

A Grid in Transition: A look at Power Systems Regulations

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Florida Energy Systems Consortia, May 21, 2015

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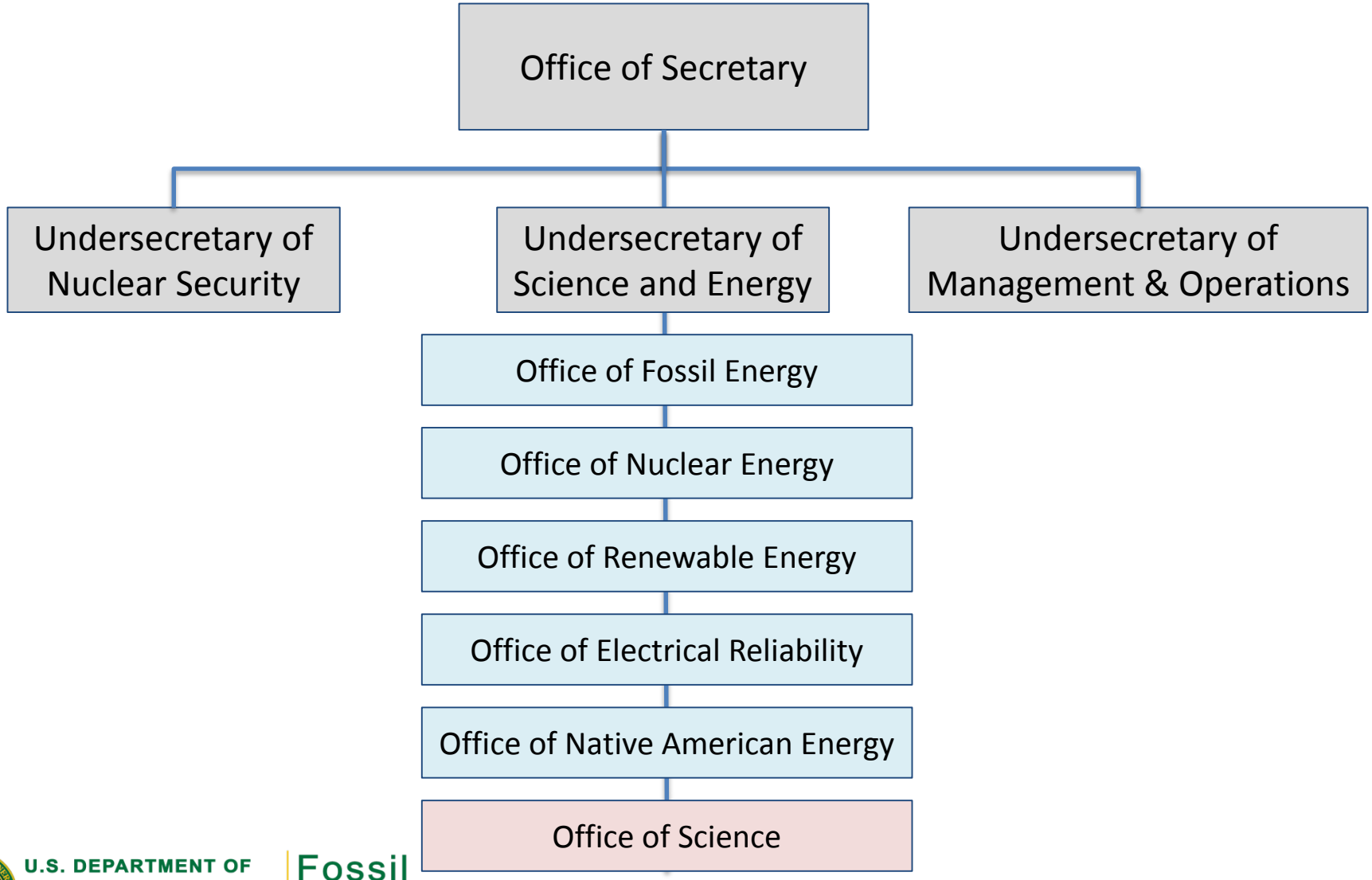
Overview:

- US Department of Energy Structure
- EPA Regulations Affecting the Power Industry:
  - Clean Power Plan
  - Carbon Storage Regulations
- Emissions and Generation Trends
- Coal's R&D Focus: Carbon Capture and Storage

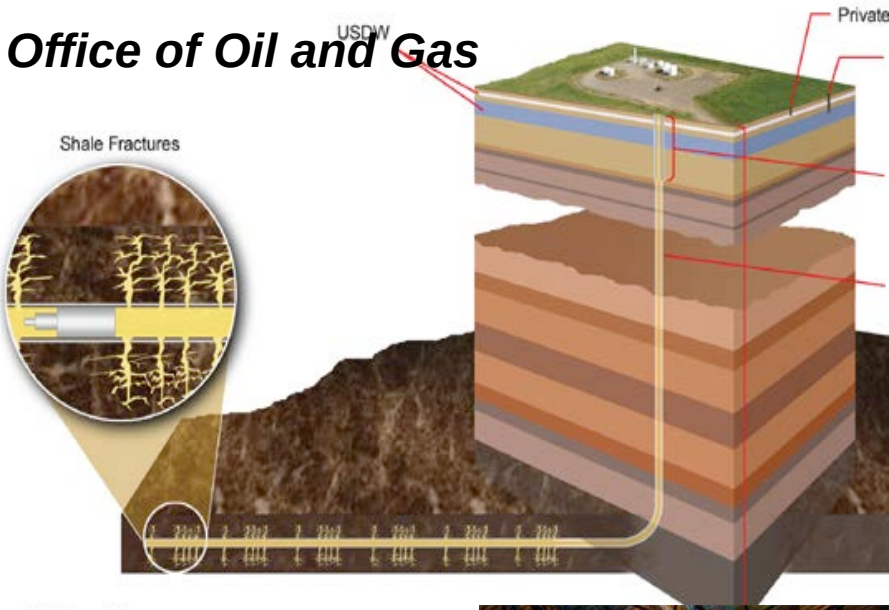
Department of Energy Organization



Office of Fossil Energy

Office of Clean Coal and Carbon Management

Office of Oil and Gas

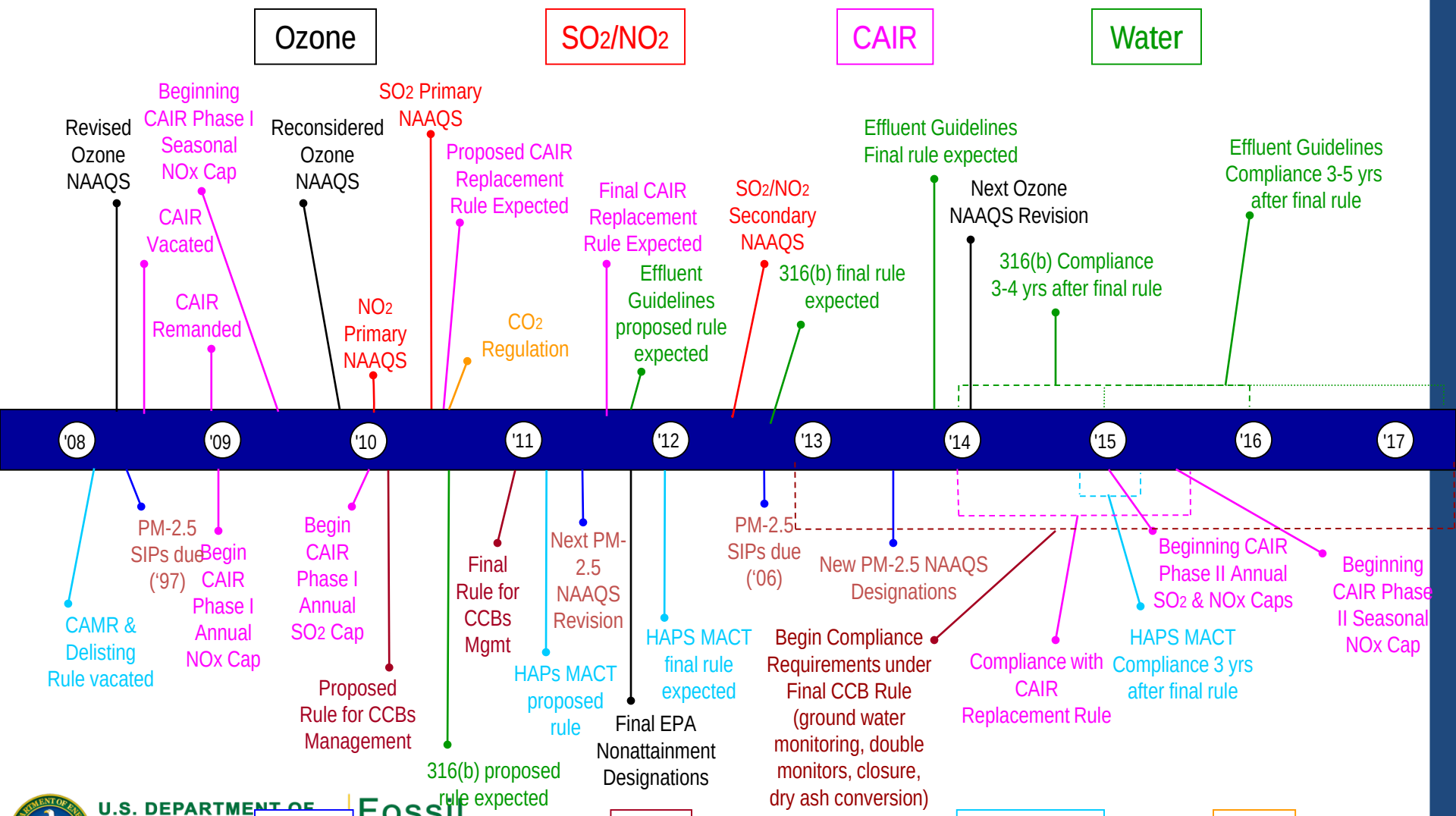


Strategic Petroleum Reserves

National Energy Technology Laboratory

Recent US. EPA Regulations: Power Sector

The EPA Regulatory Train Wreck: Regulatory Timeline for Coal-Fueled Power Plants



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PM2.5 | Ash | Hg/HAPS | CO2

Proposed 111(b) New Source Performance Standard: New Coal and Gas Fired Power Plants

