International Journal of Energy, Information and Communications
Vol.7, Issue 3 (2016), pp.11-22
http://dx.doi.org/10.14257/ijeic.2016.7.3.02

A Review on IOT Based Smart Grid

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Abstract

The Internet of Things (IoT) is the widely accepted technology that connect everyday objects to the internet for providing ease and various functionalities and the Smart Grid (SG) is defined as the power grid integrated with a large network of ICT. The SG is the combination of billions of smart objects: smart appliances, smart meters, actuators and sensors etc. This paper analyse the various accepted application requirements of Internet of Things deployed in Smart Grid and provides an effective proposal about diverse technologies and standards and of Smart Grid and it also provides an overview about several applications and driving factors of Smart Grid.

Keywords: *Internet of Things, Requirements, Smart Grid, Technologies*

1. Introduction

The term Internet of Things (IoT) is an intelligent network, that promptly achieving ground in the context of modern wireless telecommunications. The IoT has recently become universal to highlight the vision of a global structure of interconnected physical objects. The prime purpose of this concept is the universal presence around us of a variety of things or objects. This includes Radio-Frequency Identification (RFID) tags, smart meters, sensors, actuators, smart phones, *etc*. These objects or things, are able to interact with each other through unique addressing schemes, and cooperate with their neighbours to achieve common goals [1, 2]. When Internet of Things technology is deployed in Smart Grid, it forms an immense smart network comprised of people and equipment, with various kinds of distributed recognition or information sensing equipment (RFID device, laser scanning, Infrared sensors, the global positioning system, *etc.*), that collaborated with the existing network technology, middleware technology, database technology *etc.*, [3]. The functions are as following:

1. The Running status including Temperature, humidity, air pressure, etc. of the electrical equipment in power system.
2. Electrical parameters that monitor all network nodes in the power system.
3. Main equipment to check health state in power system;
4. Management information of Technical personnel's;
5. Service condition of environmental protection equipment.

Thus controllability, observability, self-redemption for a power system can be accomplished, for association between equipment and personnel management [4].

1.1 IoT Technology:

The IoT has the prospective to alter the methods of various innovative services and applications, such as observing real-time things, search engine for things *etc.*, and also work with their communication and interaction [5, 6]. The Internet of Things is a vision

ISSN: 2093-9655 IJEIC

that includes several technologies like Information Technology, Nanotechnology, Biotechnology and Cognitive Sciences. The rapid increase in the storage capacity and processing power of the devices, global connectivity, miniaturization and self-determining behaviour and the capability of devices to connect and to sense. The potential of the devices to be intelligent act as the technology basis for the IoT and leads to further technological developments. Various technological advances must be carried out by the research community in order to actualize the vision of the IoT from the technological point of view [7].

The two essential components of IoT are RFID systems and sensor networks which are discussed as following:

1. RFID Systems [8], [9]: Radio-Frequency Identification (RFID) tags are used to identify everyday objects that facilitate the tracking capability of objects through space and time in a supportable manner. The complete deployment of the IoT is determined by the excess utilization of RFID tags. By using RFID tags, it is possible for an object to identify itself to another object, and on that account RFID systems form the fundamental structural unit of the IoT. RFID is considered as an enabling technology and it has a broad scope of applications such as access management systems, electronic toll collection systems, airport baggage tracking logistics etc. RFID systems are comprised of:

- Tags are uniquely identifiable that can be allocated to different objects. Each tag is able to receive a reader's signal, and it is able to transmit its ID back to the reader.
- The responsibility of readers is to produce appropriate signals to receive tag IDs.

2. Sensor Networks: Sensor Network is made up of a huge number of sensing nodes. In Sensor Network, there is a special node called sink, which is used to gather sensing results reported by other nodes in the network. They have an important role in the IoT development. They are used in diverse fields such as e-health, smart homes, military and industry. Sensor Networks can combine with RFID systems to increase objects tracking. [10]

