# BPA background

BPA is a Federal agency established in the 1930's

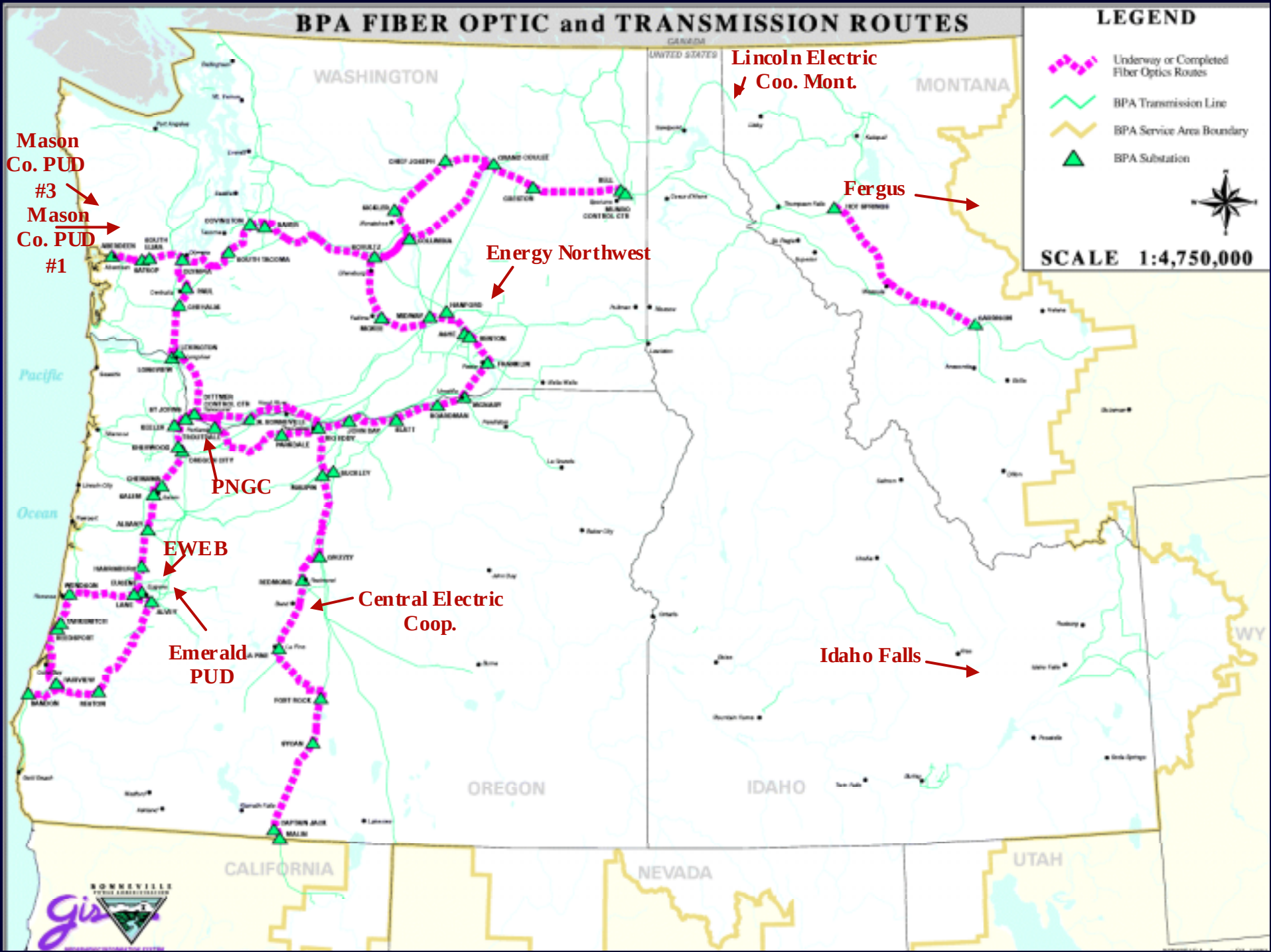
BPA is completely funded by rate payers - Power at Cost - no profits

