



GeoRePORT Case Study Examples: Reporting Using the Geothermal Resource Portfolio Optimization and Reporting Technique (GeoRePORT)

Amanda Kolker, Kate Young, Alex Badgett, and John Bednarek

National Renewable Energy Laboratory (NREL)

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Introduction to GeoRePORT

GeoRePORT Background and Overview

- Developed to help DOE's GTO track and measure project progress, the impact of geothermal R&D funding, and to communicate with stakeholders.
 - Tool development led by NREL and LBNL
 - Users: geothermal experts
 - Audience: non-technical stakeholders
- Provides uniform assessment criteria for resource **grades** and developmental **phases** of geothermal projects.
 - Provides consistency in reporting
 - Not a prescription for exploration/development
 - Not a replacement for conceptual or reservoir models and geothermal expertise



GeoRePORT

Geothermal Resource Portfolio Optimization & Reporting Technique

A Barrier to Development

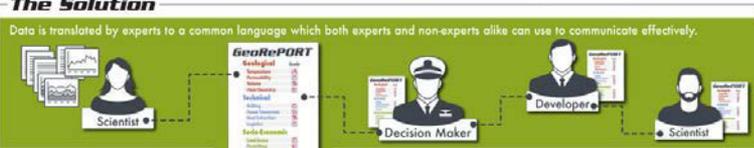
Experts in their fields produce large amounts of complex data.



Volumes of scientific data can be incomprehensible and overwhelming for decision makers.

The Solution

Data is translated by experts to a common language which both experts and non-experts alike can use to communicate effectively.



The GeoRePORT System

- Expert assigns grades to his/her data**
GeoRePORT provides a manual for experts in their field to translate to a common scale the suitability of their data for geothermal applications.
- Grades from many experts are assembled**
Grading from many different experts on a large quantity of data can be collected and assembled, and individual reports can be added, removed or updated as needed.
- GeoRePORT is compiled**
Collected reports can be combined into a complete GeoRePORT, which takes everyone to speak the same language and allows non-experts to understand the suitability of the data.
- Reporting**
GeoRePORT is used to report the combined grades from many different experts, and is also used to report and track project progress.

Resource Management	Type	Weight	Character	Weight Product	Activity	Excellent
1. System Permeability	1	A	3	15	A	A
2. Seismicity	1	B	3	3	B	B
3. Cyclic	1	C	3	3	C	C
4. Supplemental Injectant Cost	2	B	6	12	B	B
5. Cold-water Breakthrough	2	C	6	12	C	C

Reporting Data: Two Ways to Do It, Many Ways to Use It

I. The National Level

As the national level, GeoRePORT allows for the creation of baseline maps using publicly available data which can be used by DOE to identify the greatest barriers to geothermal development and to aid in setting quantifiable, measurable program goals.

- Identify Major Barriers
- Identify Resource Availability
- Set Baseline Goals
- Measure Impact

II. The Project Level

At the project level, GeoRePORT allows for different projects to be directly compared in terms of resource quality and project readiness. It can also be used to monitor project progress.

- Location Specific
- Highly Detailed
- Track Progress
- Compare Projects

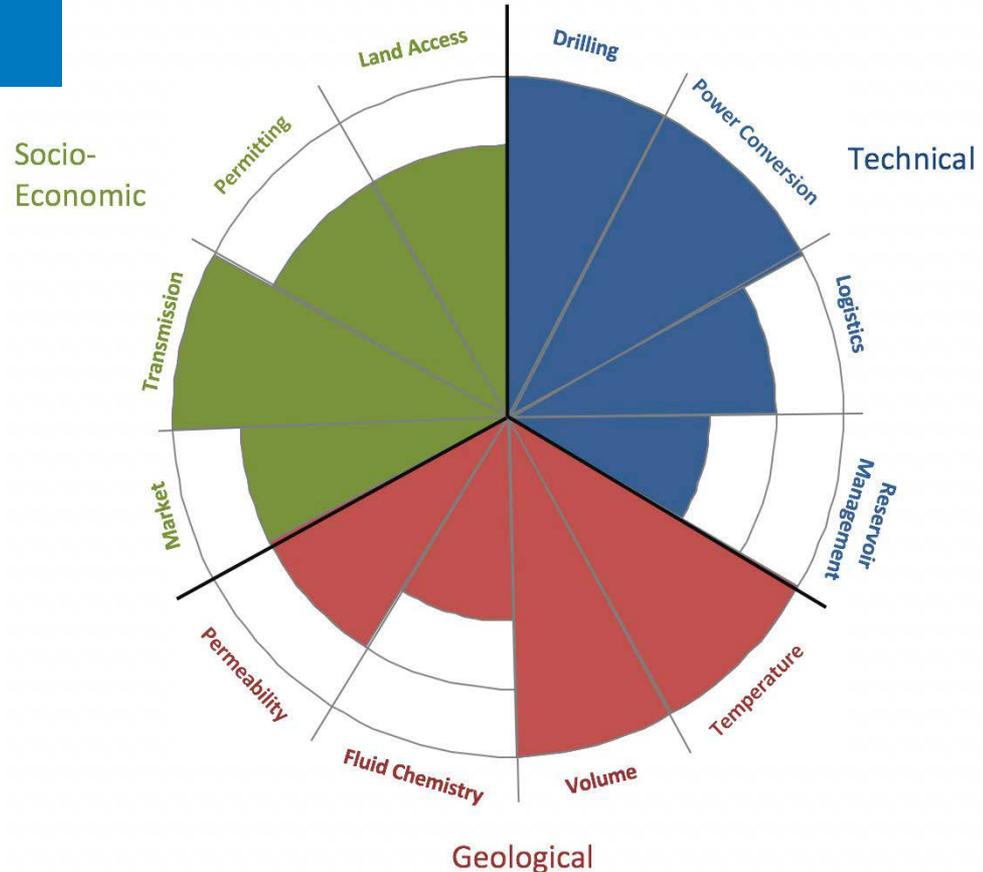
Developed by NREL and LBNL for the DOE Geothermal Technologies Office, July 2017

