WESTCARB Annual Business Meeting

WESTCARB Phase III

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Phase III WESTCARB Objectives

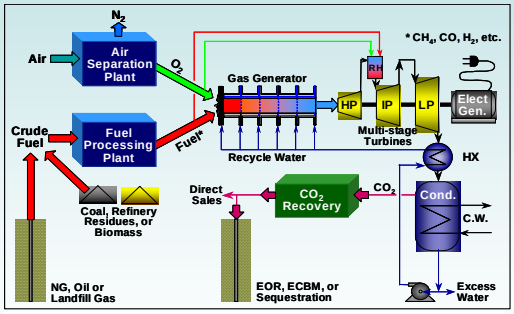
- Conduct a commercial-scale CCS test
  - Accessing the best geologic target in California
- Demonstrate advanced, commercial "sequestration friendly" oxy-combustion technology by Clean Energy Systems (CES)
  - Technology currently funded by both DOE and CEC
  - Planned as first commercial-scale facility of its type in U.S.
- Demonstrate commercial-scale sequestration for site operations, maintenance, characterization, and monitoring (Schlumberger)
- Conduct research supporting the subsurface sequestration methodologies and advancing technologies in reservoir engineering, risk assessment, and monitoring (LBNL, LLNL, Stanford)
- Address and provide important information for evolving institutional, regulatory, and legal frameworks – "frame the debate"

WESTCARB Phase III Complements California Environmental Goals (AB 32)

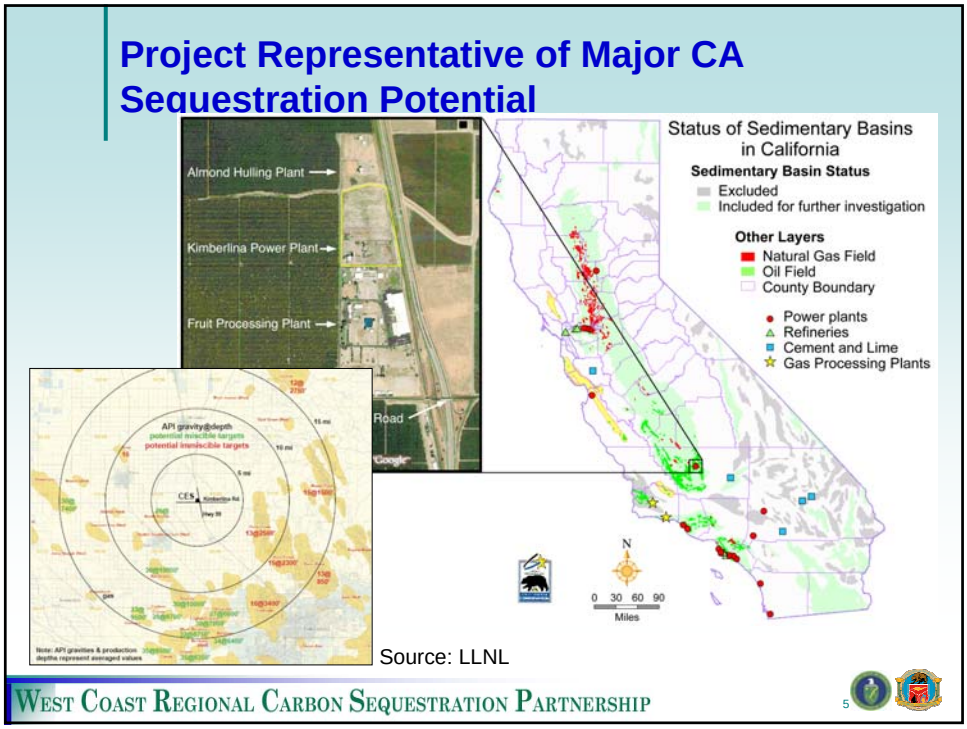
- California IOUs are seeking to reduce CO_2/MWh and increase the diversity of their carbon-neutral portfolios
- New generation with virtually no emissions eases the task of economy-wide GHG reductions and attainment of ozone ambient air quality standards
- There will be an ongoing market for CO_2 for EOR in CA
- California technology developers are seeking to scale up new power systems via in-state projects – these may come on-line before CO_2-EOR infrastructure is in place

