Resource Reporting Methodology

Project Officer: Eric Hass

Total Project Funding: $375k

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Track 2: HRC

Challenge: How does GTO measure the impact of its funding?

Need for metrics for goal-setting and measuring impact

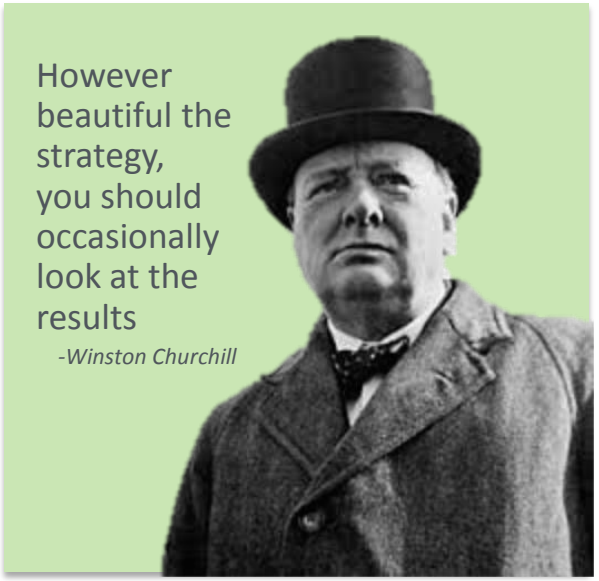
Example:

- When ARRA funding became available, the USGS National Geothermal Resource Assessment had just been released 30 GW (mean) Undiscovered, 9 GW (mean) Identified
- One current program goal "Accelerate development of 30 GWe of undiscovered hydrothermal resources" – but how is this measured?

What portion of the 30 GW does each funded project represent before funding?	Would have needed to collect this data as part of the applications
What portion of the 30GW was expected to be moved by the funding?	
What portion of the 30 GW was moved by funding – what was the funding impact?	Would have needed to collect this information in a required final close-out report
How could we ensure consistency in reporting across projects?	Would need a standard method for reporting consistency (e.g. the way GETEM was used for cost)

Additional Industry Challenges

- Apart from temperature and depth, how do we, as an industry, **grade** geothermal resources?
- What **data** are needed to measure baseline values and advancement?
- Which industry **barrier**, if overcome, has the potential to have the **largest impact** on geothermal deployment?
- How do you **set goals** to be impactful, and what is the potential impact realized by overcoming the prescribed program goals?
- How do we **communicate** these **goals, impacts and advancements** to non-technical audiences (e.g. congress, policy makers, the public)?

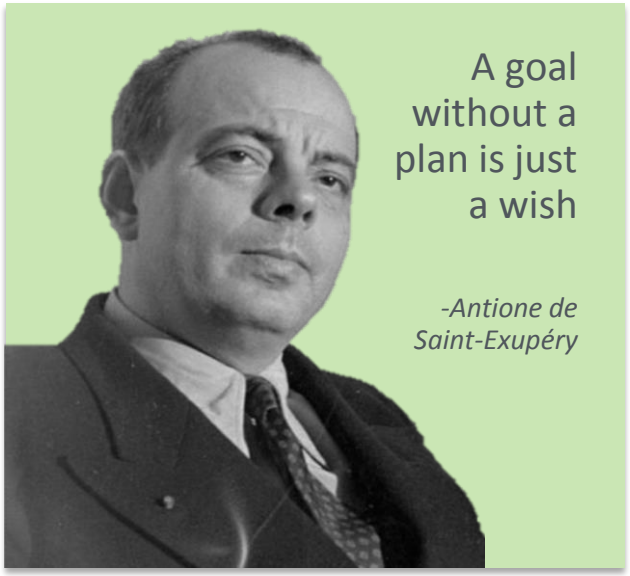


Relevance/Impact of Research

Objective

The goals of this project are to:

- Develop a clear, objective, comprehensive, understandable (to technical and non-technical audiences) methodology for reporting geothermal resource grade and project progress.
- Provide examples for using the methodology for GTO goal setting, measuring baselines, and reporting the impact of GTO-funded projects.



