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Carbon Sequestration in the Southwestern United States:

Using the 'String of Pearls' Model for Cost and Source-to-Sink Assessments

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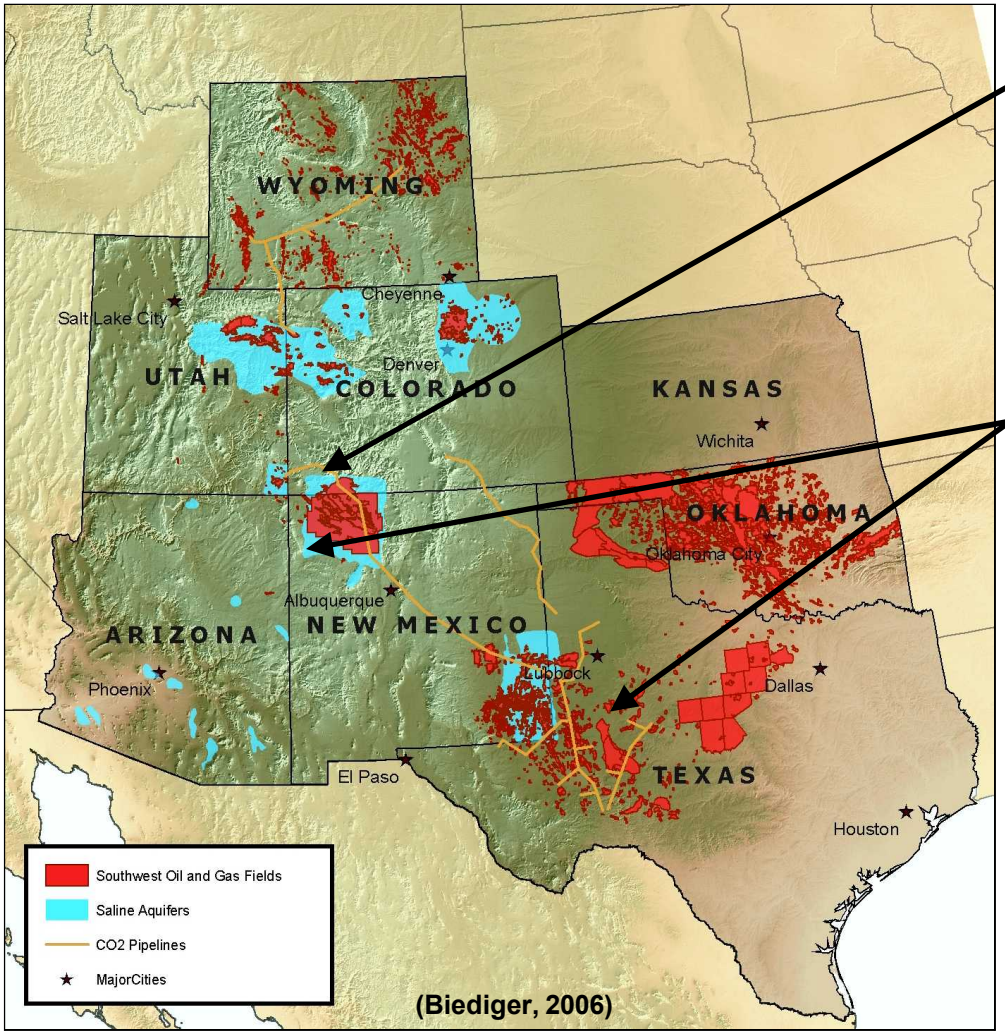
The Southwest Regional Partnership on Carbon Sequestration (SWP)

- ***One of seven*** regional partnerships throughout the U.S.
- Evaluating ***available technologies*** to capture and to reduce CO_2 emissions
- ***Source to Sink*** matching (Power plants to Geological Formations)
- String of Pearls Model ***'Tells the Story'*** for the SW Partnership
  - → Technology
  - → Economics
  - → Scale of the Issues



(Biediger, 2006)

CO_2 pipelines in NM, TX, CO, WY, UT

Potential Sequestration:

- Oil Fields
- Natural Gas Fields
- Saline Formations

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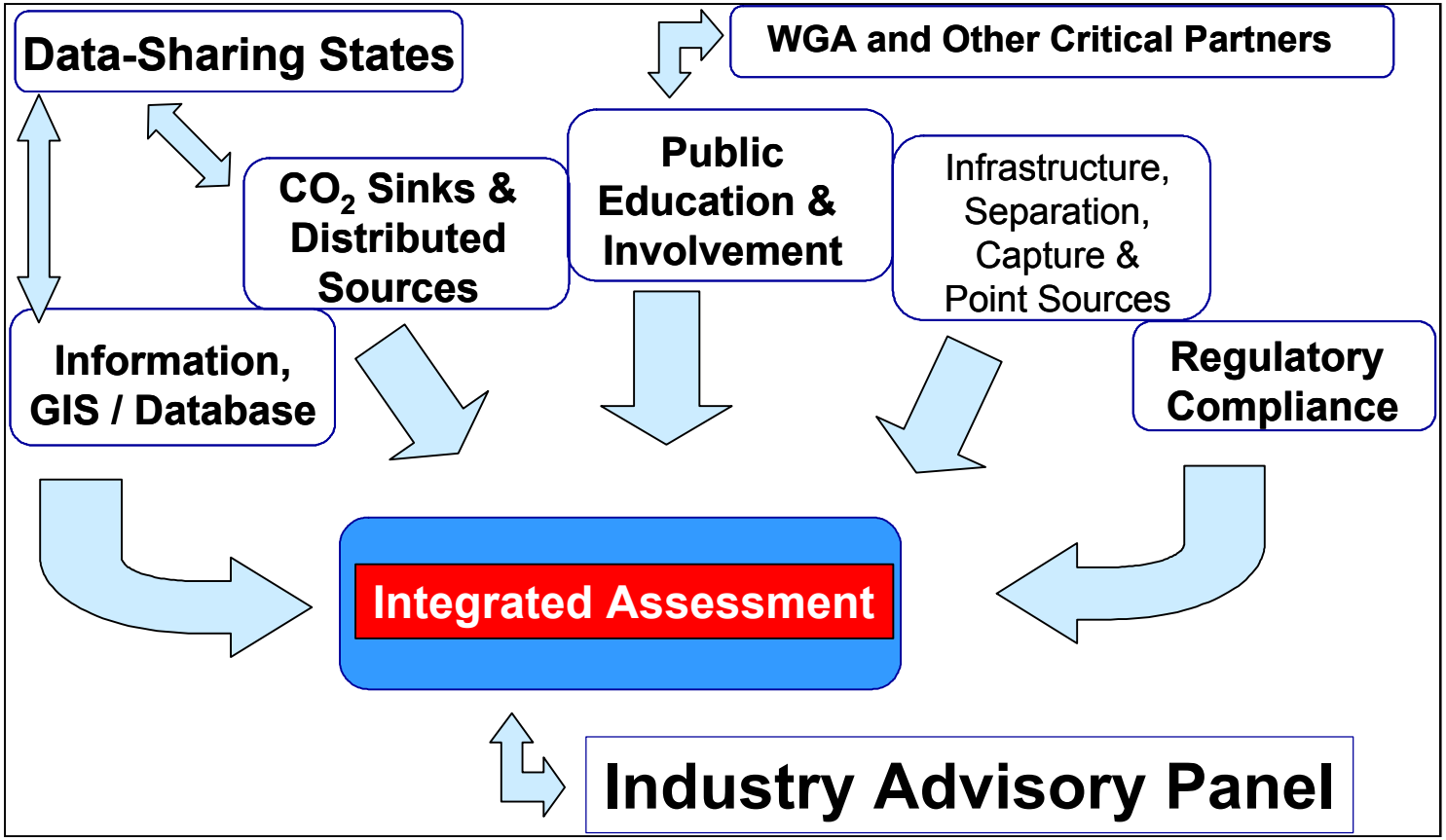
Thematic Committees & Partner Integration



Adapted from McPherson, 2005a

An Update on the Integrated Assessment

Timeline

2004

2005

2006

2007

2008

*
*
*

- **Completed a Test Case Model**
- **Completed the String-of-Pearls Beta 1.0 model algorithms**
- **Where we are:**
  - Refining Regional Totals
    - » CO_2, Cost, Sequestration Volume potential
  - Developing a complimentary website to access Sandia's SWP work
  - The Carbon Capture working group is looking to more fully integrate with the GIS capabilities
- **Thinking about:**
  - Including a financial payback model for CCS technology in the model
  - A cost optimization module capability to find the least cost solution for a Carbon-constrained future

