Community energy security and green resilience strategies for municipal critical facilities, distributed energy and microgrids

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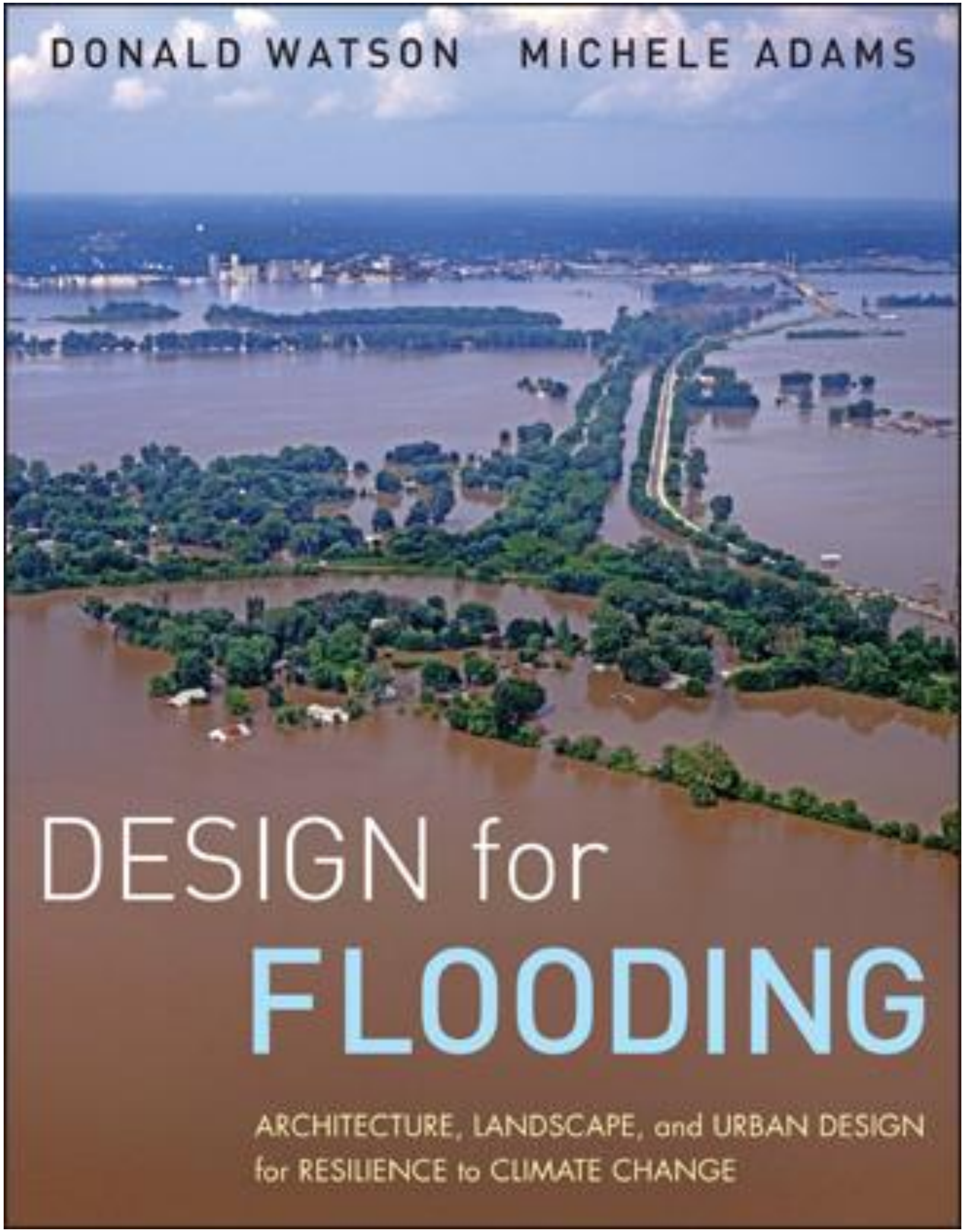
May 20th, 2014

Energy security strategies

- Energy efficiency, self-sufficient buildings
- Emergency generators
- Combined heat and power
- Renewable resources + energy storage
- Microgrids



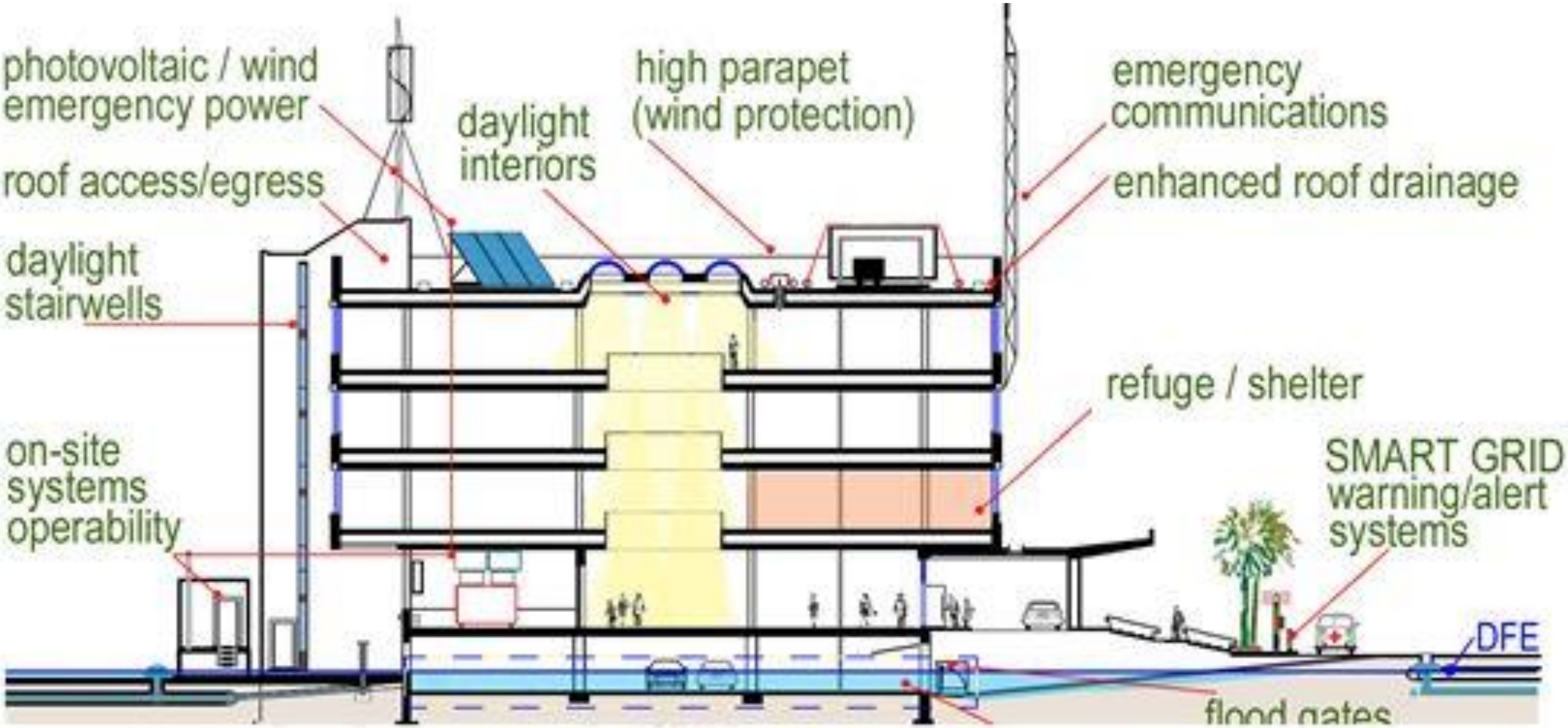
EarthRise001@SBCglobal.net

Sustainable design can be resilient

Xerox Corporation International Facilities Division
Design Architect: Donald Watson, FAIA • Lighting consultant: William Lam

