



The CCP3 Collaboration Project – Main Achievements & Forward Plans

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CCP3 “Demonstrate technologies that will reduce the cost and accelerate deployment of CCS”

“Project **Delivery** Focus”

“Field/plant **access** for pilot/demo’s”

“Company **Expert** Collaboration”

“**Mid TRL** level technology development”



“Independent **Verification** of Cost
and Performance”

“**Global** network of external
partners”

“Technology **Agnostic**”

“**Effectively** managed and run”

• Separation & Capture

- Supply of CO₂ from a range of oil and gas industry scenarios
- Finding and validating low cost CO₂ capture (flue gas) technologies
- Finding and validating lower cost CO₂ separation (feed gas) technologies
- Advancing CO₂ Metering, Compression, and Transportation technologies

• Utilization & Storage

- Validating that CO₂ can be safely and securely stored
- Developing and trialing surveillance and monitoring technologies
- Assessing & predicting existing well integrity
- Providing tools that can help regulatory site certification
- Understanding the science of fundamental subsurface processes

Capture Program



•Image courtesy of Petrobras

- Field demonstration of Fluid Catalytic Cracking (FCC) oxy-firing capture technology at Petrobras, Brazil
- FCC is one of the main sources of oil refinery CO₂ emissions (20-30%)
- Aim: to evaluate operability, test start-up, shut down procedures and obtain data for scale-up



- Capture from multiple Once Through Steam Generators (OTSGs) in the Canadian oil sands has been studied in CCP3
- Cases were designed to provide the same amount of useful injection steam as the reference case



Image courtesy of Cenovus

Development projects

- Capture of CO₂ from refinery heaters using oxy-fired technology
- Chemical Looping Combustion (CLC)
- Membrane Water Gas Shift (MWGS)

Economic evaluation

A detailed study by Foster Wheeler on state-of-the-art technologies for the capture of CO₂

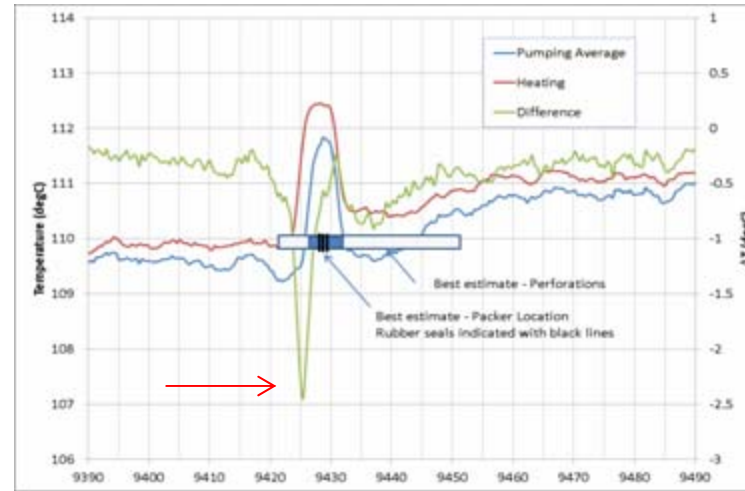
- Refinery process heaters (4 x 150 MMBTU/hr) – US location
- Regenerator of FCC unit (60,000 bpd) – US location
- Hydrogen production for chemical (Steam reforming) or fuel use (Autothermal reforming) – US location
- Natural Gas Combined Cycle (NGCC) power station (400 MW) – European location
- OTSG for Steam Assisted Gravity Drainage (SAGD) oil extraction – Alberta location

