US NATIONAL CARBON CAPTURE CENTER AND INTERNATIONAL CCS TEST CENTER NETWORK

IEA – MOST Workshop:
Advances in deployment of fossil fuel technology
Beijing
June 25, 2014

US DOE National Carbon Capture Center

Power Systems Development Facility (PSDF) started combustion testing June 1996 and gasification September 1999.

In May 2009, PSDF transitioned to the National Carbon Capture Center (NCCC).

Existing facilities used to support development of pre-combustion CO_2 capture and gasification technologies.

Additional facility, the Post-Combustion CO_2 Capture Center (PC4) built and started testing March 2011.

Located at adjacent power plant, Alabama Power's Plant Gaston, which provides commercially representative flue gas for testing (hot ESP, SCR, and wet FGD).

Project Facts

U.S. DEPARTMENT OF ENERGY

NETL

SOUTHERN COMPANY

Performance Period
10/01/2008 to 09/30/2014

Total Project Value	**$251M**
DOE	$201M
Non-DOE	$50M

Award Number DE-NT0000749

Performance Period
5/01/2014 to 04/30/2019

Total Project Value	**$188M**
DOE	$150M
Non-DOE	$38M

Award Number DE-FE0022596

EPRI ELECTRIC POWER RESEARCH INSTITUTE

nrg

ArchCoal

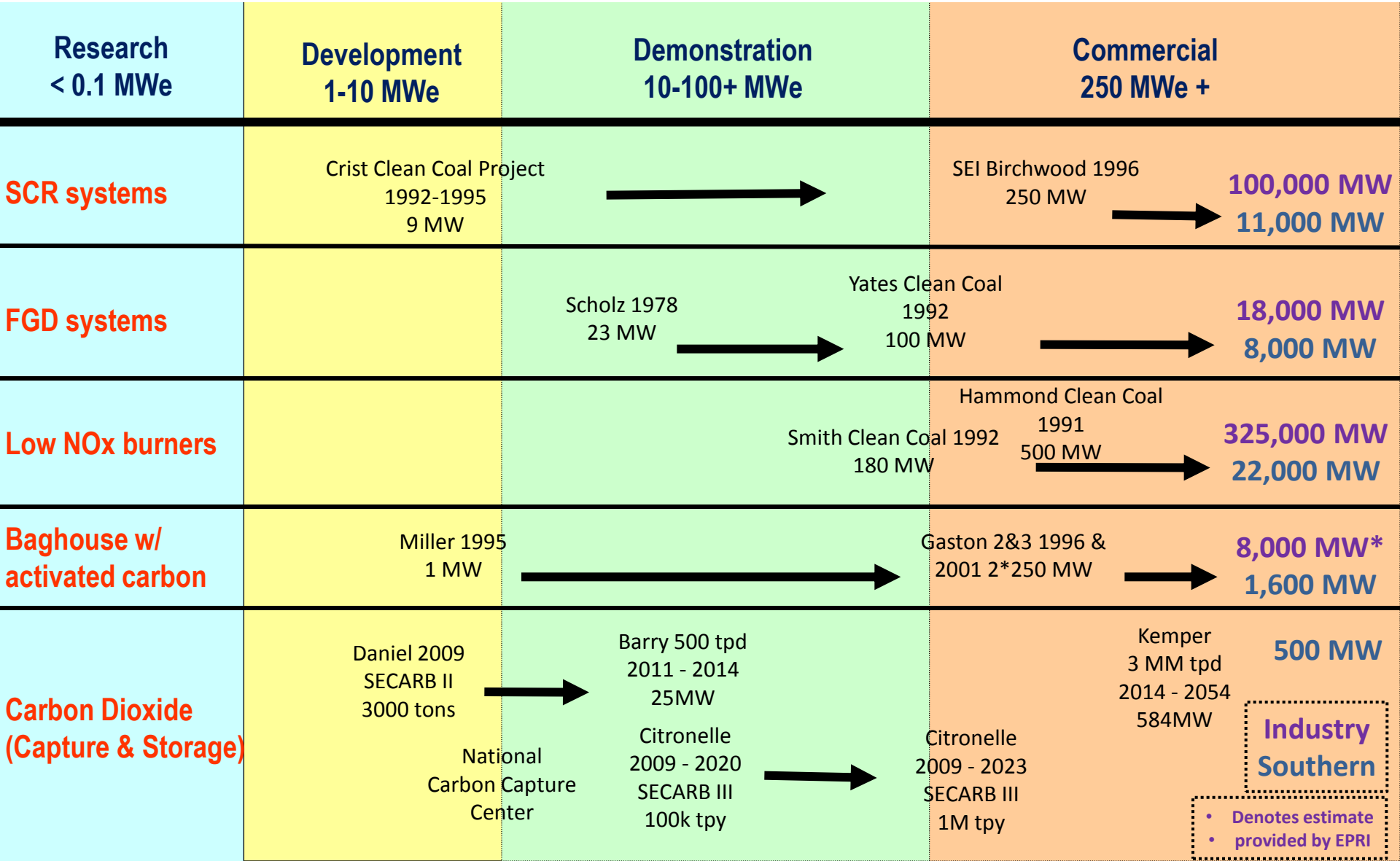
Luminant

AEP AMERICAN ELECTRIC POWER

DUKE ENERGY

CLOUD PEAK ENERGY

Coal-based Technology Development Directly Resulting from DOE/Southern Company R&D Partnership

