“What If the Grid Were Backup?” - A 20-year update

How fuel cells are interacting with today’s electrical grid

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2011 Fuel Cell Seminar
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We Saw Pressure for Change in 1992

- Utilities were under pressure to consider nearly every form of non-traditional generation
- Environmental regulations were putting a premium on clean generation
- There were efforts to put a price on “externalities,” but implementation was slow
- There was new competition in the utility industry
  - Deregulation provided an opportunity for resellers and aggregators

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The Technology Landscape Was Just Beginning to Shift

- PURPA was promoting CHP (with limited success)
- Wind was just rising
- Solar was struggling in niche markets
- Fuel cells were a true novelty and rare

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2011: Things *Have* Changed

- ✓29 States + DC have renewable energy standards
  - Renewables are traded to meet RPS
  - Customers can choose renewable power independently
- ✓Carbon regulations joining smog/soot/SOx rules
- ✓Separate generation, transmission and sale, new in 1992, now a reality
- ✓Net metering continues to spread

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2011: Things *Have* Changed

- ✓No money down solar brings solar to residential rooftops in large numbers
- ✓Huge increase in wind projects
- ✓There is competition
  - Duke Power has 5% of California market
- ✓Open access for renewables in some states
- ✓Utilities seem to be embracing change

Where do fuel cells fit in changed environment?

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Fuel Cells 2011

Residential

Commercial &

Municipal Applications

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Fuel Cell Products Are Better Than Ever

- ✓ Commercial, but not yet cheap enough
- ✓ CHP combined efficiencies ~80%; electric-only 50%+
- ✓ Residential CHP guarantees to 40,000 hours (Japan)
- ✓ Industrial CHP guarantees to 80,000 hours (UTC)
- ✓ Increasing fuel flexibility (biogas, propane)
- ✓ Operation on digester gas opens new markets
- ✓ Incentives still essential for marketplace success

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Fuel Cells and the Grid - 2011

- Prime power: fuel cells operate 24/7, supplying some or all the customer load
- Combined heat and power: customer harvests some or all of the system heat
- Grid Connected: fuel cells offset a portion of the customer load
- Backup power: fuel cells supply all power or emergency load in event of grid disruption
- Independent: fuel cells completely disconnected from the grid

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Fuel Cells and the Grid - 2011

- Tri-Generation: Fuel cell heat and power are utilized locally, some hydrogen diverted for use as a vehicle fuel
  - Adds value, enables long-range fuel cell electric vehicles
  - Demonstration stage

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What if the Grid Were Backup: 2011

Location	Fuel Cell System	Grid Independence
Central Park Police HQ	UTC Power PC25 – 200 kW	100 %
The Octagon	UTC Power PC400 – 400 kW	100 %
Palace Hotel	ClearEdge5 – 10 kW	100 % (w/ PV)
Sonoma County Administrative Campus	FuelCell Energy – 1,400 kW	90 %
Safeway	Bloom Energy – 200 kW	60-70 %
St. Helena Hospital	UTC Power PC400 – 400 kW	63 %
Whole Foods Market	UTC Power PC400 – 400 kW	50 %
Tulare WWTP	FuelCell Energy – 1,200 kW	45 %

