



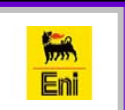
CO₂ Capture Project

CO₂ Capture Project Phase 2: Storage Monitoring and Verification Program (SMV) An Overview

CCP2 NGO Focus Group Meeting

Washington DC

October 27, 2005





CO₂ Capture Project

The SMV Team

BP	Charles Christopher (co-Lead) Dan Ebrom Murali Venkataramanan
ConocoPhillips	Chip Feazel Alan Rezigh
Chevron	Scott Imbus (Lead) Dan Kieke
Eni	Antonio Pellagrino
Hydro	Lars Ingolf Eide
Petrobras	Rodolfo Dino
Shell	Nigel Jenvey Tom Mikus
Suncor	Cal Coulter





CO₂ Capture Project

Review CCP1-SMV

30+ Studies from R&D organizations and consultants from the US, EU, Norway and Australia addressing issues in storage:

- 1) Integrity of geologic and engineered systems
- 2) Optimization of processes and economic offsets
- 3) Monitoring of performance and leakage
- 4) Risk assessment of containment systems

Major findings include:

- Containment of geologic systems is predictable using 3D stratigraphic structural models and fluid history analysis
- CO₂ geo-storage compares favourably with natural & industrial analogs
- Well integrity is a concern but mitigating factors and engineering solutions exist
- Economic efficiencies and offsets are available for capture purity, pipeline transportation and enhanced recovery
- Cost-effective monitoring technologies from multiple vantage points are available or under development but testing is needed
- Suitable probabilistic and deterministic risk assessment protocols have been developed but need to be benchmarked, simplified and tested





CO₂ Capture Project

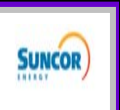
CCP2-SMV Program

Major Objectives

- Address issues arising from CCP1-SMV and other JIP work
- Move from R&D to deployment-ready
- Testing of CCP technologies and protocols

Projects

- Well Integrity
- Certification Framework
- Operational Parameters
 - Coupled Geochemical / Geomechanical Simulation
 - Efficiency and HSE Limits
- Monitoring
 - Direct Remote Sensing of CO₂ & Methane
 - Novel Geophysical Concepts
 - Well-Based *In Situ* detection
- Pilots & Demos





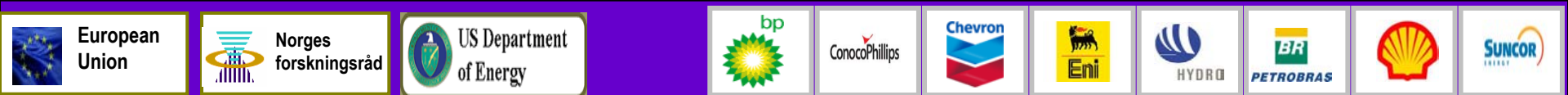
CO₂ Capture Project

Well Integrity

SMV is developing a well “autopsy” and “prognosis” study for use on a decommissioned well that has been CO₂-exposed for 2-3 decades. Scoping is in progress.

- Well selection based on design, production history and logging assessment
- Extensive sampling / analysis of solids and fluids to assess current state
- Experiment on well materials to infer reaction kinetics
- History model developed for alteration over time
- Forward simulation to predict well stability over extended time
- Identification of engineering solutions to vulnerabilities in well design and materials with insight into intervention and remediation efforts

The well integrity study will provide quantitative information on well stability during the operational phase and a realistic prognosis for long term stability. Insight into well design and materials and options for remediation, intervention and abandonment will provide appropriate regulatory criteria.

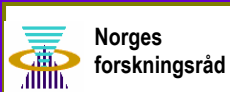




CO₂ Capture Project

Well Integrity – Feedback from the Group

- 1) Will this program address some of the major concerns about well integrity?
 - Assessing condition of existing wells
 - Capability to build models and production / work over history match
 - Projection of well fate into the future
- 2) Should there be more emphasis on well materials / design or radical ideas in rehabilitation-remediation and intervention?





CO₂ Capture Project

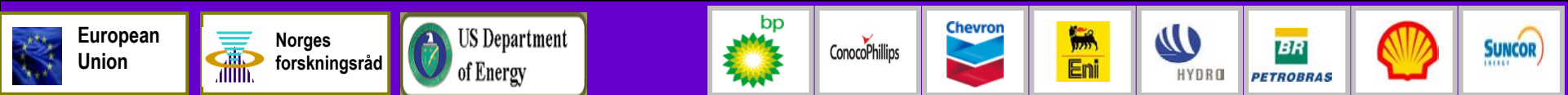


Certification Framework

SMV recognized the need for a simple, transparent and systematic process for storage site assessment, including risk assessment. Proposal by Lawrence Berkeley NL and the University of Texas nearing completion.

