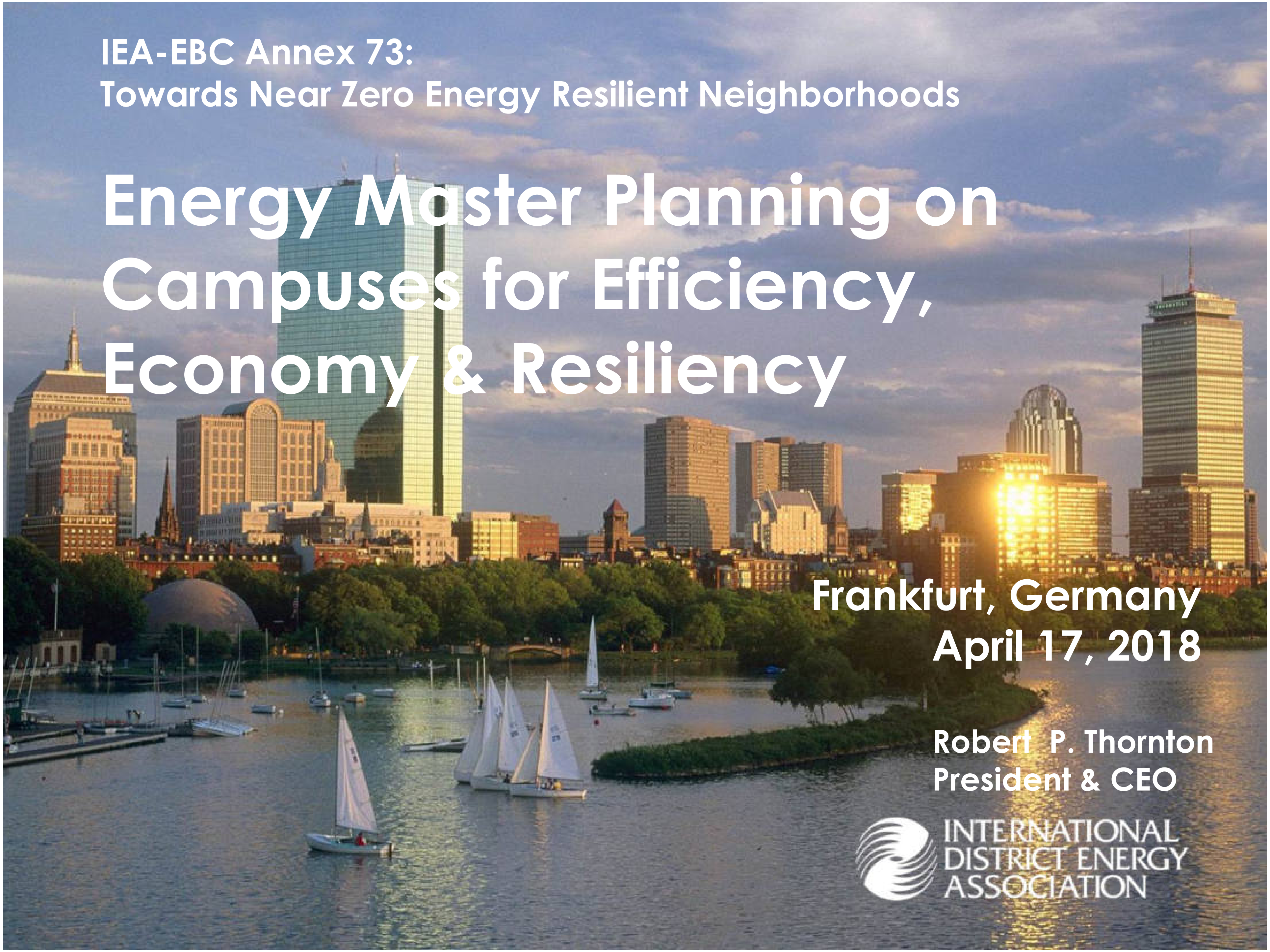
IEA-EBC Annex 73:
Towards Near Zero Energy Resilient Neighborhoods

Energy Master Planning on Campuses for Efficiency, Economy & Resiliency

Frankfurt, Germany
April 17, 2018

Robert P. Thornton
President & CEO
INTERNATIONAL DISTRICT ENERGY ASSOCIATION



ABOUT IDEA

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

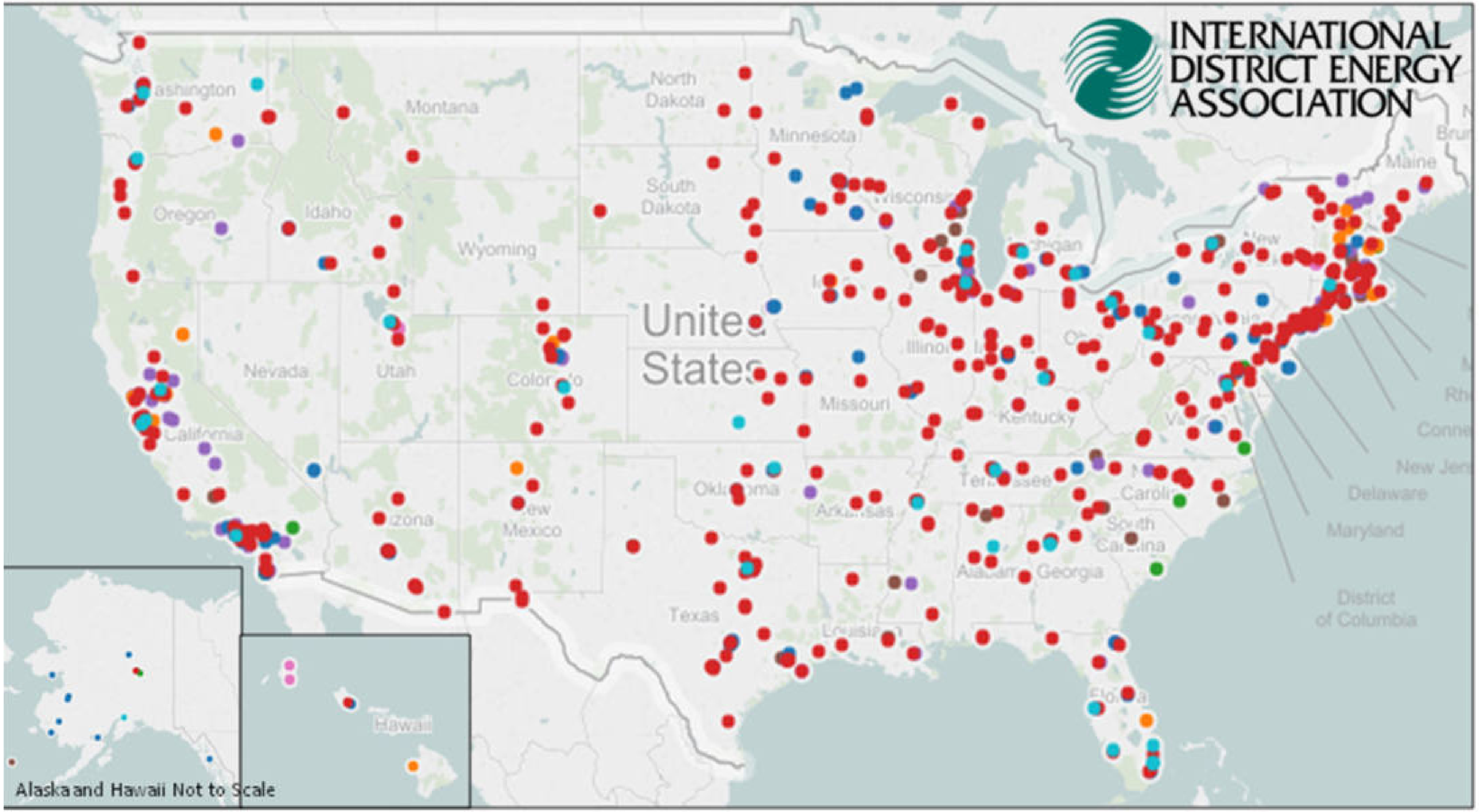
Formed in 1909: 109th year

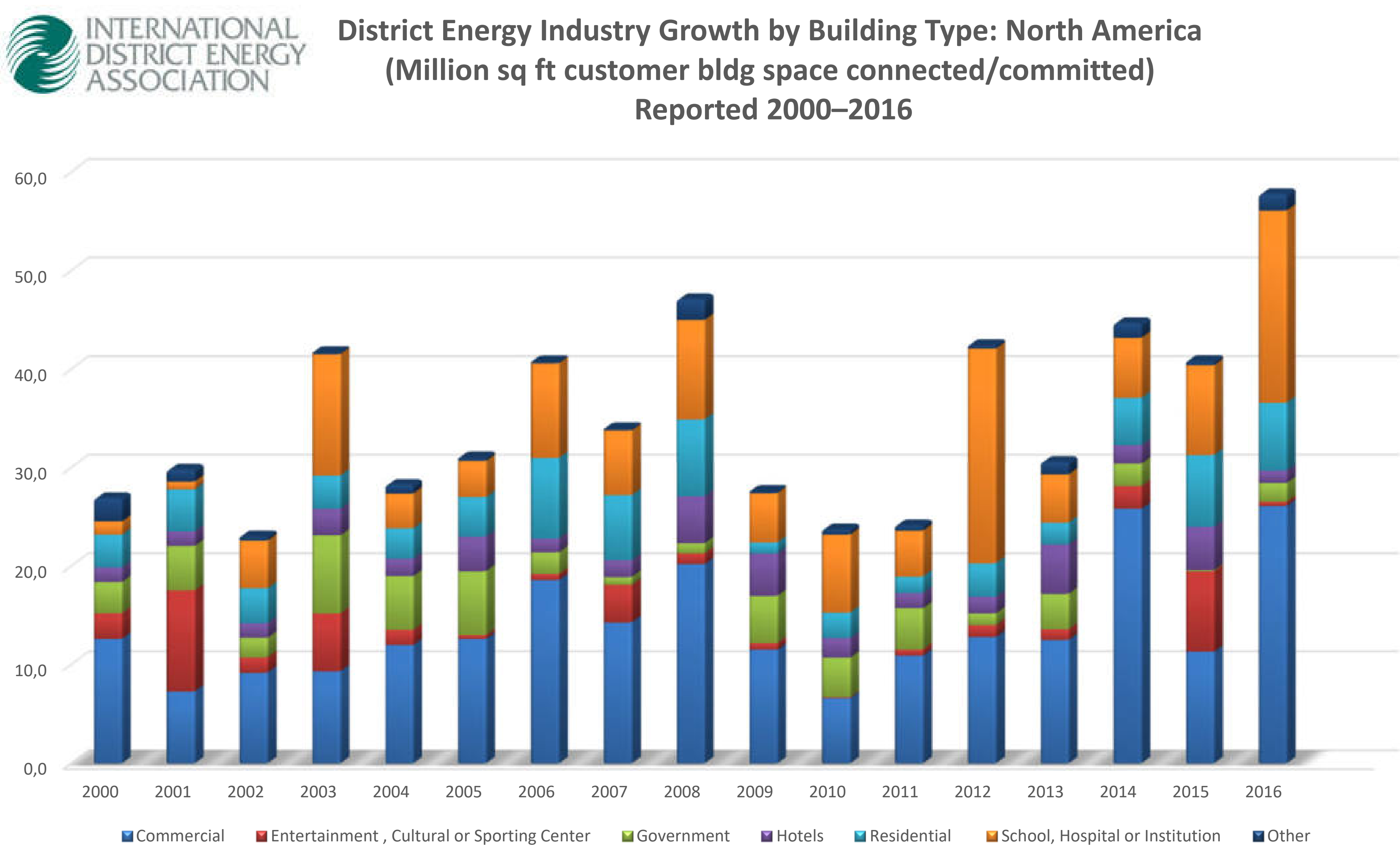
501 (c) 6 industry association

2300+ members – 25 nations
56% end-user systems, majority in North America: 6 provinces; 48 states

Major urban utilities, public and private universities & colleges, healthcare, pharma, airports, industry, etc.

