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Challenges and opportunities for successful capacity management

Decarbonization is putting grid operators under stress, which is why grid planning has become more important than ever before. In this article, we describe how grid operators can effectively approach the issue and safeguard grid reliability.

For decades, electricity was generated by centralized, fossil-fueled, predictable power plants and demand rose annually at a relatively stable pace. This allowed transmission and distribution grid operators to efficiently plan the grid and manage grid capacity. Distribution grids were dimensioned taking into account the anticipated load growth during component lifecycles, reducing the need for grid monitoring and active decision making. Especially on the low voltage level, capacity management was rather a reactive practice triggered by arising malfunctions in the electricity network. On the medium voltage level, yearly measurements indicated when transformers were reaching their design capacity and needed to be replaced. In recent years, the fast rise of decentralized electricity production and electrification of transportation and heating is putting the electricity network under bigger stress. The established sustainable energy goals of the Dutch climate agreement aim to further accelerate renewable production and uptake, which affects the operating landscape of grid operators. Proactive capacity management efforts are therefore required to ensure a reliable and safe grid operation in the future.

A three forces model on capacity management can be consulted to expound drivers, measures, and enablers to addressing the necessity and implementation of effective capacity management (Figure 1). The *drivers* describe the changes in electricity supply and demand caused by the energy transition. The rise in decentralized electricity production and electrification increases the need for grid capacity and decreases the predictability of power flows on a local and national scale.

These challenges can be dealt with by deploying *measures.* Traditionally, the most obvious solution to capacity shortcomings is to increase the installed grid capacity. However, nowadays more measures could be applied and should be considered, unlocking flexibility at both the supply and demand side. Smarter grid tariffs, curtailment, smart storage, and flexibility markets could prevent or delay costly grid reinforcements.

Last but foremost, *enablers* are needed to support the network operators' measures to ensure effective capacity management. This requires the formulation of a clear strategy and vision on capacity management. Grid operators should be capable of determining the right, case-specific solutions for which a positive societal business case should be developed. Grid analytics should be applied to give indispensable insight into the current and expected load on the grid and to enable the deployment of flexibility measures. Furthermore, governments should facilitate capacity management efforts by establishing transparent and effective laws and regulations.

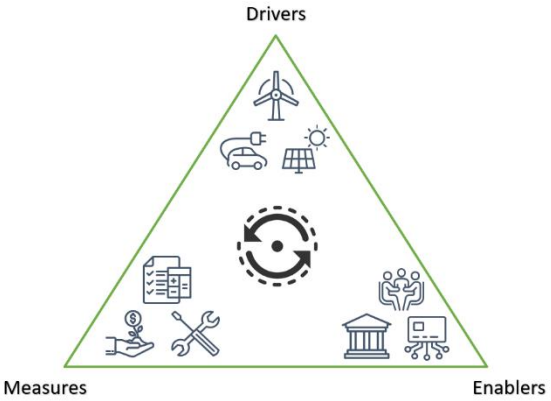

FIGURE 1: THREE FORCES MODEL ON CAPACITY MANAGEMENT

DRIVERS FOR INCREASED CAPACITY MANAGEMENT EFFORTS

The main trends that influence the need for active capacity management are threefold:

- In the Netherlands, the electricity production by sustainable energy sources increased by 8 percent in 2018 compared to the previous year and continues to show an increasing trend in the upcoming years. Especially the installed capacity of decentralized solar farms expanded substantially with a

40% increase compared to 2017 standards [1] . This is important to consider since the intermittent character of solar and wind energy decreases the predictability of the increased electricity production, and increases the need for capacity on the distribution grid.

- The Dutch government announced new regulations in the climate agreement to significantly reduce the amount of natural gas being used. Before 2030, 200.000 buildings should replace natural gas as an energy source for satisfying heat demand. Full-electric heat pumps provide a solution but cause electricity consumption to increase[2][3].
- The number of full-electric vehicles doubled from approximately 22.500 in 2018 to 45.000 in 2019 [4] and is expected to grow further till the year 2030, in which the government aims to sell new cars which are exclusively 100% emission-free[5]. As modern EVs can charge at 11 kW, it dramatically increases the average power drawn by a single household of 1 to 2 kW. The need for capacity is further increased by the high concurrence of EV charging and heat pumps.

Grid malfunctions can occur if components become overloaded or when voltage- and frequency levels in the electricity network can't be maintained by the network operator, endangering the reliability of the electricity network. In congested grids, the network operator may not be able to react to new connection requests, resulting in reputational damage and potentially a deceleration of the energy transition. Network operators are therefore required to efficiently adjust grid capacity to facilitate the energy market. For this purpose, they should be able to develop future scenarios and describe an approach with which the organization envisions to comply with future standards. Understanding the need for capacity in the short, medium and long term, and being able to steer the energy transition is essential for maintaining high grid reliability.

MEASURES TO DEAL WITH GRID FLUCTUATIONS

Network operators' default approach to these drivers would be to renew current grid assets and physically expand the overall grid capacity. However, these grid reinforcement projects are characterized by their large investments and long duration, questioning whether network operators will be able to sufficiently deal with arising capacity challenges in time. Limitations to the scalability of the DSO's technical workforce further increases the issue. Therefore, it is essential to exploit alternative measures that facilitate grid operators with the regulation of grid capacity in the short, medium, and long term. Several measures can be applied, of which four stand out:

- Curtailment is the directly interference of a network operator on grid load, by reducing or restricting electricity production. As solar and windfarms usually do not operate at their maximum capacity, restricting peak production is expected to have a limited impact on the business case of these projects. However, as grids are dimensioned based on the peak load, curtailment could significantly reduce the need for additional capacity investments while still integrating renewable energy generation.
- Smarter grid tariffs can be applied to foster flexible electricity consumption and a reduction of peak loads, by shifting residential- and industrial

[1] CENTRAAL BUREAU VOOR DE STATISTIEK. (2020, JULY 6). TRENDS IN NEDERLAND 2019. RETRIEVED FROM CBS: HTTPS://LONGREADS.CBS.NL/TRENDS19/ECONOMIE/CIJFERS/ENERGIE/

[2] RIJKSOVERHEID . (2019). KLIMAATAKKOORD . DEN HAAG : RIJKSOVERHEID.

