High-Pressure Electrolysis for Clean, Renewable Hydrogen Transportation Fueling Systems

Avälence Hydrofiller Electrolyzer

Avalence Presentation to the Granite State Clean Cities Coalition April 3, 2009
Spinout in 2002 From Two CT Industrial Gas Equipment Manufacturing Firms

ELECTRIC HEATING EQUIPMENT CO.
70 Years In Low Pressure H2 Electrolyzers

GAS EQUIPMENT ENGINEERING CORPORATION
40 Years In Oxygen Generators To The Navy Fleet

The Companies Synergistically Share Facilities and Resources

➢ ~$3 M Cumulative Revenues Through 2008
➢ Projecting >$2 ½ M in Revenues for 2009
How it Works – Cell Level Electrolysis

Electrolyzer cell diagram

Cathode: $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$
Anode: $4OH^- \rightarrow O_2 + 4e^- + 2H_2O$
Overall: $2H_2O \rightarrow 2H_2 + O_2$

Gas Rises Through “Flooded” Cells to Gas Liquid Separating Chambers
Avalence Technology Description

- **Avalence Produces Ultra-High Pressure Hydrogen Directly in the Electrolysis Cells**
  - Globally Unique Product
  - Eliminates Costly Pre-Compressor Chillers and Dryers
  - Eliminates or Minimizes Mechanical Compression Requirement

- **Links Directly to Renewable Power Sources**
  - Can Blend in Available PV
  - Able To Operate Totally Off-Grid
  - Can Use Grid as Prime or Back-Up Power

- **Targeting Four Applications/Markets**
  - Back-Up Power (Remote, Extended, Mission-Critical)
  - Hydrogen Fueling for Transportation (Cars, Busses, Fork Lifts, etc)
  - On-Site Industrial Gas Supply (Renewable, H2 and O2)
  - Renewable Energy Storage (Peak Shaving, Guaranteed Dispatch)
# Competitive Potential Of H2 Alternatives

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<td>Low Pressure Electrolysis</td>
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Avålence Competitive Advantage Is Maximized In Local, Renewably Linked Applications Favoring High Pressure
Distributed Scale Systems
“Commercial Ready”

- 1 - 10 kg/day
- Units in All Application Areas
- 3 Vehicle Fuelers in Field
- 3 Fuelers in Construction

Large Scale System
in Development

- 300 kg/day Large
*Hydrofiller* in Development
- to Demonstrate in 2010
- Funded under $1.9M DOE
Competitive Grant Award

2003 Prototype Unit with
> 15,000 hrs Operation
Production, Storage and Fuel Cell

*Hydrogen Energy Systems*

Technology Status
Simple Fueling Station at University of Toledo

Used for Fueling Fuel Cell Research Vehicles

Storage Tank Not “To Code”
Grid Independent Hydrofiller 50
Integrated Fueling Station

- Dual Power Inputs (~7 kW)
  - 220 V AC Grid
  - 30 – 60 V DC PV
- 6 kg Storage and Dispenser Included
- Rechargeable Battery with Five Days System Control Power
Unit Testing at GM Proving Grounds, Milford, MI

- “Prototype” for a Home Fueling System
- In Proof Testing Prior to Use in Public Fueling Demonstrations
Hydrofiller 50 Typical PV Performance

- **11:00 am – System Start-Up**
  - 60 Volts
  - 2.7 kg/day
  - 16°C Cell temp

- **1:30 pm - Peak H₂ Production Rate**
  - 54 Volts
  - 3.5 kg/day
  - 55°C Cell Temp

- **5:20 – H₂ Production Ceases**
  - 30 Volts
Basic Station Specifications:

- **Production Capacity (at 2500 psi):**
  - Initially 10 kg/day
  - Expandable in 10 kg/day increments

- **Dispensing Capacity (at 5000 or 10,000 psi):**
  - Three 5 kg “Full” Sequential Fills
  - Two Additional Partial Fills in a single day
  - 10 kg/day average use

- **Input Power (Rated at 25kW):**
  - 12 to 48 Volt DC nominal PV
  - 480V or 240 V, 3 Phase AC

- **Water Use**
  - 25 gpd
  - Tap or Equivalent

System Cost is $750 to $900K (Includes Assistance With Installation, Training, Permitting, 1 year Maintenance)
Small Scale PV-Electrolyzer Integration

1 kg/day Capacity

Powered by PV Array and/or Grid Power

20 to 30 % PV Supplied Renewable Hydrogen During Full Capacity 24 hr Operation
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Prototype Unit With > 10,000 hrs of Operation

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