District Energy:
Local Solution, Global Benefits

Robert Thornton, President

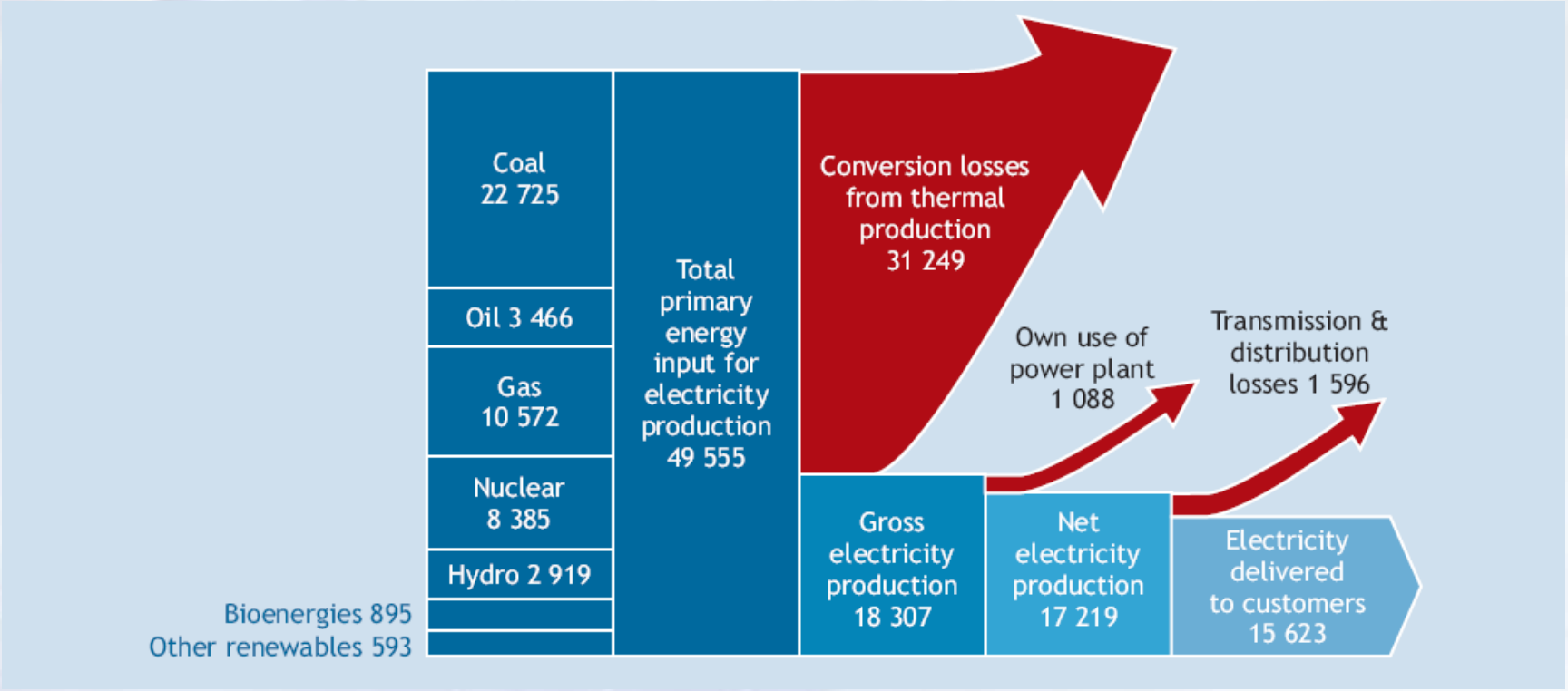
Integrated Community Energy Solutions

Metropolitan Council of Governments

January 26, 2011

Wasted Energy Is a Huge Challenge and Opportunity

Energy Flows in the Global Electricity System

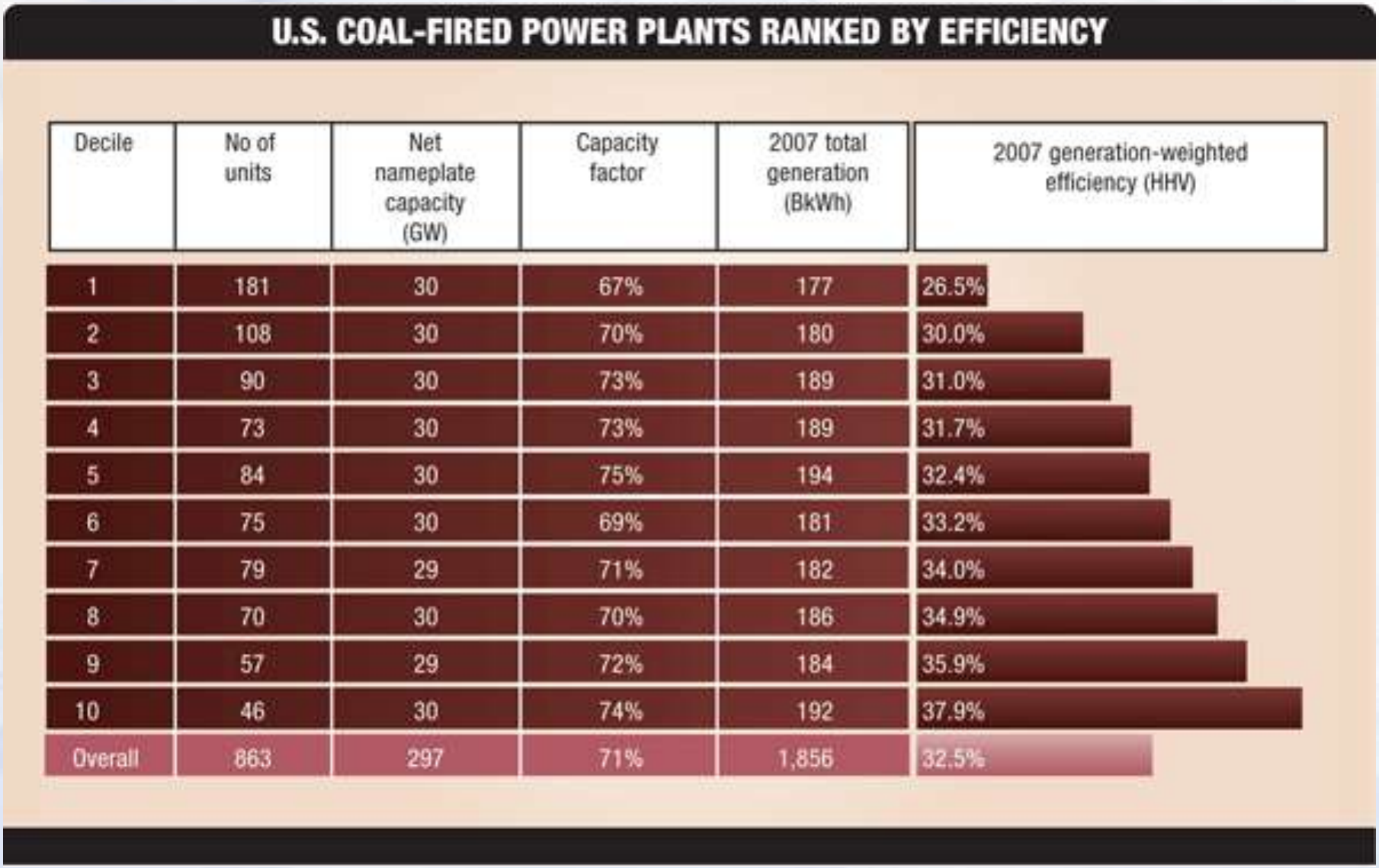


Source: IEA, *CHP: Evaluating the Benefits of Greater Global Investment* (2008).

2/3 of the fuel we use to produce power is wasted --

CHP can more than double this efficiency

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

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 increasing energy security."

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

IPCC Cites District Energy

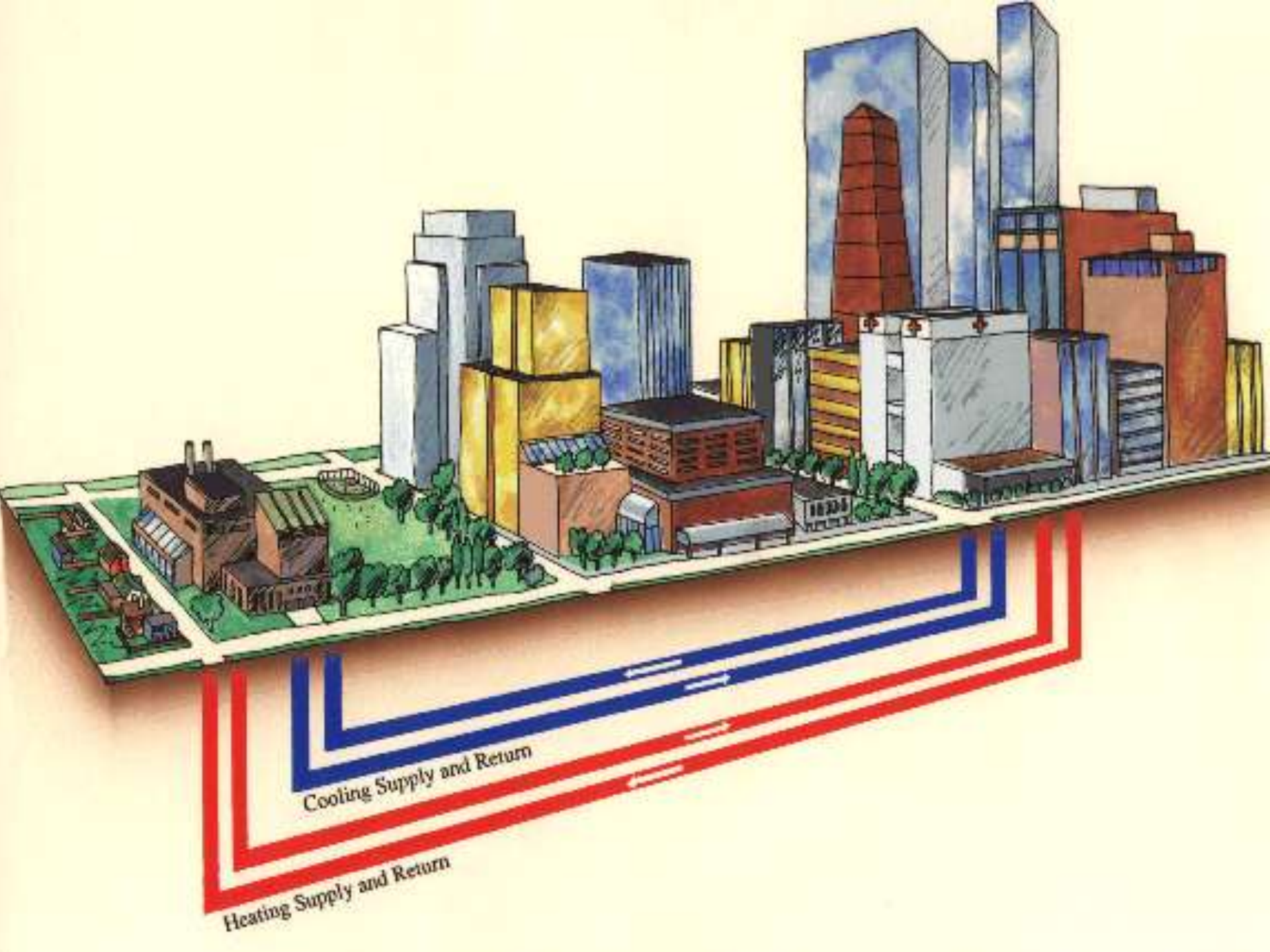
"Measures to reduce greenhouse gas (GHG) emissions from buildings fall into one of three categories: reducing energy consumption and embodied energy in buildings, switching to low-carbon fuels including a higher share of renewable energy or controlling the emissions of non-CO2 GHG gases."

"Community-scale energy systems also offer significant new opportunities for the use of renewable energy."

ipcc
INTERGOVERNMENTAL PANEL ON climate change

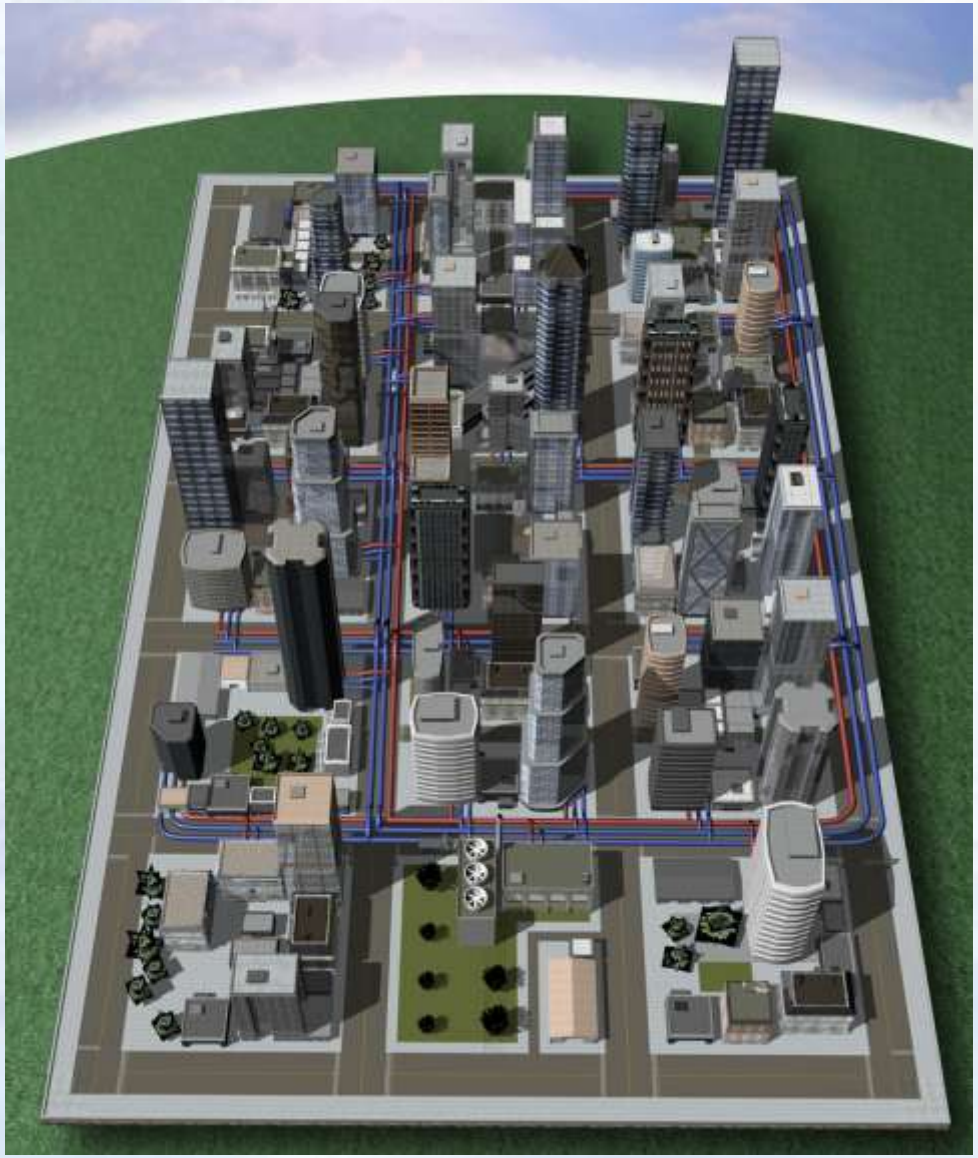
Intergovernmental Panel on Climate Change
Chapter 6 - Residential and Commercial Buildings

