Whitepaper

The challenges and opportunities of decarbonisation for European network operators and energy retailers

Powering Business Worldwide

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1. Executive summary

European distribution network operators (DNOs) and energy retailers have experienced enormous upheaval since the liberalisation of the market and the decoupling of generation and distribution in the 1990s. Yet these changes are a minor ripple compared to the waves of disruption set in motion by decarbonisation, digitalisation and electrification. While each of these disruptive forces are in different stages of development, their shape and direction of travel is already clear. The decarbonisation of electricity generation is already well under way due to steep declines in the cost of renewables and European Union leaders recently committed to make the bloc carbon neutral by 2050.

In this paper we share economic data and perspectives based on our experience working on several ground-breaking technology pilots on what the future holds over the coming few years, how we are helping our customers to adapt and what this means for your business.

We firmly believe flexibility must be the cornerstone of a grid in the age of renewables and mass electrification. In this regard, we explore why DNOs should more quickly take on the responsibilities of a 'distribution system operator', which means being incentivised to play more actively in local flexibility procurement to facilitate electrification of transport, heat and industrial processes. This would enable network operators to manage local networks more cost-effectively and integrate distributed energy resources (DER), rather than simply manage and upgrade wires and sub-stations. Ultimately, this would widen the role of network operators to include procurement of flexibility services from DER via local auction platforms.

We also explore the opportunities for energy retailers in helping their customers build and operate flexibility resources behind the meter such as for example combining onsite photovoltaic and wind generation, energy storage and electric vehicle charging infrastructure.

Much of our analysis is drawn from the BloombergNEF report: "Sector Coupling in Europe, Powering Decarbonisation", co-sponsored by Eaton and Statkraft. The full report can be downloaded here. We hope this paper will help provide you with some fresh insights and ideas to help you on this journey and look forward to discussing and sharing your perspectives over the coming years.

2. Secular trends impacting utilities today

The energy industry will be upended over the coming decade by four distinct, but closely inter-related secular trends:

1. **Decarbonisation through the integration of vast new sources of distributed and variable renewable power**
2. **The missing money problem – how to adjust to a world where the marginal cost of renewable energy production is close to zero**
3. **The automation and digitalisation of energy management processes**
4. **The coupling of the energy, transport, buildings and industrial sectors to the electrical grid**

While the integration of generation from renewables into the energy system is now technically feasible and the corresponding regulatory and changes required are already being discussed, the sector so far is lacking the coordinated approach required to properly tackle the other three challenges.

Of all these disruptive events, sector coupling - the electrification of more areas of the economy - is potentially the most significant and far-reaching. Mass electrification will bring about major changes not only in power generation, but also in energy retail and grid operation.

Sector coupling will drive mass electrification

According to the BloombergNEF Sector Coupling study, the electrification of the transport, buildings and industrial sectors in Europe could slash greenhouse-gas emissions by 60% between 2020 and 2050 (see table). This revolution in the use of energy by these three sectors is likely to play out over the next 30 years, bringing about sharp reductions in CO2 emissions. According to BNEF, this electrification could take place via a mix of 'direct' and 'indirect' changes. 'Direct' would involve the proliferation of electric vehicles in as much of the transport sector as possible, and the spread of electric heating systems such as heat pumps in buildings and some parts of industry; and 'indirect' would involve a switch to 'green hydrogen' – produced by electrolysis using renewable electricity – as a fuel to provide heat for buildings and as many industrial processes as possible, that otherwise would rely on fossil fuels.

