Geothermal Resource Potential and Supply Curve Improvement

Project Officer: Tim Reinhardt
Total Project Funding: $544k
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Systems Analysis: Systems Analysis, Resources Assessment, Data System Development & Population, Education

Relevance/Impact of Research

Objectives: The overall objective of this task is to improve the resource potential and supply curve estimates for key geothermal resources. This objective encompasses:

1. Update cost estimates for hydrothermal and EGS resource types to the most current version of GETEM
2. Improve resource potential estimates for shallow EGS resources.
3. Improve resource potential estimates for in-field EGS resources.
4. Develop an estimate for low-temperature EGS geothermal resources in the Eastern US, focusing on the ability and potential for the thermal resource used by direct-use and co-generation projects to offset the use of fossil fuels that could otherwise be used to generate electricity.

Relevance/Impact of Research

Impacts: The updates and studies in this task are required for accurately assessing the potential of current and future geothermal technologies to have a material impact on the US energy landscape. Cost estimate and resource potential updates, especially for in-field and shallow EGS resources, will aid GTO in setting program goals, strategy, and RD&D priorities.

GTO Goals: This project will help GTO develop the studies and information required to meet their stated goals. For example:

- Drive industry deployment of a targeted 100+ GW of EGS
  - Improvements in in-field and shallow EGS resource potential and cost estimates will aid GTO in setting technology goals and targets and understanding impacts of R&D advances on resource deployment
- Accelerate development of 30 GWe of undiscovered hydrothermal resources
  - Improvements in cost estimates (in GETEM) aid in identifying key cost and technology barriers, setting R&D priorities, and estimating deployment potential through market penetration models
- 3 GWe of installed low-temperature geothermal capacity by 2020
  - By identifying resources and deployment opportunities

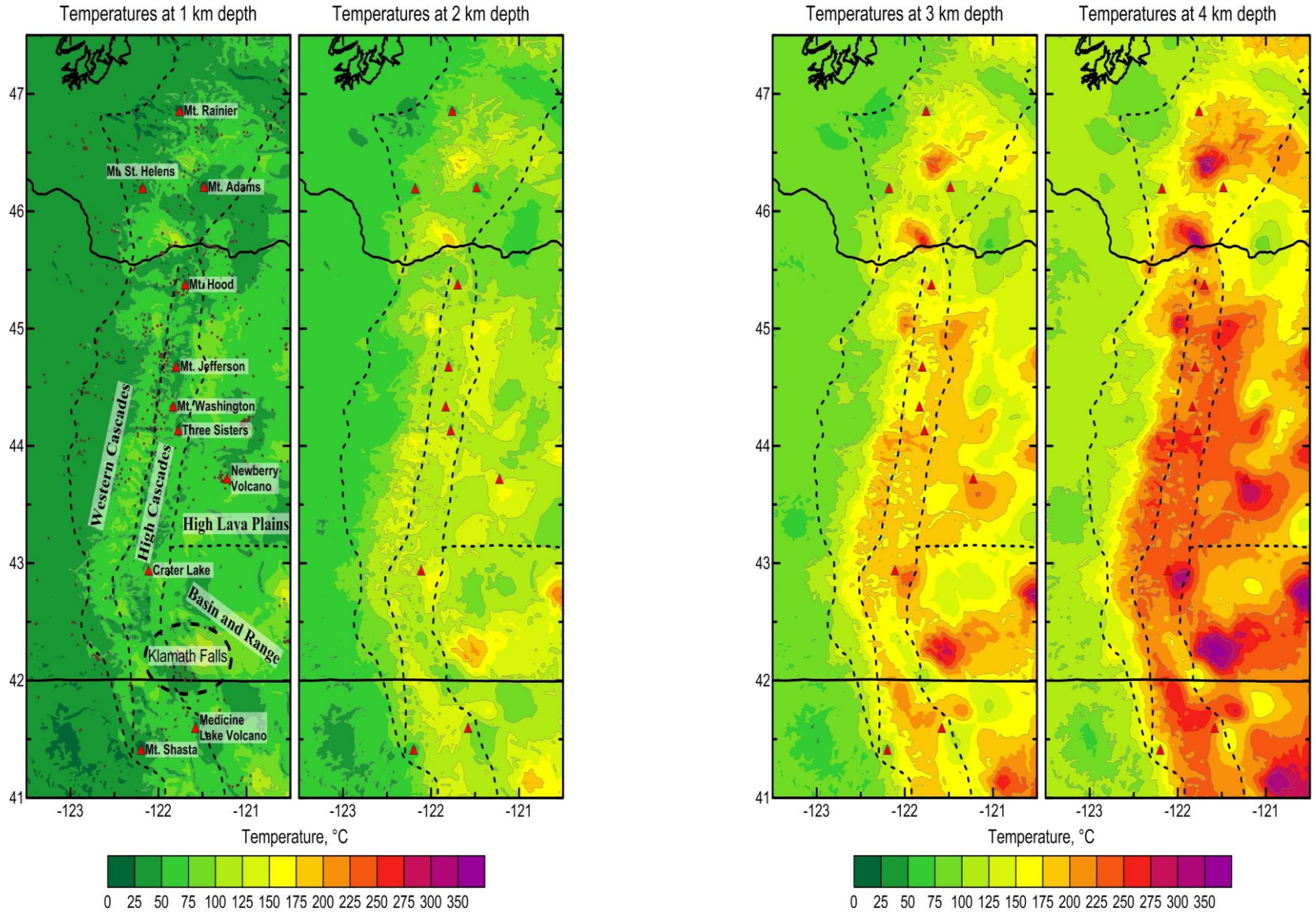
Shallow EGS Resource Potential Improvements:

Improve estimates of the “shallow” (and hence more commercially viable) EGS resource by developing detailed temperature maps in the 1 to 4 km depth range at regional scale (FY14 – Cascade Range)

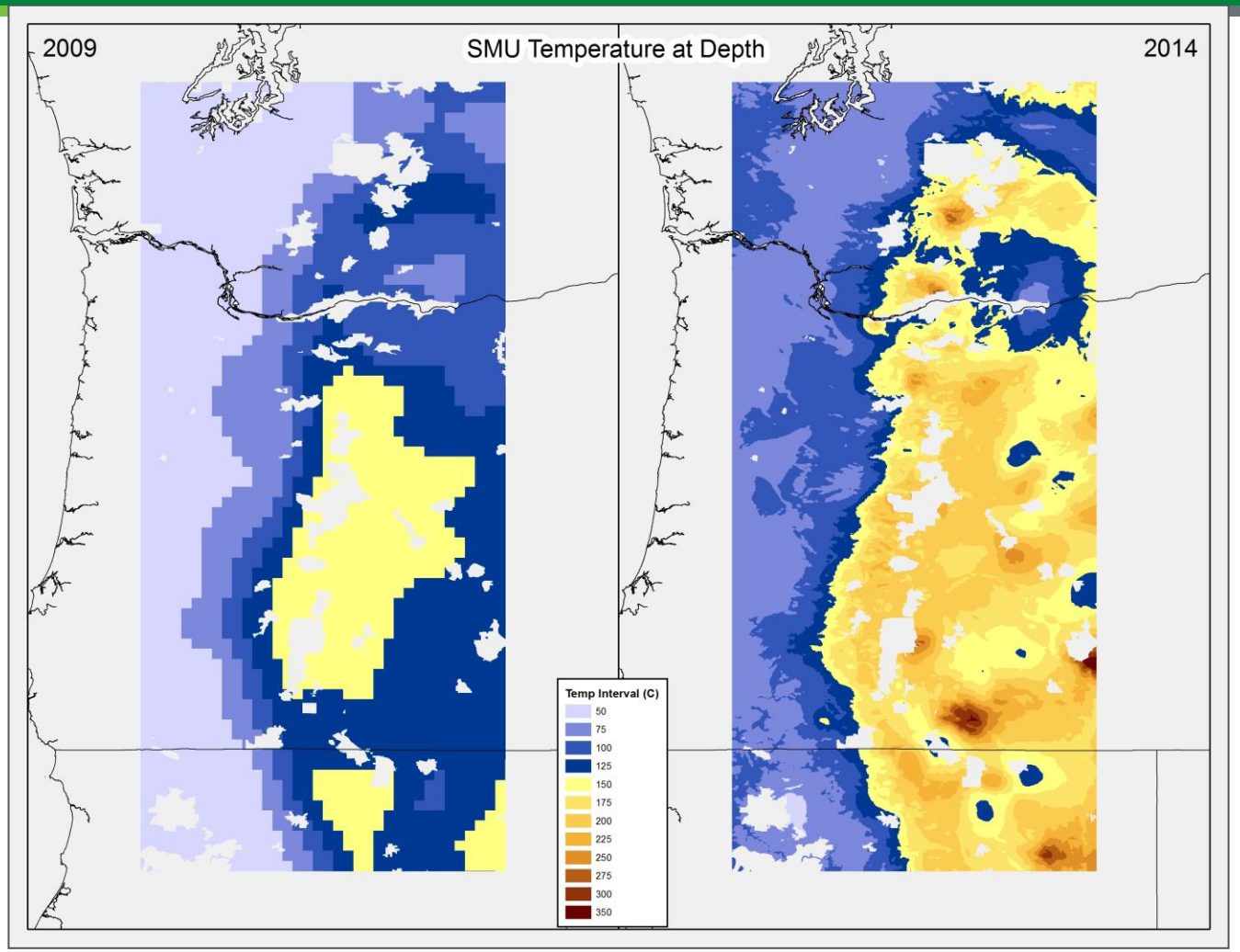
The temperature at depth maps will be developed in collaboration with the SMU Geothermal Laboratory.