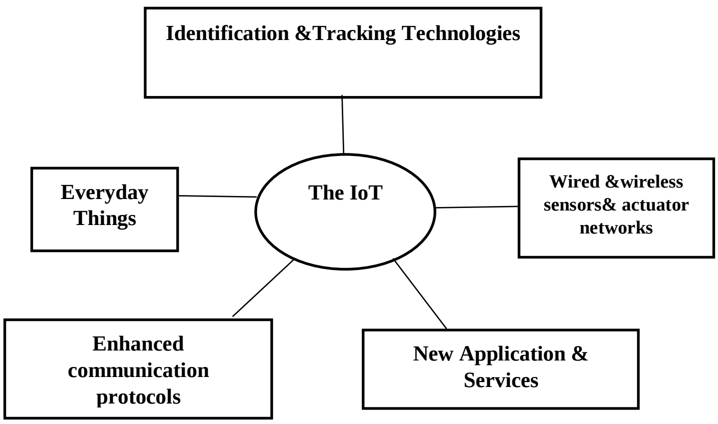

Figure 1. The Technologies and Communication Tools used in IoT

1.2. Smart Grid:

According to the U.S. Department of Energy; a smart grid is considered as an intelligent grid that integrates technologies of advanced sensing, control methodologies and communication capabilities into current electricity grid at the both transmission levels and distribution levels. Following are some features of smart grid:

- A smart grid is a powerful grid that provides an interface between appliances of consumer and the assets of traditional power system in generation, transmission and distribution levels.
- A smart grid is able to optimize the capability of assets of the power system.
- A smart grid provides support for integration of distributed generation into the optimized conventional centralized power system [11].

2. Related Work:

Lazarescu, M.T *et al.*, [12] designed and implemented a fully deployed WSN platform which is used for large number of long term monitoring IoT applications. The requirements of these application is low cost, low maintenance, sensors, high quality of service, fast exploitation, long lifetime. V. Trifa, *et al.*, [13] presented a versatile and light-weight Web Service transport protocol called Lean Transport Protocol (LTP), which allows the transparent exchange of Web Service messages between all kinds of resource-constrained devices and server or PC class systems. He describes LTP in detail and shows it by real-world measurements that LTP has the capability to serve as standard Web Service transport protocol in the Internet of Things. Yashiro, *et al.*, [14] proposed a new architecture of uID-CoAP, which is designed to host IoT services on common embedded systems, like usual consumer appliances. They frequently provide a wide number of sophisticated functions compared to simple sensor nodes that collaborates the constrained application protocol (CoAP) with the ubiquitous ID (uID) architecture which provide a software framework for embedded appliance nodes, designed to reduce the load of embedded appliances, manufacturers by providing an intuitive, framework provides functions to build restful services in addition to the low-level communication API. Manisa, *et al.*, [15] proposed an algorithm that manages household loads according to their preset priority and assurance the total household power consumption would be below to preset certain levels. He developed a simulation tool to demonstrate the applicability of the proposed algorithm in performing DR at an appliance level and to analyse DR potentials for residential customers. HEM algorithm takes into account both load priority and customer comfort level settings. Dae-Man, *et al.*, [16] proposed New SHEMS based on the IEEE802.15.4 and zigbee and Develop Routine Protocol called "DMPR" (Disjoint Multi Path Routine) to enhance the performance of Zigbee sensor networks that provides intelligent service to consumers. Nils, *et al.*, [17] has introduced methods for the evaluation of wireless home and home automation networks in indoor scenarios and examine their performance. The technologies are compared in European indoor scenarios which provides guideline to choose suitable wireless technologies.

3. Various Application Requirements of IoT Deployed in Smart Grid:

- IoT is widely deployed in various types of e-health applications and provides various facilities for coping with health issues.

- IoT can be used for unit monitoring, plant area monitoring, distributed power plant monitoring, coal material monitoring, pollutants and gas emissions monitoring, power prediction, energy consumption monitoring, pumped storage power plant monitoring, wind power plant monitoring, biomass electricity generation, energy storage monitoring, power connection etc. in the various area of power generation. [11].

- IoT is deployed for transmission line monitoring and controlling, equipment management, tower protection, distribution automation and intelligent substations [11].

- IoT is basically used for smart meter and smart power consumption, multi-network convergence, electric vehicle charging, energy efficiency monitoring and management, power demand side management, *etc.* [11]

- High reliability AMR based on IoT: Auto meter reading system plays an important role in smart grid. It is a system responsible for collecting, processing and real-time monitoring power consumption information intelligently. IoT supports the automatic collecting, abnormal measuring, electricity quality monitoring, and consumption behaviour analysis and the system also enables functions such as information release, distributed energy monitoring and information exchange between smart power devices. [18]

- Smart home based on IoT: It is the essential part of smart grid, smart home is incorporating a communication network that connects the prime electrical appliances and services, and allows them to be distantly observed, controlled or accessed. It increases the ability of integrated services of the grid, meeting the demand of marketing and improving the quality of service. Smart home service is widely used in daily power consumption. Residents can monitor the status of their homes at any time they are not at home and call the police when there is a hacking. [18]