Customers are publicly owned utilities and direct services industries

Many BPA customers are rural utilities east of Cascade mountains

BPA -a history of innovation - 500kv lines, conservation, fiber optics

Service area shown on following slide


BPA FIBER OPTIC and TRANSMISSION ROUTES
LEGEND
Underway or Completed Fiber Optics Routes
BPA Transmission Line
BPA Service Area Boundary
BPA Substation
SCALE 1:4,750,000
Lincoln Electric Coo. Mont.
Mason Co. PUD #3
Mason Co. PUD #1
Fergus
Energy Northwest
PNGC
EWEB
Central Electric Coop.
Emerald PUD
Idaho Falls
WASHINGTON
MONTANA
OREGON
IDAHO
CALIFORNIA
NEVADA
UTAH
WY
Pacific
Ocean

# DOE/DOD FY2001 Budget Requests
# Over $100 Million For Fuel Cell Programs

Stationary Fuel Cells -- $42.2 million

Cogeneration/Fuel Cells -- $5.5 million

Hydrogen Research & Development -- $23.0 million

Transportation Fuel Cells - $41.5 million

DOD Civil Engineering Research Lab (Army)/Navy for Military Buildings $15 million

# DOE FY2001 Budget Requests
# Over $100 Million For Fuel Cell Programs

*Stationary Fuel Cells -- $42.2 million*

Programs to be funded in this section will continue R&D to reduce costs and improve performance leading to market ready fuel cell power systems within three years.

In FY01, the program will begin testing a 300kW to 1MW size prototype solid oxide fuel cell distributed power generator at a commercial site.

Funding will also focus on developing hybrid fuel cell power systems and reducing fabrication costs.

The request is 12.2% higher than FY2000 enacted funding for this program.

# DOE FY2001 Budget Requests
# Over $100 Million For Fuel Cell Programs

*Cogeneration/Fuel Cells -- $5.5 million*

Formerly the "Fuel Cells for Buildings" program, the cogeneration - Fuel Cells funding will go towards:

develop a fuel processor for a low-temperature fuel cell system;

completing the design competition for a 50kW PEMFC cogenerator for buildings;

continuing R&D of a membrane that will operate in the 120-140ºC temperature range.

The request is 55% higher than FY2000 enacted funding for this program.

# DOE FY2001 Budget Requests
# Over $100 Million For Fuel Cell Programs

*Hydrogen Research & Development -- $23.0 million*

Funded within the DOE's "Solar and Renewable Resources Technologies'" budget,

the Hydrogen Program performs R&D of integrated hydrogen systems for power generation and transportation applications.

The FY01 budget includes funding for R&D of hydrogen generation processes, technologies for fueling hydrogen vehicles,

and development of a regenerative wind/fuel cell system.

# DOE FY2001 Budget Requests
# Over $100 Million For Fuel Cell Programs

*Transportation Fuel Cells - $41.5 million*

Through the Partnership for a New Generation of Vehicles (PNGV), the FY01 budget includes funding for:

integrating fuel cell stacks with fuel processors and balance-of-plant technologies for testing.

The program will also address technology barriers to fuel-flexible fuel cell systems for automotive applications.

The request is 12.1% higher than FY2000 enacted funding for this program.

# DOD buy down $1000/kw

ONSI example:

DOD “bought down” ONSI 250kw systems by $250,000 with original cost of $600,000

but then ONSI raised price to $800,000

BPA has received $30,000 rebate on our 10 alpha units (3kw stack size times 10 units)

# Net Metering - a US issue

The policies and posture of the electric industry regarding net metering, load aggregation and grid interface requirements may well affect the economic viability of fuel cell and other distributed generation technologies.

Generator side: Net metering provides an efficient way of integrating a distributed generation unit with a grid system and facilitating the social and environmental benefits. In effect, net metering means that when the generator is exporting power back onto the grid, the generator is viewed as a negative electricity user and the meter is turned backwards.

Utility side: The IOUs contend that net metering can lead to gaming by the eligible customer-generator by taking power from the distribution system when the value of electricity is high, and offsetting that by delivering power to the grid when the value is low. Also, when the customer-generator takes power from the grid, it receives the commodity, as well as transmission and distribution services. However, the customer-generator is only supplying the commodity to the grid.

# BPA Conservation and Renewables Discount

Regional program to return up to 1/2 mill (50 cents per megawatt hour) on all power sales to BPA customers (public distribution customers) for qualifying measures,

which will includes fuel cells powered by renewable fuels - ethanol

# BPA cost share with customers

Alpha units cost: $56k

BPA pays $ 31k (1/2 system cost plus inverter cost & data gathering)
Customer utility pays $25k
DOE rebate to BPA $3k (3kw X $1000/KW)
* Idatech will purchase alpha units back for $10k at end of test (2yrs?)

