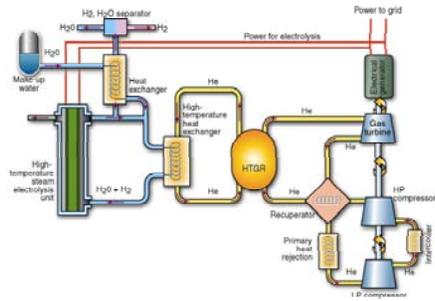


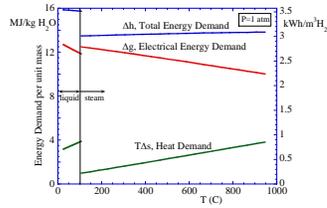
# High Temperature Steam Electrolysis for Hydrogen Production from Nuclear Energy

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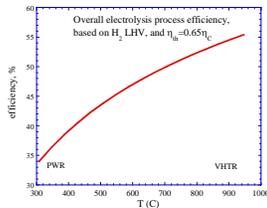
## High Temperature Steam Electrolysis System coupled to an Advanced High-Temperature Nuclear Reactor



In this concept, the reactor supplies both the electrical power and the process heat required for hydrogen production. High temperature operation results in a high thermal efficiency for power production and a reduced power requirement for electrolysis, yielding significantly higher hydrogen production efficiency when compared to low-temperature electrolysis (see figures below).

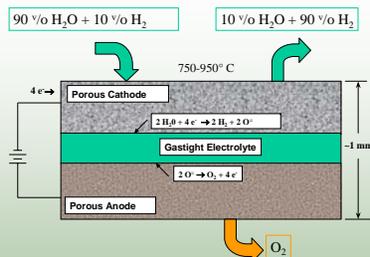


Energy budgets for steam electrolysis are more favorable at high temperature



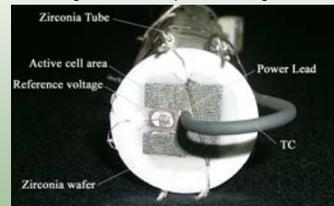
Overall process efficiency is competitive with thermochemical cycles

## Schematic of steam electrolysis cell

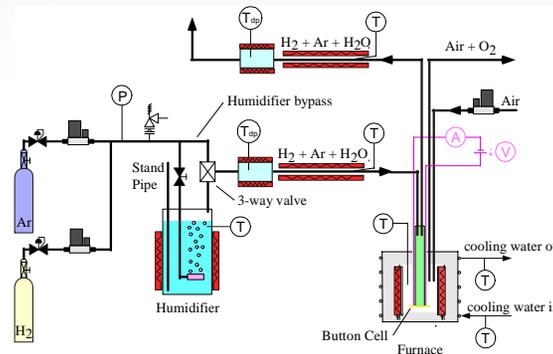


## Ceramtec button cell for single-cell testing:

- Anode: Nickel zirconia cermet (cathode in electrolysis mode)
- Cathode: Strontium-doped lanthanum manganite (anode)
- Electrolyte: YSZ or ScSZ, 175  $\mu\text{m}$  thickness
- Active cell area:  $\sim 2.5 \text{ cm}^2$
- Includes an electrically isolated electrode patch for monitoring of reference open-cell voltage



## Schematic of Single-Cell Test Facility for High Temperature Steam Electrolysis at INEEL



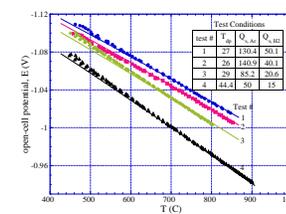
## Experimental hardware for electrolysis testing at INEEL



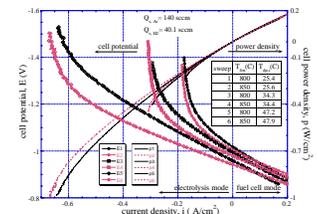
## Research Objectives

- Development of energy-efficient, high-temperature, regenerative, solid-oxide fuel cells (SOFCs) for hydrogen production from steam.
  - Reduce ohmic losses to improve energy efficiency
  - Increase SOFC durability and sealing with regard to thermal cycles
  - Minimize electrolyte thickness
  - Improve material durability in a hydrogen/oxygen/steam environment
  - Develop and test integrated SOFC stacks operating in the electrolysis mode
- Specification and testing of hydrogen-permeation-resistant materials for a high-temperature heat exchanger

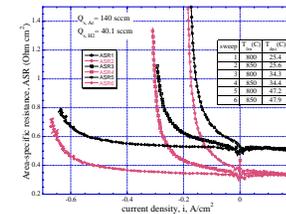
## Results



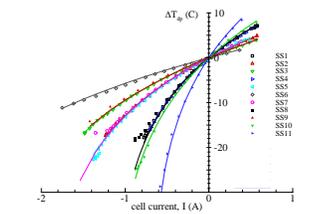
Open-cell potential variation with temperature, measured and predicted



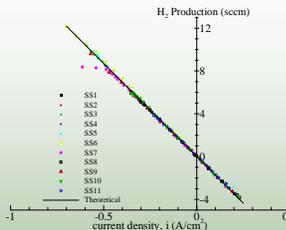
Cell operating potential and power density as a function of current density



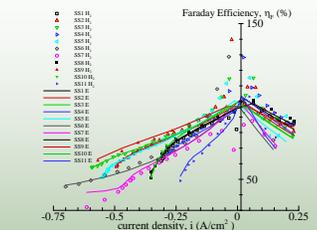
Area-specific resistance versus current density, showing the effects of steam starvation



Dewpoint change versus current density, measured and predicted



Hydrogen production rate as a function of current density, measured and predicted



Faraday efficiency variation with current density

