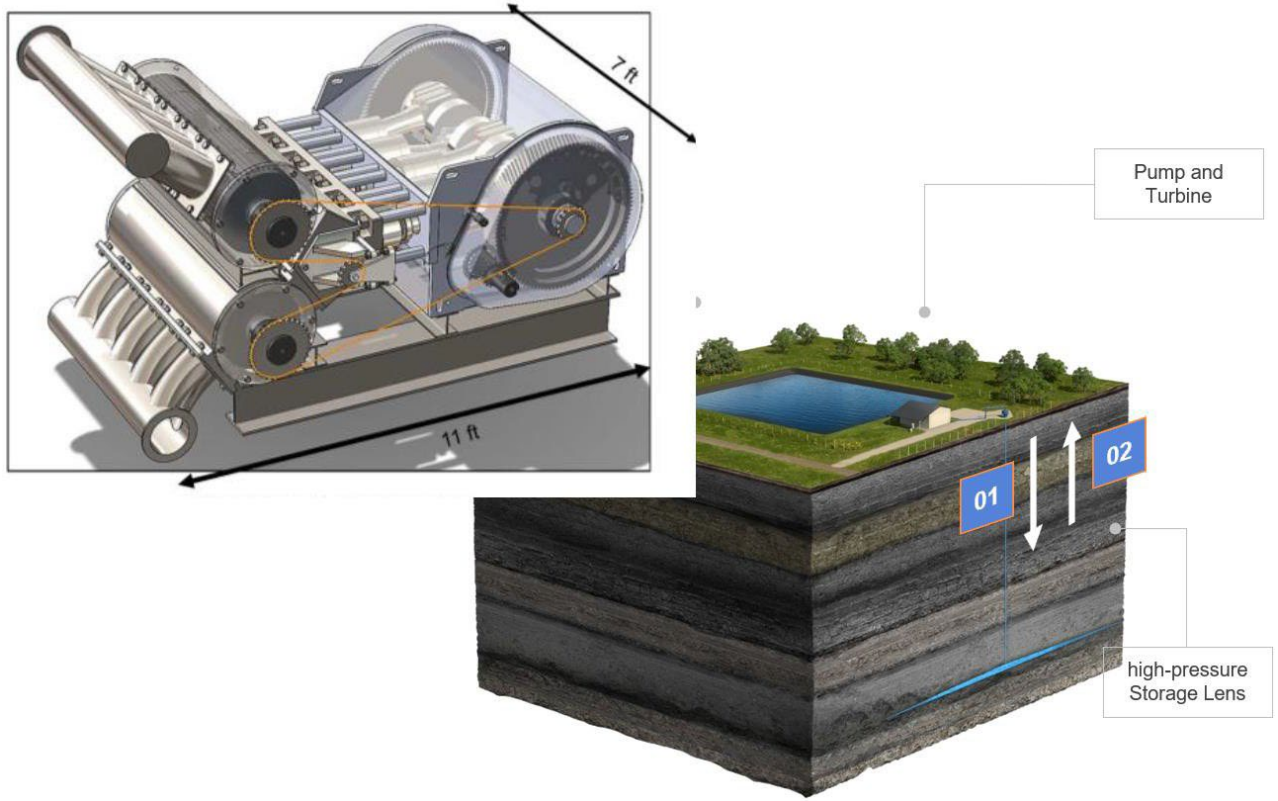
EE00008780 - Geomechanical Pumped Storage



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Project Overview

Project Summary

- 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).

Intended Outcomes

- 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.

Project Information

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

Project Objectives: Relevance

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

Project Objectives: Expected Outputs and Intended Outcomes

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 geopressured cogeneration at hydrocarbon production sites
- Enable rapid low cost production of power from geopressured 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

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,200,000	$764,705	$1,964,705

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$52,988 Federal $33,767 Quidnet	$514,209 Federal $327,681 Quidnet	$283,364 Federal $146,896 Quidnet	$850,562 Federal $508,344 Quidnet

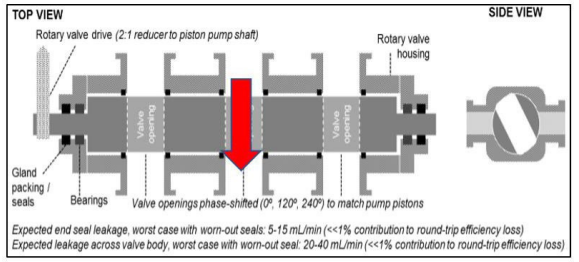
- No variances from planned budget
- Project timeline increased via no-cost-extensions

