Community Energy: Essential Infrastructure for a Clean Energy Future

Robert Thornton, President & CEO

Microgrids in New England Workshop

PACE Energy & Climate Center

Legislative Office Building

Hartford, CT

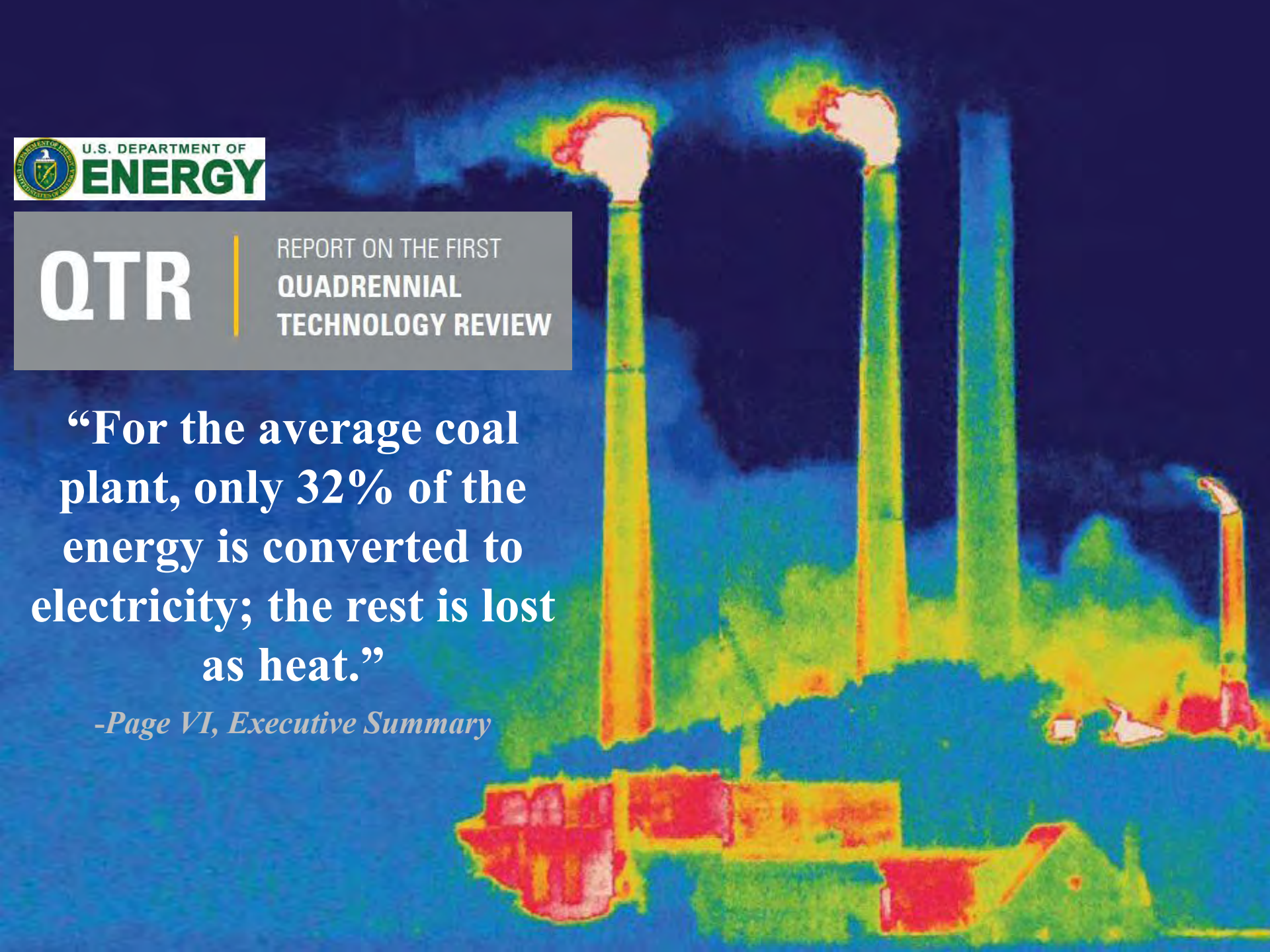
October 10, 2012

Agenda

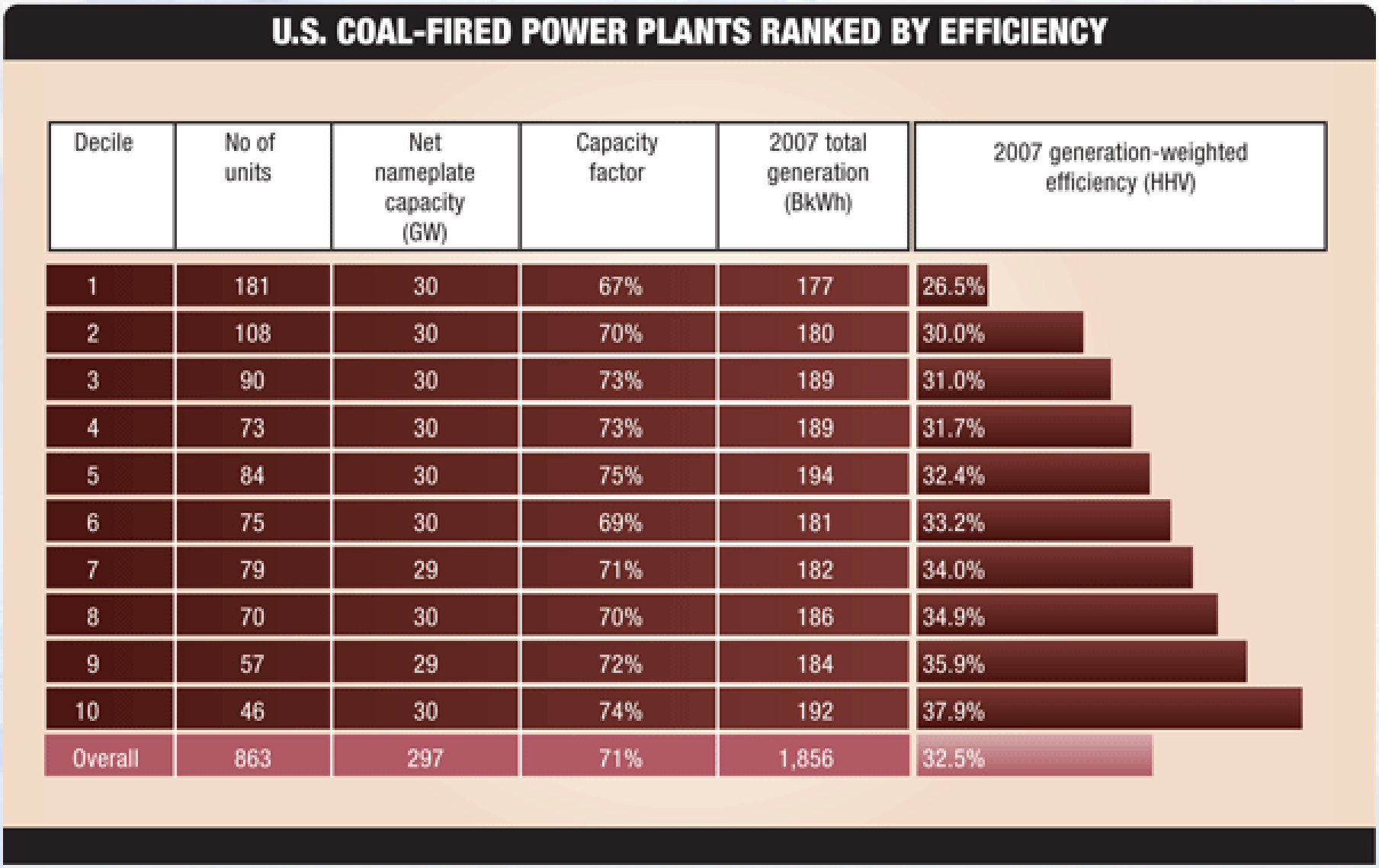
- Are we in a electricity paradigm shift?
- Combined Heat & Power - Heat matters
- District Energy and Microgrids
- Community energy planning
- Emerging policy drivers
- Q&A

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

- Formed in 1909 – 103 years in 2012
- 501(c)6 industry association
- 2000+ members in 25 nations
- 56% end-user systems; majority in North America
- Most major public & private colleges and universities; urban utilities.


U.S. DEPARTMENT OF
ENERGY
QTR
REPORT ON THE FIRST
QUADRENNIAL
TECHNOLOGY REVIEW
"For the average coal plant, only 32% of the energy is converted to electricity; the rest is lost as heat."
-Page VI, Executive Summary

Efficiency of US Power Generation



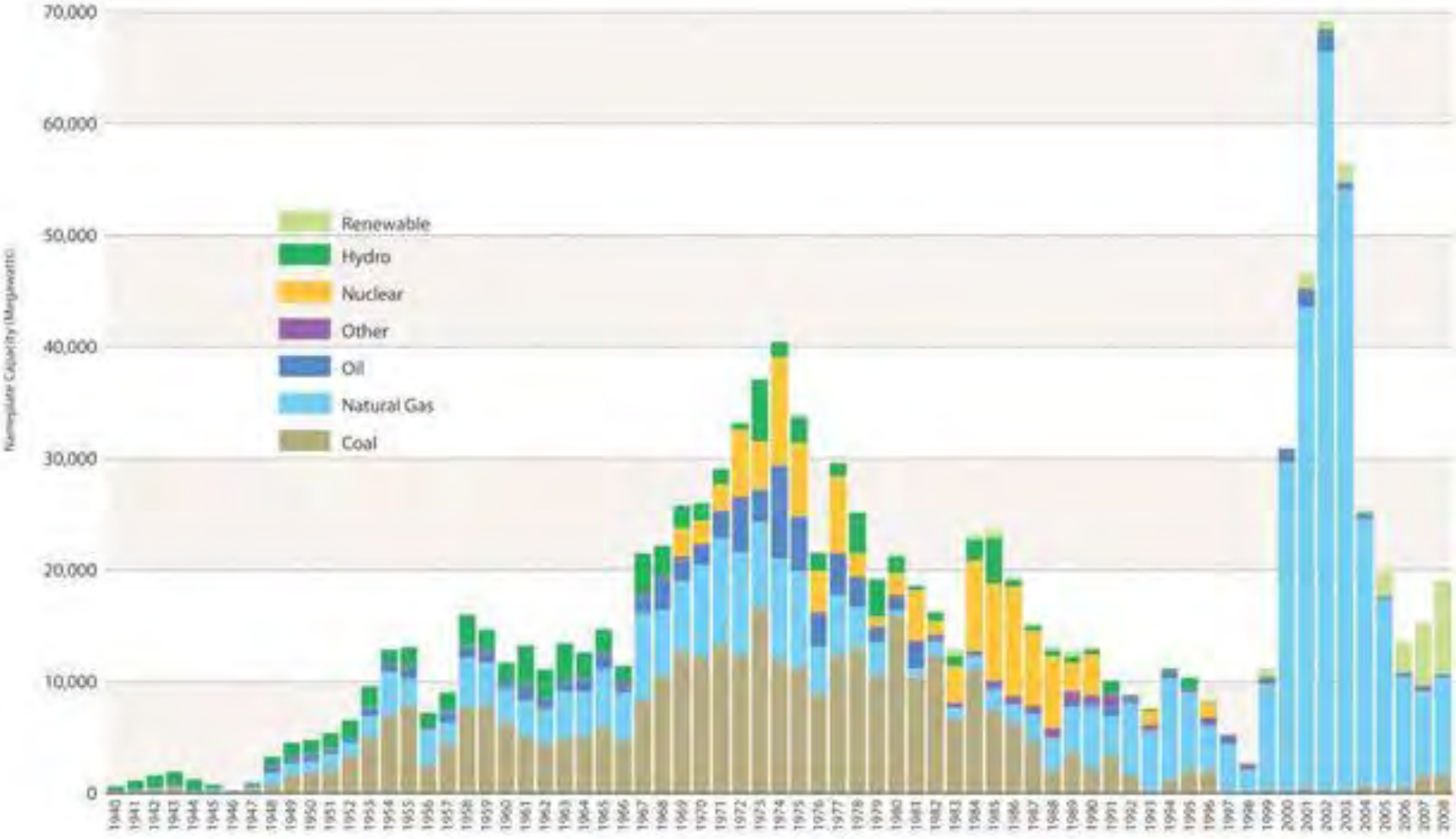
U.S. COAL-FIRED POWER PLANTS RANKED BY EFFICIENCY

Decile	No of units	Net nameplate capacity (GW)	Capacity factor	2007 total generation (BkWh)	2007 generation-weighted efficiency (HHV)
1	181	30	67%	177	26.5%
2	108	30	70%	180	30.0%
3	90	30	73%	189	31.0%
4	73	30	73%	189	31.7%
5	84	30	75%	194	32.4%
6	75	30	69%	181	33.2%
7	79	29	71%	182	34.0%
8	70	30	70%	186	34.9%
9	57	29	72%	184	35.9%
10	46	30	74%	192	37.9%
Overall	863	297	71%	1,856	32.5%

Power Engineering Magazine, November 2009

FIGURE 4

U.S. Electric Generating Capacity by In Service Year



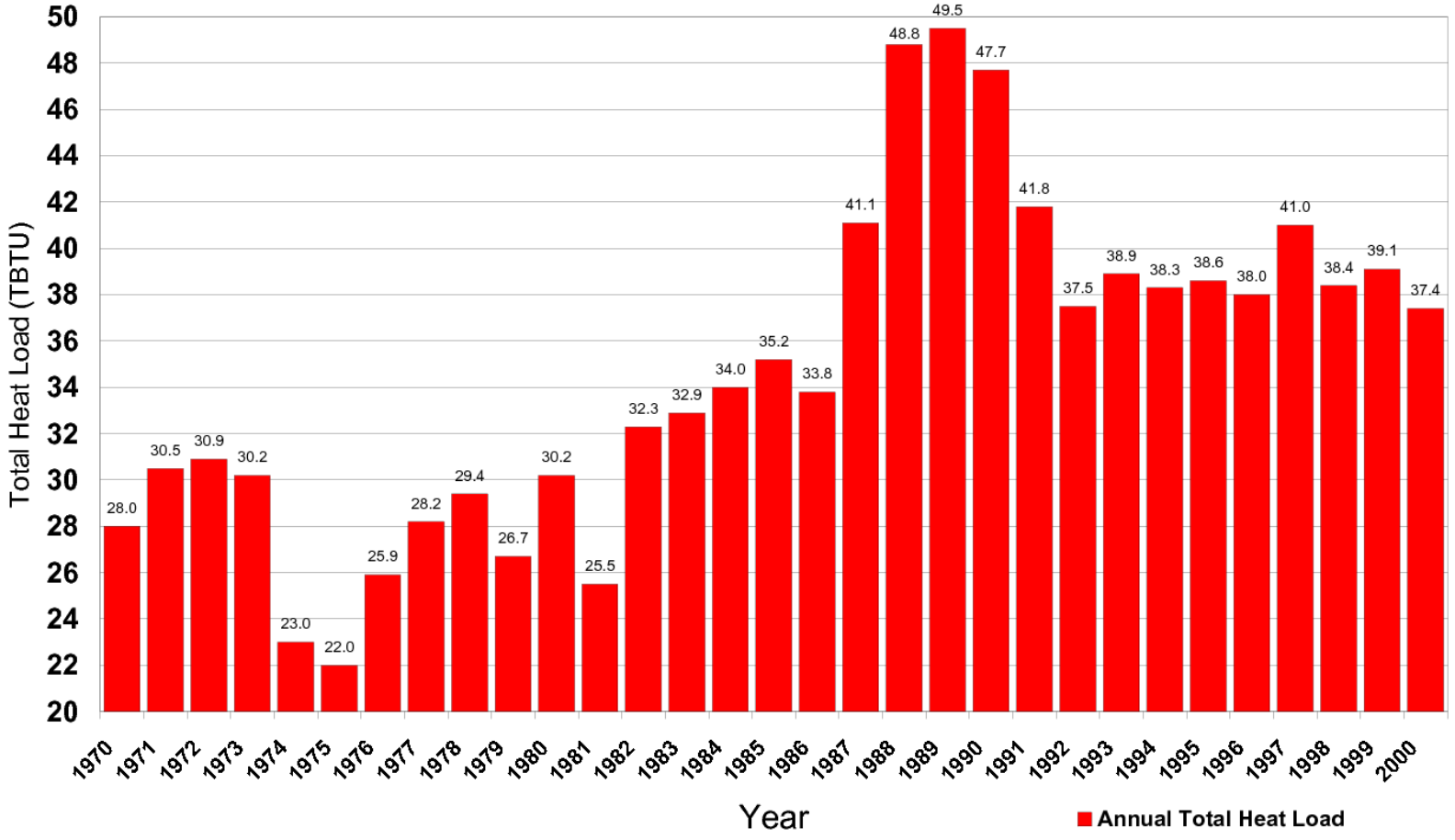
SOURCE: ENERGY INFORMATION ADMINISTRATION, ANNUAL ELECTRIC GENERATOR REPORT, FORM EIA-860 (2008).
http://www.eia.doe.gov/cneaf/electricity/page/eia860.html

Shifting on Scale and Risk

- In U.S., during the first half of 2012,
  - 165 new electric power generators were installed
  - totaling 8,100 megawatts (MW) of new capacity added.
- Of the 165, 105 of those units were under 25 MW and,
- most were renewable using solar, wind or landfill gas.