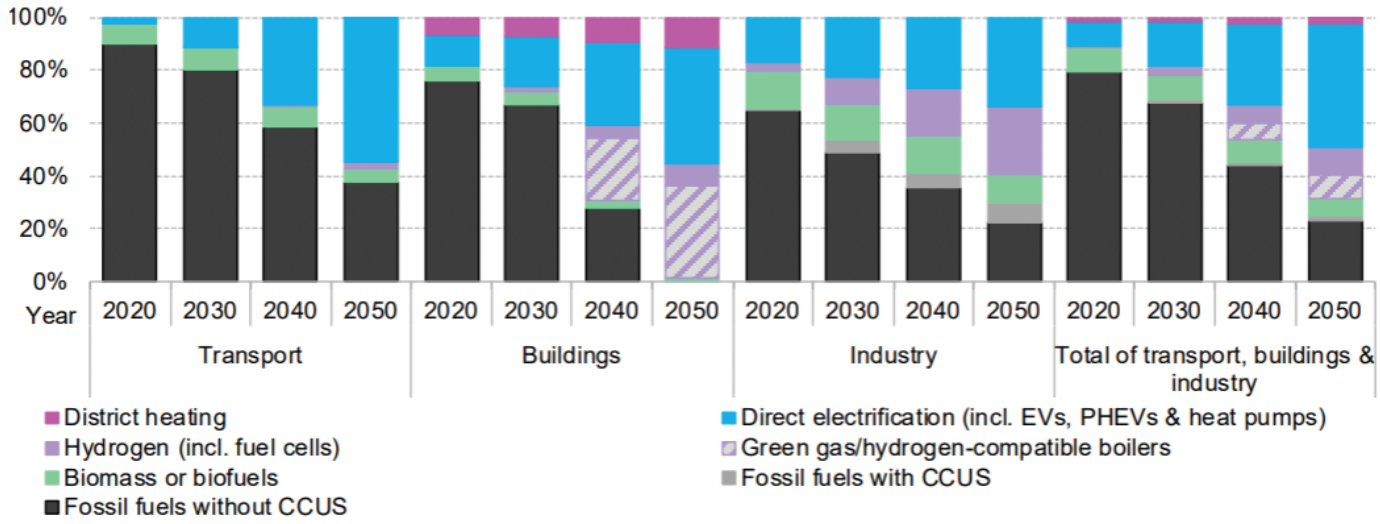
Action from policy makers will be needed if these changes are to happen - governments will need to introduce incentives or requirements to cut emissions from building heat, support demonstration projects for electrification, and iron out barriers to the production of green hydrogen. Government and the utility industry will also need to work together to consider how to engage energy consumers and civil society as they will have a crucial role to play in enabling electrification of these new sectors.

All this indicates that it is highly probable that we are moving towards an energy system consisting of many autonomous power cells, which optimally coordinate local consumption and production in a self-organised and highly automated manner. The aim of future research and development investments will be to make these cells resilient and black-start capable. It is also true that distribution network operators and energy retailers will no longer be the sole drivers when it comes to the design of this future energy system: end consumers, consumer goods manufacturers, home automation companies, the automotive industry and even oil and gas majors are all starting to make inroads into the traditional utility's territory. Ongoing relevance in this new world will require constant innovation and experimentation but offers rich potential rewards for the winners.

Changes in the merit order

Due to market reforms driven by the European Commission, over the past few decades, energy markets have been gradually liberalised. At the same time, grid operations, power generation and sales were separated. Until about 20 years ago, almost all utilities in Europe were integrated companies handling the generation, transport and sales of energy sources and services under one roof. Grid operation, power generation and energy sales are now strictly separated, as the different business areas were spun off and merged into new specialised companies.

The success of renewable energy over the past ten years, especially wind and solar power, has forced utilities to undergo additional transformations. The merit order, the regulatory structure governing energy production facilities, ensures that renewable power plants with very low marginal costs are increasingly pushing expensive peak-load power plants (essentially gas-fired power plants) out of the market. Since the European electricity markets are coupled, this phenomenon is playing out across the whole region.



Source: BloombergNEF. Note: Weighted by each sector's energy consumption in the Northern European archetype (Eurostat).

Figure 1. Breakdown of energy consumption by fuel source across transport, buildings and industry in the Northern European archetype

As a result, the market price for a megawatt-hour of electricity is likely to decline considerably over the next decade, and many power plants will no longer be profitable as revenues from energy production collapse. Many large power plants will be decommissioned, while many smaller distributed generation plants will come online. Grids increasingly need to manage fluctuating quantities of electricity from distributed generation facilities and transport them to consumers - and those grids are therefore also facing major challenges.

