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Dynamic pricing in electricity: research potential in Indonesia

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Abstract

Dynamic pricing is a pricing strategy in which businesses set highly flexible prices for products or services based on current market demands. Dynamic pricing is popular because of its ability to increase revenue for a company. For the scope of Asia, China, Japan and Korea, are include three countries which pioneered the dynamic pricing application in electricity. There are three different programs are well-known in dynamic pricing in electricity which includes Time of Use (TOU), Critical Price Pricing (CPP) and Real Time Pricing (RTP). Other programs is Peak Rebate Time (PRT). Not just increasing the revenue, dynamic pricing can also be collaborated with environmental issues, such as dynamic pricing of electricity based environment. The main objective of environment based dynamic pricing is to reduce CO2 and SO2 emissions from the combustion of fuels such as coal, gas and oil. This paper is a literature review of various journals published by Elsevier from 2009 to 2015 that specifically discussed electricity pricing. Dynamic pricing concept can also be applied in Indonesia. Supply side and demand side management are discussed in this paper are related to the research potential in Indonesia

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Keywords: Dynamic pricing; pricing electricity, emission reduction; revenue management; optimization.

1. Introduction

In general, the physical function of electricity consists of generator subsystem, transmission subsystem and distribution subsystem [1], as it is shown in Fig. 1. Each sub-system has its own problems. Environmental issues often associated with this type of generator and fuel to generate power, issues of efficiency and network losses are

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usually always related to the subsystem transmission and distribution, while another issue is the latest shift in consumption patterns in sector customers by using the concept of dynamic electricity pricing.

Dynamic electricity pricing is becoming more popular due to its ability to influence consumption behavior of customers. In electricity customer behavior related to consumption patterns, which most customers use large electric load at the same time. Consumption patterns like this cause a surge of electricity load in a certain time that is often referred to as a peak load. The peak load is usually not all the time, only a few hours of total work load power plants. Top 1 % peak load can determine 5–8% of the total installed capacity. Dynamic pricing program is expected to affect the behavior of customer demand. Behavior where customers want to reduce electricity consumption at peak loads or moving it to another time. Changing consumption patterns in the macro level can influence strategic decisions such as the construction of power plants, as well as improve the efficiency of operational costs.

Dynamic electricity pricing has been developed in Europe and the USA but there are differences in characteristics between the two locations, while in Asia has not obtained the complete results. In the United States, dynamic pricing program aimed at deregulation allowing the development based on the market, while Europeans prefer the mass installation [2], in Asian countries, dynamic electricity program only up to the project status with incomplete results. Countries in Asia that has developed is China, Korea and Japan. While other countries, including Indonesia, have not obtained relevant data research or program dynamic pricing electricity.

Environmental issues become much research conducted in Europe, the United States and Asia. Electrical system is prepared to take into account the reduction of carbon emissions, $SO2$ emissions, the use of new and renewable energy, and the combined use of various fuels such as gas, coal and oil to reduce pollution on the one hand and production cost savings on the other side. This paper is based on a review of the Electricity Pricing several journals published by Elsevier from 2009 to 2015 to get a global context related to the development of Dynamic electricity pricing and then try to adjust the global context for the case of Indonesia

2. Definition and types of dynamic electricity pricing program

2.1. Definition of dynamic pricing

Dynamic pricing is the tactic of varying price over time [3]. In the context of electricity, dynamic pricing is a strategy determining electricity rates vary depending on the time, where time is tailored to the electrical load. The United States and Europe are the two pioneers who actively conduct research in the field of dynamic pricing, although there are differences in implementation. United States focus more on deregulation allowing the development of market-based, whereas the European is more emphasis on the installation of smart meters for easy control of electricity consumption. Dynamic electricity pricing could influence the behavior of customers to shift electricity consumption [4]. Mean of consumption behavior is shifting electricity demand usually occurs simultaneously at a time thus causing the peak load to another time when electricity demand is usually low. Making of a good schedule for the use of household appliances can reduce energy costs significantly [5].

2.2. The types of program

There are three programs of dynamic pricing for electricity in the United States namely TOU, RTP and CPP [2]. Paper [6] has conducted a survey in the US implementation of TOU programs are aimed at industrial customers. TOU programs in the United States have also been developed in anticipation of the increased greenhouse effect [7]. Excellent mathematical models used in solving problems of dynamic pricing [8]. CPP Program Development in Korea has to offer intuitive guidelines and rules for selecting those parameters that maximize the profit [9] . Later in the same year, they investigate demand response of commercial and industrial business to the Korean CPP which was implemented in the winter of 2013 [10]. China developed the RTP for the future. They studied different real-time electricity pricing mechanism based on load structure, cost structure and bidding and analyses the situation of user satisfaction and the total social surplus under different real-time pricing scenarios [11].

