RESILIENTPOWER

A project of CleanEnergyGroup

Hydrogen and Fuel Cells for Resiliency: Secure, Sustainable Resilient Energy for Commercial/ Residential Buildings

July 28, 2016

CleanEnergyGroup

Innovation in Finance, Technology & Policy

Northeast Electrochemical energy storage Cluster

Housekeeping

All participants are in "Listen-Only" mode. Select "Use Mic & Speakers" to avoid toll charges and use your computer's VOIP capabilities. Or select "Use Telephone" and enter your PIN onto your phone key pad.

Submit your questions at any time by typing in the Question Box and hitting Send.

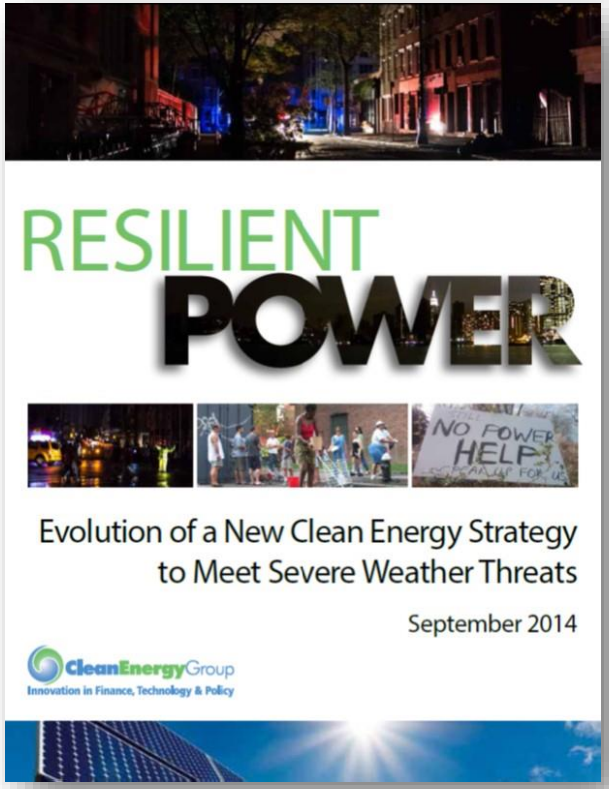
This webinar is being recorded.

You will find a recording of this webinar, as well as previous Resilient Power Project webinars, online at:

www.resilient-power.org

Clean Energy Group (CEG)

CleanEnergyGroup
Innovation in Finance, Technology & Policy



Meridian Institute
Connecting People to Solve Problems

CleanEnergy States Alliance

THE JPB FOUNDATION

Barr Foundation

Cummings Foundation

THE KRESGE FOUNDATION

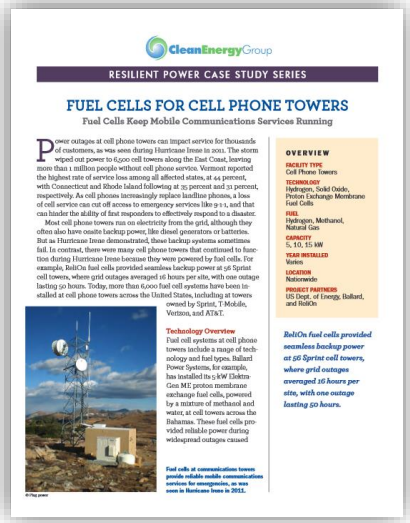
SURDNA FOUNDATION
Fostering sustainable communities in the United States

www.cleanegroup.org

www.resilient-power.org

CEG's Resilient Power Project

- Increase public/private investment in clean, resilient power systems
- Engage city officials to develop resilient power policies/programs
- Protect low-income and vulnerable communities
- Focus on affordable housing and critical public facilities
- Advocate for state and federal supportive policies and programs
- Technical assistance for pre-development costs to help agencies/project developers get deals done
- See www.resilient-power.org for reports, newsletters, webinars, and more.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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR CELL PHONE TOWERS

Fuel Cells Keep Mobile Communications Services Running

Power outages at cell phone towers can impact service for thousands of customers, as was seen during Hurricane Irene in 2011. The storm wiped out power to 6,500 cell towers along the East Coast, leaving more than 1 million people without cell phone service. Vermont reported the highest rate of service loss among all affected states, at 44 percent, with Connecticut and Rhode Island following at 35 percent and 31 percent, respectively. As cell phones increasingly replace landline phones, a loss of cell service can cut off access to emergency services like 9-1-1, and that can hinder the ability of first responders to effectively respond to a disaster.

Most cell phone towers run on electricity from the grid, although they often also have onsite backup power, like diesel generators or batteries. But as Hurricane Irene demonstrated, these backup systems sometimes fail. In contrast, there were many cell phone towers that continued to function during Hurricane Irene because they were powered by fuel cells. For example, ReliOn fuel cells provided seamless backup power at 56 Sprint cell towers, where grid outages averaged 16 hours per site, with one outage lasting 50 hours. Today, more than 6,000 fuel cell systems have been installed at cell phone towers across the United States, including at towers owned by Sprint, T-Mobile, Verizon, and AT&T.

OVERVIEW

FACILITY TYPE
Cell Phone Towers

TECHNOLOGY
Hydrogen, Solid Oxide, Proton Exchange Membrane Fuel Cells

FUEL
Hydrogen, Methanol, Natural Gas

CAPACITY
5, 10, 15 kW

YEAR INSTALLED
Varies

LOCATION
Nationwide

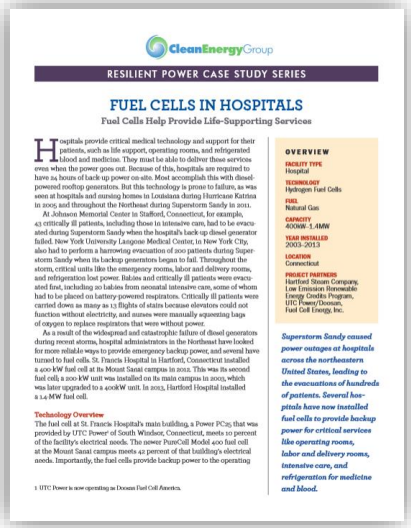
PROJECT PARTNERS
US Dept. of Energy, Ballard, and ReliOn

Technology Overview

Fuel cell systems at cell phone towers include a range of technology and fuel types. Ballard Power Systems, for example, has installed its 5 kW Elektra Gen ME proton membrane exchange fuel cells, powered by a mixture of methanol and water, at cell towers across the Bahamas. These fuel cells provided reliable power during widespread outages caused

ReliOn fuel cells provided seamless backup power at 56 Sprint cell towers, where grid outages averaged 16 hours per site, with one outage lasting 50 hours.

Fuel cells at communications towers provide reliable mobile communications services for emergencies, as was seen in Hurricane Irene in 2011.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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS IN HOSPITALS

Fuel Cells Help Provide Life-Supporting Services

Hospitals provide critical medical technology and support for their patients, such as life support, operating rooms, and refrigerated blood and medicine. They must be able to deliver those services even when the power goes out. Because of this, hospitals are required to have 24 hours of back up power on-site. Most accomplish this with diesel-powered rooftop generators. But this technology is prone to failure, as was seen at hospitals and nursing homes in Louisiana during Hurricane Katrina in 2005 and throughout the Northeast during Superstorm Sandy in 2012.

At Johnson Memorial Center in Stafford, Connecticut, for example, 43 critically ill patients, including those in intensive care, had to be evacuated during Superstorm Sandy when the hospital's back-up diesel generator failed. New York University Langone Medical Center, in New York City, also had to perform a harrowing evacuation of 200 patients during Superstorm Sandy when its backup generators began to fail. Throughout the storm, critical units like the emergency rooms, labor and delivery rooms, and refrigeration lost power. Babies and critically ill patients were evacuated first, including 20 babies from neonatal intensive care, some of whom had to be placed on battery-powered respirators. Critically ill patients were carried down as many as 13 flights of stairs because elevators could not function without electricity, and nurses were manually squeezing bags of oxygen to replace respirators that were without power.

As a result of the widespread and catastrophic failure of diesel generators during recent storms, hospital administrators in the Northeast have looked for more reliable ways to provide emergency backup power, and several have turned to fuel cells. St. Francis Hospital in Hartford, Connecticut installed a 400 kW fuel cell at its Mount Sanai campus in 2012. This was its second fuel cell, a 200 kW unit was installed on its main campus in 2005, which was later upgraded to a 400kW unit. In 2013, Hartford Hospital installed a 1.4 MW fuel cell.

OVERVIEW

FACILITY TYPE
Hospital

TECHNOLOGY
Hydrogen Fuel Cells

FUEL
Natural Gas

CAPACITY
400kW- 1.4MW

YEAR INSTALLED
2003-2013

LOCATION
Connecticut

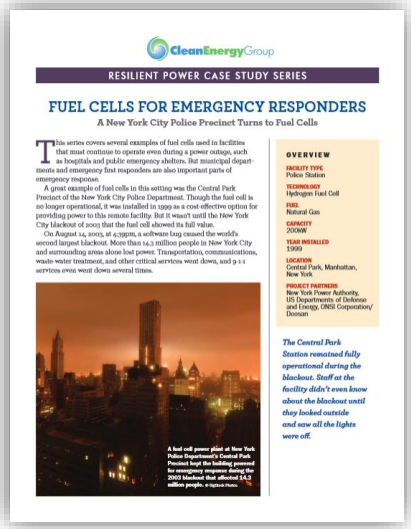
PROJECT PARTNERS
Hartford Steam Company, Low Emission Renewable Energy Credits Program, UTC Power/Doosan, Fuel Cell Energy, Inc.

Technology Overview

The fuel cell at St. Francis Hospital's main building, a Power PC25 that was provided by UTC Power of South Windsor, Connecticut, meets 10 percent of the facility's electrical needs. The newer PureCell Model 400 fuel cell at the Mount Sanai campus meets 42 percent of that building's electrical needs. Importantly, the fuel cells provide backup power to the operating

1 UTC Power is now operating as Doosan Fuel Cell America.

Superstorm Sandy caused power outages at hospitals across the northeastern United States, leading to the evacuations of hundreds of patients. Several hospitals have now installed fuel cells to provide backup power for critical services like operating rooms, labor and delivery rooms, intensive care, and refrigeration for medicine and blood.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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR EMERGENCY RESPONDERS

A New York City Police Precinct Turns to Fuel Cells

This series covers several examples of fuel cells used in facilities that must continue to operate even during a power outage, such as hospitals and public emergency shelters. But municipal departments and emergency first responders are also important parts of emergency response.

A great example of fuel cells in this setting was the Central Park Precinct of the New York City Police Department. Though the fuel cell is no longer operational, it was installed in 1999 as a cost-effective option for providing power to this remote facility. But it wasn't until the New York City blackout of 2003 that the fuel cell showed its full value.

On August 14, 2003, at 4:10pm, a software bug caused the world's second largest blackout. More than 14.3 million people in New York City and surrounding areas alone lost power. Transportation, communications, waste-water treatment, and other critical services went down, and 911 services even went down several times.

A fuel cell power plant at New York Police Department's Central Park Precinct kept the building powered for emergency response during the 2003 blackout that affected 14.3 million people. © Peyton Hoyt

OVERVIEW

FACILITY TYPE
Police Station

TECHNOLOGY
Hydrogen Fuel Cell

FUEL
Natural Gas

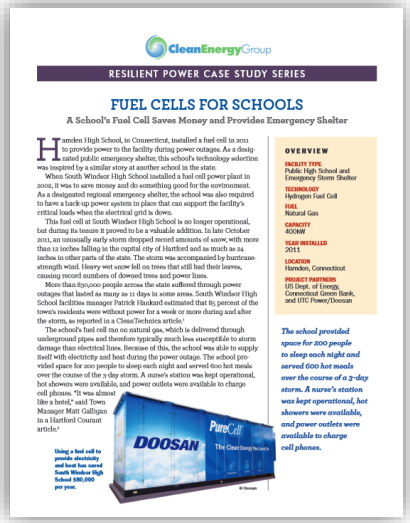
CAPACITY
200kW

YEAR INSTALLED
1999

LOCATION
Central Park, Manhattan, New York

PROJECT PARTNERS
New York Power Authority, US Departments of Defense and Energy, ONSI Corporation/ Doosan

The Central Park Station remained fully operational during the blackout. Staff at the facility didn't even know about the blackout until they looked outside and saw all the lights were off.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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR SCHOOLS

A School's Fuel Cell Saves Money and Provides Emergency Shelter

Hamden High School, in Connecticut, installed a fuel cell in 2011 to provide power to the facility during power outages. As a designated public emergency shelter, this school's technology selection was inspired by a similar story at another school in the state.

When South Windsor High School installed a fuel cell power plant in 2010, it was to save money and do something good for the environment. As a designated regional emergency shelter, the school was also required to have a back-up power system in place that can support the facility's critical loads when the electrical grid is down.

This fuel cell at South Windsor High School is no longer operational, but during its tenure it proved to be a valuable addition. In late October 2011, an unusually early storm dropped record amounts of snow, with more than 12 inches falling in the capital city of Hartford and as much as 24 inches in other parts of the state. The storm was accompanied by hurricane-strength wind. Heavy wet snow fell on trees that still had their leaves, causing record numbers of downed trees and power lines.

More than 830,000 people across the state suffered through power outages that lasted as many as 11 days in some areas. South Windsor High School facilities manager Patrick Haskard estimated that 85 percent of the town's residents were without power for a week or more during and after the storm, as reported in a CleanTechnica article.[1]

The school's fuel cell ran on natural gas, which is delivered through underground pipes and therefore typically much less susceptible to storm damage than electrical lines. Because of this, the school was able to supply itself with electricity and heat during the power outage. The school provided space for 200 people to sleep each night and served 600 hot meals over the course of a 3-day storm. A nurse's station was kept operational, hot showers were available, and power outlets were available to charge cell phones. "It was almost like a hotel," said Town Manager Matt Galligan in a Hartford Courant article.[1]

OVERVIEW

FACILITY TYPE
Public High School and Emergency Storm Shelter

TECHNOLOGY
Hydrogen Fuel Cell

FUEL
Natural Gas

CAPACITY
400kW

YEAR INSTALLED
2011

LOCATION
Hamden, Connecticut

PROJECT PARTNERS
US Dept. of Energy, Connecticut Green Bank, and UTC Power/Doosan

The school provided space for 200 people to sleep each night and served 600 hot meals over the course of a 3-day storm. A nurse's station was kept operational, hot showers were available, and power outlets were available to charge cell phones.

Using a fuel cell to provide electricity and heat has saved South Windsor High School $80,000 per year.

Northeast Electrochemical Energy Storage Cluster (NEESC)

NEESC is a network of industry, academic, government and non-governmental leaders working together to help businesses provide energy storage solutions.

Northeast Electrochemical energy storage Cluster

www.neesc.org

Today's Guest Speakers

- **Bruce R. Becker**, President and Owner, Becker and Becker Associates, Inc.
- **Jesse E. Hayes**, Product Manager, Doosan Fuel Cell America, Inc.

BECKER + BECKER

DISTRIBUTED GENERATION WITH FUEL CELLS IN MIXED-USE BUILDINGS

POWERING THE FIRST 1285 HOMES

360 State Street, the Octagon
and now . . . 777 Main Street

BRUCE R. BECKER, AIA, LEED AP

CT CENTER FOR ADVANCED TECHNOLOGY

JULY 28, 2016

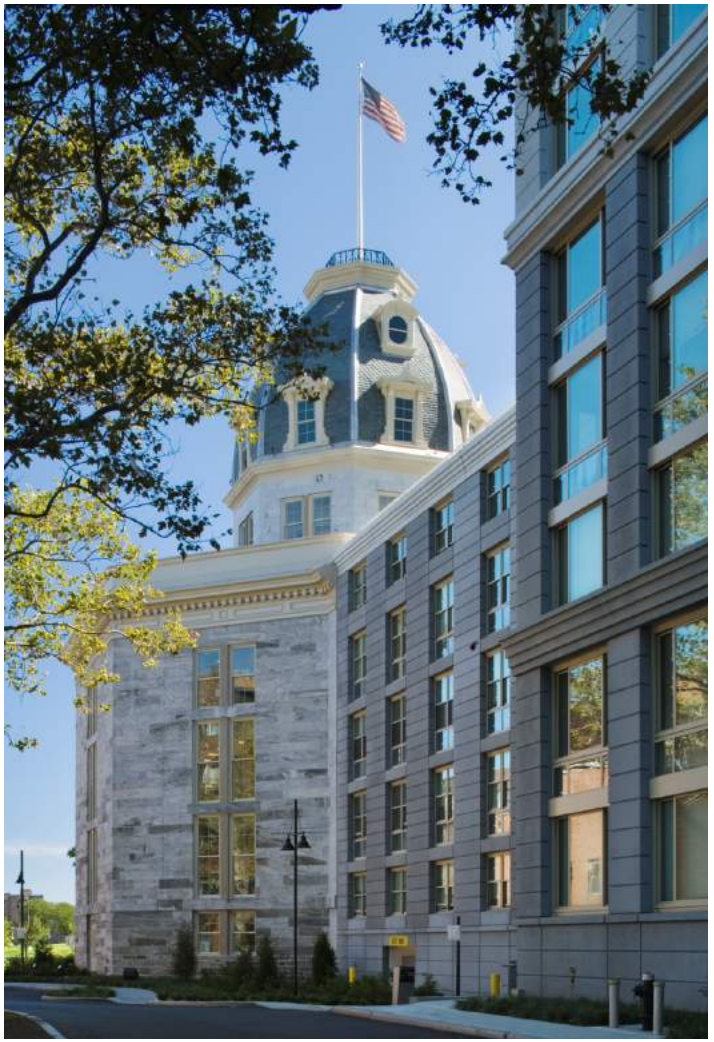
FIRM PROFILE

Experience

Over the past 60 years, **Becker + Becker** has participated in the planning, design and development of master planned communities with over 3,000 apartments including 1,200 affordable housing units. We pride ourselves on our successful **integration** of planning, development, design and preservation experience.