This methodology, when completed will help GTO to:

- quantitatively **identify** the greatest barriers to geothermal development,
- **develop** measureable program goals that will have the greatest impact to geothermal deployment,
- objectively **evaluate** proposals based (in part) on a project's ability to contribute to program goals,
- **monitor** project progress, and
- **report** on GTO portfolio performance.

Scientific/Technical Approach

Methodology consists of three main topics:

Geological Assessment

Resource Grade - *temperature, volume, permeability, fluid availability*

Project Progress - *undiscovered, inferred, tested, measured, examined*

Technical Assessment

Resource Grade - *drilling, chemistry, heat extraction, power conversion*

Project Progress - *unknown, potential, discovered, confirmed, demonstrated*

Socio-Economical Assessment

Resource Grade - *land access, permitting, transmission, demand*

Project Progress - *uncertain, feasible, likely, commercial, secured*

Resource Grades

How feasible is it to develop this resource?

The **grade** of a resource can be described as a combination of intrinsic features of the resource that contribute to economic viability.

Representation:
Polar area / rose diagram

Project Progress

How much do we know about this area?

The **progress** of a project can be objectively be defined by the activities completed at that location.

Representation:
3D Feasibility Grid

The DOE-funded effort has been interacting with IGA, GEA, and UNFC's efforts. One result of this interaction has been the shift from our original effort to focus solely on the geoscience attributes for the resource assessment to a broader scope which includes technical and socio-economic aspects.

Resource Grade

- To evaluate each attribute (e.g., temperature, volume) systematically, we developed three indices - *character*, *activity*, and *execution*.
- Indices are independently evaluated for each attribute using qualitative grades of A-E (A being the "best").

Character Index
- used to describe the attribute itself;
- should not change throughout the project (unless originally incorrectly assigned)

Activity Index
- qualitative ranking of activities used to assign the character index; appropriate for each attribute;
- progressive throughout the project as additional activities are conducted

Execution Index
- compares the diligence with which the technique was executed for the activity.
- may progress, if activities are repeated.