Brayton Point Power Station, Somerset, MA – 1,537 MW
Pre-2011: Once-through cooling – Taunton River:Mount Hope Bay

Figure 12: Brayton Point Station Heat Rejection versus Time (1970 - 2000)



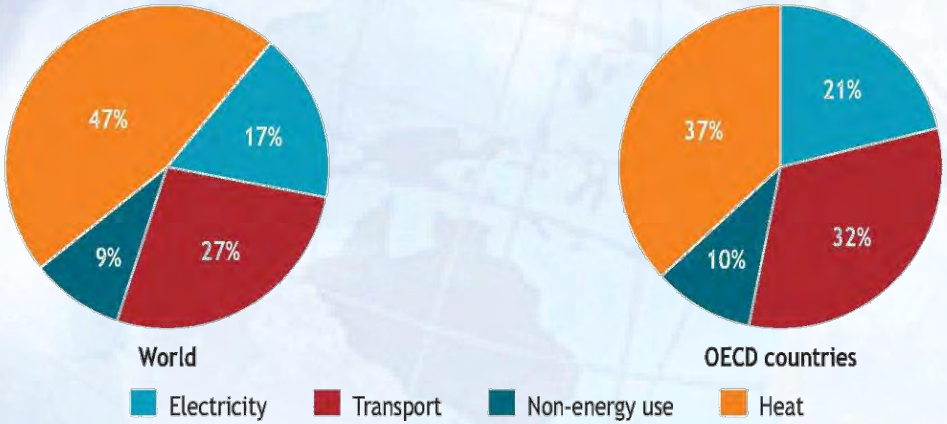
Brayton Point Cooling Towers - 2011

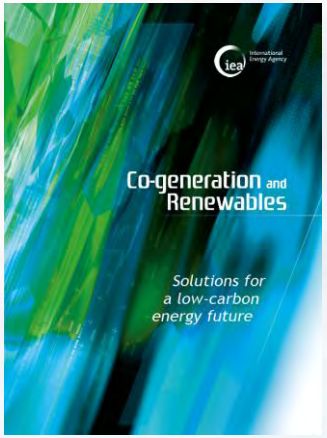
Capital investment - $ 570 Million

Millstone Nuclear Generating Station, Waterford, CT – 2100 MW
Once-through cooling Long Island Sound

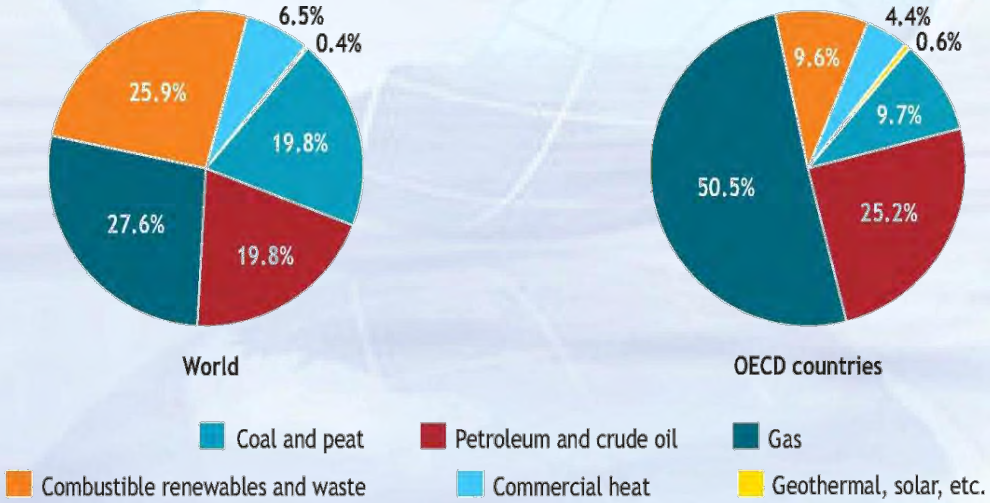
International Energy Agency 2011 Report

- Heat dominates all other energy uses



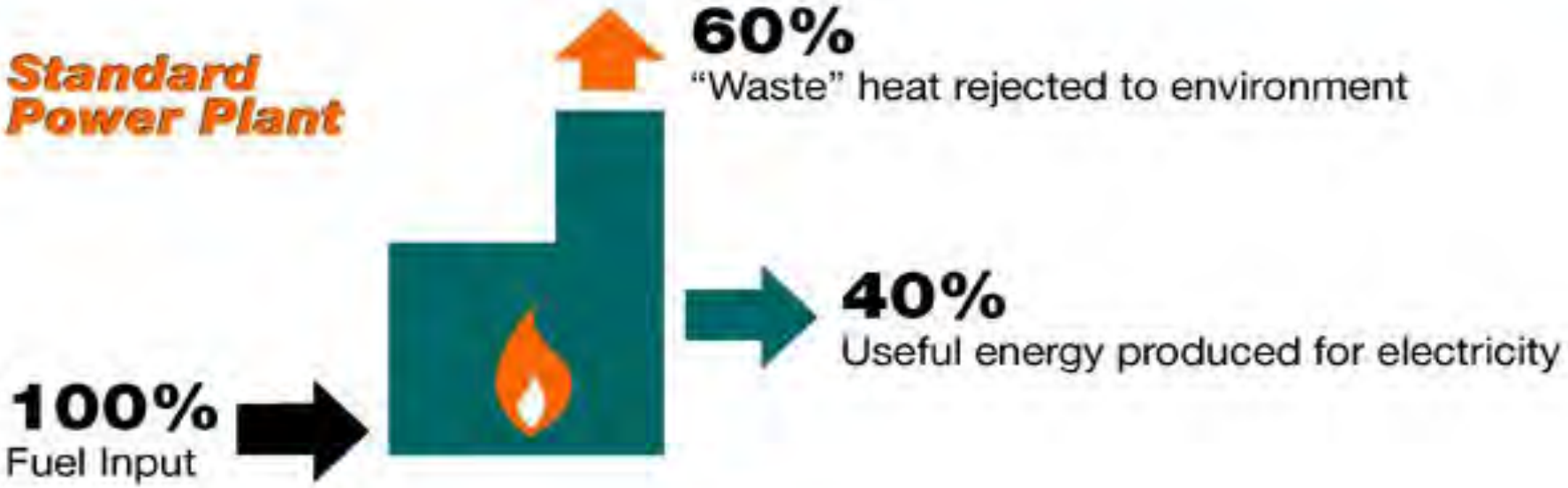


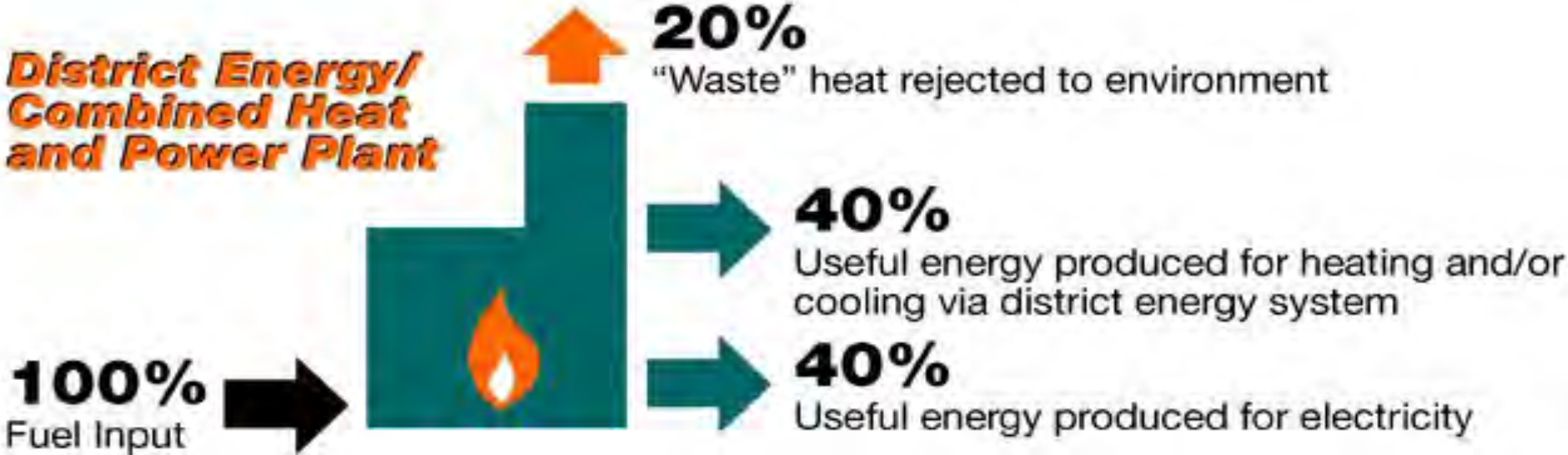
- Heat production is dominated by fossil fuels



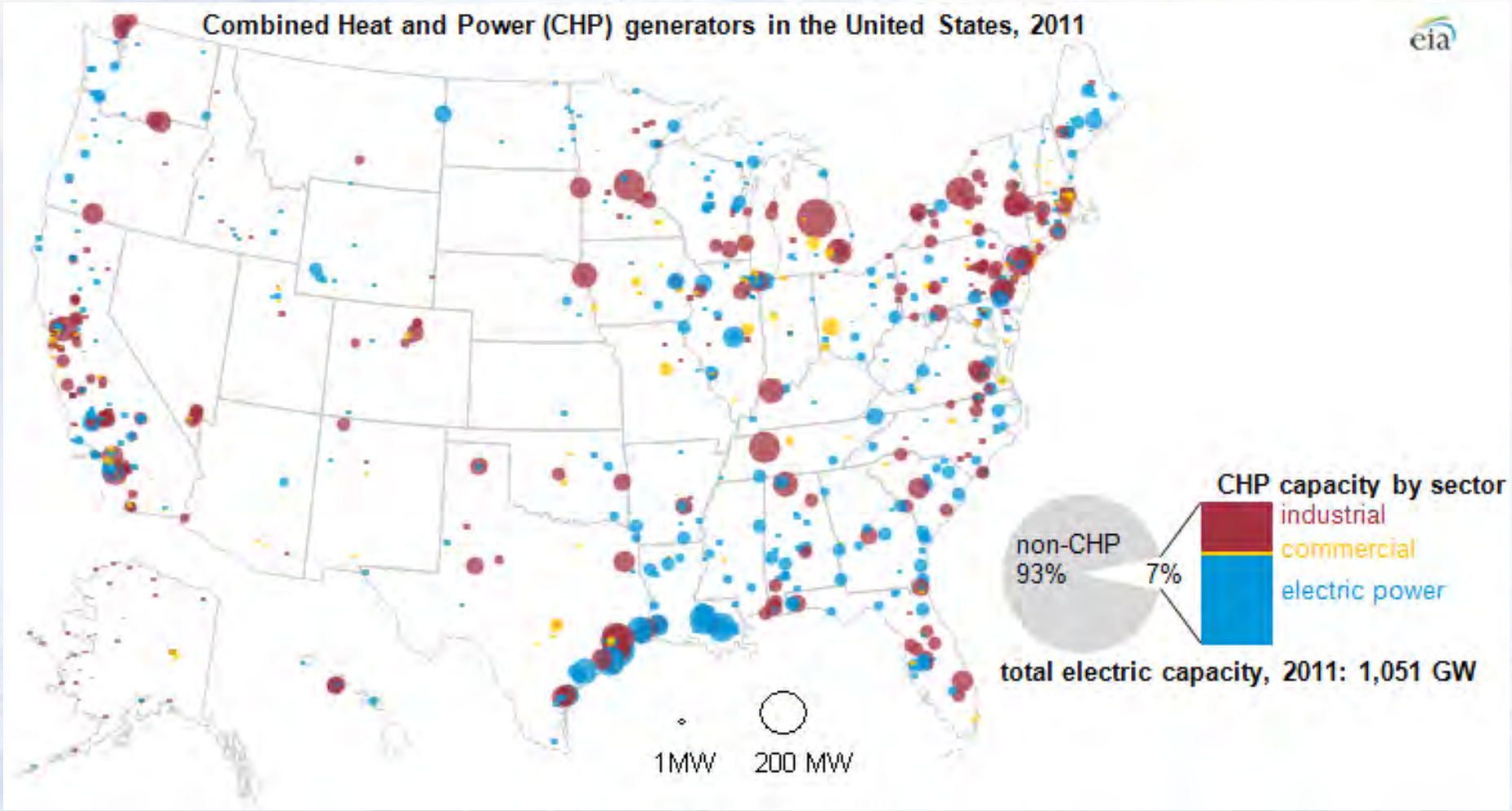
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Energy-Efficiency Comparisons



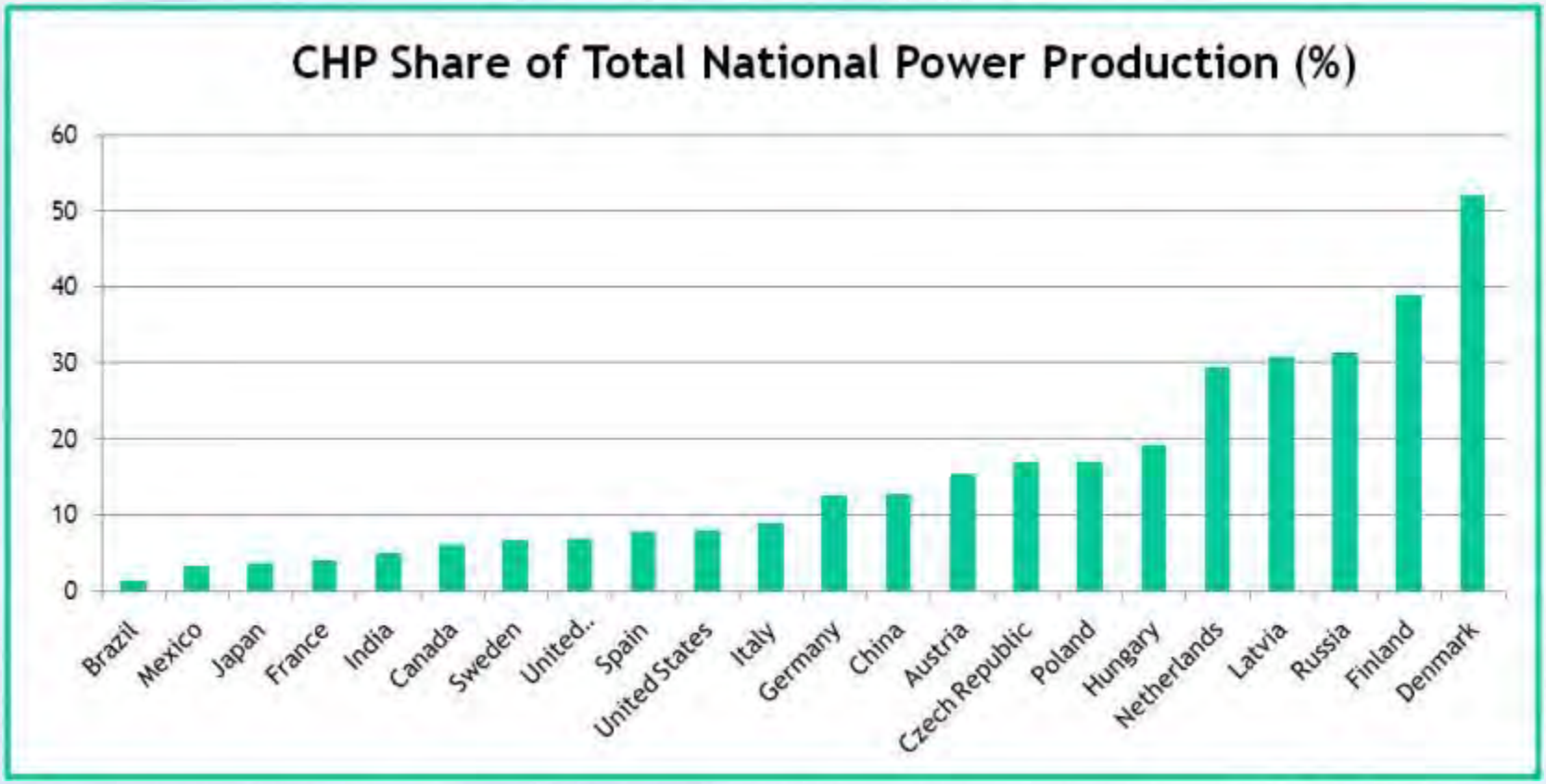


Combined Heat and Power Technology Fills an Important Niche



Energy Information Administration, October 4, 2012
http://www.eia.gov/todayinenergy/detail.cfm?id=8250

CHP as a Share of Total National Power Generation



Source: IEA, *CHP: Evaluating the Benefits of Greater Global Investment* (2008).

