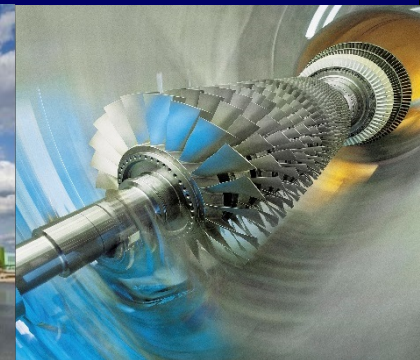


U.S. DEPARTMENT OF
ENERGY

Office of
Fossil Energy



US DOE Carbon Capture R&D International Collaboration

John Litynski, PE
Carbon Capture
Program Manager

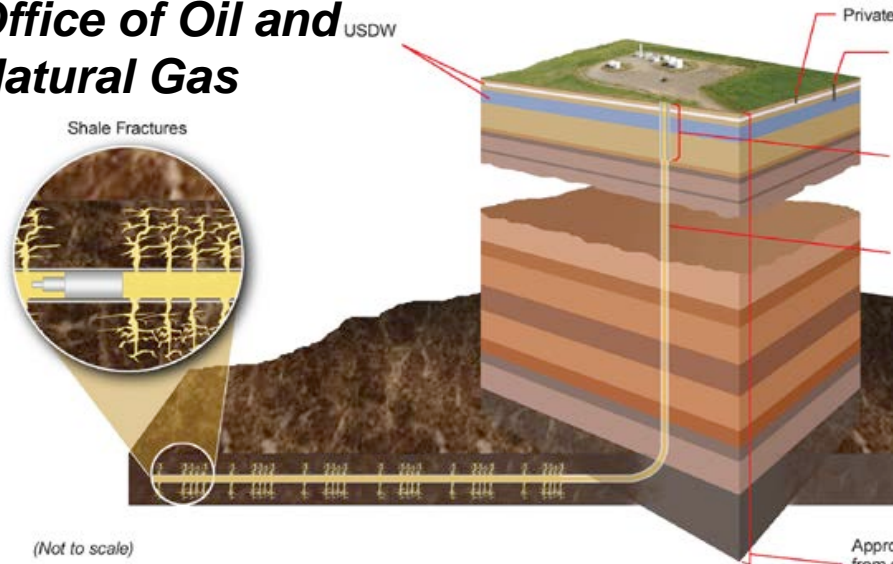
Nov 13, 2017

Office of Fossil Energy

Office of Clean Coal and Carbon Management



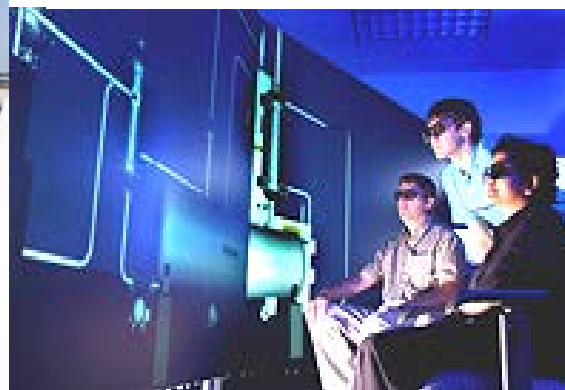
Office of Oil and Natural Gas



Strategic Petroleum Reserves



National Energy Technology Laboratory



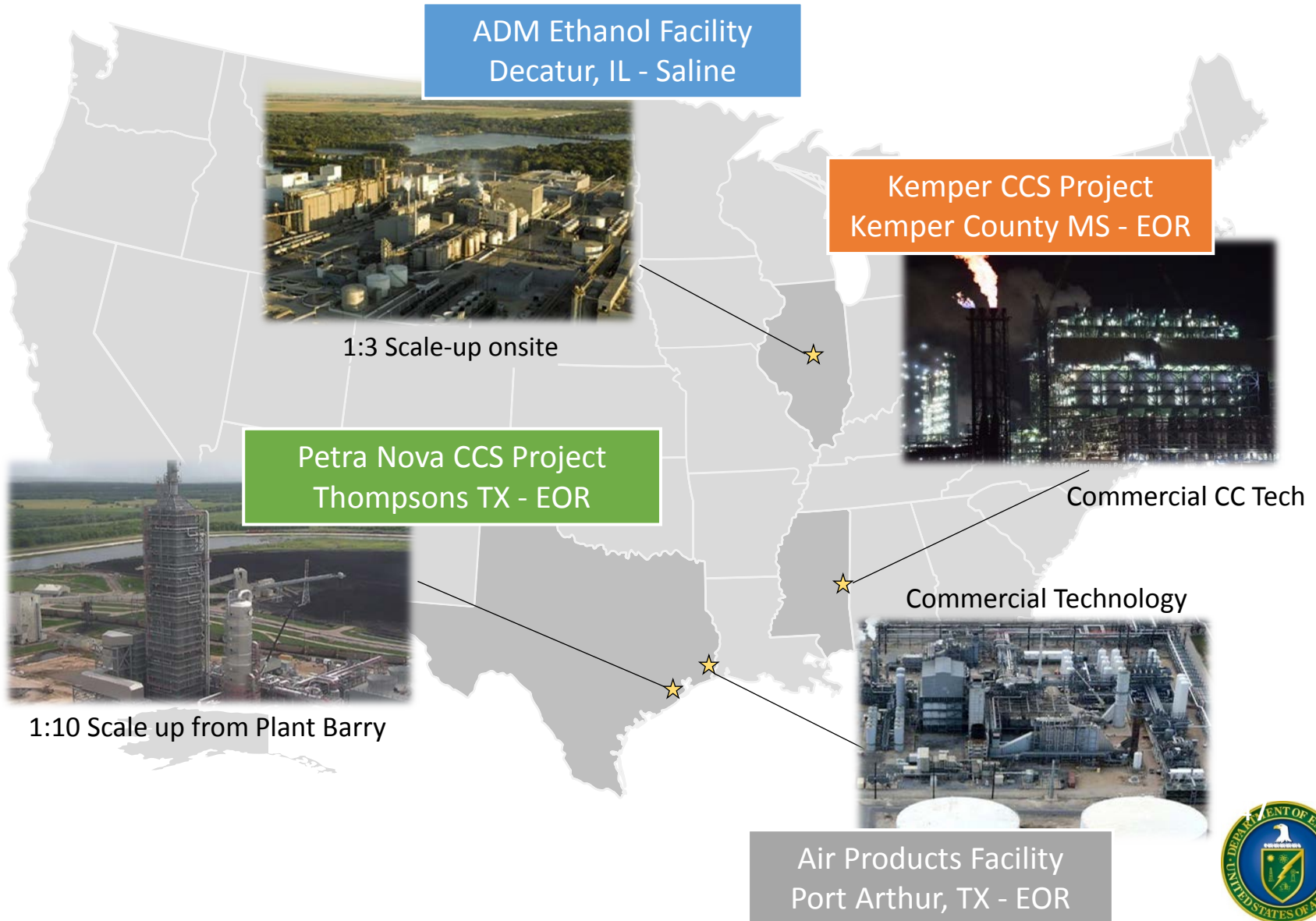
Administration Goals/Priorities

- **US Energy Dominance**
- **Grid Reliability and Resiliency**
- **Infrastructure**
- **Job Creation**
- **Energy Security**



SOTA CCUS - Major Project Demonstrations

Large Pilots Critical to Success



FY 18 Budget Request Overview and Priorities

\$280M for Fossil Energy R&D

- ✓ *Focus on cutting edge, early stage R&D*
- ✓ *Continue operations of the National Laboratories*

Coal Program Priorities

- Stabilize coal—improve the efficiency and reliability of coal-fired plants
- Carbon Capture, Utilization, and Storage (CCUS)

(in thousands)

	FY18 Request
TOTAL FOSSIL ENERGY	479,800*
Coal	114,800
Oil and Natural Gas	21,500
Other Corporate	58,678
NETL	141,200
TOTAL FOSSIL ENERGY R&D	280,000*
Office of Petroleum Reserves	199,800

**Reflects total new Budget Authority funding; the total request is \$335,178 with \$55,178 in prior year balances to reach the requested amount of \$280,000 for the FER&D budget.*

Oil and Gas Program Priorities

- Advance R&D to promote domestic production
- Infrastructure safety
- LNG Authorizations
- Advanced EOR

