District Energy and Combined Heat & Power: Local Solution, Global Benefits

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Agenda

• Overview U.S. industry
• Review technologies - district heating, district cooling, combined heat & power
• Efficiency, economic and environmental advantages
• Development and policy trends
• Global case – Heat Plan Denmark
District Energy = Thermal Energy Networks

• In most major US cities, campuses

• District heating –
  – Steam, hot water (usable energy) piped to customer buildings
  – Heat supplied to slow heat loss in space; dhw
  – Metered volume/rate in Btu’s “supplied”

• District cooling –
  – Chilled water supply (40 deg F) & return (54 deg F) absorbs heat from building space
  – Space (air) conditioning; process cooling
  – Metered volume/rate in Btu’s “rejected”
# US District Energy Industry Capacity

<table>
<thead>
<tr>
<th>Systems Reporting</th>
<th>Gross SF Customer Building Space Served</th>
<th>Heating Capacity (MMBtu/Hr)</th>
<th>Cooling Capacity (Tons)</th>
<th>Electricity Generation (CHP Mwe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtown Utilities</td>
<td>85</td>
<td>1,898,037,560</td>
<td>49,239,000</td>
<td>1,082,355</td>
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<tr>
<td>Campus Energy Systems</td>
<td>330</td>
<td>2,489,216,071</td>
<td>82,107,191</td>
<td>1,855,546</td>
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* 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 - 467,686,922 SF
(Annual average 24.6 Million SF/Yr – North America)

Commercial, Government, Events
Residential, Hospitality, Healthcare

District Energy – Community Scale Heating and Cooling

• Underground network of pipes “combines” heating and cooling requirements of multiple buildings
• Customer diversity aids economics; efficiency
• Creates a “market” for valuable thermal energy
• Aggregated thermal loads creates scale to apply technologies not feasible on single-building basis
• Fuel flexibility = energy security
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)

New District Cooling Systems in North America

1960s
- City, Calif.
- Hartford, Conn.
- Los Angeles, Calif.
- Omaha, Neb.
- Pittsburgh, Pa.
- San Antonio, Texas
- Waukegan, Ill.

1970s
- Brookline, Mass.
- Commerce City, Colo.
- Minneapolis, Minn.
- Nashville, Tenn.
- Oklahoma City, Okla.
- San Diego, Calif.
- Toledo, Ohio

1980s
- Dodge County, Ill.
- Nassau County, N.Y.
- New Haven, Conn.
- Trenton, N.J.

2000s
- Austin, Texas
- Detroit, Mich.
- Las Vegas, Nev.
- Mayhew, Ont.
- Montreal, Que.
- Caribou
- New Orleans, La.
- Orlando, Fla.
- Phoenix, Ariz.
- St. John's, N.B.
- Canada
- Tampa, Fla.
- Washington, D.C.
• 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

District Cooling Plant

<table>
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<tr>
<th>Multiple Chillers</th>
<th>Ice/CHW Storage</th>
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Cooling Tower Eliminated

Water, Chemical Use Reduced

Electricity Kwh Reduced 20%; KwD Cut 50%

"Overtime" A.C. Easier

Chillers/CFCs Eliminated

Electrical Vault Size Reduced; Capacity Re-use

District Cooling Customer

Electric Demand Profile

1994 - Before District Cooling

1995 - After District Cooling

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.
Customer Cooling Requirements
On-Site Installed Chiller Capacity vs. District Cooling System
Contract Capacity
(Annual Peak)

On-Site Design
Actual Results

A - Built 1988
315,000 sq. ft.

B - Built 1982
504,000 sq. ft.

C - Built 1986
946,000 sq. ft.

Higher Value Buildings

Without District Energy
With District Energy
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)
- Facilitates Collection/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

District Energy/CHP = Fuel flexibility plus emissions reductions

District Energy/CHP = Grid relief
**Energy-Efficiency Comparison**

**Standard Power Plant**
- 60% "Waste" heat rejected to environment
- 40% Useful energy produced for electricity

**District Energy/Combined Heat and Power Plant**
- 20% "Waste" heat rejected to environment
- 40% Useful energy produced for heating and/or cooling via district energy system
- 40% Useful energy produced for electricity

100% Fuel Input
CHP Cuts GHG Emissions

• CHP uses excess heat; often reaching total fuel efficiencies above 70% - up to 90%
  – Displaces other fossil fuel combustion for thermal heating/process (boilers; etc)
• Heat is generated for thermal load (primary) and electricity is byproduct
  – Displaces less efficient electricity from local generation fleet
• Heat–based chilling or chilled water shifts load from wires and avoids peak demand
  – Displaces least efficient generation; reduces brownouts; cuts sources of smog, etc
Wasted Energy Is a Huge Challenge and Opportunity

Energy Flows in the Global Electricity System

2/3 of the fuel we use to produce power is wasted --
CHP can more than double this efficiency

District Energy Networks Facilitate Recovery and Use of Surplus Heat

Warm Water Vapor Exhaust = Heat Recovery Opportunities
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

Low Carbon Energy Plan for London
IPCC Recommendations

“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.”

