PAPER

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Reaching 32%: How the integration of Distributed Energy Resources will help the EU achieve its renewable energy target in 2030

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Executive Summary

With the adoption of the Clean Energy Package, a binding target for the integration of renewables into the EU's energy system has been set to 32 % by 2030, with an even higher percentage foreseen in the future for contributing to climate change mitigation. While large renewable energy generation facilities are being built, a major proportion of the clean energy capacity will originate from small distributed sources, if we are to reach the EU target. The efficient integration of variable DER into the system requires careful networks management technology and new digital tools.

The distribution network will need to accommodate ever increasing levels of DER and adaptation will be required to manage ever increasing levels in intermittent sources of energy and the flexible technologies that can help manage the impacts of these. To ensure the future-readiness of the grid across the EU, we need to develop tools to increase our knowledge of the electricity network operation. We welcome the Electricity Directive[1] (Art 59) provision giving the power to national energy regulators to use local indicators to monitor and assess the performance of network operators to develop a smart grid able to integrate large share of renewable energy. Such a grid monitoring process will be a critical tool to help grid operators to assess the essential needs of the infrastructure and provide regulators with data to track progress.

As a global leader in the fight against climate change, the European Union has set itself ambitious targets and has adopted a significant revision of its energy legislation. With the clear vision for 2030 and beyond and a modernised legislative framework the focus now needs to be on future-proofing the energy system. The necessary technological solutions are available (and in certain cases already integrated in part of the network). The key challenge for the

[1] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) EU https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944&from=EN

stakeholders of the electrical grid is to enable a relatively swift upgrading and modernisation of the network.

The integration of Distributed Energy Resources will help the EU achieve its renewable energy target in 2030 and it can be done if we act on the following recommendations:

- Introduce measurement points to support DSOs in their decision-making about DER connection, smart meter, MV/LV substations and BTM devices.

- Ensure sure that cyber-security is properly addressed since the attack surface is progressing.

- Deploy DERMS in distribution systems to manage the DER flows and electrotechnical constraints (voltage, congestion).

- Progressively integrate AMM for real time automation further pushing the limit of their integration.

- Add planning tools, and this would include among others the EV integration

- Develop local markets for trading flexibility and enable the creation and functioning of Virtual Power Plants (VPP)

- Develop customer engagement portals to facilitate the energy transition and create standardised processes and offerings

- Ensure that technologies, solutions and communications are interoperable, seamless and open. Without this the future of large scale DER integration will be impacted. Market players (DER, DSO, aggregators, VPPs) are currently very fragmented and interoperability is key in removing this fragmentation and in ensuring integration and any necessary standardisation of technologies, systems, services and solutions can happen.

1. Introduction

As a global leader in the fight against climate change, the European Union has set itself the target of reducing greenhouse gas emissions by 40% (compared to 1990) in 2030. It will do so by ensuring that by 2030 at least 32% of its final energy consumption comes from renewable energy. Apart from building enough new wind farms and installing more photovoltaic panels, it will also need to create a flexible and optimised energy network to bring the increasingly renewable electricity to the consumer.

In this paper T&D Europe's experts outline the challenges and solutions for integrating distributed energy sources into the European electricity network and what needs to be done now to reach the ambitious climate and energy objectives.

Distributed Energy Resources (DERs) are distribution connected loads, storage devices or generation with controllable demand or output. Often these are new or emerging low carbon technologies and can include solar panels, heat pumps, energy storage devices, electric vehicles and other controllable loads, such as electric heating.[2]

Distributed Energy Systems (DES) encompass a multitude of DER including storage, generation, control, load and automation assets. DES can be designed around specific user requirements to reduce cost, greenhouse gas emissions, and improve security of supply and efficiency. This term is used to refer to the system element that DER play a fundamental role in delivering.[3]

The Electricity Grid

DER offer a key solution in meeting the growing need for low-carbon electrical power. Whilst connected to the grid DER can be controlled to ensure optimum network reliability and performance. One example of this is technology solutions such as Active Network Management (ANM) which issues control signals to generation assets when output is high and demand low to constrain the generator and manage the flows on the distribution network. DER also plays a role in managing and optimising network capacity. With demand for renewable connections and new loads, DER resources and control systems can ensure the network is balanced and make best use of existing assets by freeing up latent capacity. This will require flexibility in the system, and effective integration of DER.

The successful integration of increasing numbers of DER in the European electricity network requires a concerted effort of all grid stakeholders, including network operators, generators, consumers, technology providers, policy-makers and regulators.