The global average is just 9%

HEAT PLAN DENMARK

LOW CARBON URBAN HEATING

ANDERS DYRELUND
MARKET MANAGER RAMBØLL DENMARK

WWW.RAMBOLL.DK

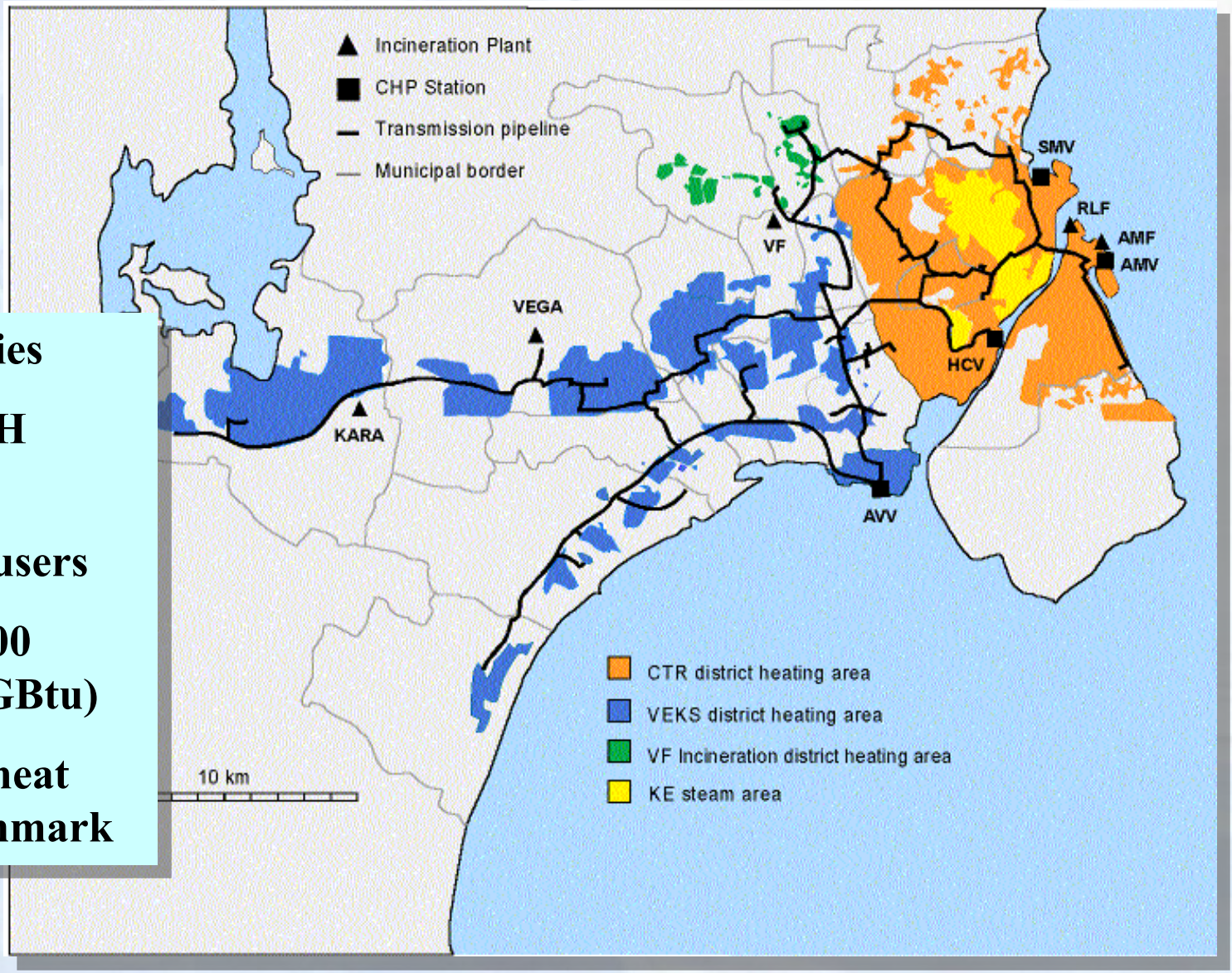
RAMBØLL

World Class CHP – 90%+Efficiency
Avedore 1&2, Copenhagen

Unit 1 (810MW) – Coal; Unit 2 (900 MW) – Multi-Fuel (straw; biomass, etc)

Heat Transmission Systems

The Greater Copenhagen DH System



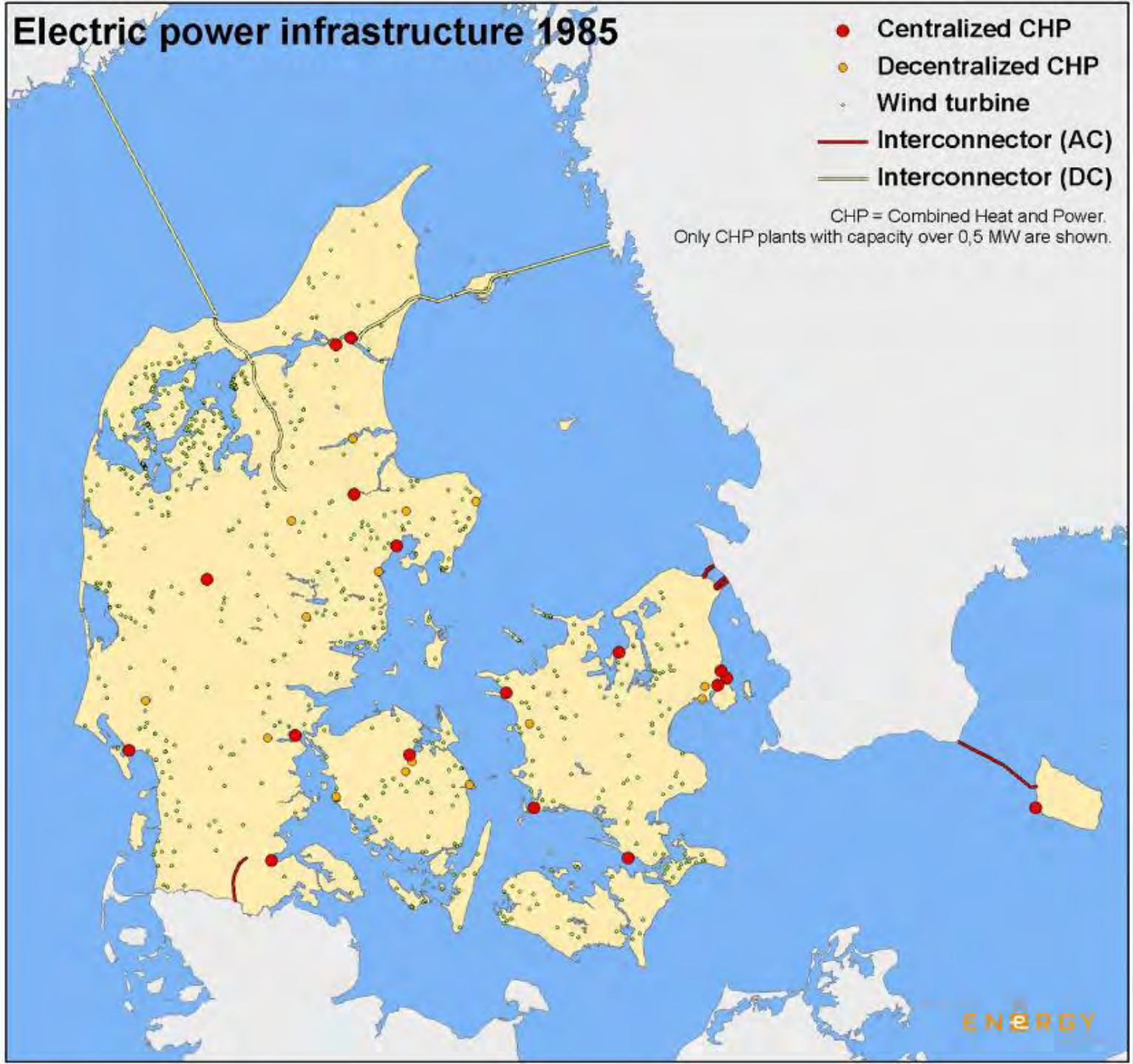
18 municipalities

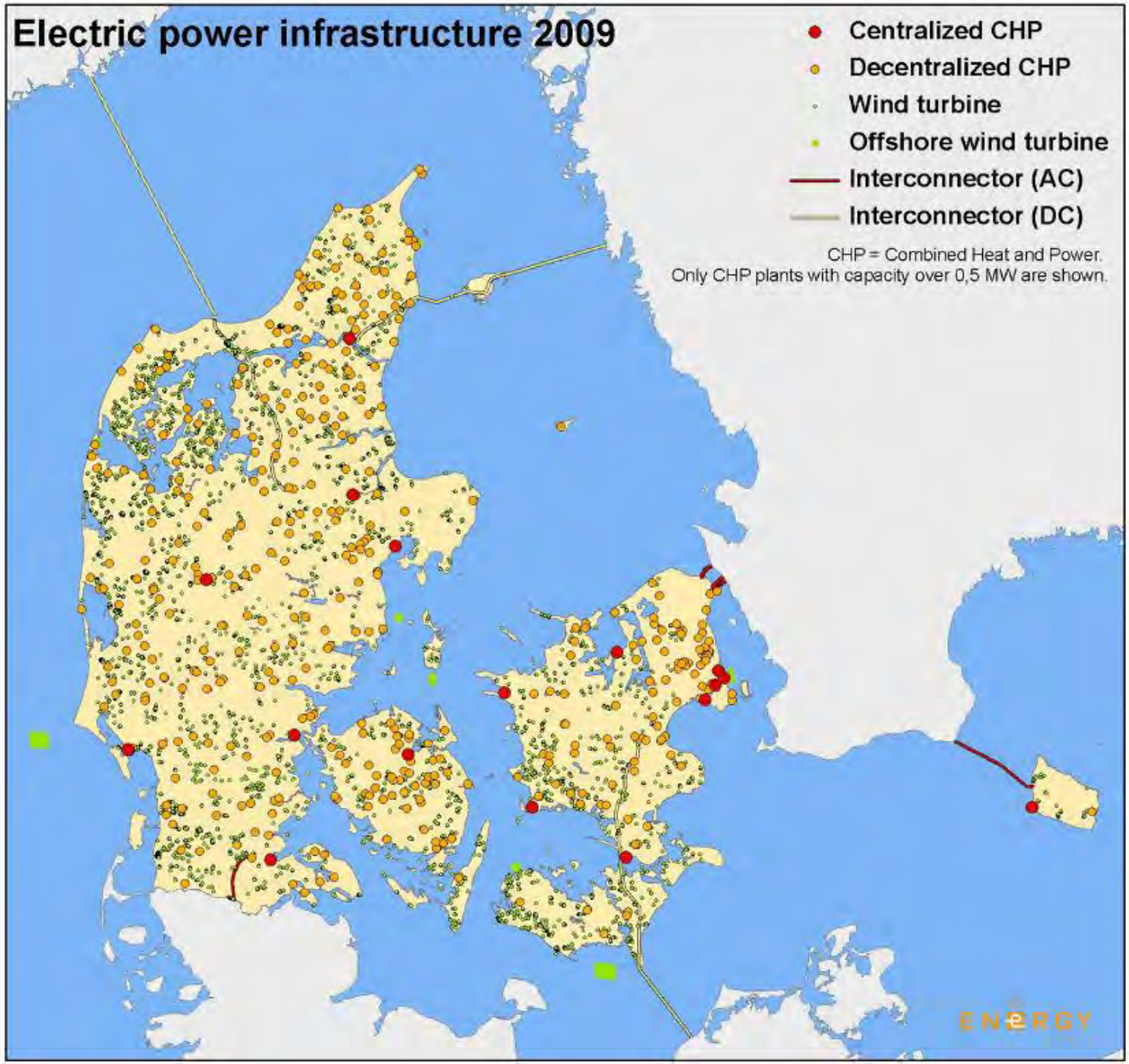
4 integrated DH systems

500,000 end – users

34,500 TJ (9,600 GWh, 32,700 GBtu)

Approx 20 % heat demand in Denmark


Electric power infrastructure 1985
Centralized CHP
Decentralized CHP
Wind turbine
Interconnector (AC)
Interconnector (DC)
CHP = Combined Heat and Power.
Only CHP plants with capacity over 0,5 MW are shown.
ENERGY


Electric power infrastructure 2009
Centralized CHP
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Wind turbine
Offshore wind turbine
Interconnector (AC)
Interconnector (DC)
CHP = Combined Heat and Power.
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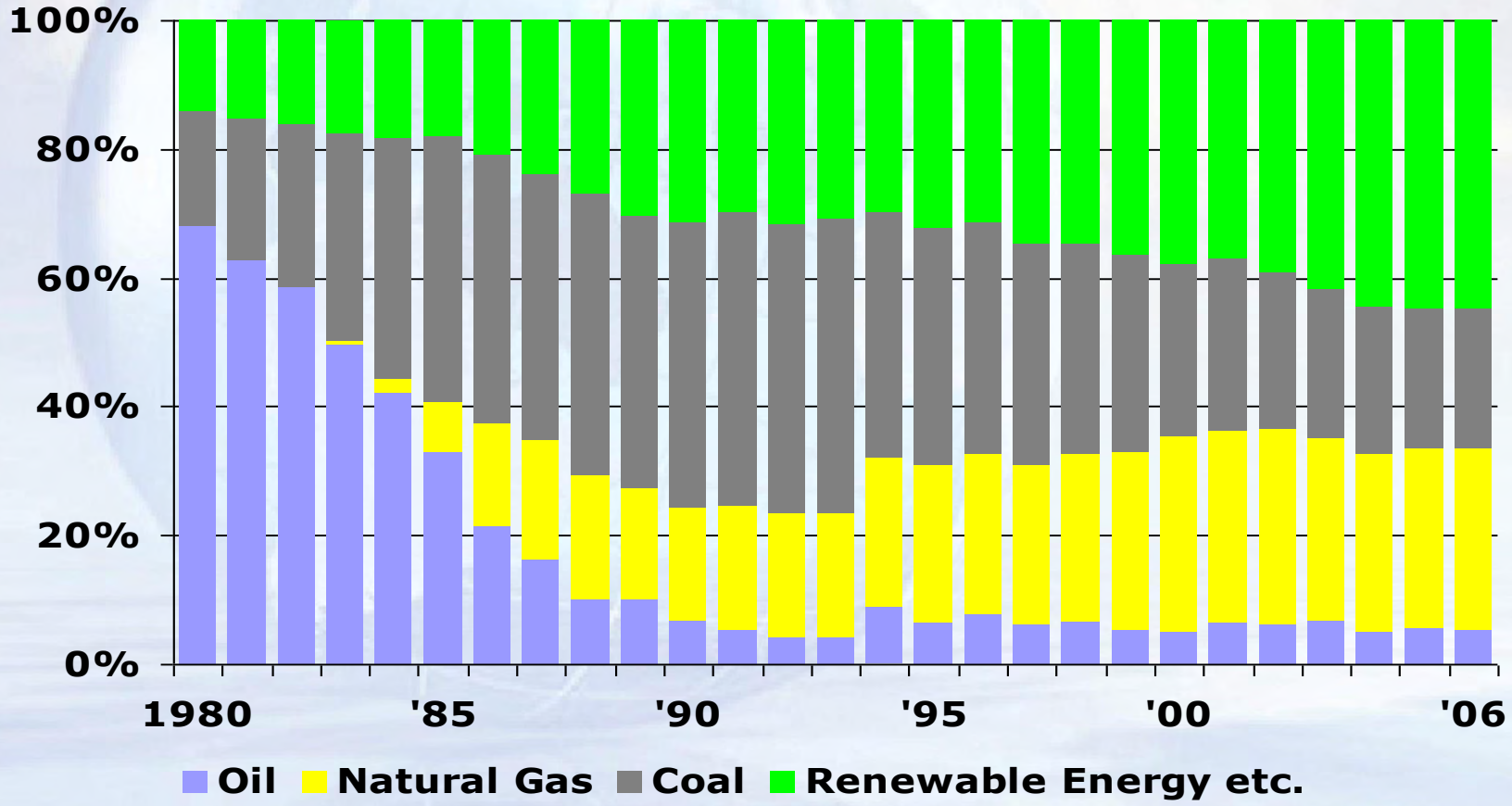
ENERGY

District Heating and RE

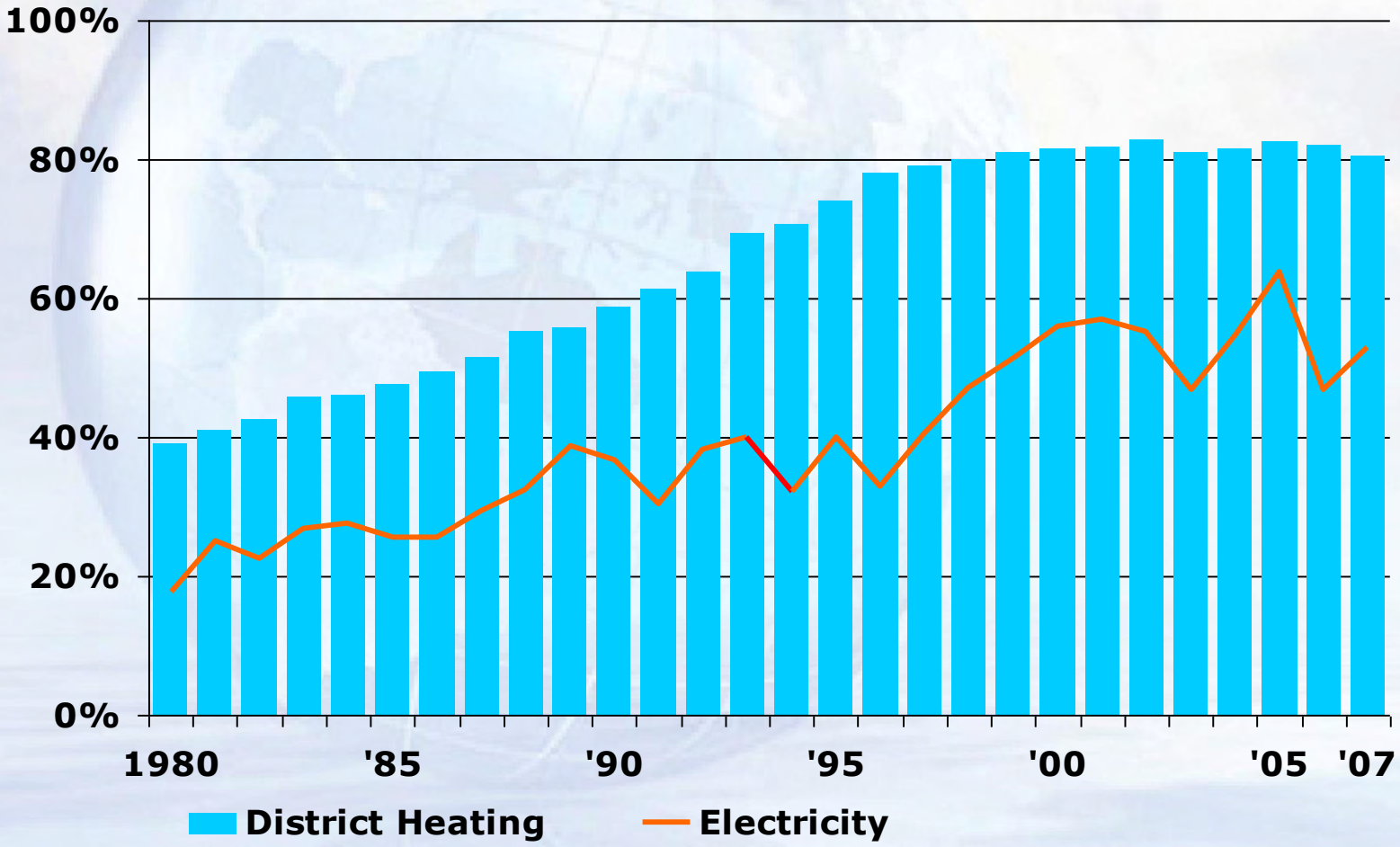
- Composition of Fuels for District Heating Production



