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SMART METERING – A BRIEF OVERVIEW OF PROJECTS, BENEFITS AND APPLICATIONS

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Smart metering is a topic that recently has attracted much attention all over the world. Smart metering appears to be a remedy for rising prices of electricity, gas or water. The evidence from many project running in Europe and the USA showed that this technology is technically feasible and can generate the value added for the households and suppliers. In this paper we aim to systematize the knowledge of smart metering solutions, point out the benefits of smart metering and present a short overview of the SMEPI project led by Vedia S.A. in cooperation with GridPocket and SGGW.

Keywords: smart metering, smart grid, measurement, resources saving

1. Introduction

Smart metering generally concerns the usage of a „smart“ meter at customers place and the regular process of reading, processing and giving the feedback of consumption data to the customer. These „smart“ meters have been called smart since the introduction of static meters due to the fact that they included at least one microprocessor. For over 15 years smart meters were in use at big customers (plants, huge companies) but only recently they are available for mass application including households and small business. Nevertheless, it is still a rather slowly emerging field, mainly due to the cost of smart meters, but also due to the lack of

the infrastructure that can manage both the meters network and the large amounts of data from meters as well as provide devices for various end-user applications.

There is no universal definition of smart metering system but when referring to the literature [3], [7] the following definition can be developed. Smart meters are electronic measurement devices used by utilities to provide information about the usage, billing and operating their electric systems, water, gas or heating. In order to be intelligent, smart metering need to have the following features:

- automatic processing, transfer, management and utilisation of metering data;
- automatic management of meters;
- two way data communication protocol with meters;
- should provide meaningful and timely consumption information to the utilities and their systems;
- should support services that enable the savings of energy, water, gas or heating.

These features help consumers with time-based pricing options, such as peak-time pricing and time-of-use prices, and detailed energy usage, cost and billing. These features also enable utilities to manage better their infrastructure and line losses. In this context a smart grid term also appears which is a grid or a system that uses information and communications technology to operate based on the information about the behaviour of suppliers, intermediaries and end-users, to improve the efficiency, reliability, and sustainability of the production and distribution of electricity, water, gas or heating.

Usually, a smart metering system is considered for registry of electricity and but also water, gas and heating usage registration is a possibility. In Figure 1, an example of smart meter architecture and its functions are shown.

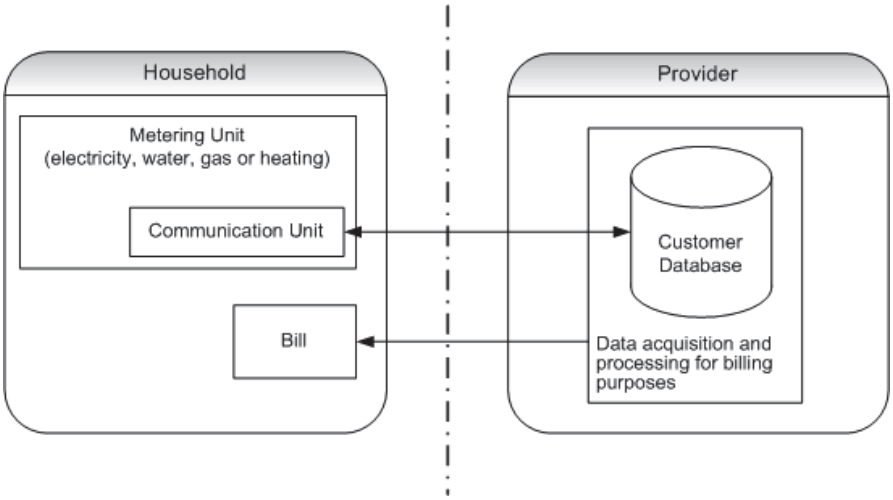

Figure 1. Scheme of example smart meter architecture

Generally, a smart metering architecture consists of three elements: a metering unit, a communication unit, and a central system with database. The metering unit tracks the customer's utility usage, provides information about the usage and forecasts, processes the billing. The communication unit enables two way communications with the utility supplier. The central system is on supplier's site and it has possibility, inter alia, to start/shut down the utility supply, to process data for customer relationship purposes, and to archive data according to legal requirements.