Indicates grade

Indicate certainty

Example: Geological | Technical | Socio-Economic

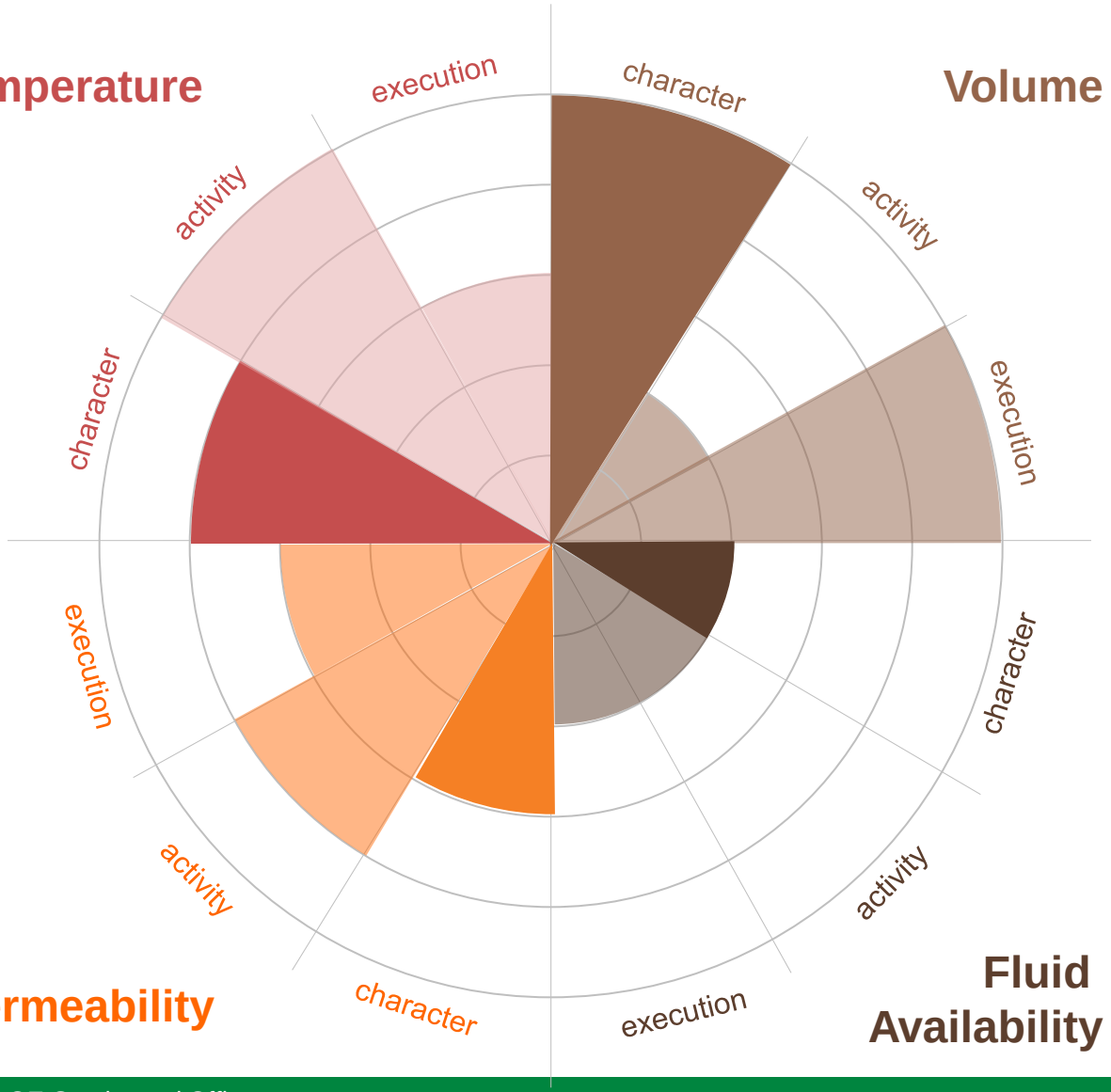
Four attributes:

Geological	Technical	Socio-Economic
Temperature	Fluid Chemistry	Land Access
Volume	Heat Extraction	Permitting
Permeability	Power Conversion	Transmission
Fluid Availability	Drilling	Demand

Resource Grade: Example Attribute Indices - Temperature

(a) Character Index			(b) Activity Index		(c) Execution Index (Ex: Subsurface Temperature Probe Readings)	
A	>300°C	High-temperature two-phase liquid-dominated OR high enthalpy vapor-dominated	A	Measured temperatures: Downhole temperature probe readings (well(s) drilled into reservoir)	A	• Probe allowed to equilibrate • Cuttings and/or geophysics confirms measurement within the reservoir (i.e. downhole alteration mineralogy consistent with reading)
B	230 - <300°C-	Two-phase liquid-dominated systems: - high T, high enthalpy - moderate- T, moderate enthalpy	B	Extrapolated temperatures: (TGH/well(s) not drilled into reservoir)	B	• Probe allowed to equilibrate • Cuttings and/or geophysics have *not* confirmed measurement within the reservoir (i.e. downhole alteration mineralogy not consistent with readings)
C	150-<230°C	Moderate to low temperature, moderate to low enthalpy liquid-only systems	C	Geothermometry (reservoir brines or gases)	C	• Probe *not* allowed to equilibrate • Cuttings and/or geophysics have *not* confirmed measurement within the reservoir
D	90-<150°C	Low temperature systems	D	Geothermometry (immature or mixed fluids, inconsistent results between geothermometers)	D	• Results taken from previous third-party studies of the area (either literature or contractors) with little or limited information on survey methods, replication, or error.
E	<90°C	Very low temperature systems	E	Regional heat flow data	E	• Assumed from studies of analogous geothermal settings, or extrapolated from studies of nearby areas.

