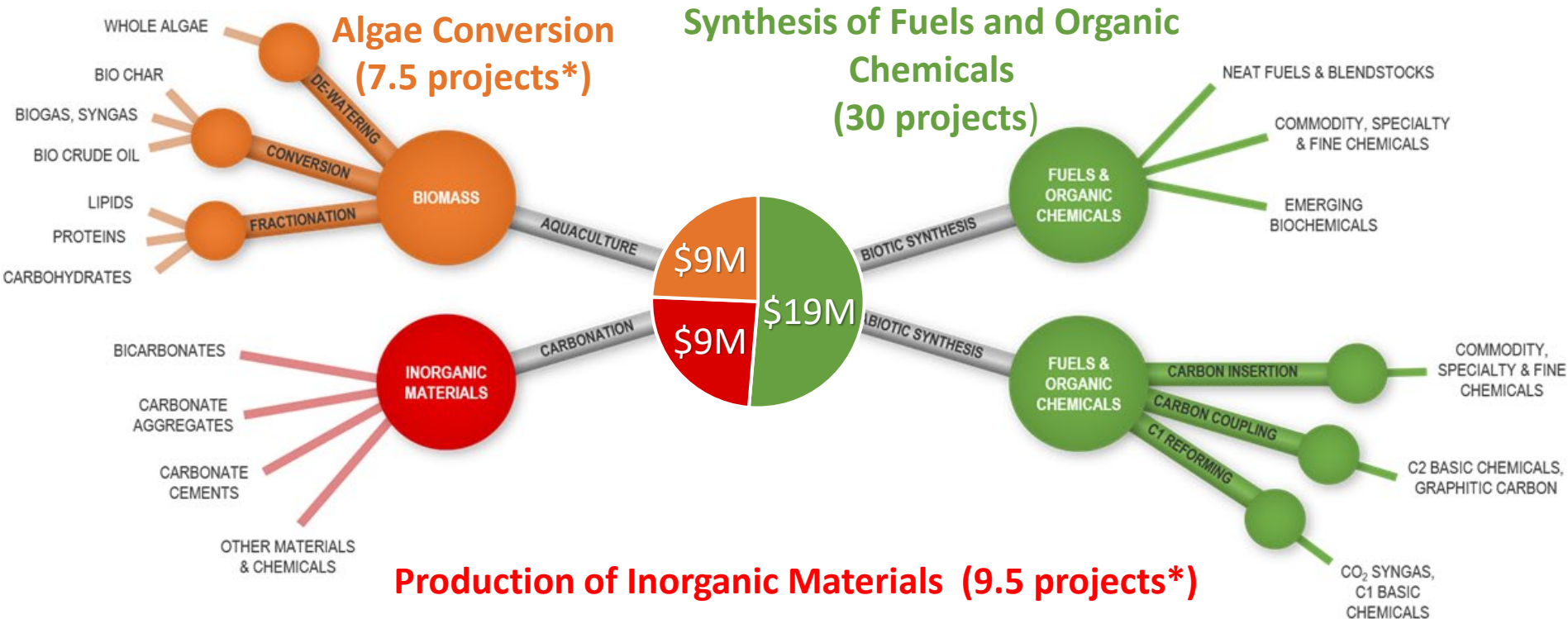
2020: \$40

2030: \$30

Source: NETL, Cost and Performance Baseline for Fossil Energy Plants, Revision 3, July 2015

Getting Additional Value from CO₂

Carbon Utilization R&D Program



*Some projects incorporate multiple conversion pathways

Mission: Develop technologies to recycle CO₂ into economy by transforming carbon waste streams into value-added products. Areas of research include, but are not limited to, catalytic conversion to chemicals and polymers; mineralization to building products; generation of solid carbon products; and algal conversion platforms designed to integrate into large CO₂ point sources.



Carbon Capture Can Help Enable a Hydrogen Economy

Hydrogen enables a number of clean energy and transportation platforms using hydrogen from fossil energy, including oil and gas – AND coal.

