# NYSERDA Fuel Cell Product Development

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# CHP Demo vs. Development

- CHP – Demo
  - End user contractors
  - Commercial products
  - Long term  Demos.
  - Goals:
    - Megawatts
    - Best practice
    - Mitigate early adaptor risk
    - Establish economic benefits
- Product Development
  - Contractors are manufacturers
  - Pre-commercial technology
  - Field test/Demos.
  - Goals:
    - Technology advancement
    - Commercial product development

# Power Systems Program Objectives

- Technology Advancement
  - Improve energy & environmental performance of power systems
- Product Development
  - Create economic benefits for the state: jobs, reduced energy costs, etc.
- Overcome non-technical barriers to adoption
  - Document performance/benefits for policy decisions

# Power Systems Program
# $4 MM SBC + $1 MM Statutory

| Solicitation | Response (Proposals) | Projects (Awards) |
|---|---|---|
| PON 536 (May 2001) | 33 | 17 |
| PON 669 (March 2002) | 34 | 11 |
| PON 750 (April 2003) | 49 | 16 |

# Power Systems Program Portfolio

| Project Category | Number of Projects |
|---|---|
| Fuel Cell Technology | 14 |
| Turbine/Other Generation Tech. | 15 |
| Reliability | 6 |
| Environmental Performance | 4 |
| Barriers and Policy | 4 |

# NYSERDA Fuel Cell History

- $3M investment in fuel cell development from 1992-97
- +$7.5M  investment since 1998
- Over 90 field test/demos
- Currently Supporting six New York State companies  PEM & SOFC technologies

# Fuel Cell Project Types

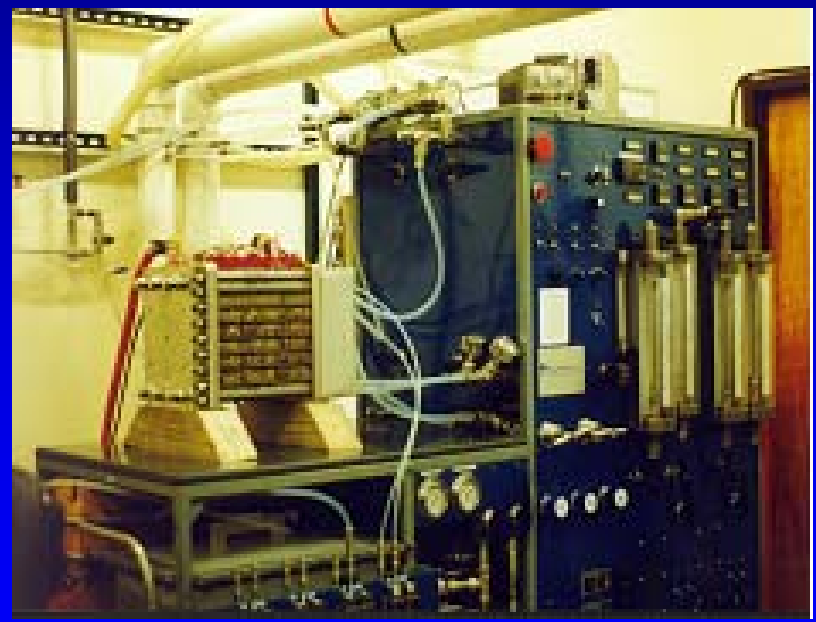
- PEM technology (8 projects, $5.2M)
  - Integrated Product Development
    - High temp. stack / CHP products
    - Telecom product
  - Subsystems
    - Fuel processor (propane); Inverters / Power Conditioning
  - Field tests
- SOFC (4 projects, $1.2M)
  - Materials
  - Components/Subsystems
- Direct methanol (2 projects, $700k)
  - systems

# PEM Fuel Cell Field Test/Demonstration

- 3 Phase project to build, test, evaluate and demonstrate Plug Power 7 kW fuel cells
- $6M project ($3M funding provided by through New York State Clean Air Clean Water Bond Act of 1997 matched by equal funding by Plug Power)
- Deploy units at publicly-owned and accessible facilities across the state
- Verify the clean, environmentally friendly nature of PEM fuel cells and garner public support for their early introduction
- Accelerate wide scale commercialization

