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**Poster**

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## 2004 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Review

**May 24 - 27, 2004**

# NextEnergy Microgrid and Hydrogen Fueling Facility

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**NextEnergy**

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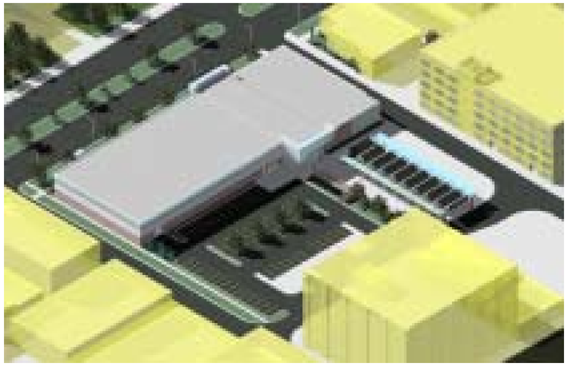
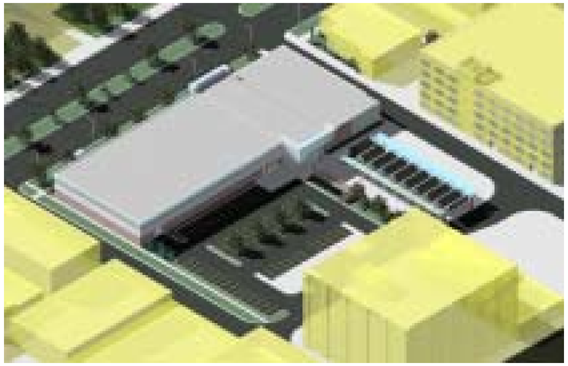
# Objectives - 0



- To support the DOE "Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project" in the Detroit area
- To collect and analyze data with existing codes and standards and establish a "Best Practices" training and educational program

# Objectives - I



- To integrate, within a core urban environment, critical hydrogen infrastructure components and systems for multi-use operations
- To optimize SYSTEM solutions/integration to advance the hydrogen infrastructure for vehicular and stationary use

# Objectives - II

- To provide hydrogen to vehicles at 3,600 psig and 5,000 psig (for demos in the Detroit area)
- To study the system interactions/integration for power generation (~ 1 MW) in a Microgrid with fuel cells, ICE generators, Stirling engines, and solar PV