The missing money problem

The BloombergNEF Sector Coupling study concludes that a high-renewables power system is very likely to face a 'missing money' problem. This means the power sector may fail to deliver a clean and reliable supply of electricity because the wholesale market does not offer credible signals for investment in renewable and dispatchable capacity. Additional policies (or new market designs) will therefore be needed to provide revenue certainty for renewable generators in order to drive the investment needed. If – as some EU countries have done – policy makers introduce a capacity mechanism, BloombergNEF anticipates that they will need to implement alternative measures to ensure that the required low-carbon capacity is built. If not, this could blunt the decarbonisation benefits of sector coupling by favoring the construction of carbon-emitting power plants.

Furthermore, carbon-intensive power stations and conventional Combined Heat and Power (CHP) plants are slowly going offline, leading to the build-up of a potential seasonal gap. In addition, the development of new capacity from renewable energies is proving difficult, as lengthy planning processes and complaints from residents often prevent the required expansion of renewable power generation.

Grid operators in the meantime remain the strongest actors in the utility sector and will remain so for some time to come due to their position as a natural monopoly.

Challenges in front and behind the meter

In many European countries, the obligatory rollout of smart meters is well underway. Many current regulations all over Europe allow consumers to carry out optimisation activities on their side of the meter, i.e. behind the meter in their home or building. This enables energy consumers to implement generation and consumption controls that reduces consumption at the meter nearly to zero. Such control systems are increasingly being developed for larger residential projects.

However, the lack of smart meter uniformity and standards makes it very difficult to connect and commission embedded generation or flexibility assets. The connection of these assets to smart meters is essential in order to facilitate the performance and measurement of ancillary services, so this introduces complexities and costs in the introduction of distributed flexibility that could be avoided.

3. Generation and load management challenges of Sector Coupling and the importance of flexibility

Due to rising demand for electricity, sector coupling will require power generation capacity to double in size. This would not only require much more generation from wind and sun, but also sufficient reserve capacity, such as gas peaker plants, to provide the necessary generation reserves in the system to bridge seasonal gaps that flexibility cannot address. At the same time, the potential for synergies is significant by linking these sectors. Linking sectors with very different consumption profiles and some demand-side flexibility would make the energy system more flexible, reduce emissions and system costs while creating opportunities for utilities to actively shape and participate in these new energy markets.

The electricity sector must grow substantially, with low-carbon generation, for the potential of sector coupling to be fully realised. Based on 2018 electricity demand, the above-mentioned study predicts that by 2050, personal electric vehicles will require 13% more electricity, while the use of electricity for heating and cooling residential buildings will increase by 24%. Road transport and commercial fleets will account for an additional 15% increase in demand, the study says. Furthermore, these additional loads will not be spread evenly. In regions with high levels of population density this load increase will quickly strain local grids absent the development of effective flexibility markets. Due to the gradual phasing out of conventional power plants, this additional demand for electricity will require huge further expansion of wind and solar energy supplies as well as constant local grid reinforcements. In this regard, local utilities and energy retailers can play a central role in the planning and implementation of generation and grid upgrades or course, but also of incentive schemes to nudge consumption patterns towards sustainable practices that help to limit superfluous investment, with the support of local residents and politicians.

As mentioned earlier, in order to enable the energy system to cope with this massive growth in variable generation, flexibility will be key. Active and automated grid control, and flexibility both on the demand and supply side will be necessary in order to meet future challenges. To this end, tariff structures and grid charges must be adapted to the new requirements. The BloombergNEF study therefore also identifies government policy and regulatory decisions as essential factors in supporting sector coupling.

The energy system of the future will have to make intensive use of and expand both the electricity and gas grid infrastructure in order to meet the growing demand with the help of distributed and variable generation. Consequently, the European Network of Transmission System Operators (ENTSO-E) and the European Network of Transmission System Operators for Gas (ENTSOG) are now working closely together on the European planning processes for the Ten-Year Net Development Plan (TYNDP).

