



WESTCARB Region Update

Elizabeth Burton

*WESTCARB Technical Advisor
LBNL Program Manager*

eburton@lbl.gov
(925)899-6397



Acknowledgments

- Department of Energy, NETL RCSP Program
 - Brian Dressel
 - Traci Rodosta
 - John Litynski
- California Energy Commission
 - Jim Boyd, Commissioner
 - Laurie ten Hope, PIER Director
 - Mike Gravely, Program Manager and WESTCARB P.I.
- WESTCARB's Partners and Members

Special Thanks to Dawn Deel For Her
Years Of Service to WESTCARB

FY 2011 Overview

- Status of CCS in the WESTCARB region
 - Policy
 - Projects
- Way Forward: Phase III Status/Lessons Learned

In the WESTCARB region, half the region has policy on carbon sequestration and mandatory GHG reduction

State/Province	Terrestrial	Geologic	Mandatory GHG reduction
Alaska	No	No	No
Arizona	No	Yes	No
British Columbia	Yes	Yes	Yes
California	Yes	Yes	Yes
Hawaii	No	No	Yes
Nevada	No	No	No
Oregon	Yes	No	No
Washington	Yes	Yes	Yes

California's policy is (seemingly) at the forefront

- In 2007
 - Report to the Legislature on CCS (AB 1925)
- In 2010
 - California CCS Review Panel and Report
 - CCS included in energy planning (California's Energy Future: The View to 2050)
- In 2011
 - Rubio bill (SB 669)
- In 2012-2013
 - Cap-and-trade rollout

California CCS Review Panel 2010

- Formed by three regulatory agencies, with support from two others
- WESTCARB provided technical expertise and information to Panel members
- Developed specific recommendations addressing
 - permitting, regulatory structure
 - MVA
 - long-term liability
 - pore space ownership
 - EOR vs. storage only
 - inclusion of CCS in cap-and-trade

http://www.climatechange.ca.gov/carbon_capture_review_panel/meetings/index.html

Legislation followed on CCS Review Panel recommendations

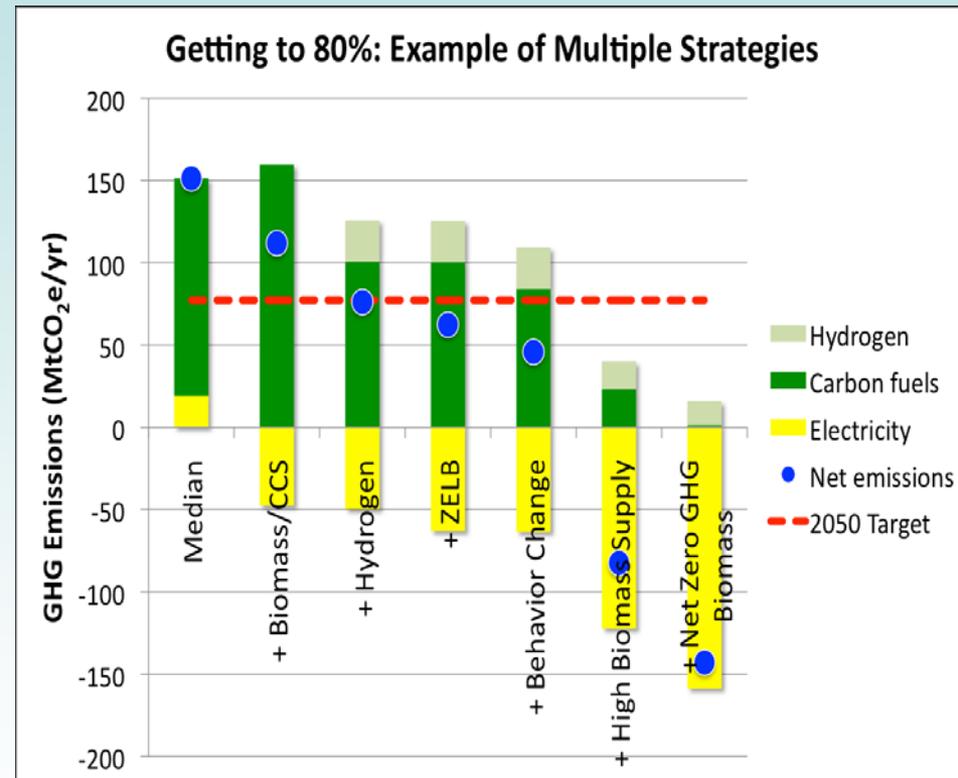
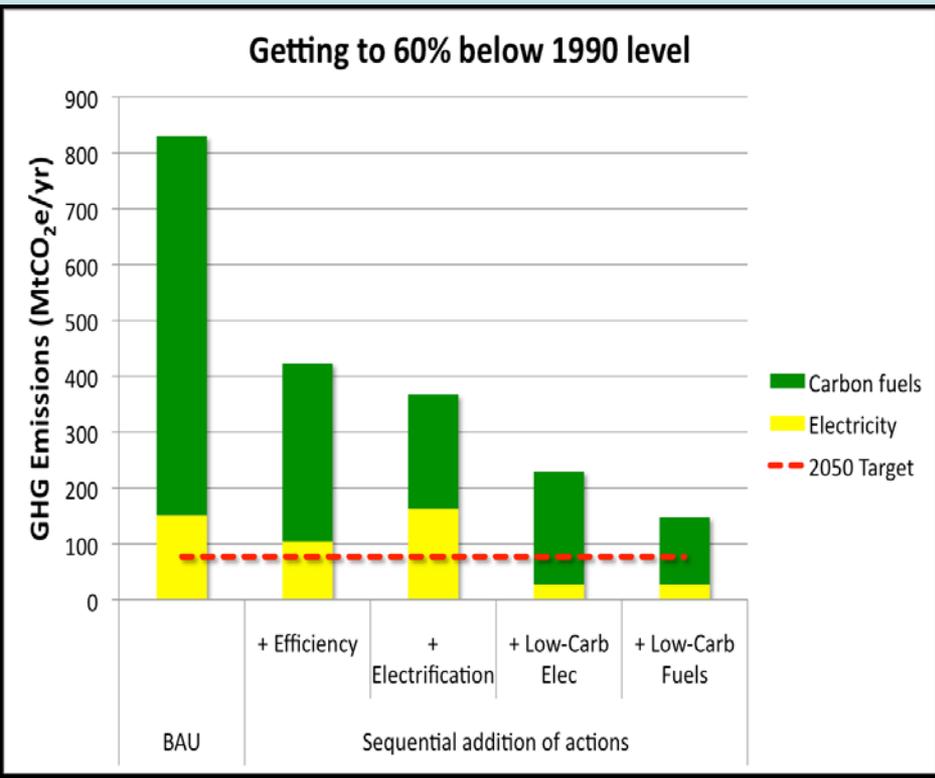


