



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

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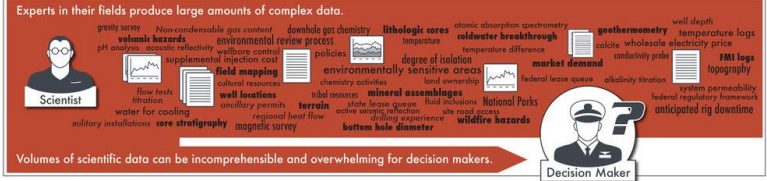
Introduction to GeoRePORT

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



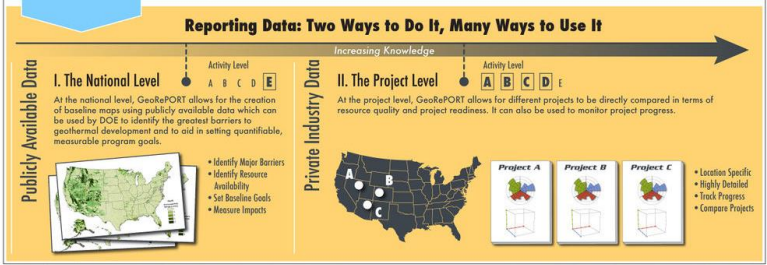
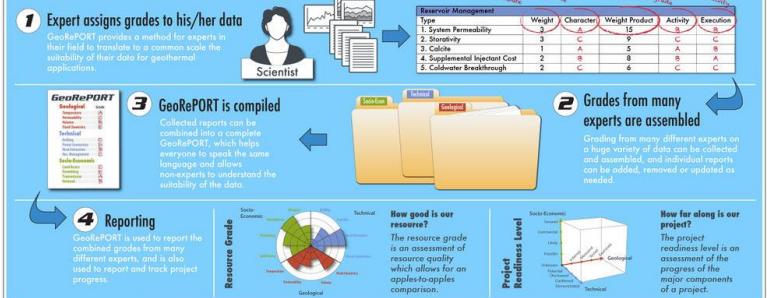
A Barrier to Development



