District Energy: Local Solution, Global Benefits

Robert Thornton, President & CEO

A National Vision for District Energy/CHP

NYSERDA/NECHPI Conference & Workshop

NYU Kimmel Center

New York, NY

June 22, 2012

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

- **Formed in 1909 – 103 years in 2012**
- **501(c)6 industry association**
- **1500+ members in 25 nations**
- **56% end-user systems; majority in North America; 42 states**
- **Most major public & private colleges and universities; urban utilities.**

U.S. DEPARTMENT OF ENERGY

QTR

REPORT ON THE FIRST
QUADRENNIAL TECHNOLOGY REVIEW

"Thermal image of houses in front of a coal-fired power plant. White and red are hottest; blue and green coolest. For the average coal plant, only 32% of the energy is converted to electricity; the rest is lost as heat. The red shows the significant heat loss from the roofs of the houses."

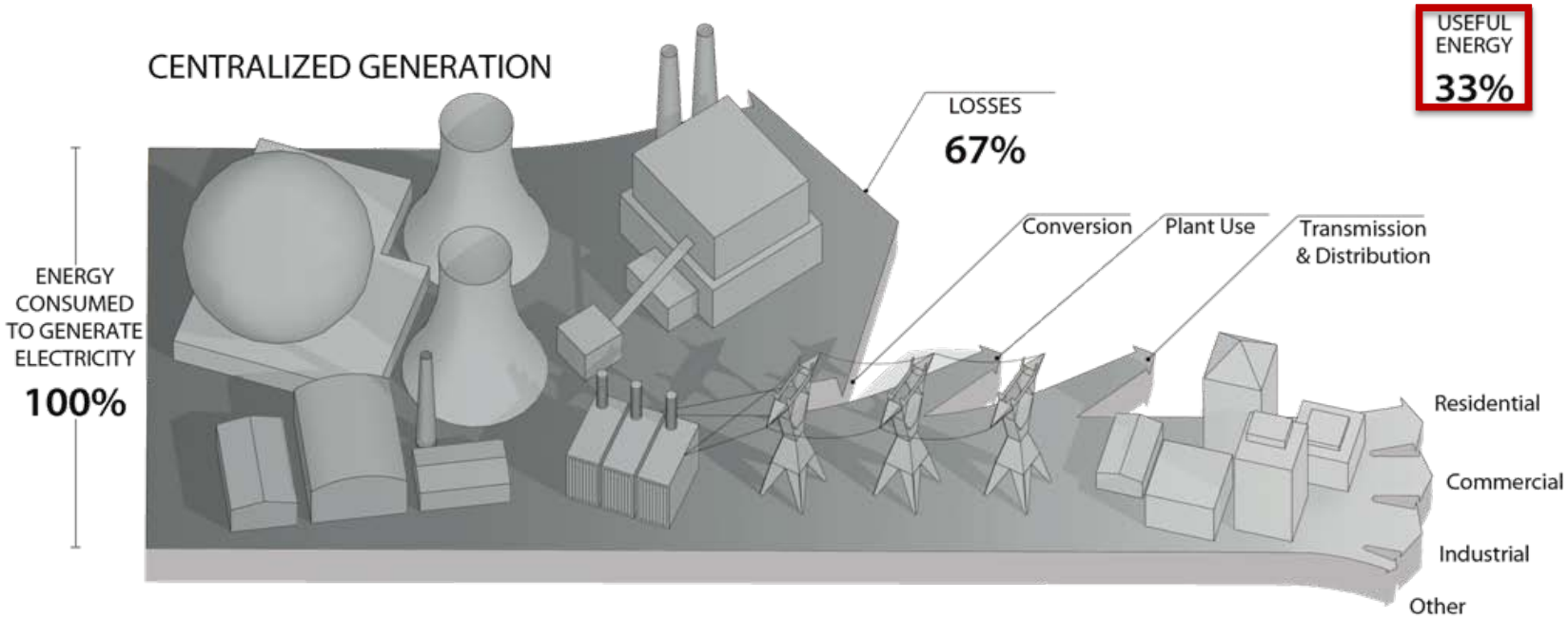
-Page VI, Executive Summary

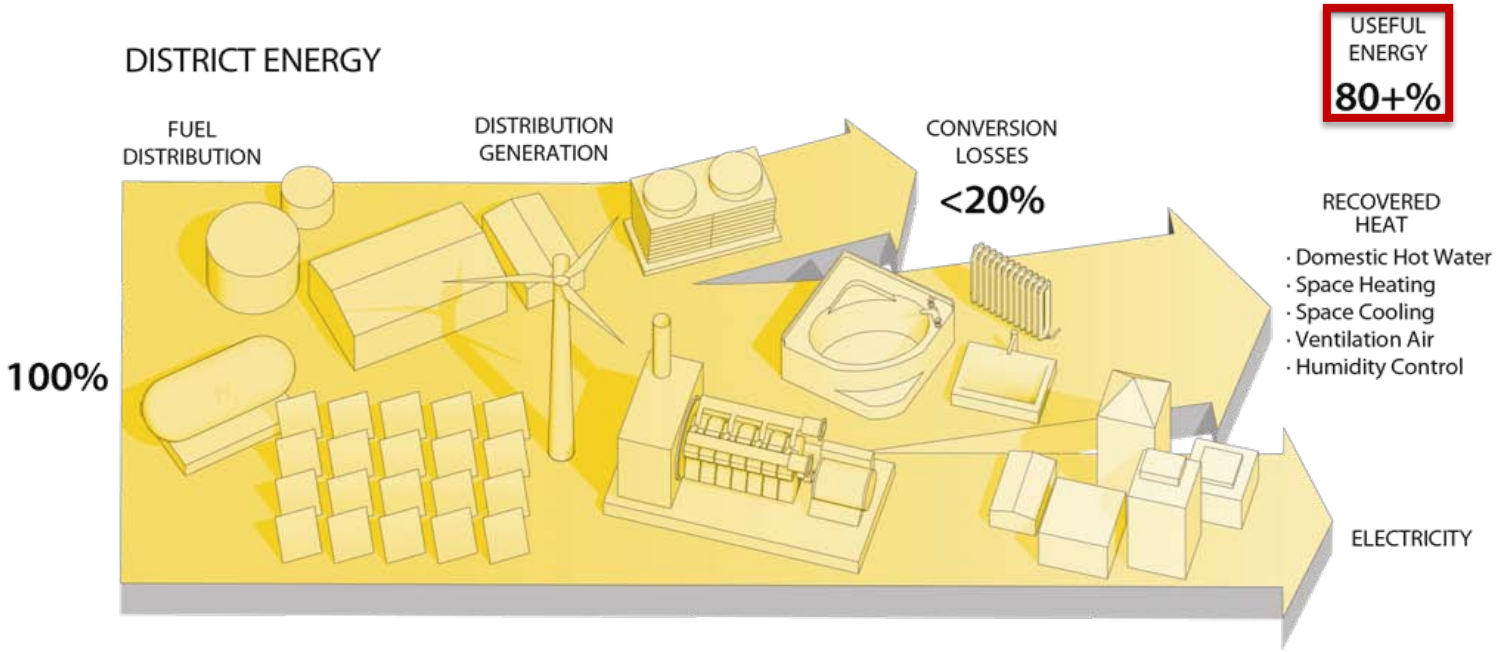
Efficiency of US Power Generation

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





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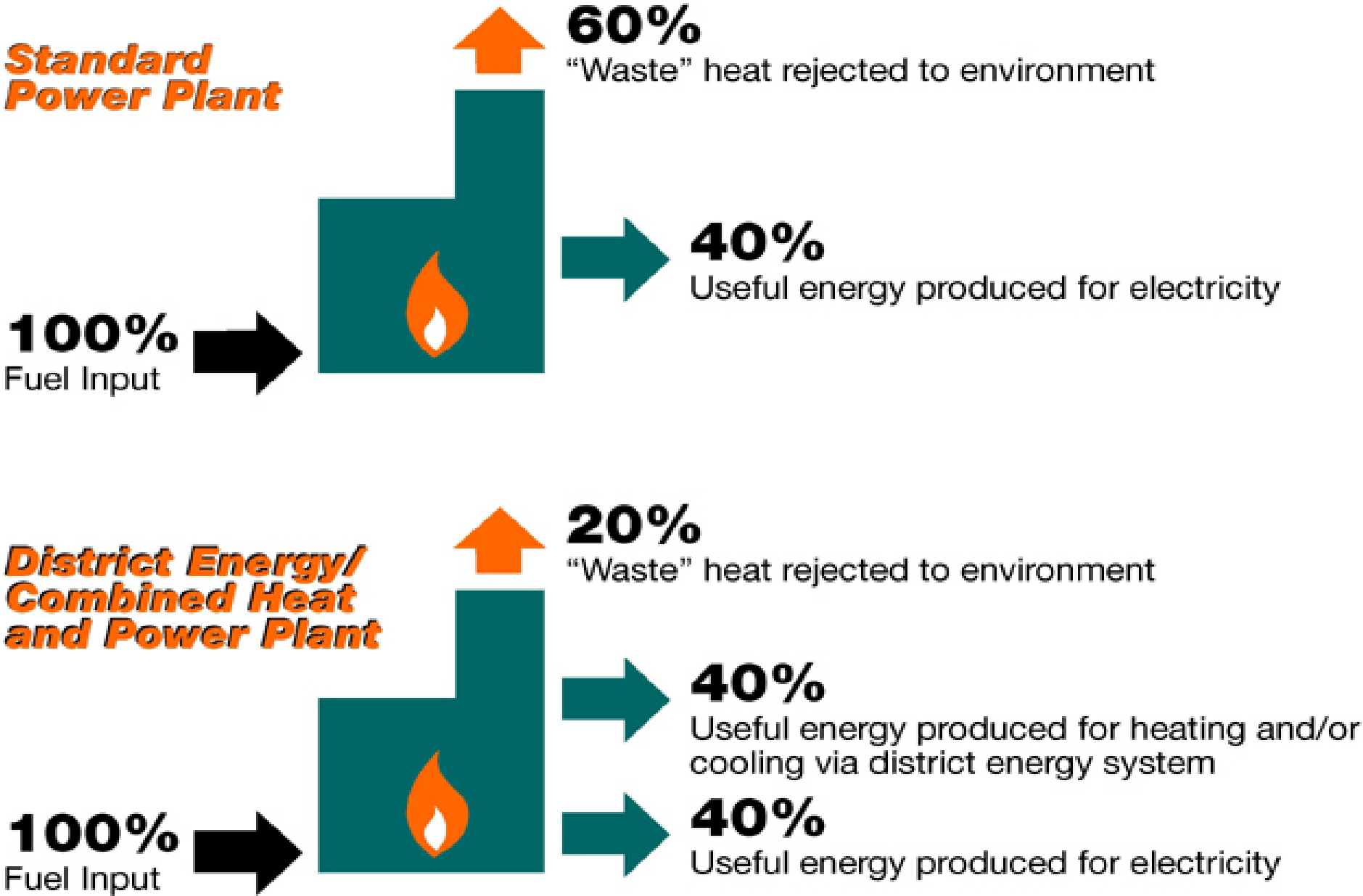
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Energy-Efficiency Comparisons



Opportunity: District Energy

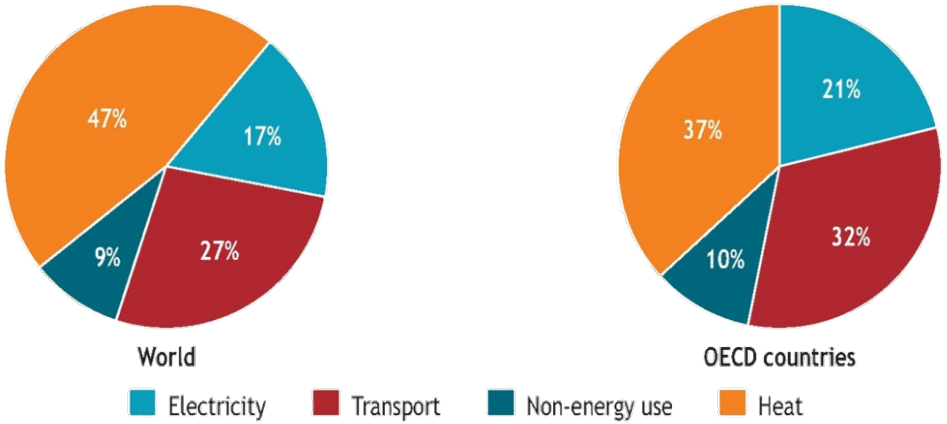
"District heating and cooling is an integrative technology that can make significant contributions to reducing emissions of carbon dioxide and air pollution and to <u>increasing energy security."</u>