- Smart patrol based on IoT: The patrol of the power transmission, substation and distribution equipment is mainly conducted manually at a regular time. It is based on IoT enabled wireless sensor network, and can help positioning equipment by identifying labels, thus improve the standardization and regulation of patrol work.[18]

- IoT applications in green smart computer room management: The consumption of power in computer room and data storage center is highly substantial. Administrators could able to have accurate knowledge about the running conditions of equipment and when to switch hibernate in machines for reducing computing load of over-heated machines according to the situation. This is done with the help of IoT enabled network equipment and temperature monitoring servers. Computer room needs a sound security solution, as a place where excess security requirements, are required. We can realize seamless link between computer room and data center and the combination of equipment running status and operation environment sensor, with the help of IoT positioning technology, video monitor technology and powerful calculated tracking technology. IoT also provides technical support to power consumption analysis, power environment sensor, information system interaction and joint offices.[18]

4. Communication Technologies and Standards of Smart Grid:

Following are the various communication technologies and standards of Smart Grid discussed in the Table 1 below:

Table 1. Communication Technologies and Standards of Smart Grid

TECHNOLOGIES AND STANDARDS	EXPLANATION
1. DLMS/COSEM	DLMS is an application layer protocol. It defines general concepts for modelling object related services, client-server structure, in which data exchange is occurred between metering equipment and data collection systems using the COSEM interface object model and it is based on the client/server model. It stands for device language message specification included with IEC 62056[19].COSEM stands for Companion Specification for Energy Metering, it comprises a set of specifications that defines protocols of the Transport and Application Layers. It include metering specific objects based on OBIS (Object Identification System) codes that are used with (x) DLMS. The main objective of the COSEM approach, while keeping backward compatibility, is to provide a business domain oriented interface object model for system of metering devices to the existing standard of DLMS.
2. IEC 62056-31 “Euridis”:	Euridis [20] is the protocol standard for the Automatic electricity Meter Reading with a twisted-pair cable. It is a reliable solution for remote and local meter reading. It is introduced at the beginning of the 90's, and international workgroup IEC TC13WG14 standardized this protocol in 1999. The standard has been evolved from IEC 61142 to the actual IEC 62056-31. This standard is an efficient and low-cost open solution for AMM.
3. PRIME, PLC:	Power Line Communications (PLC) [21] CENELEC norm EN 50065-1. PLC is a developing technology that uses the existing power lines for data transmission. It is a specification for narrow band power line communication. On Broad–Band PLC for in home PLC–based Local Area Networks and internet access (IEEE P1901.1), various standardization efforts are made. Standardization of Narrow–Band PLC for Smart Grid applications at the physical and MAC layer, IEEE P1901.2 is known as Narrowband Power Line Communications (NB-PLC) system that provides transmission of data over power lines.
4. KNX:	The KNX [22] The primary objective of KNX is to provide encapsulating today’s existing home and building electronic system into single standard that is common and acts as a platform for future evolution. It is an OSI-based network communication protocol used for building automation. It is the convergence of BatiBUS, European Home Systems Protocol (EHS), and the European Installation Bus (EIB or Instabus), previously defined three standards. KNX technology is covered by standard ISO/IEC 14543-3-x in 2006
5. BACnet:	BACnet stands for Building and Automation Control Networking and became ISO standard 16484-5 [23] in 2003.It is an absolutely non-proprietary system, contains typical applications in the HVAC, lighting and security domain. A wide number of network technologies can be used, including Ethernet, LonTalk, ARCnet, ZigBee networks and BACnet/IP

6. ZigBee (Smart Energy Profile):	ZigBee is a low-power wireless communications technology. It is designed for monitoring and controlling devices, and is maintained and published by the ZigBee Alliance [24]. Home automation is one of the main market areas. Zigbee works on top of the IEEE 802.15.4 standard [25], in the unlicensed 2.4GHz or 915/868 MHz bands. A one of the main feature of ZigBee is the possibility to handle mesh-networking,by extending the range and making a Zigbee network selfhealing. In order to further enhance earlier HAN (Home Area Network) specifications, the Zigbee Smart Energy Profile [26] was defined in cooperation with the Homeplug Alliance.
7. Home plug (Command & Control):	The Homeplug 1.0 standard allows communication over power lines at 14 Mbps half-duplex and published in 2001 by the Homeplug Powerline Alliance. It was succeeded by Homeplug AV, allowing over 100 Mbps and meant for HD multimedia applications in 2005. Version 1.0 of Homeplug Command & Control was announced in 2007, providing a PHY and MAC specification for low-speed (up to 5Kbps), low-cost PLC usable in house-control applications (lighting, security, HVAC and metering) [27]. One of the main technical challenge was finding a way to reduce sensitivity to the electrical noise present on power lines.

