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Carbon driven energy equilibrium at the municipal scale – Energy Equilibrium

Summary report on energy system and energy storage in Sweden 2024

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ENERGY TRANSITION
Energy Equilibrium

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1 The energy system and electricity system in Sweden

In Sweden the main production of electricity origins from hydropower 40 %, nuclear 30 %, wind power 20 % and biopower 10 % year 2023. Use of renewable energy of all energy use was 66 % year 2022 (www.energimyndigheten.se).

1.1 Organisation of electricity grid

In Sweden the authority Svenska kraftnät is responsible for the transmission of electricity from production facilities to end consumers. The grid consists of three levels. The first level is the transmission grid, where large amounts of electricity is transferred from large production facilities to regional grids around Sweden. The voltage in the transmission grid is 220 or 400 kV to lessen the power losses. The transmission grid is built through the whole country, from north to south and is in total about 17 500 km. Svenska kraftnät is the owner and developer of the transmission grid. The second level is the regional distribution grid. The regional distribution grids connect to the national transmission grid and transports the electricity further to the local distribution grids. The regional grids are owned by large energy companies and the voltage is 130 kV. Vattenfall, Ellevio and E.ON owns the majority of the regional grids and are in total about 31 500 km. The third level is the local grids which transfers the electricity to consumers, industries and households. The voltage is 40 kV or lower and before the electricity is delivered to the customer, the voltage is lowered to 400 V. The local grids are owned by many different energy companies, which can be both public and private. The total length of the local grids are about 534 500 km. In addition, the Swedish electricity grid is connected to several countries electricity grid and the transfer of electricity between countries depends on the market price.

Source:www.svk.se

1.2 Distribution system operators in electricity grid

For the transmission grid it is the authority Svenska kraftnät that is the distribution operator. To adapt the Swedish electricity system to the green transmission and be able to receive and distribute electricity from wind power and solar electricity, the transmission is under development and a lot of investments are done. The current net is old and a lot of investments are needed. The net consists of 17 500 km cable and around 175 transformator and connection points. Development projects for increasing capacity and strengthening the grid are ongoing in the whole country. In the region of Skåne currently four larger projects are ongoing. Larger wind power parks and pV parks could be directly connectet to the transmission grid.

The regional distriubution grids are owned by five regional net grid owners but two are vey small. E.ON is the largest regional grid owner followed by Ellevio and Vattenfall. They own about a third each of the distribution grid. Wind power plants and pV parks are quite often connected to the regional grid.

The local grids are owned by 172 local grid owners and have the longest length of cable in the three level of grids. Out of the 172 local grid, 129 are publicly owned. Smaller solar energy installation are connected to the local grid but also large solar parks could be connected to the local grid.

Source: www.svk.se and www.iva.se

1.3 Stakeholders active of energy storage in electricity

- Vattenfall – Power as a service - Battery energy storage, Power Supply (batteries, hydrogen)
- Atlas Copco – Hybrid energy plant, battery storage combined with power supply from vind power or solar energy
- Energiengagemang – battery energy storage medium to large
- OX2 – large battery energy storage
- E.ON – battery energy storage medium to large (30 kWh to 30 MWh)
- Forum – battery energy storage
- Axpo – large battery energy storage
- Checkwatt – virtual large scale battery storage, connecting several smaller batteries in a virtual power plant

Source: Sustainable Business Hub

1.4 Role of local authorities for energy storage in connection to electricity

Local energy planning – There is a law in Sweden stating that each local authority needs to have an updated energy plan for production, distribution and use of energy. When develop this plan dialogue with stakeholders in the energy field is important and it is possible to investigate how energy storage could be located in the energy system.

As an owner of buildings, both for housing and premises, there are possibilities to work with medium scaled energy storage in own building stock.

Some local authorities own both or either energy company or electricity distribution grid. In that case there is a possibility to more directly work with energy storage on a more general level in the energy system with implementation of energy storage solutions.