For more information, see: <http://en.openei.org/wiki/GeoRePORT>

GeoRePORT Methodology

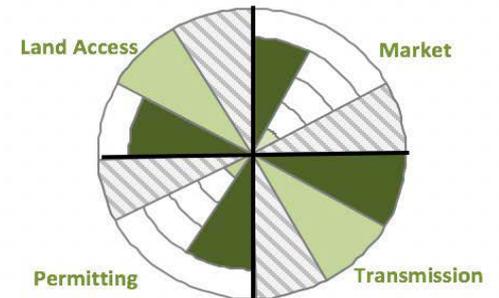
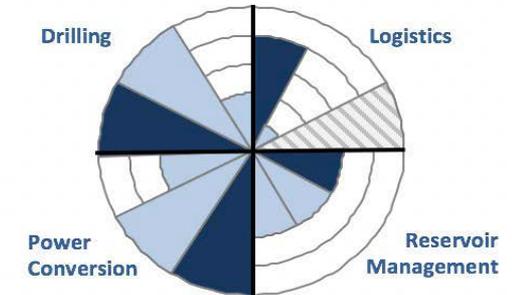
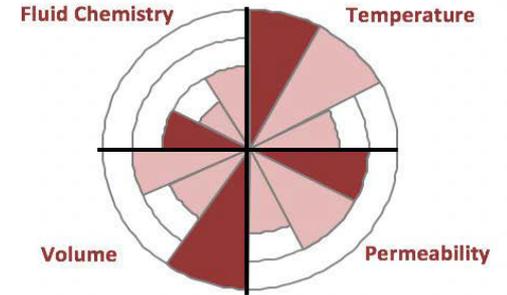
Methodology: Resource Grade

- The resource-grade system provides information on the **character** of a geothermal resource
- Resource character is a function of its **geological**, **technical**, and **socio-economic** attributes
- 3 attributes encompass 12 sub-attributes
 - Developed with heavy industry input
 - Designed for continuous update throughout a project lifetime
- 3 protocols available for download on GeoRePORT website:
<https://openei.org/wiki/GeoRePORT/Protocol#top>
 - Geologic Assessment Tool (GAT)
 - Technical Assessment Tool (TAT)
 - Socio-economic Assessment Tool (SEAT)



Methodology: Resource Grade

Character, Activity, Execution Grade Totals

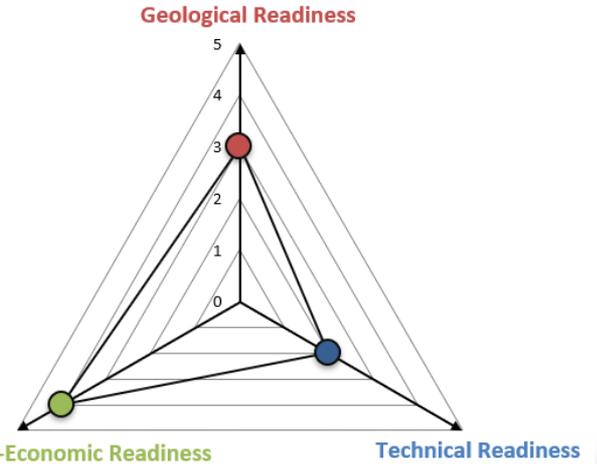


- In addition to **character**, GeoRePORT grading system also reports on what is known about the **quality of the data** collected.
- For the **geological** attributes, uncertainty in the reported data addressed by:
 - The **activities** conducted to measure each attribute
 - The **execution** of such activities (how well the activity was executed)
- Execution indices do not apply to all **technical** and **socio-economic** attributes.

Activity index example: Temperature	
A	Measured temperatures: Downhole temperature probe readings (well[s] drilled into reservoir)
B	Estimated temperatures: Geothermometry (geothermal brines and gases)
C	Estimated temperatures: Geothermometry (immature or mixed fluids, inconsistent results between geothermometers)
D	Extrapolated temperature: Thermal gradient holes (TGHs) /well(s), alteration mineral assemblages, stable isotopes, fluid inclusion data
E	Regional heat flow data

Methodology: Project Readiness Level

- Users can report on incremental **project readiness level**.
- As projects progress, they pass through activity thresholds, which are minimum activities required to qualify for the next category.
- Like the resource grade, project readiness reporting designed to be updated throughout the project lifetime.