Developing the Integrated Assessment Website: Another way to collaborate

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Carbon Sequestration

About
Partners
Contacts

String of Pearls

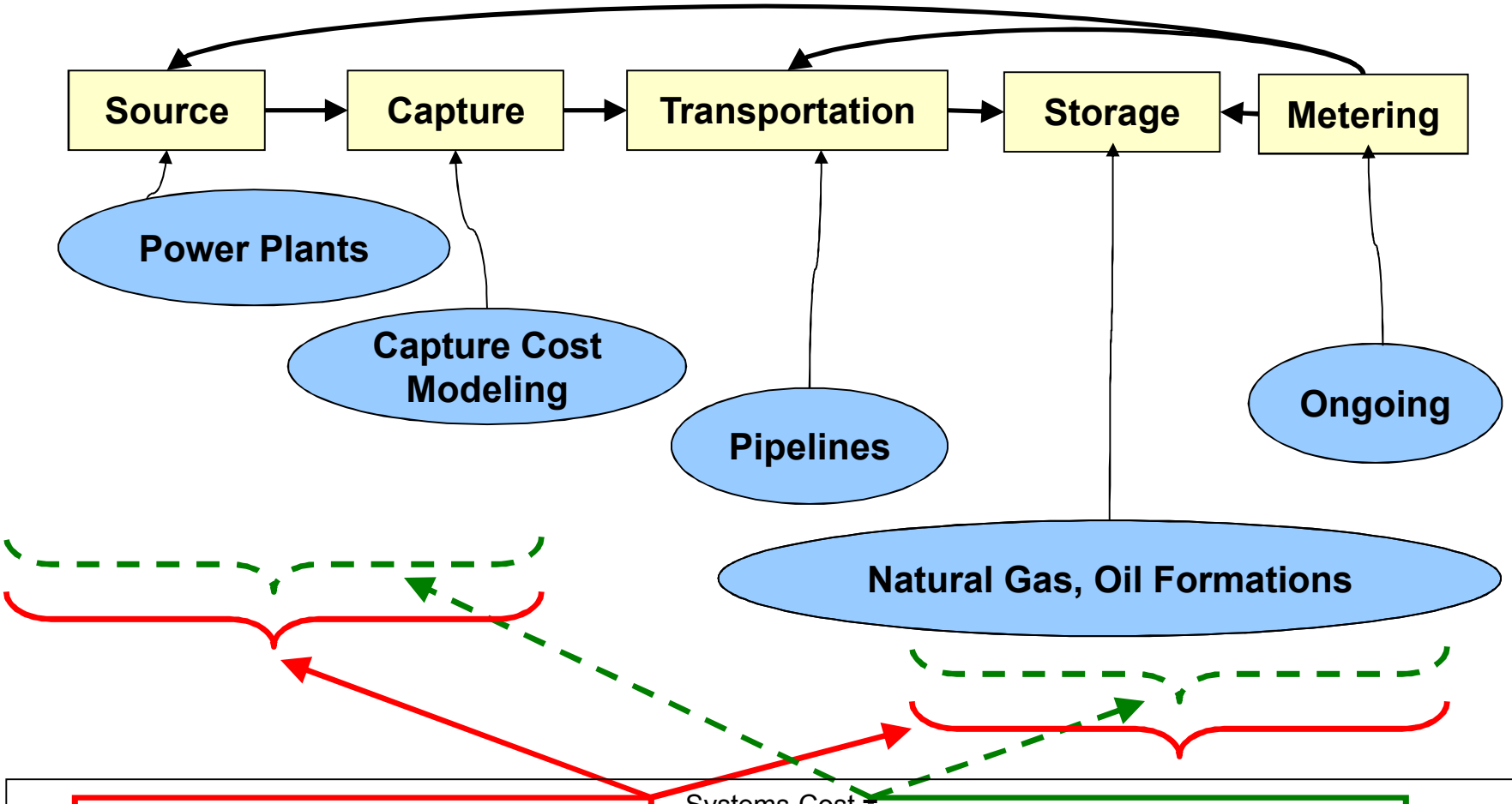
The Integrated Assessment Cost and Source-Sink Model

This research describes the 'String of Pearls' analytical model used by the Southwest Regional Partnership on Carbon Sequestration to assess potentially hundreds of carbon dioxide (CO_2) source and geological sink combinations in the Southwestern United States. The model can help decision makers (e.g., policy analysts and interested companies) determine where a power plant (or other CO_2 source) could be built given a set of planning decisions based on current power plant locations, sink availability, and existing pipeline infrastructure right-of-ways.

The working results indicate that the cost of capturing carbon dioxide is by far the majority of a project's overall capital cost. The analysis also develops overarching regional CO_2 sequestration totals and relative costs, and sink lifetimes across an initial fifty-year time horizon. The region may support anywhere from several decades to several thousand years' worth of sink capacity.

Illustrative interface only.

Working Framework for the Carbon Sequestration Modeling



Systems Cost =

Capture Cost $_{tCO2}$ + Pipeline Cost $_{tCO2}$ + Surface Piping and Well Costs $_{tCO2}$ + Measurement, Monitoring and Verification $_{tCO2}$

Performance Risk Issues

(Will it work?)

Economic Risk Issues

(Can we afford it?)