US District Energy Systems 2017



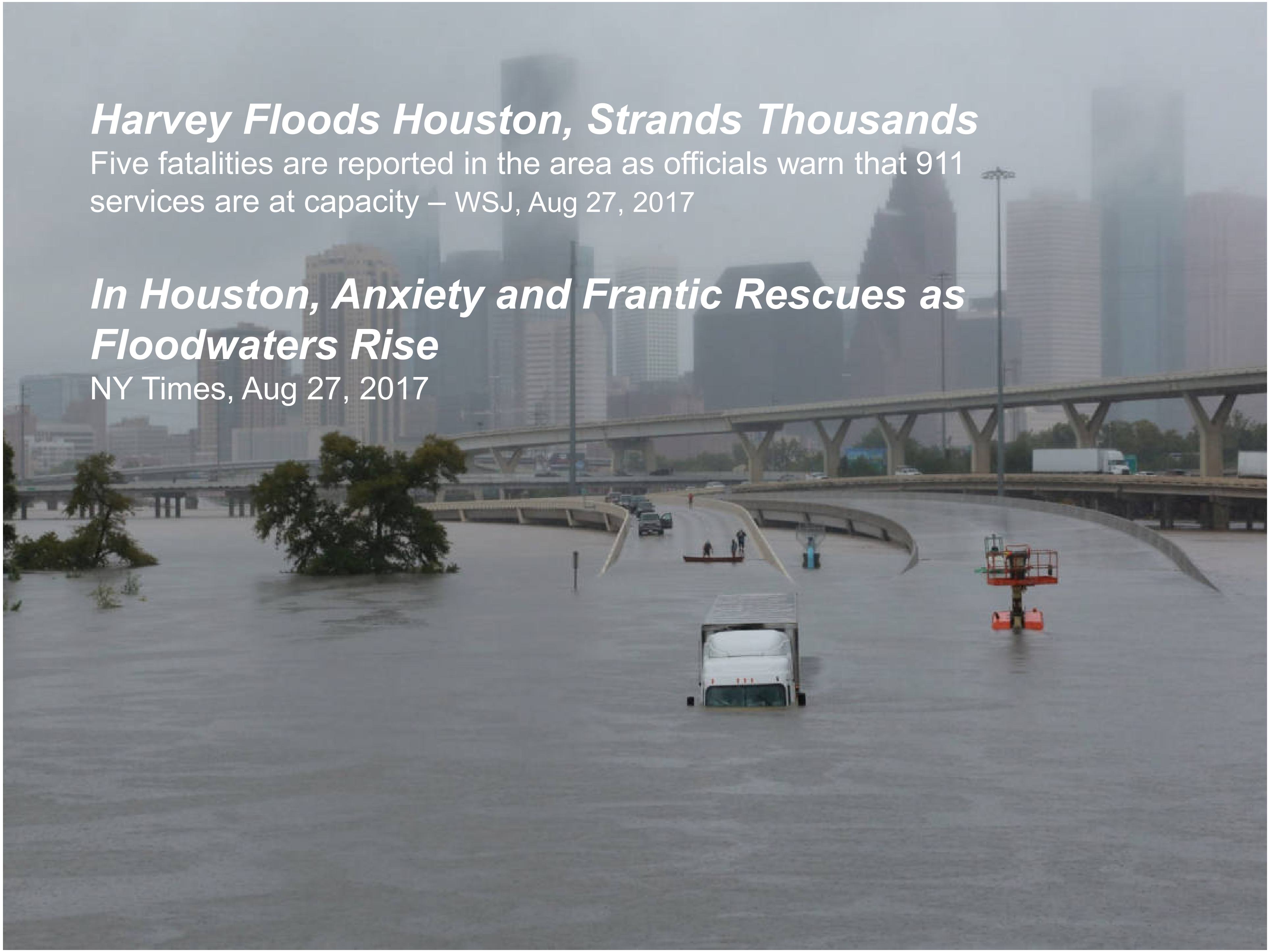

INTERNATIONAL DISTRICT ENERGY ASSOCIATION
District Energy Industry Growth by Building Type: North America
(Million sq ft customer bldg space connected/committed)
Reported 2000–2016
60,0
50,0
40,0
30,0
20,0
10,0
0,0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Commercial
Entertainment , Cultural or Sporting Center
Government
Hotels
Residential
School, Hospital or Institution
Other

INCREASING RESILIENCE WITH LOCAL DISTRICT ENERGY/CHP MICROGRID SYSTEMS


NRG Energy Center Phoenix District Cooling
June 23, 2017 record heat wave reaches 123 deg F.
Average daily temp. June 26 – July 7 – 107 deg F.

NRG Energy Center Phoenix

- 5 interconnected plants
- Ice thermal storage
- 40,000 tons District Cooling
- Serving more than 12 million sq ft
- 4+ miles of chilled water pipeline



Harvey Floods Houston, Strands Thousands

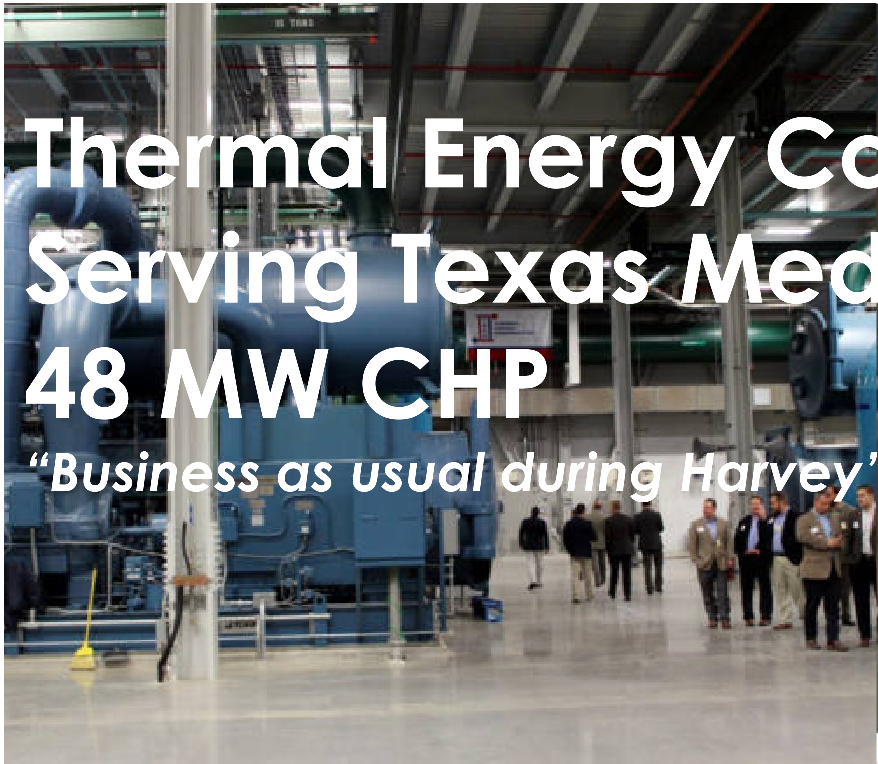
Five fatalities are reported in the area as officials warn that 911 services are at capacity – WSJ, Aug 27, 2017

In Houston, Anxiety and Frantic Rescues as Floodwaters Rise

NY Times, Aug 27, 2017

Thermal Energy Corp
Serving Texas Medical Center
48 MW CHP

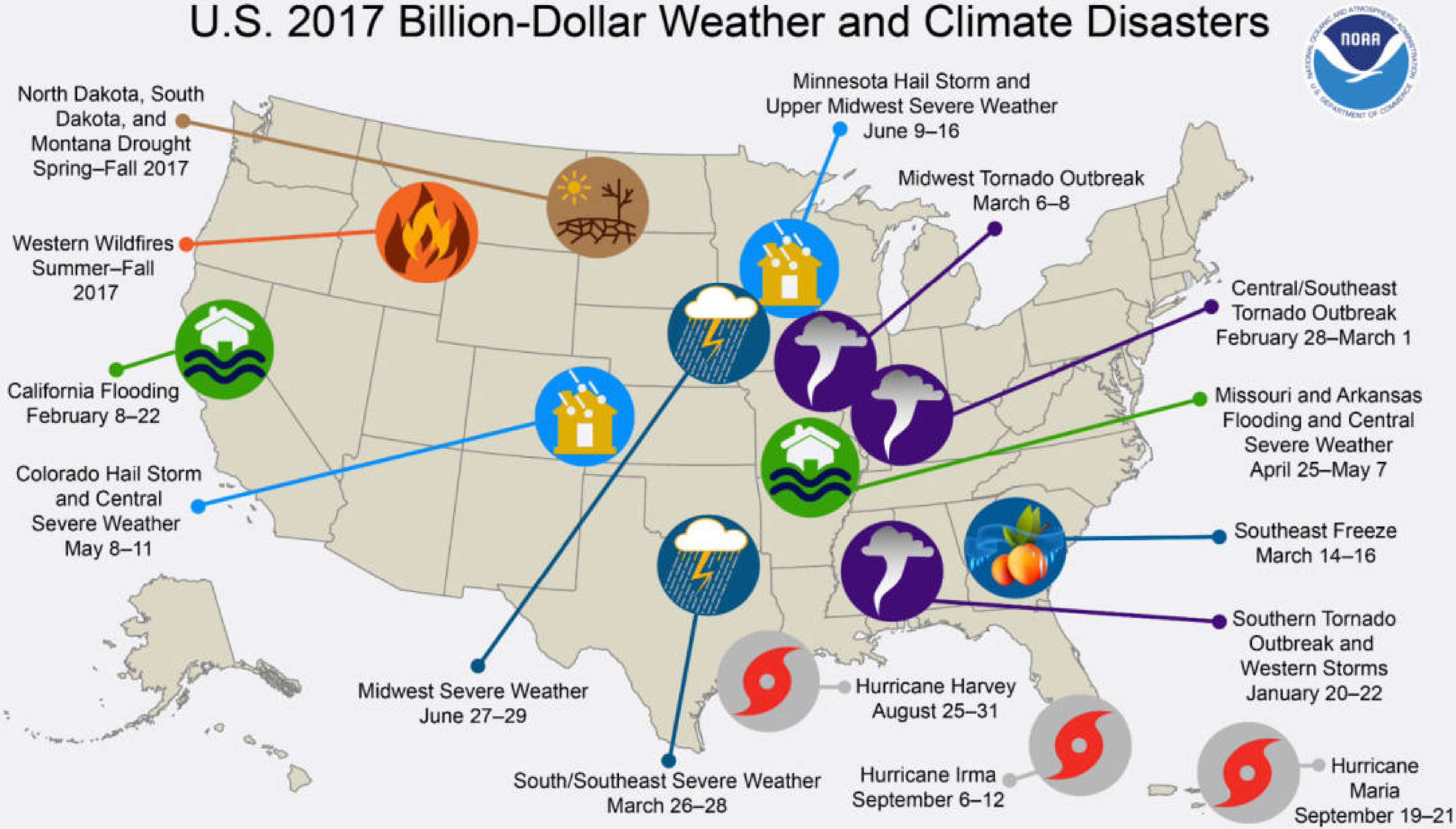
"Business as usual during Harvey"



Above: Brays Bayou August 28, 2017. Below: Brays Bayou under normal conditions October 2012.


