

Large Scale Rapid Response Energy Storage System for Addressing Intermittency in Electric Power Generation and Use

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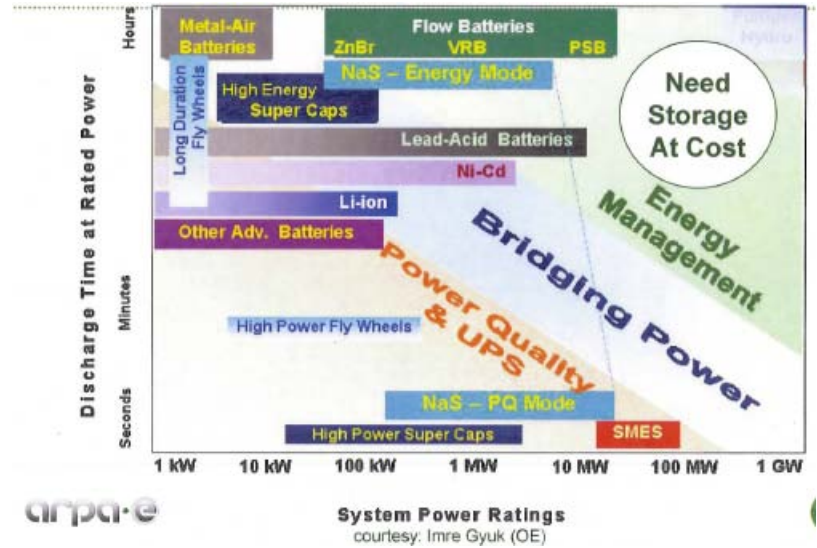
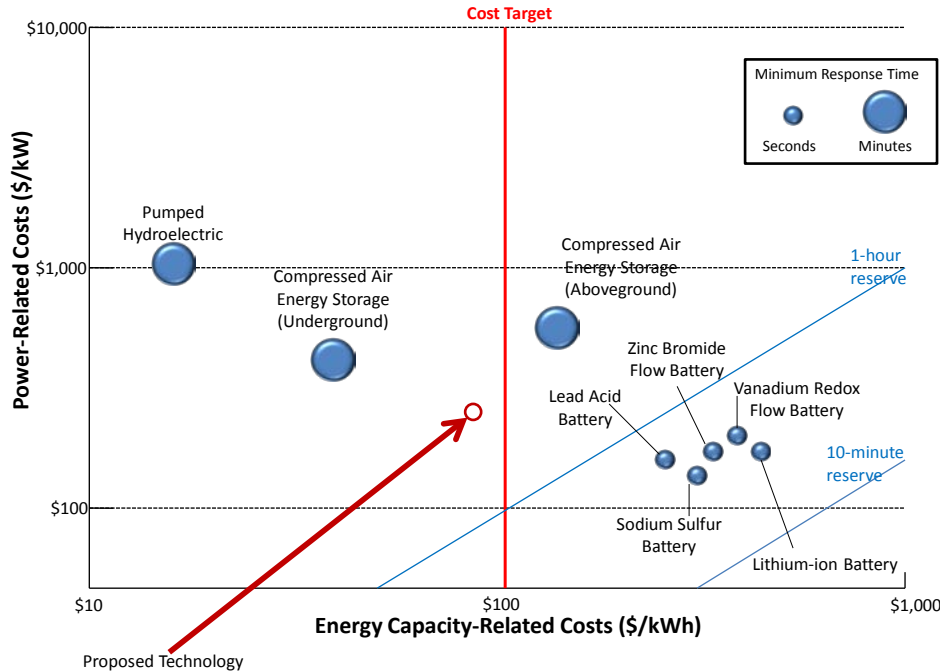
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Ignition Award Presentation (December 14, 2010)

