The PEA SmartGrids Framework for Effective Distribution

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ABSTRACT

Many electric distribution utilities need to make the most effective use of resources, including information and communication technology. A smart electricity network is flexible, accessible, reliable, and economic. Provincial Electricity Authority (PEA) is a distribution and service utility in a fast changing Thailand electric supply industry. The PEA has developed various advanced electrical power system, including Supervisory Control And Data Acquisition, Automatic Meter Reading, Geographic Information System, Enterprise Resource Planning. Information and communication technology has been also applied in the PEA. SmartGrids development is a typical challenge of the PEA. This paper shows the framework for the SmartGrids development of the PEA.

Keywords
SmartGrids, power distribution system, organisational capabilities

1 INTRODUCTION

The electricity supply industry (ESI) is neither perfect competition nor monopoly, but can be defined as a monopolistic competition that has some characteristics of a monopoly, and some of competition [1]. The ESI confronts with multifaceted challenges: high demand for electrical energy, new requirements from customers, increasing price of primary fuel, deteriorating institutional performance of the electric utilities, negative environmental impacts, and changes in economic situations, political policies, and related technologies, especially information and communication technology (ICT). Advances in information and communication technology, with accompanying new data sources, are impacting the generation, transmission, distribution and service functions of the ESI.

In order to respond to multifaceted challenges, electric utilities invest in the electric power system and the institutional development of organisation. Investment in the power electric system includes several engineering-related activities. Investment in the organisation is related to customers, suppliers, employees, investors, financial institutions, government agencies, regulators, and other stakeholders (e.g., interest groups and labour unions). An ultimate aim of the investment is to fulfil several requirements from different stakeholders.

ICT provides opportunities for electric utilities to modernise the electric power system. The modernised electric power system is safer and more reliable, secure, economic, efficient, and environmentally friendly [2]. In modernising the electric power system, it is necessary to incorporate engineering and organisational activities of the electric power system and those of the ICT. A term of SmartGrids appeared. It refers to “an electricity network that can intelligently integrate the actions of all users connected to it – generators and consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies” [3].

1.1 Thailand ESI

The Thailand ESI is to some extent a de-regulated industry by nature. There is no vertically integrated electric utility in Thailand. Three state-owned electric utilities in the Thailand ESI are separately established according to four functions – generation, transmission, distribution, and service (customer sales of electricity). The Electricity Generating Authority of Thailand is responsible for electricity generation and transmission. The Metropolitan Electricity Authority is responsible for electricity distribution and service in three provinces – Bangkok, Nonthaburi and Samutprakarn. The Provincial Electricity Authority (PEA) is responsible for electricity distribution and service in other remaining service areas of 73 provinces, 99% of the total area of the country.

The PEA is a service-based organisation that directly supplies electricity to customers. PEA’s services (i) are invisible, (ii) involve high levels of customer relationships; and (iii) can be simultaneously produced and consumed [1]. The PEA mainly deals with distribution power system, customer needs, customer relationships, quality of service, and its performance. It is neither a purely mechanistic organisation nor a purely organic one, but is rather a combination of them which has been described as a mechanistic core within an organic shell. It carries out many non-routine activities but produce only a few standardised services. Finance and human resources are mechanistic components of the PEA, while customer relationships, sales,
and purchasing are its organic components. The PEA is a technology user, rather than a technology inventor. Its technological capabilities typically refer to abilities to exploit technologies, aimed at making contributions to the PEA and its customers. Technological capabilities consist of: (i) technical knowledge; (ii) organisational arrangements; and (iii) goals [1]. The first is necessary to address, invest, utilise, and improve technologies. The second covers the structural components of an organisation that integrate with technologies. The goals are the common purposes that an organisation commits to achieve.

Like many electric utilities in economically developing countries, the PEA sometimes lack: the ability to decide what to do; the capacity to prepare, implement, operate and maintain projects; an understanding of how to deal with technological projects; the capital needed for investing in their projects; specific kinds of skilled personnel; the knowledge and skilled ability to purchase inputs such as raw materials, components, equipments; and marketing skills [4]. In addition, the lack of relevant information, the uncertainty in the technology and the environment, and the multiple objectives of different individuals and groups in the PEA also cause difficulties.