3. Methodology

Literature review is based on journals published by Elsevier (www.sciencedirect.com) for the period 2009 to 2015. Keywords used are: electricity, dynamic pricing and electricity, the economic load dispatch and electricity, joint optimization and electricity. From keyword "electricity" we got 88,921 papers. Due to the enormous amount of papers and the discussion topics are diverse, then the search was minimized by using keywords dynamic pricing and electricity. Based on this keyword it was found 11,925 papers. Due to the number of papers that are still very much, then do sampling of several papers, based on two kinds of keywords above. Based on this sampling it ultimately generates new keyword research trend, which is actually the dynamic pricing of electricity into sub-sections of the latest concept for joint optimization on the supply side and the demand side. Research on the supply side focuses on generating load dispatch, while research on the demand side focuses on the shift time electricity consumption. Keyword changed using the two key words: first is the economic load dispatch and electricity, the second is the joint optimization and electricity. Of the two types of keywords are obtained, respectively 3,225 papers and 3,695 papers. Although keywords already specified, it does not automatically generate papers on the topic in question, partly just raised the question in the keyword without detailed discussion. Therefore, the keywords are added to the title, abstract, keywords, which finally found a number of 51 and 27 papers. This paper is based on the last two key words which then are filtered based on cases which are suitable for Indonesia.

4. Global electrical systems

There are four electricity industry structure that is: vertically integrated monopoly, single buyer, wholesale competition, retail competition [1]. Each subsystem has its own characteristic problems, problems in the sub-system of plants is how to lower the cost of operating power plants with various types of fuel. The issue of the environment is also widely discussed in some countries. Power-to-gas (PtG) reduce cost of daily operation of up to 11% [12]. A reasonable residential energy price mechanism not only considers energy prices in relation to residential WTP and actual energy costs, but also takes into account the energy price mechanism's impact on the economy and the environment [13]. Carbon pricing could be the most effective strategy to reduce CO2 emissions [14].

5. Electrical systems in Indonesia

Initially the electrical system in Indonesia is a monopoly system, over time where there is an imbalance between the rate of supply with demand rate, PLN as the company that commissioned to generate and distribute electricity to customers, no longer able to carry out their duties in full, so that the electrical system is now more directed to form a single buyer where to meet customer needs, PLN uses its own generating capability and coupled with IPP. Similarly, the electrical system in general as in Fig.1, then subsystem electricity in Indonesia is divided into sub-system generator, subsystem transmission and distribution subsystem. Related to the problem of dynamic electricity pricing, so in this paper described a separate subsystem that sub-system customers such as Fig.1

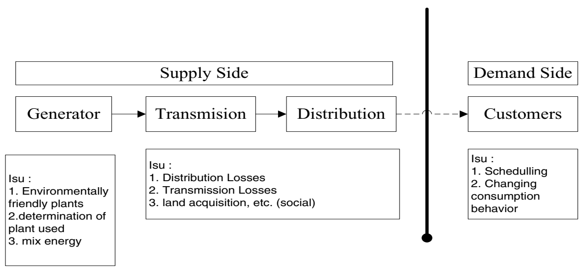

Fig. 1. Indonesia electrical system and its problems

6. Research potential in Indonesia

Refer to Fig. 1, there are three electrical subsystems in Indonesia, namely the generation, transmission and distribution. Each subsystem has its own problems. In general, problems at the plant is the determination of the fuel to generate electricity and the type of environmentally friendly power plants. Furthermore, common problem in transmission and distribution lines are network losses. Electrical problems in the future is not enough when the discussion is limited to the distribution subsystem, but it is more complex that needs to be added one subsystem again that customers subsystem. Customers become one of the key success factors in the future of electricity, customers can participate in the efficiency of electricity.

