SMART DIGITAL GRIDS: AT THE HEART OF THE ENERGY TRANSITION

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For many years the European Union has been committed to the reduction of carbon dioxide emissions and the increase of the share of renewable energies in its energy mix. The Clean Energy for All Europeans package is the latest milestone in the EU's drive towards a low-carbon economy.

Although changing the primary energy mix in the electricity sector is easier than in any other sector, the main sources of renewable energy, i.e. solar and wind power, require a funda¬men-tal re-thinking of how power systems are designed and operated. The new sources of energy are volatile, they may be geographically constrained, they are less controllable than conven¬tional sources and they will result in a much more distributed and fragmented generation sector than in the past. Therefore, in addition to delivering on the three main expectations – cost-effectiveness, sustainability and security of supply – the modern electricity network also needs to be able to serve all types of users and needs to be accessible to all new users, some of whom may not yet be known today.

Electricity grids connect and coordinate all elements of power systems to serve their end users. Grids will play a crucial role in facilitating and enabling the energy transition to incorporate increasing levels of distributed generation, changing demand patterns and the implementation of new technology and solutions. As we move from traditional energy systems, new, smarter digital solutions will be required.

This means that not only the generation sector will have to undergo a fundamental transformation, but also the grids will have to change and develop accordingly to deliver value and quality of supply to consumers. The electricity grid infrastructure is at the centre of the new market design. The grid needs to be future-proof: robust, smart and ready to adapt to the upcoming changes in the market.

WHAT ARE THE SMART GRID TECHNOLOGIES?

The future energy system requires smarter digital grids. The technology for these is available today and integrated in certain parts of the electricity network.

We can distinguish three groups of technology that need to be considered as part of such a future-proof, smart, digital network:

1 Smart digital grid infrastructure (field devices, remote monitoring and control):

Assuming that a common denominator of most, if not all smart digital solutions is to operate grids in a more precise and adaptive manner, getting information from the field and being able to control the grid remotely is a pre-requisite for increased smartness. This would be reflected by this first group: a smart digital grid infrastructure that is cost-efficient, reliable and – by increasing the capability to accommodate RES generation – sustainable. Moreover, smart devices at the edge of the grid are the basis for all types of new consumer-oriented services and for consumer empowerment.

