Advanced Alkaline Reversible Cell (AARC) for Production of Hydrogen and Oxygen from ISRU-Generated Water – ACO

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Project Overview

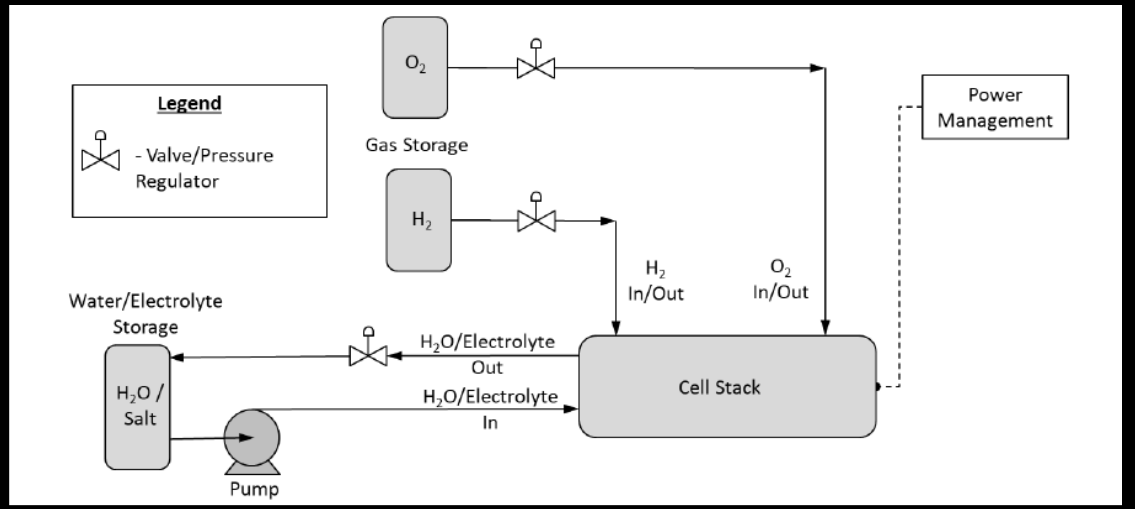
NASA needs energy storage for lunar applications where night lasts up to 354 hours. Reversible fuel cell systems are potentially well-suited for long-duration storage but must have high reliability to last the 4-year maintenance cycle. Moving parts (compressors and blowers) are the primary limitation for high reliability fuel cell systems. Further, H2 and O2 have numerous ISRU applications, including propellant, life support, and chemical processes.

Technical Approach (15 months)

The project is developing a unitized reversible fuel cell system based on a unique cell design. The mostly passive system will have no moving parts except for an electrolyte circulation pump. This project will determine water purity specifications for operating the technology with lunar-sourced water. Local water increases the launch-mass system energy density to >1,000 Wh/kg and enables the system to be used for ISRU applications.

Results/Summary

Baseline cell target performance has been established. Water contaminant recipes were developed. Initial testing of contaminants, including ammonia, methanol, and hydrogen sulfide have been examined.



Simplified process diagram

Value	NASA RFC Goal	SOA Discrete PEM System (AIRS)[4]	Proposed URFC Approach
Nominal Current Density (mA/cm^2)	N/A	200 (each stack)	**160**
Round-Trip Efficiency (RTE)	54% [4]	~55%	**55%**
Specific Energy (kWh/kg)	Highest Possible	360-850	**>1,000***
Water Purity Required**	TBD	Deionized	**>ppm**
Mode Change Speed	Seconds [4]	Minutes	**<5 s**
Number of Cell Cycles	>79***	30,000	**>1,000**
Reliability / # of Moving Parts****	No Failure for >5 yrs	Blowers (2), Pump	**Pump (1)**
Other Functionalities	As many as possible	None	**ISRU**

** Without thermal system and assuming locally sourced water (the proposed URFC would be 850 Wh/kg if water mass is included)*
*** PEM systems require D.I. water free of metal ions; proposed approach was demonstrated with ppm metal ion impurities (Ca, Mg, Fe, and Ni)*
**** Based on 5-years between maintenance, 700-hour cycles*
***** System reliability is poor for system with blowers and/or compressors*

Table of key properties

Contributing Partners

- Sister Tipping Point project to develop prototype system
- NASA Glenn Research Center
- NASA Johnson Space Center
- Power to Hydrogen, LLC
- Shell GameChanger

Infusion and Transition Plan

- Space flight test opportunities to achieve TRL 7
- Lunar surface energy storage and ISRU missions
- Commercial hydrogen / energy storage customers

Contaminant	Concentration
H_2S	44.3 ppmw
NH_4OH	8.0 ppmw
CH_3OH	0.372 moles / liter

Expected "worst case" contaminants from lunar water post-vacuum distillation being evaluated

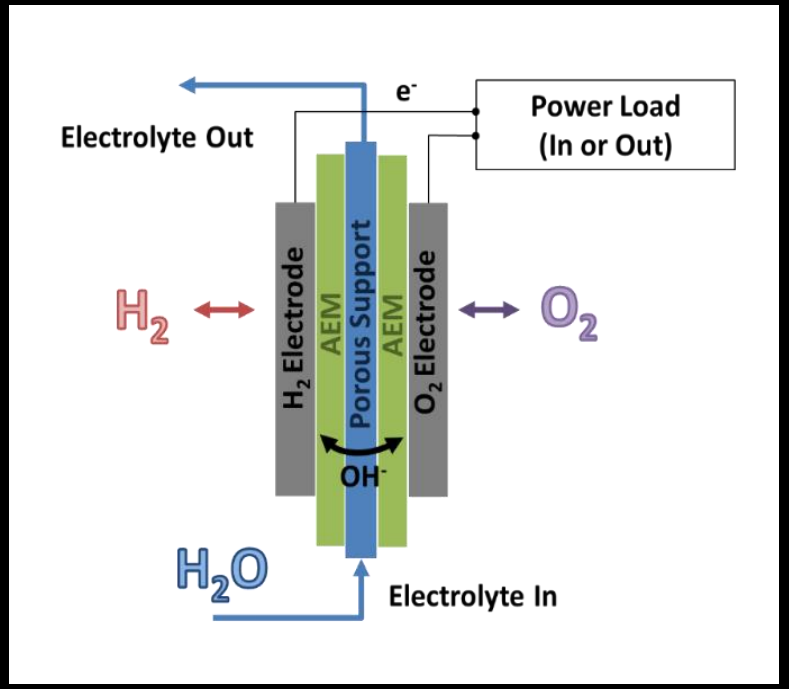
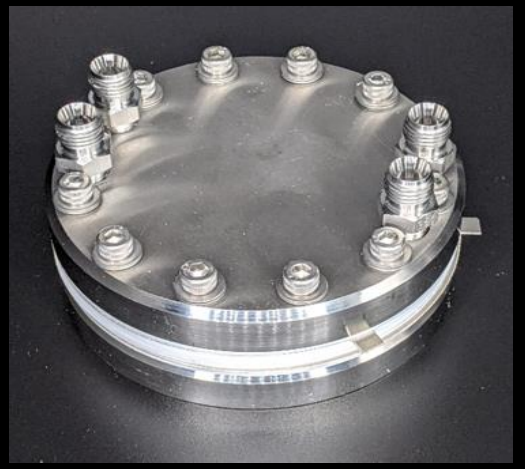


Diagram of cell design



Photograph of test cell