

# Enhanced Analytical Simulation Tool (EASiTool) for CO<sub>2</sub> Storage Capacity Estimation and Uncertainty Quantification

DE-FE0009301

Presenter: Alex Sun  
Bureau of Economic Geology,  
University of Texas at Austin

---

U.S. Department of Energy  
National Energy Technology Laboratory  
Carbon Storage R&D Project Review Meeting  
Developing the Technologies and  
Infrastructure for CCS  
August 20-22, 2013

# Presentation Outline

- Benefit to the Program
- Project Overview: Goals and Objectives
- Technical Status
- Accomplishments to Date
- Summary

# Benefit to the Program

- Major goal
  - Support industry's ability to predict CO<sub>2</sub> storage capacity in geologic formations to within  $\pm 30$  percent.
- Project benefit
  - This research project is developing an **Enhanced Analytical Simulation Tool (EASiTool)** for simplified reservoir models to predict storage capacity of brine formations.
  - EASiTool will consider advanced two-phase flow theory, geo-mechanically imposed limitations and brine management to estimate the storage capacity in open and closed boundary aquifers.
  - EASiTool will also perform uncertainty quantification.

# Project Overview: Goals and Objectives

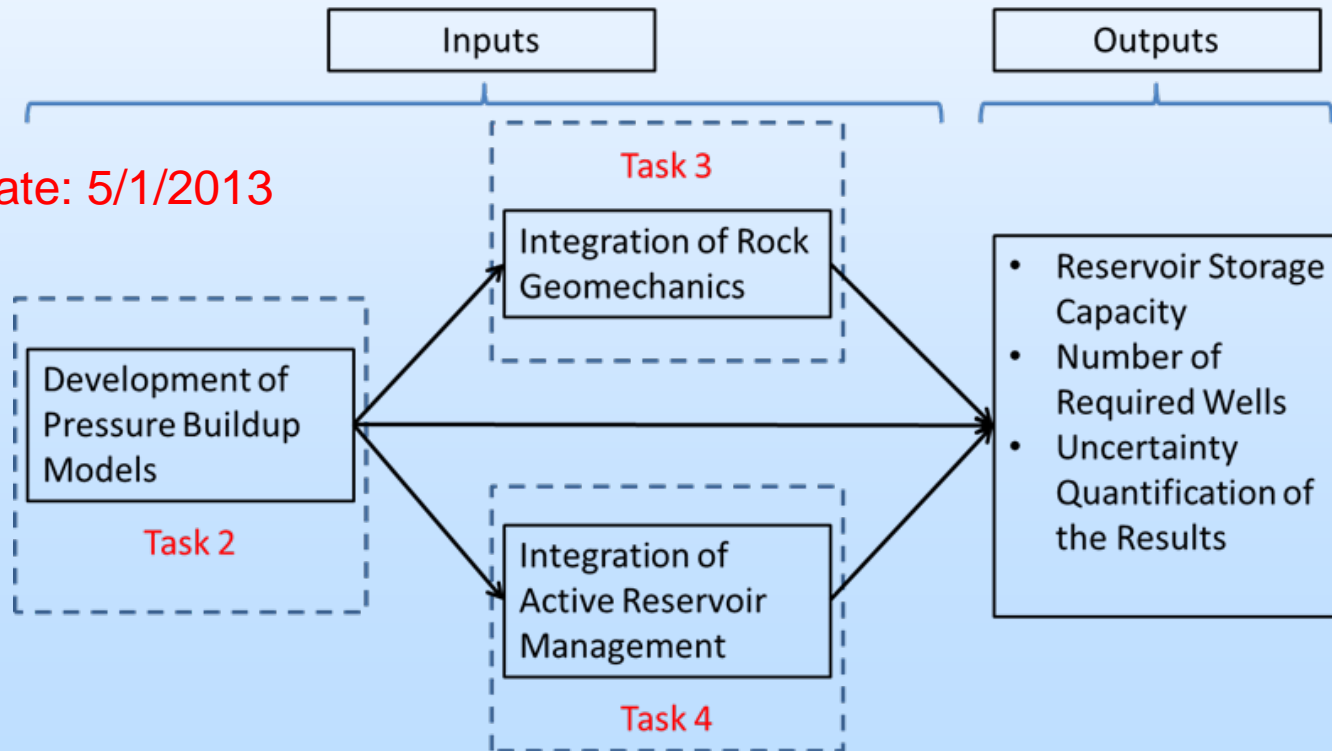
- Project goals and objectives
  - EASiTool is intended for technical and nontechnical users with minimum engineering knowledge to achieve a fast, reliable and science-based estimate of storage capacity for brine formations by using analytical and semi-analytical models.
  - At the end of the first year of project, first version of the EASiTool will be available to the public. This package is standalone and no license is required.
  - Second version of EASiTool will incorporate geomechanics.
  - Third version of EASiTool will incorporate brine management scenarios.