WESTCARB Phase III Test Developed From Phase II CES Site Characterization Pilot

- Lead industrial partners: Clean Energy Systems (CES), Schlumberger
- CES currently owns and operates 5 MW facility and is planning 49 MW power plant at Kimberlina, California
- Plant will provide 250,000 tons CO_2 per year for four years
- CO_2 injectivity test in 2009; main injection to begin in Fall 2010
- Mineral rights and initial permitting issues appear workable



CES oxy-combustion generating system


Project Representative of Major CA Sequestration Potential
Almond Hulling Plant
Kimberlina Power Plant
Fruit Processing Plant
Road
Status of Sedimentary Basins in California
Sedimentary Basin Status
Excluded
Included for further investigation
Other Layers
Natural Gas Field
Oil Field
County Boundary
Power plants
Refineries
Cement and Lime
Gas Processing Plants
0 30 60 90
Miles
Source: LLNL
West Coast Regional Carbon Sequestration Partnership
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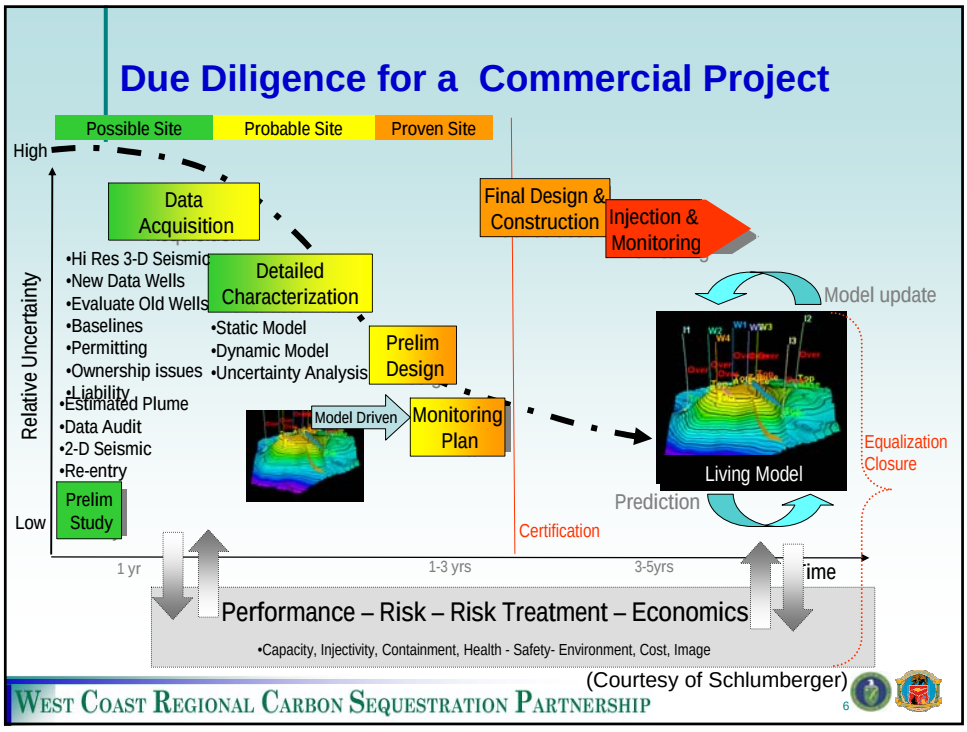
Due Diligence for a Commercial Project
Possible Site
Probable Site
Proven Site
High
Low
Relative Uncertainty
Data Acquisition
•Hi Res 3-D Seismic
•New Data Wells
•Evaluate Old Wells
•Baselines
•Permitting
•Ownership issues
•Liability
•Estimated Plume
•Data Audit
•2-D Seismic
•Re-entry
Prelim Study
Detailed Characterization
•Static Model
•Dynamic Model
•Uncertainty Analysis
Prelim Design
Model Driven
Monitoring Plan
Final Design & Construction
Injection & Monitoring
Model update
Living Model
Prediction
Equalization
Closure
Certification
1 yr
1-3 yrs
3-5yrs
ime
Performance – Risk – Risk Treatment – Economics
•Capacity, Injectivity, Containment, Health - Safety- Environment, Cost, Image
(Courtesy of Schlumberger)
West Coast Regional Carbon Sequestration Partnership
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Basic Requirements for Siting and Permitting Must First be Met