The Solution



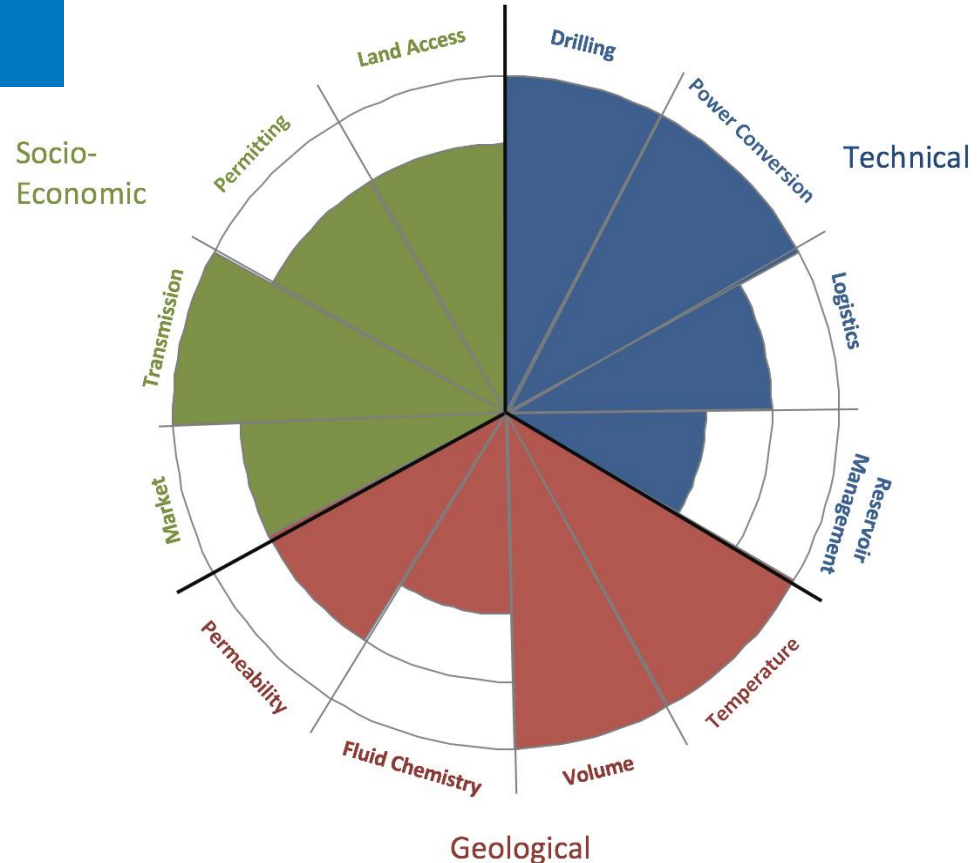
The GeoRePORT System



GeoRePORT Methodology

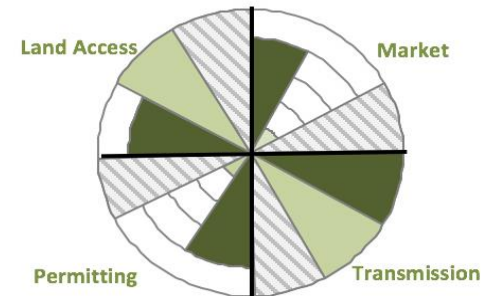
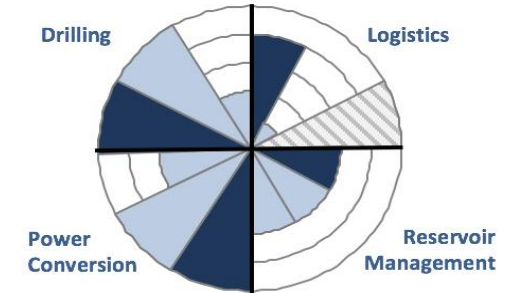
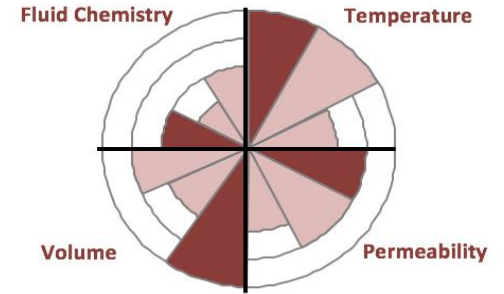
Methodology: Resource Grade

- 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



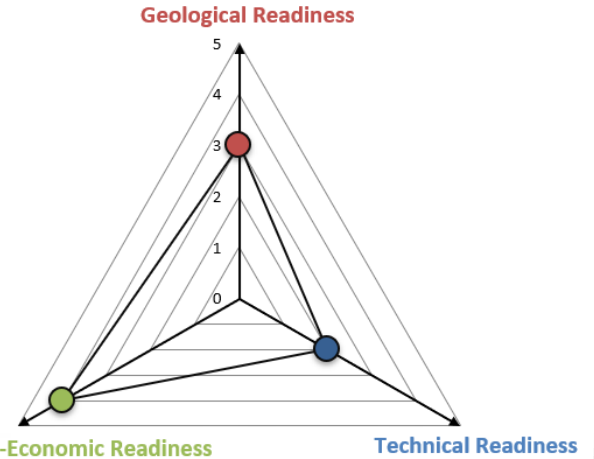
- In addition to **character**, GeoRePORT grading system also reports on what is known about the **quality of the data** collected.
- For the **geological** attributes, uncertainty in the reported data addressed by:
 - The **activities** conducted to measure each attribute
 - The **execution** of such 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 <i>(weight: 3)</i>				
Character: > 50,000 - 200,000 mD-ft	C	Medium.	3	3
Activity: Flow/Injection Testing	A	For 1 well, combination of flow tests including: step-rate injection 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 tests are completed in small-diameter production wells. (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 1 to 4 weeks. (5) Results correlated.	5	5
Execution: Most of Protocol	B		4	4
2 Storativity <i>(weight: 3)</i>				
Character: > 10(-2) mbar	B	Two-phase reservoir, high porosity.	4	12
Activity: Field Mapping	D	Properties assumed from field mapping/ surveys of surface manifestations, distribution of hydrothermal alteration, and bounding geologic structures.	2	6
Execution: Third Party Results	C	Results taken from previous Third Party studies of the area (either literature of contractors) with little or limited information on survey methods, replication, or error.	3	3
3 Cost of Supplemental Injectant <i>(weight: 2)</i>				
Character: < \$1,000/Mw	B	Water available and is economical for purchase.	4	8
Activity: Identification Noted	D	Identification of water source, owner (if applicable), and process to obtain rights.	2	4
4 Coldwater Breakthrough <i>(weight: 2)</i>				
Character: > 7.5-10 kg/kg	D	High enthalpy change per year.	2	4
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.	5	10