[2] IESO (2018) - Distributed Energy Resources – http://www.ieso.ca/en/learn/ontario-power-system/a-smarter-grid/distributed-energy-resources
[3] Siemens – Distributed Energy Systems - Flexible and Efficient Power for the New Energy Era - Executive Summary (2017)

This report is part of a series of T&D Europe publications on the development of a secure, clean and flexible energy system. In these publications we explore microgrids[4], smart digital grids[5], data[6], cybersecurity[7], electro-mobility[8], smart cities[9] and monitoring and control of MV and LV electrical networks[10].

2. The Changing Energy System

Europe has in previous years relied mainly on large base load power generation, typically coal and gas. This baseload power is the minimum amount of power that a utility needs for its consumers. The fossil fuel plant that used to provide this baseload is increasingly being replaced by renewable electricity sources at centralised and decentralised levels on the electrical distribution networks.

The way that energy is generated has changed significantly over recent years. The generation mix has evolved from large baseload power stations and, in a bid to decarbonise, the installed base of large and small scale distributed renewable generation has grown. The combination of incentives and obligations on large energy suppliers has helped to facilitate this transition towards low and zero carbon generation. The transition to renewable energy is not without its challenges: integrating them into the energy system, maximising capacity and making optimum use of largely intermittent and unpredictable renewables are just a few. Traditionally, generation was centrally planned as its output and fault levels were largely predictable. However, the intermittent nature of renewable generation is adding complexity as it is less predictable. The performance of renewable generation is dependent on timing, its location and does not always affect the fault levels on the network.

As the Distribution System Operators (DSO) move to more dynamic operation of the network, new tools will become available to operate the networks more actively, efficiently and effectively. This will give rise to new solutions and new market opportunities for industry and will help to ensure the best use of network assets and the flexible operation of the system. Demand side response, storage and renewable generation at all network levels, will help to support decarbonisation ambitions and deliver an efficient, flexible, resilient and future proofed energy system. This is driven by the need to meet the EU's 40% greenhouse gas emission reduction target by 2030 and integrate the increasing share of renewable generation (at least 32% by 2030) onto network infrastructure, as well as the increased loads brought

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[4] T&D Europe, Harnessing Microgrid Technology Opportunities to lead the Energy Transition in Europe (February 2019)
[5] T&D Europe, Smart Digital Grids: At the Heart of the Energy Transition (February 2019)
[6] T&D Europe, Data: Enabling the Energy Transition (March 2019)
[7] T&D Europe, Ensuring the Cybersecurity of Europe's electricity system (June 2019)
[8] T&D Europe, Towards Clean, Zero-Emission Transport (February 2019)
[9] T&D Europe, Smart Cities: Towards Smart Energy Management (June 2019)
[10] T&D Europe, Monitoring and Control of MV and LV electrical networks: Towards smarter distribution grids (August 2019)

about by the electrification of transport and heat, all of this whilst ensuring quality, reliability, security of supply and choice for consumers.

The integration of DER (coupled with the decreased operation of large power plants) decreases the inertia of the grid, and makes it much more difficult to manage, especially because a large number of DERs are intermittent or weather dependant. This leads to a clear need of pro-active contribution to the management of the grid, especially to contribute to its stability by design (frequency support). As a result, EU member states have adopted similar laws on grid connection requirements and observability and controllability of DERs.

A flexible and optimised energy system will balance the introduction of new technologies into buildings and those connected to the network. This is particularly relevant to the sharp increase in electric vehicle charging infrastructure. Technology that can perform load management or response functions can be connected to the network or deployed in the home, electric vehicles can be sold to the consumer and charging points installed. However, without markets that allow providers to stack revenues and build their consumer propositions the potential value of this technology will never be realised. As the rollout of new technology and services continues without the right market conditions, their value is eroded or delayed. This is even without considering the lost upstream value and savings that these services could be providing to other market participants such as focused and planned infrastructure spending and energy management supported by demand-side response (DSR).[11]

The revised Electricity Directive[12] is giving the power to national energy regulators to monitor and assess the development of smart grids, setting a base for introducing a grid monitoring process in member States. This aims to create welcome and much needed transparency on the transition to smarter grids in Europe, increase the awareness of smart technologies, their potential and promote the use of best practice. Implemented properly, it will help Member States to reach their 2030 targets for emissions reduction, energy efficiency and renewable energy, while incentivising investments in innovative grid technologies.[13]

3. What are the drivers?

3.1. Decarbonisation

The 2015 Paris Agreement drives the world's actions to address climate change by reducing greenhouse gas emissions with the aim of keeping global average temperature increases to well below 2 degrees Celsius compared to pre-industrial levels. World leaders also agreed to pursue efforts to limit temperature increases to 1.5 degrees Celsius compared to pre-industrial

[11] BEAMA – Electrification by Design (2017)
[12] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) EU https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944&from=EN
[13] T&D Europe - Monitoring the state of the European grids: Increasing transparency on the ability of electrical grids to support the energy transition (2018)

levels. The need to rapidly decarbonise electricity generation, replacing old carbon intense plants with renewable, distributed energy from decentralised plants means a much greater reliance on renewable electricity generation and as such the need to develop a flexible and optimised energy network to cope with shifts in supply and demand.

