DTE Energy

DTE Energy
Hydrogen Technology Park
2006 DOE Program Review

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This presentation does not contain any proprietary or confidential information

Project ID: TV 1

Overview

DTE Energy

Timeline:

Start Date: Oct 2002
Orig End Date: Oct 2005
New End Date: Oct 2009
% complete: ~75%

Budget:

Total (revised): $4 M
- DOE share: $2 M
- Cost share: $2 M

FY05 funding: $0.6M
FY06 funding: $0.4M

Barriers:

C. Hydrogen Refueling Infrastructure
E. Codes and Standards
H. Hydrogen from Renewable Resources
I. Hydrogen and Electricity Co-production

Partners/Collaborators:

- DaimlerChrysler
- BP
- Lawrence Technological University (LTU)
- Sandia National Laboratories
- The University of Michigan

Objectives

DTE Energy

Project Objectives

Develop and test a hydrogen co-production facility having stationary fuel cell power and vehicle fueling capability that uses renewable & non-renewable resources (FY04)

Employ representative commercial units under real-world operating conditions (FY04)

Based on performance data, project experience, and market assessments evaluate the technical and economic viability of the power park system (FY05)

DOE Objectives

By 2008, validate an electrolyzer (powered by a wind turbine) with capital cost of $600/kWe and efficiency of 68% (incl. compression to 5,000 psi)*

By 2008, develop a dist gen PEM fuel cell system that achieves 32% electrical efficiency and 20,000 hours durability at $1500/kW

***when built in quantities of 1,000**

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Objectives

DTE Energy

Project Objectives

Contribute to development of relevant safety standards & codes required for commercialization of hydrogen-based energy systems (FY04)

Identify system optimization and cost reduction opportunities including design footprint, co-production, and peak-shaving applications (FY05)

Increase public awareness and acceptance of hydrogen-based energy systems (FY04-F09)

DOE Objectives

Determine the relevant codes, safety standards, and engineering data required for Power Parks

Obtain real-world operating data to better understand performance, maintenance, operation, and economic viability of Power Parks

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Approach:
Project Overview

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Design, install, and operate an integrated hydrogen co-production facility utilizing:

- Electrolytic hydrogen production (2.7 kg/hr, 43 kg/day)
- 50kW (DC) stationary fuel cell power (320 kWh/day)
- 5000 psig vehicle dispensing (15 kg/day)
- Renewable on-site solar energy (27 kW)
- Grid-connected biomass energy

Collect, analyze, and report system performance data & lessons learned for an integrated co-production facility operating under real-world conditions

Evaluate commercialization opportunities for an advanced Power Park facility

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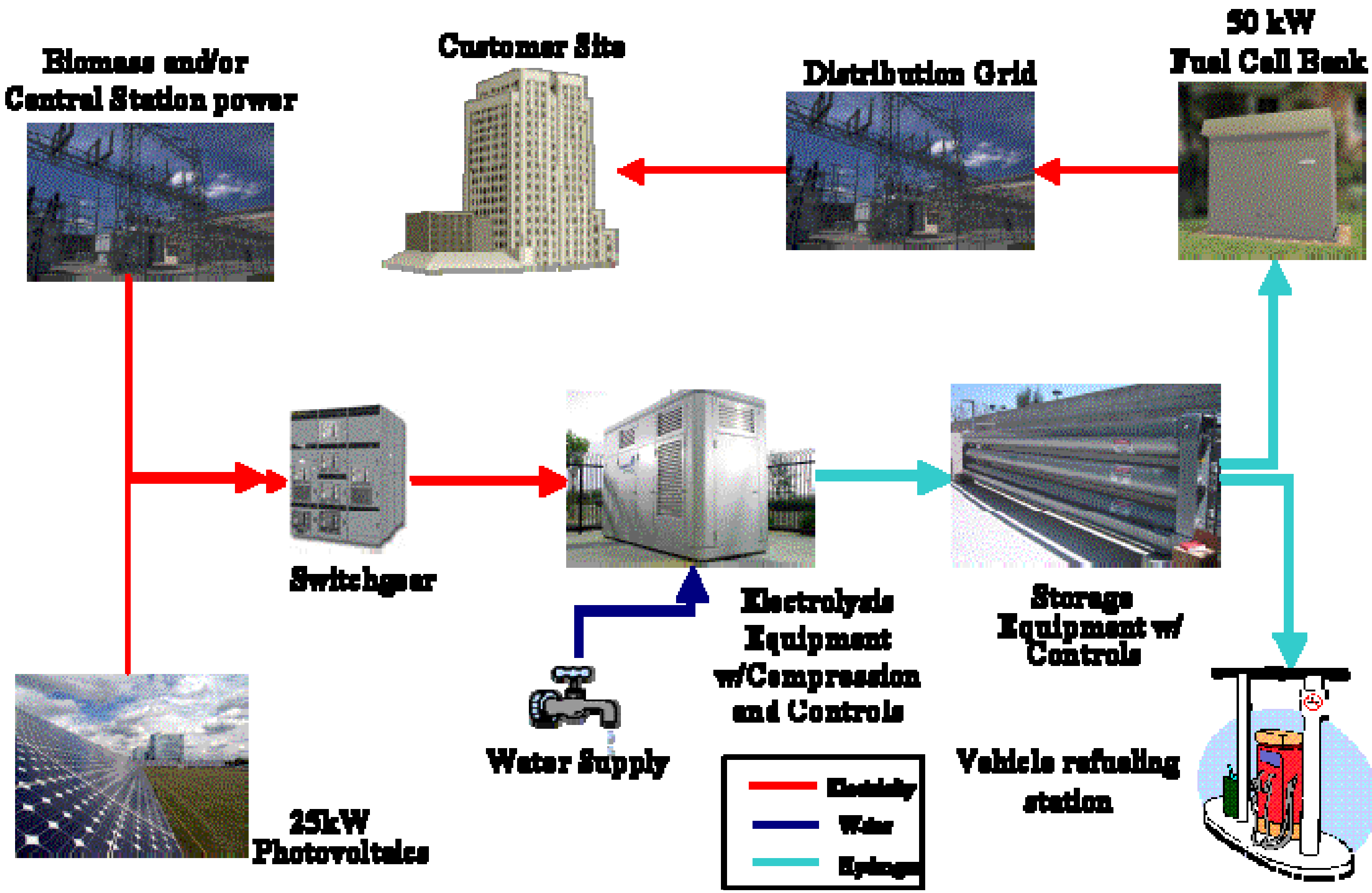
Approach:
Process Flow Diagram

System Operations Center *(not shown)*:

- Provides remote monitoring & control, all data acquisition and web access

All AC systems connected to common 480 V Bus



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Accomplishments:
Validated electrolyzer with capital cost of $1500/kWe and efficiency of 59%

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DTE HTP Demonstration Project Electrolyzer
- Measured running efficiency* 59% (DOE 2008 goal 68%)
- $1500/kWe (DOE 2008 goal $600/kWe)
- Off Peak operation (16 hrs/day) - 43 kg/day production
- 2.7 kg/hr production rate