- SB 669 (Senator Rubio) introduced in Feb 2011
- Became a two-year bill in April 2011, should move forward as a more focused version of SB669 or a new bill
- California CCS Coalition identified legislative needs:
 - Permitting and regulatory authority for CCS for various industries
 - Pore space ownership addressed

CCS in California's Cap-and-trade regulation

- Includes language that the compliance obligation will be reduced by the amount of CO₂ verified to be geologically sequestered through a CARB-approved quantification methodology (which doesn't yet exist)
- Resolution 10-42 directs Air Resources Board to
 - Initiate a public process to establish quantification methodology (cap-and-trade and the LCFS)
 - Provide recommendations for how to address sequestration
 - Ensure separate requirements for CO₂-EOR to assure compliance with ARB's monitoring, reporting, verification and permanence requirements

Energy planning emphasizes the importance of CCS to meeting 2050 goals



Scenarios from California's Energy Future: The View to 2050

<http://www.ccst.us/publications/2011/2011energy.php>

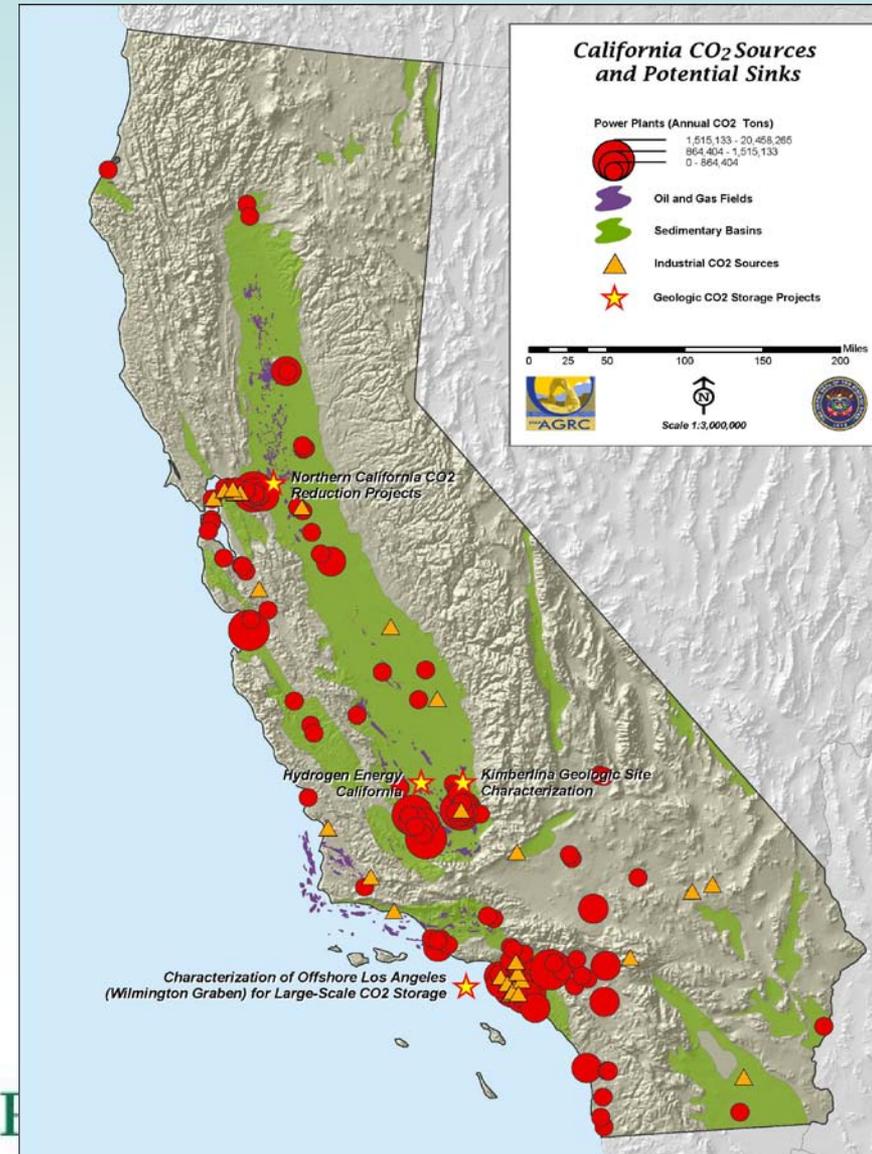
There are potential markets in California for captured CO₂

- Proven uses
 - CO₂-EOR depends on price of oil
- Potential uses (unknown CO₂ price)
 - CO₂- compressed-air energy storage (CAES)
 - CO₂ cushion gas for natural gas storage
 - CO₂-enhanced geothermal systems (EGS)
 - Building materials
 - Other materials/fuels

Research Roadmap for Carbon Sequestration Alternatives, produced by LBNL and CIEE for the California Energy Commission (draft available)