POLAR
L
VORTEX
PACIFIC
AIR
CUT OFF
EXTREME
COLD
H
LATE-MONTH
PATTERN
AccuWeather.com

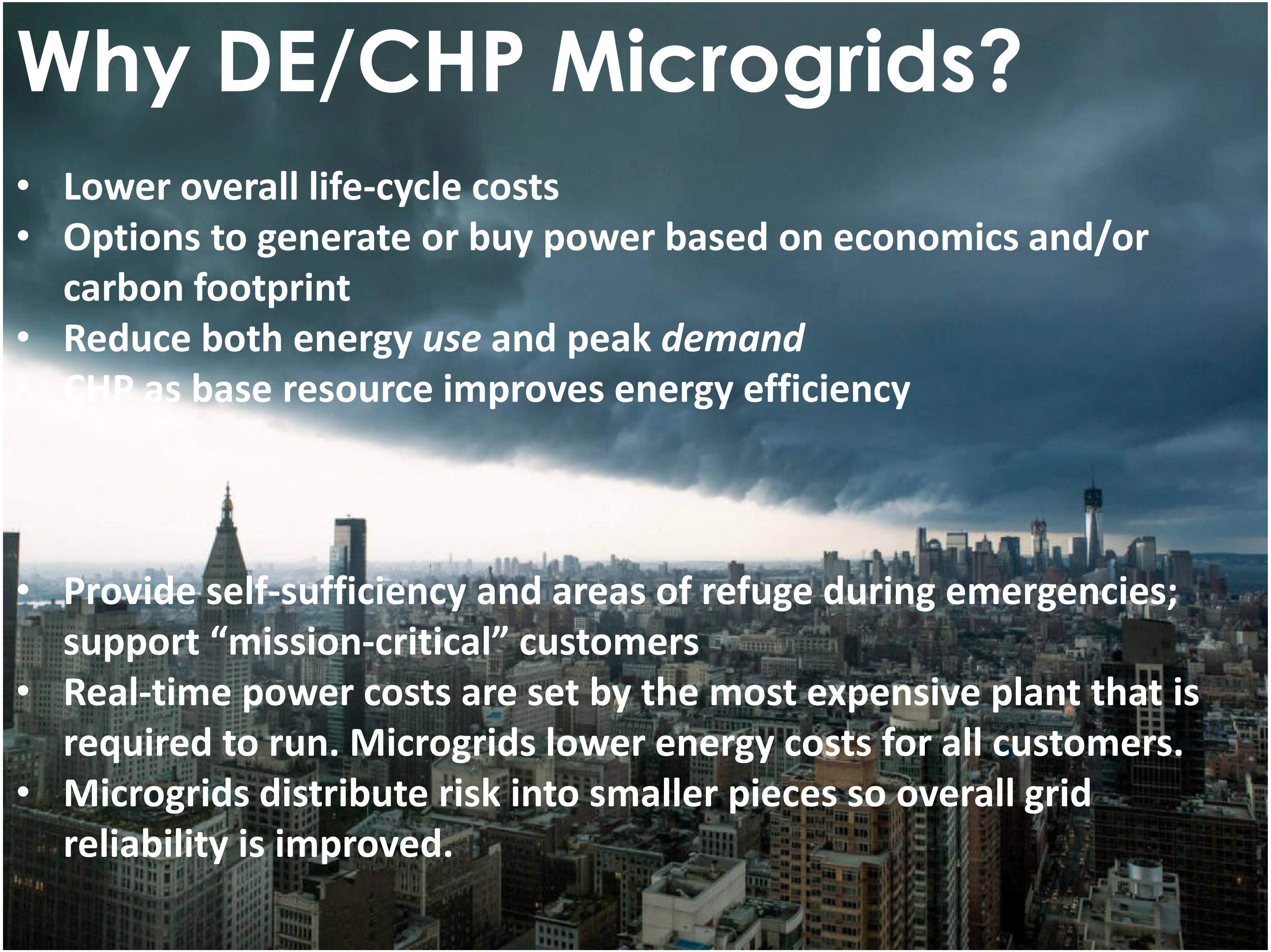
U.S. 2017 Billion-Dollar Weather and Climate Disasters



*This map denotes the approximate location for each of the **15 billion-dollar weather and climate disasters** that have impacted the United States **January through September of 2017, a record pace**.*


The Washington Post
'No excuse': Atlanta airport power outage strands travelers in darkness for nearly 11 hours Dec 17, 2017
The New York Times
Power Failure at Airport Snarls Air Traffic Nationwide Dec 17, 2017

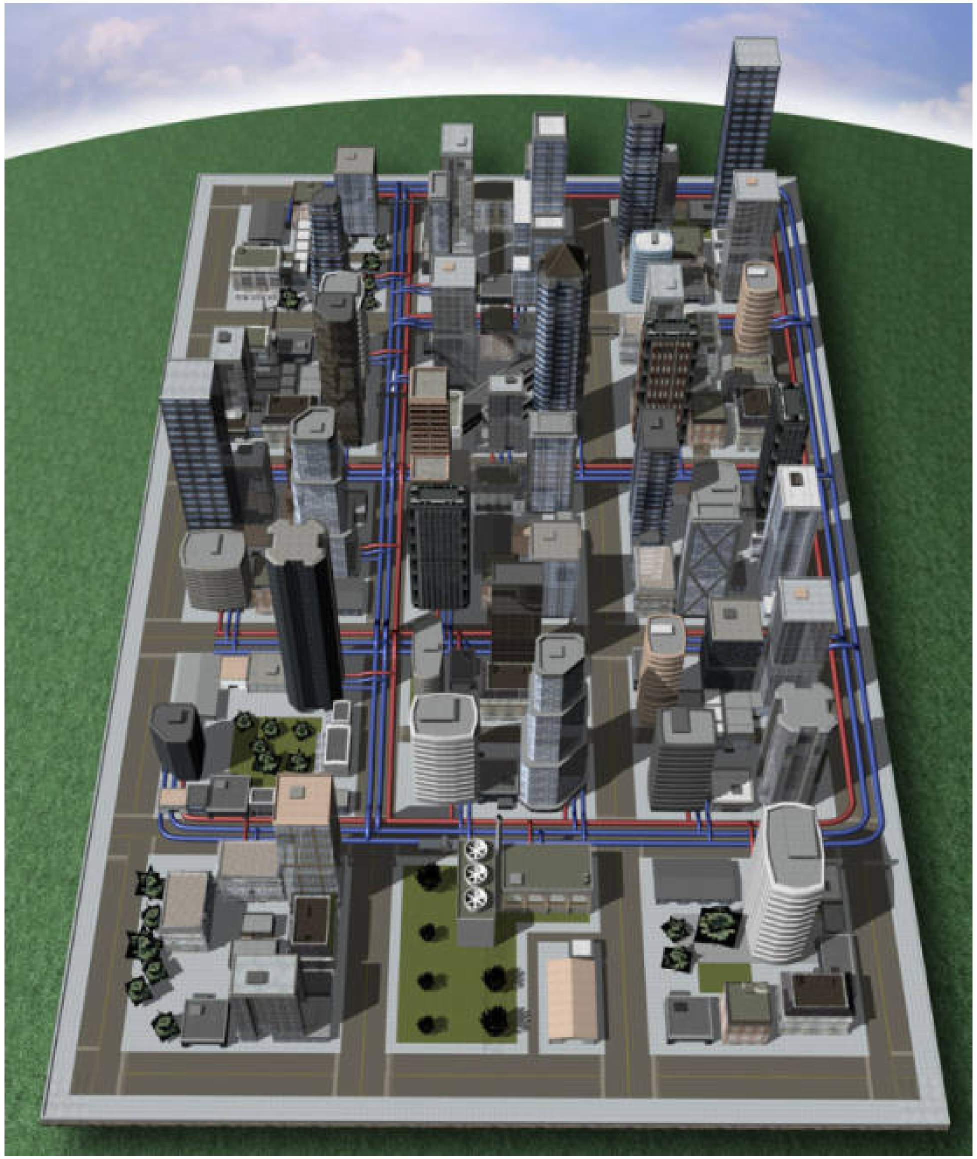
Why DE/CHP Microgrids?



- Lower overall life-cycle costs
- Options to generate or buy power based on economics and/or carbon footprint
- Reduce both energy *use* and peak *demand*
- CHP as base resource improves energy efficiency
- Provide self-sufficiency and areas of refuge during emergencies; support “mission-critical” customers
- Real-time power costs are set by the most expensive plant that is required to run. Microgrids lower energy costs for all customers.
- Microgrids distribute risk into smaller pieces so overall grid reliability is improved.

District Energy/CHP/Microgrid – Community Scale Energy Solution

- Underground network of pipes "combines" heating and cooling requirements of multiple buildings
- Creates a "market" for valuable thermal energy
- Aggregated thermal loads creates scale to apply fuels and technologies not feasible on single-building basis
- Fuel flexibility & distributed generation improves energy security, strengthens local economy



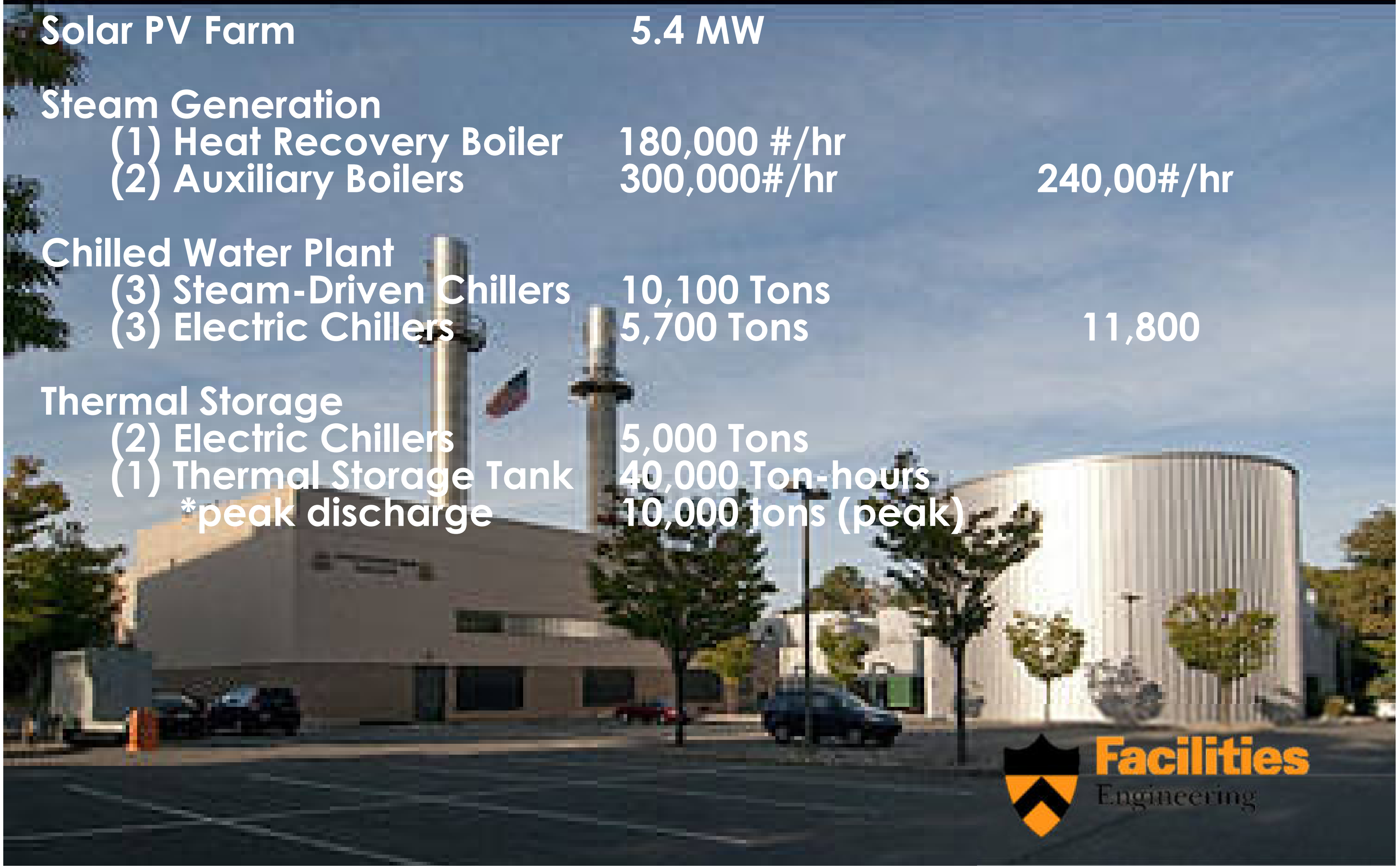
PRINCETON
UNIVERSITY
15 MW District
Energy CHP
STORM-TESTED
+PROVEN ANNUALLY

