This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

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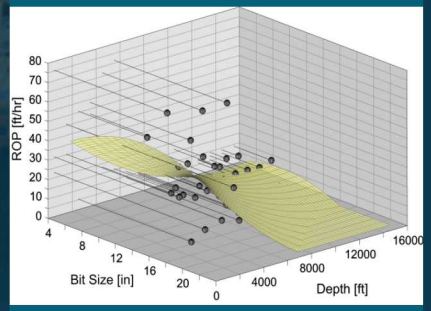

Reservoir Management and Development

PRESENTED BY

Thomas Lowry, Adam Foris, Mack Kennedy, Charles Carrigan, John Finger, Stephen Pye, Douglas Blankenship

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Reservoir M&D

Looks at a project after reservoir exploration and confirmation are complete

- EGS and hydrothermal power generation
- Sedimentary and crystalline rock environments

Investigate the technologies and practices that establish and affect the below-ground thermal, hydraulic, and economic performance of a geothermal system

- Baseline
- Future improvements

Support NREL – Potential to Penetration (P2P) task by providing RM&D related inputs to GETEM

Investigate broader implications of RM&D that are not able to be addressed in the P2P task

- THMC processes
- Reservoir characterization
- Long-term management

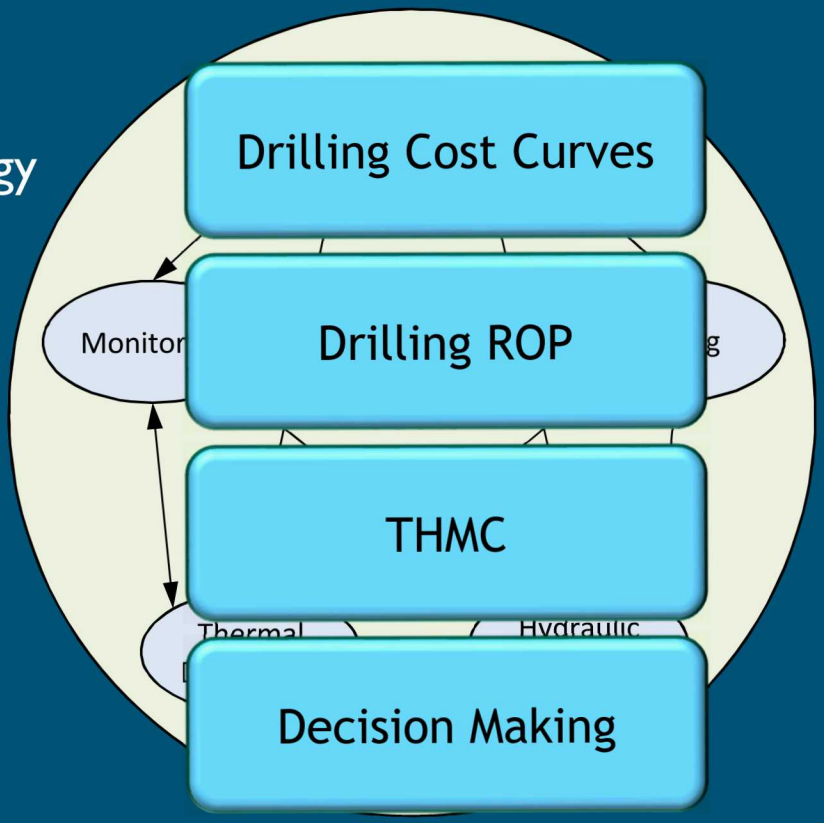
RM&D Report

Development
- 13 Sections
- Focused on drilling costs and technology
- Stimulation