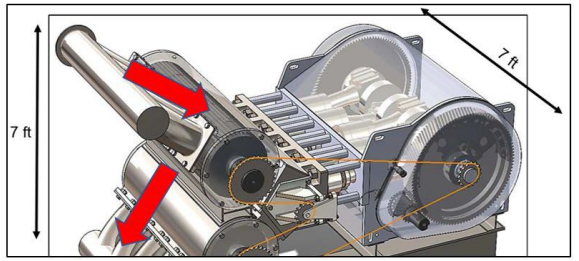
End-User Engagement and Dissemination

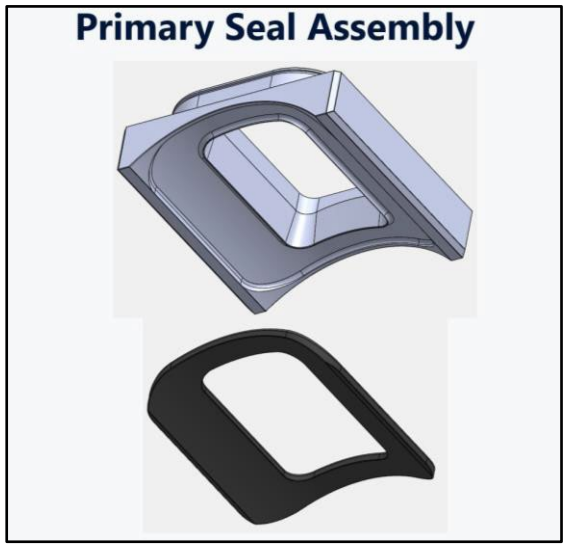
- End-user engagement strategy
  - First customer is Quidnet Energy – for long duration energy storage
  - Initial production with vendors that manufacture for OEMs routinely
  - Potential new applications:
    - Co-generation at high pressure hydrocarbon wells (1000 -6000 PSI)
    - Co-generation from 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

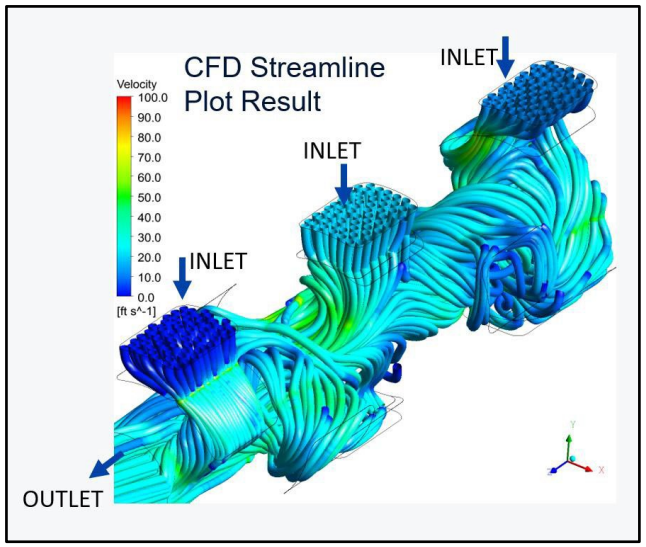
Performance: Accomplishments and Progress

- 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 CFC & 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







