Grid Evolved: Power System Flexibility

FOR MORE INFORMATION:

Clean Energy Ministerial (CEM) | http://www.cleanenergyministerial.org
IEA International Smart Grid Action Network (ISGAN) | https://www.iea-isgan.org
ISGAN Annex 6 Power T&D Systems | https://www.iea-isgan.org/flexibility-in-future-power-systems
Mission Innovation (MI) | http://mission-innovation.net
MI Innovation Challenge 1: Smart Grids | https://www.mi-ic1smartgrids.net

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Power system flexibility will play a key role in next generation electric grid; it will allow countries to

- Replace fossil fuel generators with clean and renewable energy sources,
- Increase reliability and resilience against disruptive events,
- Improve performance and reduce costs of new and existing assets, and
- Transition to a low carbon economy.

Flexibility will enable all stakeholders and elements of the grid (generators, consumers/end-users, storage, and infrastructure) to be active participants in the energy system, also enabling the cost-efficient development of renewable sources and more resilient power systems.

Developing new avenues of power system flexibility is a prime space for innovation. To accelerate the adoption of innovative solutions, policy makers can drive to

- Assess, measure, and develop new potential resources and tools for flexibility supported by research organizations,
- Stimulate commercial development to put new tools and business concepts on the market enabling end-users to contribute with their flexibility assets by means of demand response to a more efficient use of the grid,
- Speed up business and private sector adoption and open opportunities for full deployment thus resulting in GHG and cost reductions,
- Support innovative grid operation practices to fully exploit flexibility assets to improve system performance and minimizing grid costs, and
- Encourage demonstration and strategic adoption of flexibility options to reach GHG targets through government initiatives and policies.

Developing and implementing clean energy solutions for the electric grids are key objectives to both the ISGAN and Mission Innovation IC1 initiative. To reach this goal, there is a need for innovation within the area of smart electric grids. This fact sheet expands on one key focus area: flexibility of the electric grid.

The cornerstone of power system operation is ensuring that electricity demand is always balanced by its supply. To enable this, the electric grid system requires flexibility: "the ability of a power system to reliably and cost-effectively manage the variability and uncertainty of demand and supply across all relevant timescales."[1] In the past, most variability (and thus the need for flexibility) has come from the demand side – changes in the load driven by consumer behaviour. Large generators (such as hydro or natural gas plants) have usually provided this required flexibility.

Courtesy India Mission Innovation Resource Center

1 Status of Power System Transformation: Advanced Power Plant Flexibility, International Energy Agency, Paris.

Decarbonising the energy system calls for additional flexibility to unleash its benefits.

- First, flexibility enables the integration of more renewables on the grid thus allowing progressive decommissioning of non-carbon neutral electricity generation. Wind, solar, and low-impact hydro (the bulk of new renewables) are mostly variable. Flexibility will enable system operators to balance their supply with demand by harvesting renewable or flexible thermal plant output in a more efficient manner, thereby, reducing network congestion and costs on other parts of the system.
- Second, flexibility contributes to grid reliability and resilience to disruption. With more flexibility available to operate the grid, utilities can better configure their systems to be able to prevent outages in the event of possible contingencies (e.g., equipment failures) or extreme events (e.g., storms, floods). In the case of an outage, flexibility will allow operators to quickly restore systems and power supply, thereby improving network key performance indicators.
- Third, flexibility can increase grid utilization and thereby decrease energy and infrastructure costs. Load, which is growing and increasing in variability, calls for infrastructure upgrading needs. Flexibility can lower peak demands and increase efficient use of available assets. Furthermore, flexibility will give the grid more regional and local supply options, ultimately reducing electricity rates and giving consumers more options.

More system flexibility can be added by (i) strategically investing in additional capital-intensive infrastructure, (ii) taking stock of new smart grid technologies, and/or (iii) implementing new and innovative market and system operation solutions. These options are complementary, and their ideal mix depends on such factors as system architecture, reliability targets, regulatory frameworks, and costs.

New infrastructure investments are large-scale options that include adding or upgrading generators, transmission or distribution lines, or energy storage systems. These options can be highly capital expensive but can use well-established, proven, and reliable technologies; sometimes, they are the only option to meet capacity needs. However, when strategically placed, they can enable additional flexibility and make use of the potential deriving from the interconnection with other systems. For instance, new generators and storage systems can enable utilities to utilize the full potential of low cost renewable solutions by allowing their maximum production; new lines and interties allow neighbours to share resources, thus making a more efficient use of their network strengths. Behind the meter as well as utility scale, battery energy storage plays a significant role in enabling power system flexibility.

Smart grid technologies utilize advanced algorithms and technologies to bring additional capabilities to existing power system elements. Since these new capabilities are additional to the primary role of the elements they are attached to, costs are incremental (and much less than adding new infrastructure). With the recent push to deploy new information and communications technology to the grid, there is a lot of potential flexibility to be gained (though realization is still to come). Recent advances include, for example, advanced inverter functions that can better help solar PV integrate into the grid or microgrids that, through advanced control capabilities, can increase flexibility, resiliency, and reliability of the connected distribution networks.

New market-based solutions or system operation paradigms are also avenues to increased flexibility. Market-based solutions encourage flexibility by distinguishing it as a product and giving it value, e.g., as a flexibility service. Smart grid technologies also pave the way for prosumers to take an active role on the grid, contributing not only to increase penetration of renewables but also to flexibility via demand response. Such solutions also permit, e.g., energy management systems that give consumers better control over their energy costs and new methods to integrate rooftop PV and electric vehicles. New operating and planning paradigms will follow the introduction of new grid participants and flexible capabilities.

Deep decarbonisation will require electrification of the world's economy. For this to be achieved the electric grid will have to evolve; this will require innovation within the smart grids to unlock the electric grid's vast flexibility potential that still remains unexploited.