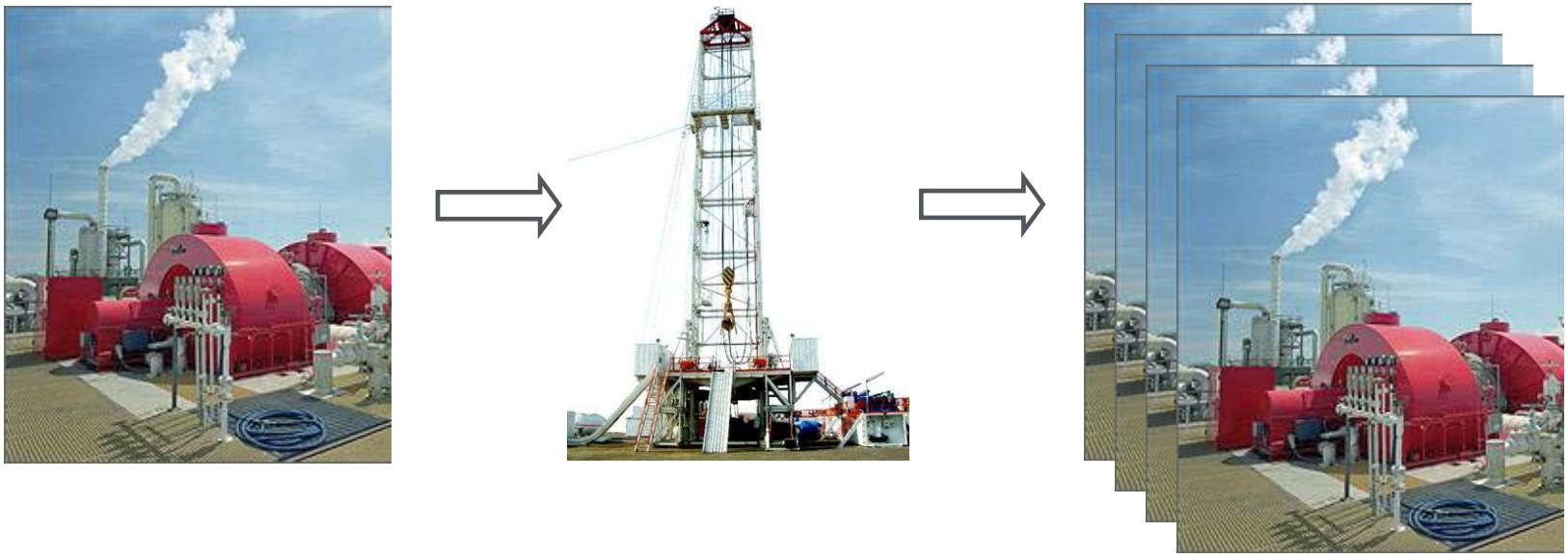

Energy Returned On Investment of Engineered Geothermal Systems

May 19, 2010

EROI of EGS

Principal Investigator:
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Analysis, Data System and Education

This presentation does not contain any proprietary confidential, or otherwise restricted information.

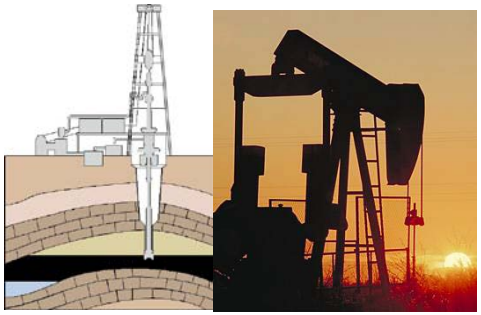
Overview

- Timeline: 3/2010 through 10/2011
  - The work is phased to match annual GRC meetings,
  - ~15% completed.
- Budget: $68K (DOE $50, cost share $18k)
  - FY09: $0, FY10: $30.
- Partners: none
  - But working in cooperation with Argonne National Laboratory and Sandia National Laboratory.
  - Receiving assistance from ThermaSource and Hydro Resources.
- Barriers:
  - W: Benefits – The environmental, economic, and security benefits of the Enhanced Hydrothermal Systems and EGS are *not fully understood* or articulated.
  - X: Data, Assumptions and Guidelines – *Inconsistent and largely uncontrolled datasets* are used by individual analysts and organizations making their own value decisions in performing analyses.