Perhaps the greatest challenge is to develop new approaches for an integrated energy sector. This common planning process at the transmission grid infrastructure level needs to be extended all the way down to local distribution networks. This is because variable generation is typically connected regionally into the distribution grid. That creates significant additional challenges for the many distribution system operators all over Europe. The specific technology where both systems meet is electrolysis facilitated by renewable electricity. The term 'Power to X' describes a new branch of industry that is now rapidly developing to help address what will be from the mid 2020s a fast-growing requirement for long term flexibility. In future, hydrogen, either directly or refined into methane, will fulfil two functions: increasing the storage capacity of energy systems to the required level, and alleviating transport bottlenecks in the electricity system by utilising gas infrastructure. Hydrogen will thus play a decisive role in the energy system of the future (either directly or combined with captured CO2 into methane), whether it is locally produced or transported via large-scale gas grids.

Generation

Conventional generation plants will be subject to rising CO2 prices and will go out of business over time. In the long term, the last remaining thermal power plants will take the form of gas-based peaker capacity that can be quickly activated, and even these may eventually be replaced by more efficient fuel cells.

The expansion of renewable energy needs to proceed rapidly. This will require more efficient planning processes and ideally revenue sharing schemes with residents to help speed approval for the development of onshore wind and solar parks. The operation and integration of these distributed generation facilities – both in front of and behind the meter on customer premises will increasingly emerge as a core business for utilities.

Demand

The electrification of heat and transport is already an accelerating trend. According to the BloombergNEF study, sector coupling will lead to increases in electricity demand of more than 60%. For energy retailers, this creates a huge opportunity to create value by making their customers' flexibility assets available for system stabilisation. They can help support distribution system operators' need for more data and information on specific demand side dynamics as well as local asset condition measurement. As a result, future flexible, customised tariff systems, coupled with the operation of customer facilities and power purchase agreements (PPAs), will enable energy retailers to secure their relevance far into the future.

Flexibility

Flexibility will be the new corner-stone of energy management systems. Providers that are able to activate the available flexible resources in an optimised and cost-effective way will have a clear advantage in tomorrow's decentralised and hyper-connected energy system. Metering, switching and controlling, the collection and processing of large amounts of data and process automation will be the future core competencies of utilities.

Grids

A European integrated energy grid needs to be developed and the DSOs will be a core player. On the highest voltage levels the European Ten-Year Net Development Plan specifies and coordinates the necessary measures at international level and lays down the basic processes. The necessary technologies and methods are largely known and are rapidly developing. This specific process needs to be extended down to the distribution grid levels since the power-distribution system faces much greater challenges than the transmission system. It is not only necessary to implement distributed generation and integrate it in a cost-optimised manner, but grids also need to meet the increase in demand due to the electrification of buildings and transport. At the same time, the regulatory framework, proliferation of embedded generation, management software and behind-the-meter flexibility assets is contributing to the formation of local and island networks, which are increasingly seeking to become close to self-sufficient. This potentially means that DSOs will lose their regular source of income from grid operation. They therefore need to develop strategies to secure their business by supplementing the simple operation of local grids with comprehensive services that meet customers' varied requirements around resiliency, carbon elimination and cost efficiency.

4. How DSOs and energy retailers can capitalise - future value-creation potential

In anticipation of future developments, energy services and the operation of customer power plants will be an important value-added area for energy retailers in particular. At the same time, DSOs should be free to offer whichever contract best suits their mix: for instance, aggressively rewarding users for installing and making available flexible capacity behind-the-meter if they have a high proportion of variable renewables and face congested networks.

The scale of the challenge for the power system depends on the uptake of the new sources of demand-side flexibility created by sector coupling. The potential new sources of flexibility include 'dynamic' electric vehicle (EV) chargers and electric heating systems that respond to pricing signals, virtual power plants and industrial demand response – if the right enabling policies and technologies are in place. More dynamic demand also means less investment in generation and the electricity grid, lower system costs and ultimately lower power emissions.