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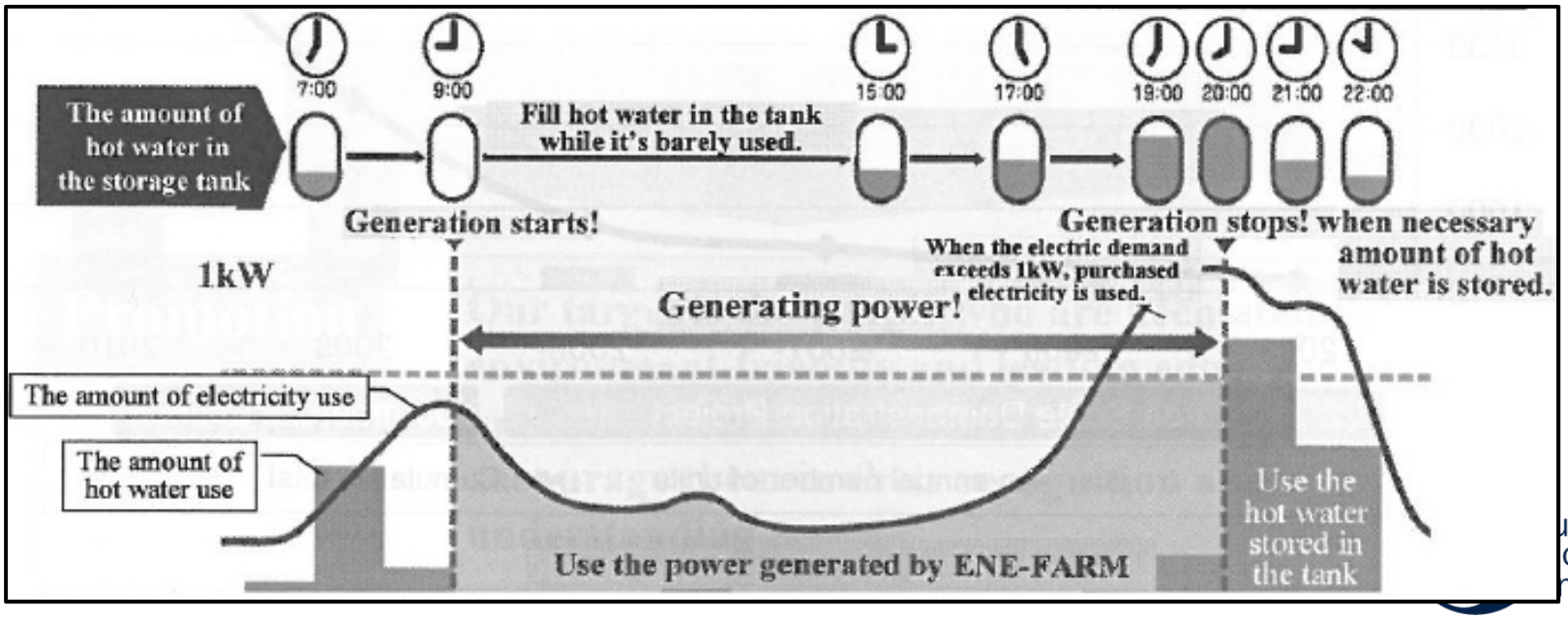
Residential: ENE-FARM, Japan

- 7,500 CHP units installed or on order
- Often co-located with solar
- Starts and stops daily with household demand; Grid supplies residual
- Cuts home energy use 33%, CO_2 by 45%



Residential: ClearEdge5

- Lower cost than grid
- Cleaner than grid: 37% less CO_2 negligible levels of NO_x and So_x
- Continuous base-load power, can operate when grid fails
- High efficiency: Up to 90% CHP; designed for 40% electrical

Source: ClearEdge Power

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Multi-Family Residential: New York

- Supplies 100% of power to 500 residents & all common areas, 70 % waste heat utilization
- Provides consistent, significant heat load, simplifies design
- Sub metering enabled with independent third-party monitor
- Essentially grid-independent for power
- Connected to grid in case fuel cell goes down or requires maintenance
- Energy cost savings per year: $221,500

The Octagon

New York, New York

UTC Power 400 kW system

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Commercial: Agribusiness

Stone Edge Farm and Vineyard

Sonoma, California

- Grid-parallel operation
- Helps assure continuous power to irrigation system and lights – critical loads at the farm
- Expected to save 49 percent on electrical bills

ClearEdge Power 5 kW system

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Commercial: Grocery Store

- Spoiled food, closing are costly
- Green image sells
- Provides half of the store's electricity needs
  - Heating, cooling, refrigeration
  - Overall efficiency ~60 %,

  twice the efficiency of the grid
- During hurricane Irene, Whole Foods maintained freezers, refrigeration, minimizing loss

Whole Foods Market

Glastonbury, Connecticut

UTC Power 400 kW system

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Commercial: Grocery Store

- Fuel cell system provides 60 - 70 percent of power needs at 60,000 sq. ft. retail site
- Fuel cells work in tandem with store's 896 solar panels
- Reliable emergency power in case of grid failure

Safeway

Santa Cruz, California

Bloom Energy 200 kW system

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Commercial: Data Center

- One hour of downtime equals $6 million in lost revenue
- Fuel cell system provides primary power, diesel generators provide backup
- Electric grid secondary backup
- Operating since 1999: well over 89,000 hours operation
- Cost savings: $107,000 per year, >$1 million to date

1st Nat'l Bank of Omaha Technology Center

Omaha, Nebraska

UTC Power 800 kW system

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Municipal: Office

- Baseload power to jail, buildings
- Waste heat recovery for hot water and space heating
- Annual natural gas savings 75% ($350,000)
- Able to meet about half of County's peak load (2,500 kW)
- Can export excess electricity to the grid, uncompensated
  - FC rating greater than minimum load so utility will not compensate