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

- 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



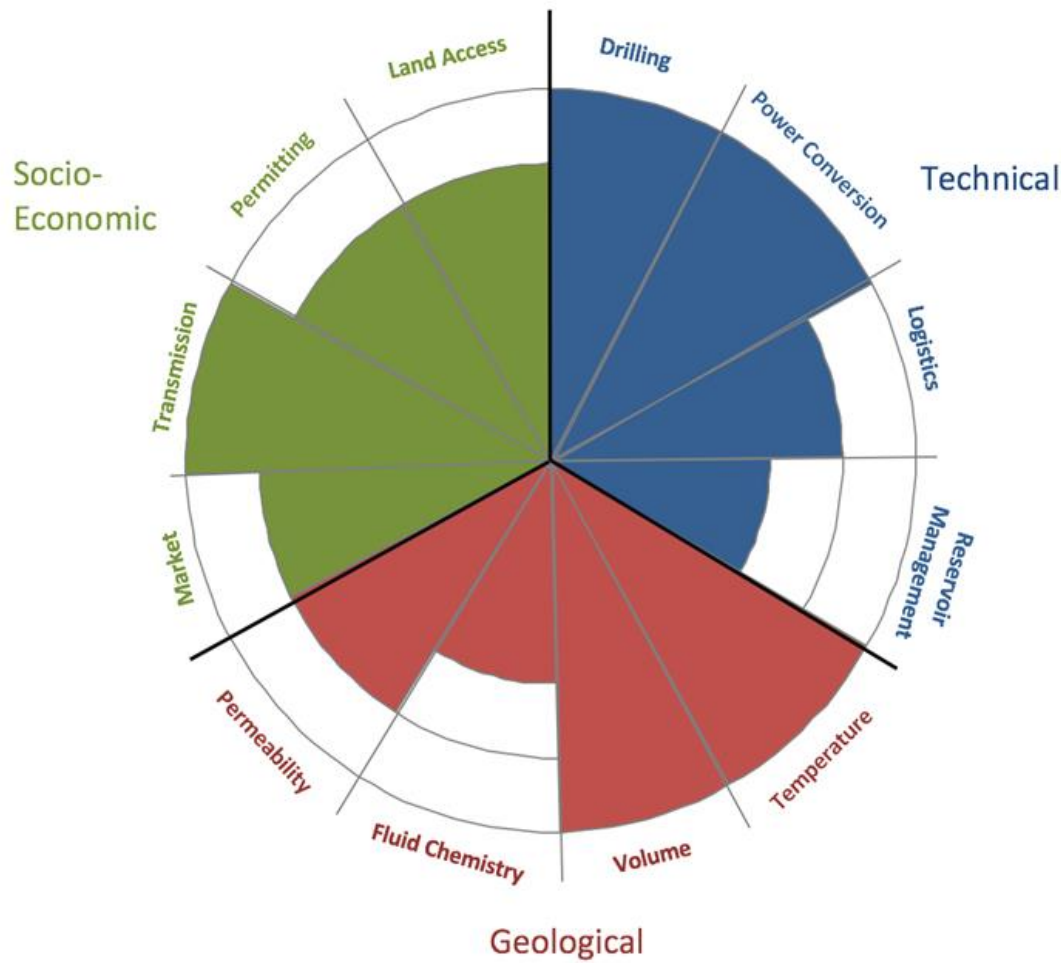
Chena Hot Springs Resort

Where hospitality and sustainability go hand in hand

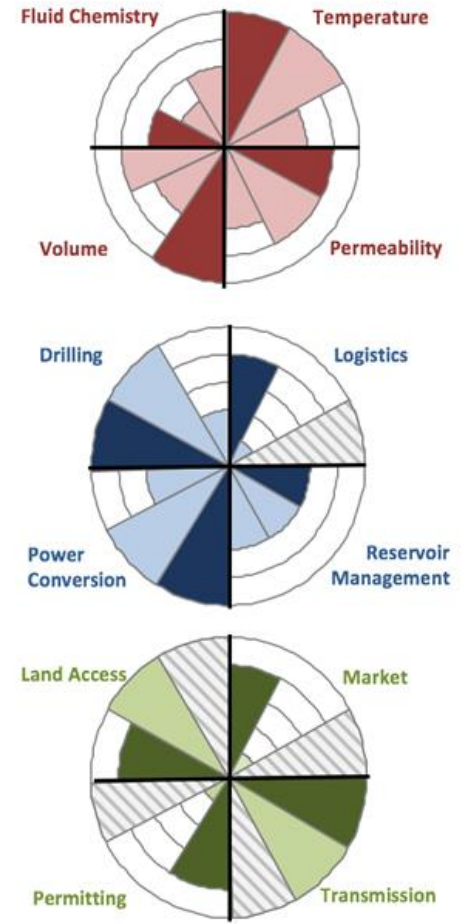