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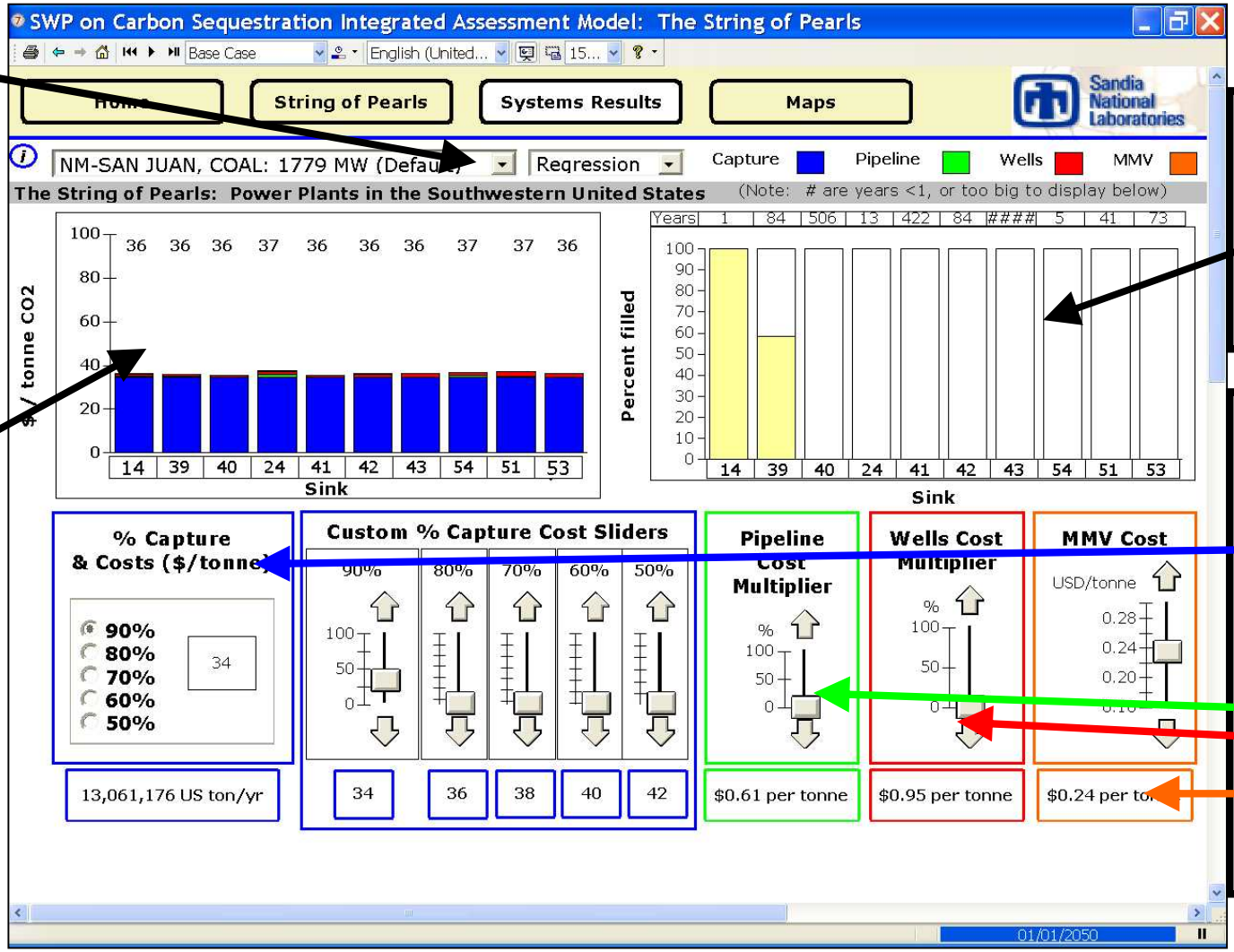
The String of Pearls Model's Working Interface

Select the Specific Power Plant in the SW U.S.

Stacked systems costs



Years of Useful Sink Fill Time

Users can Adjust the:

- % of CO_2 captured
- costs to capture CO_2
- pipeline cost
- Well costs
- Baseline MMV cost.

Illustrative model results as of September 2007

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A Model Scenario, Selecting only Oil and Gas formations & those ≥ 500 million metric tonnes

Results for the San Juan Power Plant (1779 MW)

Select only Oil & Gas Sinks ≥ 500 mmt

Only 6 sinks are ≥ 500 mmt in the SW Partnership's Oil & Gas database

500 mmt = ~ 60 years of fill capacity per sink for the San Juan Plant

SWP on Carbon Sequestration Integrated Assessment Model: The String of Pearls

Base Case | English (United... | 15...

Home | String of Pearls | Systems Results | Maps | Sandia National Laboratories

Region CO2 Totals | Plant Assumptions | Other

The String of Pearls: Choose a CO2 source (Coal, Gas, Custom), and watch or select the String of Pearls sinks.

Source: Select a Source

- Use selected Source (e.g., San Juan)
- Use custom Source (e.g., Lat., Long.)