Beta unit cost projection: $30k plus inverter costs (Spring 2001)

BPA - $15k plus data gathering cost
Customer $15k plus inverter cost

Goal - commercialized cost of $10-12k for 3KW unit with inverter

# Utilities in the (Alpha) fuel cell test

Central Electric Cooperative, Oregon
City of Idaho Falls, Idaho
Emerald PUD, Oregon
Energy Northwest (formerly Washington Public Power Supply System), Washington
Eugene Water and Electric Board, Oregon
Fergus Electric, Montana
Grant County PUD No. 2, Washington
Lincoln Electric Cooperative, Montana
Mason Co. PUD No. 3 & Lewis Co. PUD No.1 (in partnership), Washington
Pacific Northwest Generating Cooperative, Oregon

Underlines have web sites

# BPA Beta unit information

Upon completion of the ten alpha fuel cell test phase, BPA has the potential to obtain 100 beta units.

The Alpha test participants have the option to purchase five Beta units.

The remaining 50-plus units are available to any customer including public utility districts, municipal utilities, investor owned utilities, and Federal, State and local Government agencies in the following geographical areas within the NW Region:

British Columbia, Idaho, Montana, Nevada, Oregon, Washington and Wyoming.

# *Criteria for BETA unit placement*

**Public Utility**

BPA will cost share

Exclusive utility retail territory rights for commercial products

Commercial preferential price

**Municipality**

BPA will cost share

Exclusive utility territory rights

Commercial preferential price

**External Utility or Government Agency**

Commercial preferential price

**Investor Owned Utility (IOU)**

Commercial preferential price

**Gas Utility**

Commercial preferential price

# BPA's Fuel Cell Partnership - mghoffman@bpa.gov

*Why **BPA** and fuel cells? (speed commercialization, solve customer problem - rural line extensions or remote applications)*

- 60 years of Power at Cost
  - World Class Technical Innovation (fuel cells & fiber (ADSS) on 230/500kv lines
  - Infrastructure Development to Benefit the Region (500kv lines, Reactive voltage control, DC Intertie PNW to LA, Conservation leader)
- History of Partnering with PNW firms to Innovate and Develop Infrastructure
- 1980 Power Act *Requires* BPA to Lowers Costs of Power Via R&D, sec 6d
- 1996 - Northwest Power Systems brings fuel cell proposal to BPA
  - Unique Fuel Processor -
  - Patentable
- NPS - history & address (http://www.idatech.com/) IDA Corp. owns 70%
  - MicroMonitors (Transformer oil sensors), Consep (Membranes)
  - Sandia - Alaska remote processor for kerosene
- Falling R&D under deregulation of 1990's, affected IOU's and BPA
- Regional Firms Emerged As Players During Program Development (NPS, Trace)

# Feed back from the private sector

## Chastened Bonneville Bets Conservatively on Fuel Cell
## By Rob Eure - 05/26/1999 The Wall Street Journal

The Bonneville Power Administration is going down the alternative power-generating road again.

Past trips ended rather badly. Who can forget the $55 million windmills with blades too heavy to turn, or the geothermal plants scrapped because there wasn't enough steam to run them?

This time, it's making a relatively minor investment -- $3.5 million -- and in a technology that utilities seem eager to buy into: fuel cells, which can create electricity out of ethanol or kerosene without a generator.