Source: Sustainable Business Hub

1.5 Role of hydrogen and power to x in todays energy (electricity) system

There are a lot of possible Power to X and production of hydrogen from renewable energy

production in Sweden but it is actually hard to implement and start to construct the facilities. One example is Flaghsip one in Örnsköldsvik, developed by company Liquid Wind, where 55 000 tons of e-methanol should be produced as fuel for the shipping industry. The project was bought by Örested in 2022, the facility should be constructed 2023 and running 2025. Örsted informed in August 2024 that they will not proceed with the project since it is impossible to run it with profit. Örsted states that the interest for green fuels in the shipping industry is lower than expected and that is difficult to develop long term agreements with realistic pricing and adapted to commercialization. This together has resulted in Örested leaving the project since it is impossible to gain the profit needed in the project.

Liquid Wind are planning for the second project Flagship two in Sundsvall where 130 000 ton e-methanol will be produced 2027.

Source: www.liquidwind.com and www.orsted.se

1.6 Business models for energy (electricity) storage

There are serveral possibilities to use electricity storage as a business case.

1 Electrical arbitrage

The first is to be able to use the locally produced renewable electricity when there is no wind or no sun and the market price for electricity is expensive. The battery can be loaded with electricity from renewable energy sources when the electricity price is low. When the price for electricity has increased the battery can be unloaded and cheap electricity from the battery can be used. With a larger battery there is also the possibility to sell electricity to the grid when the prices has increased.

2 Peak shaving

It is more common that the electrical grid owner and DSO price the subscription for electricity in reference to the used load, meaning the used maximum peak of capacity by the customer. By using electricity from the battery to lower total load and minimise used peak capacity the cost for the electrical subscription can be lowered. Peak shaving also leads to a more stable electricity grid.

3 Back up power supply

If the business relies on continuous power supply, a battery can support the facility with electricity if the electricity grid is not working. If the facility has a solar electricity installation, there is a possibility that the pV installation can continue to operate in island mode.

4 Support services in the grid

There is a possibility to use energy storage for electricity, normally batteries, for support services to the grid. The national operator of the transmission grid, Svenska Kraftnät, needs to have different services available to balance electricity production and electricity consumption in the grid. One service is frequency management, where batteries play the role of stabilisers to the grid. The owner of the battery get paid for either store electricity in the battery from the grid or produce electricity in

the battery to the grid. The reason why frequency management is needed is that the frequency in the grid needs to be 50 Hz, which there is when there is a balance between electricity production and consumption.

The owner of the resource

By constantly analyzing the market and making sure to use the resources for what gives the highest return, the profitability of the person who owns the resource is maximized.

The electricity market operator

By making resources available to electricity grid operators and offering increased flexibility regarding both production and consumption, costs for electricity grids and operation of the electricity system are reduced.

Society

By using the existing resources in a more efficient way, the electricity system becomes more cost-effective, operationally reliable and creates better conditions to greatly expand renewable electricity production.

Swedish power grids must have access to various services and measures to balance and manage disturbances in the power system. We do this primarily by purchasing various types of reserves from electricity market players.

As far as possible, Svenska kraftnät uses various reserves that are procured using bidding on the so-called balance markets. Svenska kraftnät also buys certain reserves on longer contracts.

Fast frequency reserve (FFR), Upward Frequency Containment Reserve (FCR-D,N), Automatic Frequency Restoration Reserve (aFFR), Manual Frequency Restoration Reserve (mFFR).

5 Local flexibility markets

A challenge in the energy transition is sufficient network capacity. The increase in electricity use, the establishment of new electricity-intensive facilities and distributed production puts pressure on the electricity grid. This applies today at all voltage levels because it is challenging to expand the electricity grid at the same rate as demand increases.

