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Network Operator: No Pain, No Gain

The electricity distribution network – Part 1

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- **The growth of renewable resources and the rise of electrification enables us to meet sustainability targets but…**
- **… they are increasingly putting pressure on the electricity grid**
- **The electricity grid can become a game-changer for the energy transition**
- **A new approach is needed to ensure the electricity grid can cope with the transition**

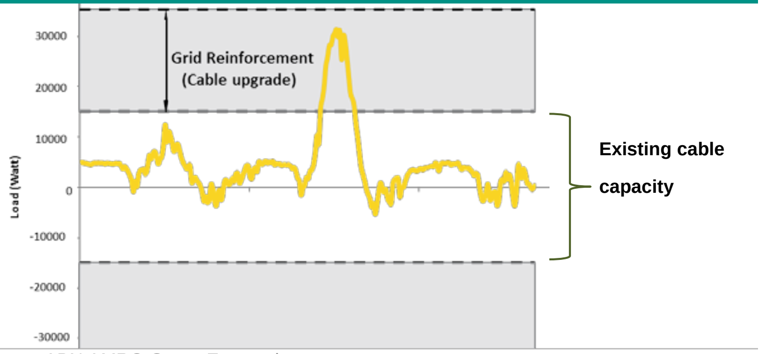
Introduction

In some areas in the Netherlands, grid operators are delaying hooking up some wind/solar farms to the grid to avoid network complications. The rise of renewable energy and the electrification drive are revealing a bottleneck. The electricity grid is expected to transport more and operate bi-directionally, which will increasingly put pressure on the existing grid. If this situation continues, it can either threaten the reliability of the electricity grid or delay its integration unless new market models are adopted to transform the electricity grid so that it can cope with this higher penetration level of renewable energy sources and the rise of electrification. Either way, this will impede the energy transition. A new approach is needed to address the expected rise in pressure.

The good old days

Traditionally, electricity has made its way from centralised power plants through High Voltage (HV) transmission lines, down through the distribution network (Medium Voltage (MV) and Low Voltage (LV)), all the way to the end consumer. The Distribution System Operator (DSO) is responsible for reinforcing grid assets (cables and transformers). To ensure the distribution network (MV/LV) remains reliable, traditionally a DSO needed to increase the capacity of the cables and transformers (grid reinforcement) to ensure the load continues to fit within the grid (see Figure 1). Part 1 of this publication will discuss the distribution network (MV and LV). Part 2, which will be published later, will discuss the transmission network (HV).

1. Grid reinforcement to increase grid capacity

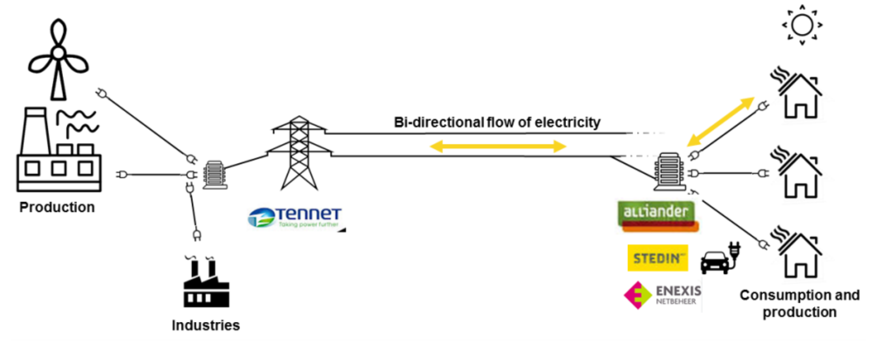


Source: ABN AMRO Group Economics

The new worries of the Distribution System Operator

With the advent of decentralised generation (such as solar panels on roof tops), there is a growing pressure on the distribution grid (LV/MV). The surplus of electricity from solar panels, for instance, is fed back into the grid and hence results in a reverse flow of electricity (see Figure 2). This bi-directional flow of electricity alongside an increase in electrification in mobility (electric vehicles) and heating (electric heat pumps) increases the risk of electricity grid congestion. Congestion occurs when the load on an electricity grid exceeds the capacity of the electricity grid cables and transformers (see Figure 1). This can have a multitude of implications for the electricity distribution grid. The effects may include (1) deterioration of cables and transformers due to overheating, (2) higher transportation losses, and (3) and a higher risk of blackouts.

2. Current and future electricity network (bi-directional flow of energy)



Source: ABN AMRO Group Economics

To avoid these complications, in some areas in the Netherlands, hooking up wind and/or solar farms to the grid is being delayed. In Groningen, solar farms are not being hooked up because the grid cannot handle the load. In Friesland, the burdened electricity grid is facing similar struggles. In other words, the current outdated grid stands in the way of achieving the decarbonisation and renewable energy targets that have been agreed.

Although electricity grid reinforcement (increasing the electricity grid capacity – see Figure 1) can help alleviate the pressure on the electricity grid, it has its limitations. Besides being an expensive exercise (~ €2 billion/year in potential cost, equivalent to 5% of total Dutch government spending), it is time-consuming, which is why it is no match for the rapid increase in renewable generation and electrification. In other words, obtaining the right licenses and permits to dig up the roads and add bigger cables and connections can take few years, while the grid is battling with interim and short-term congestion.