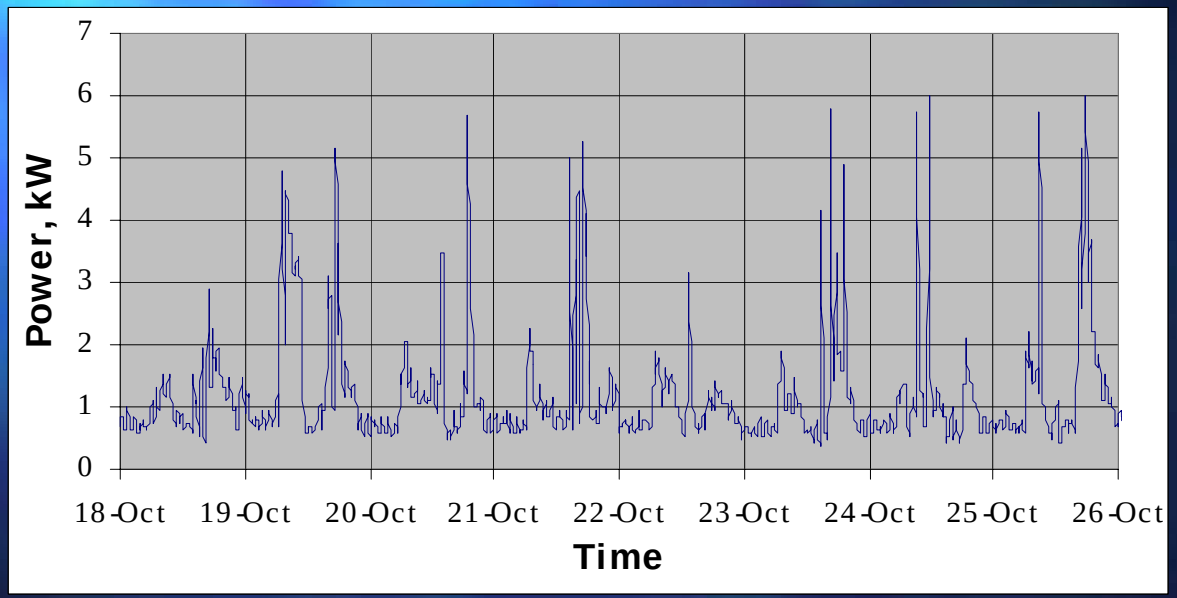
"There are people who think the fuel cell is on its way to becoming a mass energy source," says Jason Eisdorfer, staff attorney with the Citizens' Utility Board, a Portland consumer advocacy group. "And it sounds like Bonneville has learned its lesson. It is going into fuel cells in a much more modest way."

"We are accelerating the development of this technology," says the BPA's Mr. Jackson. "In the long run, fuel cells can make up 10% to 15% of the total market for electricity in the region."

# Why a 3KW PEM? - Residential Load Profile

## Residential Load Profile

Bend, Oregon October, 1998




Northwest Power Systems

# Alpha Prototype Residential Fuel-Cell System

**HxWxD (inches): 36x43x30**

**26.9 cubic feet**

# Alpha Prototype Specifications

| | |
|---|---|
| • Electric Output | 110 V/60 Hz |
| • Net Electric (contin.) | 2.5 to 3.0 kW |
| • Peak Electric | 8 kW (for 1 hr) |
| • Net Thermal | 3 kW (at 110°F) |
| • Fuel | Methanol |
| • Fuel Consumption | 0.5 gal/hr at 3 $kW_e$ |
| • Water Consumption | <0.4 gal/hr |
| • Noise | 55 db @ 5 feet |

# Alpha Site Requirements

- Domestic cold water line.
- Water drain.
- Methanol supply from storage tank.
- Exhaust vent to outside.
- Phone line (optional)

# System Installation at Utility

## Central Electric Coop, Oregon

# Installation Completed

**June 2, 2000**

**Central Electric Coop**

**System provides electricity and hot water to:**

- **bathroom with shower**
- **treadmill**
- **coffee pot**
- **water cooler**
- **lights and computers in four offices and crew room**

# Completed System Installation

**Emerald People's Utility District, Oregon**

# Completed System Installation

**Pacific Northwest Generating Cooperative at Consumers Power, Oregon**

# Alpha Fuel Cell Systems Are Running Well

- All 10 systems have been built
- First 5 systems have accumulated over 2500 hrs operation (as of 1Aug2000)
- Automated controller has been “debugged”
- Thermal recovery has been demonstrated

# Analysis of Discharge Water

- Total dissolved solids 15 mg/L
- Nitrate <0.01 g/L*
- Total organic carbon 1.0 mg/L
- Total phosphate <0.05 g/L*

* Below detection limits of analysis

# Minimal Exhaust Emissions

- CO 0 ppm
- NO 0-1 ppm
- $NO_2$ 0 ppm
- $NO_x$ 0-1 ppm
- $SO_x$ 0 ppm
- HCs 0.08%-0.11% (mostly methane)

# Anticipated Maintenance for Alpha Systems

| | |
|---|---|
| • Fuel Filter | Replace 4000 hrs |
| • Air Filter | Clean 4000 hrs |
| • DI Cartridge | Replace 2000 hrs |
| • Fuel/Water Pumps | Inspect 2000 hrs |
| • Fuel Cell Stack | ??? |
| • Fuel Processor | Replace catalyst at 4000 hrs |