Mission

B+B focuses on understanding and addressing distinct community needs to develop spaces that are architecturally innovative, socially interactive, community-focused, **environmentally sustainable** and economically strong.



The Octagon Apartments

Existing
Multi-Family Housing
Fuel Cell Installation
2010-2011

Developer/Architect:
Becker + Becker

Investment Partner:
Kennedy Associates | MEPT

Engineer:
LN Consulting

The Octagon
New York, New York

The Site – Roosevelt Island, NYC

CASE STUDY

Development – 550,000 SF | 500 Units

The Octagon
New York, New York

Sustainability – Certified LEED® Silver

The Octagon
New York, New York

The Octagon uses 35% less energy than a baseline residential building… **and we continue to make it greener**

LEED

LEED-NC Version 2.1 Registered Project Checklist
Octagon Park Apartments, Roosevelt Island
888 Main Street, New York, NY 10044

Yes	?	No		
9	**4**		**Sustainable Sites**	**14** Points
Y			Prereq 1 **Erosion & Sedimentation Control**	Required
			Credit 1 **Site Selection**	1
1			Credit 2 **Development Density**	1
1			Credit 3 **Brownfield Redevelopment**	1
1			Credit 4.1 **Alternative Transportation**, Public Transportation Access	1
1			Credit 4.2 **Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1			Credit 4.3 **Alternative Transportation**, Alternative Fuel Vehicles	1
1			Credit 4.4 **Alternative Transportation**, Parking Capacity and Carpooling	1
	?		Credit 5.1 **Reduced Site Disturbance**, Protect or Restore Open Space	1
1			Credit 5.2 **Reduced Site Disturbance**, Development Footprint	1
	?		Credit 6.1 **Stormwater Management**, Rate and Quantity	1
	?		Credit 6.2 **Stormwater Management**, Treatment	1
1			Credit 7.1 **Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
	?		Credit 7.2 **Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
1			Credit 8 **Light Pollution Reduction**	1
	3	**2**	**Water Efficiency**	**5** Points
	?		Credit 1.1 **Water Efficient Landscaping**, Reduce by 50%	1
		1	Credit 1.2 **Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		1	Credit 2 **Innovative Wastewater Technologies**	1
	?		Credit 3.1 **Water Use Reduction**, 20% Reduction	1
	?		Credit 3.2 **Water Use Reduction**, 30% Reduction	1
5	**1**	**4**	**Energy & Atmosphere**	**17** Points
Y			Prereq 1 **Fundamental Building Systems Commissioning**	Required
Y			Prereq 2 **Minimum Energy Performance**	Required
Y			Prereq 3 **CFC Reduction in HVAC&R Equipment**	Required
3			Credit 1 **Optimize Energy Performance**	1 to 10
		1	Credit 2.1 **Renewable Energy**, 5%	1
		1	Credit 2.2 **Renewable Energy**, 10%	1
		1	Credit 2.3 **Renewable Energy**, 20%	1
1			Credit 3 **Additional Commissioning**	1
		1	Credit 4 **Ozone Depletion**	1
1			Credit 5 **Measurement & Verification**	1
	?		Credit 6 **Green Power**	1

continued...

Yes	?	No		
5	**1**	**6**	**Materials & Resources**	**13** Points
Y			Prereq 1 **Storage & Collection of Recyclables**	Required
		1	Credit 1.1 **Building Reuse**, Maintain 75% of Existing Shell	1
		1	Credit 1.2 **Building Reuse**, Maintain 100% of Shell	1
		1	Credit 1.3 **Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1			Credit 2.1 **Construction Waste Management**, Divert 50%	1
	?		Credit 2.2 **Construction Waste Management**, Divert 75%	1
	1		Credit 3.1 **Resource Reuse**, Specify 5%	1
		1	Credit 3.2 **Resource Reuse**, Specify 10%	1
1			Credit 4.1 **Recycled Content**, Specify 5% (post-consumer + ½ post-industrial)	1
1			Credit 4.2 **Recycled Content**, Specify 10% (post-consumer + ½ post-industrial)	1
1			Credit 5.1 **Local/Regional Materials**, 20% Manufactured Locally	1
1			Credit 5.2 **Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
		1	Credit 6 **Rapidly Renewable Materials**	1
		1	Credit 7 **Certified Wood**	1
13	**2**		**Indoor Environmental Quality**	**15** Points
Y			Prereq 1 **Minimum IAQ Performance**	Required
Y			Prereq 2 **Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1 **Carbon Dioxide** (CO_2) **Monitoring**	1
1			Credit 2 **Ventilation Effectiveness**	1
1			Credit 3.1 **Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2 **Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1 **Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2 **Low-Emitting Materials**, Paints	1
1			Credit 4.3 **Low-Emitting Materials**, Carpet	1
1			Credit 4.4 **Low-Emitting Materials**, Composite Wood & Agrifiber	1
1			Credit 5 **Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1 **Controllability of Systems**, Perimeter	1
	?		Credit 6.2 **Controllability of Systems**, Non-Perimeter	1
1			Credit 7.1 **Thermal Comfort**, Comply with ASHRAE 55-1992	1
	?		Credit 7.2 **Thermal Comfort**, Permanent Monitoring System	1
1			Credit 8.1 **Daylight & Views**, Daylight 75% of Spaces	1
1			Credit 8.2 **Daylight & Views**, Views for 90% of Spaces	1
2			**Innovation & Design Process**	**5** Points
1			Credit 1.1 **Innovation in Design**: AVAC Underground Garbage Removal System	1
			Credit 1.2 **Innovation in Design**: Provide Specific Title	1
			Credit 1.3 **Innovation in Design**: Provide Specific Title	1
			Credit 1.4 **Innovation in Design**: Provide Specific Title	1
1			Credit 2 **LEED™ Accredited Professional**	1
34	**11**	**12**	**Project Totals** (pre-certification estimates)	**69** Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

CASE STUDY

Renewable Power

The Octagon
New York, New York

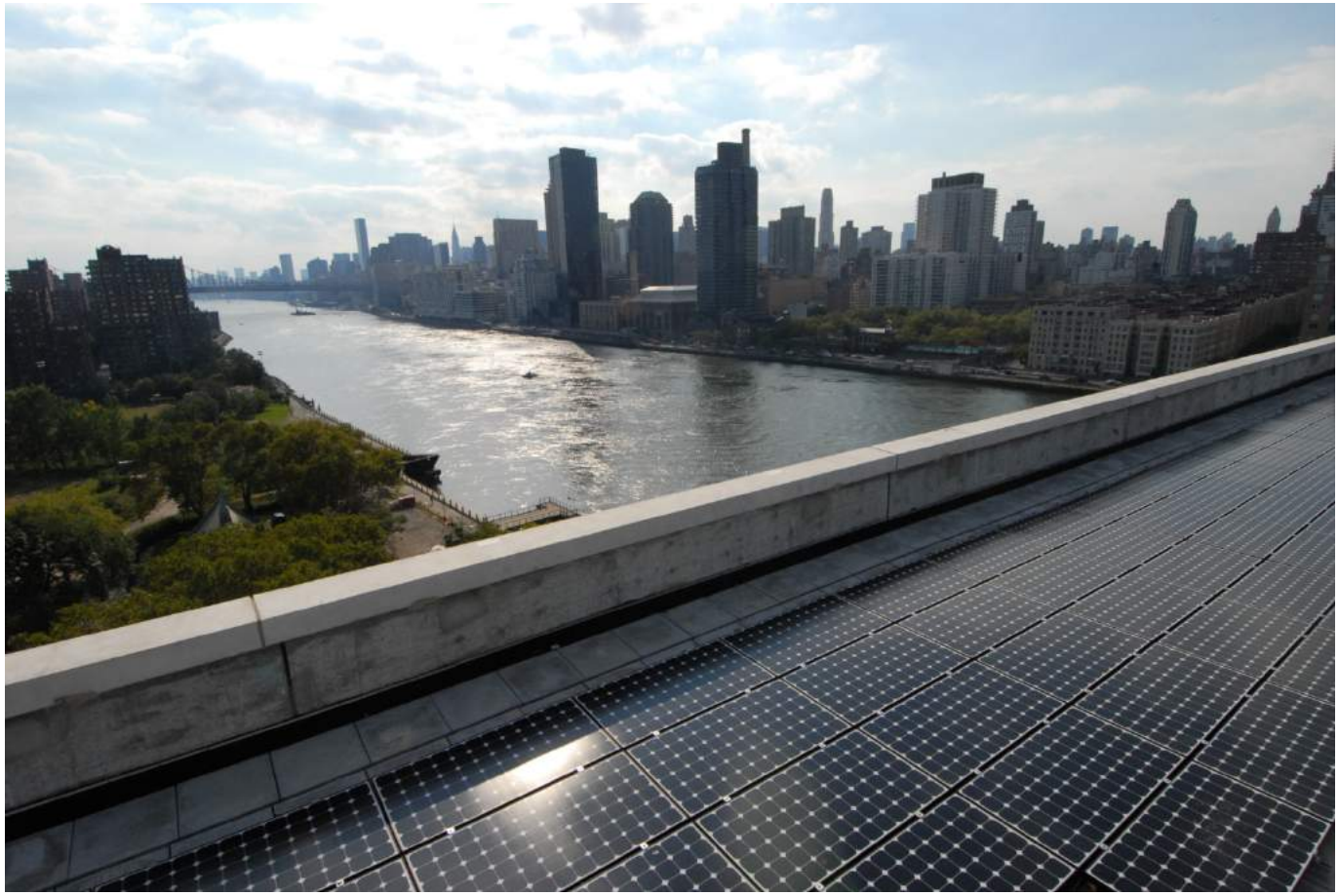


Image of the Octagon 50 KW Photovoltaic array – the Largest Array in New York City

CASE STUDY

The Octagon
New York, New York

Fuel Cell Analysis

- Base Load: 600 KW
- 24/7 demand for heat/hot water
- Financial Incentives:
  - Federal Fuel Cell Tax Credits
  - NYSERDA DG CHP Demonstration Program Grant
- Submetering permitted
- Construction/Design challenges with existing building

CASE STUDY

The Octagon
New York, New York

Fuel Cell Installation

- Installation: Fall 2010, 6 months
- Electric Utilization: 100%
  - Provide electric to 500 residents and all common areas
  - Excess will go back to utility grid, but without reimbursement
- Waste heat Utilization: 70%
- Waste heat will be used for domestic hot water heating and space heating
- Fuel Cell life: 20 years with stack overhaul in year 10

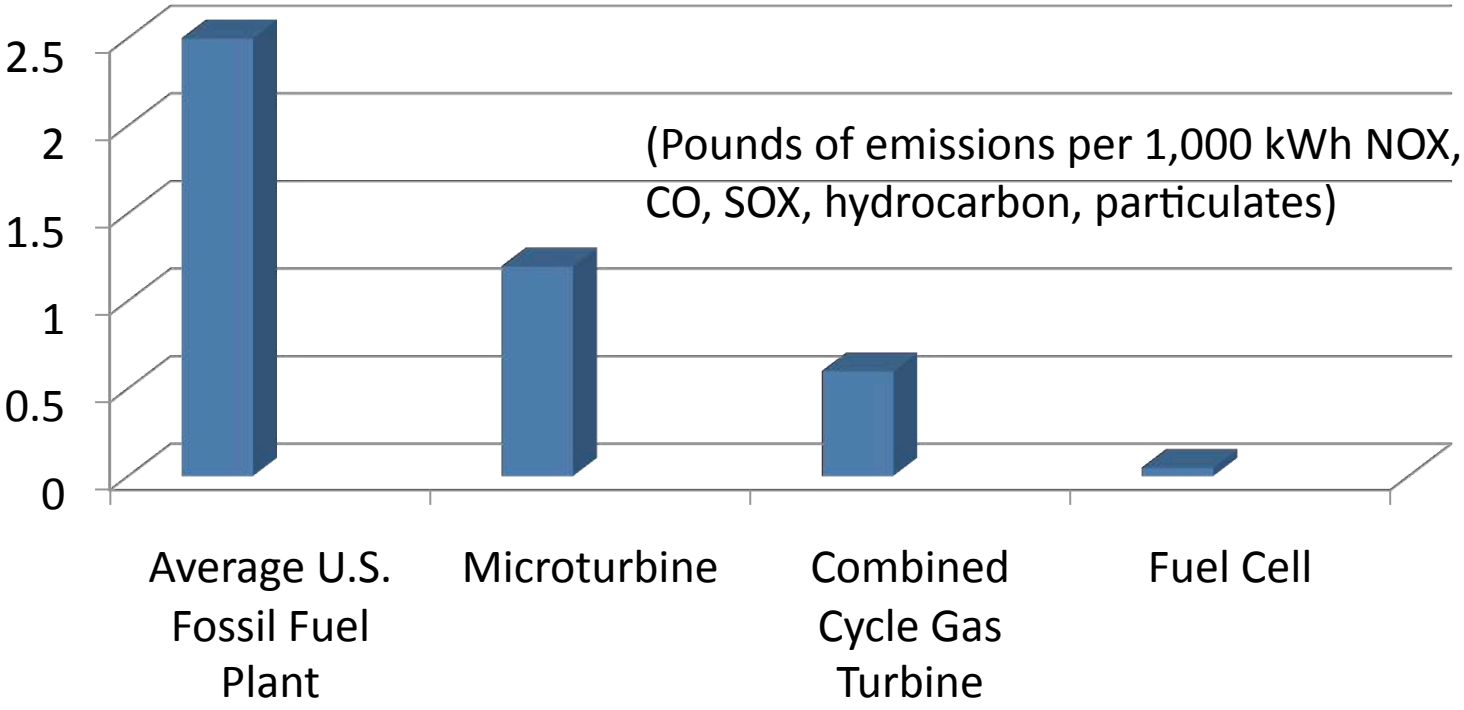
Fuel Cell Economics

- Total Install Cost: +$3,000,000
  - $2,175,000 for fuel cell unit + installation and existing system tie-in and upgrades
- Total Incentives: $1,200,000
  - NYSERDA Grant $1,200,000 upfront
  - Federal Tax Credit: $3,000/ kWh or 30% of install cost: $1,200,000
- Annual Energy Cost Savings: $221,500
- Payback without incentives: 14 Years (not including stack overhaul in Yr. 10)
- Payback with incentives: 5 Years