Sonoma County Admin. Campus and Jail

Sonoma County, California

FuelCell Energy

1.4 MW system

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Municipal: Office

- Configured to operate in tandem with, or 100 % independent of, the electrical grid
- Connected to UPS system providing back up power to critical IT equipment
- UK's largest capacity fuel cell
- Estimated 40% CO2 reduction, cost saving of £90,000 ($142,000)/year

Transport for London – Palestra Building

London, England

UTC Power 200 kW system

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Municipal: School

- Load peaks at 600 kW, can go as low as 120 kW nights, weekends
- Fuel cell capable of grid-parallel or grid-independent operation
- The school can be emergency shelter, providing housing, lighting, heat, hot water, and kitchen service to 3,000 people

South Windsor High School

South Windsor, Connecticut

UTC Power 200 kW system

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Municipal: Hospital

- Meets 63 percent of electrical demand
- Programmed to be primary source of heat and power
- Boilers and generators kept online for some low-level energy needs and emergency backup

St. Helena Hospital

St. Helena, California

UTC Power 400 kW system

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Municipal: Waste Treatment/ADG

- Utilizing waste gas in four FuelCell Energy units since 2007
- Generates 45 percent of its electrical needs annually
- Electrical efficiency 47%
- 90% efficiency with heat
- Reduced electric bill by over $1 million/year, $3,200/day!

Tulare Wastewater Treatment Plant

Tulare, California

FuelCell Energy 1.2 MW system

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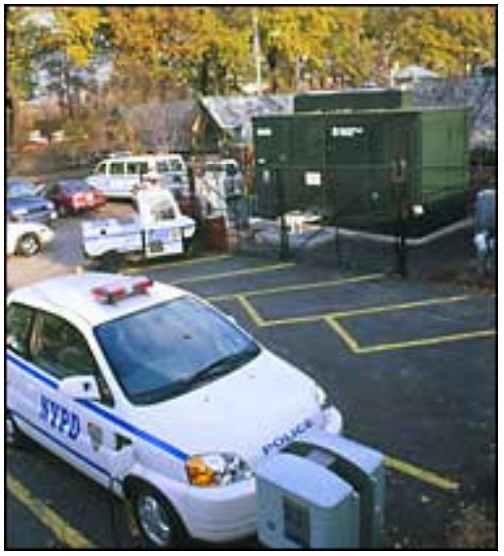
Still Running Strong…

- Natural gas fuel cell system has provided 100% of power since 1999
- Provides 700,000 BTU heat
- Electric vehicle charging station
- One of only a few buildings in New York City to stay powered during the massive Northeast blackout in 2003

Central Park Police Precinct

New York, New York



UTC Power 200 kW system

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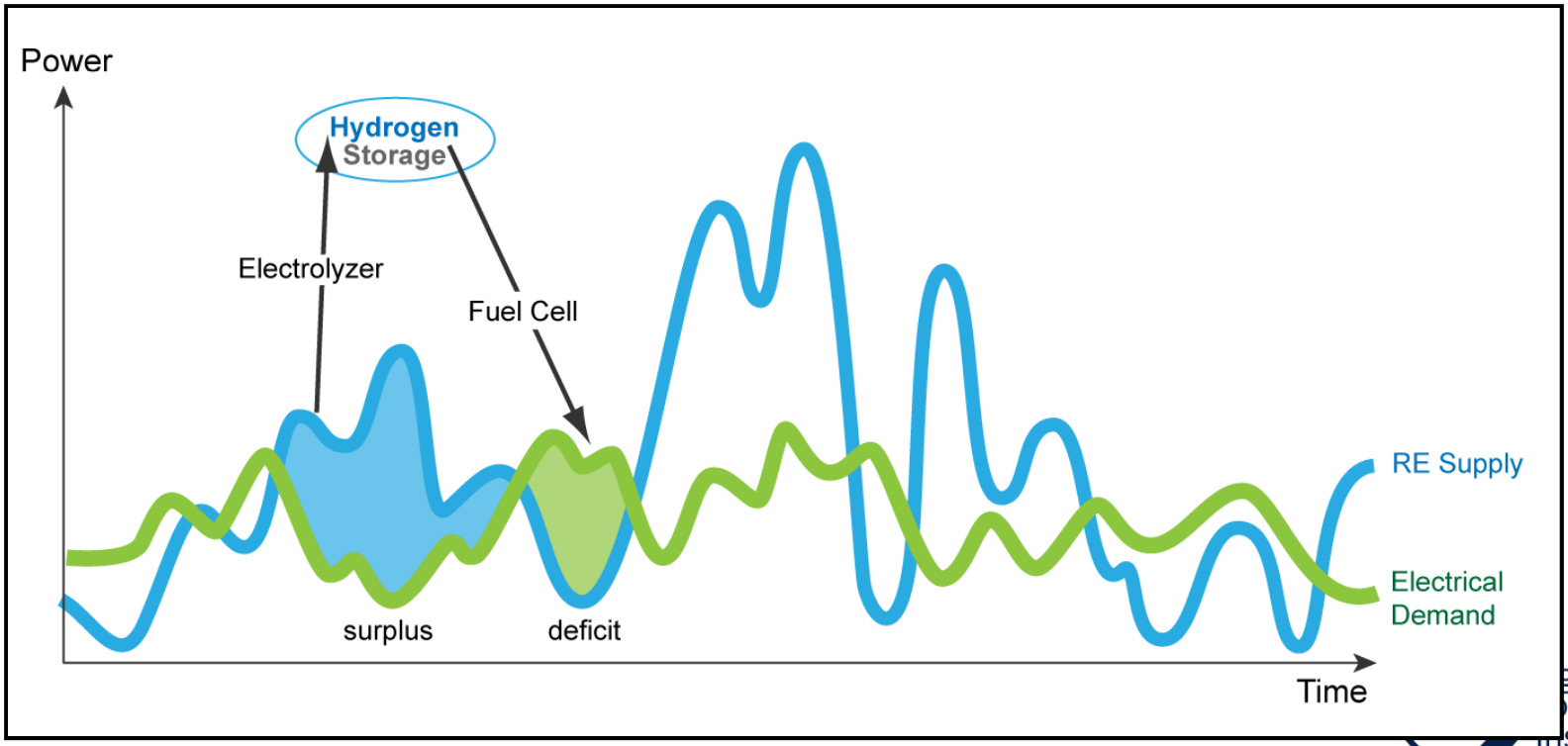
Hydrogen Could Enable a Green Grid

