Osmotic Heat Engine for Energy Production from Low Temperature Geothermal Resources

Project Officer: Timothy Reinhardt
Total Original Funding: $910,997 Federal with 2:1 cost share
Pending rescope: $372,329 Federal (w/ $205,502 outstanding & 1:1 cost share)
April 22, 2012

PI (new as of 09/12):
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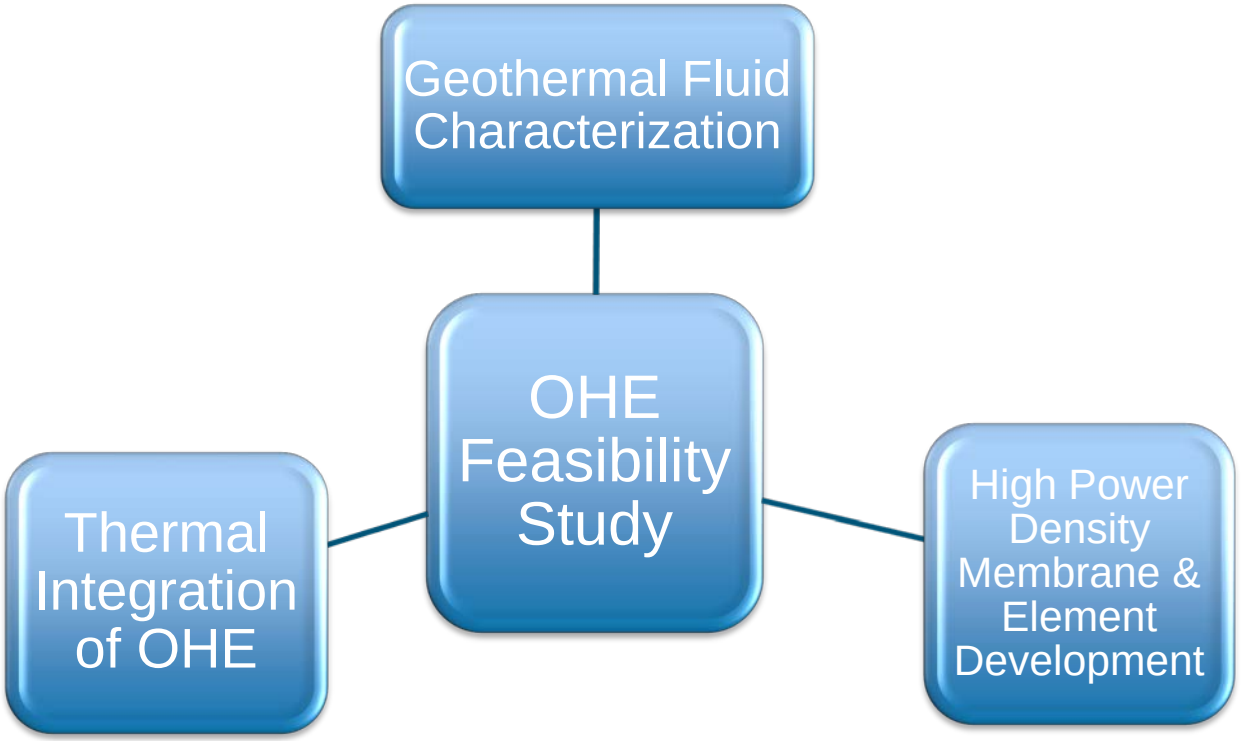
Oasys Water Inc.
Low Temperature

Relevance/Impact of Research

- The primary objective of this project is to demonstrate the economic viability of an Osmotic Heat Engine for electricity production from very low-grade geothermal resources
- The award is being rescoped to focus exclusively on a process modeling and implementation feasibility study with three core areas of development:



- Geothermal power is an attractive potential source for sustainable energy production, but the high heat temperature requirements (typically >250°C) of most geothermal capture systems reduce the geographic distribution and economical viability of geothermal energy production

Relevance/Impact of Research (cont.)