Coal-Fired Units: less than 1,100 lbs CO_2/MWh [~500 gCO_2 / kWh]

Reference: New Super Critical: 1,800-2,000 lbs CO_2/MWh [800-900 gCO_2 / kWh]

Coal may comply with ~ 40% capture

NGCC: 1,000 lbs CO_2/MWh [453 gCO_2 / kWh]
Gas CT: 1,100 lbs CO_2/MWh [500 gCO_2 / kWh]

- Compliance is on a 12 month rolling basis
- Captured CO_2 may be sent for geologic storage
- EOR may be used with appropriate reporting (Subpart RR)

Timeline:
Proposed Regulation: November, 2013
Final Regulation expected Summer, 2015

Note: 111(b) must be final before 111(d) is final!

EPA
United States
Environmental Protection
Agency

CLEAN POWER PLAN

Reducing Carbon Pollution From Existing Power Plants

2014 Proposal

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This Proposal Deals With the Largest Source of GHG Emissions in the U.S.

U.S. GREENHOUSE GAS POLLUTION INCLUDES:

CARBON DIOXIDE (CO_2) 82%

Enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement).

FLUORINATED GASES 3%

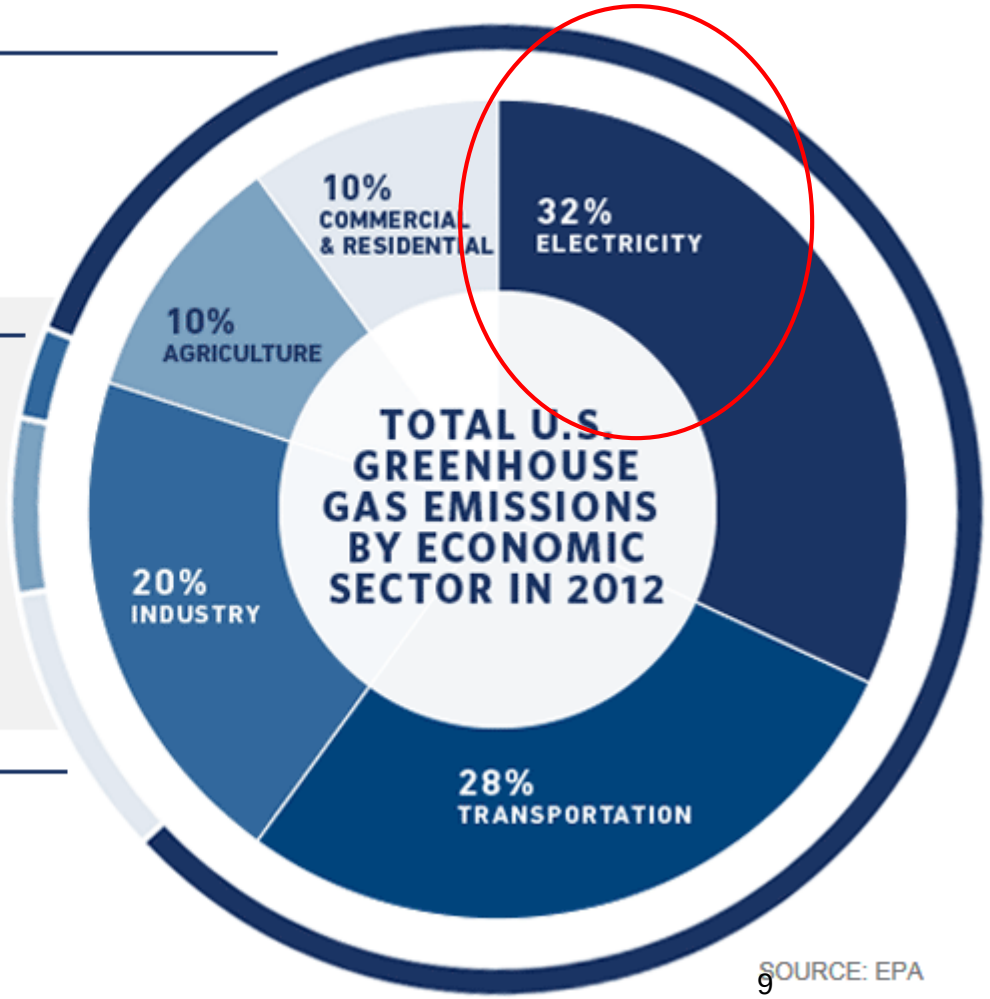
Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

NITROUS OXIDE (N_2O) 6%

Emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

METHANE (CH_4) 9%

Emitted during the production and transport of coal, natural gas, and oil as well as from landfills.



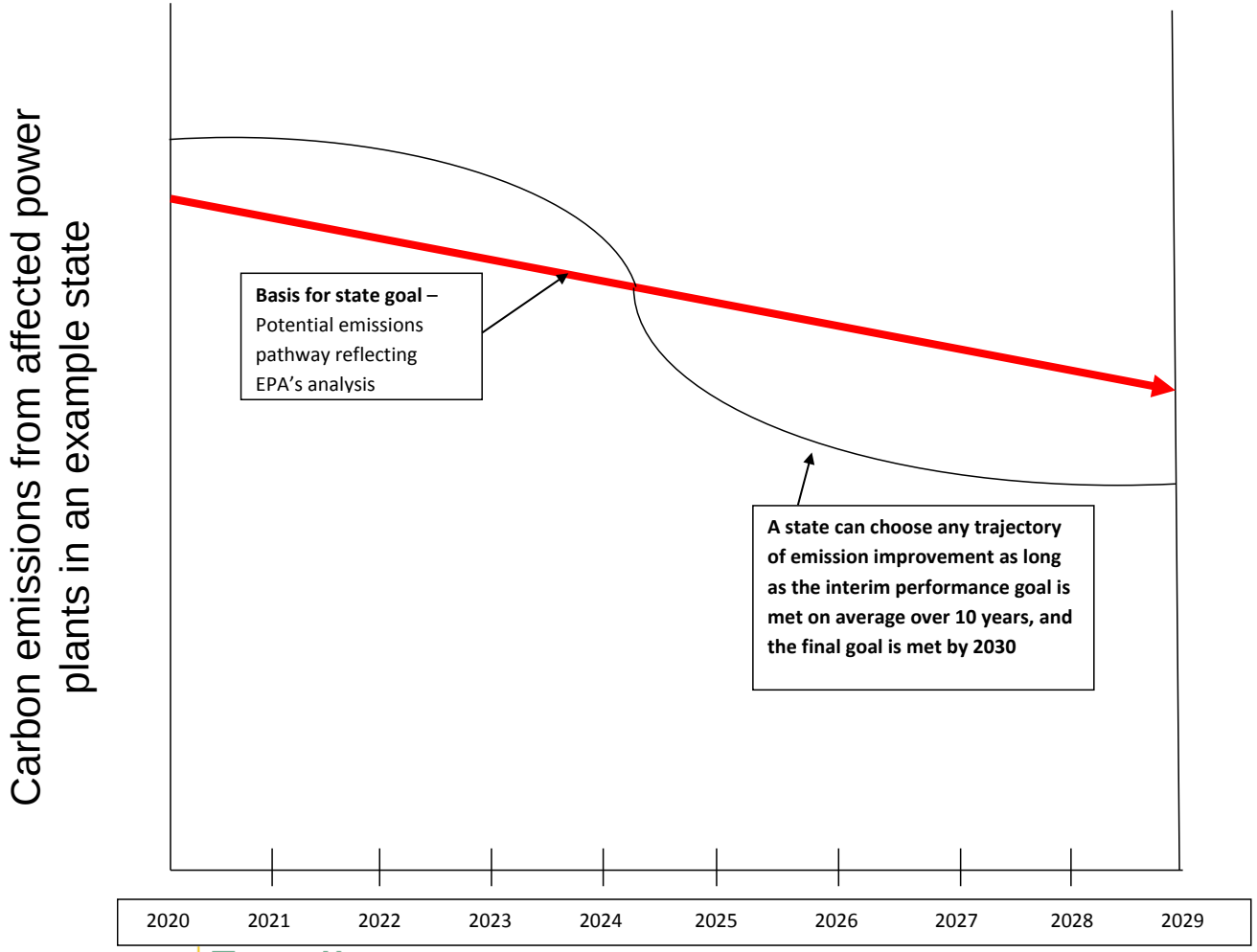
SOURCE: EPA

Clean Power Plan: The Building Blocks

Building Block	Strategy EPA Used to Calculate the State Goal	Maximum Flexibility: Examples of State Compliance Measures
1. Make fossil fuel-fired power plants more efficient	Efficiency Improvements	Efficiency improvements Co-firing or switching to natural gas Coal retirements Retrofit CCS (e.g.,WA Parish in Texas)
2. Use lower-emitting power sources more	Dispatch changes to existing natural gas combined cycle (CC)	Dispatch changes to existing natural gas CC
3. Build more zero/low-emitting energy sources	Renewable Energy Certain Nuclear	New NGCC Renewables Nuclear (new and up-rates) New coal with CCS
4. Use electricity more efficiently	Demand-side energy efficiency programs	Demand-side energy efficiency programs Transmission efficiency improvements Energy storage

