3600 SqFt
Both electronic and machine shops
9916 Bell Ave SE
Albuquerque, NM 87123

Well Monitoring Systems for EGS

Project Officer: Bill Vandermeer
Total Project Funding: $2,869,978
March 14th, 2013

Principal Investigator:
Randy Normann

Track: 2, HT Tools

Relevance/Impact of Research, Pg 1

Objective of our project is to develop a well monitoring system supporting EGS from well stimulation to power production.

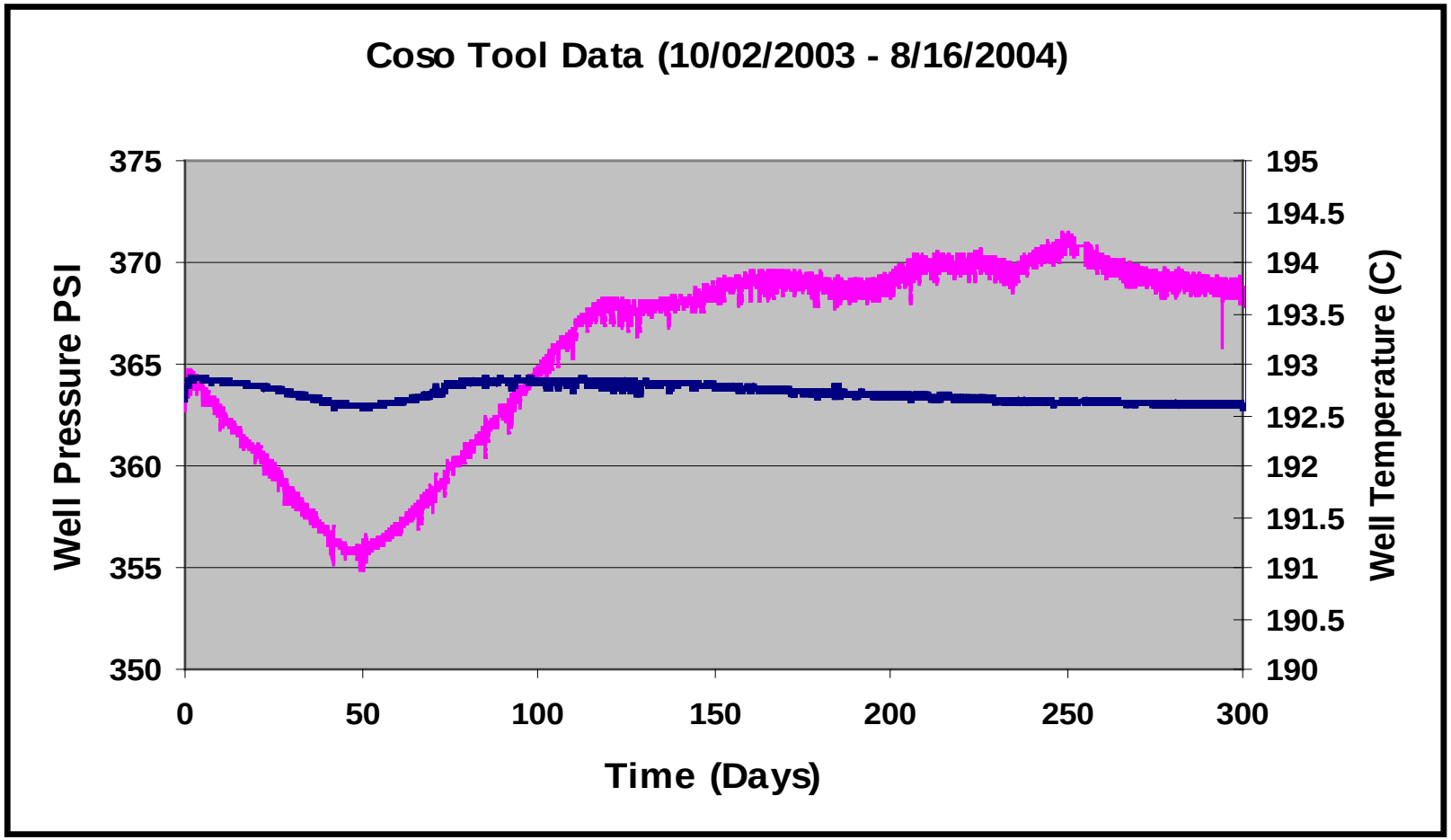
- Existing instrumentation can only stay in the geothermal well for a few hours at a time, requiring a logging truck and crew. Our system can stay in the well and operate unmanned for days or years. This reduces cost for well stimulation and improves reservoir tracking.
- Well stimulation through hydro-fracturing is very expensive
  - Our system can be in the well before stimulation, during stimulation and after stimulation for production testing at the production zone
  - Our system can provide data on the effectiveness of well stimulation real time allowing feedback on the value of additional stimulation
  - Once in place, the system can run unmanned (no logging truck!)