2. Benefits and costs of smart meters and parties involved

Many benefits are attributed to smart metering, including lower operating metering cost, energy savings for individual customers, more reliability of supply, variable pricing schemes to attract customers and easier detection of fraud.

Smart meters offer different benefits to different parties. Therefore, we should distinct the **users**, **distribution service companies** (grid operators), energy, gas and water **suppliers**, **metering companies** and the **governments**.

Smart metering is supposed to give individual **customers** such benefits as:

- more accurate and timely billing;
- possibility to benefit from demand flexibility;
- improved safety of the household and equipment through better power quality and breakdown management.

Additionally, to the benefits mentioned above, in SMEPI project we see other benefits (which is a great value added) such as: home appliances failure detection, detection of waste, and detection of unexpected activity or inactivity. This would be possible as a result of event recognition algorithms aimed to detect typical behaviour of the household.

On the other hand there are costs associated with smart meters roll out. Firstly, it is clear that the implementation of smart meters will be related to a number of costs, ranging from the initial cost of the meters, communications costs to possibly higher maintenance costs of electric devices. These greater costs will be accompanied by the benefits listed above and their balance will differ from implementation to implementation. Secondly, smart metering systems are likely to consume more power than conventional metering. Based on current technology and the increasing number of function in meters, this could potentially raise residential electricity demand by 0.5% [5]. Thirdly, smart meter systems are vulnerable to hacking as they are widely accessible for extended periods and possess large amount of sensitive data. Therefore, there will be also a substantial cost of ensuring their current and future security.

What concerns the **grid operators,** it is mainly the use of infrastructure that can bring substantial benefits. In particular, networks monitoring in terms of power

flows and faults gives grid operators a certain advantages: problems can be detected and solved faster; damages at customers' sites and any risks exposing safety can be avoided; efficiency of management and customer service can be improved. What is more, with the implementation of smart metering technology, grid operators can better plan the use of infrastructure and balance the system, for instance in terms of integration of renewable.

To the **supplier**, the smart meter offers possibilities to introduce demand response approach what is especially important on electricity market dealing with peak loads. Electricity storage is expensive and causes substantial losses. Thus, it is important to maintain the balance between generation and consumption in the system. Therefore, smart meters may become a gateway into the home of the customer, and provide the data about real usage to gain stability in the power system.

The **metering companies** face the challenge replacing old meters by new smart meters. These smart meters require another type of operation including data collection and data communication. Since smart meters introduce a high amount of frequent data, all the processes and systems must be prepared accordingly. The data collection process will be run independently as a continuous and fully automated process (clients presence is not required), which would simplify daily routine at metering company.

For **governments** improving competition and efficiency in energy markets seems to be the most important aspect. The other thing is environmental aspect that comes directly from energy savings but also due to the requirement to connect small hydro power plants, wind plants or solar plants to the electricity market to use of renewable energy sources instead of power plants using fossil fuel what increases greenhouse gas emission.

Smart metering enhances competition on the energy market (also applicable, to some extent, on gas and water markets) in following ways [4]:

- providing correct metered data allows to shorten or possibly to automate retail energy supplier switching procedures;
- it makes it easier for retail electricity suppliers to gain metered data for potential customers and make better electricity contract offers to them;
- smart metering diminishes technical barriers between national markets and makes it possible to create international electricity retail markets;
- new products that improve demand response may bring more price elasticity to the market thus reducing the risk for electricity market failures and collusive market behaviour.

3. Smart metering in Poland and Europe

Due to the regulatory push by the European Union's Third Energy Market Package, most EU Member States have or are about to implement some form of

legal framework for the installation of smart meters [1]. UE directive (2009/72/CE) states if the roll-out of smart meters is assessed positively, at least 80 % of consumers should be equipped with intelligent metering systems by 2020.
Moreover, in some UE member countries electronic meters with bidirectional communication are installed for economic reasons even without any specific legal requirements.

The following figure (Fig. 2) provides an overview of the legal and regulatory situation in relation to the process of implementation of smart metering technologies and services with the goal of achieving energy savings. Austrian Energy Agency report [1] classified European countries in five groups.