3.2. Security of Supply

Consumers and Government expect reliable and secure energy, whilst no system can be truly free of risk, network reliability is high on the agenda as it is critical infrastructure. Generators and demand-response participants can and will provide services to manage peaks in demand and to maintain supply and maintain energy security. Imported fuels such as coal and gas are affected by global markets in terms of demand and cost, alternately renewable generation is less exposed to these risks and over time in combination with a smart energy system and DER supply can be optimised to minimise threats to energy security.

3.3. Consumer Choice

Consumers choice will drive some elements of the energy system transition, for example connecting generation, installing a heat pump or in the longer term providing demand response services for the DSO. As consumers increasingly interact with their energy usage they will seek to connect DER and DSOs will need to facilitate this.

As DER proliferate and consumer acceptance and interest increases, for example in purchasing electric vehicles (EVs), DSOs will face new challenges. They will need to adopt new approaches and deploy new technology and products to manage and mitigate against these. Clusters of DER can have both positive and negative effects on the networks i.e. battery storage can help to smooth peaks in demand and conversely generation export at times of low demand can serve to cause power quality issues.

3.4. More efficient use of system

The underlying real-time capacity of the network can be realised through connected generation and storage on a managed basis. This will improve the hosting capacity of the network and is a key regulatory driver in terms of maximising the capacity of existing assets.

The cost of delivering power from centralised power stations includes the losses on the network. As DER is closer to the point of use, the losses will be smaller with respect to the distribution grid. Additionally, as DER/control is close to the point of use, bulk supply points will not need to be constrained to meet the reliability targets of all users.

4. What are the Challenges?

The integration of DER faces technical, policy, commercial and societal challenges. Technical challenges include the limited physical network capacity, the optimisation of renewable generation, the timing of resource and resource availability, the lack of network access, communications and voltage issues due to reverse power flows. Policy-makers have the challenge to deal with constraints at the planning stage, while having to plan for an uncertain future. Commercial constraints relate to the time it takes to connect DER to the network as well as to uncertainty about demand side response. Finally, from a societal perspective there are questions about whether and how consumers will engage with the energy system. At the same time consumers expect to have a continuous and secure energy supply.

5. Technology and Network Solutions

Traditional DER owners and operators would seek a firm connection to the grid, meaning that their assets could generate as much power as they wanted, and whenever they wanted, providing they stayed within the agreed connection capacity. However, with the saturation of the transmission and distribution networks, and the increasing costs of connections, there is a move towards network flexibility as users are moving from passive operation to actively participating in the network. Existing and developing network services, such as reserve and balancing services have been introduced to support the operation of the network and to assist in avoiding or deferring reinforcements for connection. This is supporting the objectives of the ETIP SNET R&I roadmap[14] of reducing the cost of distributed generation integration. At the distribution level there may also be services surrounding constraint management. An example in the UK is the UKPN Flexible Plug and Play project which uses active network management software to monitor the network in real time and to instruct generators to reduce output to maintain the network within operational limits.[15]

Owners of DER, such as retailers, aggregators, industrial and commercial consumers, battery developers, and EV charging operators will want to optimise their DER portfolio for charge reduction, participate in ancillary services, and may have issues connecting to the grid due to costly or time-consuming grid reinforcements to provide a firm connection.

The majority of DER are characterised by the variability and intermittency of electricity supply, which increases the need for flexibility on the network. DER can displace conventional generation on a short-term basis, especially during peak times and with flexibility and smart solutions can balance supply and demand more effectively. As networks transition from passive networks (comprising only loads) to active networks (which also include generation) they can manage power production and consumption locally.

[14] ETIP SNET, Final 10-year ETIP SNET R&I roadmap covering 2017-26 (December 2016)
[15] UK Power Networks – Flexible Plug and Play (2015) – [http://www.smarternetworks.org/project/ukpnt202]

5.1. Increase capacity of existing networks

There is a broad portfolio of technology and network solutions, which DSOs can use to overcome the challenges associated with the integration of DER. The introduction of flexible connections – i.e. a non-firm connection which may be constrained at times of high generation output and low demand - and real-time control ensures that DER can be added to networks that would otherwise be considered "full" or at capacity without running the risk of exceeding network operational limits.