1.2 Aim of the Research
An aim of this research is to create the SmartGrids framework of PEA. The framework provides a way of understanding the PEA SmartGrids. To achieve this, a qualitative review of literature and basic theories with respect to the development of the SmartGrids provides a basis for forming the SmartGrids framework. Significant elements of the framework are analysed and illustrated.

2 INITIATIVES OF THE SMARTGRIDS
The development of SmartGrids is notably started in two continents – North America and Europe. In the North America, the U.S. is a main developer. In the Europe, European Union is a key developer.

A 21st-century U.S. economy cannot be built on a 20th-century electric grid. This statement results in an initiative of modernising the electric grid. Several stakeholders from both government and private sectors make contributions to the development of the SmartGrids. Such stakeholders are for example the U.S. department of energy (DOE), the national energy technology laboratory (NETL), the Electric Power Research Institute (EPRI), and the Institute of Electrical and Electronics Engineers (IEEE). In addition to a name of SmartGrids, other typical names (e.g., IntelliGrid, GridWise, GridApp) are lunched. The modernised grid is characterised by self-healing, motivating and including the consumer, resisting attacks, providing high power quality, accommodating all generation and storage options, enabling markets, optimising assets, and operating efficiently [2]. In other words, the smart grid is: (i) self-healing and adaptive, (ii) interactive with consumers and markets, (iii) optimised to make best use of resources and equipment, (iv) predictive to prevent emergencies, (v) distributed across geographical and organisational boundaries, (vi) integrated, merging monitoring, control, protection, maintenance, energy/demand management system, marketing and information and communication technology, and (vii) more secure from attacks.

In Europe, the European Technology Platform (ETP) SmartGrids was set up in 2005 to formulate and promote a vision for the development of Europe’s electricity networks looking towards 2020 and beyond [5]. The publicly-announced Europe SmartGrids vision is about the programme of research, development and demonstration. The vision shows that the Europe’s electricity networks must be flexible, accessible, reliable, and economic. Five key elements of strategy include: (i) creating a toolbox of proven technical solutions, (ii) harmonising regulatory and commercial frameworks, (iii) establishing shared technical standards and protocols, (iv) developing information, computing and telecommunication systems, and (v) ensuring the successful interfacing of new and old designs of grid equipment.

Other SmartGrids initiatives can be observed in various forms of seminars, conferences, research programmes, and products from manufacturers. Workshops and conferences are, for example, “smart energy management system”, held in Singapore, the conference on “intelligrid uma solução empresarial”, held in Brazil, “smart grids Africa”, held in South Africa, “metering, billing/CRM”, held in India. It was an attractive topic in the CEPSI2008 conference, held in Macau.

The evolution of SmartGrids moves from a definition stage, passes through a framework stage and an implementation stage and ends in a future stage [6]. In the definition stage, the vision of SmartGrids is announced. In the framework stage, strategic research agenda is set up. SmartGrids knowledge is developed in the framework stage. The framework is required to provide a way of understanding the SmartGrids. In the implementation stage, developed knowledge is put into action to make the SmartGrids happen. In the future stage, the SmartGrids emerge. Interventions, a series of actions, are needed to create, shape and make the SmartGrids real. Currently, the SmartGrids development is in the definition and framework stages. Main activities include defining the SmartGrids, setting vision, strategies and research agenda, and conducting researches.

SmartGrids interventions will lead a traditional electric grid in an industrial era to an intelligent electric grid in an ITC
era. However, the interventions of SmartGrids are not a naturally-emerging manner. They need contributions from all stakeholders. Stakeholders of SmartGrids include scholars, government agencies, manufacturers, regulators, network operators, electric utilities, investors, and electricity users. Even though some SmartGrids formations are satisfied, both fundamental and advanced foundations of SmartGrids need investment, to be developed, and financially supported. Investment in the SmartGrids itself does not guarantee that the electric grid will be effective. It should be noted that in-depth knowledge about the constituent of the SmartGrids and the relationships between the SmartGrids and other components is in a rudimentary stage of development.

