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Category: Expansion

INNOVATIVE DISTRICT COOLING CYCLE NETWORK IN VÄXJÖ

APPLICATION WRITERS: LANDER, DAVID & NIELSEN SOFIE

Summary

The district cooling (DC) network in Växjö is designed in order to increase the efficiency and be able to control the production in an economical beneficial way.

Växjö Energi AB (VEAB) is using DC return temperature for cooling two computer server centers and heating a football stadium. Furthermore, a new innovative system is developed for the DC network. To make the system even more efficient and environmental friendly, and utilize the already produced energy even more in the cooling recycling system.

There are two DC production plants in Växjö located on different sides of the city, namely at Sandviksverket (SVV) and Västra Mark (VM). The DC plant at SVV consist of absorption cooling, free cooling from the ambient air via air-cooled liquid chillers and an accumulator to store cooling, while the one at VM is based on compressor chillers and free cooling via cooling towers. In total the two production plants have a total capacity of 11.5 MW, excluding the free cooling of 2.9 MW, which is one way of utilizing cold air for cooling.

The two existing DC networks in Växjö have been connected in order to increase the renewable energy sources (RES) production and increase the amount of waste heat used in the system. The district heating (DH) network and the DC network are integrated via the absorption cooling machines (ABS) at SVV, providing the possibility to produce chilled water utilizing heat when the electricity price is high. During hours with low electricity rates the chilled water can be produced in the compressor chiller (CC) machines at VM. In addition, this affect the electricity grid, since it is possible to change the amount of electricity being produced or consumed in the grid.

The DC network in Växjö is developed to be flexible, energy efficient and with high availability. The construction of the DC system provides a versatile production strategy and enables more potential customers to connect to the grid. VEAB recommend other DC producing companies to have different production techniques integrated in one DC network, which enable control of the production technique with respect to the electric price. Additional recommendation is to look for more opportunities of using DC return and the same energy in order to get a stable return temperature.

VEAB
VÄXJÖ ENERGI

Background
Växjö Energi AB (VEAB) has developed the district cooling (DC) network in Växjö to become highly flexible, energy efficient and to have high availability. After the DC network was fully integrated, the system became more efficient, environmental friendly and economically beneficial. This by having two production plants, with different techniques for the production of chilled water, one at Sandviksverket (SVV) and another at Västra Mark (VM), however, peak-loads and reserve production do sometimes still takes place in the local establishments. The current DC system makes it possible to use a flexible production strategy and enables more potential customers to connect to the grid, due to DC pipes are available through the city. VEAB is continuously looking at new possible ways to expand the system and utilize return temperature of DC and use the same energy in more steps. Moreover, find new ways of utilize the return DC in order to get a larger temperature difference, cool down or heat up.

System history
The DC network in Växjö was introduced in 2010. Historically, many types of researches have been done related to the DC network in Växjö, and many alternatives of finding sources for free cooling have been studied. However, the alternatives did mostly get a negative result, due to an economical aspects and/or some complications related to the temperatures in the lakes, since the depth of the lakes considered were insufficient. Currently, the DC network is utilizing free cooling from the lake Växjösjön during the winter season, which is located in the center of Växjö.

The DC pipes was sized with a larger dimension from the beginning of the development of the system, until 2011. However, after 2011, the DC network was started to be built with smaller dimension on the pipes due to the demand was lower than expected and this related to new building areas. Moreover, supplied capacity was expected to be much higher in the beginning than today's calculations and the estimation for the future. Different types of estimations and calculations regarding the supplied energy was made during the start of the DC business.

From the beginning there was two separated DC networks in Växjö, one that operating from SVV, which supplied the area around SVV, and another at VM that cover the sounding area. The DC production plant at VM, located at Arenastaden in Växjö, went into operation in the spring of 2012. The production plant at VM shares the building together with VEAB's subsidiary Wextnet´s data center (Green Data Center). Green Data Center (GDC) was opened and connected to the DC return in 2012. Green operation center (GOP), another computer server center, was connected to the DC return in 2017. And the football stadium was connected to the cooling (heat) return in 2015.

