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Geothermal Electricity Technology Evaluation Model (GETEM) Development

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Track: Analysis, Data Systems and Education

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Project Overview

- **Timeline:**
  - **Original model development completed in 2006**
  - **Initial revision for EGS (incorporating prior work): 3rd Q FY2008 through 2nd Q of FY2009**
  - **Current revisions started in 4th Q of FY2009**

- **Budget:**
  - **FY2008: $230K**
  - **FY2009: $350K**
  - **FY2010: $350K**

- **Barriers:**

  GETEM addresses those barriers that limit the GTP's ability to quantify the outcome of its R&D activities. It is a cost-performance model that evaluates the relative contributions of all phases of a geothermal project to the total generation cost, and provides a means of comparing different scenarios and technology improvements

- **Partners: None**

Relevance/Impact of Research: Project Objective

Project Objective

- **Provide a tool for estimating the performance and contributions of all phases of a geothermal project to power generation costs**
  - **Use a PC platform available to public**
  - **Estimate costs in current dollars**
  - **Provide estimates for Hydrothermal or EGS resources**
  - **Utilize air-cooled binary or flash-steam conversion systems**
  - **Include impact of declining resource productivity on generation cost**

- **Provide means of assessing the impact of technology advances**

- **Provide sufficient detail in characterizing cost contributors that results of DOE R&D can be readily integrated**

GETEM is unique in its ability to provide these estimates of cost and performance. Its importance to DOE is its ability to the contributors that are the drivers for generation costs and assess technology benefits

Scientific/Technical Approach

General Approach:

- Continue development in Excel to facilitate usage

- User defines scenarios

- Utilize Bureau of Labor Statistics Producer Price Indices (PPI) to keep costs current

- Characterize phases of project development to assess impact of technology improvements (including DOE R&D results) and to allow PPI's to be applied

- Focus initial efforts where prior work and/or work by others exits

- Include all cost contributors (even if can not be characterized in detail)

- Validate and improve estimates using proprietary data, published results and feedback from industry, DOE analysts and the public

- Modify as necessary to accommodate current GTP needs

Scientific/Technical Approach - continued

Model Calculations:

- Model has individual modules that define each phase of a project development

- User provides necessary input necessary for each module

- Project size based on defined Power Sales or Number of Production Wells.

- Calculated # of wells or power sales are based on flow rate per well, plant performance metric (brine utilization – net power per unit mass flow) and geothermal pumping power

- Well field cost based on # of wells calculated or inputted

- Plant cost based on plant size (sales plus geothermal pumping power), produced fluid temperature, and plant performance

- O&M costs calculated based on plant size and calculated capital costs

- Effects of a decline in resource productivity are calculated and included in LCOE calculation

Scientific/Technical Approach - continued

Milestones:

Dec 09	Revise to allow for air-cooled binary plant design air temperatures other than 10C
Mar 10	Provide module for low-temperature resources
Aug 10	Provide module for expanded exploration characterization

Status:

- An expanded exploration module was provided to DOE for comment (March 2010)
- Work to allow for other design air temperatures postponed due to higher priority tasks
- Work on low temperature resources delayed until PI's have access to cost estimating software

Accomplishments, Expected Outcomes and Progress

- Updated estimates of the impact of a declining resource temperature on power production by incorporating a relationship that varies the plant 2nd law efficiency with the change in geothermal fluid temperature.

- Included additional refinement to the methods used to predict geothermal pumping (calculation of well friction factors, and inclusion of hydraulic resistance at the injection well).

- Included provision to estimate well field surface piping costs based on distance from well to plant and allowable pressure drop in piping.

- Incorporated additional detail to characterization of the Exploration module; emphasis on those exploration activities not associated with drilling. Included this modification in version of model provided to GTP for review and comment

# *Accomplishments, Expected Outcomes and Progress*

- **Revised methodology used to determine well costs that base cost on well casing configuration**
  - **Accounts for cost differences resulting from different injection and production well diameters**
  - **Facilitates use of PPI's for commodity costs**

- **Incorporated methodology (Ramey) for estimating temperature loss in production wells. The magnitude of this loss increases with increasing well depth and/or lower well flow rates, making it an important parameter for EGS scenarios.**

- **The user interfaces for the model are being revised**

The modifications to the model to incorporate the increased detail for both exploration and drilling costs, and to predict temperature losses in the well are being integrated into GETEM, but have not been completely vetted. A beta version with changes is expected to be available this summer.