ENERGY FEATURES:
Daylighting: light shelf, venetian blinds
Thermal time-lag / evaporative cooling: operable windows, planters, drip irrigation

Critical facility resilient design



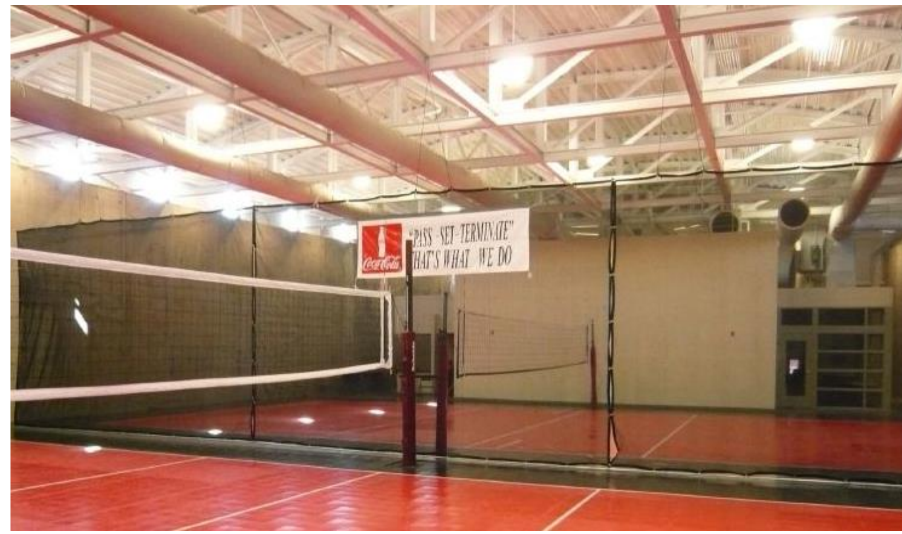
Critical facilities: new construction

Hancock County Mississippi

Emergency Operations Center and Community Safe Room

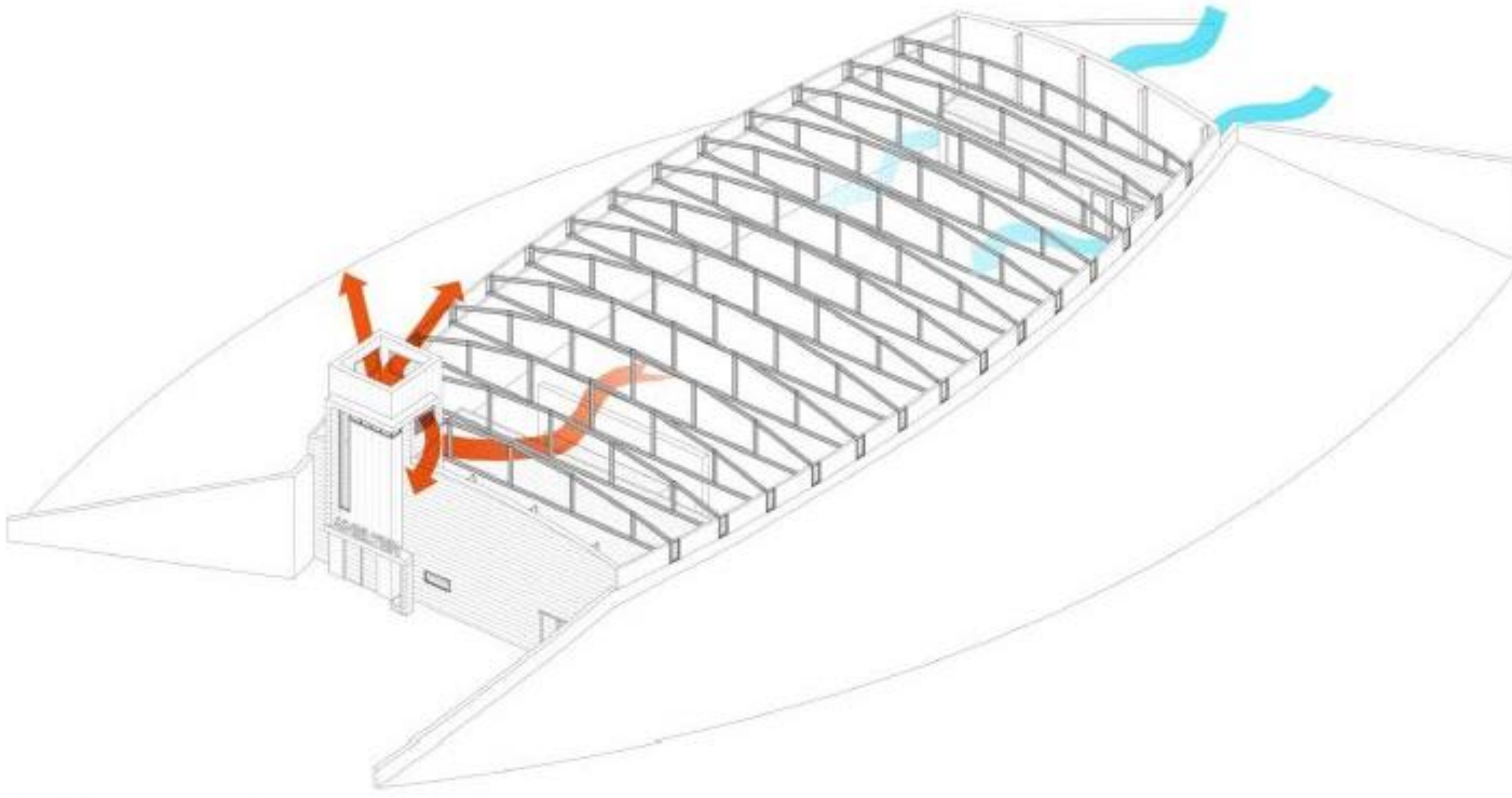
SOURCE: Dean Sakamoto HURRIPLAN
Image Courtesy of Unabridged Architects

Hancock County Mississippi Emergency Operations Center is designed to be an indoor tennis court when it is not needed for sheltering.