Scale

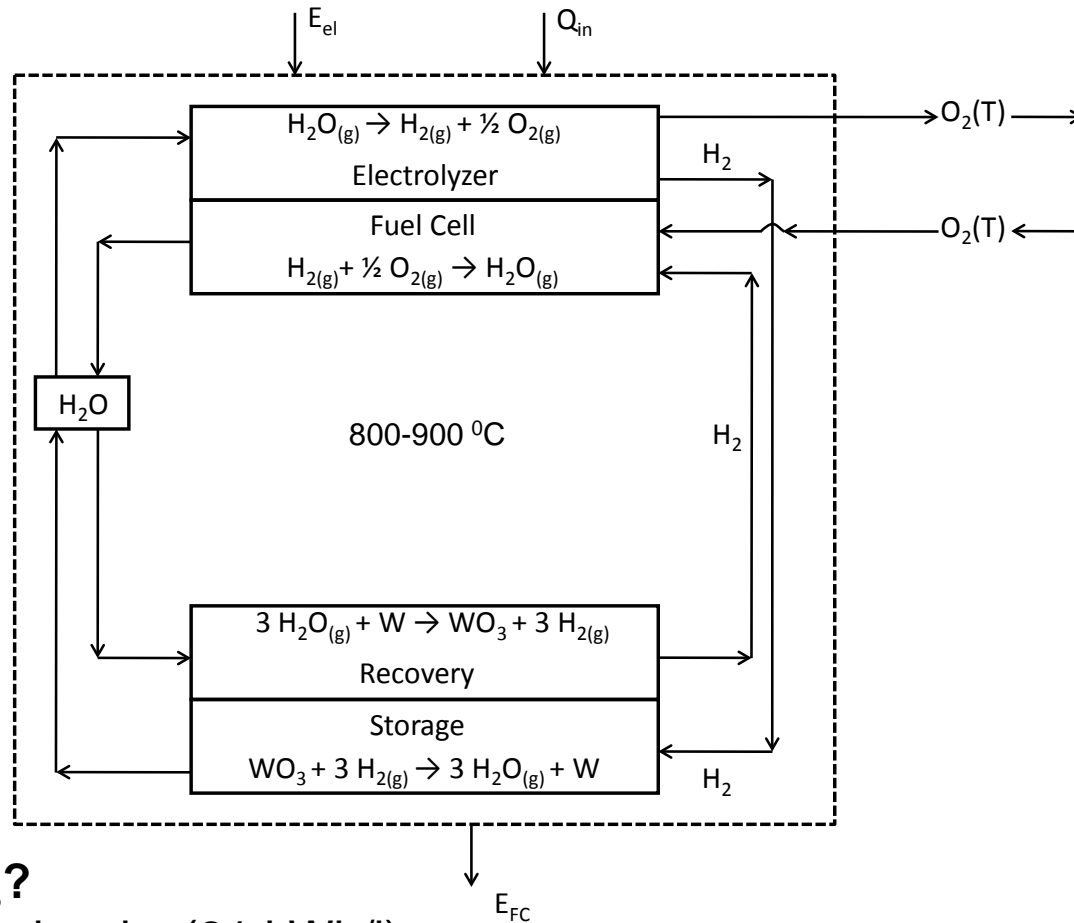
- US Generation Capacity (1,100 GW)
- Existing Storage Capacity (22 GW)-Mostly Pumped Hydro
 - Expand Storage Capacity
 - Penetration of Renewable Energy Generation
 - Peak Demand Shaping
 - Power Quality and Grid/Load Management
 - Time is important
 - 1 cycle to 1 second –frequency
 - 1 second to 1 minute-voltage
 - 1 minute to 10 minutes-power
 - 10 minutes to hours-energy

Technology Landscape (Cost and Need)



Proposed Technology Concept

Cost-effective and innovative rapid response energy storage and recovery system for grid-scale application




Why W/WO₃?

- High energy density (21 kWh/l)
- High conversion efficiency of energy storage and recovery cycles
- Refractory material-provides structural stability at elevated temperatures

Problems and Opportunities

- Large-Scale Energy Storage with response time in minutes to hours range is needed
 - (475 GWh per hour is needed in US for 20% market penetration of renewables)
- Pumped hydro has restricted siting flexibility and high power-based cost
- Batteries have response time in seconds to minutes range and have high energy-based cost



Proposed technology will enable penetration of renewable electricity generation and reduce existing use of fossil fuels for balancing the intermittency of currently used renewables

Value Proposition

- Provide high energy AND high power delivery in the minutes to hour range
- Half the energy capacity-related cost of the state-of-the-art battery systems and half the power-related cost of pumped hydroelectric with siting flexibility
- Expand market opportunities for fuel cells

IP and Technology Status

- Patents
 - Provisional Patent Application filed
 - PCT Application in preparation
- Proof of Concept
 - Preliminary mass and energy balance calculation of the integrated system (reversible SOFC plus energy storage and recovery unit) suggests round trip efficiency of 75% or higher can be obtained
- ARPA-E Finalist
 - Energy storage and recovery concept was evaluated to be novel and worthy of support (reviews available)
 - Invited to participate in the ARPA-E innovation summit (March 2011) to connect with potential sponsors (industries and agencies)

Work Plan

- Demonstrate feasibility of the reversibility of the high-energy density W/WO₃ energy storage and recovery system (0-9 months)
- Model systems-level integration of the W/WO₃ energy storage/recovery system with reversible solid oxide electrochemical cells to determine round-trip efficiency of energy storage and conversion (9-12 months)

Project Cost

Salaries for Graduate Students-12 months \$30,000

Benefits (Student) \$2,225

Supplies and Analysis \$15,000

Other (travel to Washington/federal agencies) \$2,775

TOTAL \$50,000

Future Plan

- Seek federal (DOE, DARPA, NASA) funding (\$4-5 million) for systems-level demonstration by partnering with industries engaged in the commercialization of solid oxide electrochemical cells (eg. Delphi, Bloom Energy, NexTech Materials, Accumetrics, United Technologies, Fuel Cell Energy, Ceramatec, ATK launch system..)-**13 to 36 months**
- Partner with Utilities and companies engaged in renewable energy generation and seek federal and state funding for pilot-scale demonstration of the **technology-37-60 months**
- Ready for market penetration

Team

Inventors

- Prof. Uday Pal
 - 7 years in industry (Allegheny Ludlum and Westinghouse)
 - 20 years in academia
 - Many licenses and industry collaborations
 - Licensed technology is responsible for a New-England based clean technology start-up
- Prof. Srikanth Gopalan
 - 3 years in industry (Siemens Westinghouse)
 - 9 years in academia
 - Several licenses and industry collaborations

Collaborator

Prof. Soumendra Basu (Expert in materials characterization)

- 20 years in academia
- Industry collaborations