Progress toward CCS implementation in California remains difficult

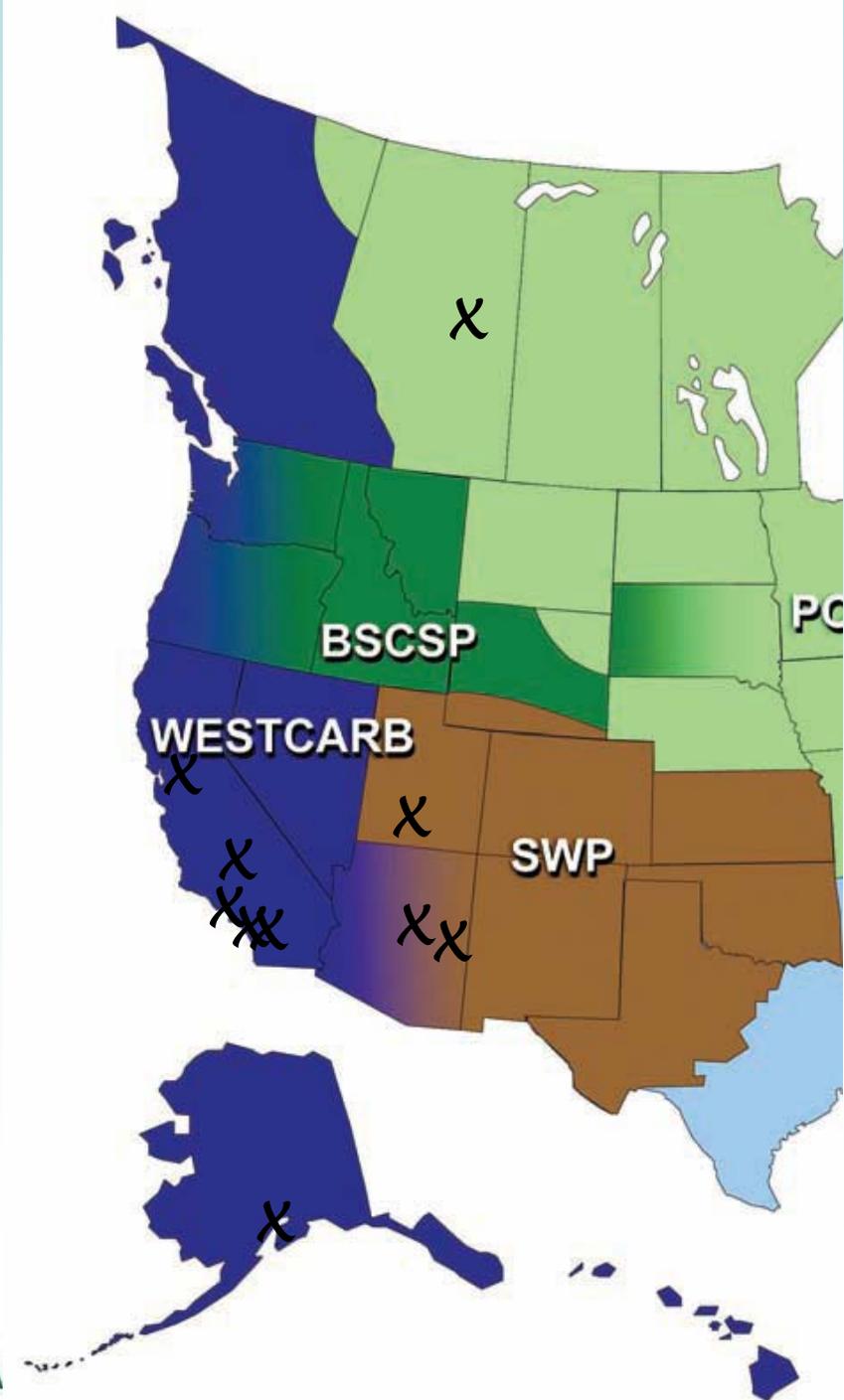
- C6's and WESTCARB's Northern California Reduction Project cancelled (RCSP, ARRA)
- BP and Rio Tinto exit from HECA (CCPI); SCS Energy steps up
- Clean Energy Systems turbine testing and revisiting CCS
- Terralog Technologies field characterization
- No new FOA-441 projects
- WESTCARB field characterization but no CO₂ injection



WESTCARB's quest for a new LVST site



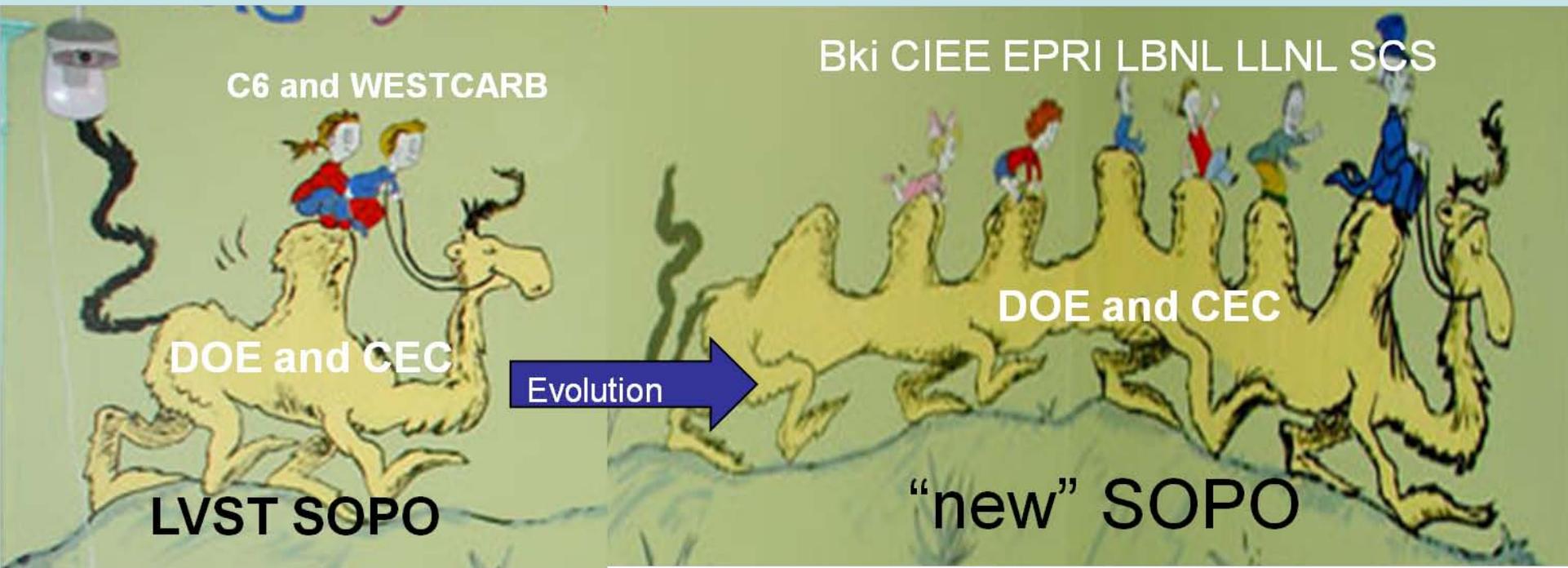
Lesson learned: Without a price on carbon, CCS is a “hard-sell,” not buried treasure



