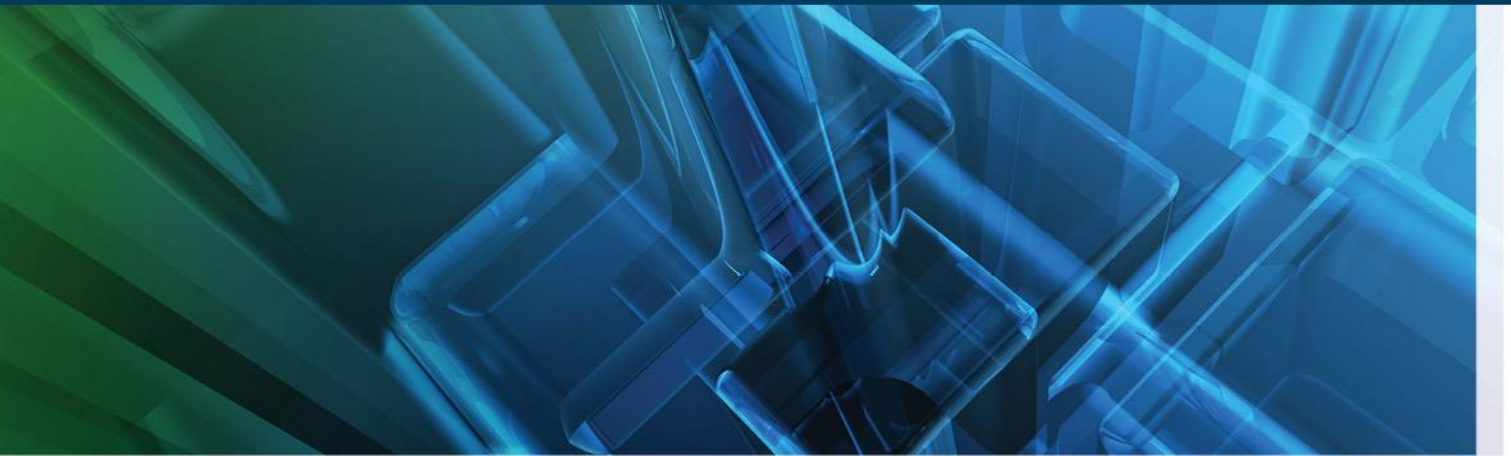
International Collaboration on CCUS R&D

Frank Morton – Director Technology Development



NATIONAL CARBON CAPTURE CENTER

International Collaboration for the Development of CCUS R&D

- **Overview of the NCCC**
  - **Establish cost-effective test facility which protects IP**
- **International activity**
  - **NCCC test collaborations**
  - **ITCN**
- **Path forward**
- **Importance of operating facilities**
  - **Policy, messaging, funding commitment from industry and gov't**

NATIONAL CARBON CAPTURE CENTER

National Carbon Capture Center

*Offering a **world-class neutral test** facility and highly specialized staff to **accelerate the commercialization** of advanced technologies and enable coal-based power plants to achieve **near-zero emissions (low-cost CO_2)**.*

- Over **97,000 test hours** since founding in 2008
- Technology developers from **U.S. and six other countries**
- **First coal-derived gas testing** of solid oxide fuel cells and certain solvents, membranes and enzymes
- On-site **scale-ups** and **process enhancements** for 10 technologies
  - Scale-ups for testing at larger sites for five solvents
  - Scale-up to commercial operation for one solvent