FY18 Budget (in thousands)	Request Level	House Mark	Senate Mark
TOTAL FOSSIL ENERGY R&D	280,000	668,000	572,700



Highlights from Congressional Appropriation Reports - Pilots

- **National Carbon Capture Center (NCCC) – Full support per the cooperative agreement**
- **FY16 – Large scale pilots through programs (AES and CC) – FOAs for prelim FEED completed**
- **FY17 – Large Scale Pilots and Commercial FEED studies**
 - Fossil Proviso - \$50M – Large Scale Transformational Pilots
 - Commercial Feed Studies for Carbon Capture Systems - \$6M
- **FY18 – TBD, but committee reports mention...**
 - Fossil Proviso
 - NCCC
 - Continued support for commercial carbon capture systems



National Carbon Capture Center

- Operated by Southern Co Services
- Hosted at Plant Gaston, AL
- DOE funds 80% of operations
- Over 100,000 test hours (*10+years*)
- Technologies from U.S. and **six other countries** since 2008 founding of NCCC
- More than 40 carbon capture technologies tested
- Dedicated staff of plant engineers
- Standard design guidelines
- Complete MEA baseline and CCSi2 model

PROGRESSION FROM LAB TO SMALL PILOT On Real Flue Gas



Lab-Scale Unit



Bench-Scale Unit



Small Pilot-Scale Unit



Carbon Capture Small Pilot Projects – International Investments in DOE R&D



**1.5 MWe Solvent Pilot
(Linde and BASF)**



**NCCC: 0.5 MW PSTU, 1
MW test bay
(CCSI/Cansolv)**



**0.7 MWe Solvent System
(Univ. of KY – CCSI - Hitachi)**



**Alkalinized Alumina Sorbent
(TDA, Inc, SINOPEC)**



**Cold Membrane System
(American Air Liquide, Inc.)**

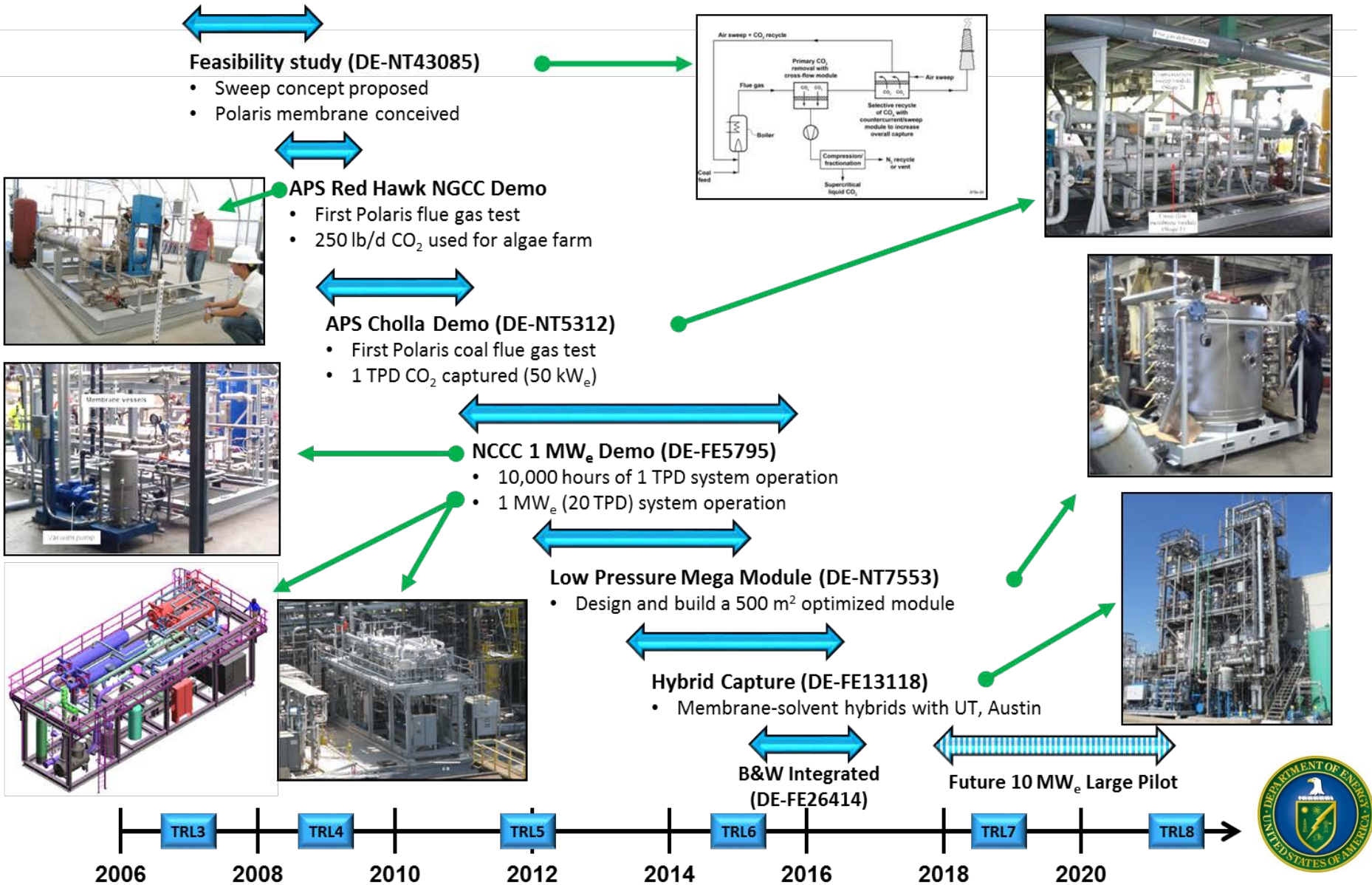


1 MW Membrane System (MTR)



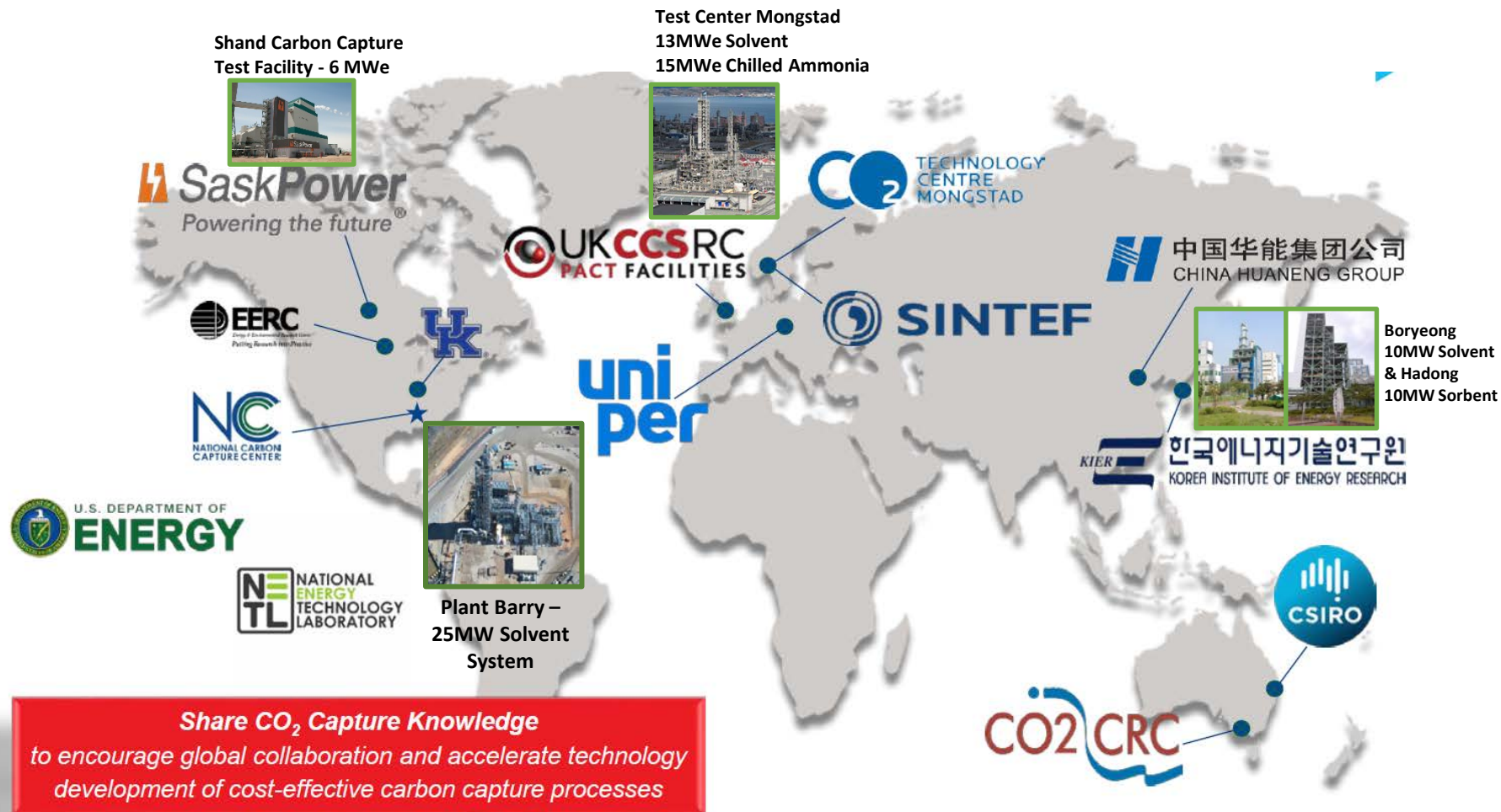
**25 MW Solvent Heat Integration
(Southern Company - MHI)**