Steam methane reforming primary source of H₂
(~ 95% of global production).

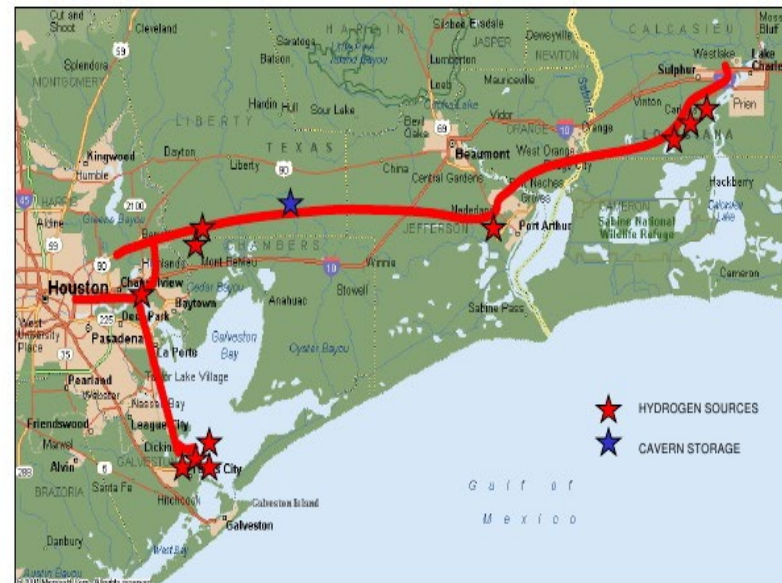
Hydrogen production from gas and coal with CCUS can reduce emissions to near zero at lowest cost.

Market opportunities:

- Transportation vehicles
- Clean energy
- Energy storage
- Clean products

R&D Opportunities:

- Materials embrittlement
- Autothermal and gasification
- Electrolysis, turbines, SOFC
- Hydrogen storage
- Conversion technologies
- Hybrid Systems