Technical Readiness

Place an "x" in all applicable boxes

Qualifying Criteria

<input checked="" type="checkbox"/>	Site analysis completed including a geotechnical site analysis
<input type="checkbox"/>	Site evaluated and determined not to have economic potential
<input checked="" type="checkbox"/>	Promising geophysical analyses and conceptual model completed
<input checked="" type="checkbox"/>	Well drilled into reservoir proves reservoir temperature and fluid flow
<input type="checkbox"/>	Two or more successfully drilled and tested wells
<input type="checkbox"/>	Production wells produced geofluids at necessary temperatures and flow rates for a minimum of 30 days
<input type="checkbox"/>	Well field and supporting infrastructure must be operational for a minimum of 30 days
<input type="checkbox"/>	Plant must produce power at or above initial power production estimates

Socio-Economic Readiness

Place an "x" in all applicable boxes

Qualifying Criteria

<input type="checkbox"/>	No site Environmental or Transmission Interconnection Analysis
<input type="checkbox"/>	Site evaluated and determined not to have economic potential (No-Go)
<input checked="" type="checkbox"/>	Environmental and Transmission Interconnection Analysis complete
<input checked="" type="checkbox"/>	Site evaluated and determined to have economic potential
<input checked="" type="checkbox"/>	Approval of Notice of Intent to Conduct Geothermal Exploration and Geothermal Drilling Permits
<input type="checkbox"/>	Approval of a Utilization Plan for construction and operation and a Commercial Use Permit (if on a federally managed resource)
<input checked="" type="checkbox"/>	Approval of any state or level local permits/approvals for construction, operation, and sale of the resource
<input type="checkbox"/>	Power Purchase Agreement Secured with off-taker

Methodology: Case Studies

Grade Totals for Reservoir Management

Sub-Attribute Details

Select	Grade	Description	Comments	Sub-Attribute Character, Activity, Execution Grades
1 System Permeability (weight: 3)				
Character: > 50,000 - 200,000 mD-ft	C	Medium.		
Activity: Flow/Injection Testing	A	For 1 well, combination of flow tests including: step-rate injectivity or productivity tests, image log and/or core description, pressure temperature-spinner (PTS) logs, or distributed temperature sensor (DTS) log. For multiple wells, combination of: pressure build-up/draw-down flow test, tracer (1) flow test or comparison in small reservoir production well. (2) Tests performed in multiple wells (2 or more). (3) Multiple test types are performed (e.g. pressure buildup and falloff tests, interference tests, step-rate tests, and tracer tests), but not at all wells. (4) Test duration of the 4 wells. (5) Results combined.		
Execution: Most of Protocol	B			
2 Storativity (weight: 3)				
Character: > 10 ⁻² mbar	B	Two-phase reservoir, high porosity.		
Activity: Field Mapping	D	Properties assumed from field mapping surveys of surface manifestations, distribution of hydrothermal alteration, and bounding geologic structures.		
Execution: Third Party Results	C	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.		
3 Cost of Supplemental Injectant (weight: 3)				
Character: < \$1,000/MPa	D	Water available and is economical for purchase.		
Activity: Identification Needed	D	Identification of water source, owner (if applicable), and process to obtain rights.		
4 Calibrates Reservoir through (weight: 3)				
Character: > 7.5-10 kg/g	D	High enthalpy change per year.		
Activity: > 5 years production data	A	Well calibrated reservoir model - tracer data, > 5 years production data, complete temperature, pressure and fluid chemistry data for all wells.		

4 | ... | Cover Page | Project Readiness | GeoSummary | Temperature | Volume | Fluid Chemistry | Permeability | TechSummary | Power Conversion | Logistics | Drilling | Reservoir Management | 5 | ... | +

- Spreadsheet tool facilitates reporting using the GAT, TAT and SEAT protocol (<https://openei.org/wiki/GeoRePORT/Protocol#top>)
- Case study data collected using best practices outlined in the protocol documents
 - Maximum input from site experts
 - Publicly available information (OpenEI, NGDR, Geothermal Prospector, lit. reviews)

Thanks to our partners

DOE GTO team, plus:
Adam Brandt
Greg Nash
David Meade
Andy Sabin
Joe Iovenitti
Bernie Carl
Dick Benoit
...and many others