Opportunity – Use Surplus Heat

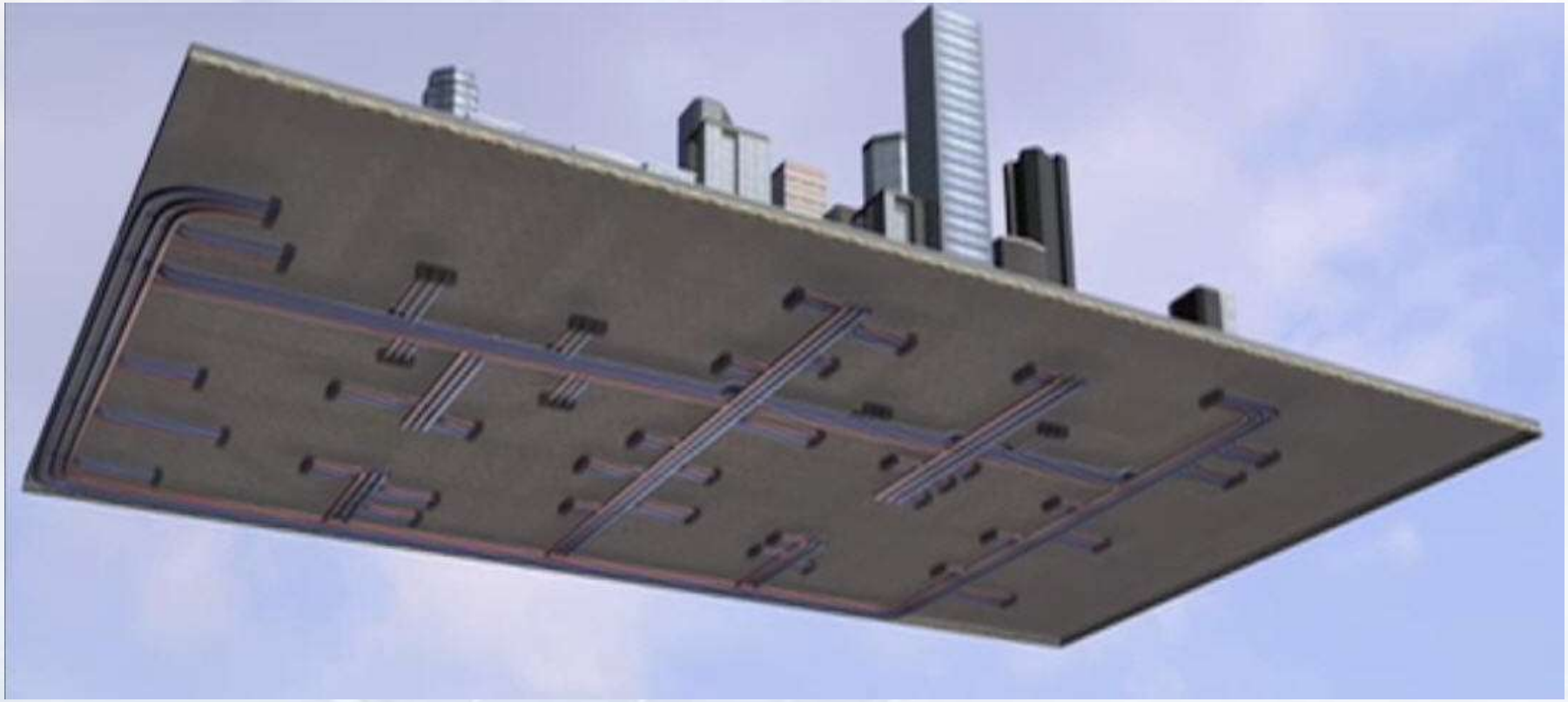

Cooling Supply and Return
Heating Supply and Return

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

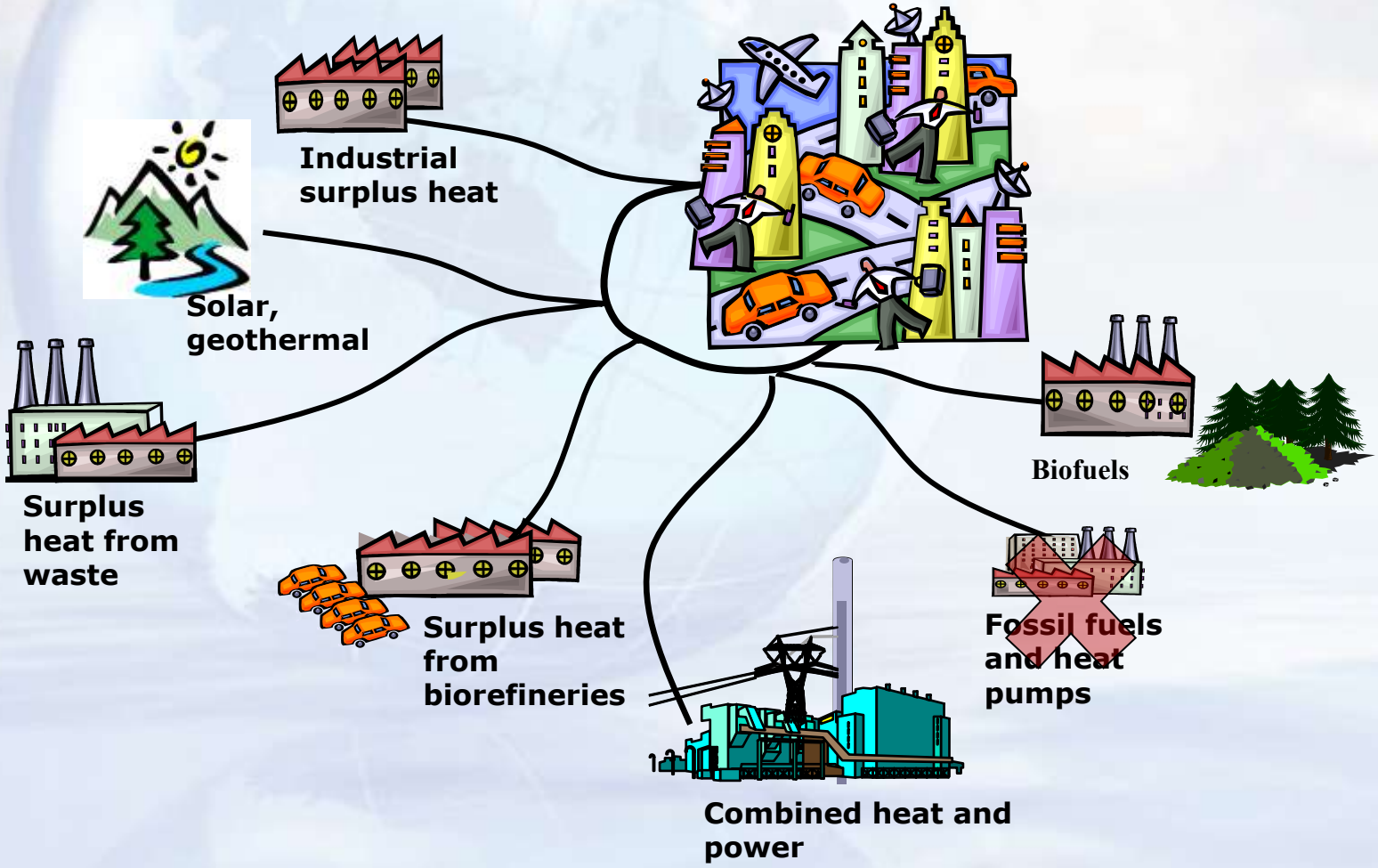


Infrastructure for Local Clean Energy Economy



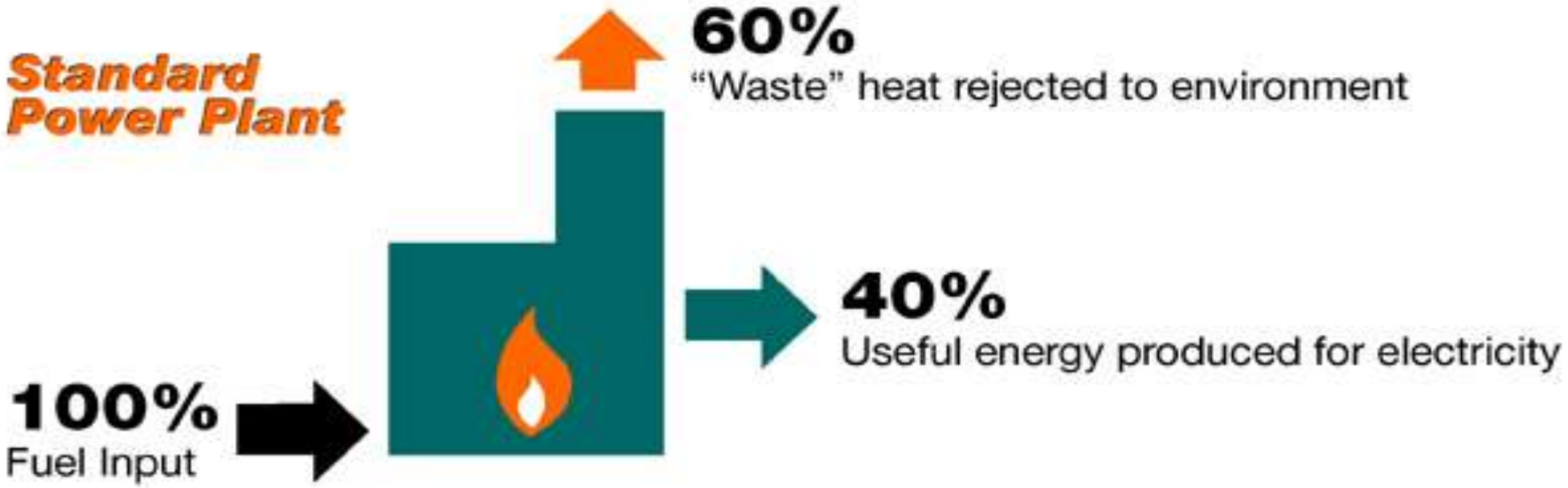
- Connects thermal energy sources with users
- Urban infrastructure – hidden community asset
- Energy dollars re-circulate in local economy
- Locate generation near the power & thermal load

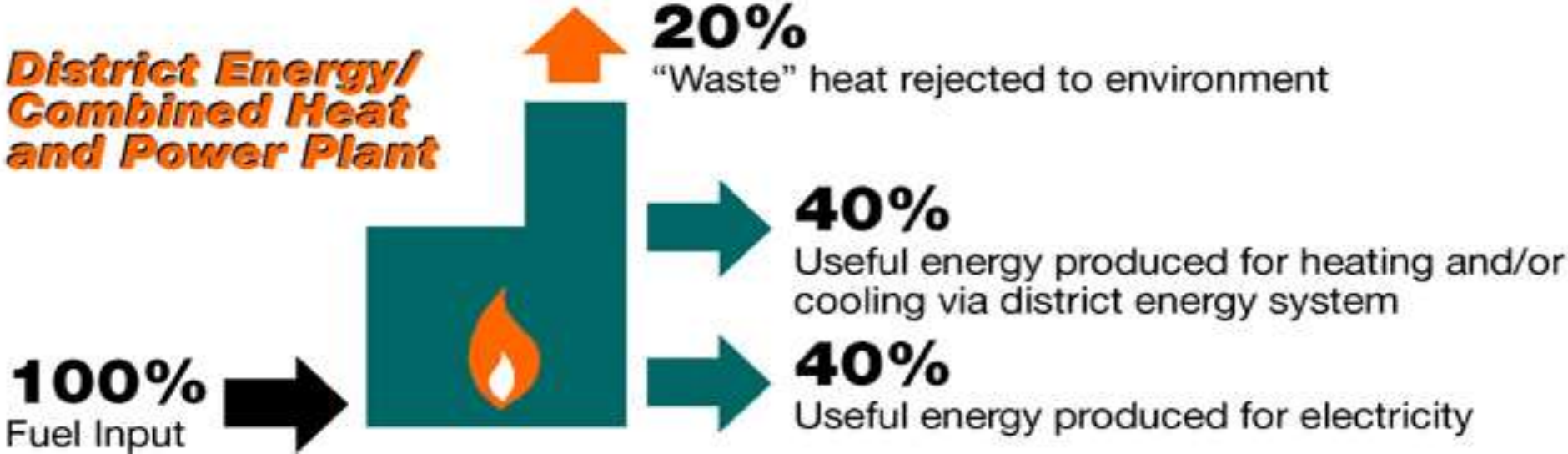
District Energy Networks Make Efficient Use of Local Renewable Energy Sources and Surplus Heat

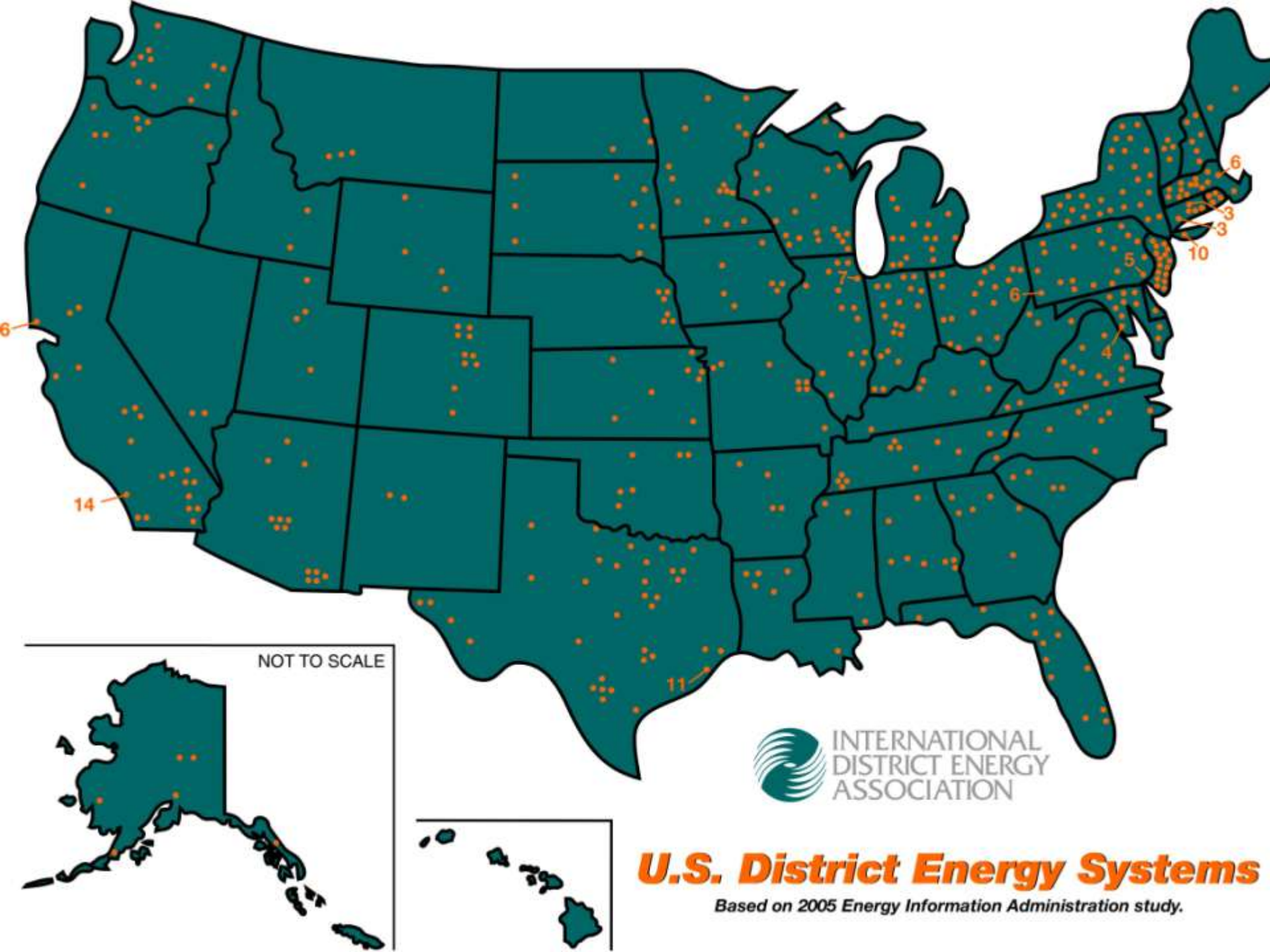


INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Energy-Efficiency Comparisons







INTERNATIONAL DISTRICT ENERGY ASSOCIATION

U.S. District Energy Systems

Based on 2005 Energy Information Administration study.