Cavern and Pipeline system connected to 11 out of 14 refineries

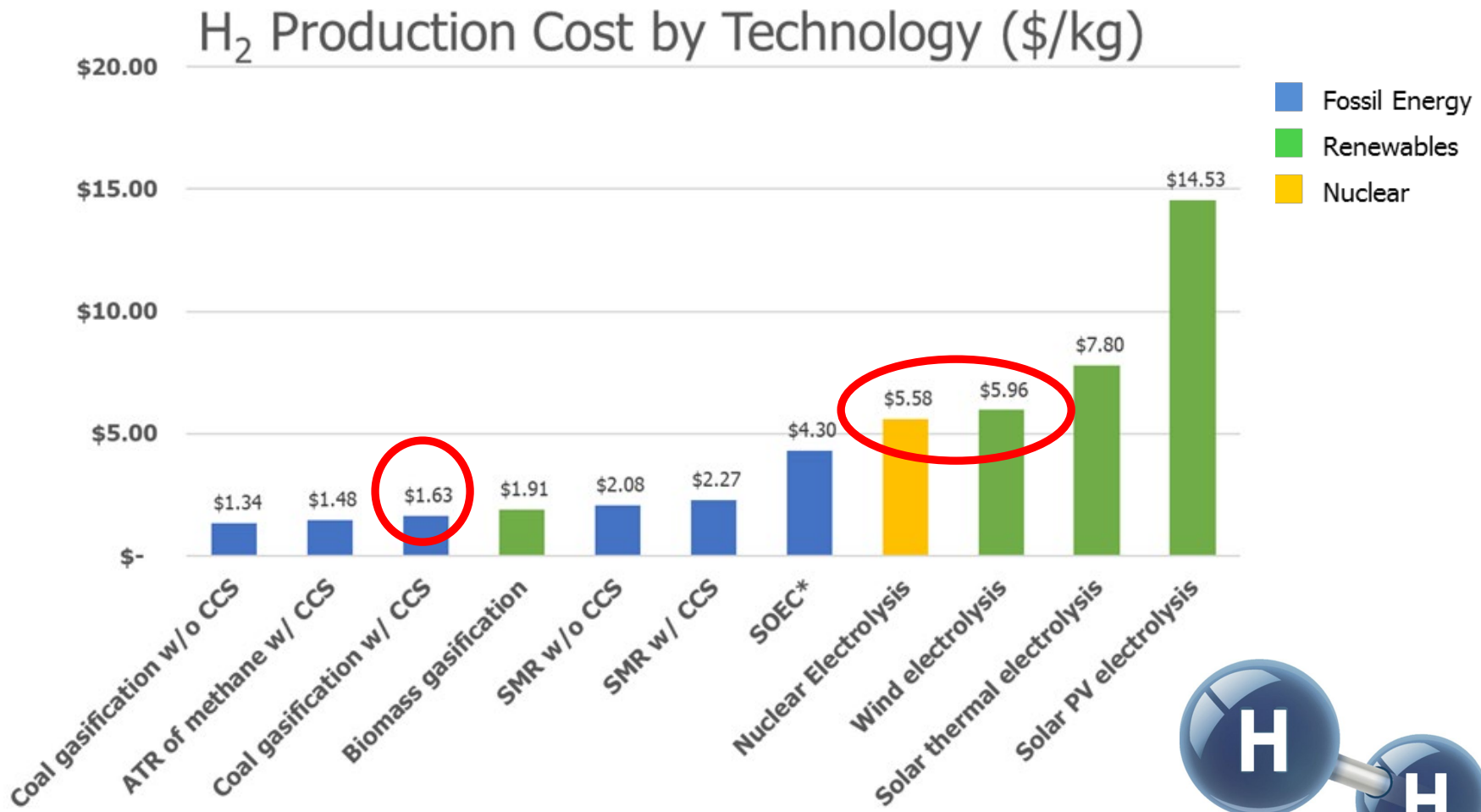
Praxair Canada Inc. – Calgary, Alberta, Canada