NM-SAN JUAN, COAL: 1779 MW (Default)

Sinks: Select from the database of Sinks

- Arizona
- Colorado
- New Mexico
- Oklahoma
- Utah
- Coal Bed Methane
- Oil/Gas
- Saline Aquifer
- Pipelines

Maximum Distance from Source (km): 1,000

Minimum Capacity of Sink (mmtonnes): 500

Sink(s): Automatic String of Pearls, or Custom Sink Option

Electricity: 9.70 cents per kWh — *Note: illustrative electricity cost only*

Power Plant

Plant	Sink	Distance (km)	Cost ($/tonne)
Selected	53	81.2	39

Sinks

from Sink	to Sink	Distance (km)	Cost ($/tonne)
53	52	30.5	37
52	37	123.2	57
37	126	747.2	80
126	146	102.9	39
146	68	521.7	63
0	0	0.0	?
0	0	0.0	?
0	0	0.0	?

Note: The "0" for a Sink indicates the end of the string of pearls.

Click here to Select Specific Sinks

Click here to Show Regional Perspective

01/01/2000

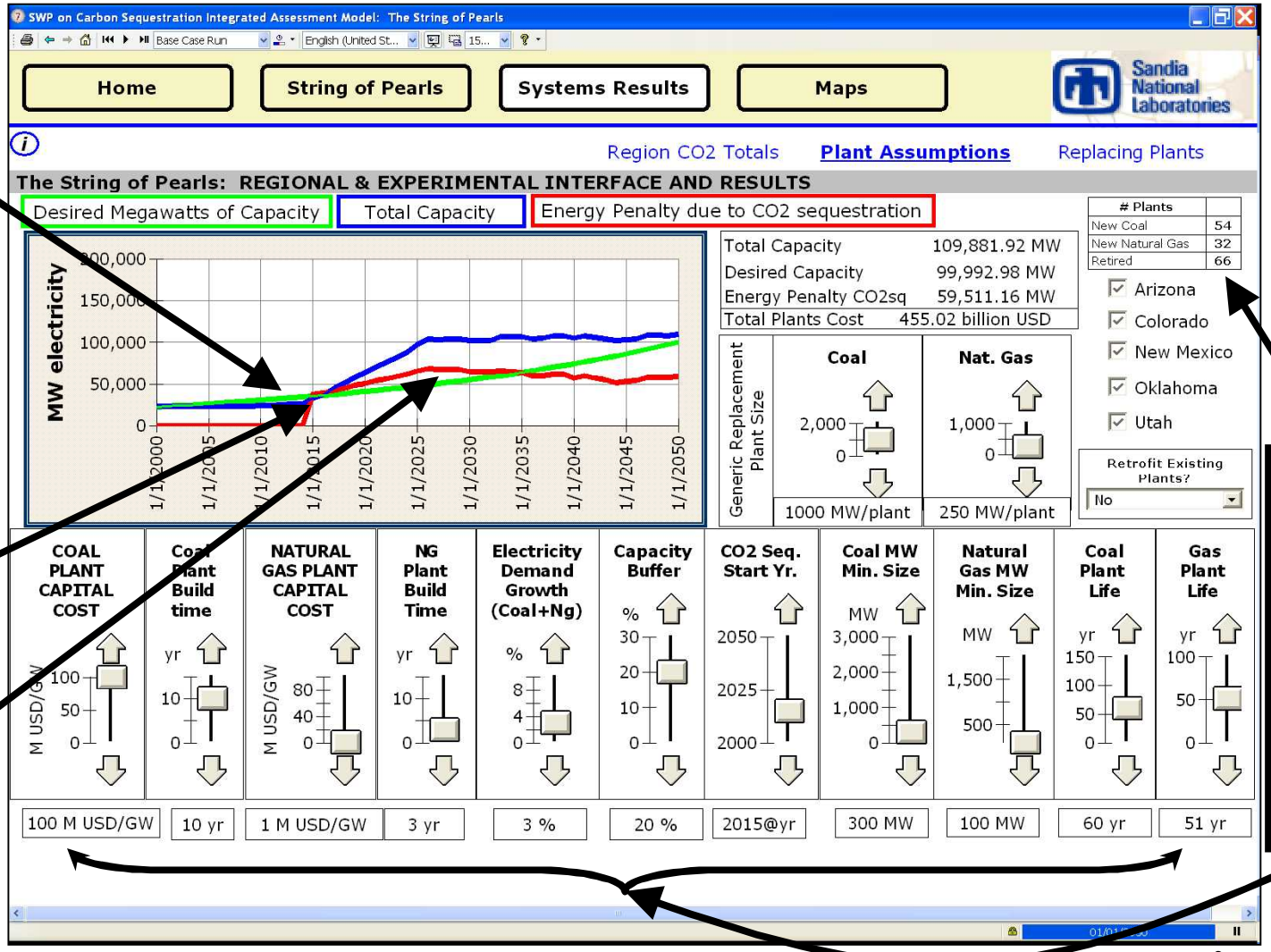
Illustrative model results as of September 2007