# Blueprint: Plan Layout for Power Generation Systems (Hydrogen and Natural Gas) in the Microgrid

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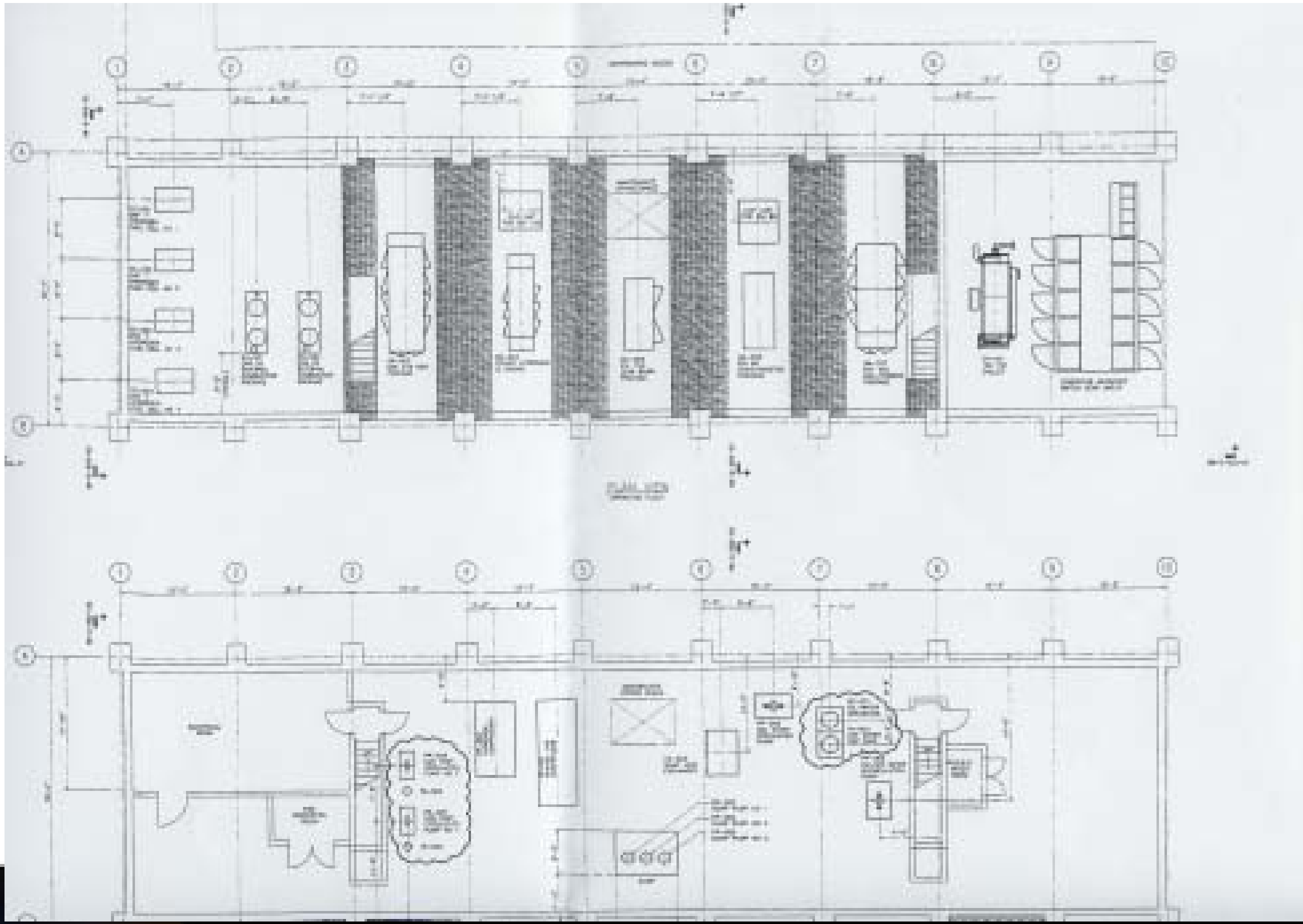
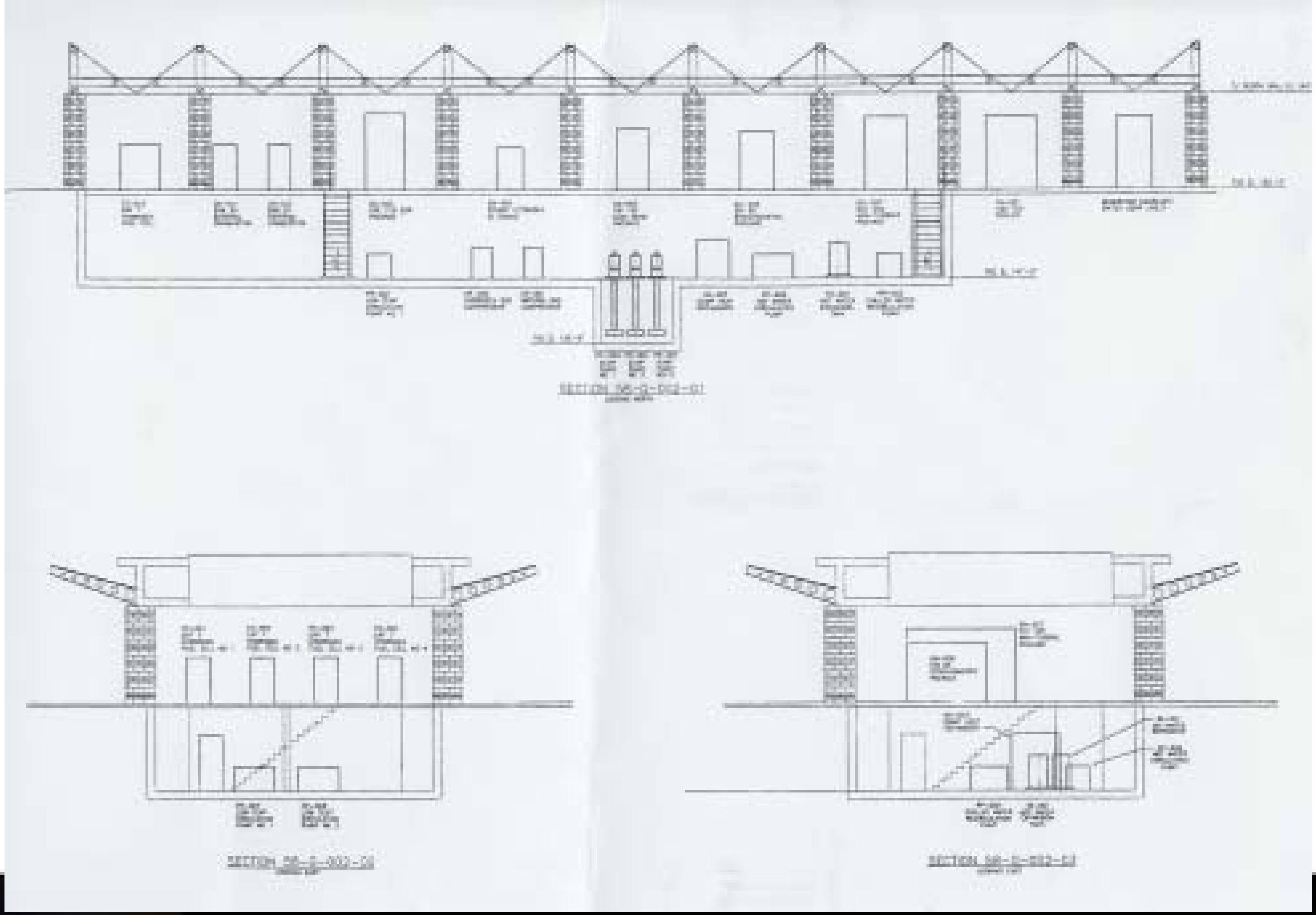
*(Note: in the actual poster session, the blueprints will be larger in size)*