GeoRePORT Case Study Results

Character Grade Totals



Character, Activity, Execution Grade Totals



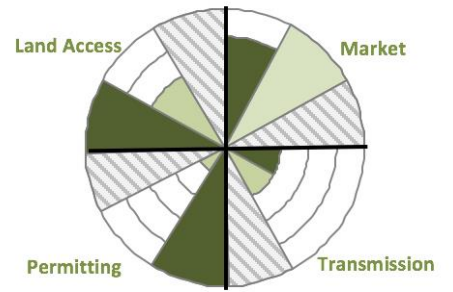
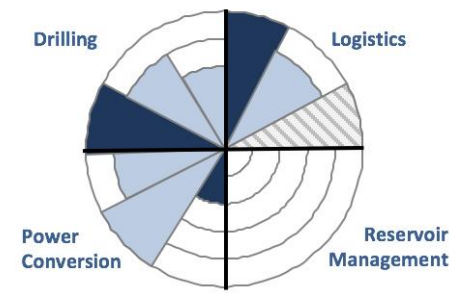
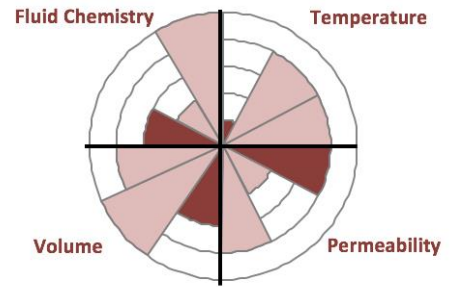
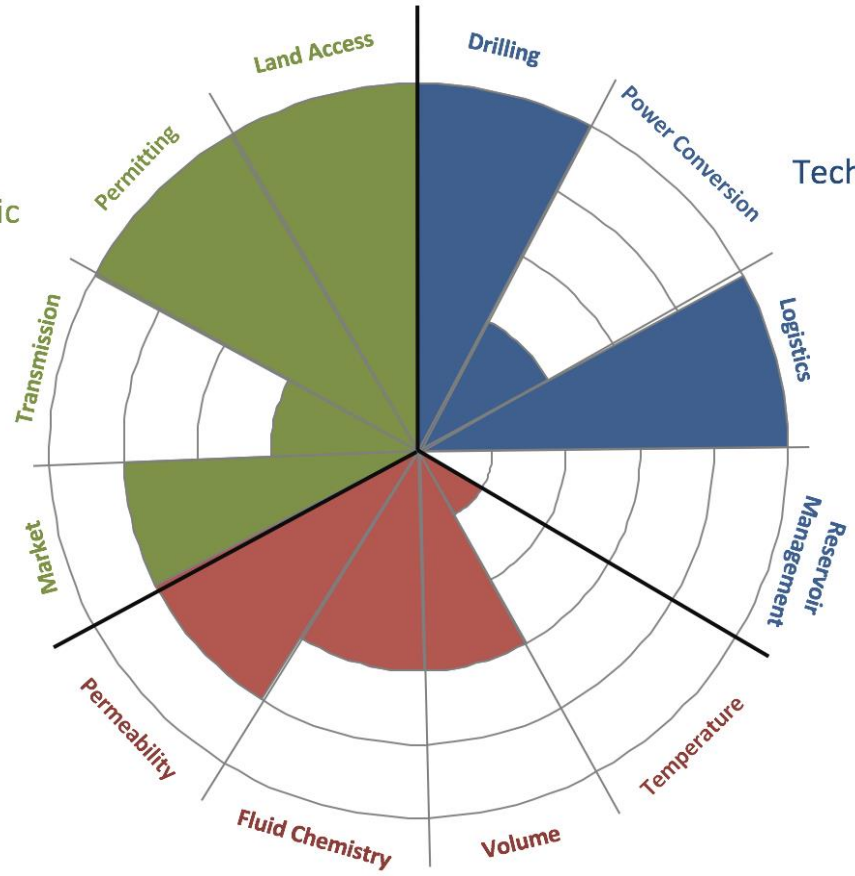
Character Grade Totals