Source: Danish Energy Authority

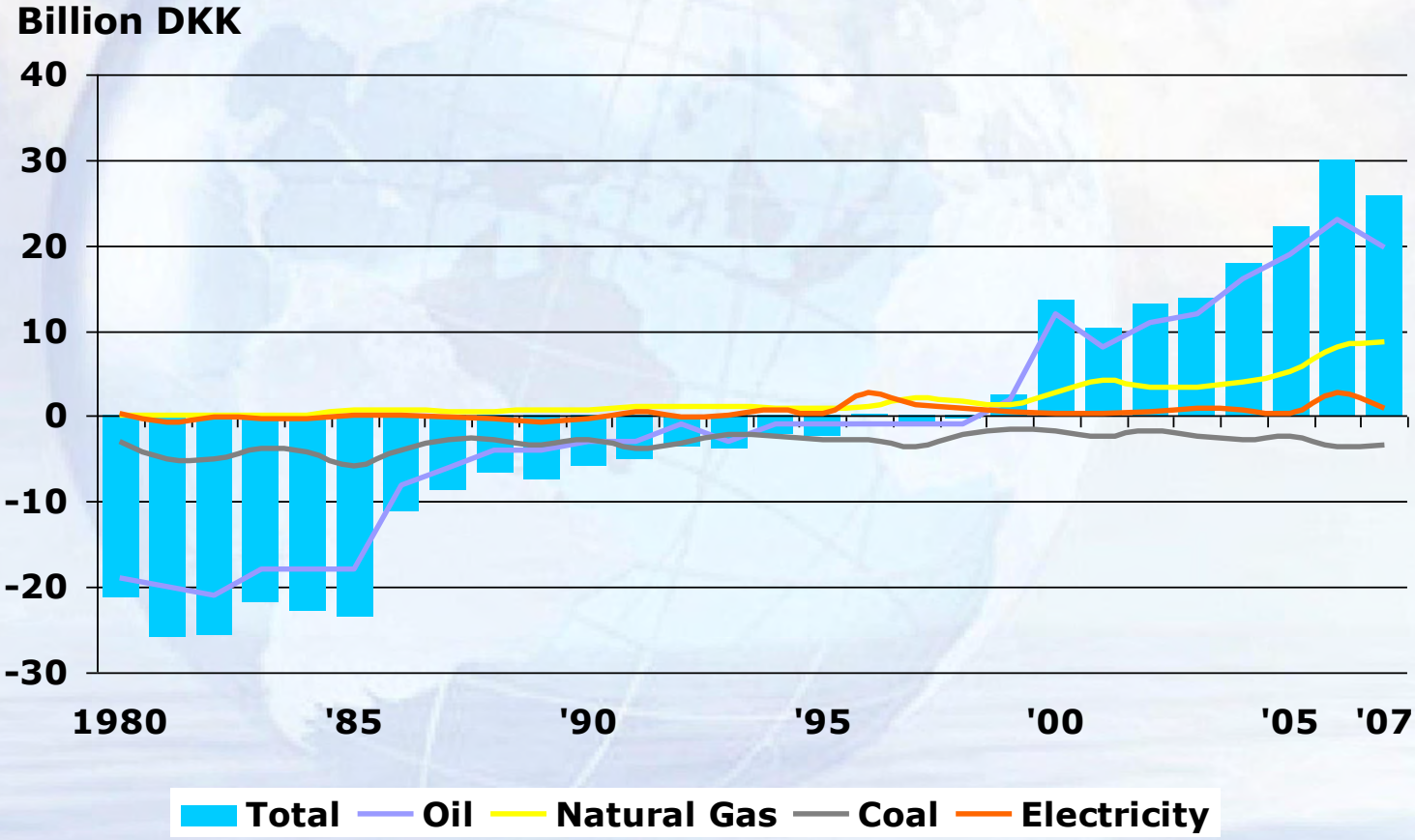
DBDH

CHP share of DH and Power



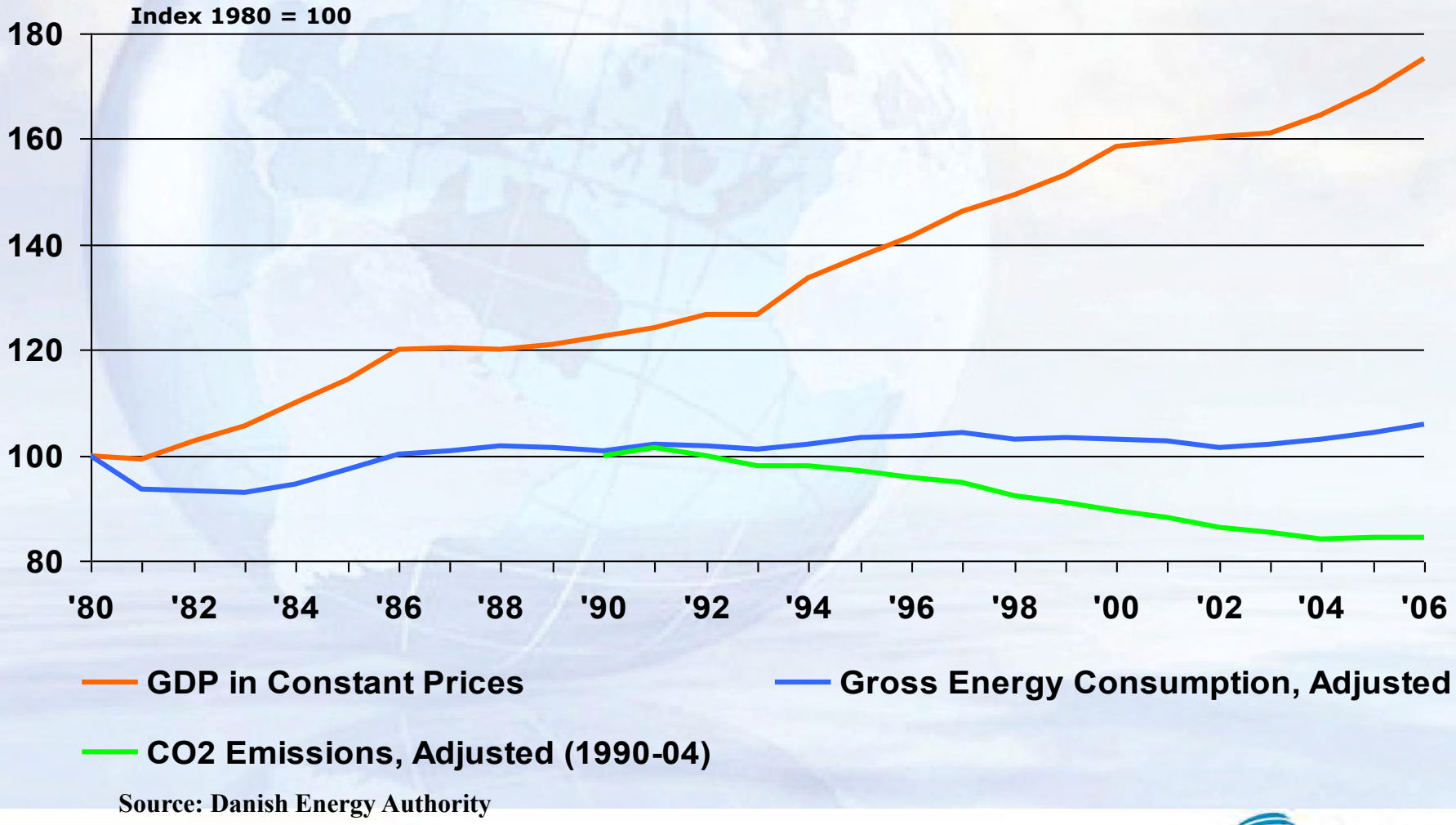
Source: Danish Energy Authority

National Energy Account



Source: Danish Energy Authority

Economic Impact in Denmark
- GDP, CO_2 and Energy Consumption



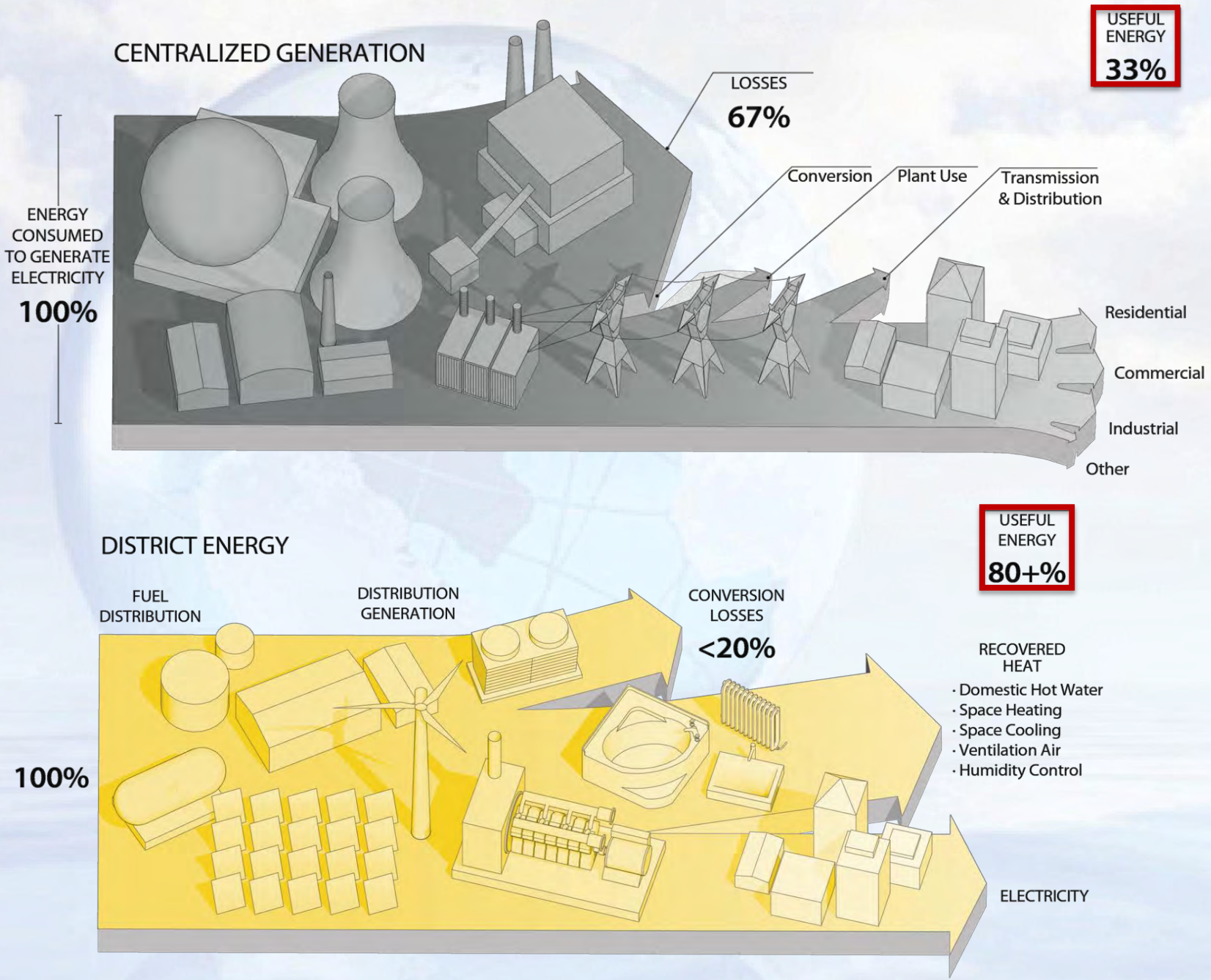
Source: Danish Energy Authority

DBDH

Opportunity: **District Energy**

"District heating and cooling is an integrative technology that can make significant contributions to reducing emissions of carbon dioxide and air pollution and to <u>increasing energy security</u>."

International Energy Agency DHC/CHP Executive Committee
District Heating and Cooling: Environmental Technology for the 21st Century

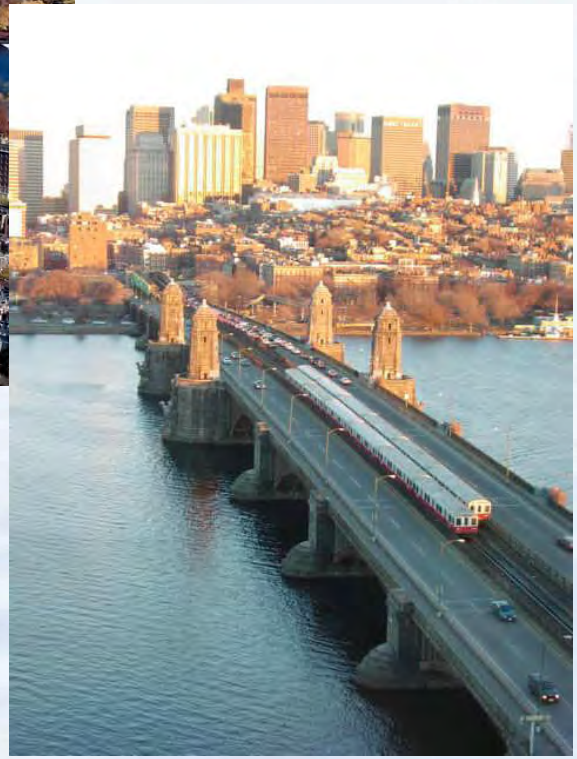


Win/Win/Win - It Can Be Done!

GenOn Kendall Station/Veolia Energy

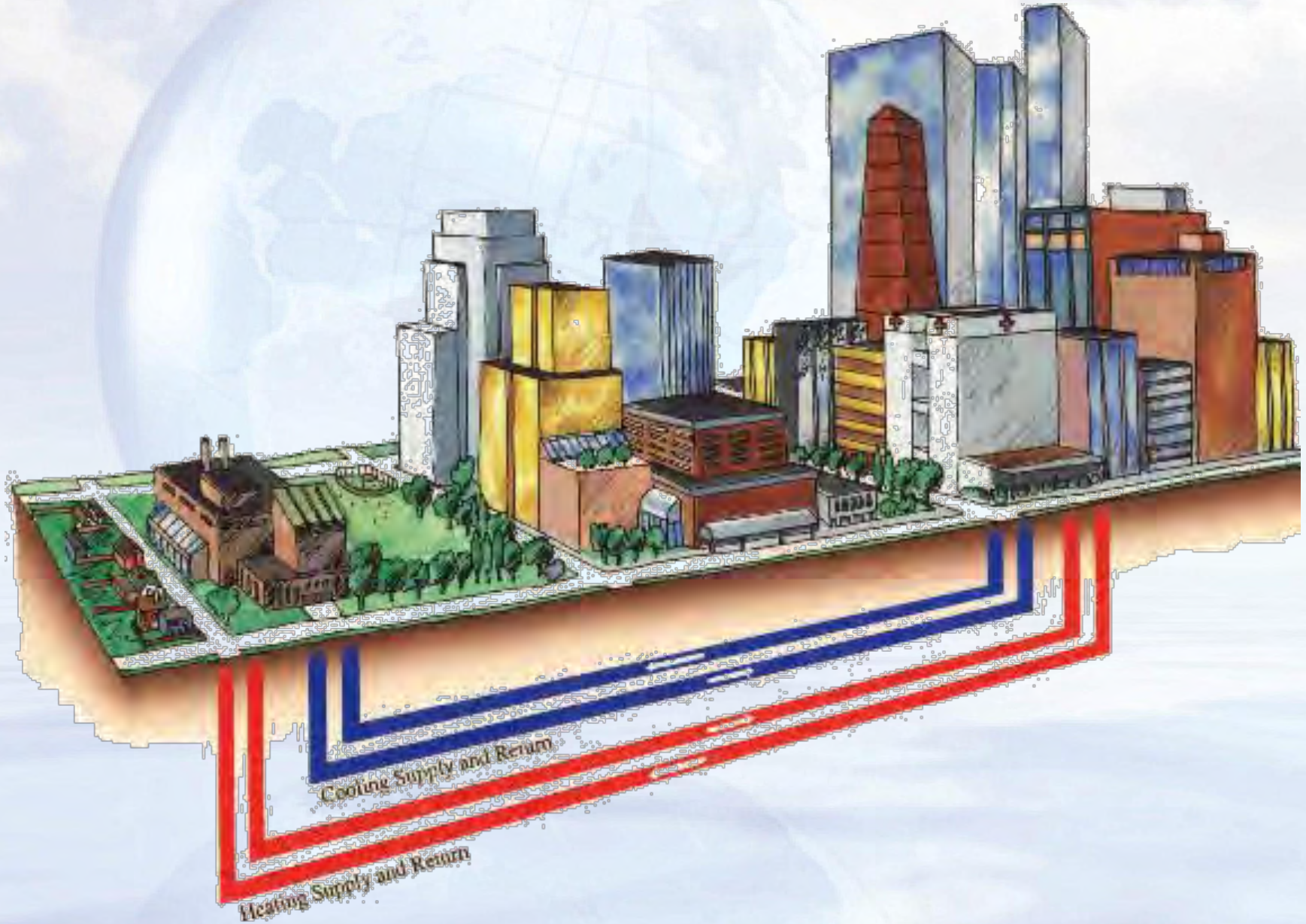
Cambridge, MA

- 256 MW Gas Fired Facility – CHP
- Supplies Cambridge – Kendall area
- Once through cooling to Charles River
- Install pipeline across Longfellow Bridge