Phase III: Large-Volume Storage Test Lessons Learned in WESTCARB Region

- No large supplies of CO₂
 - The region lacks large natural CO₂ domes, CO₂ pipelines of size, large-scale pure streams from industrial CO₂ sources (e.g., natural gas upgrading, ethanol plants)
 - Using CO₂ captured from likely industrial sources (power plants, refineries, cement plants) requires between \$100 million - \$1 billion in capital investment—well outside the limits of the RCSP budgets)
- Must have reasonable geologic certainty of commercial-scale capacity and containment
 - Much of the region is tectonically active
 - Geology is not “layer-cake”
 - Data for saline formations is very limited

WESTCARB's Phase III is a new kind of animal



Our destination of “enabling CCS technology deployment” is the same

WESTCARB's Phase III activities address the barriers to commercial-scale projects

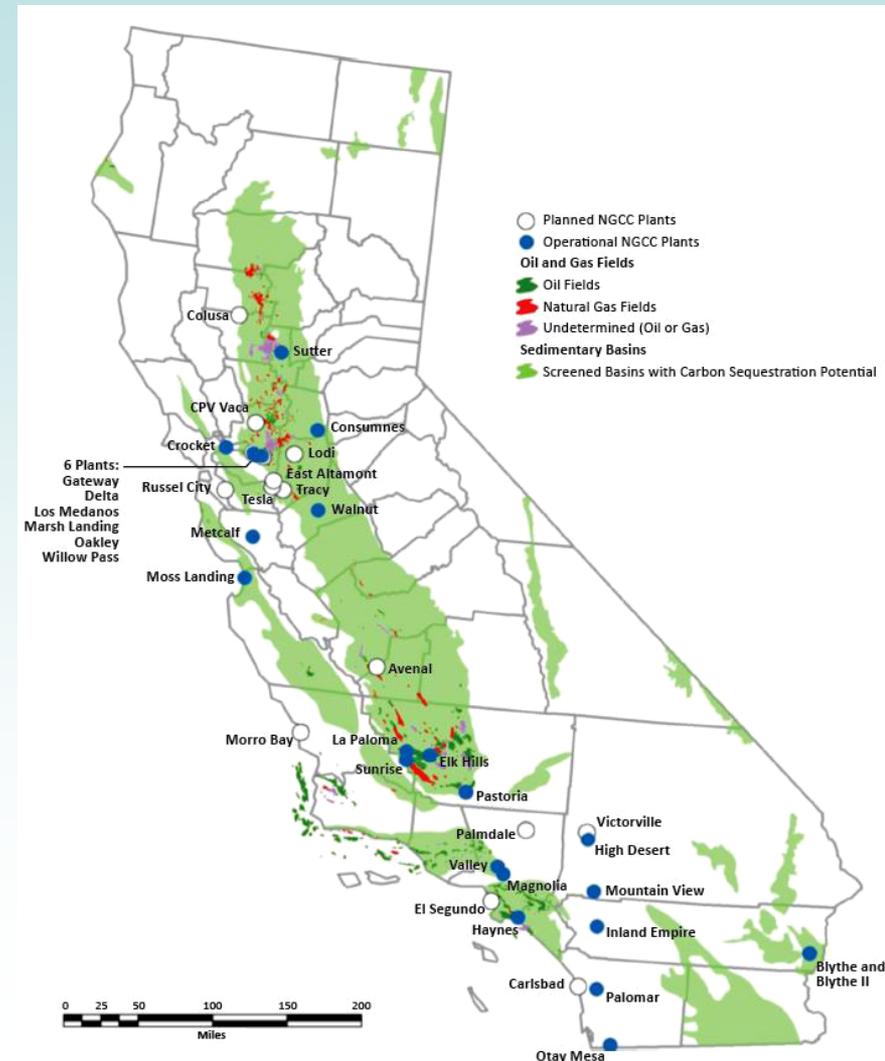
- Study of retrofits and storage options for NGCC plants in California
- Seismic hazards
- Regional characterization activities
- Detailed field site characterizations at high CCS-potential sites
- Integrated opportunities to achieve economies-of-scale
- New tools and analysis to support outreach to stakeholders and policy makers
- RTIP in technical and policy context

Study of NGCC Retrofits: Why CCS on natural gas power plants?

- California's power mix is ~50% natural gas and 10–20% coal (mostly imports); most of U.S. is opposite
- 2050 goals require deployment of CCS on natural gas
- In anticipation, California utilities are actively seeking information on:
 - costs
 - technical feasibility
 - operational impacts of CCS
- Bki provided preliminary assessment to inform RFP issued by the Energy Commission

Natural Gas Combined Cycle (NGCC) Project Highlights

- Shaw Group will work with utilities to screen candidate capture technologies for both retrofits and new-builds
 - Pre-, post- and oxy-combustion to be evaluated
 - Permitting, HSE, and water use to be considered
- LLNL will screen plant sites for CO₂ storage options; build static geomodels for injection simulation



NGCC Project Steps

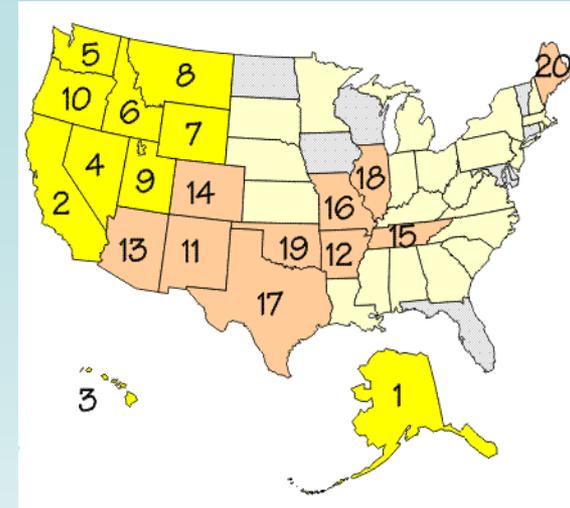
- Build engineering models of select NGCC plants and CO₂ capture processes; evaluate performance impacts and conduct sensitivity studies
- Examine plot plans and lay out equipment; estimate costs and permitting issues and conduct sensitivity studies
- Develop/evaluate a conceptual design for a pilot-scale CCS test on an NGCC or cogeneration unit
- Communicate results to stakeholders (CPUC, CAISO, etc.)