US District Energy Industry Capacity

	# Systems Reporting	Gross SF Customer Building Space Served	Heating Capacity (MMBtu/Hr)	Cooling Capacity (Tons)	Electricity Generation (CHP Mwe)
Downtown Utilities	**85**	**1,898,037,560**	**49,239,000**	**1,082,355**	**950**
Campus Energy Systems	**330**	**2,489,216,071**	**82,107,191**	**1,855,546**	**2,197**

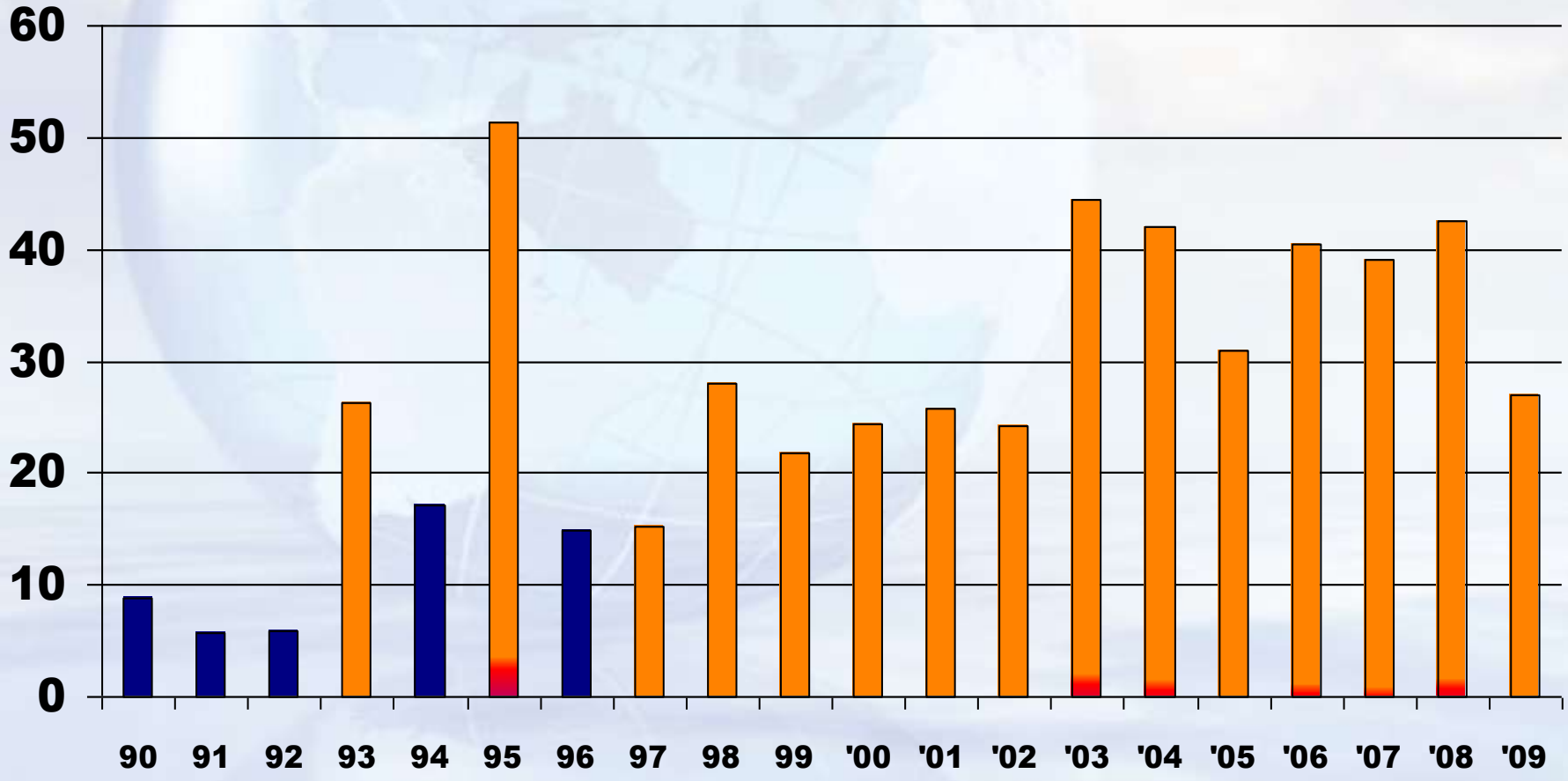
* Based on systems reporting 2005 data to EIA Survey

District Energy Industry Growth

(Million sq ft customer bldg space connected/committed)

Aggregate SF reported since 1990 - 495,127,348 SF

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

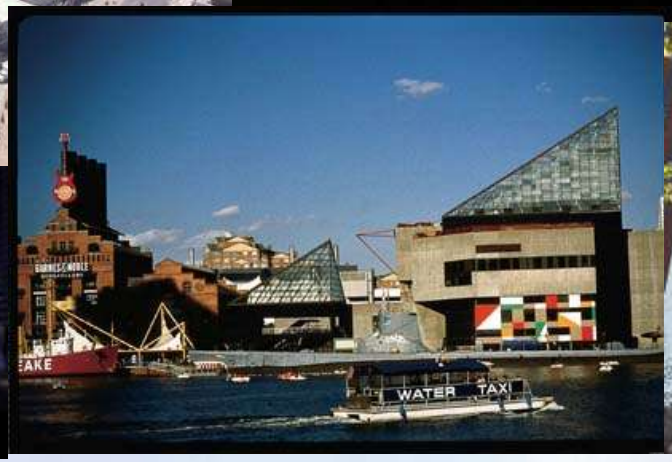


Commercial, Government, Events








Residential, Hospitality, Healthcare

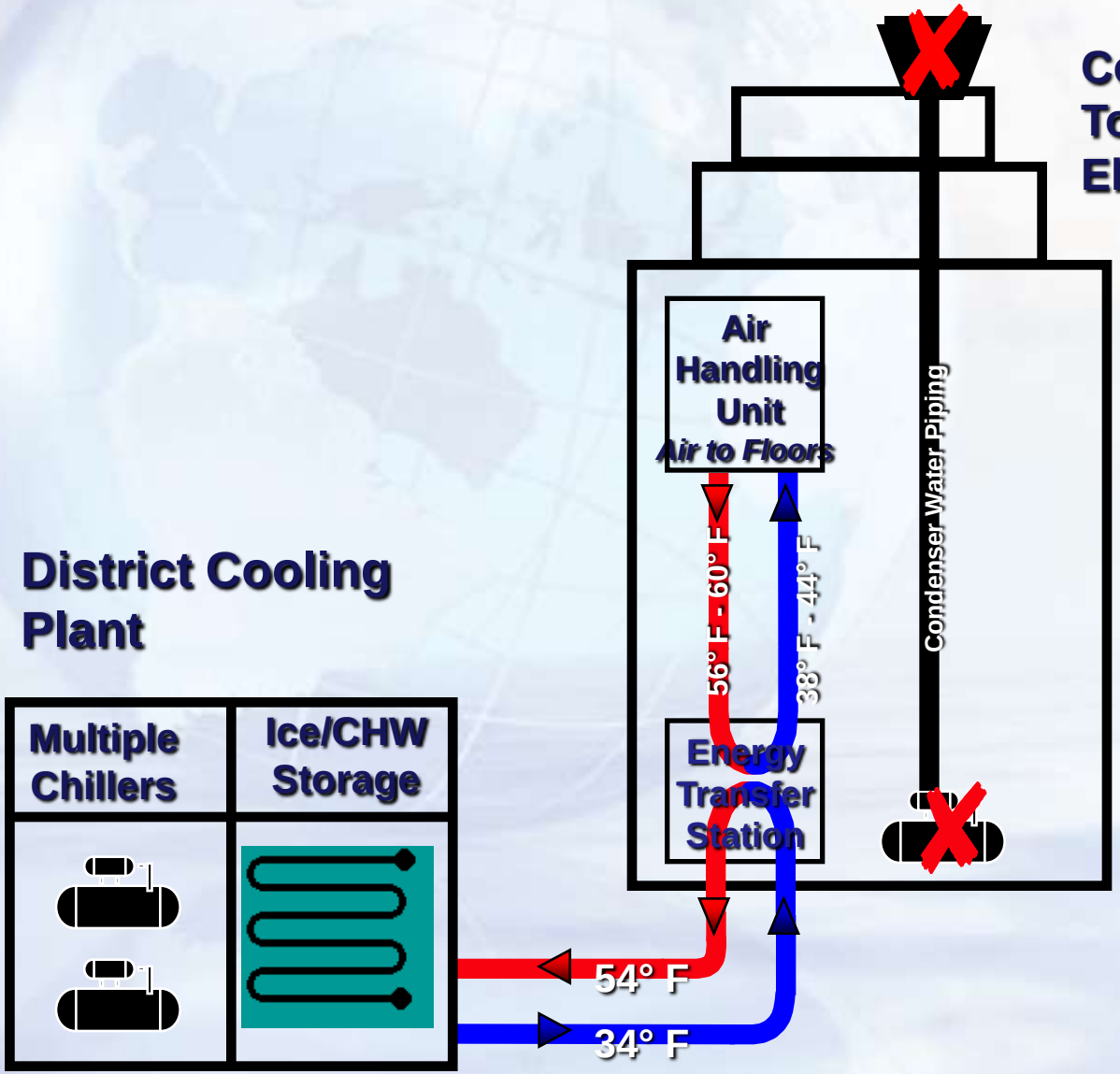
District Energy: Creating Scale for Efficient and Cleaner Energy Solutions

- **Promotes Energy Efficiency and Conservation**
- **Eases Transition to Alternative Energy Sources**
  - Local fuel supplies (biomass, surplus wood, waste, etc)
  - Renewable thermal (lake/ocean/river cooling; geothermal)
- **Enables Use of Surplus Thermal Energy**
  - Heat from power generation stations
  - Excess industrial heat sources
- **Increases Energy Security Through Fuel Flexibility**
- **Decreases Emissions of Carbon**
- **Energy Dollars Re-circulate in Local Economy**
- **Improves Air Quality**

Impact on End User

- Customer capital costs reduced or amortized over long term service agreement
- Reduces size mechanical room; electrical vaults; condenser shafts and roof loads
- Colder CHW supply improves HVAC performance
- Lower owning, operating and maintenance costs
- More leasable space

Building Interconnection



Cooling Tower Eliminated

AVOIDED
- Boilers/Chillers
- CFC's
- Fuel Combustion
- Stacks/Chimney
- Fuel Delivery & Storage
- Emissions

REDUCED
- Electrical Vault
- Water Use
- Chemicals
- Mechanical space

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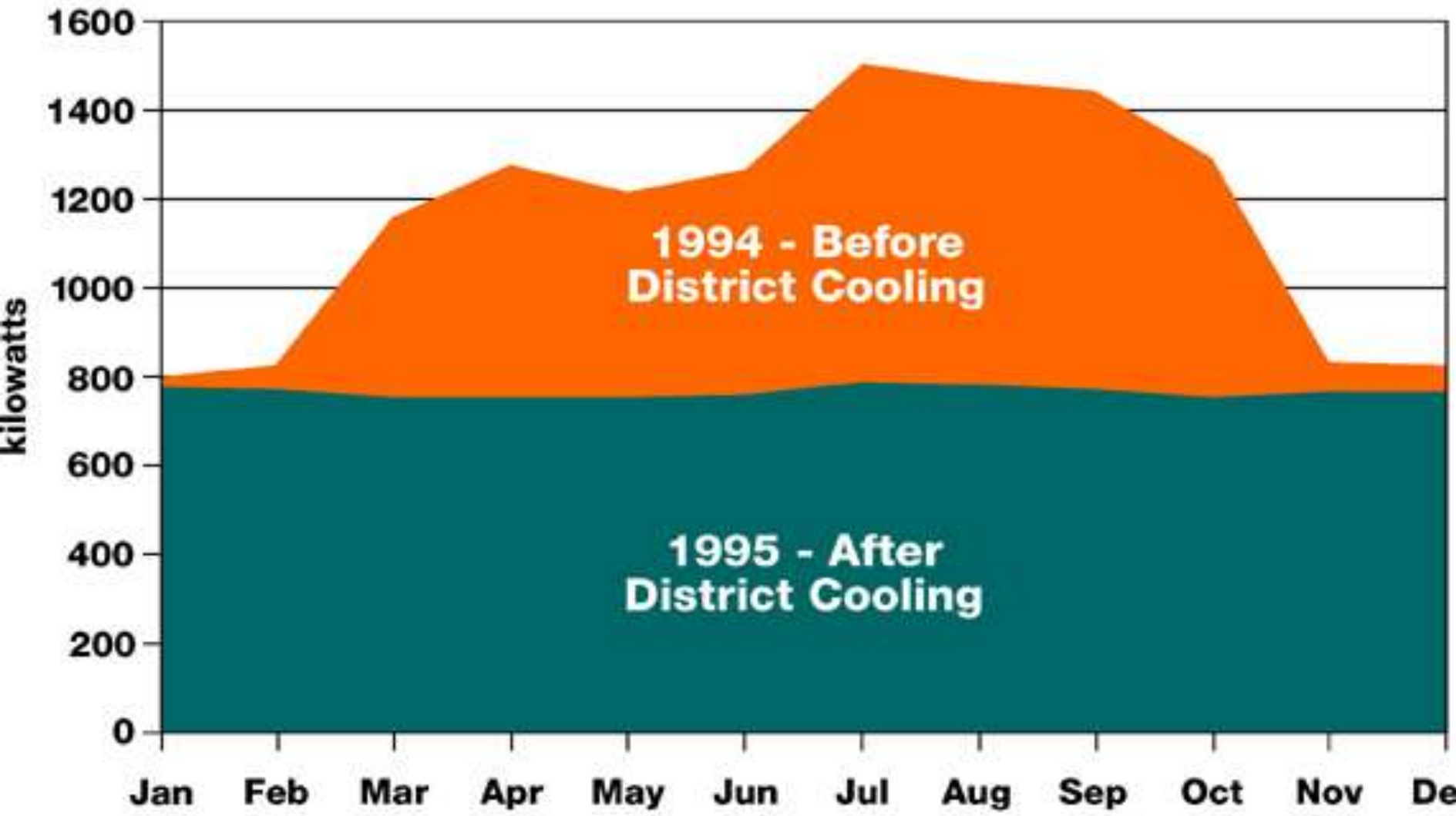
District Cooling Customer Electric Demand Profile