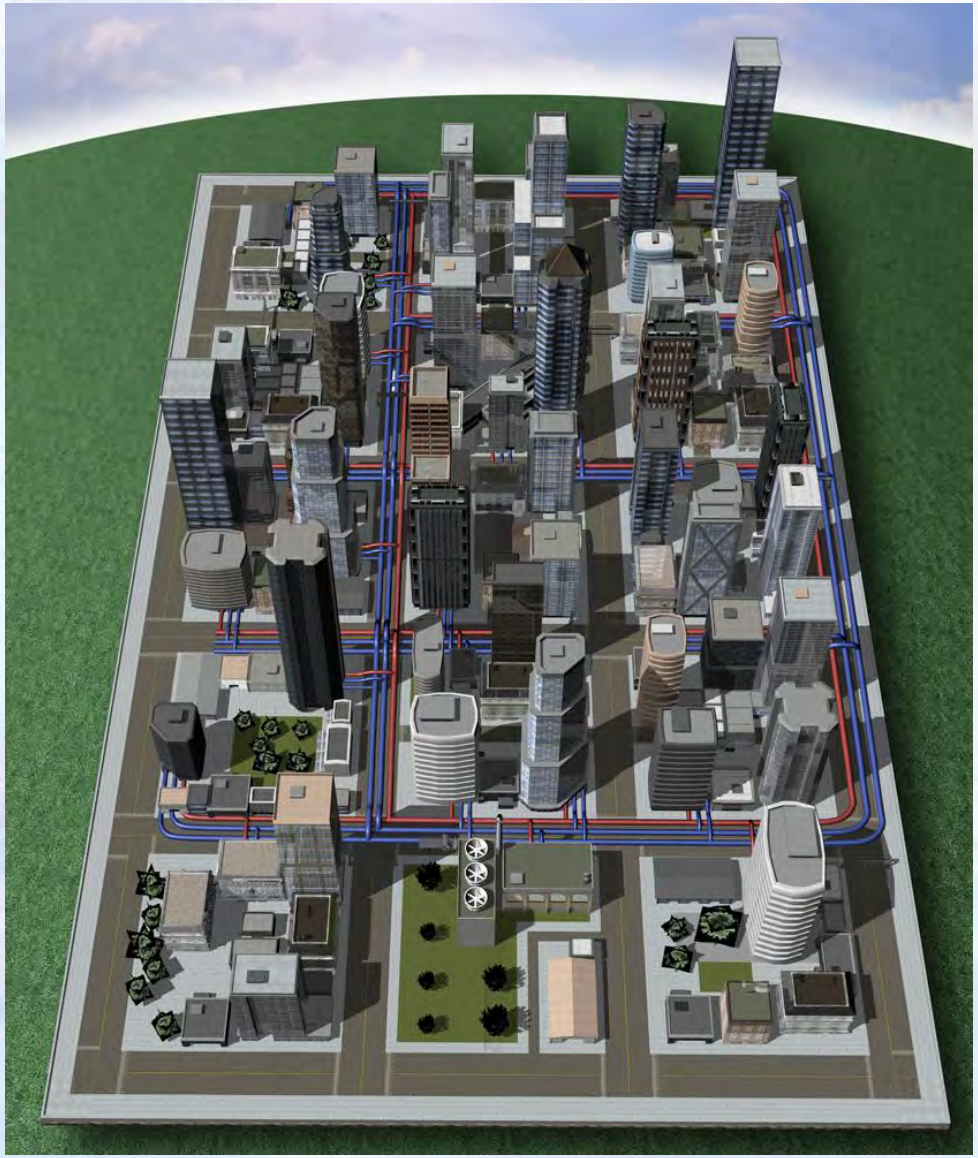
- Deliver valuable steam heat to Boston customers rather than thermal pollution to Charles River
- 15% efficiency gain at plant; improves heat rate; enhances power sales queue in NE ISO
- Cuts emissions equivalent to removing 52,000 cars

What is District Energy?

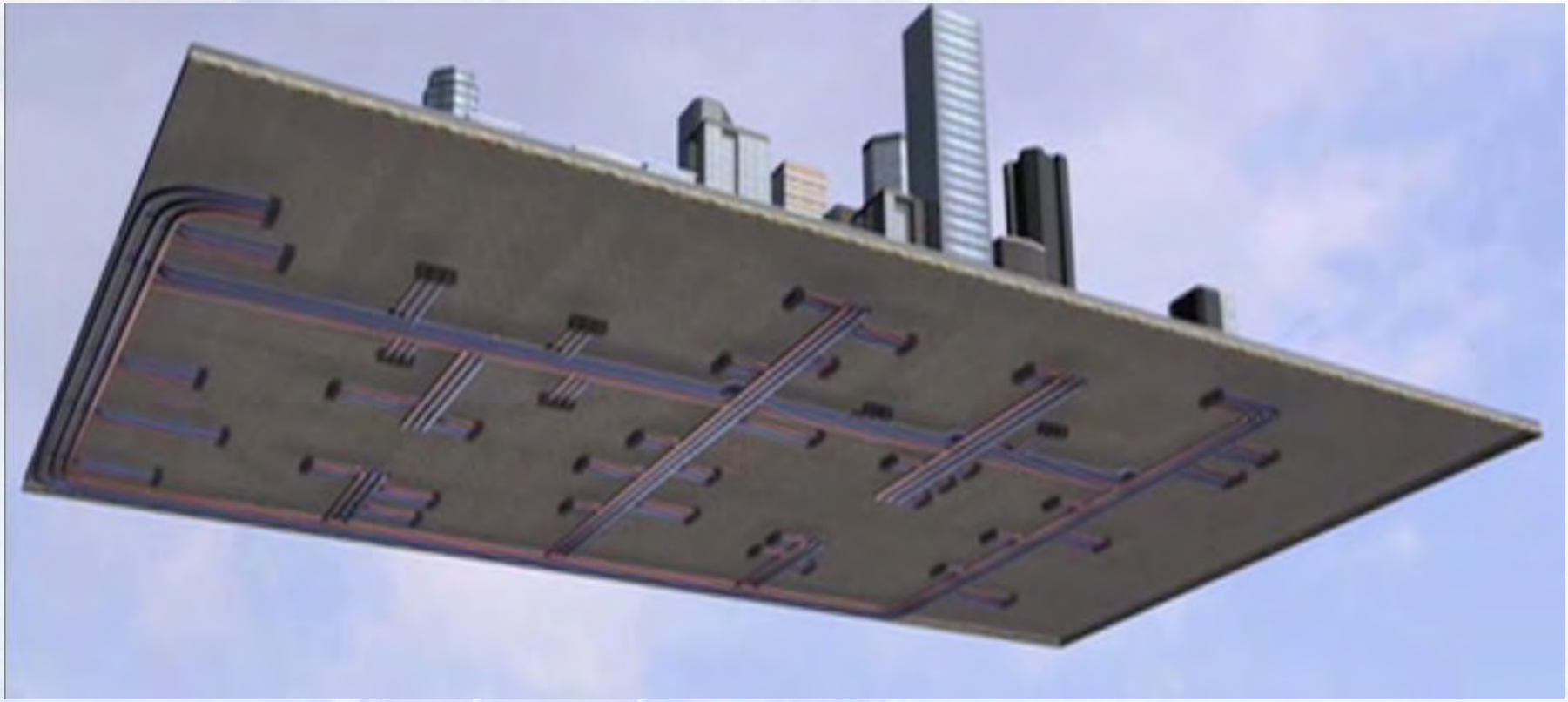


District Energy – Community Scale Heating and Cooling

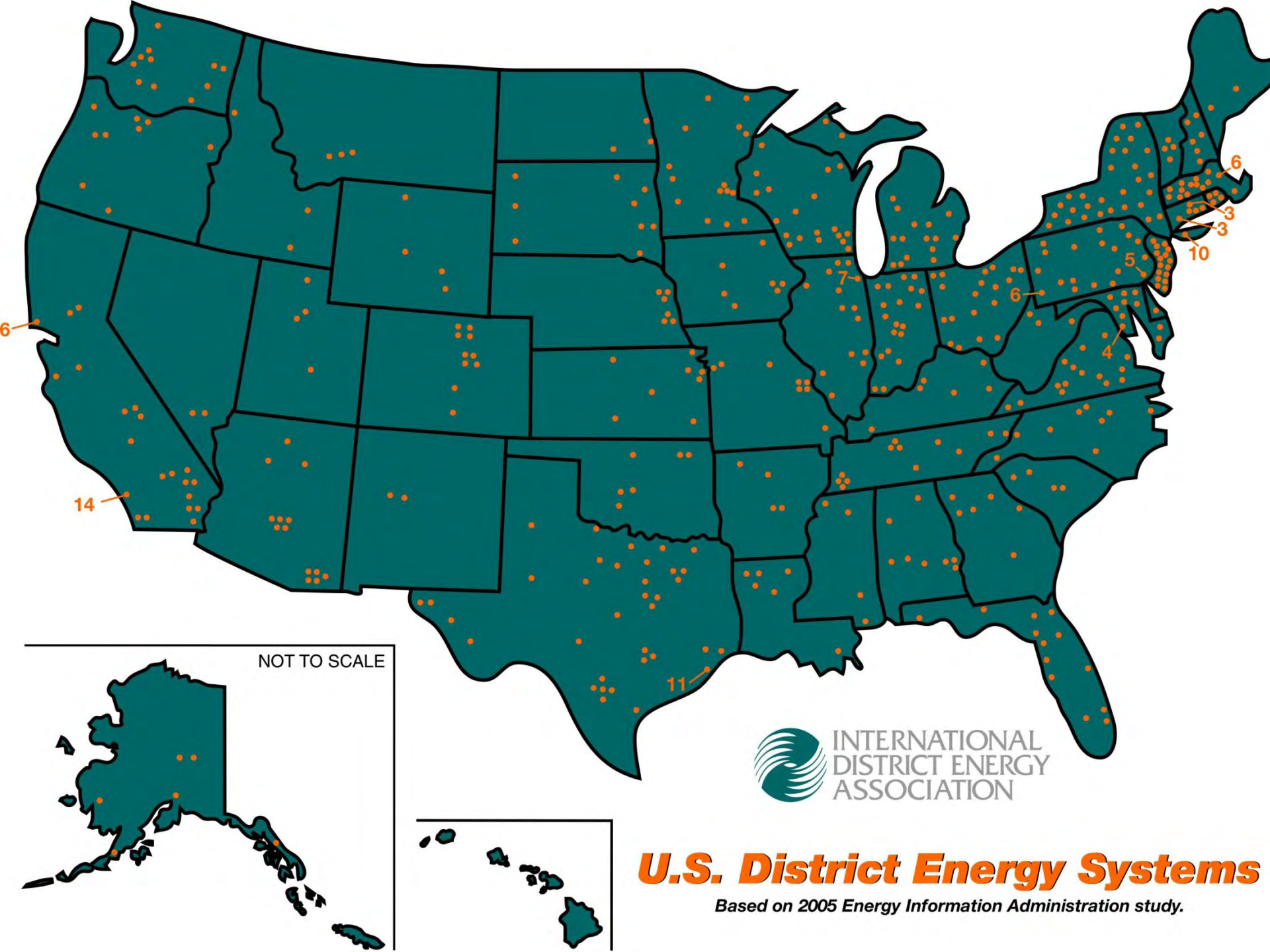
- Underground network of pipes "combines" heating and cooling requirements of multiple buildings
- Creates a "market" for valuable thermal energy
- Aggregated thermal loads creates scale to apply fuels, technologies not feasible on single-building basis
- Fuel flexibility improves energy security, local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



Infrastructure for Local Clean Energy Economy



- Connects thermal energy sources with users
- Urban infrastructure – hidden community asset
- Energy dollars re-circulate in local economy
- High quality jobs in construction & operation



INTERNATIONAL DISTRICT ENERGY ASSOCIATION

U.S. District Energy Systems

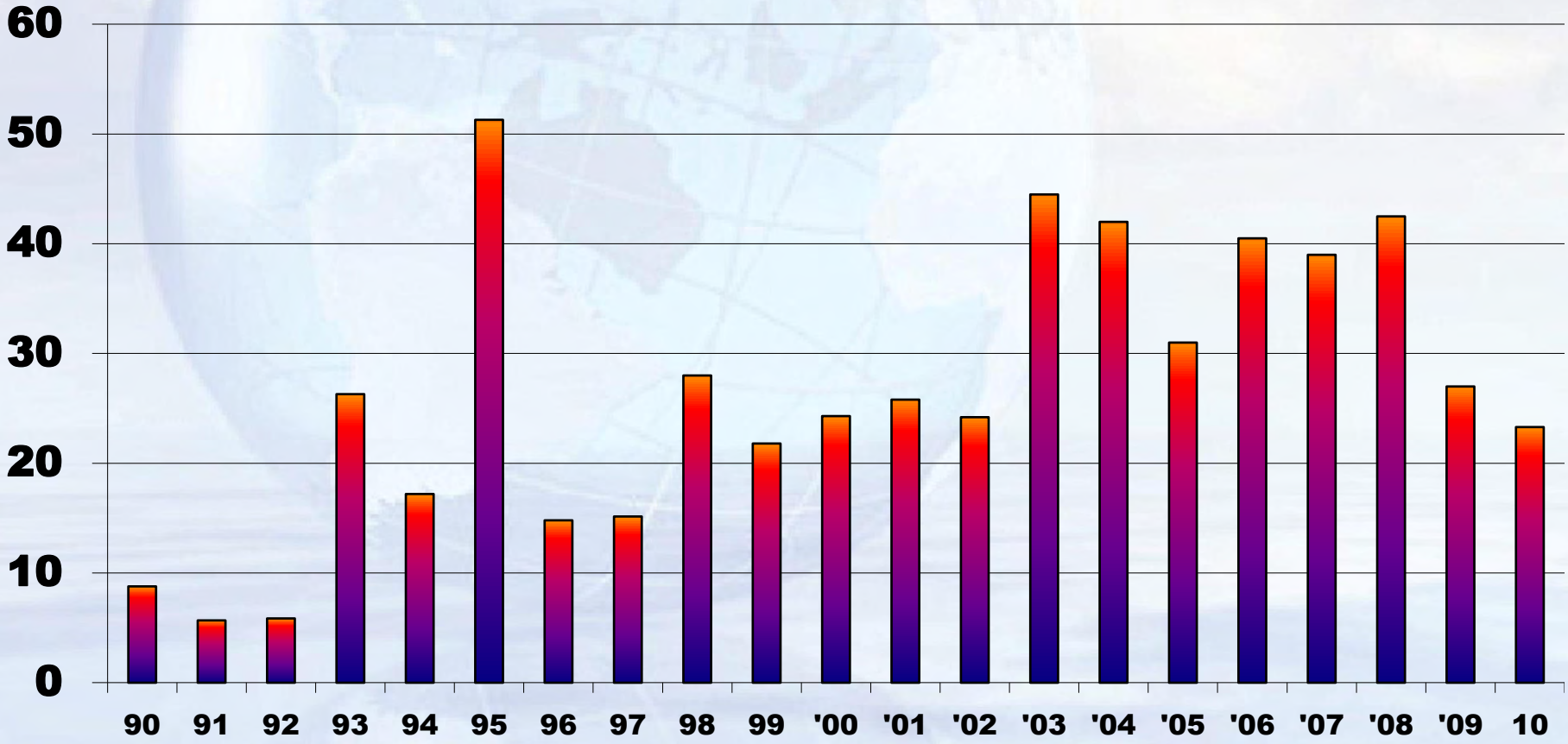
Based on 2005 Energy Information Administration study.

