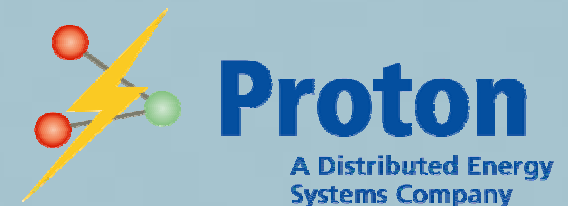




UNIGEN[®] Regenerative Fuel Cell For Uninterruptible Power Supply

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This presentation does not contain any proprietary or confidential information



Objectives

- **Demonstrate Hydrogen Fuel Cell Based Uninterruptible Power Supply**
 - Economic Viability
 - Real World Applications
 - Regulatory Code Compliance
- **Performance Goals**
 - Power Output 3+kW
 - Storage Capacity of 50 Hours
 - Instantaneous Operation Upon Grid Failure
 - Maintain Digital Equipment

Budget

- **Department of Energy / State Energy Program**
- **Total Budget for Program \$1,671,040**
 - DOE Cost Share \$400,000
 - Proton Share \$1,271,040

Technical Barriers and Targets

- **Technology Validation**
 - **I. Hydrogen and Electricity Co-production**
- **Education**
 - **B. Lack of Demonstrations or Examples of Real World Use**
- **Hydrogen Codes and Standards**
 - **O. Insurance Companies Recognize Current Standards**

Approach

- **Fabricate UNIGEN[®] RFC UPS Using Modular Components Allowing Flexibility in Power Output, Run Time, and Recharge Time**
- **Demonstrate Technology Performing Useful Work in a High Visibility Location With Access to Decision Makers**
- **Obtain Permits for Siting and Operation of the UNIGEN[®] RFC UPS Unit Through Co-authoring of New Code With Local Authority**

Safety

- **Focus on Limiting Release of Hydrogen and Avoiding Combustible Atmosphere**
 - Components Rated for Hydrogen Use and Environment
 - Dilution of H₂ Release by Mixing and Ventilation
 - Limit Flow of Hydrogen From Storage Into Building
 - Independent Hardwired Safety Chain
- **HAZOP and FMEA Analysis Performed at Module and System Level**
 - Results Drove Design of Safety System and Built-In-Test
- **Design of Each Module Type Based on Best-fit Standards As No Specific Standard Exists**
 - Fuel Cell Module Per CSA 3.01-US
 - Electrolyzer Modules Per NFPA 496
 - Hydrogen Storage Module Per NFPA 50A

Timeline

10/02 – 4/04

Development

5/03 – 2/04

Build and Test

3/04 – 9/04

Demonstration

- **Kickoff in October 2002**
- **Development**
 - Modular Architecture
 - Multiple Fuel Cells
 - Power Transfer
- **Build and Test**
 - Fabricate Unit and Validate Design
- **Demonstration**
 - Install Unit
 - Performance Testing / Live Demonstrations
- **Program Ends September 2004**

Accomplishments/Progress

- **Completed Build of UNIGEN[®] RFC UPS**
 - **Completed Design and Analysis**
 - **Build and Acceptance Test of Modules**
 - **Integrated Modules and Performed System Validation Testing**
- **Achieved Modular Architecture**
 - **Hydrogen Generation, Storage, and Fuel Cell Power Generating Functions in Separate Modules**
 - **Semi-autonomous Operation of Modules**
 - Determines Operating State Based on Conditions
 - Determines Own Health and Reports Status
 - Independent Shutdown in Presence of Fault
 - **Common Control Hardware and Software in Each Module**

UNIGEN[®] Regenerative Fuel Cell System

- **4 Power Generating Modules**
 - Ballard NEXA PEM Fuel Cell-based 1.2 kW
- **Low Pressure Hydrogen Generating Module**
 - PEM, 250 psi, 10 scf/hr
- **High Pressure Hydrogen Generating Module**
 - PEM, 2000 psi, 0.2 scf/hr
- **Interface Module (IM)**
 - User Interface
- **Inverter and Related Power Switching Components**



UNIGEN[®] Regenerative Fuel Cell System

- **Hydrogen Storage Module**
 - **Outdoor Unit**
 - **12 Groups of 3 DOT 3AA 2400 Steel Tanks**
 - **150 kWhr Hydrogen Storage (8400 SCF)**
 - **Integrated Control System**
 - **Self-Health Safety Monitor**



Accomplishments/Progress

- **Installed UNIGEN[®] RFC UPS at Mohegan Energy, Environment, Economics Education Center**
 - **Exposure to Decision Makers in Public Policy, Energy, and Pollution Prevention Fields**
 - Mohegan Sun Resort Is Site for Several Government, Industry, and State Agency Conferences Every Year
 - Tours of the On-going Technology Demonstrations
 - **Mohegan Tribe Recognized as Leading the Way in the Use of Environmentally Friendly Technologies**
 - UNIGEN- RFC UPS is the First Demonstration of Hydrogen Generation and Storage on Reservation
 - **System Provides the Centers Fuel Cell Room Safety System With Uninterruptible Power**
 - Safety Systems Required to be On-line for Operation of Centers Twin 200 kW PC-25 Fuel Cells