Findings from above-mentioned sources show that: (i) attempts to develop the SmartGrids are strongly and globally expressed; (ii) characteristics of the SmartGrids are initially expressed; (iii) there are four stages of SmartGrids evolution; (iv) impacts of SmartGrids are predicted; and (v) forward steps drive the SmartGrids towards the future. This paper will make the SmartGrids more clear to understand for the purposes of further development.

3 SMARTGRIDS

3.1 SmartGrids Foundation

The SmartGrids are not the newly-constructed electric grids. In geographic areas where the electric grids exist, the existing grids are further developed to be the SmartGrids. The developed grids with new characteristics become the SmartGrids. The new characteristics are developed by applying the information and communication technology. ICT provides the great opportunity to merge electricity, delivered by traditional electric grids, with communications and computer control to achieve gains in capacity, reliability, quality and security of the electric grids and customer services. ICT provides a new way for real-time interaction between electric utilities, customers, and suppliers. Advanced communication and computer provide, for example, advanced metering, distribution automation, demand response, and wide-area measurement for electric utilities to modernise their electric grids. The SmartGrids are characterised by (i) customers who are both producer and consumer of electricity, (ii) integration of millions small scale generators, (iii) bulk power and small scale sustainability coexistence, (iv) demand and supply balance solutions, and (v) efficient operated and reliable network [7].

3.2 SmartGrids Aims

Aims of SmartGrids include: (i) apply user-centric approach allowing new services; (ii) establish innovation as an economical driver for electricity grids renewal; (iii) maintain security of supply, ensure integration and interoperability; (iv) support market accessibility and competition; (v) enable distributed generation and renewable energy resources; (vi) ensure best use of central electricity generation; (vii) reduce environmental impacts; (viii) enable demand side management; (ix) inform political and regulatory issues; (x) contribute to a society [3].

3.3 SmartGrids Stakeholder

The SmartGrids initiatives are challenges and opportunities of not only electric utilities, but also customers, manufacturers, suppliers, consultancies, regulators, power traders, investors, governmental agencies, researchers, scholars, politicians. In other words, they are both technological and commercial challenges and opportunities. The electric utilities need monitoring, communications, computing, and information technologies to support advanced applications, automation, and system integration. The system integration will efficiently and effectively enhance system operation and maintenance, demand response, energy efficiency, and customer services. Customers can be usual electricity users and empowered electricity producer, enabled by technologies of mini and micro turbines in a popular term of distributed generation. With advanced metering technologies, customers have a great potential for energy saving. The SmartGrids will provide customers many energy-efficient and cost-effective options to quickly improve end-use demand-side efficiency. Manufacturers have demands for producing smart and ICT-supported devices, equipment, tools and machines. Consultancies need practical knowledge to enable electric utilities to change their traditional electric grids to smart ones. Regulators will enjoy close real-time cooperation between them, electric utilities, and electricity users as well as improved performance of electric grids. Power traders and investors can quickly get investment information and enlarge their investment areas of electricity and related businesses. Scholars identified five research areas that are (i) smart distribution infrastructure, (ii) smart operation, power flows, and customer adaption, (iii) SmartGrids assets and asset management, (iv) interoperability of SmartGrids, and (v) SmartGrids cross-cutting issues [7]. Politicians can deliver superior prosperity to their supporters and a whole society.

For a successful transition to SmartGrids all the relevant stakeholders must become actively involved: government agencies, regulators, electricity users, electricity producers, consultancies, power traders, power exchanges, investors, electric utilities, power, communication and computer equipment manufacturers and ICT providers.

3.4 SmartGrids Technologies

Some important SmartGrids technologies are described. SmartGrids technologies are related electrical network and information and communication network. Functions of SmartGrids technologies are, for example, real-time
simulation and contingency analysis, distributed generation, alternate energy sources, protection, islanding, power system planning, maintenance management, asset management, energy management system, distribution management system, supervisory control and data acquisition, geographic information system, outage management system, customer information system, call centre, billing, sale planning and forecasting, bidding and scheduling, trading and contracts, resource dispatching, settlements, on-line equipment monitoring, demand response, dynamic pricing, market operation, advanced meter reading, feeder automation, and substation automation [8].