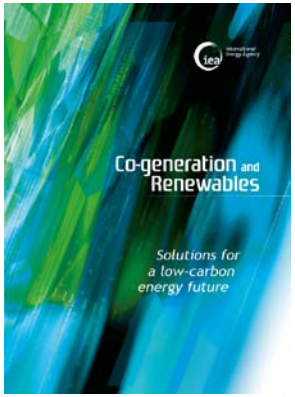
International Energy Agency

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

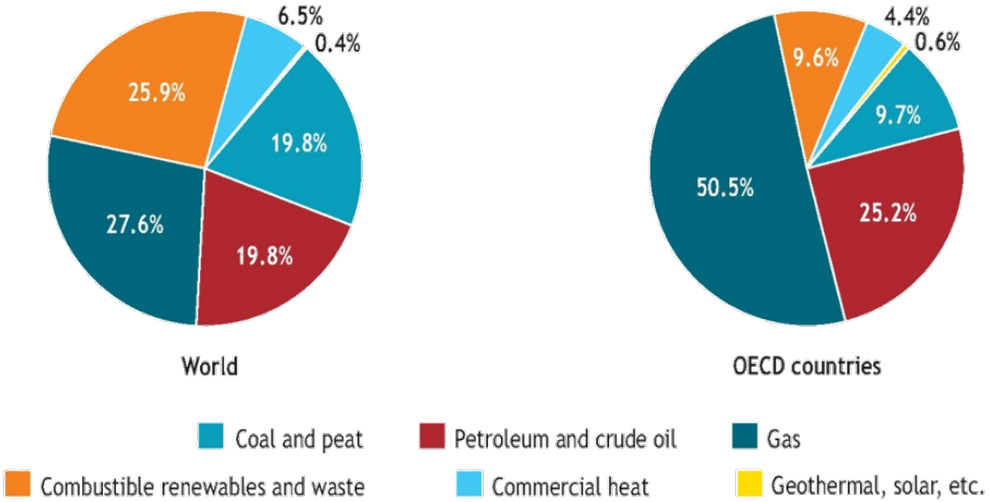
IEA 2011 Report – Spotlight on Heat

- **Heat dominates all other energy uses**

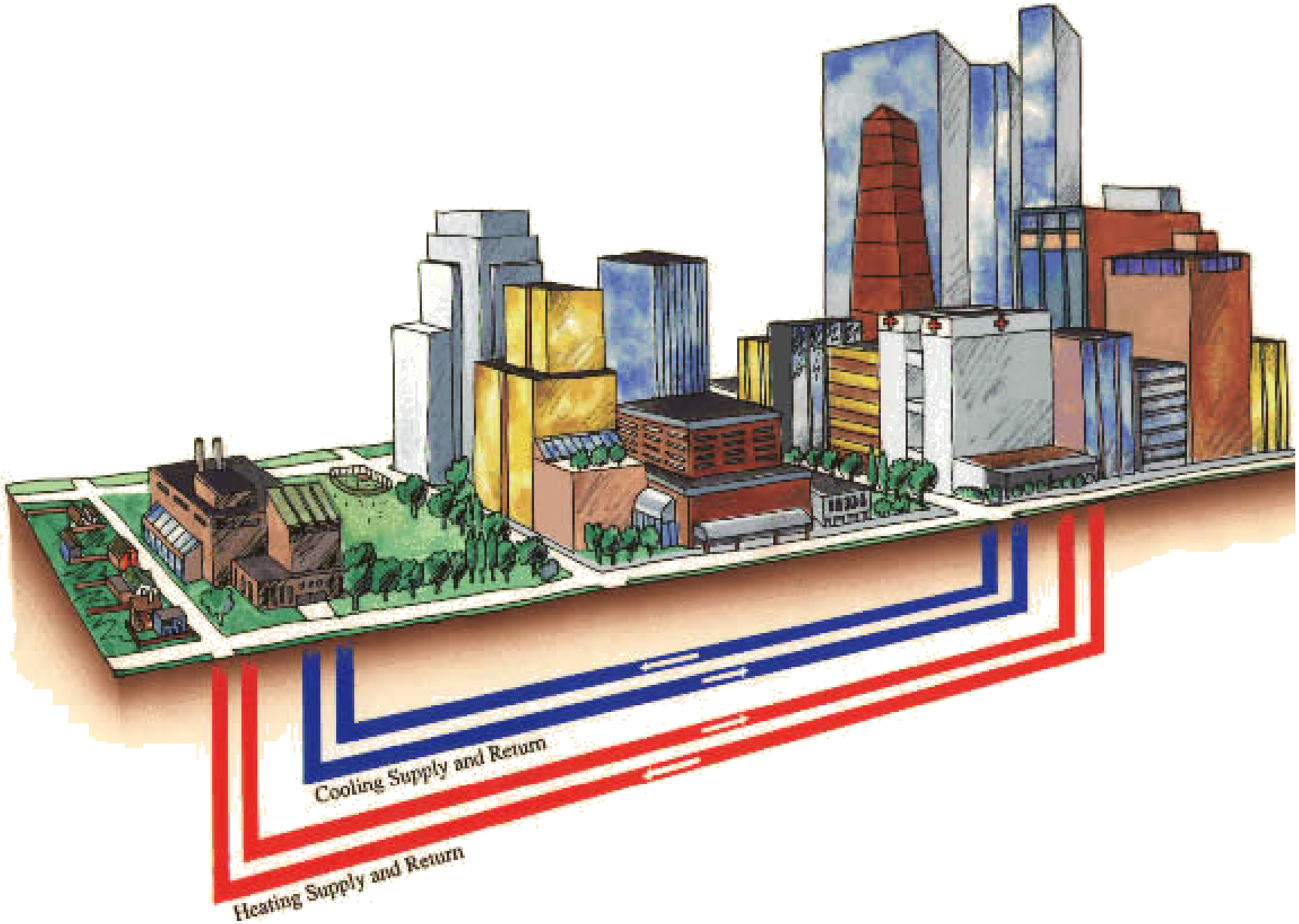




- **Heat production is dominated by fossil fuels**

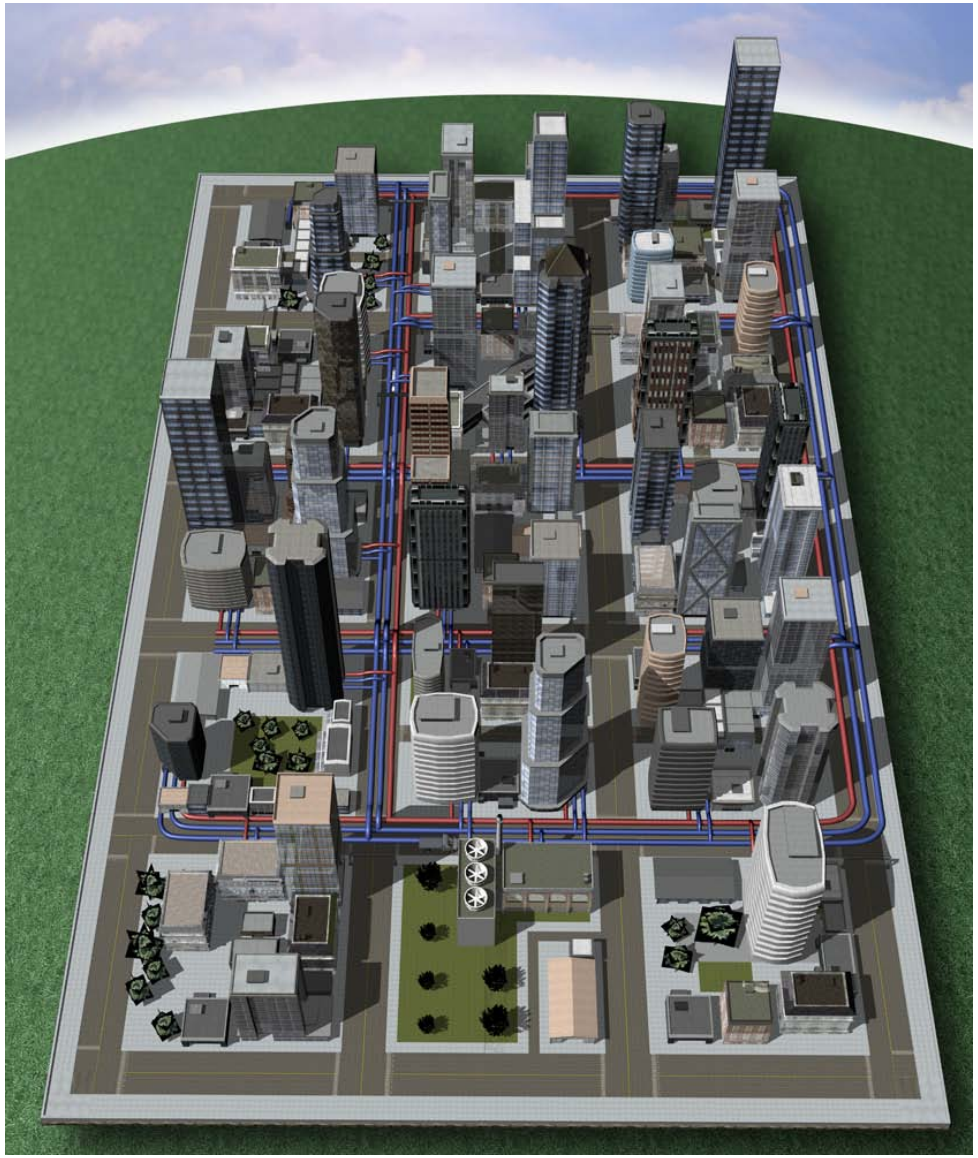


What is District Energy?

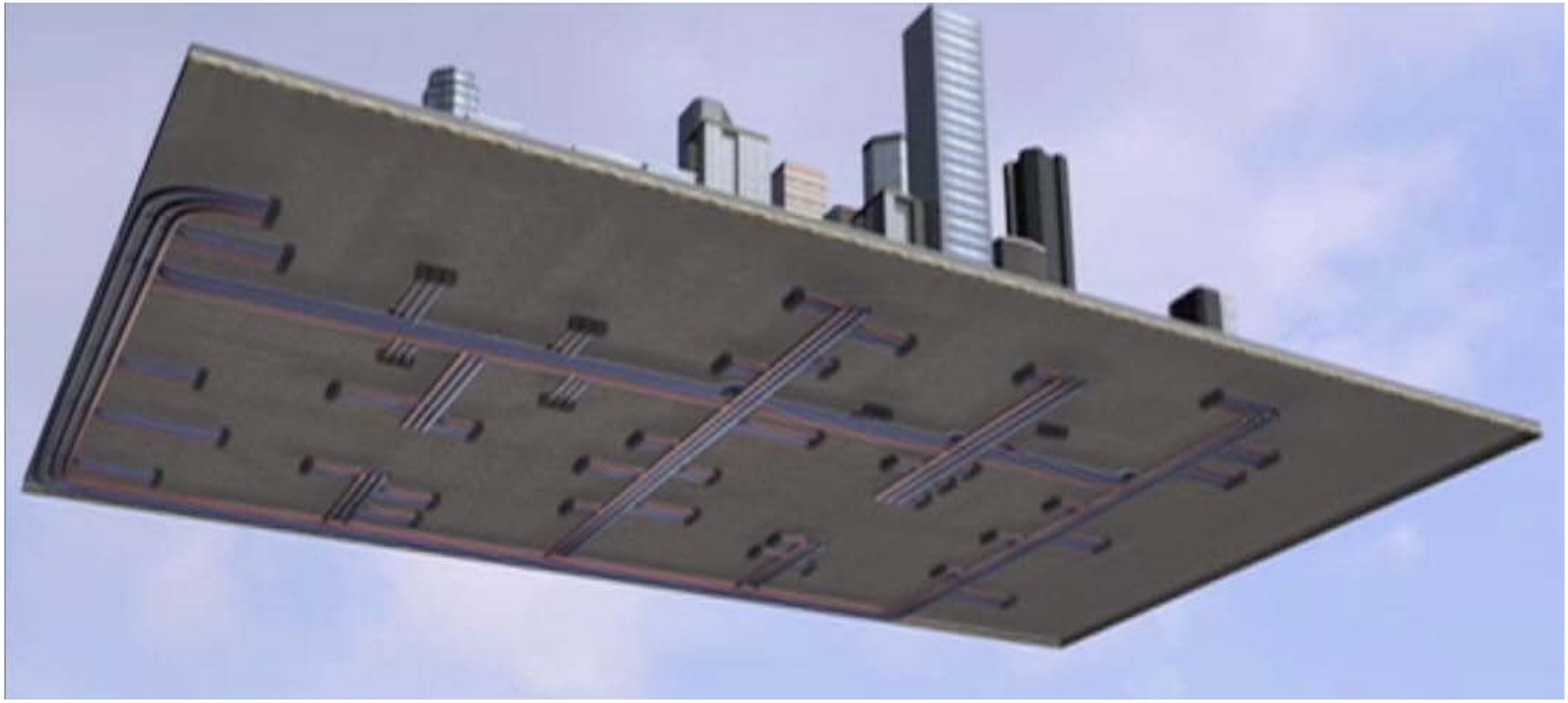


District Energy – Community Scale Heating and Cooling

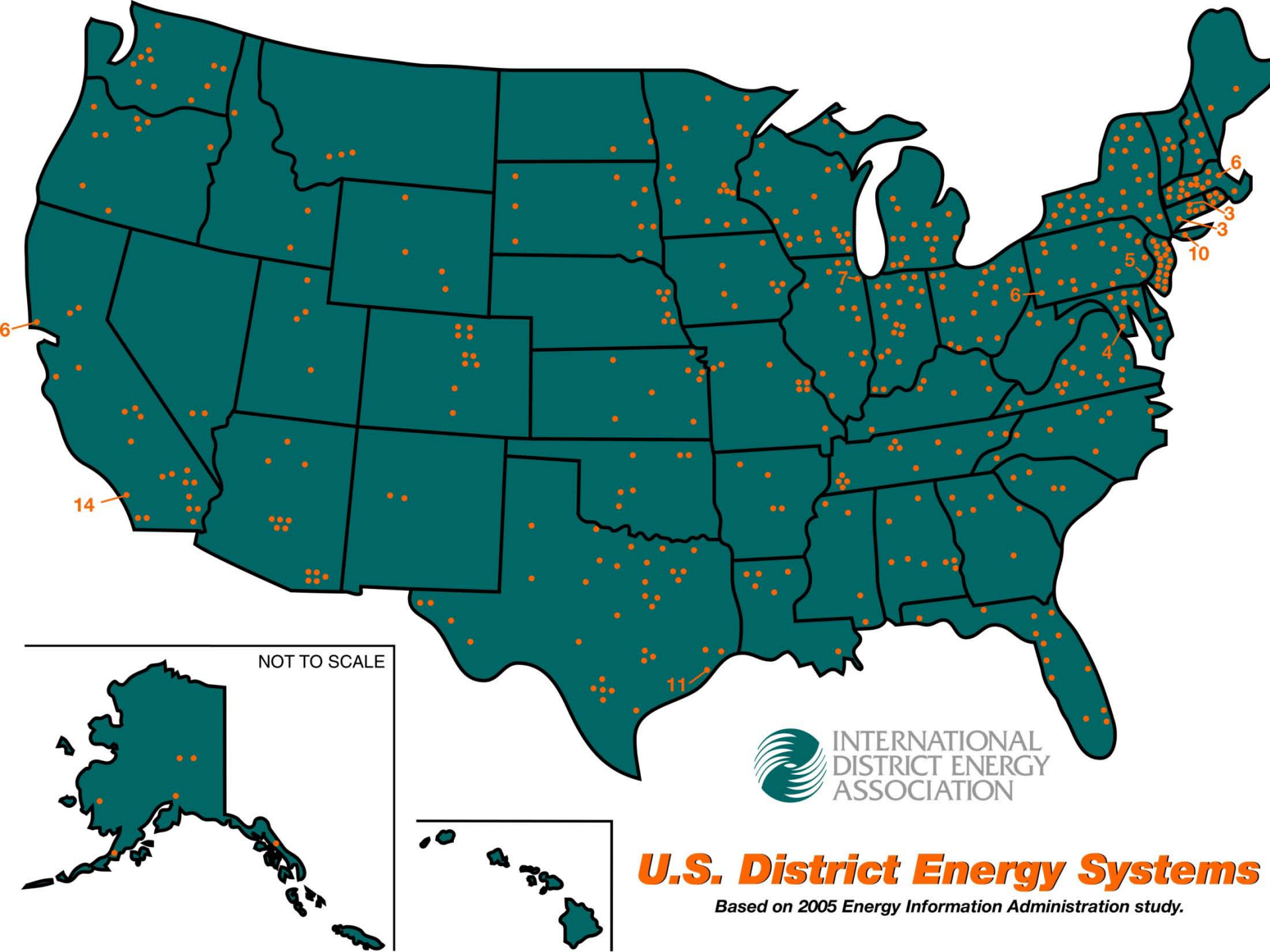
- **Underground network of pipes "combines" heating and cooling requirements of multiple buildings**
- **Creates a "market" for valuable thermal energy**
- **Aggregated thermal loads creates scale to apply fuels, technologies not feasible on single-building basis**
- **Fuel flexibility improves energy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



