



U.S. Carbon Capture and Storage Program An International Approach

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Much has changed in the last four years



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	Dec 2011	Dec 2014
CCS large-scale demonstrations	0	4 (1 Operational)
Nuclear construction	1	5
Solar (TWh)	1.3	>8
Geothermal (TWh)	15	17+
Hydro (TWh)	260	230
Wind (TWh)	95	175+



Much has changed in the last four years



- EPA draft rules 111 (b) and 111 (d)

President's Climate Action Plan: Three overarching themes

Mitigation (Emissions Reduction)

- *ALL OF THE ABOVE*
- Efficiency, Renewables, Nuclear, Gas
- Coal with CCS/CCUS

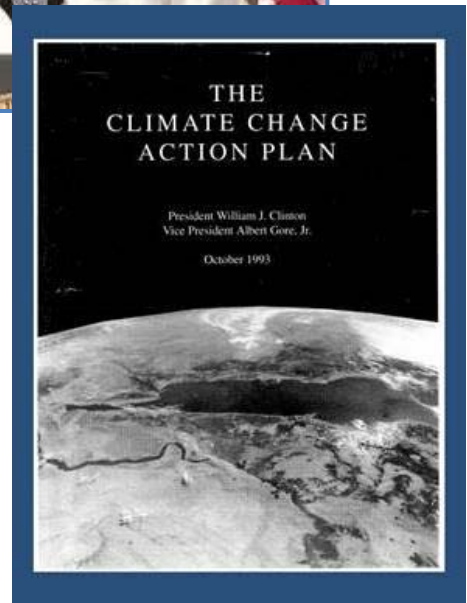


Adaptation and Resilience

- Smart, reliable grid
- Key infrastructure investments

International Partnerships

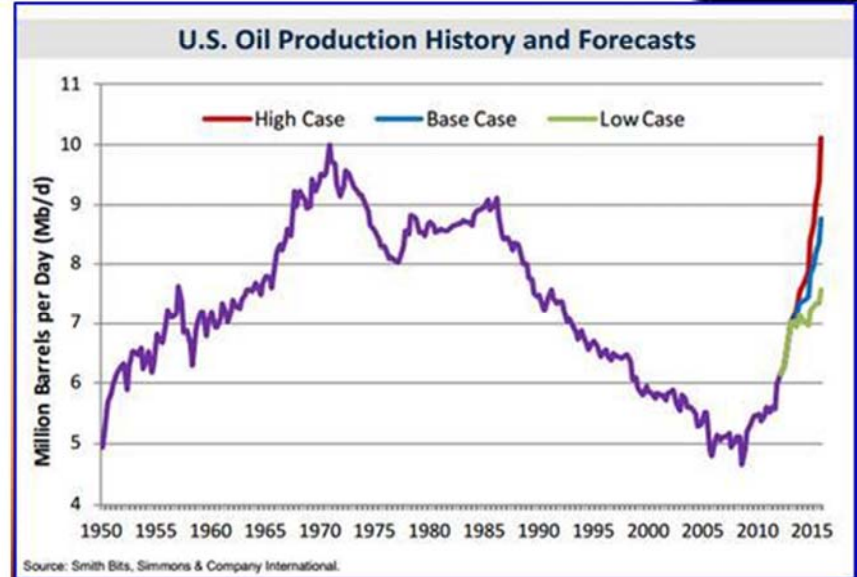
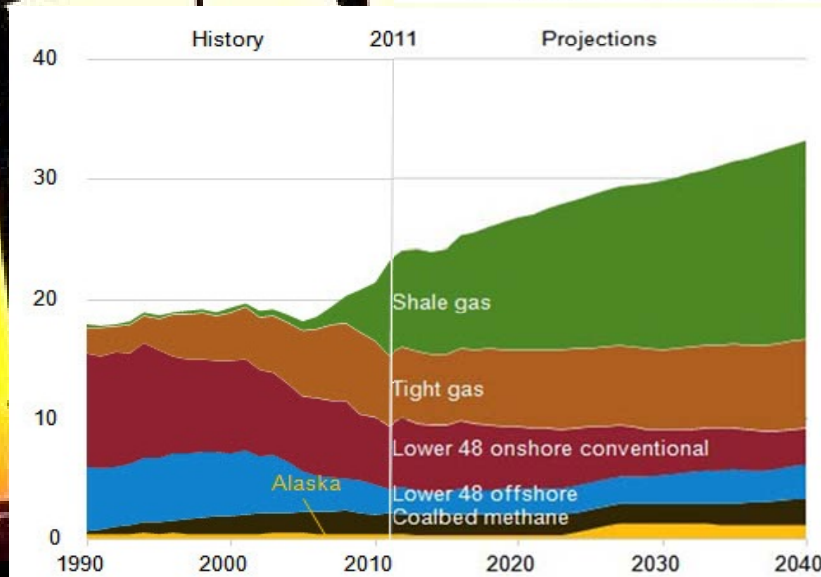
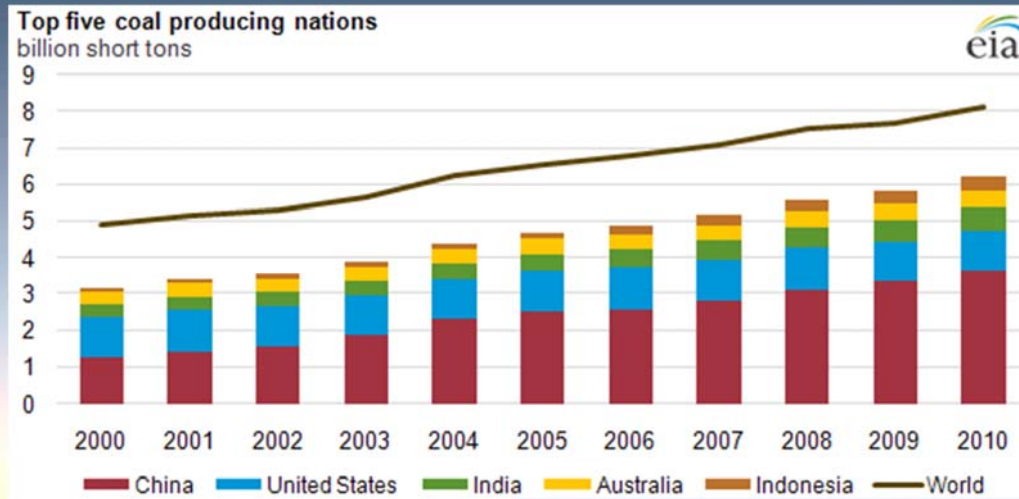
- China and Asia
- Coordinated Intl. Efforts



