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A Cloud-based Online Access on Smart Energy Metering in the Philippines

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***Abstract*— *This qualitative study was conducted to identify how smart energy metering could utilize the energy consumption remotely through cloud-computing and the utilization of the data management, and data visualization of a cloud-computing. Participants are working directly in smart energy metering and cloud-computing. Results revealed that most participants believed that smart energy metering can be controlled by cloud-computing and smart energy metering offers a robust and reliable modem enabling efficient communication. Moreover, some participants believed that existing application can deliver accurate data analysis, management, operations, and customer engagement. Few participants were direct users of cloud-computing but in some utilizations particularly in high-rise buildings, malls, and manufacturing plants, they were using cloud-computing to monitor their power usages and the harmonics power supplies in their facilities. Participants believed that application can edit, collect, deliver data through the utility-grade of meter data management system and most of cloud-based has utility on data visualization from web-based energy portal and reporting tools for consumers and utilities. Some participants said thatthe system is usually compatible in the SAP system. More so, most participants believed, that the scalability, central data storage, cost-efficiency, real-time response, and securities are advantages of the system and the location of data, inefficient cloud security policy, mixing of data, term of agreement, compatibility, application programming interfaces, redundant data management and disaster recoveries are the challenges of the system.*

Keywords*— Cloud-computing, commercial and industrial utilization, power electric subsystem, smart energy metering.

I. INTRODUCTION

Smart energy metering are those technology devices that record consumptions of power electric subsystems such as generation, transmission, distribution and utilizations of commercial and industrial sectors. Nowadays, smart energy meters can work over IOT (internet of things) through the various techniques of cloud-computing [1]. In smart energy metering, the energy usage is done in real time with the ability of smart meters' network communication and more reliable and fast communication is guaranteed with the smart grid distributed energy data management which practices digital and other innovative technologies to manage the transport of energy from power plants to see the changing energy demands of the consumers and these energy demands can measurable through advanced metering infrastructure (AMI) that multiconnected into smart grid today. The AMI solution is combined energy metering, network-communications, and IT platform. It is intended to carry smart energy metering functionality equipped for back-office integration even though hiding the difficulty of energy metering communication technology [2]. AMI allows two-way communications between consumers & utilities through communication networks, smart meters, data management, and data visualization systems. The main function is to offer utility companies real-time data related to power consumption and allow the consumer to make energy usage based on the price at the time of use. These systems can able to help utility companies to manage energy demand by identifying peak time of load. Moreover, these systems also help consumers manage their energy consumption as well as TOU or Time-of-Use rate. This has contested to increase the demand by the implementation of AMI. An AMI system was comprised of a number of technologies and applications that have been integrated to perform as one: the smart energy meters, the smart communications, the operational gateways, and the meter data management systems [3]. These AMI systems and its data management can able manipulate by storing energy data and viewing the data on energy consumptions by cloud-based online access.