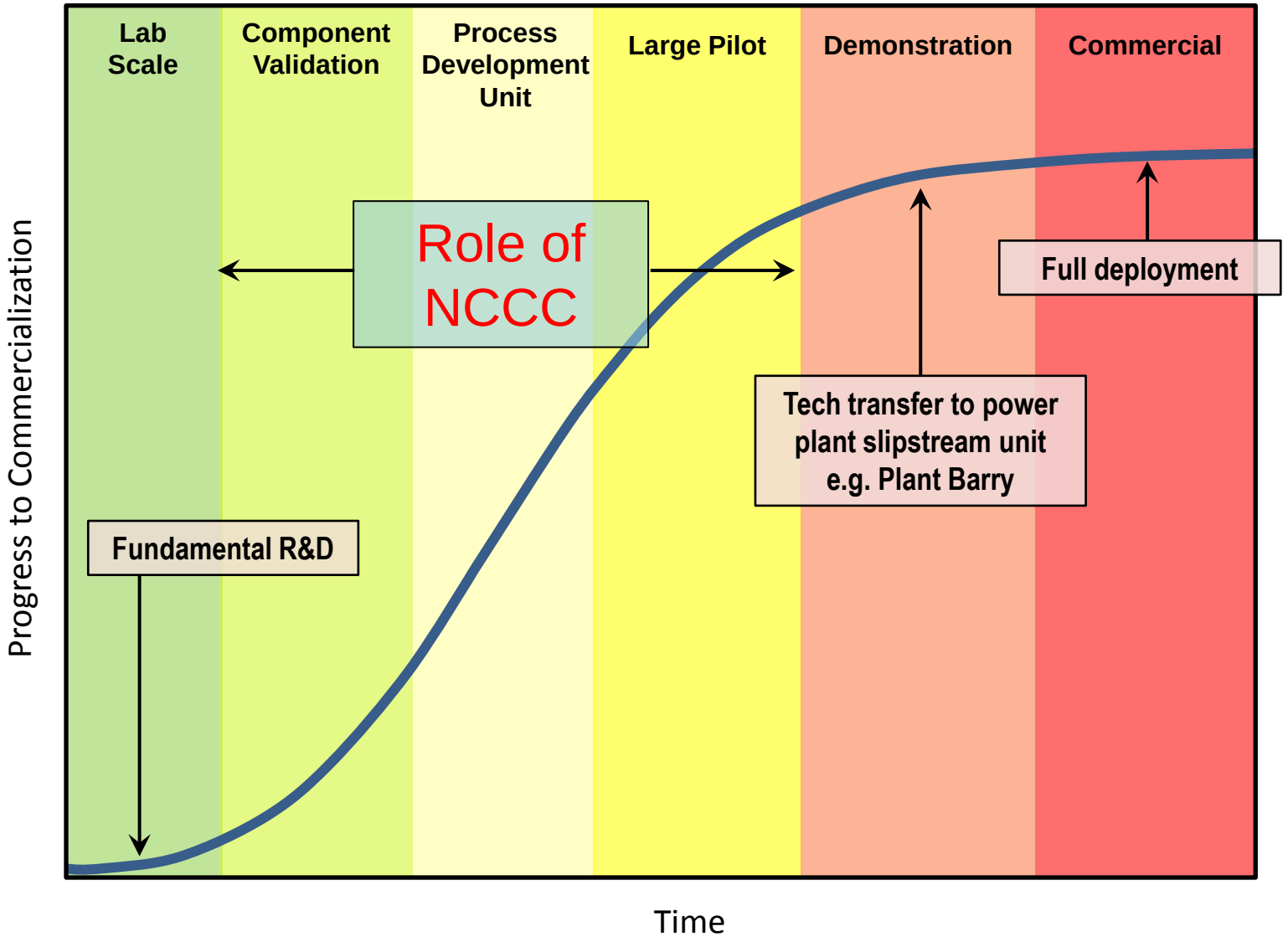


National Carbon Capture Center (NC3)