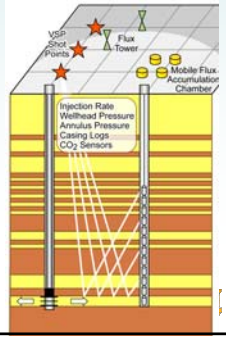
- Site permits to operate a 49 MW power plant (under way)
- Drilling and other permits for injection of carbon dioxide
- Additional work to better characterize site for injection
- Address subsurface ownership and other potential impact issues
- Address environmental justice issues as they emerge
- Develop effective public outreach campaign

These Early Efforts Will Require Collaboration Between All Parties

- Permitting for power plant – CES with ENSR
  - Cost share for project from CES
- Permitting for site preparation – Aspen, in conjunction with ENSR, funded by CEC
- Well drilling permit – Terralog in conjunction with Schlumberger
- Additional analyses to support permitting – LBNL and LLNL

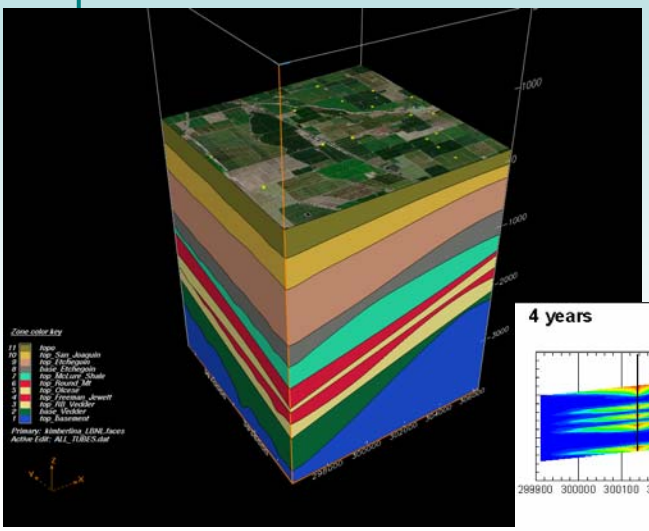
Phase III Monitoring Program Must Further DOE/FE and OS Research Goals, While Also Meeting All Permitting Requirements

Pre-Operational Monitoring	Operational Monitoring	Post-Injection Monitoring
▪ Well logs and cores ▪ Wellhead pressure ▪ Formation pressure ▪ Injection rate pressure ▪ Seismic surveys—3D and VSP ▪ Atmospheric CO_2 monitoring ▪ CO_2 flux monitoring ▪ Pressure and water quality above the storage formation ▪ Microseismic monitoring	▪ Well logs ▪ Wellhead pressure ▪ Formation pressure ▪ Annulus pressure ▪ Injection rate ▪ Seismic survey—3D ▪ Atmospheric CO_2 monitoring ▪ CO_2 and O_2 flux monitoring ▪ Pressure and water quality above the storage formation ▪ Microseismic monitoring ▪ Active source thermal logging ▪ PSInSAR	▪ Well logs ▪ CO_2 and O_2 flux monitoring ▪ Pressure and water quality ▪ PSInSAR



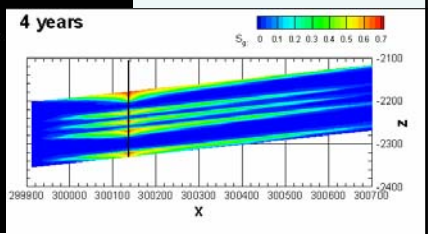
WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

