SC D2 Information systems & telecommunication
PS1 The impact of emerging information and communication technologies on electric power utilities

Internet of Distributed Energy Architecture (IDEA): new approach on transactive energy

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Conventional centralized architecture of power grids and power industry in the whole has exhausted to a considerable degree its potential of effectiveness. In the context of challenges that emerge for power industry on a global scale, its outdated architecture can no longer be considered capable of addressing these challenges effectively. The most distinctive challenges that power industry faces in its development are:

- changes in the nature of consumer demand, namely increasing its diversity and moving to so-called “digital demand”;
- the decrease in efficiency due to low utilization of existing grid and generating capacities and increasing operating costs of power systems;
- “Energy transition” (decarbonization, decentralization, digitalization): rapid spread of renewables, DER (distributed energy resources), new business models and services based on digital technologies;
- development of uninhabited and underdeveloped territories: remote and isolated areas require effective power supply.

Taking into account the above-mentioned trends and challenges, the key barrier to power industry development seems to be that the power systems are unable to address them without significant increase in costs and decrease in system’s efficiency. The growing trend towards the use of renewables only exacerbates the inefficiency of the existing power systems, lowering the installed capacity utilization factor (ICUF) of power sources and requiring more peak and stand-by capacities. Distributed energy, including small-scale power generation, energy storage systems, adjustable load on the side of end users will play the crucial role in upcoming development of power industry. These solutions, being interconnected and integrated into the centralized grid represent an untapped resource for raising the electrical efficiency of power systems and thus have a potential to address the current challenges. Introduction of DER increases the efficiency of power grid due to lower dependency on connected capacity, emerging of local self-balanced low-scale generators and consumers, involvement of power assets of end users into power grid control. Thus, the power system that is capable to integrate new users with plug&play interaction and manage large numbers of DER in decentralized way can successfully address the above-mentioned challenges. With present power grid architecture, the large-scale development of distributed energy is facing the growth of various costs:

- transaction costs that increase as the number of participants of each transaction grows;
- high capital expenses on digital integration of equipment into control loops;
- high capital and engineering expenses on integration of equipment into the grids and system stability maintenance costs.

Therefore, we must introduce a vision of decentralized power industry architecture where such costs are eliminated or reduced to their minimum while the distributed energy itself could increase operational efficiency of the grid. The power grid based on new architecture will become:

- Transactional: Economic interactions between users should be based on peerto- peer-transactions that allow implementation of wide range of services that provide users with customized values. Within this paradigm the users can play various roles.
- Smart: Simplicity of integration (plug&play) of power equipment into the loops of automated control of various services.
- Sustainable and flexible: physical connection of equipment units with the grid should be established in a convenient and user-friendly way using plug&play technologies to ensure static and dynamic stability of the system where large number of devices and equipment units influence each other.

Users integrate into the system through specific interfaces and become participants of new services and business models. They can carry out transactions that will lead to optimal and coordinated work of power equipment while the sustainability of power system is ensured. They can carry out transactions that will lead to optimal and coordinated work of power equipment while the sustainability of power system is ensured.

The Internet of distributed energy represents a decentralized power grid where smart distributed control is performed through energy transactions among users of the system. The Internet of distributed energy represents a System of Systems which is composed of three integrated platforms:

- Transactive Energy (TE): a system where smart contracts are composed, implemented and paid;
- Internet of Things (IoT): a system of machine-to-machine interaction and exchange of control actions between power cells and power equipment;
- Neural Grid (NG): a system that provides mode control, power balance maintenance, and ensures the static and dynamic stability of the power grid.