Installation

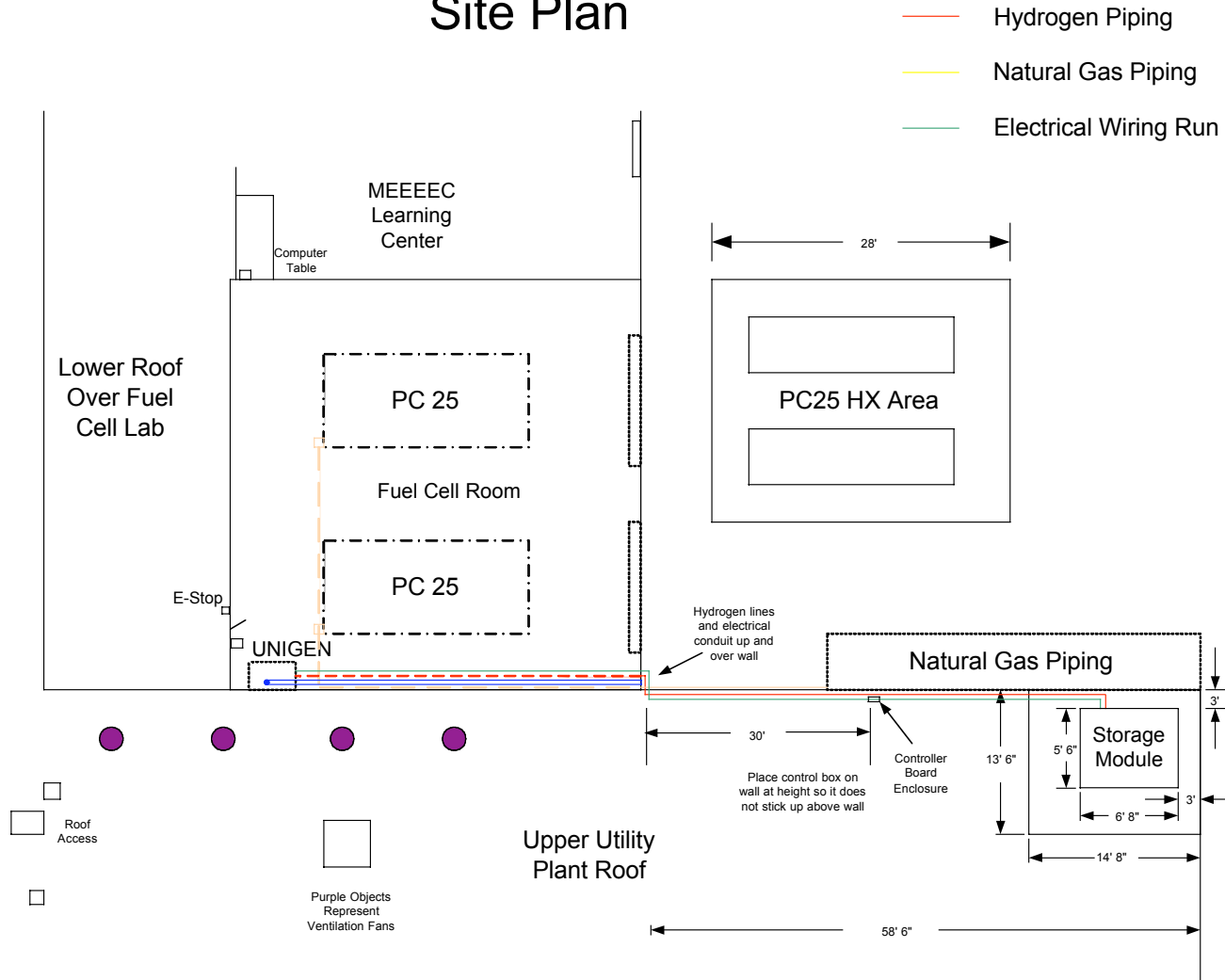


Accomplishments/Progress

- **Completed Siting / Applicable Codes Negotiations With Mohegan Public Safety Office**
 - The Mohegan Tribe Has Its Own Government Including Building, Fire, and Environmental Regulation & Enforcement
 - Main Issue Was Hydrogen Storage Cylinder Types Allowed Per NFPA 50A
 - Use of Steel Tanks Alleviated Concerns
- **Installation Plans Completed**
 - Site Plan for Installation Accepted
 - Permit Application Accepted by Building Department

Accomplishments/Progress

Site Plan



Interactions and Collaborations

- **Connecticut Office of Policy & Management, State Energy Office**
 - Local Funding Administration
- **Connecticut Clean Energy Fund**
 - Control Architecture Development Funding
- **The Mohegan Tribe**
 - Host Site Owners



Future Work

- **Commission Unit for Operation**
 - Inspections by Mohegan Building Department
 - Review Meeting With Mohegan Public Safety Officials
- **Monitor and Test System Performance**
 - Connected to Actual Load
 - Extensive Data Logging
- **Live Demonstrations of System As Part of Fuel Cell Center Tours**
 - Simulated Power Outages