Scientific/Technical Approach

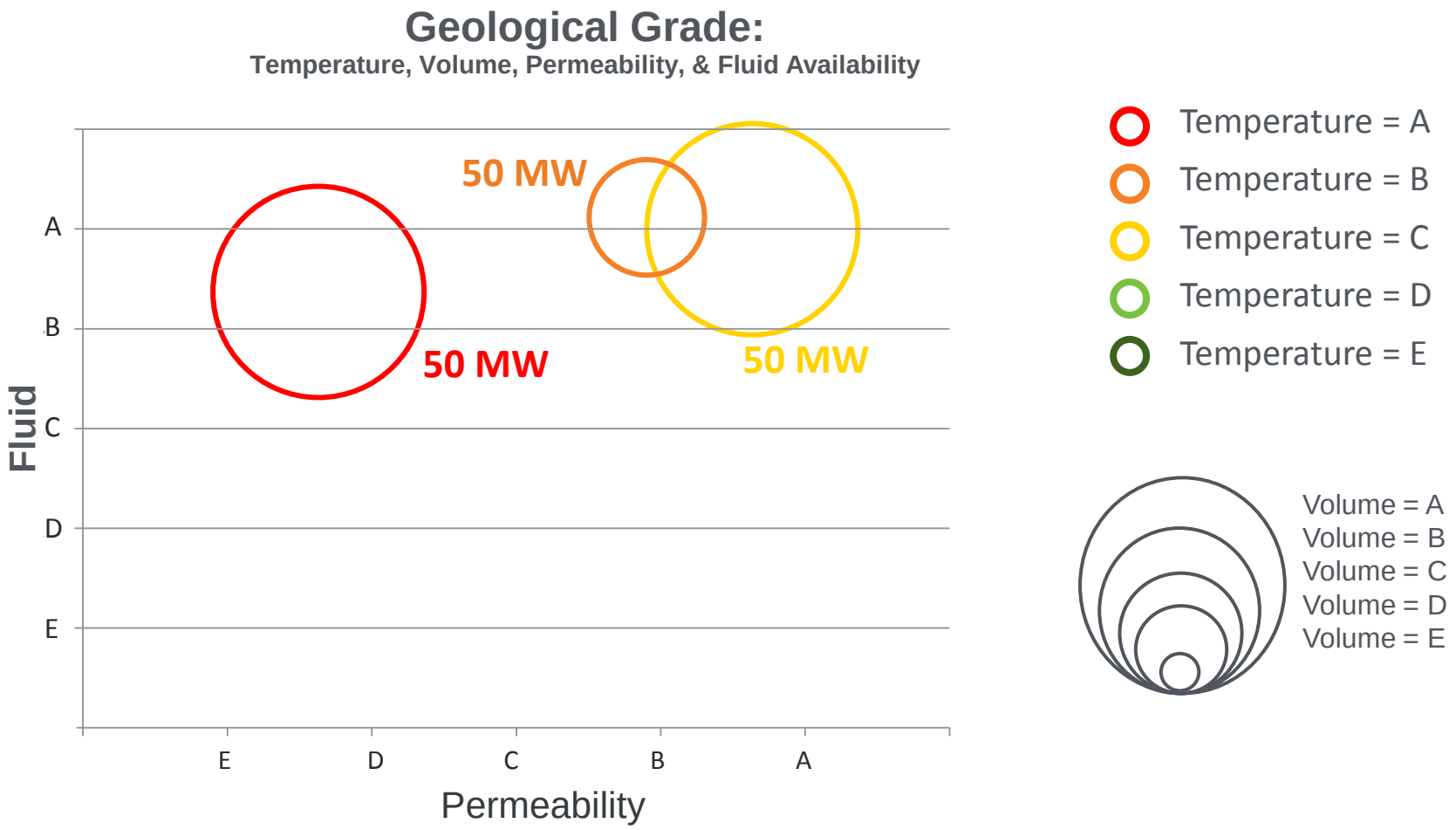


Resource Grade Polar Area Chart

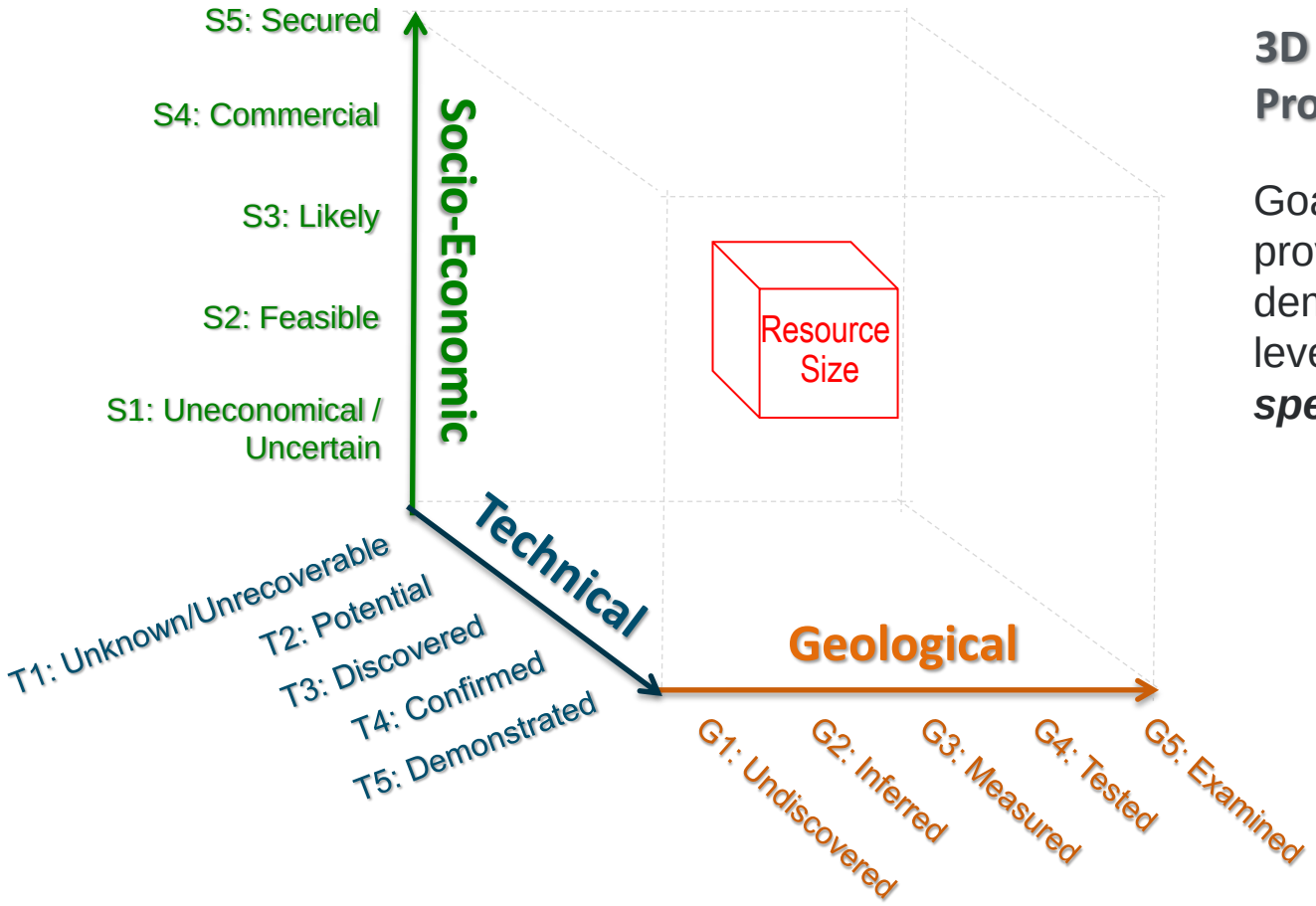
Dark Wedges indicate grade

Light Wedges indicate certainty

Visualizing Grade for Multiple Geothermal Areas



Project Progress



3D Project Progress Grid

Goal of this figure is to provide ***verbal cues*** that demonstrate various levels of project progress ***specific to each axis***.