*PG&E's Colusa Generating Station
(in-service December 2010)*

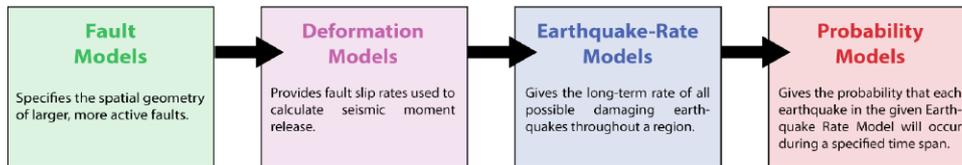
Seismic Hazards—Induced and Natural

The WESTCARB Region encompasses the most seismically active areas in the U.S., but the issue is pervasive. Annually, there are over 1.4 million earthquakes in the U.S. ($M > 2$)



We need experts to join us for a conversation at AGU in San Francisco

Components of the Uniform California Earthquake Rupture Forecast 2



Components (??) of an Induced Seismicity Rupture Forecast



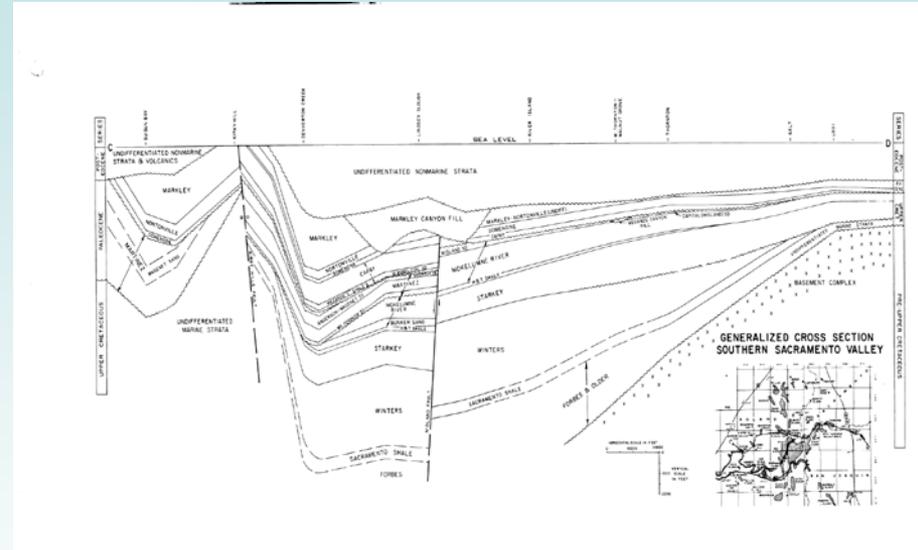
- Do we know enough about relevant seismic hazards to permit CCS projects?
- If not, what do we still need to know?
- Are we able (with what we know now) to identify appropriate protocols?

Adding and improving state and provincial regional characterizations

- Hawaii--first geologic resource assessment
- Arizona—improving resource estimates for the Colorado Plateau, salinity screening, characterizing Tertiary basins
- Nevada—reassessment of storage resource in vicinity of major sources
- California—detailed assessments of oil and gas pool capacities; preliminary offshore resource estimation
- Region-wide updating of sources and geologic data using any new databases

Field Characterization Project: Selected site in California will assess potential in depleted gas pools and underlying saline formations

- Univ. of California (CIEE)
Sandia Technologies,
Schlumberger
- Mokelumne and Starkey contain gas trapped against sealing faults, but volumes of pools generally small
- Numerous stacked sands below gas zone have high potential as CCS reservoirs and intervening thick shales
- Proving injectivity and continuity of stacked sands is key to making resource and capacity estimates



Citizen Green Well is An Important Step to Characterizing the Resource

WESTCARB annual meeting attendees tour well site



Workover rig preparing the existing well for re-entry to drill the deviated Citizen Green well (Sept. 1, 2011)