1. NREL, with guidance from SMU, will gather and clean data on well temperature, heat flow, temperature gradient, and thermal conductivity in the region of interest.
2. SMU will then apply techniques and technologies developed by SMU to develop temperature at depth maps. Maps will cover depths from 1 to 4 km.
3. The resulting maps will be used to develop estimates of resource potential (SMU/NREL collaboration).

Accomplishments, Results and Progress



Accomplishments, Results and Progress



Comparison of SMU temperature estimates at depth of 3.5 km in the Cascades regions from previous national-level study (MIT, 2006) and regional-level study (this study). Federally-protected and DoD lands removed.

Accomplishments, Results and Progress

Temperature Interval	2006 National Map (MIT, 2006)			2014 Cascades Map (this study)		
	CA	OR	WA	CA	OR	WA
150-175	2,834	11,548		1,713	8,041	3,307
175-200				3,490	11,052	1,856
200-225				3,236	14,048	523
225-250				1,488	2,837	257
250-275				572	697	159
275-300				163	363	
300-325					284	
325-350					117	
Totals	2,834	11,548		10,662	37,438	6,102
	14,382			54,202		

Comparison of estimated electricity generation potential from previous national-level study (MIT, 2006) and regional-level study (this paper) at depth of 3.5 km for the Cascades region based on maps in Figure 2. Federally-protected and DoD lands excluded.

For full results, see Frone, Z., M. Richards, D. Blackwell and C. Augustine, 2015. "Shallow EGS Resource Potential Maps of the Cascades." Fortieth Workshop on Geothermal Reservoir Engineering, Stanford University, CA, January 26-28, 2015, p. 15.

