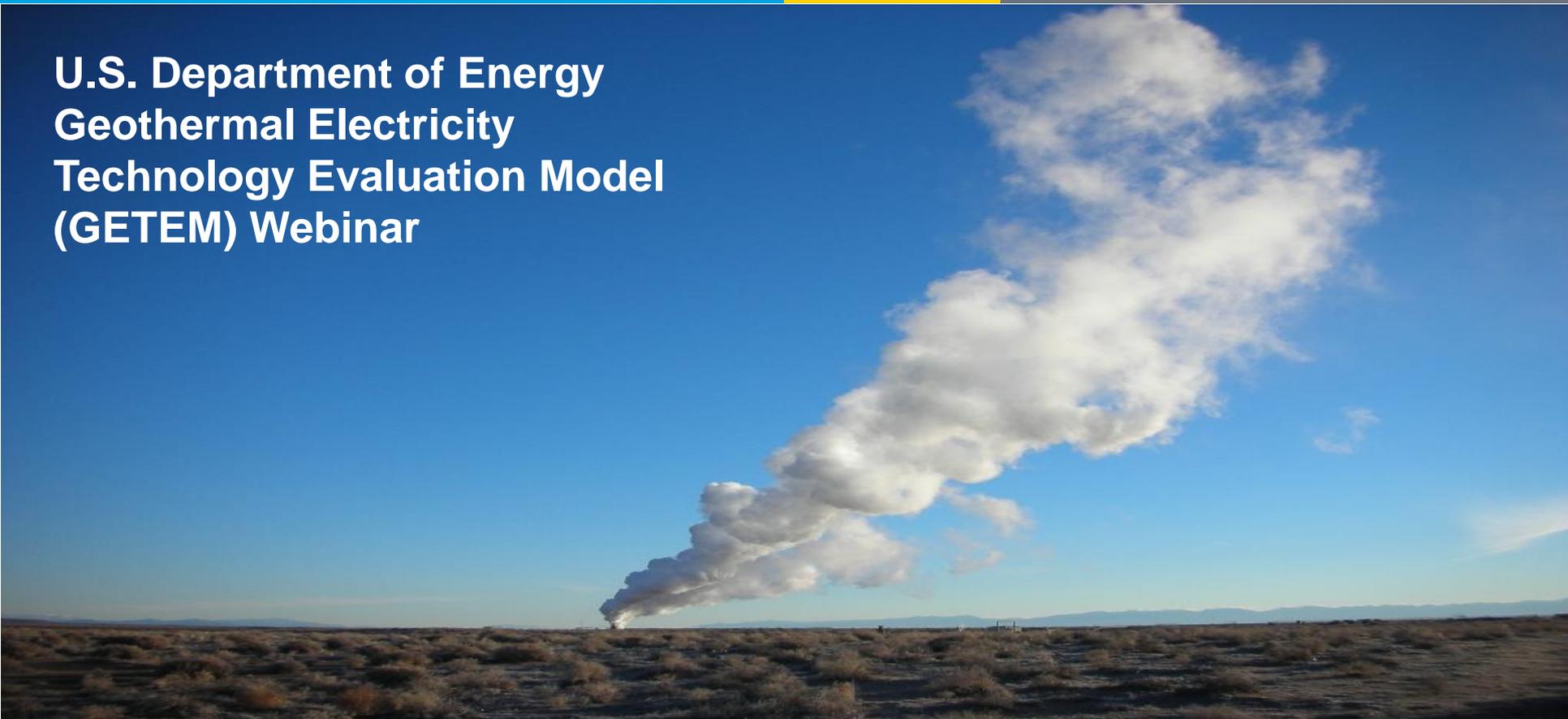


U.S. Department of Energy Geothermal Electricity Technology Evaluation Model (GETEM) Webinar



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Idaho National Laboratory
June 30, 2011

- Please type in and submit questions as they occur to you during the presentation
- DOE will attempt to answer as many as possible after presentation
- All Q&As will be posted on <https://eere-exchange.energy.gov/>
 - Click on the link for 522 and then the link for FAQ
- Please submit additional questions to FOA522@GO.DOE.GOV

- It does not readily quantify the benefit of reducing risk
- It does not quantify benefit of expanding the resource base

- Provides representative power generation costs from geothermal resources
 - Original focus was on hydrothermal
 - Recent focus has been on EGS
- Identifies cost drivers and provides a means of assessing how technology can impact costs
- Calculates levelized cost of electricity (LCOE) for baseline or reference condition
- Determines an “improved” LCOE based on user defined improvements resulting from advances in technology

- GETEM is an Excel-based tool
- We recommend you download it to your computer from:
<http://www1.eere.energy.gov/geothermal/getem.html>
- Assure macros are enabled and the Solver add-in is active
- If macros will not run, unprotect sheets and run Solver – the Solver parameters should be loaded
- Inputs are linked to other sections of the model - changes in one input section can affect calculations elsewhere in the model
 - Be careful with well flow rate and resource temperature