- Develop generic model
- Simulate CO₂ injection in model reservoir
- Screen leakage and accumulation scenarios at vulnerable assets (e.g., potable aquifers and surface water, soil zones, hydrocarbon deposits)
- Simulate impacts to vulnerable assets
- Risk assessment
- Visualization and stakeholder outreach (convene review panel)

The application developed could comprise the frame work for screening prospects, a "certification" protocol for regulators and a means of defining success criteria to justify field decommissioning.

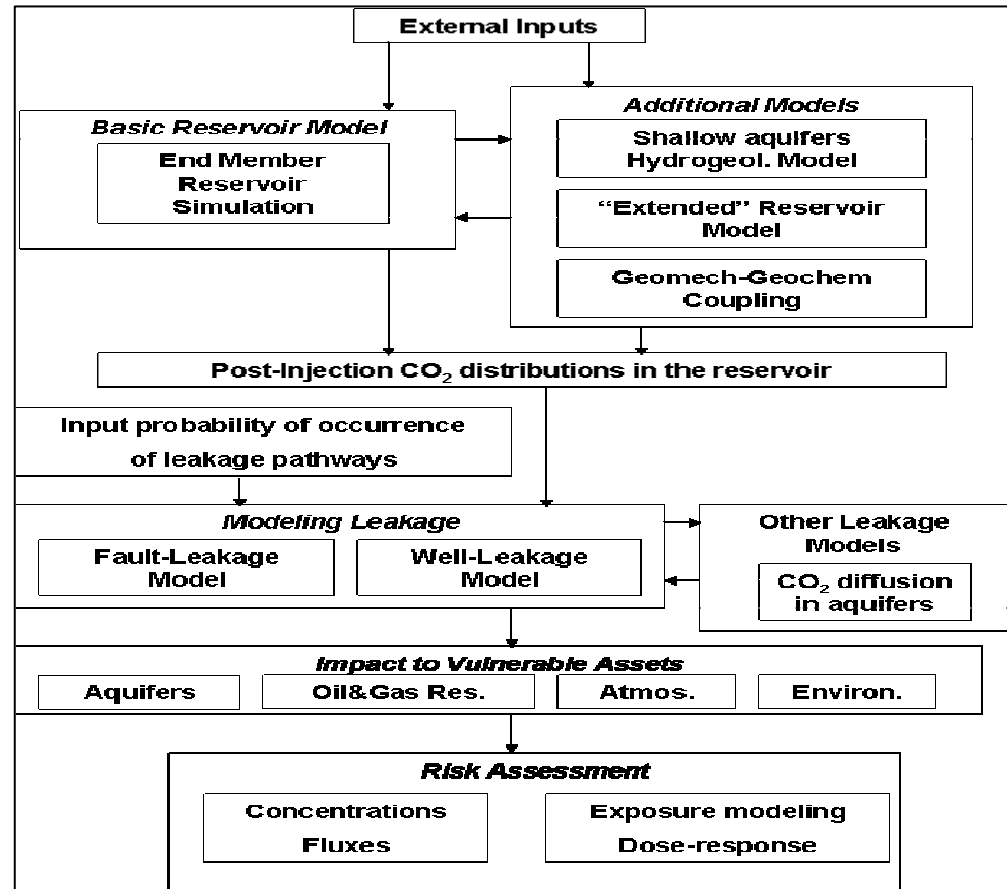




CO₂ Capture Project

Certification Framework (cont.)

Study Work Flow





CO₂ Capture Project

Certification Framework – Feedback from the Group

- 1) Does the project have the right balance of technical rigor and simplicity / transparency to be acceptable to the regulator / NGO stakeholders?
- 2) Should the project be fast-tracked to be of more immediate use?
- 3) At present, application development is out of scope. Should funding be increased to include this?
- 4) What would a credible yet constructive review board look like?





CO₂ Capture Project

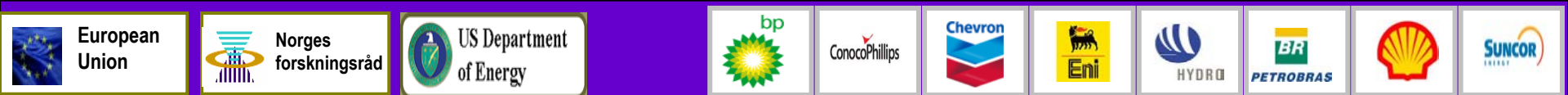
Operational Parameters - Coupled Geochemical-Geomechanical Simulation

Short- and long-term interactions between CO₂ (and its phases) and reservoir-seal fluids and rocks is recognized as near-term operability and lifecycle containment issue. An assessment tool will be developed by the University of Bergen (with a possible inclusion of a second EU technology provider).