Character, Activity, Execution Grade Totals

Socio-Economic

Technical

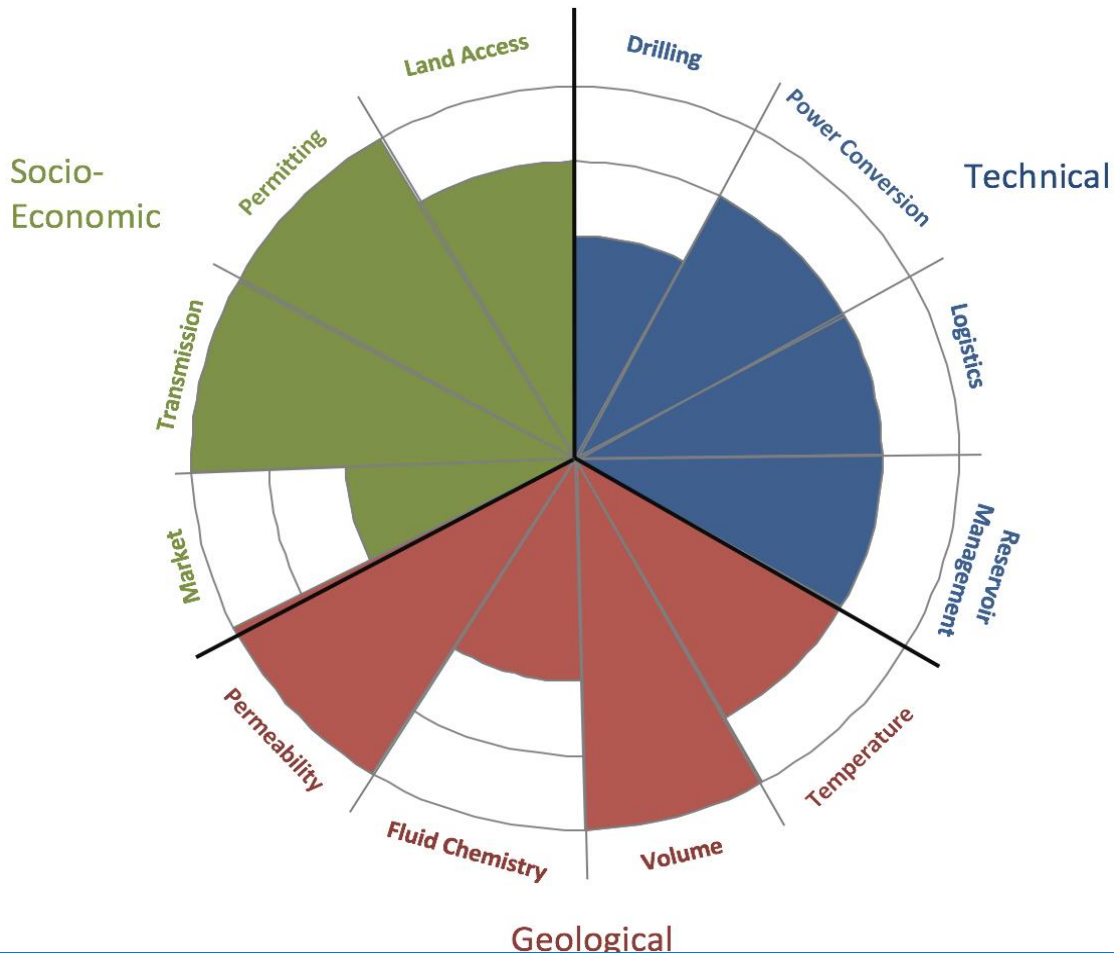
Geological



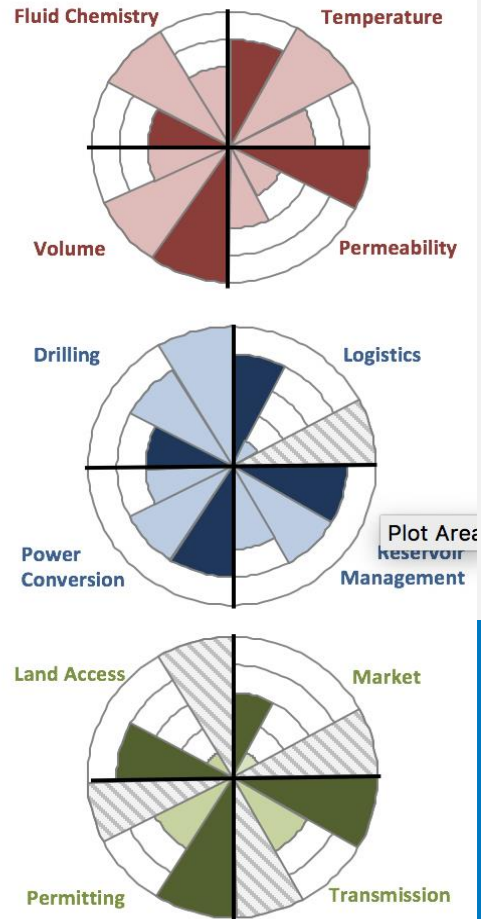
Chena Hot Springs