U.S. District Energy Systems

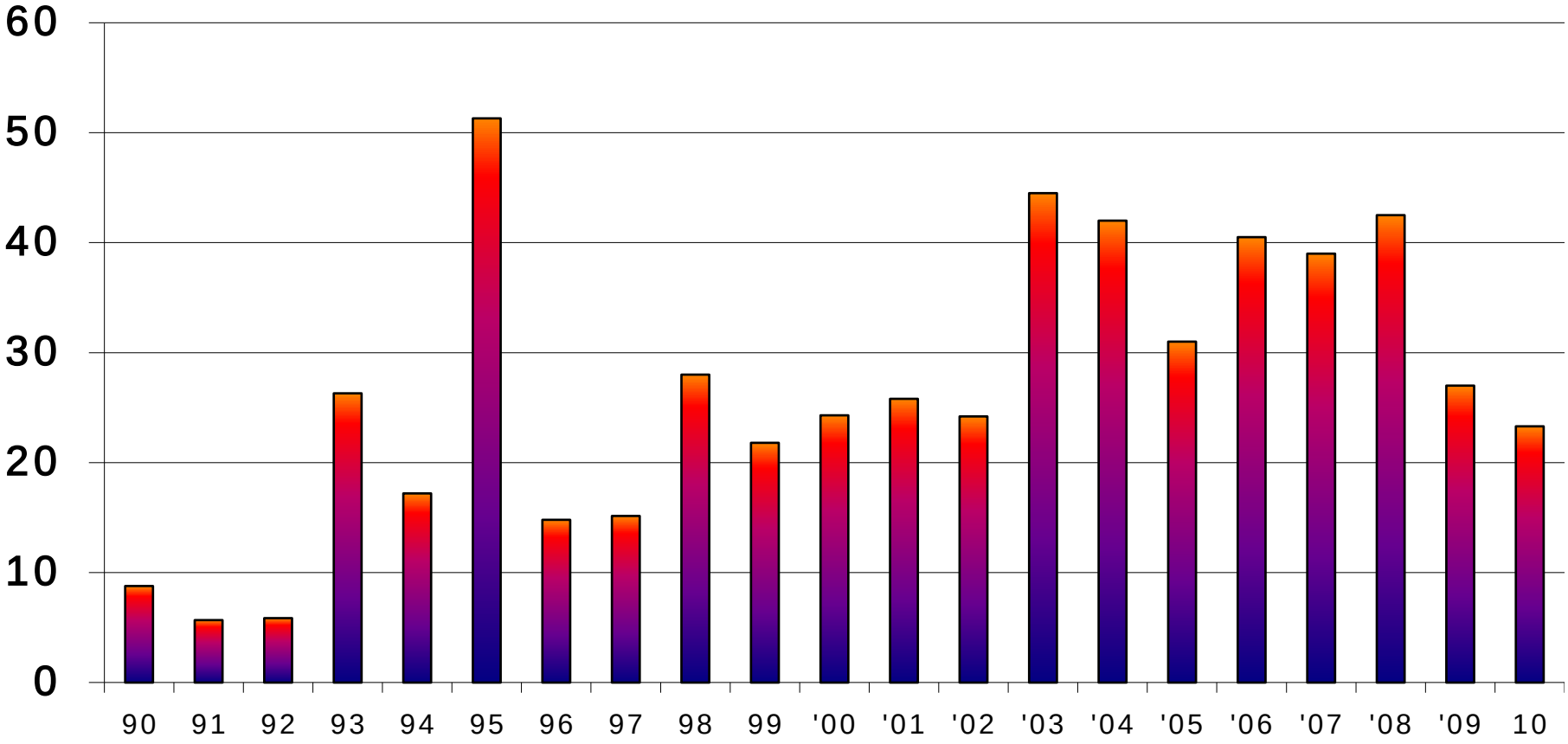
Based on 2005 Energy Information Administration study.

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)



Global Concerns, Local Opportunities

- **Communities are considering becoming energy producers**
- **Challenges:**
  - **rising cost of traditional energy**
  - **national and local energy security**
  - **local 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

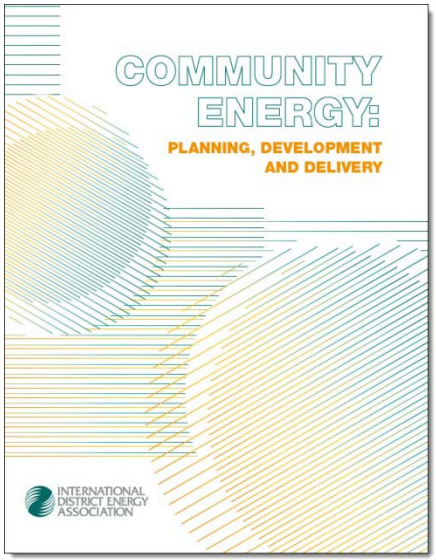
- **Improved energy security and resilience attracts businesses, attract residents who appreciate a lower-cost, cleaner, and secure energy supply.**
- **Economic multiplier: cash that would leave the area to pay for outside energy supplies stays local**
- **Compact communities with mix of uses and density of buildings reduce sprawl and supports public transit systems**
- **District energy enables model of a high-quality and attractive place to live and work**

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
- attractive local environments
- livable towns and cities

Planning for 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**
  - **Property developers**
  - **Landowners and building operators**
  - **Private sector developers**



For release 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
- Classify unique energy character areas

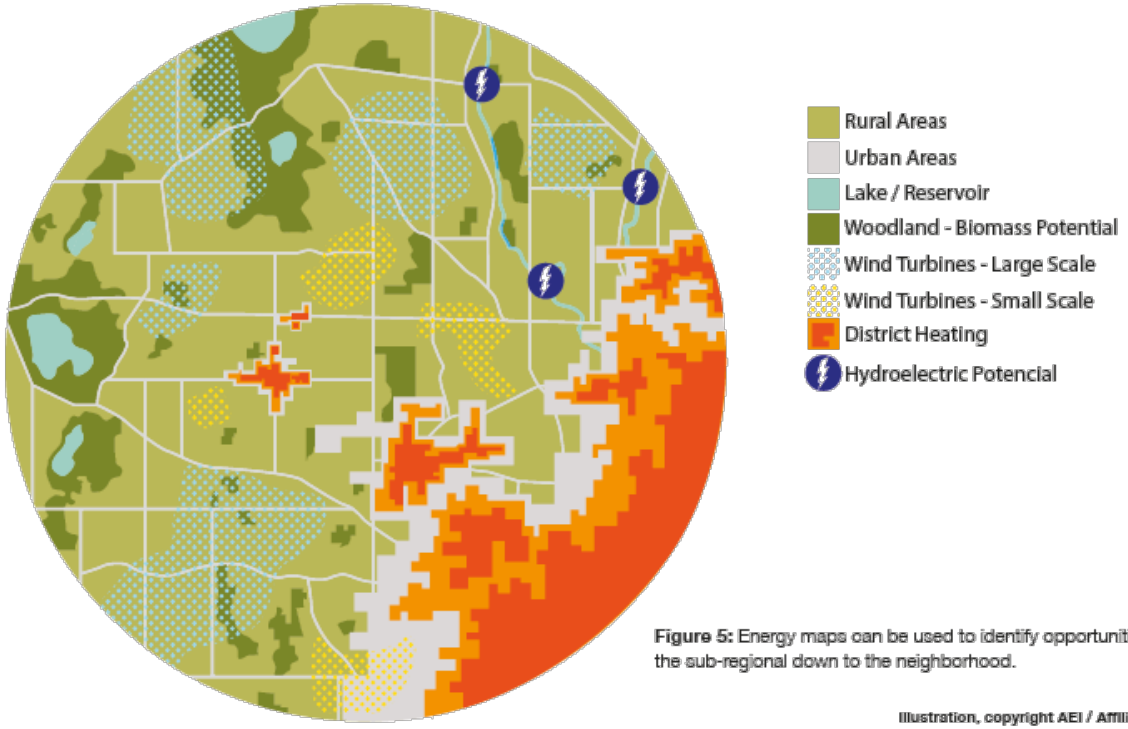


Figure 5: Energy maps can be used to identify opportunities at scales from the sub-regional down to the neighborhood.

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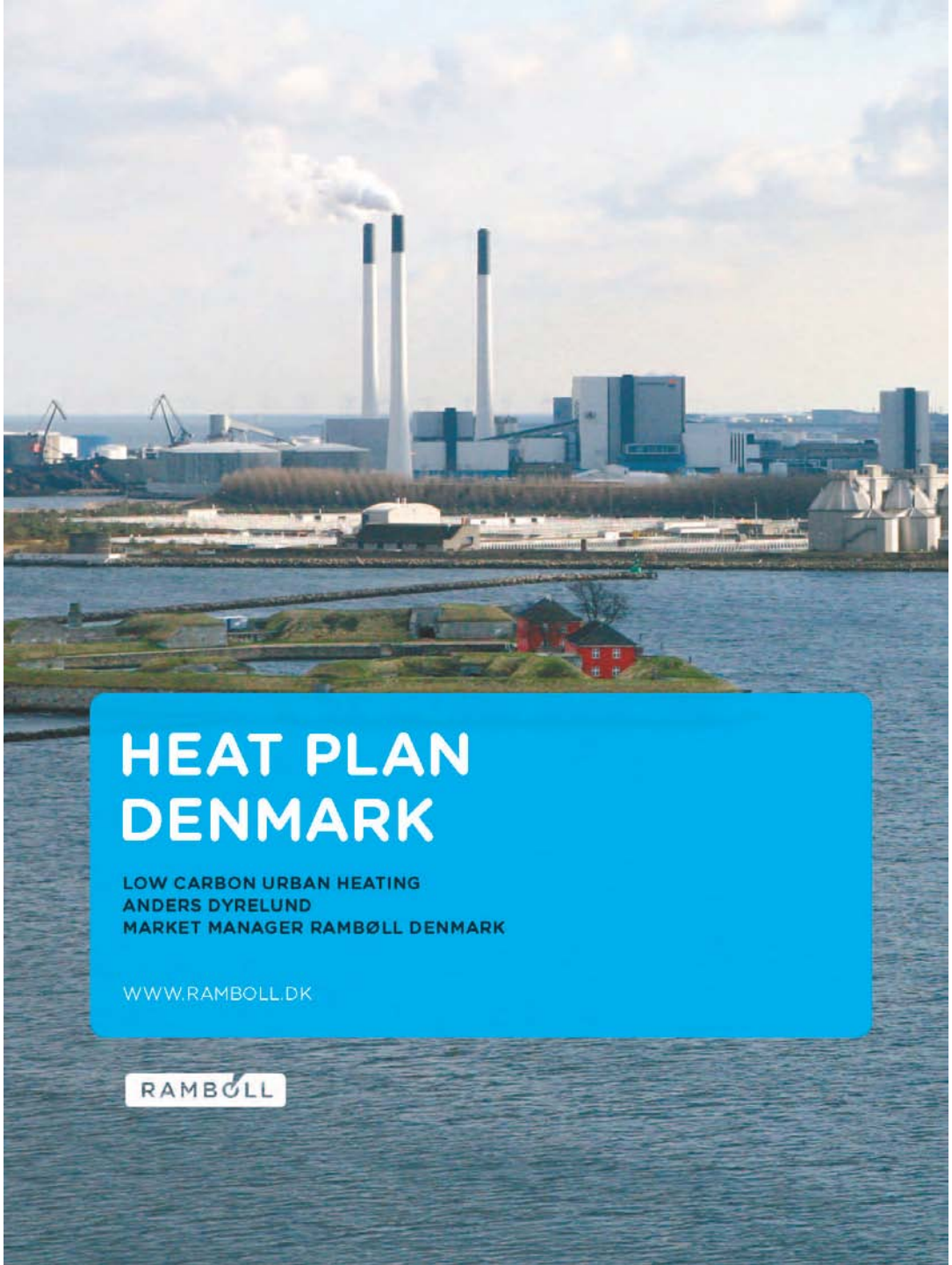