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

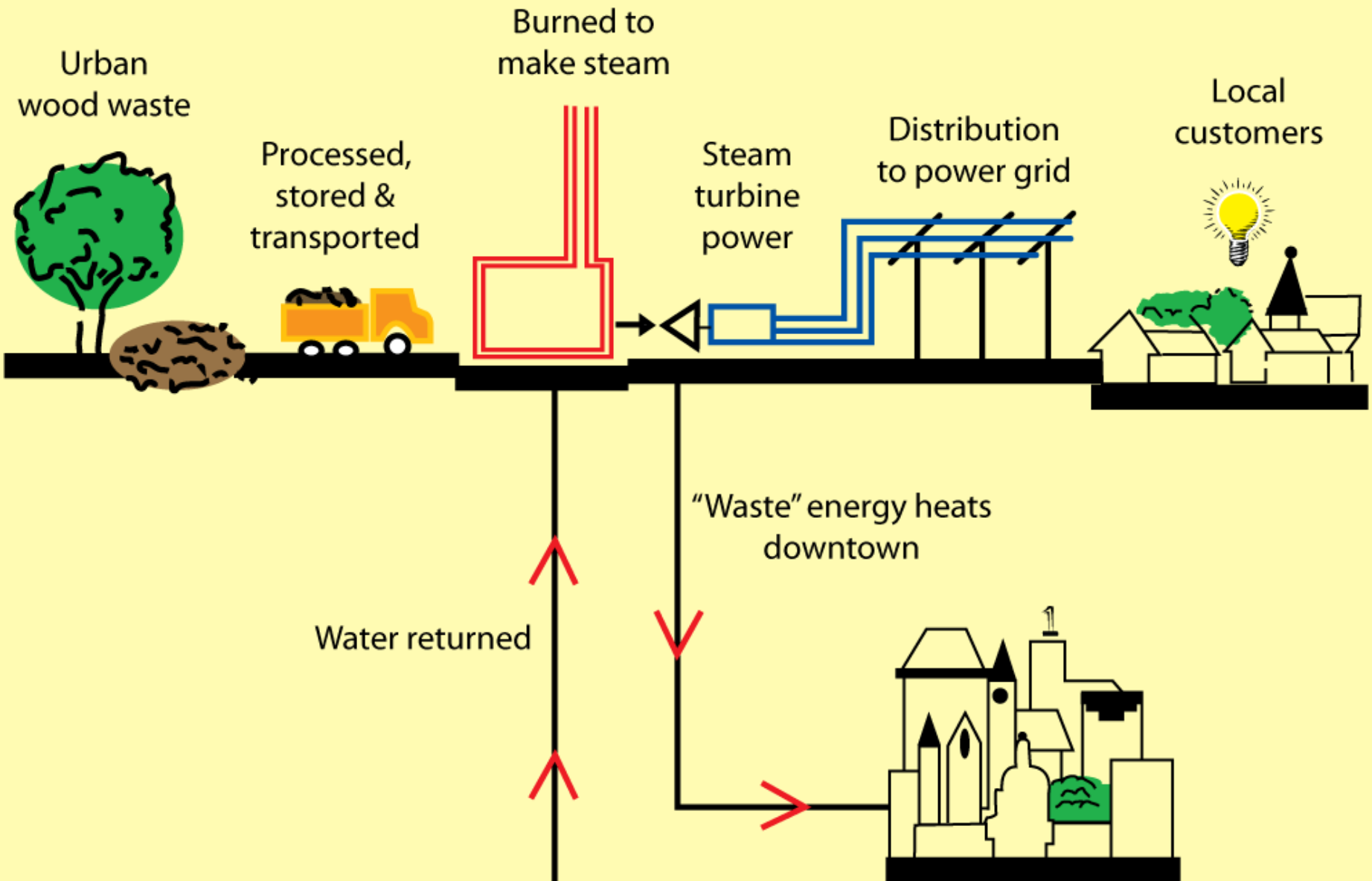
Without District Energy

With District Energy

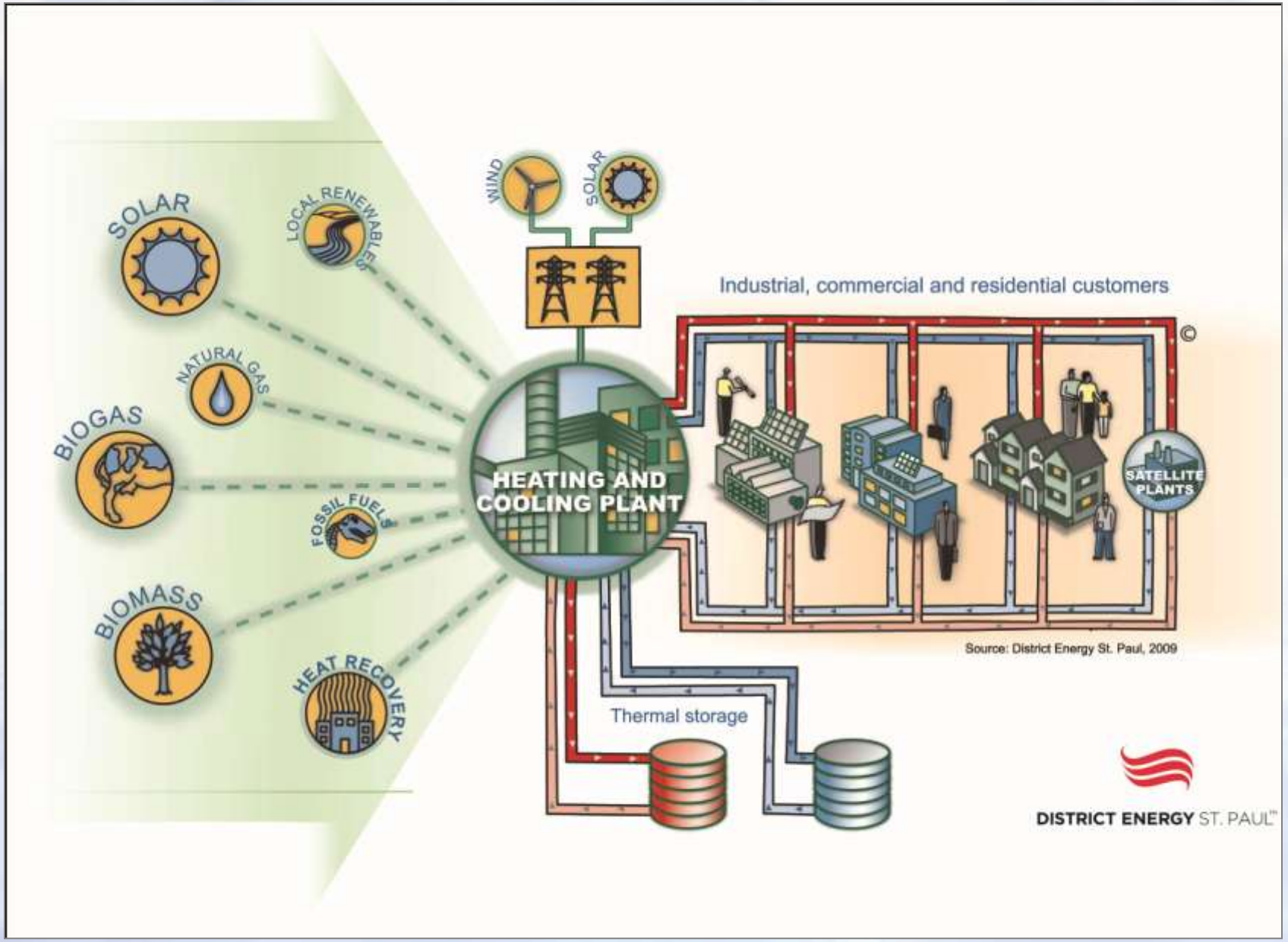
District Energy St. Paul

- District hot water service to 29,000,000 SF (90% market)
- District cooling service to 17,000,000 SF
- Combined heat & power: 25 Mwe; 65 MWt
- Waste wood, coal, oil, natural gas – fuel flexible
- Municipal wood waste displaces 275,000 tons coal/yr
- Double the efficiency of conventional electricity only power plants
- Greenhouse gas CO2 cut by 280,000 tons per year

Biomass-Fueled Combined Heat and Power



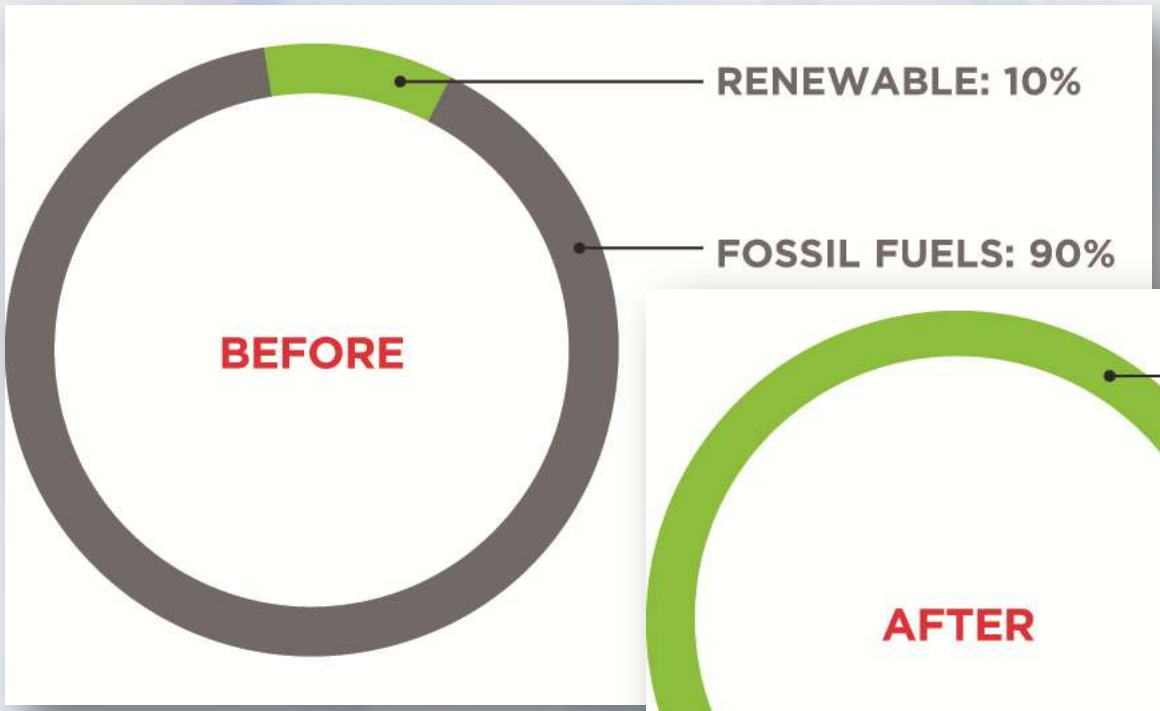
Integrated Community Energy Systems

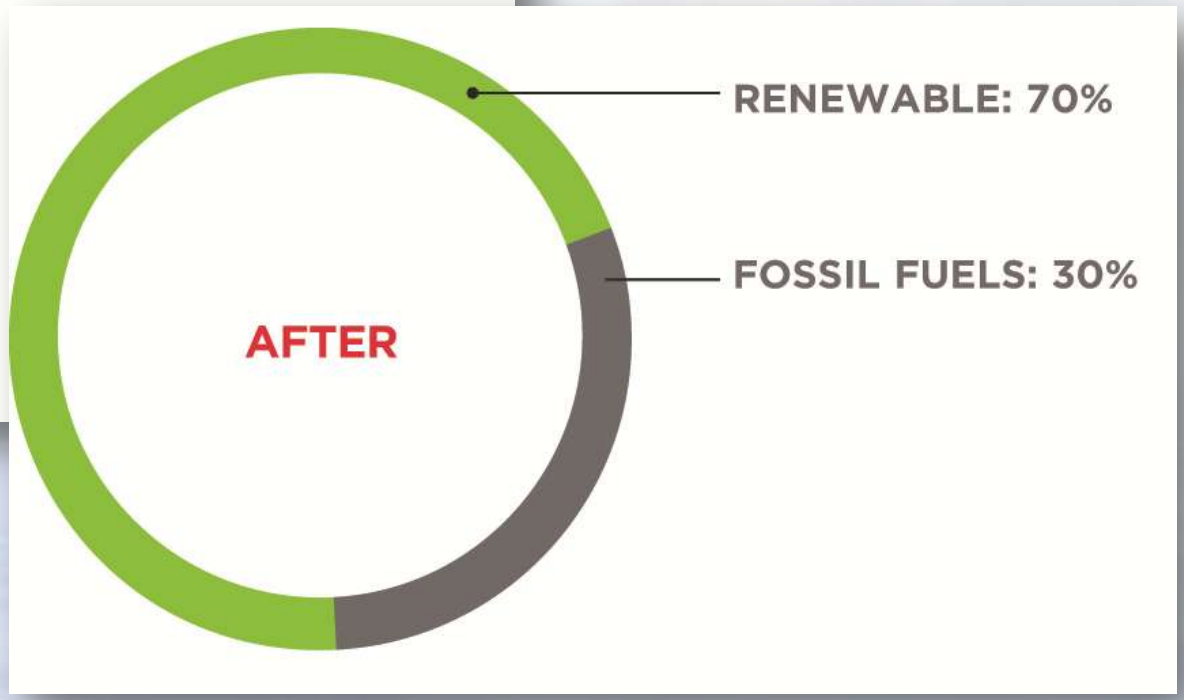


Benefits of Biomass District Energy

- Cut CO2 emissions by 280,000 tons per year
- Decreased urban waste disposal/landfill problem
- Using local fuel source improves energy security, creates jobs
- Keeps $12 million re-circulating in local economy
- Stable, competitive energy prices to customers