Maintenance
- Characterization
- Monitoring
- Modeling

Other
- THMC
- Geopressured systems

All is Connected to All



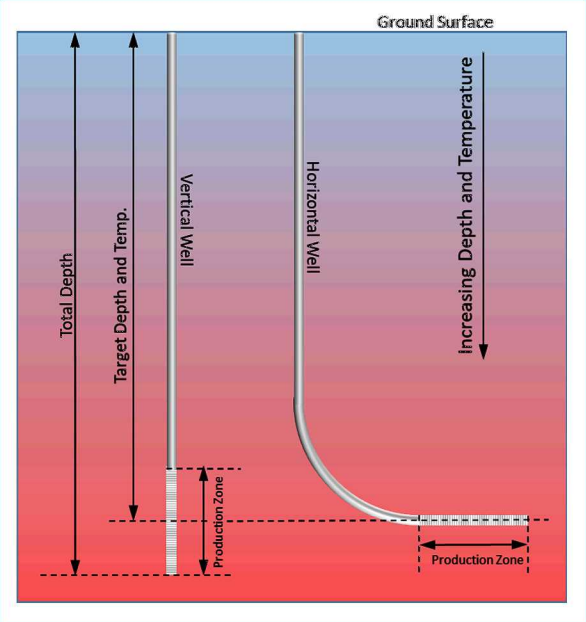
Drilling Costs

Four Time Cost Categories + Material Costs

- Drilling Time: Rotating on bottom, tripping drill pipe, bit and BHA costs, labor, etc.
- Non-Drilling Time: Flat time, running casing, cementing, logging, etc.
- Trouble Time: Costs that arise from adverse hole conditions and unexpected failures (e.g. lost circulation)
- Additional Time: Site prep, mob-demob, wellhead equipment, etc.

Base Assumptions – Use GETEM Design Defaults

- Minimum # of intervals = 3
- From 3 – 5 km = 4 intervals
- > 5 km = 5 intervals
- Production zone = 304.8 m (1000 ft)



Well Cost Simplified

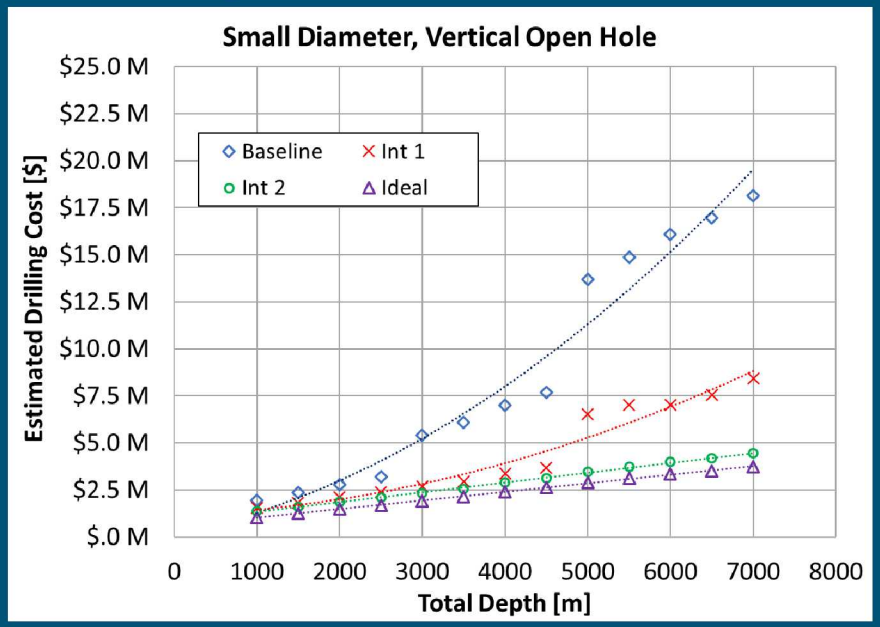
Drilling Cost Scenarios

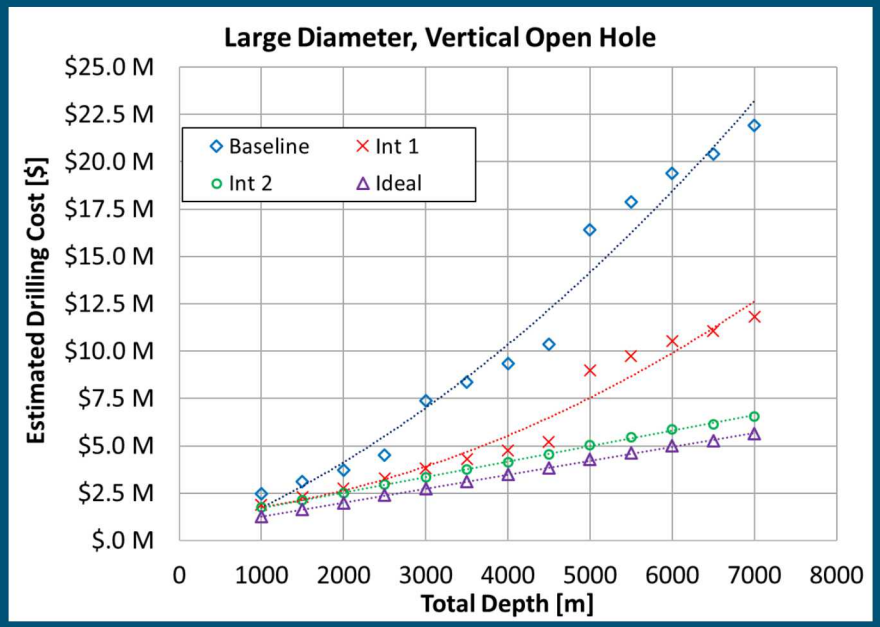
Base, Intermediate 1, Intermediate 2, and Ideal