The cost of various generation technologies, and now battery storage, has been dropping in recent years. These now offer financially viable, low carbon alternatives for energy systems. For grid operators the challenge is allowing different technologies to share grid access and maintain grid stability as renewable penetration levels increase. Various standards and technical approaches have been developed to address these challenges and maximise the use of existing grid infrastructure. Western Power Distribution's Low Carbon Hub project focussed on how to improve the connection of renewable energy generation.[16]

Solution Overview - Dynamic Line Rating (DLR) is a proven solution that can free up capacity on distribution networks. DLR works by dynamically increasing the ampacity of conductors based on the real conditions and atmospheric conditions that the conductors operate to free up capacity [17]

DER Management Systems (DERMS)

DER management systems (DERMS) offer utilities the data, insights and control capabilities needed to efficiently operate diverse distribution grids. DERMS combine sensors, controls, hardware and software to drive the intelligence needed to harmonize distribution and transmission systems and to optimize DER input and centralized generation.

DERMS extends beyond managing grid operations through the support of billing systems, especially where net-metering tariffs are in place, and by facilitating the implementation of retail-level demand response programs connected to customers' smart thermostats and other IoT-connected devices. DERMS can also support blockchain-based community energy markets, enabling customers who participate in transactive energy models. IDC forecasts 30% of utilities will have invested in such management systems by 2019.[18]

[16] Western Power Distribution – Low Carbon Hub (2015) – [http://www.smarternetworks.org/project/cnt2002]
[17] ENTSOE - Dynamic Line Rating for overhead lines (2015)
18 IDC - FutureScape: Worldwide Utilities 2017 Predictions (November 2016) via Schneider – Digital Grid Unleashed (2018)

Active Network Management Systems

Active Network Management is the "use of flexible network consumers autonomously and in real-time to increase the utilisation of network assets without breaching operational limits, thereby reducing the need for reinforcement, speeding up connections and reducing costs." [19] ANM enables distribution network operators (DNOs) to make better use of existing assets and free up capacity in the networks to allow generation to be more readily connected, this acts as a lower cost alternative to reinforcement and has allowed numerous generators to get connected for less, in addition to helping to displace traditional fossil fuelled generation.

ANMs are a combination of technologies deploying algorithms running from a central hub that utilises Remote Terminal Units (RTUs) in the field to achieve the repeatability and time-bounded control of applications. These systems incorporate fail-to-safe functionality ensuring that the operating limits of the grid are never exceeded.

5.2. Create Microgrids

Microgrids help to better integrate the increasing production from renewable energy sources by managing the necessary flexibility at the local level. A microgrid is an actively integrated controllable energy system consisting of interconnected energy producers (e.g. wind turbines, solar panels, cogeneration), storage facilities, and consumers (households, industry, data centers, electrical vehicles charging points) in a geographical area (e.g. a village, town, business park, neighbourhood). A microgrid can operate as part of the main electricity grid but is also able to operate autonomously (for example remote areas or islands).

There are three more reasons why the creation of microgrids is a good idea. First, prosumer empowerment: Microgrids will give consumers and communities the power to maximize the value of electricity they produce possibly by selling it to the market through an aggregator or by storing it into a battery when the market price is low and reduce the need to buy electricity. This gives them the opportunity to earn money as prosumers. Second, microgrids help to improve the energy efficiency of the network. Energy efficiency goes beyond the optimization of the electrical part and includes also other energy flows, such as heat (which cannot be optimized at grid level). And finally, microgrids can also help to increase the resilience of the electricity network against cyberattacks and the spread of the impact of a black out.

Microgrids offer a technologically mature solution to the decarbonization of local energy systems while ensuring a positive impact on the existing energy infrastructure and the local economy.[20]

19 ENA – Active Network Management Good Practice Guide (2015)
20 T&D Europe - Harnessing Microgrid Technology Opportunities To Lead The Energy Transition In Europe (2018)

5.3. Ensure effective Network Monitoring and Communications

To meet the real-time intervention requirements and achieve the necessary level of flexibility on the networks, an effective communications infrastructure, characterised by its speed of response and reliability, is essential. This results in more detailed, accurate and real-time information of the T&D networks and thereby in more added value for consumers and DSOs. Monitoring and control technologies for MV and LV electricity networks have a tangible positive impact on decarbonization, quality of service and financial efficiency[21]. The ETIP SNET R&I roadmap[22] has highlighted the need to deploy monitoring and control solutions to enable the network flexibility allowing hosting of DER on MV and LV networks.