HEAT PLAN DENMARK

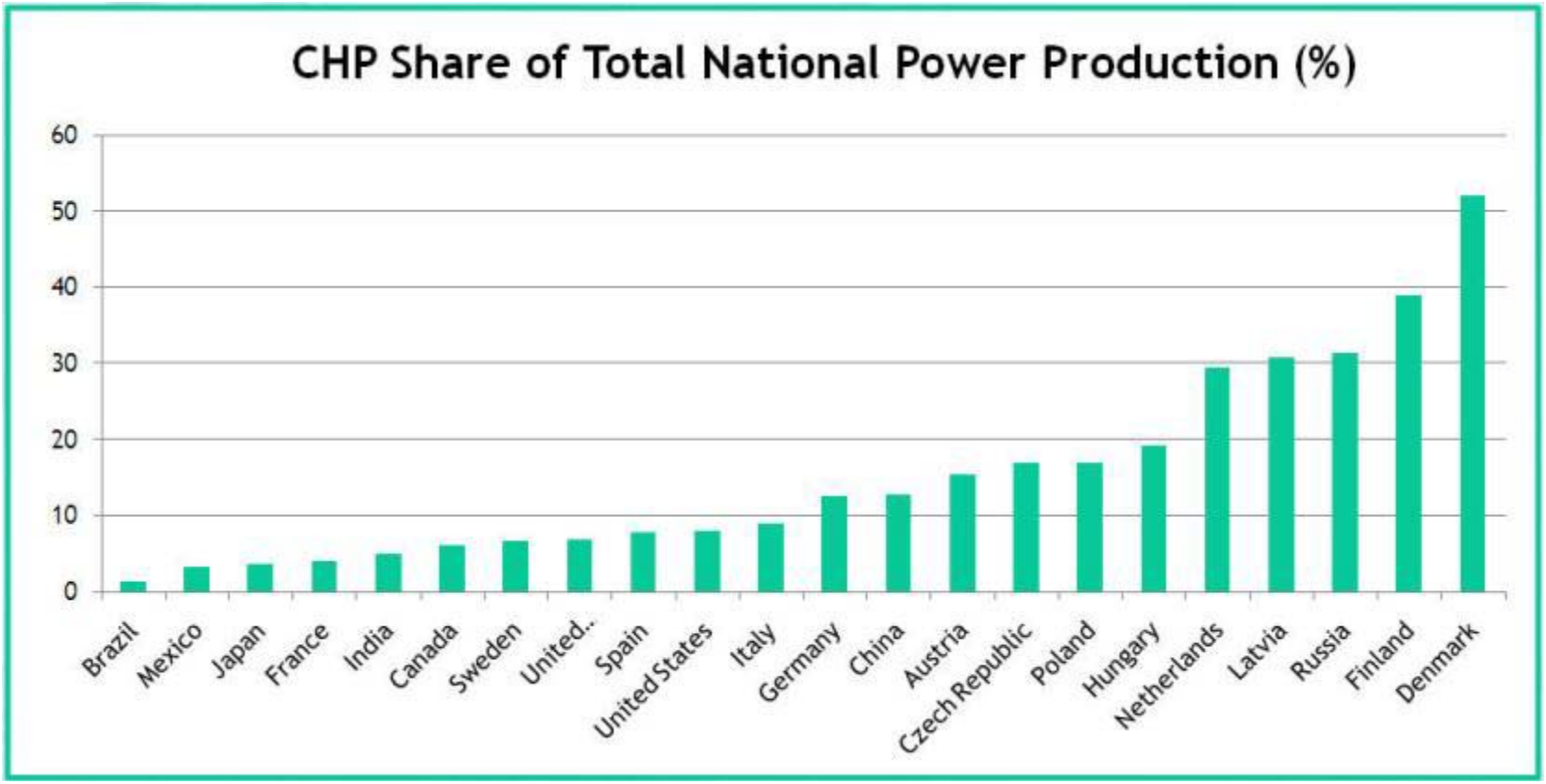
LOW CARBON URBAN HEATING

ANDERS DYRELUND
MARKET MANAGER RAMBØLL DENMARK

WWW.RAMBOLL.DK

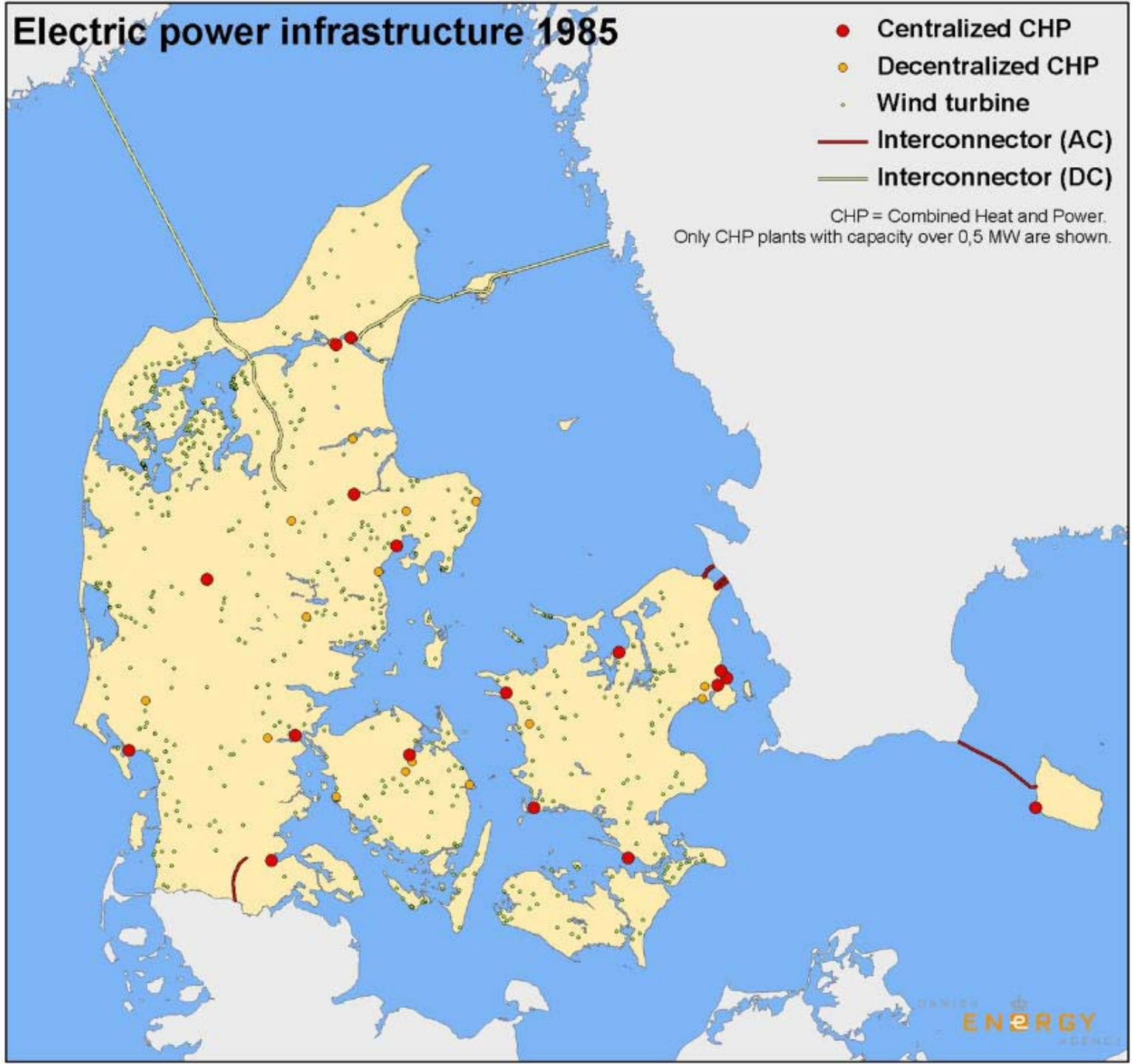
RAMBØLL

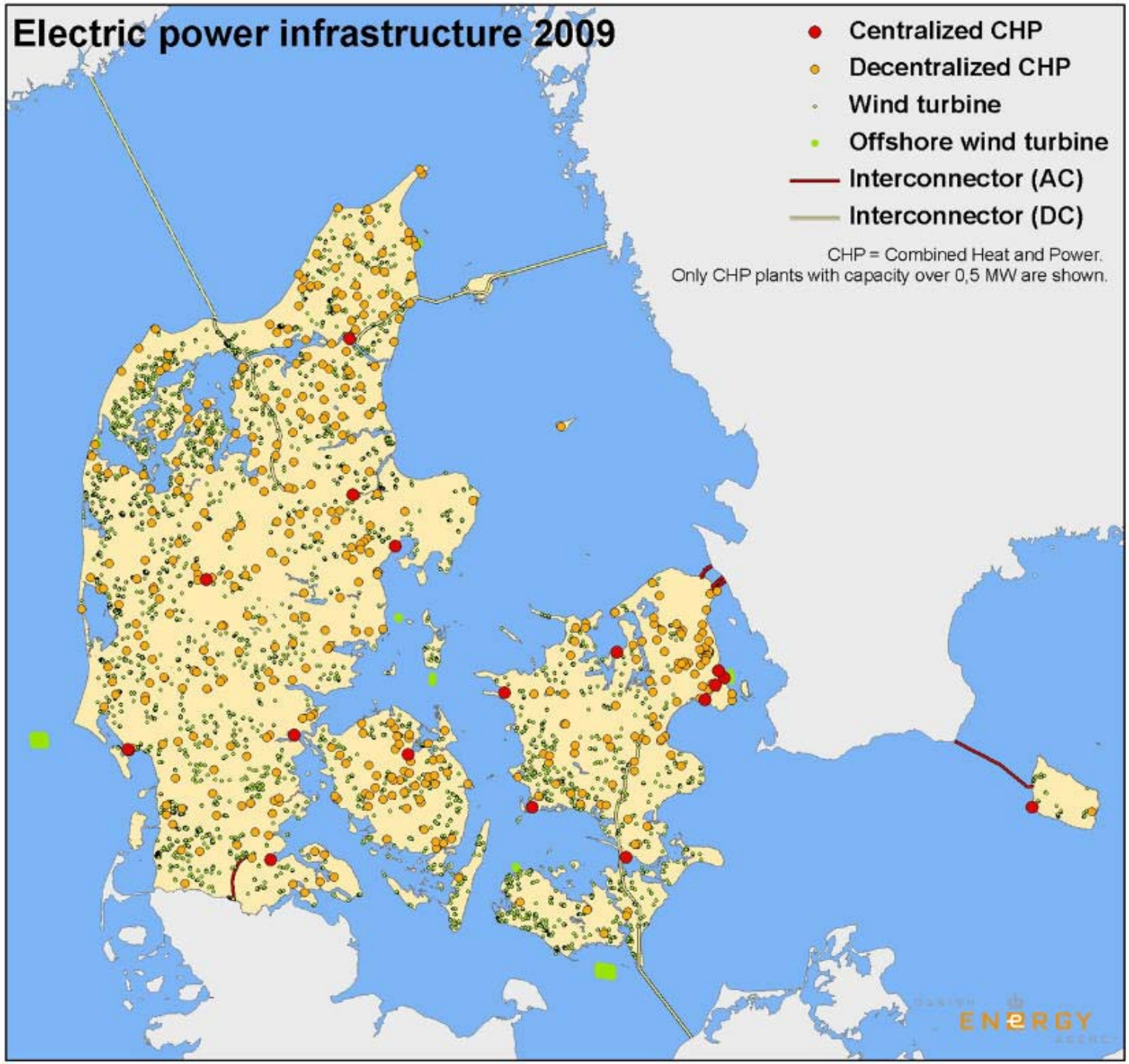
CHP as a Share of Total National Power Generation



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

The global average is just 9%


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.
DANISH ENERGY AGENCY


Electric power infrastructure 2009
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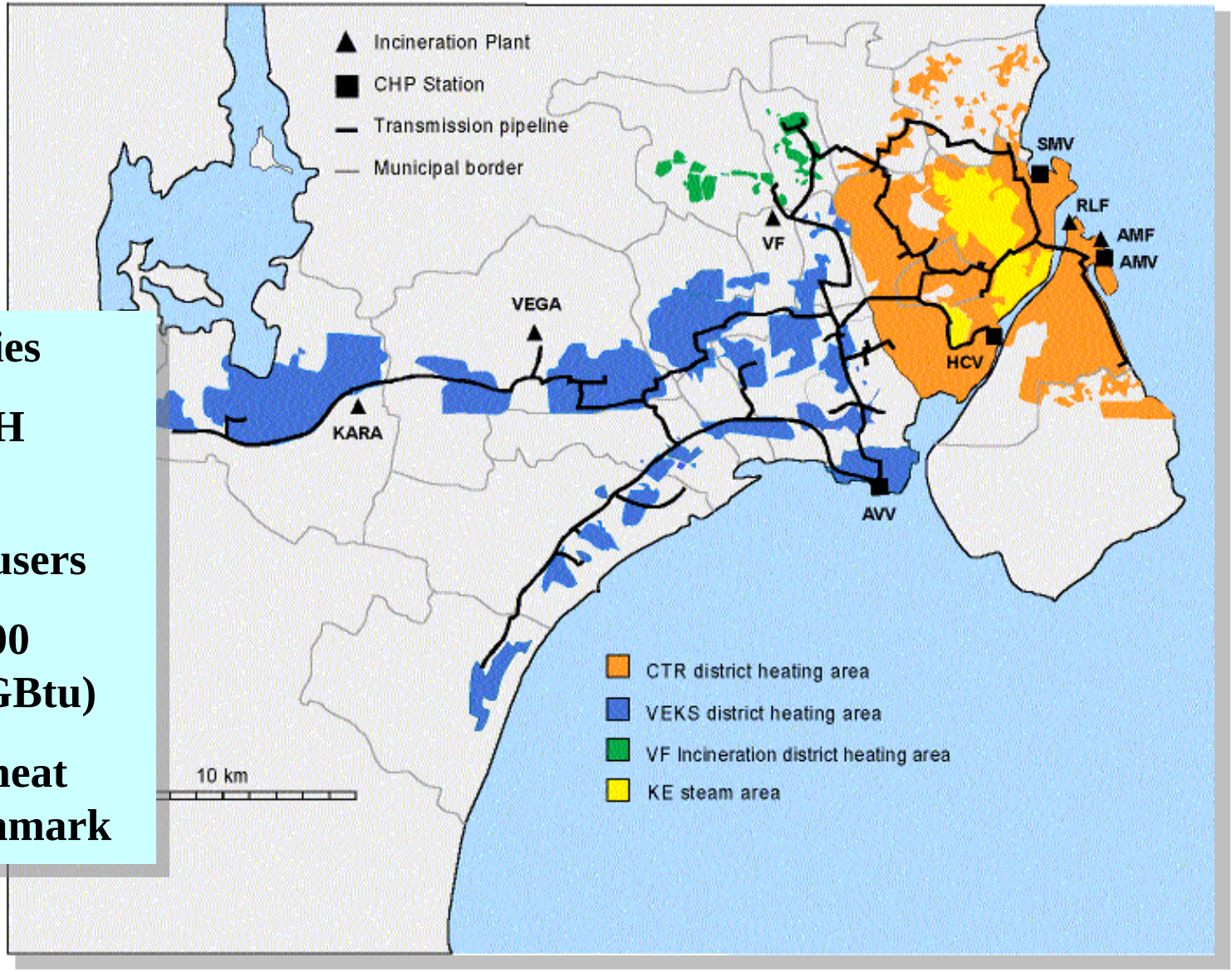
DANISH ENERGY AGENCY