SOURCE: Dean Sakamoto HURRIPLAN
Image Courtesy of Unabridged Architects

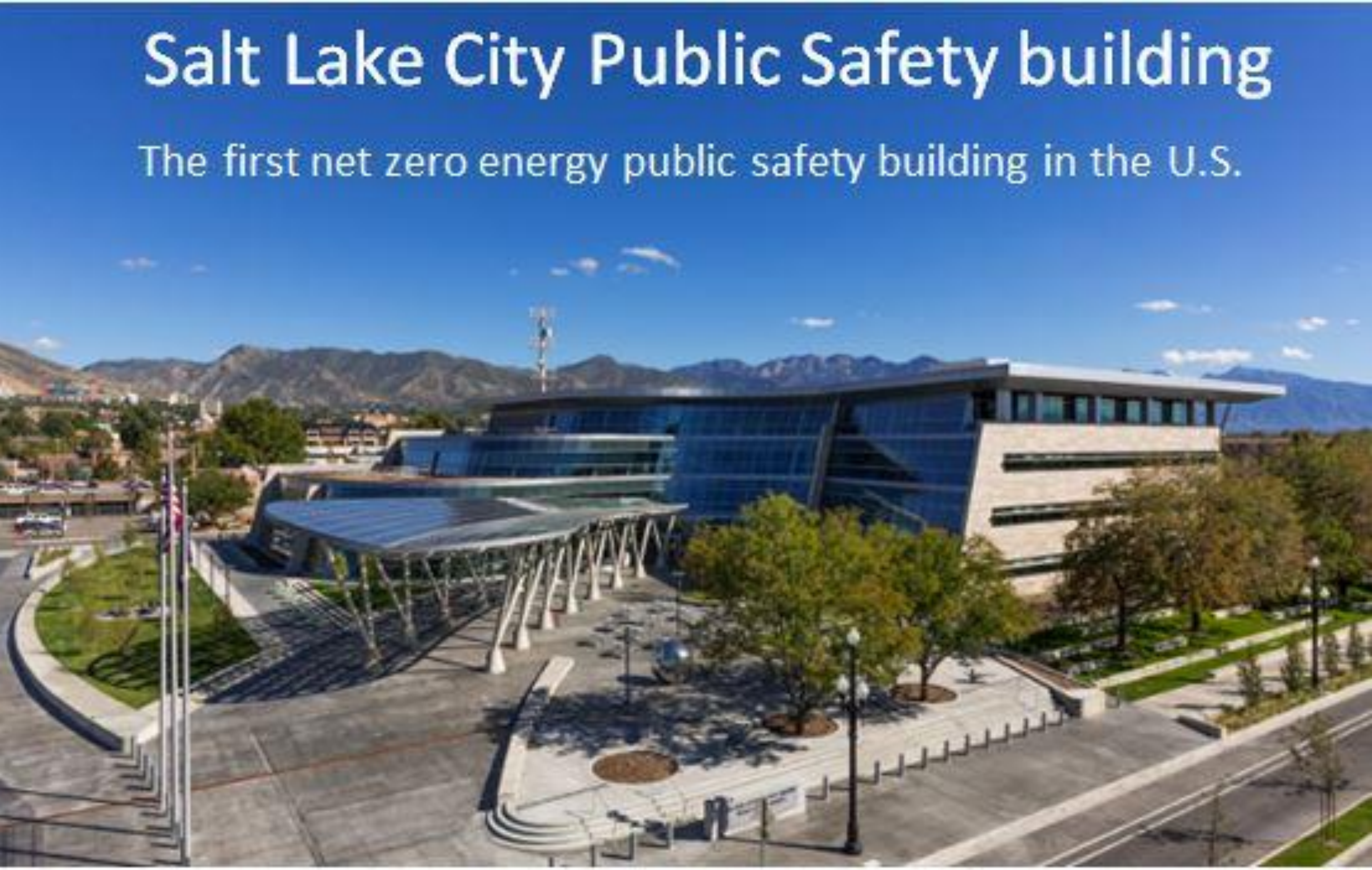
Hancock County Mississippi Emergency Operations Center and Community Safe Room includes passive ventilation strategies.



SOURCE: Dean Sakamoto HURRIPLAN
Image Courtesy of Unabridged Architects

Salt Lake City Public Safety building

The first net zero energy public safety building in the U.S.



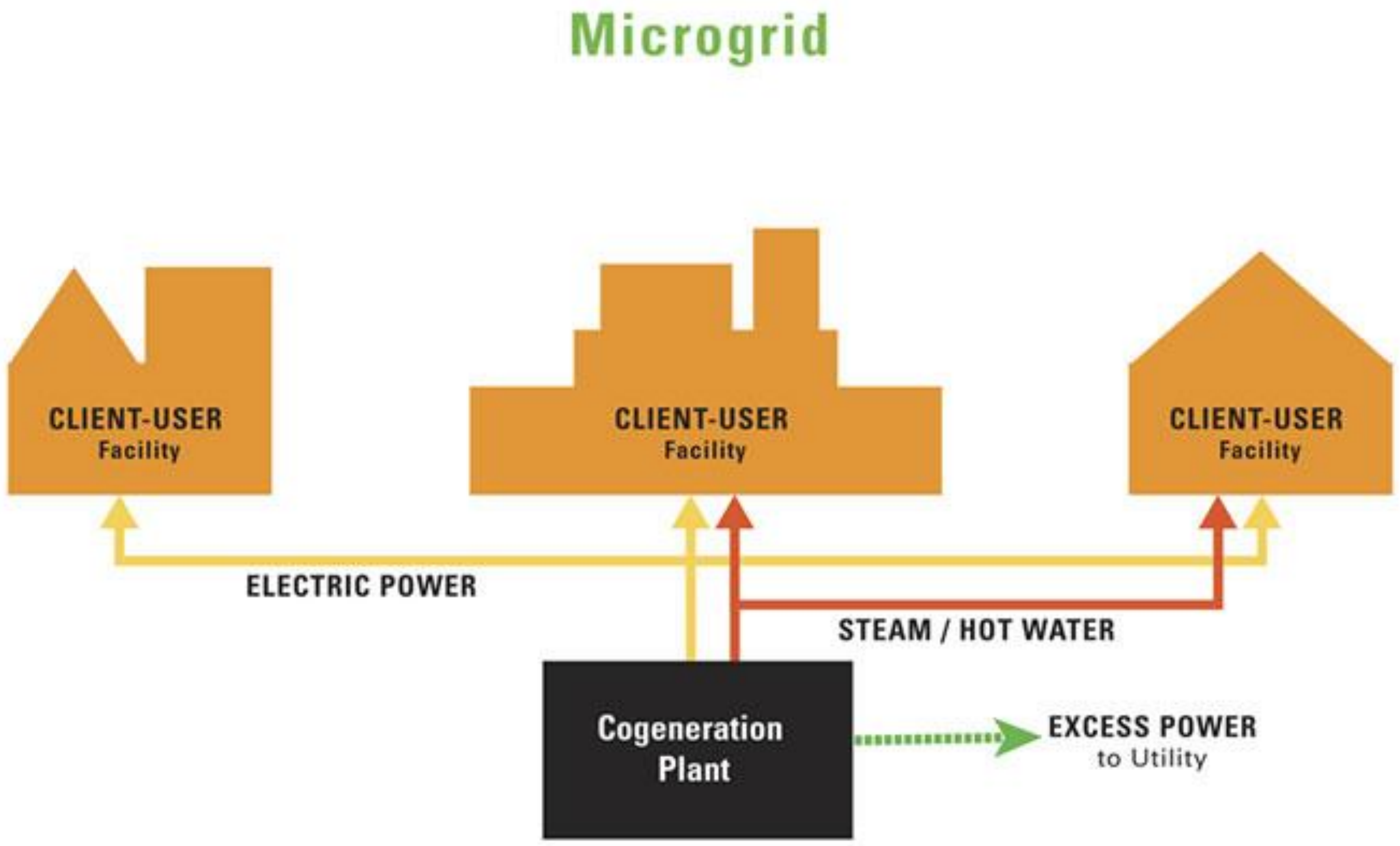
320,000 SF, $80 million facility completed in 2013

Image by Jeff Goldberg/Esto. From EDC magazine, 12/16/13.