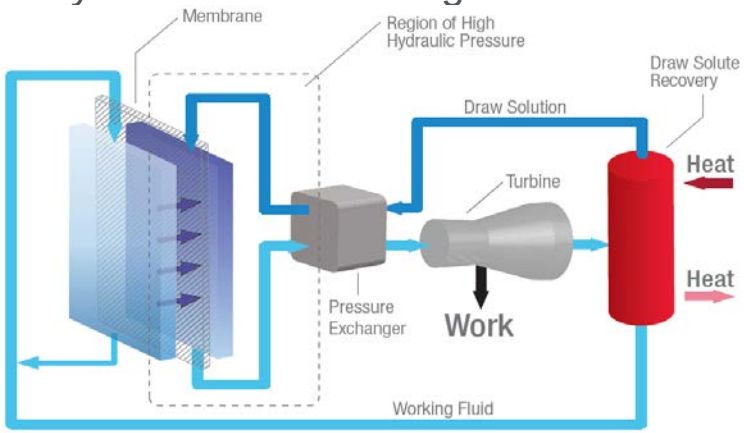
- A thermal energy conversion process capable of economically converting lower temperature heat sources (40-100°C) into power would enable the use of much shallower wells, could reduce the risk associated with deep well injection systems, and would expand the geographical range of geothermal energy production

- Low-temperature heat capture systems are also critical for improving the economic viability of existing geothermal harvesting systems, such as EGS. EGS expands the geographic range of geothermal energy production by injecting water into bedrock to harvest high quality heat, but the engines used to convert geothermal energy to electricity (Stirling, Rankin, or Binary) do not use heat below 70°C

- Economically viable systems for harvesting low-grade heat (40-100°C) from geothermal sources can provide abundant sustainable energy production

Scientific/Technical Approach

- Oasys is investigating a transformative Engineered Osmosis (EO) technology that could enable cost effective energy production from extremely low temperature geothermal sources
- The osmotic heat engine (OHE) is a closed cycle pressure retarded osmosis (PRO) system capitalizing on low temperature heat to recycle an engineered osmotic draw solute
- In the fully realized technology:
  - **Sole input:** slow-grade heat (40-100°C)
  - **Outputs:** heat rejected to a cold reservoir and electricity from hydropower turbine
- If successful, the OHE would economically use the lowest temperature heat of any engine cycle on the market today, and the compact, closed loop system design enables integration of the system with existing high-grade conversion systems to improve energy recovery and reduce cooling costs



Scientific/Technical Approach (cont.)

- Former scope used phase approach:
  1. Feasibility and Engineering Design
  2. Procurement, Fabrication, and Installation
  3. Field Operation

- Proposed rescope:
  1. Feasibility and Engineering Design

- Project Milestones:
  - Geothermal Fluid Chemistry Characterization
  - Stripper and Absorber Optimization
  - Membrane Development
  - Module Development
  - Membrane Module Testing
  - Integration of OHE system into Existing Recovery Systems

Accomplishments, Results and Progress

Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
Stripper and Absorption Optimization	Developed integrated thermal R&D facility and proprietary thermophysical database for process engineering models	2/1/12
Membrane Development	Commercial scale production of high performance membrane for FO and PRO	6/15/12
Module Development	Repeatable production of membrane elements capable of withstanding >200 psig of applied pressure & PRO (SW v DI) power densities >7 W/m^2	9/15/12
Integration of OHE into geothermal systems	Developed mass balance process model and preliminary PFD	6/1/12

Future Directions

Milestone or Go/No-Go	Status & Expected Completion Date
Geothermal fluid chemistry characterization	Not complete; TBD → pending rescope
Stripper and absorber optimization	Validation of low temperature heat stripping and subsequent draw solution vapor absorption; task 50% complete → 8/15/13
Membrane development	Prototype membrane development complete, working to refine chemistry for optimum power production vs. water purification; task 80% complete → 9/15/13
Module development	Module design validated, working to optimize membrane and hydrodynamic properties to increase pressure tolerance; task 80% complete → 10/15/13