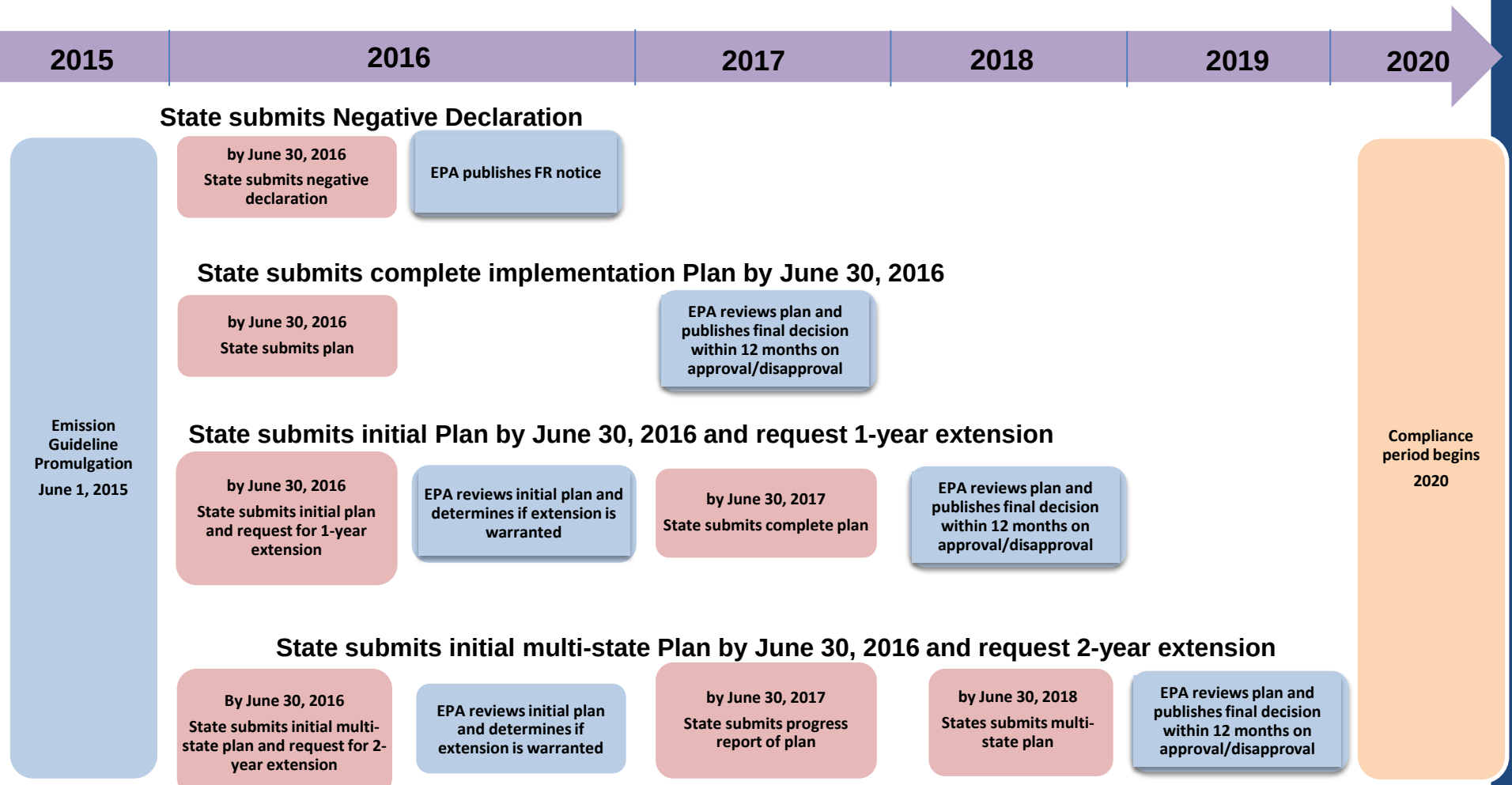
States Have Flexibility

As an example, states could do less in the early years, and more in the later years, as long as on average it meets the goal