SMV Program

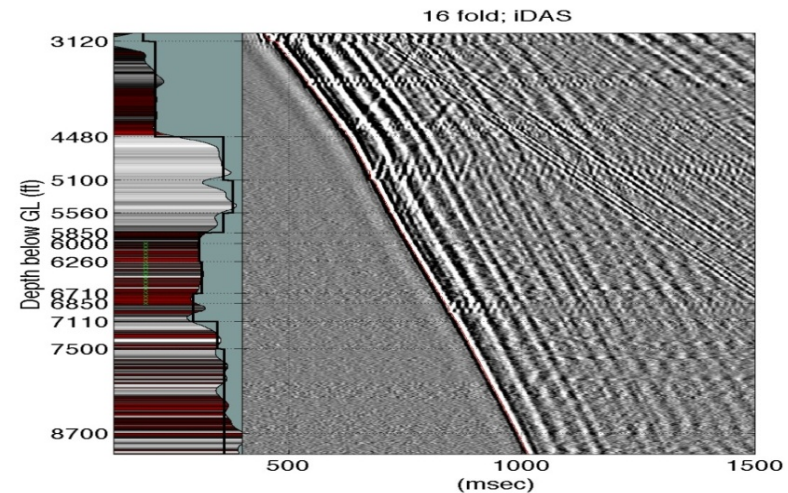
- **Well Integrity** – Stability of well barrier function with geomechanical and geochemical alteration
- **Subsurface Processes** – Physicochemical interactions that affect storage assurance
- **Monitoring & Verification** – Retrospective performance of past deployments and decision support; Technology development
- **Optimization** – Risk-based analysis of storage program development, economics of CO₂ EOR/storage and EGR utilization challenges in unconventionalals
- **Field Trialing** – Deployment and performance analysis of new and adapted monitoring technologies at third party field sites
- **Contingencies** – Detection, characterization and intervention in unexpected CO₂ migration through top/fault seals

SMV Program – Field Trialing

- Time-Lapse TCR and RST – comparability of pre-flood, open hole resistivity and post-flood TCR logs to infer saturation [T. Dance, CO2CRC/CSIRO; A. Datey, Schlumberger]
- Borehole Gravity – Resolution and reproducibility at Cranfield [SECARB; CSM, LBNL]
- Decatur – Remote detection capability
 - InSAR [G. Falorni, TRE-Canada]
 - GPS [T. Dixon, U Florida]
- Modular Borehole Monitoring system
 - Design (Design) [T. Daley et al., LBNL]
 - Deployment (Citronelle) [SECARB, LBNL, EPRI, ARI]
- Downhole to surface EM evaluation at Aquistore [LBNL, Groundmetrics,]
- Soil Gas Monitoring Method [K. Romanak, UT-BEG]



Successful diagnosis of pressure bleed off issue – i.e., DTS showed fluid influx above packer due to off depth perforations, not the MBM assembly (B Freifeld, LBNL & R Trautz, EPRI)

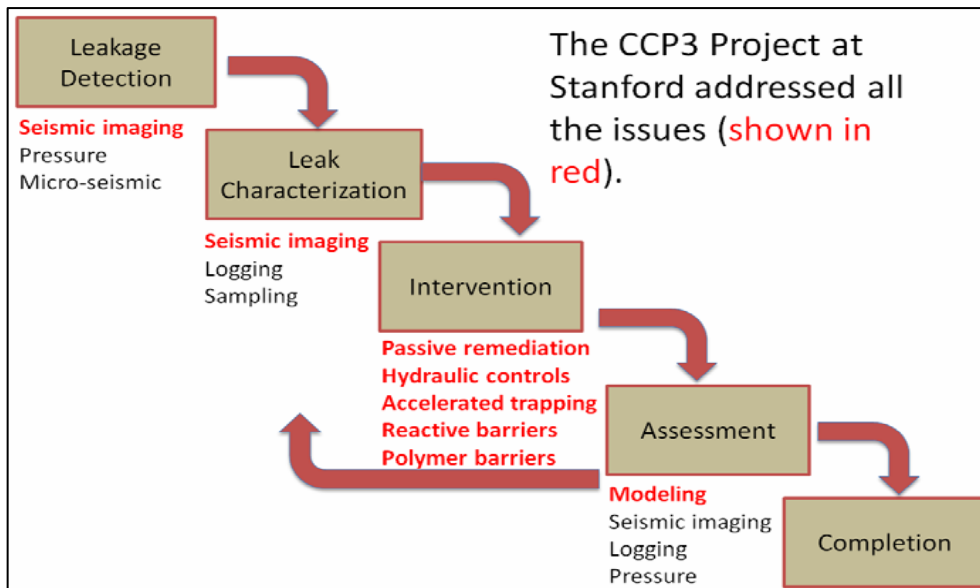


Fiber Optic DAS VSP quality (T Daley, LBNL & D Miller Silixa)

SMV Program – Contingencies

Projects

- Detection, characterization and intervention in top or fault seal CO₂ leakage (Stanford) [S. Benson & A. Agarwal et al., Stanford]
- Feasibility and design for a “fracture-sealing experiment at Mont Terri Underground Lab. [P. Ledingham, GeoScience Ltd., et al.]