In-Field EGS Resource Potential Improvements

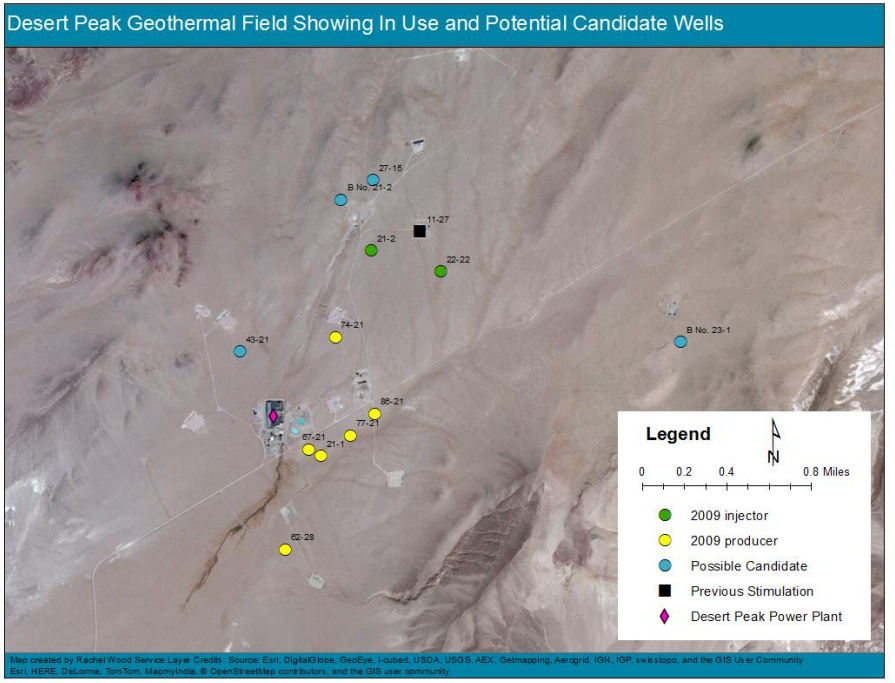
Analyze the number of dry wells at existing hydrothermal fields that are suitable for application of EGS techniques to increase generation capacity.

1. Develop database of geothermal wells with well name, location, and status for each operating geothermal site. Design database to track data sources for each data point so that discrepancies or errors (which are almost guaranteed to exist) in the database can be tracked and corrected in the future.
2. Generate maps that can be used to identify wells of opportunity for in-field EGS stimulation at each site and to estimate the overall in-field EGS potential. The database aggregation will begin with Nevada, then move on to California, and then the remaining states with installed capacity.

Accomplishments, Results and Progress

In-Field EGS Resource Potential Improvements

1. Developed a database of commercial-sized geothermal wells at all existing geothermal fields in Nevada from 6 publicly available datasets of geothermal wells and identified their status as injection well, production well, idle, or plugged and abandoned.
2. Validated database using published data for Desert Peak facility.
3. Applied database to Blue Mountain facility and identified 5 potential candidate wells for stimulation.



Blue Mountain is a newer facility that was put online in 2009. This site has 11 injection and 5 production wells. We identified 5 potential candidate wells for stimulation

For full results, see: Hanson, H., R. Wood, C. Augustine, G. Mines, A. Lopez and D. Hettinger, 2014. "Development of a Geothermal Well Database for Estimating in-Field EGS Potential in the State of Nevada." Geothermal Resources Council Transactions, v. 38, p. 629-633.