Accomplishments, Expected Outcomes and Progress

- **Cost and performance estimates have been developed for several scenarios**
  - **Model Australian EGS projects**
  - **Life Cycle Cost Analysis**
  - **Use of EGS technologies (stimulation) to supplement production for hydrothermal resources**
    - **Use of wells within or adjacent to hydrothermal projects to provide additional flow to existing production**
    - **Development of separate power production facilities adjacent to existing hydrothermal**
    - **Make use of existing infrastructure**
- **Use model to perform sensitivity studies of different parameters (to assess relative impact) and the impact of improvements**
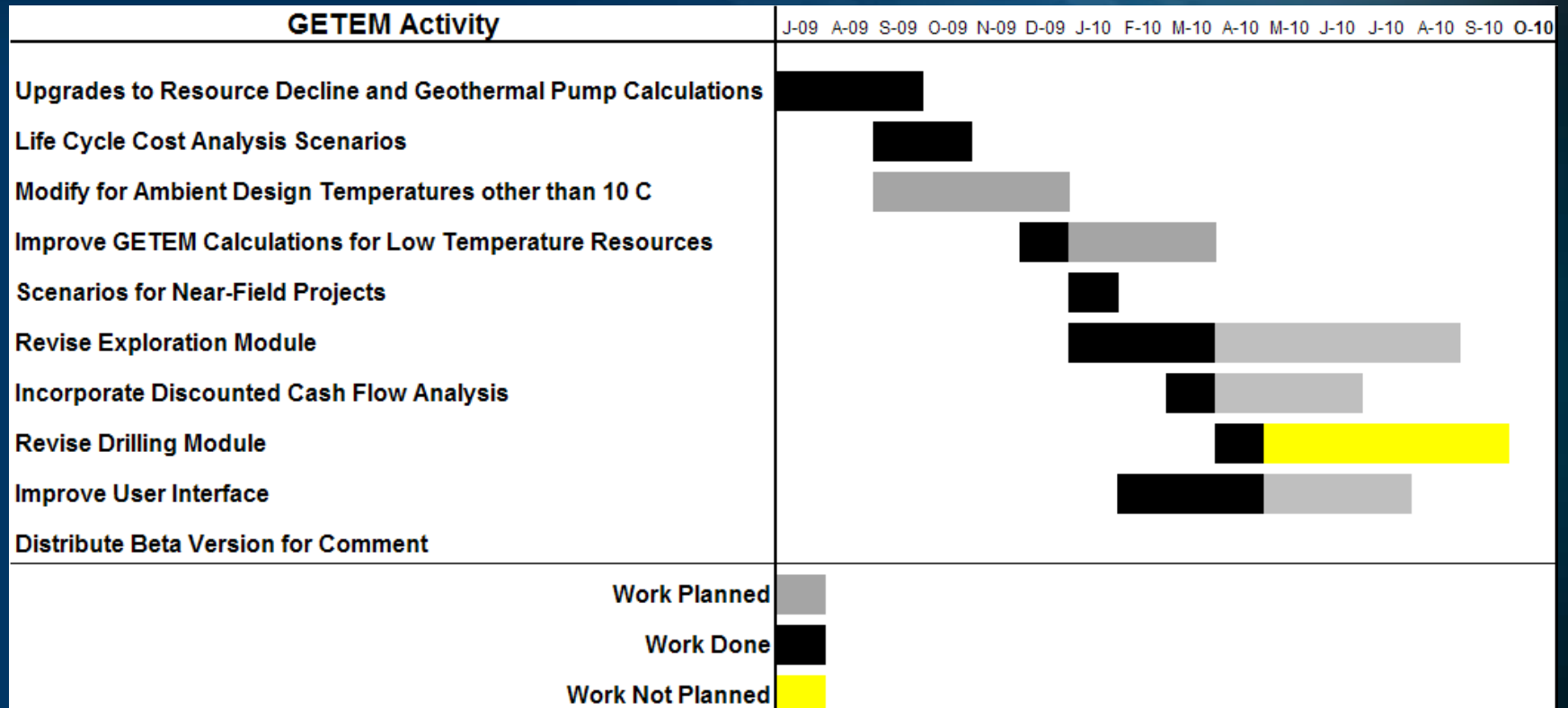
Accomplishments, Expected Outcomes and Progress
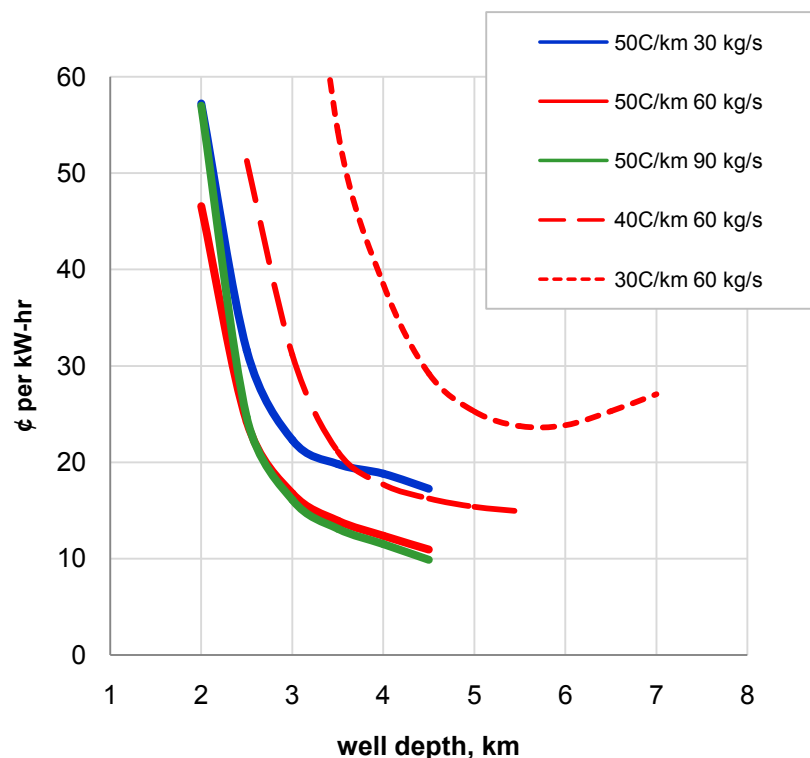
Effect of Well Depth, Flow Rate and Temperature Gradient on Generation Costs for an EGS Resource
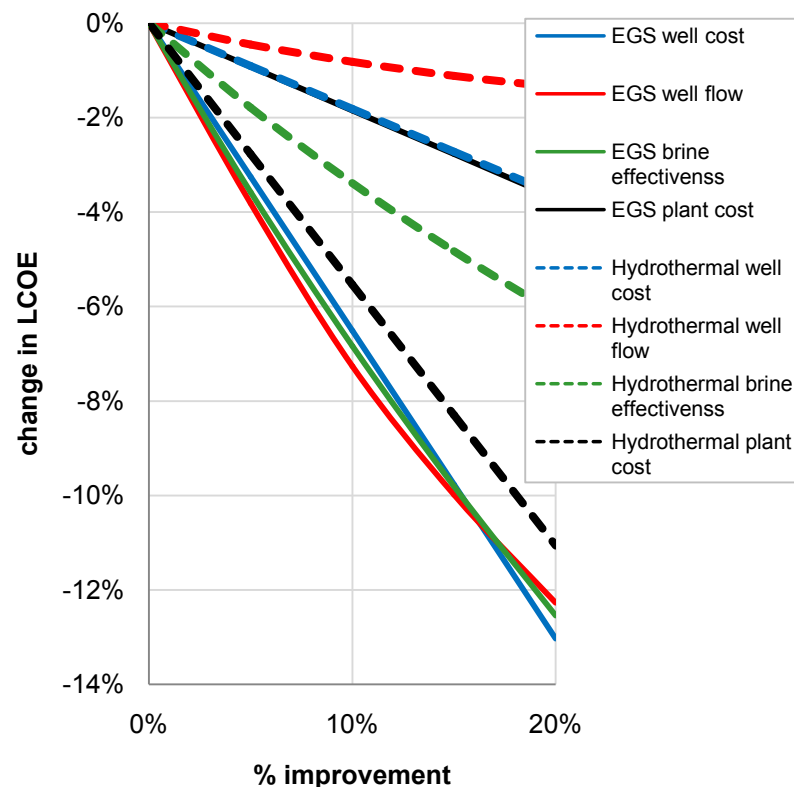
Effect of Technology Improvements on LCOE for EGS and Hydrothermal Scenarios
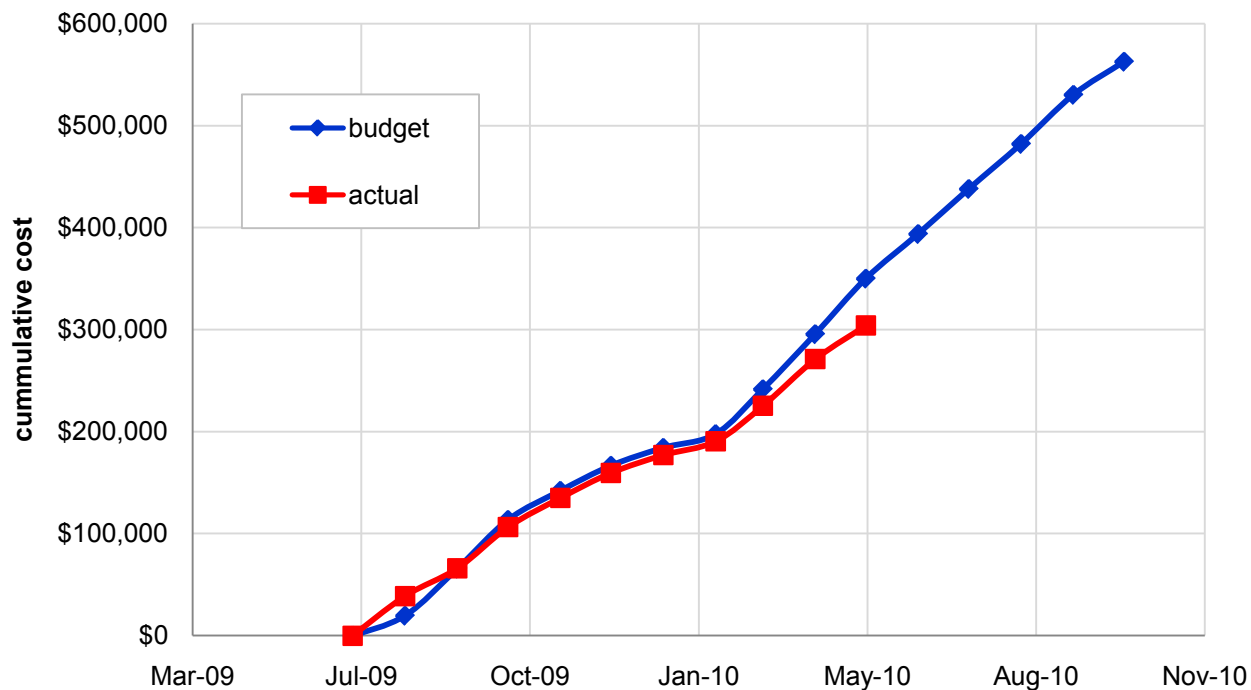
Project Management/Coordination