October 2011
Hurricane Irene

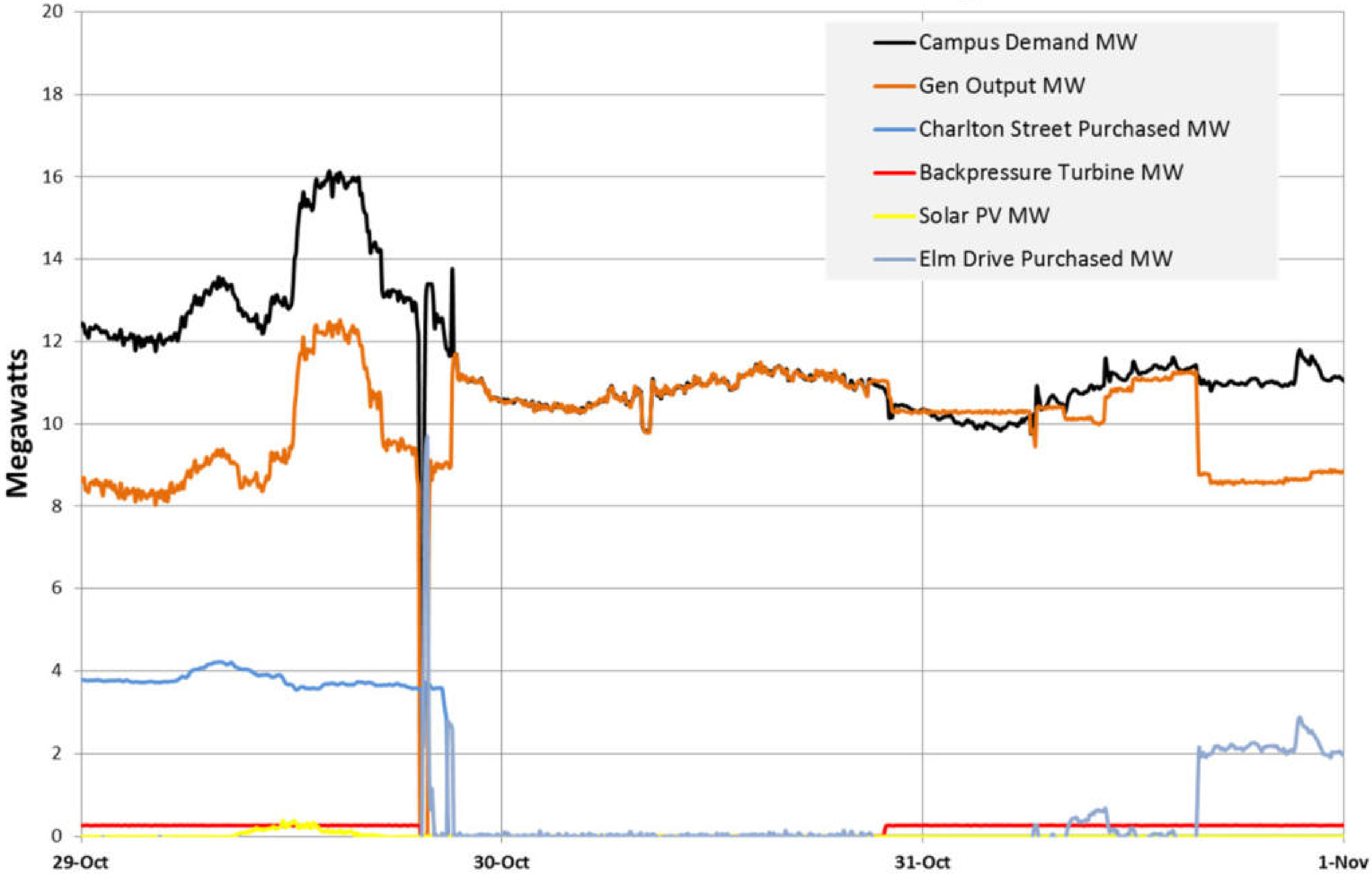
October 2012
Super Storm Sandy

Lights. Stayed. On.

		Campus Peak
Gas Turbine Generator	15 MW	27 MW
Solar PV Farm	5.4 MW	
Steam Generation		
(1) Heat Recovery Boiler	180,000 #/hr	
(2) Auxiliary Boilers	300,000#/hr	240,00#/hr
Chilled Water Plant		
(3) Steam-Driven Chillers	10,100 Tons	
(3) Electric Chillers	5,700 Tons	11,800
Thermal Storage		
(2) Electric Chillers	5,000 Tons	
(1) Thermal Storage Tank	40,000 Ton-hours	
*peak discharge	10,000 tons (peak)	



Campus Power During Hurricane Sandy



MIT CHP - 2020

- Expanding CHP from 22 to 44 MW
- Higher energy efficiency to offset 10% growth in energy demand from new buildings and research
- Critical to MIT's commitment to reducing campus GHG emissions at least 32% by 2030

Capitol Power Plant – Washington, DC
Adding 7.5 MW CHP

Capitol Hill District Energy – Washington, DC

HUDSON YARDS, NYC

Related Companies

$20 Billion Multi-Use Real Estate Development

13 MW CHP Microgrid in two plants

Provides electricity, hot and chilled water to the community

First-of-its-kind microgrid, with Con Edison allowing a commercial property to island from grid w/o manual intervention

image courtesy of related / oxford properties

HARVARD gazette
December 8, 2016

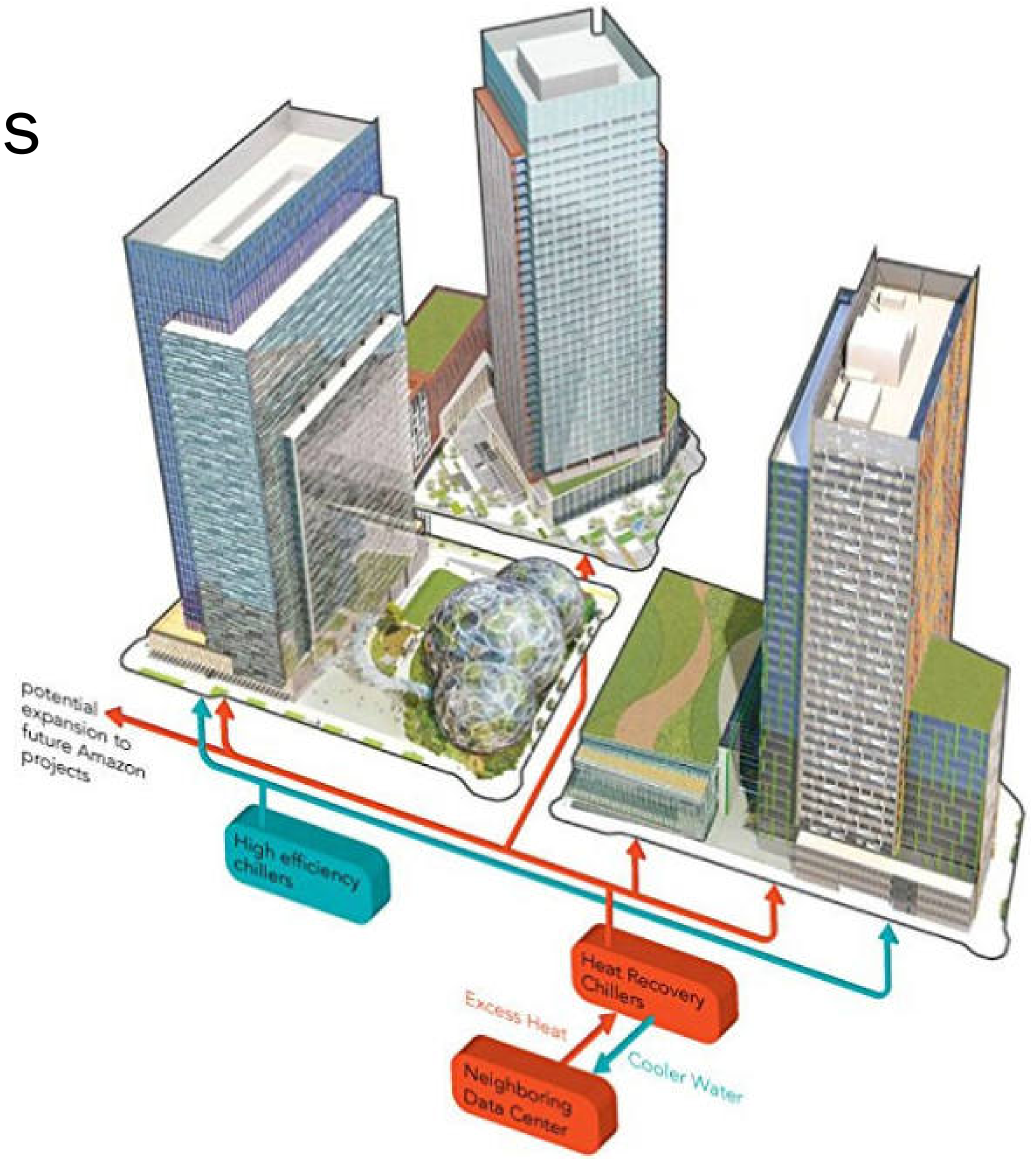
Curbing carbon on campus

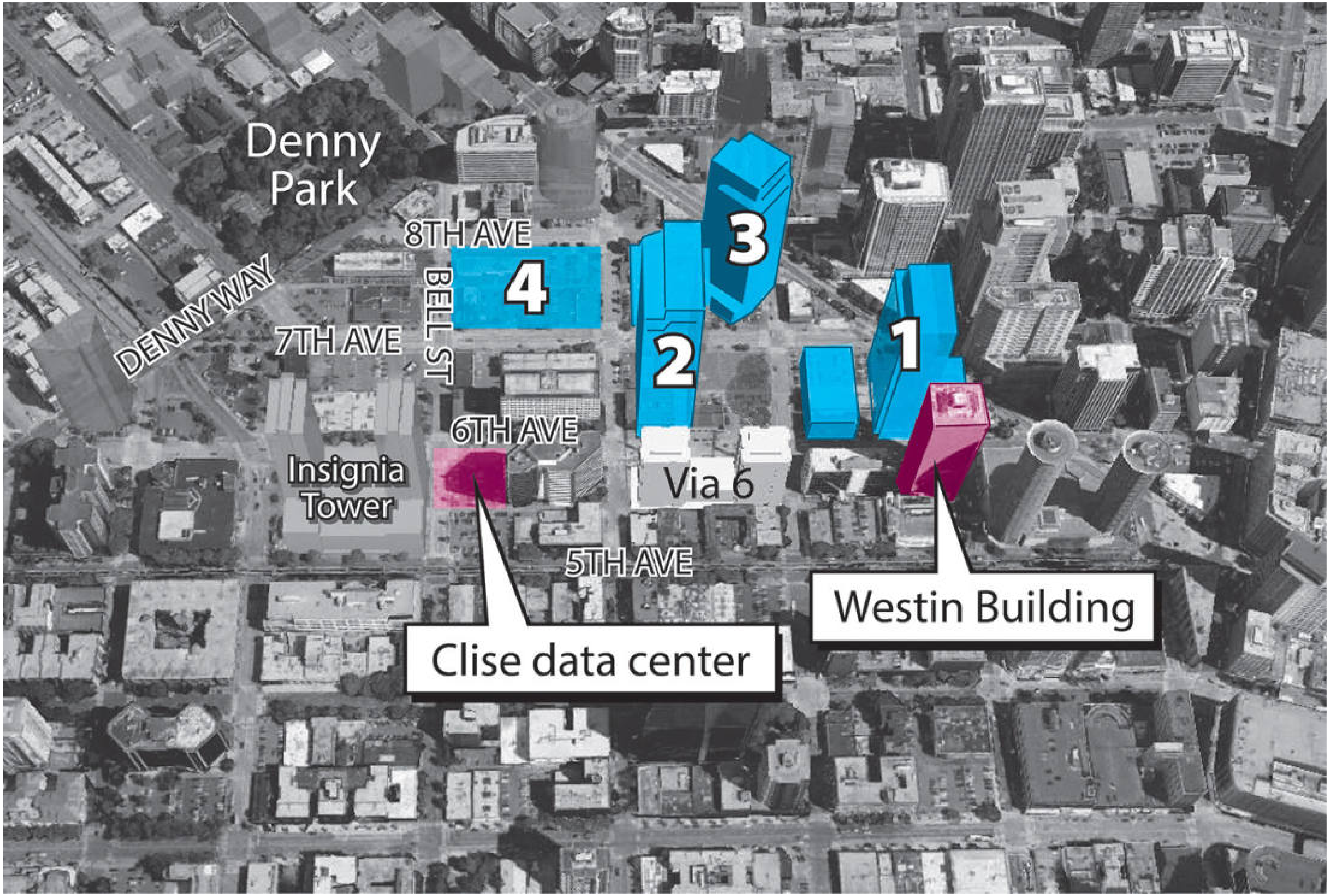
Harvard achieves science-based climate goal set in 2008