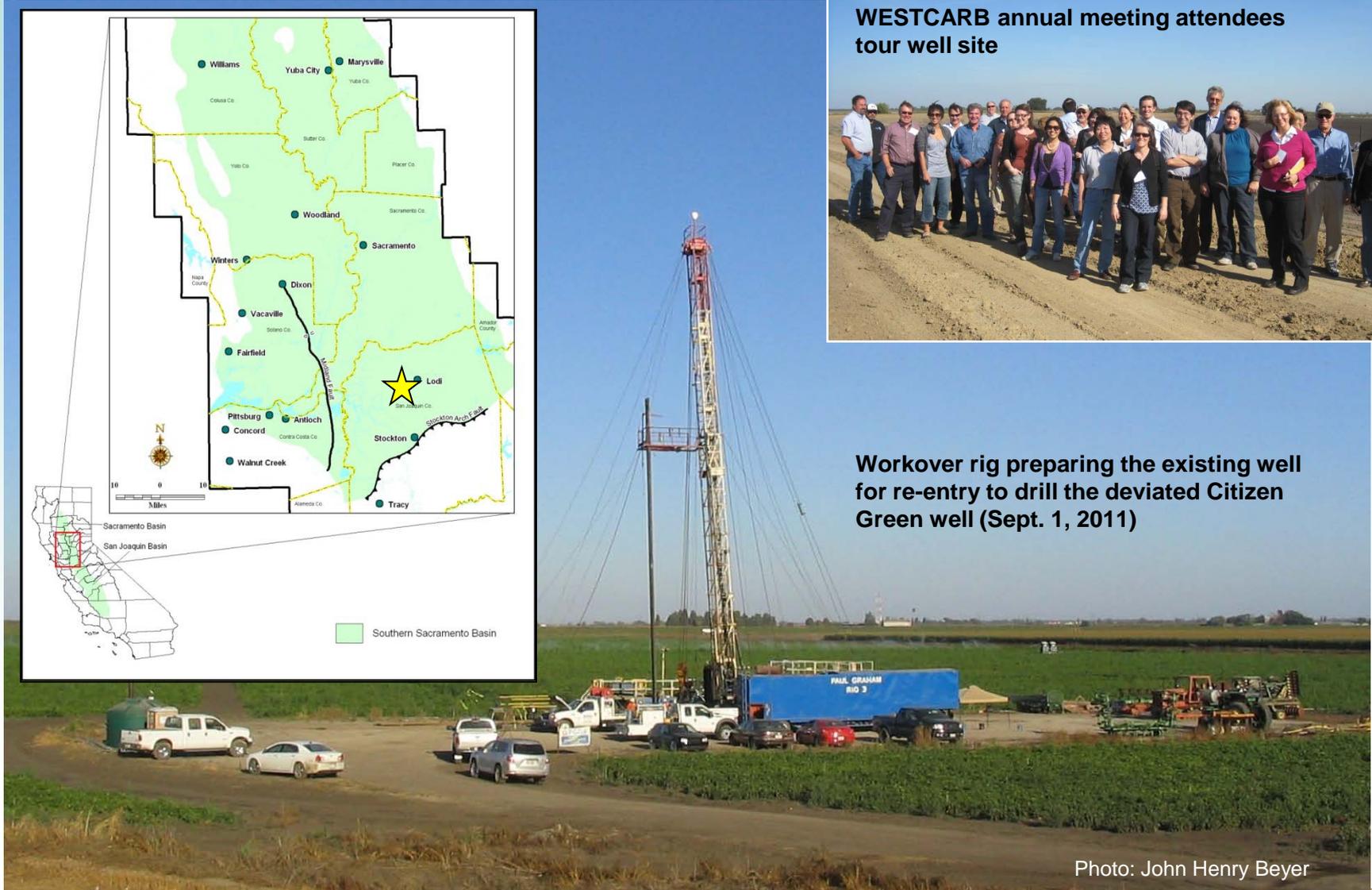
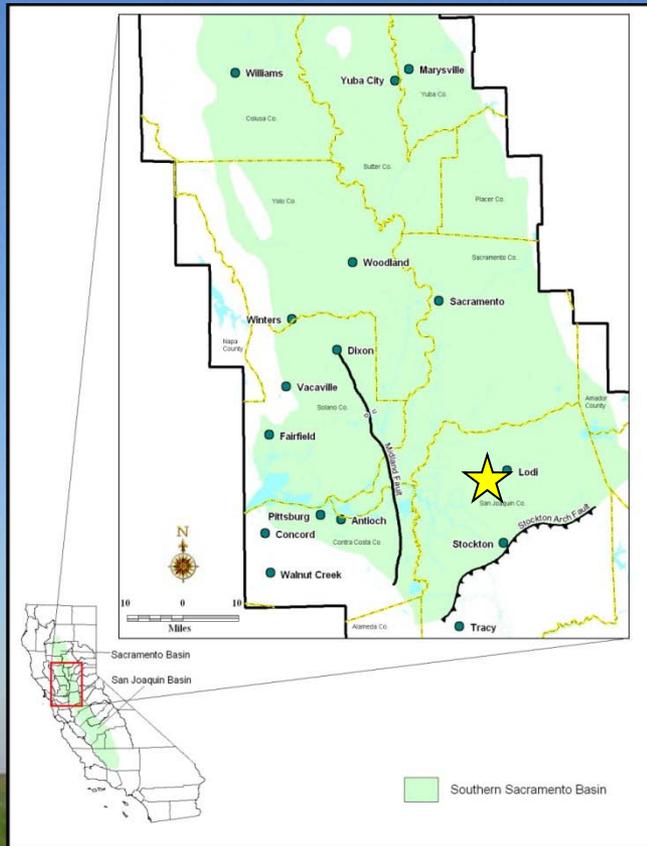
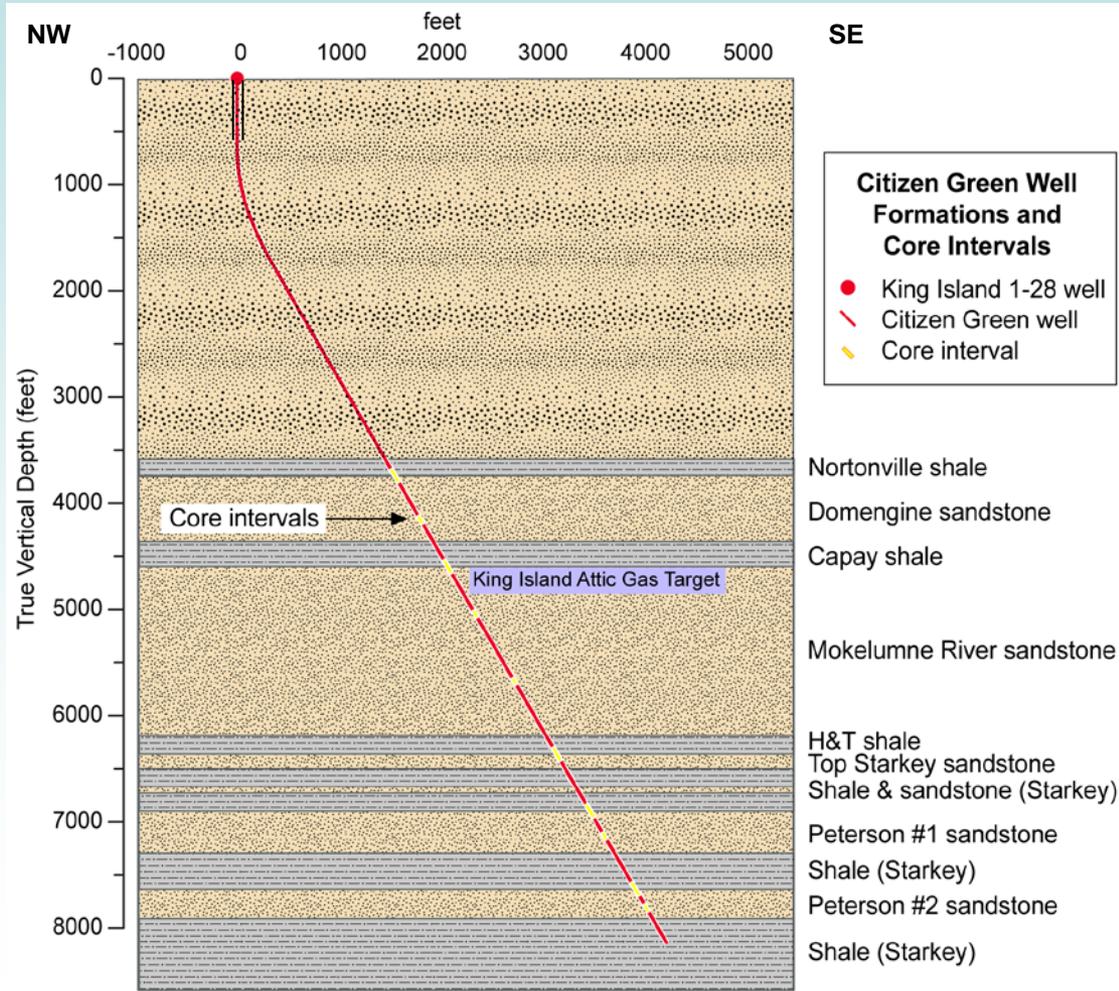


