Part II:

Reduction of Electric Energy Consumption and Peek Power by DC compared to Conventional Local Cooling Plants

By

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2. Electric Energy Consumption and Peek Power by District Cooling compared to conventional local Cooling Plants (Part II)

It is commonly known that the peek power on the electricity grid in modern cities in warmer climate normally occurs in the summer time when small, electric driven, cooling equipment and smaller local cooling plants are running for air conditioning of residential and commercial buildings.

One of the reasons for this is that smaller cooling equipment has a low ratio between the cooling output and the electricity input to the cooling compressor.

We may use some of the simulation results from Part 1 to exemplify in broad terms how district cooling plants will reduce electric energy consumption and peek power by District Cooling (DC) compared to conventional local cooling plants.

2.1 Efficiency of cooling plants

Figure 2.1 shows, compared to a Carnot process, how the efficiency increases with increased size of the compressor (i.e. increased cooling plants) for an average cooling system.

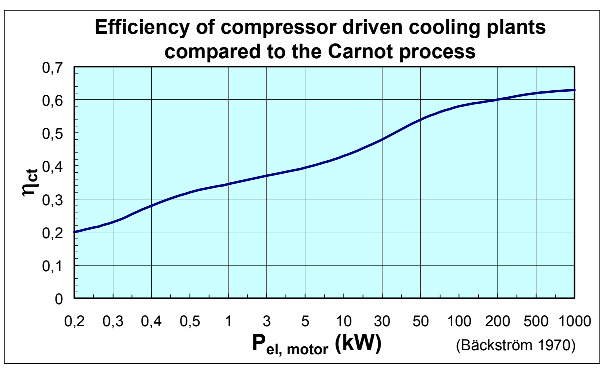

Figure 2.1

Some systems might be more efficient and some might be poorer than shown in fig. 2.1.

2.2 The effect of DC in office buildings

We choose here to use the results from Oberhausen shown in the figures 1.5 and 1.10 for office buildings.
For a cooling plant in an office building with a total maximum cooling load of ~50 kW, a chilled water system with two compressors, each with a cooling capacity of 25 kW, would be a fairly common choice.

Using a sprayed coil cooling tower, with outside air as the cooling source for the condenser, it is assumed that the cooling process should be working in the range of 5 ^{o}C in the evaporator and in the range of 35 ^{o}C in the condenser as the typical situation.

These conditions will, according to figure 2.1, give an efficiency factor, $\eta_{ct,}$ in the range of 0,42.

Then we will have the following Coefficient Of Performance (COP) for the cooling process:

$$COP_c = \eta_{ct} \cdot \frac{273+5}{35-5} = 0{,}42 \cdot 9{,}3 = \underline{3{,}9}$$

With this conditions the peek power of the two electric motors for the two compressors will be:

$$P_{el,peek} = 2 \cdot \frac{25}{3{,}9} \sim \underline{13kW}$$

This will be the peek electric power for the cooling production for the single “standard” office building.

Assuming that the office building would be connected to a DC-system, and assuming that the working conditions for the compressors would be similar, the efficiency factor, $\eta_{ct,}$ will be in the range of 0,6 or higher already with ten “standard” buildings connected to the district cooling system.

The COP_c will then at least be in the range of 5,6 or higher and the peek power for one building will be:

$$P_{el,peek} = \frac{50}{5{,}6} \sim \underline{9kW}$$

The seasonal electric energy efficiency will be somewhat different from the figures of η_{ct} used here, but for relative comparison of the yearly energy efficiency of different plant sizes this will be of minor importance. We should also bear in mind here that the seasonal electric energy efficiency tends to be relatively higher when the size of the plant increases.

2.3 The effect of DC in residential buildings

We choose also here to use the results from Oberhausen shown in the figures 1.19 and 1.24 for residential buildings.

For the residential building 2-4 wall or window mounted split units, with air cooling of the evaporator and the condenser, would be a common choice of equipment for the indoor air cooling.

We may assume here that the typical temperatures in the evaporator and the condenser would be in the range of 15 ^oC and 40 ^oC respectively. With these conditions, and assuming tree units in each flat, we will have an efficiency factor, $\eta_{ct,}$ in the range of 0,33.

Then we will have the following Coefficient Of Performance (COP) for the cooling process:

$$COP_c = \eta_{ct} \cdot \frac{273+10}{40-10} \sim 0{,}33 \cdot 9{,}5 = \underline{3{,}2}$$

With this conditions the peek power of the electric motors for the tree compressors will be:

$$P_{el,peek} = 3 \cdot \frac{1{,}7}{3{,}2} \sim \underline{1{,}6kW}$$

If the flat was connected to the same DC-system as in the example under point 2.2, the COP_c will be in the range of at least 5,6 and the peek power for one building will be:

$$P_{el,peek} = \frac{5{,}2}{5{,}6} \sim \underline{0{,}9kW}$$

The seasonal electric energy efficiency will also in this case be somewhat different than the figures of η_{ct}, but for relative comparison of the yearly energy efficiency of different plant sizes this will be of minor importance.

We also here have to bear in mind that the seasonal electric energy efficiency tends to be relatively higher when the size of the plant increases.

2.3 Some conclusions to Part II

- When drawing conclusions from these examples, we have to notice that a lot of different factors will have some influence on the results from case to case.

In spite of that, the effect of the plant size on the efficiency is so significant, that we are here talking about an effect of different magnitude compared to other effects that might have some influence in this context when the other conditions are kept equal.

- The calculations done here for the office buildings show that; The yearly electric energy consumption and the peek power could be reduced in the range of 30 % or higher by DC compared to conventional local cooling plants.

- The calculations done for the residential buildings show that; The yearly electric energy consumption and peek power could be reduced in the range of 45 % or higher by DC compared to local, conventional wall or window mounted cooling equipment in the flat.

- When presenting these comparisons, we have to mention that a DC-system will need some electric power for the pumping of the water in the DC pipelines. This need of electricity will however be comparatively small and in another magnitude than the figures we are comparing here.

- The fan power for the cooling equipment in the rooms should also be mentioned. This power need should normally be the same or less by DC-systems than for the systems we have compared in this context.

- We also have to mention that the potential cooling loss from the pipelines throughout the year is neglected in this comparison. This potential loss will be very much depending of the lying of the piping system.

When the pipelines is laid directly in the soil the water temperature in the pipelines normally will be in the same range as the soil temperature or even below the soil temperature on the average.