Amazon's Seattle Campus

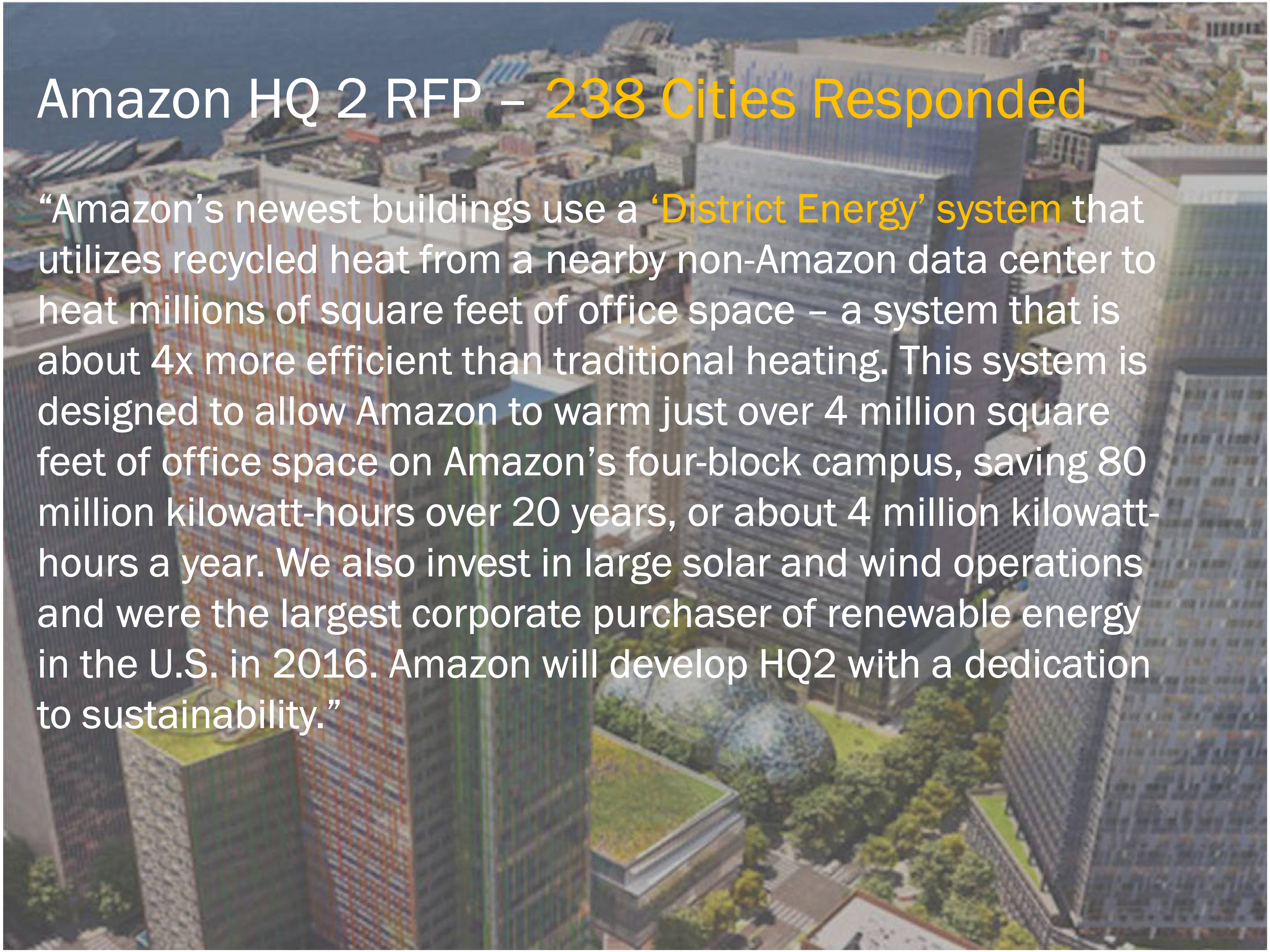
Heats 4 million sqft of office space using waste heat from a neighboring data center

"4x more efficient than traditional heating methods"





Eco District LLC constructed a system to circulate waste heat from a data center in the Westin Building into Amazon's Denny Triangle campus. The four phases of the campus are shown here in blue.



Amazon HQ 2 RFP – 238 Cities Responded

"Amazon's newest buildings use a 'District Energy' system that utilizes recycled heat from a nearby non-Amazon data center to heat millions of square feet of office space – a system that is about 4x more efficient than traditional heating. This system is designed to allow Amazon to warm just over 4 million square feet of office space on Amazon's four-block campus, saving 80 million kilowatt-hours over 20 years, or about 4 million kilowatt-hours a year. We also invest in large solar and wind operations and were the largest corporate purchaser of renewable energy in the U.S. in 2016. Amazon will develop HQ2 with a dedication to sustainability."

Google's Sidewalk Labs signs deal for 'smart city' makeover of Toronto's waterfront –

TRISH McALASTER / THE GLOBE AND MAIL. IMAGE: WATERFRONT TORONTO

“buildings would be linked by an energy system that would reduce the district's energy consumption by 95 per cent below city regulations.”

“The future of urban sustainability is renewable district energy” – Sidewalk Labs

Energy Supply to Mission-Critical Facilities – Best Practices and Lessons Learned from University Campuses

- University of Texas Medical Branch at Galveston – Planning Post Hurricane
- University of Texas Austin – Supporting A Fast Track Mission-Critical Campus Healthcare Expansion
- Planning and Optimizing Energy Efficiency at University of Missouri Columbia

THE UNIVERSITY OF TEXAS MEDICAL BRANCH (UTMB) AT GALVESTON

Energy Security on a Barrier Island

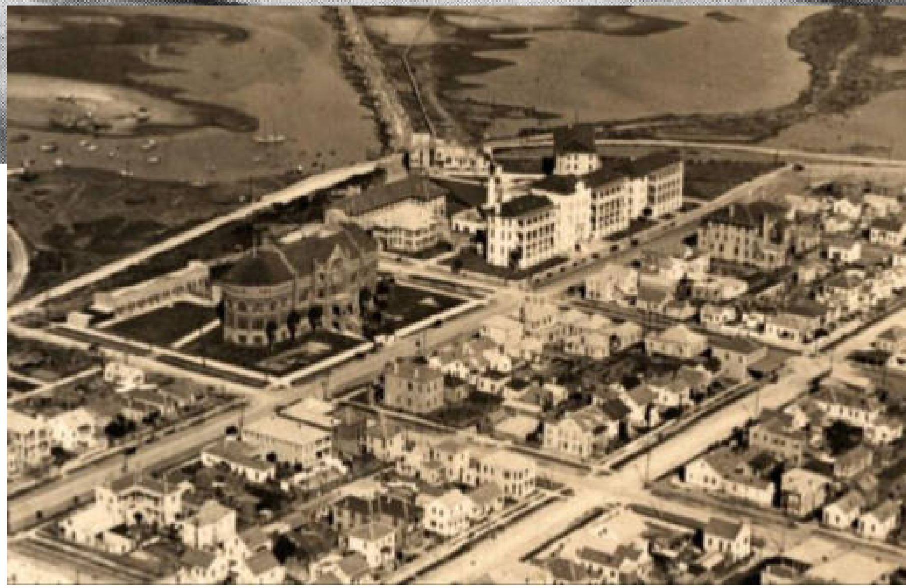
Presented to
Energy Master Planning for Resilient Military Installations
December 6, 1017

Jerry A. Schuett, PE
Principal, Energy and Utilities
jschuett@aeieng.com

Affiliated Engineers

utmb Health

Galveston Island, circa 1890's

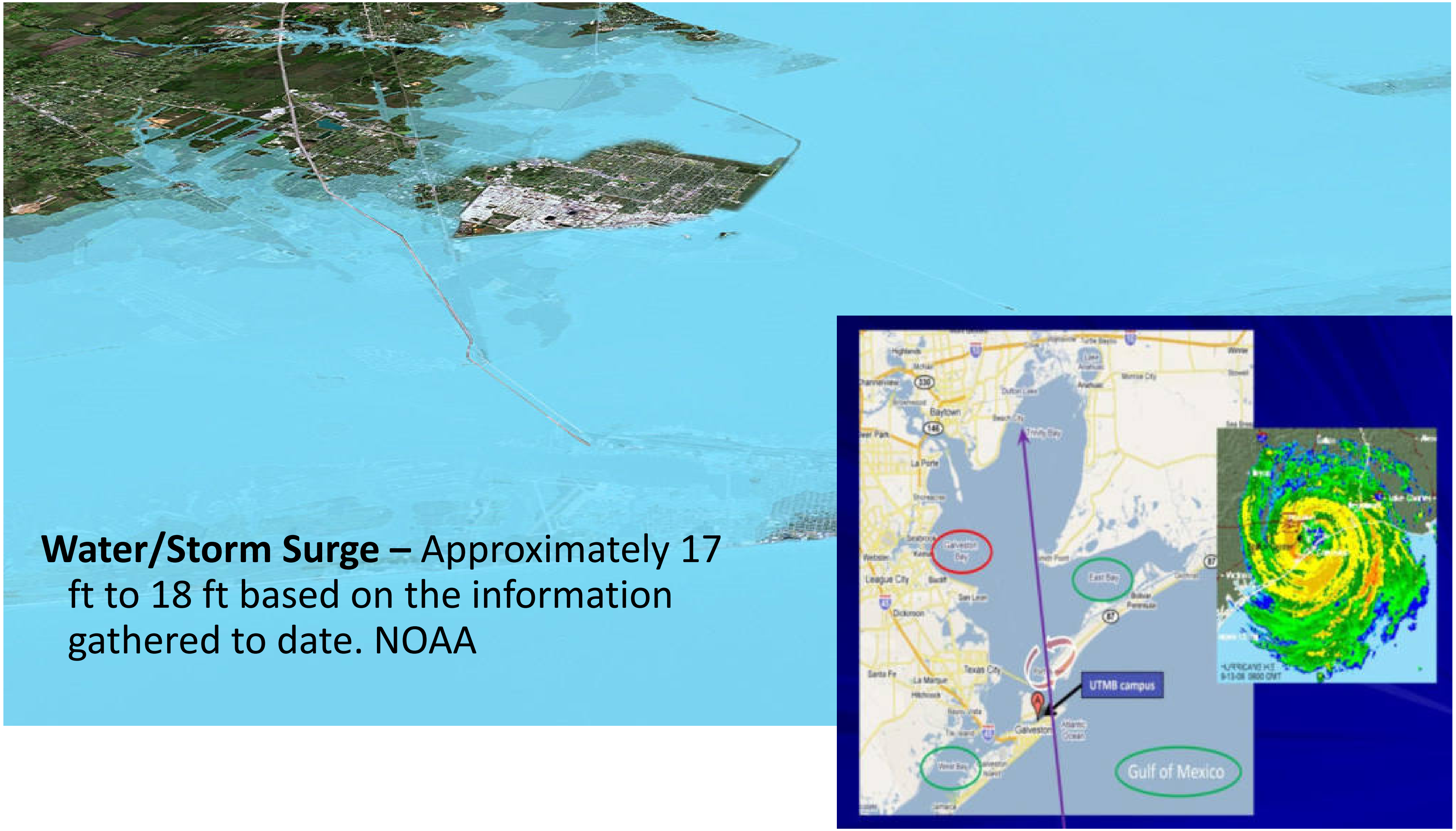


UTMB Photos: Old Red/John Sealy

The Great Storm of 1900

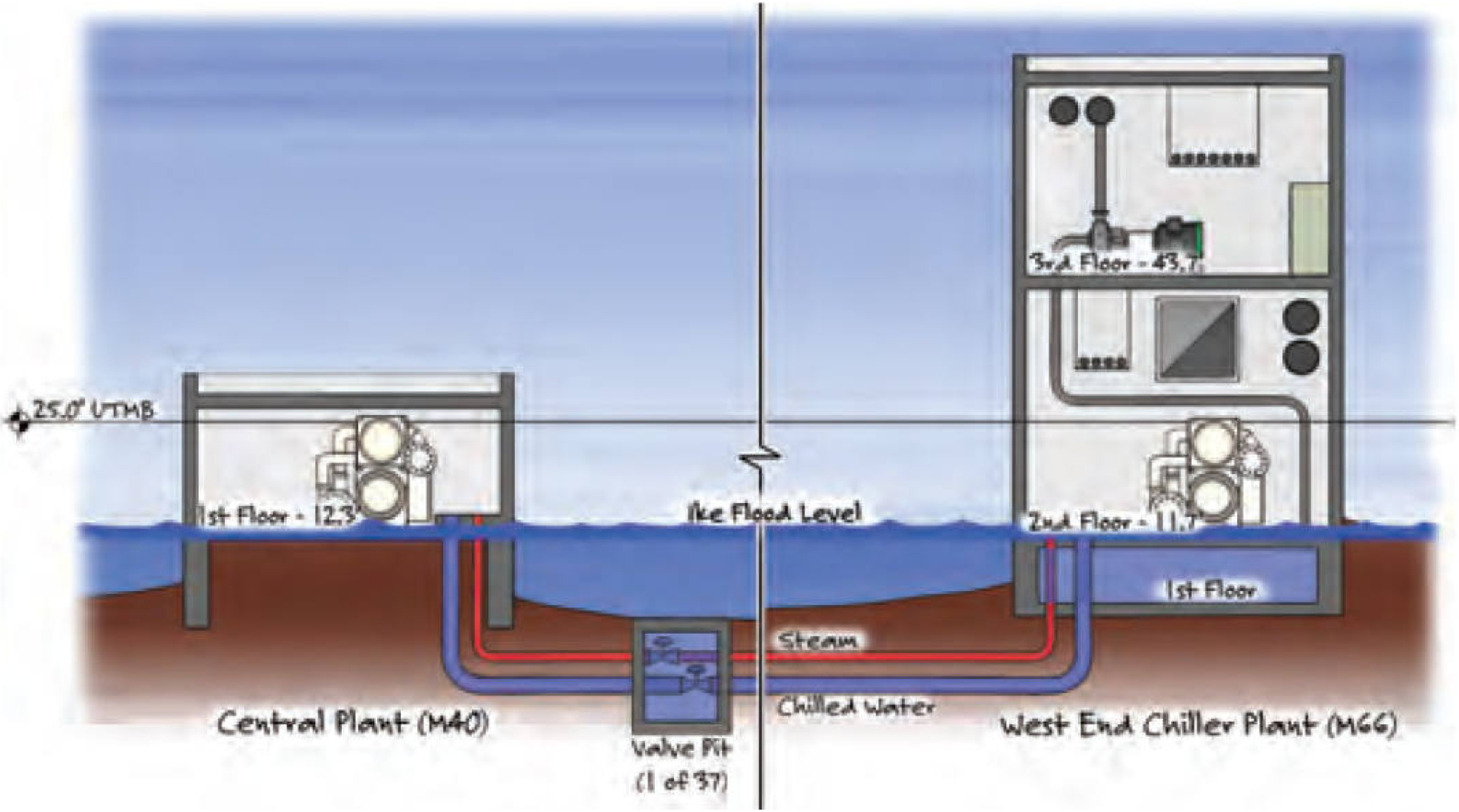
UTMB Photos: Old Red/John Sealy

Hurricane Ike, September 13, 2008



Water/Storm Surge – Approximately 17 ft to 18 ft based on the information gathered to date. NOAA