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

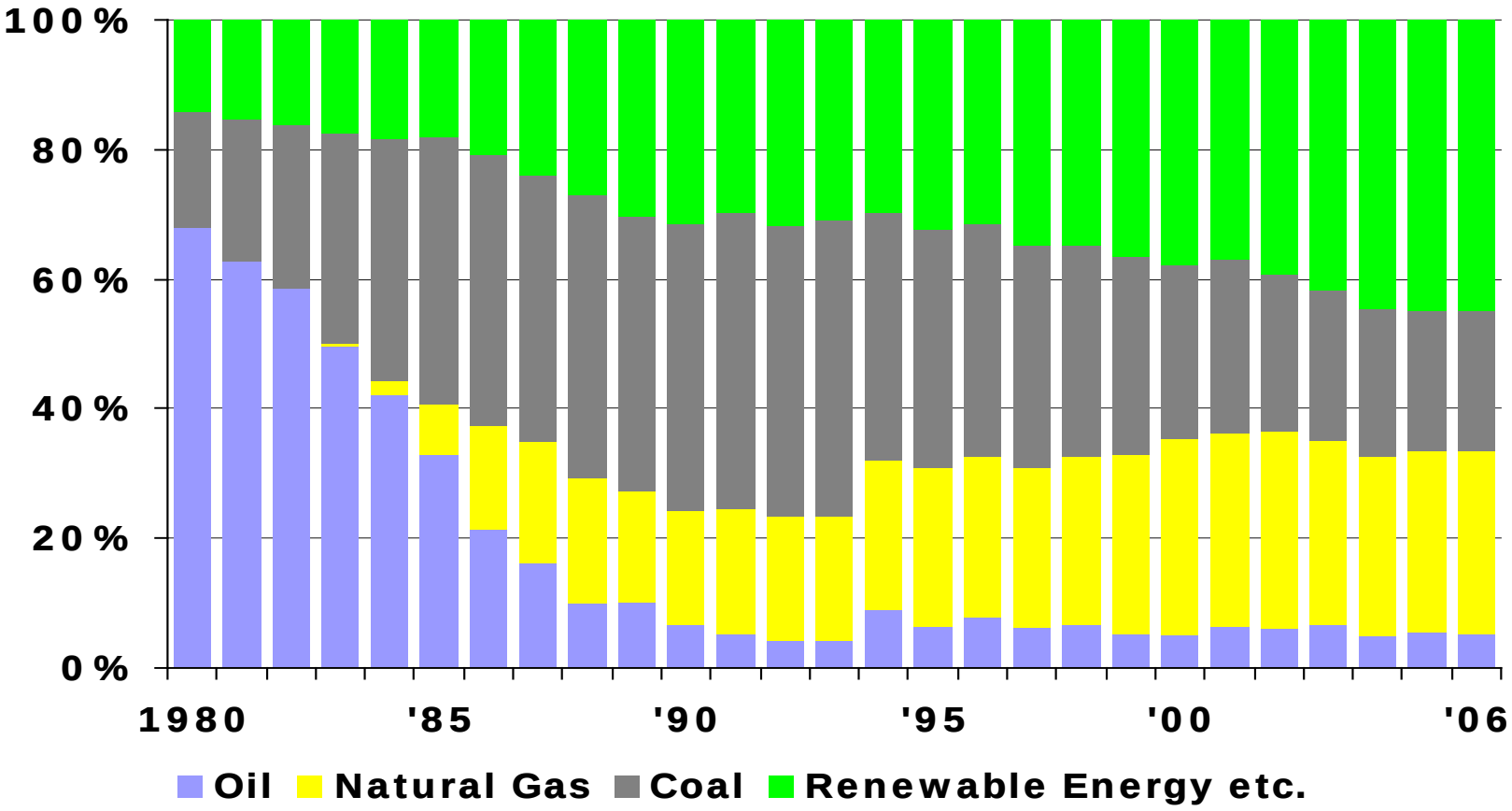
World Class CHP – 90%+Efficiency
Avedore 1&2, Copenhagen

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

Heat Transmission Systems

District Heating and RE

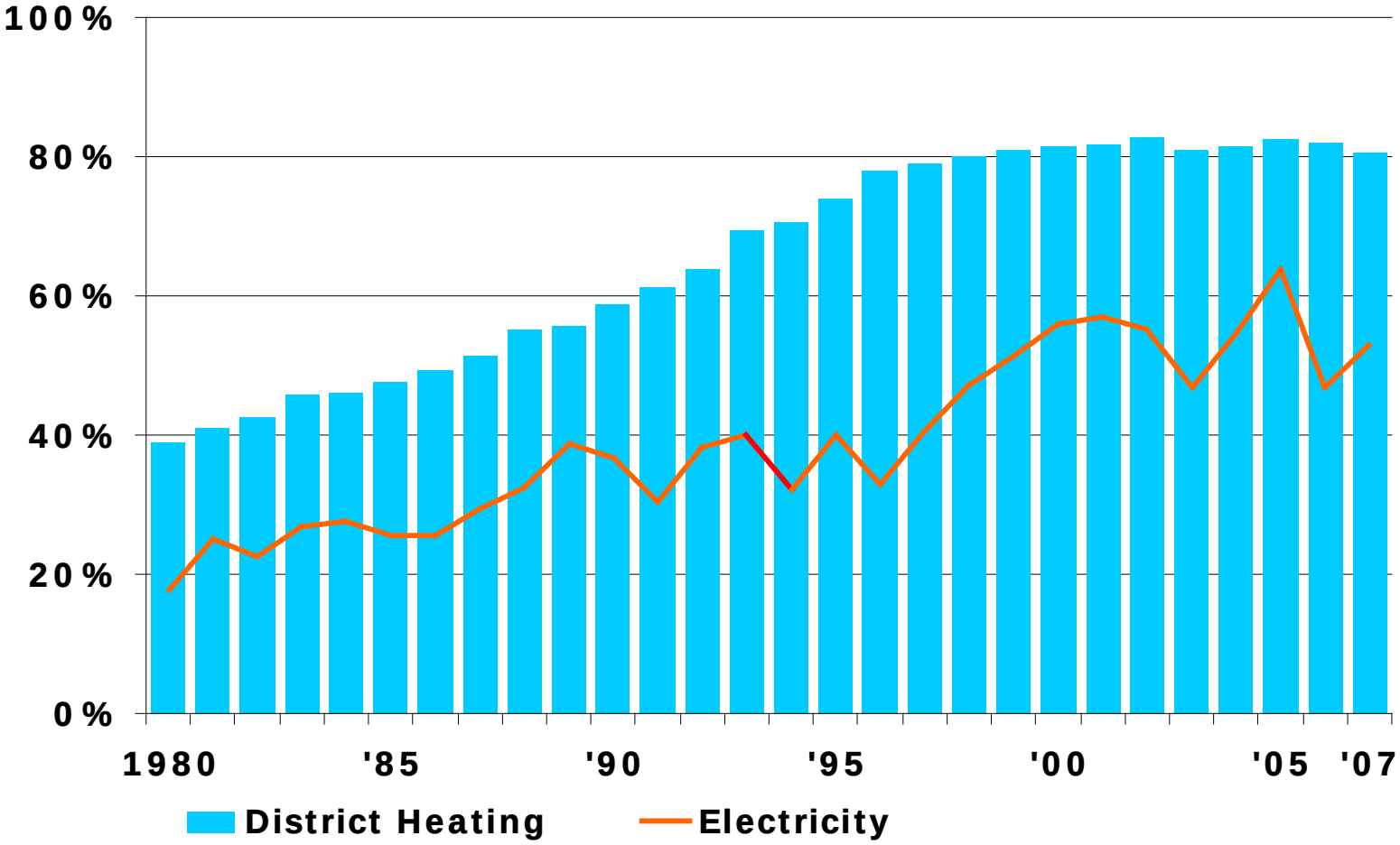
- Composition of Fuels for District Heating Production



Source: Danish Energy Authority

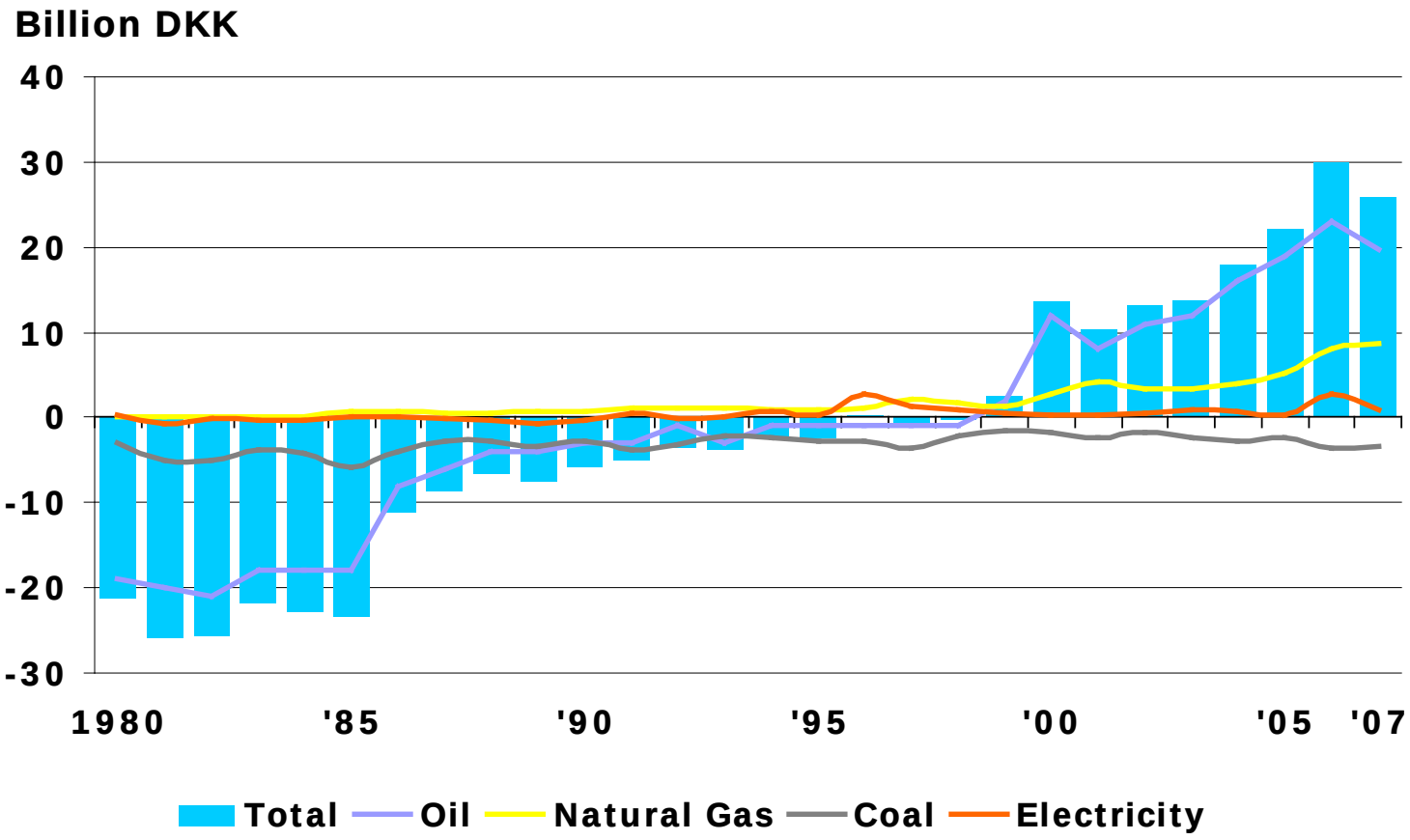
DBDH

CHP share of DH and Power



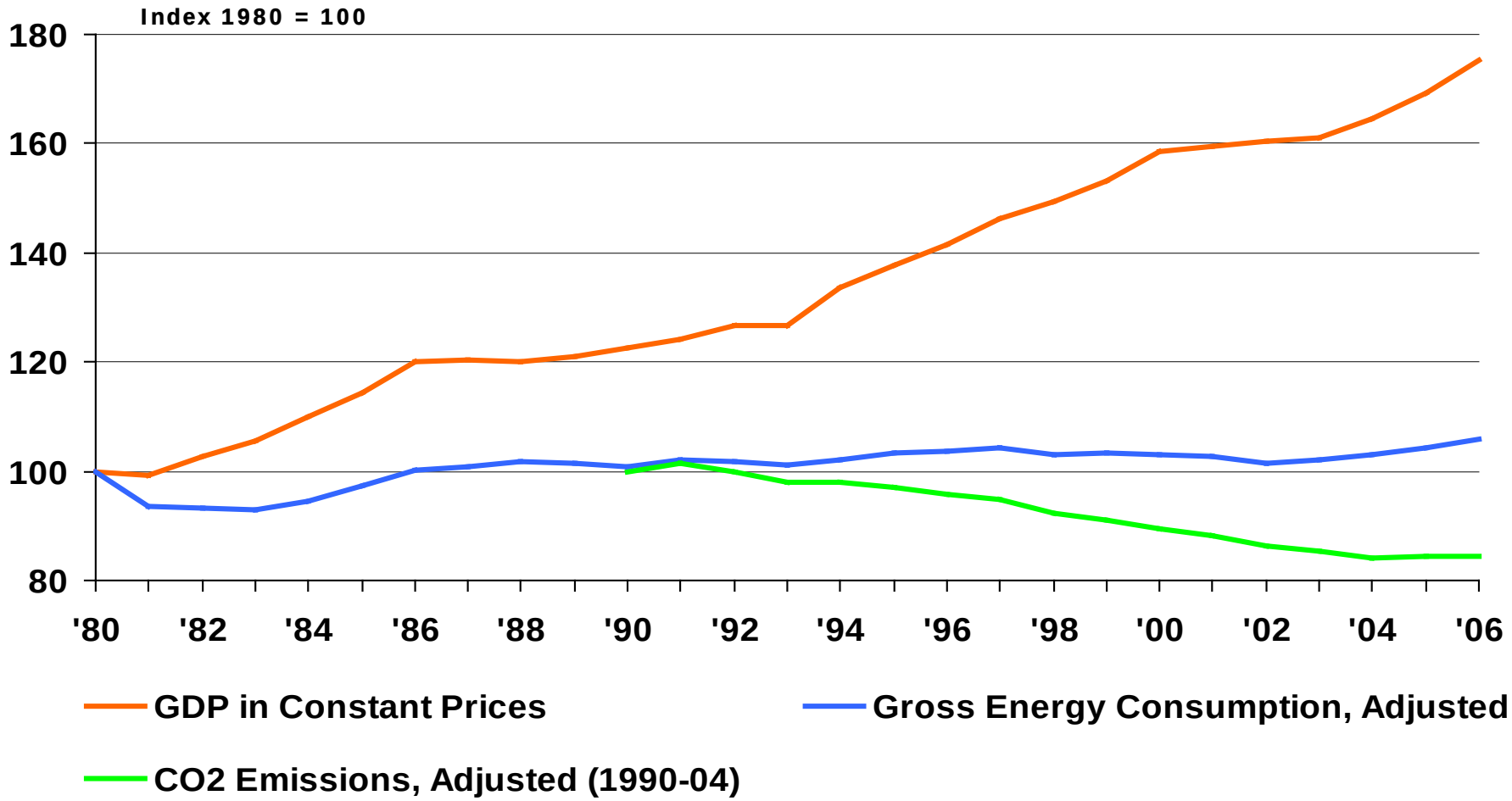
Source: Danish Energy Authority

National Energy Account



Source: Danish Energy Authority

Economic Impact in Denmark
- GDP, CO_2 and Energy Consumption



Source: Danish Energy Authority

DBDH

Policy Drivers - Germany

German CHP law (2009) – main points

Doubling CHP electricity share in the market to 25 % until 2020.

