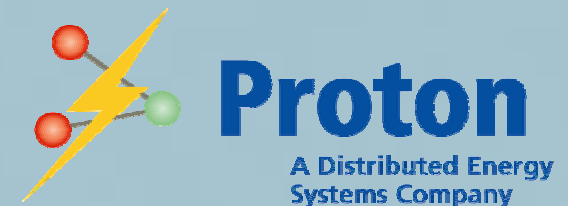




# **UNIGEN<sup>®</sup> Regenerative Fuel Cell For Uninterruptible Power Supply**

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**Proton Energy Systems**  
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This presentation does not contain any proprietary or confidential information



# Objectives

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- **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

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- **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**

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- **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**

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- **Fabricate UNIGEN<sup>®</sup> 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<sup>®</sup> RFC UPS Unit Through Co-authoring of New Code With Local Authority**

# Safety

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- **Focus on Limiting Release of Hydrogen and Avoiding Combustible Atmosphere**
  - Components Rated for Hydrogen Use and Environment
  - Dilution of H<sub>2</sub> 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

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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**

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- **Completed Build of UNIGEN<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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



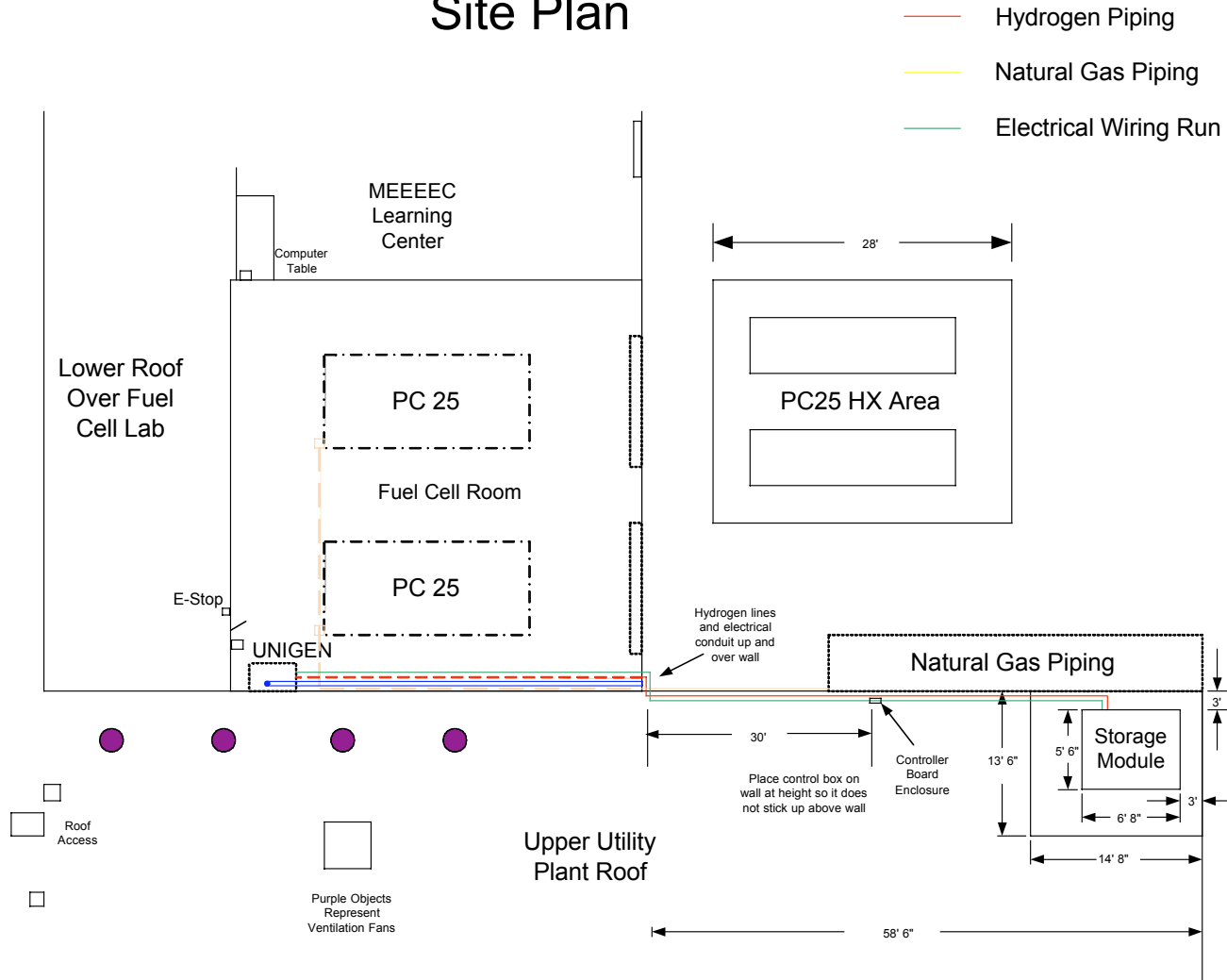
# **Accomplishments/Progress**

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- **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

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- **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