Fuel Diversification: Before & After CHP

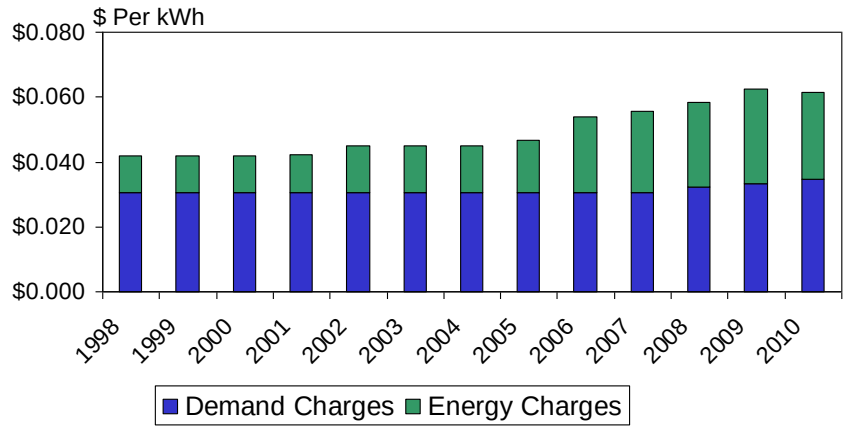




System Benefits: Stable Rates

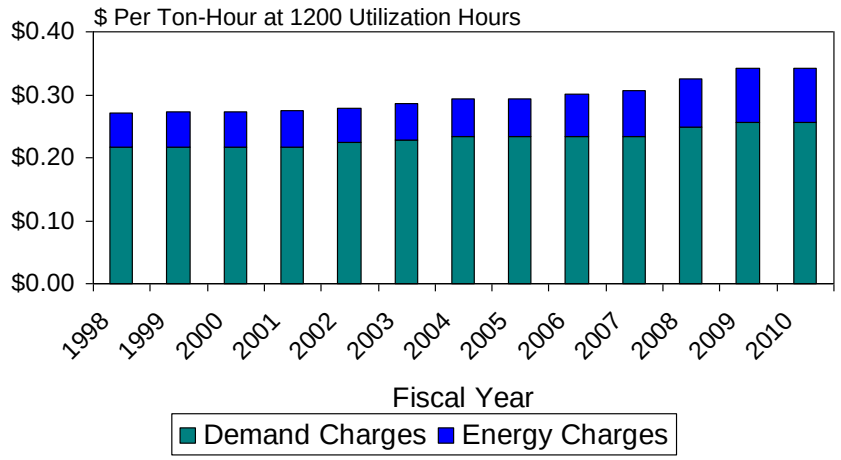
District Energy St. Paul

Combined Rate Summary, FY-1998 to 2010



District Cooling St. Paul

Combined Rate Summary, FY-1998 to 2010

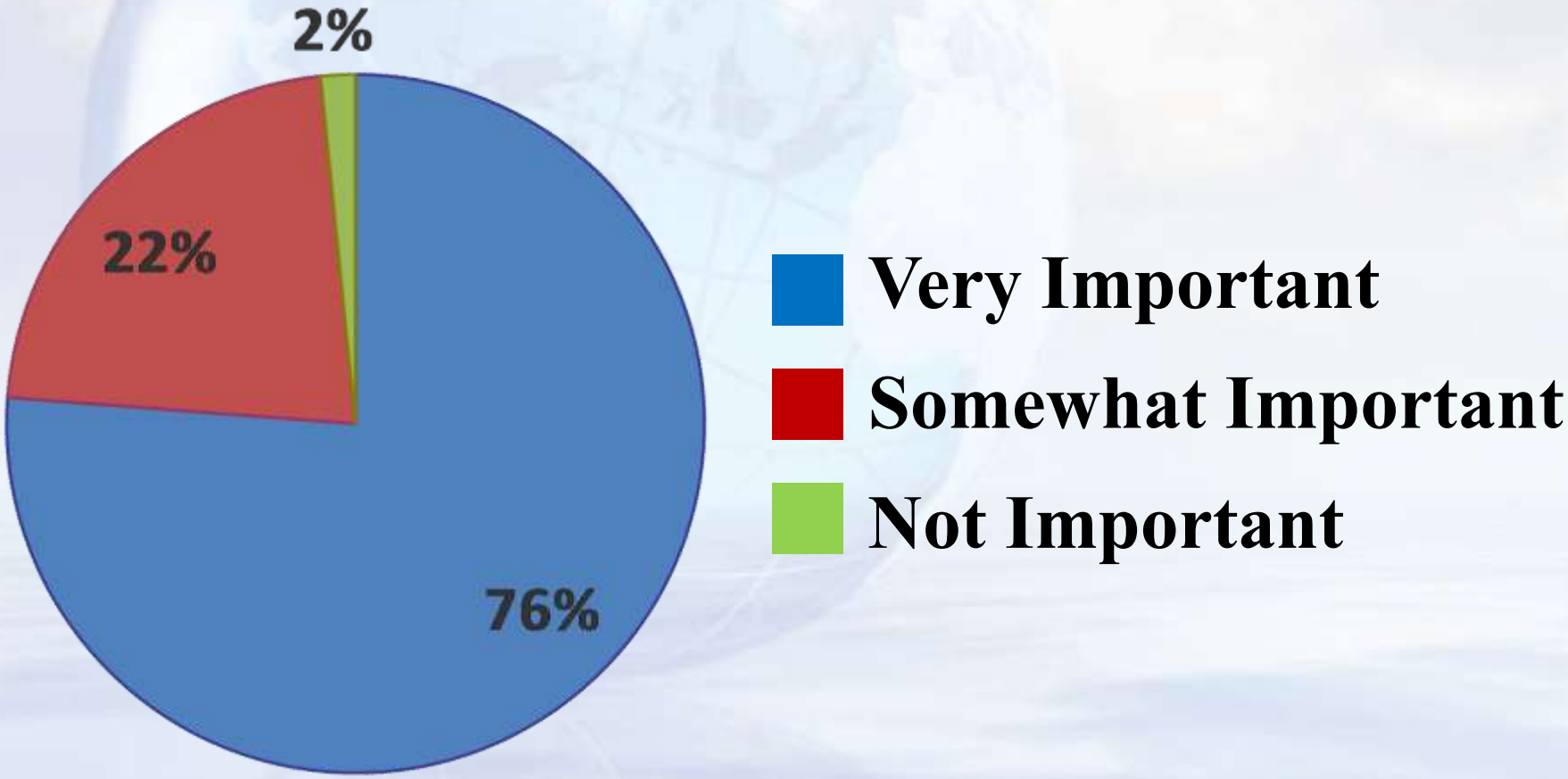


Customers pay less today than they did in 1983*

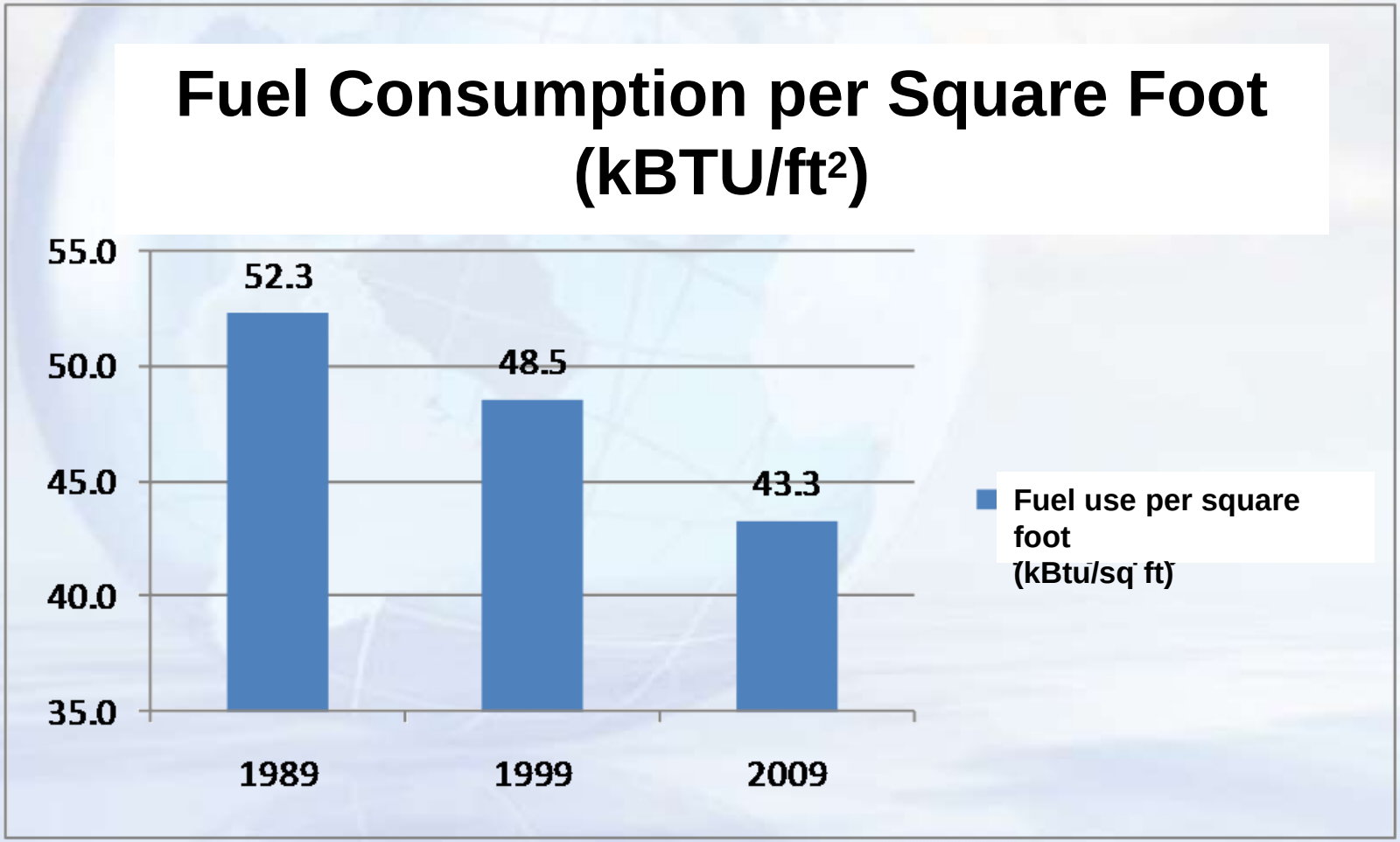
***adjusted for inflation**

Importance to Customers

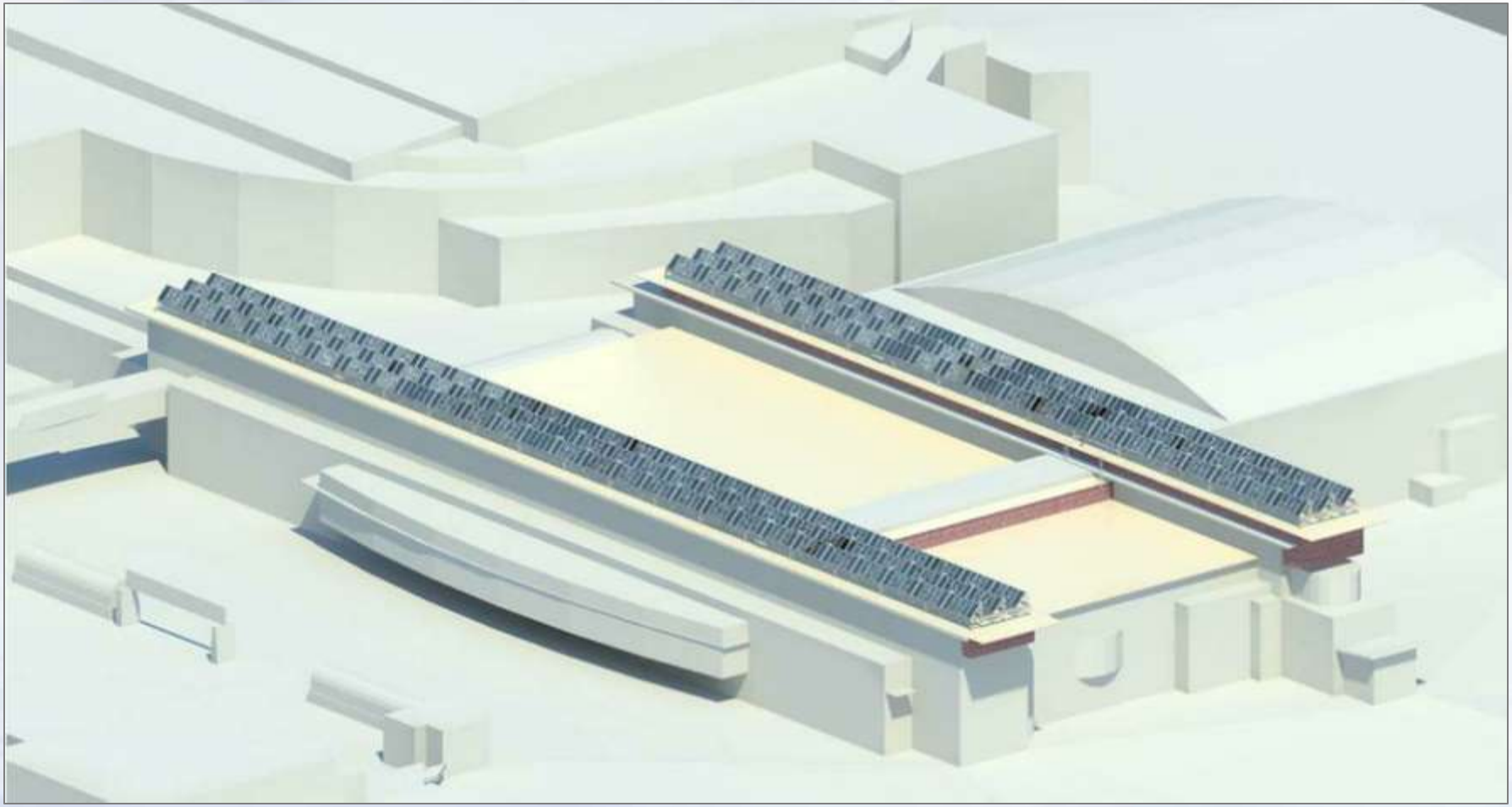
How important is our usage of renewable fuels?