Relevance/Impact of Research

What is EGS EROI?

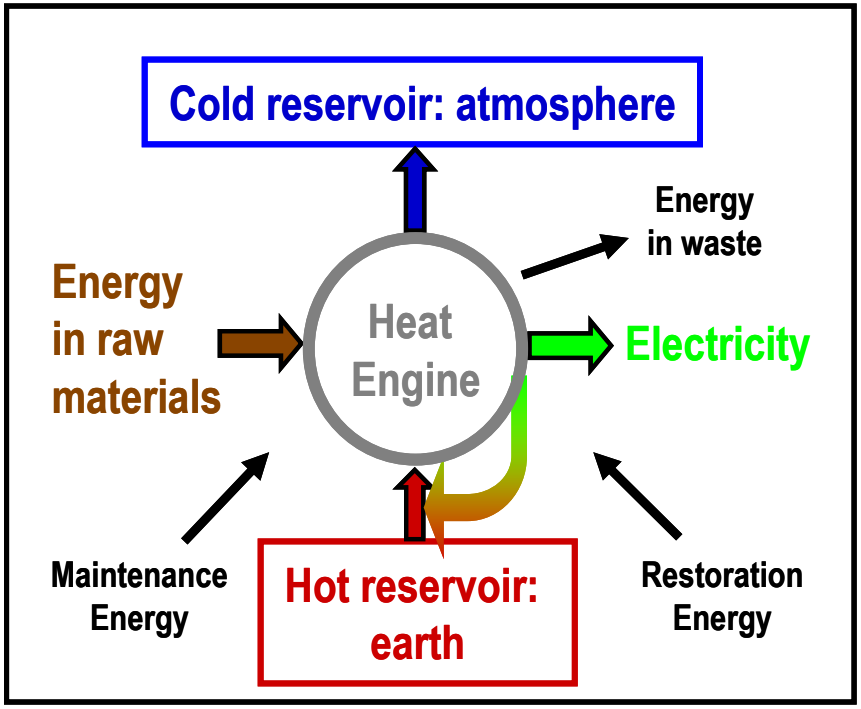
Energy investment



Return on investment EROI = 20

Refinement into fuel & delivery: 80% efficient

Applying EROI to EGS



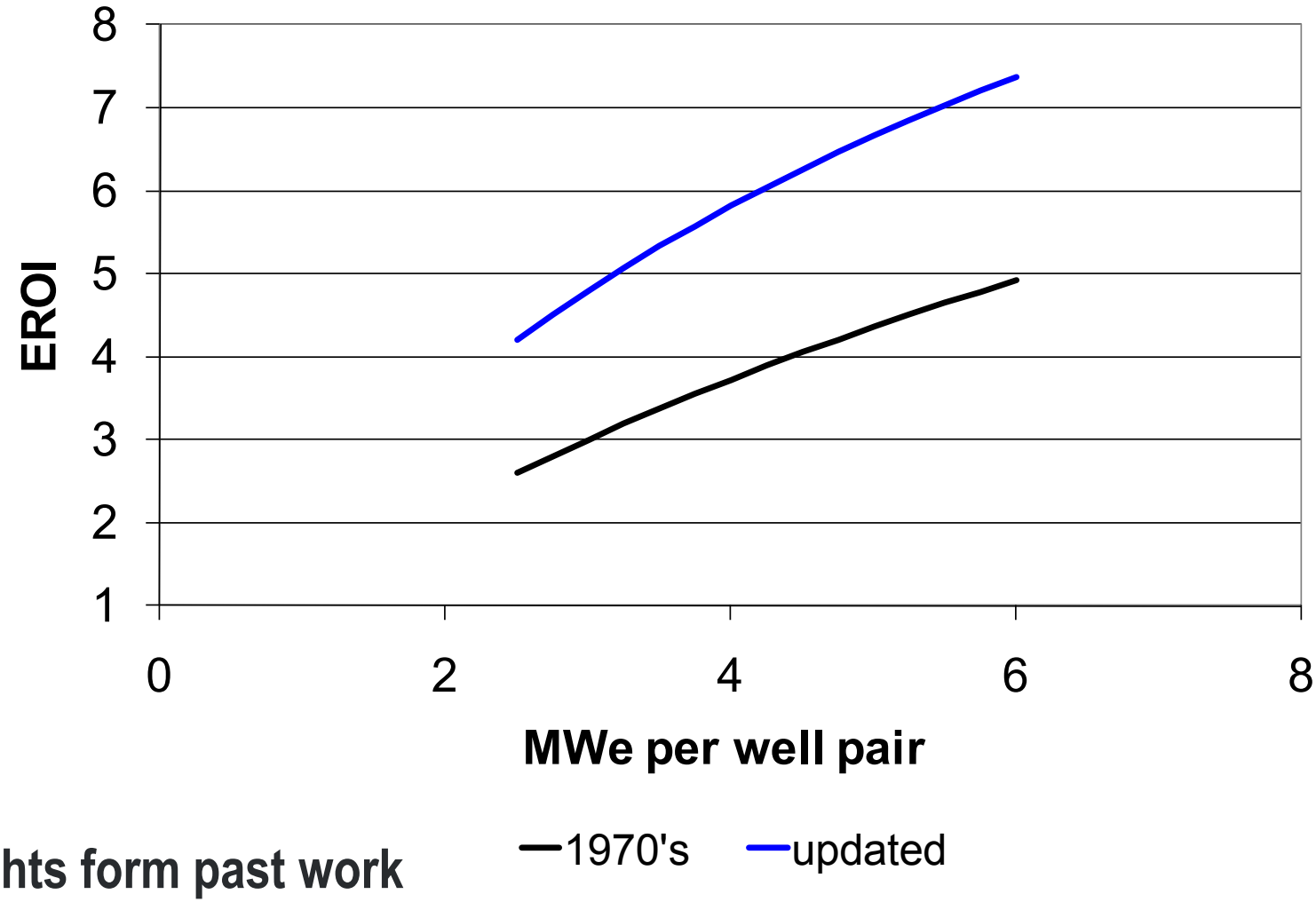
An EGS power plant involves four energy streams

- heat extracted from the reservoir,
- heat rejected to the atmosphere,
- energy to construct, operate, and decommission,
- electrical energy delivered to the customer.