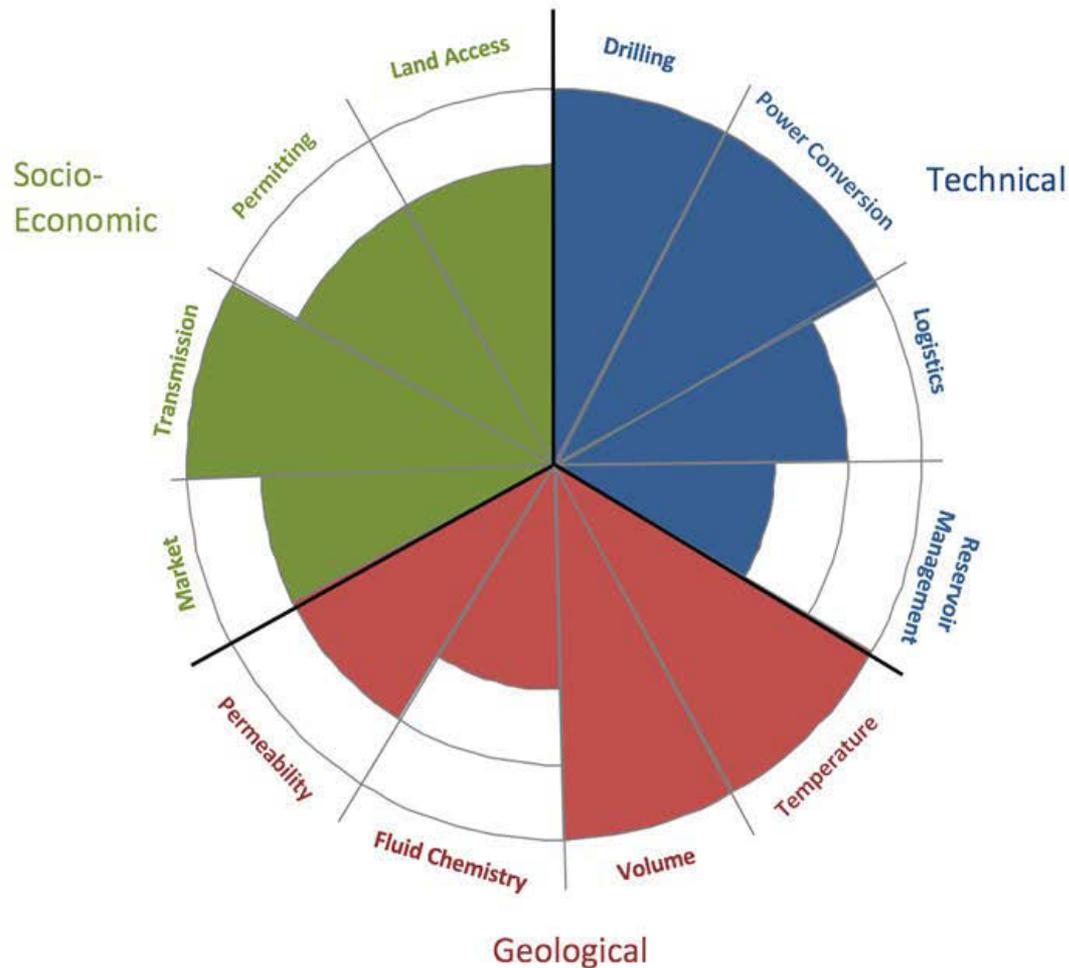
Chena Hot Springs Resort

Where hospitality and sustainability go hand in hand

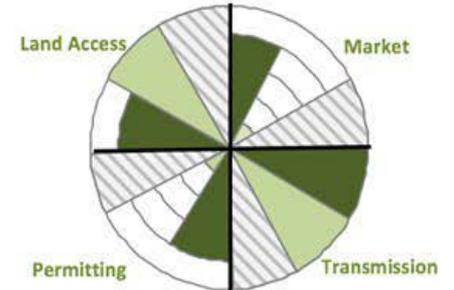
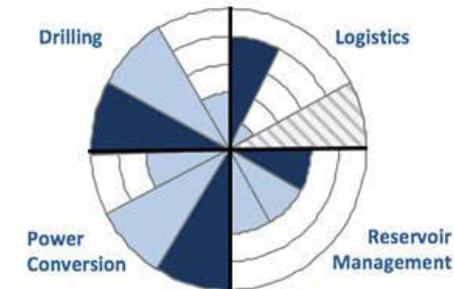
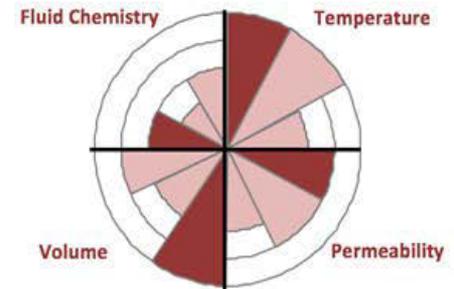


GeoRePORT Case Study Results

Character Grade Totals

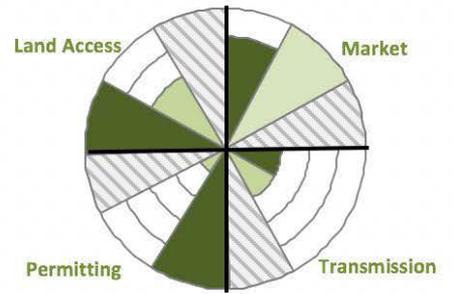
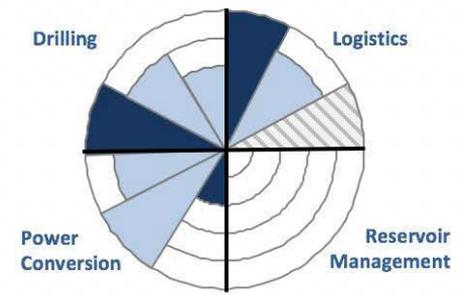
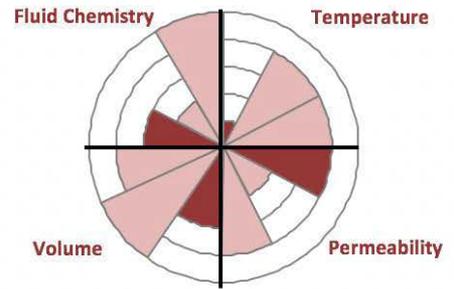
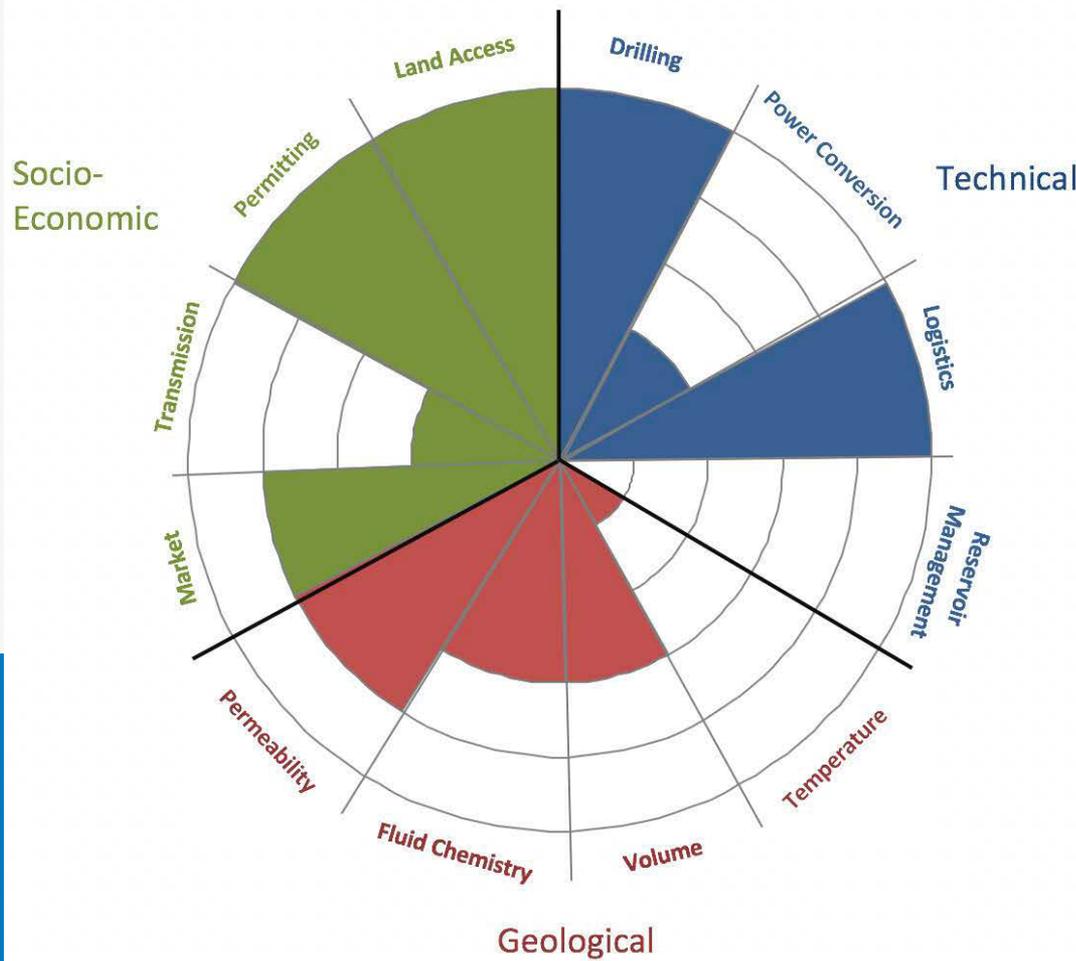