Customer Benefits: Energy Efficiency

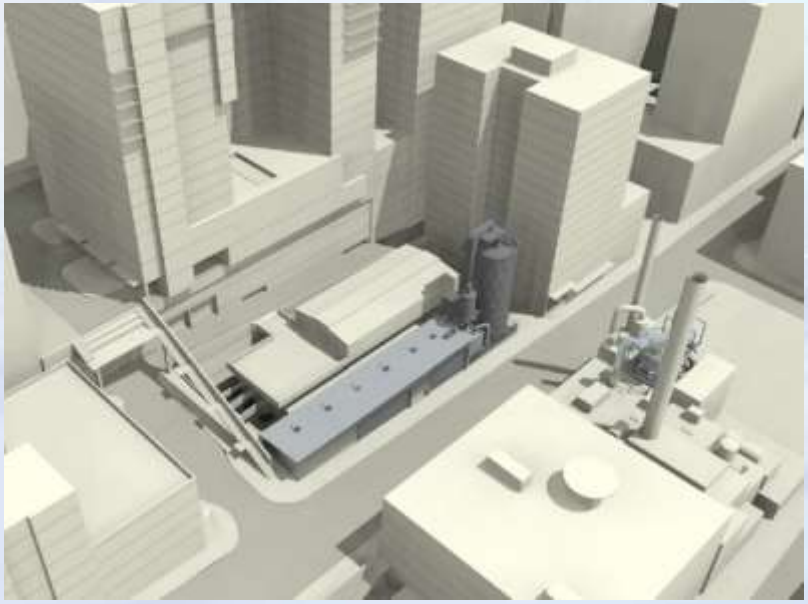


Solar Thermal Integration



2010: Design & Installation of Largest Solar Thermal Energy System in Midwest

Seattle Steam – Urban Biomass

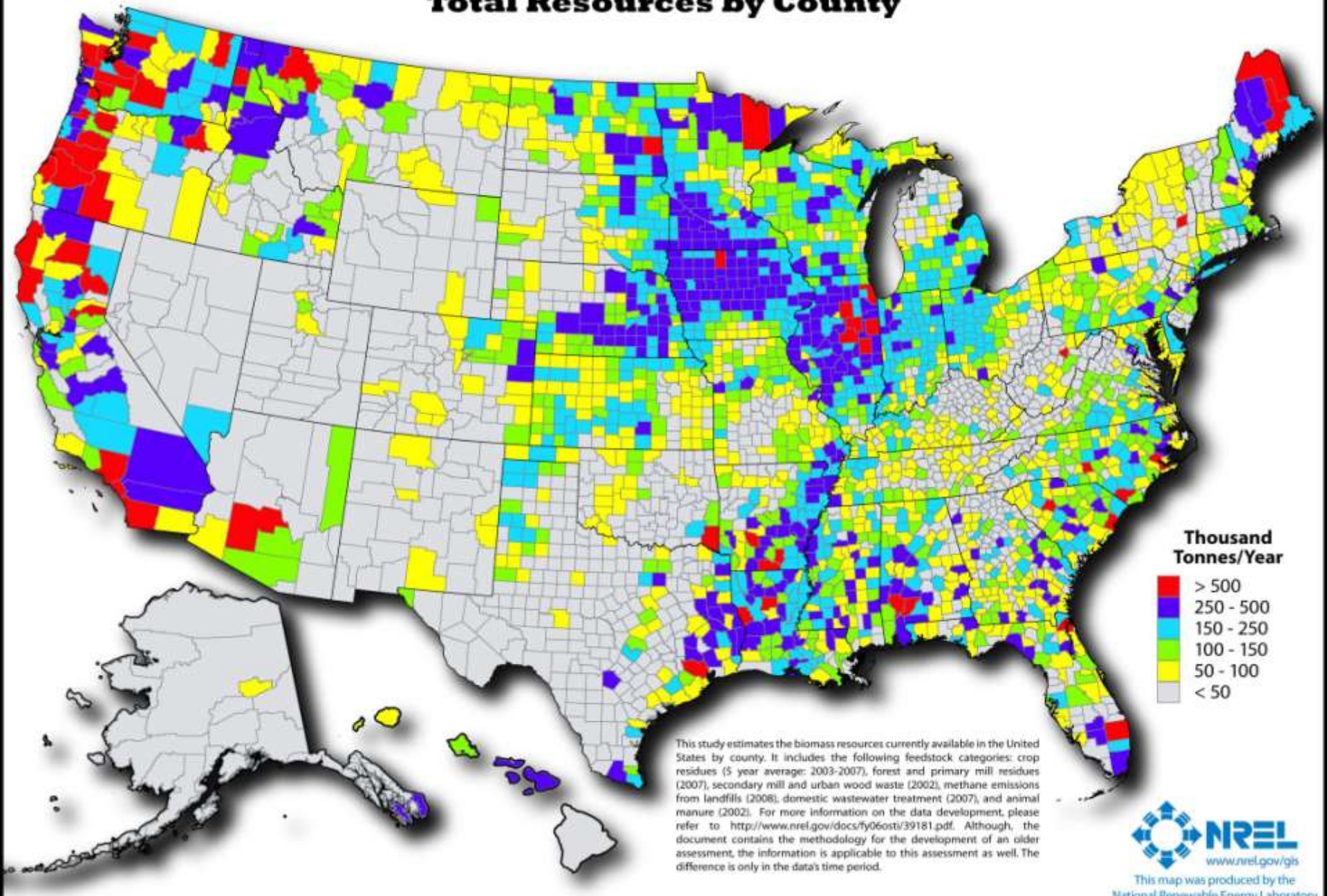


Seattle Steam – Urban Biomass

- Utilizes waste wood, avoiding landfill
- Serves approx 200 buildings downtown
- Reduces CO^2 output by 55,000 tons/year
- Cuts carbon footprint by 50-60%
- Supports LEED points for customers

Biomass Resources of the United States

Total Resources by County

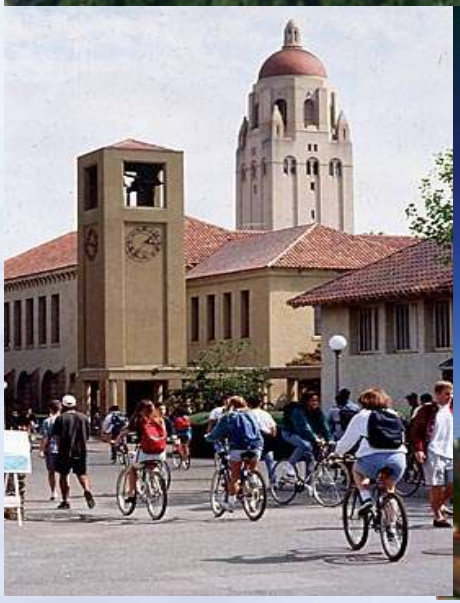


This study estimates the biomass resources currently available in the United States by county. It includes the following feedstock categories: crop residues (5 year average: 2003-2007), forest and primary mill residues (2007), secondary mill and urban wood waste (2002), methane emissions from landfills (2008), domestic wastewater treatment (2007), and animal manure (2002). For more information on the data development, please refer to http://www.nrel.gov/docs/fy06osti/39181.pdf. Although, the document contains the methodology for the development of an older assessment, the information is applicable to this assessment as well. The difference is only in the data's time period.

Author : Billy Roberts - September 23, 2009

NREL
www.nrel.gov/gis
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

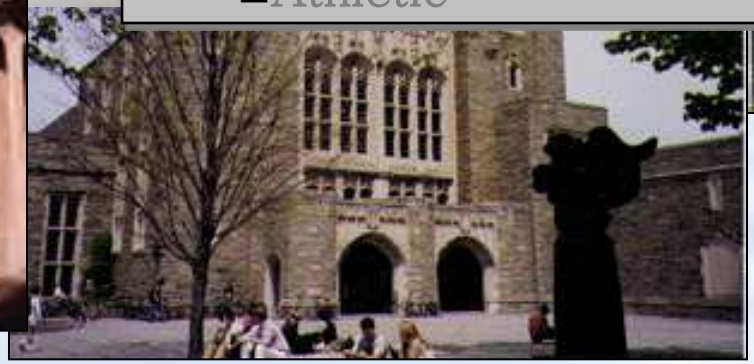
Institutions - Campus Energy Systems



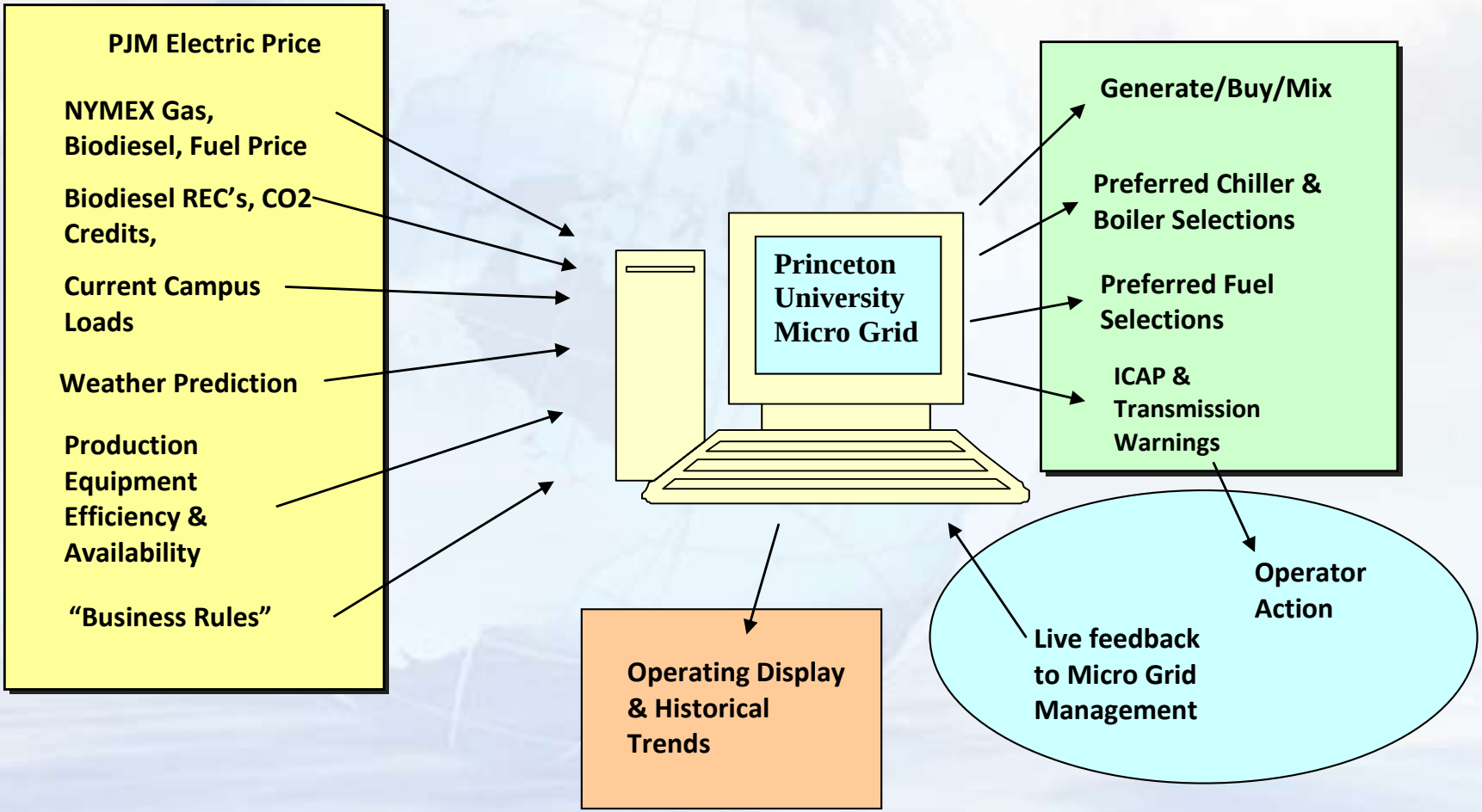
- Load growth driven by building construction
- Critical care research facilities - reliability is paramount
- Common ownership between plant/buildings
- Able to retain 100% energy savings
- Longer investment horizon
- History of success with combined heat & power (CHP)