- Literature variables and geomechanics code inserted into ATHENE
- Analysis of geomechanics and fractures
- Geochemical effects on porosity / permeability and geomechanics
- Test case 1 (Utsira) and test case 2 (TBD)

Coupling of geochemical and geomechanical simulations will be predictive of reservoir-seal integrity and thus guide regulatory field operational and abandonment parameters. The application developed will become public domain once tested.

Co-Funder: Norway Climit

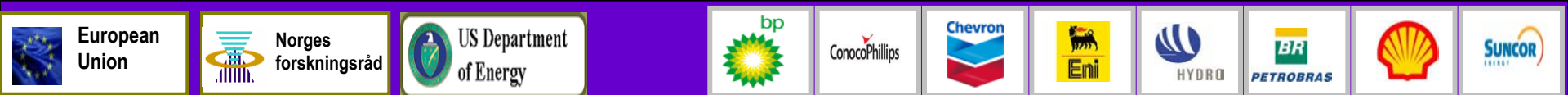




CO₂ Capture Project

Operational Parameters - Coupled Geochemical-Geomechanical Simulation – Feedback from the Group

- 1) Is availability of a fully coupled geochemical-geomechanical application essential?
- 2) What would be the most useful 2nd Norwegian North Sea case study (note that Norway is moving forward on offshore storage of onshore emissions)?





CO₂ Capture Project

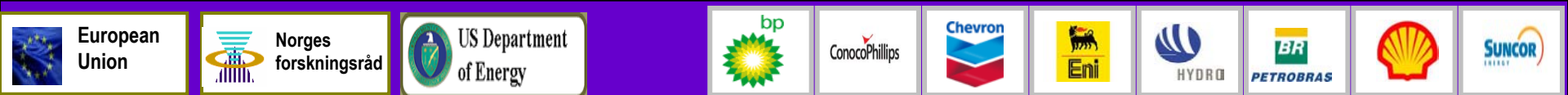
Operational Parameters – Efficiency and HSE Limits

Efficient operating conditions are needed to ensure the technical and economic success of CO₂ storage projects within HSE limits. A coal seam / cap rock simulation program is underway with Sproule associates.

- Data acquisition and initial simulations
- Secondary simulations and model development
- Final simulations and optimal settings / strategies

The operational parameters study is relevant to coal but an analog study could be applied to siliciclastic reservoirs and aquifers. The results of the study may be used to regulate operational parameters and establish system “preservational” conditions necessary for secure field decommissioning.

Co-Funder: US DOE

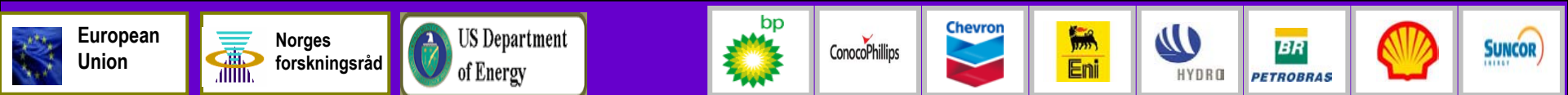




CO₂ Capture Project

Operational Parameters – Efficiency and HSE Limits – Feedback from the Group

- 1) Will this project increase HSE confidence for CO₂ storage in coal beds?





CO₂ Capture Project

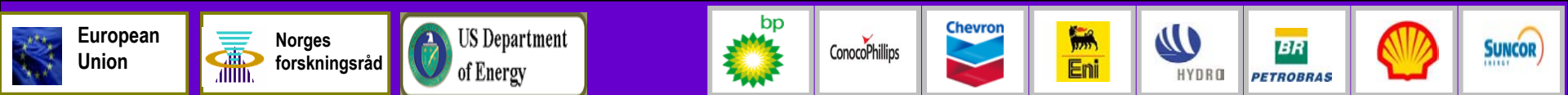
Monitoring – Direct Remote Sensing of CO₂ & Methane

Development of direct aerial CO₂ and methane detection methods would be a cost-effective means of monitoring leakage from CO₂ large storage projects. Study underway at University of California – Santa Cruz.