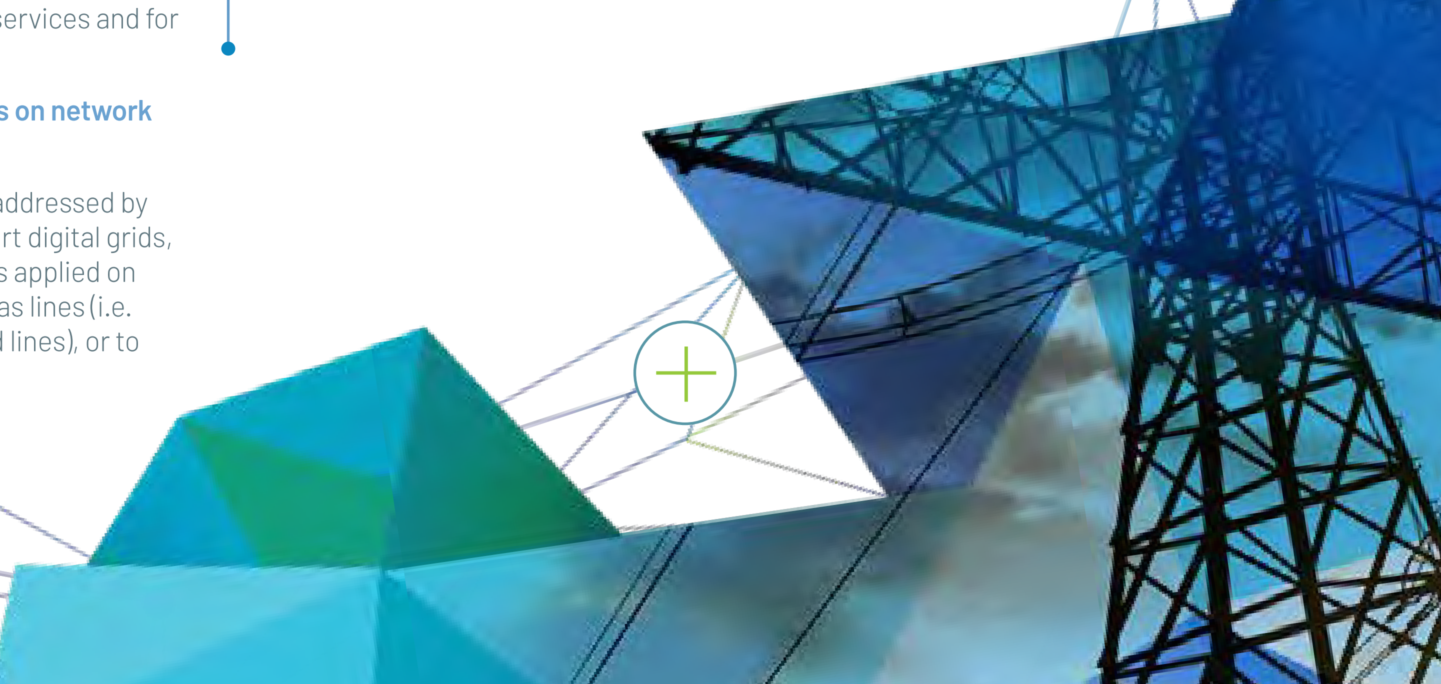
2 Smart digital grid functions (operational features on network level, software):

Using information provided by the infrastructure addressed by the first group is the second building block of smart digital grids, which contains primarily out of software functions applied on network level – either on parts of a network, such as lines (i.e. underground cables, overhead lines, gas insulated lines), or to entire grids.

3 Smart digital actuators (new non-conventional components to operate the network):

Combining the first two groups means to operate conventionally equipped grids with more monitoring and remote control more digitally. This is an important first step towards smart digital grids. However, there are more opportunities if non-conventional elements are added, allowing faster adaptation of the grid to new situations and by that to increase utilisation without reducing reliability of supply. Such solutions are frequently based on power electronics.

Wind and solar power as well as new types of load, in particular electric vehicle (EV) charging infrastructures, are rapidly evolving and are challenging the grids with high and rare peaks. Traditional design of the grid based on the peak load would result in decreasing utilisation due to changing demand patterns and projected increases in peak demand affected directly by consumer charging behaviour. Deferring investments in primary equipment and reinforcement by digital operation of the grids therefore gains importance.



HOW DO SMART GRID TECHNOLOGIES CONTRIBUTE TO THE ENERGY TRANSITION?

The electricity grid infrastructure is at the centre of the energy transition. It is therefore essential to ensure that the grid is future-proof: robust, smart and ready to adapt to the upcoming changes in the market. A future-proof, smart digital grid contributes to the energy transition by:

- Ensuring cost-effectiveness of the electricity system through, for example, dynamic loading of components, Increased ability to accommodate distributed energy resources (DER) by dynamic voltage control, reasonable curtailment of rare peaks of renewable energy sources (RES) feed-in or load such as Active Network Management, advanced asset health management, minimization of fuel and carbon cost of conventional generation by maximizing accommodation of renewables increasing network capacity and headroom using smart techniques such as reactive power compensation.

- Supporting sustainability and the energy transition, through, for example, loss reduction by increasing energy-efficiency of the grids, accommodating increasing levels of renewable generation, support of electrification of new sectors, e.g. EV charging and heat, optimization of the grid load at all voltage levels including phase balancing, to increase the energy efficiency of the grid;

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- **Ensuring security and quality of supply as well as resilience,** through, for example

  Advanced planning procedures and tools, reflecting distributed resources and new loads, in particular EV charging infrastructures, and consideration of operational measures (e.g. peak shaving) when assessing and planning the infrastructure.