Once in a Generation Opportunity to Build



This is a time of fossil energy abundance

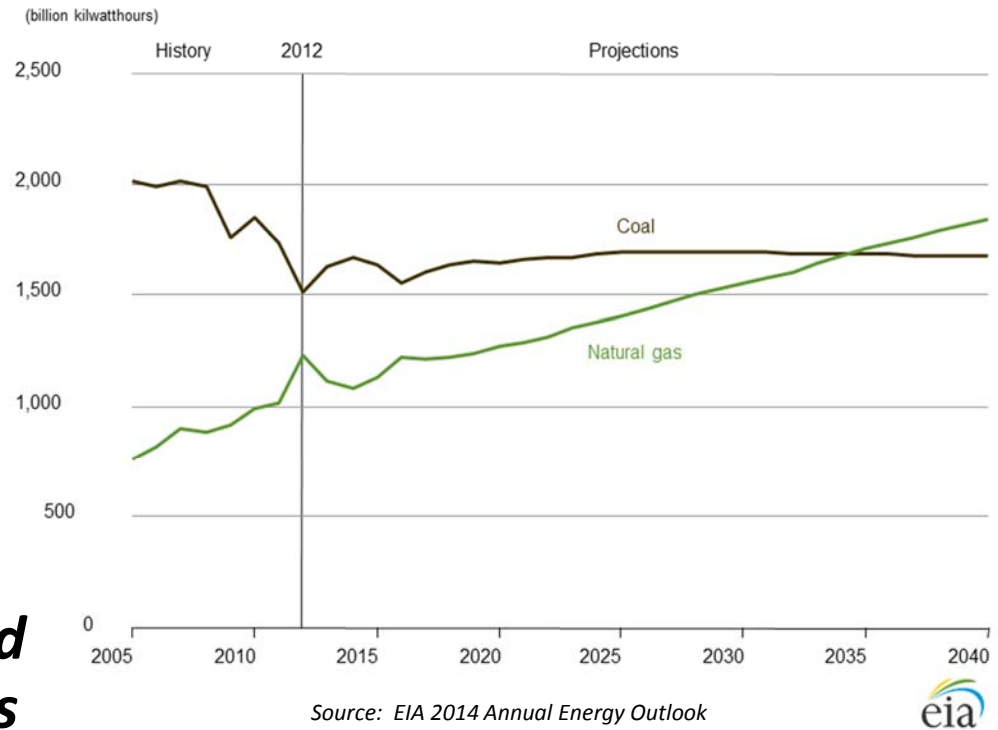


Once in a generation opportunity to build

Future of Fossil Energy Demand and Generation

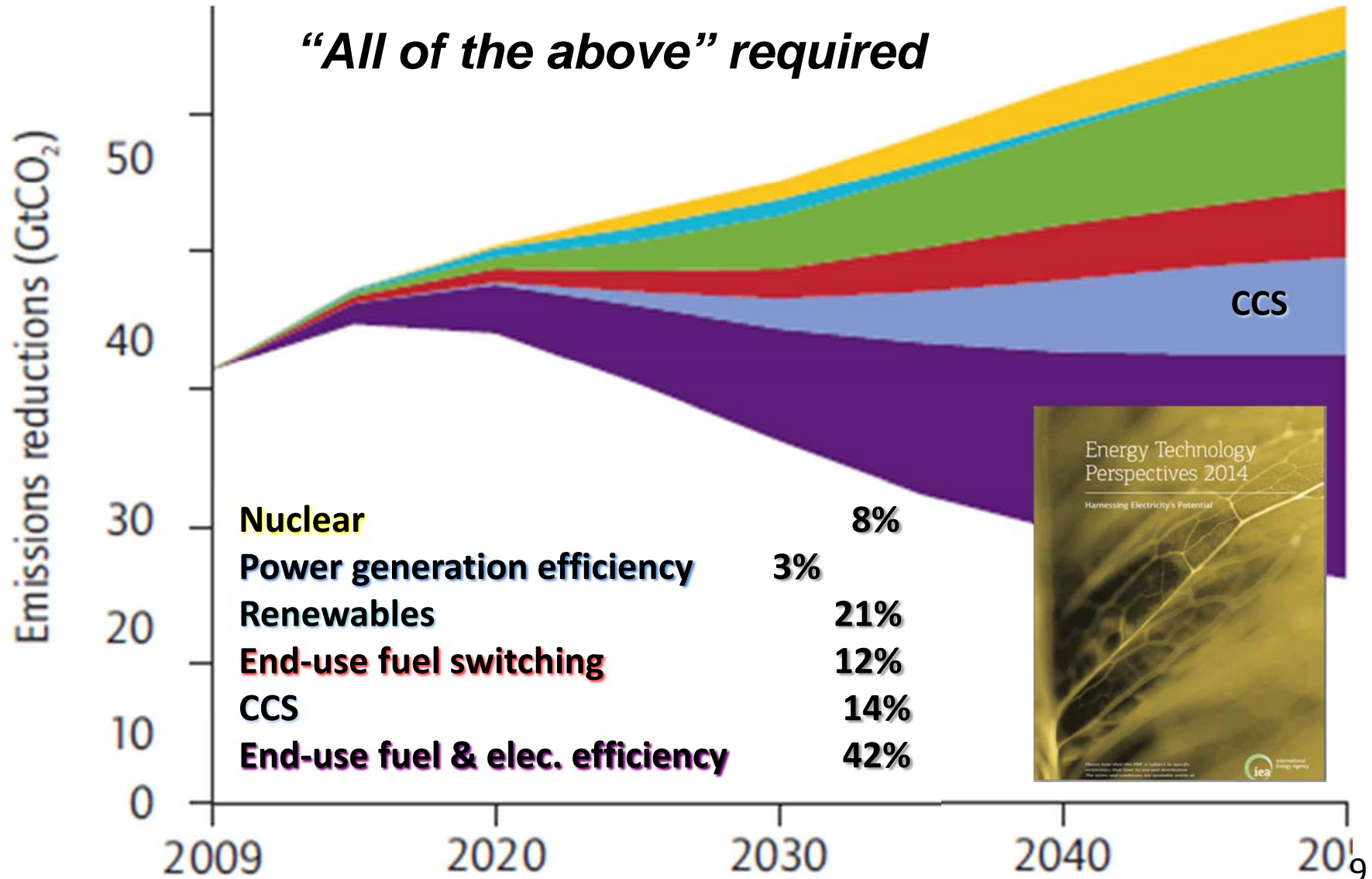
- Even with robust natural gas growth, coal is still a major source of global energy demand and domestic electricity generation
- Fossil Energy remains dominant share (68%) of United States electricity generation in 2040
- ***With this continued use and growth is a need to address CO2 emissions***

Figure 3. Electricity generation from natural gas and coal, 2005-2040







CCS technology remains critically important: abundant, low-cost fossil energy is why

“All of the above” required



Clean coal, with CCUS, will be the cheapest option in many markets

Percentage increase in total discounted mitigation costs (2015-2100) relative to default technology assumptions – median estimate

2100 concentrations (ppm CO ₂ eq)	no CCS	nuclear phase out	limited solar/wind	limited bioenergy
450	138% 	7% 	6% 	64% 

Symbol legend – fraction of models successful in producing scenarios (numbers indicate number of successful models)