District Energy Industry Growth

(Million sq ft customer bldg space connected/committed)

Aggregate SF reported since 1990 – 518,461,287 SF

(Annual average 24.7 Million SF/Yr – North America)



District Energy St. Paul, MN

- District hot water service to 29 million sq ft buildings (90% market)
- District cooling service to over 17 million sq ft
- Combined heat & power: 25 Mwe (electric); 65 MWt (thermal)
- Double the efficiency of conventional power plants
- Fuel flexible: waste wood, natural gas, coal, oil – stable energy prices
- Municipal wood waste displaces 275,000 tons coal/yr; cuts landfill; reduces CO2 emissions 280,000 tons/yr
- Over $12 million in fuel purchases re-circulates in local economy

Hartford District Energy System

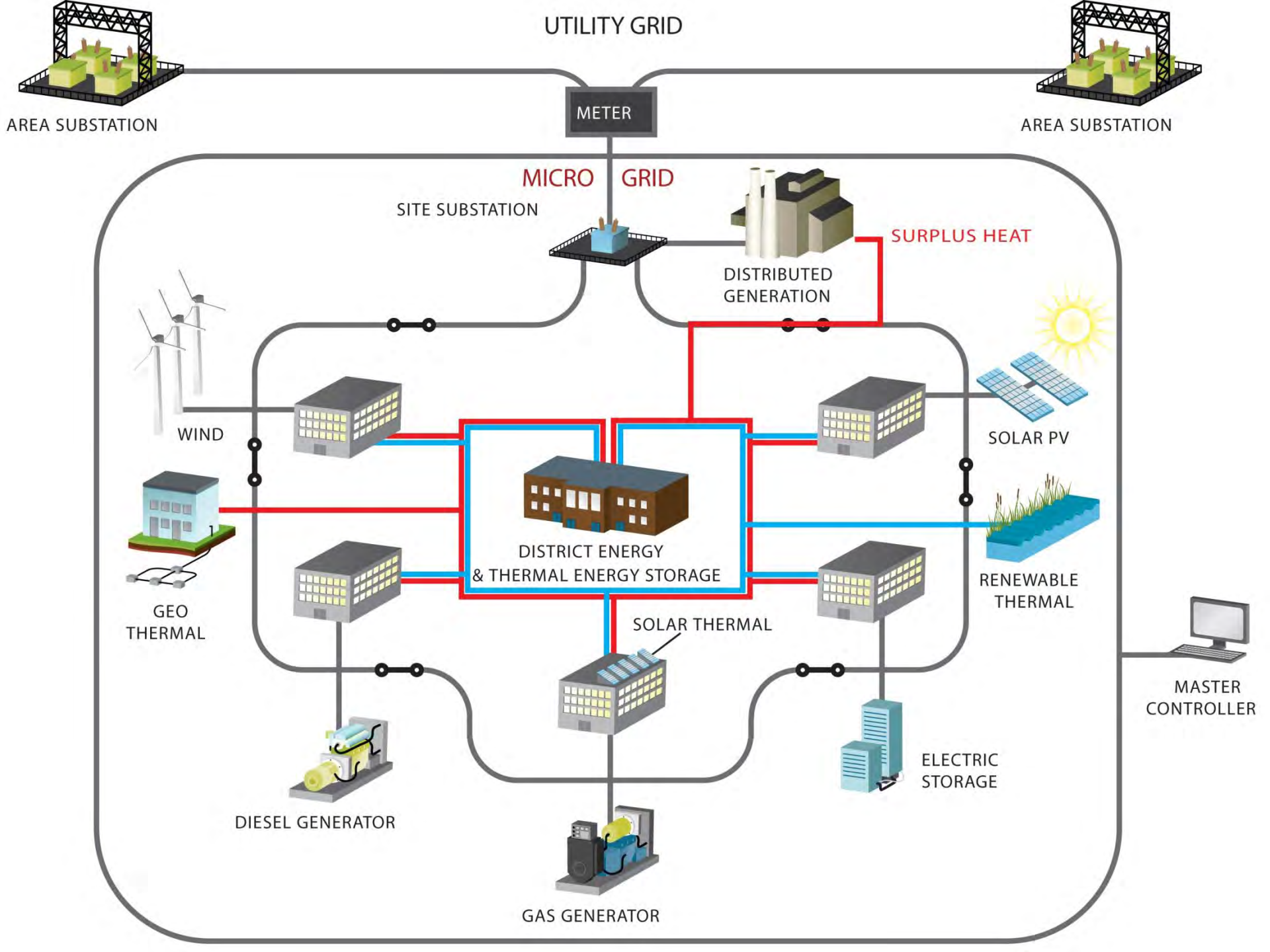
Energenic
Powerful Ideas

HSC

Began operations in 1962
Total Steam Capacity: 570,000 lbs/hr
Total Chilled Water: 31,500 Tons
Combined Electric Capacity: 11 MW
Condenser Water : Seasonal Direct Cooling from Connecticut River

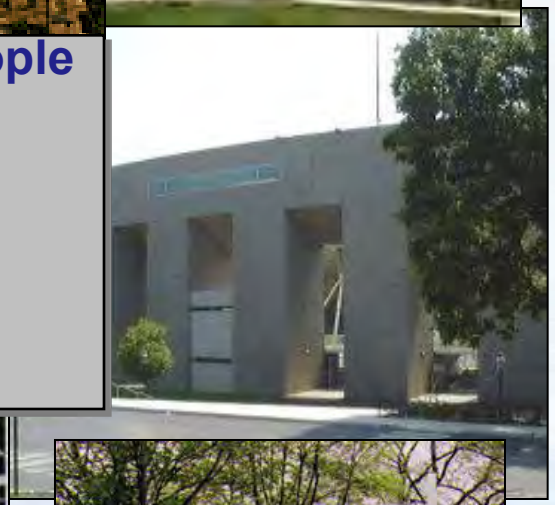
What is a MicroGrid?

- Local power generation – “distributed generation”
- Ideally integrates electricity / thermal / storage / renewables for supply diversity & resiliency
- Located near load centers & customer density
- Often supporting mission critical end-users
- Interconnected with regional/local grid
- Able to “island” in the event of grid failure


UTILITY GRID
AREA SUBSTATION
METER
AREA SUBSTATION
MICRO GRID
SITE SUBSTATION
DISTRIBUTED GENERATION
SURPLUS HEAT
WIND
SOLAR PV
DISTRICT ENERGY & THERMAL ENERGY STORAGE
GEO THERMAL
RENEWABLE THERMAL
SOLAR THERMAL
MASTER CONTROLLER
ELECTRIC STORAGE
DIESEL GENERATOR
GAS GENERATOR

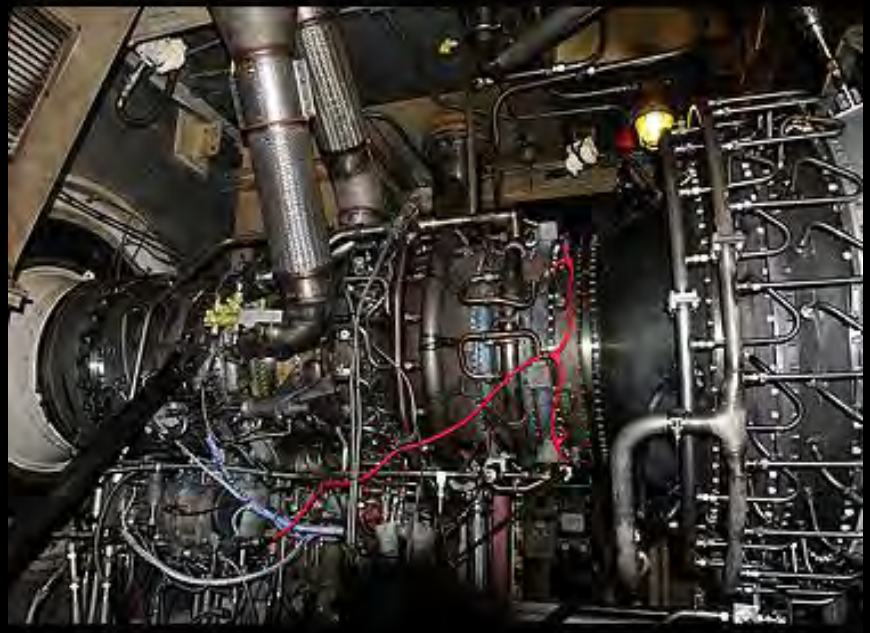
MicroGrid: Cogeneration & District Cooling – Princeton University

- > 150 Buildings; 12,000 people
  - Academic
  - Research
  - Administrative
  - Residential
  - Athletic



Production Capacity & Peak Demands – Princeton University

	Rating	Peak Demand
• **Electricity**		
– (1) Gas Turbine Generator	15 MW	27 MW
• **Steam Generation**		
– (1) Heat Recovery Boiler	180,000 #/hr	
– (2) Auxiliary Boilers	300,000#/hr	240,000 #/hr
• **Chilled Water Plant**		
– (3) Steam-Driven Chillers	10,100 Tons	
– (3) Electric Chillers	5,700 Tons	11,800 Tons
– (8) CHW Distribution Pumps	23,000 GPM	21,000 GPM
• **Thermal Storage**		
– (2) Electric Chillers	5,000 Tons	
– (1) Thermal Storage Tank	40,000 Ton-hours	
• *peak discharge	10,000 tons (peak)	
– (4) CHW Distribution Pumps	10,000 GPM	
• **Solar PV Farm**	5.4 MW	
	16,500 panels	
	11 hectares	

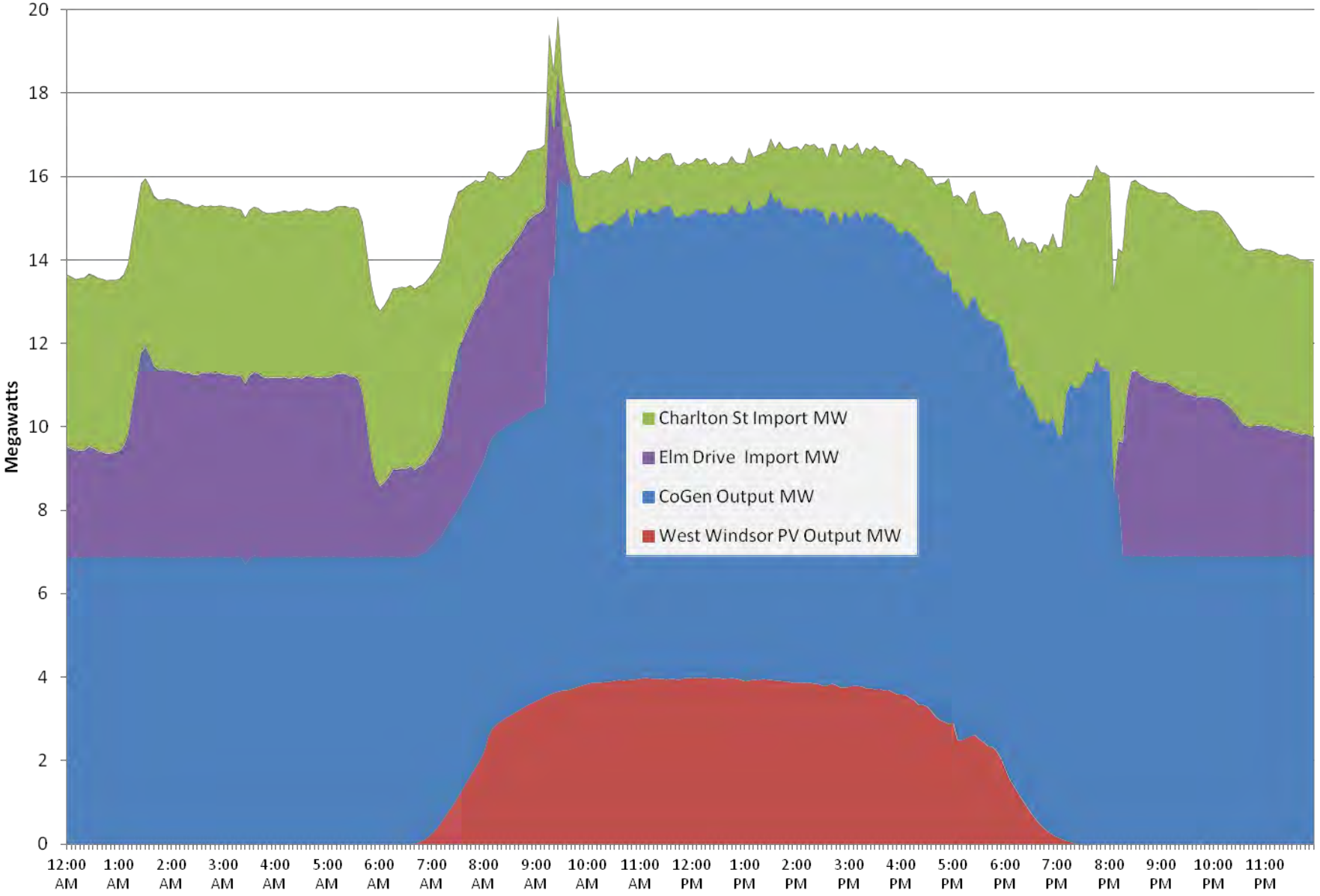


Princeton University PV Farm

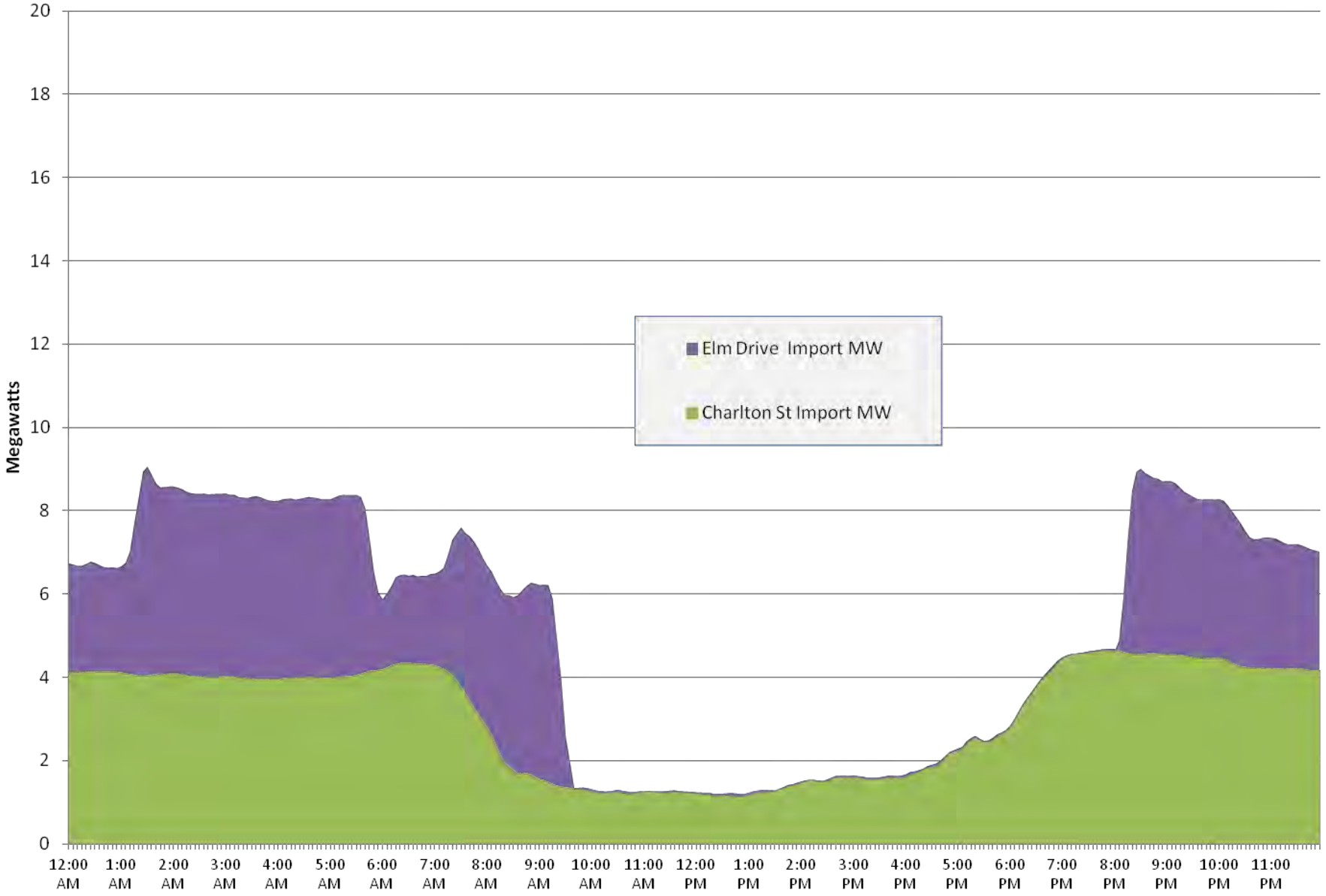
16,500 PV panels generate up to 327 Watts each at 54.7 Volts DC