  Advanced asset management, reflecting condition and importance of assets and ensuring that critical components are identified and prioritised: Such approaches are becoming more relevant in a rapidly evolving environment, in which grid enforcements and extension have to be implemented much faster than in the traditional, quite stable European environment.

  Real-time dynamic security assessment on transmission level: Historically, the European interconnected power system has been engineered to share reserves and to allow portfolio optimisation in a regionally balanced power system. Additionally the majority of generation was provided by large rotating machines, stabilizing the grid by their mechanically inertia. Today, with increasing regional imbalances caused by geographically constrained sources of renewable energy mainly connected via power electronics, the pan-European transmission grids are facing a fundamentally different task. The traditional way of operating the systems with strong focus on preventing emergencies and much less attention on curing such efficiently, which resulted in high reserve capacities in the transmission grid, is not adequate for this task any more. Instead, more real-time monitoring and network management should be applied to ensure best utilisation of the infrastructure, while at the same time maintaining security of supply. In doing so, also new grid elements based on power electronics need to be considered.

Self-healing or re-configuring distribution networks: Rapidly changing load situations caused by volatile distributed generation are requiring more operational flexibility even in the secondary distribution level, which traditionally has not been controlled or monitored.

Fast outage clearing: Reliability of supply can be improved not only by avoiding outages, but also by shortening the time of interruption of supply. Increased application of remote control and monitoring can support this and at the same time even lower costs.

Increased resilience provided by on-grid micro- or nanogrids: Distributed generation, if equipped with adequate microgrid controllers, can run independent from the grid in case of regional or system-wide blackouts. Using this opportunity given by distributed generation would reduce the negative impacts of such blackouts significantly.

Demand response programmes helping to avoid critical situations: Such programmes may help to balance load and generation, they may help accommodating renewable generation, but they may also give relief to the grids in critical situation, and help the grid to manage changing demand patters and increasing connected loads in a more effective and efficient way.

Cyber security assessments: All the items above imply the use of more digital control and communication technologies. Moreover, integrating and coordinating highly distributed resources means a quantitatively much broader exposure of the system to cyber crime. Cyber security and cyber security assessments are therefore crucial for ensuring security of supply in future power systems.

- **Empowerment of all types of users of the grids** and letting them participate more actively is a new, additional requirement complementing the traditional triangle. An important pre-requisite for such partici¬pation is transparency of the user's influence on the service received and on the system, both for the user and for service providers. Examples for implementation are:

  Smart metering infrastructure and services providing information to users and grid operators

  Time of use tariffs

  Facilitation of participation of all players   even very small ones in markets by efficient and functional regulation for registration, qualification and settlement.

  Allowance for the grid operator to use reasonable curtailment of rare peaks as an alternative to grid extension based on economical decisions.