Prototype:
Total Installed Megawatts Regional Summary
(SWP under an Aggressive, Hypothetical Scenario)

Annual 3% growth rate in capacity (green line)

Total installed MW for the region (blue line)

Total energy needs due to carbon seq. (red line)



Coal and Natural Gas Power Plants (retired, replaced, new energy needs

Model User can Adjust the Plants' Parameters

Illustrative model results as of September 2007

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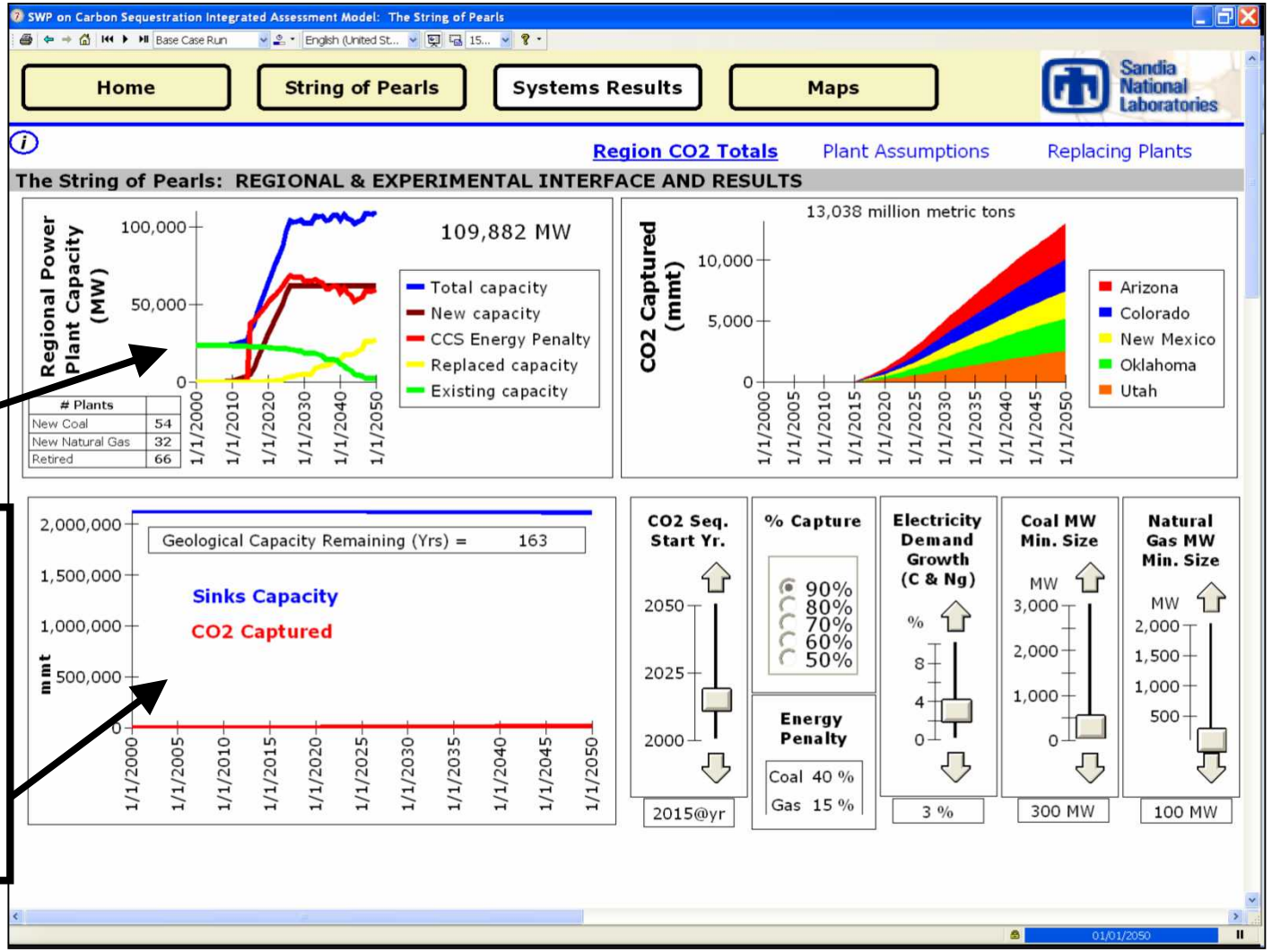
Prototype Power Plant, Carbon Capture and Sink Lifetime Summary for the SWP