5. Smart Grid Technologies (SGT):

There are five fundamental technologies defined by the US Department of Energy that derive the Smart Grid systems. These technologies are sum up together in order to make smart grid more efficient and reliable than the present grid.

5.1. Integrated Communications

For providing real-time information and control, components are connected to open architecture that allow every part of the grid to talk and listen.

5.2. Sensing and Measurement Technologies

Various sensing and measurement technologies are used for distantly controlling, management of demand-side and for generating bills, to assist faster and accurate responses.

5.3. Advanced Components

Various components are used for latest research in power electronics, storage, superconductivity and diagnostics.

5.4. Advanced Control Methods

Advanced methods are used for controlling essential components, faster diagnosis and provide appropriate precise solutions according to any event.

5.5. Improved Interfaces and Decision Support

Improved smart systems are used to intensify human decision-making, changing grid operators and managers literally into futuristic approaches [28].

5.6. Smart Transmission Grid

- The backbone of delivering electricity power from the power generation end to consumer end, the network of transmission lines plays an important role.

- Transmission of electric power is originated to be a direct current (DC) transmission and in complex network topologies, the transmission is diverse to HVAC, HVDC transmission at different voltage levels.

- Due to advances in technology in the various areas of information technology, sensing, communication and computing. By identifying the major smart characteristics and performance features, it gives an exclusive perception of the future smart transmission grids to handle the challenges. Table 2 describes the features and their characteristics of a Smart Transmission Grid [29].

- Under the three main interactive and smart components; smart control canters, smart transmission networks and smart substations, a brief analysis is made on the smart transmission grid development [30].

- The goal of unique vision of smart transmission grid is to promote technology innovations to deliver reliable, flexible, continuous, inexpensive and sustainable electric power to consumers. It also provides some of the important features such as:

  i. Greater flexibility in monitor, operation and expansion.

  ii. Development in embedded intelligence.

  iii. Sustainability and reliability of the grids.

  iv. Improve customer benefits.

  v. Provides quality of service.

Table 2. Features and Characteristics of Smart Transmission Grid

SMART TRANSMISSION GRID	
Flexibility	Innovation and diverse generation technologies, Adaptability , Multiple control strategies, System upgradation
Customization	Smart consumer, Market liberty, Transparency, Efficient power consumption

Sustainability	Eco-friendly, Alternative energy resources, Decarbonisation, Mitigation network, Congestion
Resiliency	Rapid-response, Robustness, Real-time analysis, Self-healing
Intelligence	Self-awareness, Online monitoring, System stability, Self-healing, System security
Digitization	Fast and reliable sensing communication, effective protection, User friendly visualization.

5.7. Information and Communication Technology (ICT)

- Various limitations of classical power system such as poor visibility, poor response of mechanical switches and lack of automatic analysis, lack of remote controlling switch us for the use of smart grid.

- Consistent information flow is the prime factor for the reliable electric power delivery from the generation stations to the end-customers in the smart grid.

- Deployment of advance technologies and applications in the smart grid, it increases the capacity and flexibility of the network. It is able to provide more advance control and sensing via advance technology enabled topologies and protocols.

- For the transmission and communication of information and data between the utility systems and smart consumers, wired and wireless modes are operated. On the basis of various factors, each wired and wireless mode of the communication has their own advantages and disadvantages over each other.

5.8. Smart Metering Technology

- Smart metering system is considered as an efficient method used for improvement in efficiency of energy consumers and power consumption patterns and helps in reduction of financial burden of electricity. It is developed by combining power system, telecommunication and other technologies. Many other facilities have been added to the smart grid area due to the development of cutting edge technologies of science.

- Smart meter is known as an advance energy meter which determines the energy used by the end-consumer and provides information to the utility company.

- The bidirectional communication of data enables the ability to collect information considered with infrastructure of communication and various smart control devices. The smart meter is used to control and monitor home appliances and collect information for diagnosis about the utility grid. It support sources of decentralized generation, power storage devices, and concatenate the metering units.

5.9. Smart Control and Monitoring System

Due to the adoption of very complex system of smart grid, a dynamic, stochastic, computational and scalable (DSCS) with various advance control technologies can be a promising trait for an effective, secure and reliable power network [31].