5.4. Utilise Smart Metering for network management

The next generation of gas and electricity meters, smart meters are a vital upgrade to the energy network and will bring significant benefits for industry and consumers. Very few of the innovations discussed in this paper would be possible without it. Most existing pre-smart meters must be read manually, so neither consumers or energy suppliers have a clear picture of real-time energy use. Smart meters communicate directly with the energy supplier, which removes the need for a site-visit to read the meter; it will also bring an end to estimated billing. Energy suppliers will be allowed to access monthly data for billing purposes, but consumers must give their consent to sharing more frequent and detailed data. Smart metering is justified on its own terms but also as an enabler for flexible and responsive network management, to shift peak load and increase the proportion of renewable generation on the network.

Many consumers are likely to respond to the increase in near real time energy consumption data by becoming more engaged with the way they buy and consume their energy. However, this renewed interest will not be seen everywhere and may not last long. The challenge will be for Government and industry to make best use of the public's engagement with their energy bills and their new options for energy management.

5.5. Stimulate Demand Side Response (DSR) Markets

By sending signals to electricity users, they can be asked to modify their demand in response to power availability, this is known as DSR.

DSR is driven by two key objectives:

1. Matching demand to network capacity (Thermal Constraints). This seeks to move demand from periods of high network loading and aims to maximise the MWh that are

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[21] T&D Europe – Monitoring and Control of MV and LV Electrical Networks – The way towards Smart Distribution Grids (August 2019)
[22] ETIP SNET, Final 10-year ETIP SNET R&I roadmap covering 2017-26 (December 2016), p.28

distributed for a given MW network capacity and will generate savings by avoiding the need to reinforce their networks.

2. Matching demand to generation capacity (Frequency Constraints). This seeks to match demand to the availability of power and becomes more complex as we shift to renewable, intermittent generation and will generate savings by not having to pay for more expensive standby generation. It also allows consumers to benefit from periods of excess generation when power prices fall.

DNOs (future DSOs) and Electricity Suppliers can pass these savings onto their consumers. In the UK, Economy 7 has long offered cheaper power if consumers use power overnight when there is lower demand and the costs for reducing the output of coal and nuclear power stations is high. The same principle applies for DSR, as DSOs seek to accommodate new loads on the networks and the availability of power becomes less predictable with intermittent and less predictable sources of generation.

5.6. Introduce Time of Use Tariffs for Demand Management

Time of Use (ToU) tariffs incentivise consumers to use, store and/or export electricity at times that are most beneficial or least costly to the system. Engagement with consumers and ensuring enough value exists to promote anticipated response levels from consumers is an essential consideration and will be fundamental to the success of innovative tariffs.

Facilitating simple, flexible and responsive energy use without relying on continued high levels of consumer engagement will be achieved by developments in energy storage and intelligent automation. For example, more visibility of the load and cost of running specific appliances may encourage consumers to schedule their use according to static Time of Use (ToU) tariffs, but load shifting in response to dynamic ToU tariffs is most likely to be at least partially automated. Such approaches help to make best use of available energy and consumer demand.

5.7. Load Management and Optimisation

The conventional approaches to integration of DER have been to plan for the maximum secure hosting capacity, with fast acting protection tripping off the generation in the event of any network outages. This ‘fit & forget’ approach limits additional DER due to the costs of reinforcing the network and limits the hosting capacity as it only considered the worst-case conditions.

Hosting capacity is location dependent, feeder-specific and time-varying. These existing approaches avoid “constraints” and the possible curtailment of DER. This leaves latent capacity in the network, to release this latent capacity, ANM systems are used to monitor the real time capacity of the grid and reduce distributed generation output only when the grid is actually under stress. For example, in the Shetland (NINES) project[23], using ANM allowed an additional 8.8MW of RES to be connected, displacing diesel generation and making savings of £1m per year.

Curtailment is proving more cost effective than upgrading grid infrastructure Curtailment of distributed generation also has the potential to considerably increase the connection capacity and therefore accelerate the deployment of wind, solar power and other renewable energy sources. This is again supported in the Orkney smart grid project where additional 25 MW of wind generation was connected, saving developers in the region of £30m in network upgrade costs.[24]

5.8. Enhance Grid Flexibility

The DNO is responsible for maintaining voltages within certain limits. However, the integration of DER into the distribution network can change voltage profiles along the feeders. When the local DER output exceeds the local load, reverse power flows occur and the grid exports towards the higher voltage grid causing a rise in voltages along the feeder. Power system congestion then occurs when these power flows exceed the safe design capacity. Traditionally congestion has been resolved through planned network upgrades. However, irrespective of the cost, planning processes are not able to keep up-to-date with the growth in distributed generation. Additionally, reverse power flows are also influencing the design of the network as they need to cater for peak generation in addition to peak load. Utilities are seeing load profiles changing rapidly and becoming ‘spikier’. Therefore, in addition to grid reinforcement, grid flexibility and smart solutions are seen as a cost-effective solution that can maximise the existing capacity of the network.