Scientific/Technical Approach

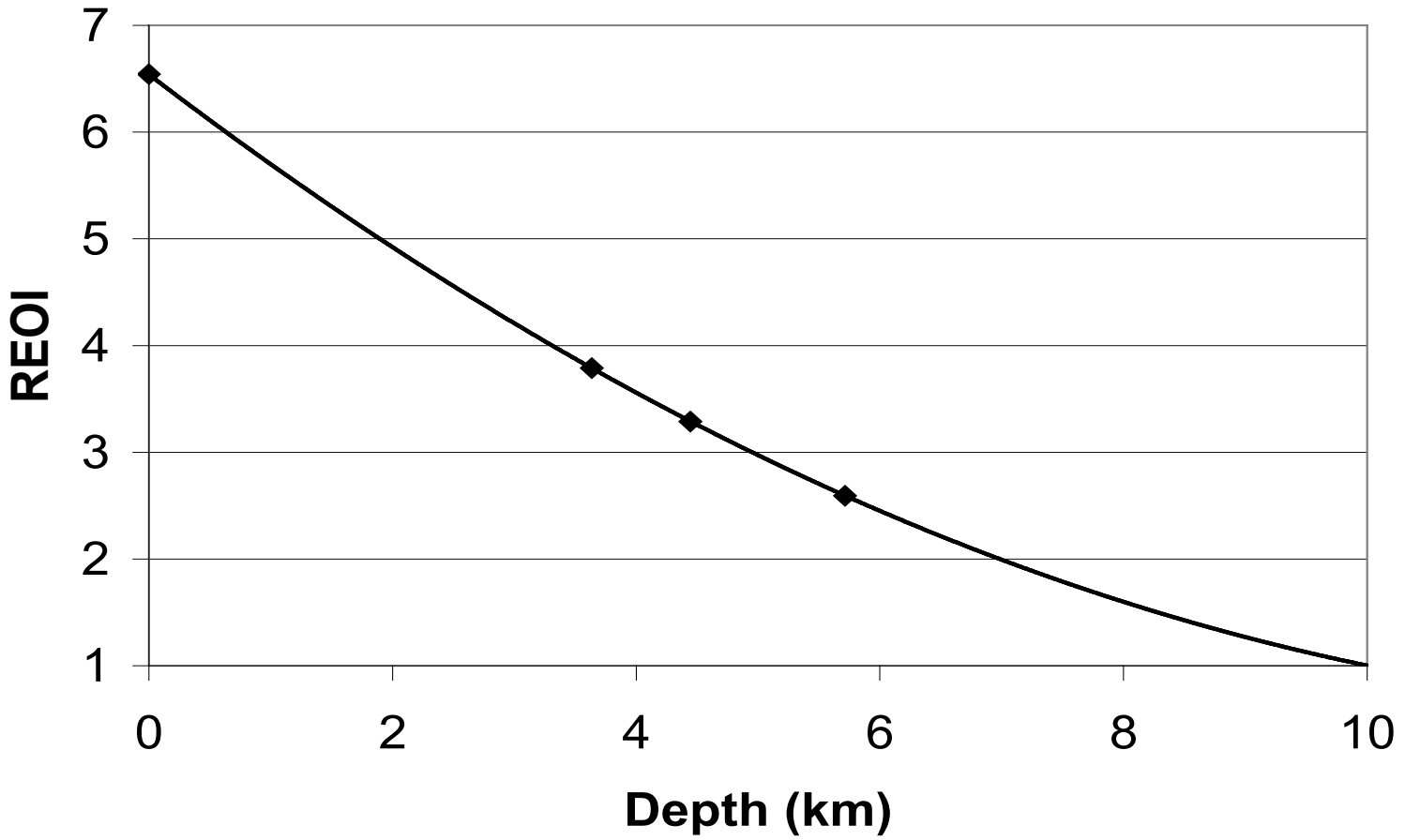
- Analyze past geothermal EROI to understand problems
  - Out of date, done in 1970's,
  - Efficiency of drilling has improved (both ROP and fuel consumption) ,
  - Uses I/O economic data: (cost)x(energy intensity or GJ/$) = GJ,
  - Energy intensity used for cementing is questionable,
  - Energy to replace depleted production is probably inadequate.
- Spot check past work with process analysis.
- Perform Process Analysis of EGS EROI
  - Coordinate with GSPAWG,
  - Cooperate with and build upon LCA work at Argonne,
  - Determine Material Inventory,
  - Use Argonne & NREL embedded energies ($/ton).
- Close the Loop.

Scientific/Technical Approach



Insights form past work

Scientific/Technical Approach



Insights form past work

Accomplishments, Expected Outcomes and Progress

- Presented a pre-project paper at Stanford Geothermal Workshop.
- Negotiated and kicked off Task 2b of a multi-task proposal.
- Established a close working relationship with Argonne National Laboratory.
- A paper has been submitted to the annual Geothermal Resources Council meeting.
- Final outcome: an up to date, defensible, peer reviewed EROI for EGS.

Project Management/Coordination

- Project is being performed by one person.
- All work is focused on publications (deliverables/milestones).
- First phase is review & update work done in 1970's.
- Second phase is Process Analysis (as a opposed to Input/Output Analysis) of embedded energies.
- Work will be documented in sufficient detail to allow independent verification of results.
- To the degree possible, results will be maintained as a living document.

Future Directions

- Outcomes: publications at
  - Geothermal Resources Council (Oct 2010)
  - Stanford Geothermal Workshop (Jan 2011)
  - Geothermal Resources Council (2011)

- Future/follow on:
  - Closing the loop
  - Distribution results outside the geothermal community
  - Transportation & EGS EROI

Summary

- **Geothermal energy should be the place of where EROI has been done thoroughly.**

- Geothermal resources are much simpler than many of the other energy alternatives
  - they don't have the complexity of soil depletion of bio-fuels
  - they integrate into the existing infrastructure without storage
  - they don't produce long term hazardous byproducts

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