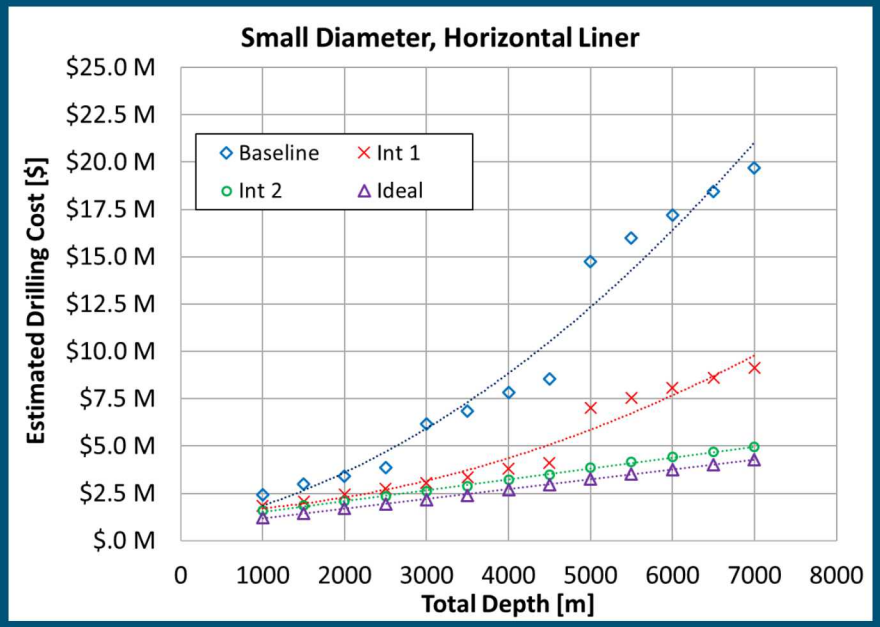
- 12 depths ranging from 500 – 6000 m
- Two Production Zone Hole Diameters: Small (8.50”), Large (12.25”)

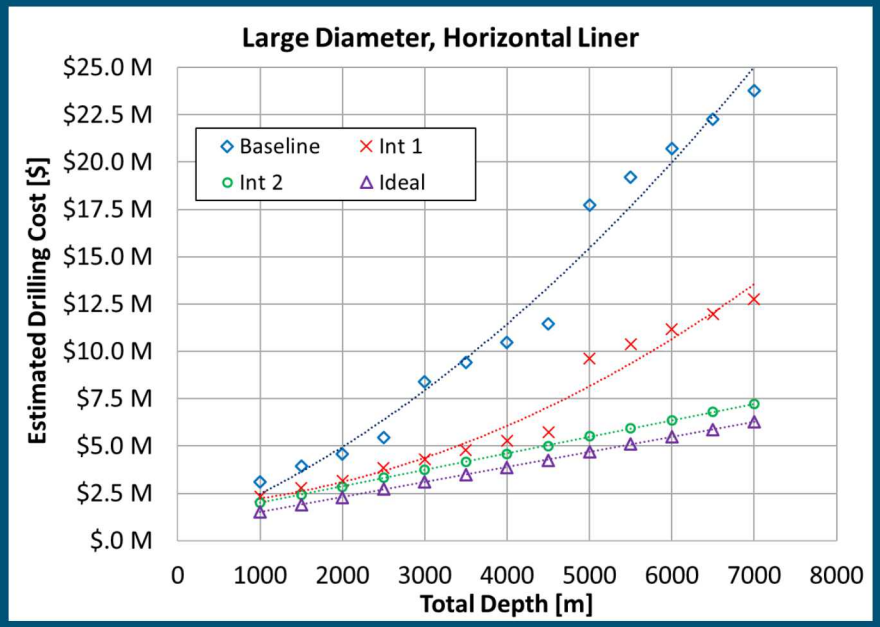
Category	Variable	Base	Int. 1	Int. 2	Ideal
Drilling Time	ROP [ft/hr]	25	50	75	100
	Bit Life [hr]	50	100	150	200
Non-Drilling Time	# Cased Intervals	3-5 Default	3-4	2-3	1
	Mud Costs	Standard	Half with air or water	Half with air or water	Full depth with air or water
	Logging	Wireline	Production interval only	Log while drilling	Log while drilling
Trouble Time	Contingency	25%	15%	0%	0%

