

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

How fuel cells are interacting with
today's electrical grid

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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

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

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

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?

Fuel Cells 2011

Residential

Commercial &

Municipal Applications

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

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

Fuel Cells and the Grid - 2011

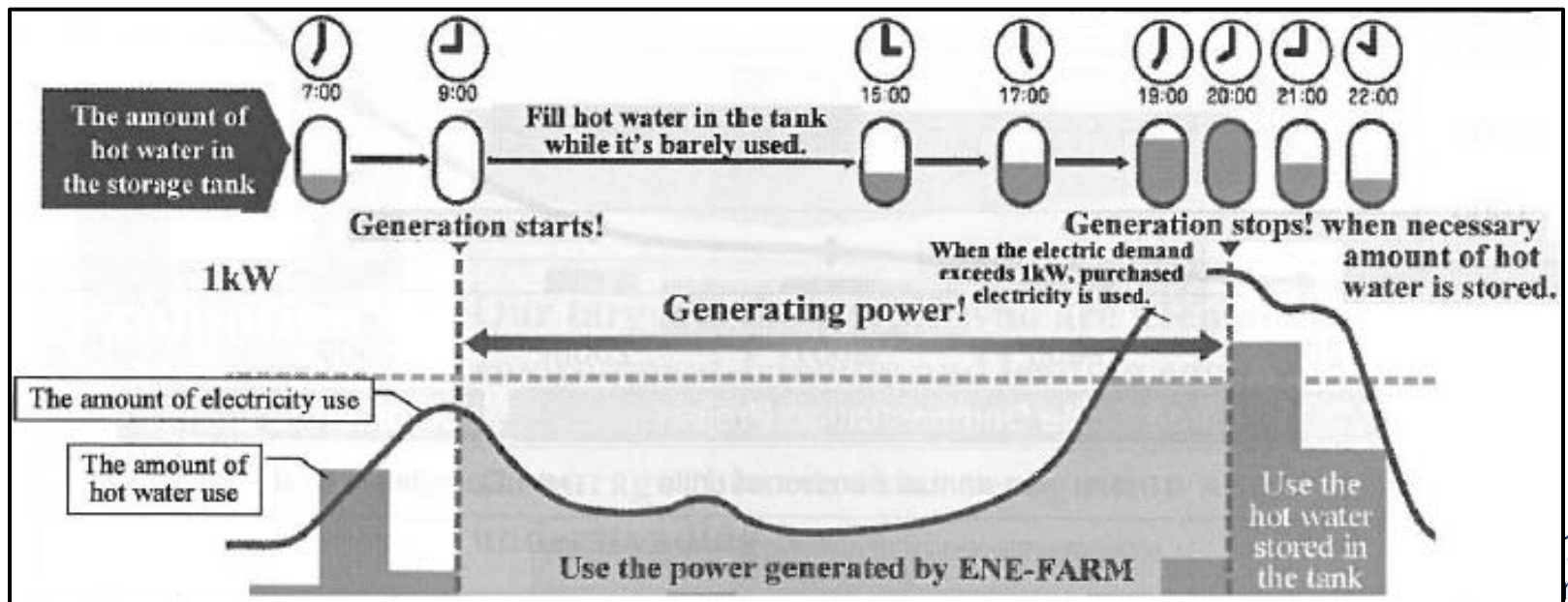
- Tri-Generation: Fuel cell heat and power are utilized locally, some hydrogen diverted for use as a vehicle fuel
 - Adds value, enables long-range fuel cell electric vehicles
 - Demonstration stage

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 %

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%, CO₂ by 45%



Residential: ClearEdge5



- Lower cost than grid
- Cleaner than grid: 37% less CO₂ 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