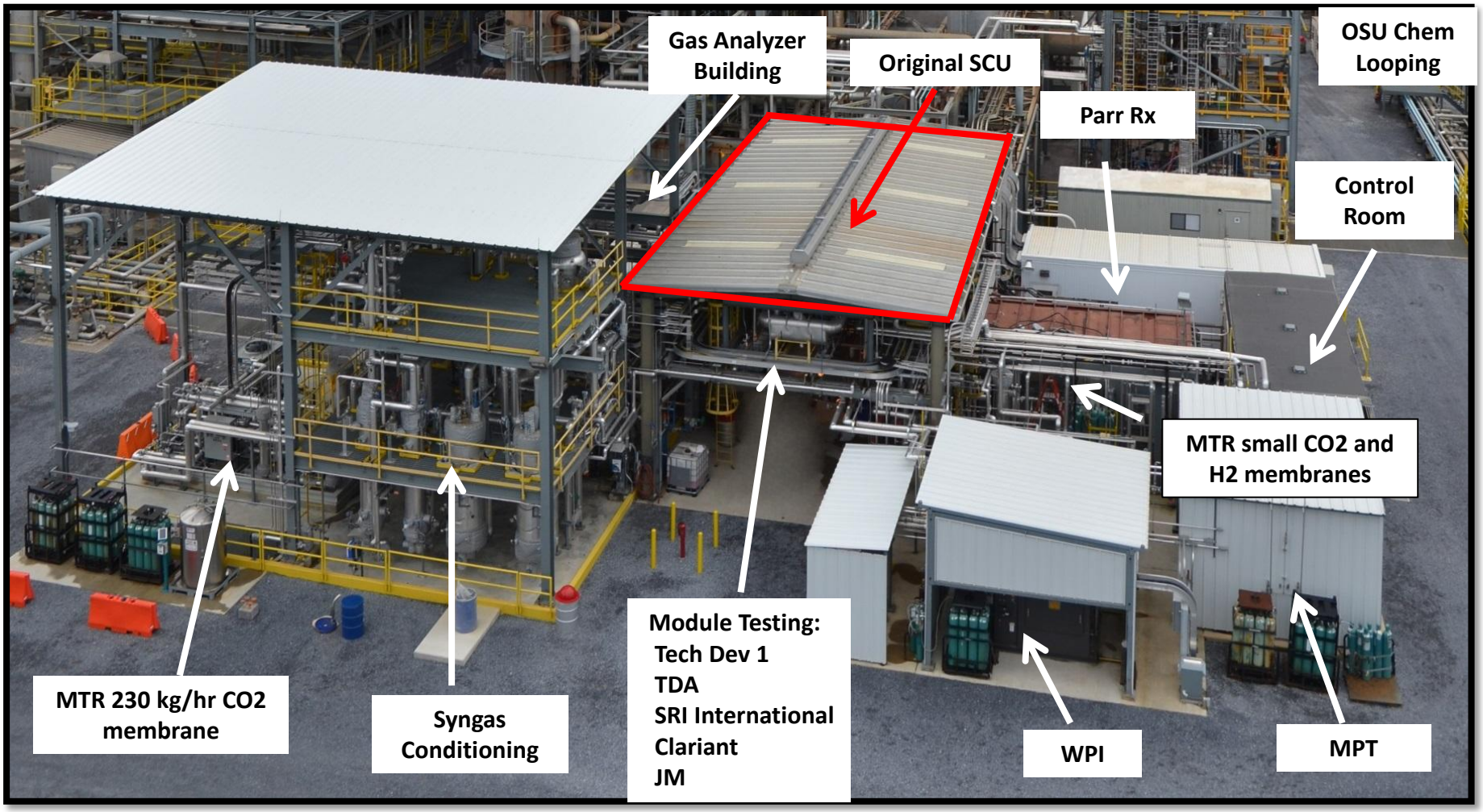
Post-Combustion CO_2 Capture

Gasification
Pre-Combustion CO_2 Capture

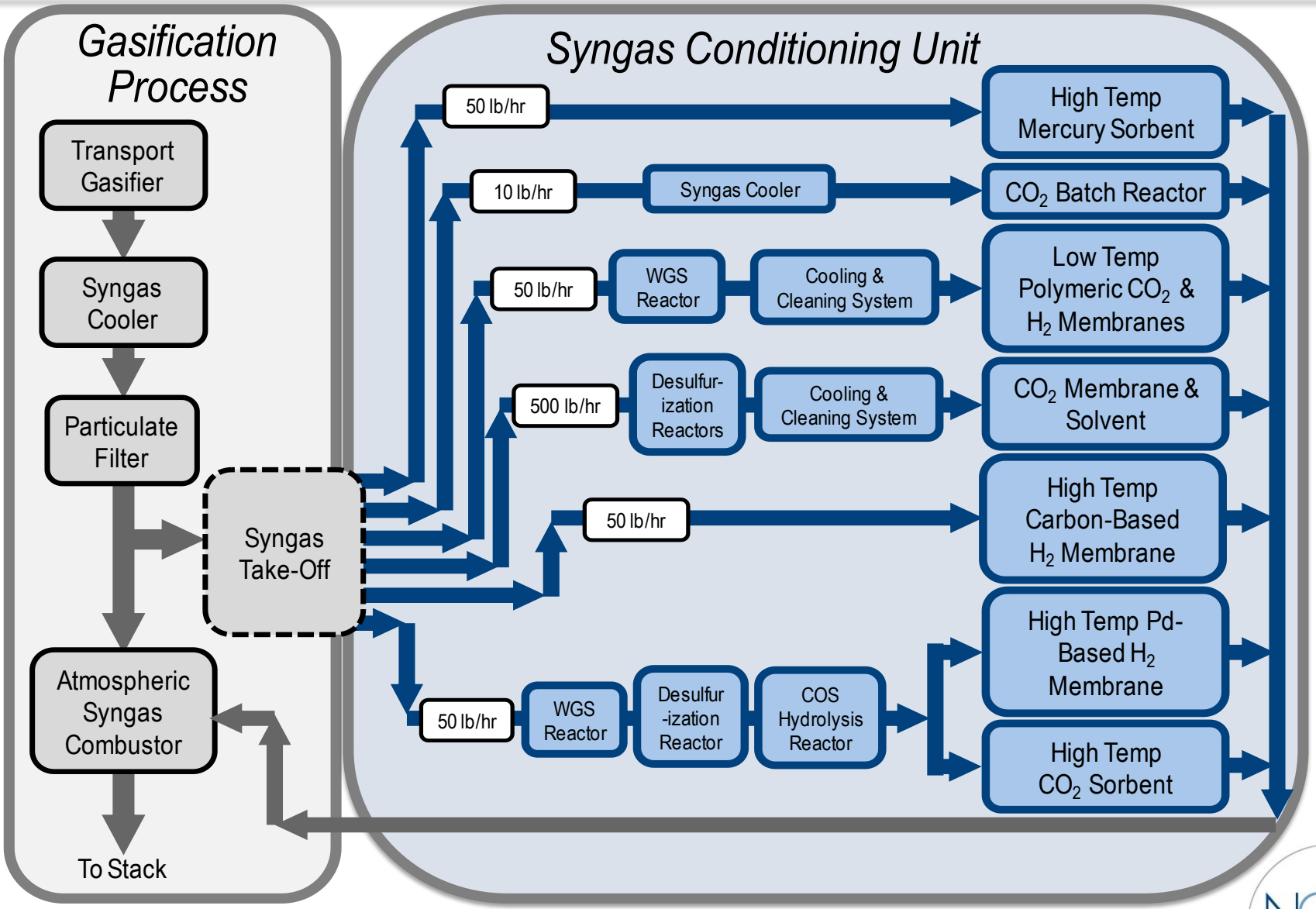
Role of NCCC


Lab Scale
Component Validation
Process Development Unit
Large Pilot
Demonstration
Commercial
Role of NCCC
Full deployment
Tech transfer to power plant slipstream unit e.g. Plant Barry
Fundamental R&D
Progress to Commercialization
Time

Pre-Combustion Facilities



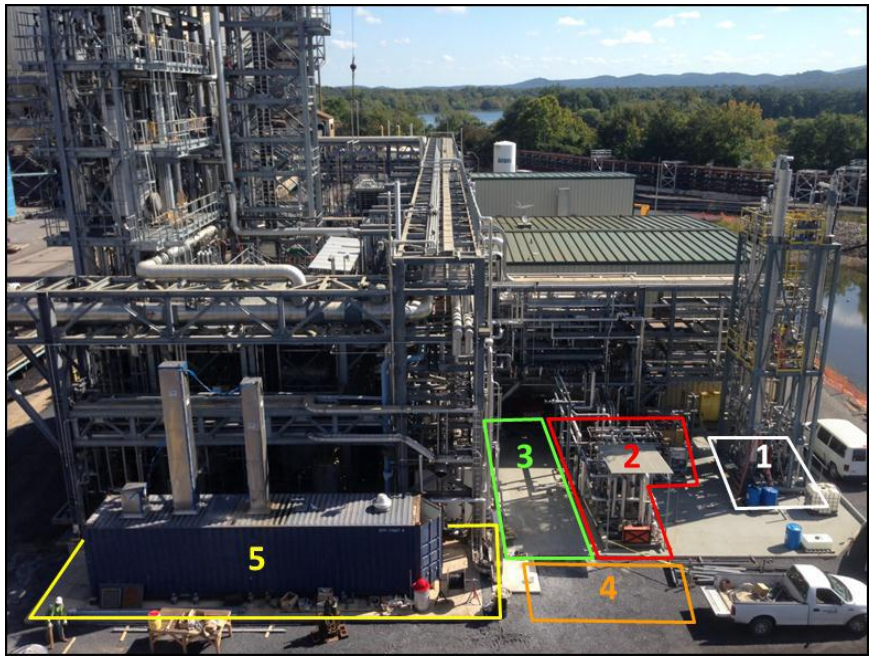
Pre-Combustion CO_2 Capture Site Overview



Post Combustion Carbon Capture Center (PC4)

Post Combustion Carbon Capture Center (PC4)