# Blueprint: Vertical View of the Microgrid Power Sources (Hydrogen and Natural Gas)

*(Note: in the actual poster session, the blueprints will be larger in size)*



# *Microgrid Components*

| | |
|---|---|
| 4-Plug Power Fuel Cells (H2) | 20 kW |
| 2-STM Stirling (H2 & NG) | 104 kW |
| 1-Menag EGR IC engine | 210 kW |
| 1-DTE Turbine | 355 kW |
| 2-DTE IC Engine (iPower) | 225 kW |
| 1-Ford/Stuart H2 IC engine | 120 kW |
| PV Array (Unisolar) | 30 kW |
| Total | **1064 kW** |
| Thermal recovery systems (Heating/Chilling) | |
| Underground electrical | |
| Underground thermal | |
| Flex. foundation/interconnects | |

# Budget

- Total NextEnergy Center Project (powered by Hydrogen, Natural Gas, Other Fuels): $ 22.0 million

THIS PROGRAM ONLY:

- NextEnergy Microgrid and Hydrogen Fueling Facility: $ 4.54 million
  - NextEnergy share: $ 2.54 million
  - DOE share: $ 2.00 million

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# SITE DRAWING

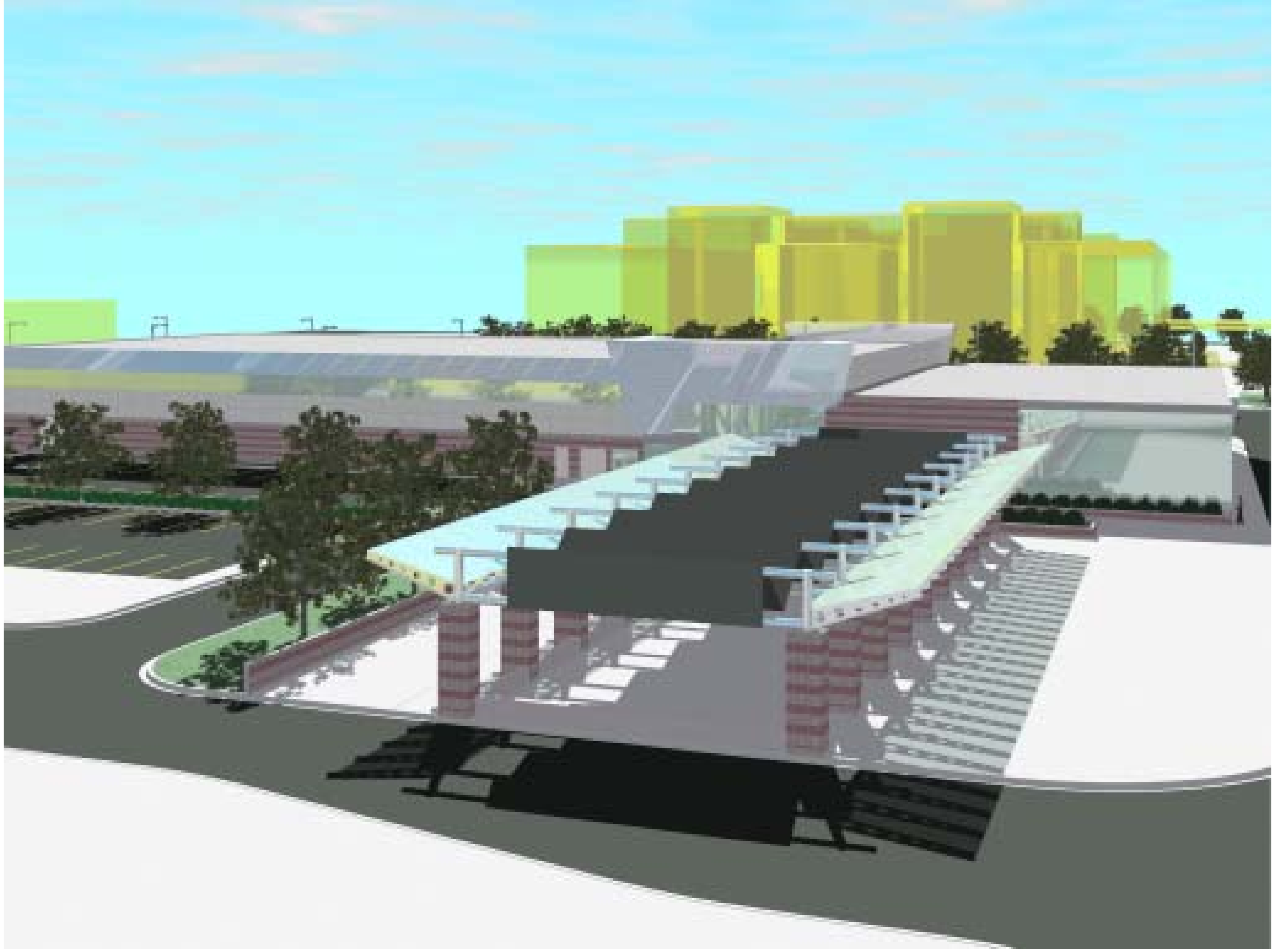
# Technical Barriers & Targets - I

- Construction Design:
  - Safety: NO above ground hydrogen / gas piping (requiring innovative construction of “feed” basement -- Class 1, Div 2, Group B classification)
  - Safety: Underground protection for hydrogen conduits (Note: NO existing codes for buried hydrogen lines!)
  - Modular “plug and play” easy interchange of power generators (requiring flexible foundation “feed” interconnections from below)