Retired, Replaced, and New Power Plants

Net Sinks Storage Capacity after a 50 year, aggressive model run



Illustrative model results as of September 2007

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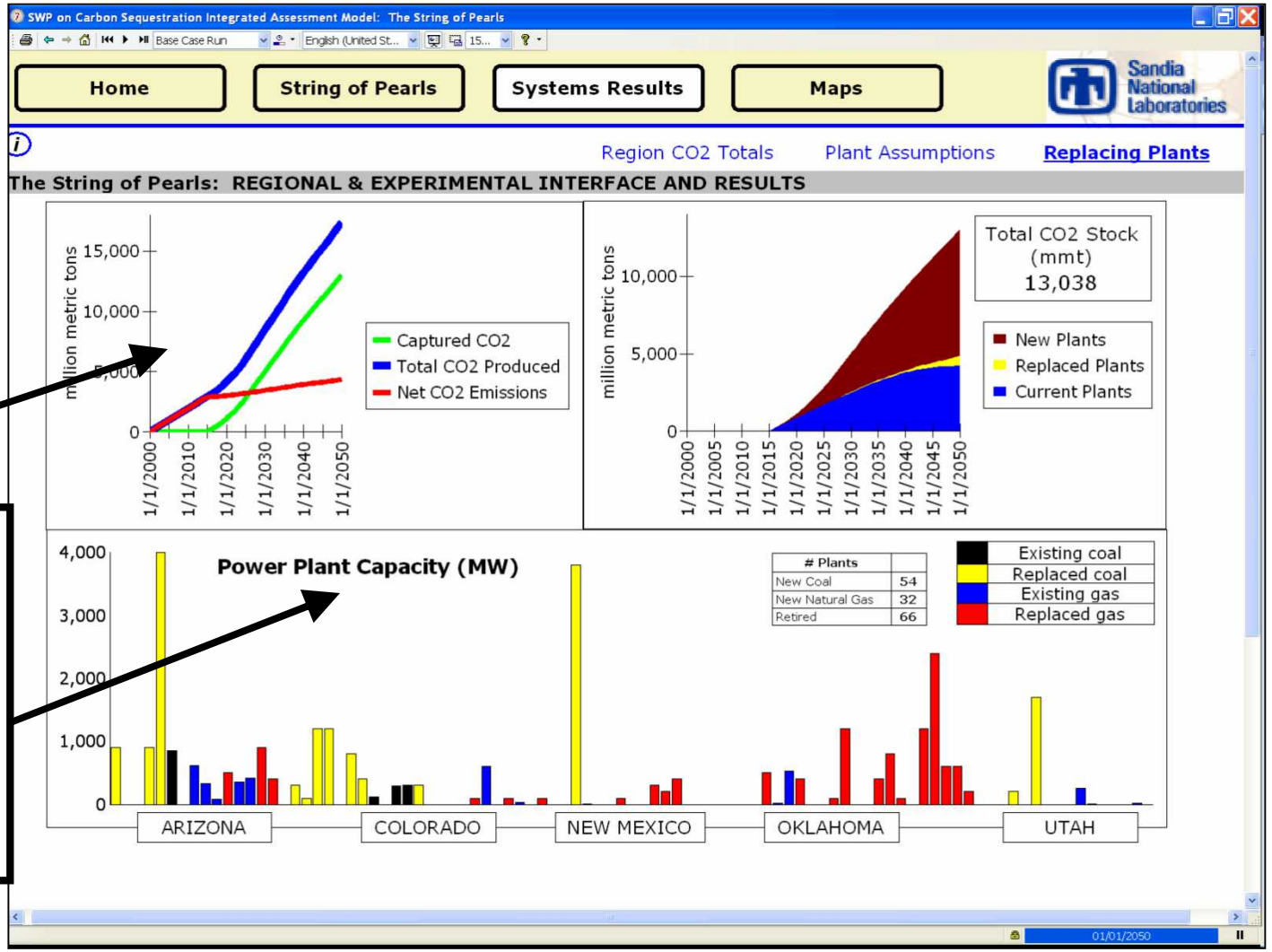
Prototype Power Plant Retirement, Replacement and Carbon Capture Interface