Project Schedule

GETEM Activity	J-09	A-09	S-09	O-09	N-09	D-09	J-10	F-10	M-10	A-10	M-10	J-10	J-10	A-10	S-10	O-10
Upgrades to Resource Decline and Geothermal Pump Calculations																
Life Cycle Cost Analysis Scenarios																
Modify for Ambient Design Temperatures other than 10 C																
Improve GETEM Calculations for Low Temperature Resources																
Scenarios for Near-Field Projects																
Revise Exploration Module																
Incorporate Discounted Cash Flow Analysis																
Revise Drilling Module																
Improve User Interface																
Distribute Beta Version for Comment																

Work Planned

Work Done

Work Not Planned

Project Management/Coordination

Spend Plan

Project Management/Coordination

Integration with other projects

- **Used for Risk Analysis and Market Penetration Studies**
- **Used for Life Cycle Analysis Studies**

Coordination with Industry and Stakeholders

- **Versions are made to industry and public for use and comment**
- **Industry is asked to provide feedback on reasonableness of estimates**

Future Direction

- **Revise and update the Reservoir Creation module - The objective of these upgrades will be to relate the size of the reservoir created to cost and to the effect of flow in through this reservoir on heat transfer and hydraulic losses.**

- **Include a discounted cash flow analysis to account for a project timeline with varying rates of return**

- **Improve the model's User interface**

- **Revisit the applicability of the hydrothermal assumptions that are being applied to EGS - The current model has inherent assumptions regarding minimum geothermal fluid outlet temperatures, plant size, and upper temperature limits for binary plants that may not be relevant for EGS applications.**

- **Use the results from DOE R&D to validate and/or improve the model's depiction of each contribution to the power generation costs**

- **The model will likely to continue to evolve in response to changing GTP needs.**

Summary

- **GETEM is a tool capable of providing LCOE estimates for different resource and conversion system types.**

- **It provides a summary of the cost contribution for each phase of the project to the total generation costs, and allows one to assess how technology can impact those costs**

- **Efforts are in progress to provide upgrades to improve the model's estimate of generation costs for EGS and provide the GTP a means of quantifying the benefits of its research**
  - **Exploration and Confirmation – in review**
  - **Drilling – available for review by end of June**
  - **Low-Temperature Resources – available for review by end of September**
  - **Reservoir Creation - FY2011**

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