6.1. The power plant subsystems

The main problems are often the topic of discussion is the type of generator. This type of generator will determine the type of fuel used. Indonesia generally use three types of fuel to generate electricity, namely oil, gas and coal. Relatively gas produces fewer emissions than diesel and coal, but the cost of purchasing very expensive compared to the other two fuels. The use of fuel oil for electricity generation in Indonesia in 2011 was 24.78%, then decreased, in 2012 and 2013, respectively 14.97 percent and 12, 35 percent. Fuel oil is used to generate diesel generators, large emissions but is still used as a reason characteristic plant of this type is still needed in Indonesia. While other fuels such as coal reached 42, 39 percent in 2011 and continued to increase to 50.38% in 2012 and 51.35% in 2013. For natural gas also increased every year from 2011 until 2013 by respectively 20.86%, 23.41% and 23.96% [15]. For the case of Indonesia, the most low-cost hydroelectric power, followed by gas-fired plants, while diesel is the most wasteful from the viewpoint of operating cost and generation cost per kWh. However, the advantages of diesel is its high flexibility in supplying electrical power associated with peak load suddenly rises significantly. Viewed from the standpoint of efficiency, the diesel produces heat equivalent of 2,534 Kcal / KWh, when using fuel at 0.2761 Liters / KWh, whereas when using gas fuel, SFC amounted to 0.0140 MMBTU / KWh. For generating steam power plant (PLTU) generated heat equivalent of 2.708 Kcal / KWh with SFC, when using fuel at 0.2800 Liters / KWh, when using SFC coal amounted to 0.4990 kg / KWh and when using gas, SFC at 0 , 0100 MMBTU / KWh. Gas Power Plant (PLTG) is the largest heat generating equivalent 3.332 Kcal / KWh with SFC, when using fuel and gas respectively Liter 0.3677 / KWh and 0.0130 MMBTU / KWh. This fact raises the issue of the energy mix with emission constraints and cost. The lowest emissions when using fuel gas but most high raw material costs, while the highest emissions when using coal but low raw material costs. This mix of energy issues interesting to study, similar research ever conducted by [14] and [13].

When viewed from the standpoint of investment, attractive investment opportunities as well as to study electricity in Indonesia. Turned out to meet the electricity demand in the Java-Bali electricity system, PLN is only able to meet the demand of 32.24% of the existing market. Insufficient supply of energy supplied by Indonesia Power for 27.11%, IPP for 17.51% and PJB by 23, 14%.[16]. IPP engagement policy since 2009 by PT. PLN interesting to study because it allows the business opportunities in this field. Based [15], electricity production originating from its own production in 2009 was 115,434 GWh (74%) of the total production amounted to 156,797 GWh, the remainder met through the mechanism of Power Purchase of 36,169 GWh (23%) and Lease Power Plant by 5,194 GWh (3%). Generating increasing resource needs for PLN, in the year 2013 PLN has a total production of 216 189 GWh, with the following composition: Own Production amounted to 144 220 GWh (67%), Power Purchase amounted to 52 223 GWh (24%) and Lease Power Plant amounted to 19 746 GWh (9%). PLN declining portion opposite the purchase and rent increases. The above data for electricity below 80%.

6.2. Transmission and distribution subsystem

Problems on this subsystem is known as network losses, which consists of the network losses are losses of distribution and transmission losses. Network losses associated with the efficiency and performance of the transmission and distribution system [15]. If the network can be reduced could impact on two things: the reduction in cost of electricity supply and improve profitability. Network Losses in 2009 amounted to 9.93% consists of distribution losses of 7.93% and transmission losses of 2.18%. PLN is still not able to significantly reduce this network losses. By 2013 network losses worth 9.91% consisted of 7.77 distribution losses and 2.33% transmission losses. This condition is still an opportunity to do research with this topic for the case of Indonesia. Another technical problem beyond the electricity is land acquisition for the construction of transmission and distribution facilities, it is a classic problem in Indonesia.

6.3. Customers subsystems

Problems on this subsystem can be regarded as a trigger for the problems for other subsystems within the electricity system. Electricity demand that occurs in customer sectors, must be met by PLN to generate electricity on demand. Requests under installed capacity owned by PLN course can be met by generating electric energy, but when there is demand which is above the installed capacity owned by PLN course requires PLN to seek other sources to meet the demand. To meet this shortfall, there are two alternatives that can be done is the construction of a new plant or can be cooperating with IPP. A shift in customer demand patterns that originally occurred at peak load to off-peak load is also interesting to study, one of them using Dynamic electricity pricing strategy as one of the tactics of Revenue Management.

Dynamic pricing for electricity has become a popular topic in many countries with the development of Demand Response (DR) and an increase in electricity demand [2]. There are four types of dynamic electricity pricing program which is well-known that TOU (Time of Use), RTP (Real Time Pricing), CPP (Critical Peak Pricing) and PTR (Peak Time Rebate). However, only the first three rapidly growing program that TOU, RTP and CPP. To PTR less get attention. The concept of these models differ so that modeling is also different.