Future Directions

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Milestone or Go/No-Go	Status & Expected Completion Date
Module testing	Work ongoing with pace dictated by advancements in membrane and module development; 80% complete → 10/15/13
Integration of OHE system into existing recovery systems	Preliminary process flow diagram and process engineering model constructed. Work must be validated with testing of materials and engineered systems under the temperature (ΔT between 40 and 100˚C) and pressure (between 250 and 500 psig) to regimes envisioned to demonstrate technology viability; 50% complete → 11/15/13
Issue final feasibility report	Ongoing; 12/31/13

Project Management

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Timeline:

Planned Start Date	Planned End Date	Actual Start Date	Current End Date
1/29/10	12/31/13	1/29/10	12/31/13

Budget:

	Federal Share	Cost Share	Planned Expenses to Date	Actual Expenses to Date	Funding needed to Complete Work
Original	$910,997	2:1	$356,013	$171,018	-
Rescope	$376,519	1:1	-	$171,018	$205,502

- Original project PI no longer with company; project as funded was substantially behind schedule and completion of original scope was not possible within current timeline
- Project not aligned with company strategic priorities (focused on water purification) → work to develop VLE & kinetics database is transferable
- Project undergoing rescope in cooperation with DOE project officer (Timothy Reinhardt) and monitor (Sara Gonnion)
- Rescoping project to focus efforts on original milestone 1 activities
- Seeking access to remainder of milestone 1 federal outlays with a 1:1 cost share
- Hope to have final agreements in place

Mandatory Summary Slide

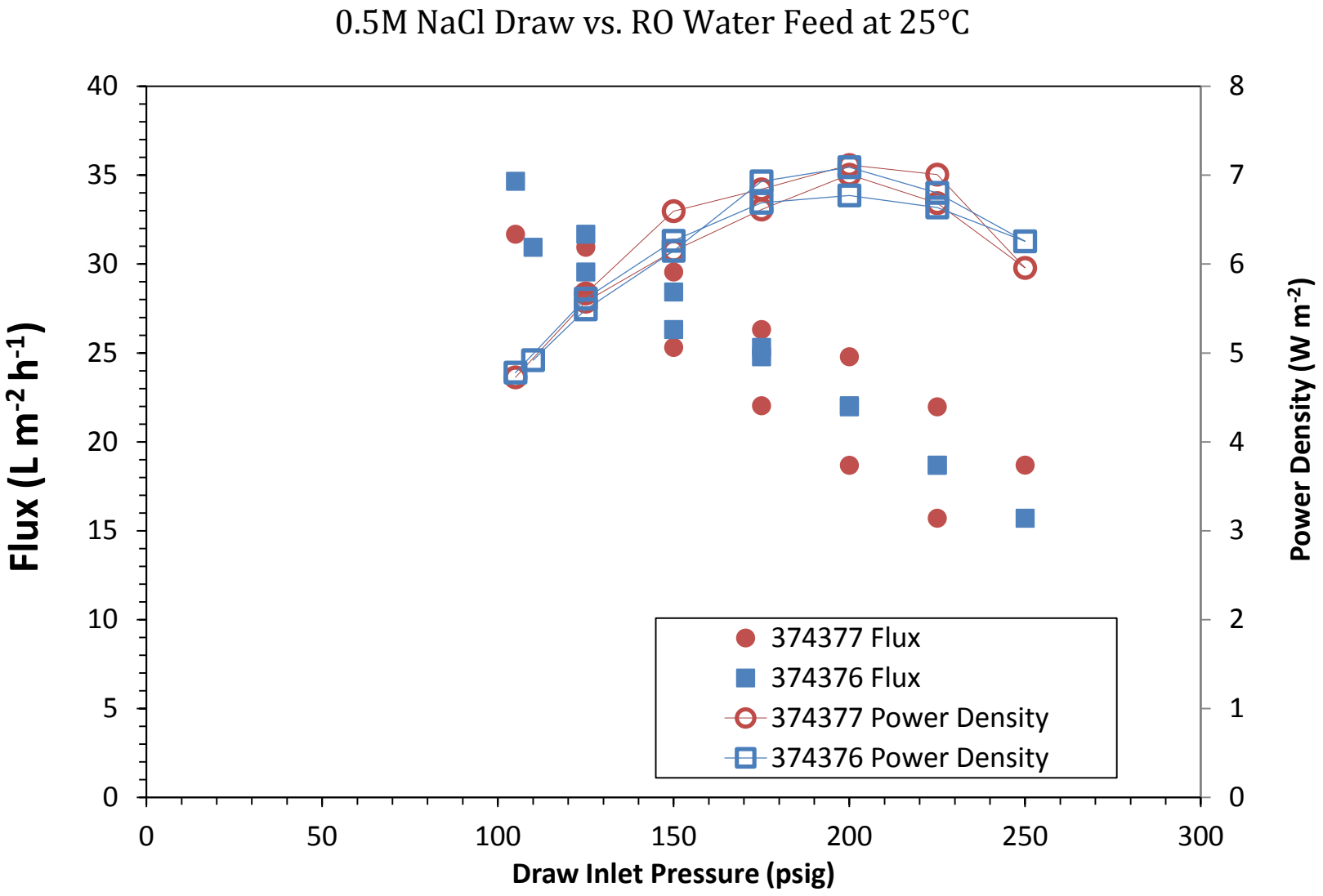
- Developing technology with potential to capture heat from low-grade geothermal resources and provide electricity
- Demonstrated effective separation of draw solution constituents from the working fluid
- Developed highly effective membrane and module configuration for PRO application with additional improvements under development to make suitable for commercial OHE
- Successful demonstration of the OHE will open new range of geothermal that is not currently usable