Hurricane Ike, September 13, 2008



Hurricane Ike, September 13, 2008



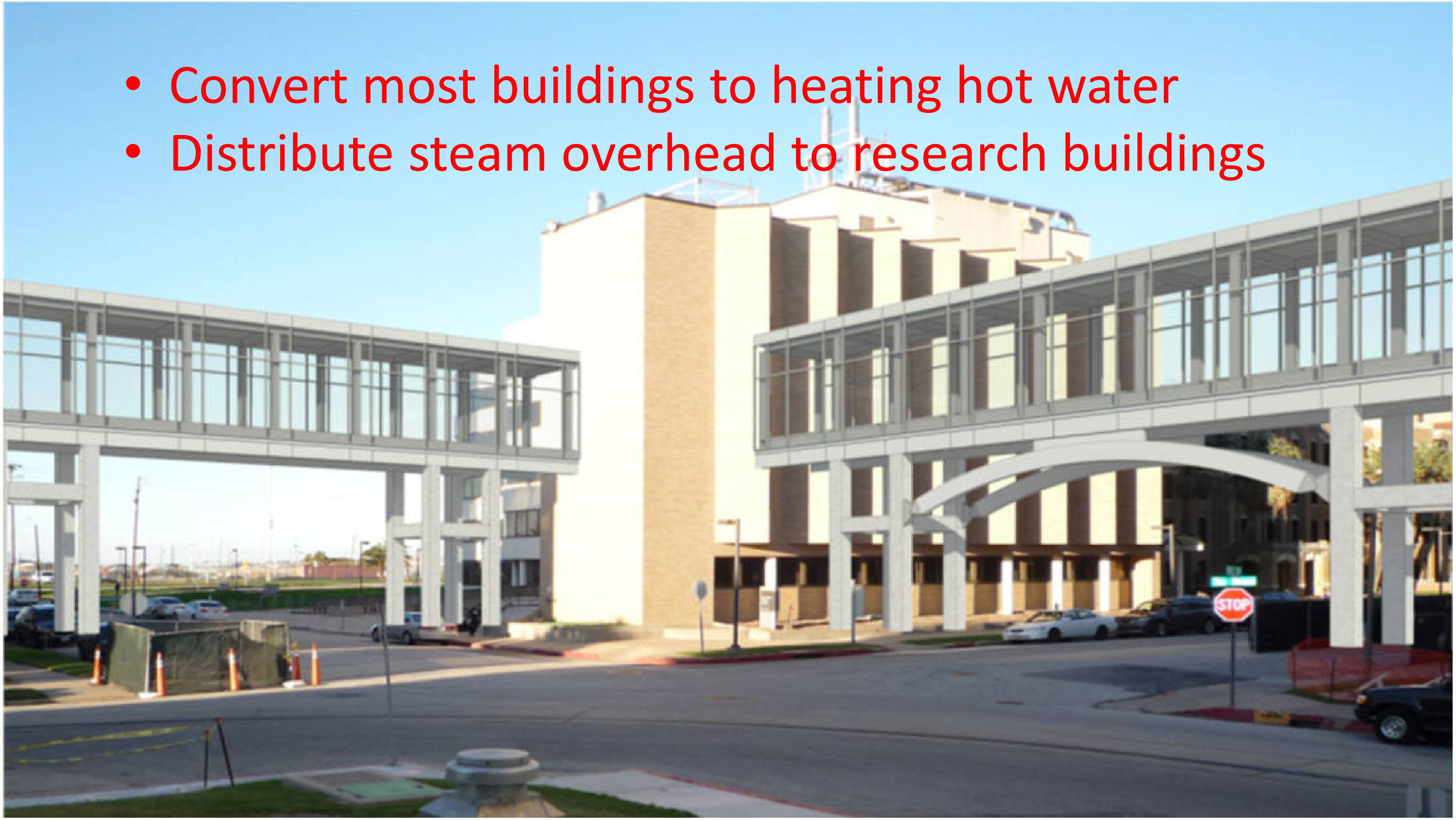

Impact of Ike

- Cost of stabilization: $14,000,000
- Unable to operate hospital: 90 Days
- Lost business revenue: $2,000,000/day
- Cost of evacuation
- Underground steam distribution system a total loss
- Lost research materials
- Over 1 million sf of campus buildings damaged
- Estimated over $1 billion in damages

A Three Step Solution

Step One Go Away from Buried Steam Pipe

- Convert most buildings to heating hot water
- Distribute steam overhead to research buildings



Step Two Elevate the Boilers and Chillers

Step Two West Plant Flood Walls

Step Three

Combined heat and power systems are approximately 50% more efficient than traditional systems

Hurricane Harvey vs. UTMB Galveston

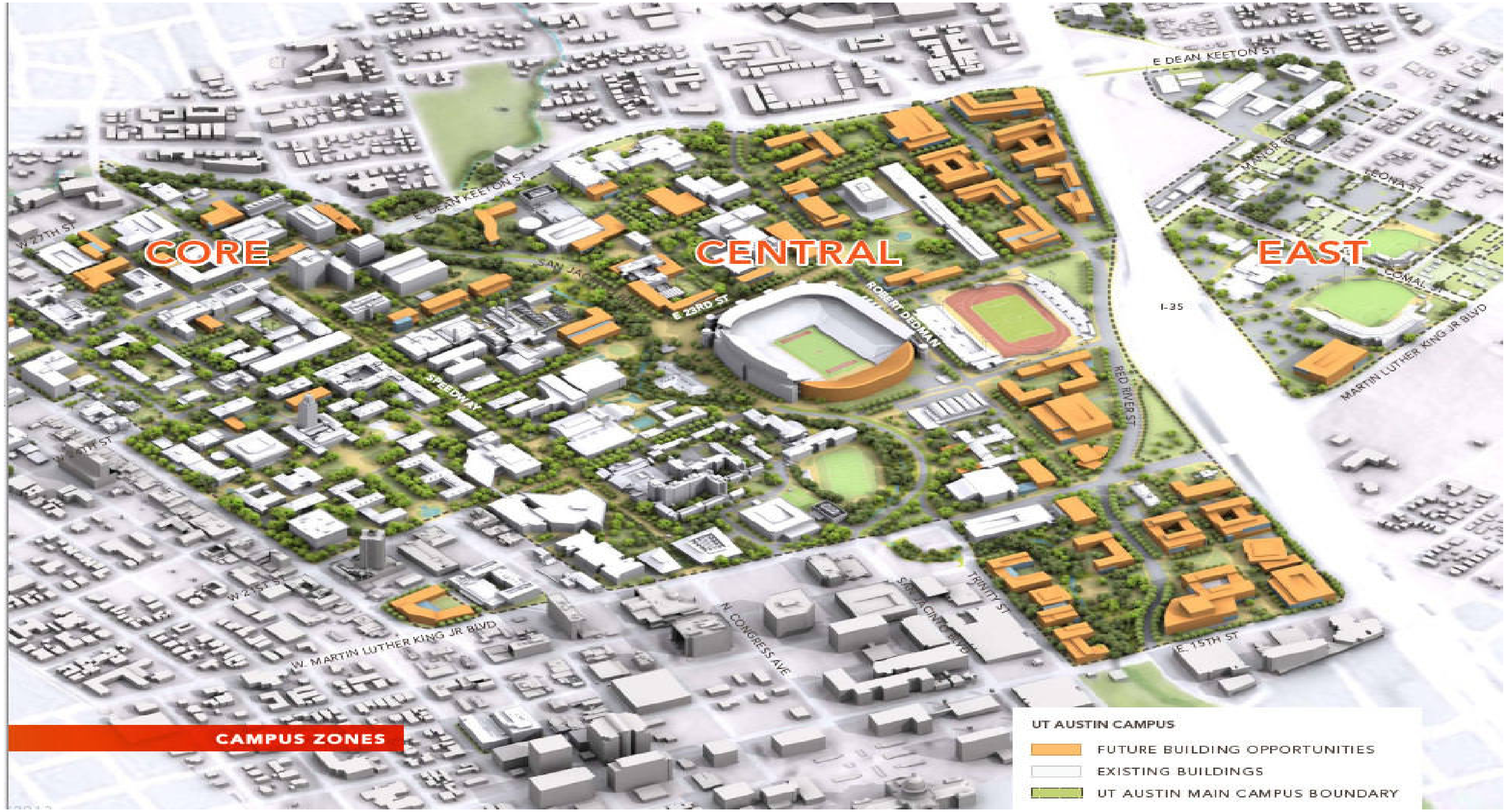
- Local utility lost two electrical feeders due to a flooded transformer vault, ***no problem***
  - The East Plant CHP system operated trouble free in "Island Mode"

- Heavy rainfall caused minor street flooding, ***no problem***
  - For the new overhead steam and underground heating hot water distribution systems "It was just another day at the office".
  - As a precaution, the gates in the new floodwall surrounding the older West Plant were secured.

Supporting A Fast Track Mission-Critical Campus Healthcare Expansion The University of Texas at Austin

New Campus Master Plan

5.5 million SF Completed June 2012



New Medical School

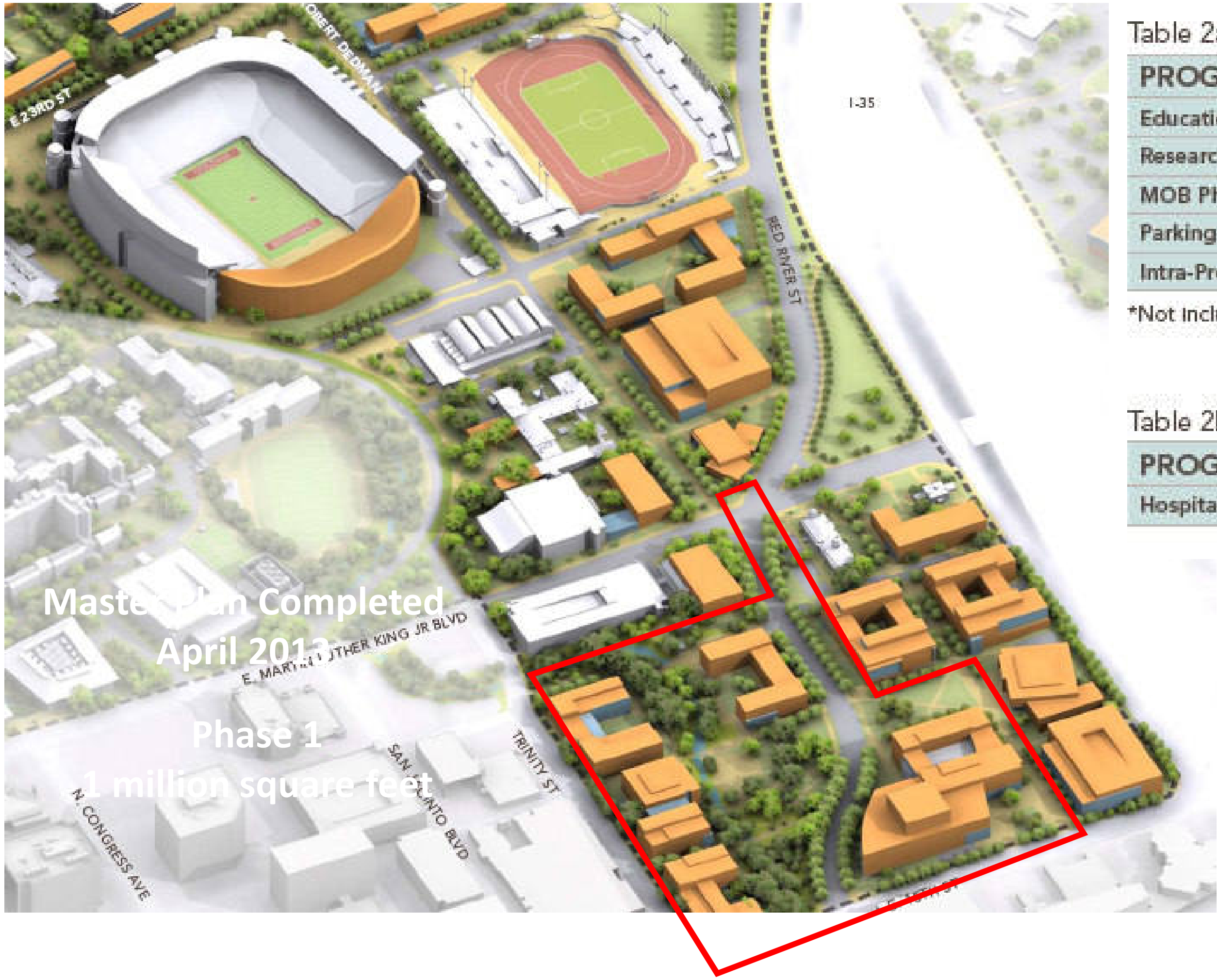


Table 2a. **Dell Medical School Program**

PROGRAM ELEMENT	GSF
Education and Administration Building	75,000
Research Building and Vivarium	240,000
MOB Phase 1	200,000
Parking Structure (1,000 spaces)	325,000
Intra-Professional Education (IPE)*	+/- 50,000

*Not included in Phase 1 planning budget.

