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Maybe only a decade ago, the loading of electricity networks was quite predictable. The highest loads within a year occur in winter, and within a day morning and evening peaks are clearly present. In a way, the absence of renewable energy sources (RES) and distributed energy resources (DER) in the distribution grid were beneficial for network planning.

It is clear that the energy system has to change to face climate issues. Fossil fuels have to be phased out – in centralised power plants, (domestic) heating, mobility and more. The shift from coal-fired and gas-fired power plants to renewable sources makes the generation more weather dependant and thereby more intermittent and less predictable. Without any countermeasures, this requires a shift from a load-following system to a generation-following system. As this is not likely to be possible or economic, electricity storage and demand-side flexibility can help to adapt demand (and generation). Though, while they are part of the solution, they also pose complications.

In the Netherlands, over 90% of all households have gas-fired heating systems. Recent regulation stipulates that from 2026 onwards, hybrid heat pumps will be the norm. Hybrid heat pumps combine a relatively small electric heat pump with gas-fired heating. The latter should only be necessary in cold periods (typically below 0°C), greatly reducing the need for (natural) gas and thus reducing CO_2 emissions. However, the hybrid system means that the owner or operator (energy company or aggregator) has access to two energy carrier markets (electricity and gas) for the heating demand. Based on (day-ahead) market prices, he may want to adjust the mix of electricity and gas used for heating. As these decisions can be taken on the short term, it is hard to plan for. However, as the maximum electric load is known and since it is quite certain that this load will be reached annually (temperatures below 0°C are not uncommon in the Netherlands), the maximum electric load can be used in network planning.

The maximum electric load of (hybrid) heat pumps can be established in one of two ways. With low penetration, the electric load can be estimated by calculating the heating requirement of (typical) homes combined with assumptions on the coefficient of performance of the heat pump. As more heat pumps are being installed, (consolidated) (smart meter) measurement data can be used to draw up a benchmark for future network planning. A recent Dutch study (Installatiemonitor) has provided quite some insight into profiles, load duration curves and differences between typical homes.

To prevent high coincident loads, attention should be paid to the anti-legionella programme. Regularly, the water in the boiler needs to be heated to a temperature above 60°C to prevent legionella. Recent examples have shown that heat pumps may have a fixed time-based setting for this programme to run, causing high coincident loads on the LV network. The Dutch heat pump installation sector has been notified of this issue and requested to randomise the activation of the anti-legionella programme.

Energy storage is a form of DER harder to predict the behaviour of. Battery energy storage systems (BESSs) – stand-alone or as part of an electric vehicle – are becoming more and more abundant in distribution grids. And they are being used for widely varying use cases. From limiting peak power to delivering system services (frequency containment reserve, frequency restoration reserve) and more (imbalance markets, arbitrage, congestion markets). The realtime operation of BESSs being highly dependent on price forming on the various markets, makes it hard to predict the network loading.

Frequency containment reserve is usually one of the first markets to be entered by BESSs. Because of the erratic behaviour of units providing these services, on the short term one may have to assume that at any moment in time a BESS could be either fully charging or fully discharging. In network planning, this translates to accounting for the full contracted capacity in both ways at any point in time. As a result, remaining capacity in the grid can be sold out very quickly.
The potential erratic behaviour BESSs, may present an additional issue. The electricity market is based on programme time units, usually 15 minutes in duration. Within those 15 minutes, the average power needs to be in line with the volumes traded on the various markets. Responses to frequency containment reserve usually being short in duration, the peak load may be significantly higher than the contractually agreed capacity. The larger the share of the(se) BESS(s) on a specific network, the more likely it will be that protections will trip.

On the longer term, many will have entered the frequency containment reserve market and prices will get lower. With business cases switching to other use cases such as curtailment, congestion markets and arbitrage, the BESS behaviour might get more predictable. How exactly only the future will tell, leaving the DSOs and TSOs to decide how incorporate BESSs in network planning.