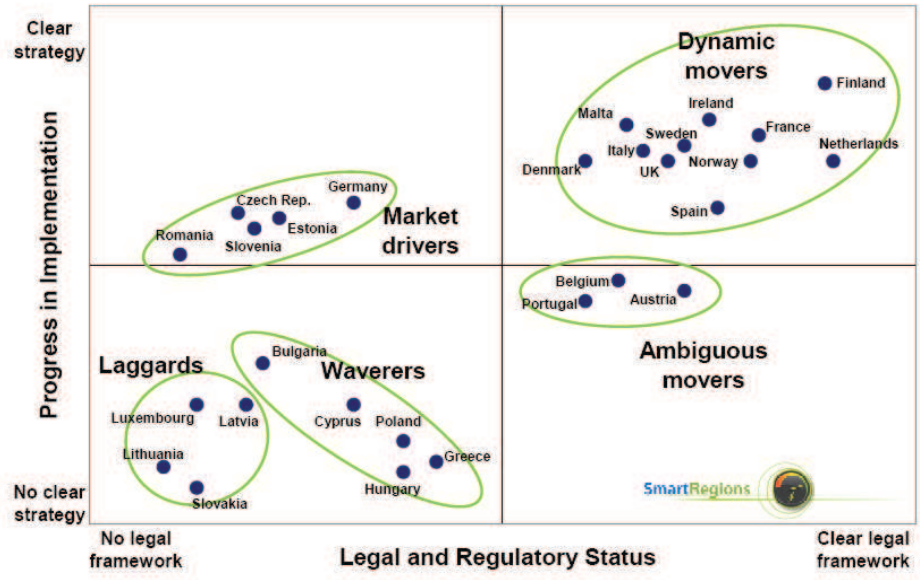

Figure 2. Overview of the implementation and regulations concerning smart metering systems in Europe. Source: [1]

There are countries called “dynamic movers” which can be characterized by a clear path towards a full rollout of smart metering or the major pilot projects have been running.

The other group consists of “market drivers”, that is the countries where no legal requirements for a rollout have been prepared but some legally responsible metering companies starts with the installation of electronic meters. Either because of internal synergetic effects or because of their customer demands.

“Ambiguous movers” countries represent a situation where the legal or regulatory framework has been prepared to some extent. However, due to lack of clarity

within the framework, at this point only some system operators have decided to install smart meters at their grids.

The "waverers" group, which also includes Poland, shows some interest in smart metering from regulators, the utilities or the governments. However, corresponding initiatives have either just started, are still in progress or have not yet resulted in a regulatory push towards smart metering implementation on a larger scale.

Finally, "laggards" group consists of countries where smart metering is not an issue yet. This group consists of Latvia, Lithuania, Slovak Republic and, what is surprising, Luxembourg.

In Poland, the driver for the implementation of smart metering in Poland is EU Directive 2009/72/EC and the so-called 20-20-20 EU-goals by 2020. An important document defining directions of development of the Polish power sector is the Polish Energy Policy until 2030 [9].

Smart Metering landscape in Poland (status at the end of 2011) can be described by a few business, research and science or government initiatives.

1. "Smart Power Grids – Poland" is consortium which consists of scientific and economic institutions that was established at the Wroclaw University of Technology on 3 November 2010 by the Energy Regulatory Office, the Office of Electronic Communications, the National Fund for Environmental Protection and Water Management and Bank Zachodni WBK. The organization aims to work on innovative technologies for the smart grid development. The consortium members will particularly deal with smart grids development as well as tools used for its optimization, protecting and steering [http://www.smargrids.pwr.wroc.pl].
2. Polish distributor Energa is a leader in smart metering innovation pilot testing. The company started the exchange of counters procedure and at the end of this process Energa plans to cover 70 percent energy transmitted to the customers with smart metering solutions. The project is estimated at 1 billion PLN and will cover about three million customers within the time span of seven years. An expected outcome of the project is to reduce the price of energy distribution, reduce technical losses by 4% and to reduce energy theft by 60%.
3. RWE operator has launched a pilot program for individual customers and provides them in devices designed to modernize the network measurement in the future. At this time all counters that are installed in the operator RWE are prepared for remote reading of electronic meters. However, the supplier does not have an action plan and it makes further decisions based on the regulatory requirements.
4. EnergiaPro is running the project worth 10 mln PLN and covering 20 thousand of customers with intelligent metering by the end of 2012. Until 2015, the company is considering extending the project to 20% of their customers. The opera-

tor indicates another benefit of this approach. Intelligent supply network will allow the calculation of the real value of deductions for interruptions in the supply of electricity. As a result, customers will receive compensation for the interruption in the supply.