-4-



Cost of Hydrogen from Fossil Energy Sources

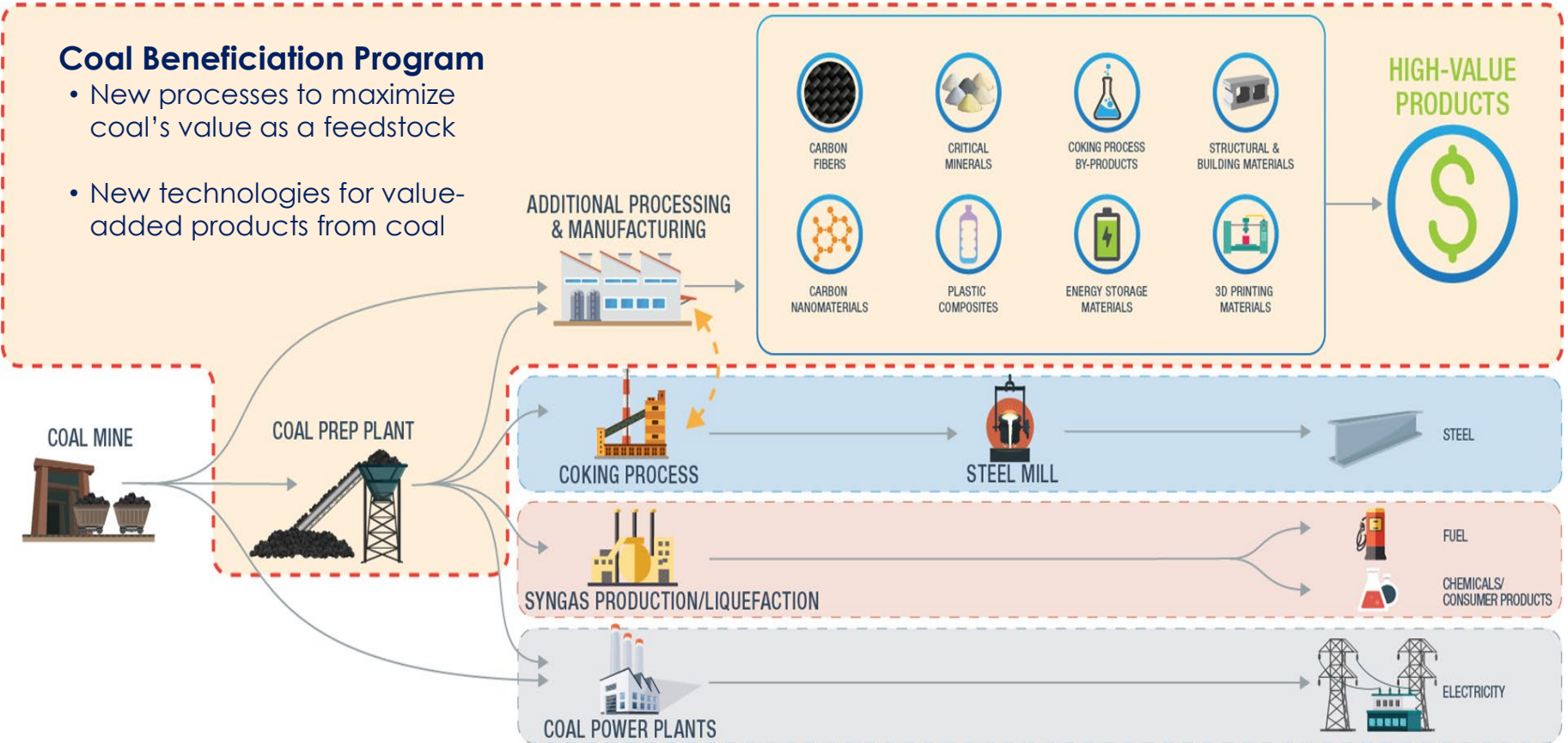
Fossil Energy is the lowest cost source of hydrogen, even with CCUS



Source: Solar Hydrogen Production, Chapter 3 – Hydrogen Production
* https://www.hydrogen.energy.gov/pdfs/16014_h2_production_cost_solid_oxide_electrolysis.pdf



Expanding the Coal Value Chain



Coal to Products – A Strong Future for Coal

Inherent carbon content of coal means it can be used as a feedstock to manufacture a wide range of products and materials

Current global market for coal-to-products is estimated to consume 300-400 million tons/year of coal