- Designed to withstand 7.5 Richter scale seismic event
- Critical facility sustained operations during power outages
- 350 kW rooftop solar power array, solar thermal hot water
- 35 kW PV canopy is public device charging station

Image by Jeff Goldberg/Esto. From EDC magazine, 12/16/13.

Combined heat & power (CHP)



Combined heat & power (CHP)

<u>Advantages</u>:

- Onsite generation of electricity, heating and cooling
- Significant sustained energy output, economical, relatively clean

<u>Limitations</u>:

- Constant fuel supply: gas pipeline, site storage capacity
- Challenge: economical use for heat in critical facilities
  - Office-type loads in 4 season climates are not a great fit
  - Power output can be constrained by thermal applications
- The smaller the CHP system, the longer the payback
- Business case less compelling with low electricity costs

CHP strategies

- Identify base load thermal applications
- Heating applications: multifamily housing, wastewater treatment, swimming pools, hospitals
- Cooling applications: data centers, refrigeration
- Size smaller systems to serve critical loads only during outages, shed non-essential loads
- Large systems with diverse loads: campuses, microgrids
- Considerations: siting, permitting, noise, vibration

CHP prime movers: reciprocating engines

- Good load following & partial load efficiency
- Lower capital cost, higher O&M cost but familiar tech
- Higher emissions & noise, requires cooling, lower-temp heat

CHP prime movers: Microturbines

- Compact, light, low emissions
- Higher costs, needs compressor, lower-temp heat

CHP prime movers: fuel cells

- High efficiency and power quality, very low emissions
- High costs, needs reformer
- PEM FC types follow changing loads in island mode
- Other FCs types (too) slow to follow very dynamic loads

Solar photovoltaic (PV) power

Advantages:

- Clean, quiet power anywhere with no fuel cost
- Innovative financing, competitive business models
  - Power Purchase Agreements (PPAs), net metering

Limitations:

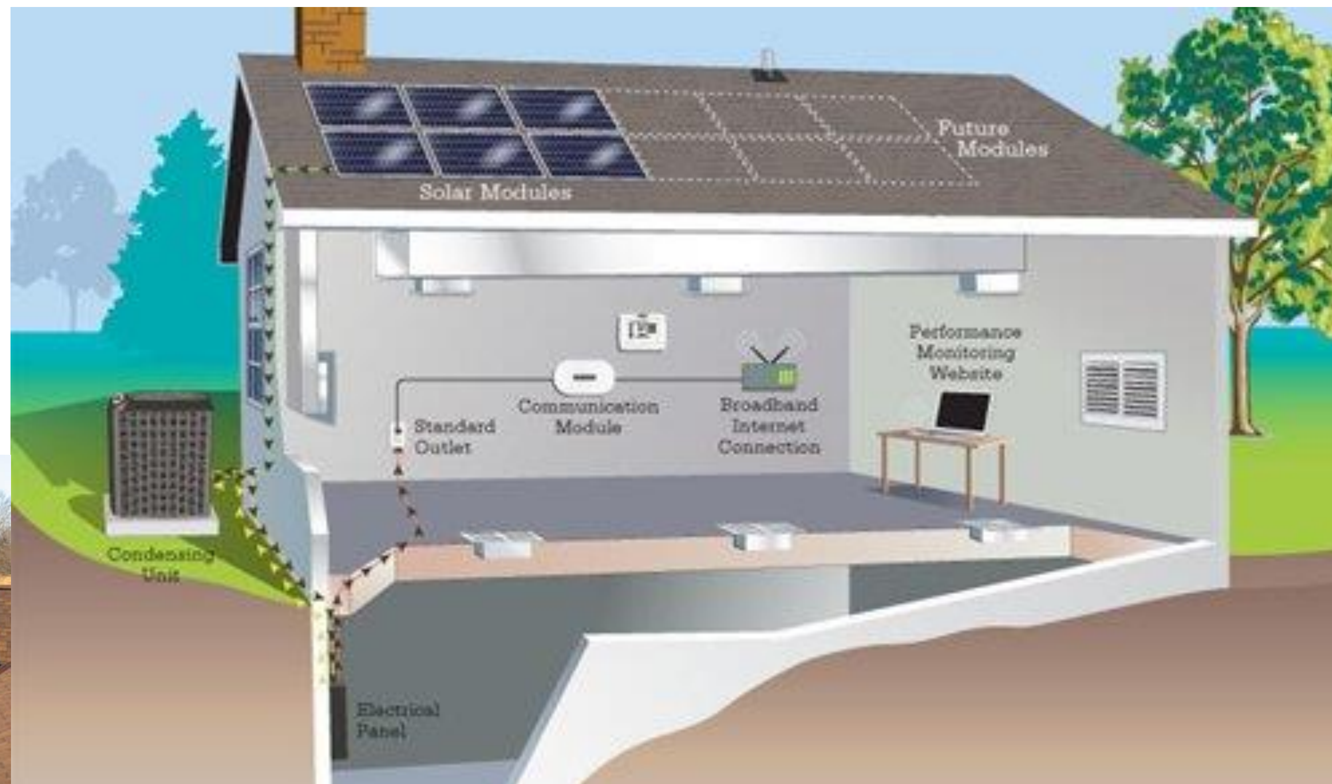
- Large physical footprint needed to serve facility-scale loads
- Requires energy storage for 24/7 applications
- High capital cost (falling rapidly); public sector can't use tax credits
- Most PPA-funded arrays configured to disconnect during outages

Strategies:

- Identify sites for large arrays
  - large flat newer roofs, parking areas, open land, capped landfills
- Size PVs + storage for most critical subset of loads
  - IT/telecom/radios, emergency shelter lighting, device charging
- Combine with other energy sources at critical facility
- Negotiate islanding capability with PPA provider

Solar thermal, PV + heat pumps

- Competitive *vs*. oil, probably not *vs*. natural gas
- PV + heat pumps = (near) net zero energy (smaller) buildings