Initial Geologic Model and Reservoir Simulations for WESTCARB Phase III Test



Initial geologic model
(Source: LLNL)

Initial simulation
(Source: LBNL)



WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

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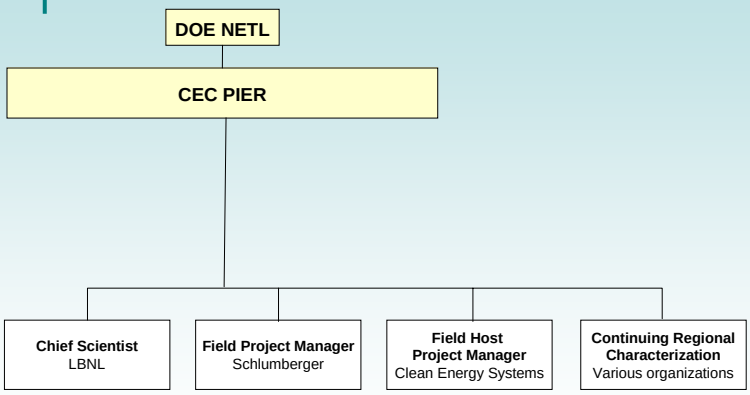
WESTCARB Phase III Management Structure

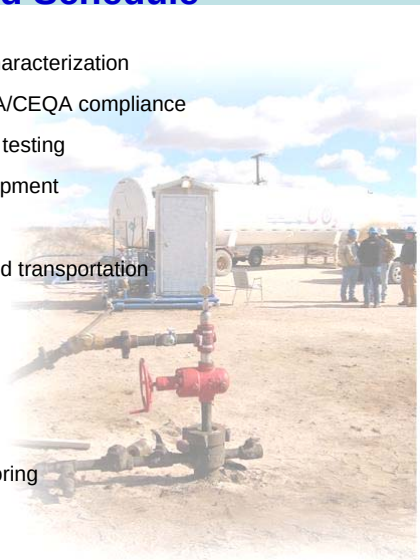


Phase III Activities and Schedule

Years 1-3
- Site selection and characterization
- Permitting and NEPA/CEQA compliance
- Well completion and testing
- Infrastructure development

Years 4-7
- CO_2 procurement and transportation
- Injection operations
- Monitoring activities

Years 8-10
- Site closure
- Post-injection monitoring
- Project assessment



DOE Regional Partnerships Phase III

Department of Energy Advances Commercialization of Climate Change Technology - Sequestration, Renewables, and Efficiency

DOE to Provide Over $450 Million to Support the Deployment of Carbon Sequestration Technologies in North America

(Oct 31, 2006 DOE Fossil Energy Techline)

- Focus on geologic sequestration
- Projects of scale – up to 1 million tons CO_2 per year to be sequestered over four years
- Requirement of 20% cost share (50% for EOR)
- Individual project Costs $80–250M
- 4 awarded as of 12/31/07, cooperative agreements for 3 others in negotiation
- PIER received a dozen expressions of interest; conducted due diligence on all

Summary of DOE Phase III Projects

- **Sources**
  - **Natural gas processing facilities, including H_2S >40%**
  - **Ethanol plants**
  - **At least 2 post-combustion capture technologies**
  - **Oxy-combustion power plant (WESTCARB)**
  - **IGCC power plant**
  - **Up to 3 Mt of CO_2 per year provided from each source**
- **Geology**
  - **6 deep saline formations, carbonates and sandstones – from 3,000 to 13,000 feet deep**
  - **1 depleted oil field (10,000 feet deep)**
- **Comprehensive site characterization, modeling, monitoring, and risk assessment**

WESTCARB Needs to Mobilize and Enhance Political Support for Overall RCSP Program

- Program activities are critical as new laws on CO_2 emissions are developed
- Technical leadership in new technologies and scientific advancement is in Western U.S.
- Will serve as an alternative to renewable energy systems, end-use efficiency, and nuclear technologies and allow for continued utilization of domestic energy resources
- Need to follow lead of other regions in mobilizing political support