- Site identification and characterization (e.g., open coal mine, landfill or controlled release)
- Thermal hyperspectral imaging (adaptation of existing or new technology)
- Data processing, anomaly identification and mapping

This project has high technical risk, but if successful will be useful for GHG monitoring of multiple settings

Co-Funder: US DOE

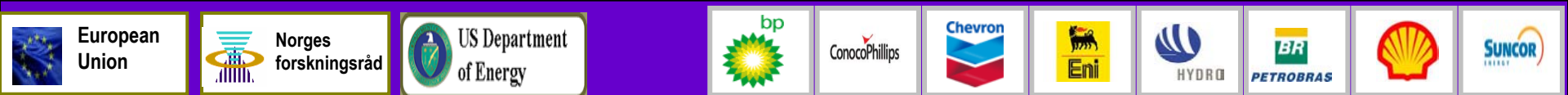




CO₂ Capture Project

Monitoring – Direct Remote Sensing of CO₂ & Methane – Feedback from the Group

- 1) Remote (satellite & aerial) techniques for GHG detection are “soft” technically. Is the risk (money) / reward (success) appropriate?





CO₂ Capture Project

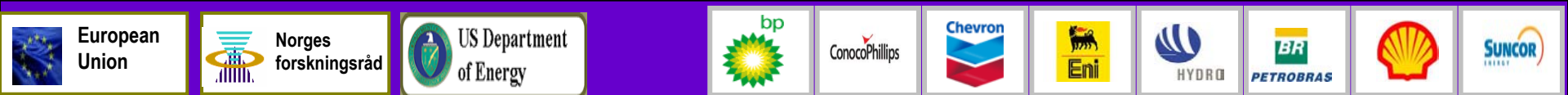
Monitoring – Novel Geophysical Concepts

Non-seismic geophysical techniques may be of sufficient resolution to monitor CO₂ flood performance and leakage. Coal-bed case study conducted by Lawrence Berkeley NL (with seam model used in Sproule Assoc. “Operational Parameters” study)

- Generation of 3D geophysical models
- Geophysical models run and simulations inverted
- Direct inversion of test data

Non-seismic monitoring methods, if proven, will be a cost-effective and environmentally benign alternative to surface seismic methods. A parallel saline aquifer case is being conducted in collaboration with the Australian CO2CRC.

Co-Funder: US DOE

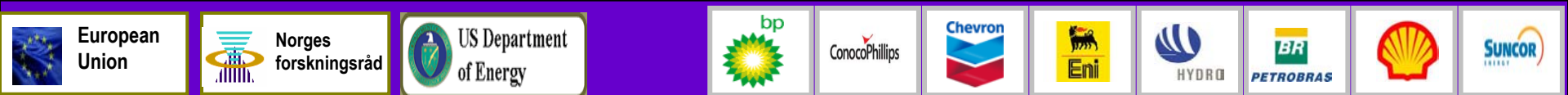




CO₂ Capture Project

Monitoring – Novel Geophysical Concepts – Feedback from the Group

- 1) Novel geophysical techniques may offer low-moderate resolution monitoring for CO₂ flood performance and possibly leakage. If successful, would this be an acceptable alternative to 3D seismic (in coal or other storage venues)?





CO₂ Capture Project

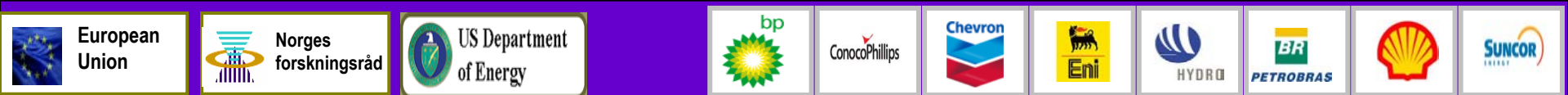


Monitoring – Well-Based *In Situ* Detection

A novel well design that allows accumulation of CO₂ in the subsurface with detection using conventional logging tools. A pressurized vessel containing water saturated sand will be injected with supercritical and vapor phase CO₂. The study is a continuation of the CCP1 2004 study conducted by Schlumberger.

- Design, specifications and materials
- Vessel construction & testing at reservoir T&P
- CO₂ charging and testing of logging tools
- Optimization of fluid accumulation and detection
- Final testing with deployment recommendations

This is a unique approach to CO₂ flood performance and leakage detection that involves modest modification of standard well designs. Early detection of leakage will facilitate intervention decisions and methods.