Cogeneration & District Cooling – Princeton University

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



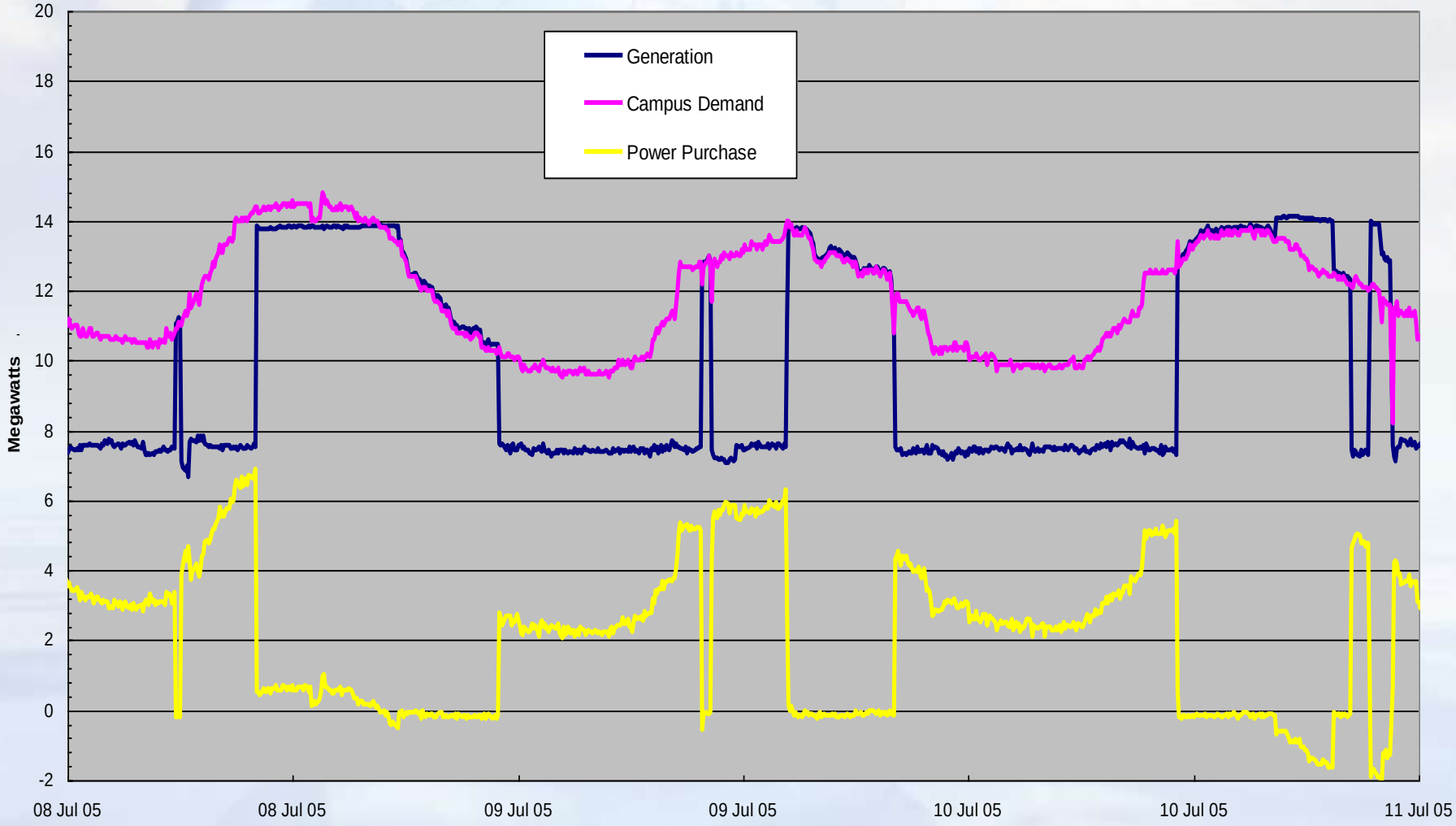
Princeton Micro - Grid Management



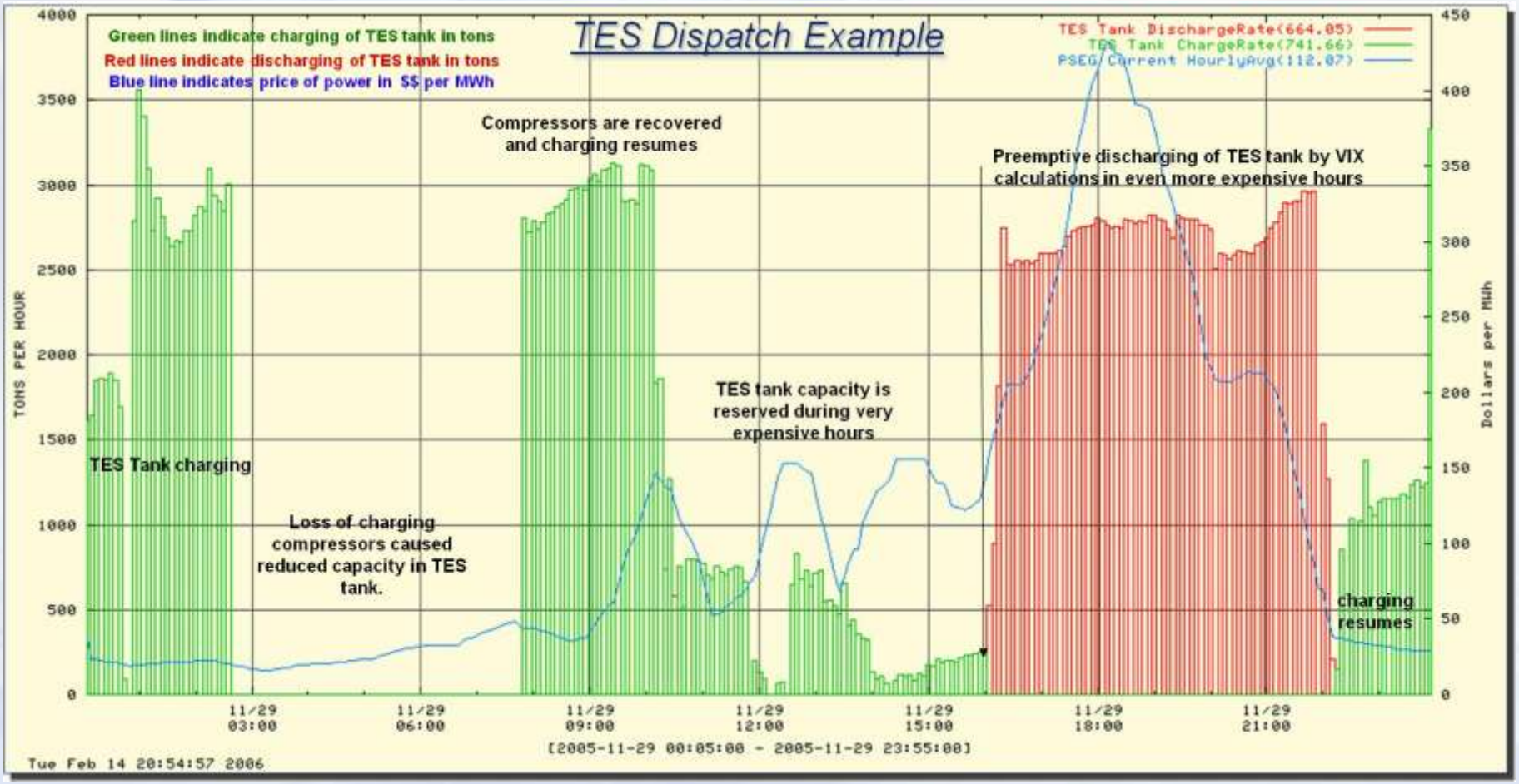
Wholesale Market Price vs. Capacity ($ per MWh)

Regional Electric Grid ISO

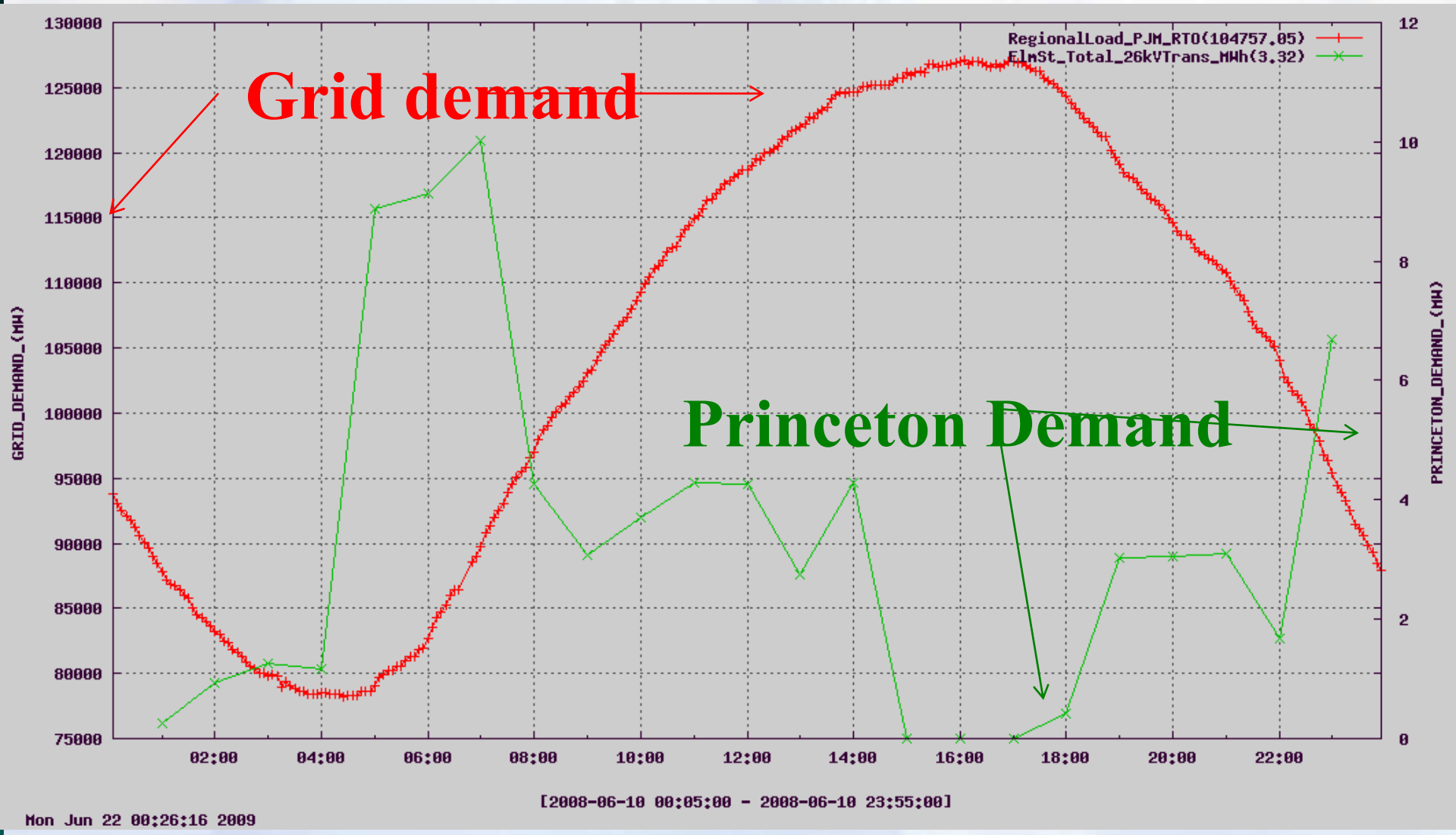
Campus Electric Generation Dispatch To Minimize Cost



Optimal TES Dispatch in Real Time Electric Market



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



Princeton Campus Energy System – 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
- CHP/District cooling reduces peak load on local wires, enhances reliability, avoids brownouts
- Benefit to local economy

Climate Neutrality at Cornell University

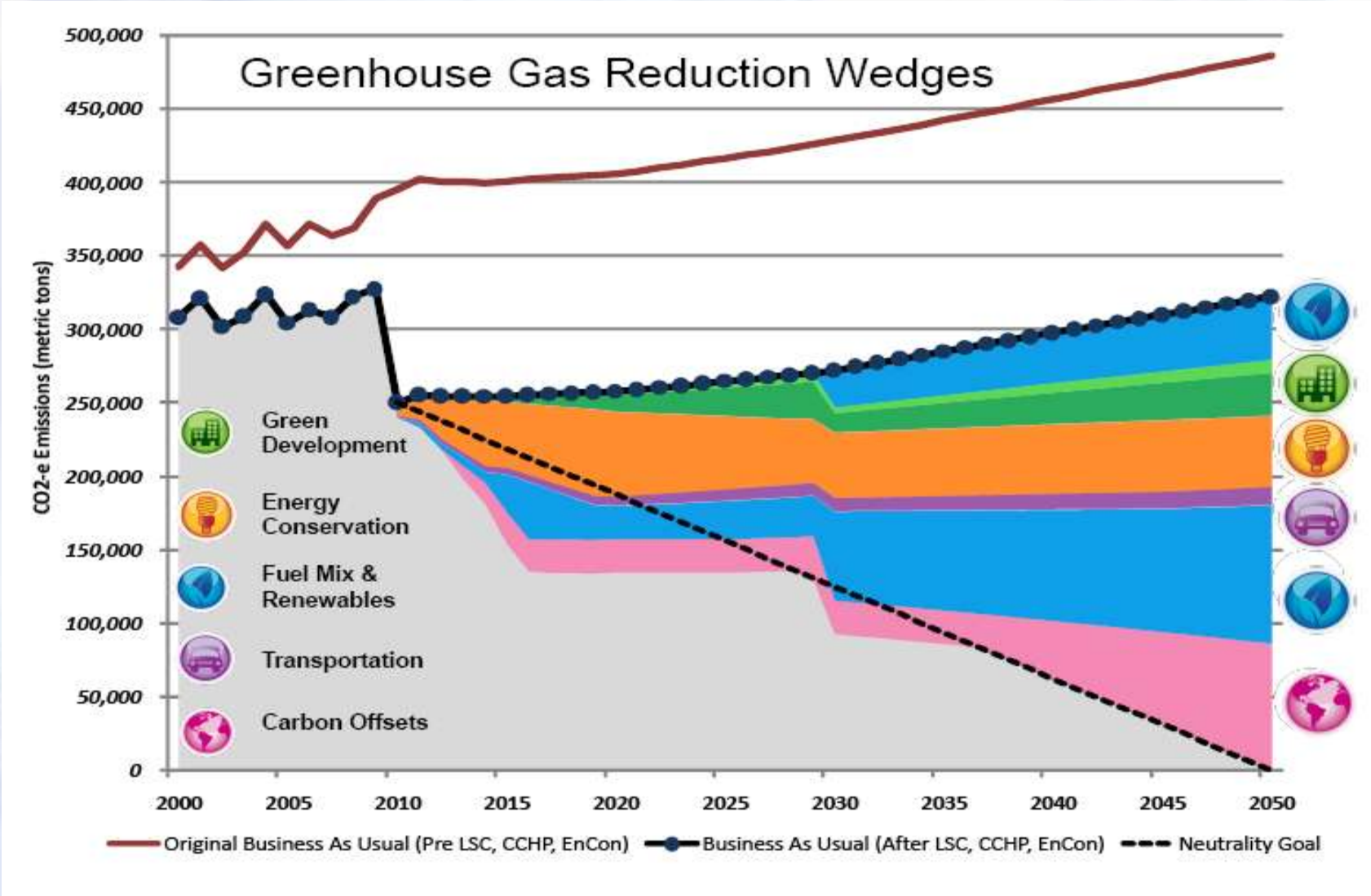
Utilities Annual Budget ~ $60 million

Enterprise Units

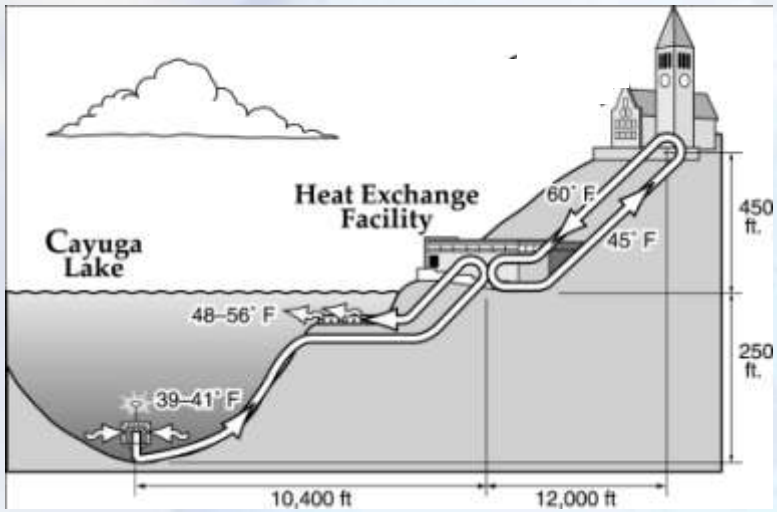
- Electric
  - 35 MW peak
  - 240 GWh/yr
- Steam
  - 380 klb/h peak
  - 1,200,000 klb/yr
- Chilled Water
  - 20,000 tons peak
  - 40,000,000 ton-hrs/yr
- Water and Sewer

- 2.5 trillion BTU's/yr since 1990
- ~275 thousand tons CO_2/yr

The Future: Climate Action Plan



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

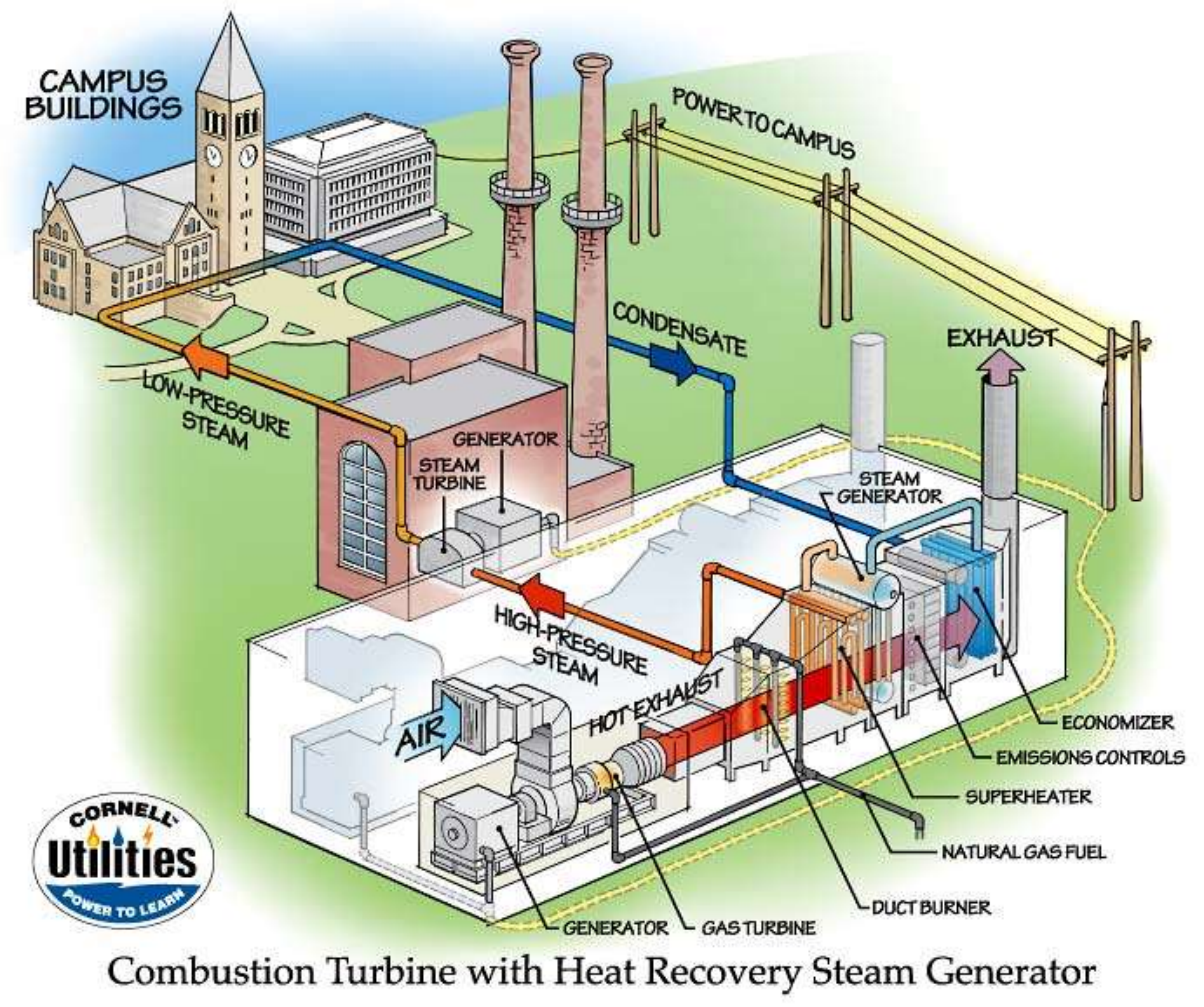
Lake source intake pipe: 10,400 ft long, 250 ft deep