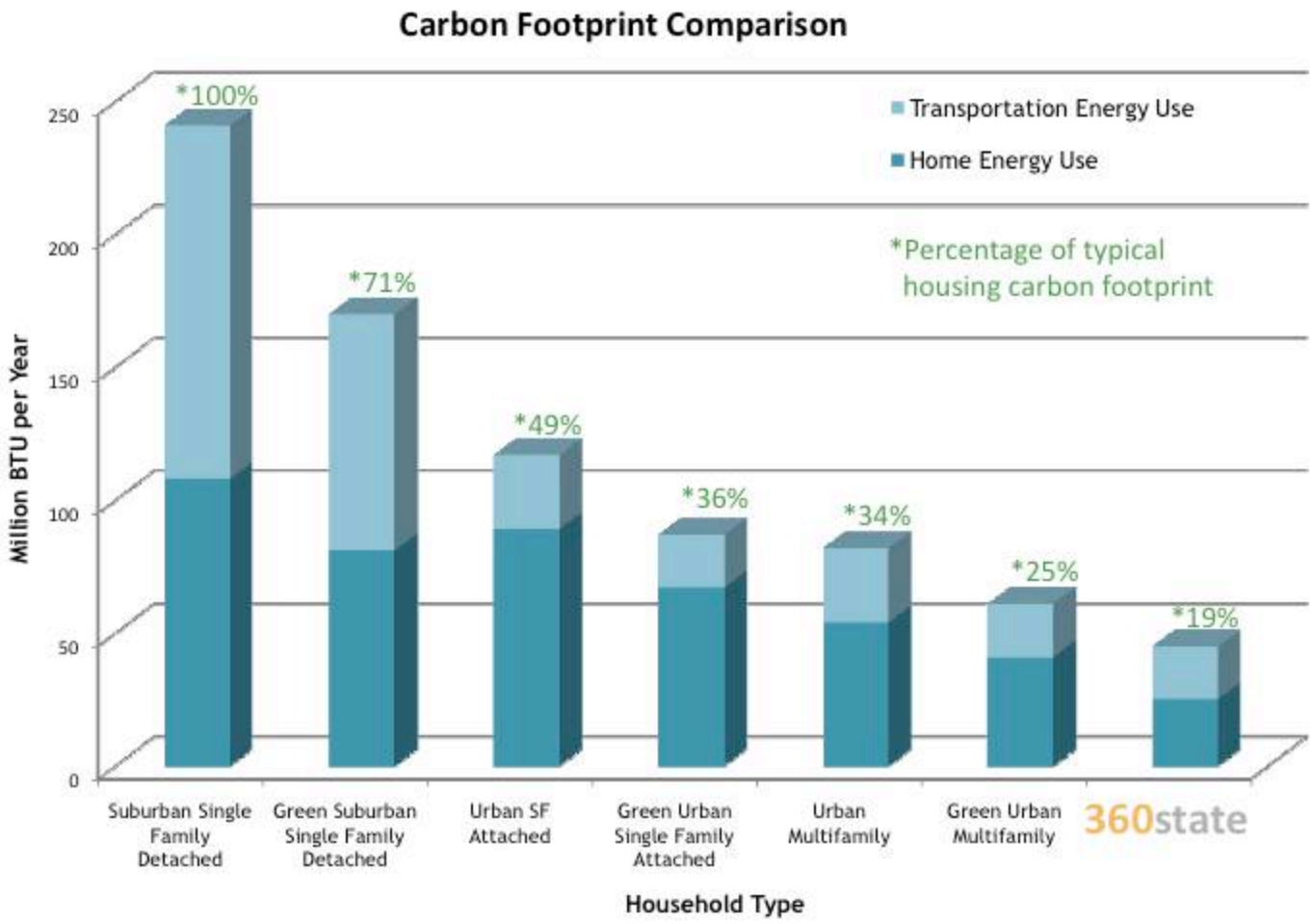
Reduced Emissions

Fuel cell creates 1 ounce of pollution per 1,000 kWh of electricity produced

Combustion generation creates 25 lbs of pollutants per 1,000 kWh of electricity produced



Carbon Footprint



360 STATE STREET

New Haven, Connecticut

Case Study

Urban Infill, Mixed-use, Mixed-Income, Transit-oriented community

Fall 2008 - Fall 2010

Awards:

American Planning Association, CT Chapter, 2011 Special Chapter Award

US Green Building Council, CT Chapter, 2011 Award of Honor

1000 Friends of Connecticut 2010 Smartie Award

Connecticut Fund For The Environment 2010 Annual Meeting Award

LEED Platinum Certification

The Site – walk score® of 95

360 State Street is one Block from New Haven Green, Yale University, the Central Business District, and Transit Hub

360 STATE STREET

New Haven, Connecticut

Development Program | 680,000 SF

Residential

500 rental apartments | 50 affordable
Studios, 1 bedroom – 3 bedroom
Market Rent: $1,300 - $5,000

Commercial

30,000 SF retail and office, bike shop, and community-owned food co-op, **Elm City Market**

Public Parking

4 story structured parking garage for 500 cars, Zipcars, and electric car charging stations

Common Amenities

32,000 SF of amenities:
½ acre **Green Roof** and pool, art gallery, library, fitness center, yoga studio, theater, communal living room and kitchen, business center, children's playroom, bicycle parking

Retail – Elm City Market

Elm City Market's mission to provide healthy, affordable food to local consumers meets a key need of an underserved community. It benefits the community in many important ways:

- Brought a full-service grocery store to the downtown – offering natural, organic and conventional groceries
- Supports local & regional farmers by purchasing $4 million annually from 200 growers and providers
- 110 construction jobs and 80 new retail jobs
- ECM works with a local job training non-profit, Strive, to help new employees become effective team members and advance their careers at the market.

Amenities – Community Living Room

The Living Room and Club Room offer cooking and dinging facilities, overlooking the green roof terrace

Green Roof

Amenities – Fitness Center

The Fitness Center and Yoga Studio overlook the Long Island Sound

Amenities – Half Acre Green Roof and Pool

6th Floor Terrace offers views of the city and Long Island Sound

Residences

360 State Street Two Bedroom Apartment Living Room

Residences

360 State Street Master Bedroom

CASE STUDY

Renewables Considered

360 STATE STREET
New Haven, Connecticut

CASE STUDY

360 STATE STREET
New Haven, Connecticut

Fuel Cell Analysis

- Base Load: 475 KW
- 24/7 demand for heat/hot water
- Financial Incentives:
  - Federal Fuel Cell Tax Credits
  - CT CEF Fuel Cell Grant
  - Fuel Cell Class I Renewable for RECs
  - Discounted DG gas rate

CASE STUDY

Fuel Cells and Residential Development

360 STATE STREET
New Haven, Connecticut

- 16.7 million multi-family housing units in the U.S.
- Consume 117 billion kWh of electricity per year (21% of US energy usage)
- 0.8% of electricity to multi-family housing is provided by renewable power

Source: EIA, 2009 RECS update

400 KW fuel cell provides 3.4 million kWh of electricity per year

35,000 fuel cells could take all multi-family buildings off the grid

How a Fuel Cell Works

Step Two: Hydrogen and air are combined in an electrochemical process to produce power, water and heat. The byproduct water is utilized in the operation of the power plant. The usable heat is available for meeting the facility's thermal energy needs.

Fuel Cell Stack

Image: UTC Power

How a Fuel Cell Works

Step Three: The DC power provided by the Fuel Cell Stack is conditioned to provide high quality Alternating Current (AC) power output.

Power Conditioner

Image: UTC Power

Fuel Cell Efficiency

- Fuel Cells are combustion free, ergo they have high efficiencies in converting chemical energy into electrical energy
- Typical electric efficiency is 50%
  - 50% of the hydrogen energy content is converted into electric energy and 50% is converted into heat energy.
- Heat energy is reused in the facility to heat domestic hot water, space heating, and absorption chilling, raising the overall efficiency to +85%.
- Traditional power plant efficiency = 25%-35%

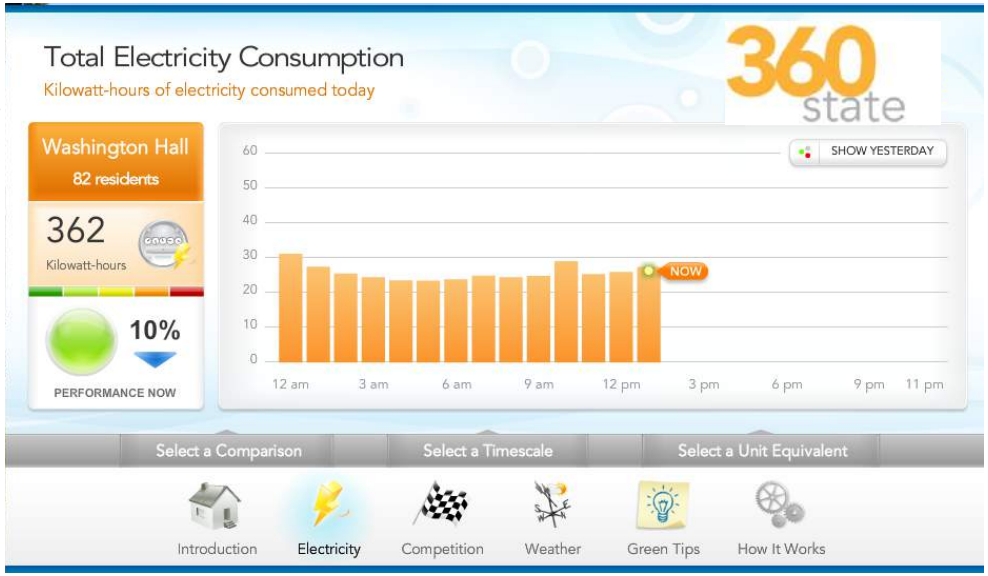
CASE STUDY

Fuel Cells and Policy

360 STATE STREET
New Haven, Connecticut

Regulations

- Submetering for residential development permitted by 2013 law, regulations issued 201
- Net Metering permitted for meter connected to renewable source only
- Net Metering reimbursable rate at wholesale time of export rate



Sustainability – LEED® ND Platinum

360 State Street uses 55% less energy than a baseline residential building

82 Points Achieved — Possible Points: 106

Certified 40 to 49 points · Silver 50 to 59 points · Gold 60 to 69 points · Platinum 80 or more points

26 Smart Location & Linkage — Possible Points: 30

Y	Prereq 1	Smart Location, Option 1	
Y	Prereq 2	Proximity to Water & Wastewater Infrastructure, Option 1	
Y	Prereq 3	Imperiled Species & Ecological Communities, No Species	
Y	Prereq 4	Wetland & Water Body Conservation, Option 1	
Y	Prereq 5	Agricultural Land Conservation, Option 2	
Y	Prereq 6	Floodplain Avoidance, Option 1	
2	Credit 1	Brownfields Redevelopment	2
1	Credit 2	High Priority Brownfields Redevelopment	1
8	Credit 3	Preferred Locations	10
8	Credit 4	Reduced Automobile Dependence, Options 1 & 3	8
1	Credit 5	Bicycle Network	1
3	Credit 6	Housing & Jobs Proximity, Option 1	3
1	Credit 7	School Proximity	1
1	Credit 8	Steep Slope Protection, Option 1	1
1	Credit 9	Site Design for Habitat or Wetland Conservation, Option 2	1
	Credit 10	Restoration of Habitat or Wetlands	1
	Credit 11	Conservation Management of Habitat or Wetlands	1

34 Neighborhood Pattern & Design — Possible Points: 39

Y	Prereq 1	Open Community	
Y	Prereq 2	Compact Development	
7	Credit 1	Compact Development	7
4	Credit 2	Diversity of Uses	4
3	Credit 3	Diversity of Housing Types	3
	Credit 4	Affordable Rental Housing	2
	Credit 5	Affordable For-Sale Housing	2
2	Credit 6	Reduced Parking Footprint	2
8	Credit 7	Walkable Streets	8
2	Credit 8	Street Network, Option 1	2
1	Credit 9	Transit Facilities	1
2	Credit 10	Transportation Demand Management, Options 2 & 3	2
	Credit 11	Access to Surrounding Vicinity	1
1	Credit 12	Access to Public Spaces	1
1	Credit 13	Access to Active Spaces, Option 1	1
1	Credit 14	Universal Accessibility	1
1	Credit 15	Community Outreach & Involvement	1
1	Credit 16	Local Food Production, Option 3	1

16 Green Construction & Technology — Possible Points: 31

Y	Prereq 1	Construction Activity Pollution Prevention	
	Credit 1	LEED Certified Green Buildings	3
3	Credit 2	Energy Efficiency in Buildings	3
1	Credit 3	Reduced Water Use, Option 1	3
	Credit 4	Building Reuse & Adaptive Reuse	2
	Credit 5	Reuse of Historic Buildings	1
1	Credit 6	Minimize Site Disturbance through Site Design, Option 1	1
1	Credit 7	Minimize Site Disturbance during Construction, Option 1	1
	Credit 8	Contaminant Reduction in Brownfields Remediation	1
5	Credit 9	Stormwater Management, Feb 2007 Version, Option 1	5
1	Credit 10	Heat Island Reduction, Option 1	1
	Credit 11	Solar Orientation	1
1	Credit 12	On-Site Energy Generation, Option 2	1
	Credit 13	On-Site Renewable Energy Sources	1
	Credit 14	District Heating & Cooling	1
	Credit 15	Infrastructure Energy Efficiency	1
	Credit 16	Wastewater Management	1
1	Credit 17	Recycled Content in Infrastructure	1
1	Credit 18	Construction Waste Management	1
1	Credit 19	Comprehensive Waste Management	1
	Credit 20	Light Pollution Reduction	1

6 Innovation & Design Process — Possible Points: 6

1	Credit 1.1	Innovation in Design: Exemplary Performance in SLLc6	1
1	Credit 1.2	Innovation in Design: Exemplary Performance in SLLc4	1
2	Credit 1.3	Innovation in Design: Exemplary Performance in GCTc12	1
1	Credit 1.4	Innovation in Design: Green Building Education	1
	Credit 1.5	Innovation in Design	1
1	Credit 2	LEED Accredited Professional	1

CASE STUDY

Fuel Cell Installation

360 STATE STREET
New Haven, Connecticut

Sustainability – Renewable Power and Heat

400 KW Fuel Cell and CHP System Produce 90% of the Building need for Electricity, Heat, and Hot Water

Fuel Cell Efficiency

Electric Utilization: 65% (100% soon)

- Provide electric to all common and commercial areas: 65% of fuel cell's capacity – to apartments once regulations finalized
- Excess will go back to utility grid with reimbursement

Heat Utilization: 90%

- Waste heat will be used for domestic hot water heating, space heating, and pool heating. Excess heat is stored in thermal storage tanks

Fuel Cell life: 20 years with stack overhaul in year 10.

Fuel Cell Economics

Total Investment: $3,500,0000 (Fuel Cell Cost: $1,875,000)

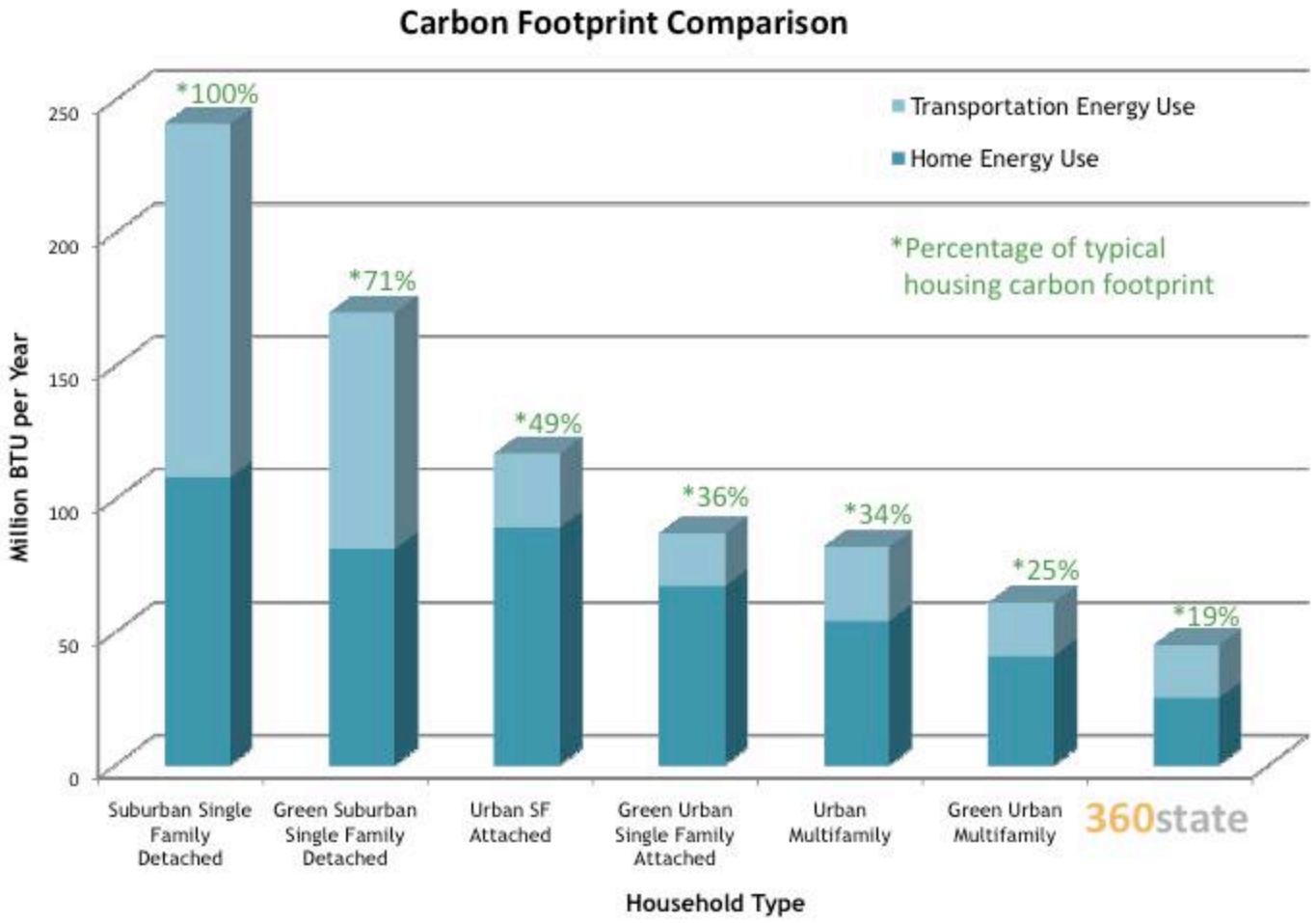
Incentives:

- CT CEF Grant: $985,000 (30% held back with 100% of Energy Conscious Blueprint grant)
- Federal Tax Credit: $3,000/ kWh or 30% of install cost: $1,200,000
- REC sales, approximately $50,000 per year depending on REC market pricing
- DG natural gas rate- discount in CT removing distribution charges

Annual Avoided Energy Costs by Landlord + Sale: $295,000

Payback with incentives: 5 Years | without incentives: 13 Years

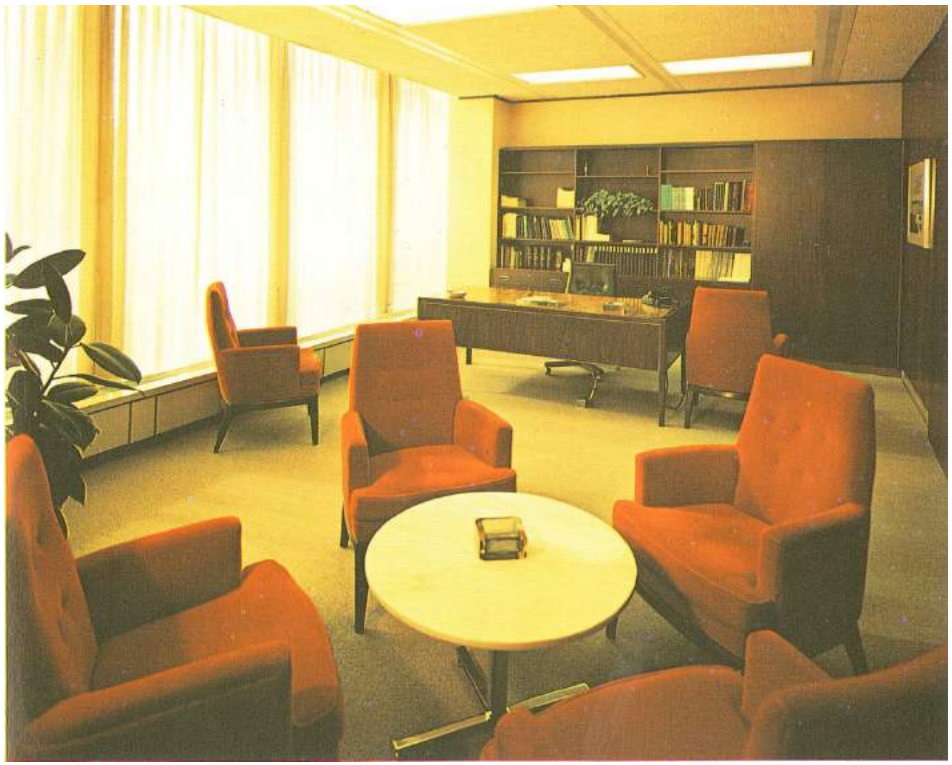
Sustainability – Gentle Footprint

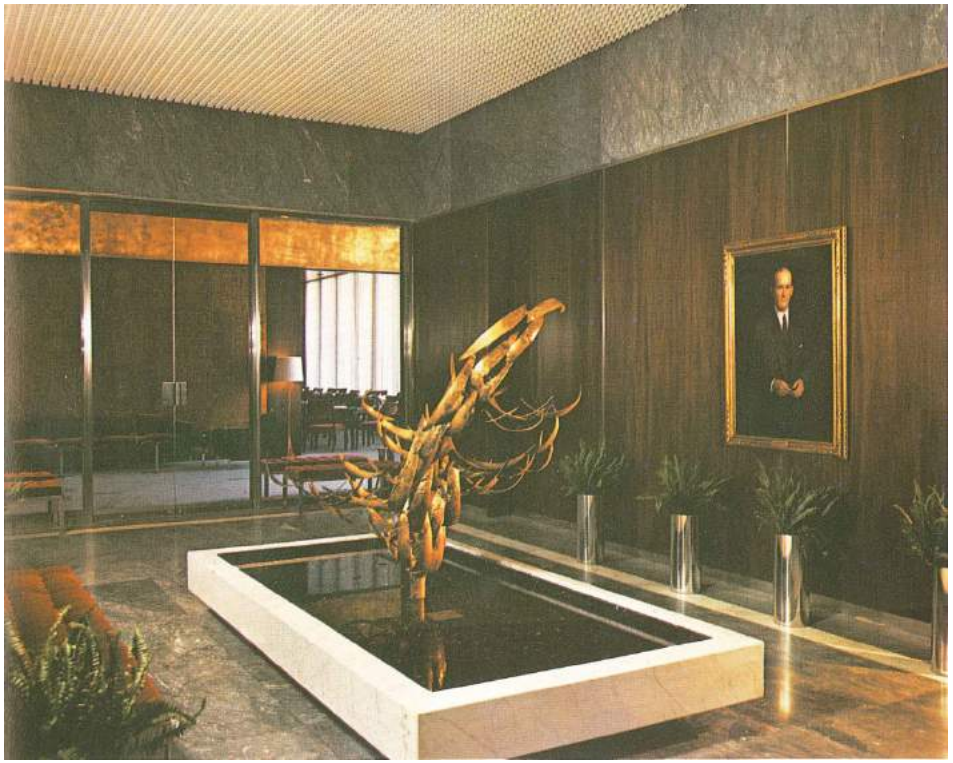


360 STATE STREET

New Haven, Connecticut

Site History





Images from Total Design: The Architecture of William Becket and Associates, William Dudley Hunt, Jr. FAIA, McGraw Hill Book Company. 1972

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Hartford, Connecticut

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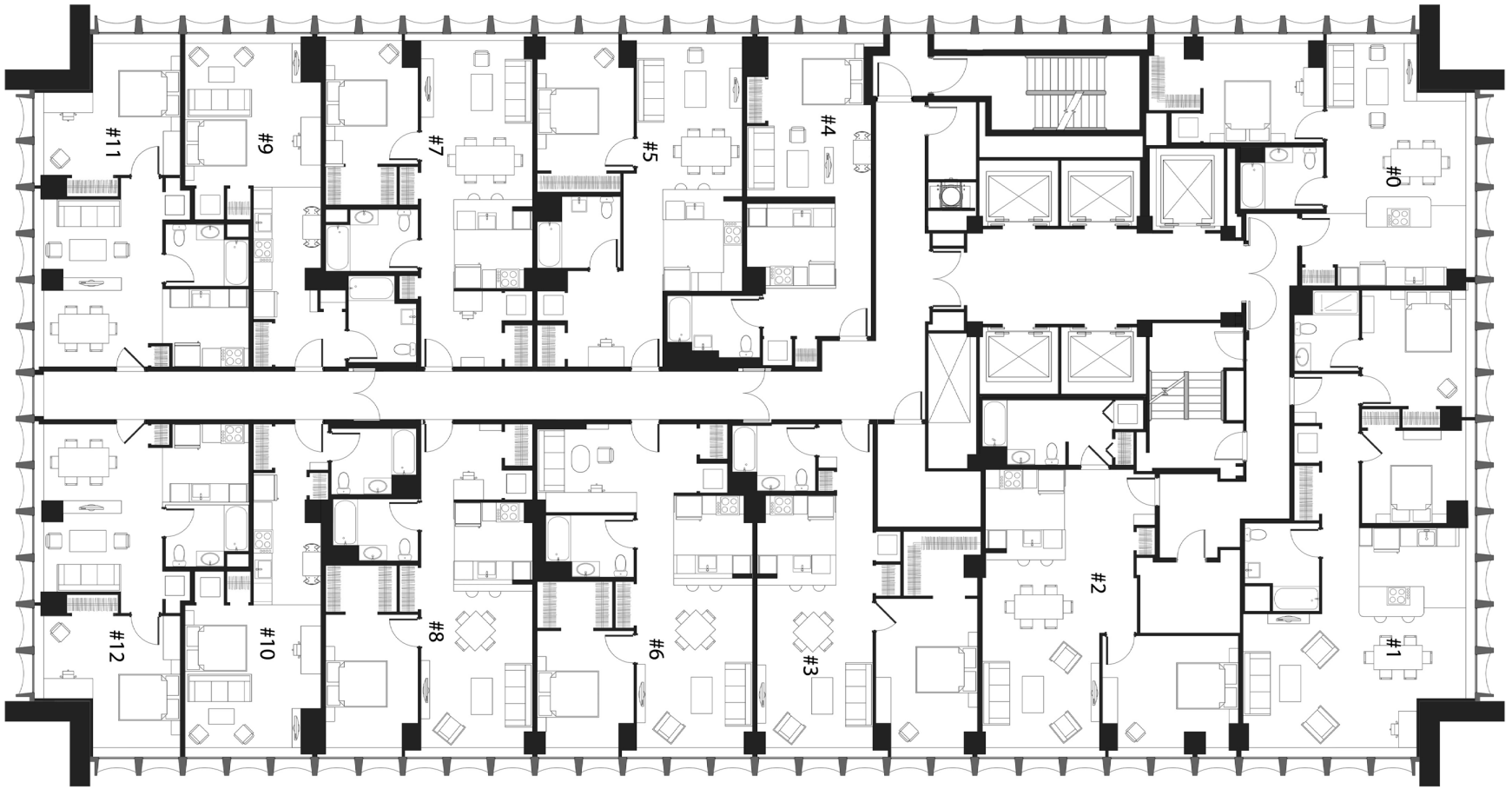
Typical Floor Plan

Levels 17-25



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Site History

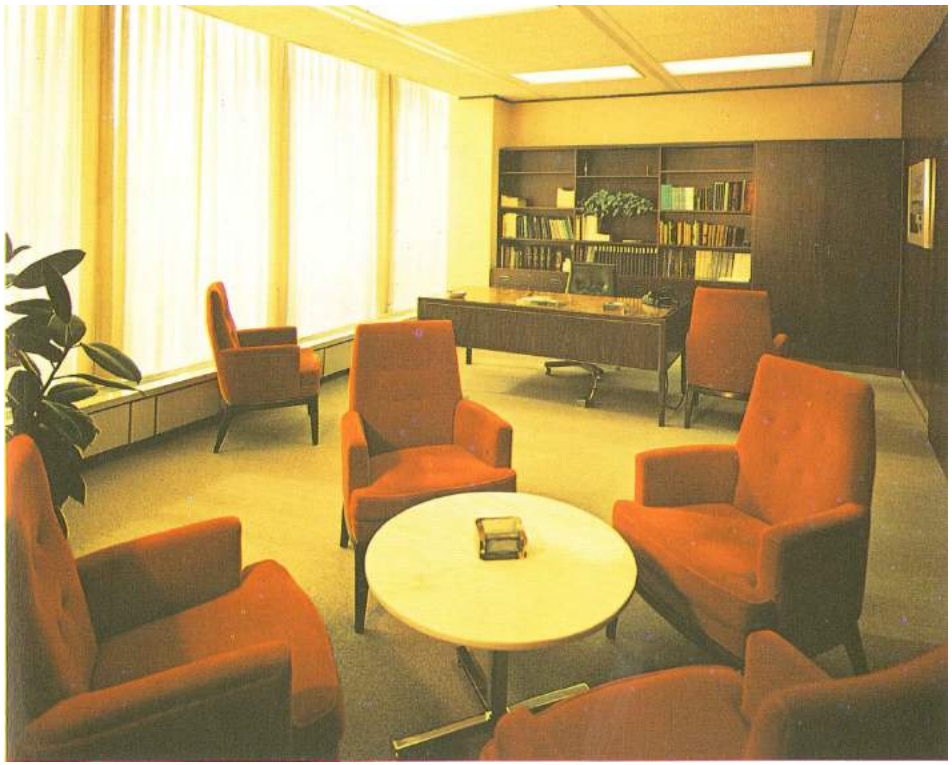
The state's first bank**, Hartford Bank,** was organized on the site at Bull's Tavern in 1792 and operated here through 1811.

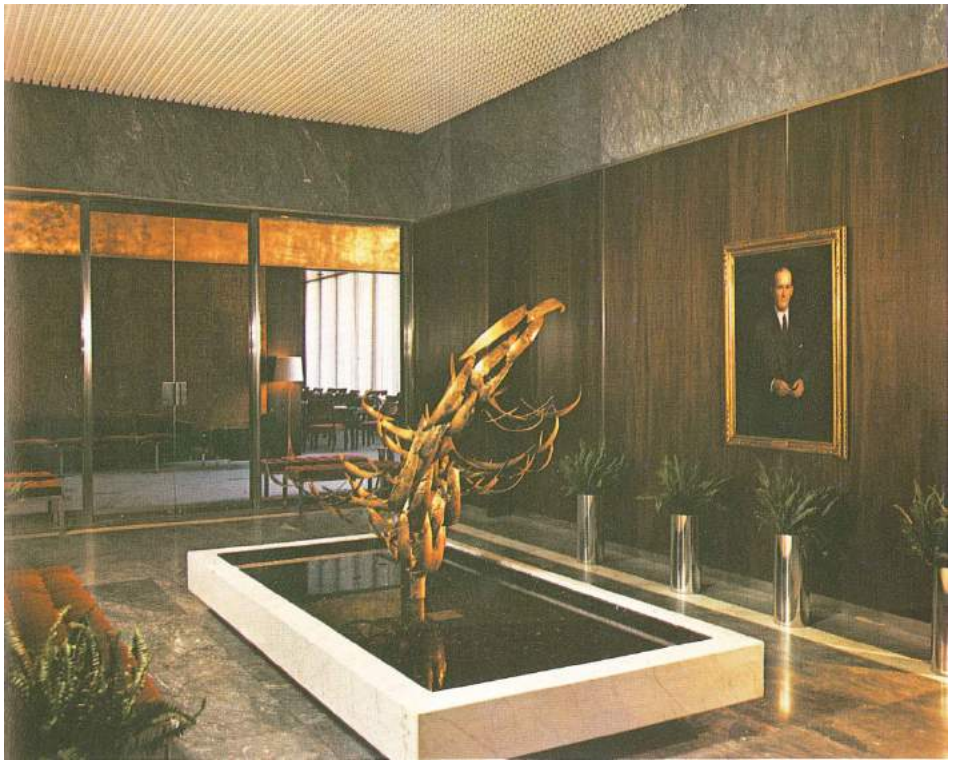
After a century down the street**,** Hartford Bank moved back to the site in 1928 into a second-empire style building.

In the 1960s**,** Hartford Bank demolished the building to make way for their new tower by renowned Los Angeles mid-century modern architect **Welton Becket,** FAIA (1902-1969).

The building was the second tallest building in the city**,** a symbol of the Bank's confidence in the city's future.

Site History





Images from Total Design: The Architecture of William Becket and Associates, William Dudley Hunt, Jr. FAIA, McGraw Hill Book Company. 1972


HARTFORD NATIONAL BANK

777 MAIN STREET

Hartford, Connecticut

Redevelopment Opportunity

Prominent Central Location

• Location at the corner of Main Street and Pearl Street – across from State House Square

• Within 3 blocks of over 8 million SF of office space and 100,000 employees

• Hartford resident population is 125,000

• At the center of the downtown transportation hub: 36 bus routes and the star shuttle stop within a block of the site; Amtrak is ½ mile away

• Easy highway access to Interstates 91 and 84

• Parking garage on site

• Growing downtown with UCONN and state office relocations, apartment buildings under construction, and increased use of the Convention Center and XL Center

777 MAIN STREET

Hartford, Connecticut

Redevelopment Opportunity

•City Initiative: Site designated as an "Immediate Initiative" in The Capital City's Near Term Development Agenda.