Projected System Performance (manufacturer quote, 2006 prices)
- Manufacturer rated efficiency 62.25%
- $700/kWe (DOE 2008 goal $600/kWe)
- Off Peak operation (16 hrs/day) - 1440 kg/day production
- 90 kg/hr production rate

*SNL data analysis for steady operation

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Accomplishments:
Validated 40kW 'peak shaving' PEM fuel cell system

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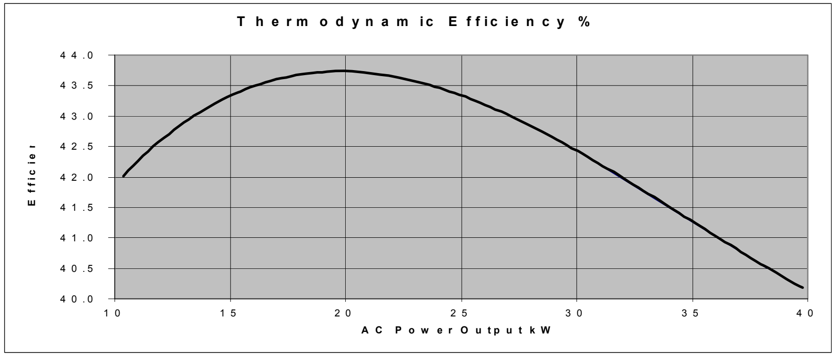
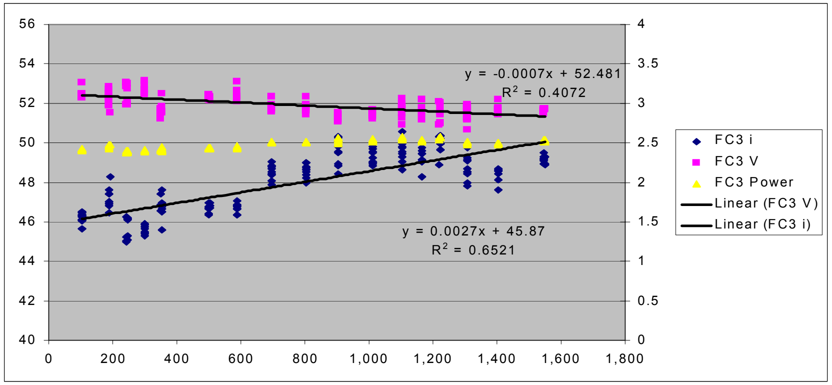
- **Achieved 44% peak fuel cell efficiency**
- **Generated 41,034 kWh from installed bank**
- **Demonstrated 1500 Hour (6,000 kWh) stack durability at capital cost of $3,000/kW (DC)**
- **Determined stack V-I Curves, transient response, and service performance for future improvement**



Running efficiency (AC) measured @ 44%



Stack performance, 1500 hr design life

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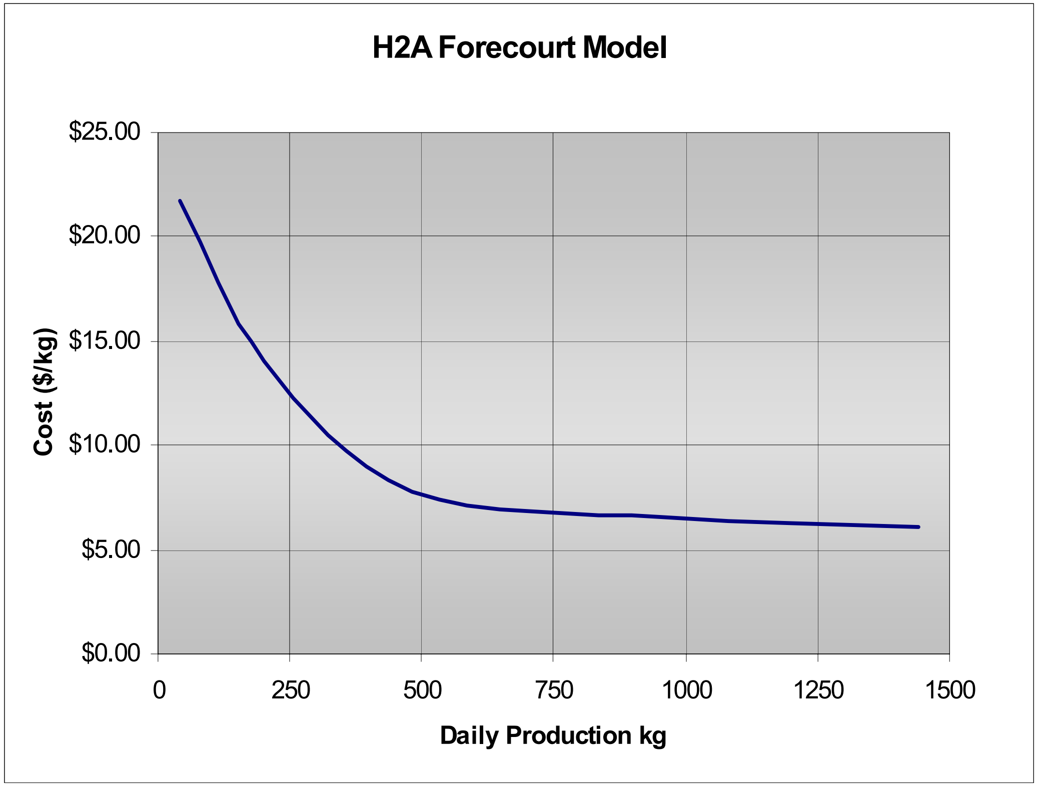
Accomplishments:
Obtained real-world data to better understand economic viability of Power Parks

DTE Energy

- **Calculated project and high volume hydrogen cost using H2A Forecourt model, 2006 prices and scaled BOP (shown at right)**
- **Determined 2005 DOE goal of $4.75 /kg may be attainable**
- **Determined hydrogen production cost using DTE financials of IRR & Capital**
- **Verified UofM financial model with H2A (for matched costs and financial assumptions)**



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Accomplishments:

Obtained real-world data to better understand economic viability of Power Parks

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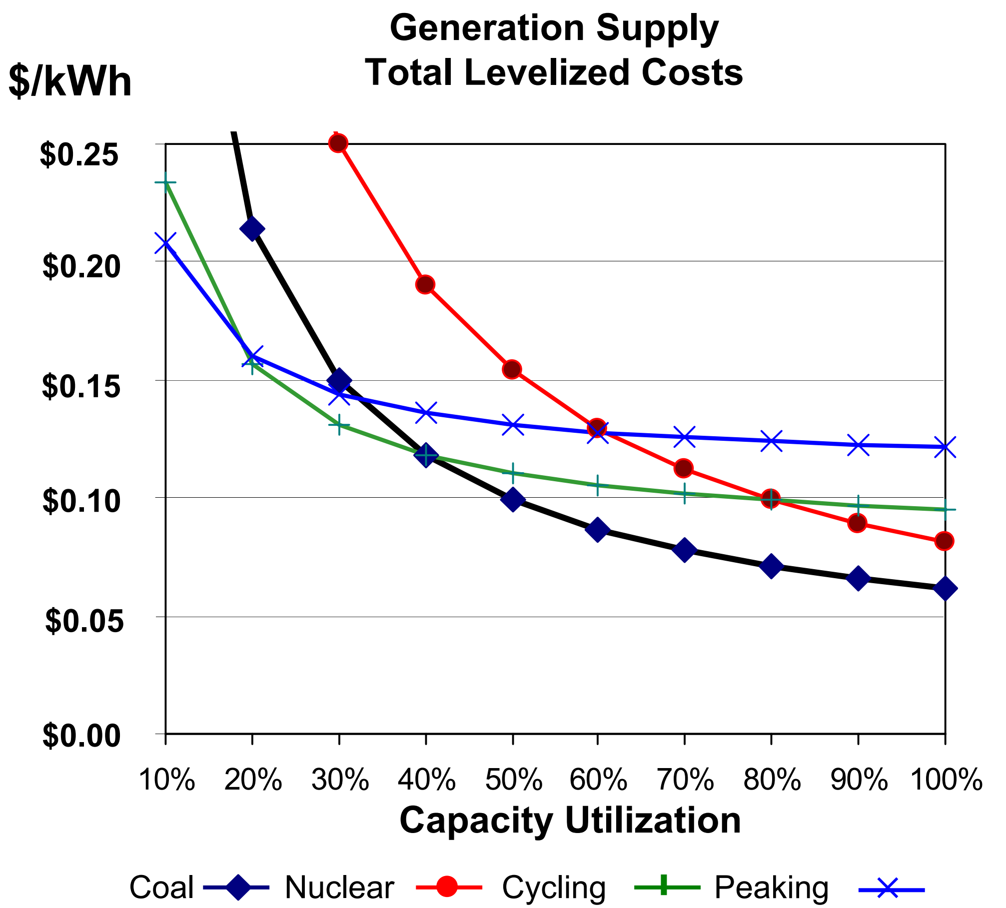
D.G Units:

	Cap/kW	Fuel	Total
Nat Gas	$870	$0.068	$0.199
Diesel	$600	$0.110	$0.200

Fuel Cells:

	Cap/kW	Fuel	Total
FC HTP	$5,000	$0.325	$1.075
FC Future	$893	$0.286	$0.420



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Accomplishments:
Obtained real-world data to better understand performance & maintenance of Power Parks

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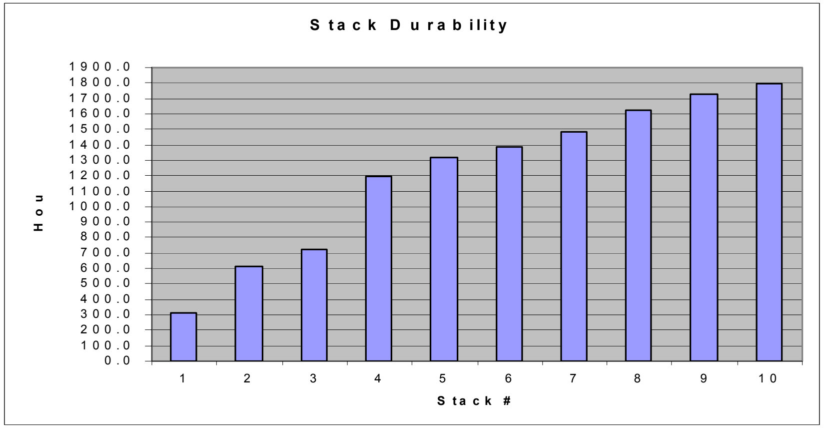
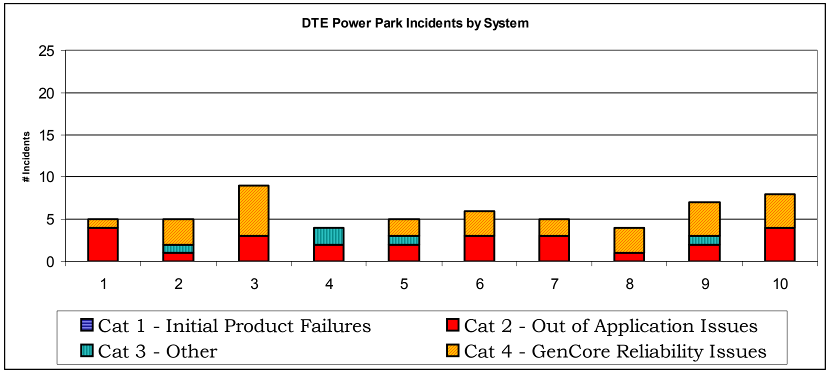
- **Overcame design & operational issues with fuel cells for cold weather climate**
- **Addressed stack life issues:**
  - Demonstrated 1500 hours (6,000 kWh) durability on recent stacks
- **Resolved key maintenance issues:**
  - Infant mortality/start up failures
  - Part defects
  - Service incidents/unit/month: down to 0.9 incidents/unit/month



Stack durability



Service incidents

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Accomplishments:
Identified system optimization and cost reduction opportunities

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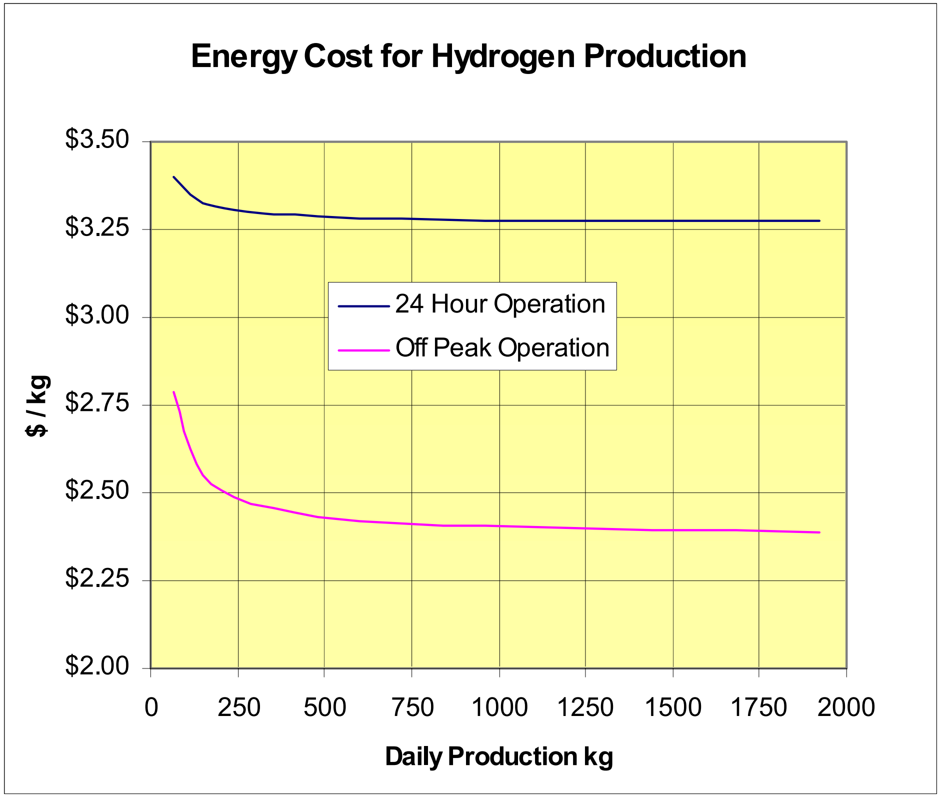
Off-Peak vs. 24 Hour Operation of Electrolyzer:

Based on actual electrical rate structure (D6) and production volumes, demonstrated benefit of Off-Peak operation

Graph: Energy cost/kg for same daily hydrogen production (same daily energy consumption)

Off-Peak and 24 hour operation shown

On-Peak 11AM-7PM, M-F



Off Peak vs. 24 Hour Operation

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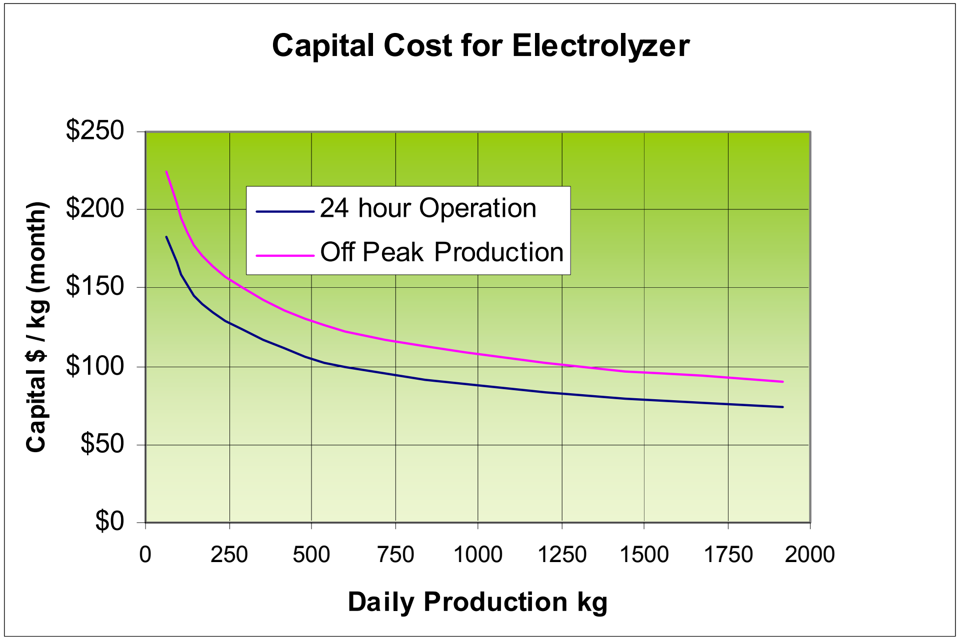
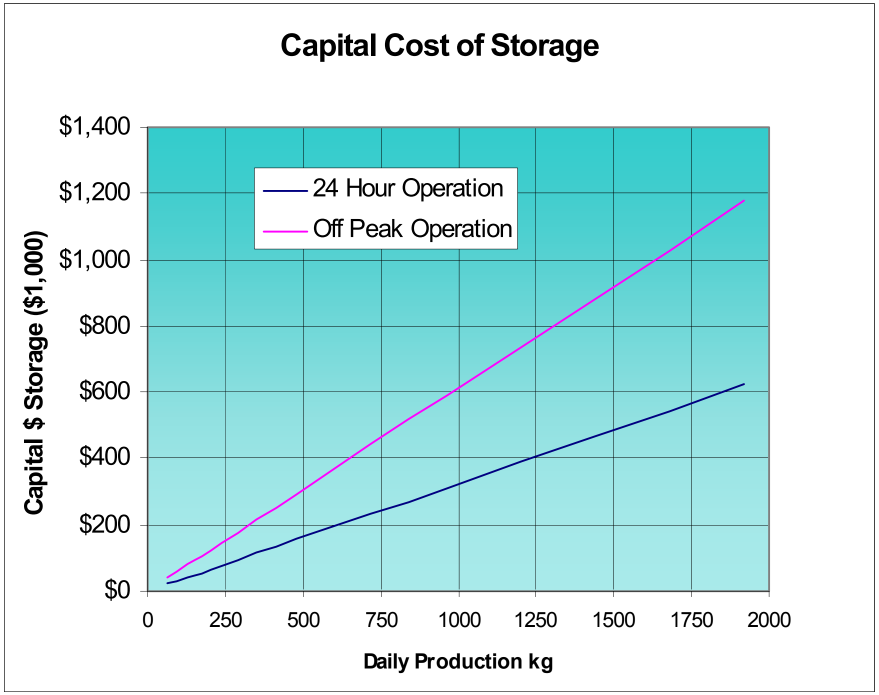
Accomplishments:
Identified system optimization and cost reduction opportunities



Impact of daily operating plan on electrolyzer cost

Impact of daily operating plan on storage cost



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Accomplishments:

Identified system optimization and cost reduction opportunities

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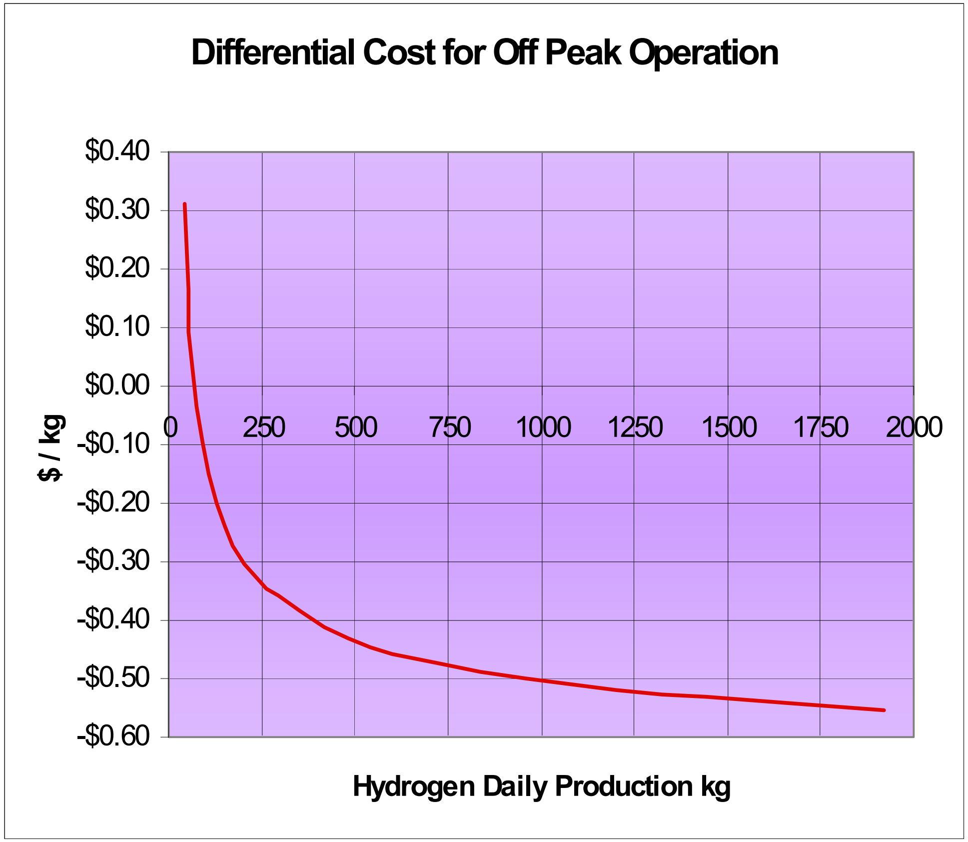
Operation plan and system design optimized for minimum production cost based on electric rate and dependent variables of electrolyzer and storage cost

