Development of an Advanced Hydrogen Energy Storage System using Aerogel in a Cryogenic Flux Capacitor

- **DE-FE0032003**

Southwest Research

PI: Joshua Schmitt

Sub-Recipients:
NASA (Through IAA)
University of Central Florida (UCF)
Air Liquide

Location: San Antonio, TX and Orlando, FL

DOE: $500,000
Non-DOE: $125,000

Total: $625,000

Technology Description

- Cryogenic Flux Capacitor (CFC) stores fluid by physisorption
- CFC contained by a pressure vessel and density is controlled with cryogenic temperatures
- Aerogel is the nanoporous material that stores the fluid

Objectives

- Validate hydrogen performance following NASA method
- Develop and commission lab to support planned test plan
- Perform test campaign on pure hydrogen and hydrogen blends with natural gas
- Analyze data and feed into techno-economic analysis (TEA)

Relevance and Outcomes/Impact

- CFC storage can enable gas storage at liquid densities for many industries
- Can be built in modular configurations for quick charge/discharge

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Target Test Metrics

- Goal is to pair the technology with an electrolyzer to demonstrate system dynamics
- Physisorption performance will be demonstrated between 80K and 120K
- Estimated storage size is 100 kWth of hydrogen, which is approximately 3 kg
- Current estimated size of the electrolyzer is 5 kW of electric power which supplies approximately 1,000 normal l/hr
- Tests will charge and store at atmospheric pressure and discharge at pressures between atmospheric and 25 bar
- Pure hydrogen will be demonstrated from an electrolyzer. Natural gas and blends will come from compressed gas storage

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Improvements over the State of the Art

- Hydrogen storage is currently low-pressure cryogenic liquid or high-pressure gas
- Cryogenic liquids can provide high energy and volume densities but require complex storage systems to limit boil-off, are not well suited for overly dynamic situations where the tank orientation can change suddenly
- Cryogenic liquid tanks are complex and need vacuum jackets and suspension systems between inner and outer vessels to enable the storage of liquid with reasonably low boil-off losses
- High-pressure gas storage bottles are less complex, are unaffected by orientation, and can be kept at room temperature. However, they require thick walls to withstand the high pressure, which makes them considerably heavy
- The energy densities associated with gas storage are dramatically lower than for cryogenic liquids, even at high pressures (up to 700 bar)

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Advancement of Technology Readiness Level (TRL)

- The CFC development for Oxygen, Air, Nitrogen, and Argon is TRL-4 because the components have been tested for storage on these fluids
- For fuels, including natural gas and hydrogen, is TRL-3 because the proof of concept has been demonstrated but the component has not been tested
- Project seeks to first mitigate risk by repeating NASA tests on hydrogen and methane, bringing the TRL on these fuels to 4
- The project will pair with an electrolyzer for hydrogen storage in a lab environment, bringing the TRL to 5 by the end of project

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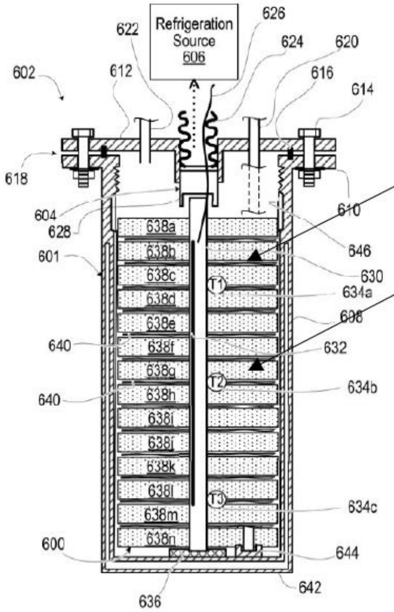
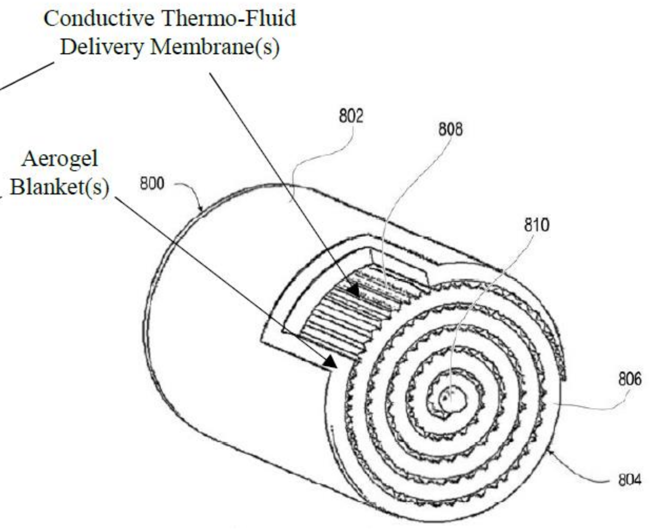
Commercialization Potential