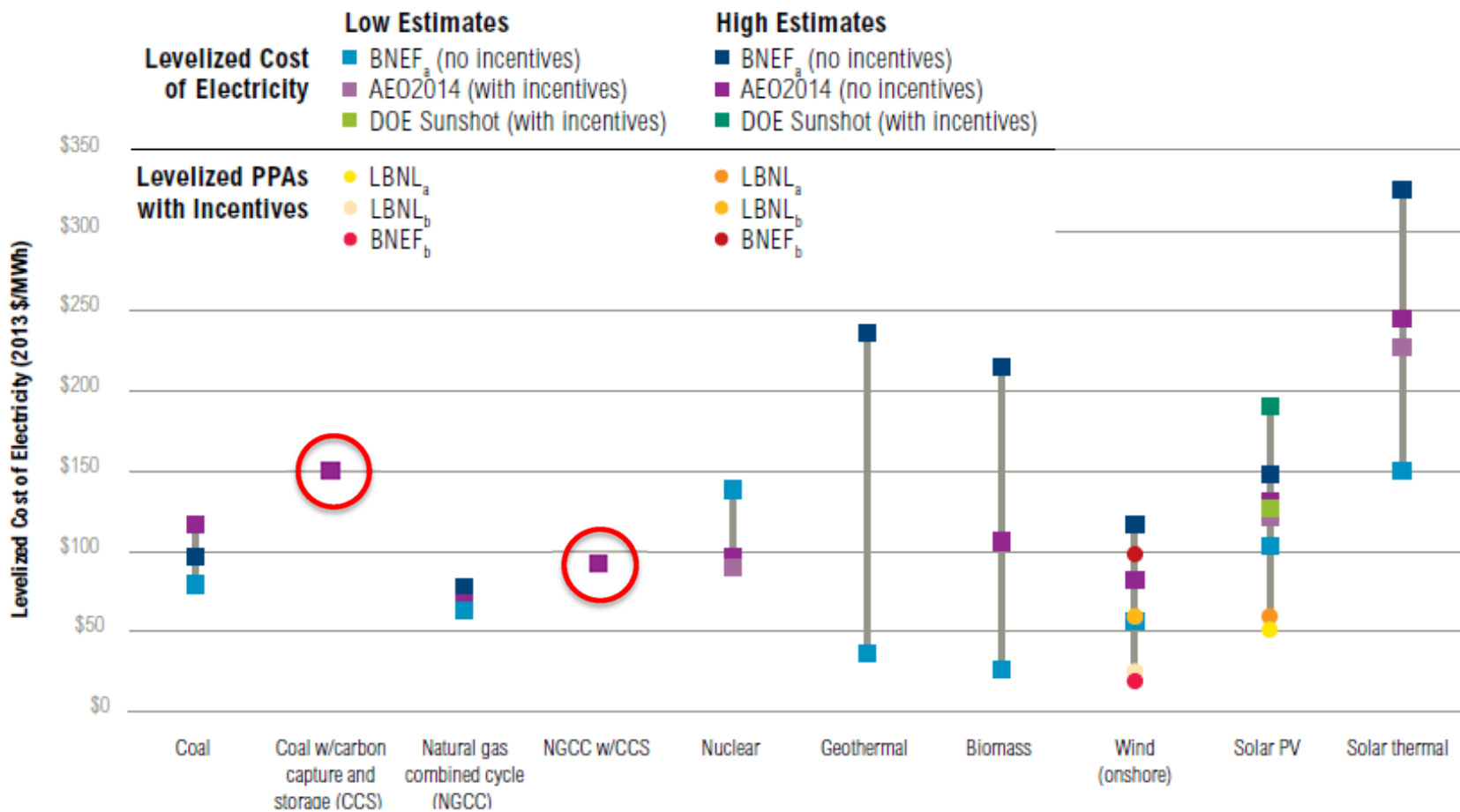


Source: IPCC Fifth Assessment Synthesis Report, November 2014.



Cost, policy, and parity

Figure 1.2 | Levelized Cost of Electricity (\$/MWh) for New Generation Sources and Levelized Power Purchase Agreement Prices for Recent Wind and Solar Projects



Technology leads and informs policy; policy leads and informs finance

DOE/FE's Top Clean Coal and CCS priorities:

- Must build and deploy large projects
- Must develop 2nd and 3rd generation technology
- Must partner with many

Funding CCS Projects in the United States

Federal Funding and Incentives for CCS

- American Reinvestment and Recovery Act (ARRA)
- U.S. DOE Office of Fossil Energy
- Loan Guarantees
- Tax Credits:
 - \$20 per ton for Saline Storage
 - \$10 per ton for EOR

State Incentives for CCS

- Financial Support – Loans and Grants
- Tax Incentives
- Off-take Agreements
- Utility Cost Recovery Mechanisms
- CCS Eligibility in Portfolio Standards
- Assumption of Liability for Stored Carbon