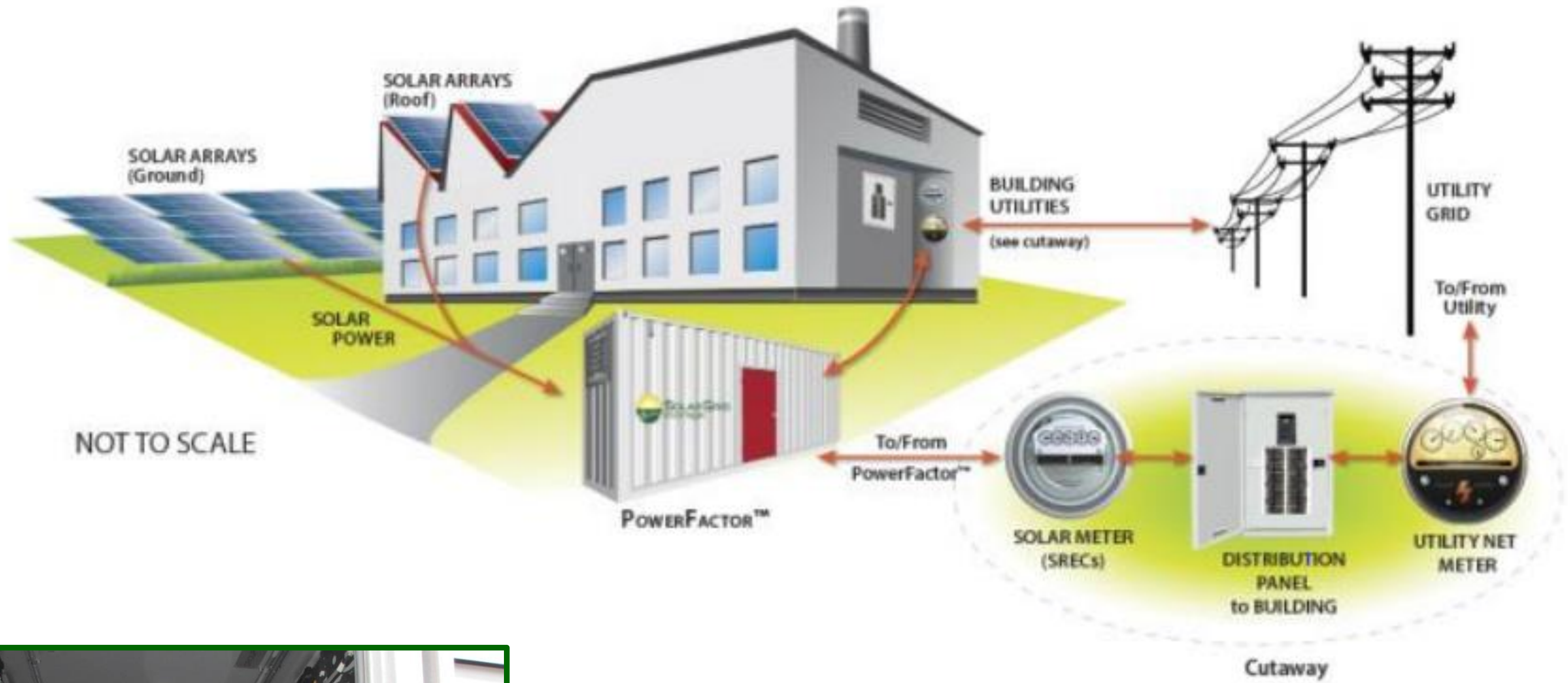


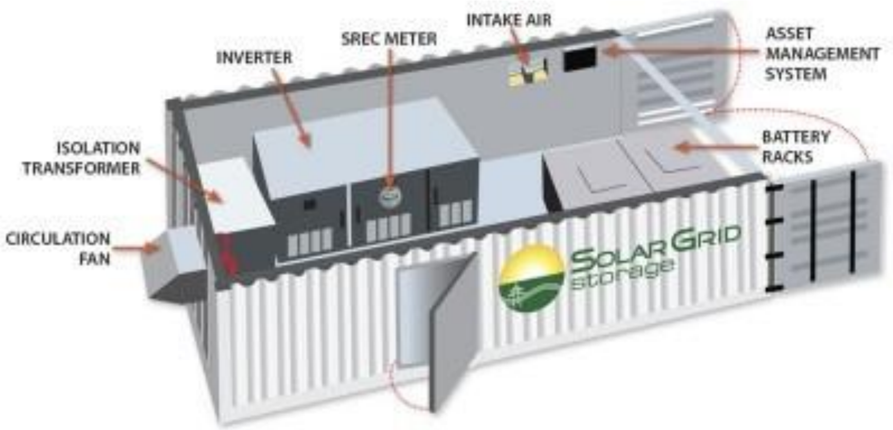
Wind turbines

- Wind resources highly variable & site-specific
- Building-integrated WT complex, maturing
- Horizontal axis WT promising
- Requires energy storage for 24/7 applications
- Not typically a compelling fit at facility scale (yet)

Tall turbines & rotors don’t mix well

Energy storage





Energy storage

Advantages:

- Expanding portfolio of technologies: batteries, compressed air, flywheels, ….
- Enables “time shifting” of stored energy, from renewables
- Clean, quiet power and energy on demand
- Capacity range from facility-scale modular units to utility-scale installations
- Emerging innovative business models
  - Revenue providing grid with ancillary services (voltage & frequency regulation)
  - PPA for energy storage service (SolarCity)