Project Progress: Example – Geological Assessment

	Geological Progress	Qualifying Criteria
Identified	**Examined**	For a resource to be considered "Examined," all of the following criteria must be met: 1. Two or more full-scale wells must be drilled and flow tested
	Multiple full-diameter wells drilled	
	Tested	For a resource to be considered "Tested," all of the following criteria must be met: 1. At least one full-diameter well has been drilled 2. The reservoir permeability has been evaluated with at least one of the following methods: a. flow tests and/or b. pressure build up/draw down
	Full-diameter well / well test	
	Measured	For a resource to be considered "Measured," all of the following criteria must be met: 1. Temperature is measured at the reservoir level using the following method: a. Downhole probe in slimhole(s) drilled into the reservoir 2 Temperature is corroborated using at least one of the following methods: a. liquid or gas geothermometry b. Assessment of lithology and mineral assemblages taken from cores and/or cuttings
	Drill slim / core hole into the reservoir	
	Inferred	For a resource to be considered "Inferred," both of the following criteria must be met: 1. Temperature is estimated using at least one of the following methods: a. a well-executed geothermometry b. thermal gradient holes 2. Conceptual model of the reservoir is supported by data from surface geophysical surveys
	Field testing/sampling	
Undiscovered		For a resource to be considered "Undiscovered," the potential is estimated by at least one of the following activities: 1. field mapping - structural, surface manifestations, etc. 2. shallow heat flow studies (2 m probe) 3. extrapolation of third-party data 4. remote sensing

- Qualifying criteria developed for each axis
- Designed to be objective, clear, and reproducible
- Based on existing criteria, when available (e.g. GEA's Development Phases)

Use as a DOE Metric: Goal Setting

Geological Progress		Play Types			
		CV-1: Magmatic	CV-2: Plutonic	CV-3: Extensional	etc.
Identified	Examined	# MW	# MW	# MW	# MW
	Tested	# MW	# MW	# MW	# MW
	Measured	# MW	# MW		
	Inferred	# MW	# MW		
Undiscovered		#			

Geological Progress		Resource Types		
		Low Temperature	Hydrothermal	EGS
Identified	Examined	# MW	# MW	# MW
	Tested	# MW	# MW	# MW
	Measured	# MW	# MW	# MW
	Inferred	# MW	# MW	# MW
Undiscovered		# MW	# MW	# MW

Use as a DOE Metric: Evaluating Applications

Potential Use of Resource Grade (each FOA may vary)**:**

- GTO may **require a minimum Socio-economic grade and/or project progress** to ensure that the funded work can proceed within the funding time period
- GTO may be looking to **fund projects with a particular grade** (e.g. EGS projects will have low permeability/fluid availability grades, but high temperature grades).

Potential Use of Project Progress (each FOA may vary):

- GTO may **focus on projects that target overcoming a particular barrier** to project progress along a particular axis (e.g. well drilling)
- GTO may selectively choose stalled projects (e.g. low project progress or delays) to **focus on identifying what is causing the barrier** (technology? financing? permitting? etc.)

NOTE: *It is not the design nor intent of this system to provide all metrics or evaluation criteria for GTO*