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

Timeline: June 1, 2014 – May 31, 2019

Southern Company

CLEARPATH

AEP AMERICAN ELECTRIC POWER

CLOUD PEAK ENERGY

DUKE ENERGY

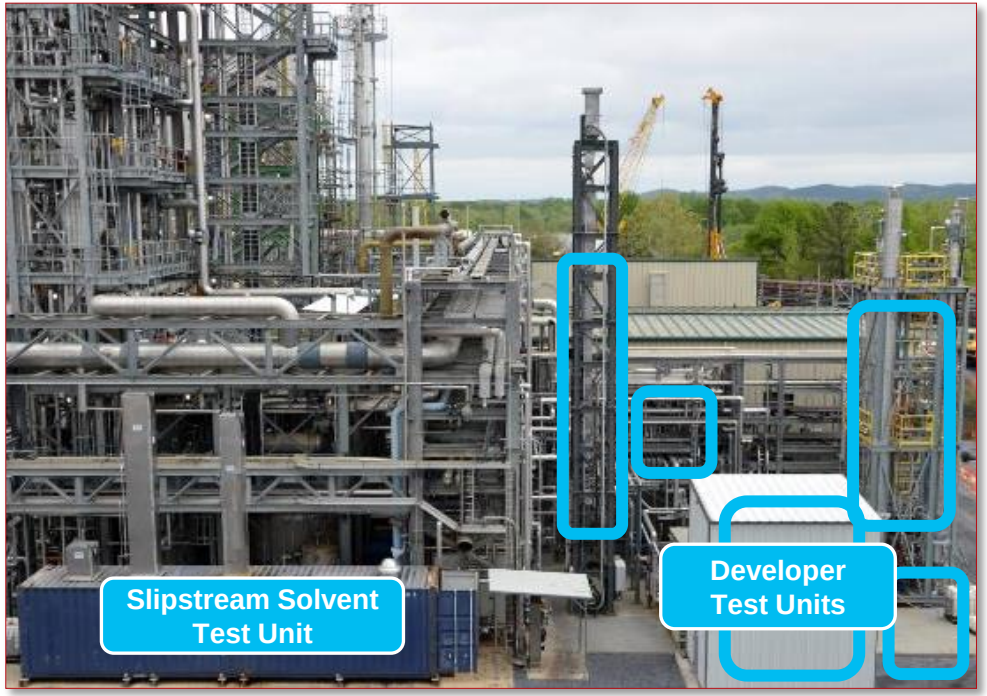
EPRI ELECTRIC POWER RESEARCH INSTITUTE

What the Project Provides

- **Cost-efficient test site** with **infrastructure** for numerous technology developers
- **Real-world conditions** with coal-derived flue gas and syngas
- Flexible capability for testing at **multiple scales** and **on-site scale-ups**
- Expert **technical staff for** design, installation and testing support
- High-quality **data acquisition** and gas/liquid **sampling and analysis**

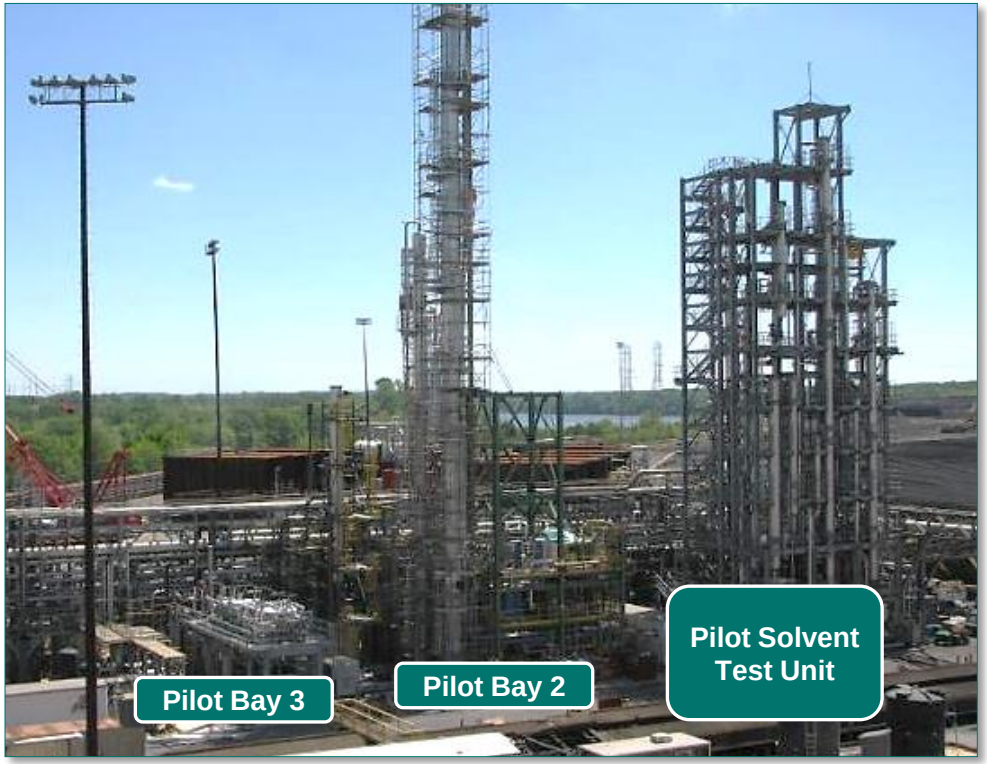
PC4 Bench-Scale

- Simultaneous operation of up to five developers' test units
- Slipstream Solvent Test Unit (SSTU) for solvents in early development
- SSTU also used for solvent emissions studies and emission mitigation processes
- Flue gas/utilities and gas analysis systems operating independently of PC4 pilot-scale area



PC4 Pilot-Scale

- Simultaneous operation of developer test units and Pilot Solvent Test Unit (PSTU)
- PSTU offers flexible operation to match developers' planned commercial configuration
- PSTU also supports solvent emissions and degradation studies



NCCC International Collaboration

Carbon capture R&D is an international issue that requires international collaboration

- Support DOE goal of international cooperation
- Multiple paths for involvement; partners, developers, network members, consulting services and workshops
- Ease of collaboration since intellectual property is not being shared
- Broad effort China, India, Middle East, Korea, Japan, EU, Australia, Canada, Norway







NATIONAL CARBON CAPTURE CENTER

China

- Shenhua - NICE
  - MOU for knowledge sharing
  - Exploring test collaboration
- China Partner 1
  - Research group partnered with major power company
  - Signed MOU 2015
  - Negotiating contract for collaboration
- Huaneng – Clean Energy Research Institute
  - Joined ITCN
  - Exploring test collaboration
- Initial Meetings
  - Sinopec, Datang, CPI, Tsinghua Univ, Zhejiang Univ, Guodian, CATF, Wuhuan

Signing Ceremony
GDCCUS Facility

Post-Combustion

India

CCSi Test at Solvay Chemical in India

- Could become largest emitter of CO_2
- CCSi – Tested at the NCCC
- TIFAC within the Dept of Science and Tech is coordinating collaboration with government agencies
- In discussion with major oil & gas and power companies for knowledge sharing.