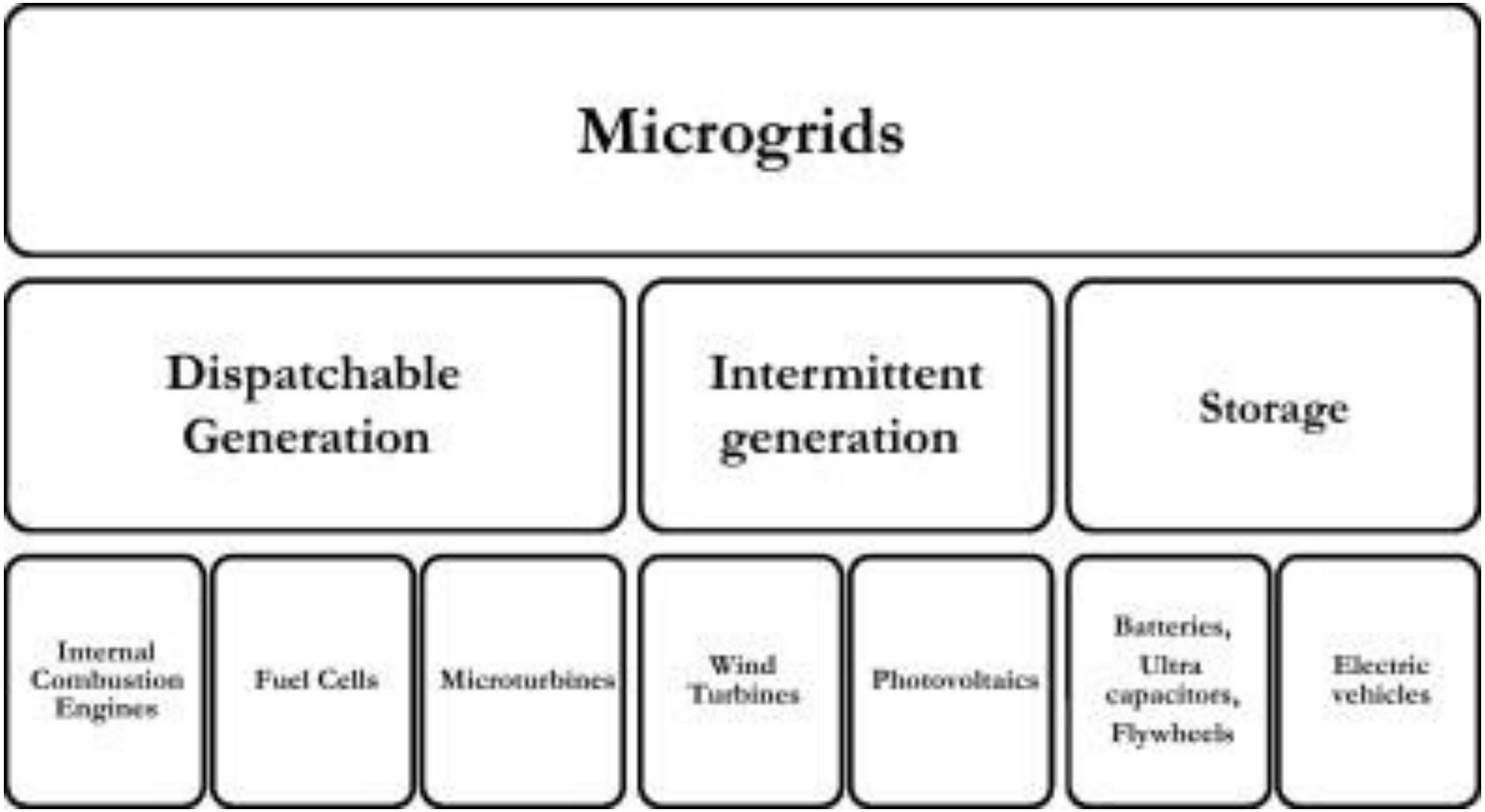
Limitations:

- Many technologies at varied stages of development
- Relatively high capital cost, complex cost-benefit analysis
  - Typically no big savings from “spark spread” arbitrage of off-peak/on-peak rates
- Larger physical footprint needed to serve larger loads for longer durations

Strategies:

- Size renewables + storage for most critical subset of loads, remote locations
- UPS, bridging power role until backup generation online
  - DOE’s Imre Gyuk: “The most valuable energy storage is the first 15 minutes”

Microgrids provide integrative framework



From Mendes, Loakimidis and Ferrão, “On the Planning and Analysis of Integrated Community Energy Systems: A Review and Survey of Available Tools”, *Renewable and Sustainable Energy Reviews*, Volume 15, Issue 9, December 2011, Pages 4836–4854.

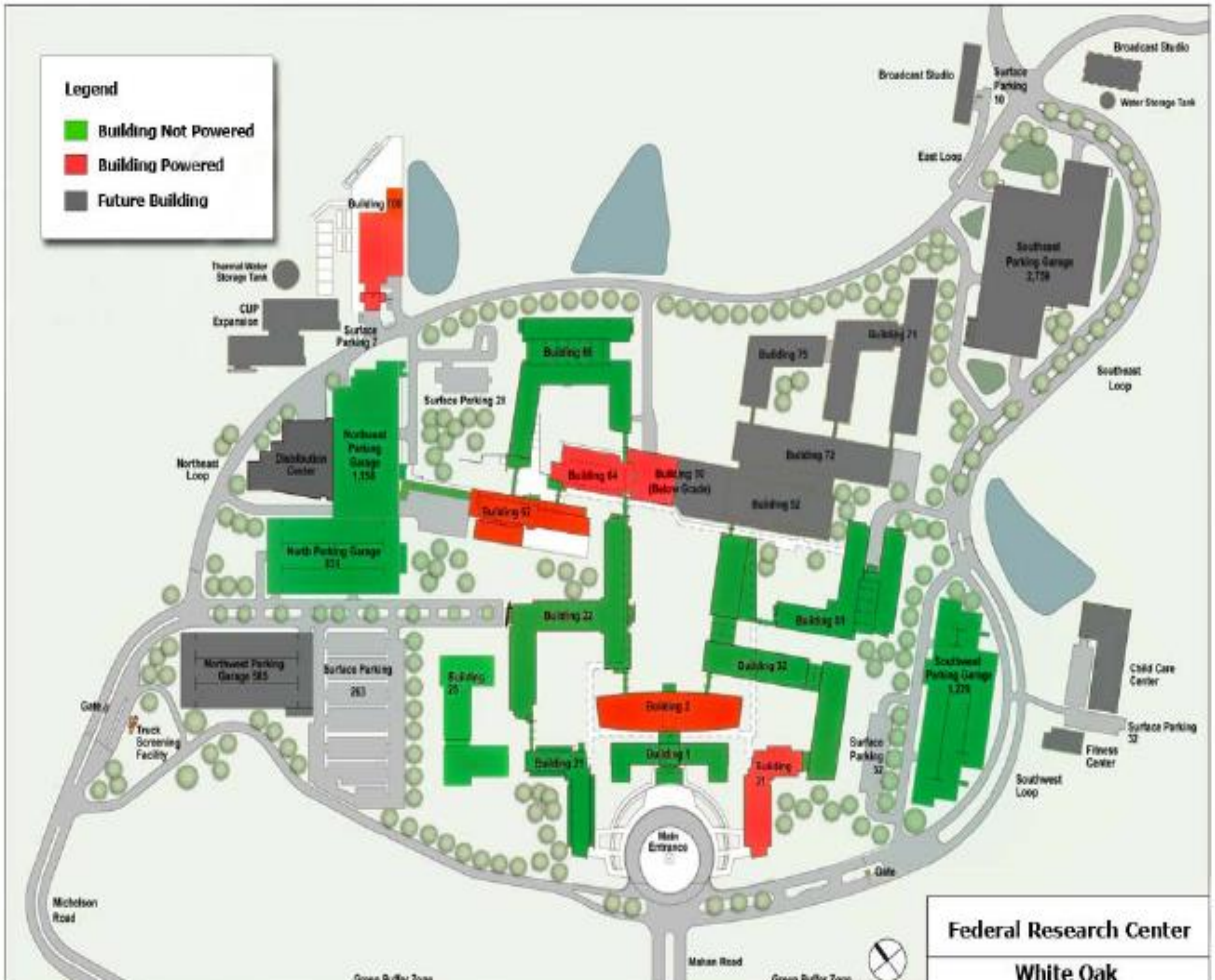
Microgrid design considerations

- Crossing public rights of way challenges utility franchise
- Seek proximal loads
  - Cost to harden / bury /flood proof distribution infrastructure
- Safe interconnection
  - How to disconnect or “island” then reconnect
  - Maintain voltage stability & quality
- Critical facility operation 24/7 in island mode
  - Load shedding, ride-though, black start
- Diversity of generation and fuels
- Control of multiple generators within microgrid
- Consider cyber security, physical security
- Strategy: import-only microgrids