Campus S/R loop pipe: 12,000 ft

Benefits:

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

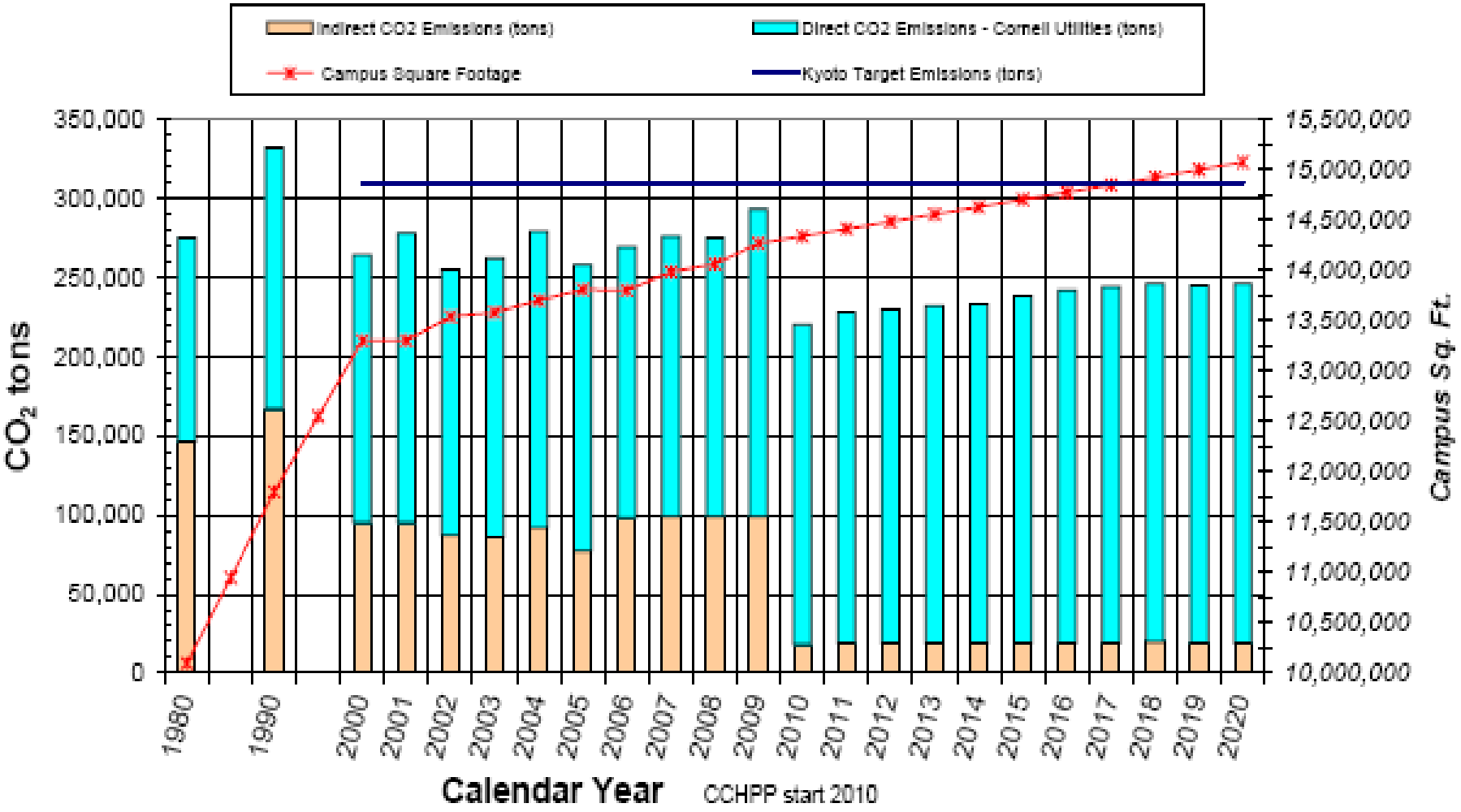
Cornell Combined Heat & Power



Combustion Turbine with Heat Recovery Steam Generator

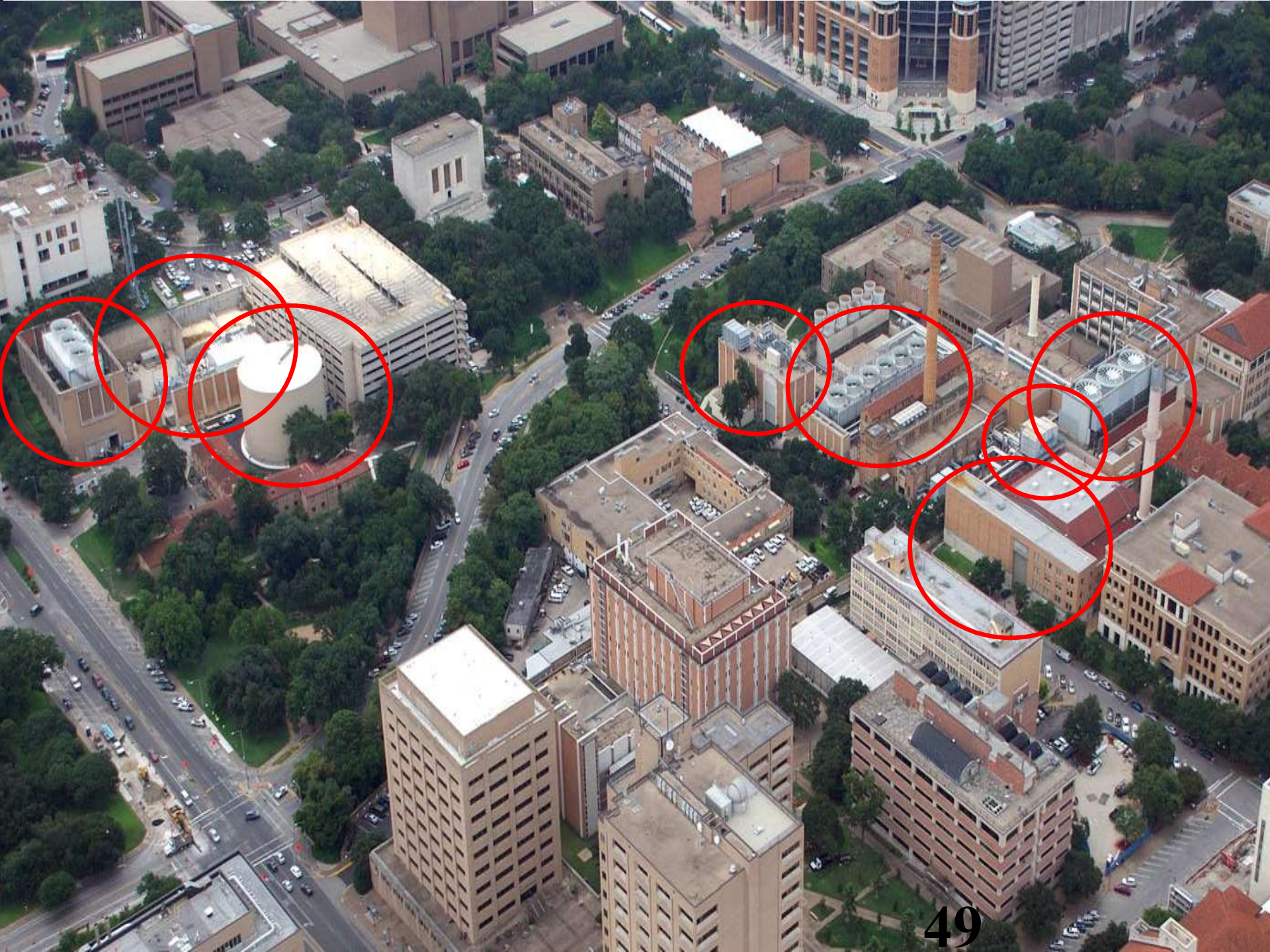
- Commissioned December 2009
- 30 MW and 300 klb/h
- Produce 180 GWh/yr and 750,000 klbs/yr
- Offset indirect emissions
- Reduce coal usage by 50%
- Reduce campus CO_2 20% (50,000 tons/yr)
- Provide efficient steaming capacity
- Electric reliability
- Fuel flexibility (HP gas line)
- Dual fuel capability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

Cornell's Carbon Footprint

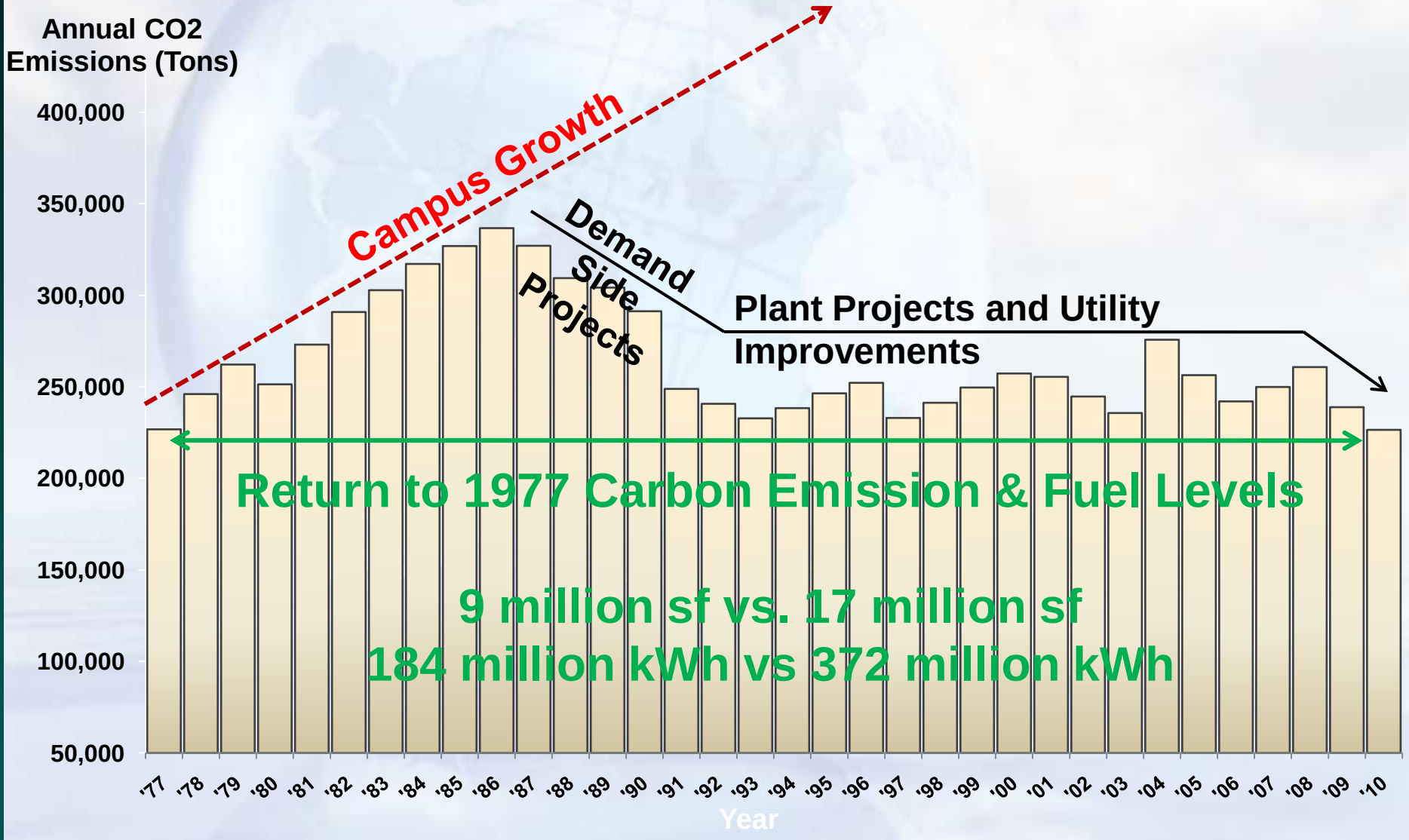


University of Texas Austin
District Energy /CHP

- 100% power, heating and cooling requirements for 16 million sf
- 150+ buildings - $70 million budget
- Power Plant – Dense urban location
  - 137MW of on-site CHP (65 MW Peak)
  - 1.2 million lb/hr of steam generation (200K Peak)
- Chilled Water
  - 46,000 tons capacity in 4 plants (35K Peak)
  - 4 Million Gallon/36,000 ton-hr TES Tank
- 6 miles of distribution tunnels
- 99.9998% reliability over last 35 Years



Effects of Utility Improvements on Carbon Emissions



Typical US Business Models

- **Private, utility subsidiary (IOU)**
  - **Non-regulated, competitive market, long term user agreements, non-exclusive franchise**
- **Private, non-profit or Cooperative**
  - **St. Paul, MN; Rochester, NY, etc**
- **Public, Municipal utility**
  - **OUCooling (Orlando), Duluth Steam, etc**
- **Private, special purpose entity (ESCO)**
- **Hybrid Public/Private Partnership**
  - **Assets owned by agency, managed 3d party**

Role of Local Government

- Catalyst for early stage feasibility study; market development effort up to RFQ/RFP
- Anchor Customer – essential for early project phase
- Owner/Developer through Municipal Utility
- Sponsor/Issuer of Economic Development Bonds or tax exempt financing
- Provide franchise agreement; right of way
- Establish Business Improvement District and encourage system interconnection

Key Success Drivers/Best Practice

- Lead/lag on capital investment for system
- Realistic load growth planning; market intelligence (age of bldg systems, etc)
- Variance installed vs contract capacity
- Focused business development champion
- Nodal approach to network; hydraulics
- Transparent hurdle rate analysis
- Capitalize all connection costs
- Compete on life cycle “value”

Customer Connections

- Provider must analyze HVAC system integration; optimize interconnection (^T)
- Cooling system performance; controls; tenant configurations; space uses
- Reclaim valuable space; vault; capacity
- Exterior routing; interior equipment (heat exchanger; pumps; valves; metering, etc)

Thank you for your attention. Questions?

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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