- **'Off peak' design also offers increased surge capacity and maintenance advantages**



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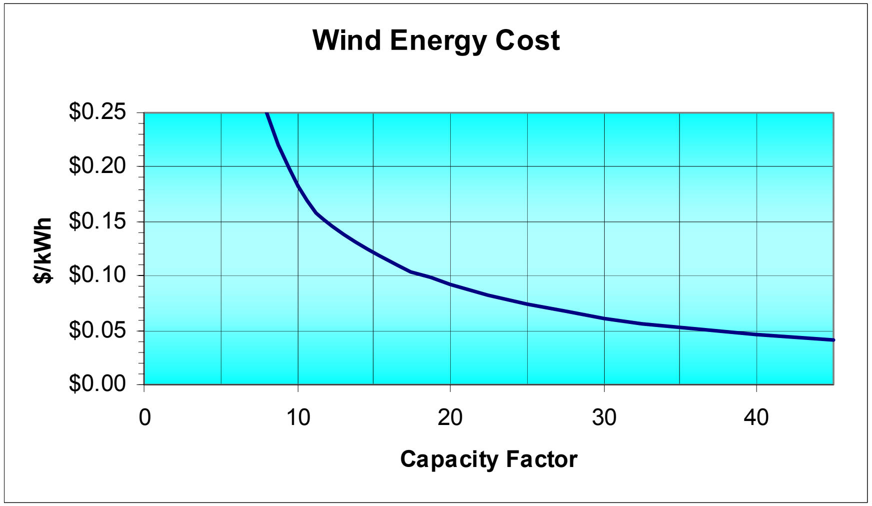
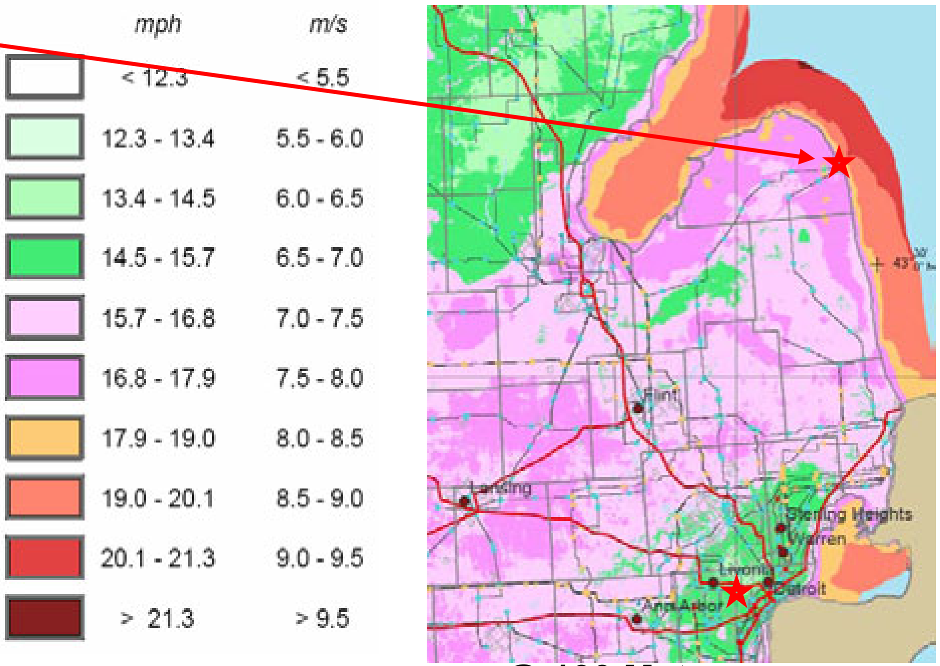
Accomplishments:
Examined best case wind resource*

Harbor Beach Power Plant Site

Best Wind Resource* Available

- **30% Annual Capacity Factor**
- **$1,000/kW installed (assumed)**
- **$0.06/kWh Energy Cost**





@ 100 Meters

Investigated 10/14/05 (LTU)

Using Weibll – NREL ArcGis

*** in DTE Energy service territory**

Accomplishments:
Calculated hydrogen production cost from renewables

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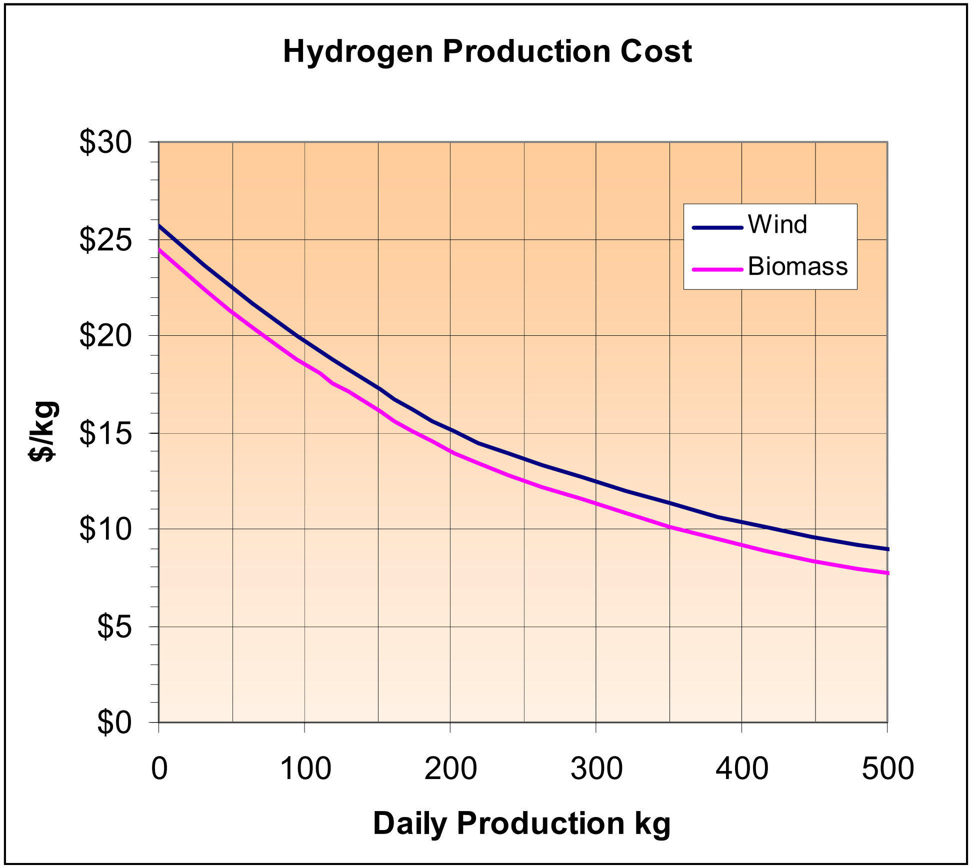
Hydrogen Production Costs