Resource grade summary

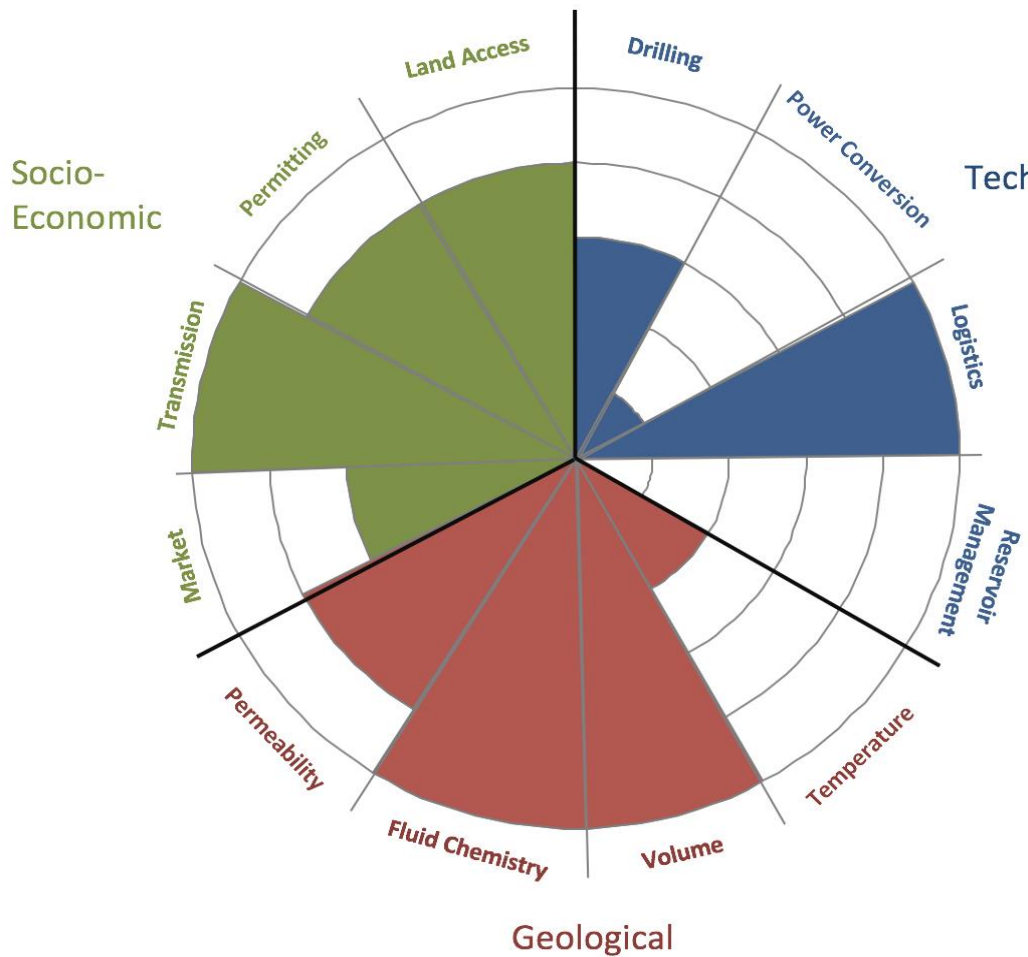
Character Grade Totals



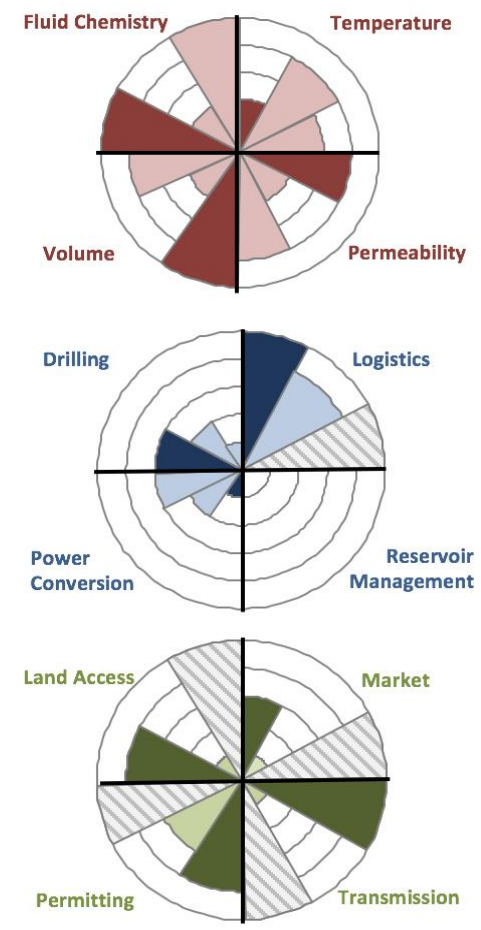
Character, Activity, Execution Grade Totals



