District Energy Systems

Week 7

7LYM30
Building performance and energy systems simulation

Where innovation starts
District Energy Systems

District energy systems have the goal of connecting local resources to local needs in order to build up a sustainable energy system.

HEATING (or/and COOLING)    DHW    (Electricity)
• District Energy Systems. Main parts

DISTRIBUTION

GENERATION/SOURCE

STORAGE

DEMAND
Origins of District Heating systems

Wooden pipes for distribution
Source: http://www.sewerhistory.org/

First documented DHS
14th century, Chaudes Aigues, France;
Hot spring water
Distribute hot water for bath;

Birdsill Holly and his boiler plant
Source: Alexis Madrigal

First commercial (patented) DHS
1877, Lockport, New York, U.S.;
Bring DHS to business;
Centralized boiler.
Evolution of DHS

- Low energy demands; low temp. DH network
- Smart energy; integrate in smart cities
- Multiple choices of thermal sources;
- Two-way DH;

• From the single Building to the District approach
• From the single Building to the District approach
• From the single Building to the District approach
• From the single Building to the District approach by 2020 nZEB
73% of the population in cities, 80% by 2030.

69% of the total primary energy demand is concentrated in urban areas.
• Is it the best approach then?
• From the single Building to the District approach
• District Energy Systems. Main parts

- DISTRIBUTION
- GENERATION/SOURCE
- STORAGE
- DEMAND
Current district heating systems in EU27

• What is district energy system?
Generation/Source for D.E.S.

- Municipal solid waste, waste oil, animal waste
- Sawdust, hog fuel, sawmill residue

- Flue gas, industrial and commercial waste heat
- Anaerobic digestion, sewage and animal effluent, landfill gas

- Solar thermal, geoxchange, geothermal
- Wood chips, surface water, straw, switchgrass, fuel crops

- Heat pumps, wood pellets, biodiesel, renewable natural gas,
  Hydrogen

- Syngas, natural gas, oil, coal
- Peat

Generation technology

Waste Heat Recovery
• May not be able to guarantee supply
• Require backup boilers
• Increases the energy efficiency of a city

Solar Thermal Plant
• Require significant land
• Backup/peak load source is require
• Free energy source
Generation technology

CHP
- Best used in combination with boilers and storage
- for baseload generation

Geothermal
- Favorable to supply baseload
- Potential uncertainty of resource available until wells drilled
- Cheap running costs and “fuel” for free
Heat demand in DES

Buildings

Industrial Sector

Space Heating

DHW, > 55 °C

Heating demand in DES

Other heating demand

Street Heating

Greenhouses

Football Arenas
Cooling demand

- Space Cooling for buildings

- Cooling in data center

Source: Aqua Chill Systems India Pvt. Ltd.

Source: Fortum Värme
Source: UNEP (2015). District energy in cities
PROS

- Fuel flexibility
- Energy Efficiency (Heat+Electricity)
- Ease of Operation/Maintenance
- Reliability
- Lower Life-cycle Costs
- Lower Building capital costs
- Architectural design flexibility

CONS

- Long-term investment
- Not attractive for low population-densities/Low heating demands
- Environmental impact?

DES Overview video ➔ [https://youtu.be/H3ef6dz8BGg](https://youtu.be/H3ef6dz8BGg)
• Energy system (From primary energy to demand)

The integration allows **optimizing** energy efficiency and exploiting **local available sources** (e.g. renewables, waste heat).
Distribution

• DH: steam, hot water 70 °C ~95 °C
• DC:
  • Conventional chilled water temperatures: 4 °C - 7 °C
  • Ice water systems: 1°C
  • Ice slurry systems: -1°C
Current status of district cooling systems in Europe

Source: Euroheat & Power. Possibilities with more district cooling in Europe. [Report]
Examples of District Energy Systems
100% renewable district heating, Marstal, Denmark

Provide DH to 1,500 current consumers:
- Solar thermal - 55%
- Local biomass - 45%

Source: PlanEnergi
Gothenburg - Flexibility in Fuel Supply

The district heating system began being built back in the 1950s, and today it is over 1,300 km long. Gothenburg is basing 60% of its district heating on waste/recycled heat including from industries, waste incineration and waste water treatment. Currently 90% of all buildings are heated using district heating.
Stockholm - District cooling system

Cooling production heat pumps  Heat exchanger substation

Source: Capital Cooling Europe AB.
SeASONAL THERMAL STORAGE SYSTEM COMBINING SOLAR THERMAL AND INDUSTRIAL WASTE HEAT, CHIFENG, CHINA

Heat storage: 10600GJ/year
Area of solar collector: 3300 m²
TU/e campus – ATES district

- 36 Wells
- 6 Clusters
- 2 Rings
- 25MW capacity
- 30GWh maximum energy delivery (cold and heat each)
Imbalance Heating/Cooling

Heat & Cold extraction

Energy [MWh thermal]

2003 2004 2005 2006 2007 2008 2009 2010 2011

Heat extraction CT
Heat use
Cold use

Imbalance Heating/Cooling

CT 30%
Heat 21%