# Lessons Learned

- Feed water quality
- Abuse during shipping
- BOP is not trivial
  - Pumps, flow meters, solenoids, etc. can be problematic
- Power electronics is not trivial
- Fuel cell durability is unknown

# Customer Feedback

- Require low noise level
- Packaging is important
- Simple installation
- Strong interest, but wary about claims

# Fire Marshal Feedback

- No stored fuels inside systems
- Little concern for small hydrogen inventory
- Strong interest, but don’t know how to classify systems

# Fuel Processor has Good Durability

- >2,000 hrs continuous operation demonstrated
- More than 150 fuel processors have been built
  - Logged an estimated 25,000 hrs of operation
- Product hydrogen is exceptionally pure
  - >99.95% $H_2$, <1 ppm CO
  - very low levels of trace contaminants

# Fuel Processor has Good Durability

- Two-stage purifier is unique
  - Based on hydrogen-selective membrane
- Membrane has proven to be durable
  - >10,000 hrs continuous operation
  - >250 pressure cycles
- Affordable purification method
  - <$120/kW electric (at $850/troy ounce Pd)

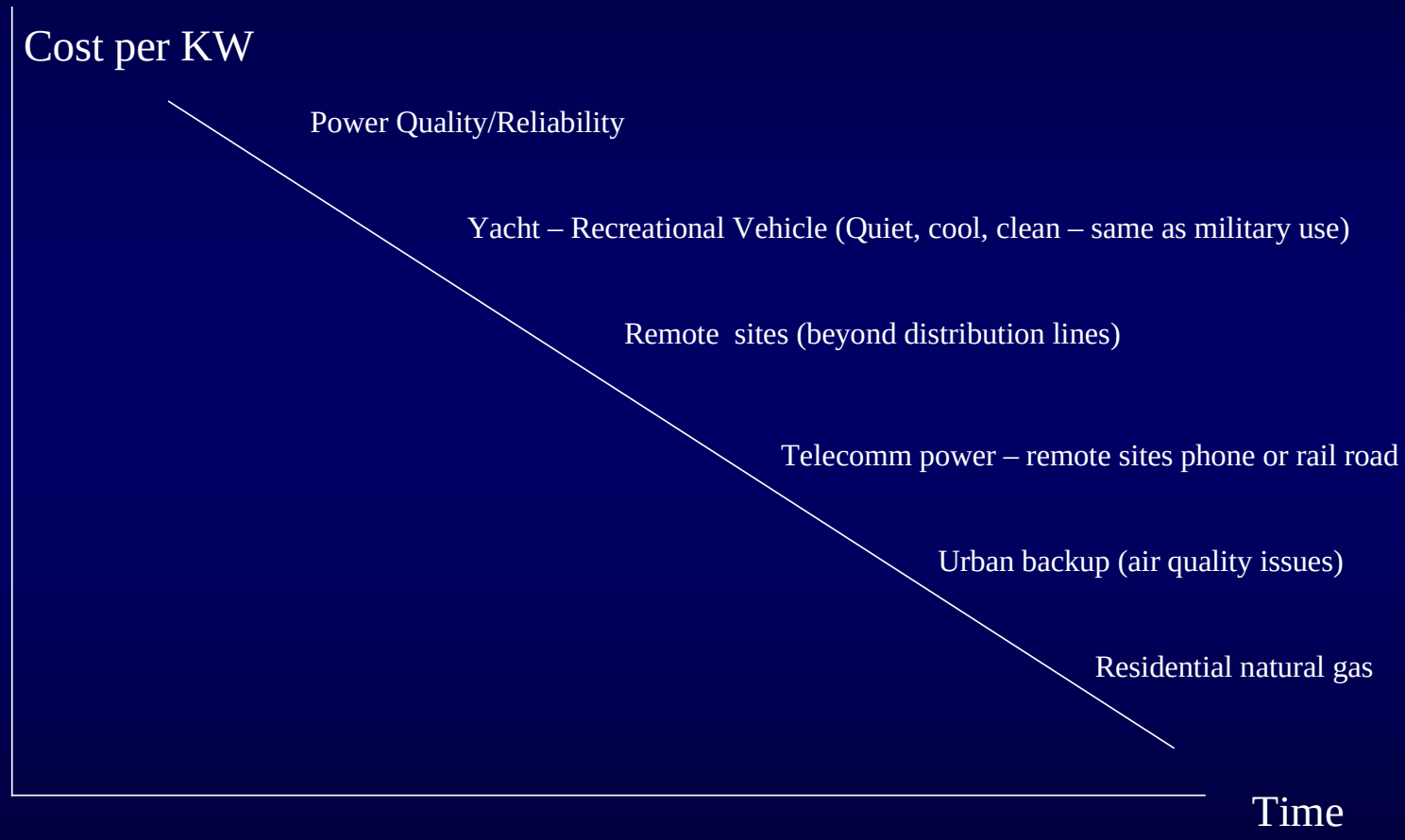
# Commercialization Plans - IdaTech

- Probably 2-3 years to commercial residential fuel cell systems.
- Portable and backup-power systems are 1-2 years away.
- 5-yr. plan: 10,000 to 30,000 systems annually
  - 1-10 kW, portable and stationary

# Conclusions on Alpha test to date

- Alpha prototype fuel cell systems have been delivered and are performing well
- Lessons learned: water quality; shipping abuse; BOP and power conditioning are not trivial
- Proceeding with beta phase and natural gas systems

# Possible adoption curve < 10KW fuel cells




Distributed Power implementation slope - high value comes first

# Where *could* PEM work?

- **Rural** – line extensions alternative (Low Density Discount power replacement)
  - Overhead line extensions $40k/mile,
  - Underground +$80k/mile
- **Remote** – Telecommunications
  - Microwave Radio Stations or Cellular, (DC to batteries - filtering & small inverter)
  - PCS,
  - Paging sites -
  - Grounding issues -
    - safety - fault current potential requires isolation, could be engine generator
- **Marine** or **Recreational** –
  - Boat or RV (quiet operation),
  - Relatively Small Cost Compared to Cost of Boat or Rv
- **Emergency/Backup Power**
  - Reliability and Power Quality
  - Security Sites - Jails, Telecomm, Computer Centers