In 2015, the two existing DC networks in Växjö was connected in order to increase the renewable energy sources (RES) production and increase the amount of waste heat used in the system being utilized. The initial plan with the DC integration of network development was to produce as much cooling as possible by the ABS at SVV and the goal was to only use VM to cover the peak loads. The district heating (DH) network and the DC network are integrated via the absorption cooling machines (ABS) at SVV, providing the possibility to produce chilled water utilizing heat when the electricity price is high. During hours with low electricity rates the chilled water can be produced in the compressor chiller (CC) machines at VM.

Supply flow temperature is primarily +6°C, while the return temperature is minimum +16°C and during winter season minimum +13°C. Stated flow temperature relates to the design outdoor temperature. A lower return temperature than specified above can be okay if the supplier has approved the temperature. The specified return temperature can otherwise not be lower at any operating conditions, moreover, the specified return temperature is the minimum value that need to be followed under all circumstances for operation conditions.

Configuration of production units

The two production plants for chilled water holds a total production capacity of about 12 MW, with additional backup capacity of 3.6 MW. The table shown below visualize the production capacity available to be distributed in Växjö.

Production capacity at Sandviksverket & Västra mark	**Total capacity available**
Absorption cooling machines + Accumulator (SVV)	4 MW + 2 MW
Compressor cooling machines (VM)	5.5 MW
Free cooling exchanger (SVV+VM)	2.9 MW
Backup production capacity at the Hospital and Videum	**Total capacity available**
Compressor cooling machines	2 MW
Compressor cooling machine	0.37 MW
Free cooling exchanger	1.2 MW

Sandviksverket DC production plant

VEAB produce DC in an environmental friendly and energy efficient way, by using resources close to the production plant. Resources are retrieved from the nature, moreover, residual products from the forest around Växjö, such as wood chips, bark and sawdust, as well as logging residues such as branches and tops.

During the summer, VEAB is using energy from the forest to produce heat at the combined power and heating plant at Sandviksverket 2 and Sandviksverket 3. From the surplus of heat, which is not needed in the DH grid, VEAB produce DC. The DC at SVV is produced through two ABS machines, each with a capacity of 2 MW. Further, air-cooled liquid chillers produce free cooling with help of fans convectors. The fans pulls the cold air through exchangers' surfaces inside the air-cooled liquid chiller. Furthermore, during the summer air-cooled liquid chillers are remove low grade waste heat to cool down the ABS machines.

Figure 1. 144 fans on the top of the air-cooled liquid chiller at Sandviksverket in Växjö.

Usually, VEAB produce chilled water day and night, and during the night the cold water is stored in the accumulator tank. During the day customers' demand cooling and need to cool down their facilities or processes, the stored chilled water can then utilized. Providing the possibility for VEAB to cover demand peaks during the day, thereby running the cooling system and ABS in a more balanced and efficient way. When VEAB is producing more than the demand or more than is required to support the DC network, the overshoot produced can be stored in a large accumulator which accommodate 2000 m^3 cold water.

Figure 2. The Accumulator Tank at Sandviksverket in Växjö.

During the winter season, VEAB is using the low temperature of the out-door air and the cold water from the nearby lakes. The out-door air is used as free cooling with help of air-cooled liquid chillers.

The cold water in the lakes can be used because some distance of the pipes are placed in one or in both lakes. The lakes provides free cooling and no extra energy is needed to cool the DC water.