6.4. Electricity dynamic pricing in Indonesia

TOU is the simplest dynamic pricing program, where the program is only divided into two types of rate : peak and off peak. The second type is the RTP. This program illustrates the actual usage. The price of electricity is displayed in real time. It takes adequate technology to connect between the power producers with customers, to provide pricing information. The third type is Critical Peak Pricing. This type of program will set a high price at the time of the electrical load increases, or there is a threat to the electrical system in the form of excess demand, disasters and so on. Related to the peak load, there are differences in the characteristics of peak load in the United States and Indonesia. In the United States is usually the peak load began to occur in the morning until late in the evening. Peak load in the United States triggered by production and business activities. Electrical load began to decrease at night until the morning because at night the production facilities and businesses reduce their activities, so that electricity consumption is also down. In contrast, in Indonesia it is an increasing demand began to occur after business hours ended at around 17.00 pm and continued to increase until midnight. Therefore, the Government of Indonesia called on its citizens to save electricity consumption from 17:00 pm until 22:00 pm. In the afternoon, when the majority of people are at home and turn on the household appliances peak load began to take place. Load electricity continue to rise until about midnight when the majority of people usually fall asleep. On the morning when people start working and turn off electrical appliances at home, then the electrical load to be reduced. Peak load time is only 5 hours from 24 hours a day. While in the United States more than 7 hours a day. This characteristic differences in opportunities for research in the field of dynamic electricity pricing. Where the determination of the amount of the tariff class, the amount of tariff, and the length of the period of a tariff, it may be completely different. The difference was due to many things, such as culture, lifestyle, education level, income level, and others.

Discussion of dynamic electricity pricing becomes more interesting when it is associated with the Electric Power Supply Chain Management (EPSCM). EPSCM an extension of SCM [17]. EPSCM approach is also used by [18] to create various models of contracts in the electricity industry. Research in the field of electricity are generally divided into two major parts, namely the supply side and the demand side. Researchers in the field of the supply side [19] revealed issues of energy saving, related research joint between cost minimization and environmentally friendly performed by [20], [21]. Not just using fossil fuel energy, research on the supply side also involves fuels from renewable energy [20], [22], [23], [24], [25], [26], [27], [28]. Research on the demand side is very varied with three main strategies TOU, CPP, RTP [2]. Design for dynamic pricing program continues to grow as it has been investigated by [9], [29], [10], which examines the design of CPP, then research on TOU design also conducted by [6], RTP research conducted by [30] in China. The related research even to the scheduling scenario in household electricity consumption as is done by [31], [32], [33], [34], [35], [4], [5]

Research on both sides has resulted in contributing to the minimization of costs and benefits that can be obtained either from the electricity provider an d consumer of electricity, but gains were only seen from one side, from the supply side or the demand side alone, whereas optimal on one side may not be optimal when viewed from the other side. Dynamic pricing used in joint optimization as has been done by [36]. For the case of Indonesia, this research could still be continued, because of differences in conditions and culture. Dynamic pricing has actually been executed in Indonesia but within a limited scope that industry by reason of the ease of management due to fewer customers with the amount of usage considerable burden, while dynamic pricing for commercial and households has not been applied. It also means opportunities for the use of various optimization methods, both exact and optimization models with metaheuristic.

7. Conclusion

Research on the topic of electricity in all subsystems in the case of Indonesia is still very open, based on two main indications. First, there is no paper that discusses dynamic electricity pricing to the context of Indonesia in the International Journal (Elsevier). Second, data from PLN mention the use of three main fuel types in 2013, i.e. 12.35% of oil, coal and gas 51.35% 23.96%, it encourages research on energy mix. The generation subsystem, there are opportunities to do research related to the combination of different types of plants and also the use of a combination of various types of fuel to generate electricity, this combination has three main objectives, namely minimizing operating costs, minimizing environmental costs, and maximizing revenue. Subsector transmission and distribution also opens up opportunities for the penetration of research in the field of technology, where the technology can reduce network losses. This network losses case since 2009 did not obtain significant reductions. Sub Sector customers an opportunity study on the topic of dynamic electricity pricing. Electricity consumption in the customer sector can be optimized by scheduling. Customer in this case means the household, industrial and commercial. Dynamic electricity pricing could also be developed with the scenario that takes into account the behavior of private consumption in Indonesia is different from the United States

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