5.9. Integrate Energy Storage

Energy storage systems both consume and generate energy. They consume and store energy when there is an excess available, for example at times of low grid load or at times of high power output from renewable generators such as wind and solar. The stored energy can then be released at a later time and in a controlled manner. This flexibility makes energy storage a valuable asset for managing energy use and maintaining the stability of the electricity system.

Storage systems range in scale from very large battery banks connected directly to the network to provide network services such as frequency control, network resilience and peak demand management, down to small residential home systems to maximise the benefit of solar PV systems and, in some cases, maintain power during supply interruptions.

[23] SSEN NINES Project – Further Information available at - http://www.ninessmartgrid.co.uk/our-project/
[24] Operating the Orkney Smart Grid: Practical Experience”, 21st International Conference in Electrical Distribution, Robert Currie et al.

Reductions in cost and improvements in technology have served to make energy storage a commercially and technically viable solution which will be instrumental in increasing the penetration of energy generated by renewable resources a key enabler in the transition to a low-carbon energy system. As a result, new market opportunities and applications have arisen.

Unlike generation connections, storage connections require both import and export capability, and the connection characteristics vary depending on the use, size and location of the connection. Whilst this is true for network storage solutions (large or small), that use imported electrical energy to store energy in another form (e.g. conversion from AC to DC for battery storage, or off-peak energy used in pumped storage), it is not necessarily true for all types of energy storage. In such cases the energy for the store may have been provided wholly by localised renewable energy sources, or the energy in the store may not be reconverted to electricity e.g. in the case of thermal stores or phase change material applications. [25]

Storage can be deployed at a small scale, for example to store PV generation in a domestic battery for use at peak times, or in large scale battery storage systems deployed on the grid that can serve thousands of consumers and helping network operators manage fluctuations in demand. Storage isn't just valuable for networks management but will also be able to offer value to the consumer and to businesses to participate in paid-for services to make better use of their own energy generation.

5.10. Enable Smart Charging for Electric Vehicles

According to the International Energy Agency, between 2011 and 2016, the number of Electric Vehicles (EVs) on the road globally increased thirtyfold.[26] In an increasing number of countries across Europe, Governments are using a number of policies to increase the rate of decarbonisation of transport, these include the banning of new conventionally fuelled vehicles by fixed dates, charging infrastructure incentives and vehicle grants amongst others.

Clustering of EVs and connections of fast and rapid charging infrastructure can cause challenges for DSOs. When considering EVs as a distributed energy resource they are both responsible for load growth and could also be a key solution in providing network services to maintain network stability. For example, Virtual Power Plant (VPP) applications and aggregated EVs providing DSR services to the network.

5.11. Electrify Heating

Despite the dominance of gas infrastructure, the future of heating points to widespread electrification as 2050 scenarios which meet the 80% carbon reduction target universally

[25] BEAMA Electrification by Design – Building Energy Storage (2018)
[26] International Energy Agency (2017) – EV Growth Statistics

include an electrified heat supply. Most commonly, heat pumps are seen as the key proven technology, capable of delivering low carbon and affordable heating. [27]

A controlled and sustained switch to electric heating powered by regional or local grids will have the following benefits: decarbonisation of heat, response service benefits to upstream actors, controllable load, improved efficiency, and optimised approaches to heat and transport planning for low carbon vehicles (ensuring that the network is appropriately reinforced). Sensitivity to local conditions will also have the benefit of supporting regional development objectives.