5. Enea operator, as pilot experiments in 2011, installed 1000 smart meters in Poznań and Szczecin. Enea is another player waiting on the regulations. At present the development plan is under negotiation with the Regulatory Office, which determines the size of investment in smart meters development program.
6. SMEPI – Smart Metering Poland, a project of Vedia, GridPocket and SGGW applied for realization to National Centre for Research and Development (NCBiR) in 2011, started in 2012.

4. SMEPI – a project of Vedia, GridPocket and SGGW

The idea of the SMEPI project is to create a “smart metering" hub. This kind of hub will allow for data collecting and controlling other device. It will be equipped in an internet interface and it will support two way communications: to control the hub parameters and to send the collected metering information. This kind of communication is a basic one for smart metering. The advantages of the SMEPI in comparison to ordinary smart meters are as follow.

Firstly, it is the owner who manages information about the household. In traditional installation it is provider who decides about the volume of collected data about the household. That can lead to some kind of abuse if, for instance, such data are used to deduct about the live style. There are always voices that this is for the benefit of user. In the SMEPI a user is the party who make the decision about what data he wants to share and what is accuracy of the data. Also the user has the possibility to commercialize his data. This kind of information could be interesting not only for providers of electricity, water, etc. but also, for instance, for marketing and business advertising.

Secondly, another advantage of the SMEPI is the possibility of using relatively inexpensive metering equipment. The reason is that in the SEMPI the data from meters are sent just to the hub on short distance since long distance communication is implemented once between the hub and servers for all metering devices.

Thirdly, the encapsulation of metering devices gives the possibility of using different metering devices, which have a communication interface supported by the hub. This would enable to use devices from different providers, what should strengthen competition and as a result should have impact on prices of meters. Such approach would also enable the usage of meters with different communication interfaces, what is important in case of large buildings constructed with various materials, and implies the need of stronger communication interface. On the

other hand, stronger communication interface results in bigger supply needs what causes higher battery consumption (impact on the meters size) and shorter live time.

The last thing is a possibility of using meter readers instead of replacing old meters by new, what is much cheaper and is not without significance for the customer. The hub will not only collect data, but also synchronize data from different sources and make some processing on data to convert raw data in useful information.

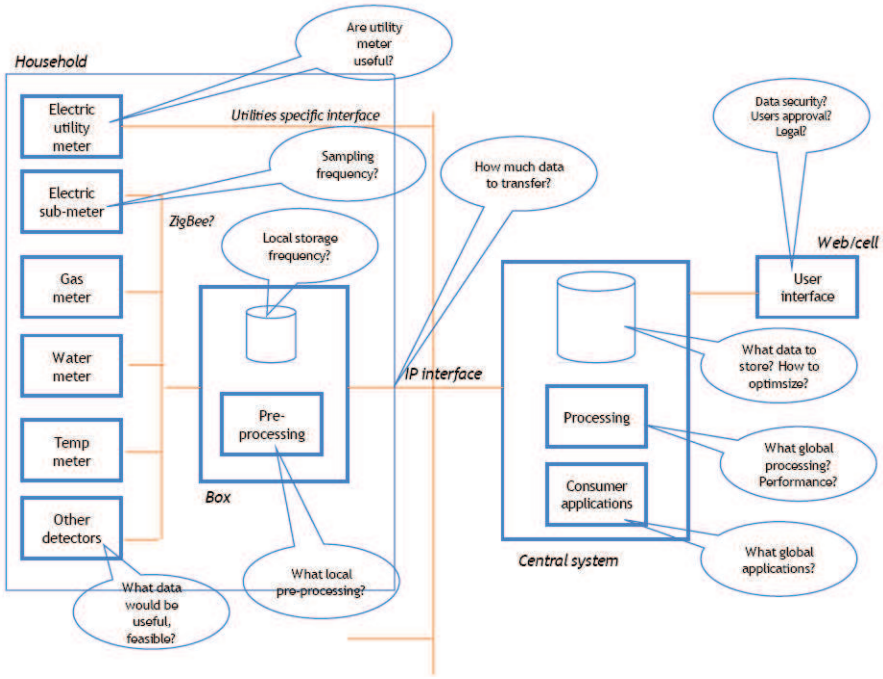

Figure 3. Conceptual scheme of SMEPI architecture.
Source: SMEPI application form

The conceptual scheme of SMEPI project, see Fig. 3, concerns more than just only scientific research aimed at preparation of algorithms to detect and recognize a household's activity. As the SMEPI is a research and development project it should lead to a commercial solution. It means that there are also technological challenges expressed with such questions as: What kind of the architectures should be chosen? Which communication protocols to use? What data should be process locally in the hub, and what data should be computed on an owner computer or on a server? What kind of information should be stored? What about data privacy and security issues?