- Aerogels are currently commercially available, so there is no barrier to production
- Scalability of materials is not an issue like lithium ion battery
- CFC is high density and could support monthly cycling, which corresponds to 10 to 100 hours of storage duration
- For a reference plant of 100 MW power output with a 50% net thermal-to-electric efficiency, 100 hours of duration would require 9,090 m3
- A module size will be defined to optimize the techno-economic performance for achieving this volume of storage





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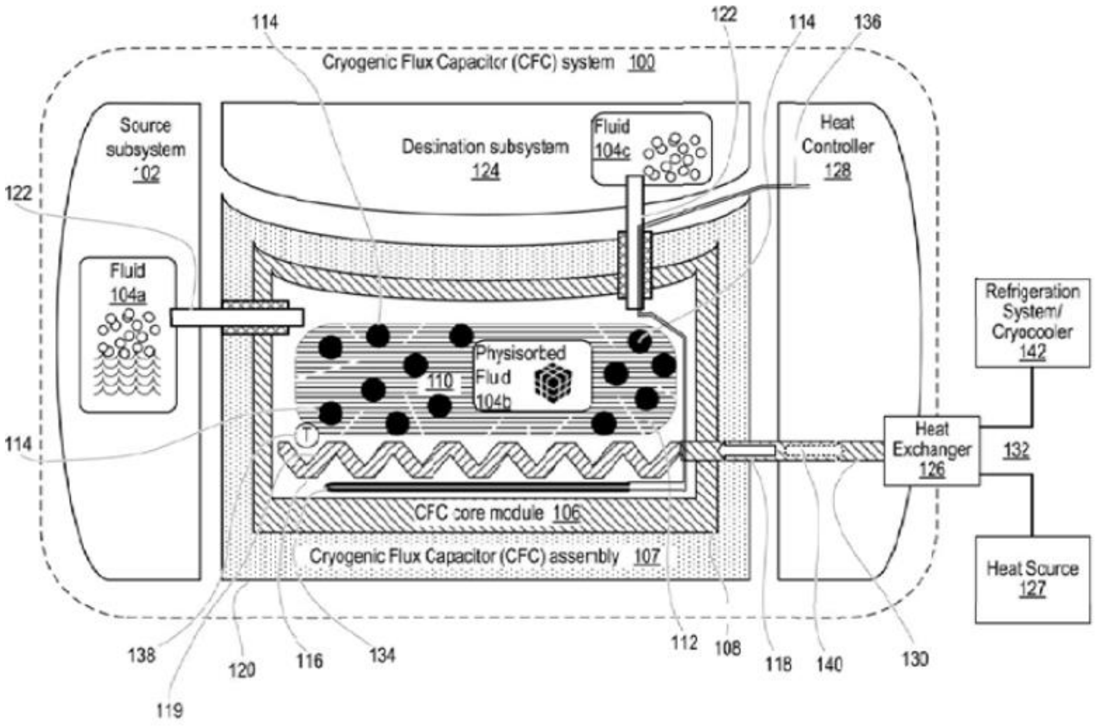
Future Integration with Target Fossil Application