- **Continuing CHP-allocation on current level, based on a premium for electricity from CHP**
- **Support for the construction of new and refurbishment of old CHP-Plants**
- **Support for high efficient CHP**
- **Support for district heating grids based on high efficient CHP and/or RES**

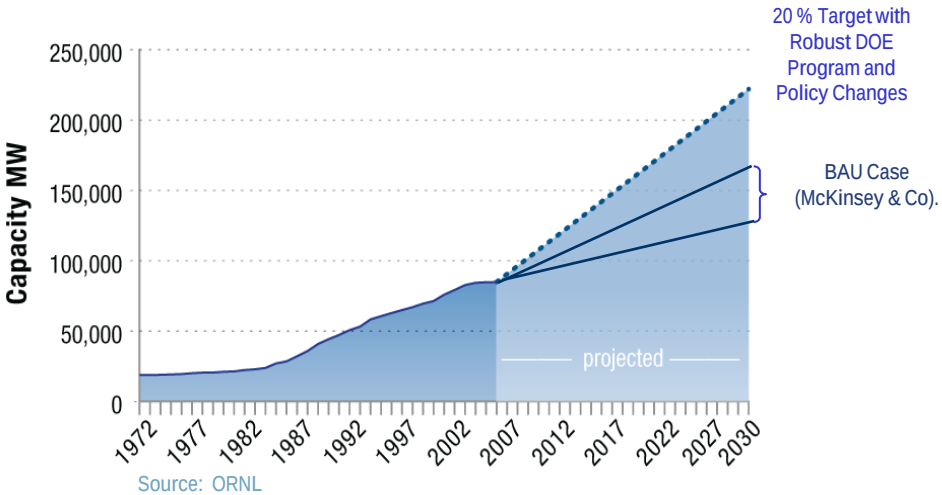
Renewable Energy Heat law (2010) – main points

Increasing use of renewable energy in heating sector from 6 % to 14 % by 2020

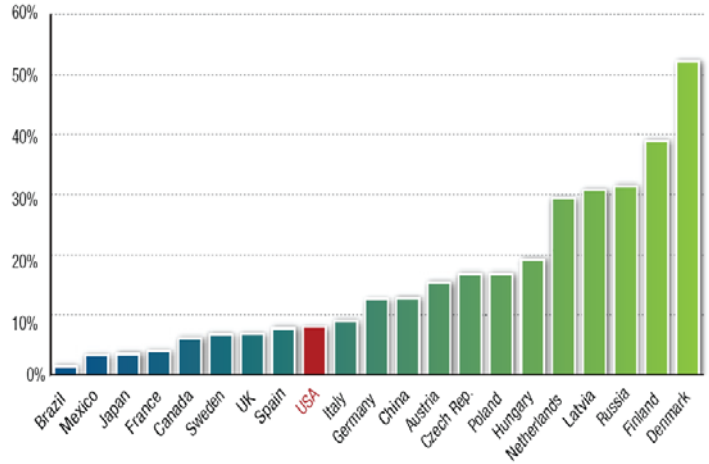
- **CHP-based district heating supply as substitute for renewable energy**
- **Obligation for the use of biogas in CHP-plants**
- **Compulsory heat planning regulated at federal level**

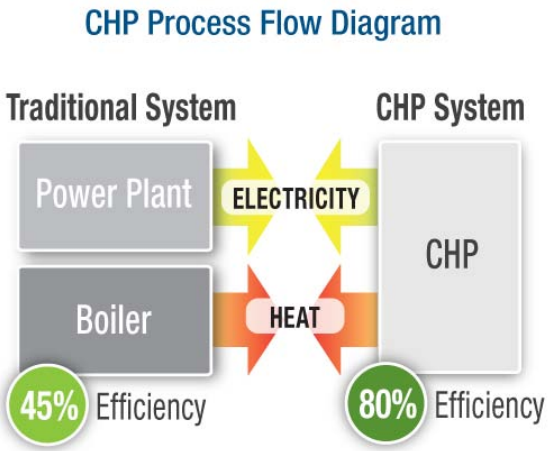
US Policy at DOE - CHP 20% of US Generating Capacity in 2030

CHP	2006	2030 Target
Total Electricity Generating Capacity	85 GW (9% of current capacity)	240.9 GW (20% of projected capacity
Annual Energy Savings	1.9 Quads	5.3 Quads
Annual CO_2 Reduction	248 MMT	848 MMT
Number of Car Equivalents Taken Off Road	45 million	154 million

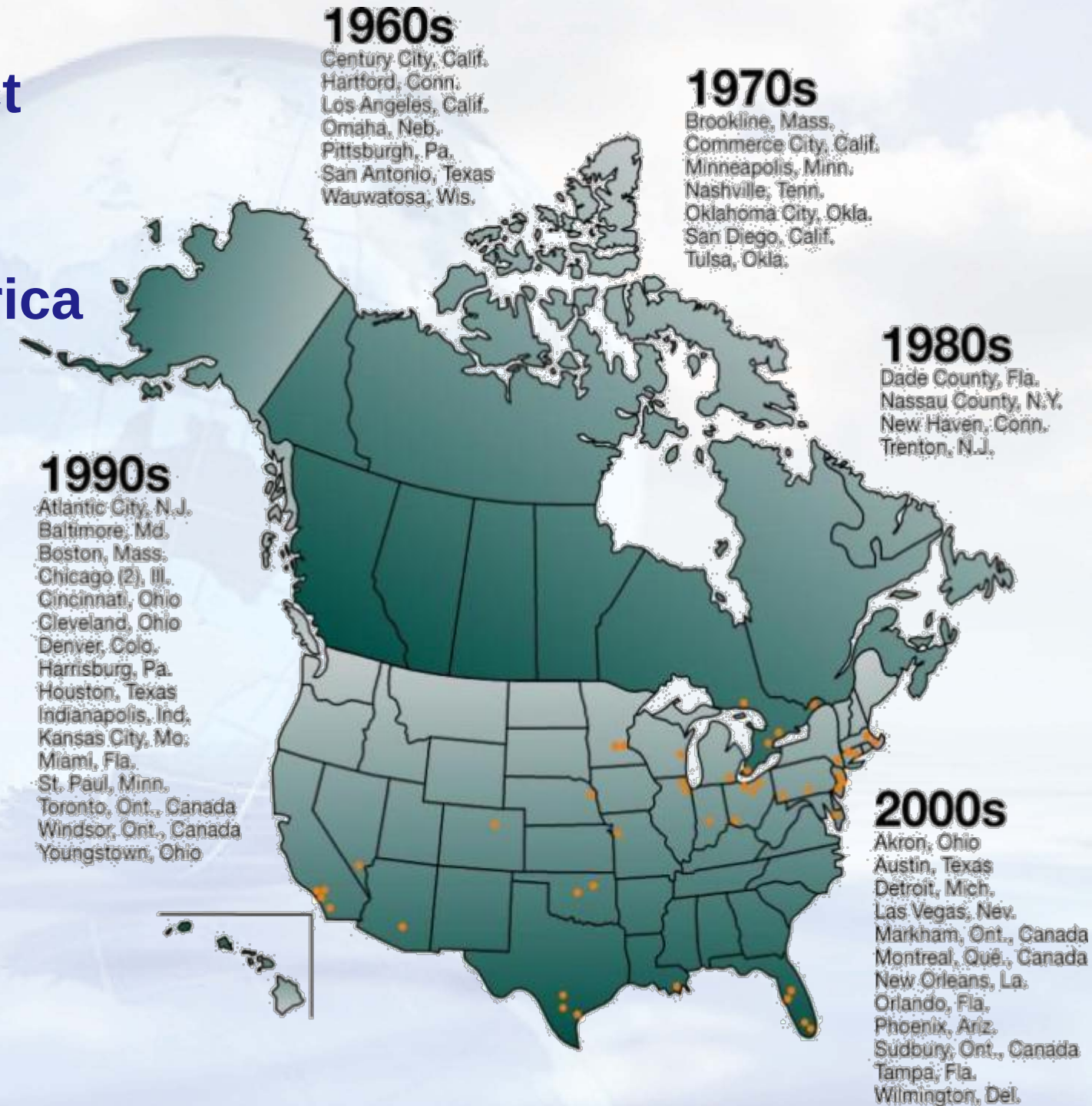


CHP in a Global Context – 20% Capacity Goal is Reachable





New District Cooling Systems in North America



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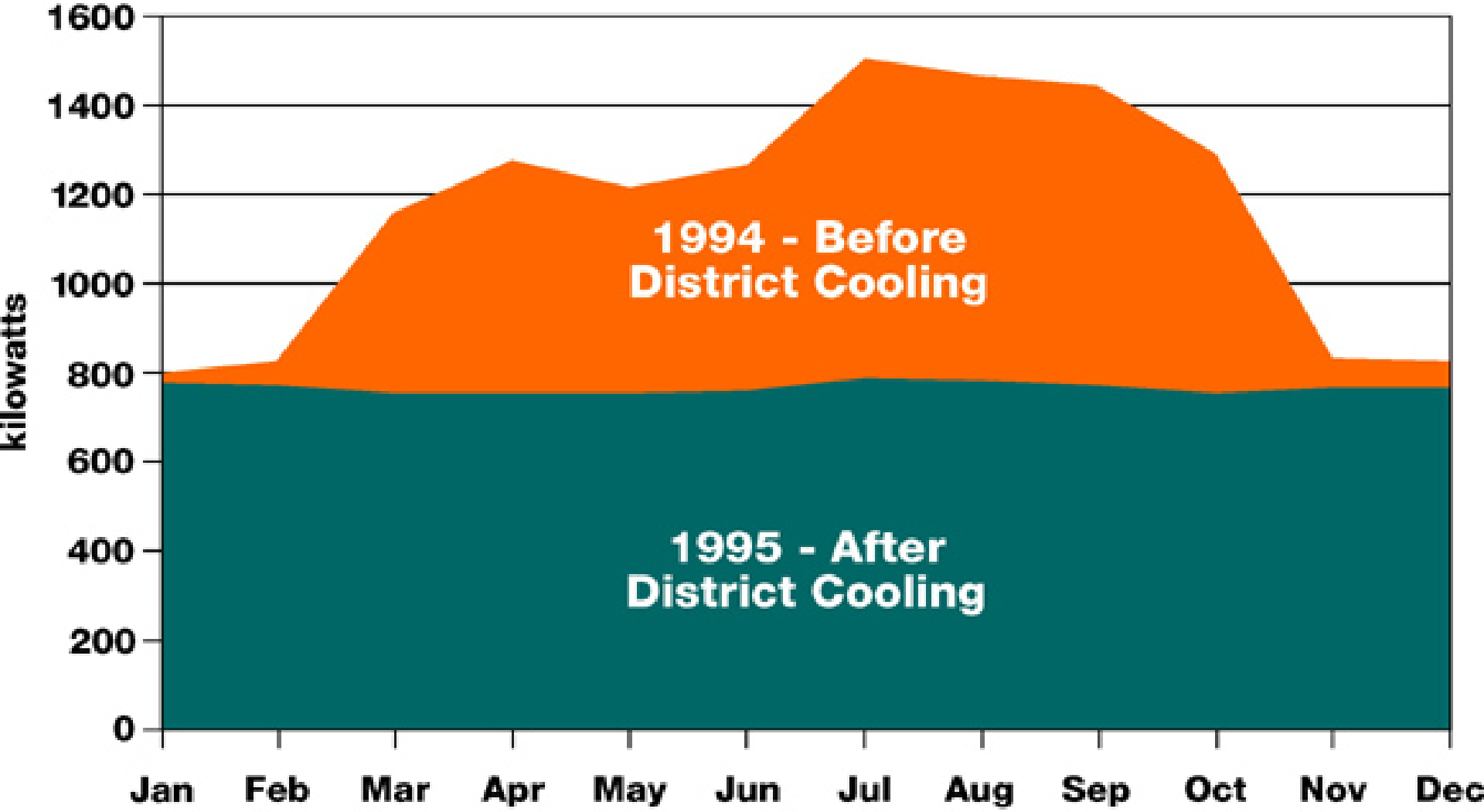
District Cooling Customer Electric Demand Profile



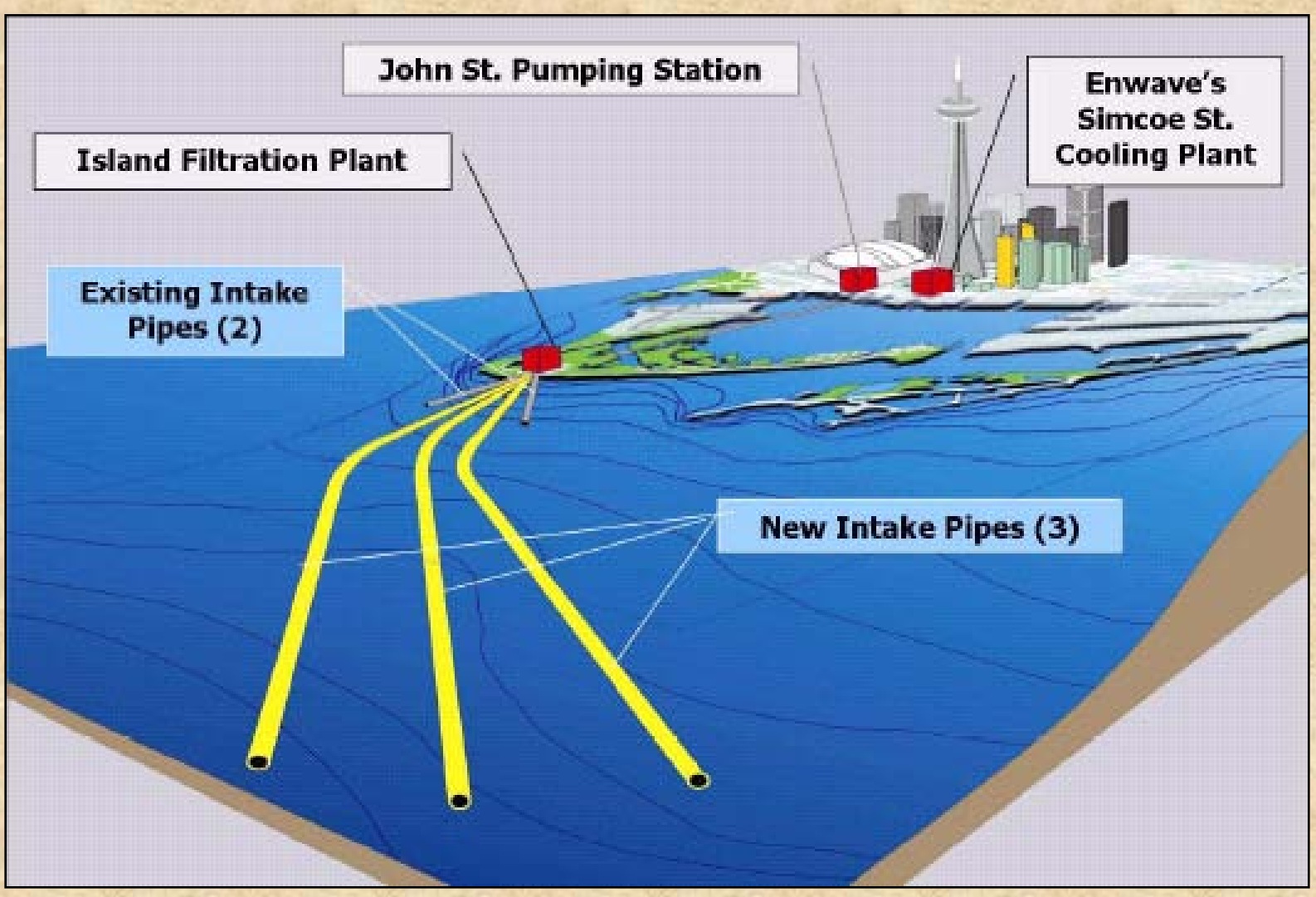
350,000 sf commercial office building built in 1965. Located in Cleveland. Two electric chillers displaced. Actual peak meter readings varied just 2% Jan-July