According to Mell P and Grance T (2011), The NIST (National Institute of Standards and Technology) definition of cloud computing [4] a cloud-computing is "*a model for enabling convenient, on-demand network access to a shared* *pool of configurable computing resources(e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*." In command to reach an accessible, demand-based IT Infrastructure, cloud-computing solutions, and smart energy meter must be incorporated.The five characteristics of cloud-computing include [5-7]: *On-Demand Service* - A customer can separately and individually deliver computing competencies as required automatically without needful human contact with eachservice's provider; *Ubiquitous Network Access* - Capabilities are available over the network. It can be accessed through standard mechanisms, to be used by heterogeneous thin or thick client platforms; *Location Independent Resource Pooling* - A multi-tenant model is used to serve multiple consumers from a pool of computing resources. The customer has no control over the exact location of the provided resources; *Rapid Elasticity* – Cloud-computing supports elastic the nature of storage and memory devices. It can expand and reduce itself according to the demand from the users, as needed; and *Measured Service* – Cloud-computing offers metering infrastructure to customers. Cost optimization mechanisms are offered to users, enabling them to provision and pay for their consumed resources only.Virtualization technology can be used in cloud-computing that categorize into three types of computing resources: *Software as a Service (SaaS)* - One to many application deliveries to a customer is provided by the SaaS model and means that only the smart grid customer can access the service that is installed on the utility's hardware via an Internet connection [8]; *Platform as a Service (PaaS)* - Service provider provides the development on environment and some of the smart grid utilities can use this model if they do not want to invest in the environment or when they want tofocus on the functionality of services and concentrate on the applications without considering development on environment [9]; and *Infrastructure as a Service (IaaS)* - Infrastructure can be offered as a service by cloud-computing to smart grid utilities and cloud-computing platforms can share or devote infrastructure to smart grid utilities who pay for their hardware usage. IaaS performance can also be increased significantly if smart grid utilities outsource cloud-computing, resources and the infrastructure from other parties [10].In the deployment model, a cloud can be classified into four groups: *Public Cloud* - In this model, users pay per use of smart grid services. There was not any limitation about which user can or cannot use cloud service because it is a public cloud. Service providers can make different offers, therefore smart grid services can be charged or not charged based on the offered conditions. Cloud Provider manages the cloud in the smart grid and users access the smart grid through the Internet [11]. All the services in this cloud are standardized to meet the comparability requirements of smart grid applications [12]; *Private Cloud* – it was internal deployment model that works like a private network. However, it can differ depending on the smart grid application's requirements. If a basic private cloud is used in a smart grid, each smart grid utility has its own data center and provides services by itself. Thus, high security, reliability, and confidentiality are ensured. But this model disallowed other utilities from accessing services and if an interrelationship is required between smart grid services that are located in different utilities, it is difficult to give access permission to utilities. This problem can be solved in two ways; one of them is by letting an external service provider realize the operation of the private cloud according to a *Service Level Agreement (SLA)* without taking data and infrastructure; the second way is to outsource the private cloud by giving all infrastructure and its management to another service provider [11]; *Community Cloud* - This cloud structure was facilitated for private use by a specific consumers from institutions that have common concerns (e.g., task, safety necessities, rule, and compliance considerations). It may be kept, accomplished, and worked by one or more institutions, a third party, or some combinations of them, and it may exist on or off premises; and *Hybrid Cloud* – Smart grid utilities that took advantage of cloud computing with a cost-efficient way can use the hybrid cloud deployment model. This model combined private and public cloud deployment models for smart grids by making a smart grid utility a cloud provider that holds its own data center and uses a private cloud model. Smart grid utility processes, analyze and combines data in the private cloud and builds services. Then, all of these services are published to all other utilities by using public clouds [11].

Cloud-based Smart Energy Metering Development and Applications

Smart energy metering deployed into power electric subsystems that can be incorporated with cloud-computing today and this development has been recognized as an innovative technology for the smart grid that strengthens all these subsystems and hence, it becomes a dominant component for smart grid applications. Within this framework, many cloud-computing based successfully

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works with smart energy meters development including devicehub.net [13], OpenHAB [14], OpenIoT[15], Particle [16], and NASA's High-End Computing Capability (HECC) Project [17] has been implemented. Two-way or bidirectional communications is one of the significant structures of the smart grid. This carries to control and processes with smart energy meters that accumulate data from smart grid stakeholders' devices and perceive their status. However, if a new system requires to be added on this smart grid application, the entire system must rehabilitate [18]. These are one of the many reasons why National Grid Corporation of the Philippines (NGCP), power plants and other power utilities connected into the grid have no such cloud computing-based access on their grid and they'd also avoided it by using the cloud smart energy meter background [19]. NGCP, generation plants, and power utilities must carefully understand that the smart grid services that perform an advanced metering infrastructure application are placed into the smart energy meter application cloud. These amenities are established, sustained and updated by the utilities inside this cloud. A smart energy meter accesses these services through a public border and controls the policies with respect to approaching response from cloud-computing. For example, cloud-computing includes heater control services that acquires the heat stability to align billing and warming of the system. A smart energy meter requests this amenity and controls the heat according to approaching data information. If the cloud provider updates this service such as changing the heat balance, the smart energy meter does not a necessity to know these variations, it ensures the equal thing with respect to a service response. This framework delivers competent solutions with these features for the Advanced Metering Infrastructure (AMI) of the power electric subsystems in the Philippines, to facilitate the fast, scalability, dependency and reliability of smart grid because all smart energy metering must be met into one connection and shared cloud-computing platform.

II. METHODOLOGY

This qualitative study was based on interviews of participants working in power electric subsystems such as power generation, transmission, distribution utilities, and commercial and industrial utilities. Researchers used qualitative research design to uncover dimensions such as beliefs, thoughts, and motivations and provide insight into complex relations. The study consisted of 4 groups from power electric subsystems. Participants were chosen purposively based on the following criteria [20]: they were directly and actively working in smart energy metering and cloud-computing and were willing to give informed consent. The researchers recruited twenty participants through a combination of electrical and IT personnel from power generation, transmission, distribution, and commercial and industrial utilization. The participants of the study were 5 working in power generation, 5 working in power transmission, 5 working in power distribution, and 5 workings in commercial and industrial utilization. Data were collected using face-to-face interview, online survey questionnaire, and focus group. All interviews were voice-recorded, transcribed and collected. The researchers used the second interview in method of focus group whereas the direct users of smart energy meter and cloud-computing from face to face interview and online survey questionnaire have been interviewed again separately in the group interview. The interviews were conducted from March 2019 to April 2019 in power electric subsystem and commercial & industrial utilities in the Philippines. The interviews conducted in coal plant in Pampanga, transmission and distribution utilities in Nueva Ecija, system integrator in Makati City, car manufacturer in Sta Rosa, Laguna, properties developer in Pasay City and Pasig City. Qualitative data analysis was used to analyze the data in this study. This is utilized to construct based on the interpretation, explanation or understanding of the participants about the questionnaires in the research study. Table 1 shows the profile of the participants as to their department, age, sex and position level.