•State Initiative: Creation of affordable housing near downtown amenities, transit, and employment centers

•Sustainable, urban-infill, mixed-use redevelopment of an historic building in excellent condition

•Transit-Oriented Development
- 1/2 miles to Amtrak; 36 bus routes and star shuttle stop within a one block radius of the site

•Improve Office Market
- Current CBD office vacancy is 30%
- Redevelopment as housing will reduce vacancy by 5%

•Economic Development Benefits
- 290 short-term jobs | 90 long-term jobs
- $2,260,000 short-term local income
- $1,260,000 long-term gov't/tax income per year
- $6,864,000 long-term local income per year
- Leverage Federal funds $20 million

*Calculations based on The Partnership for Strong Communities "Housing Economic Activity Report" National Association of Homebuilders data for affordable and market rate multifamily rental housing

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Hartford, Connecticut

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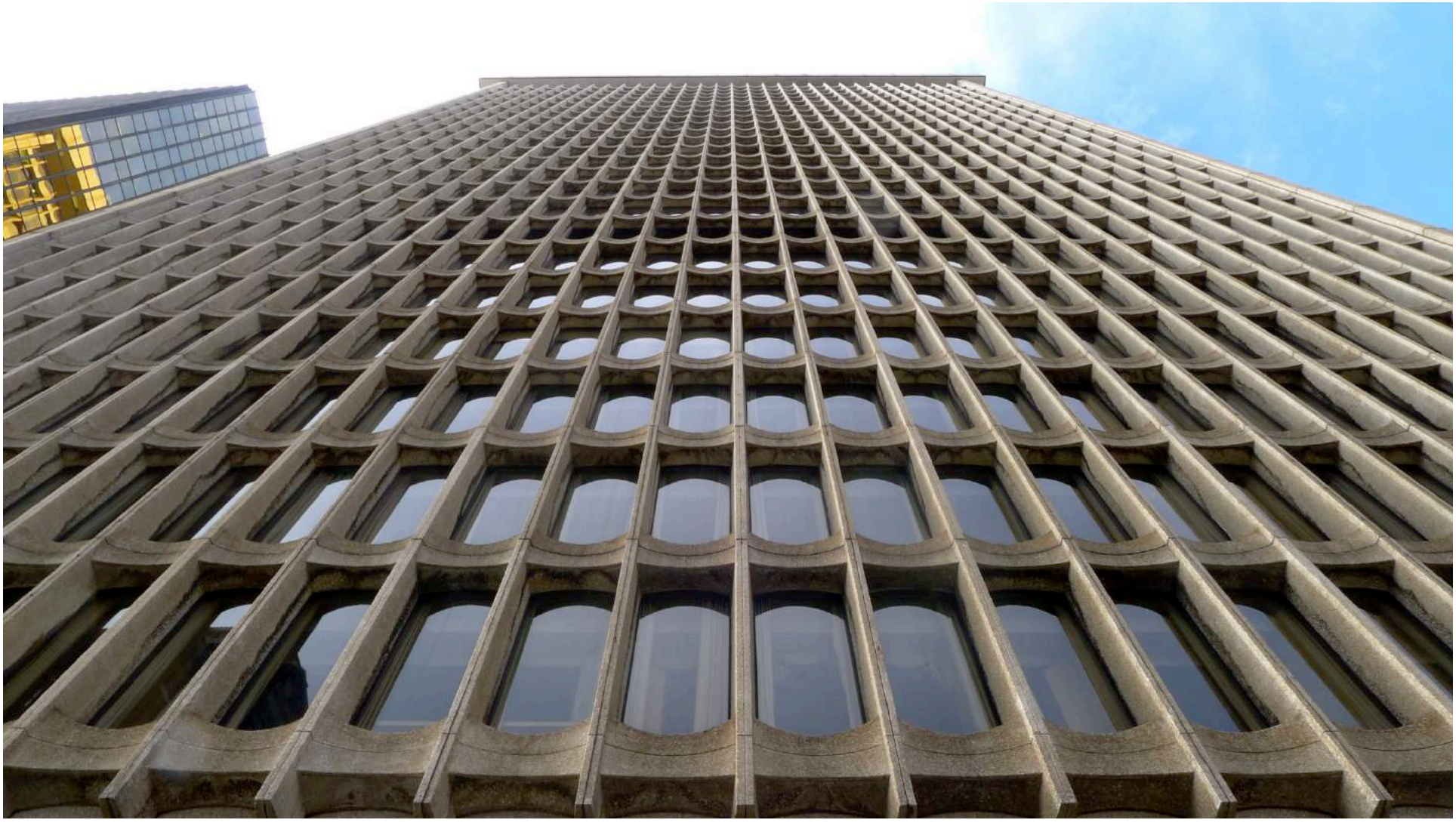
Hartford, Connecticut



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Hartford, Connecticut

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Hartford, Connecticut

Development Program

Ground Level Retail: 35,000 SF

Residential: 295,000 SF | 285 units

- 20% Workforce Housing
- 80% Market Rate
- 42 Studio, 221 One BR, 22 Two BR

Common Area Amenities: 20,000 SF

Parking: 250 spaces

Total Area: 507,000 SF

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Hartford, Connecticut

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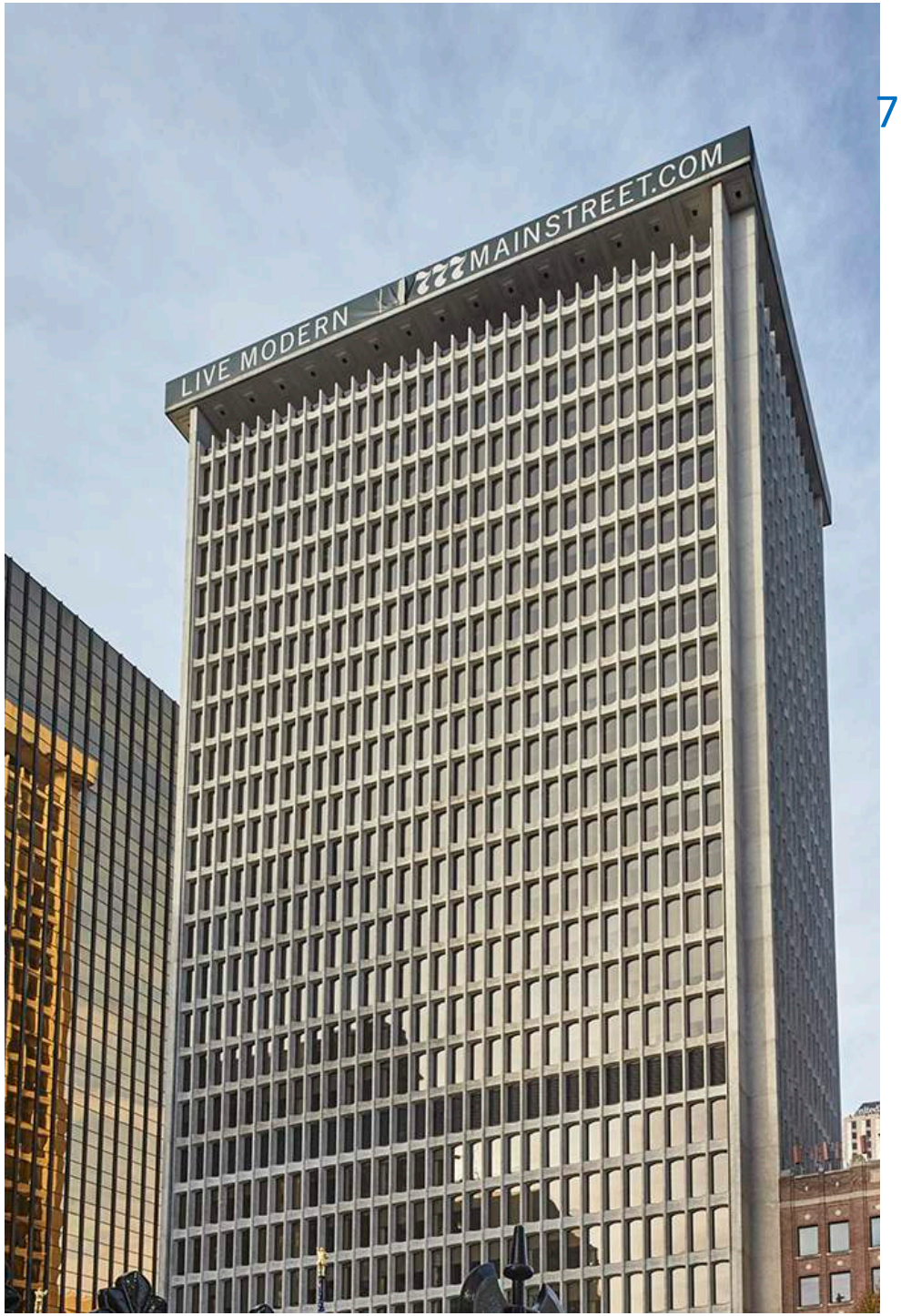

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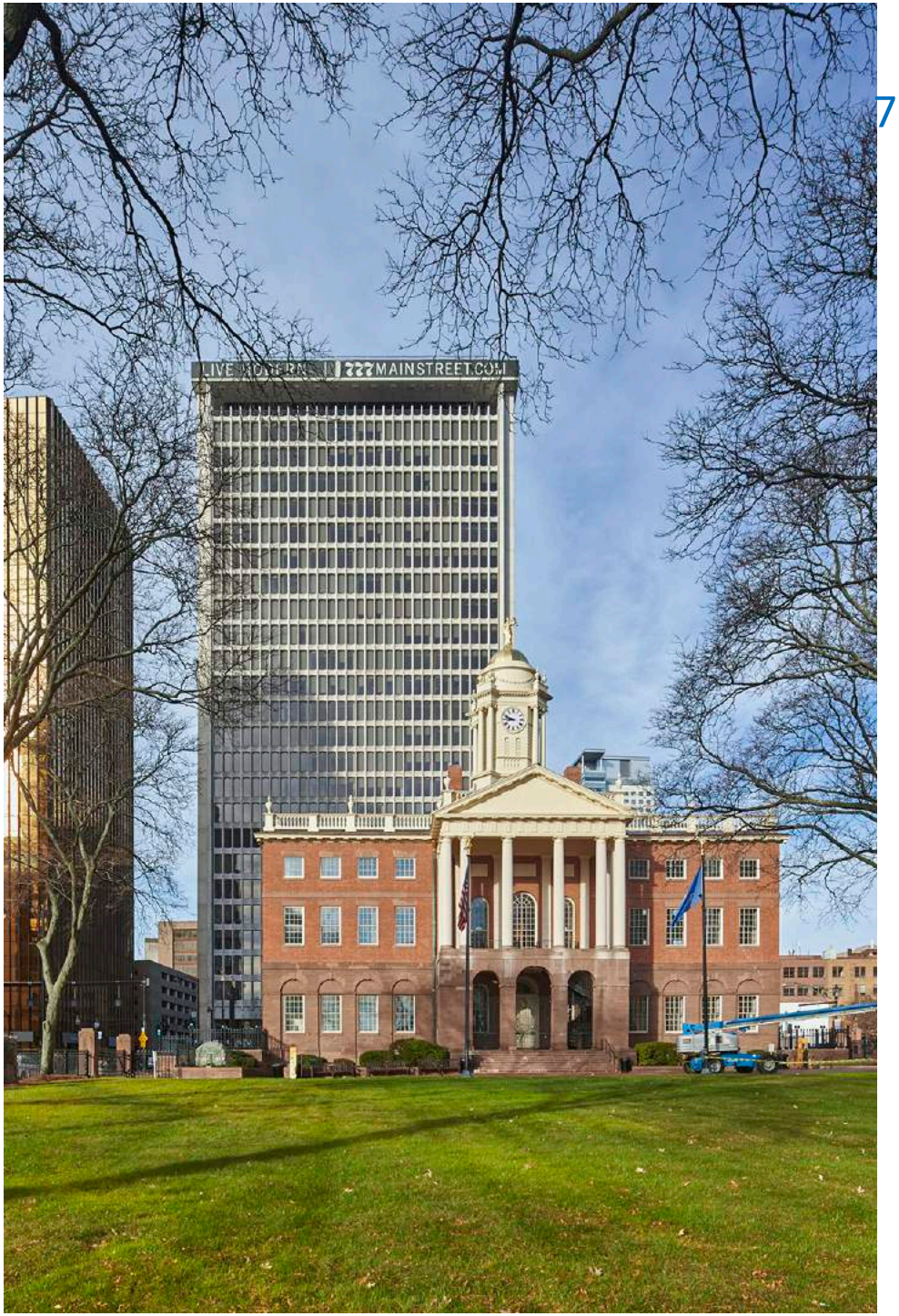

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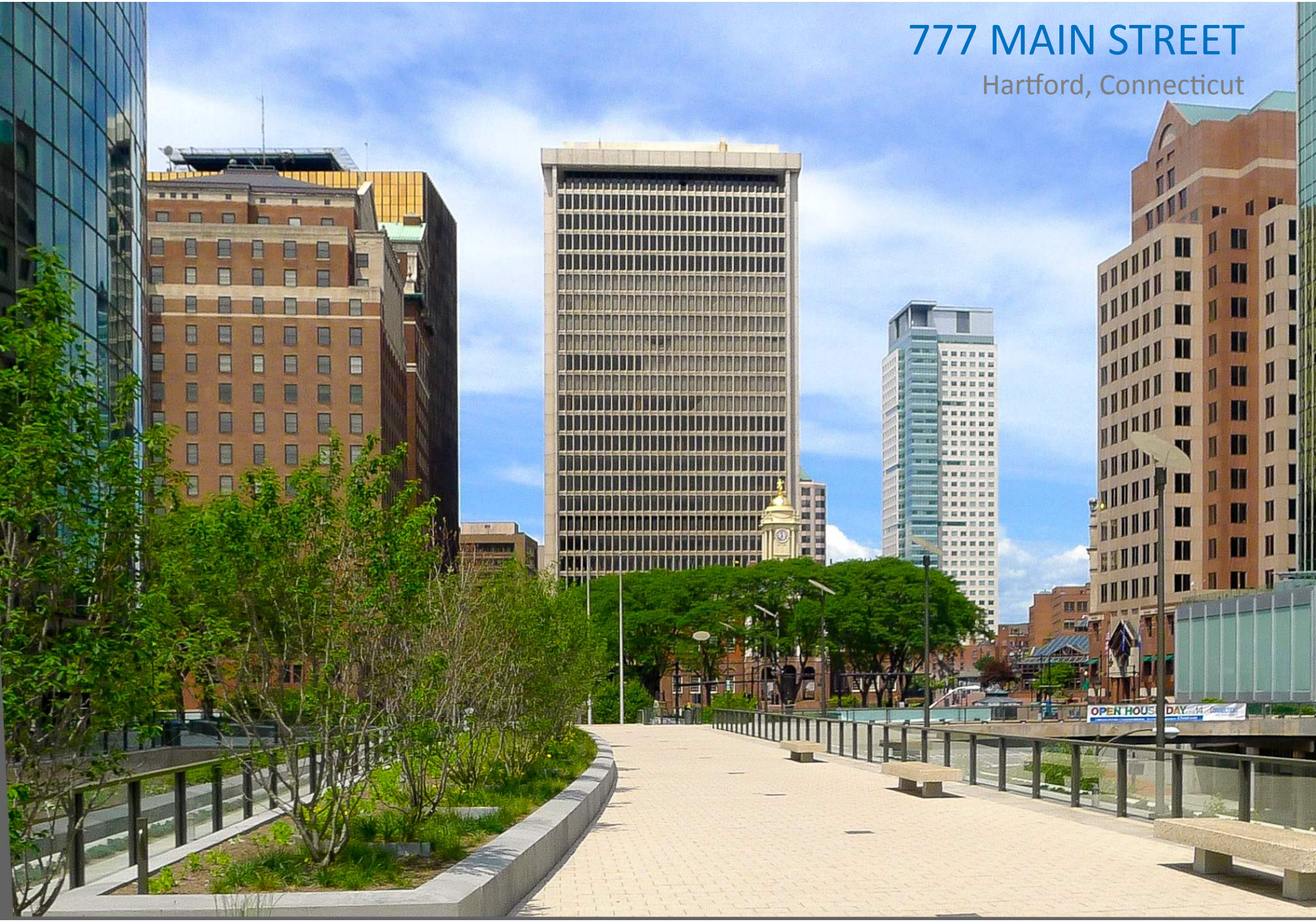
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EXIT