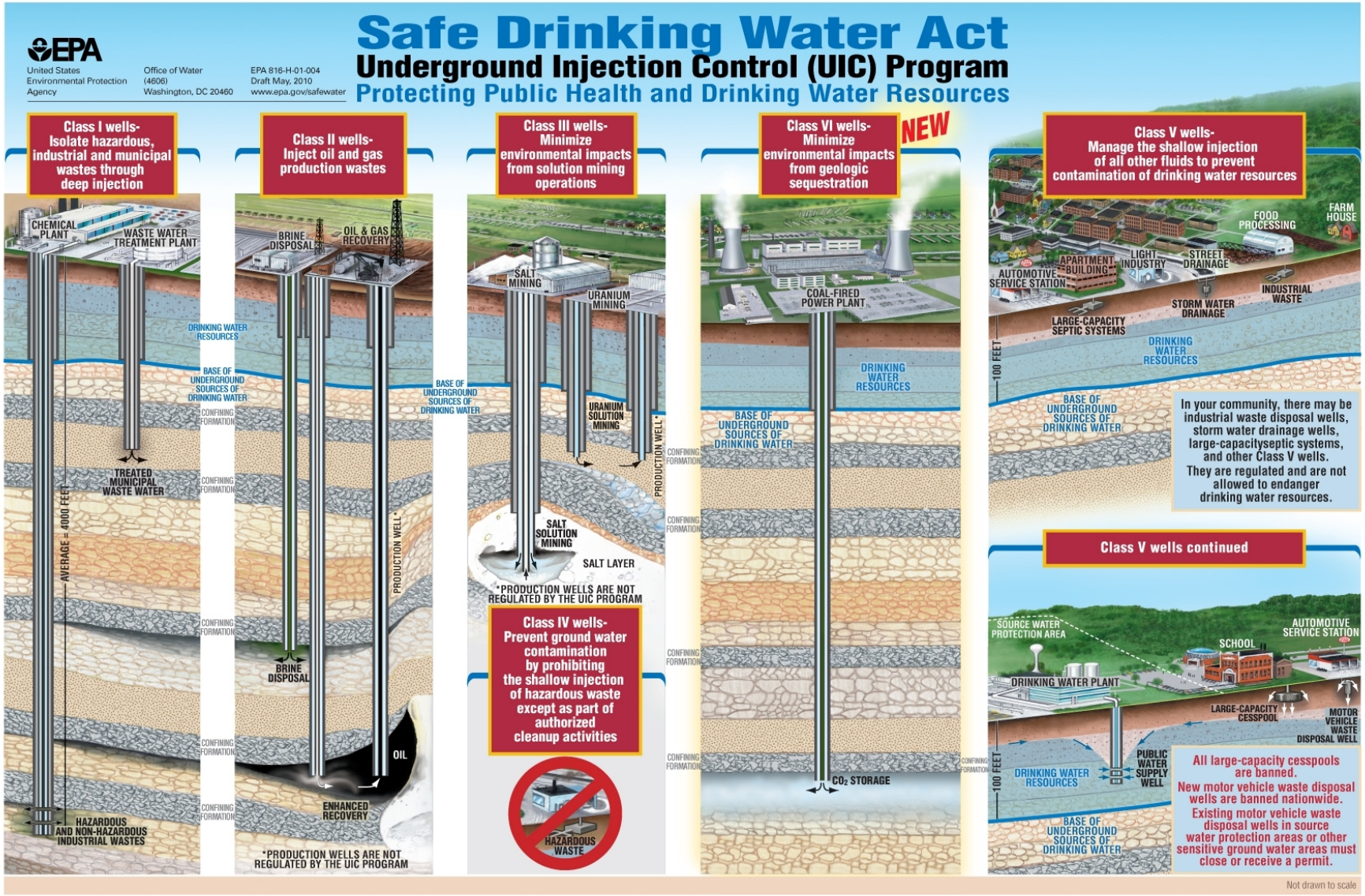


Timing of Power Plant Emission Reductions

Proposed Implementation Timeline



Underground Injection Control (UIC) Well Classes



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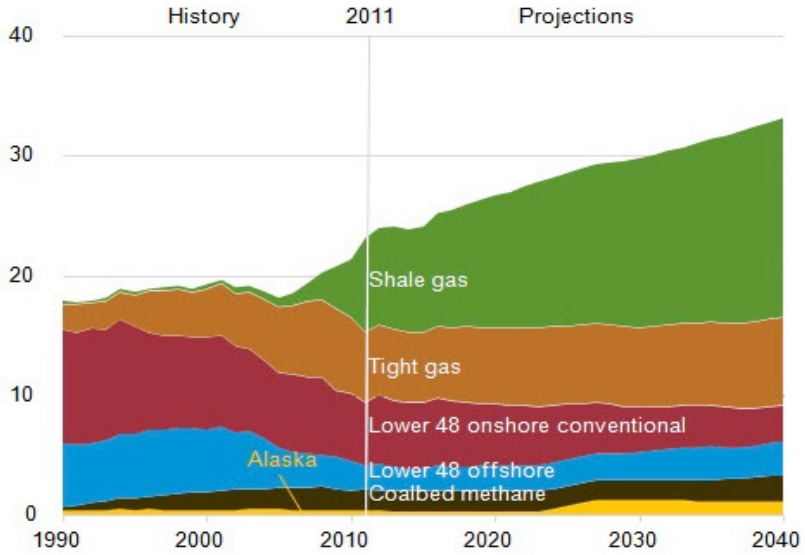
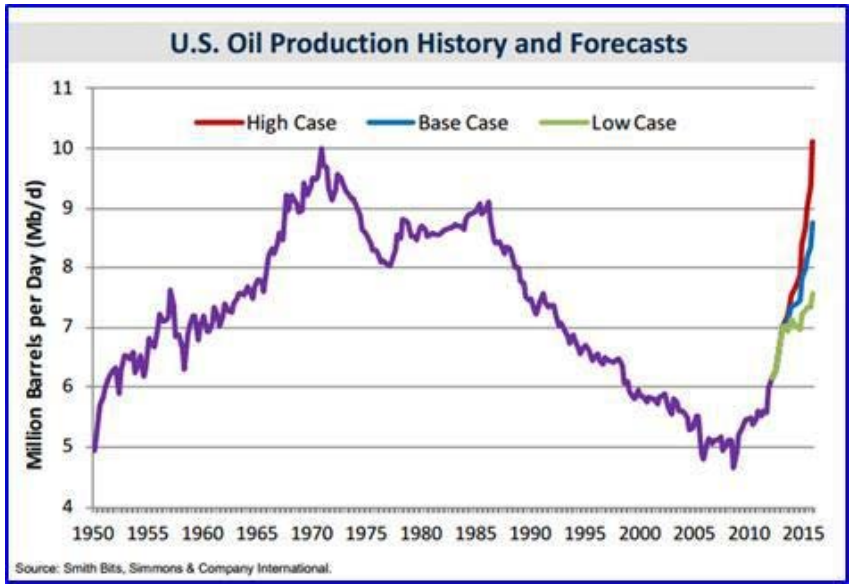
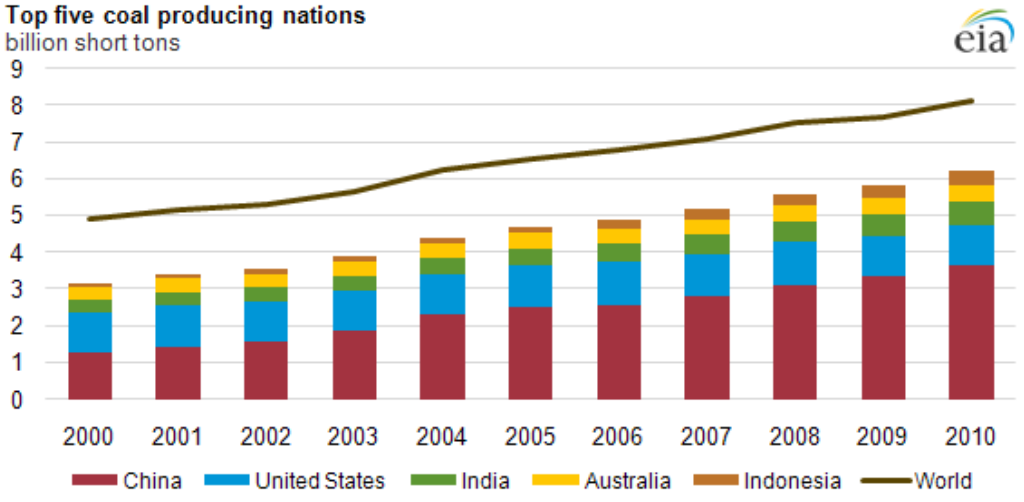
Energy Perspectives:
Future Electricity and Emission Trends

This is a time of fossil energy abundance

Once in a generation opportunity to build







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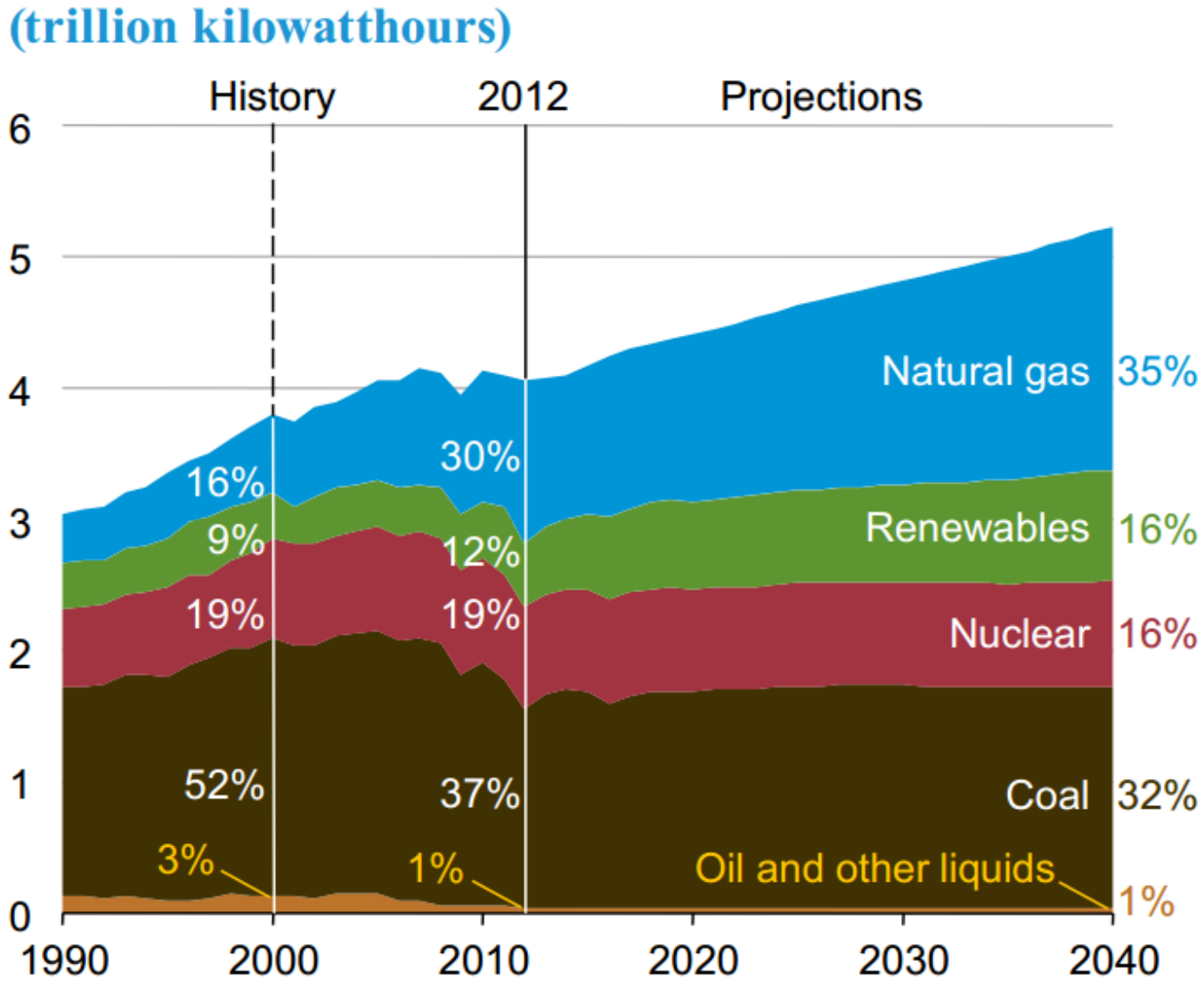
Annual Energy Outlook 2014: Electricity Projections to 2040 (Reference Case)