Bench-Scale Test Bays



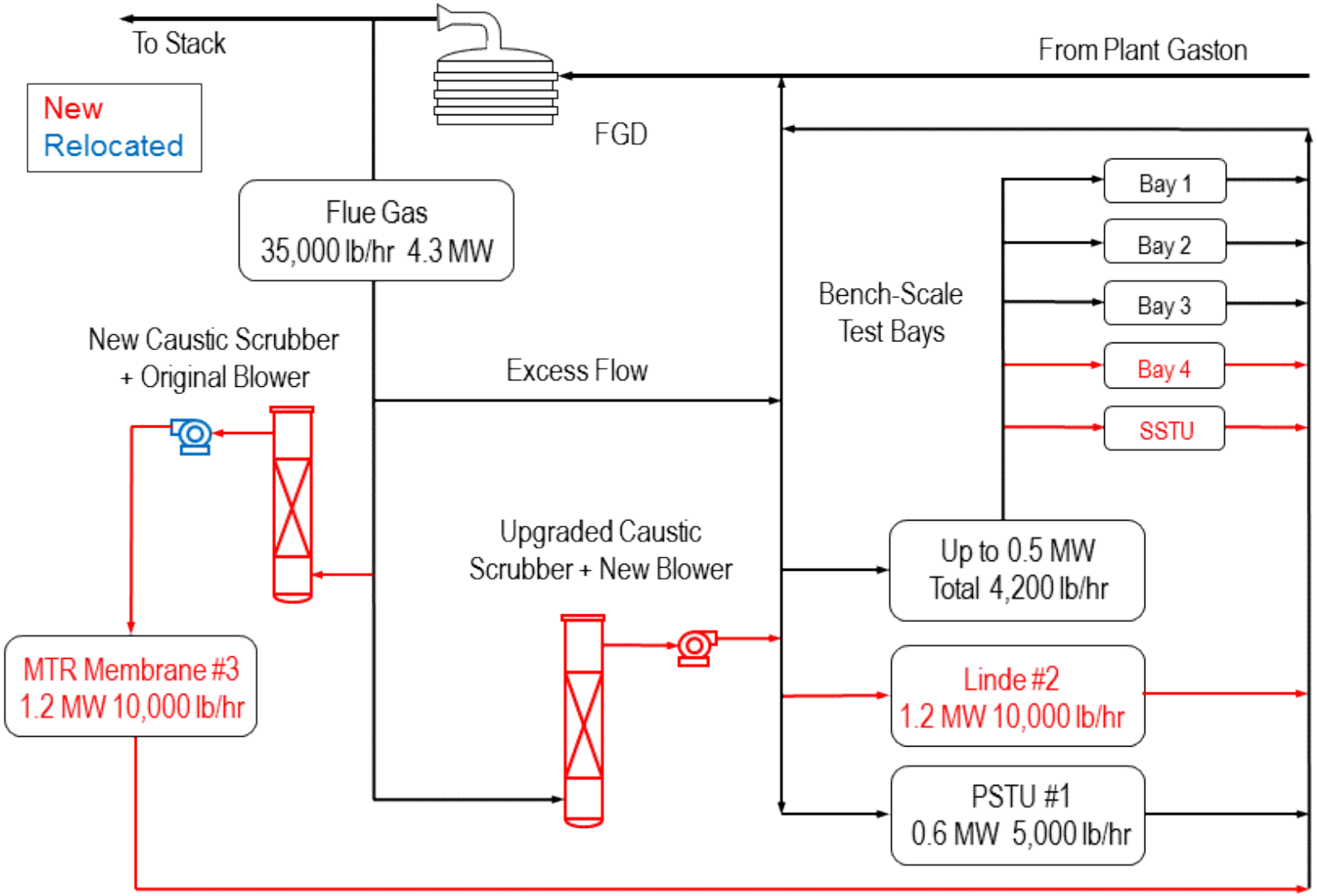
1. Akermin — solvent
2. MTR — membrane
3. SRI International — sorbent
4. DOE — sorbent
5. SSTU — solvent

Pilot-Scale Test Bays

1. 0.6-MW PSTU — solvent
2. 1.2-MW BASF/Linde — solvent
3. 1.2-MW MTR — membrane

Eight Test Bays for Technologies from 0.01 MW to 1.2 MW

Expanded PC4 Testing Capability



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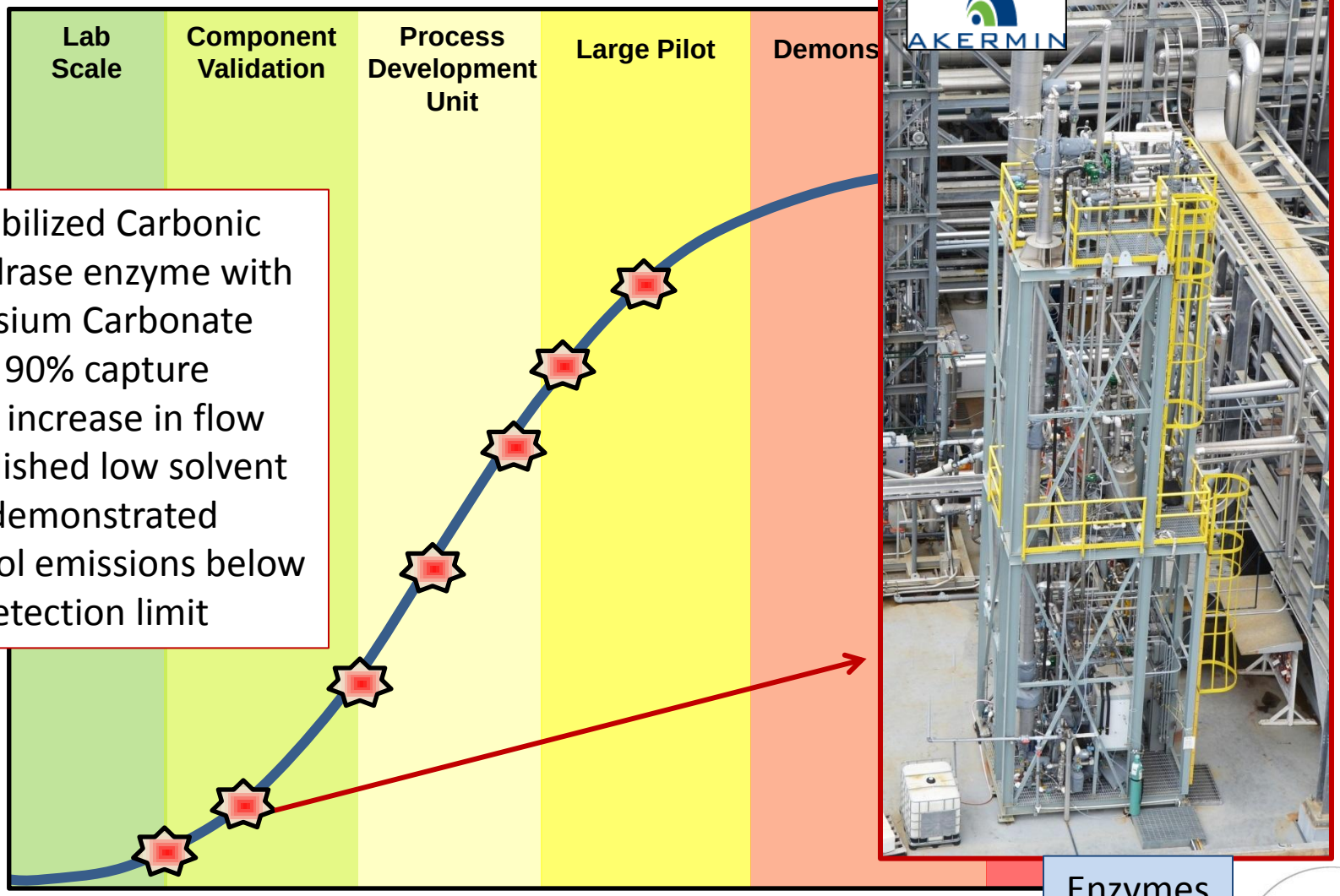
Lab Scale | Component Validation | Process Development Unit | Large Pilot | Demonstration | Commercial