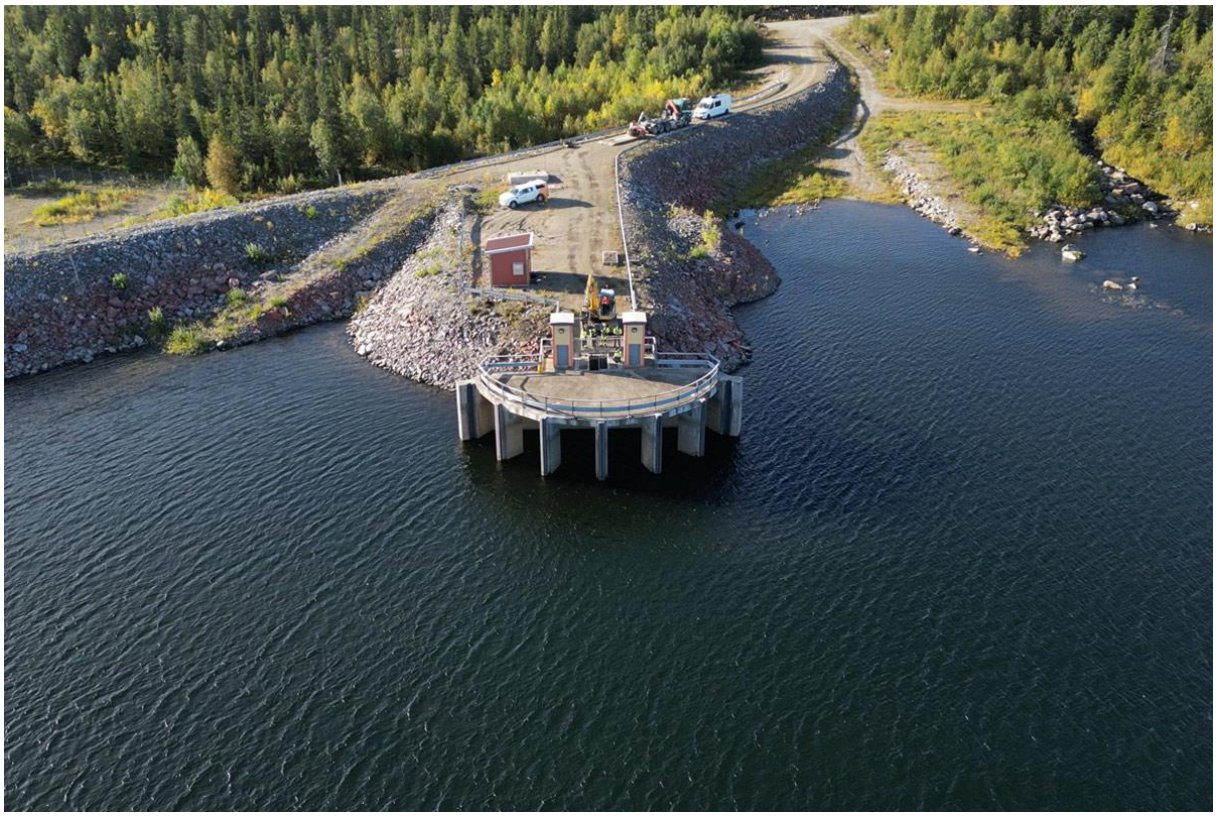
In order to deal with local grid capacity problems, so-called local flexibility markets have emerged where regional and local grids buy flexibility by calling for either increased or decreased withdrawal or input to the grid by connected electricity customers in order to manage overloading in the electricity grid within an electricity area.

In recent years, Svenska kraftnät has tested local flexibility markets as one of several ways to deal with this. The work has taken place in collaboration with the regional network owners concerned.

Source: www.svk.se, www.eon.se; and www.checkwatt.se

1.7 Organisation of other storage (biomethane, heat)

Vattenfall is in the process of establishing a pumped storage power station in the north of Sweden, namned Juktan. The power station could produce 315 MW over four days, equivalent to 300 000 EV. The facility is planned to be running in 2032. (www.vattenfall.se)



Picture:www.vattenfall.se