5.12. Stimulate Peer to Peer Exchanges

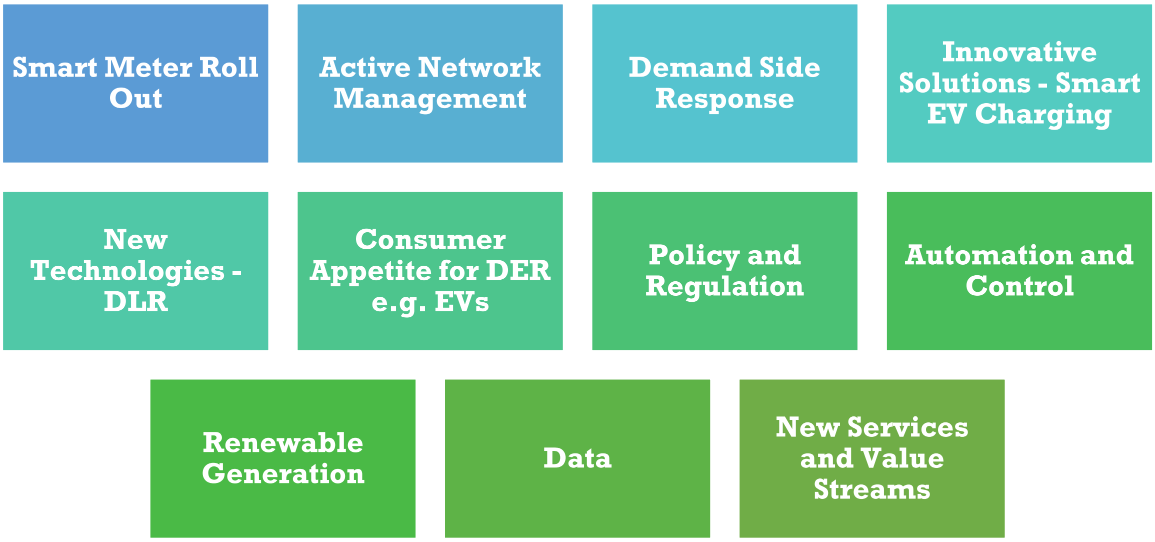
As part of the new and developing energy trends, peer-to-peer exchanges at a financial and energy level also need to be considered in the DER context. In this market, any energy consumer can choose to purchase their power from any generator who has power available at that moment. Recovery of network costs could be achieved by the generator factoring some additional (or reduced) cost or the network company providing a market for network capacity that the users can access. These peer to peer models could offer consumers increased choice, new opportunities and markets to participate in. They could allow users to realise the maximum value and benefit from installed technologies by selling to peers, to network operators or to both if capacity allows. Peer to peer trading can be open to neighbour to neighbour or household to network operator, but also business to business, matching demand with local renewable generation. For businesses, platforms already exist to match renewable generation with local demand.[28]

This can happen only if the electrical grid is equipped with one or more of the solutions outlined in this report.

6. Enablers

In the graphic below a number of key enablers are summarised, these are referenced throughout the report with further detail and explanation.

[27] BEAMA – Electrification by Design: Heat (2018)
[28] BEAMA – Electrification by Design – Our Electric Future (2018)



6.1. Data

Smart meter and real time asset data will further promote the integration of DER as greater visibility is available at each network level via monitoring technologies or in-built data capture in grid connected devices. Data will continue to create new opportunities to operate networks more efficiently. Access to data and open and standardized modelling of data is paramount for the success of the energy transition. Data sharing will be one of the key prerequisites to make the energy system smarter and ready for the decarbonised future.

The new clean energy system offers many advantages for consumers and the environment. Digital technologies are essential for the management of this system. This brings potential vulnerabilities to cyber attacks. The EU can be at the forefront and become a global leader for cybersecure energy systems. It is therefore essential to ensure a robust framework for cybersecurity based on international standards.

Data security is crucial in providing both consumer confidence, technology providers, product manufacturers and service providers should continue to build cyber security into every stage of development.

6.2. New Services Development

Network flexibility services provided by DER can benefit DSOs and reduce the levels of network reinforcement required. These savings could be passed on to the consumer directly by being paid for providing a service, or indirectly through a reduction in the networks costs that form part of their energy bill. In opening the market to a range of DER this would naturally encourage wider system applications and solutions and help to unlock their associated value.

7. Benefits and Value Added

7.1. Cost Effective Connections

ANM algorithms are helping free up latent capacity downstream in the network, thus reducing need for reinforcement for increases in demand or for new connections. This is reducing the costs of connection as well as speeding up the planning process for new connections.

7.2. Better use of existing capacity

The integration of DER is increasing the hosting capacity of the network through optimal use of RES. This is also helping balance supply and demand more efficiently at distribution. Bulk supply points may not be constrained to meet the reliability targets of all users because of this release of capacity close to the consumers. This proximity also reduces losses as DER is closer to point of use.

Network management solutions can help to manage and optimise network voltages, assist with distributing excess generation and facilitate the provision of new grid services.

7.3. Carbon reductions

New control and automation techniques will help provide a balanced introduction of new technologies through functions such as ToU tariffs or through managing the capacity on the network. This will assist with introduction of EVs and associated vehicle charging infrastructure. These capabilities will help member states to reach their emissions reduction and energy efficiency targets and help displace conventional fossil fuelled generation.

7.4. Integration of renewables

The techniques described will increases hosting capacity of networks, thus increasing the capacity to connect more DER. This will help accelerate the deployment of more RES as well as energy storage. Despite the variety of DER, the integration will allow the network to be seen as part of a whole system. The automation techniques used to help integrate DER will help in avoiding the reliance of consumer engagement to make it work. Integration of DER will help ensure continuity of supply and not adversely affect consumer expectations.

