# NYSERDA'S SECOND BIENNIAL CONFERENCE

"CHP in New York State – Two Years Later"

# Fuel Cells at New York City Wastewater Treatment Plants



Yan Kishinevsky June 25, 2004

### New York Power Authority Highlights

- A public benefit energy corporation founded 1931
- Largest non-federal electric utility in United States
- Wholesale power supplier throughout New York State and neighboring states as required by law
- 2003 energy sales: 4

47.48 million MW-hrs

- Supplied approximately 25% of New York State
- 2003 Generation:

• Transmission lines:

25% of New York State electricity needs 22.3 MW-hrs (purchased 25.1 MW-hrs) 82% hydro; 16% fossil more than 1,400 circuit miles 115kV, 230kV, 345kV and 765kV



#### NYPA Distributed Generation Program

TechnologiesPhotovoltaicsFuel CellsMicroturbinesIC EnginesCTsWind

Fuels Sun and wind Natural /ADG Gas Gas Landfill Gas Natural Gas

### **NYPA Distributed Generation Program**

Services offered to customers:

- Site evaluation
- Detailed engineering & design
- Equipment procurement
- Installation
- Financing
- Operation & maintenance

### **Fuel Cells**

**Fuel cells are electrochemical power** generators with the potential for attaining very high electrical energy conversion efficiencies while operating quietly with minimal polluting emissions. In addition, by-product thermal energy generated in the fuel cell is available for use for cogeneration of hot water or steam.

# **Types of Fuel Cells** Phosphoric Acid Fuel Cell (PAFC) Molten Carbonate Fuel Cell (MCFC) Solid Oxide Fuel Cell (SOFC) Proton Exchange Membrane Fuel Cell (PEMFC) - Also Called Solid Polymer Electrolyte • Alkaline Fuel Cell (AFC)

### **Comparison of Fuel Cell Types**

	PAFC	MCFC	SOFC	PEMFC	AFC
Electrolyte	H <sub>3</sub> PO <sub>4</sub>	Molten Carbonate Salt	Ceramic	Polymer	KOH/H <sub>2</sub> O
Operating Temperature	~ 200°C	~ 650°C	800-1000°C	~ 80°C	60-80°C
Fuels	H₂/ Reformate	H <sub>2</sub> /CO/ Reformate	H₂/CO/CH₄/ Reformate	H <sub>2</sub> / Reformate	H <sub>2</sub>
Reforming	External	External/ Internal	External/ Internal	External	
Oxidant	O <sub>2</sub> /Air	CO <sub>2</sub> /O <sub>2</sub> / Air	O <sub>2</sub> /Air	O <sub>2</sub> /Air	O <sub>2</sub> /Air
Electrical Efficiency (LHV)	36- 45%	45- 55%	50- 60%	32- 40%	50- 60%



FINALLY, the hydrogen recombines with oxygen from air to make water. The process also releases heat.

### What happens inside a Fuel Cell

# **Simplified Fuel Cell System**



### PC25 Block Diagram



### **Complete Fuel Cell Power Plant**





810f13C

#### Major Components

- Fuel Processor
- Cell Stack
- Power Conditioner



WCN15165

#### Ancillary Systems

- Fuel and Air Supply
- Heat and Water Management
- Ventilation
- · Control, Diagnostics

#### **Emissions Comparison** NMHC **Mdd** CONOX 70 60 50 40 30 20 10 Fuel Cell New PC25 0 New Boiler Federal CCGT NSPS

### **Emission Offsets Per Fuel Cell** (@ 90% load, tons / year)

NOx	6.4
CO	0.3
SOx	13.4
PM 10	0.4
Total	20.5

**Note:** Additionally, fuel cell offsets 1,223 tons / year of  $CO_2$  and 0.3 tons / year of non-organic hydrocarbons

# Phosphoric Acid Fuel Cells (PAFC)

- Phosphoric Acid Electrolyte (H<sub>3</sub>PO<sub>4</sub>)
- Operates At Temperatures Around 200°C
- Older, Well Established Technology
- Stationary Power And Transportation
  Applications
  - UTC Fuel Cells (Formerly IFC, ONSI), Stationary PC-25<sup>™</sup>, 200 kW
     Fuel Cell Buses

# Phosphoric Acid Fuel Cells (PAFC)

### ■ UTC Fuel Cells, PC-25<sup>™</sup>

- Commercialized Technology (Certified, Warranteed)
- Uses Steam Reformation
- Operates on Natural Gas and ADG
- Adjusted Commercial Fleet Reliability Averages Over 96%

# **PC25C Fuel Cell**

- Electrical efficiency: 40%
  - Overall efficiency utilizing waste heat: 85%
- Grid Parallel/ Grid Independent, 235-kVA, 480
  V, 3-Phase, 60-HZ
- ADG @ 60% CH<sub>4</sub> Flow = 3,500 scf/hr or 253 lbs/hr
  - Natural Gas @ 90 %CH<sub>4</sub> Flow = 2,050 scf/hr or 86 lbs/hr

## NYPA Fuel Cell Program

• Fuel cells powered by natural gas

• Fuel cells powered by opportunity fuels (anaerobic digester gas)

# **First Generation of NYPA Fuel Cells**

		Output		ormal	
Location	Vendor	kW	Fuel	Operation	Start Date
Yonkers WWTP	IFC	200	ADG	Grid-parallel	Apr-97
			Natural	Grid	
NYPD Central Park	IFC	200 <b>N</b>	Gas	Independent	Apr-99
N. Central Bonx			Natural	Grid-parallel /	
Hospital	IFC	200	Gas	independent	Oct-00
			Natural		
NYC Aquarium	IFC	200	Gas	Grid-parallel	Nov-01

**Over 15 million kW-hrs generated**