FDA White Oak campus microgrid, MD

Capabilities – Emergency Preparedness

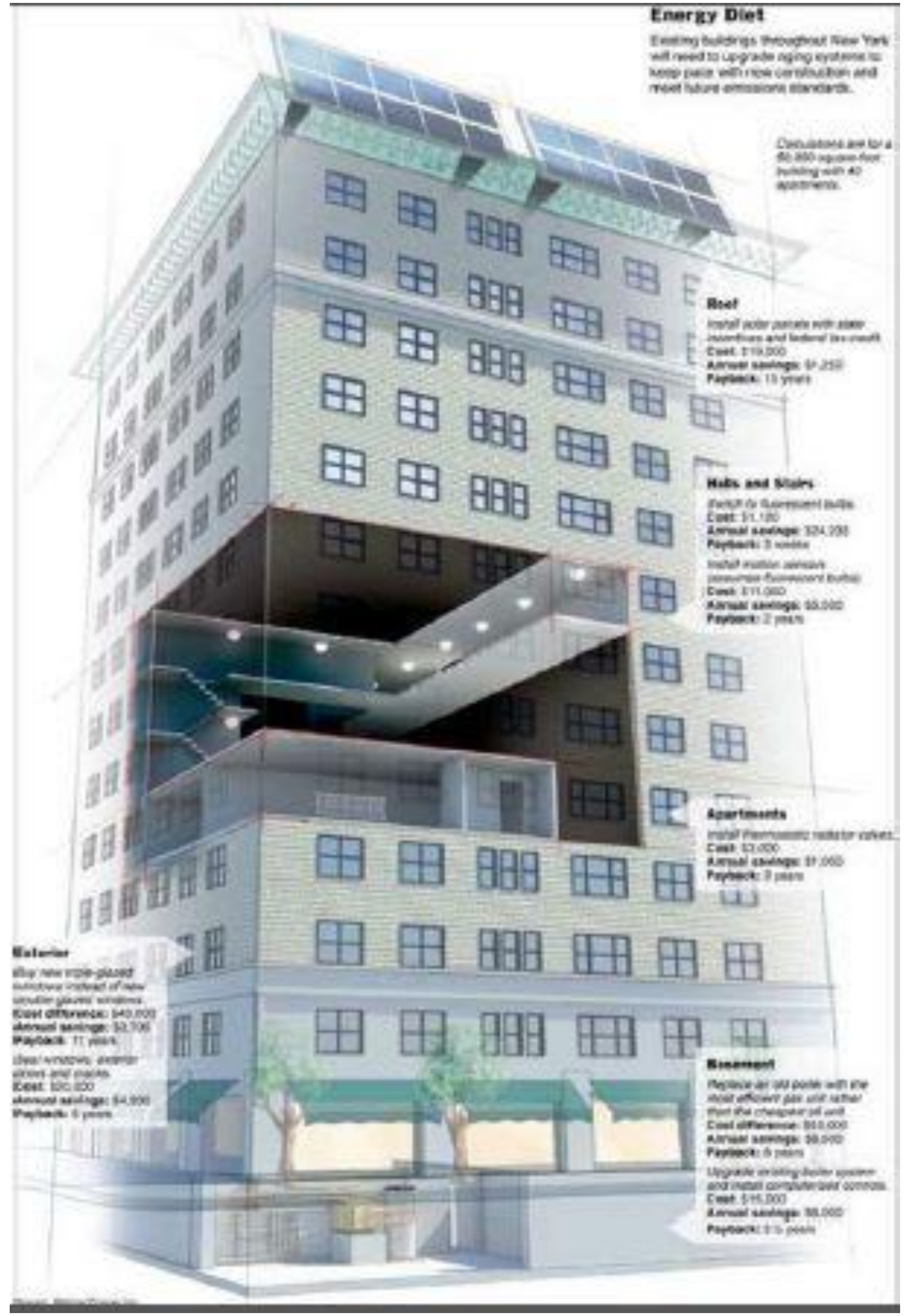
Black-Start Power Restoration: 30 Seconds – 20 Minutes



Financial integration

Incremental approaches to energy saving measures prioritized by payback or ROI alone can reduce overall energy savings and destroy value

Source: "The Cost of Saving Energy", *The New York Times,* July 15th, 2007



Retrofit costs for 40-apartment, 60,000 SF building

Measure	Cost ($)*	Savings ($/yr)	Payback (yr)
Switch to fluorescents in hall & stair lights	1,120	24,233	3 weeks
Motion sensors in hall & stair lights	11,000	5,500	2
Upgrade oil boiler and controls	15,000	6,000	2.5
Install thermostats in apartments	3,000	1,000	3
Seal cracks around doors & windows	20,000	4,200	5
Replace oil boiler with new gas boiler	50,000	6,500	8
Triple-glaze windows instead of double glaze	40,000	3,700	11
Photovoltaics on roof	19,000	1,250	15

**Net of tax credits and other government incentives*

Source: "The Cost of Saving Energy",
The New York Times 15 July 2007

Sometimes it pays to put all your eggs in one basket

Measure	Cost ($)	Savings ($/yr)	Payback (yr)
Switch to fluorescents in hall & stair lights	1,120	24,233	3 weeks
Motion sensors in hall & stair lights	11,000	5,500	2
Upgrade oil boiler and controls	15,000	6,000	2.5
Install thermostats in apartments	3,000	1,000	3
Weatherize, seal cracks around doors & windows	20,000	4,200	5
Replace oil boiler with new gas boiler	50,000	6,500	8
Triple-glazed windows instead of double-glazed	40,000	3,700	11
Photovoltaics on roof	19,000	1,250	15
Bundled measures total	**159,120**	**52,383**	**3**