8. Conclusions and Recommendations

As a global leader in the fight against climate change, the European Union has set itself ambitious targets and has adopted a significant revision of its energy legislation. With the clear vision for 2030 and beyond and a modernised legislative framework the focus now needs to be on future-proofing the energy system. The necessary technological solutions are available (and in certain cases already integrated in part of the network). The key challenge for the stakeholders of the electrical grid is to enable a relatively swift upgrading and modernisation of the network.

This is a joint responsibility for all stakeholders. With this and other publications T&D Europe wishes to make its contribution to this effort. Below we summarise our key observations and recommendations on how the integration of Distributed Energy Resources will help the EU achieve its renewable energy target in 2030. It can be done if we act on the following recommendations:

- Introduce measurement points to support DSOs in their decision-making about DER connection, smart meter, MV/LV substations and BTM devices.
- Ensure sure that cyber-security is properly addressed since the attack surface is progressing.
- Deploy DERMS in distribution systems to manage the DER flows and electrotechnical constraints (voltage, congestion).
- Progressively integrate AMM for real time automation further pushing the limit of their integration.
- Add planning tools, and this would include among others the EV integration
- Develop local markets for trading flexibility and enable the creation and functioning of Virtual Power Plants (VPP)
- Develop customer engagement portals to facilitate the energy transition and create standardised processes and offerings
- Ensure that technologies, solutions and communications are interoperable, seamless and open. Without this the future of large scale DER integration will be impacted. Market players (DER, DSO, aggregators, VPPs) are currently very fragmented and interoperability is key in removing this fragmentation and in ensuring integration and any necessary standardisation of technologies, systems, services and solutions can happen.

8.1. Engineering and Technical Recommendations

Regulators to monitor and assess the performance of transmission system operators and distribution system operators in relation to the development of a smart grid that promotes energy efficiency and the integration of energy from renewable sources, based on a limited set of indicators.

Utilities to enable technologies to share grid access and maintain grid stability as renewable penetration levels increase.

Consider EVs as a distributed energy resource. Which is both responsible for load growth and a key solution in providing network services to maintain network stability i.e. Virtual Power Plant (VPP).

Ensure an effective communications infrastructure as a key underpinning enabler, characterised by its speed of response and reliability.

Network upgrades should be triggered as networks hit set limits and reinforcement and/or smart solutions used as an interim or enduring option.

8.2. Policy, Governance and Markets Recommendations

Develop market conditions to ensure that new solutions can operate to their fullest extent. New solutions and new market opportunities will arise for industry participants and will help to ensure best use of network assets and flexible operation of the system.

Establish a flexible and optimised energy system that balances the introduction of new technologies into buildings and those connected to the network.

Grid users, generators and consumers are increasingly moving from passive operation to actively participating in the network.

Through smart metering and other engagement opportunities, the challenge will be for Government and industry to make best use of the public's engagement and to use that as a foundation.

Smart and time of use tariffs should incentivise consumers to use, store and/or export electricity at times that are most beneficial or least costly to the system.

8.3. Cyber, Data and Commercial Recommendations

Cybersecurity – the future world described is very much interconnected, with potentially millions of stakeholders exchanging data, impacting one of the most critical assets of Europe - its electricity grid. There is a need to ensure that all these interconnection and data exchange are secure so that they do not impact security of supply, consumers or leave market participants open to unnecessary risks.

There are significant requirements for defining standard cybersecurity requirements cross Europe and specifically related to DER integration

Data security is crucial in providing both consumer confidence, technology providers, product manufacturers and service providers should continue to consider cyber security into every stage of development and rollout.

Opening the market to a range of DER will naturally encourage wider system applications and solutions and help to unlock their associated value.

8.4. Societal and Consumer Recommendations

Focus on the value of intelligent automation that can make energy decisions on the customers behalf.

Consumer choice will drive some elements of the energy system transition, e.g. connecting generation, installing a heat pump or buying an EV.

As consumers increasingly interact with their energy usage they will seek to connect DER and there will be demand for DNO/DSOs to facilitate this.

8.5. General Recommendations

A continued and sustained reliance on renewable electricity generation will require a flexible and optimised energy network to cope with shifts in supply and demand.

ABOUT T&D EUROPE

T&D Europe is the European Association of the Electricity Transmission & Distribution Equipment and Services Industry, which members are the European National Associations representing the interests of the electricity transmission and distribution equipment manufacturing and derived solutions. The companies represented by T&D Europe account for a production worth over € 25 billion EUR, and employ over 200,000 people in Europe. Further information on T&D Europe can be found here: http://www.tdeurope.eu

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