# Technical Status-1

- An analytical based, Enhanced Analytical Simulation Tool (EASiTool) will be developed for technical and non-technical users.
- EASiTool will include closed-form analytical/semi-analytical solutions.
- It is intended to be very user friendly, at the same time analytical models behind the EASiTool will be cutting-edge models.
- EASiTool will incorporate effects of rock geomechanics, evaporation of brine near the wellbore as well as brine extraction.
- A net present value (NPV) based analysis will be implemented to devise the best field development.
- Uncertainty quantification (UQ) of the results based on Monte Carlo method will be provided.


# Technical Status-2

- Currently under Task 2, analytical models are gathered from literature to be implemented in Goldsim software.
- New models is under development to estimate the storage capacity in multiwell injection scenarios.



# Accomplishments to Date-1

- Suitable infrastructure and teaming arrangements established
- Literature review to investigate the analytical models carried out.
- Public website created to post project updates and eventually upload the first version of software  
(<http://www.beg.utexas.edu/gccc/EASiTool/index.php>)




The screenshot shows the EASiTool project website. The header includes the Bureau of Economic Geology logo, the Gulf Coast Carbon Center logo, and the Jackson School of Architecture logo. The main content area is titled "EASiTool" and features a "Project Overview" section. This section describes the Enhanced Analytical Simulation Tool (EASiTool) for CO2 Storage Capacity Estimation and Uncertainty Quantification, led by Project PI Seyyed A. Hosseini and collaborators from C12 Energy. The text explains that the tool is designed for technical and non-technical users, providing a fast and reliable estimate of storage capacity for any geological formation. It also mentions that the tool will be developed with a highly user-friendly interface and will be used to optimize CO2 injection projects by maximizing NPV. A list of three key benefits is provided: 1) application of advanced closed-form analytical solutions, 2) estimation of the number of injection/extraction wells, and 3) improving static storage efficiency coefficients. The website also features a "members area login" section with links to the GCCC forum, bookshelf, home, about GCCC, areas of research, sponsors, staff, and FAQs. Logos for the University of Texas at Austin and C12 Energy are also visible.

# Accomplishments to Date-2

- Selected models implemented into the Goldsim.
- Validation of the analytical models is done. As more models is integrated validation process will continue.
- Interface of the software is designed and is developing as project progresses.

EASITool - Enhanced Analytical Simulation Tool for CO<sub>2</sub> Storage Capacity Estimation and Uncertainty Quantification



BUREAU OF  
ECONOMIC  
GEOLOGY

**Input**

Temperature (C)	<input type="text" value="40"/>	Thickness of aquifer (m)	<input type="text" value="50"/>
Pressure (MPa)	<input type="text" value="10"/>	Porosity	<input type="text" value="0.2"/>
Salinity of brine (mol/kg)	<input type="text" value="1"/>	Radius of brine aquifer (m)	<input type="text" value="13700"/>

Mole fraction of CO<sub>2</sub>

Mole fraction of H<sub>2</sub>O

Density of CO<sub>2</sub>

Permeability (m<sup>2</sup>)

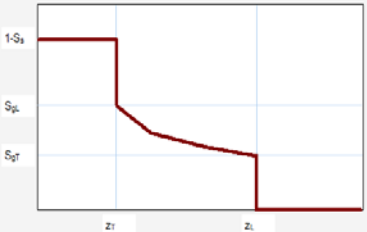
Residual saturation of brine	<input type="text" value="0.5"/>	Injection rate (kg/day)	<input type="text" value="2000"/>
Critical gas saturation	<input type="text" value="0.1"/>	Time (day)	<input type="text" value="365"/>

End-point relative permeability of brine

End-point relative permeability of CO<sub>2</sub>

Power-law exponent for relative permeability of brine

Power-law exponent for relative permeability of CO<sub>2</sub>



The graph plots 1-S<sub>g</sub> on the y-axis against position z on the x-axis. The curve starts at a high value, drops sharply at z<sub>1</sub>, and then gradually decreases to a lower value at z<sub>2</sub>.