Character, Activity, Execution Grade Totals



Character Grade Totals

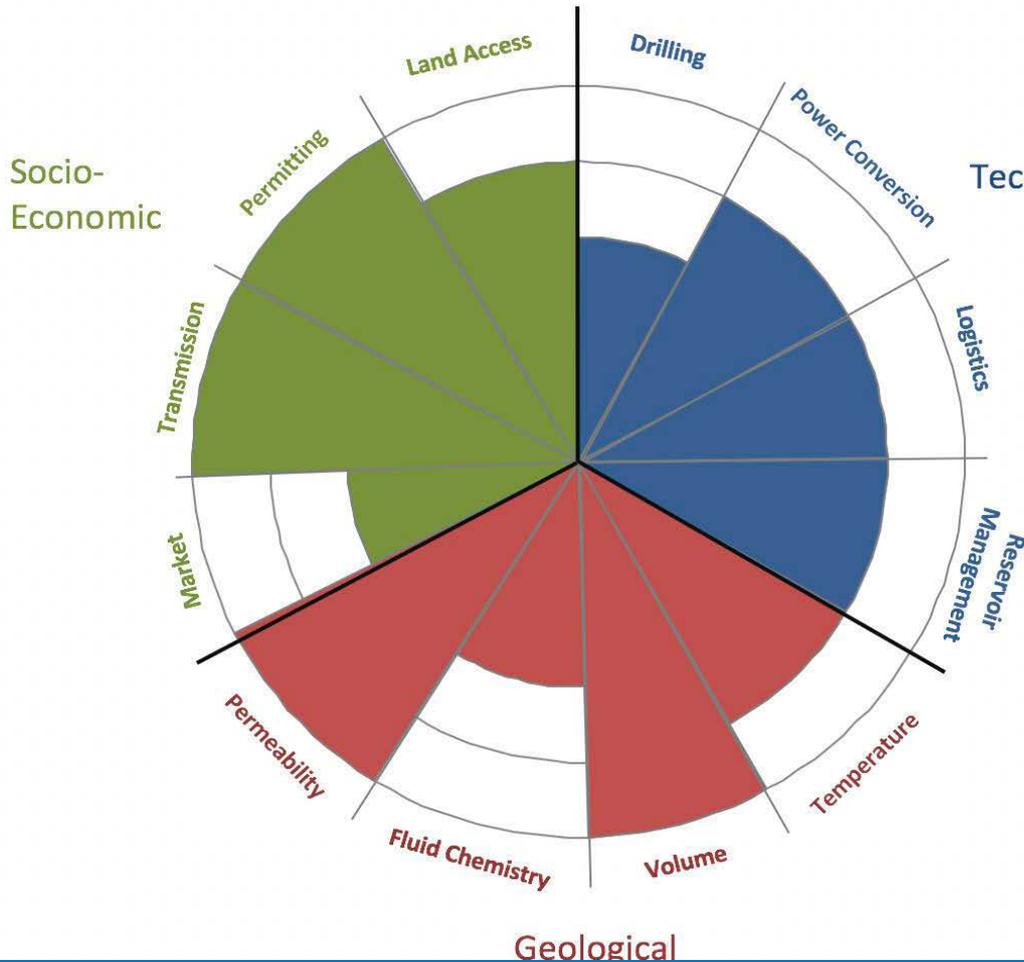
Character, Activity, Execution Grade Totals



