# nZEB headquarters of Skanska

The Entré Lindhagen Building which is the new headquarters of Skanska and the Nordic bank giant Nordea is a very low energy office building. The building is designed to be one of the greenest office buildings in the Nordic countries without compromising on indoor climate and functions for the tenants. The office building, located in the central part of Stockholm, has 57,500 m² rentable floor area and consists of three parts in 9 office floors and a common basement floor including garage in 3 levels. Skanska leases half of the building and Nordea Bank leases the other half. The building was finalized in January 2014. The expected delivered energy use is 49 kWh/m².

**Keywords:** office building, ground source heating and cooling, nZEB, energy efficient design, low energy building, seasonal heat storage.

JONAS GRÄSLUND
Technical Director
Skanska Commercial Development Nordic AB
Adjunct Professor at Chalmers University of Technology
jonas.graslund@skanska.se

## The systems

Under the garage there is an energy storage which consists of 144 bore holes with double U-tubes 32 mm PE in active depth of 220 m. The system is called Skanska Deep Green Cooling (DGC) which has a patent in Sweden, is approved for a patent in US and has patent pending in Europe.

Summer time the building is cooled by the energy storage system. In winter time the system partly heats the building by preheating the supply air for ventilation and at the same time restoring the energy storage to normal temperature.

The system solution does not include compressors and the expected COP is therefore high, between 20 – 30 (!). A smaller building consisting of 3000 m² rentable area and 12 boreholes is already in use with DGC. A validation of the performance of the system after one year of operation has resulted in COP=15 with lower annual cooling demand than expected. The system is robust, consisting only of circulation pumps, heat exchangers and a self-regulating chilled beam system in office floors.


**Figure 1.** The façade with external sun shading.

The ground temperature is used in the same level as the undisturbed ground temperature at the same depth which makes the system independent of geometry due to heat losses. The temperature level above freezing makes it possible to use normal city water in the ground loop instead of ethanol mixture.

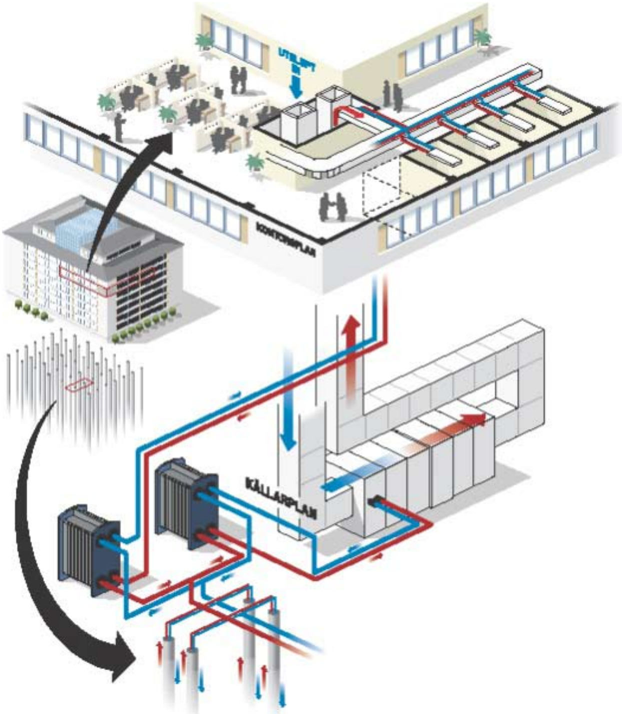


**Figure 2.** Illustration of Skanska Deep Green Cooling and a simplified technical connection scheme of the system.

The system is designed to match the entire cooling demand of the building, both indoor climate demand and process cooling of server rooms, etc. Winter time the ground temperature level is reset after a hot summer by preheating the outdoor supply air to the air handling units in an additional coil in the AHUs. The two nearby multi-family buildings are also connected to the DGC system and preheat outdoor air for ventilation with additional coils and the DGC gets rid of summer heat to achieve normal ground temperature level for next summer. Delivered Energy for heating and power including elevators, fans, pumps, heat losses from pipes and freezing protection of storm water system, but excluding lighting electricity outlets for PC, etc is expected to be 49 kWh/m² heated area (65,265 m²) where heating demand is 33 kWh/m² and power for building services 16 kWh/m². Cooling demand totally covered by the DGC system is calculated to be 26 kWh/m² including process cooling. Power to pumps and pressure drop over coils for DGC is expected to be less than 1 kWh/m² and is included in the building use above.