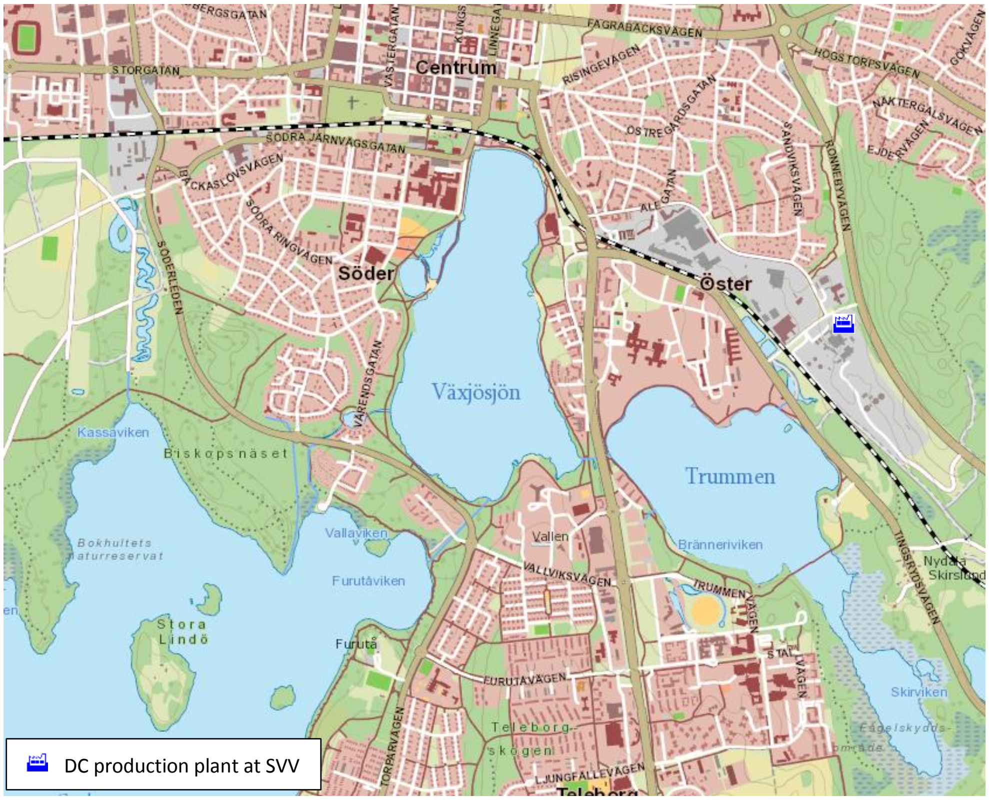

Figure 3. Visualizing the lakes Växjösjön and Trummen in which the DC pipes are located

Västra Mark DC production plant

The production plant at VM consist of four cooling machines, whereof two turbine compressor cooling machines (water-filled) and two air-cooled compressor-cooling machines. In total the machines have a capacity of 5.5 MW.

Further, the building has four cooling towers on the roof. The cooling towers produce free cooling, and with low wet out-door temperatures they can produce about 0.9 MW free cooling. However, during summer production at VM the cooling towers cool down the compressor cooling machines at VM. Further, the production plant, do also have PV-panels on the roof, which is visualized in figure 5. The PV-panels provide the compressor machines with electricity. When the electricity price is low, it is favorable to be able to use compressor cooling to provide the customers at Växjö with DC.

Distribution network

VEAB has a long distribution network for DC, starting at SVV, following the road and go down in the first lake, namely Trummen. In Trummen the grid is divided into two lines, one passing to the University of Växjö (Videum) and the other continuous through Trummen and into another lake, called Växjösjön. Further, the network is following the road and crossing the center of Växjö. The DC network is then following the road and continue all the way to VM.

In 2015, a distance of 2 200 meters, was added to the exiting DC system in Växjö, in order to connect and integrate two networks with each other.

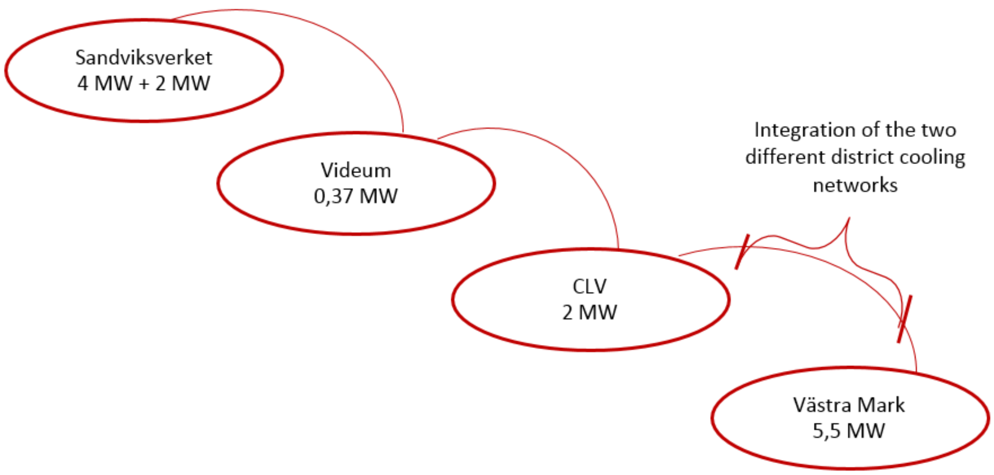

Figure 4. Visualization of the district cooling production network in Växjö (excluding the free cooling capacity).