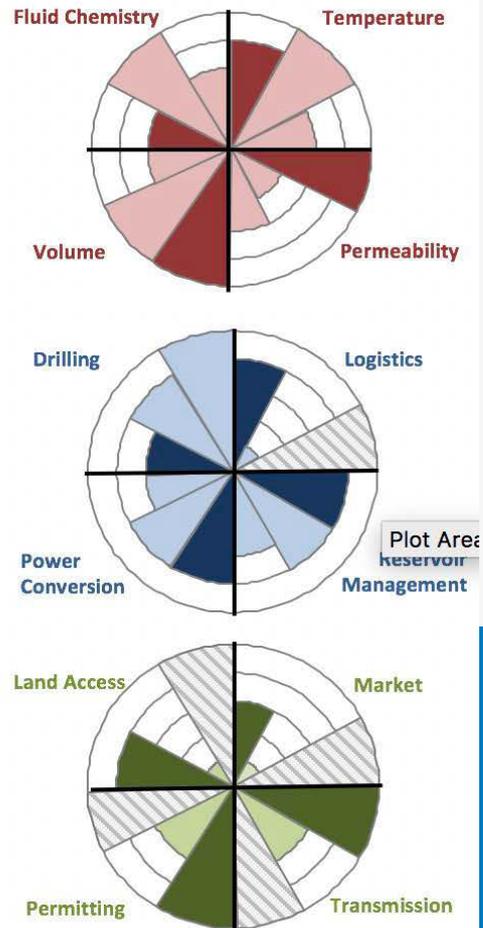
Chena Hot Springs

Resource grade summary

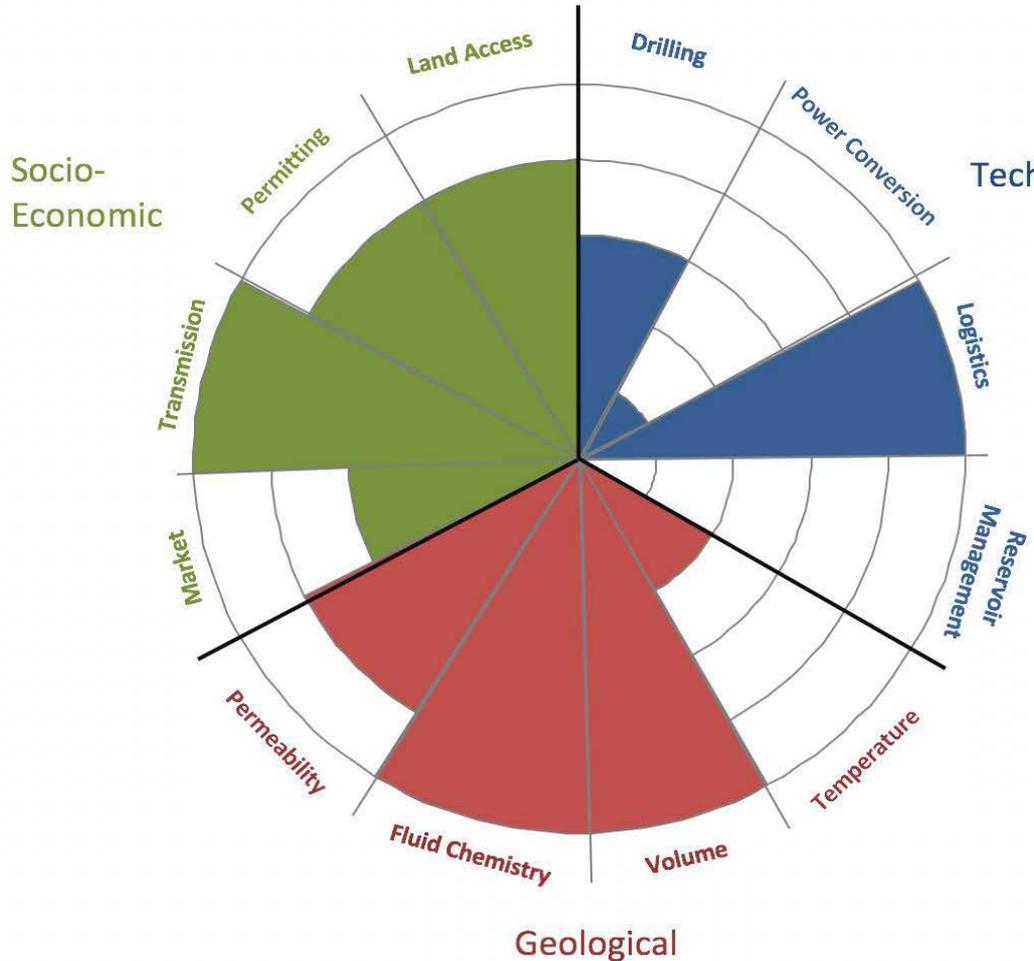
Character Grade Totals



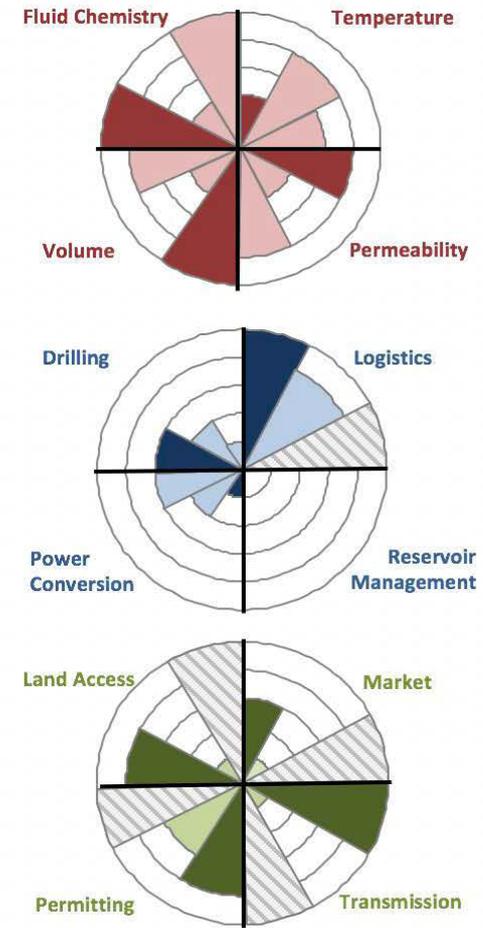
Character, Activity, Execution Grade Totals



Character Grade Totals

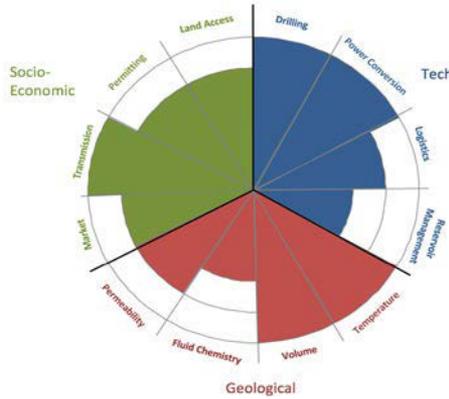


Character, Activity, Execution Grade Totals

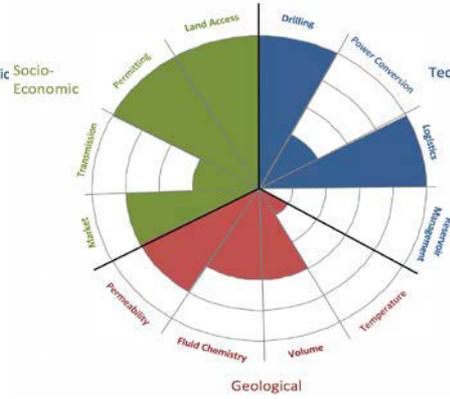