Implementation of smart metering solutions is associated with huge amount of generated data, often sampled at very high frequency (hours, minutes and even seconds). To make the most of information from smart meters it increasingly requires dealing with specific techniques appropriate for this type of data. Many parties involved in smart metering roll out are aware of the possible areas where they would like to leverage information from usage. However, the real challenge lies in how to convert data into valuable information and then further implement solutions based on the results. Although, the theory of integrating and exploring logical and statistical data relationships is not new, most utilities are still at an early stage of the possible capabilities, primarily reporting aggregate data form the smart meters they gather.

For instance, taking only energy consumption, the customers will benefit from metering solutions through greater understanding of their own energy consumption, allowing them to better manage costs of their usage. It would also allow them to understand which energy plan may suit their consumption more effectively. Suppliers benefit by meeting energy demand, improving efficiencies in load management and smoothing out demand by offering customers more tailored tariff plans. In general, everyone can benefit by better understanding and managing energy demand. Additionally, a potential value added may be also achieved by forecasting future demand to reduce the strain on the system during heavy usage periods.

In order to present a data analysis possibilities based on electricity data we used a dataset with metering data being gathered for the purpose of SMEPI project in one of the households in Warsaw, see Fig. 4 and Fig. 5. Data were collected in September and October 2012.

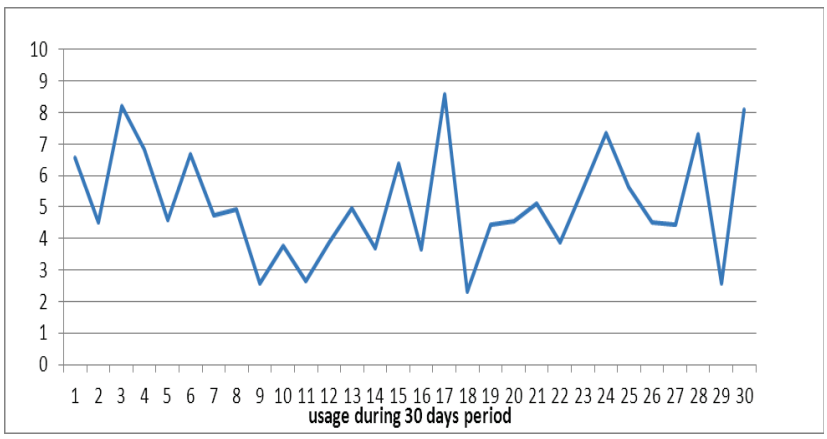

Figure 4. Daily usage data in a household consisting of 3 people over 30 day's period

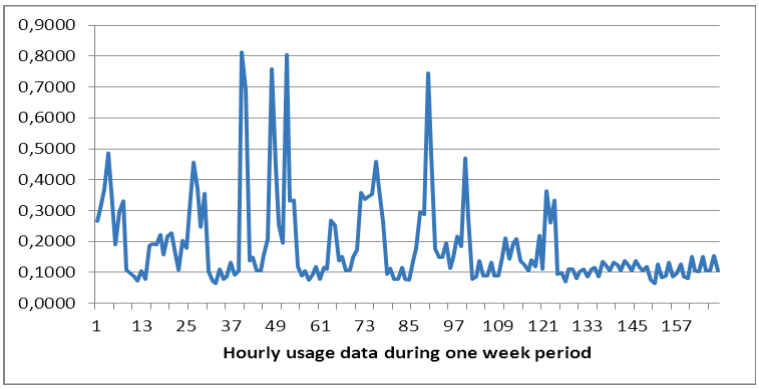

Figure 5. Hourly usage data in a household consisting of 3 people over one week period

Such data enables to perform e.g. appliance recognition [10], [11] and forecasting [8], [2].