That market has the potential to consume another 300 million tons/year of coal

National Coal Council *Coal in a New Carbon Age*



Opportunity – A Paradigm Shift in the Construction Market

Composites Require Holistic Rethink of Manufacture

Carbon Buildings + Cloud-Delivered CAD-CAM for Everyone

Materially-Driven Environmental Agendas – Not Code Driven

More Upstream Jobs (Materials, CAD-CAM), Less Site Labor

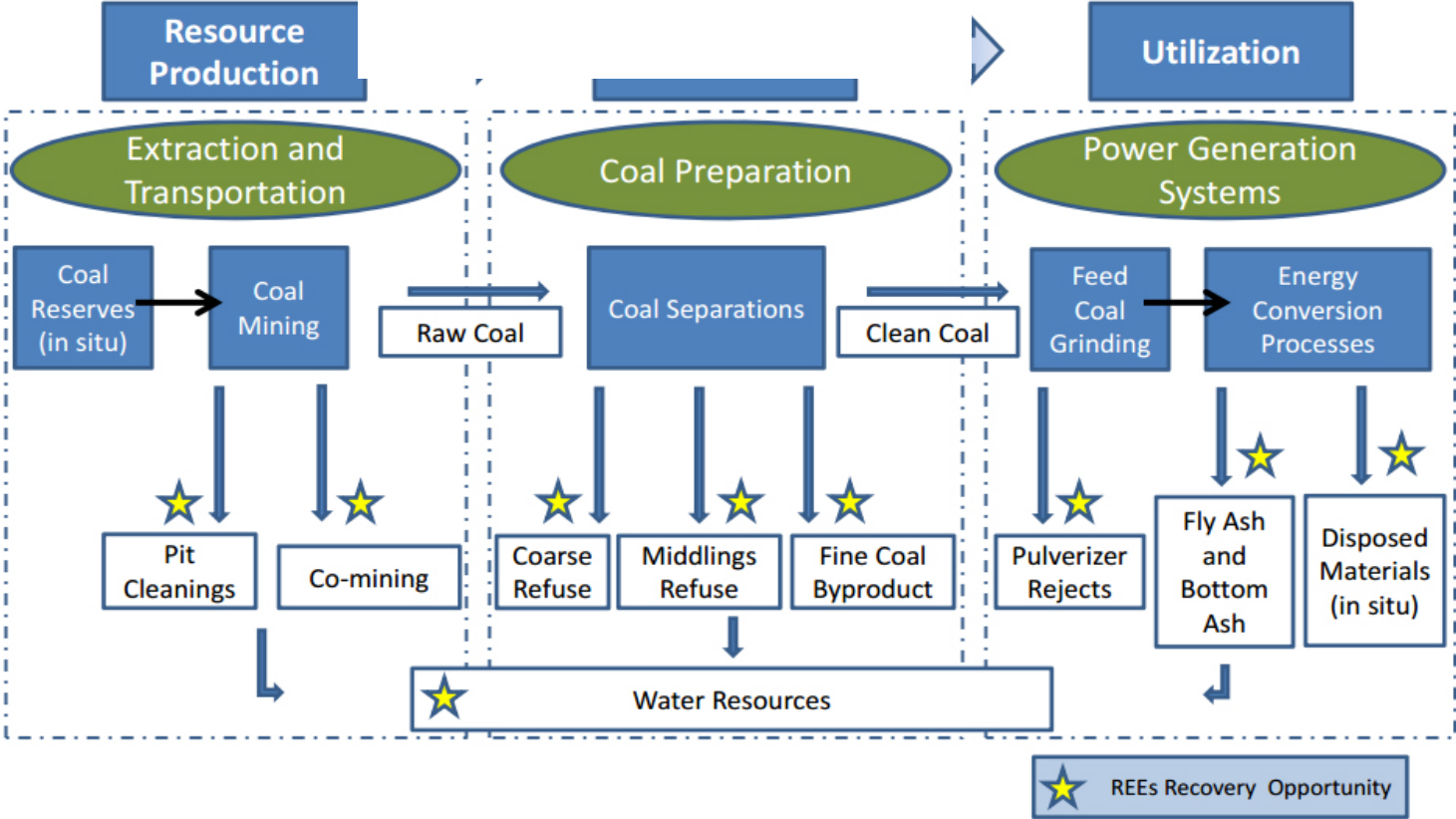
Global Building – 1 Million People Per Week Joining Urban Communities to 2050