6. Applications of Smart Grid:

Smart Grid plays a very important role in modern smart world technologies. Following are the most common applications of Smart Grids. The Table 3 provides an overview of the applications of the Smart Grids:

Table 3. Smart Grid Applications

Future Apps and Services	Real Time Energy Markets
Business and Customer Care	Application Data Flow to/from End-User Energy Management Systems
Smart Charging of PHEVs and V2G	Application Data Flow for PHEVs
Distributed Generation & Store	Monitoring of Distributed Assets
Grid Optimization	Self-healing Grid: Fault Protection, Outage Management, Remote Switching, Minimal Congestion, Dynamic Control of Voltage, Weather Data Integration, Centralized Capacitor Bank Control. Distribution and Substation Automation, Asset Protection, Advanced Sensing, Automated Feeder Reconfiguration.
Demand Response	Advanced Demand Maintenance and Demand Response; Load Forecasting and Shifting.
AMI	Provides Remote Meter Reading, Theft Detection, Customer Prepay, Mobile Workforce Management.

7. Driving Factors of Smart Grid:

Technology is considered as a main driver for Smart Grids, according to the most of European utilities [28]. Table 4 describes an overview of the main driving factors for Smart Grids [27].

Table 4. An Overview of Main Driving Factors for Smart Grids

Technology Advancement	1) Smart Grid can be seen as the convergence of IT, telecom, and energy markets 2) New products and solutions through technology advancement 3) Significant amounts of venture capital investment in Smart Grid technologies and solutions

Higher Efficiency With the Help of Grid Optimization	1) Multiple integration points for intelligent grid hardware and software from transmission to consumption 2) Embedded sensors and monitoring capabilities 3) Deployment of advanced two-way communications networks 4) Growing Supply of Renewable and Distributed Power Generation and Storage 5) Network architecture to provide many forms of distributed generation and storage 6) Intelligent support is provided for various forms of renewable power sources.
Advanced Customer Services	1) Robust, simple consumer energy management platforms 2) Networked devices within the "smart home" 3) New, efficient pricing models for electricity usage
21st Century Power Quality	1) Delivering power that is free from disturbances , interruptions and spikes

The new 'smart' way of energy use is another considerable driving factor of Smart Grid deployment. It includes energy resource optimization like having own generation or distribution grid, as well as optimization of time of use. The new grid should also be economically reasonable and environmental friendly**.**

8. Conclusion

This paper has been addressed an overview of IoT technology and its various uses in the smart grid technology. By applying Internet of Things (IoT) technologies, various intelligent services can be created. The development of most aspects of the smart grid would be enhanced by applying IoT. There are many driving factors that increases interest to switch from conventional power grid system to smart grid system as it provides very effective measures of delivering electric power to various consumers.

Acknowledgment

First of all I would like to thank Dr.Sheetal Kalra for her continuous support and suggestions throughout the research work. I am very thankful to my parents for their motivation and support.

References

[1] D. Giusto, A. Iera, G. Morabito and L. Atzori (Eds.), “The Internet of Things”, Springer, ISBN: 978-1-4419-1673-0, **(2010)**.
[2] L. Atzori, A. Iera and G. Morabito, “The Internet of Things: A survey”, Computer Networks, **(2010)**.
[3] L. Xun, G. Qing-wu and Q. Hui, “The application of IOT in power systems”, Power System Protection and Control, vol. 38, no. 22, **(2010)**, pp. 232-236.
[4] C. Shu-yong, S. Shu-fang and L. Lan-xin, “Survey on smart grid technology”, Power System Technology, vol. 33, no. 8, **(2009)**, pp. 1-5.
[5] L. Atzori, A. Iera and G. Morabito, “The internet of things: A survey Computer Networks”, vol. 54, no. 15, **(2010)** October, pp. 2787-2805.
[6] D. Miorandi, S. Sicari, F. De Pellegrini and I. Chlamtac, “Internet of things: Vision, applications and research challenges”, Ad Hoc Networks, vol. 10, no. 7, **(2012)** September, pp. 1497-1516.
[7] O. Vermesan, Outlook on Future IoT Applications.
[8] L. Atzori, A. Iera and G. Morabito, “The internet of things: A survey. Computer Networks”, vol. 54, no. 15, **(2010)** October, pp. 2787-2805.