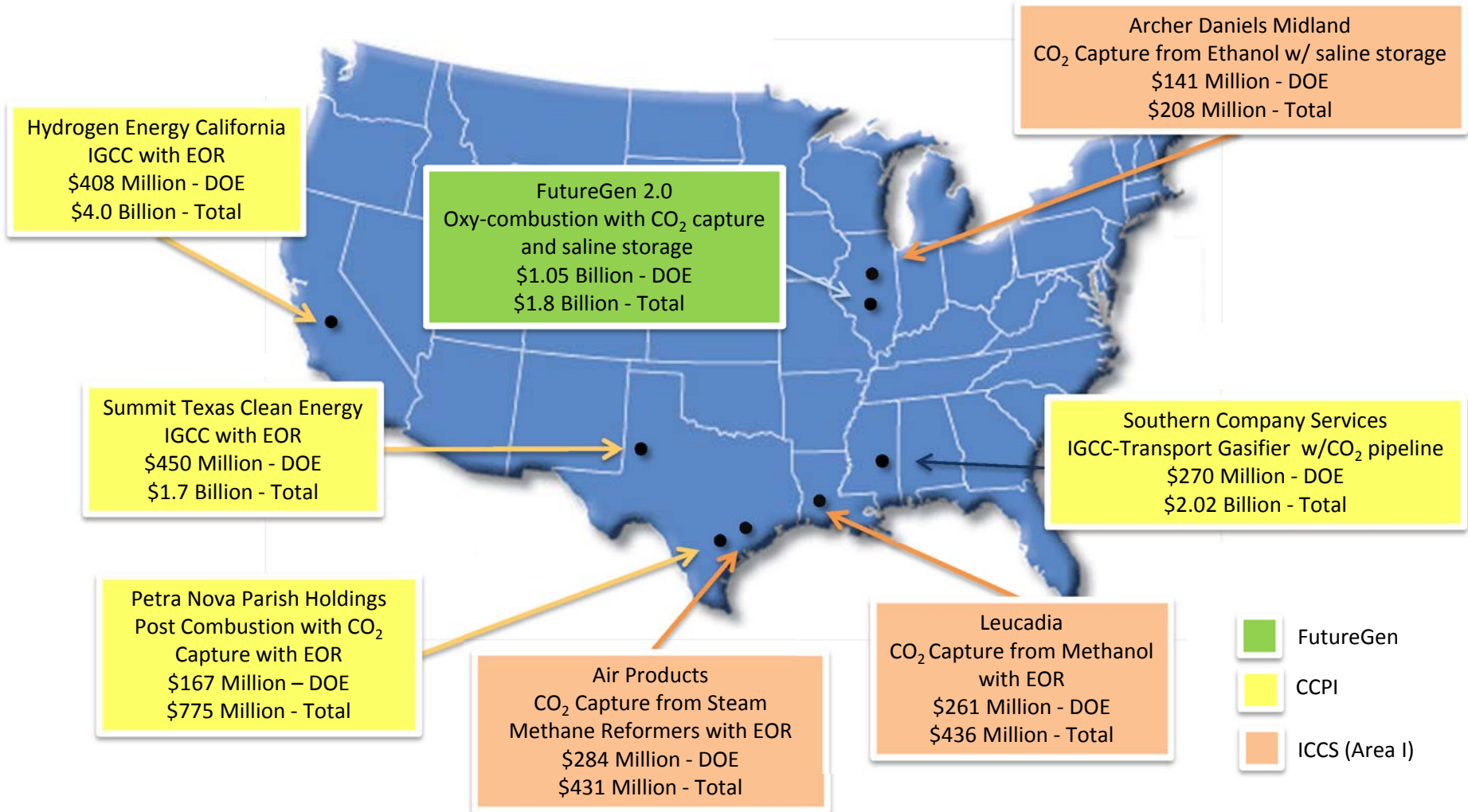
Additional CCS Tax Credit Authority

FY 2016 Budget Request:

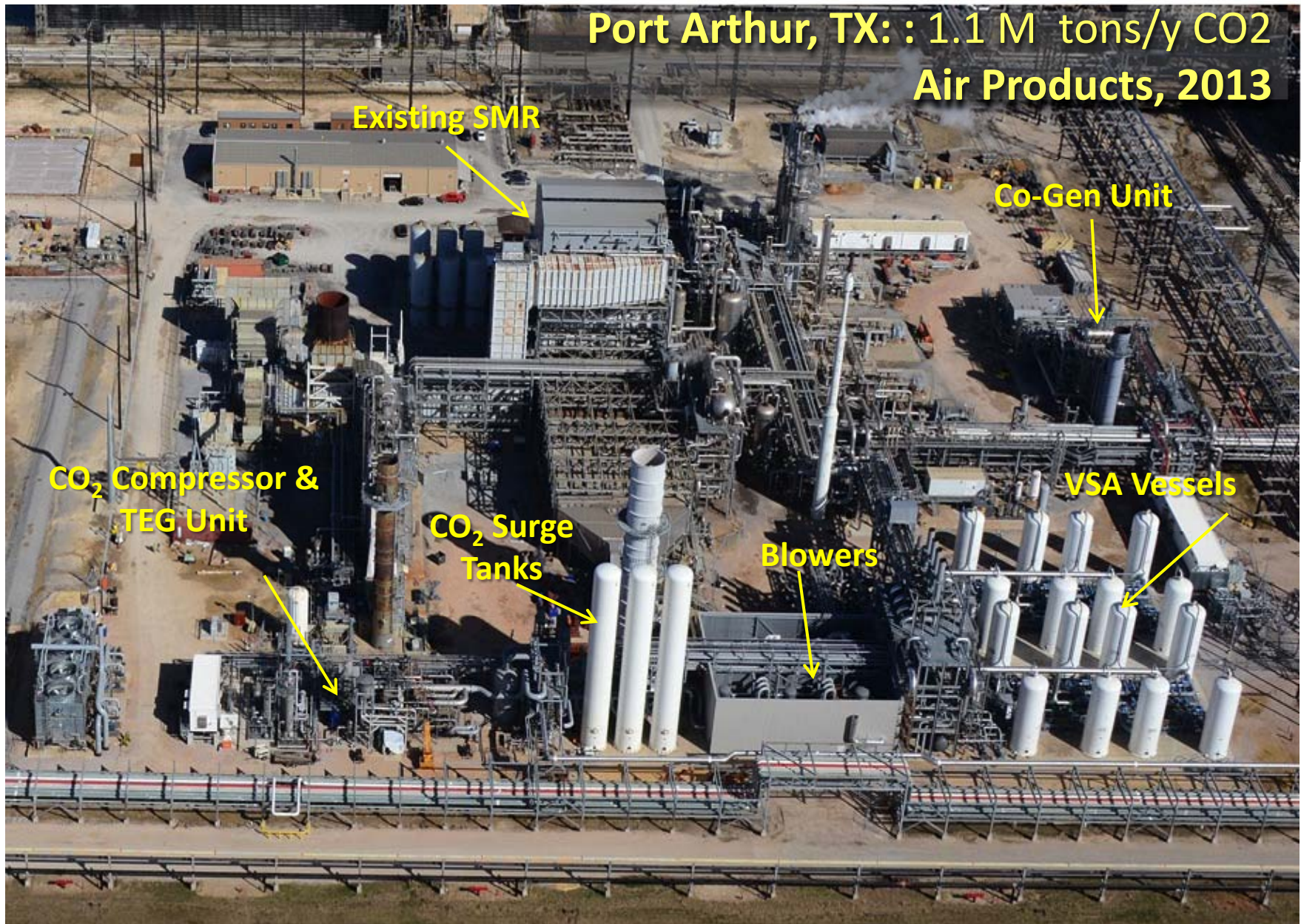
- **\$2 Billion in new refundable investment tax credits**
 - **Plants must capture > 75% of emissions**
 - **Tax credit for up to 30% of capital investment**
- **New Sequestration tax credit (STC)**
 - **\$50 / metric ton stored in saline formations**
 - **\$10 / metric ton stored in EOR**
 - **Guaranteed for 20 years**
- **Builds on the \$6 billion+ already committed to CCUS technologies**