Vast Potential Export Market



Rare Earth Elements from Coal and Coal Byproducts

Opportunities for REE Recovery Span the Coal Value Chain

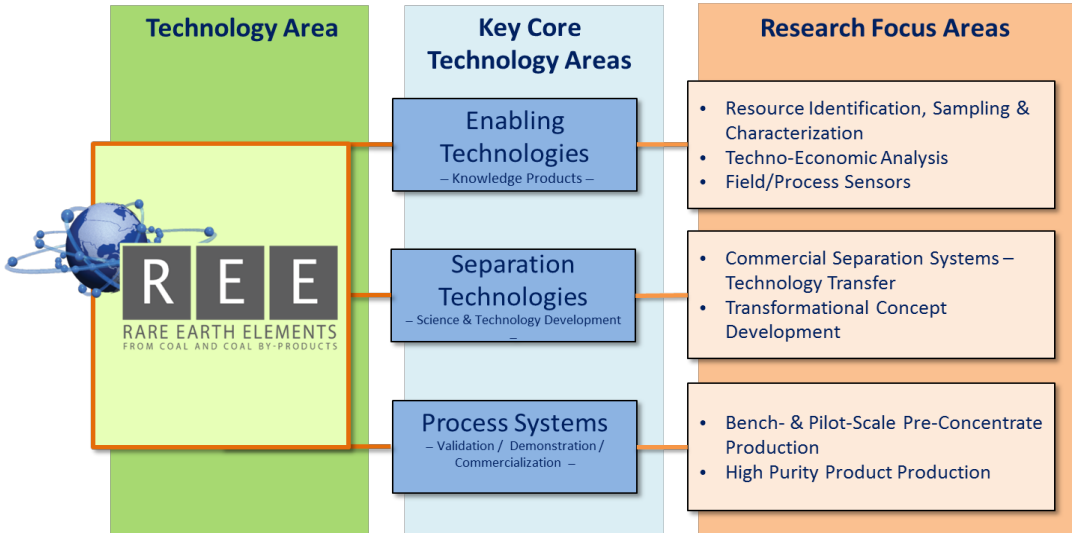


DOE Critical Minerals Efforts



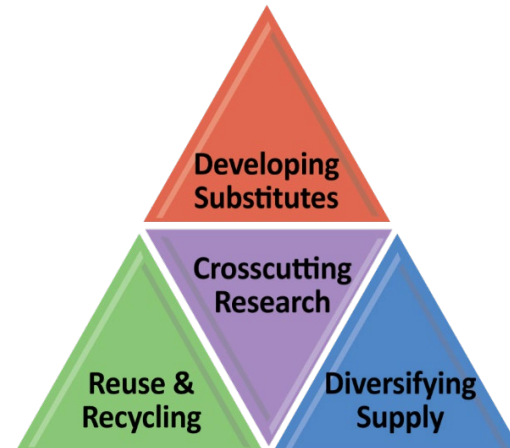
Office of Fossil Energy

Development of an economically competitive and sustainable domestic supply of rare earth elements (REEs) and critical materials (CMs) to assist in maintaining our Nation's economic growth and National Security



Critical Materials Institute
Office of Energy Efficiency and Renewable Energy

Eliminate materials criticality as an impediment to the commercialization of clean energy technologies for today and tomorrow