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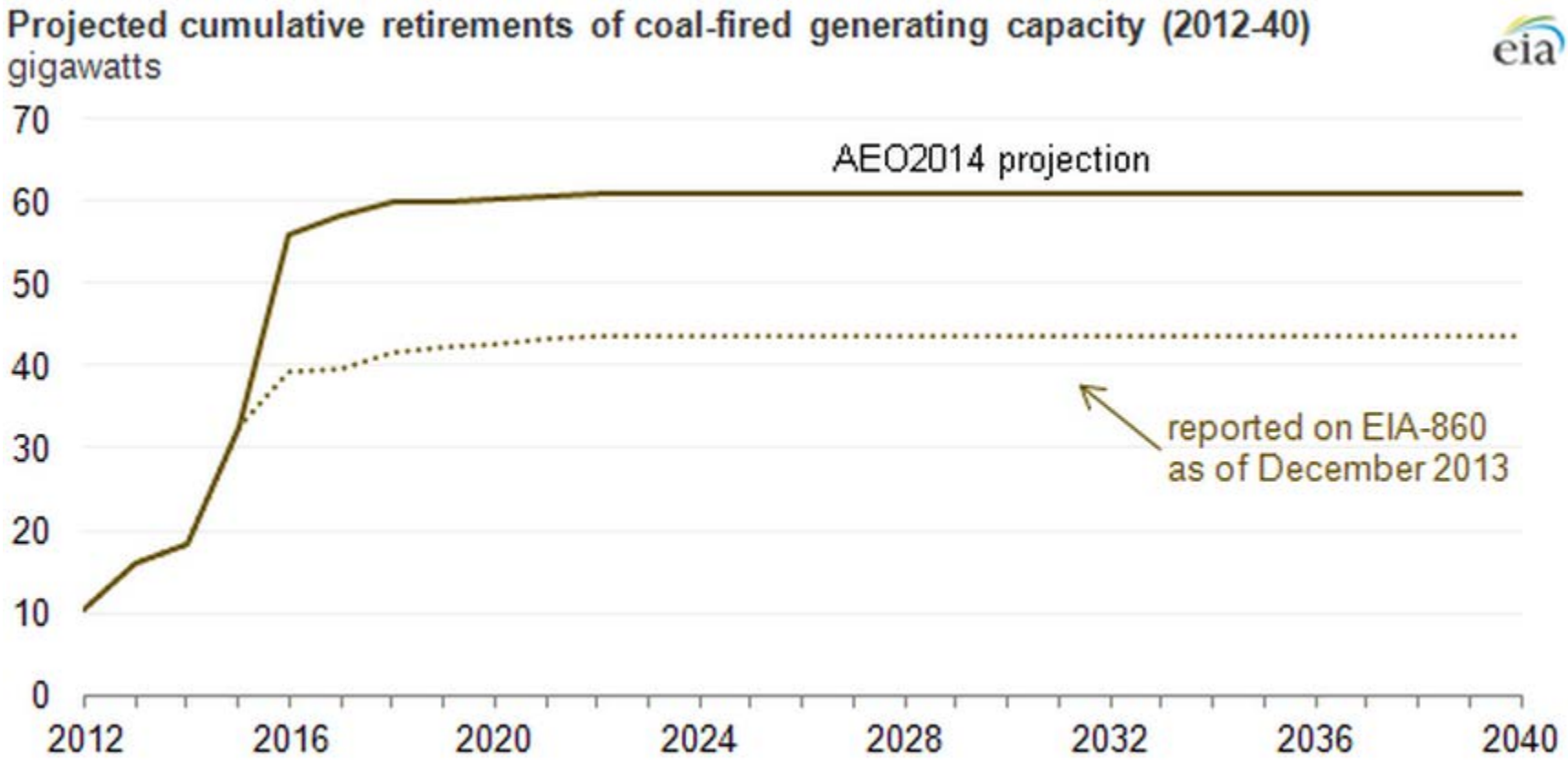
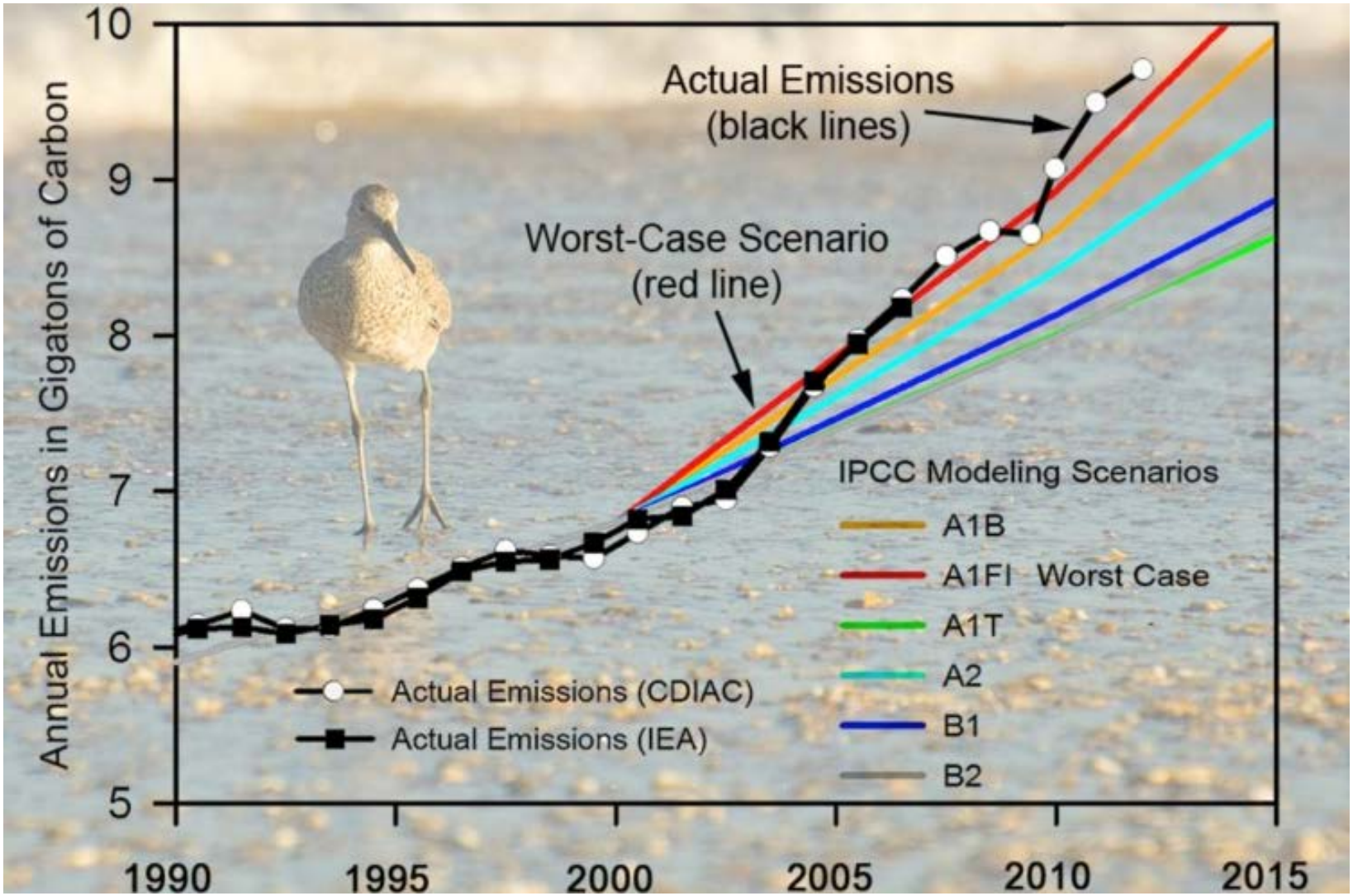
Annual Energy Outlook 2014: ~60 GW of retirements between Reported and Modeled



Source: U.S. Energy Information Administration, Annual Energy Outlook 2014 Reference Case and Annual Electric Generator Report (Form EIA-860, final 2012 data)