DOE CCUS Demonstration Projects

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



**Port Arthur, TX: : 1.1 M tons/y CO₂
Air Products, 2013**



Existing SMR

Co-Gen Unit

CO₂ Compressor &
TEG Unit

CO₂ Surge
Tanks

Blowers

VSA Vessels



**Kemper County, MS: 2.7M tons/y CO₂
Southern Co., 2013
(Anticipated start mid-2015)**



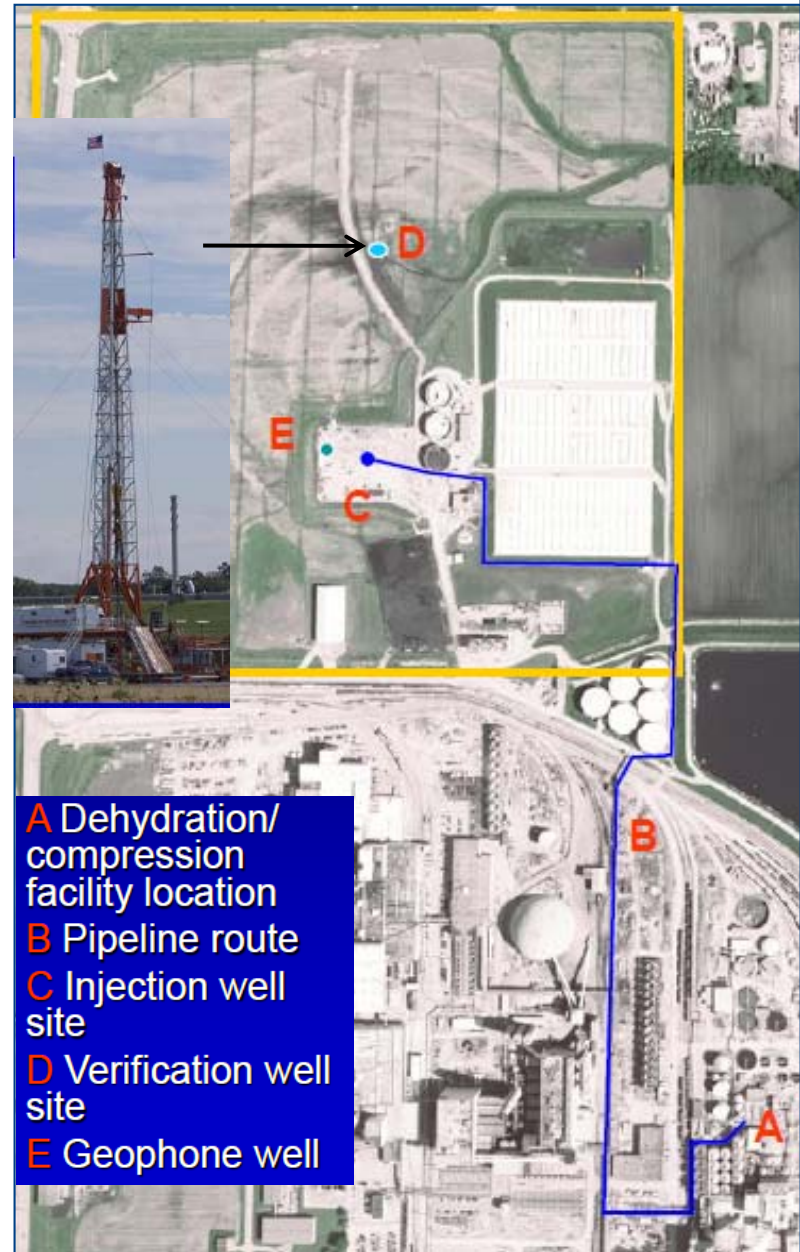


Decatur, IL
ADM 2013

300,000 tons/y today;
Over 900,000 tons to date
1 M tons/y shortly



CO₂ Pipe to Injection Well



- A Dehydration/compression facility location
- B Pipeline route
- C Injection well site
- D Verification well site
- E Geophone well

Final class VI permit

Skyonic "Skymine" Project, San Antonio, TX Operational !!



75,000 tons/y CO2 captured - >200,000 tons avoided



U.S. DEPARTMENT OF
ENERGY

Fossil
Energy

Boundary Dam : 1.1M tons/y CO₂ Saskpower, Saskatchewan



Operational now!

W.A. Parrish, TX: 1.4M tons/y CO₂ NRG/PetraNova project



Broke Ground Sept. 5th! Operational in 2016

Office of Clean Coal: Program Summary

CO₂ Capture and Compression ~ \$80 Million

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)

CO₂ Storage ~\$80 Million

Safe, permanent storage of CO₂ from power and industry

- Major Goals: 2020: technologies and tools available to measure and account for 99% of injected CO₂
2020: CCS best practices and protocols completed based upon RCSP Phase III activities

Advanced Energy Systems ~\$50 Million

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 ~ \$35 Million

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.)

Reimagining our RD&D portfolio

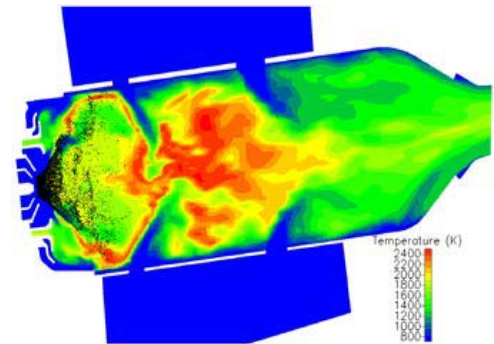
Advanced combustion

- Materials and manufacturing
- Advanced cycles (e.g., PGC, sCO₂)



Capture and Storage

- Advanced simulation (NRAP and CCSI)
- Functionalized discovery
- Mastery of the subsurface