Adjustments in the investment strategy

The BloombergNEF sector coupling study highlights the importance of investments in new renewable generation capacity. At the same time, it is important to maintain highly flexible dispatchable generation capacity for grid stabilisation. In this context, it will be exciting to closely follow the international discussions on the future market design of the real-time energy industry, since investments will decisively depend on these developments.

In order to be successful in the future we recommend operators of distribution networks seek as many opportunities as possible to procure flexibility, in order to accelerate their evolution into system operators. At the same time energy retailers should diversify services to meet customer needs beyond power supply such as power purchase agreements, flexible tariffs and bi-directional EV-charging infrastructure. They should also seek to build up their own renewable generation and storage capacity thereby strengthening the grid to enable more sector coupling

5. How Eaton is helping utilities today

Eaton believes the potential of the energy transition will require the electrical grid to be transformed into a software-defined grid enabled by 'power routers', requiring competences in building blocks, control capabilities and data architecture to build, manage and optimise power flows.

Eaton is actively developing technologies needed to make the change happen

Eaton's has a long and unique position as an energy company active both in electrical and transport markets (automotive, trucks or aerospace). This enables us to understand the energy transition and serve customers in all markets we are active in.

Eaton has deployed its expertise in power electronics and controls to create simple, cost-effective ways to control and route power at the level of every EV charger, power circuit, or to store and release power on demand and time any building's power requirements to power availability and cost.

Eaton has received widespread public recognition for its trailblazing innovations in nascent flexibility markets around the world. These include the Energy Management Circuit Breaker (EMCB) developed with the Electric Power Research Institute (EPRI), the Johan Cruijff Arena microgrid, integration of storage and EV chargers at the University of Lille and our plant as a grid in in Wadeville, South Africa. We have also developed industry first UPS-as-a-reserve capabilities at several data centres around the world, working closely with key partners including Microsoft and Stattnet in Norway on live trials of the technology.

We were also the first company to develop and commercialise SF6-free vaccum and solid state insulated switchgear in 1960. Since then we have shipped over 1 million SF6-free Medium Voltage panels to utilities around the world ensuring Eaton is ready to support customers that want to eliminate the world's most harmful greenhouse gas from their switchgear installations today.

Further down the road, our long experience with digital signal processing and data analytics applied to power paves the way for such diverse applications as flexibility assets responding automatically to frequency variations, advances in healthcare, care at home for elderly people, and of course fine-grained power management. Eaton is committed to use all possible energy management technologies to improve quality of life and the environment and play its part in helping the EU to reach its ambitious goal of reaching carbon neutrality by 2050.

Case study: Britain's Drax - how flexibility incentives might work

UK-based Drax Group was once best known as the owner of the largest coal power plant in western Europe. It is now diversifying into multiple alternatives, as it broadens its offering under a low-carbon energy transition. These alternatives include flexible, low-carbon electricity generation, such as from biomass, pumped storage and run-of-river hydro, as well as downstream energy services, through its acquisition of two business-to-business supply companies, Haven Power and Opus Energy.

As a part of this downstream expansion, Drax is now exploring whether it can market behind-the-meter storage to its new business customers. A first step is to drive down installation costs in battery trials. The next would be to seek out markets, where Drax sees a lack of visibility presently in Britain. Two key problems are the low volumes and experimental nature of emerging flexibility markets at the distribution level, and the short-dated nature of more established contracts for system-wide flexibility services.

Drax considers two options for better incentivising flexibility. First, distribution system operators should provide more transparency on how long-term, future service requirements are likely to evolve. This could include ensuring that flexibility contracts can be tied into, and are stackable with, capacity market contracts. Sharing better information, enabling whole system outcomes and forecasting how the system needs may develop in the coming years will enable informed investment decisions that minimise overall costs for consumers. Second, Ofgem could tighten the National Grid's Electricity System Operator (ESO) cost targets and incentivise the ESO to use a blend of short-term and longer-term contracts to manage cost volatility. This should reduce price risks for consumers and, at the same time, provide clearer investment signals for flexibility providers.

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