Drilling Costs



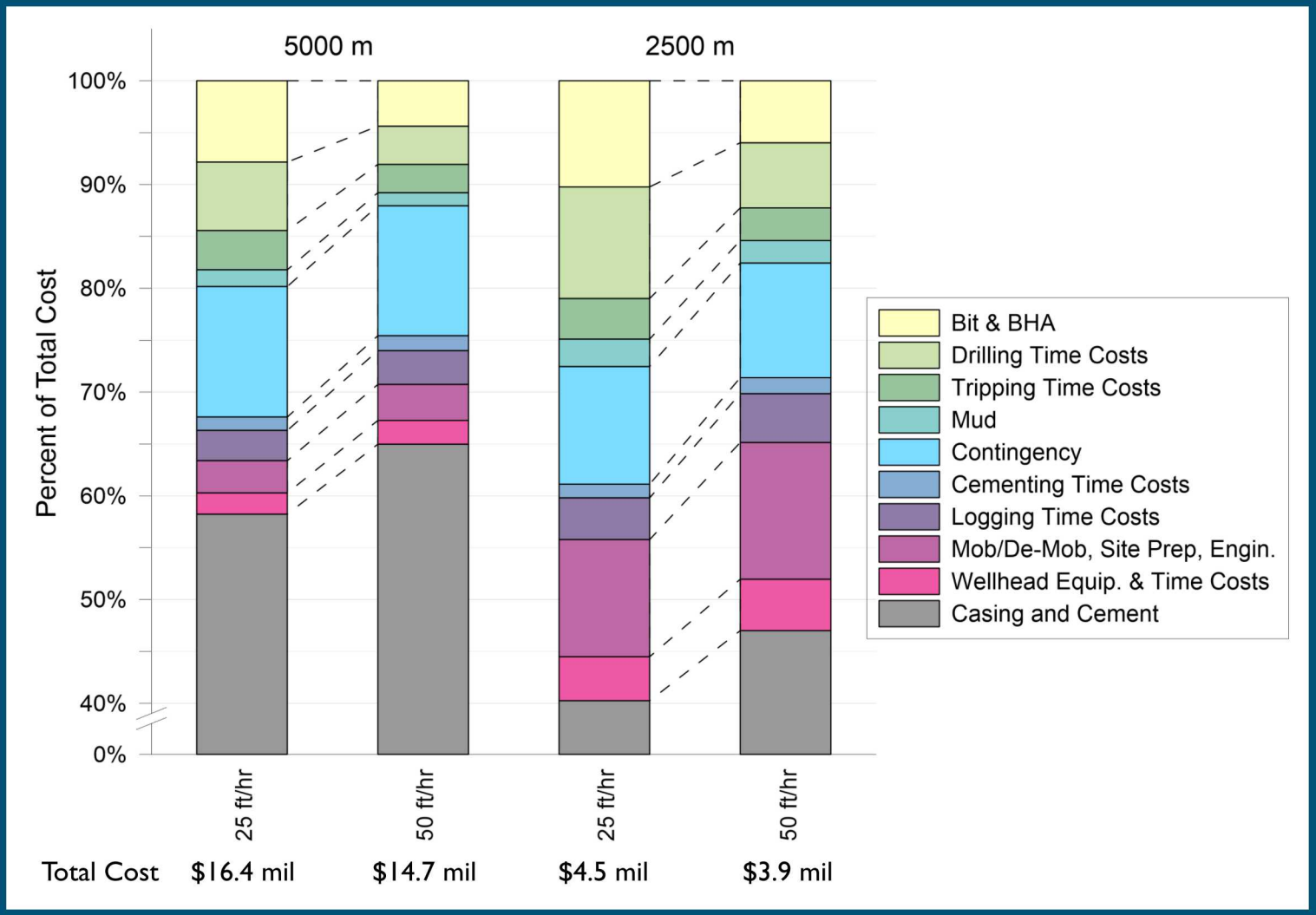






Drilling Cost Factors

Double ROP from 25 to 50 ft/hr



Drilling Cost Lessons

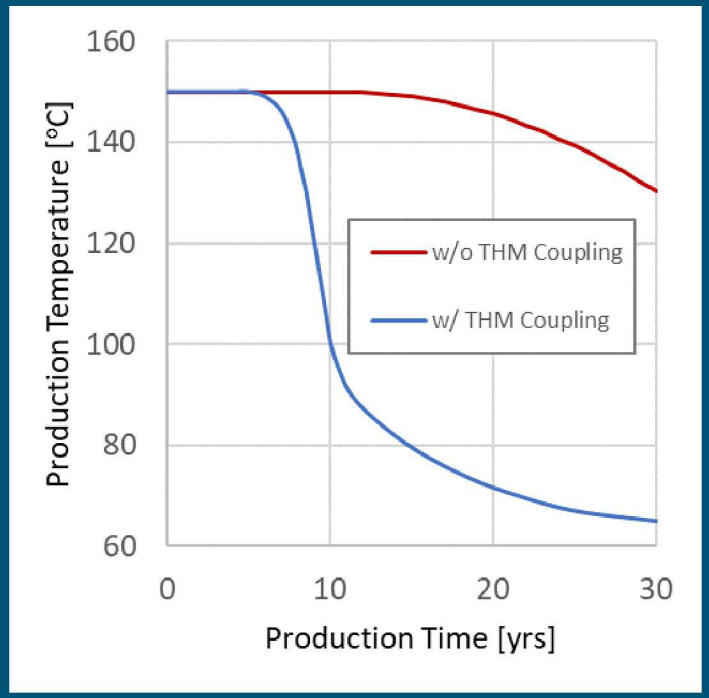
Time costs and material costs are connected

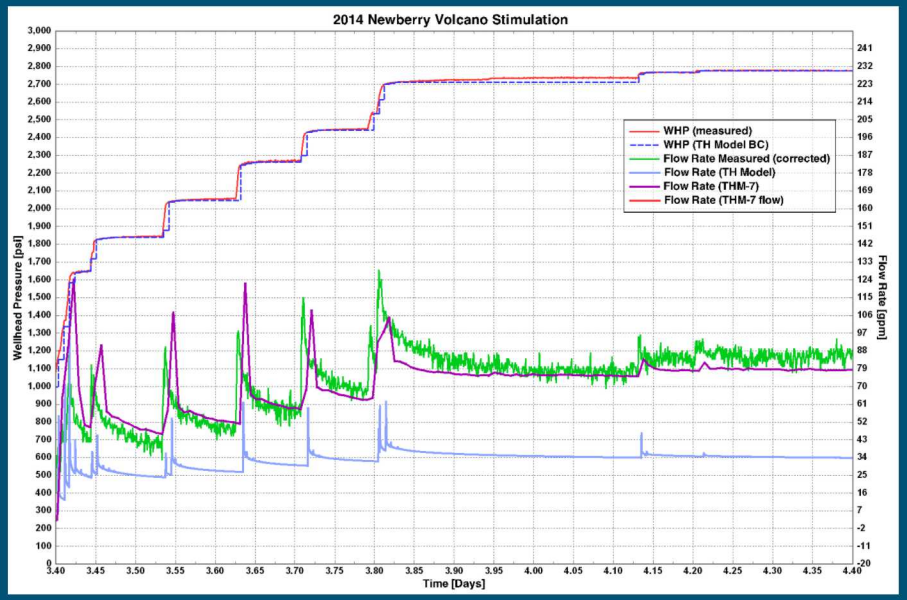
The impact of new technology is dependent on well configuration and purpose

There is no silver bullet for reducing drilling costs: the effort must be coupled and coordinated

THMC: Thermal-Hydrologic-Mechanical-Chemical

Effect of THM coupling





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THMC: Lessons

Need:

Diagnostic and predictive tools to capture THMC processes

- Diagnose cause of the Δ's
- Predict Δ's
- Optimize to minimize or counteract Δ's

Field and lab experiments to support model development

Maintenance: Decision Making

Goal: Make Geothermal Energy Profitable

- Reduce Risk

Consequence
f(costs)

×

Probability
f(uncertainty)