**Output**

Volume fraction of precipitated salt, S <sub>s</sub>	<input type="text" value="0.01290"/>
Location of trailing shock (m)	<input type="text" value="0.190575"/>
CO <sub>2</sub> saturation S <sub>g,c</sub> at trailing shock	<input type="text" value="0.51"/>
Location of trailing shock (m)	<input type="text" value="9.42407"/>
CO <sub>2</sub> saturation S <sub>g,l</sub> at leading shock	<input type="text" value="0.33"/>



# Summary

- EASiTool development started 5/1/2013 and first version of software will be available by 5/1/2014.
- Analytical models that consider CO<sub>2</sub> dissolution, brine evaporation, salt precipitation are implemented into the software.
- Current models are designed for single well models in open and closed boundary conditions.
- EASiTool will be available online for free download.

# Future Plans

- Development of the analytical models for multi-well scenarios in open and closed boundary brine aquifers.
- Adding uncertainty quantification capabilities to the software through running Monte Carlo simulations.
- Further development of the interface.
- Beta testing of the software by C12Energy.

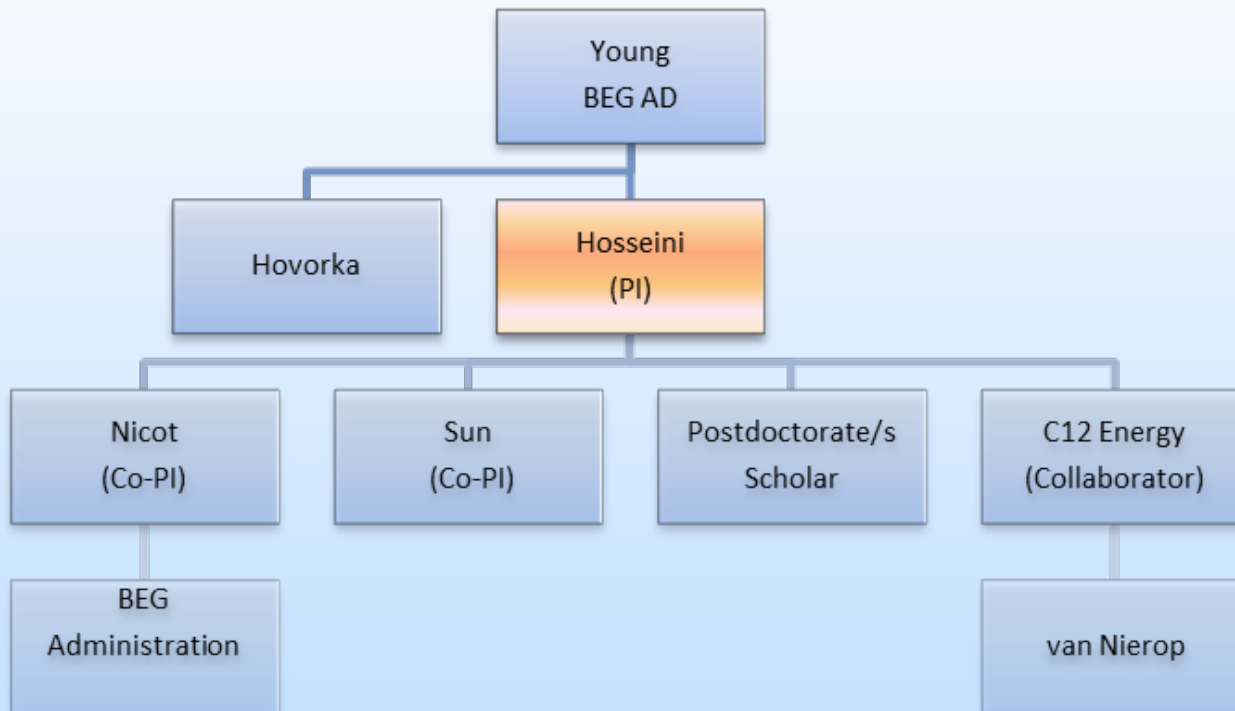