Air handling units are made for low face velocity around 1.0 m/s through the coils and filters and the ducting systems are made for max 5 m/s in the shafts and max 3 m/s on the office floors according to Skanska Commercial Development Standard, see REHVA Journal 3/2011. Heat recovery is made

**Figure 3.** The main circulation pumps for the Skanska Deep Green Cooling in the front and the ground heat exchanger in the rear.

with double run around coils and a temperature heat recovery efficiency of over 80% which enables using all exhaust air for heat recovery, even air from toilets. The lighting on the office floors is equipped with daylight control and presence control to further reduce the energy demand.

## The Skanska roadmap for Deep Green

By these measures described above the building is very energy efficient. But to reach what we in Skanska call "deep green" we have to reach net zero primary energy. As we now have gone from picking the low hanging fruits to the high hanging fruits, the next step is to

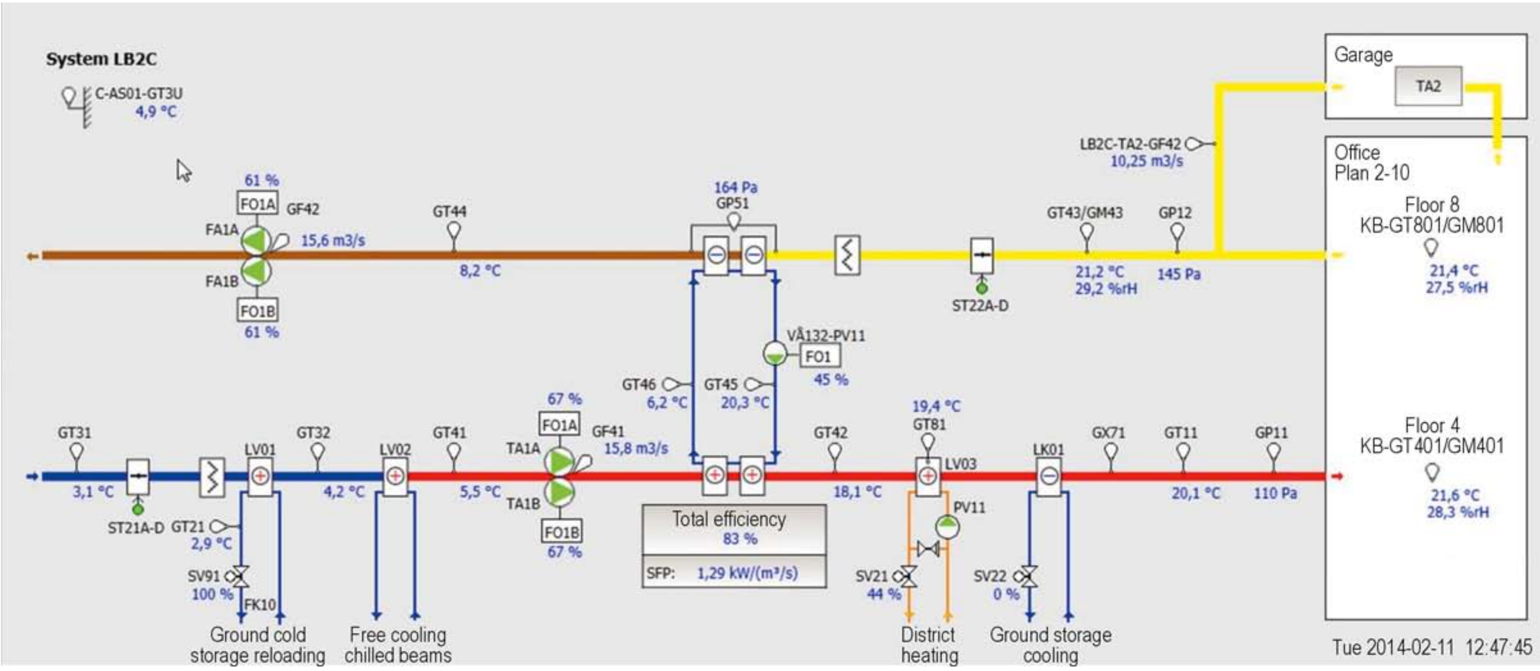


**Figure 4.** Office air handling unit in operation. Screen dump from BMS.

**Figure 5.** One of the office Air Handling Units.

include renewable energy. But when we have examined this we realized that by, for example, balancing the annual heat demand which will occur during winter with solar heating which will occur during summer, the environmental usefulness of this will be none or it could even increase the environmental impact!

*How is then the nZEB building possible?*

## Grid interaction and load matching

Now we enter into investigations and studies of the infrastructure of the local district heating and its connection to the north European power grid. If we should export heating from the solar heating panels to the district heating grid during summer, the garbage incineration fueled Combined Heat and Power plant in the district heating grid has to reduce its production, while there is less demand for/place for waste heat and that will lead to less production of power in the CHP plant which will lead to more power production in the existing coal fired power plants in the north European power grid with more carbon dioxide emissions. In winter we need the same amount of heat that we produced by solar collectors in the summer, but now it is produced not only by CHP but also by bio-fueled boilers or/and even by fossil-fueled boilers. In this case, the load matching is bad even if we use grid interaction.

*How to make the solar heating to have a positive impact in an advanced district heating system?*

In a northern location like Stockholm we need a seasonal heat storage in order to get a better load matching between the renewable energy production and the building heat demand using solar heating. This is not a new technology. Skanska was the constructor of a 100,000 m$^3$ uninsulated rock cavern filled with hot ground water used for seasonal storage and heated by solar collectors and an electric boiler for a local district heating system in Lyckebo, 80 km north of Stockholm in the 1980s. For the seasonal storage the geometry is of great importance to avoid