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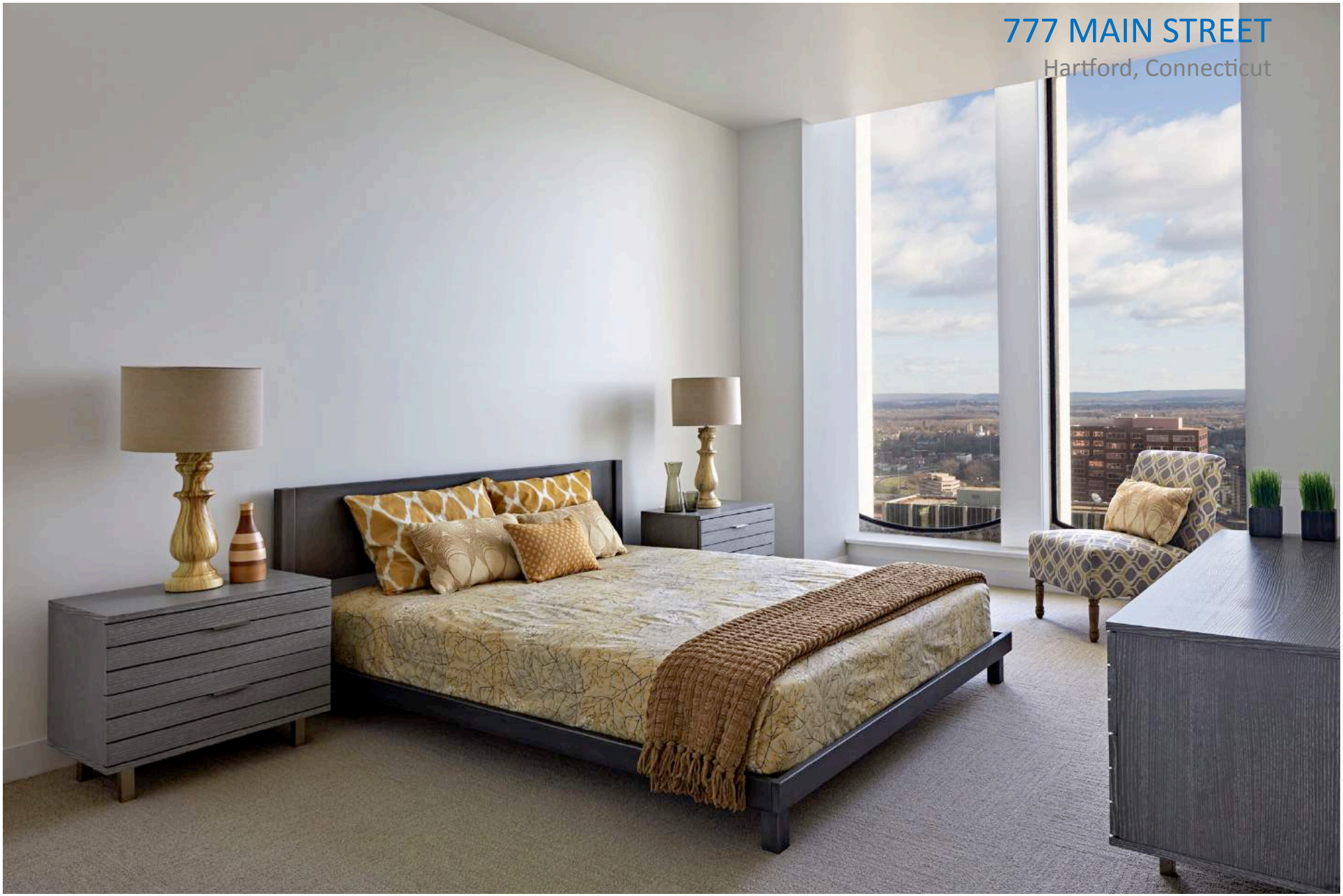

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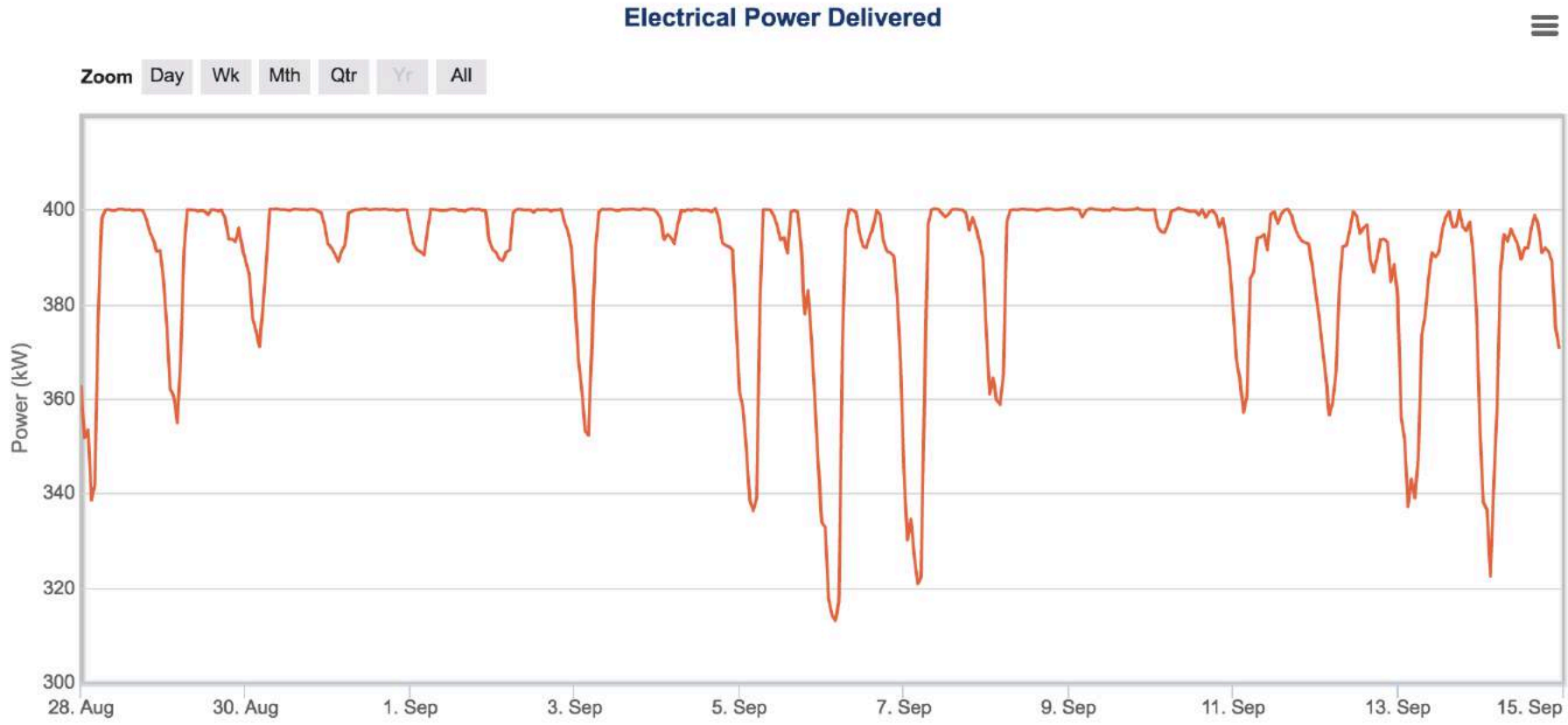
Becker & Becker at 777 Main St. Fuel Cell (9622)

Overview | System Summary | Energy Summary | Power | Cum. Power | Temps | Flows | Heat | Fuel & Power | Data

Time Step Size: Base | Hr | Day | Wk | Mth

csv




EXIT


EXIT
Vision
Vision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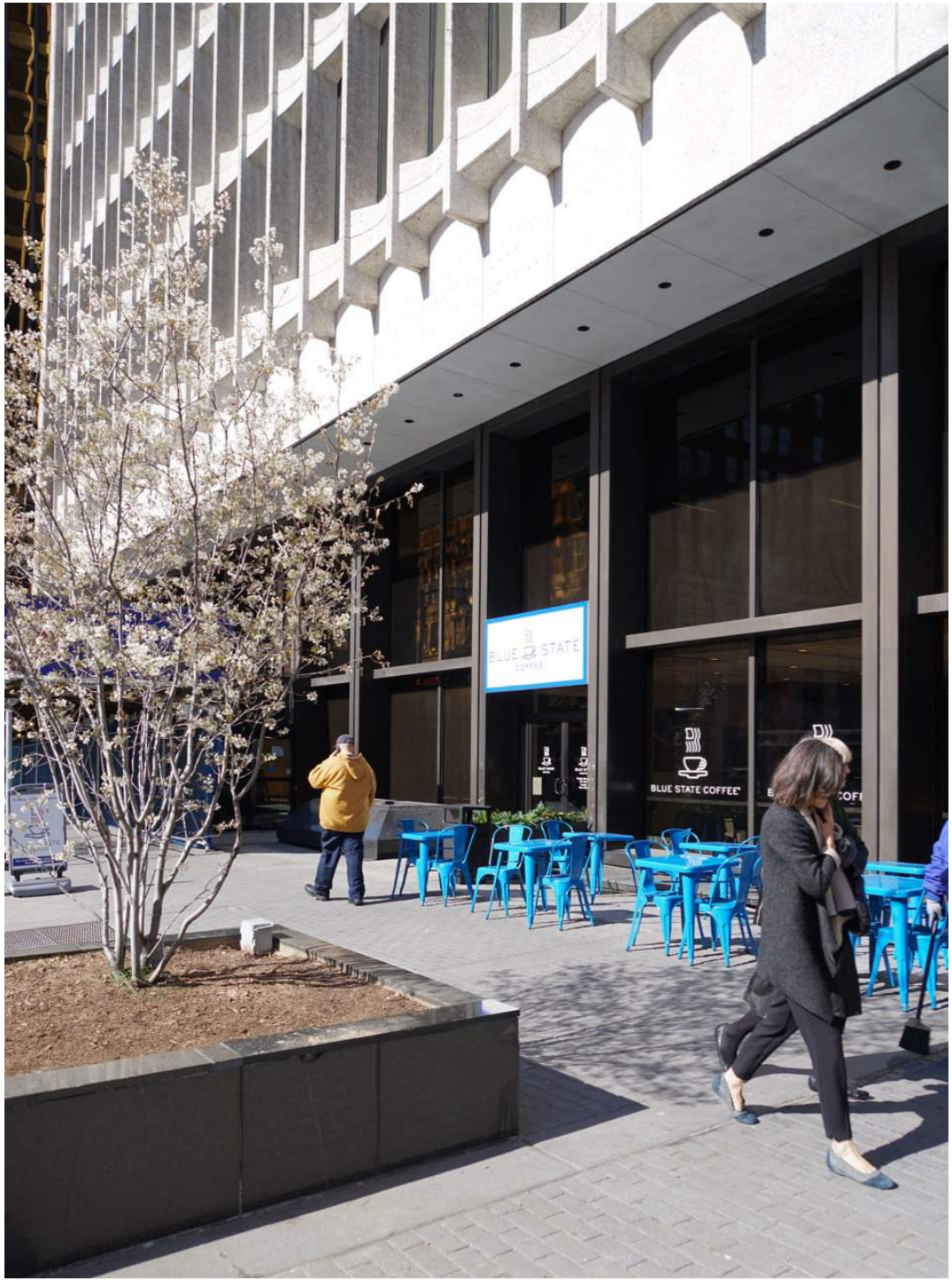
Volkswagen
Driving Experience
e-GOLF
BECKER + BECKER



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777
MAIN

Green Building Features

Targeting LEED Platinum Certification

Building reuse and rehabilitation
400kw fuel cell
Electrical vehicle charging stations
Energy star appliances
No added formaldehyde cabinets and doors
Recycled countertops
LED lighting
Smart NEST thermostats
Solar shades
Low flow faucets and showerheads
Dual flush toilets
Low VOC and recycled content carpeting
Low VOC paint
New Roofs and insulation
Solar panels
High performance envelope: low-E storm windows and rigid insulation
Water source heat pumps
Energy recovery units on exhaust air
Variable frequency drive fans
Occupancy sensors for all common area lighting and garage lighting
Heat recovery and energy recovery ventilation
Regenerative drive elevators and relative system response
High efficiency boilers and water heaters
Water and electric submetering
High efficiency cooling tower
Hot water storage from fuel cell
High efficiency motors and pumps

400 KW renewable fuel cell

777 MAIN

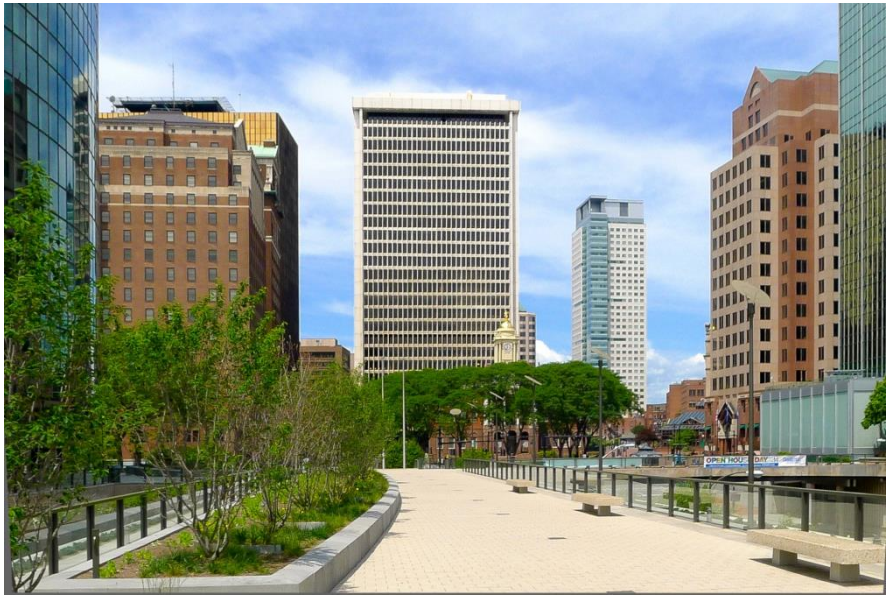
east facade

BRUCE R. BECKER, AIA, LEED AP

BECKER + BECKER
bruce@beckerandbecker.com


DOOSAN
Fuel Cells: Where Energy Sustainability and Critical Power Meet
Jesse Hayes, Product Manager
2016-07-28

FUEL CELL CRITICAL POWER – COMMERCIAL/RESIDENTIAL



777 Main Street - Hartford, CT

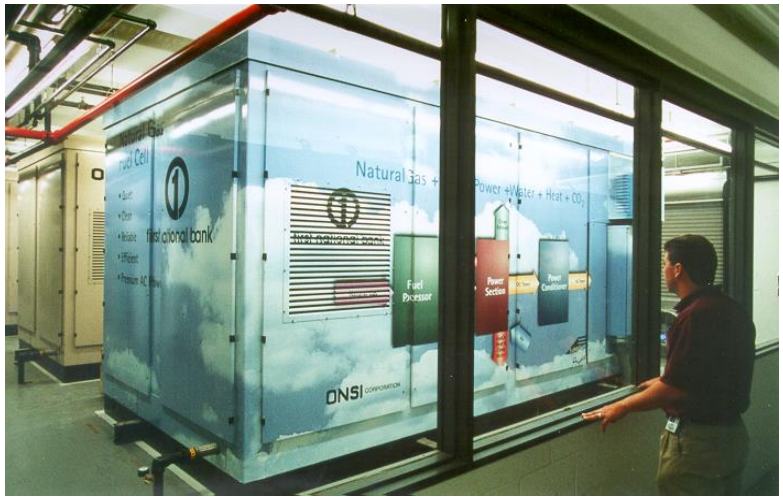
- Historic building renovation in downtown Hartford
- 285 units
- Fuel cell installed Jan 2015
- LEED platinum building
- Fuel cell used for primary power and as emergency power source

"We take a holistic approach in our design to leverage all facets of energy savings, which is the reason Doosan, whose fuel cell solutions have supplied more than 12 million hours of secure, continuous power, is the logical choice for this project."