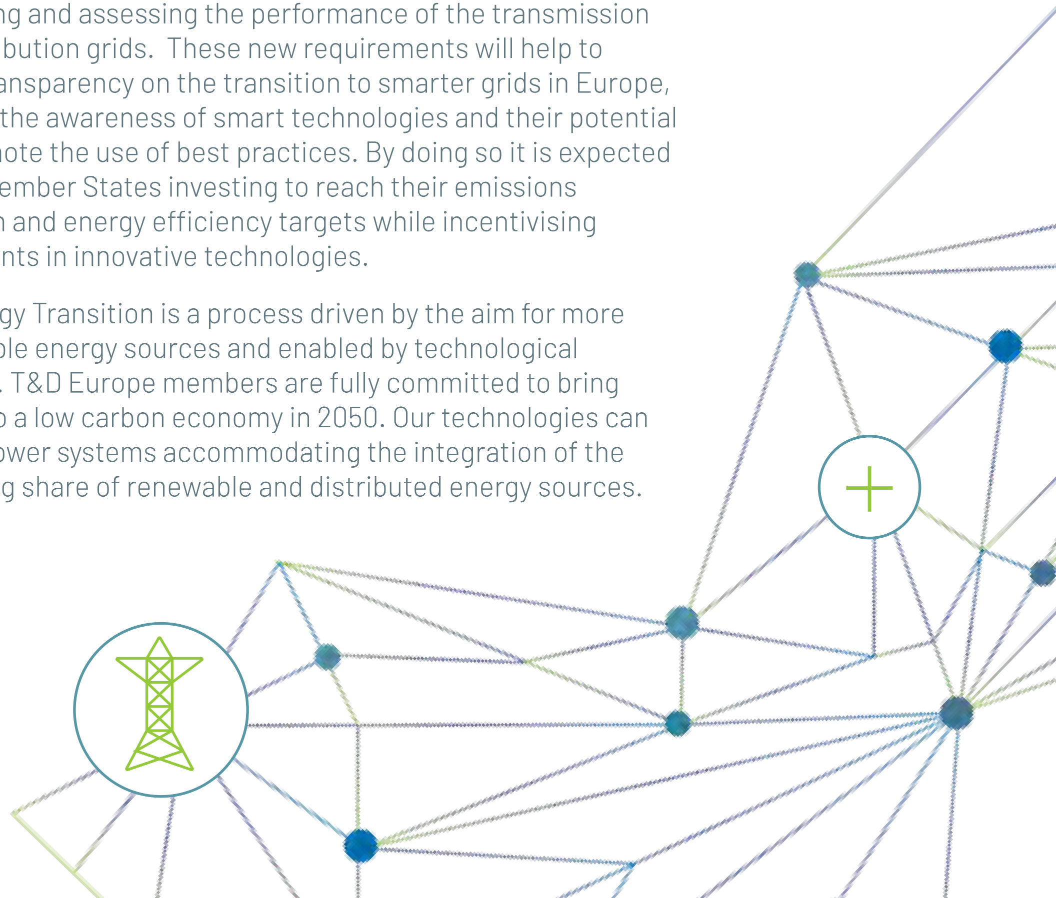
There are two more elements in the objective summarised earlier, which suggest a broadening of the traditional triangle of requirements and a need for different solutions in future than in the past: The first is the requirement to serve all types of users of the grids. In addition to the classical users – bulk power plants and passive consumers – this addresses for instance distributed generators, prosumers and new service providers, such as aggregators. The second is to be accessible to all of these new users known already today, but also to those that may evolve in future and are not known yet. This accessibility requires concepts that are capable of evolution and adaptation. Digitalisation, if properly applied, can be expected to be a key enabler to address this requirement.

CONCLUSION: REGULATION CAN HELP GRIDS BECOME SMARTER

Today's regulation does not reflect this need for transformation. Regulation is primarily or in many cases even exclusively focusing on cost-efficiency of the grids, but not on their active contribution to a successful (including cost-efficient) energy transition. There is a need to broaden this regulatory view on electricity grids. Expert Group 4 (EG4, Smart Grid Infrastructure Deployment) within the Commission's Task Force Smart Grid has dealt with this with regard to projects proposed under the framework of Projects of Common Interest (PCI).

The new EU electricity directive is complementing this by monitoring and assessing the performance of the transmission and distribution grids. These new requirements will help to create transparency on the transition to smarter grids in Europe, increase the awareness of smart technologies and their potential and promote the use of best practices. By doing so it is expected to help Member States investing to reach their emissions reduction and energy efficiency targets while incentivising investments in innovative technologies.

The Energy Transition is a process driven by the aim for more sustainable energy sources and enabled by technological progress. T&D Europe members are fully committed to bring Europe to a low carbon economy in 2050. Our technologies can enable power systems accommodating the integration of the increasing share of renewable and distributed energy sources.



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