# Technical Barriers & Targets - II

- Operations and Control:
  - Study system stability and system economics from diversity of power sources and fuel feeds
  - Provide for automatic and remote shut-offs and shutdowns (pressure sensors and in-duct hydrogen and gas sensors, and flame detectors)
- Power Pavilion:
  - Ensure all power sources are weather-proofed with in-enclosure sensors

# POWER PAVILION



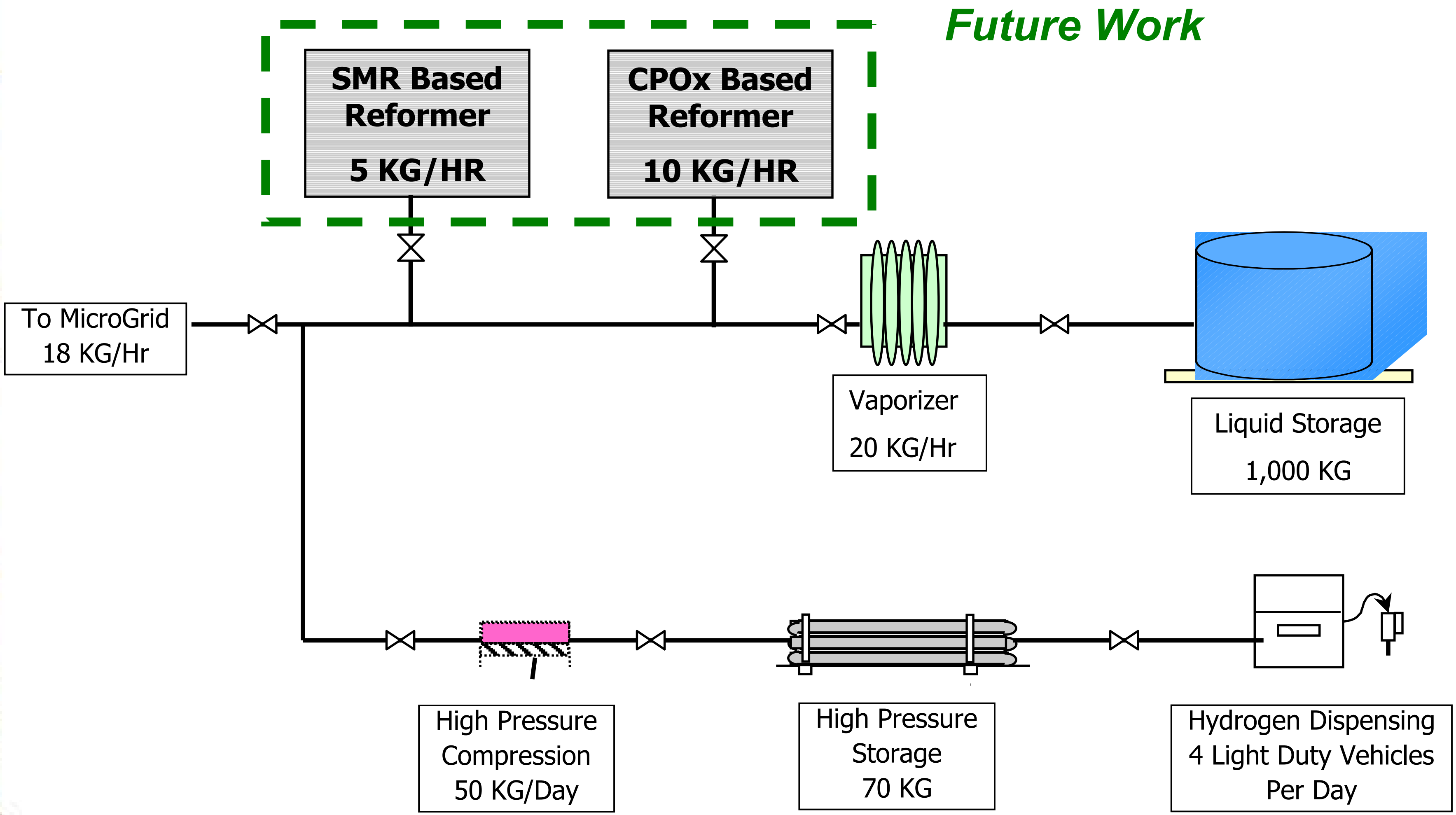
# Approach: Leverage the Microgrid Infrastructure to Evaluate System Integration Challenges - I