The real time appliance recognition is a step towards reducing energy consumption and allowing a number of major applications including load-shifting techniques, energy expenditure breakdown per appliance, detection of power wastes and appliances faults, recognition of household members' activity (customers' safety), see Fig. 6.

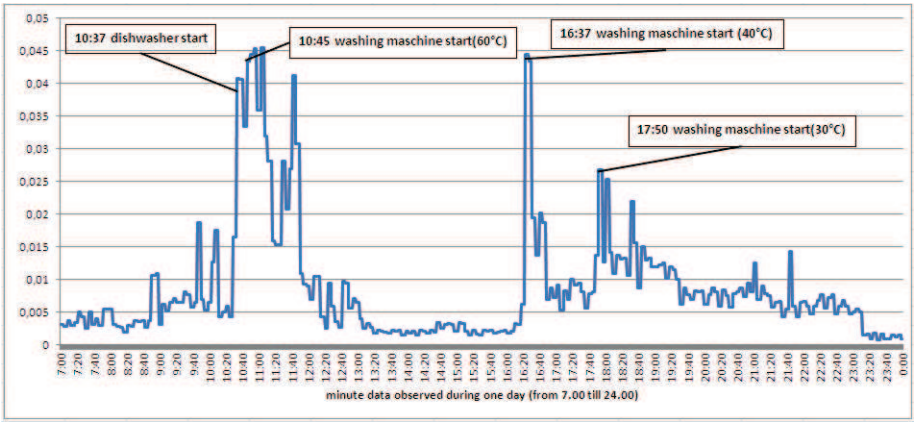

Figure 6. Minute usage data with appliances recognized during one day (from 7.00 till 24.00)

With the smart metering solutions the demand response programs will make the grid more flexible and cost efficient. However, a future where customers can directly participate in demand management needs some efforts for forecasting the loads of individual customers, see Fig. 7. As a result, accurate forecasting will ena-

ble a provider to plan the resources in advance and to take control actions like switching on/off demand response appliances and adjusting electricity tariffs.

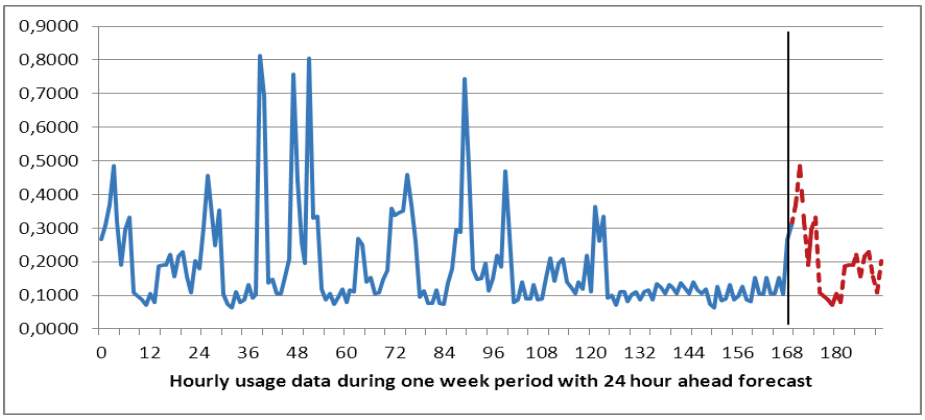

Figure 7. Hourly usage data with 24 hours ahead forecast

5. Conclusions

Since the inception of advanced meters the suppliers of electricity, water and gas have recognized the need for smart metering solutions. Smart meters seem to be the highest innovative development of the last few years, and a tool to generate a value added for all market parties including:

- metering companies to decrease meter reading costs;
- grid operators who want to modernize their grid;
- energy, gas and water suppliers who want to introduce new, customer made services and reduce call centre and communication costs;
- governments to achieve energy saving and efficiency targets and to improve market liberalization processes;
- end users to increase energy awareness and benefit lower energy costs.

The knowledge systematized in this paper was to bring the reader closer to the issue of smart metering idea, to show the benefits and indicate possible areas of application based on the collected data. The future of smart metering solutions seems to be bright as they are increasingly perceived as essential elements of more environmental friendly energy systems.

Acknowledgments

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