  - Could Displace Chunks of Substation Batteries

# Where *could* PEM work?

- Urban Backup Power – future use larger sizes 50 KW
  - Where Air Quality Constraints Could Make Siting in Downtown Areas Feasible Versus Engine Generators
- Urban Residential (Cogeneration Option), When System Prices Fall to $10k or Less Per System
- Portable power – Low Thermal Signature, Quiet (Military)
- New Multi-unit housing where there are high electric costs and the ability to design in energy efficiency and smart systems

# PEM Fuel *System - 1 KW version*


In design stage

fuel priorities:
methanol
diesel
propane

# Why Get Into Fuel Cells?

- Customer Service and Growth Potential
  - Create knowledge and infrastructure ahead of need - anybody short of peaking last summer?
  - Customers Want Innovation and
  - Products That Solve Their Problems
  - Learn technology for the long term (competitive advantage)
- Good PR with customers (they'll beat your door down)
- The Utility's Marketing and Distribution Network: *How Much Value Does It Add to Fuel Cell Sales?*
- Can You Form *Partnerships* With Fuel Suppliers? (Methanol, Ethanol, Propane)
- Do Your Customers Want Clean Power at a Small Scale?
- Are There Transmission and Distribution System Savings From Strategic Placement of Fuel Cells? Need regulators to equitably allocate benefits for Transmission, Distribution and end users
- Regenesys - large scale system may offer arbitrage opportunities (energy storage)
- There will be niches for all or most types of fuel cell techonology
- Nth Power lesson - Product development cost 1, Marketing cost pi, Channel cost pi2

# Business Issues to Consider

## Porter's Five Forces Analysis for PEM fuel cells

*Questions to Answer for Yourself*:

- **Internal Rivalry**: Competition for Market Share by Firms Within a Market.
- **Entry/Exit Barriers**:
  - Profits Attract Competition,
  - New Entrants Steal Business and Divide Market Demand,
  - High Cost to Exit,
  - Inability to Shift Resources to Other Business Activity If Industry/firm Fails
- **Substitute Products**:
  - New Entrants Erode Profits by Stealing Business and Intensifying Internal Rivalry,
  - Substitutes Based on New Technologies Lower Costs
- **Supplier Power**:
  - Ability of Suppliers to Extract Profits From the Industry/firm,
  - Monopoly Power Raises
- **Buyer Power**:
  - Ability of Customers to Negotiate Lower Purchase Prices,
  - Willingness of Consumer to Shop Around