- **Resource**
 - Hydrothermal or EGS
- **Power Plant**
 - Air-cooled binary or flash steam
- **Project Size**
 - Fixed power sales or fixed number of production wells

Once selected, these parameters are used for both the reference and improved scenarios

- User defines reference scenario and that input is used to calculate:
 - Power sales or number of wells required
 - Capital costs
 - O&M costs
 - Levelized cost of electricity (LCOE)
- User can accept model's calculated cost/ performance or input value
- Determines an “improved” LCOE based on user defined improvements to cost or performance parameters that result from advances in technology

- User can change the reference scenario
- See FOA FAQs about changing scenarios
- Applicants are asked to include in supporting analysis all changes made to the reference scenario and the technology improvements, along with the basis for changes

DOE GETEM Beta May 2011.xlsm - Microsoft Excel

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GETEM - INPUT WORKSHEET

HIGH-LEVEL SUMMARY		Reference Scenario	Improvement Change	Improved Scenario
COST OF ELECTRICITY	c /kW-h	9.255	0.0%	9.255
RESOURCE TYPE		HYDROTHERMAL		
CONVERSION SYSTEM		BINARY		
POWER SALES	kW	20,000		20,000
Number of Errors/Messages		0	note	

PROJECT PHASE

- + **ECONOMIC PARAMETERS**
- + **RESOURCE DEFINITION**
- **RESOURCE EXPLORATION**
 - + Exploration Parameters:
 - + Exploration - Drilling Costs :
 - + Exploration - Non-Drilling Costs :
- + **RESOURCE CONFIRMATION**
- + **WELL FIELD DEVELOPMENT**
- + **RESERVOIR DEFINITION**
- + **GEOHERMAL FLUID PUMPING**
- + **OPERATION & MAINTENANCE**
- + **POWER PLANT**

Ready

INPUT TRR ECONOMICS COE ECONOMICS Error-Warnings SUMMARY Binary Output Flash Output Tables

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- *Utilization factor* – ratio of number of kilowatt-hours produced annually to number of kilowatt-hours if operated at design output continuously throughout year
- *Fixed charge rate* – accounts for annual costs related to capital expenses; includes certain taxes as well as amortization of the capital costs (see original GETEM Manual Vol. 1)
 - The use a fixed charge rate to calculate the LCOE is the approach DOE uses for renewables
- *Project Life* – 30 years (can not be changed)

- Simple discounted cash flow sheets that allow the user to calculate:
 - Internal rate of return for defined/calculated cost of electricity
 - Cost of electricity for defined internal rate of return
 - Calculations based on user defined schedule for project phases
- Results only displayed on the sheets where calculations are made

- Define whether EGS or hydrothermal
- Define temperature and depth

- **Define calculation parameters**
 - Resource potential can be important for scenarios with higher thermal drawdown – can limit makeup drilling
 - Note the proportioning of exploration costs with resource potential discovered is „shut-off’
 - Can include the cost of failed projects

- **Well Drilling**
 - Success rate or # of exploration wells drilled
 - Move to confirmation phase with first successful well
 - Use of slimhole wells is allowed – User must define cost multiplier for drilling
 - Successful exploration well can support fluid production to power plant

- Define as lump sum or by activity
- Exploration activities include:
 - Survey of existing information
 - Field work (includes geochemistry)
 - Structural analysis
 - Remote sensing
 - Geophysics
 - Temperature gradient measurements
 - Reporting
 - Other

- Confirmation drilling success rate
- Base well count on user defined value or fraction of total production flow confirmed
- Use multiplier to reflect higher drilling cost during this initial phase
- All wells are production well sized; successful wells support plant operation
- Non-drilling cost
 - Well testing defined by user
 - Other costs - lump sum or % of total confirmation phase capital cost

- Define number of spare wells, dry holes
- Define ratio of injection to production wells
- Calculate well costs using
 - Cost curves
 - Estimate of cost based on well size (diameter) – Beta
- User adjusts calculated cost to match desired reference cost
- All injection wells assumed to be drilled in this phase
- Number of production wells drilled in this phase is total required less successful exploration & confirmation wells

- Non-drilling costs
 - Surface equipment cost estimated from user input
 - Other costs are % of total well field development phase capital cost

- Well flow rate
- Well stimulation cost
- Hydraulic drawdown
 - Applied to both production and injection wells
- Thermal drawdown
 - Define maximum decline in temperature allowed before makeup drilling
 - Define annual rate at which temperature declines

- Geothermal Fluid Pumping
- Operations and Maintenance
- Power Plant
- To change power plant type or whether the calculation is based on power sales or number of production wells go to → Power Plant → Power Plant Parameters

- When there is a potential issue with input, a warning/error message is generated
- Summarized on sheet with red tab „Error-Warnings’
- Active messages are displayed
- Hyperlink back to section on input sheet where issue occurs

Error-Warnings Tab

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This sheet displays error and/or warning messages that occur when there is question regarding the user input. Check these messages to see if input needs to be revised. If the macro was used to minimize the binary plant LCOE by varying plant performance, run it again after any input changes.