Relevance/Impact of Research, Pg 2

- Well monitoring: EGS power plant startup is risky with loss of reservoir fluids or poor reservoir response
  - Our pressure sensor can track reservoir levels
  - Our system monitor flow with a magnetic flow sensor not a spinner
    - Track production contributions from multiple zones
  - Our system can track changes in temperature to evaluate the EGS heat exchanger
  - Information real-time can prevent the plant going offline
  - Information could indicate reasons for increasing plant power output
- Support deep EGS of 10,000M and 300C!
  - We developed a circuit board process for electronics >300C
  - We built a 25Kpsi tool and demonstrated the tool in a geothermal well

Scientific/Technical Approach, Pg 1

Perma Works licensed the HT80SNL00 chip for building a PTS tool from HT SOI technology from Sandia National Labs.

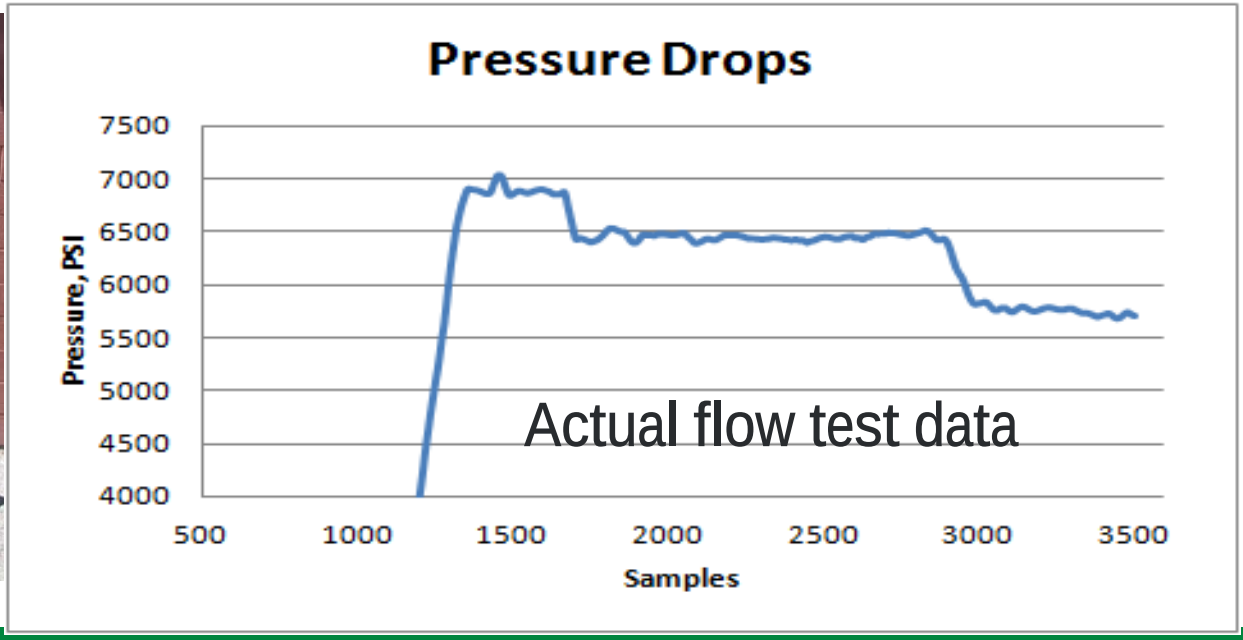


Scientific/Technical Approach, Pg 2

- Sandia Labs was a partner on this project. Unfortunately, Sandia had to redirect program funding to internal projects of higher priority which hurt the project overall and Sandia's task to develop HT solder.
- No existing supplier for 300ºC circuit boards
  - Developed CNC process to manufacture metal on ceramic circuit boards
  - Marketed circuit boards to GE and others
- No digital clock operating above 225ºC
  - Sub-Awardee Frequency Management ($100K) developed a 300C digital clock. They are now marketing that technology.
- No battery for temperatures over 200ºC
  - Sub-Awardee Electrochemical Systems ($200K) continues to have manufacturing issues. This technology is not yet commercial.
- No HT electronic memory for program storage
  - Every time the tool powers down it forgets how to be a logging tool!
  - Funded Honeywell ($68K) to commercialize their HT memory chip. This is now a commercial product.

Scientific/Technical Approach, Pg 3

- Mechanical spinners flow sensors fail after hrs in the well
  - Designed a HT magnetic flow sensor without any moving parts
  - Currently being tested