Reduce Costs

Reduce Uncertainty

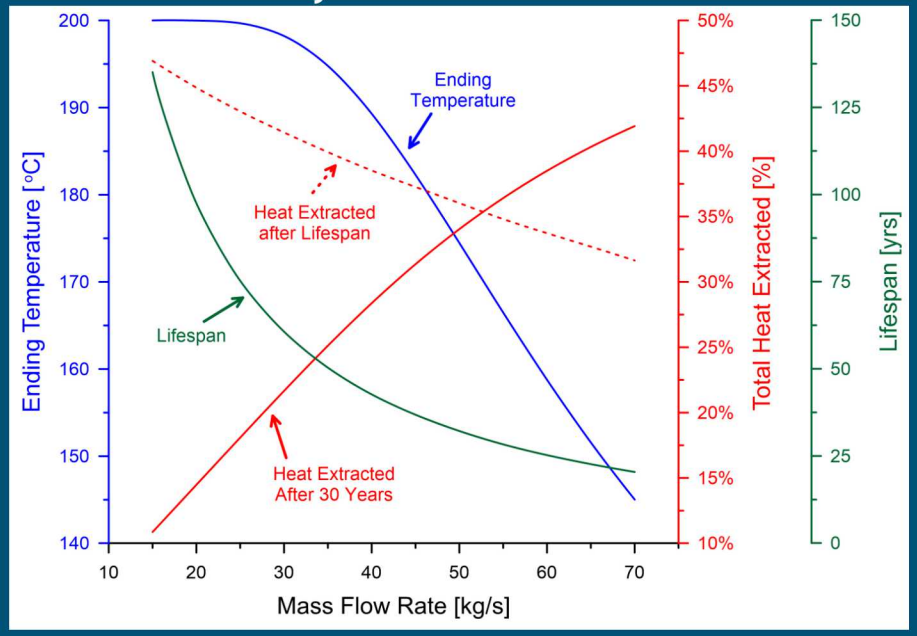
Reduce Both

Zero Costs/Uncertainty = Zero Risk

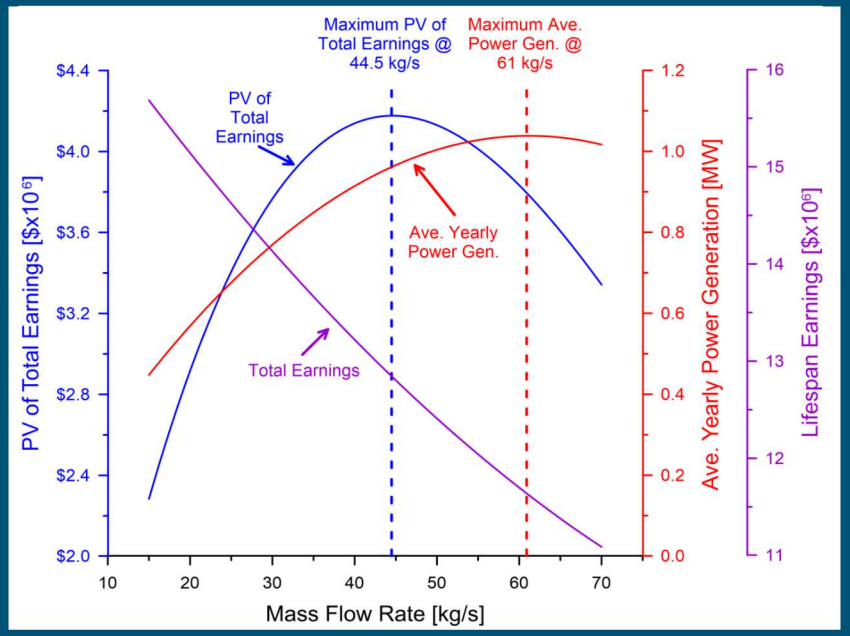
Maintenance: Decision Making Example

All Decisions Create Tradeoffs

Physical Performance



Economic Performance



Injection/Production Doublet, 500 m apart
T_o = 200 °C, Depth = 4000 m
Gringarten Solution

Maintenance: Lessons

Need:

Better techno-economic models

- Reflect THMC processes and feedback
- Handles uncertainty
- Understand tradeoffs

Continuous monitoring to detect changes early

- Pressure, temperature, chemistry
- Advanced tracers
- Characterization as a continuous process

RM&D Summary

Two High Level Challenges

- Reduce costs
- Reduce uncertainty

Drilling is the major contributor to overall cost

- Game changers: reducing casing/cement costs and reducing trouble time

Industry is hurt by lack of publicly available data

- Slows learning curve effect
- Hinders deployment of targeted, coordinated research

Need better data, modeling, and analysis tools

- THMC processes: THM and THC integration, better gridding, computational efficiency, and parameterization
- Integrated system models that capture complex physical dynamics and feedbacks to aid decision making

THANK YOU!

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