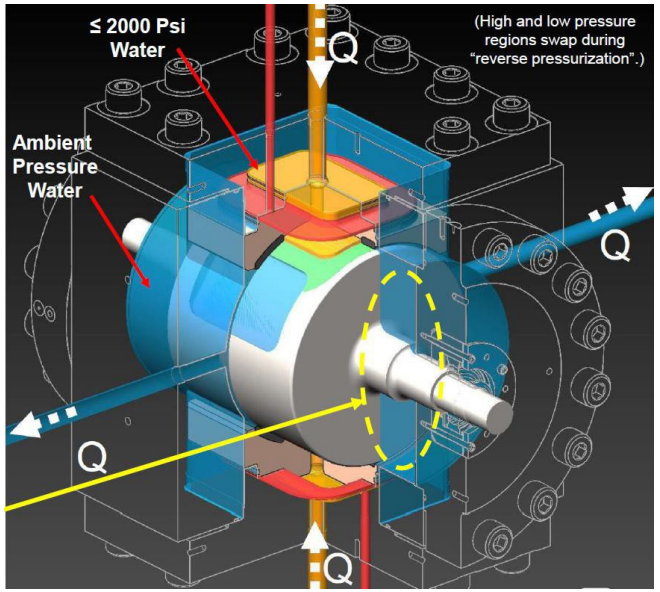


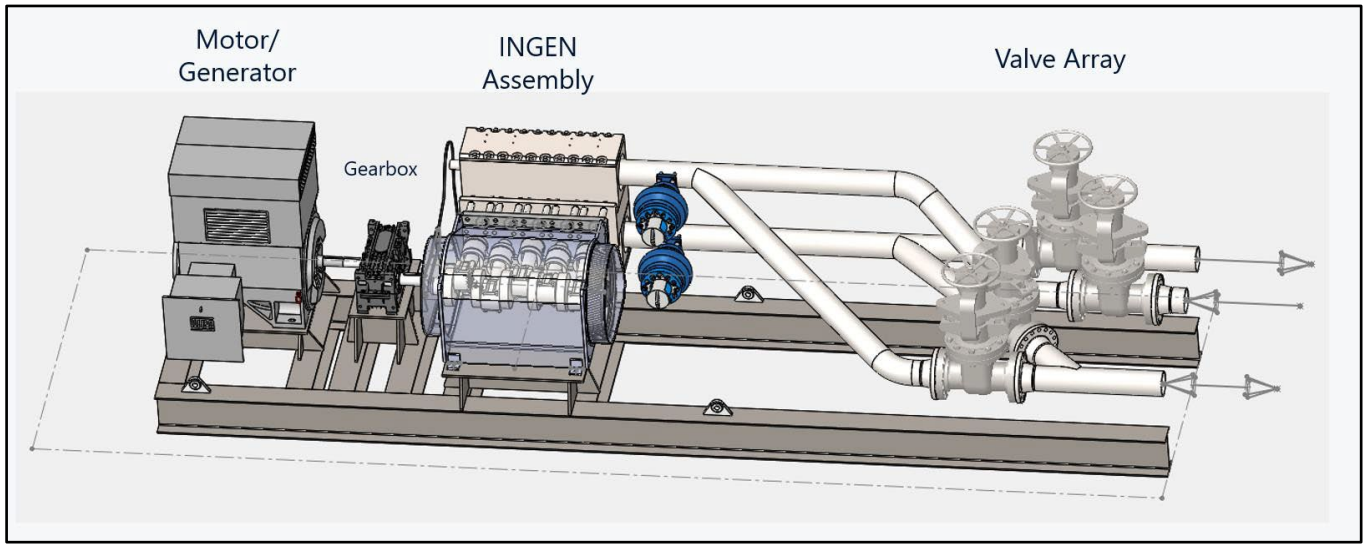
Performance: Accomplishments and Progress (cont.)

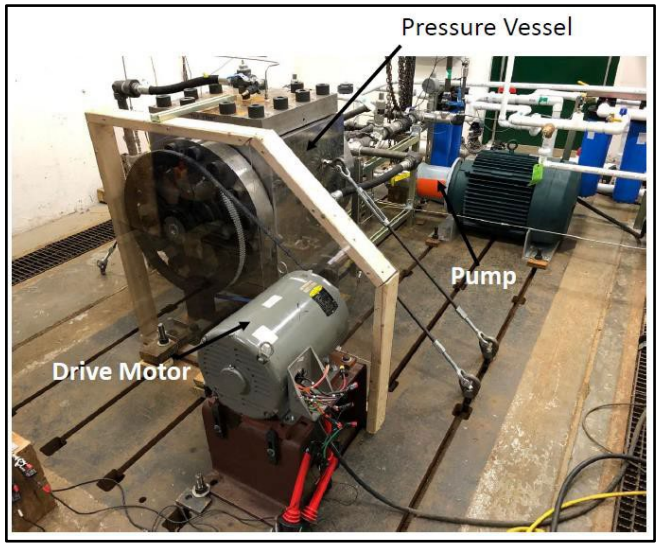
- Intellectual Property
  - IP developed during contract period:
    - Improved flow architecture for bi-directional hydraulic pump/motor
    - Floating sealing pad with hydraulic control method
  - Will file these as continuations to base patent (US 16/913,801) before award
  - Will publish results 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







Q&A