An Energy-Efficiency Workshop and Exposition
Orlando, Florida

Regenerative Fuel Cell Storage for Alternative Energy Power Sources

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Energy Security & Distributed Generation
Update on Emerging Technologies
Wednesday, Session 7 10:30 to 11:30 AM

- U.S. Navy Renewable Energy Division, Naval Air Weapons Station, China Lake, CA.
- Applying renewable energy resources to Navy shore facilities.

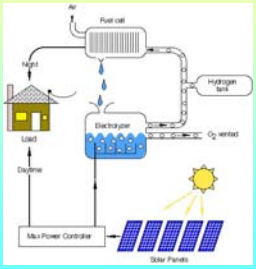
- Navy needs power in remote locations

Batteries for energy storage

- Pro: Cheap
  Recyclable
  Available
- Con: Acid in air and on floor
  ½ life per 15 deg F
  Fires
  Maintenance safety
  95% of recurring cost

Proposed Solution

- Use solar power to produce hydrogen from water.
- Energy stored as hydrogen.
- Fuel cell produces energy at night.
- Water from fuel cell returned to electrolyzer.

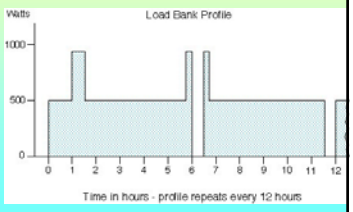


- Navy provided the 10 kW solar array

Regenerative Fuel Cell Storage for Alternative Energy Power Sources

•Navy provided the test load

- Time varying profile chosen to challenge known fuel cell weaknesses
- Automatic profile or manual operation



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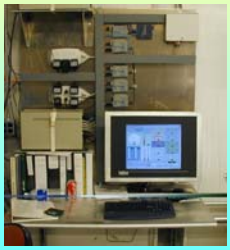
•Navy provided the data logging and display

- Windows based
- National Instruments Labview programming language
- One minute records
- One second records triggered by unusual events



Regenerative Fuel Cell Storage for Alternative Energy Power Sources

•Proton Energy Systems created the Unigen

Regenerative Fuel Cell Storage for Alternative Energy Power Sources

•HOGEN® RE electrolyzer
40 SCF of H_2/hour

•Nexa™ fuel cells (2)
1200 Watts peak each

•Trace™ PV inverter
1.5 kW at 120VAC

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•200 Liter water tank

- Size of a 55 gallon barrel

•Electrolyzer draws from it

- Continuous water circulation for cooling
- Return water carries O_2 into tank
- Tank vented outside of enclosure
- Only top ¼ usable to restrict gas void area

•Tank in enclosure for thermal mass

- Will be important in winter months.

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Hydrogen tank

•6565 gallon steel tank

- 7 foot diameter, 27 feet long
- 200 PSI Working pressure

•Shade structure

- Limits heat extremes
- Holds additional solar panels

•2000 PSI tank in the future

- For reducing space requirements

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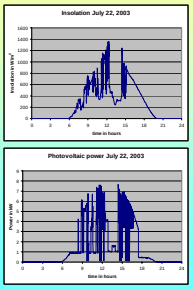
Operation

- Solar resource is large
  - 1300 Watts/meter^2 (peak)
- Ultra capacitor absorbs dropouts
  - No batteries in the unit
- Cloud cover robs significant energy
  - Minumum power level of electrolyzer stretches short cloud dips to 5 minutes.



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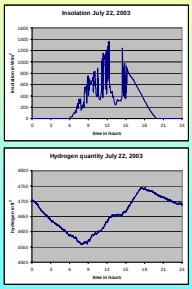
Operation

- Hydrogen production as expected
  - 30% efficient
  - Required initial hydrogen fill
  - Can be self-sustaining if matched to local solar resources
- Significant energy losses
  - Minimum power level of electrolyzer stretches short cloud dips to 5 minutes.
  - MPT derating directly affects H_2 loss



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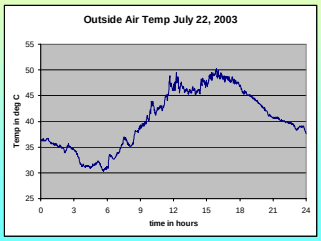
Observations

- Temperature is a big factor
  - Max power tracker derates its output to protect itself.
  - Poor air flow design
- Hydrogen safety adds heat
  - Vent fans keep interior within 4 deg of OAT.
  - Electronics run at outside temp



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Problems

- Hydrogen tank
  - Pressure tested with Nitrogen, leaks with Hydrogen
  - Determining quantity is difficult with one temperature probe.
- No problems with permits
  - Trained the Fire Marshall before installing the system.

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Problems

- Data Logging
  Typical unexplained crashes from Windows™.
- PV panels under-performed
  Brand new panels rated at 75 Watts delivered ~ 66 Watts
- Lengthy process of defining parameters in 3 interacting controllers
  - MPT, electrolyzer, system controller

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Status

- Concept works
- Ability to challenge battery systems not yet clear.
- Reliability acceptable for this phase of the project.
- Complexity of concept will require sturdy components to match the reliability of batteries.

Future plans

- Fix the problems.
  - More heat tolerant
  - Reliable controls
- Run the system for a year.
- Install in a remote location, evaluate its performance.
- Increase power to 5 kW building blocks.
- Wait for scientists to catch up to the engineers.

  Future of efforts like these directly tied to a longer fuel cell life.