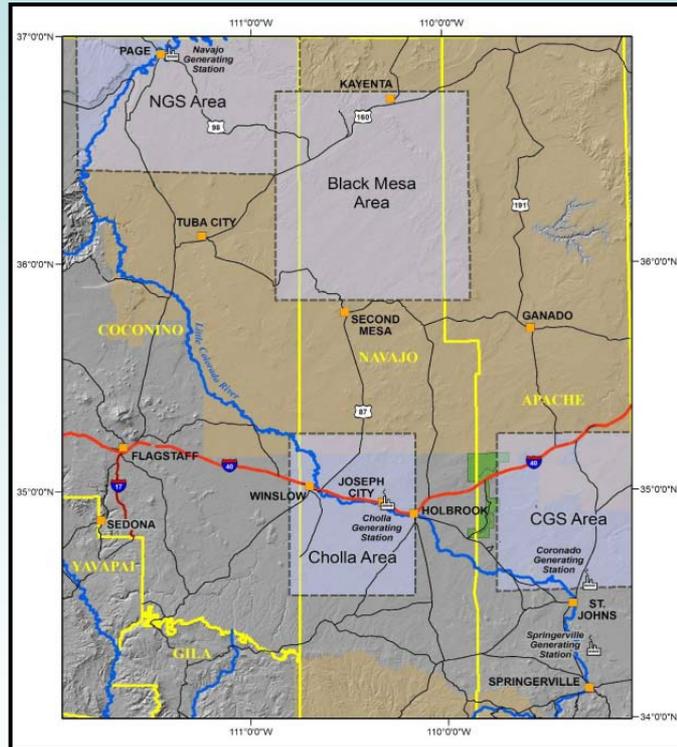
Photo: John Henry Beyer

Project Test Plan Led by LBNL Includes Extensive Coring, Analysis, and Laboratory Testing



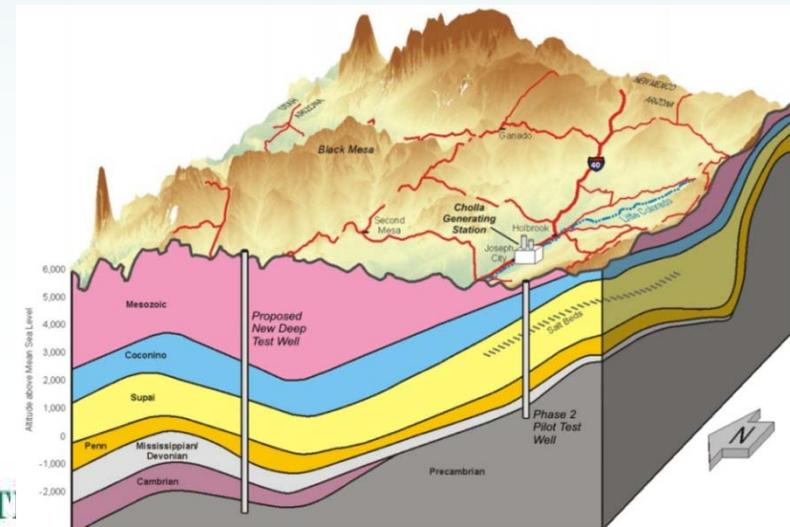
- Over 800 feet of core to capture storage and sealing formations and transition zones
- Fluid sampling from storage formations
- Gas measurements
- Data and samples for testing and analysis to researchers at many different institutions

Field site characterization in Arizona, led by EPRI, focuses on data-poor areas with high CCS potential



- Sandia Technologies will lead characterization well drilling
- Schlumberger
 - Acquire & reprocess existing seismic data
 - Obtain new seismic surveys
 - Well logging
- Static geomodel development

- LBNL will lead test plan activities:
 - Laboratory studies of fluid-rock-CO₂ interactions
 - Simulations of commercial-scale storage



Identifying Integrated CCS Opportunities



- Building optimized infrastructure
 - CCS planning around clusters of emitters
 - Shared pipeline or transportation networks
 - Shared sequestration sites

- Potential benefits include
 - Spreading risk
 - Economies of scale
 - Opportunities for focusing public investment or incentives
 - Accelerating deployment