Enzymes

- Carbonic anhydrase enzyme with MDEA
- 65% capture
- Rate of capture 25 times > than MDEA
- No apparent effect of trace metals or elevated process temperatures

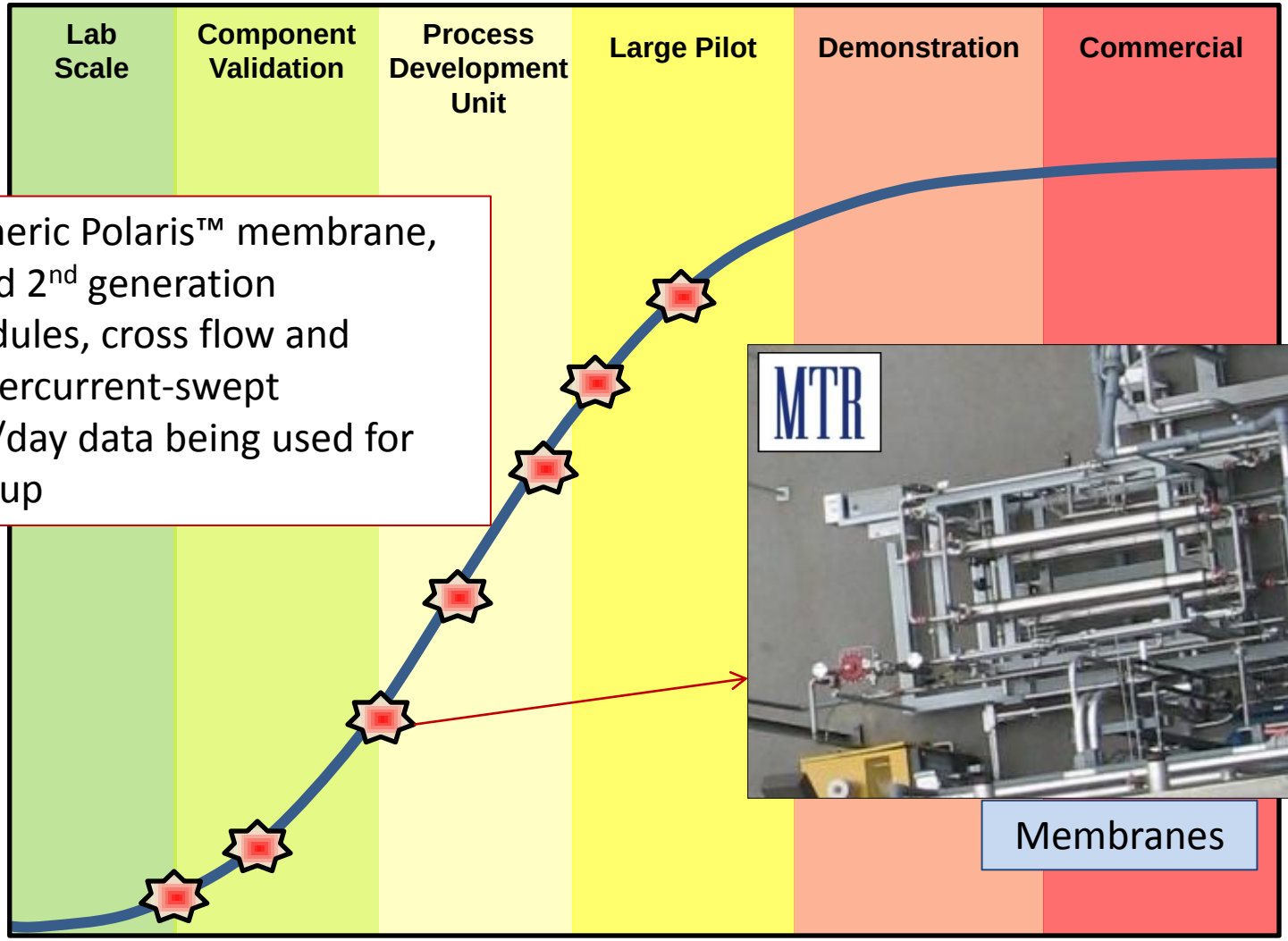
Accomplishments PC4

- Immobilized Carbonic anhydrase enzyme with Potassium Carbonate
- Up to 90% capture
- 7 fold increase in flow
- Established low solvent loss, demonstrated aerosol emissions below the detection limit