[9] M. Buettner, B. Greenstein, A. Sample, J. R. Smith and D. Wetherall, “Revisiting smart dust with RFID sensor networks”, Proceeding of 7th ACM Workshop on Hot Topics in Networks (Hotnets-VII), Calgary, Alberta, Canada, **(2008)**.
[10] Israa Alqassem, Davor Svetinovic, “A Taxonomy of Security and Privacy Requirements for the Internet of Things (IoT)”, IEEE, **(2014)**.
[11] W. Shu-wen, “Research on the Key Technologies of IOT Applied on Smart Grid”, IEEE, **(2011)**.
[12] K. Romer and F. Mattern, “The design space of wireless sensor networks”, IEEE Wireless Commun., vol. 11, no. 6, **(2004)**, pp. 54-61.
[13] V. Trifa, S. Wieland, Dominique Guinard and T. M. Bohnert, “Design and Implementation of a Gateway for Web-based Interaction and Management of Embedded Devices”, Proceedings of the 5th IEEE International Conference on Distributed Computing in Sensor Systems(DCOSS Workshop), **(2009)**.
[14] K. Yashiro and S. Koshizuka, “An Internet of Things (IoT) architecture for embedded appliances”, T. Yashiro, S. Kobayashi, N. Koshizuka and K. Sakamura, Humanitarian Technology Conference (R10-HTC), 2013 IEEE Region, 10, **(2013)**.
[15] M. Pipattanasomporn, M. Kuzlu and S. Rahman, “An Algorithm for Intelligent Home Energy Management and Demand Response Analysis”, IEEE Transactions on Smart Grid, vol. 3, pp. 1-8. **(2012)** May.
[16] D-M. Han and J-H. Lim, “Design and implementation of smart home energy management system based on zigbee”, IEEE Transactions on Consumer Electronics, vol. 56, no. 3, **(2010)** August, pp. 1417-1425.
[17] N. Langhammer and R. Kays, “Performance Evaluation of Wireless Home Automation Networks in Indoor Scenarios”, IEEE Transactions on Smart Grid, vol. 3, no. 4, **(2012)** December, pp. 2252-2261.
[18] X. Chen, J. Liu, X. Li, L. Sun and Y. Zhen, “Integration of IOT with smart grid”, **(2011)**.
[19] IEC 62056 Electricity metering - Data exchange for meter reading, tariff and load control, International Electrotechnical Commission Std.
[20] The essential of Euridis. [Online]. Available: www.euridis.org/solution details.html
[21] Z. Kapar, “Power-Line Communication - Regulation Introduction, PL Modem Implementation and Possible Application”, 12th International.
[22] KNX Specification, version 2.0, KNX Association, Diegem, Belgium, **(2009)**.
[23] ISO 16484-5 Building automation and control systems – Part 5: Data communication protocol, International Organization for Standardization Std.
[24] The ZigBee Alliance. [Online]. Available: www.zigbee.org
[25] IEEE 802.15.4-2006 Telecommunications and information exchange between systems - Local and metropolitan area networks–Specificrequirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate (LR-WPANs), IEEE Std.
[26] Zigbee Standards Organisation, “Zigbee smart energy profile specification,” Dec. 2008. [Online].Available:www.zigbee.org/Products/Download TechnicalDocuments/tabid/465/Default.aspx
[27] Devices Profile for Web Services Version 1.1, OASIS Std.[Online].Available:http://docs.oasis-open.org/ws-dd/dpws/wsdd-dpws-1.1-spec.Html.
[28] www.doe.gov. US Department of Energy.
[29] Z. Jiang, F. Li, W. Qiao, H. Sun, H. Wan, J. Wang, Y. Xia, Z. Xu and P. Zhang, “A vision of smart transmission grids”, Power & Energy Society General Meeting,2009. PES '09. IEEE, **(2009)**, pp. 1-10.
[30] F. Li, W. Qiao, H. Sun, H. Wan, J. Wang, Y. Xia, Z. Xu and P. Zhang, “Smart Transmission Grid: Vision and Framework”, Smart Grid, IEEE Transactions, vol. 1, no. 2, **(2010)**, pp. 168-177.
[31] G. K. Venayagamoorthy, “Potentials and Promises of Computational Intelligence for Smart Grids”, IEEE Power General Society General Meeting, Calgary, AB, Canada, **(2009)**, pp. 1-6.
[32] Materials from the Smart Grid Workshop in “Fortum Oy”, **(2010)** January 14.
[33] D. Leeds, “The Smart Grid in 2010”, GTM Research, **(2009)** July.

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