Architect Bruce Becker
President, Becker + Becker

FUEL CELL CRITICAL POWER – DATA CENTER

First National Bank
One with You.®



PROJECT DETAILS

- Critical credit card processing center
- (4) 200 kW fuel cells installed in 1999
- Converted to 400 kW systems in 2014
- Continuous-duty baseload operation
- Heat for space heating & snow melt

CRITICAL POWER WITH 99.9999% UPTIME

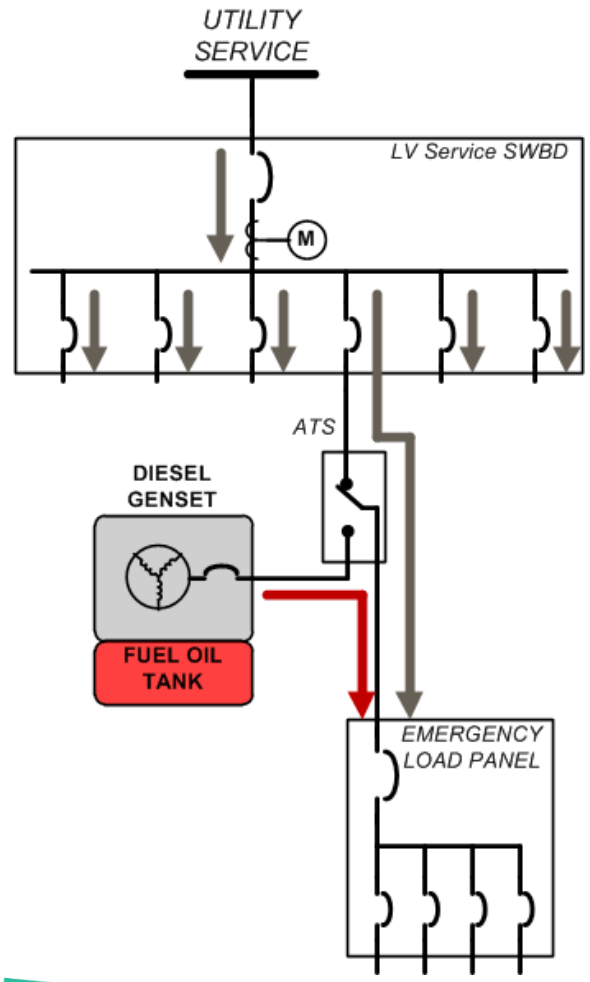
- Redundant electric utility feeds
- Redundant natural gas lines
- Redundant fuel cells
- Piller rotary UPS

DOOSAN

PILLER
Power Systems

CONVENTIONAL BACKUP POWER

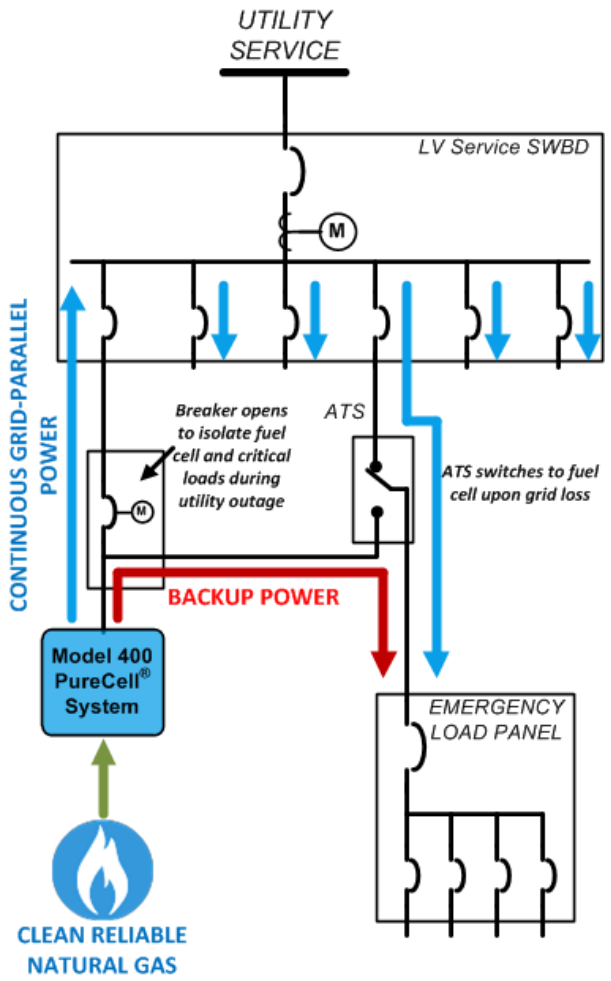
DIESEL GENSET



- Critical assets are typically idle
- High incidence of failed starts
- Requires periodic testing
- Emissions concern
- High greenhouse gas footprint
- Noise concern
- Diesel storage and trucking
- Electric only

FUEL CELL BACKUP POWER

PURECELL MODEL 400



- <10 sec transition to critical power
- Critical asset used continuously for day-to-day energy cost savings
- Continuous operation – system running when backup power needed
- No requirement for periodic testing
- Greatly reduced noise and emissions
- Highly reliable natural gas - no diesel tanks or refueling
- Heat available during grid outage
- Low greenhouse gas footprint

EMERGENCY POWER & THE NEC

Emergency Systems

NEC Article 700 applies to emergency systems essential for the safety of human life and are legally required by local, state, federal, governmental agency having jurisdiction

Examples: emergency exit lighting, fire detection, fire pumps, and in some cases ventilation, & elevators

≤10 Seconds

Legally Required Standby Systems

NEC Article 701 applies to non-emergency systems that are legally required by local, state, federal, governmental agency having jurisdiction

Examples: HVAC, refrigeration, ventilation, smoke removal, sewage disposal, lighting, and anything that otherwise would interfere with fire-fighting operations

≤60 Seconds

Optional Standby Systems

NEC Article 702 applies to systems that without power could cause discomfort, interruption or damage to production or processes

Examples: HVAC, refrigeration, ventilation, data processing, lighting, communication, & other non-life safety or legally required systems

No Time Requirement

EMERGENCY POWER & NFPA 110

NFPA 110, *Standard for Emergency & Standby Power Systems*

- Provides Performance Standards
- Does not specify technology
- Traditional Genset Focus

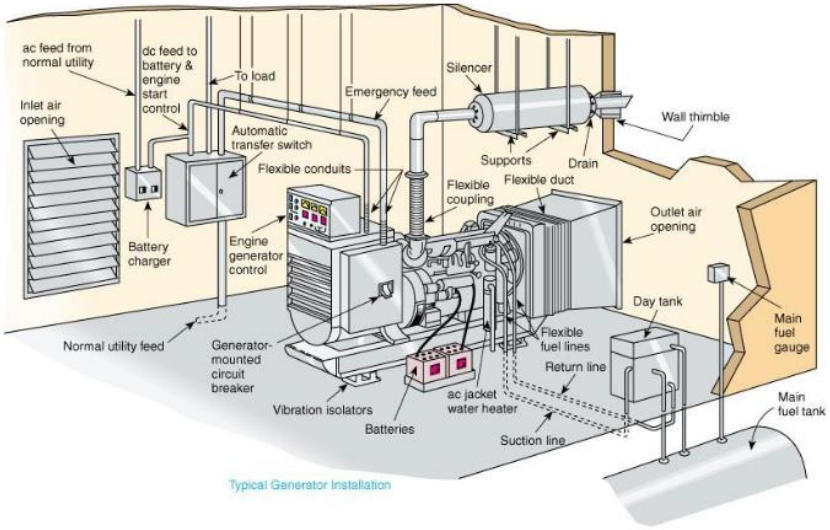


Table 10-1: NFPA 110 emergency power system types (essentially the same as [3] table 4.1(B))

Type	Power restoration time
U	Basically Uninterruptible (UPS Systems)
10	10 sec
60	60 sec
120	120 sec
M	Manual stationary or nonautomatic – no time limit

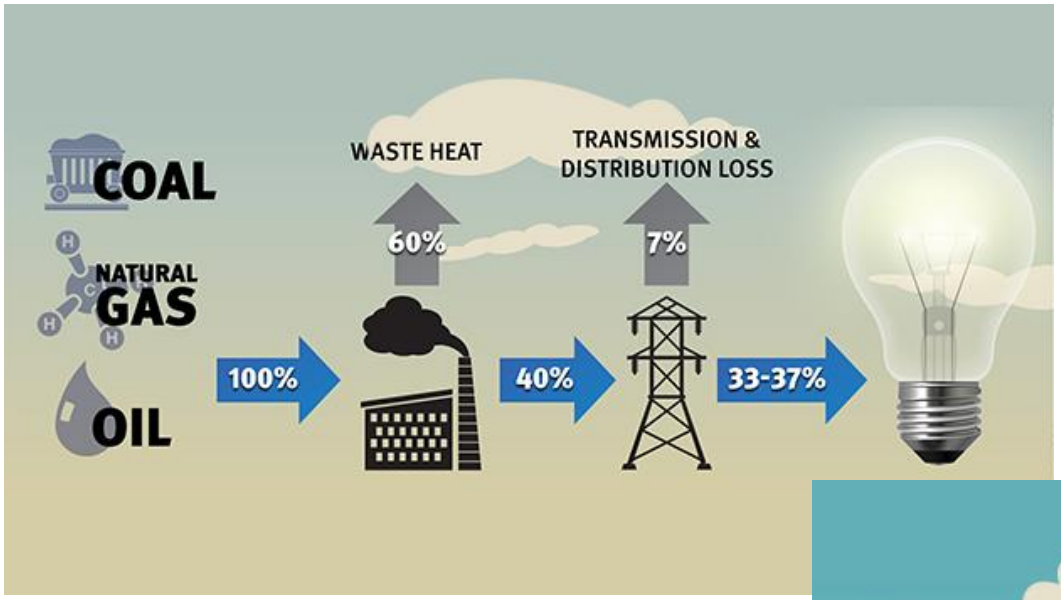
Table 10-2: NFPA 110 emergency power system classes (essentially the same as [3] table 4.1(B))

Class	Power restoration time
0.083	0.083 hr. (5 min.)
0.25	0.25 hr. (15 min.)
2	2 hr.
6	6 hr.
48	48 hr.
X	Other time, in hours, as required by the application, code, or user.

Level 1	Level 2
Life safety illumination	Heating and refrigeration systems
Fire detection and alarm systems	Communications systems
Elevators	Ventilation and smoke removal systems
Fire pumps	Sewage disposal
Public safety communications systems	Lighting
Industrial processes where current interruption would produce serious life safety or health hazards	Industrial processes
Essential ventilating and smoke removal systems	

CHP ACCELERATION INITIATIVE

Executive Order 13624 "Accelerating Investment in Industrial Energy Efficiency."

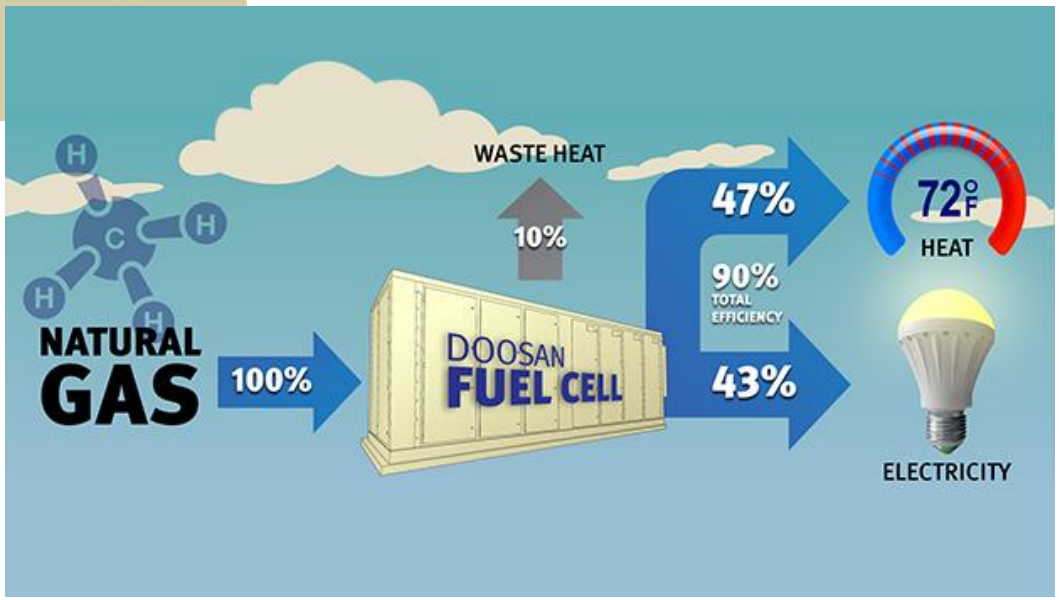


Motivations:

…improve the competitiveness of United States manufacturing, lower energy costs, free up future capital for businesses to invest, reduce air pollution, and create jobs

Goal:

40 GW of new, cost effective industrial CHP in the U.S. by end of 2020



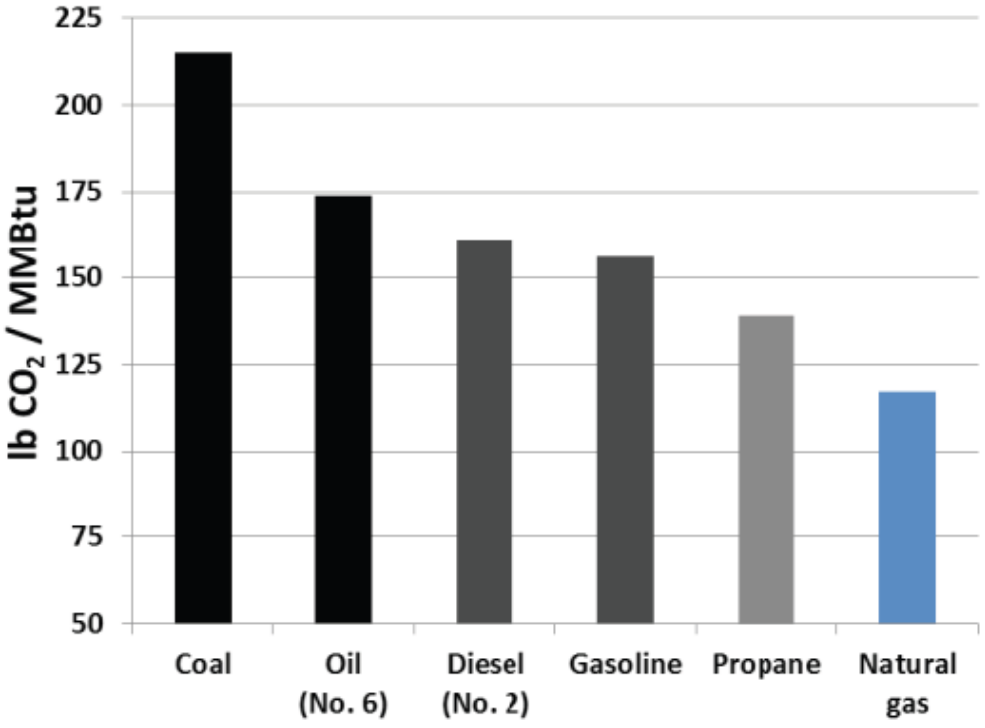
NATURAL GAS CO_2 FOOTPRINT

Natural Gas:

- Cleanest burning fossil fuel
- GHG & CAC offset varies by region
  - ISO: MISO
  - eGRID subregion: RFCM

CHP Fuel Cell Systems

- Reduce GHG emissions by 60%
- Virtually eliminate CACs
- CARB Certified
- Critical power capable
- Up to 90% system efficiency

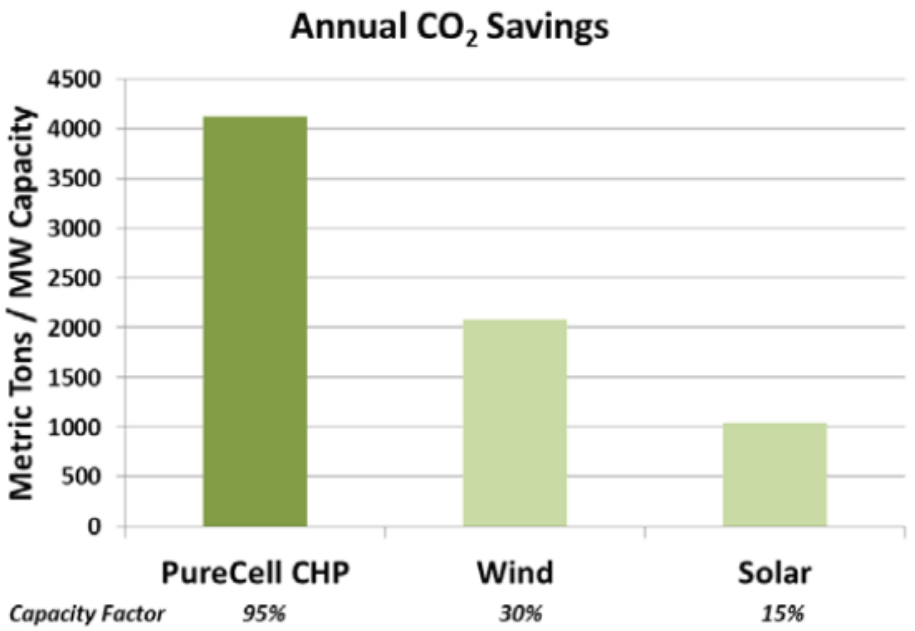


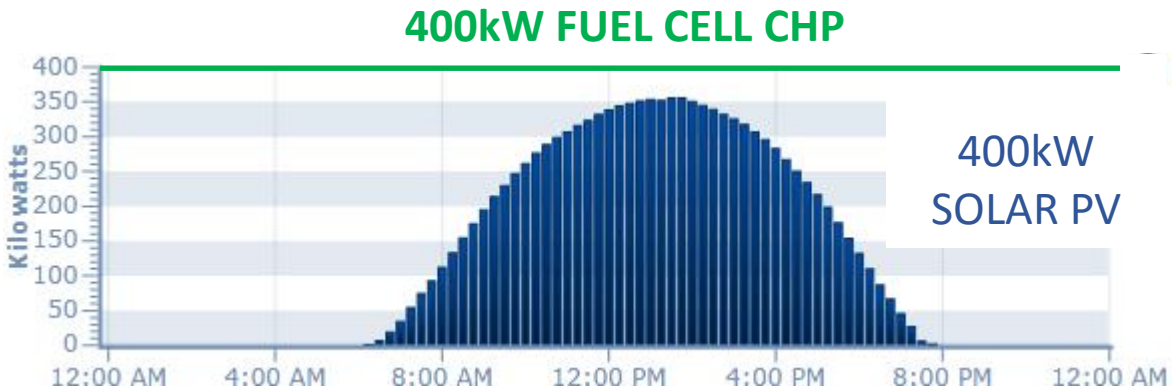
Fuel Cell Technologies Record #11006. Fuel Cells for Combined Heat & Power - CO2 and NOx Emissions. U.S. Department of Energy, July 2011.