The integration of the two different DC networks have generate a system solution that is much more flexible and efficient than prior the integration, from both a production and economic perspective. With the new system, VEAB is able to control how the system should be organized, in a strategic way. The strategic production plan is designed to produce DC from SVV or VM.

The integration of the two different production plants enables VEAB to have a flexible production for cooling, which means that if the electricity price is high, cooling is produced with the ABS cooling machines and more electricity is produced due to an increased heat demand in the turbine. When the price of electricity is low, cooling is instead produced by electricity compressor cooling machines at VM.

Recycling of energy is not as obvious as other things to recycle, such as plastics and glass. VEAB is creating a smart recycling system for DC, moreover, the same energy is used three times in one cycle-flow.

![VEAB Växjö Energi]

Figure 5. Innovative district cooling cycle network in Växjö

An innovative cooling system with an integrated piping system has been build, and through an intelligent flow the cycle contribute to an efficient way of transferring energy three times, utilizing it twice for cooling and once for heating. The process as illustrated in figure 4 is described in step by step below.

1. The feed temperature that reach shopping mall, Grand Samarkand, among others, is between 6 to 10°C, depending on season. Grand Samarkand is using cooling to create a comfortable indoor temperature for its visitors. The water temperature increases to about 12 to 14°C at the shopping mall. The water is therefore at a perfect temperature for cooling VEAB's subsidiary company Wextnet´s data center (Green Data Center and Green OPeration center), which is a central hub for all data-traffic in Wexnets network within the boundaries of Växjö city.

2. Wexnet use DC return water to cool down their computer centers. By implementing an innovative way of constructing the server room layout and the physical orientation of the servers, hot and cold “aisles” can be achieved in the data center. Allowing greater control of the air flow in the data center and thereby reducing the cooling needed and providing the benefit of recycling waste heat. Increasing the environmental gains of the system. After the water has cooled downed the servers at the Green Data Center the temperature has risen further, to an approximately 17-20°C.

   The computer centers have a combination of hot and cold aisles, making it possible to utilize heat from servers, which else would have been wasted. Furthermore, warm and cold aisles enable Wexnet to control the airflow. This type of solution is the opposite from how old computer centers was built, where the technique often was to have all rackerts in the same direction, which means that hot air from one rackert would be streaming on to a nearby racket. Further, the old technique requires a lot more cooling air.

3. As the DC network continues, the return water flows to its next destination, the football stadium at Myresjöhus Arena. Here, as the DC water releases heat to the pitch, the temperature of the water is decrease to 10°C. In this way, the playing and out-door training season for Östers IF can be extended. In the meantime VEAB able to take advantage of the additional heat from the data centers, which otherwise would had been wasted. Then the water returns to the cooling plant via distribution pumps, partly driven by solar power from the PV-panels on the roof of the plant.

Figure 6. PV-panels at cooling production plant at Västra Mark and the Green Data Centre.

4. Minimal energy is needed to fulfill the cycle, the PV-panels that are installed on the roof of the building provides electricity to cool-down the water that return from the football stadium. The cycle is to a large extent utilizing the energy that is produced while at the same time saving our environment. In this way VEAB is able to use the same energy three times and DC return will replace other cooling alternatives at Green Data Center and Green Operation Center. Before the renovation the old computer center (CNV) was using electricity to provide cooling, which is reduced with the new data center GDC and GOP.