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Table 1. Profile of the Participants

	Industry Type	Sources of Interview		Department		Age				Sex		Position Level			
First Interview:		Face to Face	Online Survey Questionnaire	EE	IT	25 below	26-35	36-45	45 above	M	F	Entry Level	Senior Level	Supervisor	Managerial
	Generation	5	0	4	1	1	1	2	1	4	1	1	2	1	1
	Transmission	5	0	4	1	1	3	1		5	0	1	3		1
	Distribution	1	4	4	1		3	1	1	5	0	3		1	1
	Commercial & Industrial	0	5	3	2	1	1	2	1	3	2	1	1	2	1
Second Interview in Focus Group:		Knows Very Well & Directly Users		Department		Age				Sex		Position Level			
		Smart Energy Meter	Cloud-computing	EE	IT	25 below	26-35	36-45	45 above	M	F	Entry Level	Senior Level	Supervisor	Managerial
		20	3	15	5	3	8	6	3	17	3	6	6	4	4

III. RESULTS AND DISCUSSIONS

All 20 participants from power generation are using smart energy metering same with power transmission except in power distribution and commercial and industrial utilizations in the Philippines. They believe that head-end or application can edit, collect, deliver data through the utility-grade of meter data management system (MDMS) and most of cloud-based have utility on data visualization from web-based energy portal and reporting tool for consumers and utilities (stakeholders).

Additionally, they have faith that most of the smart energy metering can be controlled by cloud-computing as long it is configurable and it has communication that compatible to connect in cloud-based. They said that "smart energy metering and systems can able to manage meter resources efficiently because most of the smart energy meters can import and export data, can use time of use (TOU) with multiple tariff or net-metering, load profile for energy, instantaneous reading, maximum demand, time maximum demand, alarm event logs, retrieval of power quality event data including sag/swell, total harmonic distortion, unbalance, over current exceedance, and retrieval of maximum, minimum and average voltage, current and other electrical quantities".

Moreover, the participants said it has a head-end system with communication server capability, cross-platform AMR system (Microsoft and Linux), cloud-based system, online instantaneous data reading through web and online load profile analysis. Most of them said that "smart energy metering can manage both locally and remotely and it is configurable since they have configuration tools dedicated to their system provider and that data from head-end or application can export to others system as long they are compatible with CSV files or encrypted data. Some participants said it was compatible usually in the SAP system in which is the most acquainted data management system.

Most participants particularly the direct users of cloud-computing believed, that the importance of cloud computing in the smart energy metering are the following: The system could import and export the data in less time required with high-frequency data gathering; the system has a real-time data streaming in less than few second intervals for customer engagement, power usage management, demand response, and other core applications; the system must resilient and scalable to a million's smart energy meter and reduced infrastructure cost, reduced IT operations costs, and built-in disaster recovery and high accessibility; the system has instinctive meter commissioning and fully compliant with advanced distributor load control requirement; the system could support real-time diagnostics and meter configuration; System could support dynamic service enablement (enable/disable and upgrade business services); the system has a real-time meter data, automated meter configuration and firmware upgrade; the system must control by consumers and stakeholders using user authentication (through Microsoft Active Directory and ADFS); the system could entry easy back-office systems integration through web-centric APIs and data formats; and the system must have integration with the cloud to cloud

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APIs and smart-phone applications.The direct users of cloud-computing believed, that these are the advantages of cloud-computing in smart grid in the following below: *Scalability* **-** system must receive rigorous data demand and can easily add new data storage devices as the demand growths in the smart grid; *Central Data Storage* **-** cloud-computing has wide grid access in the system and obtains availability. It must have mutual communication platform to evade various middleware software and border access by the system. Data reliability applied data formats on one dominant platform; *Cost Efficiency* - system can effortlessly switch from energy resources to other resources because it is associated in the network and all devices are associated to each other and send status data to utilities to be measured by them. This data exchange is provided at a low cost over cloud-computing and dedicated resources are used for the smart grid; *Real-time Response* **-** systems could process an enormous amount of information such as energy usage, control, meter data management, and market energy data in real-time response. Distributed data processing center could provide a scalable load balancing technology, control systems, and AMI in smart grid need a real-time response feature to process fast response against power outage and no delay on transferring and displaying control signals and pricing information for the demand management in the grid; and *Security* **-** system must deliver data security and privacy. In this case, a private cloud can be used in a smart grid to provide confidentiality, access right, data encryption, etc. This can be accomplished if SLA or service level agreement is done with the cloud provider. In cloud-computing, multiple head-ends or applications are deployed, managed, and run in one data center. Users of the same cloud cannot see each other's information and disturbances in this shared cloud.