More than 40 Gtons /y



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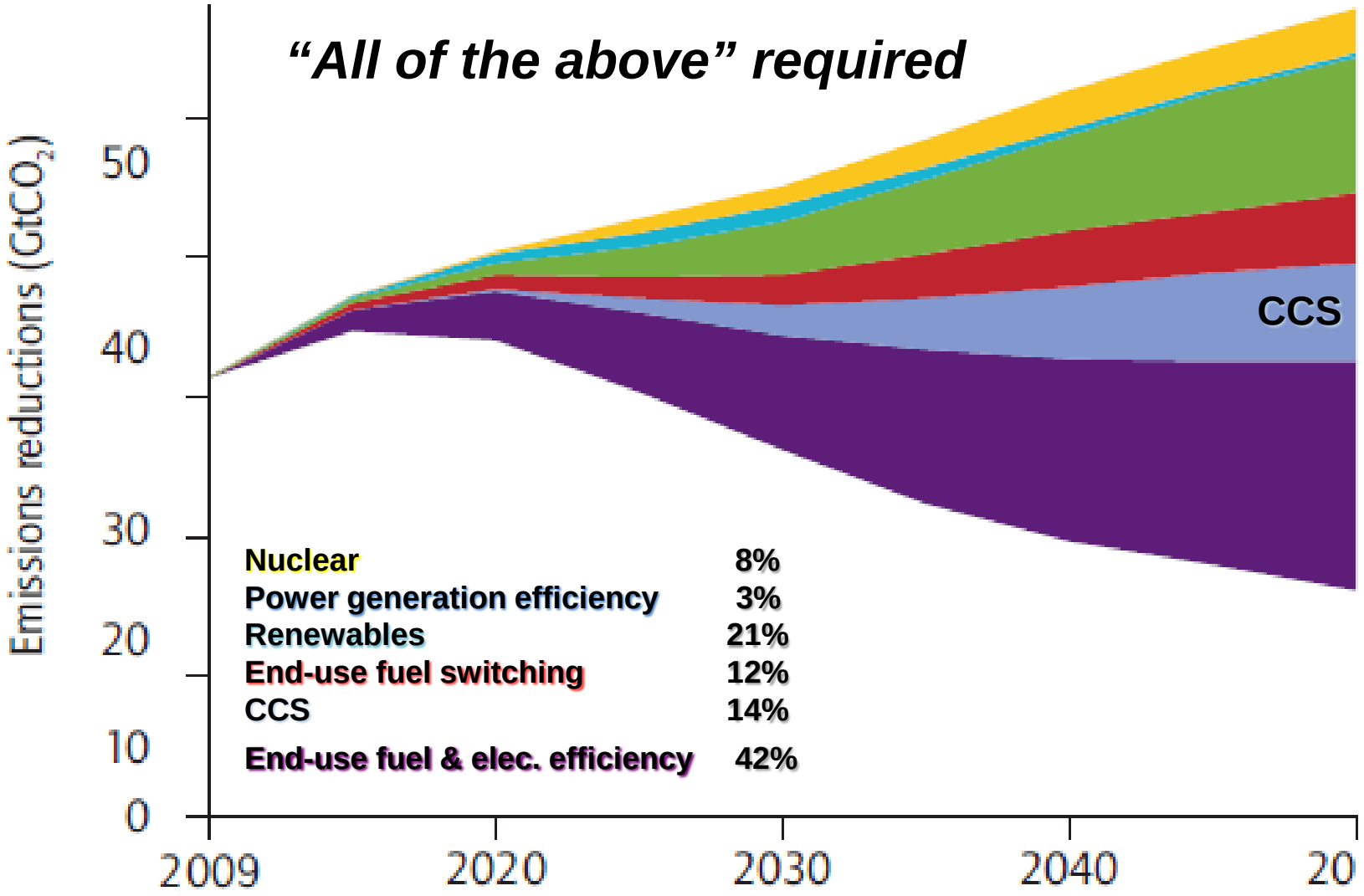
CCS technology remains critically important:



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Carbon Capture and Storage

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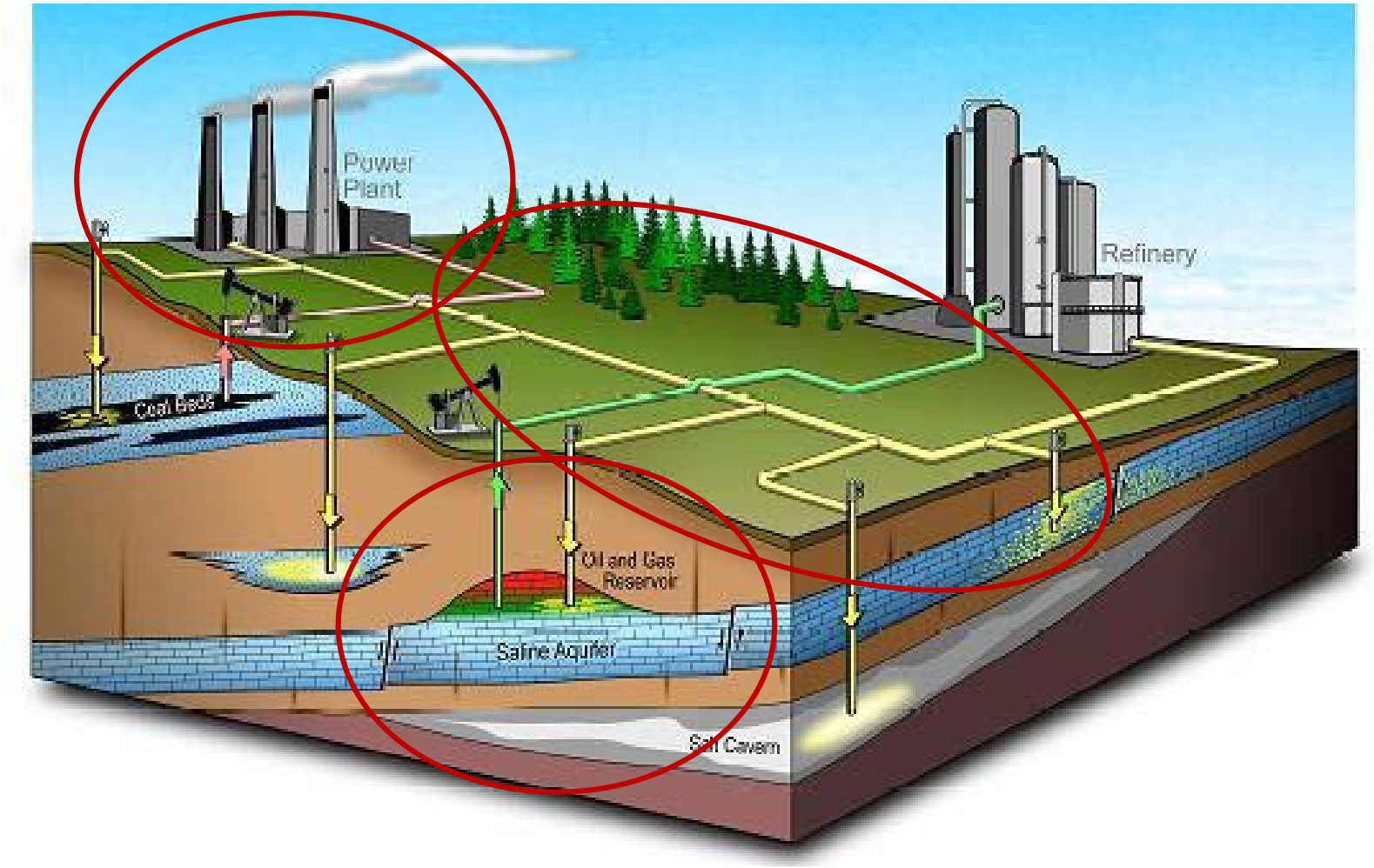
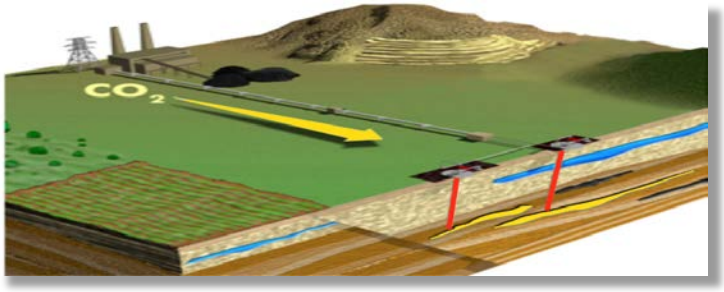


Office of Clean Coal: Program Summary

CO_2 Capture and Compression

Cost effective capture for new and existing plants

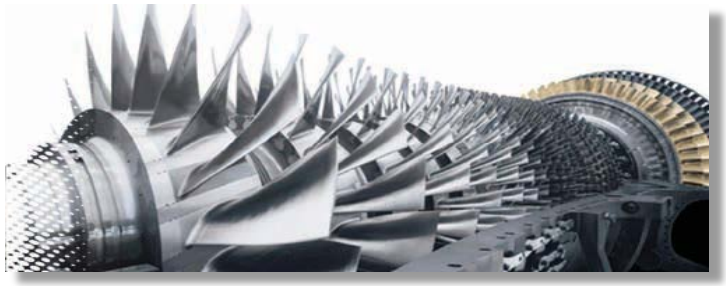
Major Goals: 2016: complete 2nd gen field tests (~1.0 MW scale)
2020: complete 2nd gen pilot tests (10 to 25 MW)
2025: complete transformational tech. field tests (~ 1.0 MW)



CO_2 Storage

Safe, permanent storage of CO_2 from power and industry

Major Goals: 2020: technologies and tools available to measure and account for 99% of injected CO_2
2020: CCS best practices and protocols completed based upon RCSP Phase III activities



Advanced Energy Systems

Gasification, Adv Turbines, Adv Combustion, CBTL, and fuel cells

Major Goals: 2016: Complete Warm Gas Cleanup demo.
2025: 20-30% Reduction in Combined Cycle Capital Cost (2nd gen)
2025: Advanced combustion ready for pilot scale operation

Cross-Cutting Research

Crosscutting technology development program

Major Goals: 2016: advance 2nd gen materials, sensors, modeling technologies to applied programs
2020: develop distributed communication sensor networks (transformational tech.)