Table 2b. **Teaching Hospital and MOB Program**

PROGRAM ELEMENT	GSF
Hospital (220 beds)	480,000

Methodology

- Used building type & actual metered energy use per GSF for existing campus buildings
  - Estimate annual & peak energy& water needs
    - Determine plant total capacity & rate impact
  - Used Termis chilled water and steam model
    - Size and plan distribution system
- Include build out of 2.2 million SF for Phase 2&3
- Include 1 million more new square feet on the campus

Over-Arching Objectives

- **New chilling station**
  - **Capacity & efficiency enough to prevent negative impact to campus**
  - **Expandable to address subsequent phases of district**
  - **Continue philosophy of loops & redundant service**
- **What is impact of other new space?**
- **Avoid power plant expansion**
- **Avoid conflict between Peak Steam and Peak Power**

Projected Loads

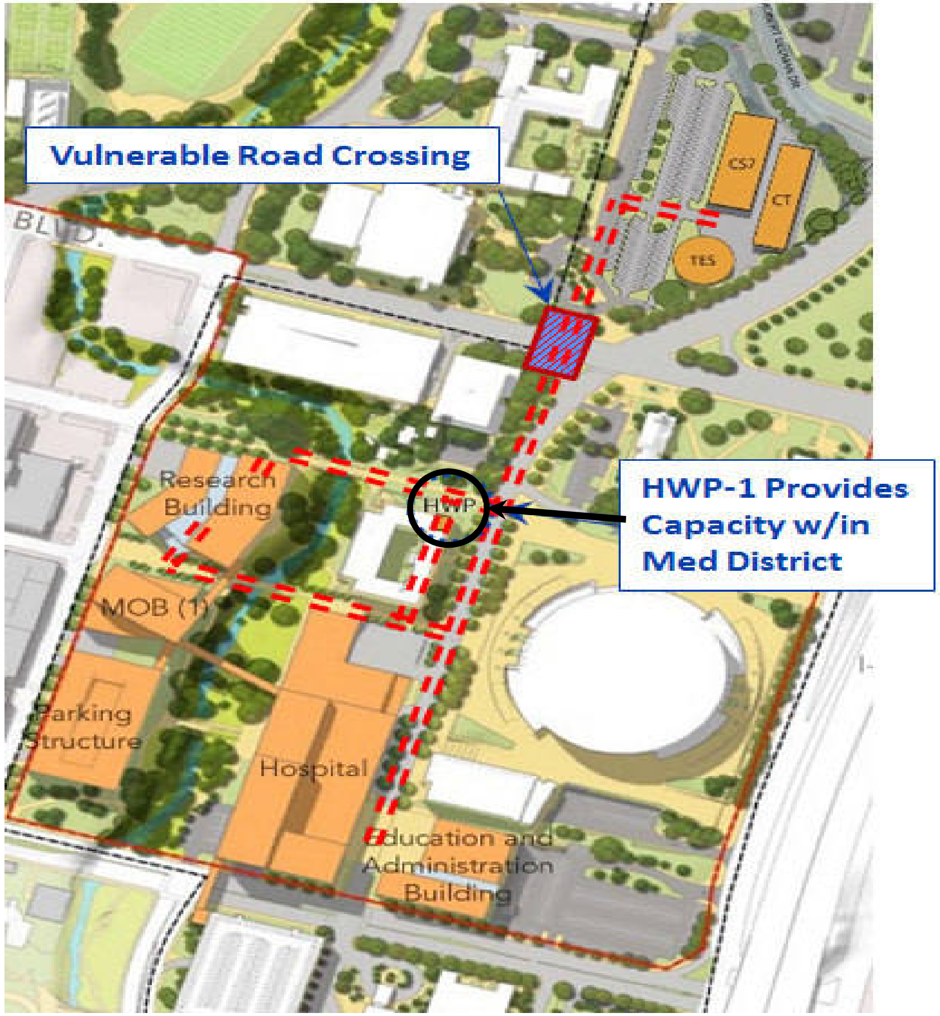
- Main Campus Load Growth
  - 6,000 Tons
- Phase I
  - Dell Medical School;
    - 7,000 Tons, 6 MW, 30,000 lbs/hr
- Hospital
  - 1,700 Tons, 30,000 lbs/hr
- Phase II- Medical School
  - 5,100 Tons, 4MW, 25,000 lbs/hr

Capacity

- Chilled Water System
  - 15,000 tons chilled water
    - 6 -2,500 ton chillers
    - 5° F approach cooling tower
    - Expandable to 20k tons
  - 5.5 million gallon TES
    - Stratified Water
    - Dedicated pumping
    - More than 5 MW load shifting capacity

Capacity

- Chilled Water
  - Proven Existing System
  - Tunnel + Direct Buried
  - Station Redundancy
- Heating Water
  - New System
  - Fuel Diversity
  - Geographic Diversity
- Single Points of Failure
  - N+1 pumps and tower cells
  - Looped Piping
  - Main tie main switchgear



Resiliency

- Multiple Water Sources
  - Recovered
  - Reclaimed
  - Irrigation
  - Domestic
- O&M Considerations
  - Bridge crane and monorails
  - Standardize components
  - Catwalks
- PLC Control Systems
  - Programming for failure

Efficiency

- Water
  - Recovered Water System
  - Heat Pump Chiller
    - 17,000,000 gal/year + Chemicals

- Gas
  - Heat Pump Chillers
    - $287,000/ year
- Electricity
  - Optimization
    - Maintain the “Sweet Spot”
    - Pumping in harmony
  - Up to 25,000,000 kWh/year savings vs. conventional plant

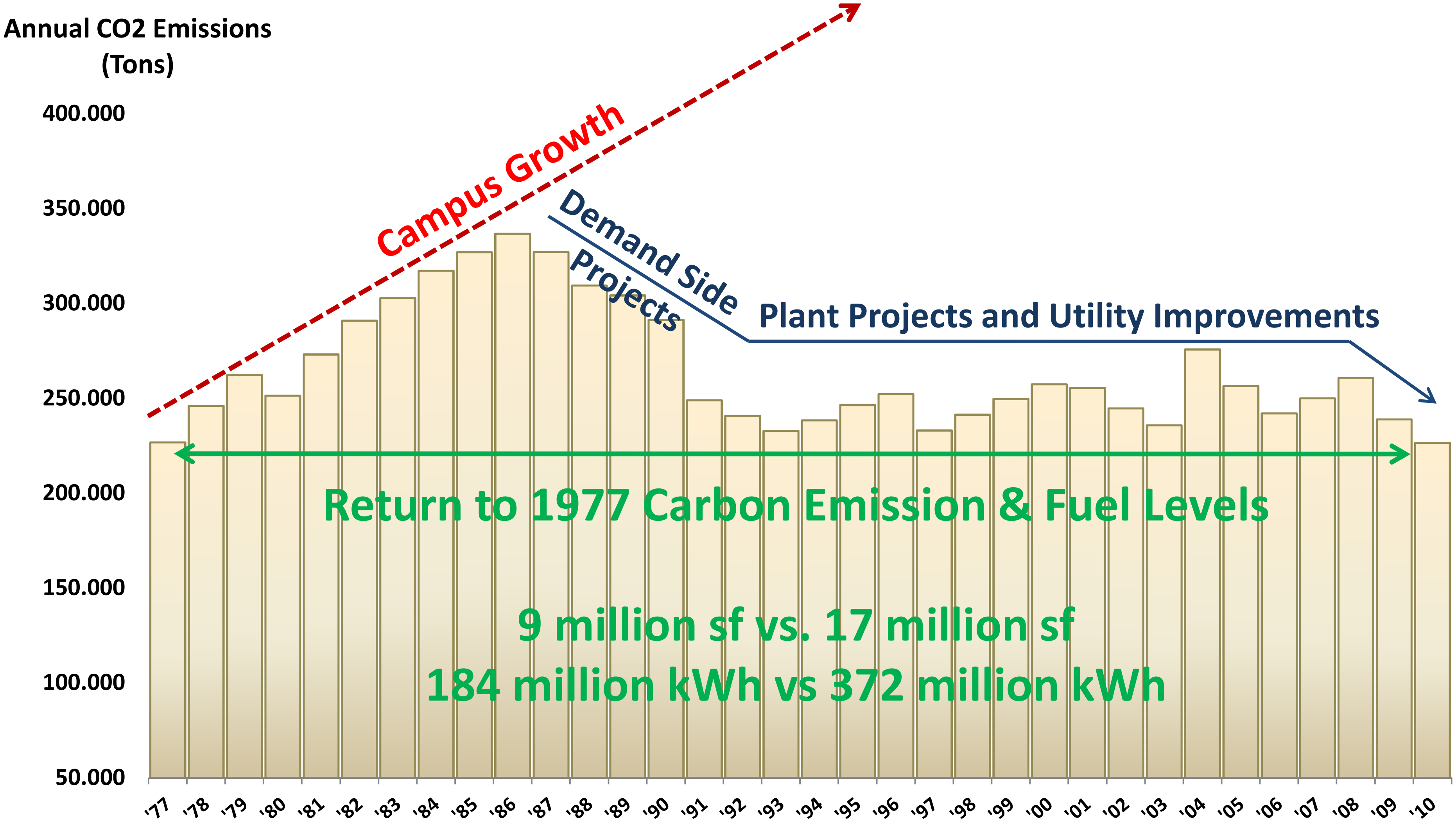
Summary

- Lower campus annual kW/ton
  - 4 yrs at .64 kW/ton annual avg
  - New plant expected .55 KW/ton
- Offset 6 MW of peak demand
  - Avoids additional CHP capacity need
- Improves campus hydraulics
- Off-loads plants in need of renewal
- Room for expansion
  - 5,000 tons more
  - 1,800 tons / 30 MMBtu with HPC's
  - 12 MMBtu via boiler

University of Texas at Austin

- Began Microgrid operations in 1928 – 100% of power load
- 17 Million SF; 150+ buildings; 71,000 population
- 143 MW CHP, 325k lb/hr peak steam; 44,000 tons CHW
- 99.9998% availability over 35+ years
- Invested $150M in energy efficiency since 1987
- Cut CO^2 emissions by > 90,000 tons/year

Effects of Utility Improvements on Efficiency and Emissions at University of Texas Austin




University of Missouri
2017 IDEA System of the Year

University of Missouri

- Founded in 1839 in Columbia, MO as the 1st public university west of the Mississippi River
- 33,000+ students from all 50 states and 120 countries
- Strong research focus and member the of the Association of American Universities
- Over 15 Million sq ft of facilities including critical utility service to hospitals and clinics, a research reactor, a safety level 3 biocontainment laboratory, and numerous research buildings

Comprehensive Utility Microgrid

Mizzou
University of Missouri

- 66 MW electric generation capacity
- 40 MW 69KV transmission connection
- 1,100,000 lb/hr steam capacity
- 32,000 Tons chilled water capacity
- 4 Million gal/day drinking water capacity
- 110 miles of under-ground utilities
- Fully metered and automated