Princeton University 5.4 MW Solar Farm

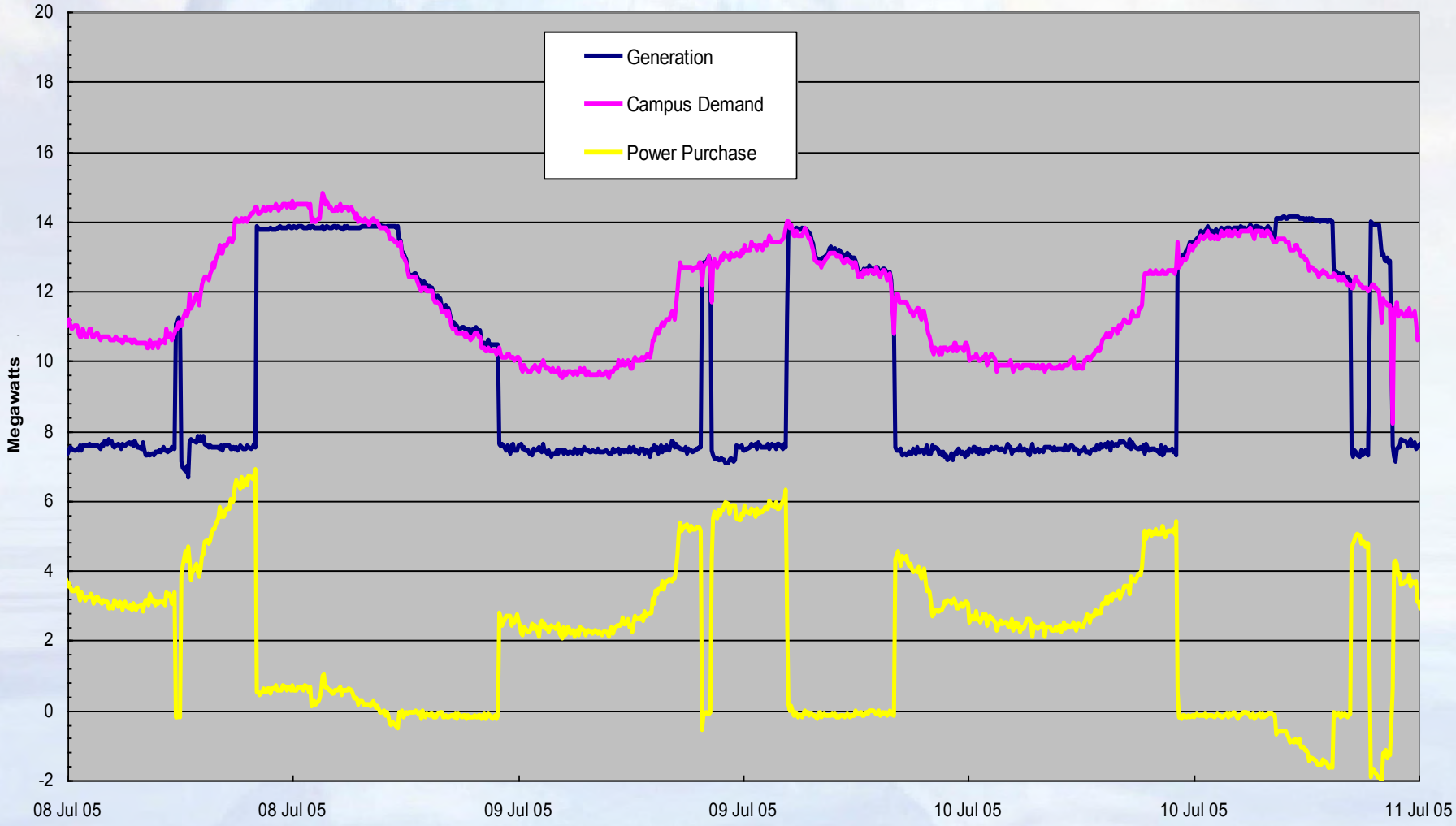
Main Campus Power, Generated & Purchased
During PV System Testing August 30, 2012



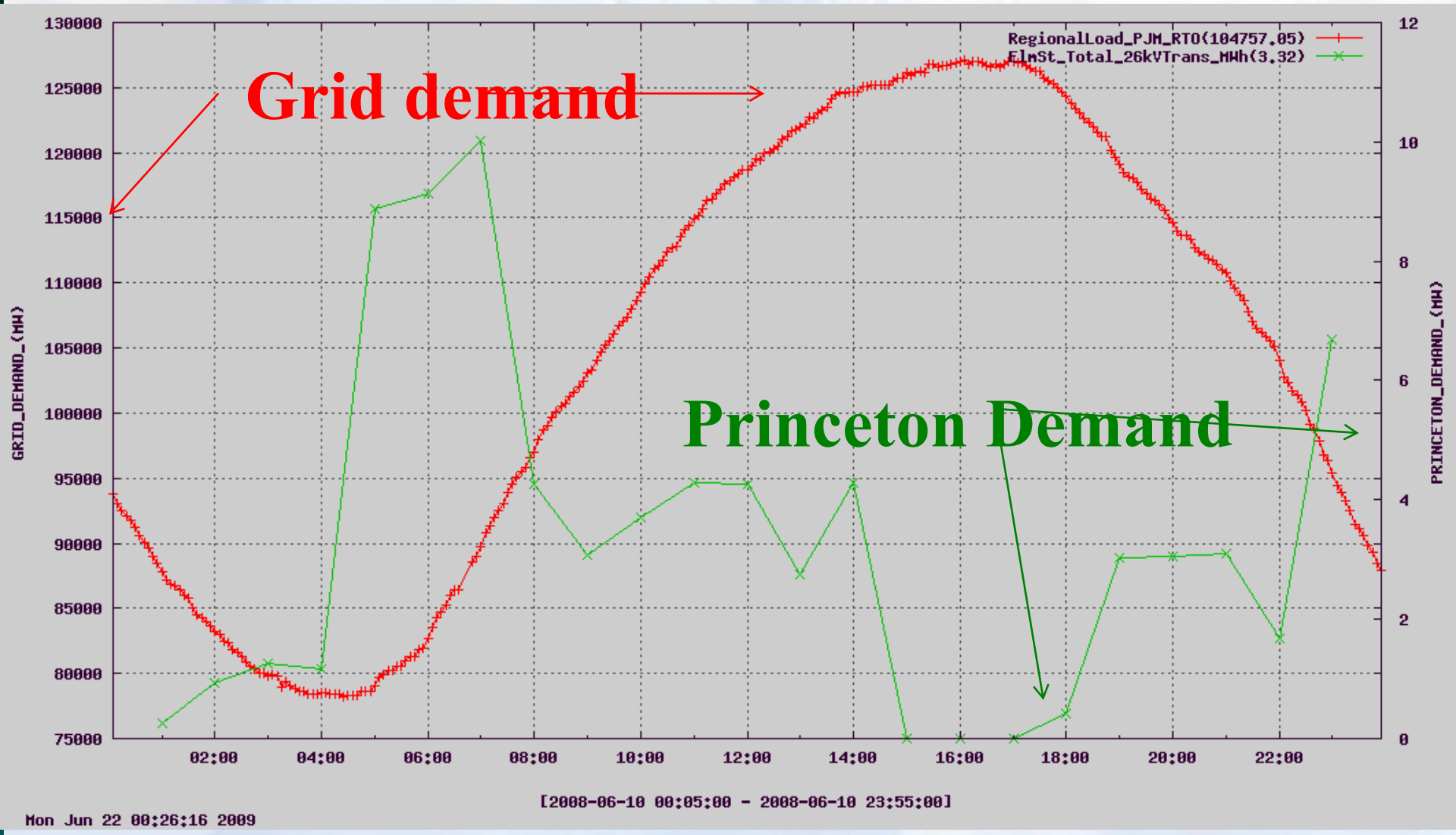
Main Campus Power Purchases
During PV System Testing August 30, 2012



Micro-Grid Electric Generation Dispatch To Minimize Cost



CHP/District Cooling Reduces Peak Demand on Local "Smart" Grid



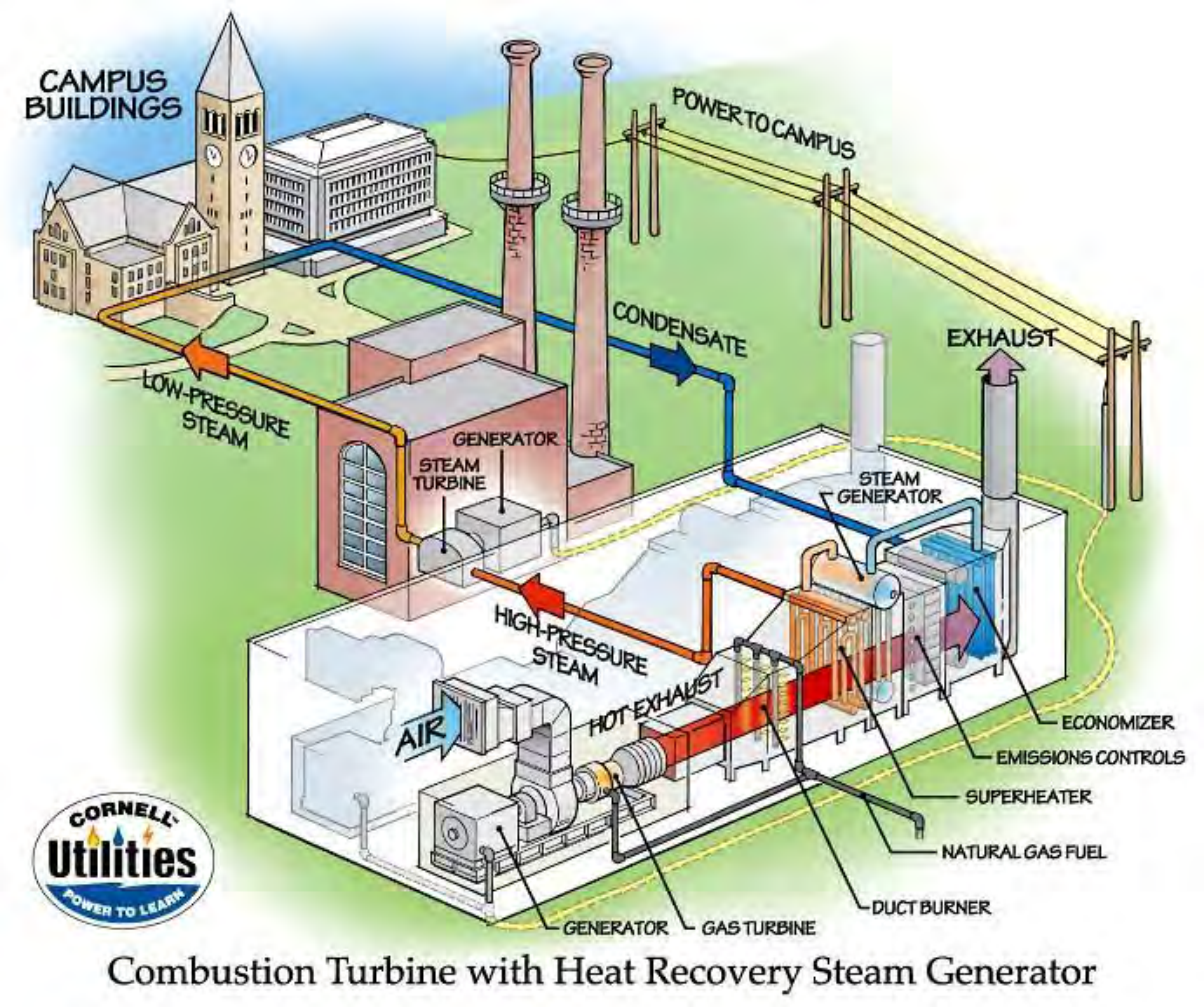
Princeton University Microgrid Benefit to Local Grid

During August, 100+ deg F; 80% RH

- 2005 campus peak demand on grid 27 MW
- 2006 campus peak demand on grid 2 MW
- Microgrid "freed up" 25 MW to local grid
  - reduces peak load on local wires, avoids brownouts, enhances reliability and supports local economy
- 2011, Hurricane Irene flooded Princeton
  - The Campus lights and services stayed on!

❖ http://www.districtenergy.org/assets/Princeton-UniversityFINAL.pdf

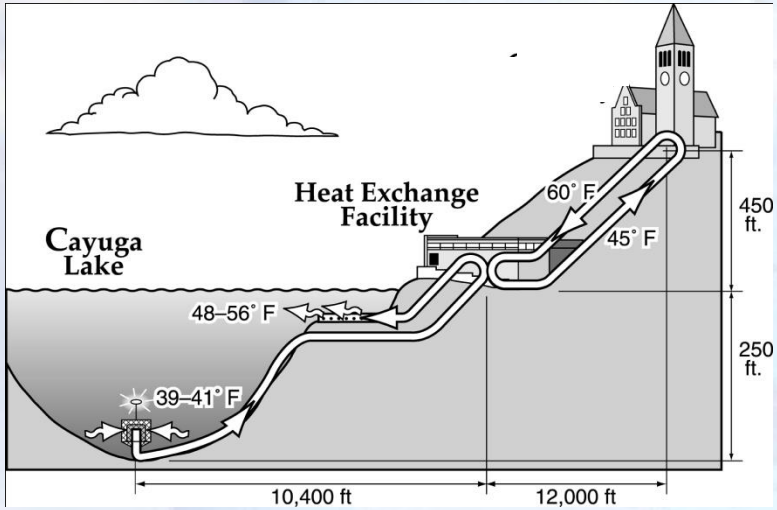
Cornell Combined Heat & Power



Combustion Turbine with Heat Recovery Steam Generator

- Commissioned December 2009
- 30 MW and 300 klb/h
- Produce 180 GWh/yr and 750,000 klbs/yr
- Offset indirect emissions
- Reduce coal usage by 50%
- Reduce campus CO_2 20% (50,000 tons/yr)
- Provide efficient steaming capacity
- Electric reliability
- Fuel flexibility (HP gas line)
- Dual fuel capability
  - Future liquid biofuel option

Cornell Lake Source Cooling



16,000 Tons Capacity - $58,000,000

Lake source water: 39-41º F

Lake return water : 48-56º F

Campus loop supply/return : 45º - 60º F

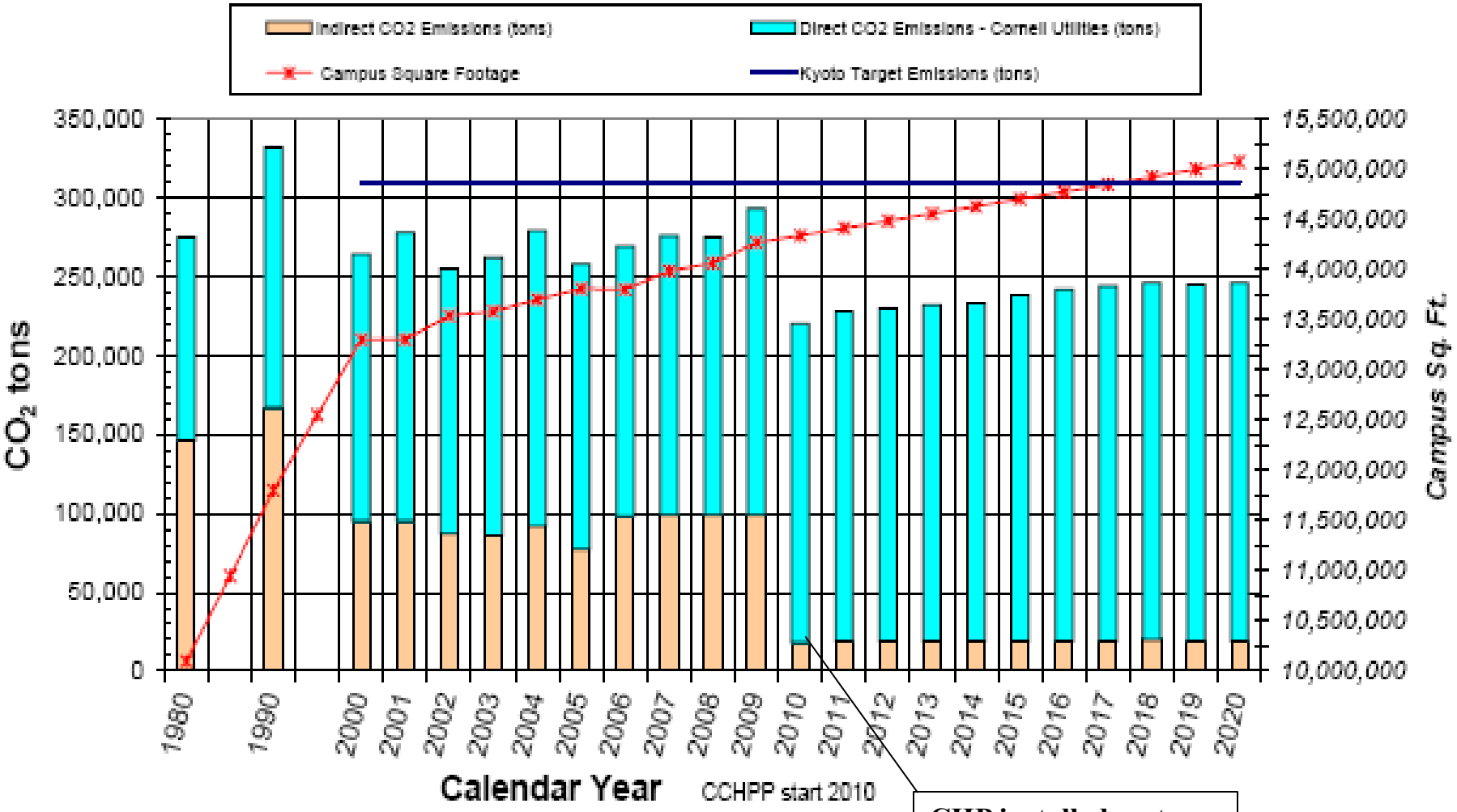
Lake source intake pipe: 10,400 ft long, 250 ft deep

Campus S/R loop pipe: 12,000 ft

Benefits:

- Reduced cooling electricity by 87% - cutting 25 million kwh/yr
- Efficiency - production at 0.1 kW/ton; fully automated (no operators)
- CO2 emissions cut 56 million #'s/yr
- Sulfur oxides cut 654,000 lbs/yr
- Nox reduced 55,000 lbs/yr
- 40,000 lbs CFC eliminated
- Traded op expense for amortization

Cornell's Carbon Footprint



Community Energy, Local Opportunities

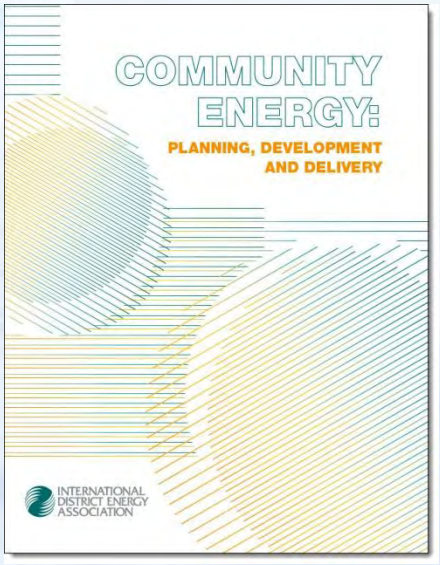
- Communities are considering becoming energy producers
- Drivers:
  - rising cost of traditional energy
  - national and local energy security
  - local energy resiliency
  - reducing emissions
  - volatile global energy market
  - replacing coal generation
- Local energy infrastructure maximizes resource efficiency and exploits local opportunities