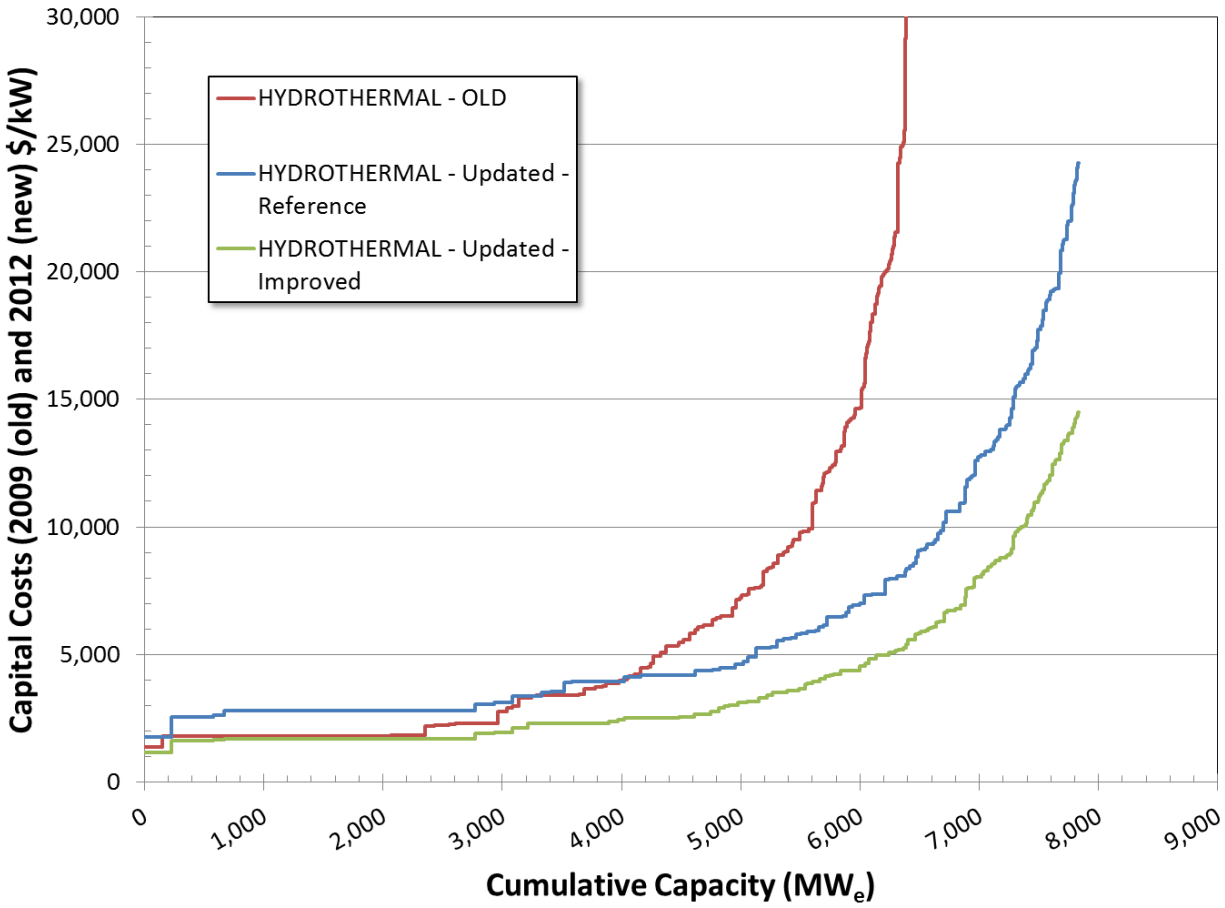
Scientific/Technical Approach

Supply Curve cost updates with GETEM

1. Acquire latest version of GETEM, developed in FY13 with updates to default geothermal costs and project assumptions based on conversations with industry.
2. Run GETEM on site-by-site basis to estimate costs of potential hydrothermal and EGS geothermal projects based on resource attributes in current geothermal resource potential estimates.
3. Incorporate results into new supply curves formatted for input into market penetration models (mainly the Regional Energy Deployment Scenario Model (ReEDS)).

Accomplishments, Results and Progress

Successfully updated geothermal supply curves with latest version of GETEM. Supply curves were incorporated into ReEDS runs throughout 2014 and 2015.



Preliminary results – do not cite!