What is more, reinforcing the electricity distribution grid is capital-intensive and involves high costs for society as it boils down to higher electricity transport tariffs. This conventional solution of increasing grid capacity, while congestion is only temporary and intermittent in nature, will not be a cost-effective solution going forward. Besides, in more populated areas with higher rates of electrification (e.g. EVs) such as in the Randstad conurbation, the risk of congestion is higher. That said, it is very expensive, due to land scarcity, to add transmission stations and transformers to alleviate the congestion on the electricity grid.

No pain, no gain

Although the increase in electrification and decentralised generation can threaten to increase congestion on the distribution grid (MV/LV), it also brings opportunities for managing system stability in more efficient ways. These opportunities evolve from flexibility[1] sources that help mitigate congestion by encouraging a change in behaviour.

Flexibility sources

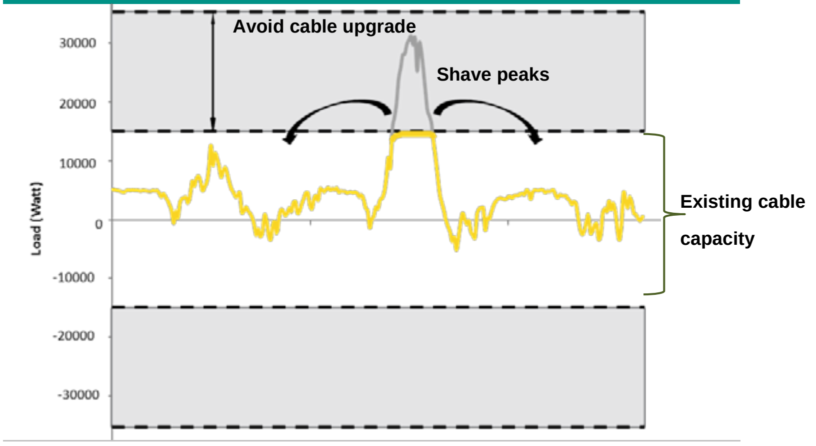
An example of demand flexibility is scheduling your electric vehicle to start charging in the middle of the night rather than at 6 p.m. when people arrive home from work and start consuming energy at the same time. For those who own a heat pump and solar panels, flexibility can be gained from heating the house using excess solar energy during the day, which results in a shift in demand for heating from peak hours (6 p.m.) to off-peak hours (mid-day). In such a case, solar energy is being put to use rather than being fed back into the grid. This in turn can help reduce congestion on the grid (shaving peaks – see Figure 3) by distributing the load across the hours of the day. In essence, the solution[2] might lie in:

(1) demand-side flexibility by controlling appliances and industrial processes (by e.g. flexible Electric Vehicle (EV) charging or hybrid Heat Pump (HP) scheduling); or
(2) supply-side flexibility by arranging decentralised generation sources (e.g. roof solar panels) to go in tandem with demand; and/or
(3) technologies to store excess renewable energy and consume it when demand is high (utility scale or small-scale storage).

[1] Flexibility is the extent to which a power system can adjust electricity production or consumption in response to variability.
2 Such a solution would require (1) forecasts of the consumption/ production patterns of different processes/ appliances, (2) aggregation of flexibility from diversified sources based on the elasticity of demand/ supply, and , (3) the Internet of Things (IoT) that connects devices/processes to smart meters.

Small-scale pilot projects are being conducted to experiment with flexibility in the Netherlands. In Nijmegen, for instance, a retail company is adjusting the temperature of its freezers (within an allotted bandwidth) to alleviate pressure on the grid. Such solutions help manage interim peaks (congestion) and contribute to postponing/avoiding capital-intensive grid reinforcement, i.e. increasing the capacity of cables and transformers. While this sounds promising, people may have to be encouraged to change their behavior by offering them incentives.

3. Levelling the load within existing grid capacity



Source: ABN AMRO Group Economics

Electricity transportation tariff

One way to encourage a change in behavior of the DSO and the end user is to introduce dynamic network tariffs. Currently, the network tariff is the flat fee on the electricity bill, which is the same for all residential properties, regardless of how much grid capacity the residents use and when they use it. Given the current network tariff structure, DSOs have the wrong incentive to change or consider flexibility sources. The tariff is based on the highest peak demand in a year, which is why they are paid to increase grid capacity even though congestion (high peaks) is sporadic and infrequent.

The road towards such a regulatory change (i.e. introducing a dynamic network tariff) is rocky. Conditions for success would include:

(1) rolling out smart meters to enable smart data collection and automatic load leveling;
(2) conducting research on the financial incentives that makes end-users and DSOs change their behaviour;
(3) creating awareness among end-users of the current problem and the impact of electrification and decentralised generation on the grid;
(4) designing the network pricing scheme such that it allows for fair socialisation of costs; and
(5) the government and the competent regulatory bodies devoting enough attention to the outdated network tariff scheme and legislation.

Conclusion

The electricity grid is about to become a game-changer to the energy transition. Distribution system operators have a critical role to play to ensure that the electricity grid can cope with this transition. The growth of decentralised generation, electric vehicles and electric heat pumps will increase congestion on the grid. Relying on grid reinforcement by upgrading grid assets (cables and transformer) is capital as well as labour-intensive and will not be enough to address grid congestion going forward. Changing the network tariff structure to encourage a change in behaviour and trigger flexibility resources can help level the burden on current grid capacity.