The Electric Power Research Institution (EPRI) conducted a study on three potential technologies [9]. Firstly, fuel cells add an option of delivering stored electricity to customers and will affect demand for electricity in the long run. Secondly, automatic meter reading (AMR) – capable of reading electricity consumption data and sending them directly to the offices – leads to a reduced need for human meter readers; reducing operating costs and saving operating time; and changing the procedures for billing preparation and improve procurement efficiencies by increasing the frequency of data collection. Thirdly, intelligent customer technologies allow customers to effectively and efficiently utilise electrical facilities. For instance, users can call their home and remotely turn on a programmable air conditioner.

Application of ICTs on the electricity market was examined [10]. ICTs have been used to offer customers additional value-added services including automated meter reading, time-of-use or real-time pricing, customer-controlled load management, energy information and billing options, home security and safety services, cable television, and personal communication services.

Emerging technologies in the ESI can be considered from six dimensions: (i) customer-managed power and service networks; (ii) electricity-related technologies enabling pervasive economic growth; (iii) a revolution in customised electricity distribution capacity for higher value power; (iv) completely new electric transmission systems for assured power reliability, security, and quality, despite increasing pressures; (v) a robust portfolio of clean and cost-effective power generation options for global use; and (vi) an era of radically new transportation systems to protect the environment and conserve both resources and time [11].

However, a number of technologies such as geographic information systems (GIS), global positioning systems (GPS), environmentally friendly and renewable energy sources, that are capable of being applied in the ESI are in an early stage of development providing challenges for both developers and users – to innovate and apply them in the electricity markets.

4 PEA SMARTGRIDS FRAMEWORK

4.1 PEA Grid in the Present

The PEA has applied and/or tries to apply several SmartGrids technologies to improve its quality of services. Investment of PEA in technologies are, for example, Enterprise Resource Planning (EPR/ SAP™), Automatic Meter Reading (AMR), Supervisory Control and Data Acquisition (SCADA), Geographic Information System (GIS), Call Centre, Distribution Management System (DMS), Outage Management System (OMS), Asset Management, and Key Account Management.

4.2 Shaping the PEA SmartGrids Framework

The PEA is not a pioneer in the development of the SmartGrids. It is a technology user. The PEA SmartGrids Framework is based on: (i) its roles and capabilities, and (ii) development of SmartGrids in EU and the US. Role and capabilities of the PEA was discussed in item 1.1 and 4.1.

PEA SmartGrids Framework consists of four stages – a definition stage, a preparation stage, an implementation stage and a future stage. The PEA SmartGrids is defined as an electricity network that can intelligently integrate the actions of all users connected to it – generators and consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. Activities in a preparation stage are, for example, deploying isolated SmartGrids technologies, developing human resource, increasing understanding about SmartGrids manners, monitoring progress of SmartGrids technologies in EU and the US, selecting and adapting suitable SmartGrids Technologies for the PEA, and setting up an implementation plan. Activities in an implementation stage are, for example, updating all existing SmartGrids technologies, installing common platform technology, integrating SmartGrids technologies, and testing and adjusting newly-installed technologies. Activities in a future stage are aimed at delivering sustainability, saving, security and welfare to all stakeholders.

5. CONCLUSIONS

This research has focused on the formulation of the PEA SmartGrids framework. Development of SmartGrids is expressed. Characteristics of the SmartGrids are stated. Roles and capabilities of the PEA are examined. Current state of SmartGrids development in PEA is addressed. Finally, the PEA SmartGrids Framework has formulated. The PEA SmartGrids framework consists of four stages – (i) a definition stage, (ii) a preparation stage, (iii) an
implementation stage and (iv) a future stage. Current development of PEA SmartGrids is in the preparation stage. Moving to the implementation and future stage is a challenge of the PEA and provides an opportunity for selling SmartGrids technologies to technology owners.

REFERENCES


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