- Determine the overall economics of hydrogen use for power generation in different power technologies; compare the economics for hydrogen as fuel in vehicular applications
- Compare the hydrogen data with data with other fuel feeds: natural gas, bio-fuels, etc. (within the context of power generation in a microgrid)

# Approach: Leverage the Microgrid Infrastructure to Evaluate System Integration Challenges - II

- Exploit microgrid data to develop high security/reliability power system applications
  – Applications development (e.g. Military, Homeland Sec.)
  – Equipment testing and verification (DG/CHP, ride-through, control/interface gear)
- Utilize hydrogen fueling system for the development of small scale on-site H2 production technologies
- Leverage laboratory to facilitate system integration/ packaging

# Hydrogen Supply System



# Project Safety - I

- Design & Construction:
  - Innovations in below-ground hydrogen lines (follow natural gas line protocols; develop flexible foundation "feed" inter-connects)
  - Classification of "feed" basement as Class 1, Div. 2, Group B (except for non-classified areas for inverters and other electrical switchgear and Class 1, Div. 1 for the sump pump pit)

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# Project Safety - II

- Operations & Controls:
  - Low pressure sensors for automatic shut-downs and in-duct hydrogen and gas sensors and flame detectors
  - Provision for remote and automatic shut-downs
  - Extensive grounding provisions
- Co-ordination with Praxair and with Michigan Dept. of Environmental Quality for liquid hydrogen storage and refueling

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# Project Timeline

| | System Design | Start Final Design | Equipment Ordered | Equipment Delivered | Env Permit Obtained | Begin Construction | System Commission-ing |
|---|---|---|---|---|---|---|---|
| **NextEnergy Center** | ✔ | ✔ | 05/04 | on-going | N/A | 04/04 | 04/05 |
| **Microgrid** | ✔ | ✔ | ✔ | 08/04 | 02/04 | 05/04 | 04/05 |
| **Hydrogen Systems** | ✔ | 05/04 | 06/04 | 08/04 | 04/04 | 07/04 | 04/05 |

# Technical Progress

- System Designs for NextEnergy Center -- all completed
- Various Power Sources for Microgrid -- specified and ordered
- Final Designs for Center and Microgrid -- accepted (Hydrogen system design to be accepted in May)
- Environmental permits obtained

# Interactions & Collaborations

- DTE Technology: Microgrid Design
- Plug Power: 5 kW PEM Fuel Cells (stacks only)
- STM: 55 kW Stirlings ($H_2$ and natural gas fed)
- iPower: 85 kW units (based on GM engine)
- Stuart Energy: 120 kW Ford $H_2$ ICE
- Praxair: Liquid Hydrogen and Fueling Station
- Univ of Michigan: Analysis / computations of emissions and efficiencies based on the microgrid components for power generation

# Power Generators in the NextEnergy Microgrid


*Plug Power 5 kWPEMFC (stack portion only; no reformers; no inverter section)*

*400 kW WaltherTurbine*

# Power Generators in the NextEnergy Microgrid

*STM Stirlings in outdoor enclosure*

*85 kW iPower ICE*

# Future Work - I

- Develop the Codes and Standards "Best Practices" database and conduct the annual workshop in cooperation with DOE
- Complete and Issue the Teaching Modules and Educational Resources for the "Hydrogen Education Teaching Module"

# Future Work - II

- Incorporate reformers into hydrogen supply (steam-methane reforming, CPOx – based reformer):
  - Post-treatment processes for purity requirements
- Explore bio-fuel feeds into Stirling engines (new hot-end designs needed)
- Develop innovations in energy storage, load-management to improve microgrid stability and reliability