Regional Carbon Sequestration Partnerships

Creating Infrastructure for Wide Scale Deployment

Representing:
- **>350 Organizations**
- **41 States**
- **4 Canadian Provinces**
- **3 Indian Nations**
- **34% cost share**

Characterization Phase

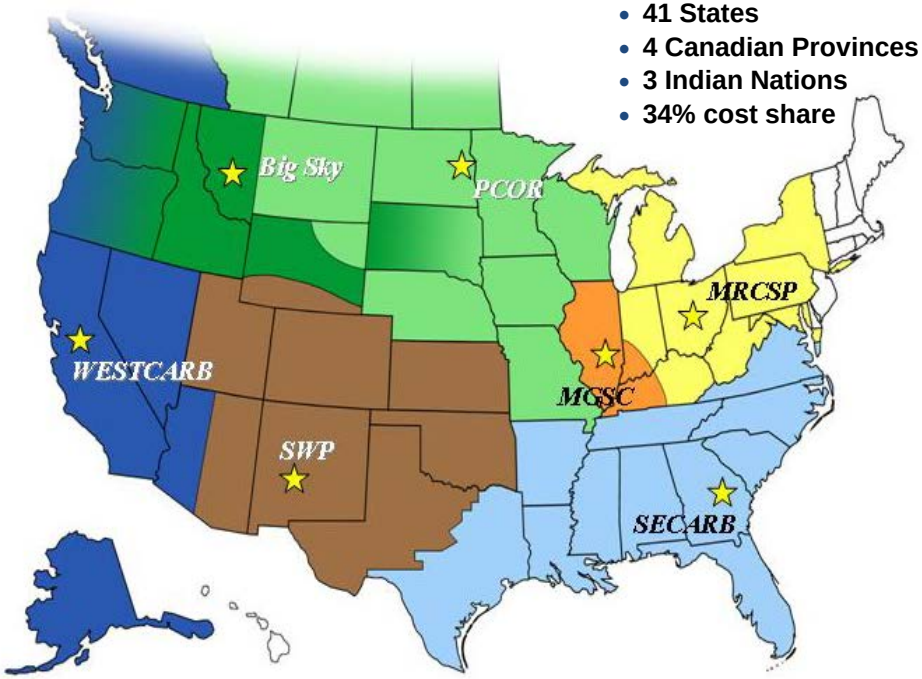
- 24 months (2003-2005)

Validation Phase

- 4 years (2005 - 2009)
- 7 Partnerships (41 states)
- 23 Geologic field validation tests

Deployment Phase

- 10 years (2008-2017)
- Several large injection tests in different geology



The Plains CO_2 Reduction Partnership PCOR Partnership

BIG SKY CARBON SEQUESTRATION PARTNERSHIP

West Coast Regional Carbon Sequestration Partnership westcarb.org

MGSC

MRCSP Midwest Regional Carbon Sequestration Partnership

SWP Southwest Partnership CO_2 Sequestration

Southeast Regional Carbon Sequestration Partnership

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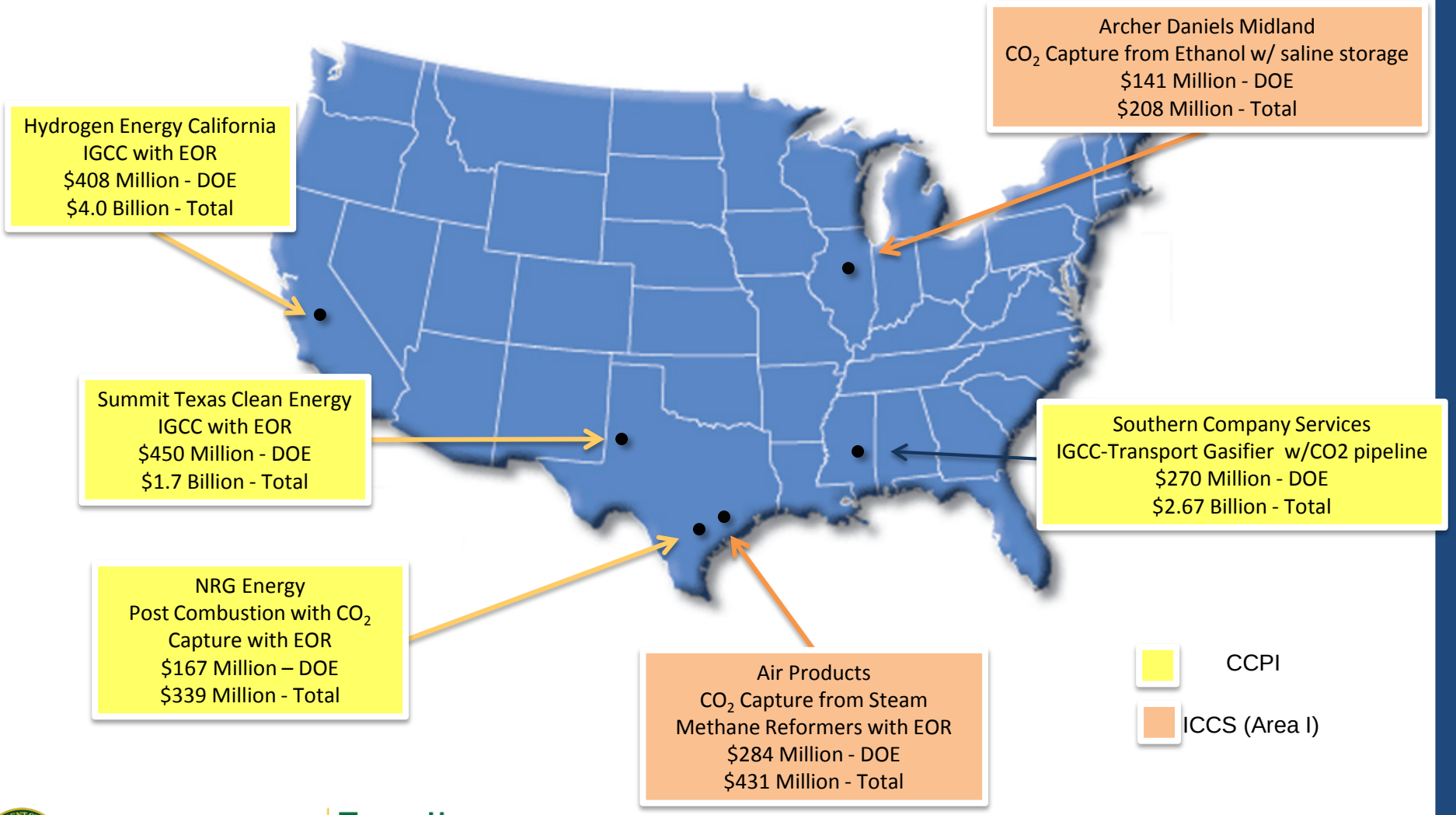
DOE CCUS Demonstration Projects

Focus – Large-scale commercial demonstration of CCUS integrated with coal power generation and industrial sources.



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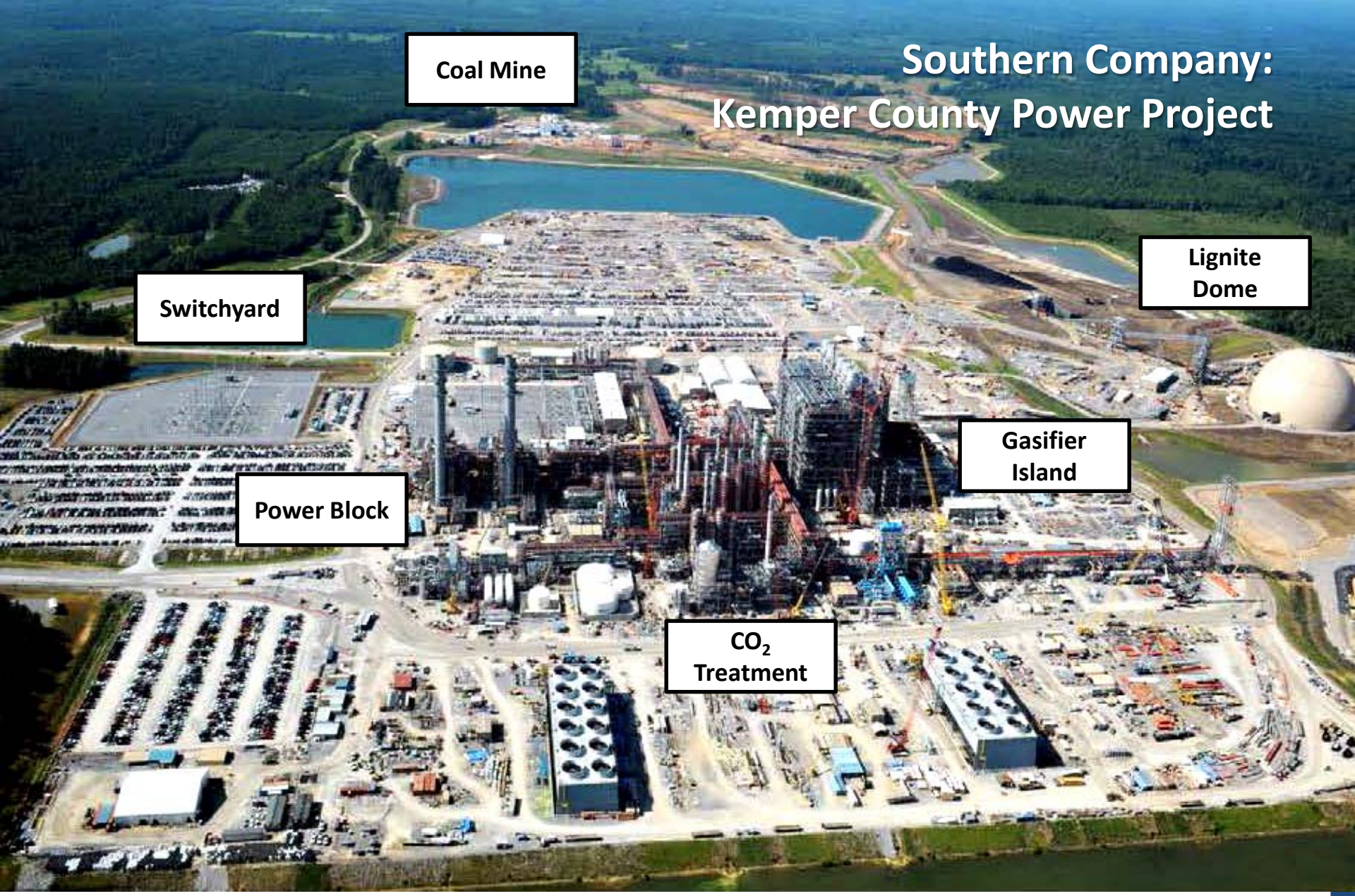