Character Grade Totals

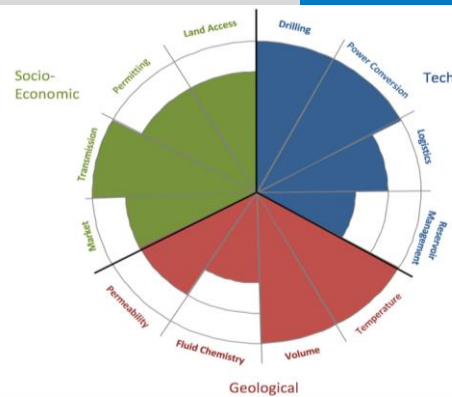


Character, Activity, Execution Grade Totals

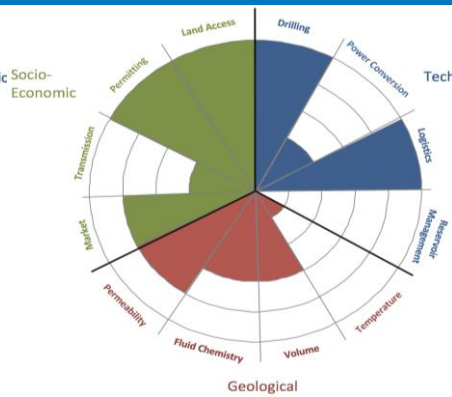


GeoRePORT Case Study Analysis: Discussion

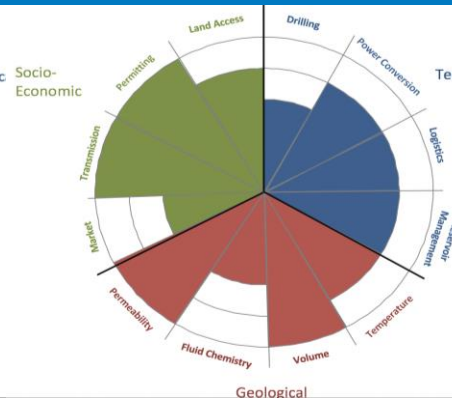
Discussion: Character Grade & Project Readiness



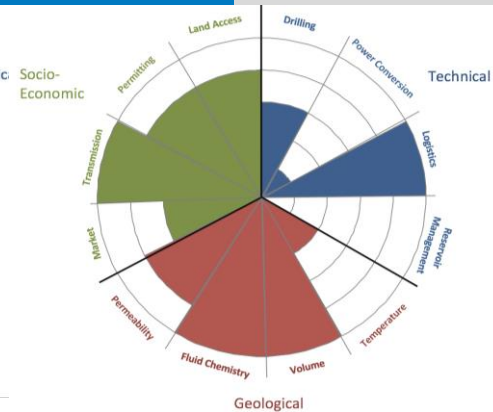
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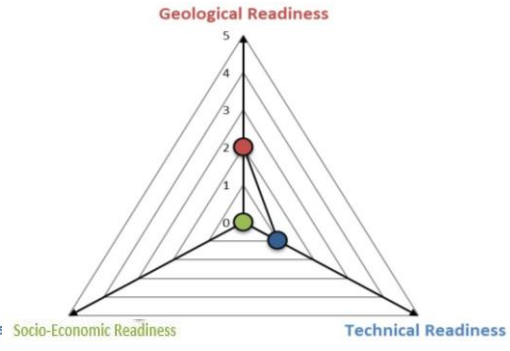
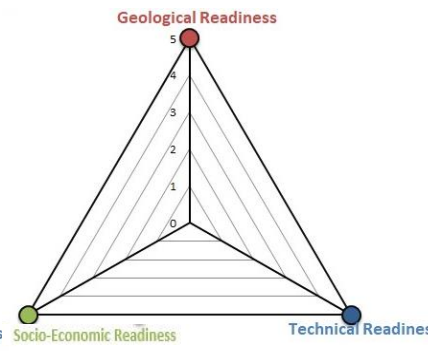
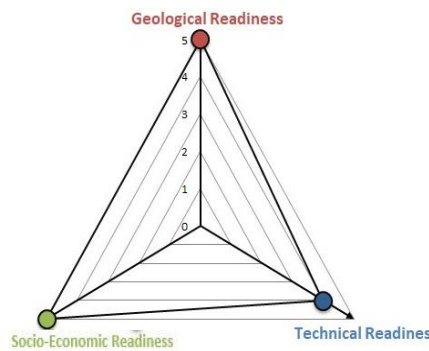
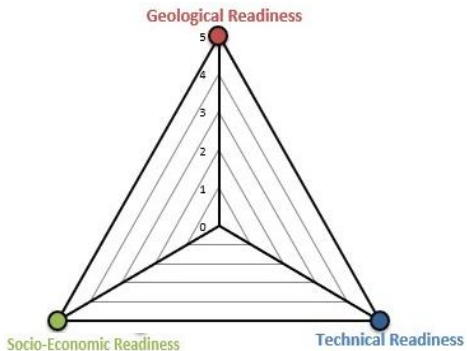
Chena HS