GeoRePORT Case Study Analysis: Discussion

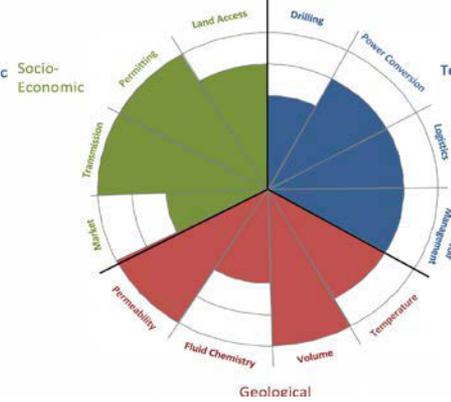
Discussion: Character Grade & Project Readiness



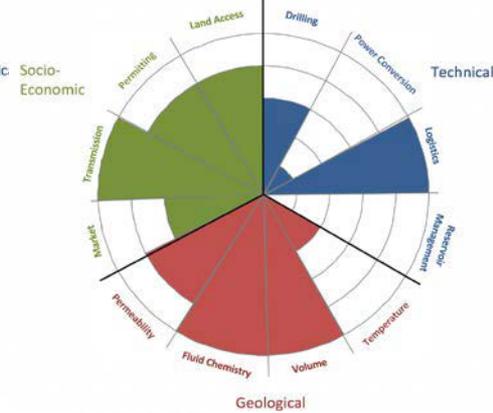
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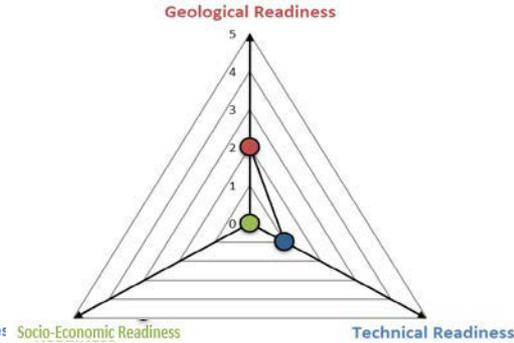
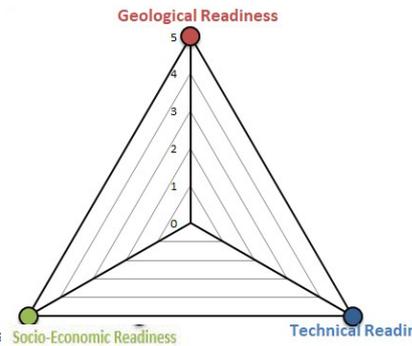
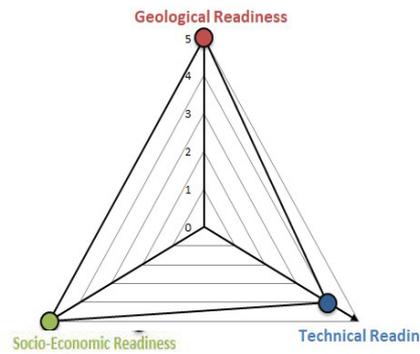
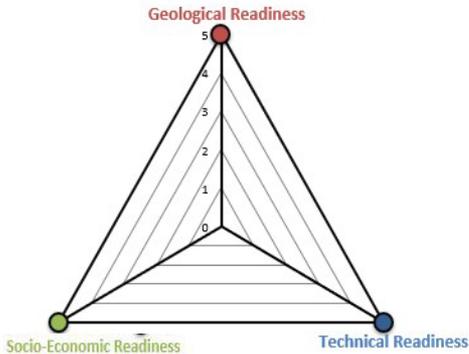
Chena HS