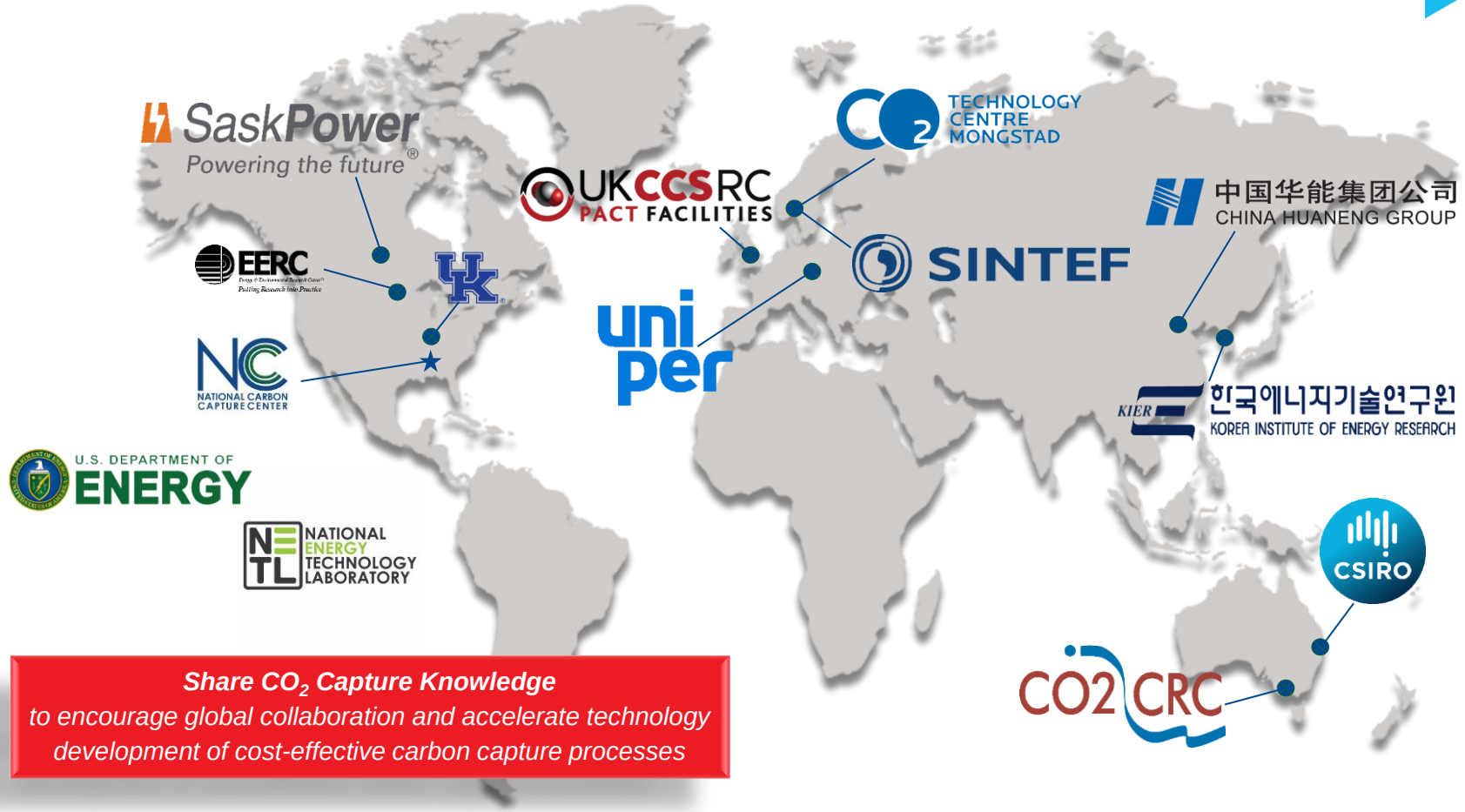
Middle East

- Growing interest in EOR
- Extensive, well-funded green movement in the Middle East
- Countries want to participate in advanced power projects internationally
- UAE - Advanced negotiation with ADNOC on NCCC membership.

Emirates Steel - CCUS

Minister of Oil - Oman

International Test Center Network Members



Share CO_2 Capture Knowledge
to encourage global collaboration and accelerate technology development of cost-effective carbon capture processes

International Test Center Network

- Share pubic knowledge with carbon capture test facilities.
  - Facility operations
  - Facility funding
  - Safety
  - Analytical techniques
- Collaborate on one technical item per year.
  - Amine carry-over and measurement techniques
  - Support advanced simulations and model development with a focus on reducing capital and operating cost and minimizing scale-up risks

Share CO_2 Capture Knowledge
to encourage global collaboration and accelerate technology development of cost-effective carbon capture processes

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