UTILITY CO_2 OFFSET COMPARED

Fuel Cell & Renewables

- **Ideal balance for low capacity factor (CF) renewables**
  - Fuel Cells are continuous
  - Solar PV is intermittent
- **400kW Solar PV @ 15%CF**
  - Yields 525,600kWh Annually
- **400kW Fuel Cell @ 95%CF**
  - Yields 3,328,800kWh Annually
  - That's 6.3x the energy of PV
- **Annual CO_2 Offset Electric Only***
  - PureCell®: 3.42 million lbs
  - 400kW PV: 1.09 million lbs





*Based on 2010 eGRID RFCM fossil fuel emission rate: 1966.47 lb/MWh

DOOSAN

FUEL CELL - AIR EMISSIONS

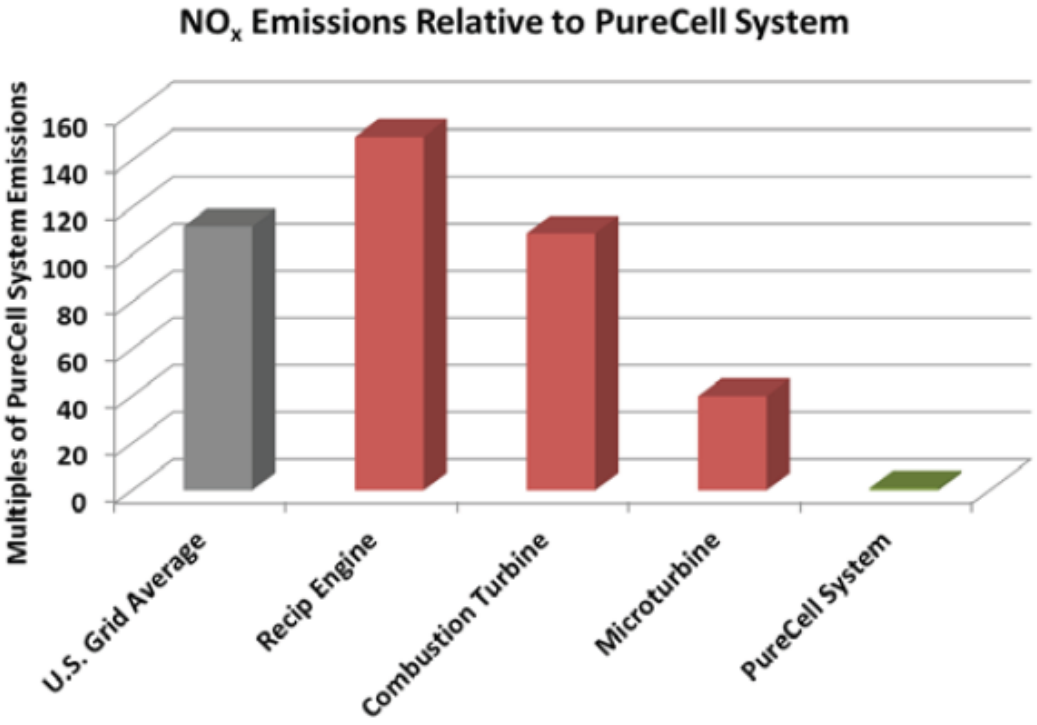
CHP Fuel Cell Systems Compared

- Lowest Air Emissions of any Continuous Duty Power Generation Option

Fossil Fuel-Fired Power Plants

- 70% of Nation's SO_2 Emissions
- 13% of NO_X Emissions
- 40% of CO_2 Emissions

Pollutant	PureCell Model 400 System (lb/MWh)	CARB 2007 Limit (lb/MWh)
NO_x	0.01	0.07
CO	0.02	0.10
VOC	0.02	0.02
SO_x	Negligible	Not applicable
PM	Negligible	Not applicable



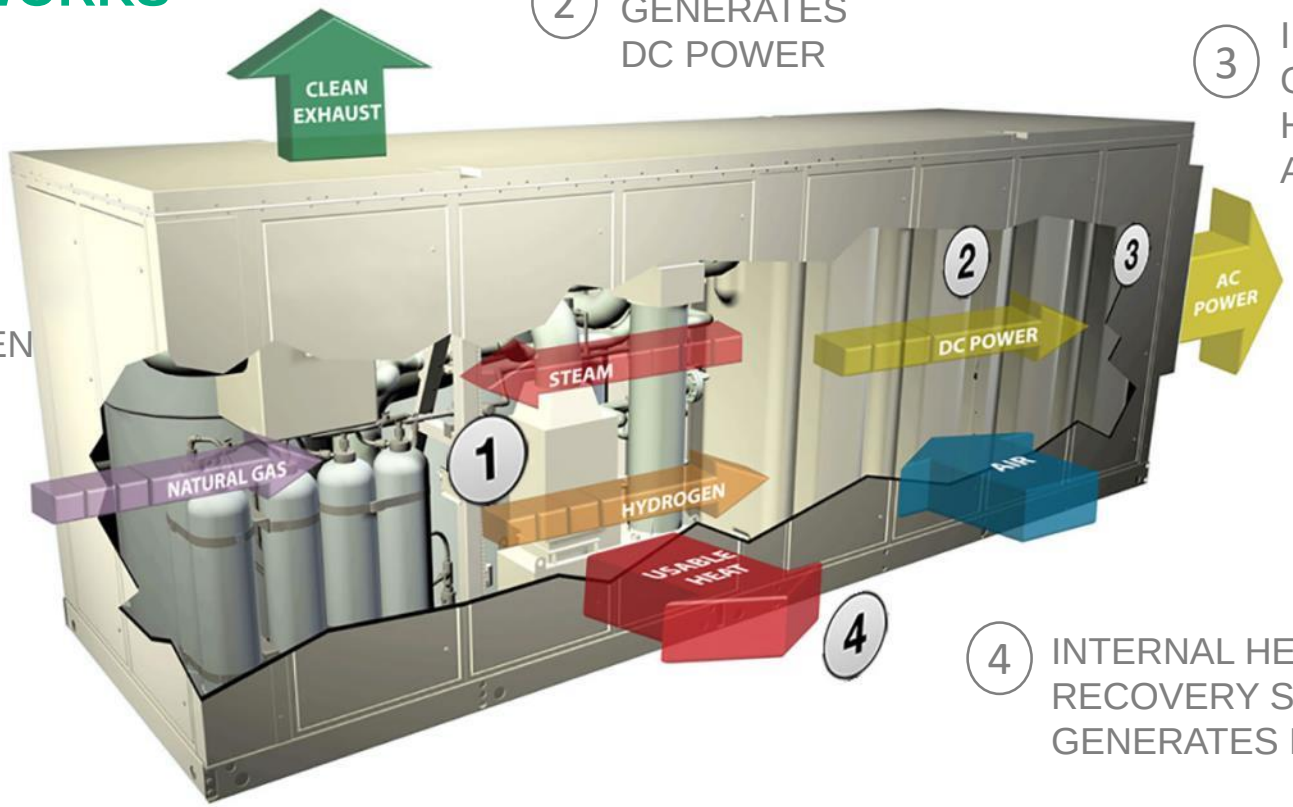
PURECELL MODEL 400

HOW IT WORKS

1 REFORMER CONVERTS NATURAL GAS INTO HYDROGEN

2 FUEL CELL STACK GENERATES DC POWER

3 INVERTER GENERATES HIGH QUALITY AC POWER



4 INTERNAL HEAT RECOVERY SYSTEM GENERATES HOT WATER

Power Output	**440 kW**
Heat Output	**1.7 MMBtu/h**
Fuel Input	**4.0 MMBtu/h**

DOOSAN

ENERGY APPLICATIONS

Natural Gas
(4.0 MMBtu/hr)

Electricity (440 kW)

Continuous Clean Power

Critical, Emergency Power

Heat

Up to 250F (0.76 MMBtu/h)

or

Cooling (50 RT)

Absorption Chiller

Up to 140F (0.99 MMBtu/h)

Heat Recovery

Hydronic heating systems
Steam boiler pre-heat

Chilled water systems
Chilled water coils in air handlers
Refrigeration sub-cooling

Domestic hot water
Condensing boilers
Process water
Pool heating
Desiccant regeneration
Hot water coils in air handlers
Water source heat pumps

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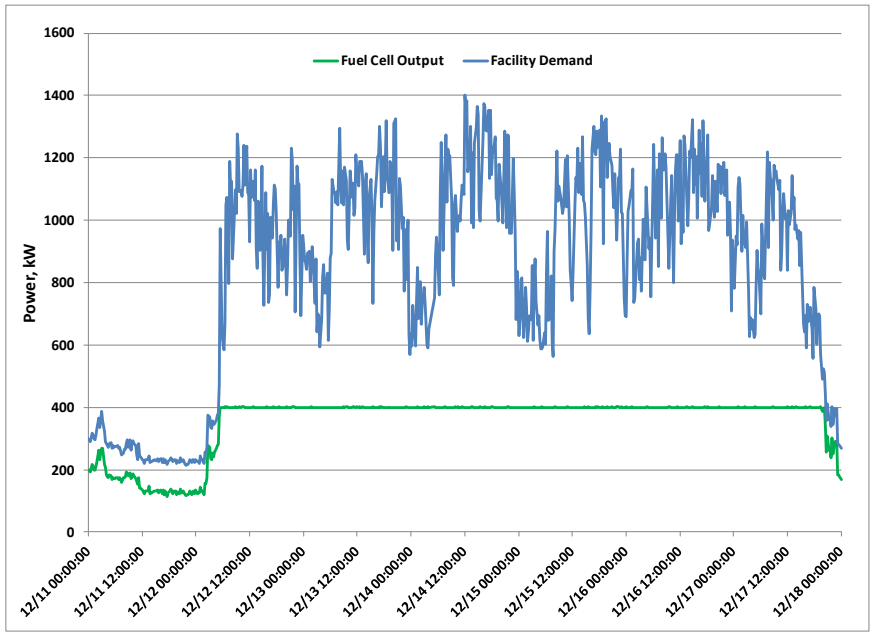
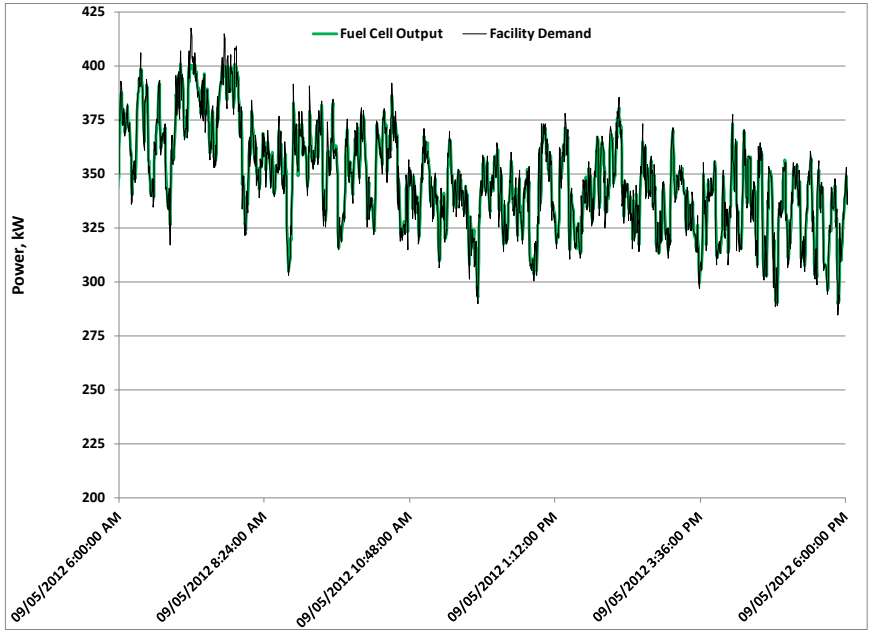
ELECTRIC LOAD FOLLOWING

UNIQUE CAPABILITY IN STATIONARY FUEL CELLS





- Coca-Cola bottling facility
- 5 day/week production facility
- 400 kW baseload weekdays
- Load-following with 100 kW minimum utility import on weekends

- Whole Foods Market
- Supermarket
- Continuous load-following
- Net-metering with zero utility power import

INSTALLATION OPTIONS

Fuel Cell Flexibility

- Outdoors
- Indoors
- Rooftops
- Multiple Units

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ENVIRONMENTAL BENEFITS

CO_2

1.1 million lbs saved**

(116 acres of trees)

NO_x

3,300 lbs saved**

(87cars)

H_2O

1.4 million gal saved**

(2.2 Olympic pools)

NOISE

65 dBa @ 10 m

(no louder than piano music)

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Fuel cell installation can provide 4-6 LEED points

DOOSAN

** Annual savings from one PureCell Model 400 compared to traditional energy sources. CA Example.

FUEL CELLS IN ACTION

CRITICAL POWER CAPABILITY

October 2012 Hurricane Sandy

- All 23 PureCell System Model 400 fuel cells in the impacted areas were operational during the storm
- Stop and Shop (Torrington, CT) automatically transitioned to grid-independent mode providing power throughout the storm

CT October 2011 Winter Storm

- South Windsor High School serves as community shelter
- Whole Foods Market prevents costly food spoilage
- CT Juvenile Training Facility operates continuously through prolonged power outage

San Diego September 2011 Blackout

- Albertsons supermarket remains open for business
- Perishable inventory protected
- One of the few retail stores operating

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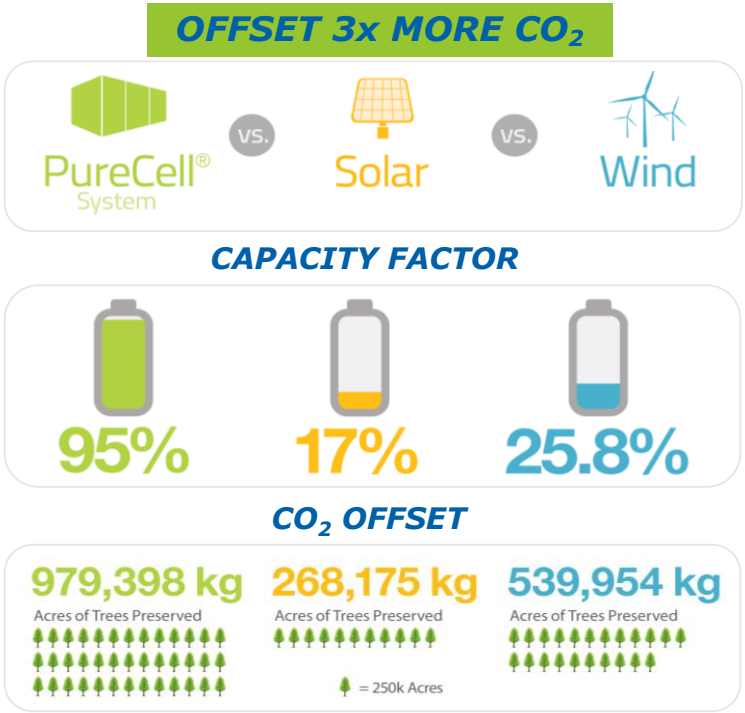
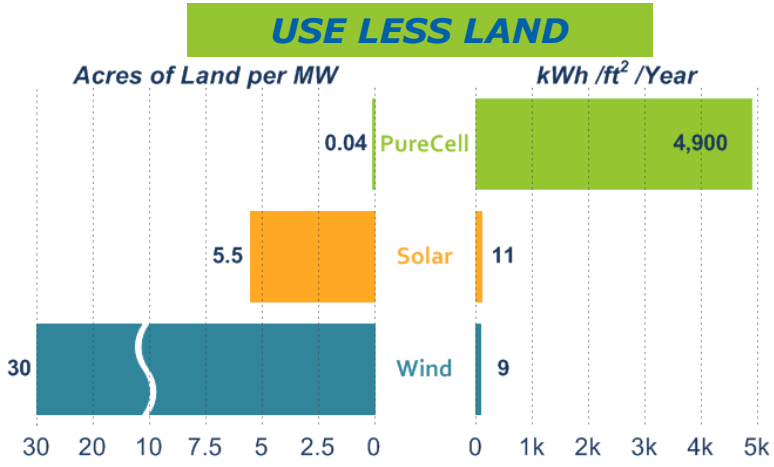
THANK YOU





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