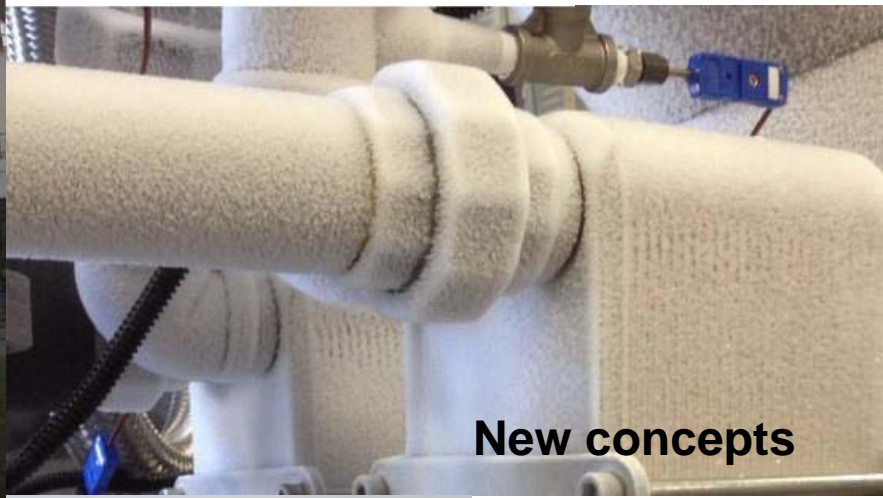
Accelerated 2nd Gen pilots

- Computational design
- International sharing



Advanced CO2 capture technologies

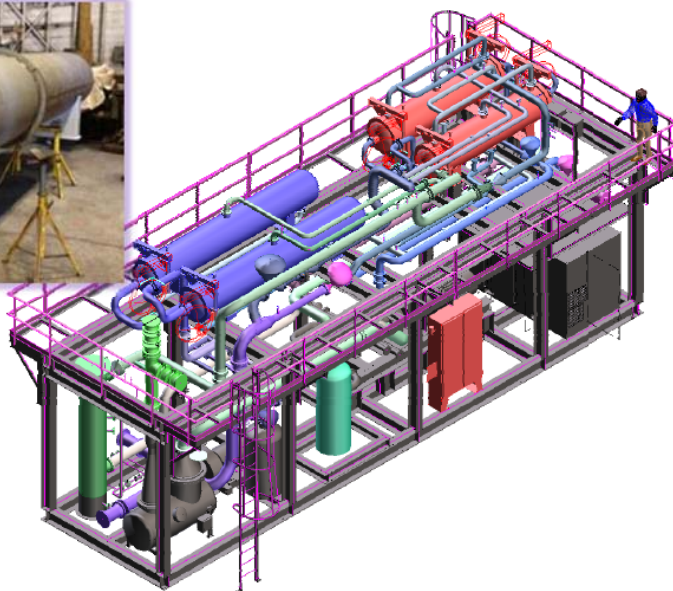
Many pathways to success



Novel Solvents

New concepts

Advanced membranes



Solid sorbents



National Carbon Capture Center (NCCC)

Goal

Test technologies under realistic conditions to reduce the cost of CO₂ capture

Advantages

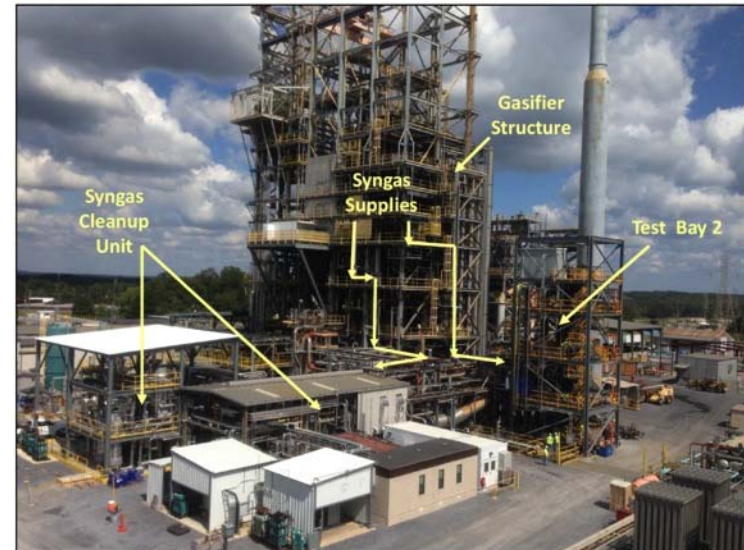
- National resource to validate performance and operations
- Consistent testing procedures and data
- Very good safety and environmental record
- Platform for international partnership and sharing

Status

- New 5 year commitment to operator (Southern Company)
- >20 technologies tested
- 100's of technologies screened



Pilot Solvent Test Unit (PSTU)



Pre-combustion Capture Center

Clean Coal deployment: most urgent and important

Not just about cost

- Costs are higher than ‘non-captured’ coal plants
- Costs are lower than many clean energy alternatives

Not just about technology

- Many technologies are well demonstrated
- Improvement potential is very large

Could finance many ways

- Rate recovery; feed-in tariffs; direct grants
- Clean energy portfolios; tax-free debt financing; others

Financing is the priority action

International partnerships required

Partnerships in Commerce

- Joint ventures
- International investment
- “Showcase” projects

Accelerated deployment

- Data sharing
- International Science Projects

Many platforms

- Bilateral
 - China, Asia, Middle East, OECD
- Clean Energy Ministerial
- APEC, G7, COP20, COP21
- WEC





Carbon Sequestration Leadership Forum (CSLF)

The CSLF aims to:

- Share information on CCS projects, policy initiatives and legal and regulatory developments in member countries
- Build the capacity for CCS in the developing country CSLF members
- Explore methods for financing CCS projects, including in developing countries
- Develop global roadmaps for research, development and demonstration of CCS technologies





Carbon Sequestration Leadership Forum (CSLF)

CSLF Policy Group Exploratory Topics

1. Communications
2. Global Collaboration on Large-Scale CCS Projects
3. Financing CCS Projects
4. Supporting Development of 2nd and 3rd Generation CCS Technologies



United Nations Economic Commission for Europe

- Recommendations for CCS use in a GHG reduction strategy
 - OECD countries will need to show leadership in validating the technologies
 - The largest deployment will need to be in non-OECD
 - A significant share of global clean energy funds must be allocated to CCS
 - Enduring economic incentives are needed to stimulate commercially attractive investment
 - National and international policies on CCS activities must have parity with other non carbon/low carbon technologies
 - CCS is essential for reaching climate goals

Post-Kyoto Landscape

US-China Accord

- Includes large CCS project
- Includes enhanced water recovery projects



New EU accord

- Policy Parity for CCUS and nuclear (also UNECE)
- Innovation funds



From Lima to Paris

- 70 nations make commitments
- Self-determination-based progress

Thank you!

Questions?