Also, most participants particularly the direct users of cloud-computing believed, that these are the disadvantages or challenges of cloud-computing in smart grid in the following below: *Location of data* **-** System server is to be found anywhere, so the location of this server that store, retrieve, and process smart grid application are not known by stakeholders or consumers. This is a very serious issue on the data management and data visualization in the smart grid. So, defining data location by the service provider is important for the stakeholders or consumers; *Inefficient cloud security policy* **-** some cloud service providers (CSPs) apply weaker security policies than others. These changes may be specific to utilities, so they may cause discrepancies from utilities and this can solve by requiring the level of service level agreement for the smart grid; *Mixing of data* **-** in this system, the location of independent resource pool can access the applications, there are many multi-user applications in CSPs but yet, security and scalability of them is an open issue. So, security technique is being applied such as data encryption to maintain the reliability and confidentiality of smart grid applications; *Term of agreement* **-** some point smart grid utilities requested to CSPs to not includes commercial papers in the contracts that hold data in cloud were utilities can pay a huge amount of charge after SLA end date; *Compatibility* **-** cloud-computing does not observe with audit necessity which most serious matter that must be overcome by CSPs. However, cloud-computing has various challenges due to the location of data, mixing of data, inefficient security policy, etc. So, it is hard for CSPs to become compatible with smart grid auditing necessities including privacy laws; *Application Programming Interfaces (APIs)* **-** various application in cloud computing are applied by CSPs and it's compatible with specific utility's APIs. Therefore, passing another CSP to CSP it takes difficult and longer time; and *Redundant Data Management and Disaster Recovery* **-** emergency data recovery is the biggest concern of utilities because the system distributes data in multiple servers in diverse location. So, reliability cannot be provided to utilities when data at a certain time is not clear. In addition, utilities know the server data and access it when disaster recovery happens. So, a system most of the time do subcontract services and also recovery processes from other parties that may grounds of the problem when data is not held by the main CSPs. They are in favor of having cloud-computing because the system could provide fast, reliable and efficient information to them but some participants said it must consider the restoration of the national grid when it comes with cloud-computing, a system need rehabilitation of grid to followed the cloud-based online access on smart energy metering. They believe that smart energy metering offers robust and reliable modem enabling efficient communication that can run with 3G/4G technology, RS232 and RS485 port, GSM, GPRS, transceiver module ready, RF transceiver module ready, WIFI, ZIGBEE, LORA, PLC, and operational gateway module. Some participants believed that existing head-end system or application can deliver accurate data analysis, management, operations, and customer engagement.

However, some participants from power distribution still use traditional or manual energy meter same with commercial and residential buildings but most participants from commercial and industrial utilizations especially in high-rise buildings, malls, and manufacturing plants where they are using smart energy metering which hinders the application and benefit such as"smart energy metering can run in SCADA and BMS ready protocol (MV90, DNp3, and MODBUS)".

IV. CONCLUSION AND RECOMMENDATION

Most participants believed that smart energy metering can be controlled by cloud-computing and smart energy metering offers a robust and reliable modem enabling efficient communication. Moreover, some participants believed that existing application can deliver accurate data analysis, management, operations, and customer engagement. Few participants were direct users of cloud-computing but in some utilizations particularly in high-rise buildings, malls, and manufacturing plants, they were using cloud-computing to monitor their power usages and the harmonics power supplies in their facilities. Participants believed that application can edit, collect, deliver data through the utility-grade of meter data management system and most of cloud-based has utility on data visualization from web-based energy portal and reporting tools for consumers and utilities. Some participants said that the system is usually compatible in the SAP system. More so, most participants believed, that the scalability, central data storage, cost-efficiency, real-time response, and securities are advantages of the system and the location of data, inefficient cloud security policy, mixing of data, term of agreement, compatibility, application programming interfaces, redundant data management and disaster recoveries are the challenges of the system.

The researchers recommended to increase the consciousness of the stakeholders from power electric subsystems in the Philippines regarding the smart energy metering. The companies should be the one responsible to study and explore the performance [21] of latest engineering technology such as this oneto be able to make accurate decisions given available information [22] for the benefit of the consumers and the company, as well. The researchers also suggested that there should be a follow-up quantitative research with large number of participants to further strengthen the finding of this study.

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