[3] RIJKSDIENST VOOR ONDERNEMEND NEDERLAND. (2020, JULY 6). AARDGASVRIJ. RETRIEVED FROM RVO: HTTPS://WWW.RVO.NL/ONDERWERPEN/DUURZAAM-ONDERNEMEN/DUURZAME-ENERGIE-OPWEKKEN/AARDGASVRIJ

[4] CENTRAAL BUREAU VOOR DE STATISTIEK. (2019, MAY 10). AANTAL VOLLEDIG ELEKTRISCHE AUTO'S VERDUBBELD. RETRIEVED FROM CBS: HTTPS://WWW.CBS.NL/NL-NL/NIEUWS/2019/19/AANTAL-VOLLEDIG-ELEKTRISCHE-AUTO-S-VERDUBBELD

[5] RIJKSOVERHEID. (2019). IN RIJKSOVERHEID, C2 MOBILITEIT. DEN HAAG: RIJKSOVERHEID.

consumption from peak to off-peak hours. This can be realized by creating financial incentives in grid tariffs, for instance with a capacity bandwidth model, that stimulates charging of EVs at lower speeds (smart charging).

- Bilateral flexibility contracts and open flexibility markets can be used in operations for dispatching flexibility on the short term to prevent or resolve congestion. In these type of arrangements, a financial compensation is paid to consumers or producers to temporarily adjust electricity demand or supply. This is especially useful for bigger connections, but smaller connection points can also contribute through an aggregator.
- Smart storage solutions can be adapted to accommodate peaks in electricity flows and store excess electricity for later use. Several ways of storage can be utilized, from which batteries and hydrogen are among the most promising and viable technologies in the Netherlands. Hydrogen storage is highly applicable for long-term storage, while battery storage is suitable for cases in which quick electricity conversion is desired. For this purpose, large community batteries, and electric car fleets in a vehicle-to-grid setting can be used to deliver capacity managing services to network operators.

ENABLERS FOR SUCCESSFUL CAPACITY MANAGEMENT

Enablers are needed to facilitate network operators with the effective gradual implementation of measures. The process of fostering effective capacity management starts with creating a clear strategy from which the development trajectory can be guided. Being asset-intensive monopolies, the regulatory framework to a large extent determines the playing field for grid operators. As laws and regulations are often lagging on technological and societal developments, active lobbying for amendments is required.

Traditionally, standardized procedures and designs form the basis of the planning and operations of grid operators. However, a higher degree of adaptability is required to cope with the growing need for flexibility and adequate capacity management. For this, Grid Analytics and data-driven decision making should be integrated into grid planning and operations. Innovative tools could be valuable enablers that gain insight into the bottlenecks in the grid and facilitate the automation of the electricity grid. Grid Analytics is also required to coordinate the deployment of short term measures and assessing their effects on the grid's load accordingly. Given the public role of the grid operator, making socially optimal decisions is key. Grid Analytics puts a high emphasis on forecasting methods retrieved from the grid's sensor data, asset data, and external data, as described in Sia Partners' whitepaper on this topic[6]. It relies on having adequate data quality and data management processes in place for it to function.

Aside from the 'hard' requirements on the legal framework, the strategy, and Grid Analytics, there are also 'soft' aspects to consider. Firstly, it is important to make sure digital tools are supporting the organization's core processes and to consider the organization's culture. An evolutional innovation approach should be maintained by grid operators to gradually build an environment of trust, security, and (financial) stability. Also, cooperation with other (client-facing) departments and external stakeholders is becoming of increasing importance, as grid operators will more directly intervene in the production and consumption of electricity. Finally, providing attention to change management successfully transforms grid operators into inclusive organizations characterized by high levels of adaptability, participation, and transparency.

[6] SIA PARTNERS. (2020). BUILDING THE PYRAMID OF GRID ANALYTICS. AMSTERDAM: SIA PARTNERS.

PREPARING THE ELECTRICITY NETWORK FOR THE FUTURE

The three forces model discusses the drivers, measures, and enablers in a systemic approach. It provides a guideline that ensures effective capacity management for grid operators. This is the first article of a series on capacity management, in which the drivers, measures, and enablers are described in more detail. Alignment and engagement are needed from a stakeholder perspective to integrate grid analytics and realize inclusive development, so not driven only by top management and the most innovative individuals. By doing so, network operators get empowered to effectively provide sufficient grid capacity, quality, and safety at the lowest cost.

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ABOUT SIA PARTNERS

Sia Partners has developed an extensive national- and international portfolio in the Energy & Utilities sector by supporting business operations, improving performance, and creating transformational strategies. Sia Partners can provide case-specific solutions by utilizing its internal data analytics teams and reaching out to its large international network of content experts. We deliver support at all facets of the three forces model and could appeal to our network for putting the right tools and resources in place. Additionally, we guide customers in the integration process of grid analytics and make sure to timely involve the right stakeholders. We understand the organizational culture of network operators and can support them by in the transitional process towards the "new energy reality".

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