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Network Operator: No Pain, No Gain
The electricity transmission network – Part 2

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- **The volatile feed of renewable electricity into the power grid along with the phase-out of baseload capacity (coal and nuclear) is set to worsen the supply/demand imbalance**
- **Not only will steady power plants help maintain the balance between production and consumption…**
- **…but integrating flexible capacity from end-consumers can help contribute to system balance and thus to the energy transition**
- **A new market design is needed to enable the energy transition**

Introduction

The story of the energy transition in Europe has two sides. From one side, renewable energy penetration is increasing and from the other, fossil fuel baseload generation is phasing out. In the midst of all these changes, grid operators are faced with volatile generation sources and the rise of electrification. This will affect the grid stability. So far, Transmission System Operators (TSOs) are responsible for the High-Voltage (HV) lines and Balancing Responsible Parties (BRP) are responsible for balancing their supply/demand portfolio. Unless they both leverage the dispatch of decentralized and distributed energy sources, these changes might threaten the stability of the grid and thereby the security of supply. This creates a pressing need for market design reforms.

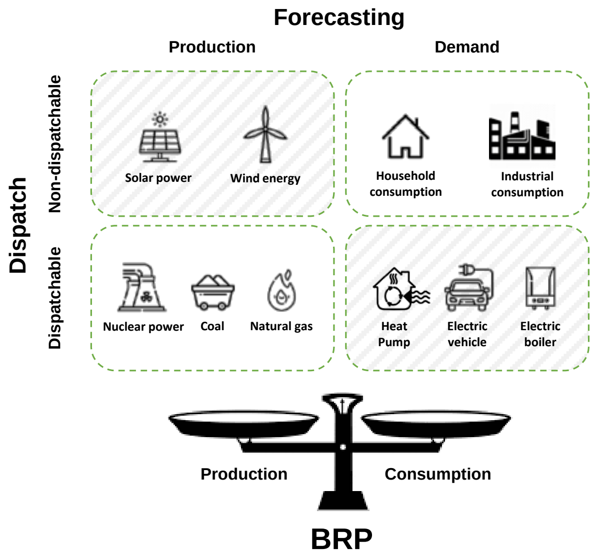
The challenge on the transmission network

Unlike a thermal power plant that can provide constant and stable generation, solar and wind farms are intermittent and volatile in nature. This means that the output is continuously changing. In the past, the electricity landscape was simple and the BRP was responsible for keeping supply and demand matched. With generation being fully centralized, predictable and dispatchable[1], and demand being inelastic, generation was adjusted to meet demand. Currently in the new landscape, generation also requires forecasting because it is decentralized, non-dispatchable and volatile. For instance, wind farms are non-dispatchable because they cannot be ramped up (they are fully dependent on wind speed and wind patterns). At the same time, demand is increasingly electrified and therefore more elastic (because there are

[1] Dispatchable generation involves those that can alter their power output and/or turn it on and off depending on demand orders.

more electrical devices within households and industries that consume electricity at various times of the day). This means both supply and demand need to be forecasted and adjusted to ensure they remain balanced (see Figure 1).

1. A two-way balance of demand and supply



Source: ABN AMRO Group Economics

If this is not the case, network imbalances might occur, which can have the following effects:

1. In the case of **short-term imbalances**, this can result in frequency deviations - upward or downward from the 50 Hertz (Hz) network frequency[2]. Deviation from this threshold can affect appliance and equipment lifetimes and may result in power failures. This was the case last year with the Kosovo-Serbia issue, where deviation from the standard 50Hz frequency was enough to cause electric clocks to fall behind.
2. **Long-term imbalances** occur when there are seasonal fluctuations with prolonged periods of limited solar or wind power, which can threaten the security of the electricity supply.

As a result, additional dispatching is needed, which is (1) a very fuel-intensive exercise because you have to ramp up and ramp down thermal power plants more often and (2) this results in a faster depreciation of thermal power plants. Consequently, higher imbalance charges are incurred.

Furthermore, relying on the international market and interconnectivity between markets to dispose of the surplus of generation or import during periods of shortages would be a challenge. This is because neighbouring countries will have similar solar radiation and wind patterns and therefore similar problems. In Germany, for instance, system imbalances will worsen on the back of the increase in renewables in the north and a phase-out of nuclear in the south. While coal met more than 35% of Germany's electricity demand last year, this fossil fuel will be capped at 30GW by 2023 and

[2] Electricity is delivered to Dutch households at 220/230 volt alternating current with an alternating frequency of 50 Hertz.

eventually fully phased out by 2038. This means that there will be less power surplus to be exported to neighbouring countries. In other words, in an increasingly interconnected power market, a spillover effect can emerge.

Electricity market is yet to be updated to mitigate short-term imbalances (days, hours, seconds)

As renewables increase their penetration, prices become more volatile intra-day and real time. When renewable energy production deviates from the forecast (forecast error) it creates portfolio imbalances. This forecast error, due to the volatility and intermittency, will demand more flexibility sources near real time. Flexibility is the extent to which a power system can adjust electricity production or consumption in response to variability. For example, 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).

At the same time, baseload production is on the decline (especially coal and nuclear), which could necessitate more expensive units (like gas peaker plants[3]) to supply high demand peaks. On top of that, demand due to electrification will also aggravate the gap and contribute to higher peak prices. Unless the market allows flexible sources to play a role during these periods, higher prices are inevitable – especially during periods of high demand and low renewables.