# 80 Unit PEM Fuel Cell Demonstration

- Phase 1 - Laboratory evaluation of 24 pre-production prototypes 5/99-3/00
  - Build an experience database for failure mode effects analysis under simulated field conditions
  - Establish operating strategies for selected applications
  - Understand & integrate sub-system modules



# 80 Unit PEM Fuel Cell Demonstration

- Phase 2 - Initial field evaluation of 6 pre-production prototype units (3/00-7/00)
  - incorporate knowledge gained from phase I, to improve performance and/or reduce cost
  - identify initial field installation/operation issues
  - Maintenance schedules developed
  - Validation of field service procedures

# 80 Unit PEM Fuel Cell Demonstration

- Phase 3 - Demonstration of 50 Test & Evaluation Units (8/00-12/01)
  - Incorporate information gained and design changes from Phases 1 & 2
  - First factory assembled systems
  - First self-enclosed units
  - Intended to achieve essentially unattended operation
  - Measure performance and emissions

# What Did We Learn? – Phase I

## Product Development

- Average Operating Time: 453 hrs
- Integration of Fuel Processor, Power Module, and Inverter Proved a Significant Challenge
- Full Integration Required Redesign of Some Module Components
- Control Scheme Required Computer Control

## Operations

- Commissioned and Validated Manufacturing Facility
- Trained Workforce
- Developed Failure Reporting and Corrective Action System (FRACAS)
- Initiated Engineering Change Discipline

# What Did We Learn? – Phase II

## Product Development

- Average Operating Time: 844 hrs between 2 and 7 kWe
- Successful Sub-system Integration
- Detailed Understanding of what it takes to Operate in the Field
- Clearly Defined the Delta Between Where We Were and Where Our Final Target Product Specifications Needed to Be

**NYSERDA SPECIFICATIONS**

| Parameter | Value |
|---|---|
| Power: | 1-7 $kW_e$ nominal range |
| AC Voltage: | 120 VAC / 240 VAC, 60 Hz |
| Grid Interface: | Manual operation |
| Operating Temp: | 4 to 40 $^oC$ |
| Fuel Source: | Natural Gas (4 to 12" $H_2O$) |
| Altitude: | Up to 6000 ft |
| Power Quality Steady: | ANSI C84 (+-5%) |
| Power Quality Trans.: | CBEMA curve |
| Harmonics: | IEEE 519, Sec 11, Table 11 |
| Steady State Emissions: | < 400 ppm CO |

## Operations

- Shipping and Deployment Processes and Procedures
- Grid Interconnection with Utilities is a Very Significant Design Consideration
- Began Review and Realignment of Component Manufacturers and Supply Base
- Developed Formal Process for Receiving Product from Manufacturing and Commissioning Systems in the Field

# What Did We Learn? – Phase III

## Product Development

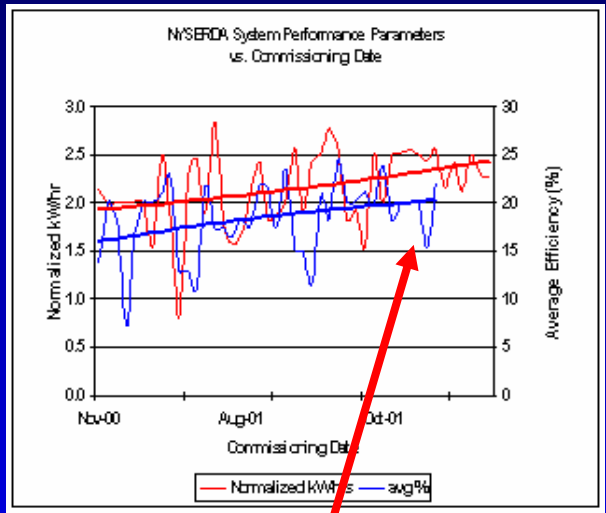
- Average Operating Time: 927 hrs between 2 and 4 kWe at an Average Eff. of ~ 20% Exposed to the Elements
- First Factory Assembled Systems Integrating Fuel Processor, Power Module and Inverter on Single Skid; “Design Lock”
- UL Listed, CSA Certified, Easily Grid Interconnectable