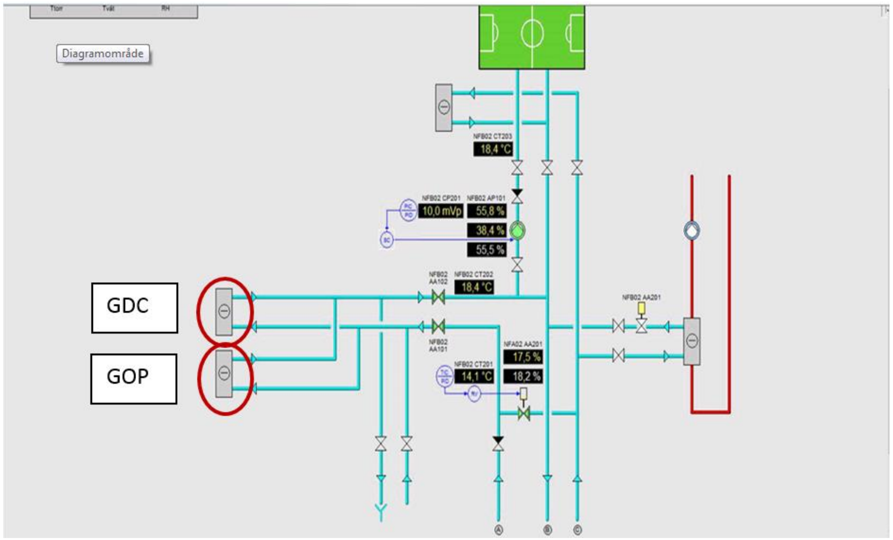

Figure 7. District cooling return system.

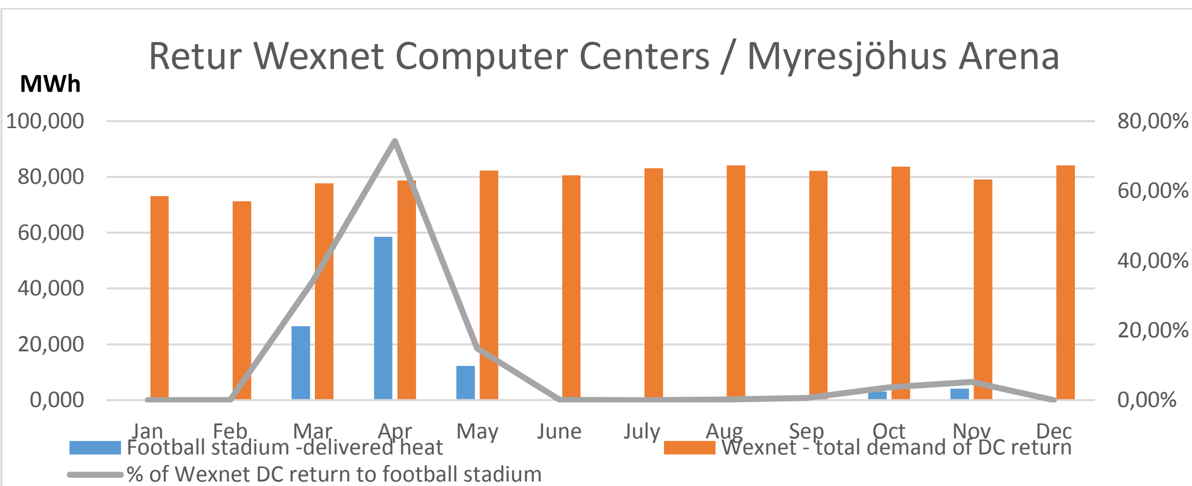

Figure 8. During 2016, the football stadium - Myresjöhus Arena used 105 MWh of DC return as heat (around 17-20 °C) to heat up football field. Delivered heat to Myresjöhus Arena during this year was approximately 11% of all DC return from Wexnet (total "produced" heat from GDC was 960 MWh).

Number of customers facilities served and average age of production and distribution system facilities

VEAB has an established DC network in Växjö, which currently includes deliveries to 19 customers. The total energy consumed by the customers during 2016 was about 11 GWh.

By implementing the innovative DC cycle network, there are two facilities connected, owned by VEAB's subsidiary company Wexnet, and then in 2015 the football stadium was connected to the DC return. The production plant at VM was start operating in 2012, and the same year the GDC was opened. Myresjöhus Arena (football stadium) was connected to the DC return 2015 and the DC for GOP was installed during 2017.