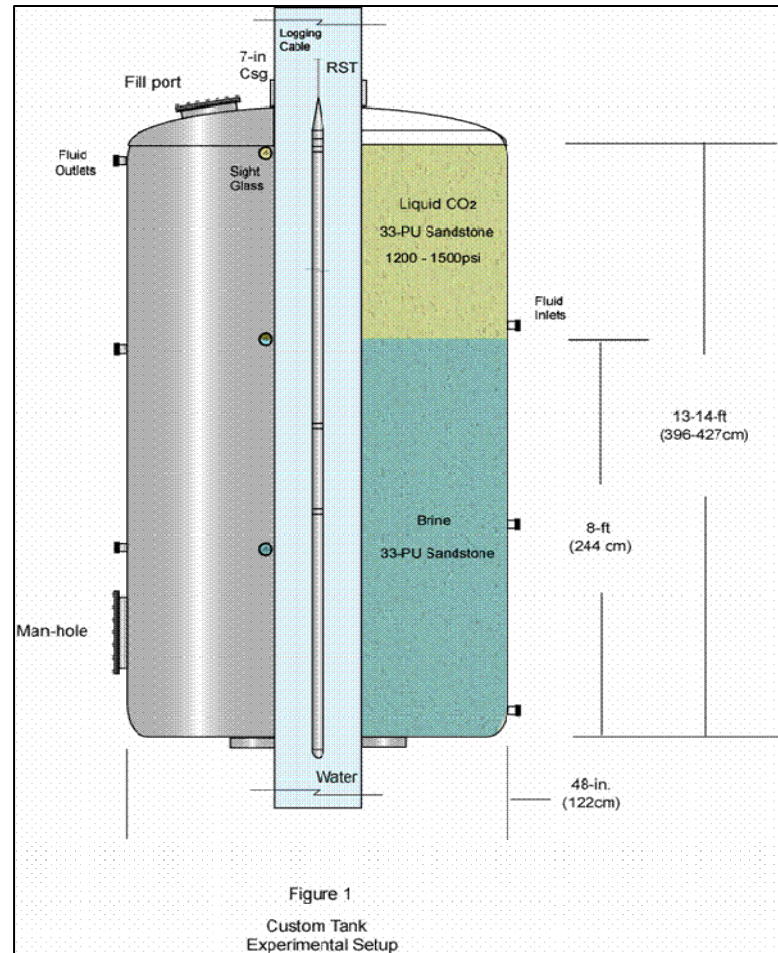




CO₂ Capture Project

Monitoring – Well-Based *In Situ* Detection (Cont.)

Well-Based In Situ CO₂ Accumulation Chamber (3.5m tall; 16 tonnes when loaded)

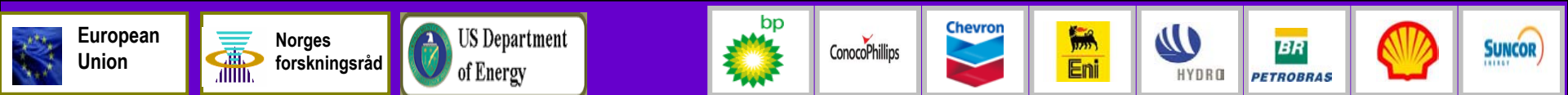




CO₂ Capture Project

Monitoring – Well-Based *In Situ* Detection – Feedback from the Group

- 1) Will this approach to monitoring reduce the need for other well monitoring equipment in the subsurface and at the surface?





CO₂ Capture Project

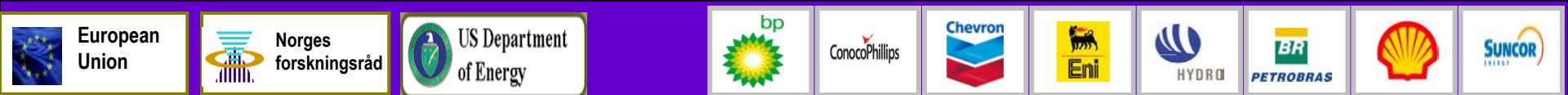
Pilots / Demonstrations

SMV is seeking to engage in pilot / demonstration projects, operated by other organizations, that meet criteria such as:

- coverage of key issues in geological storage,
- match with CCP2 timeframe and objectives and
- opportunity to test CCP2 technologies / protocols

One or two projects from 3 geographic areas (North America, EU/Norway and South America) will be selected

An option remains to collaborate with US DOE Regional Partnership and EU consortia to access pilot project data and experience





CO₂ Capture Project

Summary

The CCP2-SMV Team has developed a slate of projects aimed at:

- Addressing remaining and emerging critical issues in containment assurance, particularly wells
- Simplifying models, simulations and protocols to facilitate a systematic assessment of storage sites and regulation thereof
- Continue to develop high R&D risk monitoring technologies that, if successful, will reduce costs and leave a smaller environmental footprint.

Seeking pilot / demonstration projects that address key technical issues and CCP2 objectives

The SMV team is interested in the NGO and regulatory perspective and is willing to modify project scopes to accommodate major concerns