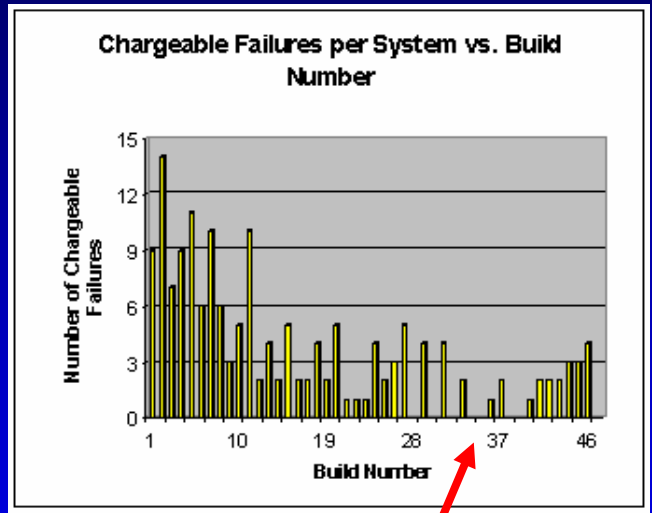
## Operations

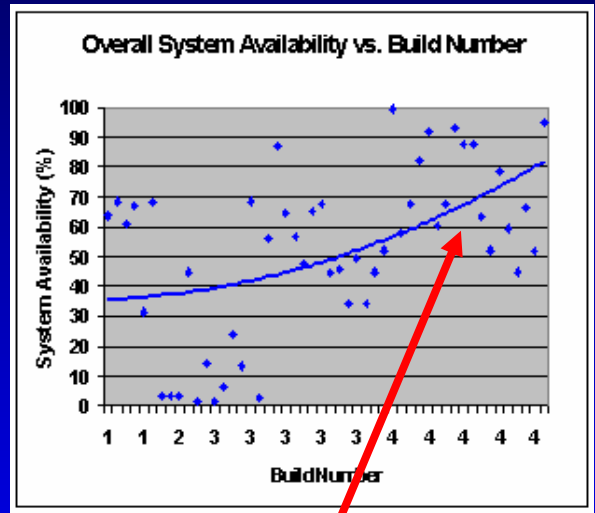
- Over 90% Reduction in Manufacturing Defects
- Reduction in Factory Certification Test Cycle Time from 3 Weeks to 25 Hours
- Developed “Requisition to Decommission” Processes: Master Build Schedule, Lean Manufacturing, Design Documentation and Control, Quality, Test & Verification, Shipping and Receiving, Field Service, Customer Support and Hotline
- Recognized Data Collection as a Significant Organizational Challenge

# What Did We Learn? – Phase III Cont.

## Overview of Phase III Data Collection




Capacity Factor from 60% to 98%
Average Efficiency from 16% to 20%

Average # of Failures/System from 10 to 2

System Availability from 35% to 82%

# Case Study – Watervliet Arsenal 2002

## Installation and Commissioning

- One Day Per Site from Flatbed to Exporting Power to the Grid

## Operation (as of April 31, 2002)

- Average System Run Time = 2,400 hrs.
- Average Availability = 96.7%
- Capacity Factor = 100%
- Average Efficiency = 26.1%
- Over 60 MW-hrs of electricity produced

## Manufacturing Capabilities

- Ability to Fill Customer Orders from Purchase to Exporting Power in Less than 12 Weeks

## Organization

- New Product Development Process
- Technology Development Process
- Research and Development and System Architecture
- Supply Chain/Extended Organization


# SOFC

## Low-Cost Yttria-Stabilized Zirconia Powders

- Refractron Technologies, Inc., Newark, NY
- Powders to be used by MA/COM to manufacture SOFC components for McDermott Technologies/Cummins Power Corp. DOE SECA Program
- Powders currently being evaluated by ENrG, Inc. in Alden, NY

# SOFC
# Planar Strip-Cell

- ENrG Inc., Alden, NY, working with NYS OEM/Stack Manufacturer
- Demonstrate mass-fabrication of planar strip-cell SOFCs using thin, flexible, high-performance ceramic electrolyte.

# SOFC
# Low-Cost Ceramic Recuperator

- Blasch Precision Ceramics, Inc. Albany, NY
- Developing recuperator for Acumentrics Corp, Westwood, MA, tubular SOFC to improve efficiency

# Power Systems Program Accomplishments

| Accomplishment | Quantity |
|---|---|
| New Products Launched | 6 |
| Jobs Created | 425 |
| Peak Load Reduction (2003) | >30MWe |
| Leveraged Development in NY | +$25MM |

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