Local Energy: An Economic Engine

- Improved energy resiliency attracts high value businesses that appreciate lower-cost, cleaner, and more reliable energy supplies.
- Compact communities with mix of uses and density of buildings reduce sprawl and supports public transit systems
- District energy shifts capital costs for developers
- Economic multiplier: cash that would leave the area to pay for outside energy supplies stays local
- Community energy infrastructure contributes to a high-quality and attractive place to live and work

Planning Guide for Community Energy

- Project champions: Mayors, community energy, economic development and sustainability staff, elected officials, planners
- Consider energy in comprehensive planning, brownfield/revitalization projects, Climate Action Plans
- Variety of project developers: opportunities for collaboration and public/private partnerships
  - Local governments
  - Communities
  - Other public sector developers
  - Institutions
  - Corporations and industrial parks
  - Private property developers
  - Landowners and building operators



Released June 30, 2012 at IDEA 103rd Annual Conference Workshop, Chicago, IL

Energy Mapping

- Identify local energy opportunities in development areas
- Inform growth options and help prioritize investment
- Exclude inappropriate areas (low density; rural)
- Classify unique energy character areas and density

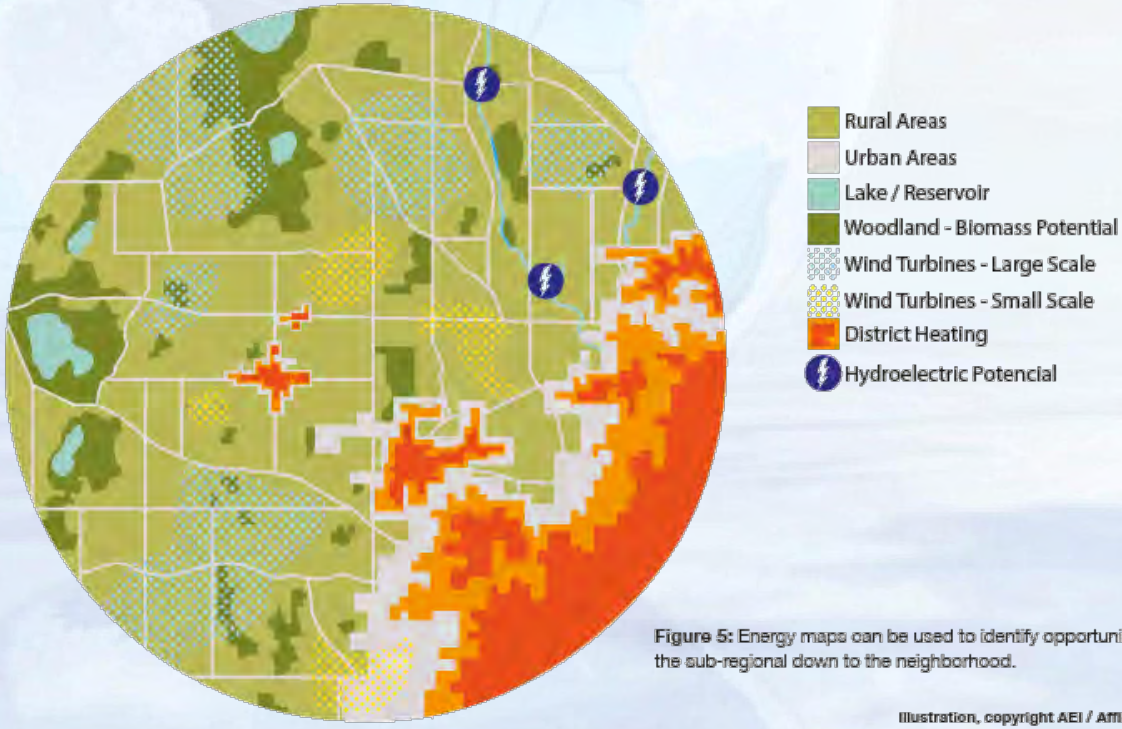
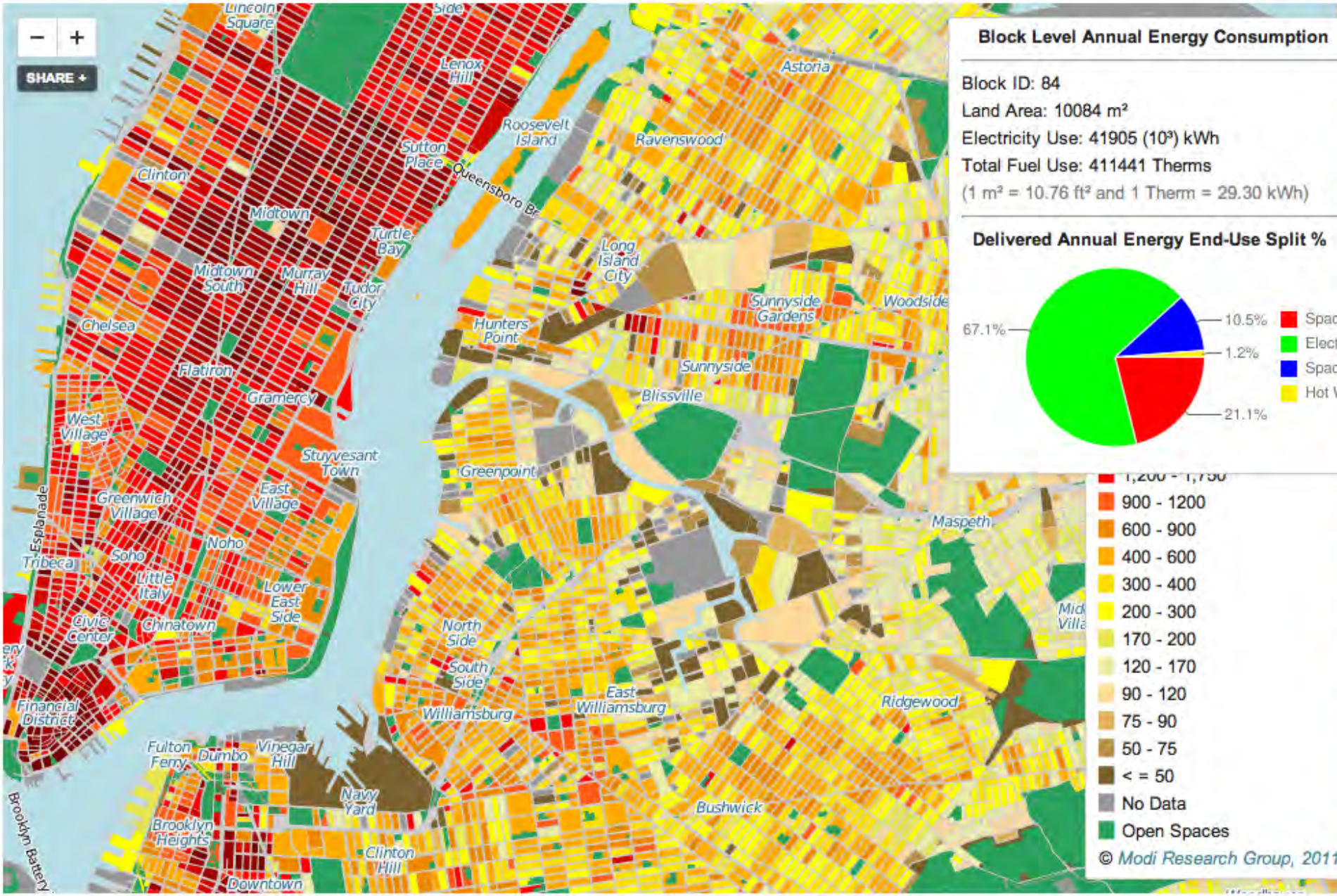


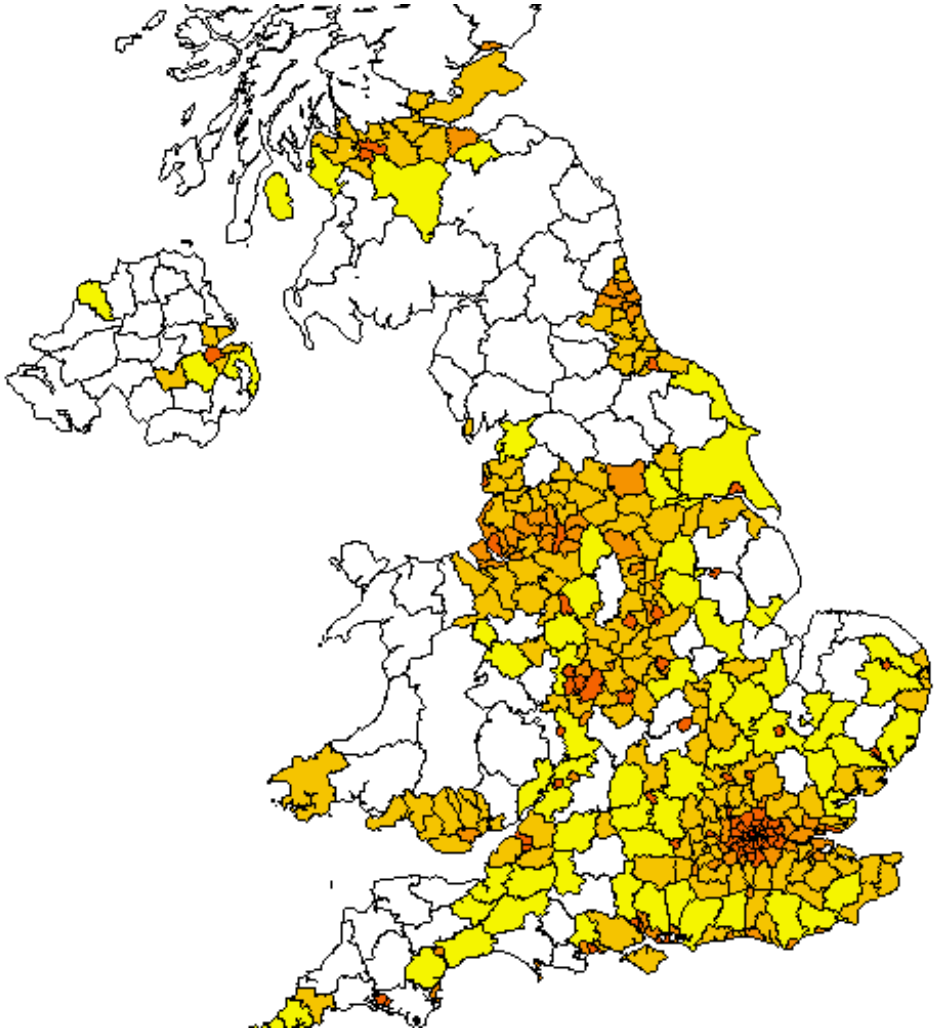
Figure 5: Energy maps can be used to identify opportunities at scales from the sub-regional down to the neighborhood.

Total Annual Building Energy Consumption for New York City



Data Source: Spatial distribution of urban building energy consumption by end use
B. Howard, L. Parshall, J. Thompson, S. Hammer, J. Dickinson, V. Modi

U.K. Energy Density Map - 2011



http://chp.decc.gov.uk/developmentmap/

Community Energy: Stages of Development

- *Stage 1:* set objectives for community energy project
- *Stage 2:* gather relevant data, i.e. building density, mix of uses, and anchor loads; display data in energy map
- *Stage 3:* identify buildings to be connected and ensure building owners commit
- *Stage 4:* assess technical options, "high-level feasibility study"
- *Stage 5:* complete detailed technical feasibility study, high-level assessment of financial viability
- *Stage 6:* evaluate financial model, including potential sources of capital and revenue; consider risks through sensitivity analysis
- *Stage 7:* identify business or commercial model, weight relationship with risk and control, cost of capital
- *Stages 8, 9, and 10:* understand legislative and regulatory environments, procurement routes, commissioning, and delivery

State Policy Landscape

- **Massachusetts**
  - Green Communities Act 2009 – Alternative Energy Portfolio
  - S.2395 (2012) calls for the study of alternative energy projects that provide "useful thermal energy"
- **New Hampshire**
  - SB 218: adds renewable thermal energy to state RPS
- **Washington State**
  - SB 6012: renewable thermal energy eligible for state renewable energy credits (RECs)
- **Ohio**
  - SB 242: renewable energy resources do not need to produce electricity to qualify for RECs
- **Connecticut:**
  - Clean Energy Finance and Investment Authority and Energy Improvement Districts (EIDs)
  - Microgrid Grant & Loan Pilot Program - Public Act 12- 48,Sec.7

Federal CHP Policy

White House Executive Order, Aug 30, 2012

"Accelerating Investment in Industrial Energy Efficiency"

- **Increase CHP capacity by 40 GW (50%) by 2020**

- **Convene federal and regional stakeholders to address barriers – policy, financial, regulatory**
- **Accounting for potential emission reduction benefits of CHP in State Implementation Plans (SIPs); employ output-based emissions approaches**
- **Providing incentives for CHP deployment of CHP: emissions allowance trading program, state implementation plans, grants, and loans**
- **Expand participation and tools of Clean Energy Application Centers and support DOE Better Buildings, Better Plants to reduce energy intensity**

Master Limited Partnership Parity Act of 2012

- Senate Bill S.3275 / House Bill HR. 6437
- Bi-partisan sponsorship
- Simple 200 word bill – common sense
- Levels playing field w/ oil & gas (fossil)
- Provides tax advantages of Limited Partnerships with liquidity of stocks
- Provides access to pools of low cost private capital

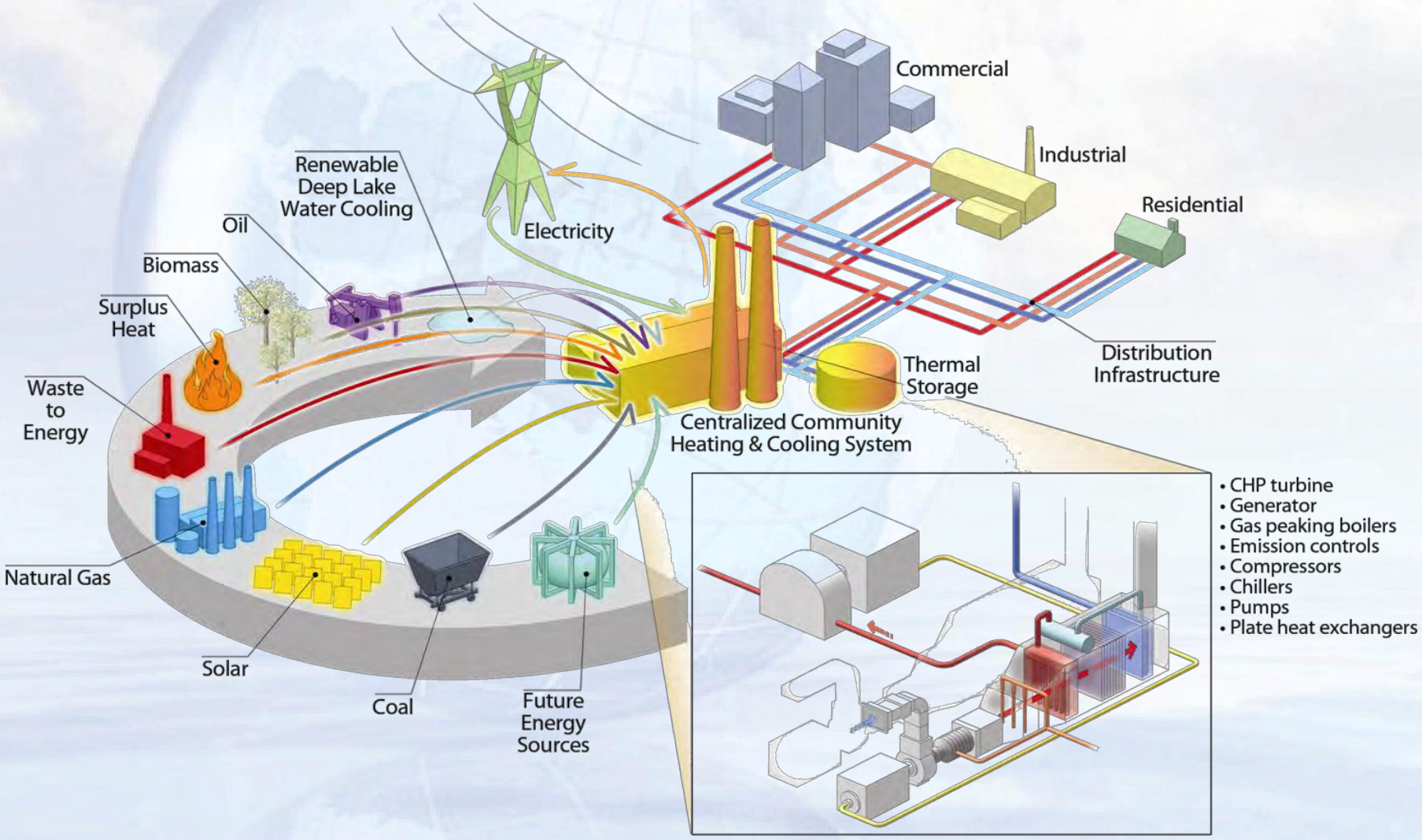
www.coons.senate.gov/issues/master-limited-partnerships-parity-act

Master Limited Partnership Parity Act

District Energy: What the Future Holds

- more efficient use of resources
- community-based economic engine
- safe, secure, and reliable energy
- affordable, high-quality thermal services
- improved environmental performance
- livable cities, towns and communities

Future Proofing the Future City



INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Thank you for your attention. Questions?

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