TSOs must respond flexibly with this volatile feed of renewable electricity into the electricity grid and the increasingly complex electricity consumption behaviour. In this context, the electricity market should allow for the integration of flexible capacity from households, corporates, industries and electric vehicle charging points. However, this is not yet the case in the Dutch electricity markets.

Wholesale Electricity Market

In the wholesale market (especially day-ahead, intra-day), industrial managers are permitted to be active on the market. However, residential owners have only been allowed access since 2018 and they are faced with administrative requirements and other obstacles (the need for smart metres, day-ahead forecasts and the lack of financial incentives). Besides, the access of aggregated flexibility[4] is not possible on the Dutch wholesale market without the energy supplier's consent. In light of this, the current regulatory framework is not yet facilitating a bottom-up integration of flexibility.

Balancing Market

On the balancing market (within 15 minutes - near real time), corporates can have access via a balancing portfolio. However, residential owners are not yet active due to (administrative) burdens similar to those in the wholesale market. Furthermore, flexibility is traditionally activated by dispatchable units like gas power plants, which

[3] Gas peaker plants are those that are ordered to run during peak demand.
[4] Aggregated flexibility is a tool that enables flexibility sources (generation or demand units) to be aggregated, which enables such small resources (electric vehicle, heat pump, solar panels on roof tops etc.) to participate in the market.

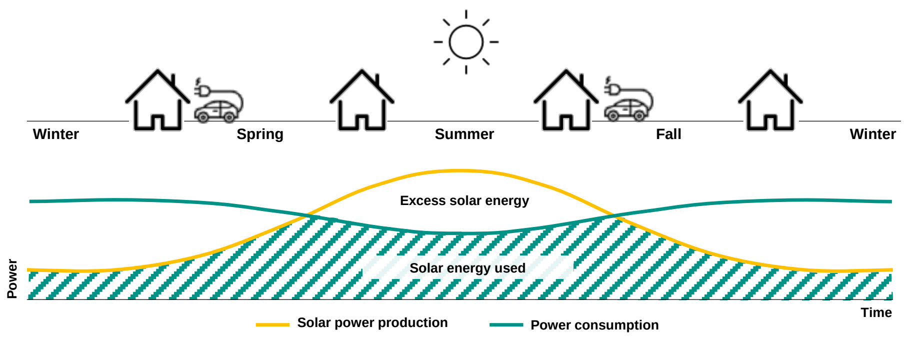
are more on the *supply* side. The market design does not yet allow for *demand*-side flexibility (electric vehicles, heat pumps, heating/cooling demand processes) to be measured, settled, and priced.

The gap between the total demand load and the generation load will only increase, especially with the phase-out of baseload production. This will necessitate a capacity market, which – unlike Belgium, Germany and the UK – is still not the case in the Netherlands. Capacity markets were introduced by governments to ensure that during periods of high demand and low generation, the reliability of supply is safeguarded at affordable peak prices. So far, dispatchable and stable generation in the Netherlands is available to balance demand and supply, but this is destined to change in the longer term.

New technologies are becoming essential to mitigate long-term imbalances

As renewable energy deployment increases and fossil fuel baseload generation is phased out, there will be periods of overproduction but also periods of underproduction (see Figure 2). The need for large-scale flexibility capacities to fill the gap will become vital. For instance, hydrogen – as a proven technology – can contribute towards mitigating the intermittency of renewables. However, this requires economies of scale. Creating hydrogen from electrolysis by using the excess of renewables (green hydrogen), storing it, and then reconverting the excess into electricity during periods of shortage is still very expensive. In addition, it will take years before this becomes the new norm as it requires a swift roll-out and ambitious cost reductions to become more cost-efficient. In the meantime, grey and blue hydrogen-based technologies from fossil fuels will be needed during the energy transition process. They can help prepare the infrastructure that enables the use and transportation of hydrogen (gas networks, pipelines, ports etc.) (DNV.GL, 2019).

2. Different production profiles



Source: DNV.GL, ABN AMRO Group Economics

Besides, the potential associated with the electrification of heating households and industries (hybrid heat pumps and combined heat powerplants (CHPs)) is rapidly advancing and will enable demand flexibility and time-flexible processes. To achieve this and ensure security of supply, it may be crucial that governments take the lead in instituting a mandate on flexibility sources and proper integration in the electricity market.

The way forward

TSOs must react flexibly to this volatile feed of renewable electricity into the power grid and the rise of electrification alongside the phase-out of baseload capacity. A revolutionary milestone is needed in the electricity market to allow TSOs to integrate flexible capacity of households, corporates, industries and charging points of electric vehicles. This would mean that not only steady power plants will help to maintain the balance between production and consumption, now the owners of vehicles, heat pumps, CHP units and solar panels on roof tops could help ensure that the grid frequency is kept at 50 Hz. This gives the end-consumer the opportunity to contribute to the energy transition.

A long-term imbalance in supply and demand requires mandates from the government on flexibility sources to ensure security of supply. Just because there is too much to transport (during overproduction periods) this does not mean we should be wasting it by curtailing renewable farms. And just because some (low production) periods are marked by low renewable generation, this does not mean we cannot move beyond fossil fuels. Enabling small and large flexibility sources to play a role is key to bridging the time and capacity mismatch between demand and supply. In short, if we do not brave the painful process of changing the existing electricity landscape, no gain will be guaranteed.