- Primary target asset is ground-based gas turbines used for electricity generation
- Currently, hydrogen can be blended with natural gas from 15-50%
- OEM’s project new turbines by 2030 that can operate on 100% hydrogen
- CFC is intended to be modular and mounted on racks, like cells in a battery
- Land-based generation should be able to provide adequate space to accommodate racks of CFC in sufficient quantities



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Discussion Topics:

1) What is needed to be able to pilot **a demo plant by 2025?**
   - Using existing assets including existing combustors to demonstrate 15-50% Hydrogen content with natural gas
   - FEED studies to kick off plant development

2) What does NETL need to consider in regard to a **low-carbon future**?
   - Hydrogen economy: focus on flexibility if pursuing electrolyzer/green hydrogen
   - Hydrogen economy: further advance low-cost CCS if pursuing SMR/blue hydrogen

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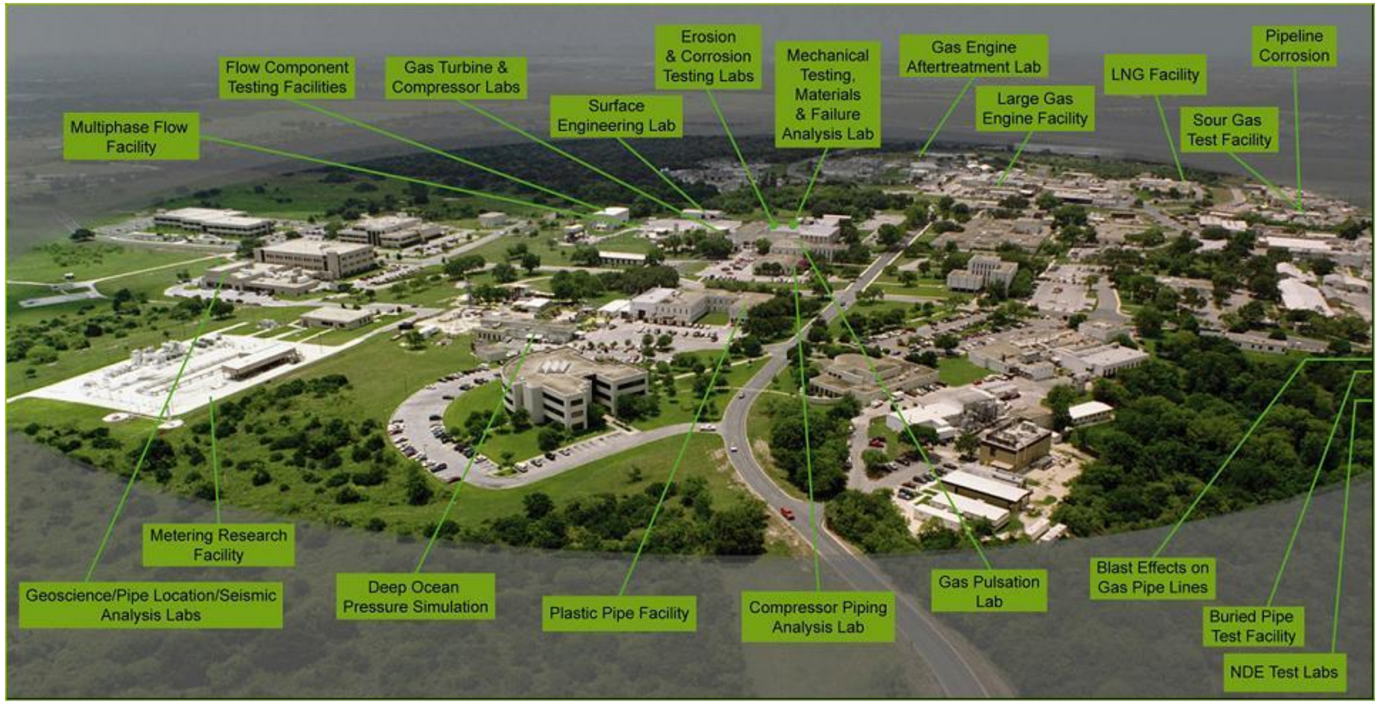
Thank You

Contact:
Joshua Schmitt
Joshua.Schmitt@swri.org
210-522-6777



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