MAXIMUM UTILITY OF WASTE INCINERATION BY FLEXIBLE DISTRICT HEATING SYSTEM

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1. History of waste incineration and district heating in Denmark - Few important milestones.

1897-1903. Impossible to find areas for landfills inside the boundaries of the municipality of Frederiksberg. Construction of a new hospital. Utilise surplus heat from a waste incineration plant and supply the new hospital with power, steam and hot water. The first CHP plant went into operation in September 1903.

1903-1914. The first steps to construct a DH system in the centre of Copenhagen was taken just after 1903. The customers were hospitals and public baths. Heat production was based on CHP.

1914-1918. German submarine boycott in 1917 results in ration of coal. CHP plants forced to make a fuel shift from coal to Danish lignite. Citizens supplied with DH were not hit by the boycott as hard as citizens using coal or coke for heating.

1918-1940. Steam accumulator taken into operation in 1931-32. During night-time the steam could be stored as condensate under high pressure. In the morning the condensate could be re-evaporated into steam and sent into the turbines for covering the power demand in the morning peak. A new CHP back pressure unit was taken into operation in 1934 (45 bars, 4000C). Back pressure steams delivered to DH consumers in wintertime. In summertime the steam was utilised for power production at the low pressure turbine. Three Incineration Plants Supply District Heating at 1940.

1940-1945. Buying coal and oil from normal suppliers were not possible. Domestic production of lignite and coke started. Fly ash – deposited earlier – was dug up, to utilise the small amounts of coal found in it. Deposits of waste oil and tar were used at the CHP plants.
Tar from cleaned gas pipelines was utilised. Again – like in 1917 - citizens supplied with DH were not hit as hard as citizens using coal or coke for heating.

1945-1973. “Period of other business”. Limited focus on security of supplies and energy savings. Still, DH pipe networks are extended, and DH industry developed.

1973-1979. War in the Middle East results in increased oil prices in 1973.
Oil supplies to Denmark are reduced. About 92 % of the gross energy consumption is based on imported oil. In 1979, the first Heat Act in the world with focus on:

- Energy supply system based on different fuels.
- Improving the reliability of energy and fuel supply.
- Increasing the overall energy efficiency.

1980-2005. From 1980 to 2005, number of dwellings connected to dh network more than double, and in the same period, share of renewable (etc.) energy in DH increases from 15% to 45%,

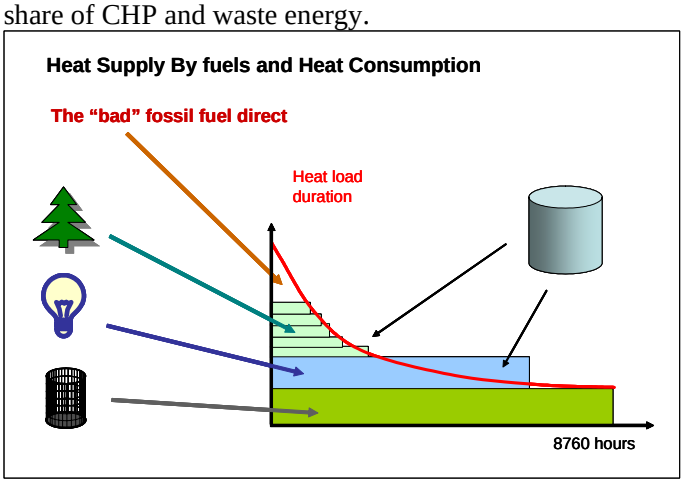
(including waste heat). Other forms are coal, natural gas and oil, but big part of these is combusted in CHP resulting in DH fuel efficiency of 2-300% (relative to the reference as the pure condensation operation of a power plant).

From 1997 all burnable waste must be incinerated in proper plants according to law.

2. Situation today in Denmark.

2008. Today less than 10% of the waste is deposited, minimum for Europe, and all burnable waste is incinerated. Denmark has highest rate of incineration of waste pr capita in Europe, more than 600 kg/y/capita. Most of the incinerated heat is utilized for district heating and electricity production. Today DH supplies more than 60% of the dwellings. About 30 waste incineration plants (consisting of more than 60 incineration units) supply heat to the district heating networks, reducing the fuel consumption of DH dramatically. Nearly all cities with more than 50.000 inhabitants and many/most cities with more than 30.000 inhabitants do have DH network with waste incineration plant. During the last 30 years the number of incineration plants has fallen from 50 to 30 due to more restrictive environmental legislation etc., making big advanced incineration units most economical. All medium and bigger incineration units are provided with a steam turbine for electricity production, and few units are additionally provided with a gas turbine, for more effective combined cycle operation. With increasing gas prices, the economics of this principle though is unclear, and they are mostly used for peak load.

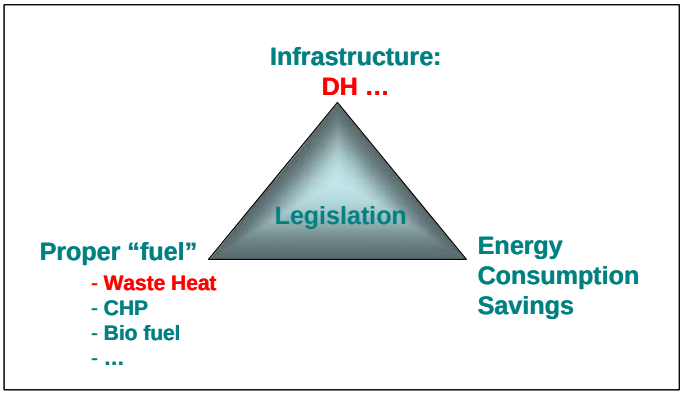
The heat from waste incineration normally has highest priority of all heat sources supplying to the DH pipe network. In very rough numbers, it is typical that waste heat supplies 10%-20% of the design heat rate (MW) of the DH network, which can cover about 50-70% of the heat energy (MWh) according to the Danish conditions. It typically covers all pipe losses as well as hot tap water consumption the whole year, and more or less the room heating during spring and autumn in the smaller cities. In the smaller cities, some cooling takes place during the summer. Classification of waste is steadily being developed, which is not only important for recycling, but also for load flexibility as it is not feasible to store standard household for long. More classification makes it possible to minimize incineration during summer time, and store some of the waste for wintertime, Thus more waste heat can be utilised saving fuel. Furthermore heat accumulators increase the utility share of CHP and waste energy.



Recent years growth has increased the rate of waste, and therefore the "cheap" waste incineration heated DH pipe systems are steadily taking over neighbouring gas heating networks! The economy in waste heated DH system is often so good, that it covers to buy the gas network and put it down and construct at district heating network. In a way this is a race against time, as gas prices are expected to rice during next 50 years (which is the time horizon of DH system) and total dependency on gas is very dangerous. On the contrary the district heating pipe network can operate on all fuels – also gas fired CHP in periods with cheap gas.

3. DH Infrastructure, renewables / waste incineration, and energy consumption savings go hand in hand

The most effective way to save fuel and CO2, and increase supply reliability, is to develop all three fields in parallel. This has reduced need for fossil fuels for energy supply in Denmark dramatically.



Triangle of success.