Example of Technology Development Timeline – 2nd Gen



Carbon Capture Global Collaborations – Existing Infrastructure

International Test Center Network and Large Scale Test Facilities



Examples of Ongoing International Collaboration - *Technology Center Mongstad (TCM)*

US Norway Bi-Lateral CCS

Test Center Mongstad

- 13 Mwe Solvent System
- Two types of gas:
 - Refinery Cracker
 - NGCC

ION Engineering – Semi-aqueous solvent (2016-2017)

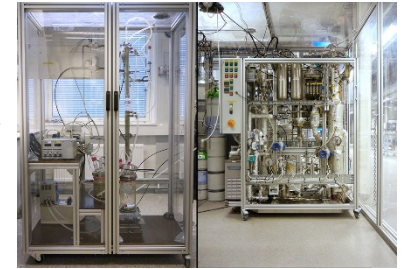
- Completed Testing
- Carbon Capture Simulation Initiative for Industry (CCSI2)

Fluor/PNNL – Water lean solvent (2018)

Pathway to Scale-up



NCCC 0.5Mwe



SINTEF

Amine
Degradation
Testing



Ion Engineering at TCM (13MWe)

Key Lessons Learned from International Agreements

- Intellectual Property Rights
- Labor requirements (% domestic vs. international)
- Liability requirements
- Reporting requirements between parties and sponsors
- Lessons learned in contracting between international agencies
- Flow down provisions
- Cost share requirements and timing
- Shipping/VAT/Logistics
- Engineering support and construction requirements
- Capabilities of facilities

FY2017 Funding Opportunity Announcements Supporting Large Pilots

DE-FOA-0001791 - Design and Testing of Advanced Carbon Capture Technologies

- Closes 11/14/2017
- Topic Area 1 (\$30M): Scaling of Carbon Capture Technologies to Engineering Scales Using Existing Host Site Infrastructure
 - Solvents encouraged to use existing infrastructure
 - Membrane systems at relative engineering scale and easily replicated
 - Testing on coal or similar flue gas required
- Topic Area 2 (\$6M): Initial Engineering, Testing, and Design of a Commercial-Scale, Post-Combustion CO₂ Capture System
 - **Responsive to FY2017 Congressional direction** – *“The agreement provides \$6,000,000 to support a new solicitation for initial engineering, testing, and design-related work for a commercial-scale, post-combustion carbon dioxide capture project on an existing coal fueled generating unit. Within available funds, the Department shall provide to the Committees on Appropriations of both Houses of Congress an estimate of the costs required to fully retrofit such a unit.”*

DE-FOA-0001788 – Fossil Fuel Large Scale Pilots (\$50M FY17, \$\$ in FY18+)