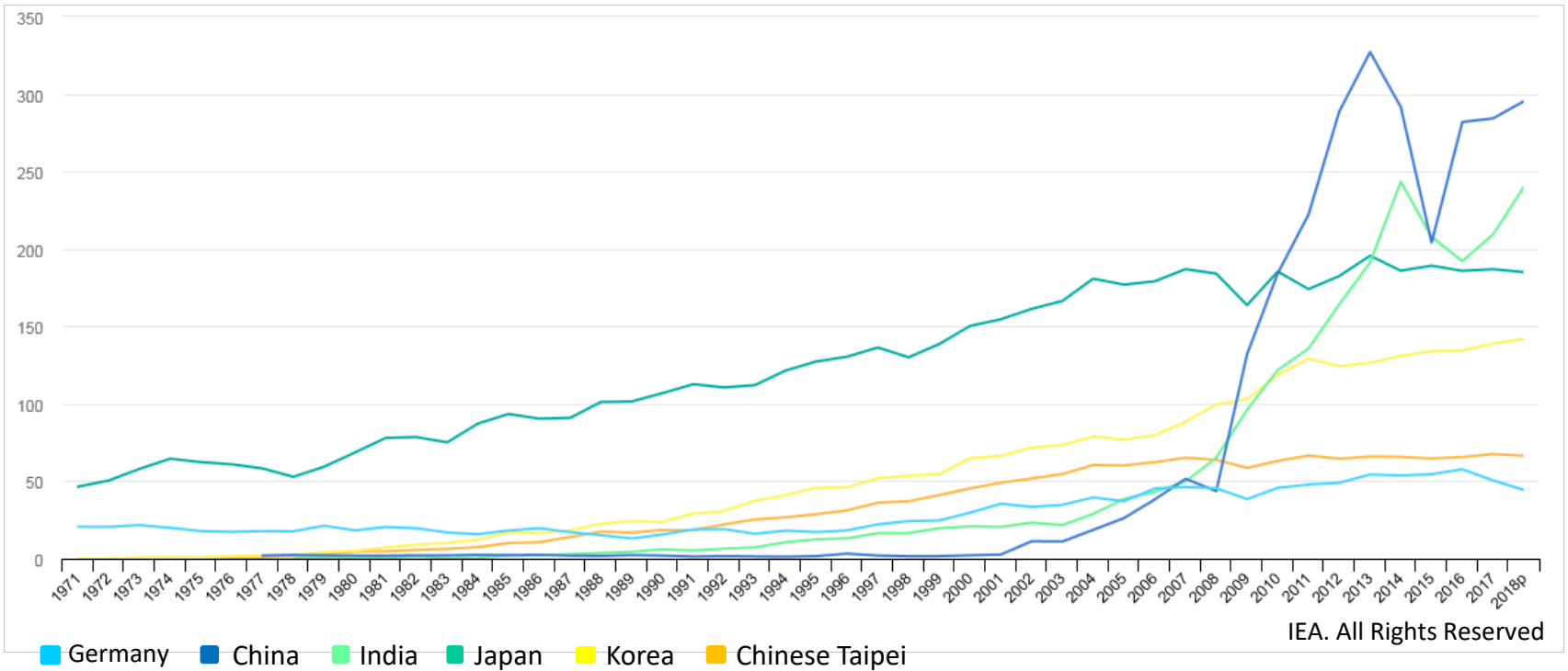


Global Coal Trade – Opportunities for U.S. Coal

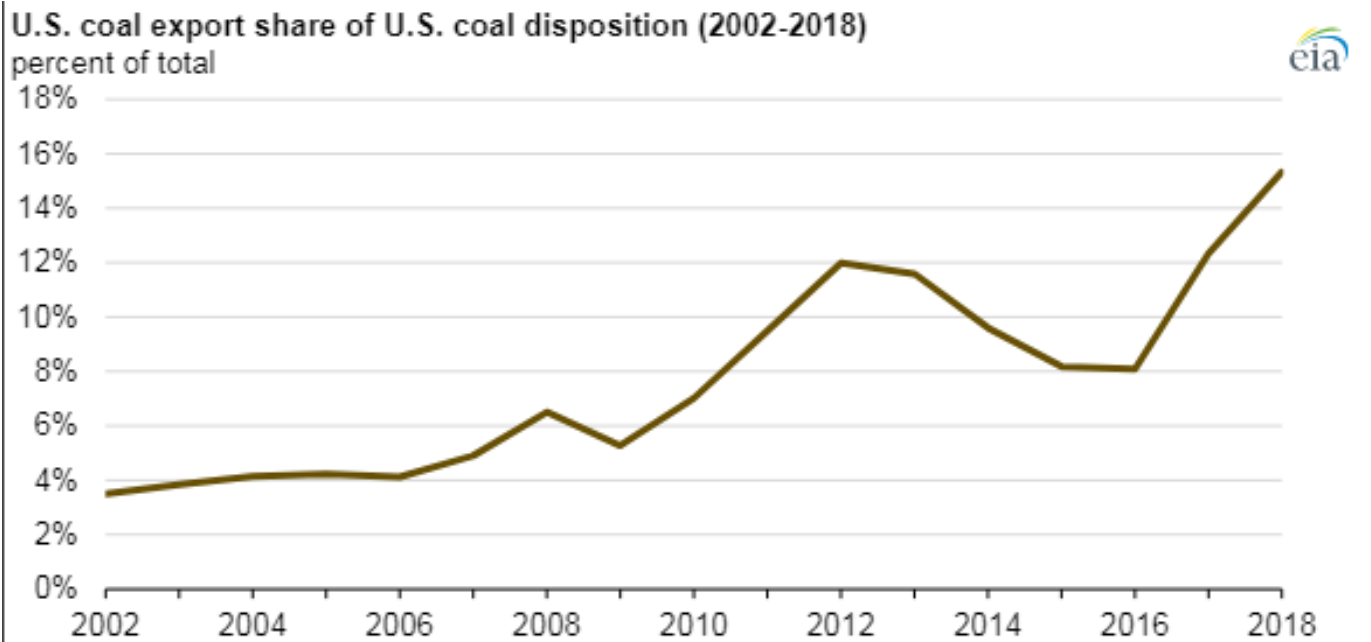


Global Coal Imports

Total coal imports by major importers, 1971-2018
Mt

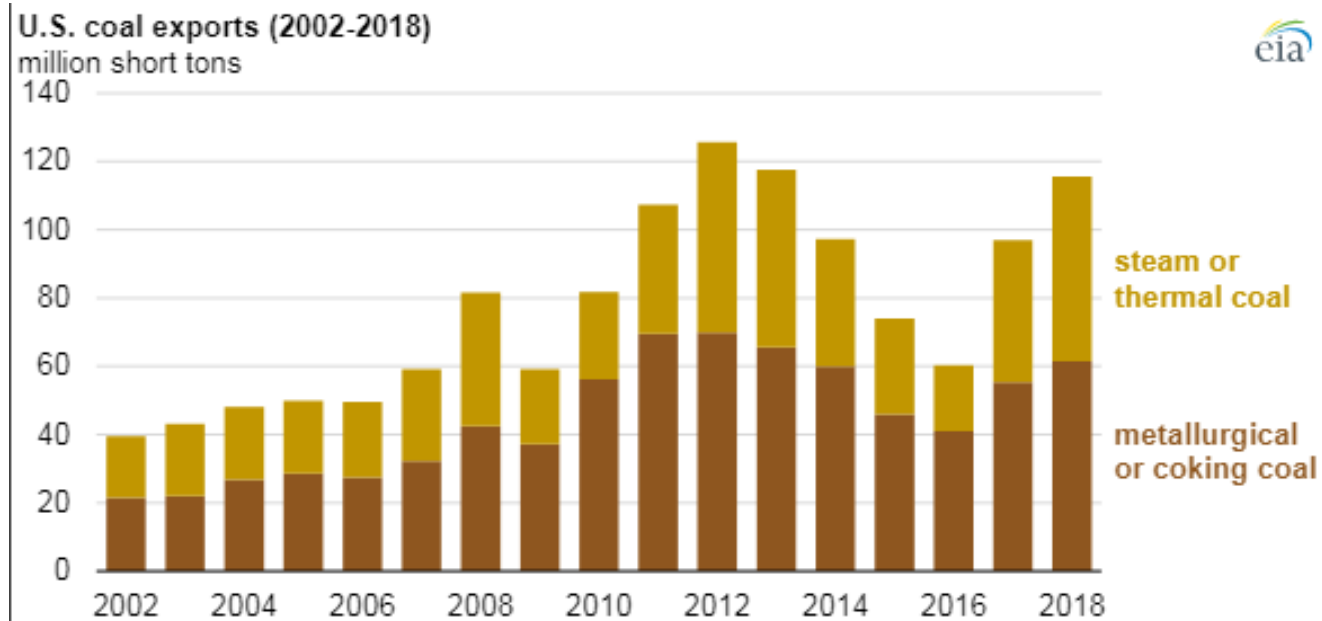


Exports – Increasing Share of U.S. Coal Disposition



Source: U.S. Energy Information Administration, Annual Coal Report, and the U.S. Department of Commerce, Census Bureau

Coal Exports – 116 MST in 2018



U.S. Energy Information Administration, Annual Coal Report, and the U.S. Department of Commerce, Census Bureau

For More Information



www.energy.gov/fe



<https://www.netl.doe.gov>



facebook.com/FossilEnergy



twitter.com/fossilenergygov