District Energy/CHP Policy Drivers
The global average is just 9%

Danish Experience - Energy Policy

- In 1973, First Oil Embargo crippled Danish economy, importing nearly 90% foreign oil
- Moratorium – no driving on Sundays; fuel rationing; thermostats reset; conservation
- Electricity Supply Act of 1976
  - All utility power generation MUST recover useful heat
- Heat Supply Act of 1979
  - Build district heating networks
  - Integrate municipal waste to energy heat supply
  - Municipal heat planning/natural gas infrastructure
  - Tax policies on fossil fuels to fund infrastructure
The Denmark Story: II

Denmark’s cities said “Yes, in my backyard!”
Heating Transmission Systems
Denmark’s Win-Win-Win Approach

- Enhanced energy security
- Reduced GHG emissions
- Use of local resources


CHP share of DH and Power

Source: Danish Energy Authority
District Heating and RE
- Composition of Fuels for District Heating Production

Source: Danish Energy Authority

National Energy Account

Source: Danish Energy Authority
Denmark in Numbers
- GDP, CO₂ and Energy Consumption

Index 1980 = 100

US Federal Energy & Climate Policy Initiatives

- Thermal Renewable Energy and Efficiency Act (TREEA)
  - Production tax credits for thermal energy derived from renewable or recycled sources
  - Expand tax exempt financing to include district energy plant as well as distribution piping
  - Amend authorization for Title 471 in EISA 2007 and provide appropriation
  - Expand availability of federal loan guarantees to include production and distribution of recycled and renewable thermal energy
Sample State Policies & Legislation

New Jersey Cogeneration Act – December 2009

• Provides a sales and use tax exemption for the purchase of natural gas and utility service used for co-generation
• If the end use customer is purchasing thermal energy services produced by the on-site generation facility, for use for heating, air conditioning, or both, regardless of any intervening property, public thoroughfare, or transportation or utility-owned right-of-way;
• The electric public utility having franchise rights within the geographical area involved shall provide electric delivery services at the standard prevailing tariff rate that is normally applicable to the individual end use thermal customer.

FERC Ruling – Cornell University CHP – February 2010

• The ruling clarifies that the existence of a competitive electric market is not sufficient to deny new QF cogeneration facilities the opportunity to have power purchase agreements.
• Simplified - Because Cornell “must” provide thermal energy, not eligible for competitive power market and therefore incumbent utilities must continue to purchase power under PURPA
Thank you for your attention

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Appendix

• Please visit www.districtenergy.org for more details

District Energy Development Policy Footnotes

• http://193.88.185.141/Graphics/Publikationer/Forsyning_UK/Heat_supply_in_Denmark/html/chapter03.htm
• http://193.88.185.141/Graphics/Publikationer/Forsyning_UK/Heat_supply_in_Denmark/html/chapter09.htm
• http://www.enr-network.org/danish-energy-authority.html
• www.seattle.gov/environment/documents/GBTF_NewBldg_Vancouver_Heating_Case_Study.pdf
• www.london-first.co.uk/documents/Powering_ahead_DE_report.pdf
• www.londonheatmap.org.uk/Mapping/
• www.pitchengine.com/internationaldistrictenergyassociation/why-waste-the-heat/37592
Thermal Energy Production Tax Credits

Background
• The Internal Revenue Code (U.S.C. 26 Section 45) provides a Production Tax Credit (PTC) for generation of electricity using certain renewable resources. Wind, geothermal, and “closed-loop” bio-energy (which is powered by dedicated energy crops) are eligible for PTC of 2.1 cents per kilowatt-hour (kWh) of electricity produced. Other technologies, such as “open-loop” biomass, incremental hydropower, small irrigation systems, landfill gas, and municipal solid waste, receive 1.1 cents per kWh.

What the Act Does
• The Act expands the PTC to production of renewable thermal energy.

Rationale
• By limiting PTCs to electricity only, we are significantly limiting our ability to shift to a low-carbon sustainable future. There are substantial opportunities to expand the use of renewable resources to meet thermal energy needs (space heating, air conditioning, domestic hot water, and process heating and cooling). There is support for this concept. For example, renewable thermal energy production tax credits were included in S. 1370, the Clean Energy Investment Assurance Act of 2007, sponsored by Senators Maria Cantwell, D-Wash.; John Kerry, D-Mass.; and Gordon Smith, R-Ore. A renewable thermal energy PTC would provide an extremely important incentive to invest in these systems, accelerating our Nation’s transition to a low-carbon future.

Expansion of Tax Exempt Bonding

Background
• The Internal Revenue Code (U.S.C. 26 Section 142) provides for Exempt Facility Bonds for financing a range of facilities with public benefits, including airports, facilities for the furnishing of water, electric energy or gas, and “local district heating or cooling facilities” (defined as “a pipeline or network (which may be connected to a heating or cooling source) providing hot water, chilled water, or steam to 2 or more users for residential, commercial, or industrial heating or cooling, or process steam.”)

What the Act Does
• The Act enables tax exempt bonds to be used for financing district energy plant and building connection assets as well as distribution piping.