Enzymes

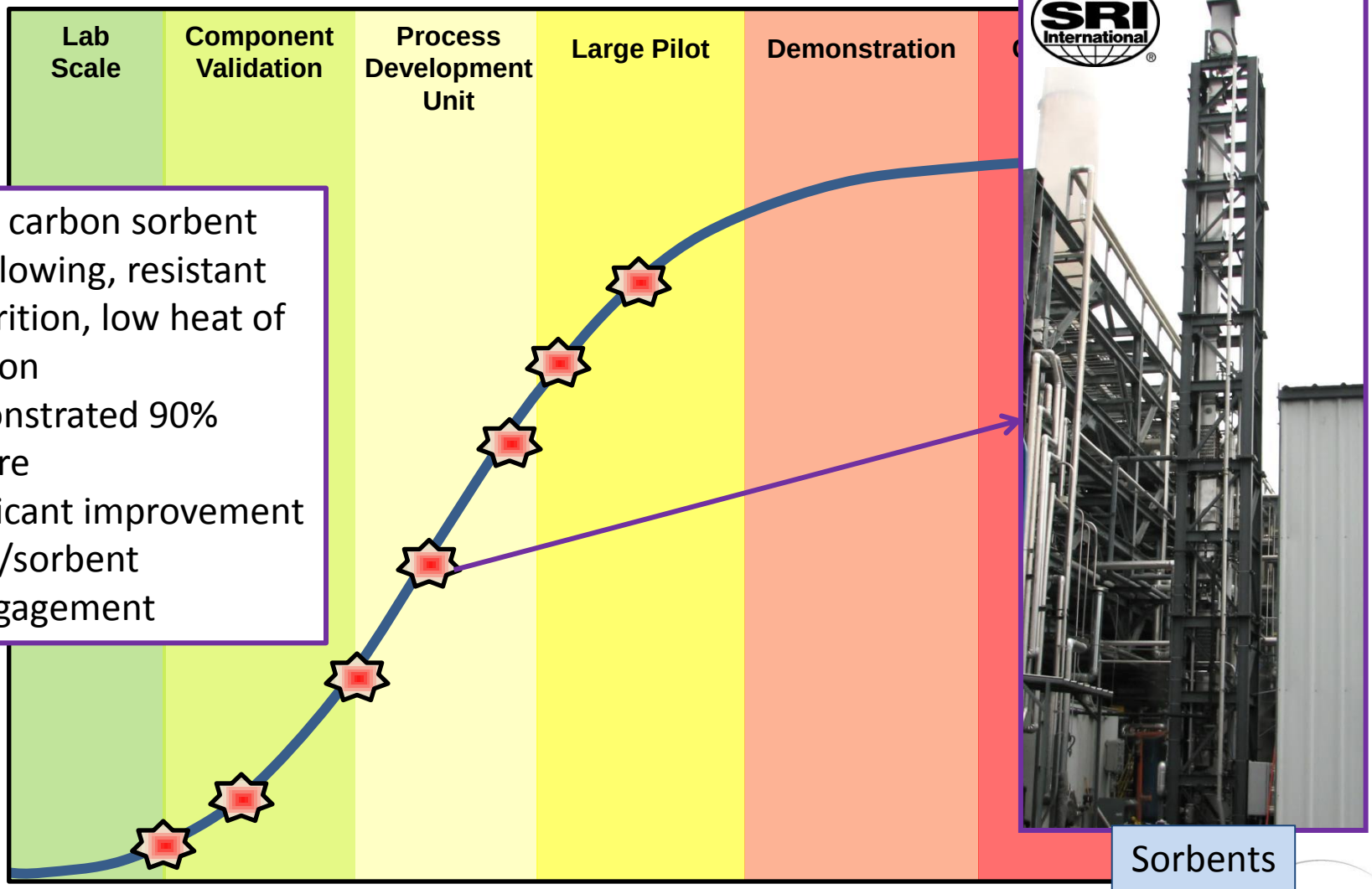
Accomplishments PC4



- Polymeric Polaris™ membrane, 1st and 2nd generation
- 2 modules, cross flow and countercurrent-swept
- 1 ton/day data being used for scale-up

Membranes

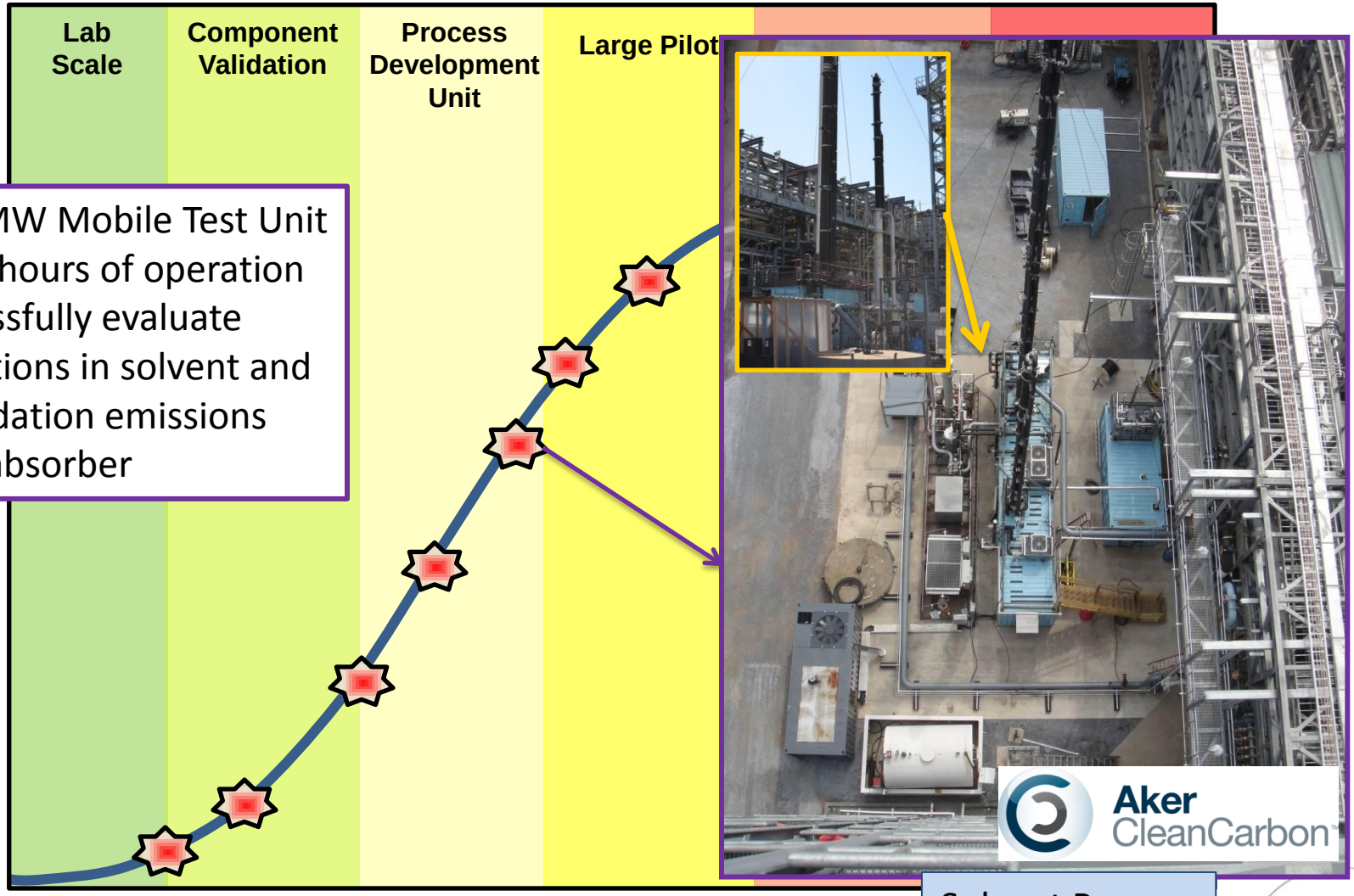
Accomplishments PC4



- Novel carbon sorbent
- Free flowing, resistant to attrition, low heat of reaction
- Demonstrated 90% capture
- Significant improvement in gas/sorbent disengagement