Accomplishments, Results and Progress

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	Original Planned Milestone/ Technical Accomplishment	Actual Milestone/ Technical Accomplishment	Date Completed
FY14	**Review existing methodologies;** review/analysis of existing resource assessment and reporting methodologies for the geothermal, mining, and oil and gas industries	Expanded scope to include all renewables including solar, wind, biomass, hydropower, etc.	ongoing
FY14	**Draft report** (with an "executive summary" giving an overview) and presentation to DOE that defines key parameters of a geothermal reporting metric.	Drafted paper for submission presentation at the World Geothermal Congress – circulated to industry for review and comment	Draft: 6/2014 Final: 12/2014
FY14	Convene 2-3 meetings with a **small working group** of industry, investors, and contractors to vet the details of the developed metric.	Discussed/presented/workshopped: 1. Knowledge Exchange in CA (Sacramento, CA) 2. Discussion at GEA/GRC board meeting (Reno, NV) 3. Workshop at GEA Summit (Reno, NV) 4. Workshop at GRC Ann. Meeting (Portland, OR) 5. UNECE/IGA Meeting (Bonn, Germany) 6. IGA Working Group Meeting (Wash, D.C.) 7. Workshop at 2015 Peer Review (Westminster, CO) 8. Workshop at GEA Summit (Reno, NV)	 June 2013 June 2013 August 2014 September 2014 December 2014 March 2015 May 2015 June 2015
FY15	**Summarize feedback and comments** from industry on the developed methodology, including responsive comments from the NREL/LBNL team	Keep a running log of comments from industry	ongoing
FY15	**Draft Methodology Documents** for using the resource reporting methodology	Drafted a Background Document and two of the four supporting handbooks for project evaluation.	Draft 1: 4/2015 Draft 2: 6/2015
FY15	Memo **identifying fundamental information/data gaps** in current resource potential estimation driving assessment uncertainty	ongoing	*Due 9/2015*
FY15	**Presentation of the results** of the development of methodology at least once at an industry-attended event.	• Presented at WGC • *Planned for GRC – not part of original plan*	April 2015 *Sept 2015*
FY15	*Not planned*	*Student Undergraduate Laboratory Intern (SULI) hired to research data at worldwide operating plants to be used as analogues for developing areas in early research stages for estimating resources size.*	*Spring 2015*

Future Directions

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Future (FY16 and beyond) work includes:

Part II: Finalize the protocol for Technical and Socio-Economic Categories

Part III: Test and refine the system (see sidebar example):

- Conduct a review of past DOE projects (if data are available), to provide a quantitative measure of the impact of DOE funding
- Conduct an assessment of all current DOE projects to create metrics for ongoing project progress – to test and refine the system, as needed (see sidebar example)
- Develop guidance for resource reporting necessary for DOE applicants or awardees
- Develop case studies of well-characterized geothermal systems for DOE examples.

- Developed in 2009 (not as complex as GRRM)
- Went through assessment period to systematically test the protocol, and to inform the final revision
- Trials assessed and provided recommendations for improvement on:
  - Objectivity and replicability
  - Understandability
  - Scope and comprehensiveness
  - Ease of use
  - Impact and effectiveness
  - Applicability to a range of scale and regions
  - Adequacy of implementation guidance
  - Presentation of Results

Summary

Geothermal Resource Reporting Methodology

I. Background Document

II. Geological Assessment Tool

- Project Progress
- Resource Grade
- Examples

III. Technical Assessment Tool

- *Project Progress*
- *Resource Grade*
- *Examples*

IV. Socio-Economic Assessment Tool

- *Project Progress*
- *Resource Grade*
- *Examples*

V. Resource Size Assessment Tool

VI. Case Studies

VII. DOE Goal Setting, Impact Measurement

For more information, see: http://en.openei.org.wiki/GRRM

Need for standard reporting methodology

- To create baselines and set goals
- To aid in objectively evaluating funding applications
- To clearly report on funding success/impacts

Methodical, outreaching development process

- Discussed with industry prior to project proposal
- Reviewed/evaluated current reporting systems (geothermal and others)
- Continuously reach out to industry with workshops, interviews, and draft documents to solicit critical feedback
- Participate in IGA working group on development of UNFC geothermal specifications
- Iterate, iterate, iterate
- Collaborative effort between multiple entities (NREL, LBNL, New West, DOE)

Positive Feedback

- Feedback so far has been overwhelmingly positive
- Welcome all feedback (positive or negative!) and suggestions for improvement of this methodology