Rationale
• The capital costs of district energy systems include not only the piping distribution systems but also the plant facilities for producing thermal energy and the equipment for transferring thermal energy to building heating and cooling systems. Potential plant investments provide key opportunities for increased efficiency, use of renewable energy and reduced carbon emissions. By reducing interest costs, tax exempt financing reduces debt service costs and thus stimulates increased application of these low-carbon systems and the public benefits they provide.
## Energy Sustainability and Efficiency Grants for Institutions

### Background
- The Energy Independence and Security Act of 2007 (EISA) authorized the Energy Sustainability and Efficiency Grants for Institutions program. In conjunction with efforts to appropriate funds, TREEA would amend the authorization to eliminate constraints that impair the effectiveness of the program.

### What the Act Does
- Raises the cap on the program's grants to $20,000,000 (while increasing the local cost-share requirement from 40% to 70%);
- Increases caps on technical assistance grants (while retaining local cost-share requirements);
- Increases authorized annual funding for the grant program to $500,000,000;
- Extends program eligibility to not-for-profit district energy systems; and
- Extends the time period of the grant and loan program through FY 2015.

### Rationale
- The increase in the cap will enable grants to larger projects with greater efficiency gains, and the increase in authorized funding will result in an increased number of beneficial projects. These increases are consistent with the characteristics of projects submitted in response to a DOE solicitation using $156 million in ARRA funds. In this solicitation, which was oversubscribed by a 25:1 ratio, the maximum requested federal share was $60 million, with an average of over $10 million. The time extension will allow Congress to appropriate funds to this program—which remains to be done. These changes will expand the ability of this program to reduce GHG emissions, create jobs, increase grid reliability, and enhance energy security.

## State Policy & Legislation

### New Jersey Cogeneration Act
- Provides a sales and use tax exemption for the purchase of natural gas and utility service used for co-generation
- If the end use customer is purchasing thermal energy services produced by the on-site generation facility, for use for heating, air conditioning, or both, regardless of any intervening property, public thoroughfare, or transportation or utility-owned right-of-way;
- To avoid duplication of required electrical infrastructure and to maximize economic efficiency and electrical safety, the delivery of electric power from an on-site generation facility to an end use customer's property that is not geographically located next to the facility, or is otherwise separated from the facility by an easement, public thoroughfare, transportation or utility-owned right-of-way, shall utilize existing locally franchised public utility electric distribution infrastructure.
- The electric public utility having franchise rights within the geographical area involved shall provide electric delivery services at the standard prevailing tariff rate that is normally applicable to the individual end use thermal customer.
FERC Ruling Cornell CHP, February 2010

- The ruling clarifies that the existence of a competitive electric market is not sufficient to deny new QF cogeneration facilities the opportunity to have power purchase agreements.
- More specifically, FERC recently ruled that two utilities must maintain their requirement under the Public Utility Regulatory Policies Act of 1978 (PURPA) to enter into new power purchase obligations or contracts with Cornell University regarding the excess electricity generated by its CHP/cogeneration facility.
- Under section 210(m) of PURPA, utilities are permitted to terminate mandatory power purchase obligations to qualifying facilities if certain conditions are met. The NYSE&G and RG&E request to cancel the aforementioned obligation was denied because the electricity generated from Cornell’s large QF-certified cogeneration facility is tied to its thermal (steam) output; an output that varies considerably depending on weather conditions and therefore out of Cornell's control.
- This variability limits the cogeneration facility’s ability to consistently meet participation requirements in the New York Independent System Operator, Inc (NYISO) wholesale electric market, such as sales in auction-based, day-ahead and real-time markets. Therefore, incumbent utilities required to purchase excess power (PURPA)

The Denmark Heat Supply Act

1. (1) The objectives of this Act are to promote the most socio-economical and environmentally-friendly utilization of energy for heating buildings and supplying them with hot water and to reduce the dependence of the energy system on oil. (2) In agreement with the objectives mentioned in subsection (1), the supply of heating shall be organized with a view to promoting the highest possible degree of cogeneration of heat and power.
- 2. (1) For the purposes of this Act, collective heat-supply plant indicates any undertaking that operates the following plants with the object of generating energy for heating buildings and supplying them with hot water:
  - plants for transmitting natural gas as well as plants for producing and transmitting other inflammable gasses;
  - plants for transmitting heated water or steam from combined heat and power plants, waste-incineration plants, industrial enterprises, geothermal installations, etc.;
  - district-heating supply plants, waste-incineration plants, etc., including combined heat and power plants with an electric capacity not greater than 25 MW;
  - block-heating stations with a generating capacity exceeding 0.25 MW including combined heat and power centres with an electric capacity not greater than 25 MW.
- (2) Excepting heat and power plants with an electric capacity not greater than 25 MW, the collective heat supply plants referred to in subsection (1) do not include undertakings regulated by the Act on the Supply of Natural Gas, the Act on the Exploitation of Danish Minerals or the Act on Electricity Supply.

- http://www.energy.rochester.edu/dk/hsa.htm