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

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

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

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

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

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

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

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

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

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



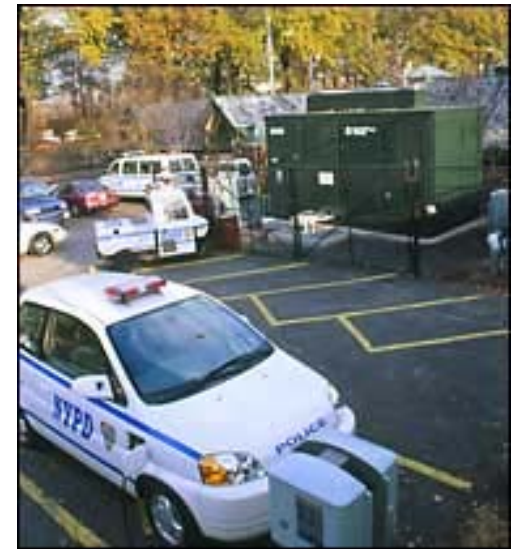
FuelCell Energy 1.2 MW system

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

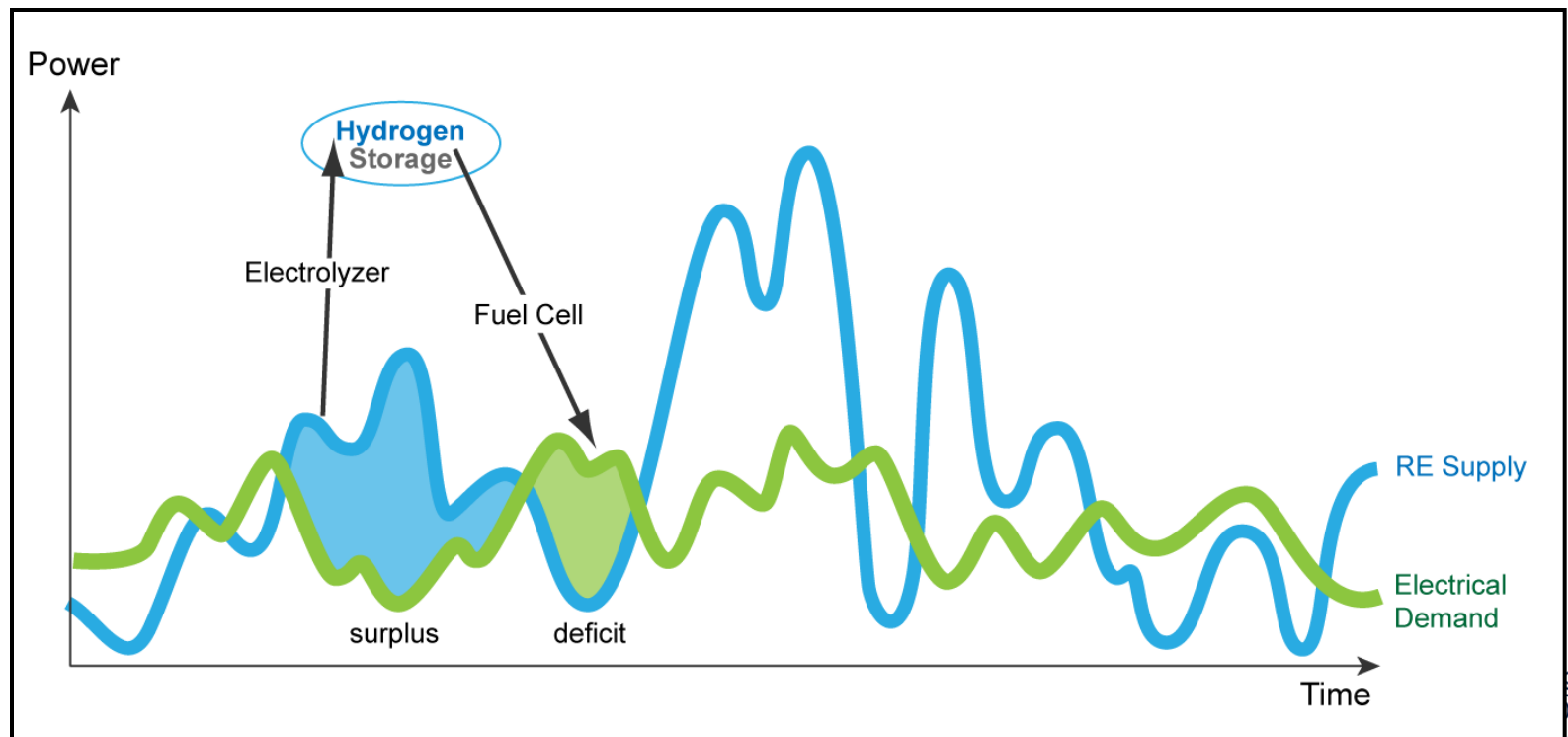
New York, New York



UTC Power 200 kW system

Hydrogen Could Enable a Green Grid

- H₂ 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

Conclusions

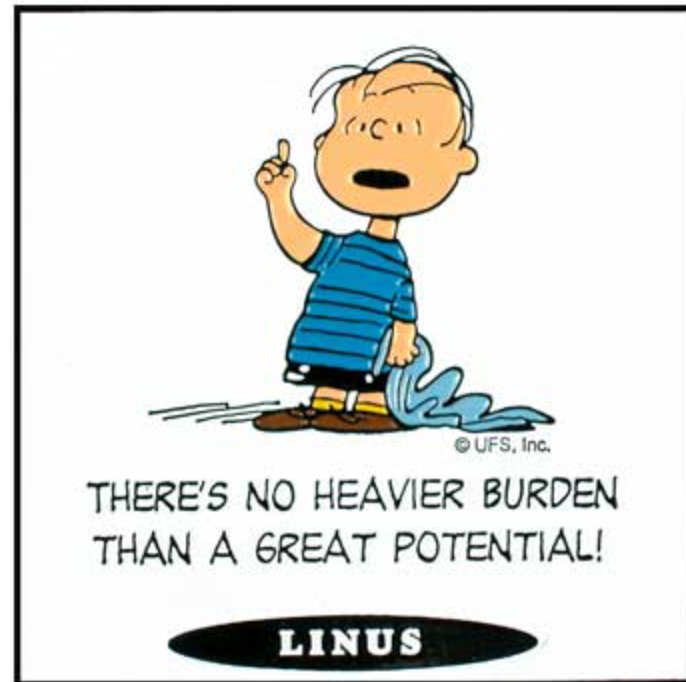
- Customers will continue to demand things the grid cannot deliver: reliability, power quality, security
 - ENE-FARM developing grid-independent option for 2012 in response to customer demand post “3-11”
- Clean, quiet, reliable, efficient fuel cells are the preferred solution for early adopters

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

We Saw “Substantial Potential . . .”

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



Questions?

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