Higher Value Buildings

Without District Energy

With District Energy

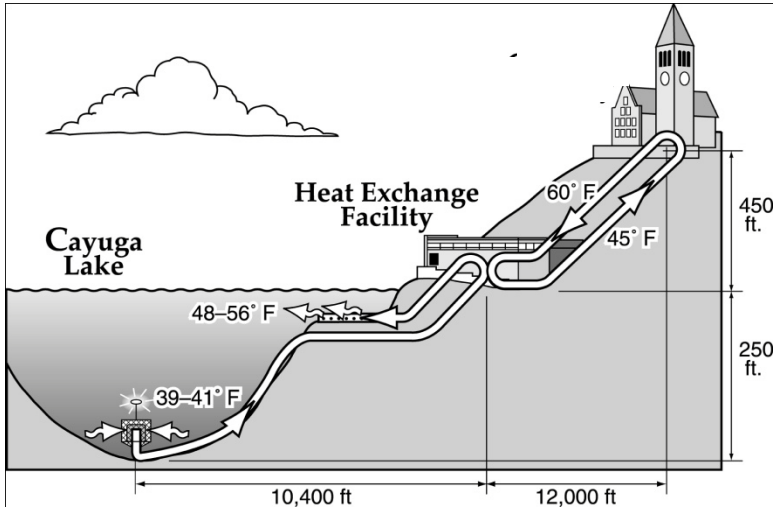
Toronto Deep Lake Cooling – Enwave Energy Corp



- Electricity use reduced by up to 90%
- 61MW demand & 85M kWh consumption reduced each year
- CO_2 emissions reduced by 79,000 Tonnes / Year
- Eliminates ozone depleting refrigerants
- Reduces harmful NO_x and SO_x

enwave

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

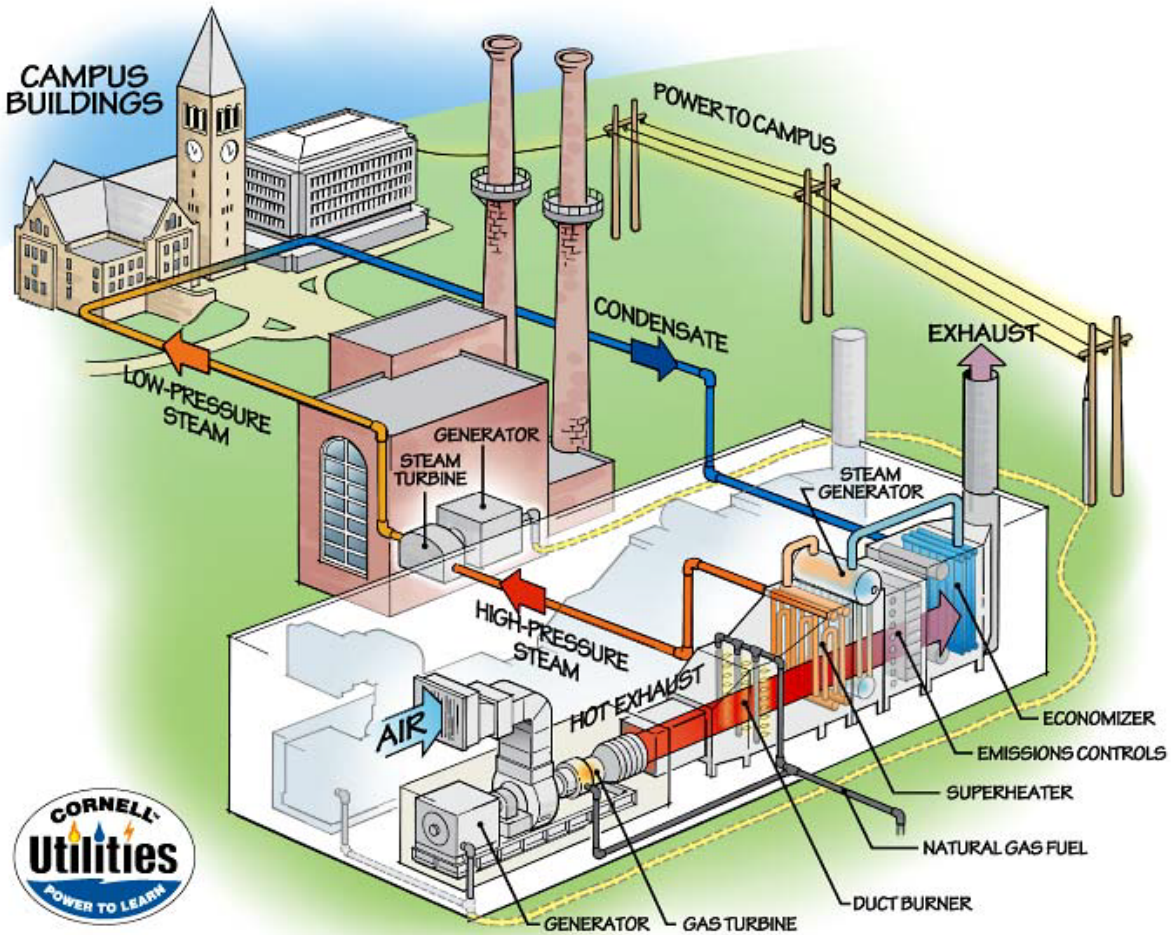
Lake source intake pipe: 10,400 ft long, 250 ft deep

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**

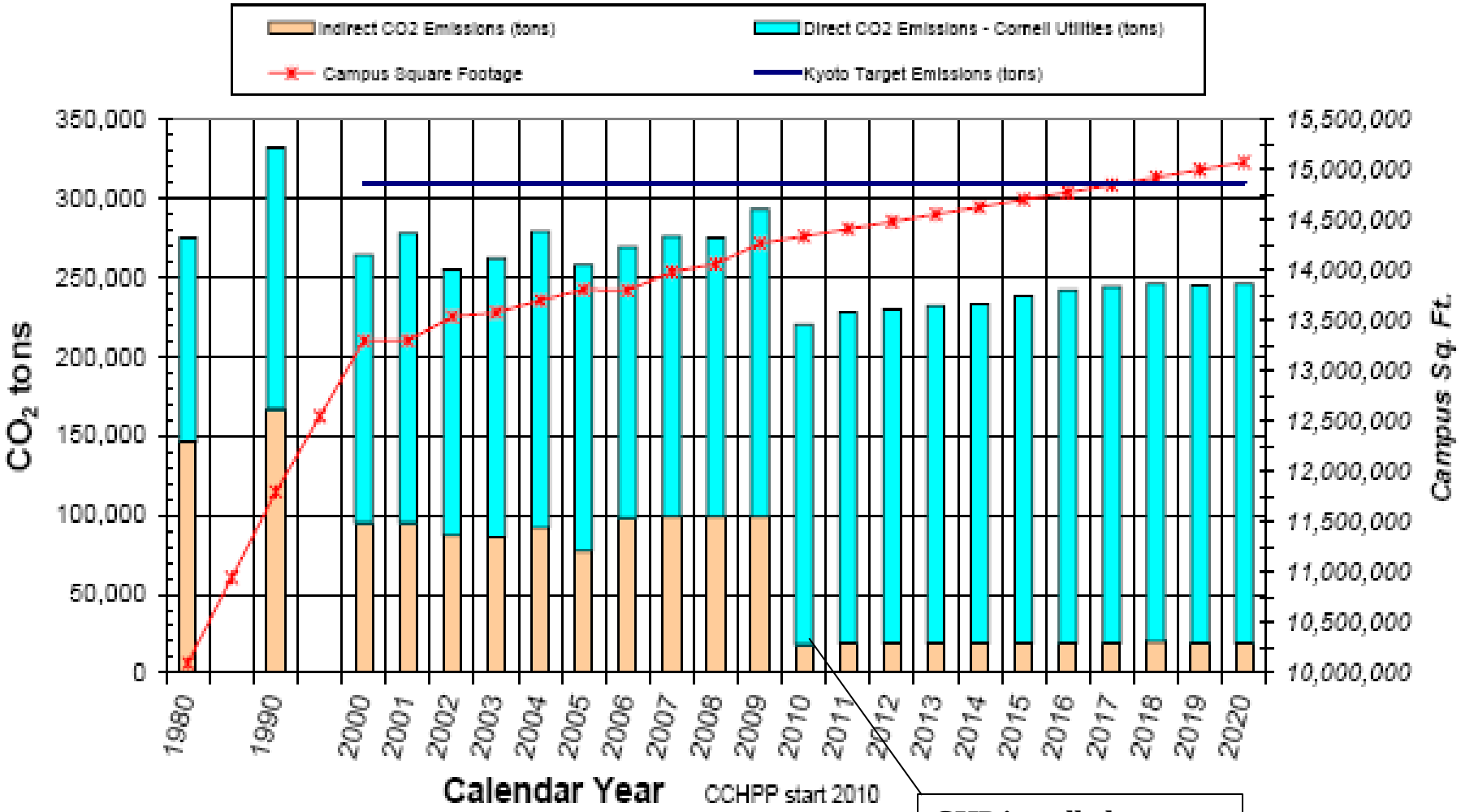
Cornell Combined Heat & Power



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's Carbon Footprint



CHP installed; cut indirect emissions 75,000 tons

District Energy/CHP in Healthcare
Thermal Energy Corp - Houston

Thermal Energy Corp. (TECO)

- District Energy System provides thermal energy, (chilled water & steam) for air conditioning, heating and process for Texas Medical Center – largest health care campus in the world
- Now, largest district cooling system in US – 120,000 Tons
- 18 Institutions, 18.9 million sq ft; all not-for profit
  - 7 hospitals
  - 2 medical schools
  - 3 nursing schools
- 6,800 hospital beds; mission-critical loads; research; surgeries

Texas Medical Center –

For comparison, would be 11th largest city in U.S.

TECO 48 MW Combined Heat and Power

TECO District Energy/CHP

- $377M utility master plan expansion added 48 MWe CHP
- Increased fuel efficiency to over 80%
- Further improved system & grid reliability
- Will save $200 million over 15 years
- Reduced CO^2 by 302,000 tons per year
  - equivalent to taking 52,000 cars off the streets
  - or planting 83,000 acres of new forest

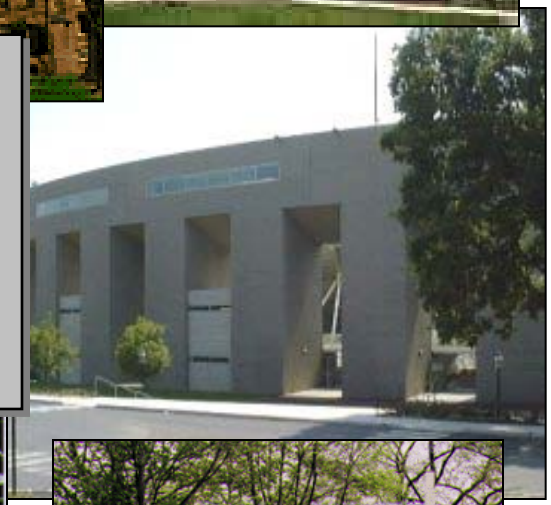
Texas Summer 2011

- More than 70 consecutive days over 100 deg F.
- Texas set record demands for electricity
  - ERCOT (grid) at maximum capacity charge ($3000/MW hr) for extended periods
  - ERCOT resetting price cap higher in 2012 ($4500/MW hr +)
- TECO was able to produce 100% of their electric requirements and still support the power grid
- Benefited a congested transmission area
- Reliability to mission-critical customer base