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Power to the Grid: 2014 Gasifiers Starting Up

W.A. Parrish, TX
NRG/PetraNova project

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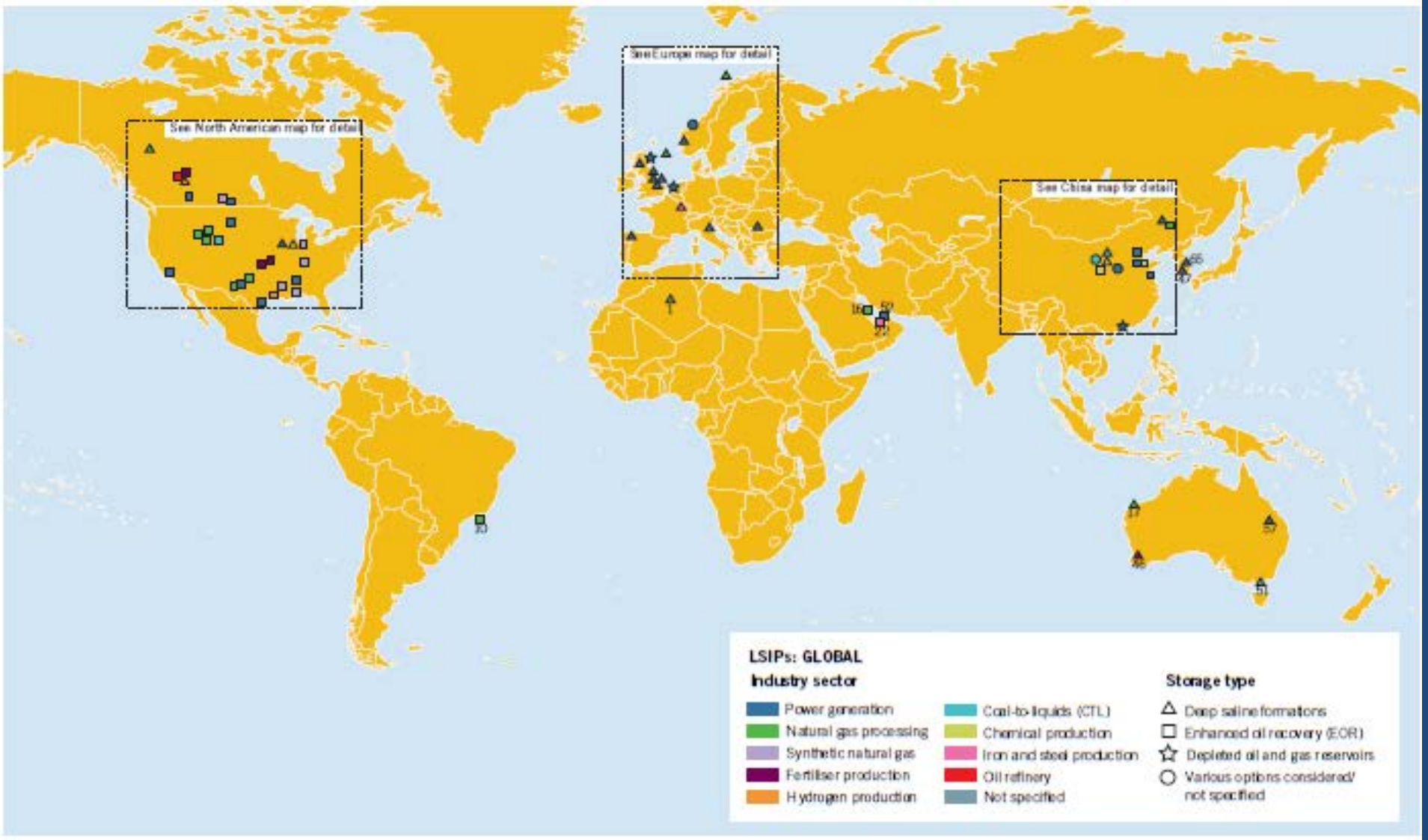
Broke Ground Sept. 5th

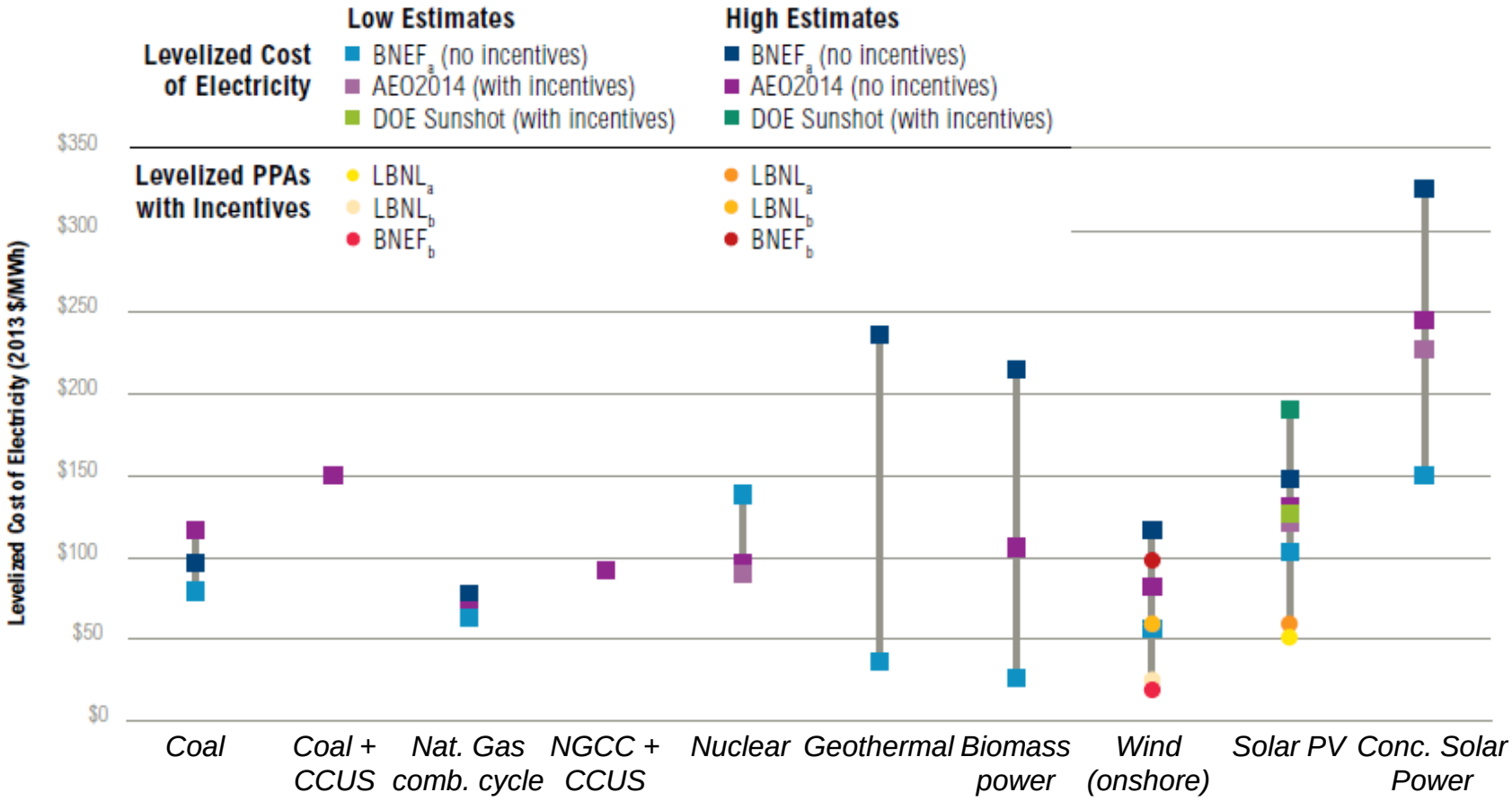
International Community Has Committed a Lot of Funding for Large CCS Demonstration Projects



Global CCS Institute, Global Status of CCS 2013 Report, http://cdn.globalccsinstitute.com/sites/default/files/publications/116211/global-status-ccs-2013.pdf

Cost, policy, and parity

Levelized cost of electricity ($/MWh) for new generation sources and levelized power purchase agreement prices for recent wind and solar projects



WRI, Oct. 2014

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Summary:

- EPA Regulations causing major investment changes in the Electricity Sector
- Natural Gas abundance creates a fuel “bridge”
- Emissions remain high - much work needs to occur!

- US: Strong regulatory basis for CCS
- New regulations providing a policy push
- R&D and incentives will provide a technology pull

For Additional Information

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