Dixie Valley



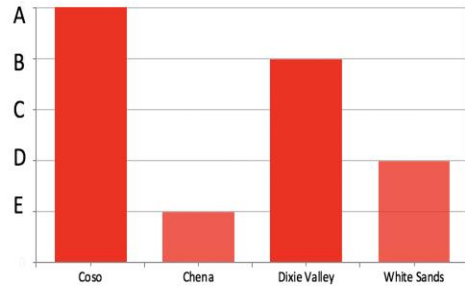
WSMR



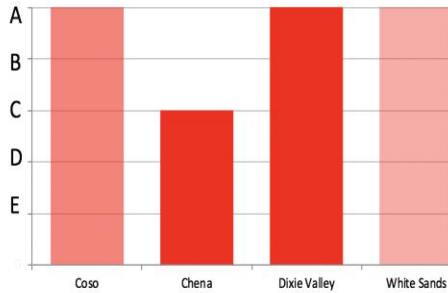
Discussion: Grade & Activity Levels

Geological Attributes

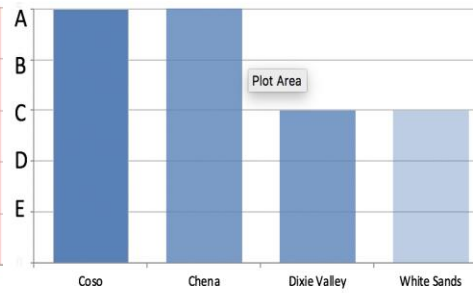
Temperature



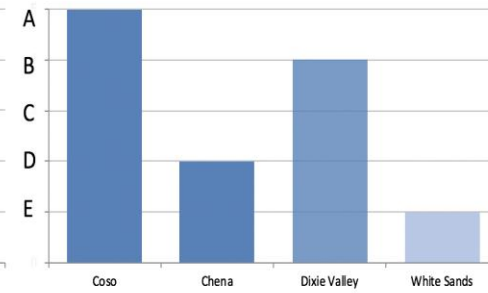
Volume



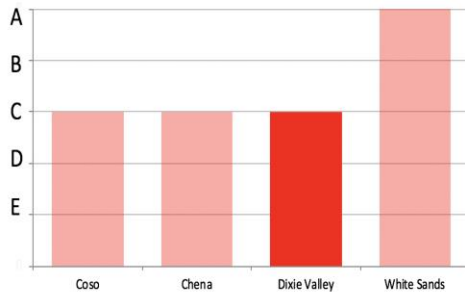
Drilling



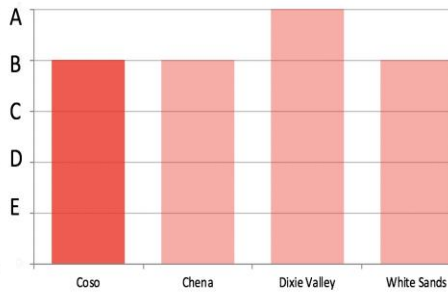
Power Conversion



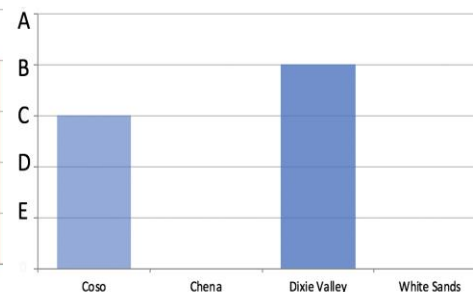
Fluid Chemistry



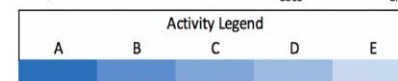
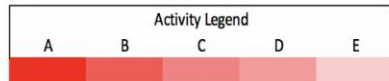
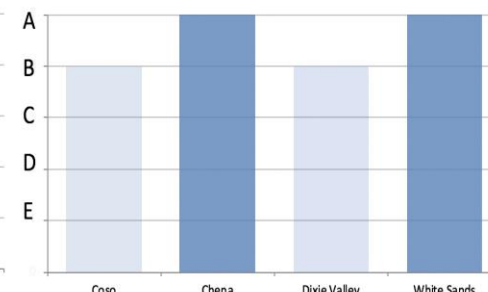
Permeability



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

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

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