(calculation assumptions)

- Harbor Beach Wind Turbine
  - 30% CF, $1000/kW
  - (11% CF in August)
  - Sized for daily production
  - H2A model assumptions
  - No storage cost penalty
    - (Grid back-up)
  - Electrolyzer on site
- Biomass at $0.04/kWh
  - 24/7 availability
  - Electrolyzer on site



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Accomplishments:
Validated renewable (PV) generation to common bus for hydrogen production and 'parasitic' loads

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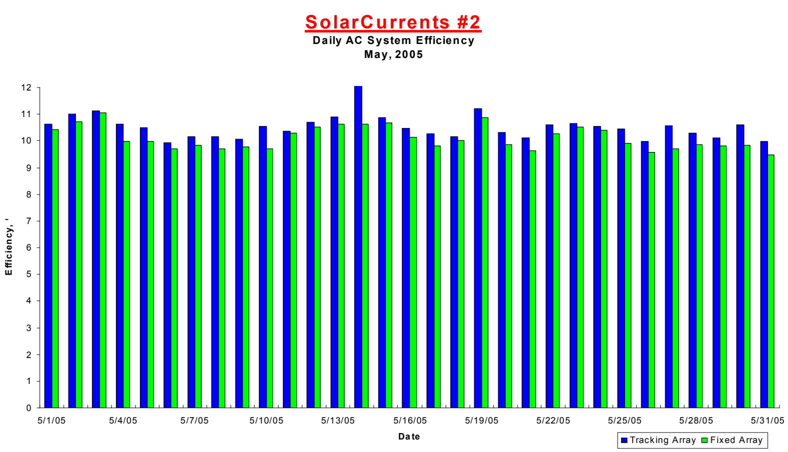
46,201 kWh of PV generation at 9-12% efficiency

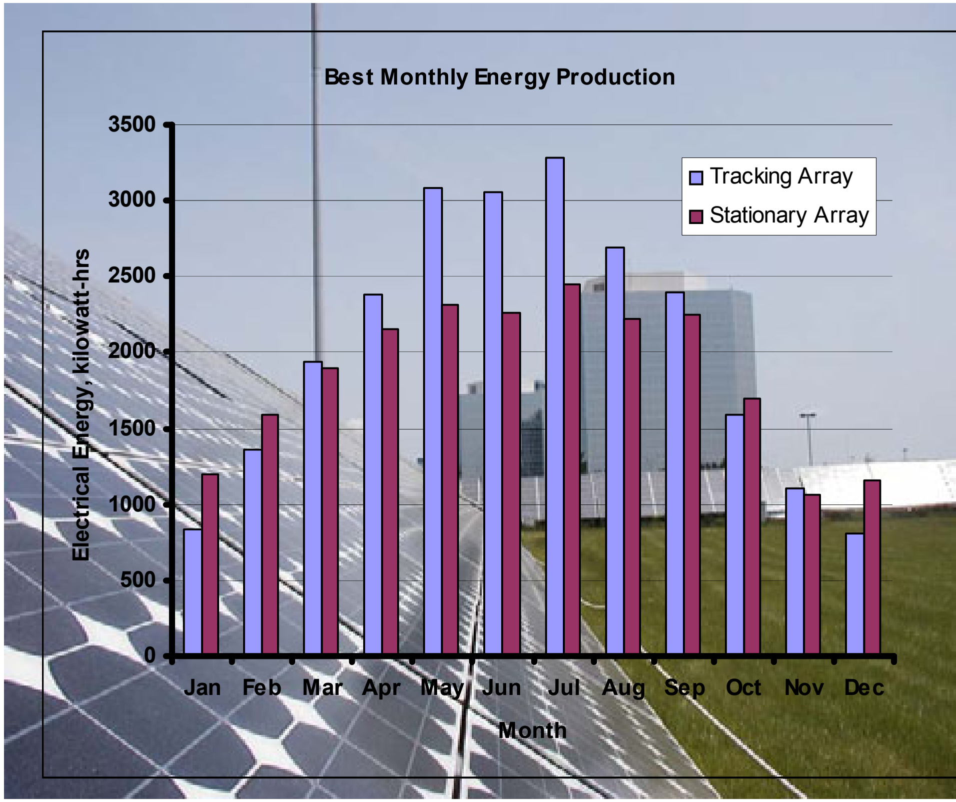
Hydrogen Production:

- **22,176 kWh Off-Peak Energy producing 394 kg Hydrogen**

Energy for Parasitic Loads:

- **24,025 kWh On-Peak**





27 kW Solar Panels

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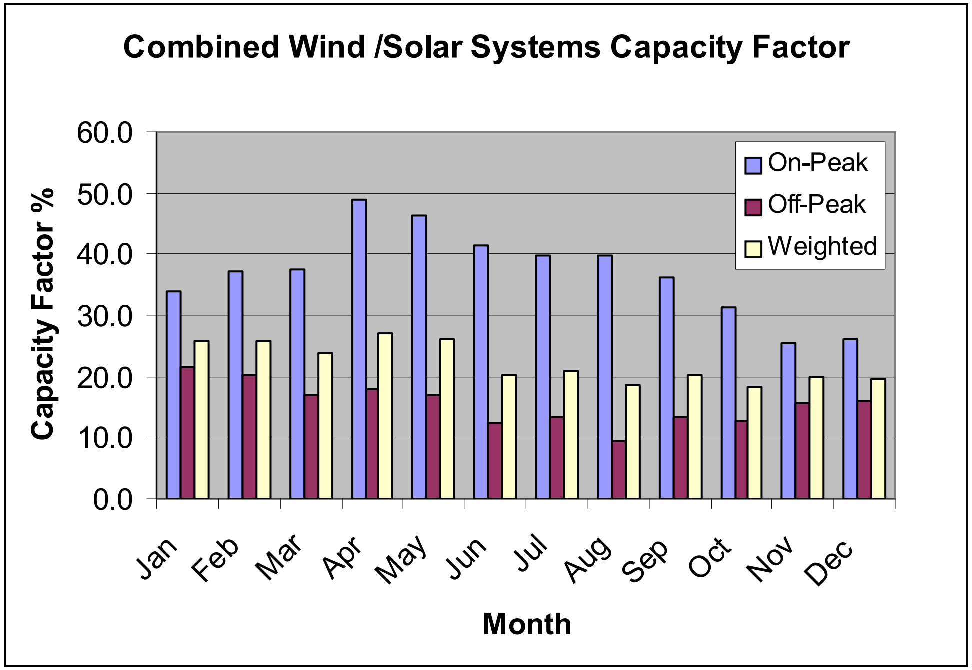
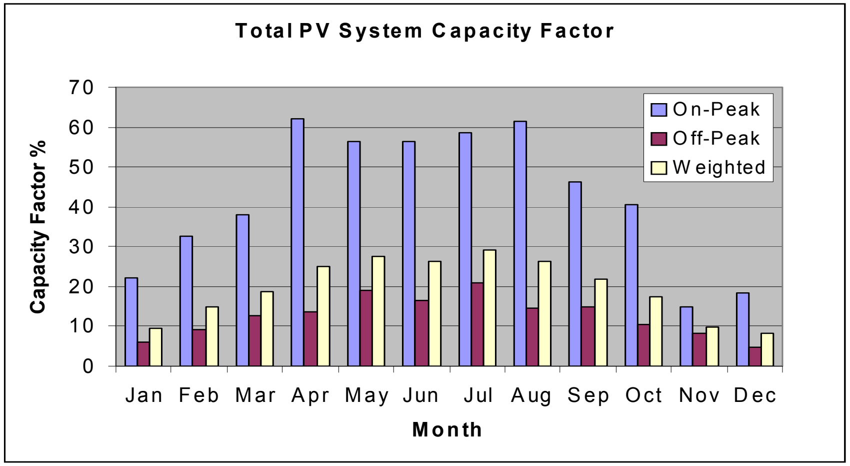
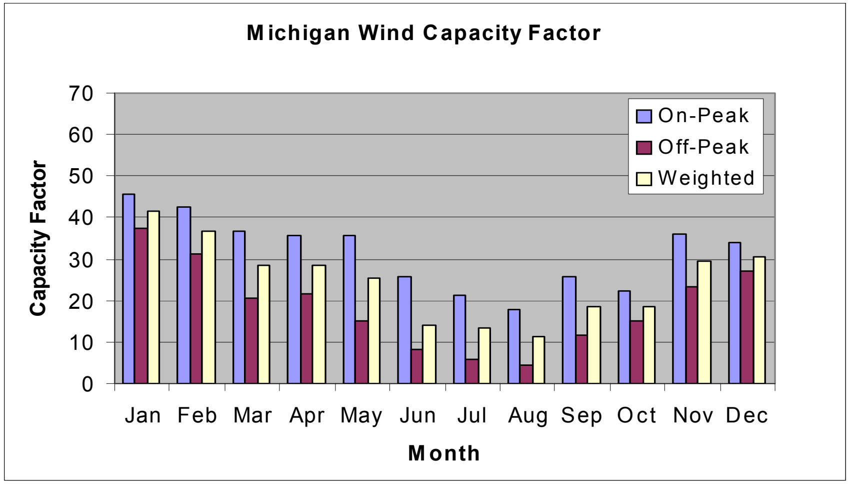
Accomplishments:
Investigated renewable PV and wind generation for complimentary capacity factor

Identified combined wind/solar systems for future technical and economic analysis







Accomplishments:
Closely coordinated work with partners / collaborators

DTE Energy

Lawrence Technological University

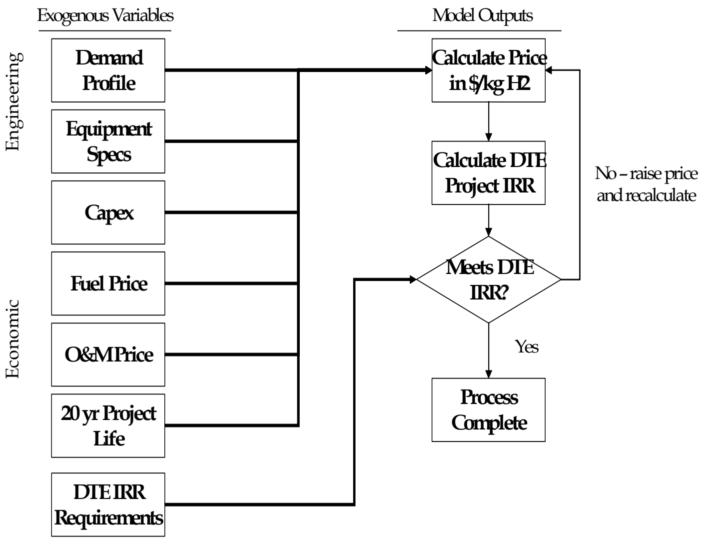
Dr. Rob Fletcher, Department of Mechanical Engineering

- Analyzed and recommended course of action for improving PEM fuel cell stack durability
- Developed wind resource site study
- Provided quarterly data collection, analysis, and reporting to DOE Hydrogen Fleet Demo project
- Performed student internship at Sandia Nationa Labs to develop DTE Hydrogen Park model

University of Michigan

Student masters degree team project at School of Business and Natural Resources

- Title: DTE Hydrogen Park Economic Model and Market Assessment
- Economic viability assessment based on DTE Energy business requirements
- Project results validated by comparison to DOE H2A model



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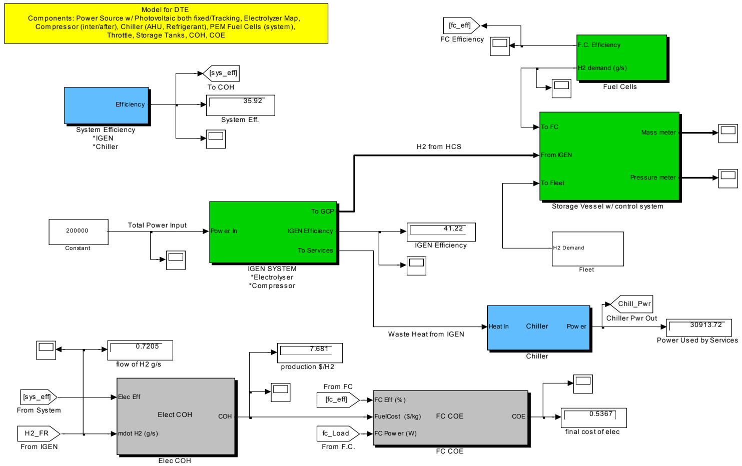
Accomplishments:
Closely coordinated work with partners / collaborators