END

# Appendix

---

- Organization Chart
- Gantt Chart
- Bibliography

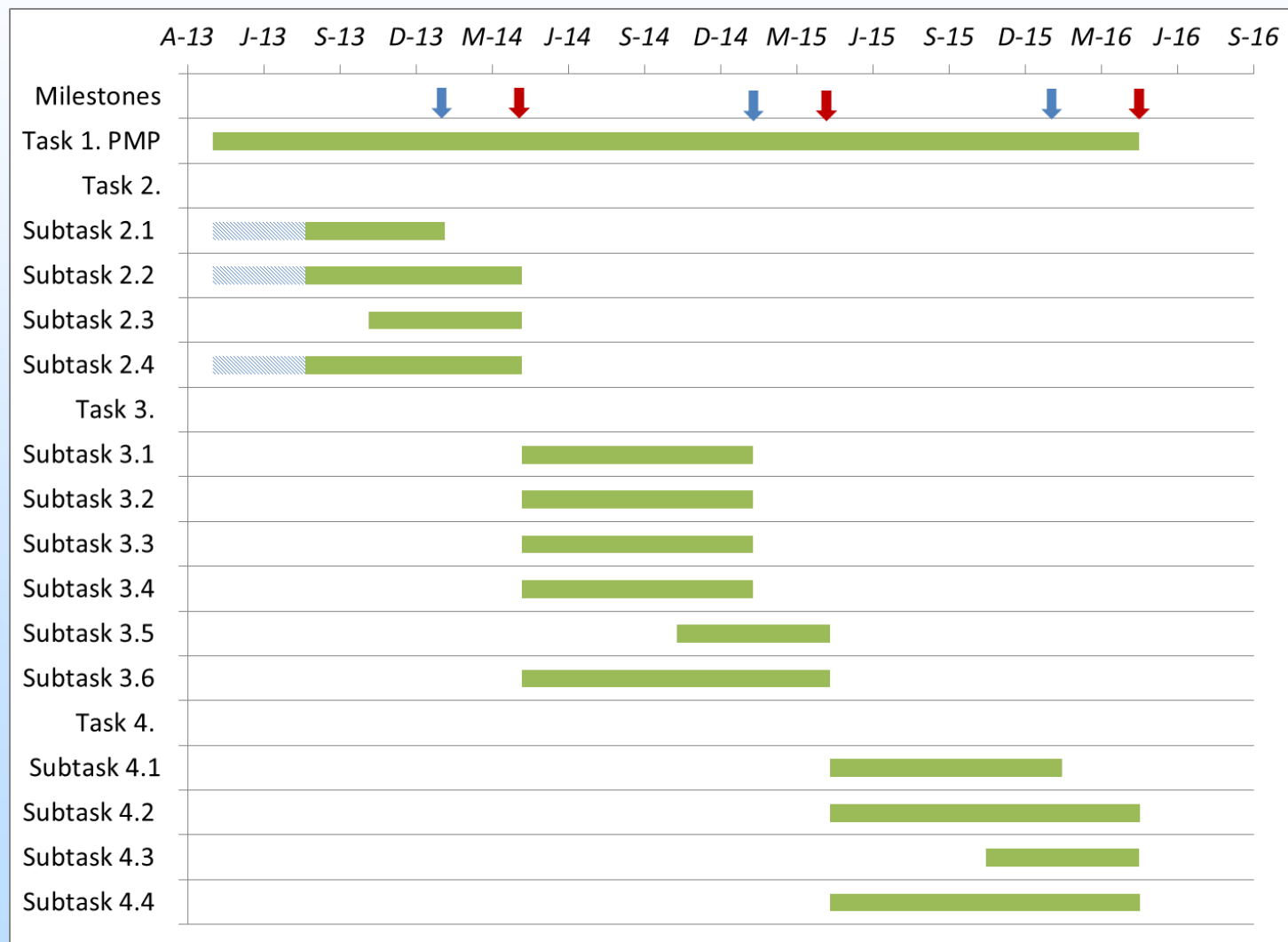
# Organization Chart



# Organization Chart

<b>Project PI: Seyyed A. Hosseini</b>			
<b>Task 1</b> Project Management and Planning	<b>Task 2</b> Development of Analytical Solutions for Pressure Buildup	<b>Task 3</b> Rock Geomechanics Impact on Pressure Buildup and Capacity Estimation	<b>Task 4</b> Brine-Management Impact on CO <sub>2</sub> Injectivity and Storage Capacity
Task Leader/Backup Nicot/Hosseini	Task Leader/Backup Hosseini/Sun	Task Leader/Backup Hosseini/Sun	Task Leader/Backup Hosseini/Sun
Task 1 Team Nicot/Hosseini/ Young/Hovorka	Task 2 Team Subtask 2.1 Hosseini/Sun/ Postdoc/s Subtask 2.2 Hosseini/Sun/C12 Energy Subtask 2.3 Sun/Hosseini Subtask 2.4 Sun/Hosseini	Task 3 Team Subtask 3.1 Hosseini/Sun/ Postdoc/s Subtask 3.2 Hosseini/Sun/ Postdoc/s Subtask 3.3 Sun/Hosseini Subtask 3.4 Hosseini/Sun Subtask 3.5 Sun/Hosseini Subtask 3.6 Sun/Hosseini	Task 4 Team Subtask 4.1 Hosseini/Sun/ Postdoc/s Subtask 4.2 Sun/Hosseini/ Postdoc/s Subtask 4.3 Sun/Hosseini Subtask 4.4 Sun/Hosseini

# Gantt Chart



# Bibliography

---