EE00008780 - Geomechanical Pumped Storage

Howard K. Schmidt / CTO
Quidnet Energy

hkschmidt@quidnetenergy.com
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The objective of the project is to design, engineer, model, build and test a prototype, and characterize a novel combination of known mechanical elements (modern plunger pump and early water engine technologies) to realize a highly efficient and economical bidirectional medium pressure, high power injector-generator system – the Injector-Generator (INGEN) – for high head applications including Quidnet’s Geomechanical Pumped Storage (GPS).

The specific outcomes of this project are to produce a 0.5 to 10MW homologous design series capable of operating at 700psi to 3,000 psi, as well as a small-scale prototype used to characterize performance, with the goal of achieving mechanical efficiencies better than alternative reversible rotodynamic machines, targeting >95% mechanical efficiency (each way) in both the pumping and generation modes. This project also will generate a manufacturing plan to achieve <$100/kw INGEN manufacturing cost at-scale long-term.

Principal Investigator(s)
- Howard K. Schmidt, Ph.D. / CTO
- Joe Zhou / CEO

Project Partners/Subs
- Mechanical Solutions, Inc.
- ACI Services, Inc.
- Norm Shade, Ph.D.,
- Steve Todaro, P.E.

Project Status
- Ongoing

Project Duration
- Project Start Date: 8/1/2019
- Project End Date: 12/31/2022

Total Costed $1,964,705
Relevance to Program Goals:

- Supports a key HydroWIRES objective – developing innovative technologies for improved grid service capabilities
  - Directly optimizes Geomechanical Pumped Storage – a new PHS modality
    - Ideal for granular deployment in the 0.5 to 10 MW range
    - Serves longer duration storage > 10 hours
  - Positive displacement platform has inherently high efficiency
- Applicable to small scale traditional Pumped Hydro Storage
  - All facilities above grade
  - Easier to scale to high efficiency at low power compared to Francis Turbines
- Applicable to power generation using GeoPressured Brines
  - Module size matches typical well flow-pressure characteristics
  - Easier to scale to high pressure than Pelton/Impulse turbines
Project Objectives: Approach

Approach:

• Adapt a robust and efficient positive displacement plunger pumping platform with a modified valve train with bi-directional flow to support both INjection and GENeration (INGEN) operations
• Replace unidirectional check valves with novel bi-directional cylindrical rotary valves
• Develop hydrodynamically lubricated sealing pads to optimize life with minimal drag and leakage
### Outputs:

- 375 KW class INGEN prototype supporting GPS storage in the 500 to 2000 PSI range
- INGEN design guide and performance testing results
- IP covering the basic mechanical device, seal materials and designs, seal dynamic control method
- Technology transfer & license to US-based manufacturer for commercial production.

### Outcomes:

- Enable rapid GPS deployment at new sites with reduced capex
- Expand PHS deployment at smaller sites without cavern development
- Enable geopressed cogeneration at hydrocarbon production sites
- Enable rapid low cost production of power from geopressed fluids
**Project Timeline**

**FY 2019**
- 8/01/2019 Start BP1
- M 1.1 Complete 3D design, component selection & analysis

**FY 2020**
- M 2.1 Complete balance of system design
- M 3.1 Demonstrate path to < $100/kw cost
- 9/30/2020 Initiate GNG

**FY 2021**
- 4/01/2021 Start BP2
- 6/30/2022 complete bench testing rotary valve ports
- Upcoming: detailed design, fabricate, assemble & test prototype
### Total Project Budget – Award Information

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- No variances from planned budget
- Project timeline increased via no-cost-extensions
End-User Engagement and Dissemination

• End-user engagement strategy
  – First customer is Quidnet Energy – for long duration energy storage
  – Initial production with vendors that manufacture for OEMs routinely
  – Potential new applications:
    − Co-generation at high pressure hydrocarbon wells (1000 -6000 PSI)
    − Co-generation from RO desalination facilities
    − Small scale Pumped Hydro Storage (PHS) facilities (< 1 MW)
    − Power generation from geopressured geothermal brine resources.
  – Have engaged participants in
    − Hydrocarbon production
    − RO desal cogeneration
    − GPGT brine resource owners

• Technology transfer & commercialization plans
  – Licensing to established plunger pump manufacturers
  – Peer reviewed publications
  – Direct customer contacts for demonstration projects in new applications
Performance: Accomplishments and Progress

- Technical accomplishments
  - Developed CFD & FEM models for basic cylindrical rotary valve system
  - Identified key factors dominating performance/losses
  - Evaluated dozens of alternative flow geometries and architectures
  - Selected and modeled promising candidates
  - Completed CFD & FEM modeling of improved rotary valve architecture
  - Designed and built full-size single-port test bed for sealing pads
  - Evaluated pad materials
  - Evaluated pad designs and control methods
  - Selected sealing pad design, control and material for prototype
• Intellectual Property
  – IP developed during contract period:
    • Improved flow architecture for bi-directional hydraulic pump/motor
    • Floating sealing pad with hydraulic control method
  – Will file these as continuations to base patent (US 16/913,801) before award
  – Will publish results when testing is completed
Future Work

- **Key Steps**
  - Just reached final key decision point with successful sealing pad tests on laboratory bench test system
  - Detailed Design for 375 KW Prototype INGEN at MSI
  - Fabricate and Integrate Prototype at ACI
  - Test and Characterize Prototype at Hydro, Inc.
  - Re-sized prototype from 1875 KW to 375 KW to reduce integration time and cost
  - Planned completion by Jan 2023