DTE Energy

Daimler Chrysler and BP

Klaus Bonhoff, Giorgio Zoia

- Co-sponsored First Responder, hydrogen training event – first in State of Michigan
- Conducted hydrogen dispenser vehicle interface analysis FMEA



Sandia National Labs

Andy Lutz

- Developed component/system thermodynamic and economic models for DTE Hydrogen Park
- Sponsored student internship from LTU

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Accomplishments:
Increased public awareness and acceptance of hydrogen-based energy systems

Conducted numerous public and media tours (>40 groups & >300 individuals)

- Educational institutions (LTU, Wayne State)
- Industry, Community & Government Groups
- State Fire Marshals
- Local and regional media, print and TV (4 interviews)

Sponsored open house event – over 350 from general public in attendance:

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Accomplishments:
Conducted tour and initial assessment of pyrolysis demonstration project

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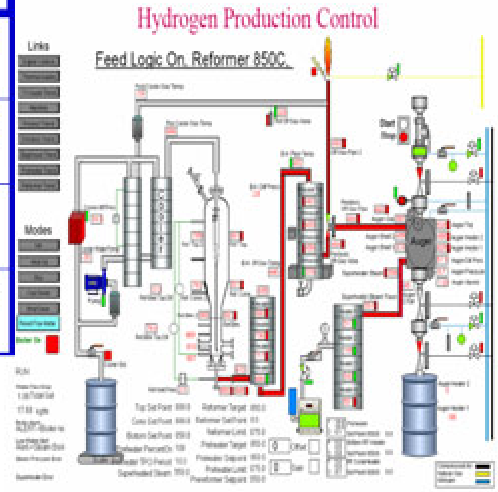
- Toured EPRIDA peanut shell pyrolysis project (Athens, Georgia)
- Obtained preliminary syn gas composition data
- Determined analyses required to assess suitability of syn gas as a hydrogen source for use in a Power Park

Pyrolyzer (Yields)	
Char	32%
Water	32%
Bio-Oils	31%
Gases	5%

Reformer (Gas product composition, on dry N_2-free basis)	
Hydrogen	49%
Carbon Dioxide	36%
Carbon Monoxide	9%
Methane	8%



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Other Accomplishments

Participant in Michigan Department of Environmental Quality (MDEQ) Hydrogen Ad Hoc Storage Rules Committee

Participant in NextEnergy Hydrogen Infrastructure Working Group

Co-developed rapid mass loss detection system with vendor

Evaluated dispenser pad grounding issues re: SAE J2578 and SAEJ1645 and DIN EN 1081, plans made to resurface filling area

Participant in other projects: Advanced Communication and Control of Distributed Energy Resources at Detroit Edison: DE-FC02-04CH11234 and Development and Demonstration of Advanced Distribution Operations With Distributed Energy Resource Integration: DE-FC02-06CH11347

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FY05 Comments & Responses

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Major Questions / Comments from FY05

1. Solar power system appears to add little value to the project.
2. Geographic location not ideal for renewable resources.
3. Needs more emphasis on data sharing.
4. Include hydrogen and electricity production cost estimation.

Response

1. PV panels are a significant contributor to the project both in energy and for analysis of On/Off peak capacity factor and coordination with potential wind resources.
2. Site chosen for availability of scaling up grid source (at electrical substation), proximity to PV (at site), local customer hydrogen demand, public outreach (central to population center.)
3. Data sharing with all partners/collaborators, NREL Hydrogen Fleet Demonstration Project, and three university programs.
4. Complete reporting of cost calculations in this presentation.

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Future Work (FY06-07)

- Integrate and install new electrolyzer (October 06)
- Resurface fueling area by hydrogen dispenser
- Analyze combined wind/solar resources
- Determine cost of ‘cleaning’ syn-gas product to 99.995% purity
- Determine market value of carbon product from pyrolysis as soil supplement
- Determine economics and practicality of pyrolysis based hydrogen
- Continue safe operation of site (FY06-FY09)
- Continue participation with project partners DCX and BP in DOE Hydrogen Fleet Demonstration Project
- Continue data collection, analysis and periodic reporting to DOE
- Continue education & outreach activities
- Publish final project reports (including recommendations)

DTE Energy Hydrogen Technology Park

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Supplemental Slide

D6 Rate Parameters

- Peak Hours: 11AM-7PM weekdays (no holidays)
- On-Peak demand: $10.93/kW
- On-Peak energy: $0.02364/kWh
- Off-Peak energy: $0.02064/kWh
- Delivery charge: $0.00703/kWh (all)
- Max demand: $4.55/kW
  - » (30 minute max demand or minimum of 50kW and not less than 65% of On Peak demand June-October)
- Service Charge: $275.00 / month

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Supplemental Slide

DTE Energy

Fully Integrated Hydrogen Park into Fleet Demo Program

- Conducted 119 fueling activities
- Dispensed 134 kg hydrogen
- Provided infrastructure data to NREL through March ’06 – (Holly Thomas - fuel purity)
- DCX customers: Inergy, City of Farmington Hills, Wayne State University
- Ford Vehicle (ICE) Fueling as requested

Report Date			3/31/2006		
Energy Provider			DTE Energy Hydrogen Technology Park		
Unique Station Identifier			25613		Date [3]
	Constituent	Chemical Formula	Detection Limits	Analytical Method	9/20/04
1	Hydrogen Purity [2]	----------	%, dry	----------	99.9952
2	Ammonia [1]	NH_3	< 6 ppm	SOP-112	----------
3	Carbon Dioxide [1]	CO_2	< 1 ppm	SOP-103	< 1.0
4	Carbon Monoxide [1]	CO	< 1 ppm	SOP-103	< 1.0
5	Total Sulfur	----------	< 0.01 ppm	SOP-1100 / ASTM D-5504	< 1.0
6	Carbonyl Sulfide	COS	< 0.01 ppm	SOP-1100 / ASTM D-5504	----------
7	Hydrogen Sulfide [1]	H_2S [1]	< 0.01 ppm	SOP-1100 / ASTM D-5504	< 1.0
8	Carbon Disulfide	CS_2	< 0.01 ppm	SOP-1100 / ASTM D-5505	----------
9	Methyl Mercaptan	CH_3SH	< 0.01 ppm	SOP-1100 / ASTM D-5506	----------
10	Sulfur Dioxide [1]	SO_2 [1]	< 0.01 ppm	SOP-1100 / ASTM D-5504	----------
11	Total Inert Gases [1]	$N_2 + He + Ar$	< 200 ppm	SOP-2000 / ASTM D-2650	5.0
12	Nitrogen [1]	N_2	< 200 ppm	SOP-2000 / ASTM D-2650	5.0
13	Argon [1]	Ar	< 200 ppm	SOP-2000 / ASTM D-2650	----------
14	Helium [1]	He	< 200 ppm	SOP-2000 / ASTM D-2650	< 6.0
15	Oxygen [1]	O_2 [1]	< 5 ppm	SOP-116	8.0
16	Water [1]	H_20 [1]	< 5 ppm	SOP-109 / ASTM D-5454	33.0

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