- H_2 a favored storage/grid balancing option in Europe
- Siemens: “Hydrogen … only viable option to store energy quantities >10 GWh”



Conclusions

- Fuel cells will remain technically and operationally attractive due to their efficiency, reliability, and demonstrated success in residential, commercial, industrial and municipal applications
- Fuel cell costs are high compared to engines and turbines, but their high efficiency and ultra-clean operating characteristics provide value

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Conclusions

- Customers will continue to demand things the grid cannot deliver: reliability, power quality, security
  - ENE-FARM developing grid-independent option for 2012 in response to customer demand post “3-11”
- Clean, quiet, reliable, efficient fuel cells are the preferred solution for early adopters

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Conclusions

- Fuel cells today are roughly where solar was in 1992, taking advantage of niche markets (e.g. forklifts) to leverage technology and lower costs
- Incentives are essential for fuel cells, just as they still are for solar and wind

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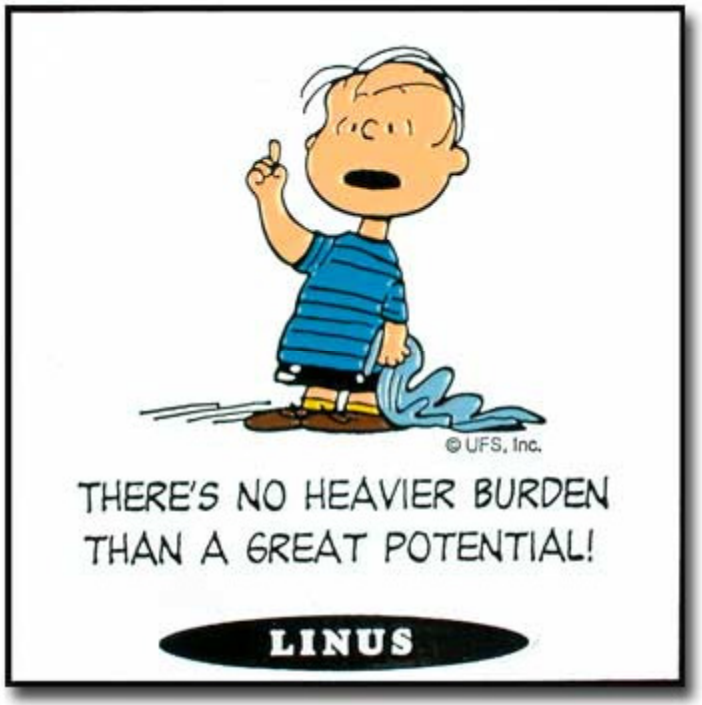
We Saw "Substantial Potential . . . "

- Sales still rely heavily on incentives
- Cost remains the critical limiting issue



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Questions?

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