too high annual heat losses. To use this technology in cities, you need large outdoor areas in remote places near railways, motorways, etc to mount solar collector fields and large seasonal storages to reduce the losses (heat losses per m$^3$ will decrease by increasing the volume of the storage). So this has to be made as business development with many stakeholders. One single building owners do not have the possibility to build such a system. The district heating company that owns the network has to be involved, a number of building owners has to agree to invest or to go into long-term energy agreements with a solar heating seasonal storage system owner. The LCC cost is also higher than traditional district heating and that has to be financed somehow, as a part of a green offer to the tenants. We are doing potential studies, thesis about customer opinions, legal matters, planning case studies together with the universities, energy companies and the customers.

Skanska is also developing similar business cases with wind mill organizations on how to keep out of the certification systems to assure a real addition of green – not only greenwashing - to have an alternative to put renewable installations on the buildings if and when that seems wise.

## nZEB and RES

Our efforts in these projects are aimed at finding reasonable solutions which will increase the use of renewable energy sources and replace fossil fuels. At the same time the solutions have to be robust and allow the use of different solutions in cooperation with the grid when that seems as a good opportunity, instead of doing it only on the building level and calculating energy meter figures without taking into consideration the consequences out in the grid, such as load matching. This implicates the demand for a wider definition of nZEB in order to make it possible to include initiatives for renewable energy made out in the grid to be part of the nZEB definition, given that it is a proven real addition that is equal with initiatives for renewable energy made on the building. During February 2014, REHVA is starting up a production of a guidebook lead by **Jarek Kurnitski** that will show the implications of on-site and nearby renewable energy systems (RES). IEA annex 52 and task force 40 are working with monthly time steps of load matching and grid interaction. In Sweden, the consulting company IVL in February 2014 started a project funded by three different organizations to define methods and different time steps to show energy performance and carbon dioxide emissions where load matching and grid interaction are taken into consideration when using RES.

## Summary

These initiatives and business development steps are parts of a long-term process that will hopefully result in real solutions and products that will be accepted by the market players, the building codes and the classification systems to make rational decisions possible, and not just sub-optimizing when adding renewable energy to the buildings in the near future. The result will be a very low energy building with RES added to the infrastructure grid to reduce the energy demand down to zero. ■