- **Responsive to Congressional direction** – *“The agreement includes \$50,000,000 to support a new solicitation for two large-scale pilots which focus on transformational coal technologies that represent a new way to convert energy to enable a step change in performance, efficiency, and the cost of electricity compared to today’s technologies. Such technologies include thermodynamic improvements in energy conversion and heat transfer, such as pressurized oxygen combustion and chemical looping, and improvements in carbon capture systems technology. In making the awards for large-scale pilots, the Department should prioritize entities that have previously received funding for these technologies at the lab and bench scale.”*
- **Three Phases: 1 - Feasibility - 2 - FEED - 3 - Construction and Operations**

Accelerating the Rate of RD&D - Transformational

Partnership between national labs, academia, and industry

Accelerate deployment by 50% in TRL 2-5 range

Parallel paths for materials discovery – synthesis – process design

Leverage advanced computing

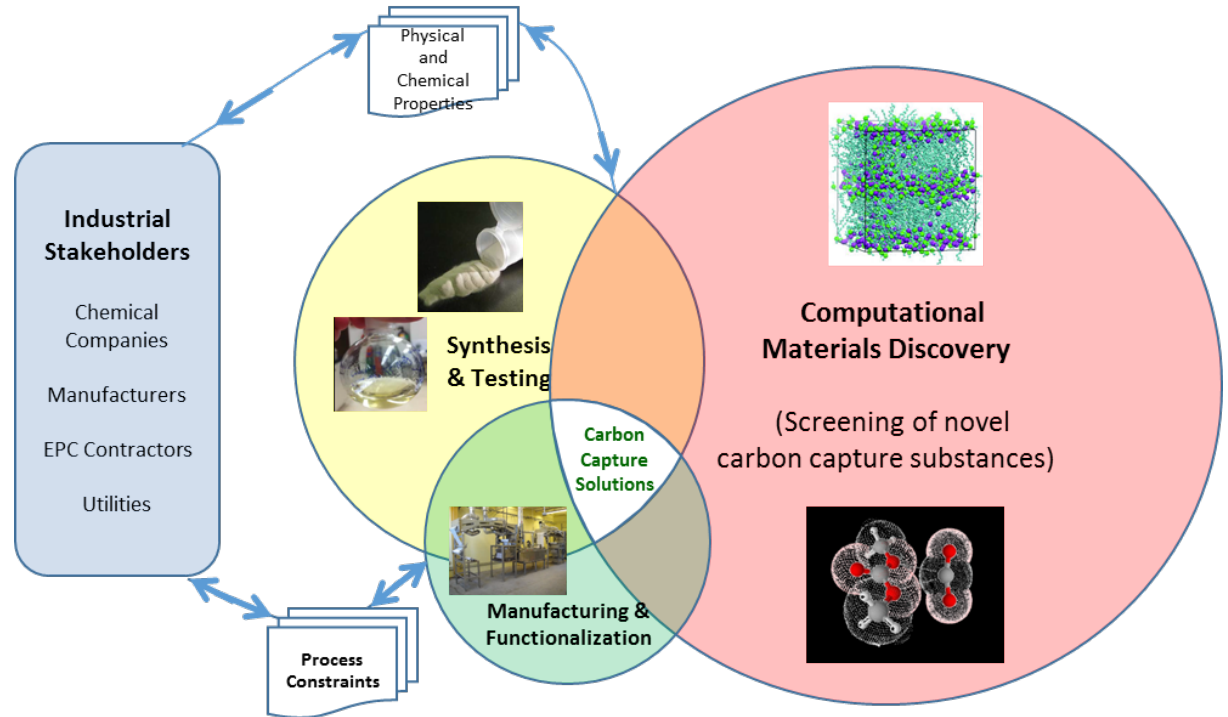
Robotics for rapid synthesis and analytical capabilities

Lab Selection 2017

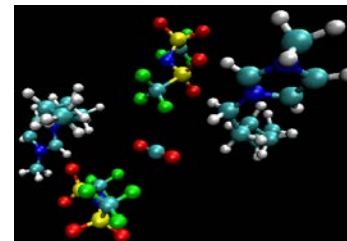
- PNNL
- LBNL
- LLNL
- ORNL

Ready for large pilot by 2022

“Transformational Technology Development”



Non-aqueous and phase change solvents



Molecular Design



Advanced Manufacturing

Questions?