Dixie Valley



WSMR



Discussion: Grade & Activity Levels

Geological Attributes

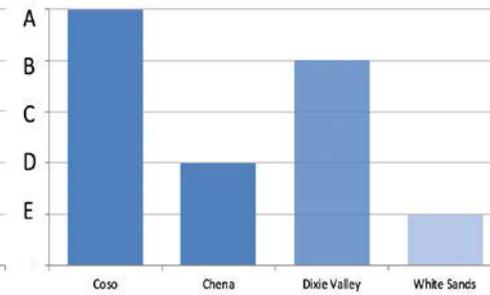
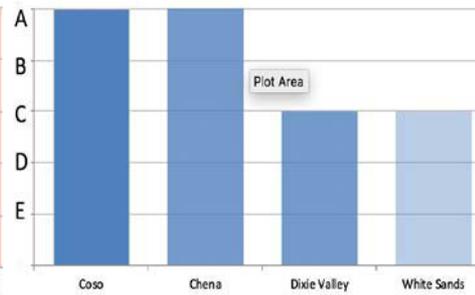
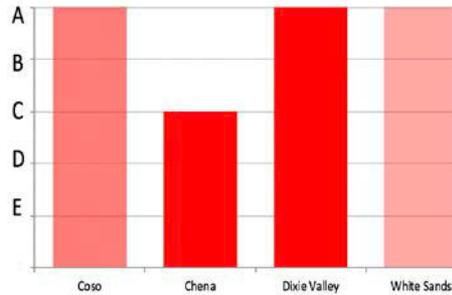
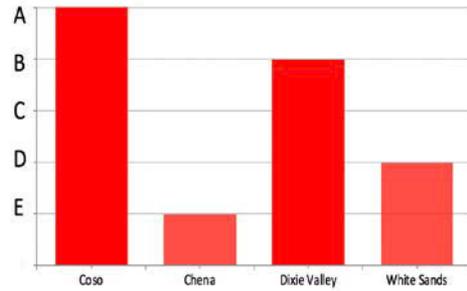
Technical Attributes

Temperature

Volume

Drilling

Power Conversion

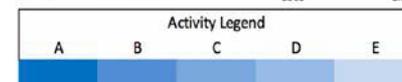
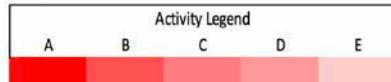
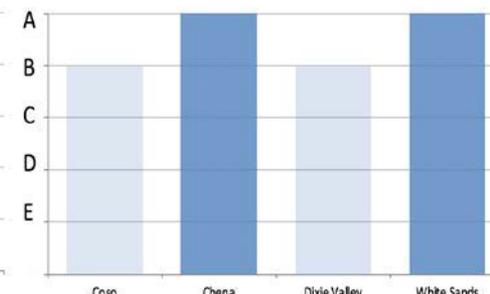
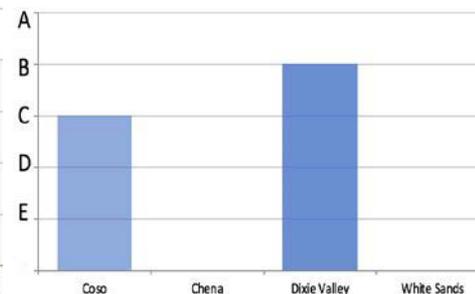
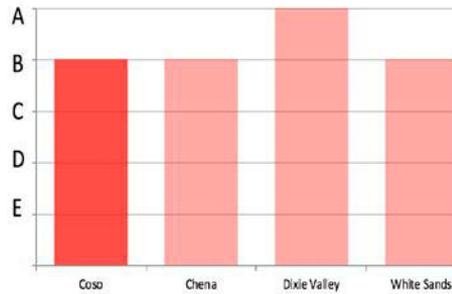
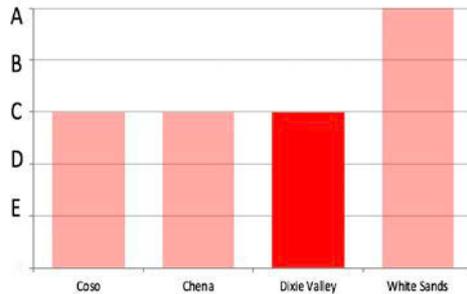


Fluid Chemistry

Permeability

Reservoir Management

Logistics



GeoRePORT Case Study

Analysis: Conclusions

Conclusions & Future Work

- Four case studies illustrate:
 - The ability of GeoRePORT to succinctly provide a project snapshot and tell a story
 - The success of GeoRePORT in making explicit the degree of uncertainty in the data, and missing data (via activity/execution indices)
- GeoRePORT's outputs for four case studies reveal:
 - Trends in which data are collected and reported across several projects
 - Industry-wide areas for improvement and/or streamlining
- Tool development ongoing
 - New insights from case study evaluations and industry feedback
 - Future work: add Resource Size Tool, international expansion of socio-economic attributes, adapt reporting parameters to EGS and direct use projects, etc.
 - More case studies!

Thank you

www.nrel.gov

amanda.kolker@nrel.gov

<https://openei.org/wiki/GeoRePORT>

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