Supplemental Slides

Demonstrated Energy Density of Oasys PRO Membranes

Demonstrated PRO membrane power density using 24 Atm osmotic pressure difference.

Demonstrated Energy Density of Oasys PRO Membranes



THERMAL R&D FACILITY

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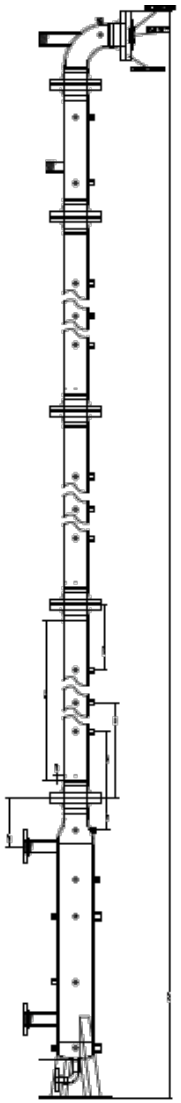
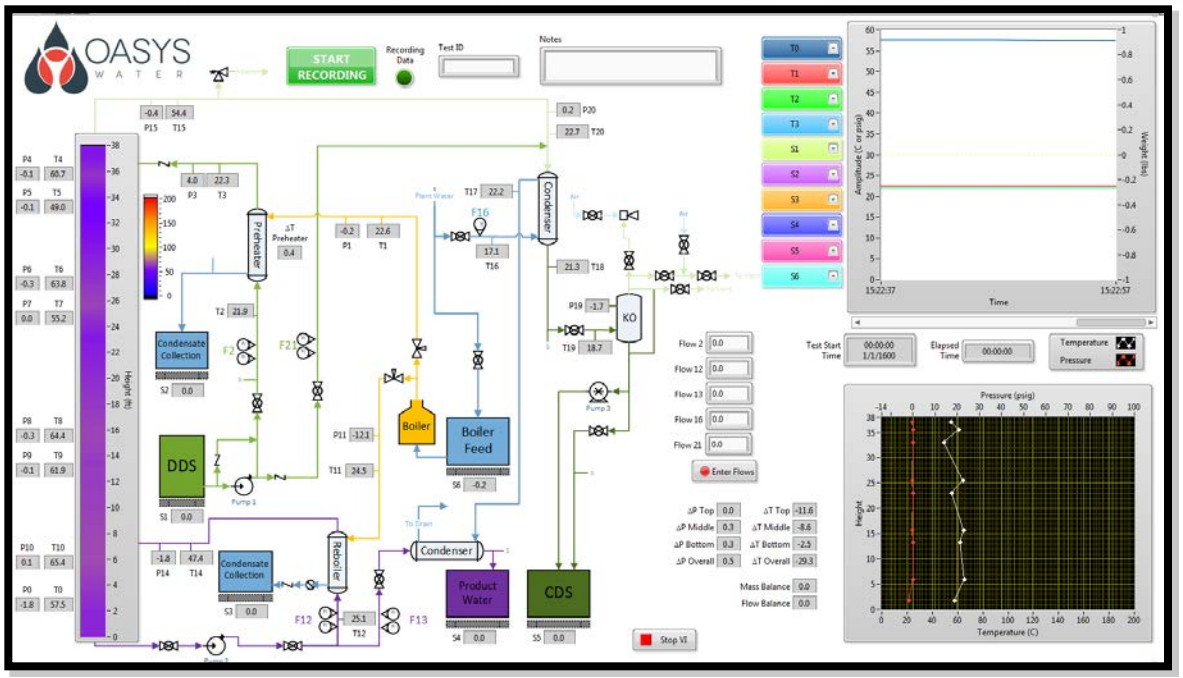
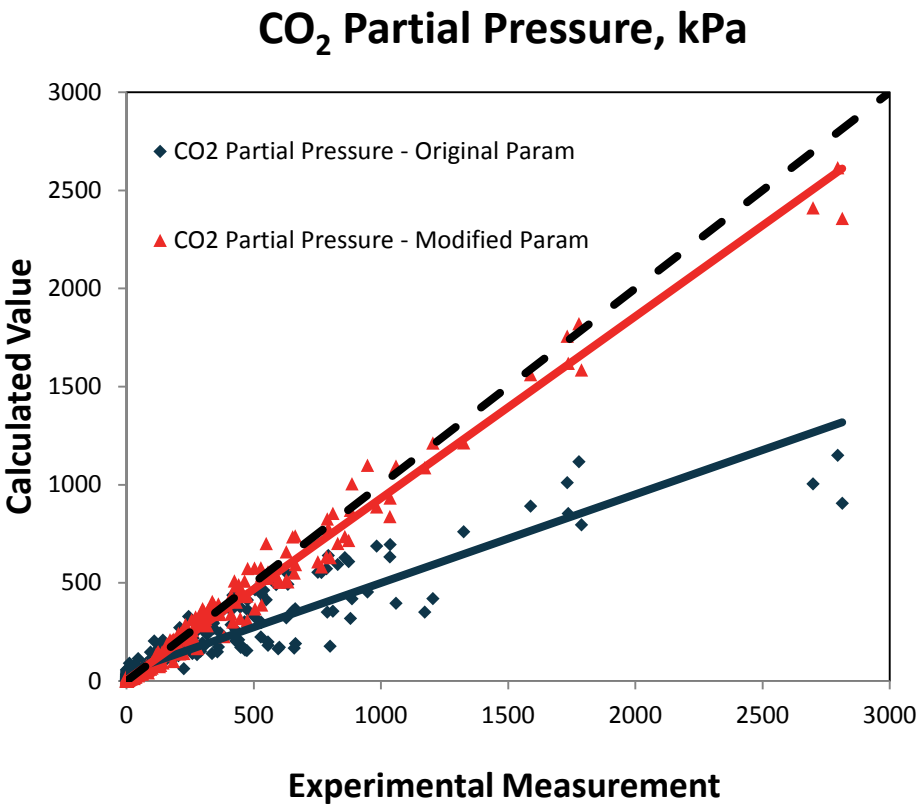




Proprietary Thermophysical Database



Reducing Technology Risk

Proprietary Thermophysical Model

Commercial Packing Evaluation

Membrane Array Level Testing

Absorber Testing

Capability to Rapidly Assess New Draw Solutions