Internet of Energy (IoE) in Smart Power Systems

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***Abstract*— The accelerated trend of development in the areas of information and communications technology (ICT), as well as energy systems, has been led to emersion of a new concept called the internet of energy (IoE). This concept is classified as a subsector of the internet of things (IoT), which means the utilization of advanced digital controllers, sensors, actuators, and meters with the ability of information exchange through IT infrastructures. The phrase "internet", in this context, does not exclusively refer to the World Wide Web rather than any type of server-based or peer-to-peer network. These communicational tools are able to receive information for local analyze and control, receive analyzed commands, send raw data, or send instructions. The incorporation of IoT in power systems conveys a brilliant future for overcoming power system operation hurdles and environmental challenges, although it incurs a large capital investment portfolio initially. However, it is hoped that the evolution of current technologies and the advent of new technologies with economically affordable prices can help to increase the pervasiveness of these state-of-the-art technologies. IoE covers the entire energy scope such as thermal or electrical energies. However, in this study, the applications of IoE in power systems, as the central core of the energy ecosystem, will be addressed. At first, the basic terminology of this topic such as IoE, IoT, plug & play capability, smart energy, future networks, smart grid 2.0, energy 4.0, prosumers, AMI, API, digitalization, and grid edge are described to make the rest of paper more intelligible. Then the role of IoE in supply-side and demand-side of power systems encompassing renewable generation section, large-scale energy storage section, thermal power plant section, system operation and protection as well as execution of demand response programs (DRPs), microgrids, integration of plug-in electric vehicles with V2G capability, and end-user residential consumption management in smart buildings are explained. In this study, it is tried to outline a different classification of IoE in power systems which has not been drawn by previous similar works.**

***Keywords*— Internet of energy (IoE), Internet of things (IoT), Digitalization of power systems, Energy 4.0 and smart grids 2.0, Information and communications technology (ICT) infrastructure;**

I. INTRODUCTION

Internet of energy (IoE) is a cutting-edge concept in the field of energy research which is a combination of energy systems and information and communications technology (ICT). IoE is classified as a subcategory of the internet of things (IoT). In the IoT concept, all objects are connected to each other through modern communicational platforms and the internet. Hence, IoT is known as the third revolution in information technology [1]. IoT drastically improves the smartness and automation levels of systems. It also improves the visibility of complicated systems and procures real-time monitoring. The power systems are regarded as the central core of the energy ecosystem. IoE is an indispensable part of the implementation of smart grids and its corresponding components.

There are some studies conducted on the IoT applications in the energy sector, particularly in various parts of power systems. A comprehensive review is carried out in [2], where the various applications of IoT are described including the implications of IoT in power systems. The fundamental terms pertinent to IoT (such as Identification, sensing, communication, computation, semantics, and services) are explained in this work. The authors, in [3], have evaluated the roles of IoT in smart grids. In this work, different layers of IoE in power systems are concisely described. For example, the applications of IoT in smart electrical grids (such as demand-side management (DSM), renewable energy sources, power lines and monitoring of faults, smart homes, electric vehicles, smart meters, demand response modeling) as well as management services provided by IoT (such as security control, planning, power flow data, system monitoring data, distribution process data, load management data, customer profiling data, and pricing and market data). Besides, different types of gateways and networks (such as WiFi, WiMax,

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