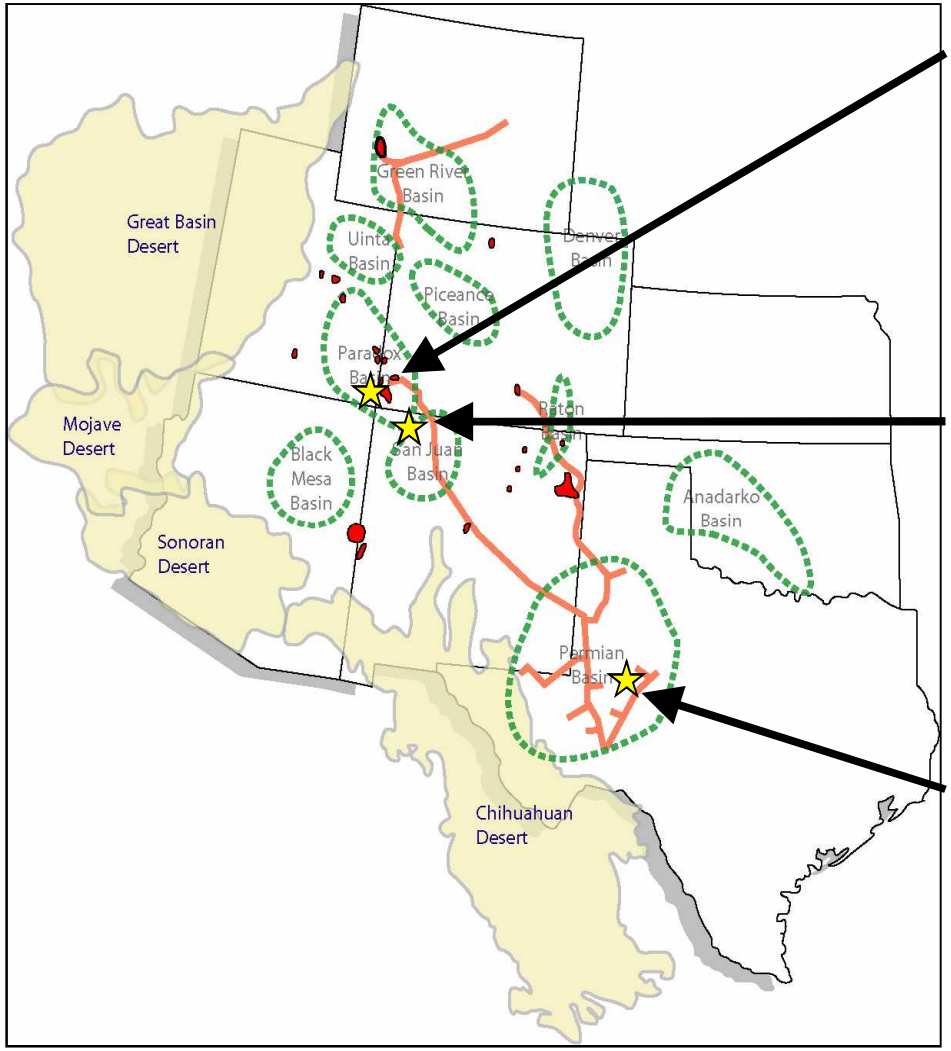
CO_2 Balance for the Region

Retired (Blue & Black) and new Power Plants (Red & Yellow)



Illustrative model results as of September 2007

Phase II Demonstration Options: Working towards Geological Sequestration



McPherson, 2005

- **<u>Paradox Basin, Utah</u>**: combined EOR and deep saline aquifer sequestration pilot test *(Jim Rutledge)*

- **<u>San Juan Basin, NM</u>**: combined ECBM and terrestrial sequestration pilot test *(Scott Reeves, Joel Brown)*

- **<u>Permian Basin, TX</u>**: combined EOR and sequestration pilot test at SACROC & Claytonville *(Mark Holtz)*

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Future Modeling Efforts

- **Focus on test cases, & plant / CO_2 Source characteristics**
  - Keeping the information flowing is key to the model's development
- **Coordinating with other Regional Partnerships**
  - Tell a more 'seamless story' for Carbon Capture and Sequestration
  - Potentially standardize the capture cost metrics (NETL working group)
- **Looking to include more CO_2 sources**
  - The Capture Working Group (other partnerships, GIS working group, etc.)
  - Assistance/development efforts with other sources where possible (e.g., ethanol plants, cement facilities, etc.)
- **Ongoing iterative Partnership feedback**
  - » Workshops, Conferences
  - » One-on-one (interested groups), other methods

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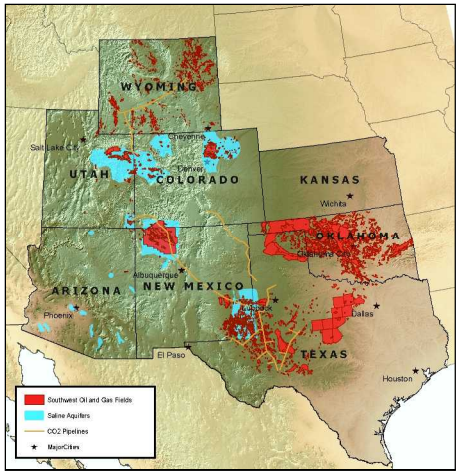

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