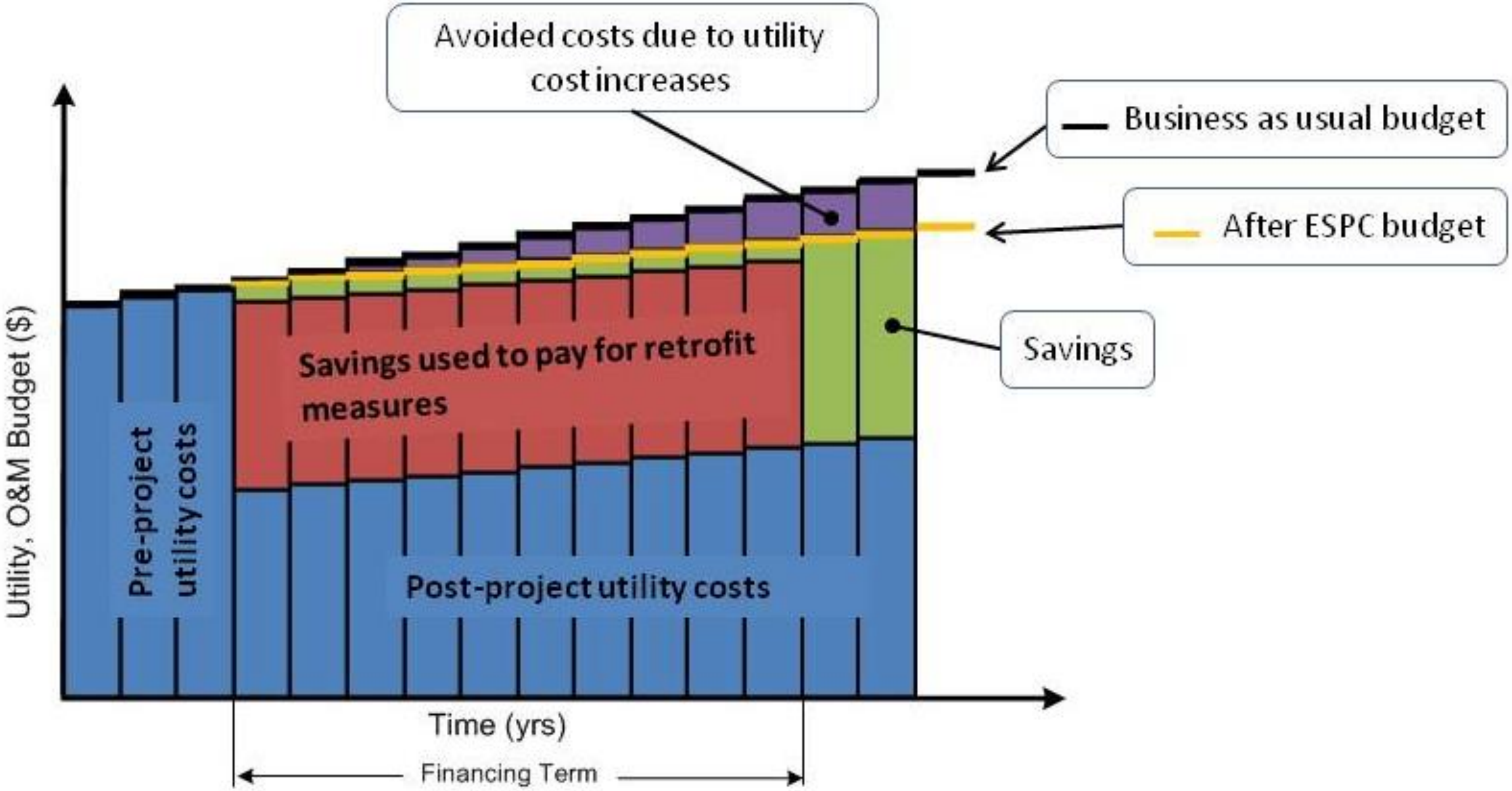
Savings increased >20%

Source: "The Cost of Saving Energy", The New York Times 15 July 2007

Energy Savings Performance Contracts (ESPCs) can retrofit for resilience

- Municipality engages Energy Services Company (ESCO)
- ESCO guarantees savings from energy upgrades
- Cash flow from lower bills repays third-party financing
- Capital improvements without capital expenditures
- Finance & install critical facility resilience enhancements
- ESPC can be used with new construction

How ESPCs work



ESPC provides integrative framework

- Finance today’s upgrades with tomorrow’s energy savings
- Balance energy efficiency with generation capacity cost
- Portfolio of buildings and energy conservation measures
- Bundle measures for bigger savings, shorter payback
- Pooled resources support critical facility capital improvements
- Fund charrette, owner’s rep via project financing
- Plug-in supplemental funding (*e.g.*, grants, rebates)
  - LEAP, C-PACE, EDA post-disaster grants, RECs, etc.
- Climate change mitigation & adaptation via same measures

Thank you for your time...
QUESTIONS?

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- Director of Sustainability Services at Celtic Energy Inc. in Glastonbury, CT
- Lead author of microgrid proposals for 2 Connecticut municipalities
- Lead author of Integrative Design Module for Singapore's CEM Course
- Assistant to Amory Lovins at Rocky Mountain Institute for 7 years
- 2 Master's degrees from Yale School of Management and Yale School of Forestry & Environmental Studies
- Volunteer Firefighter/EMT in 3 states

- Energy efficiency, renewable energy and sustainability consulting firm in Glastonbury, CT
- Offices in Charlotte, North Carolina & Hoboken, New Jersey
- Focus on municipal, state & Federal agencies and higher education clients, GSA schedule contractor
- Core business is serving as Owner’s Representative for Energy Savings Performance Contracts (ESPC), also for Power Purchase Agreements and other services
- Staff Experience on ESCO side and owner’s side of 75+ ESPCs on over $1 Billion of projects
- See www.celticenergy.com

Suggested resources for further study

Resilient facility design

- Resilient Design Institute: www.resilientdesign.org

- US Green Building Council on resiliency:

http://www.usgbc.org/advocacy/priorities/resiliency

USGBC Green Building and Climate Resilience Design Guide:
http://www.usgbc.org/Docs/Archive/General/Docs18496.pdf

- *Design for Flooding* by Don Watson & Michele Adams

- *Two Degrees* by Alisdair McGregor, Cole Roberts & Fiona Cousins

Suggested resources for further study

Integrative Design

- Rocky Mountain Institute: www.rmi.org

- *The Integrative Design Guide to Green Building*, 7group and Bill Reed

- "Integrating HVAC & Life Safety," Daniel Nall PE FAIA, *ASHRAE Journal*, Dec. 2013, pp. 48–51.

Suggested resources for further study

Combined heat and power

- EPA CHP Partnership:

http://www.epa.gov/chp/index.html
http://www.epa.gov/chp/technologies.html

- EPA/DOE/HUD guide to CHP for resiliency:

http://portal.hud.gov/hudportal/documents/huddoc?id=CHPSept2013.pdf

- International District Energy Association (IDEA):

http://www.districtenergy.org/
IDEA community energy planning guide:
http://www.districtenergy.org/community-energy-planning-development-and-delivery

Suggested resources for further study

Microgrids

- "Doing it Right: Top 6 Things to Consider When Doing Microgrids", Stuart McCaffery, SmartGridNews.com, January 14th, 2014:

http://www.smartgridnews.com/artman/publish/Delivery_Microgrids/Doing-it-right-Top-6-things-to-consider-when-developing-microgrids-6279.html#.Uz2Ua2eYbrd

- Connecticut Department of Energy & Environmental Protection microgrid grants and loans program:

http://www.ct.gov/deep/cwp/view.asp?a=4120&Q=508780

CT DEEP microgrid grant program RFP, presentations & documents (look under "web filings"):

http://www.dpuc.state.ct.us/DEEPEnergy.nsf/$EnergyView?OpenForm&Start=1&Count=30&Expand=1&Seq=1

Suggested resources for further study

Energy Storage

- Energy Storage Association:

http://energystorage.org/

Energy Savings Performance Contracts

- Energy Services Coalition:

http://www.energyservicescoalition.org/

- National Association of Energy Service Companies (NAESCO):

http://www.naesco.org/

- Best Practices Guide for Energy Savings Performance Contracting:

http://www.energizect.com/sites/default/files/111003%20Final%20CT%20ESPC%20Best%20Practices-1.pdf