Scientific/Technical Approach

Potential of low-temperature direct use geothermal resources in Eastern US

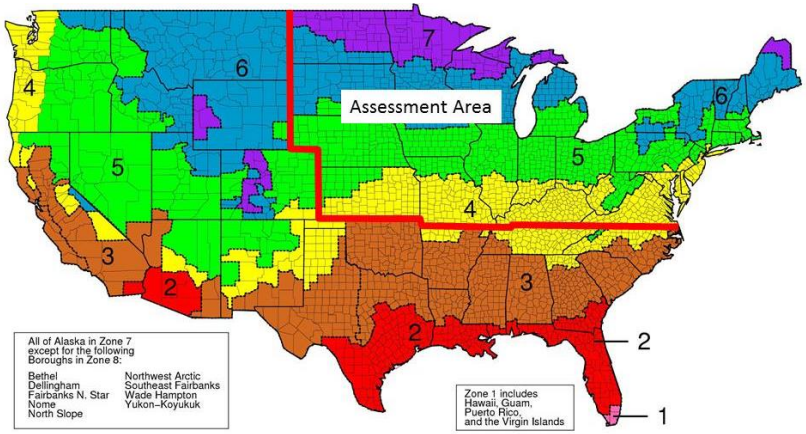
1. Catalogue the number and size of the current installed capacity of direct-use geothermal resources
2. Convert that installed capacity to an equivalent electricity generation potential fossil fuel equivalent (e.g., BOE, tons coal, MMcf natural gas, electricity generation potential, etc.) in order to benchmark the current installed capacity and to characterize the typical size and impact of these installations.
3. Identify demand centers for heating in the Eastern US, focusing on facilities such as campuses, prisons, and hospitals that tend to have cogeneration installed and can be most easily converted.
4. Develop a strategy document that discusses the potential and options for direct use geothermal in the Eastern US to make a significant contribution to the US energy landscape, with an emphasis on the potential in the Eastern US.

Accomplishments, Results and Progress

Summary of the GHC Geothermal Direct-Use Database

Direct Use Application	No. of Systems	Total Capacity (MWt)	Average Capacity (MWt)
Agricultural Drying	3	19.78	6.59
Aquaculture	48	120.74	2.57
District Heating	19	99.60	5.24
Greenhouse	41	107.14	2.90
Industrial	3	6.90	2.30
Pool and Spa	221	105.29	0.47
Snowmelt	5	1.70	0.34
Space Heating	103	83.44	0.82
Total	**449**	**544.59**	**1.24**

The low-temperature direct use resource evaluation was hampered by a lack of direct use resource potential data in the Eastern US. The direct use market effort has been picked up by other tasks (Strategic Analysis and Vision Study).



Number of demand centers in the study area above and below 100°C at 5.5 km depth

Type	Total No. in Study Area	No. in Study Area <100°C at 5.5 km	No. in Study Area >100°C at 5.5 km
Hospitals	2,425	782	1,643
Prisons	584	158	426
Campuses	1,196	231	965

Accomplishments, Results and Progress

Original Planned Milestone/ Technical Accomplishment	Target Date	Date Completed
Complete analysis that discusses the potential and options for direct use geothermal to make a significant contribution to the US energy landscape, with an emphasis on the potential in the Eastern US	12/31/13	12/31/14
Complete database of geothermal wells for operating geothermal plants in Nevada for analyzing in-field EGS potential	3/31/14	9/30/14
Complete draft version of temperature-at-depth map for depths of 1-4 km for Cascade Range	6/30/14	1/28/15
Complete updating cost estimates in GETEM of hydrothermal and EGS resources	9/30/14	9/30/14

Future Directions

- Project is completed. No funding for FY15. No future directions.

Publications and Presentations, Intellectual Property (IP), Licenses, etc.

- Hanson, H., R. Wood, C. Augustine, G. Mines, A. Lopez and D. Hettinger, 2014. "Development of a Geothermal Well Database for Estimating in-Field EGS Potential in the State of Nevada." Geothermal Resources Council Transactions, v. 38, p. 629-633.
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Summary

This project successfully:

1. Updated the geothermal supply curve cost information used in market penetration modeling
2. Improved characterization of shallow EGS resource potential, using a regional analysis of temperatures-at-depth for the Cascade region to increase the estimated EGS resource potential at 3.5 km (for example) from 14 GWe (previous estimate) to 54 GWe.
3. Improved characterization of the in-field EGS resource potential by developing a database of geothermal wells in Nevada that can be used to identify those with EGS-stimulation potential
4. Developed a methodology for converting direct use potential to electricity equivalent and identified thermal load centers for direct use in the Eastern US