Mont Terri CS-B Experiment
Schematic Experimental Setup

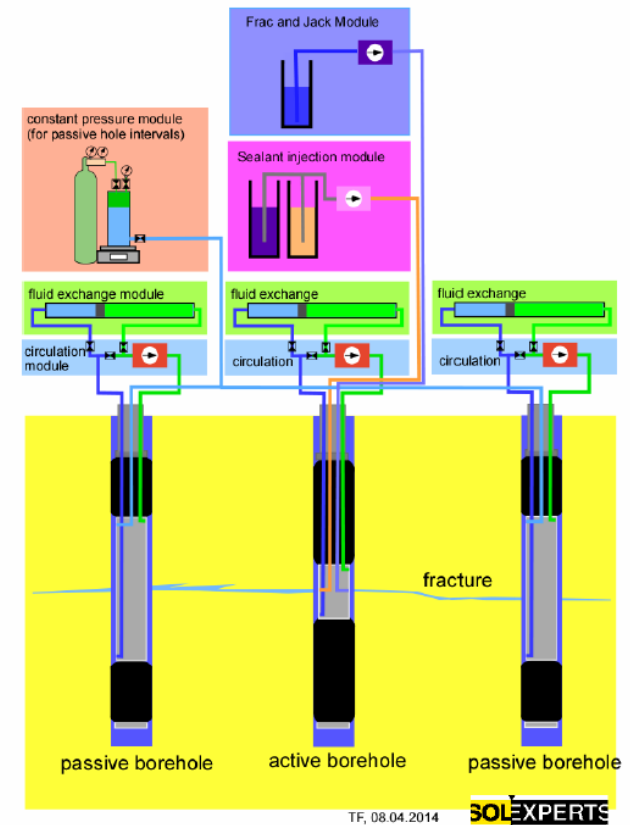


Figure 11: Schematic experimental setup

Modeling and simulation topics covered for Stanford / CCP3
Contingencies study

Our teams:

SMV:

Mark Bohm (Suncor), Marco Brignoli (eni), Stephen Bourne (Shell), Andreas Busch (Shell), Mark Chan (Suncor), Walter Crow (BP), Rodolfo Dino (Petrobras), Kevin Dodds (BP), Grant Duncan (Suncor), Scott Imbus (Chevron), Dan Kieke (Chevron), Claus Otto (Shell).

Capture:

Jonathan Forsyth (BP), Ivano Miracca (eni), Raja Jadhav (Chevron), Betty Pun (Chevron), Leonardo de Mello (Petrobras), Gustavo Moure (Petrobras), Jamal Jamaluddin (Shell), Mahesh Iyer (Shell), Frank Wubbolts (Shell), Dan Burt (Suncor), Iftikhar Huq (Suncor), David Butler (David Butler & Associates), Michael A. Huffmaster (P.E. LLC).

Capture Research partners, collaborators and funders:

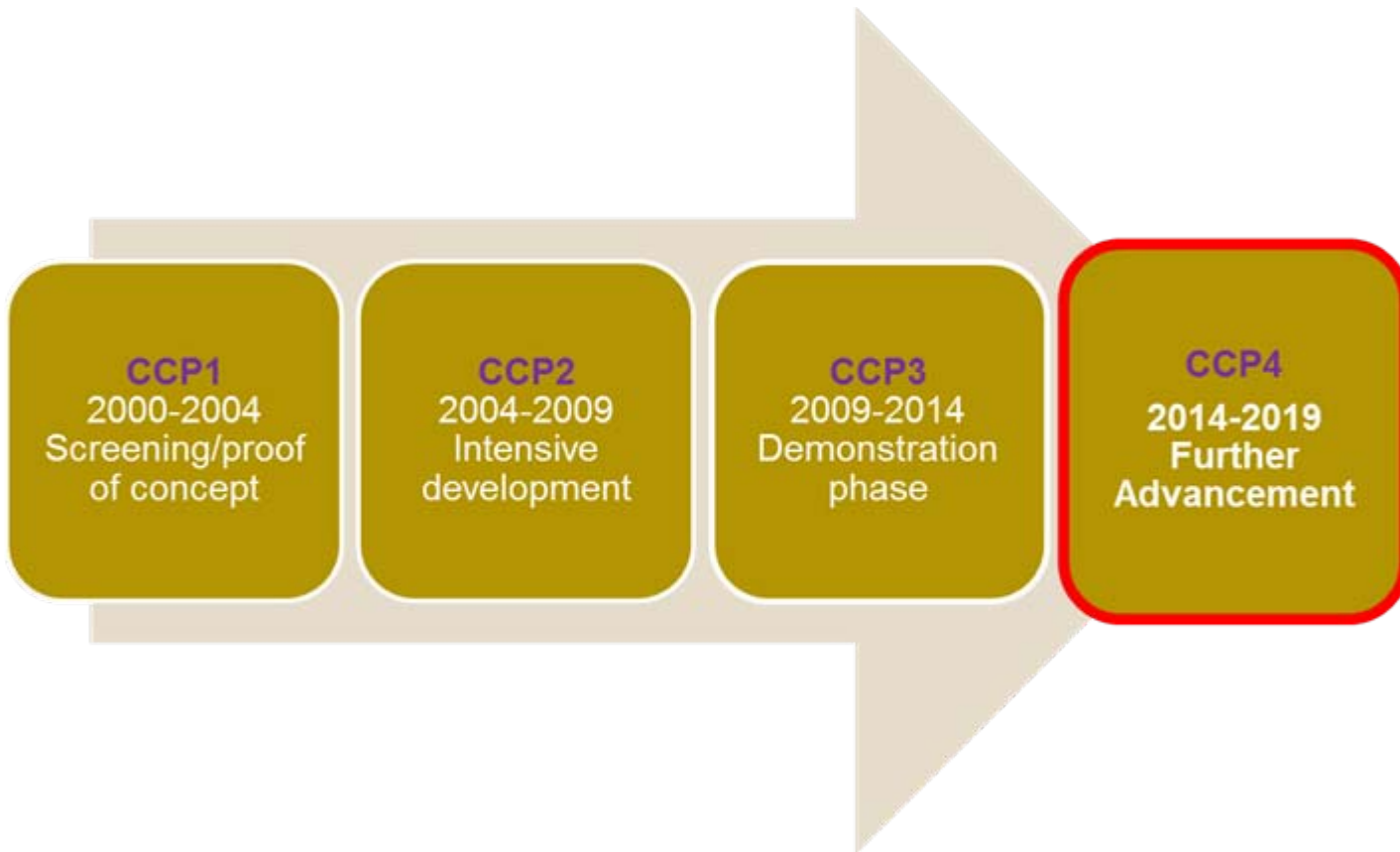
Alberta Climate Change and Emissions Management Corporation (CCEMC), Cenovus FCCL LTD., Chalmers Tekniska Hoegskola AB (Chalmers), Consejo Superior De Investigaciones Cientificas (CSIC), CO2Solutions Inc., Devon Canada, Flemish Institute For Technological Research (VITO), Foster Wheeler Energy Ltd., Ion Engineering LLC., Johnson Matthey Public Limited Company (JM), John Zink Company LLC., Josef Bertsch Gesellschaft MBH & CO KG (Bertsch), MEG Energy, NTNU Faculty of Engineering Science and Technology Department of Energy and Process Engineering, Pall Corp., Petróleo Brasileiro S.A., Process Design Center B.V., Praxair Inc., Shell Global Solutions International B.V, Suncor Energy Services Inc., Statoil Canada Ltd., University of North Dakota Energy & Environmental Research Center (EERC), Vienna University of Technology (TUV).

SMV Research partners, collaborators and funders:

Lawrence Berkeley National Lab (LBNL), Los Alamos National Lab (LANL), Southeast Regional Carbon Sequestration Partnership (SECARB), Univ. Texas Bureau of Economic Geology (UT-BEG), Univ. Texas Center for Petroleum & Geological Engineering (UT-CPGE), Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), Midwest Geological Sequestration Consortium (MGSC), Colorado School of Mines (CSM), Stanford University, Schlumberger, TRE Canada, Univ. of Florida, EPRI, ARI, Groundmetrics, Merchant Consulting, Taurus Reservoir Solutions, Univ. of Aachen RWTH, Silixa, Geoscience Ltd, Denbury.



CCP4 “Advancing CCS technology deployment and knowledge for the oil and gas industry”



Tactical Demonstration (short-medium term)

Capture: Incremental Improvement Technologies, NG Treating
SMV: Pilot/Demo scale of scientific fundamentals, Utilization
P&I: Regional Incentives & Global Regulations
Comms: Industry Knowledge Sharing

Strategic Deployment (medium-long term)

Capture: Breakthrough Technologies, NG Power/Cogen
SMV: Basin Scale Development and Operation
P&I: FOAK to NOAK Pathway
Comms: External Stakeholder Engagement

Advancing CCS

Questions?