Sorbents

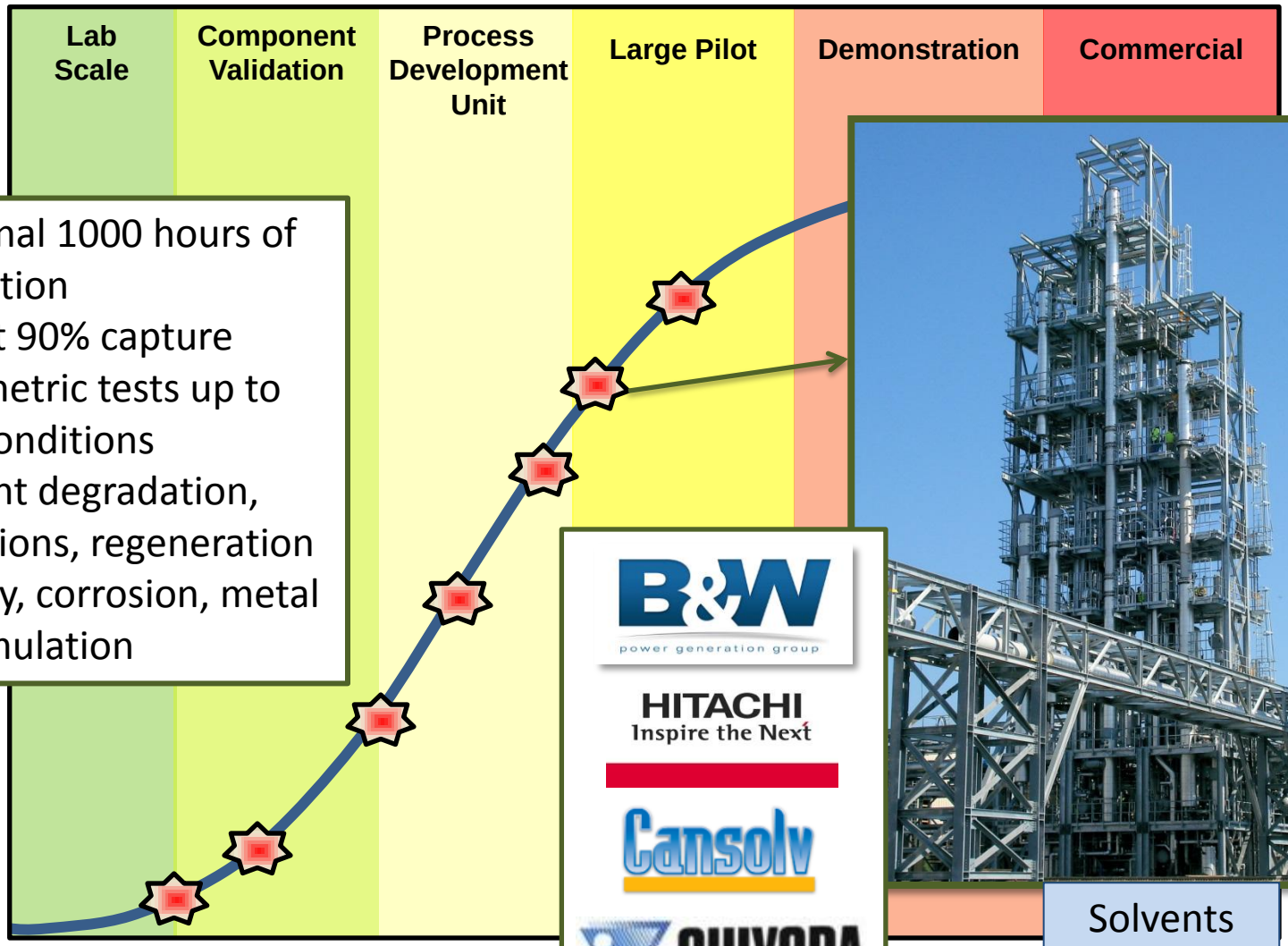
Accomplishments PC4



- 0.25 MW Mobile Test Unit
- 2,400 hours of operation
- Successfully evaluate reductions in solvent and degradation emissions from absorber

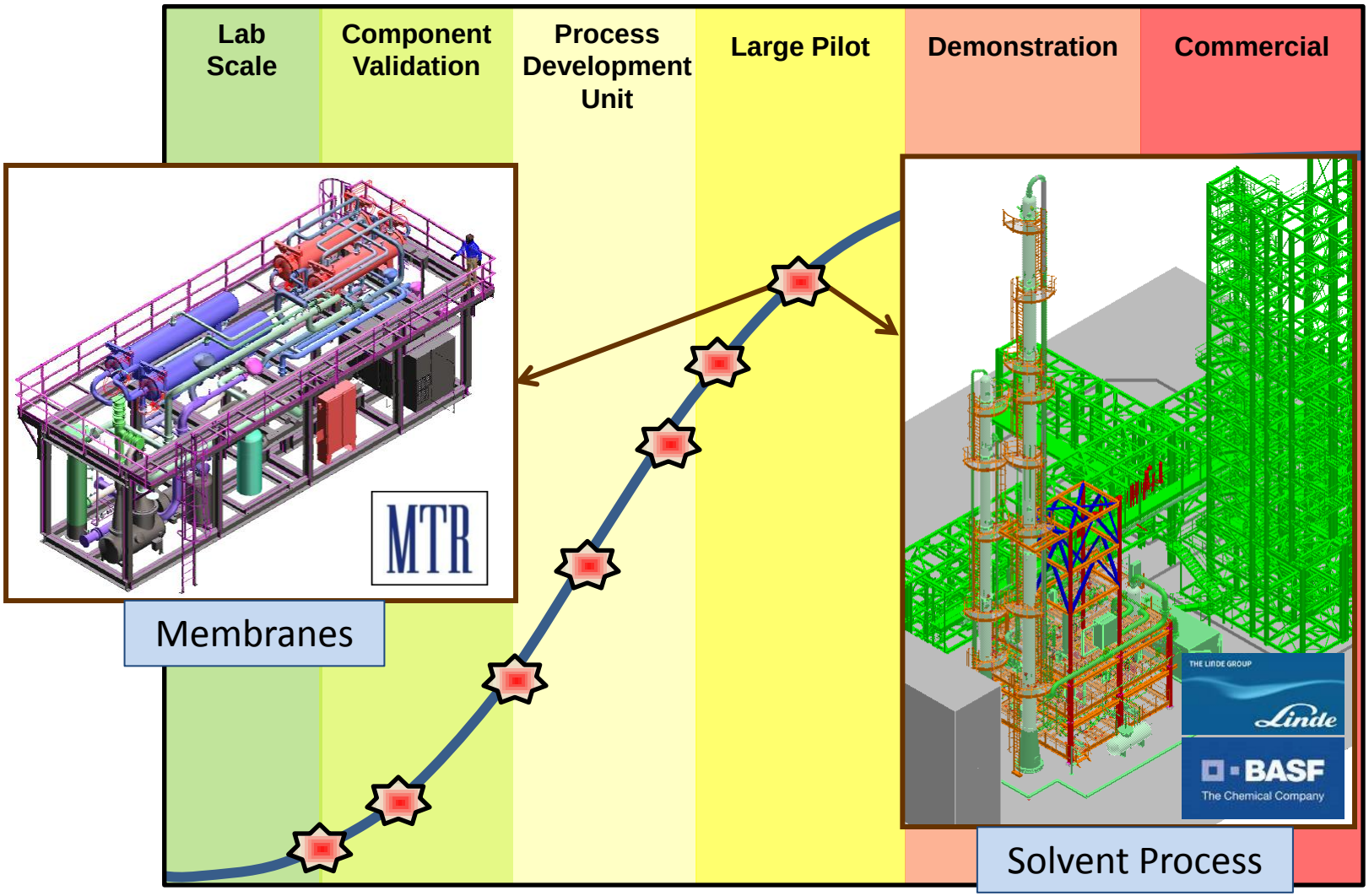
Solvent Process

Accomplishments PC4



- Nominal 1000 hours of operation
- Target 90% capture
- Parametric tests up to 100 conditions
- Solvent degradation, emissions, regeneration energy, corrosion, metal accumulation