- Conventional geothermal tools limited to hrs in the well
  - PW-PT535A analog tool for well EGS well monitoring is now commercial.
    - Supports stimulation, production flow testing and long-term production monitoring in the well



Accomplishments, Results and Progress

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
HT 300C Ceramic Circuit Board	Conversion CAD to Hardware	Sept 2011
HT 300C Digital Clock	HT 300C Digital Clock Commercial	Dec 2011
HT Battery	HT Prototype manufacturing issue	On going
HT 300C Solder	Not completed, not moving forward	----
300C Analog Tool	HT Prototype Field Tested	Aug 2012
300C Digital Tool	HT Digital Tool Prototype Build	July 2013

Future Directions

- This program is completing in 2013. We plan to continue working with Electrochemical Systems to develop a HT battery such that we can offer both a wireline and a slickline HT memory tool.

- We plan to complete the digital tool and finalize testing of the magnetic flow meter this summer.

- Perma Works is furnishing a complete tool and wireline receiver to a sensor developer working on a line of new HT sensors.

Milestone or Go/No-Go	Status & Expected Completion Date
Digital Tool	July 2013

Mandatory Summary Slide

- This project has had periods of difficult progress. One of the major efforts not outlined in the project as a task is simply interfacing with IC manufacturers. The contract with Honeywell for non-volatile memory took almost two years to get in place.

- However, in building our tool and demonstrating it, Perma Works has gained notice and there appears a greater interest from suppliers.

- Perma Works has a fielded commercially available system suited for EGS stimulus monitoring. With time, we hope to prove in this technology for long-term (years) of well monitoring.

Project Management

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Timeline:

Planned Start Date	Planned End Date	Actual Start Date	Current End Date
9/30/2008	11/31/2011	1/1/2009	5/31/2013

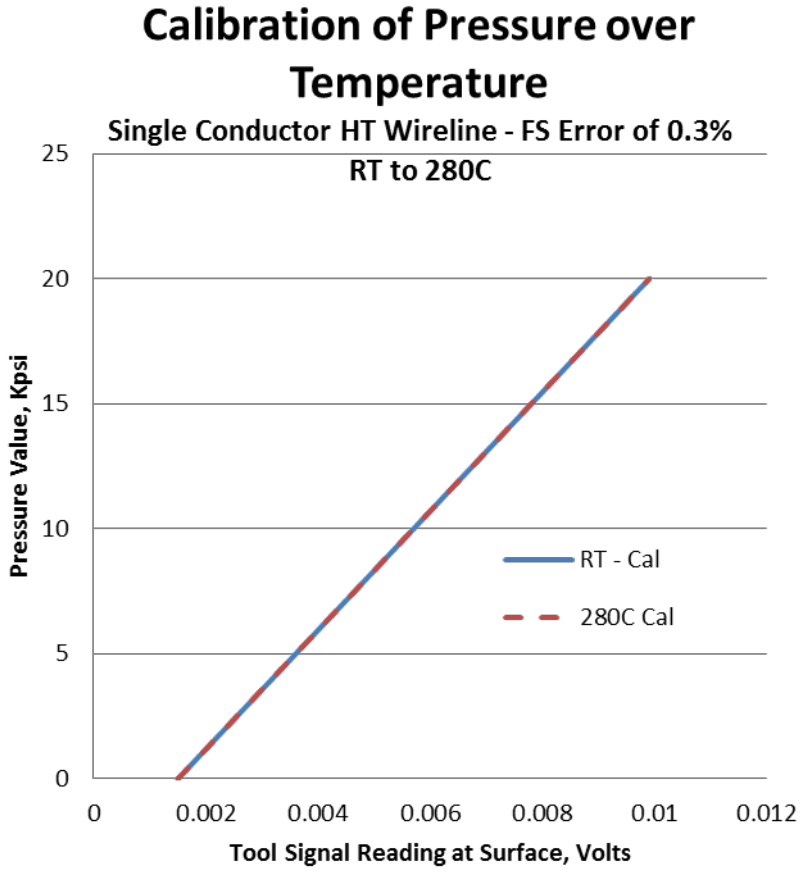
Budget:

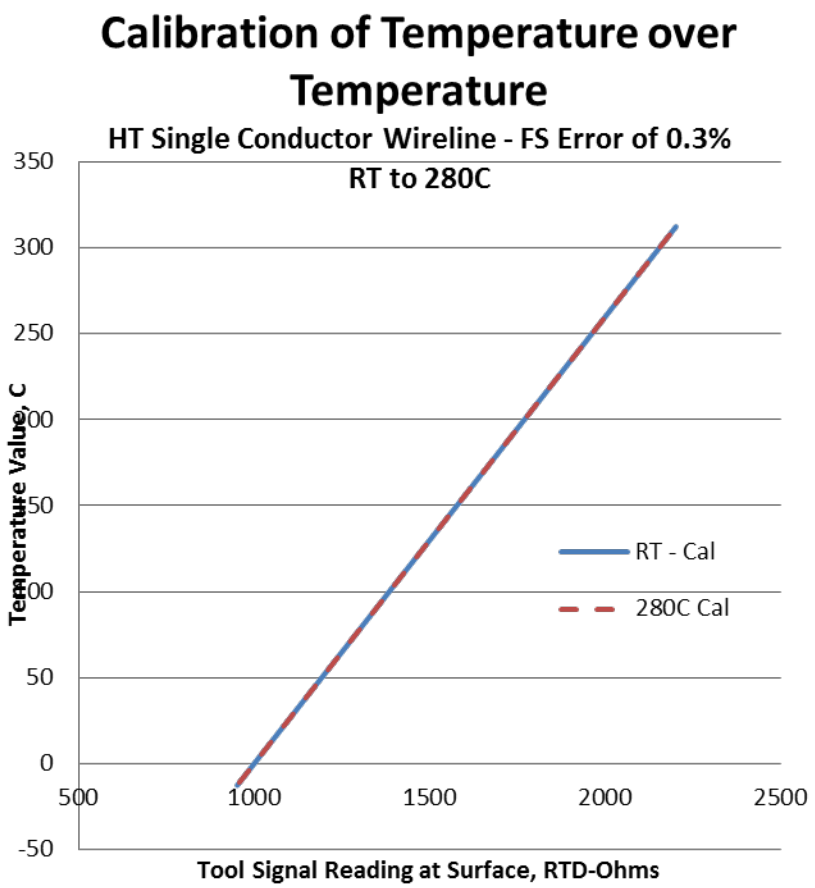
Federal Share	Cost Share	Planned Expenses to Date	Actual Expenses to Date	Value of Work Completed to Date	Funding needed to Complete Work
2,100,000	769,978	2,869,978	2,032,963.91	2,468,181.08	364,413.75

- This project has been approved for a no-cost extension, 18 months.
- Several significant slow downs in progress include:
  - Staffing
  - Supplier Delays (HT memory)
- With the extensions we have the feasibility to bring a successful close to the third and final phase of the grant this May 2013.
  - There are no more anticipated staff changes
  - All necessary long lead time components are now on site

Additional Information

- Below are calibration runs on the new PW-PT535A tool. Here the tool "RAW" calibration numbers are plotted for both room temperature and 280C. No correction factor is used as the tools automatic compensation is doing a great job.





Additional Information

- Below are actual well tests from the PW-PT535A well monitoring and EGS stimulation tool.
- The data to the left, is a well log of a geothermal well where the tool was placed at 250C for almost 24hrs. It was then lowered to a higher temperature near 260C.
- The data to the right is a 10K psi well head test of the tool with well head pressure data to compare results.