Reliable and Resilient

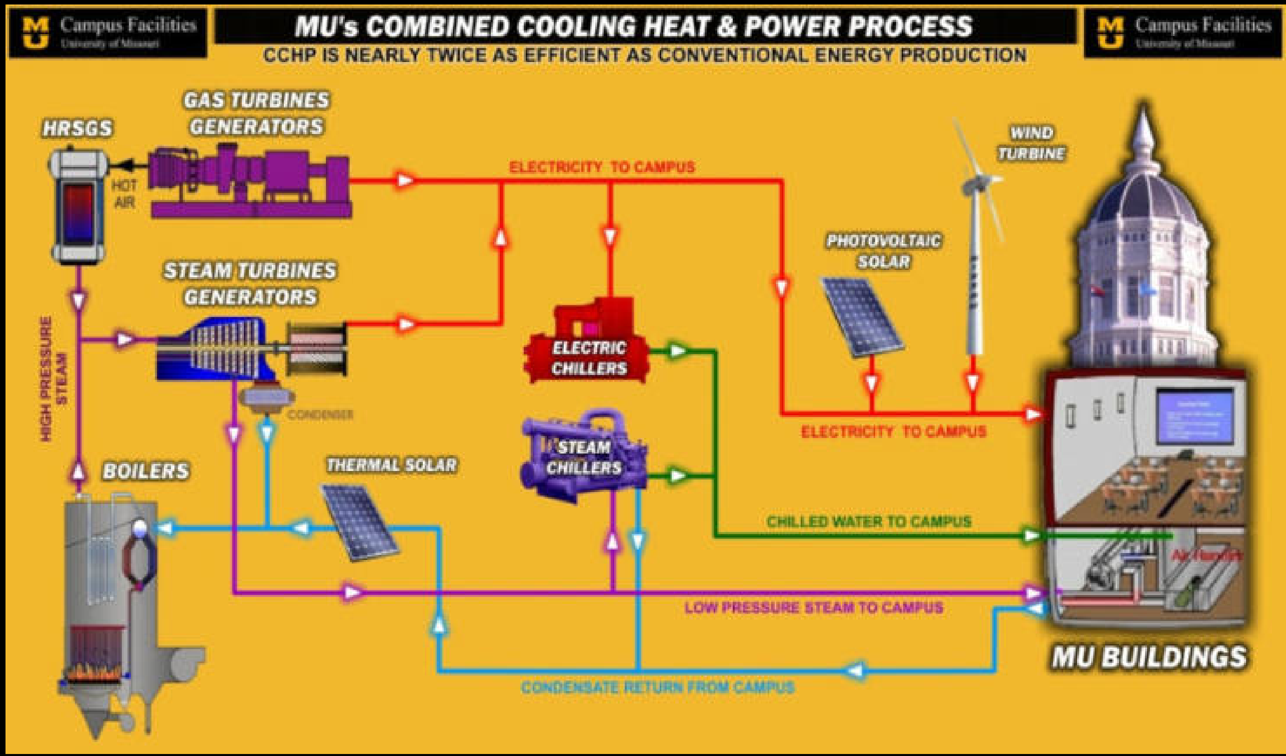
Mizzou
University of Missouri

- Full on-site generation
- N-1 operational availability practice
- 40 MW 69kV electric grid tie
- Black start capability
- Multi-fueled energy plant
- Underground distribution and looping
- Proactive maintenance practices
- Over 99.9993% utility availability

24/7 monitoring and optimization to ensure highly reliable utility service

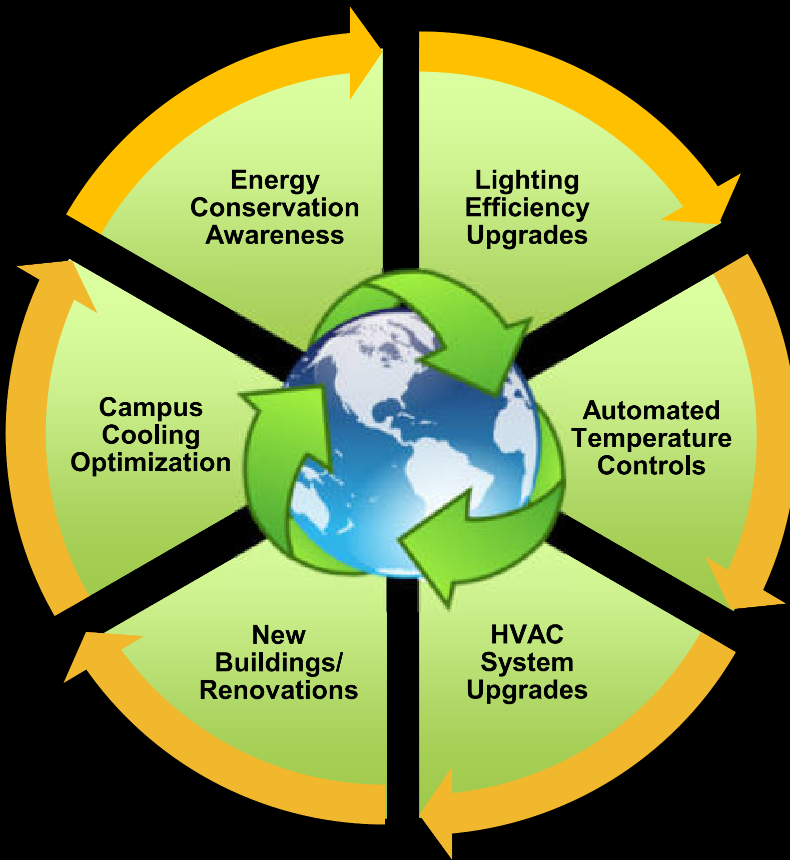
Combined Cooling Heat & Power at Mizzou

MU produces its utilities using highly efficient technologies dispatched with a focus of cost effectiveness!



Mizzou
University of Missouri

Energy Optimization and Conservation



MU's nationally recognized energy conservation efforts began in 1990!

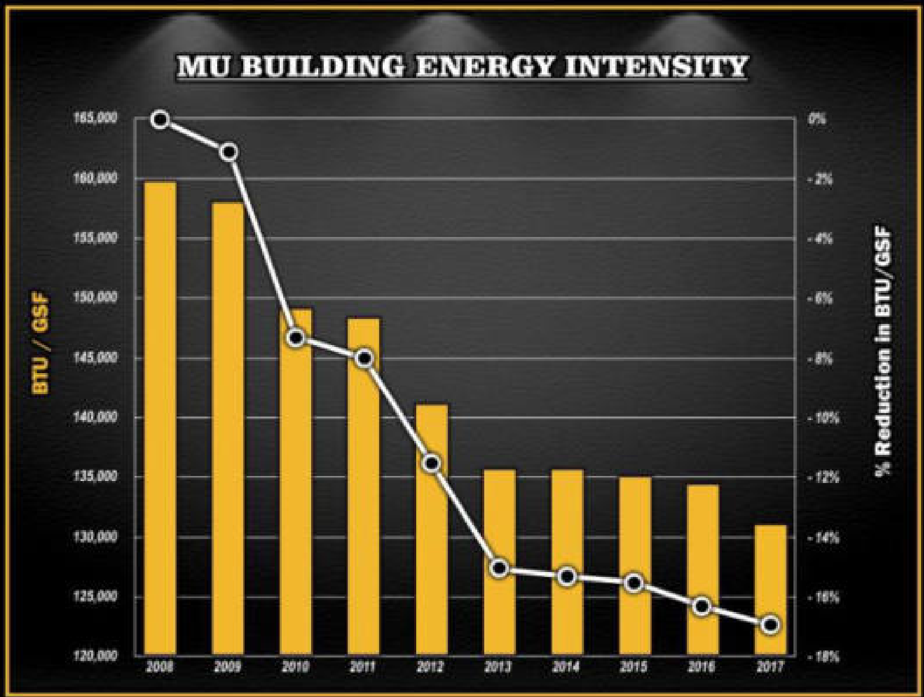
21% Reduction in Energy Use (per GSF)

$9.5 Million Annual Utility Cost Avoidance

$85 Million Cumulative Utility Savings

Mizzou
University of Missouri

Energy Intensity Continues to Drop



Current Initiatives:

- LED Lighting Conversions
- Improved HVAC Controls
- Automated Fault Detection
- Retro Commissioning
- Waste Heat Recovery

Mizzou
University of Missouri

Renewable Energy for Mizzou

Biomass Combined Heat & Power
Grid Wind Energy
On-Campus Wind Energy
On-Campus Solar PV
On-Campus Solar Thermal

Mizzou
University of Missouri

Our on-site renewable technologies are education resources for students!

Energy Sustainability Success!

- **Over 39% total renewable energy portfolio of biomass, wind, and solar**
- **Over 51% reduction in greenhouse gas emissions since 2008**
- **Over a 21% reduction in academic building energy use and a 50% reduction in water use through conservation efforts**
- **EPA's Green Power Partnership recognized MU as a national leader in the development and use of renewable energy**

Mizzou
University of Missouri

EPA GREEN POWER Leadership Award Winner 2017

Annex 73 Structure & IDEA Scope for Participation

Subtask A	Collect and evaluate input data for Energy Master Plan (EMP)
Subtask B- IDEA	Collect 3 existing US/Canadian existing Case Studies or pilot studies Subtask B will be carried out between 2017 and 2019
Subtask C	Describe existing and innovative technologies, architecture and calculation tools for performance analysis (including resilience) of central, decentralized and combined energy systems (power and thermal)
Subtask D	Develop Guidance for Energy Master Planning
Subtask E- IDEA	Assist with Data to Develop a Functional Modeling Tool to Facilitate the Net Zero Energy Resilient Communities Master Planning Process
Subtask F	Business, legal and financial aspects of Net Zero Energy Master Planning.

Time Schedule

- Preparation phase - one year (through November 2017)
- Working phase - 3 years (starting February 1, 2018)
- Reporting and dissemination phase – 1 year

Subtask B: Collect Existing Case Studies/Pilots

Characteristics of Cases

- District refurbishment/new construction/mix
- Technical and methodical innovations shall be (or have been) subject of planning and implementation.
- Focus on Public Communities, Neighborhoods and Quarters
- The projects should have low energy usage and/or use large amount of renewable energy
- 3 US or Canadian energy master planning project case studies
- Existing /Pilot -started in 2017 progress reported by the end of Annex 73
- Level of detail expected for pilots will not be the same as for completed projects

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Results and Deliverables for Sub Task B

- Basic principles used for long term energy master planning
- Which policies and energy goals have been used in energy master planning?
- How do these policies and energy goals vary between different countries?
- Descriptions of methods and tools used for energy master planning and evaluation of their applicability in practice.
- Methods for verification of the project success.
- Is the project a success in the eyes of users, decision makers?
- Conclusion on organization of transition processes.

Progress-to-Date and Deliverables for June 2018

- IDEA attended several project team meetings and the Technical Meeting in Washington D.C, December 5, 2018
- IDEA participated in discussions on how best to collect data for tool and modeling
- IDEA and Member organizations organized panel and made presentations at ***Energy Planning for Resilient Communities – Best Practices EBC Annex 73 Symposium, December 6, 2017***
- IDEA engaged in discussion on methods and tools used for energy master planning and evaluation of their applicability in practice.
- IDEA is in process of identifying 3 cases studies for Sub-task B.
- **Potential candidates:** Univ of Texas Austin; Univ of British Columbia (UBC); UTMB Galveston; University of Missouri; Univ Illinois at Champaign-Urbana; Arizona State University
- IDEA plans to assemble data, including distribution losses for Subtask E after the next IDEA operational survey (Summer 2018)

INTERNATIONAL DISTRICT ENERGY ASSOCIATION


IDEA2018
Local Solutions, Global Impact
109TH ANNUAL CONFERENCE & TRADE SHOW
June 11-14 | Vancouver Convention Centre | Vancouver, BC
Visit www.districtenergy.org for details.

Save the Date!

Microgrid 2.0

Advancing Industry Growth

OCTOBER 29-31, 2018 ▾ BALTIMORE, MD

Visit www.districtenergy.org for details.

DistrictCooling2018

Efficient Energy for Smarter Cities

DECEMBER 9-11, 2018 – ATLANTIS, THE PALM – DUBAI, UAE


DistrictCooling2018
Efficient Energy for Smarter Cities
DECEMBER 9-11, 2018 – ATLANTIS, THE PALM – DUBAI, UAE


DistrictCooling2018
Efficient Energy for Smarter Cities
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INTERNATIONAL DISTRICT ENERGY ASSOCIATION

THANK YOU

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