Accomplishments PC4



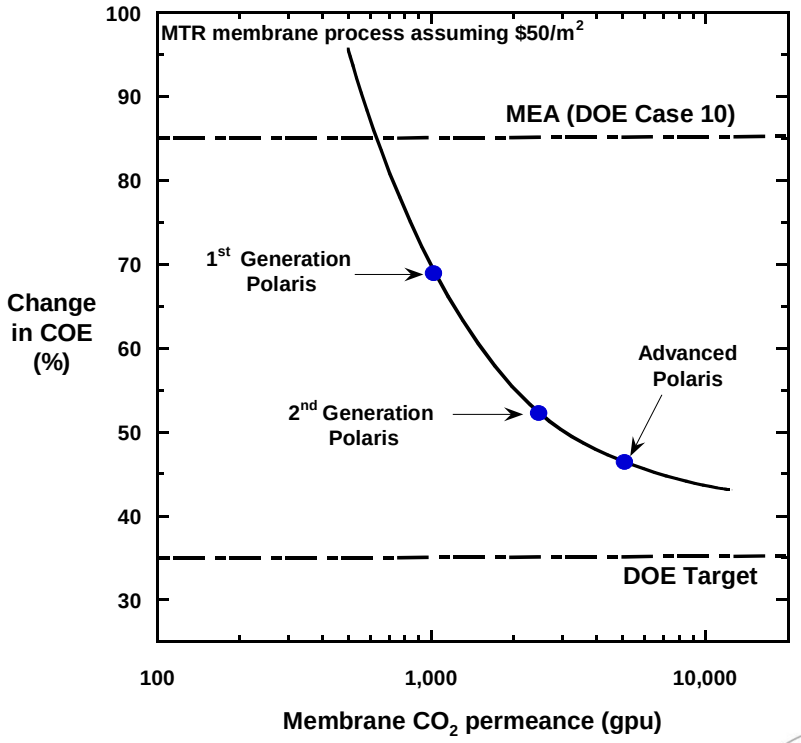
Cost Reduction for Carbon Capture - example

Develop 2nd-Generation technologies that:

- Are ready for demonstration in the 2020–2025 timeframe (with commercial deployment beginning in 2025)
- Achieve capture costs of approximately $40/tonne of CO_2 captured

MTR – Membrane

- 1 TPD Unit – 9000 hrs of operation
  20 TPD Unit – Starting this year
- Improved performance (permeance)
  - Coating application thinner
  - Coating materials
- Module cost
  - Low cost components
  - Membrane casting improvements
  - Production automation
  - Use of multi-insert module vessels



- Pilot Testing of a Membrane System for Post-Combustion CO2 Capture at NCCC, DOE-NCCC Review Meeting, March 12, 2014

Accomplishments

Designed and built unique R&D facility and assembled a world class staff

- Hosted 20 developers testing 24 different technologies
  - Tested innovative technologies emerging from NETL and ARPA-E development programs, as well as developers worldwide funded internationally
  - Provided reliable data to support continued development of their technologies.
- For pre-combustion/gasification
  - In last five years, 12 gasification test runs for 8,700 hours on coal
  - More than 20,000 hours combined testing of technologies
- For post-combustion tested more than 22,800 hours of testing

International CCS Test Center Network

CCS TEST CENTRE NETWORK

Accelerate carbon capture technology development by sharing lessons learned between the world's leading test centers

SaskPower – Boundary Dam

- Build confidence with targeted groups outside the CCS community by sharing positive stories from its research efforts
- Experts sharing knowledge in a private fashion
- Knowledge sharing among a core group of participants that operate large, technology-independent test centers
- Established knowledge sharing techniques

TCM - Mongstad

NCCC

TECHNOLOGY CENTRE MONGSTAD

SaskPower

e·on

Enel
L'ENERGIA CHE TI ASCOLTA.

Principals

Clear outcomes

- The network will focus on solving problems in a collaborative way. Analysis and problem solving should be the focus of the network, not data collection.
- We will clearly identify knowledge gaps and specific areas of focus.

Practical approaches will be taken to information sharing

- The network will share non-confidential information
- We will leverage the large amounts of public information already available.

Digital technology for better connectivity

- The network will use digital technologies for international knowledge sharing.

Financial sustainability

- Through common digital technologies and by collecting non-confidential information only the costs for running the network will be manageable.

CCS TEST CENTRE NETWORK

Criteria for Joining

Criteria	Participant Type		
	Core Organization	Participating Organization	Participating Individual
Operating a capture facility connected to a coal or gas fired power plant or an industrial plant	X		
Willing to provide fee payments as described below.	X		
Willing to host visitors for a site tour as its site facility (restrictions to be communicated by the test center)	X		
Aiming to be as neutral as possible in technology decisions	X	X	
Willing to share non-confidential knowledge and jointly work together to solve joint problems	X	X	X
Has appropriate subject matter expertise	X	X	X
Will sign off on appropriate procedures for knowledge sharing	X	X	X

CCS
TEST CENTRE
NETWORK

Topics for Knowledge Sharing

	Description	Priority
Health, safety & environment	Sharing good practice in health, safety and environment.	High
Laboratory methods	Establishing recognized methods for sampling and analysis	High
Monitoring & instrumentation	Sharing experience with measurement, monitoring and instrumentation.	High
Waste management	Sharing experience with reclaimer units and the removal and / or treatment of waste.	High
Benchmarking	The definition of standard methods necessary and proper key performance indicators, such as energy consumption per tonne of CO_2 captured. Will apply to currently tested processes only	High / Medium
Scale-up	Risks and lessons learnt regarding challenges around scaling up a test center	Medium

CCS TEST CENTRE NETWORK

Topics for Knowledge Sharing

	Description	Priority
Technology verification	Verifying that the technology being tested does as is claimed	Medium / Low
Harmonization of requirements	Accelerating technology development through harmonization of testing requirements. This is rated as low priority as harmonization of requirements across test centers is unlikely to be achieved.	Low
Operational experience	Sharing experience with common equipment such as pumps, compressors and heat exchangers.	Low
Regulations	Sharing experience with legislation and regulatory framework conditions.	Low
Technology Screening studies	Assessing what companies are leading in capture technology and should be used as potential candidates for technology testing. Screening studies have been defined as technologies that have the potential to be implemented in future (beyond 5 years)	Low

CCS TEST CENTRE NETWORK