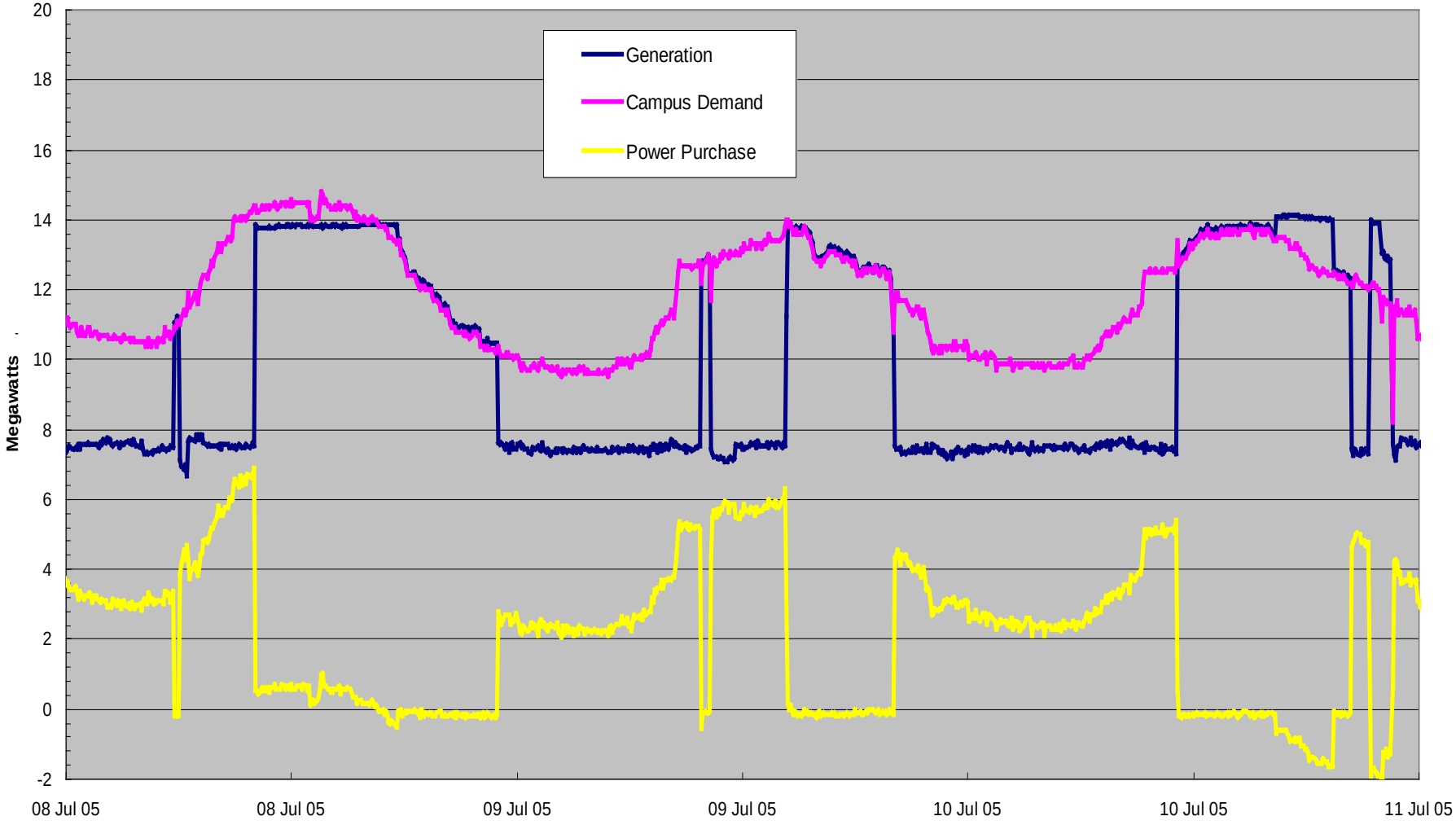
Robust and Reliable Thermal Utility

Cogeneration & District Cooling – Princeton University

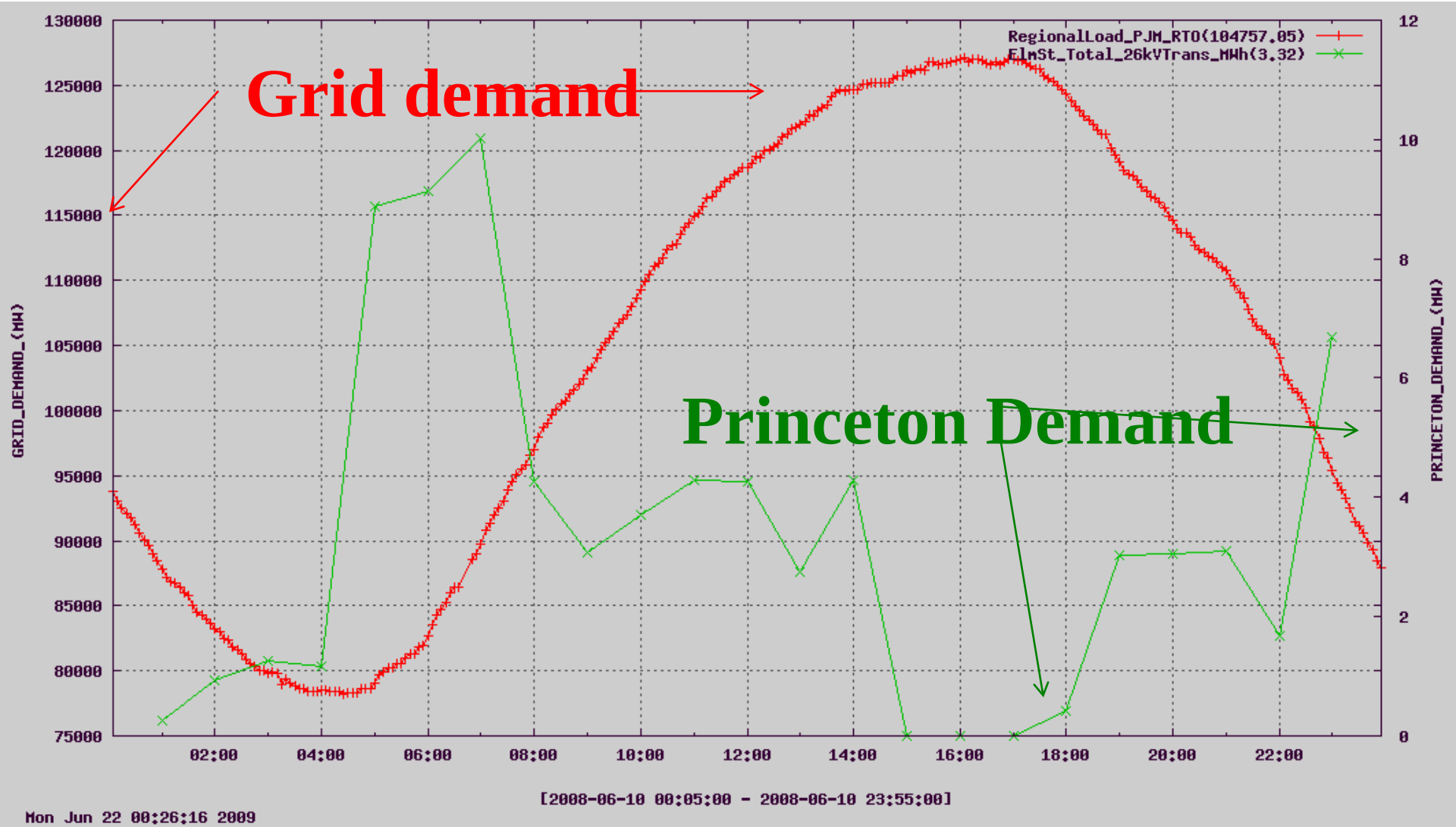
- > 150 Buildings
  - Academic
  - Research
  - Administrative
  - Residential
  - Athletic

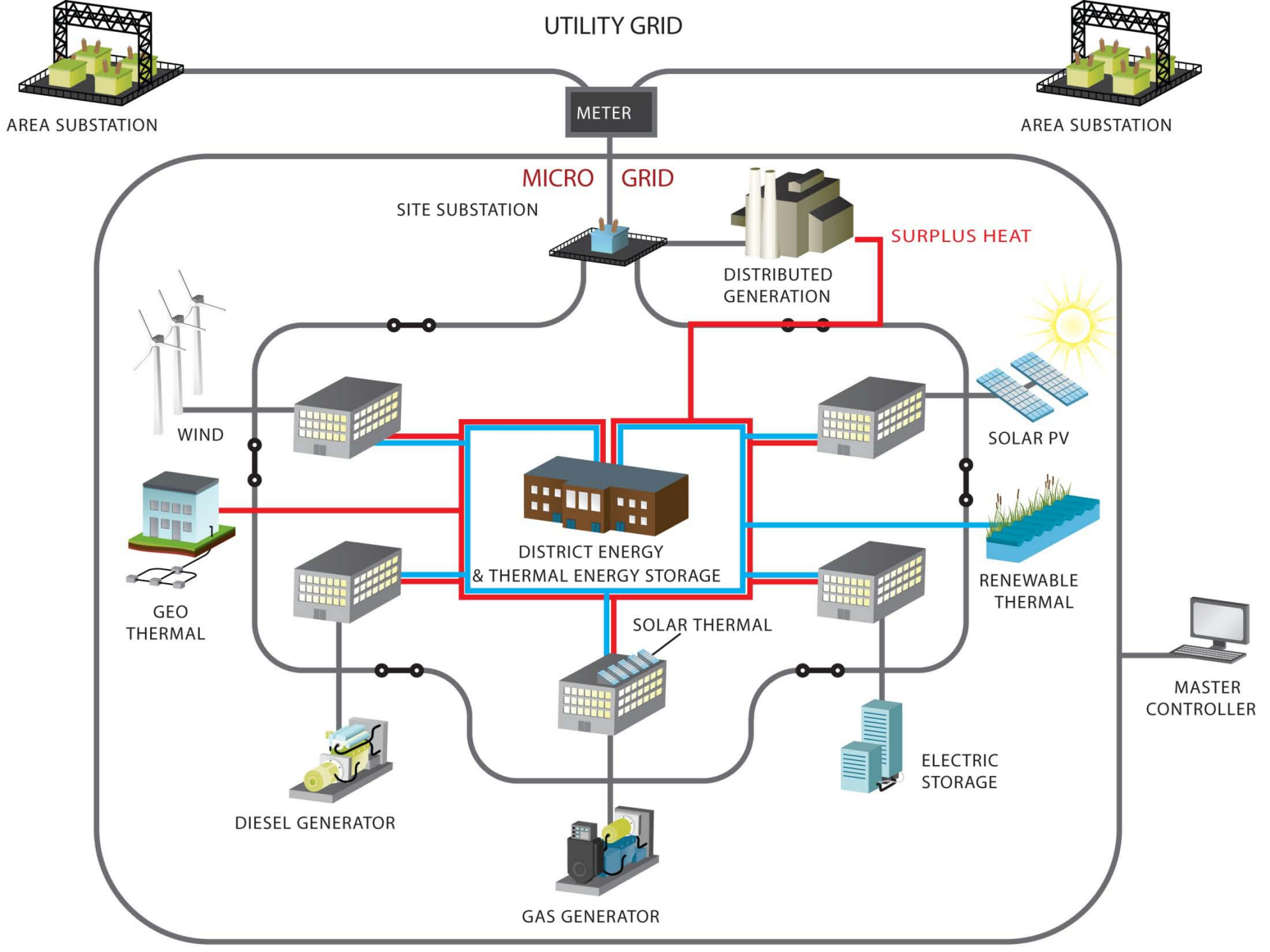


Micro-Grid Electric Generation Dispatch To Minimize Cost



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



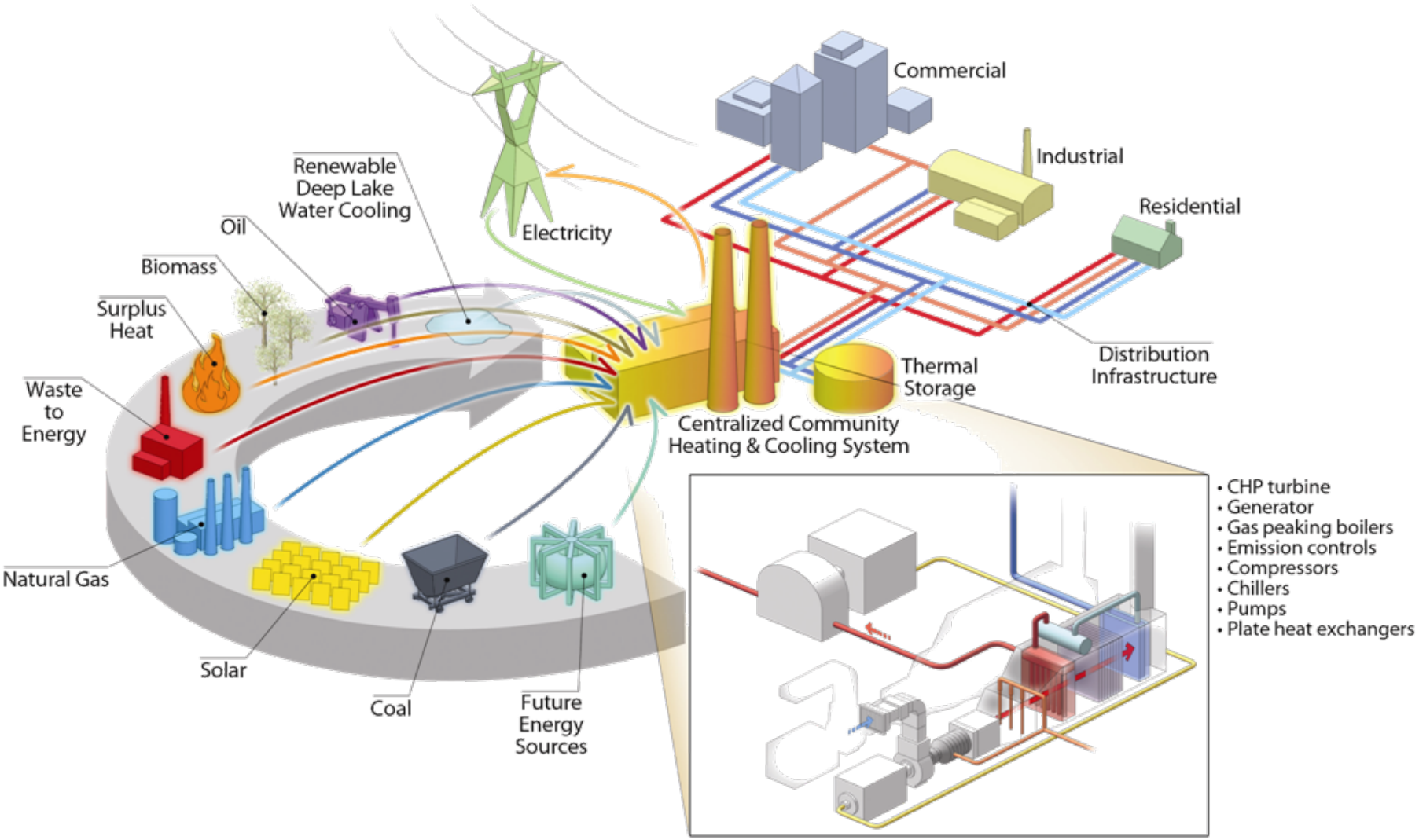

UTILITY GRID
AREA SUBSTATION
METER
AREA SUBSTATION
MICRO GRID
SITE SUBSTATION
DISTRIBUTED GENERATION
SURPLUS HEAT
WIND
SOLAR PV
DISTRICT ENERGY & THERMAL ENERGY STORAGE
GEO THERMAL
RENEWABLE THERMAL
SOLAR THERMAL
MASTER CONTROLLER
ELECTRIC STORAGE
DIESEL GENERATOR
GAS GENERATOR

Princeton University District Energy – Benefit to Local Grid

- 2005 campus peak demand on grid 27 MW
- 2006 campus peak demand on grid 2 MW
- Campus energy system "freed up" 25 MW to local grid
- District energy reduces peak load on local wires, avoids brownouts, enhances reliability and benefits local economy

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Future Proofing the Future City



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Conclusions/Observations

- **Existing district energy (thermal only) systems hold excellent near term potential for highly efficient CHP.**
- **Aggregated thermal networks create scale and the economics for renewable, clean energy investments: (i.e. biomass; geothermal; surplus industrial heat, etc).**
- **More and more cities & communities are seeking local energy solutions to enhance sustainability, drive smart development and keep energy dollars in local economy.**
- **Urban populations will exceed 5 billion by 2030 and more resilient urban infrastructure will define quality of life and determine future economic winners and losers.**
- **Paradigm shift from central generation is underway.**
- **Heat matters…**

Thank you for your attention.

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