Location		Message	Number of Errors/Messages
1 1.6173937	Input: RESOURCE CONFIRMATION	A minimum of two successful confirmation wells are required for EGS resource	1
1 0	Input: RESOURCE CONFIRMATION	Stop - Confirmation Wells are not being stimulated for EGS Resource	1
0 0 2000000	Input: RESOURCE CONFIRMATION		0
1.6173937 3	Input: RESOURCE CONFIRMATION		0
1 2500	Input: RESOURCE DEFINITION WELL FIELD DEVELOPMENT		0
0 0	Input: WELL FIELD DEVELOPMENT		0
0 1	Input: RESERVOIR DEFINITION RESOURCE DEFINITION	STOP - Must simulate wells with EGS Resource	1
0 0	Input: RESERVOIR DEFINITION		0

Ready | INPUT IRR ECONOMICS COE ECONOMICS **Error-Warnings** SUMMARY Binary Output Flash Output Tables | 125% | 7:39 AM

Example – Decrease well drilling costs for \$5.75M/well by 25%

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GETEM - INPUT WORKSHEET

HIGH-LEVEL SUMMARY		Reference Scenario	Improvement Change	Improved Scenario
COST OF ELECTRICITY	c /kW-h	11.567	-6.2%	10.847
RESOURCE TYPE		HYDROTHERMAL		
CONVERSION SYSTEM		BINARY		
POWER SALES	kW	20,000		20,000
Number of Errors/Messages		0	note	

Well Drilling Costs :

	Cost Curves	Production Well		Injection Well	
		Low		Low	
How are costs for drilling wells determined ?					
Cost Curve to be used for each Well Type					
Well Cost per cost curve	\$ / well	\$3,020,244		\$3,020,244	
This method of estimating costs has been added to provide a means of evaluating a different configuration for the injection well allowing trade offs between well cost and injection pumping power to be evaluated. This method for estimating costs has not been thoroughly checked.					
GETEM Estimates					
Calculated Well Cost per GETEM estimate		\$4,329,299	note	\$4,214,080	

Adjustments to Production and Injection Well Drilling Costs :

		Reference		Improved
Reference - Scenario Production Well Cost	\$ / well	\$3,020,244		
User Adjustment to Production Well Cost		1.90382	note	
Production Well Cost Used	\$ / well	\$5,750,001	0.75	\$4,312,500
Reference - Scenario Injection Well Cost	\$ / well	\$3,020,244		
User Adjustment to Injection Well Cost		1.90382	note	
Injection Well Cost Used	\$ / well	\$5,750,001	0.75	\$4,312,500

INPUT COE ECONOMICS ... Binary Output Flash Output Tables

Ready

Example – Decrease well drilling costs for \$5.75M/well by 25%

GETEM - INPUT WORKSHEET				
HIGH-LEVEL SUMMARY		Reference Scenario	Improvement Change	Improved Scenario
COST OF ELECTRICITY	10.963	-3.6%	10.572	
RESOURCE TYPE	HYDROTHERMAL			
CONVERSION SYSTEM	BINARY			
POWER SALES	20,000		20,000	
		Number of Errors/Warnings	0	note
Well Drilling Costs :				
How are costs for drilling wells determined ?		GETEM Estimate	Production Well	Injection Well
Cost Curves				
Cost Curve to be used for each Well Type			Low	Low
Well Cost per cost curve		\$ / well	\$3,020,244	\$3,020,244
GETEM Estimates		<p>This method of estimating costs has been added to provide a means of evaluating a different configuration for the injection well allowing trade offs between well cost and injection pumping power to be evaluated. This method for estimating costs has</p>		
What is the Well Configuration in Production / Injection Zone ?		Perforated / Slotted Liner	note	Open Hole
Production Well Interval Liner OD or Hole Diameter		inch	8.625	note
Injection Well Interval Liner OD or Hole Diameter		inch		10.625
If Liner Specified, Diameter Used		inch	8.625	0
User Adjustments				
- Trouble Index / Multiplier			1.18	note
- Rate of Penetration Index / Multiplier			0.5	note
Embedded Rate of Penetration Shallower than 3,048 m (10,000		m / hr	7.62	
Embedded Rate of Penetration Deeper than 3,048 m (10,000 ft)		m / hr	4.57	
- Bit Life Index / Multiplier			0.75	note
Embedded Baseline Bit Life		hrs	100	
- Casing Cost Index			1	note
Baseline Casing Cost Determined		\$ / lb	\$0.92	note
Embedded Cost Multiplier Used for Casing Exposed to Geofluid			1.5	note
- Cement Cost Index			1	note
Embedded Baseline Cement Cost		\$/ft ³	\$65	note
Calculated Well Cost per GETEM estimate			\$5,499,386	note
Adjusted Well Cost per GETEM estimate			\$5,499,386	note
Adjustments to Production and Injection Well Drilling Costs :		Reference		Improved
Reference - Scenario Production Well Cost		\$ / well	\$5,499,386	
User Adjustment to Production Well Cost			1	note
Production Well Cost Used		\$ / well	\$5,499,386	0.75
				\$4,124,539

GETEM Demonstration