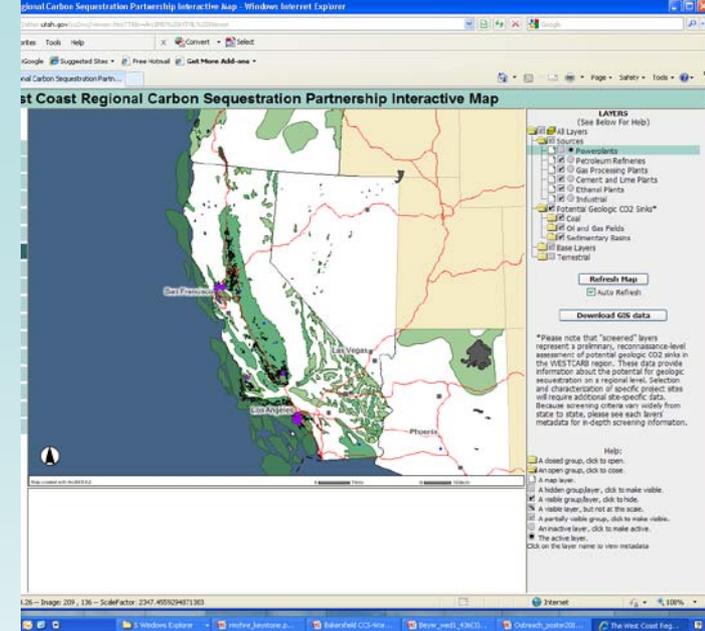
Bki leads Outreach, Knowledge-sharing, and Education

- Technical outreach includes data and sample sharing from field projects
- Knowledge-sharing through DOE publications, working groups, scientific meetings
- Knowledge-sharing to regulators and policymakers
- Providing online tools for stakeholders
- Educating the public and communities



New WESTCARB Geospatial Data Portal

- Geospatial Innovation Facility (GIF) at UC Berkeley
- GIF will provide data layers to NATCARB and Atlas images
- Will develop a new web interface for
 - Predefined static maps
 - Online map visualization interface
 - Data access via ArcGIS or ArcGIS Desktop
 - Cross-reference with other spatial data (e.g. Census datasets)
 - Adapt to new custom maps for printing



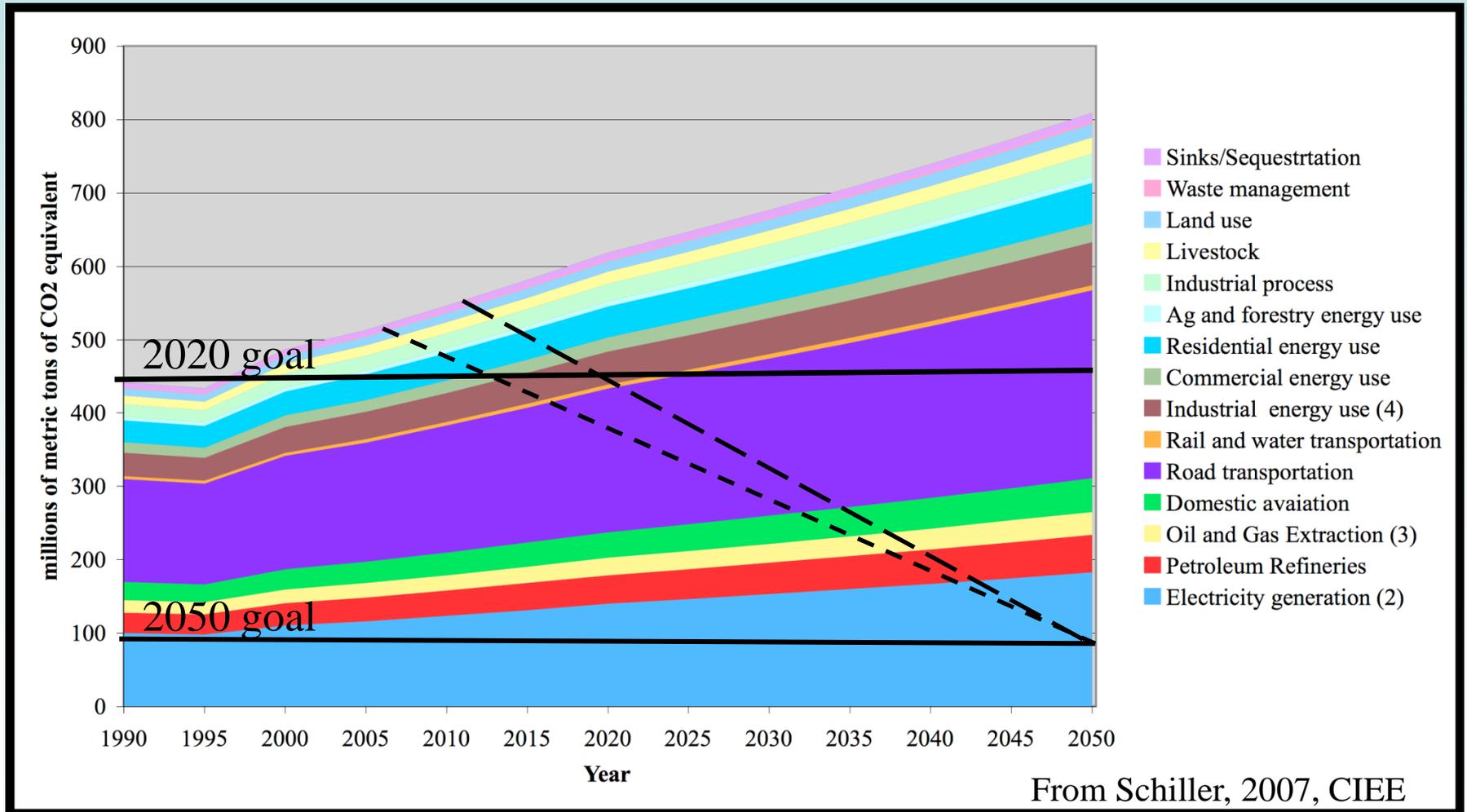
Link to Carbon Atlas
www.westcarb.org

We would like user
feedback

Outreach to stakeholders and policymakers: Regional Technology Implementation Plan

- Captures technical and nontechnical fundamentals learned in WESTCARB's Phases I, II and early III
- Incorporates stakeholder input from 2010 WESTCARB Annual Meeting and RCSP Review meeting,
- Applies materials from other DOE CCS publications
- Includes CCS in policy context (WCI, cap-and-trade)
- To be completed in December 2011

RTIP message needs to include urgency: The path to 2050 keeps getting steeper



Or:

