Minimizing Energy Cost of Air Conditioner in a Residential House under Demand Side Response Model

Marwan Marwan and Syafaruddin

Abstract—This research is aimed to develop a consumer demanding side response model to assist electricity consumers to mitigate peak demands during the peak season. The main contribution of this research is showing that consumers can mitigate peak demands by optimizing energy costs of air conditioner (AC) when a spike happens. It may only occur in a one and a half hours spike during the peak season. This model also investigates how AC applies the pre-cooling method when there is a substantial risk of a price spike. The results indicate that the potential benefit of the model is achieving energy savings for consumers and aggregators, also reducing electricity bills for the consumers. The model is tested with selected characteristics of the room, and based on the standard room in a residential house in Makassar, city of Indonesia.

Index Terms—Consumer, cooling, costs, modeling, pre-cooling, temperature.

1. Introduction

The strong economy and population growth in Makassar, city of Indonesia have large contributions to significant increases in electricity demand both in the residential and commercial sectors. Continuing to build and maintain inefficient buildings that rely on air conditioner (AC) will compound the sectors’ increased in energy requirements. Therefore, AC usage contributes greatly to peak load growth and is responsible for higher energy costs which use both in commercial and residential sectors in Indonesia.

AC usage contributes greatly to peak load growth in both the commercial and residential sectors in Makassar city. The reason is the increasing dwelling area served and the increasing duration of using AC. The increasing contribution of AC to energy consumption has received considerable attention in the past and will continue in the coming years.

Fig. 1 shows the details of the load curve in 2030 in the business as usual (BAU) scenario in Indonesia. In 2030, the electricity demand at the peak is mostly distributed among residential AC (29%), commercial and industrial sectors (18% and 20%), residential lighting and refrigerators (10% and 8%). As can be seen, the share of residential AC, lighting, and refrigerators is larger than the share of commercial and industrial sectors at the peak in 2030. Particularly, the contribution of AC to peak load grows roughly five times form 2010 to 2030. Together with its high UEC levels, residential AC have a large impact on the peak load in 2030. On the other hand, the share of lighting at the peak decreases due to progressive phase-out of incandescent lamps[1].

Based on the regulation of electricity market, small consumers are not allowed to direct participate in the wholesale electricity market. Under such a mechanism, only large consumers can curtail or shift a proprate of their load, or bid the wholesale electricity market price and demand. The small consumer is only able to register in the electricity market through the aggregator. It is envisaged that this mechanism could rolled smaller consumers out.

Fig. 2 indicates the competition of power structure in the electrical system. An aggregator is a third party that allowed to negotiate the electricity market directly with the market operator and transmission company. The physical electricity flows delivery from the generator to the consumer by transmission and distribution companies. In contrast, the financial electricity flow delivery from consumers to the market operator through the retailer company then continues to the generator. In the competitive electricity market structure, an aggregator needed to coordinate with the retailer and
distribution companies to provide good services to consumers. These services include the information about the electricity market price and demand. As a result, small consumers can participate in the wholesale electricity market.

![Fig. 2. Competition in the power system structure](image)

In this paper, the Indonesian electricity market price is chosen for the case studies. Collective benefits are the primary consideration for the small consumer and aggregator, so these prices are used to demonstrate the minimisation procedure.

## 2. Literature Review

### 2.1 Overview of Electricity System in Indonesia

In Indonesia, the state electricity company or called Indonesia national power grid (PLN) is responsible to provide and maintain most of power station, transmission, distribution. It is also responsible for selling electricity to the consumers. PLN holds primary responsibility for achieving the government’s accelerated generation targets through the Fast Track programs. Since the law passed in 2009, PLN is no longer a legal monopoly over the electricity generation, transmission, and distribution, but it has the right of first refusal over any activity in the sub-sector and this is an effective deterrent for private enterprises in many cases.

In 2010, the total Indonesian on-grid electricity capacity company was around 170 TWh. Approximately 83% of this was generated by PLN. In contrast, the national electricity demand is expected to grow around 9% from 2009 until 2019. It indicates the electricity demanded in 2019 will be around 400 TWh. Table 1 illustrates total installed on-grid generation capacity in 2010.

<table>
<thead>
<tr>
<th>Energy Sources</th>
<th>Installed Capacity GW</th>
<th>Share</th>
<th>Production TWh</th>
<th>Share</th>
<th>Capacity factor %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>116</td>
<td>40%</td>
<td>75.6</td>
<td>44.9%</td>
<td>74</td>
</tr>
<tr>
<td>Oil</td>
<td>8.4</td>
<td>29%</td>
<td>43.6</td>
<td>25.9%</td>
<td>59.6</td>
</tr>
<tr>
<td>Gas</td>
<td>6.1</td>
<td>21%</td>
<td>40.4</td>
<td>24%</td>
<td>76</td>
</tr>
<tr>
<td>Hydro</td>
<td>23</td>
<td>8%</td>
<td>8.8</td>
<td>5.2%</td>
<td>35</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.6</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>100%</td>
<td>168.4</td>
<td>100</td>
<td>66</td>
</tr>
</tbody>
</table>

### 2.2 Price Spike in the Electricity Market

A price spike can be generally defined as an abnormal price value, which is significantly different from its expected value. The price spike in the electricity market is an abnormal market clearing price at the time point and is significantly different from the average price. The price spikes could rise 100 or 1000 times higher than the normal price, which brings a high risk for the market participants. This impact could be on any market exposed consumer, including the electricity retailer.

On the basis of this definition, price spikes may be classified into three categories:

1. Abnormal high price: A price that is significantly higher than its expected value.
2. Abnormal jump price: If the absolute value of difference between the electricity price values in two successive time intervals is greater than a jump threshold (JTH), we have

   \[ |P(t) - P(t-1)| > JTH \]

   where \(P(t)\) is defined as a price spike of the abnormal jump price type.
3. Negative price: A price value lower than zero is defined as a negative price.

   There are many factors that can cause a price spike. In general, the underlying causes may include:
   1. High demand requires the dispatch of high cost peaking generators.
   2. A generator outage affects the regional supply.
   3. Transmission network outages or congestions restrict the flow of the cheaper imports into a region.
   4. A lack of effective competition in certain market conditions.

In the deregulated electricity market, the price spikes are highly randomized events. It can be caused by market power or unexpected incidents. And it can be influenced by many complex factors which include physical characteristic of the system, supply demand, fuel prices, plant operating costs, and weather conditions. The most significant factor theoretically is the balance between the overall system supply and demand. Therefore, when demand is larger than the supply, or the supply is lower than demand, the price spike will occur.

### 2.3 Smart Grid Demand Side Response

The smart grid is a promising concept to cope with increasing energy demand and environmental concerns. As the main feature and construction goal of the smart grid, intelligent...
interaction includes two-way interaction of information and energy. It encourages electricity consumers to change the traditional using styles and participate in the network operation actively, such as the adjustment of energy consumption patterns according to the real-time price and achieving the plug-and-play grid-connection of the distributed generation. Thus, demand side management (DSM) technology is one of the most important parts of the smart grid. The demand side response (DSR) is a part of the smart grid system, which can be defined as the changes in electric usage by end-users customers from their normal consumption patterns in response to changes in the price of electricity over time.[11][12]

The smart grid includes two-way communications, and it allows the consumer to control their energy usage better, provide more choices to the customer. Furthermore, the two-way communications also allow demand-side management to get better, in certain situations, the system operator can be given the right to control loads in the system, and enable more agile responses to system behaviour.[13] Therefore, under the recent trends of developing smart grid systems, the demanding side response issue has been raised again as one of the important methods of energy saving.[14] The concept of the smart grid is that the electric grid delivers electricity in a controlled and smart way from points of generation to consumers.[15] Therefore, using this technology will improve reliability, efficiency, and responsiveness of the electrical power system.

In a smart grid system, the consumer is an integral part of the power system, and it is encouraged to participate in the system’s operation and management. From the perspective of market operators, the controllable demand is another resource that will help balance supply and demand to ensure the reliability of the systems. The mechanism of the smart grid offered consumer is to transform the energy consumption into economic choice.[16]

DSR as described by [17] can be defined as the changes in electricity usage by end-use customers, which is from their normal consumption patterns in response to changes in the price of electricity or other incentives over time.[18] Effective DSR schemes bring benefit to all the participants in the electricity system: 1) avoiding or deferring capacity cost for generators; 2) deferring network infrastructure investment for network operators; 3) bringing financial benefit for participated customers. Future electricity systems will contain a large amount of low carbon technologies (LCTs), such as energy storage, electric vehicle (EV), and micro-combined heat and power (CHP) that could take part in DSR.

3. Research Methodology

3.1 Numerical Method

Numerical modeling is a feasible solution to allow unpredictable market price changes due to the interruption of major generation or other supply-side constraints. To conduct this investigation, mathematical models for the consumer participant were developed to quantify the economic effect of the demand-side variation. A linear programming-based algorithm was developed to determine the optimal solution for achieving the best outcomes. In additional, the developed model was designed to be applicable for load demand constraints, and to give good economic performance for electricity generation, transmission and distribution.

The model shows how AC should decrease temperature loads during high temperature periods. When there is a substantial risk of a price spike, a pre-cooling method will be applied to avoid high prices in a critical peak period. Consumers are able to operate the AC usage by controlling the desired levels of room temperature, turning on the AC when the temperature rises to a maximum threshold (i.e., 24 °C) then turning it off for the next period until the temperature drops to the minimum threshold (i.e., 20 °C). In additional, this research investigated how consumers can optimize energy costs when they have not committed to the permitted temperature. On this optimisation process, when the room temperature is lower or higher than the minimum or maximum temperature threshold then a penalty for the optimization process will be identified. The cycling time of the AC is based on the result of temperature optimisation.

In this research, a pre-cooling method was examined as a way to minimise energy costs. Pre-cooling is the method to reduce the room temperature in advance of a possible spike. This method is considered to be effective because it can minimise energy costs and keep room temperature comfortable for the consumer. However, pre-cooling is only undertaken when there is a substantial risk of a price spike. Because it costs a lot and the spike may not always occur in the system. In the meanwhile, applying this method is expensive, it is more efficient if switching on the AC at all times during the critical time.[19]

The objective is to minimise energy costs by optimising the room temperature. The energy cost is based on the AC status, that is, no cost when the AC status is off (Ut=0) and market cost if the AC status is on (Ut=1). To achieve this objective, an optimisation package such as MATLAB is used allows the user to carry out optimisation within operational constraints such as a permitted temperature range.

In the optimisation process, the MATLAB optimisation toolbox function fmincon and the ordinary differential equation solver ODE45 were used. The toolbox functions of fmincon were applied using the default option to be acceptable in this work. The fmincon was used to determine the optimal parameter of the ordinary differential equation. The ODE45 is used to solve the initial value of problems involving an ordinary differential equation. The ODE45 is more complicated and will take longer steps. However, the accuracy of the result obtained in this study was higher than the accuracy of the result using the ODE23, making the ODE45 more favourable and reliable than the ODE23.

In order to formulate the participation of the consumer in the DSR program, the energy cost model which represents the
changing temperature and electricity price was developed. The optimization problem can be represented as minimized energy cost \( Z(t) \) mathematically\(^{[20]} \):

\[
Z(t) = \min_{n=1}^{t} \int [(S(t)P(t)D(t)U(t))dt].
\]  

(1)

Subject to constraints\(^{[19][20]} \):

\[
dT = \frac{QA(T_o(t) - T_t(t))}{H} - BU(t)
\]

(2)

where:

- \( Z = \) Minimised energy cost (\$/h)
- \( S = \) Electricity price (\$/kWh)
- \( P = \) Rating power of AC (kW)
- \( D = \) Duration time for operating AC during a day (hours)
- \( U = \) Continuous time binary variable (1 or 0)
- \( Q = \) Heat transfer coefficient from floor walls and ceiling (W/m\(^2\)-\(\circ\)C)
- \( B = \) Heat transmission from the AC (W)
- \( A = \) Total area (m\(^2\))
- \( H = \) Heat capacity of the room (J/\(\circ\)C)
- \( T_o = \) Temperature outside (\(\circ\)C)
- \( T_t = \) Temperature inside the room at time \( t \) (\(\circ\)C)
- \( n = \) the nth interval time \( t \) (hour)

During the optimization, if the room temperature is higher or lower than the maximum or minimum temperature \((T_{max} \) or \( T_{min} \)) threshold, a penalty will be added to the computed cost.

\[
\text{If } T(t) > T_{max} \text{ or if } T(t) < T_{min} \text{ Then }
\text{Penalty} = \text{Pen}
\]

(3)

Otherwise,

\[
\text{Penalty} = 0
\]

(4)

Therefore, the energy cost will be calculated by

\[
Z(t) = \min_{n=1}^{t} \int [(S(t)P(t)D(t)U(t))dt] + \text{Pen}
\]

(5)

3.2 Price Spike in Electricity Market

In present research, after the analysis of the historical data, a threshold value of $50 per MWh was used for analyzing the electricity market in June 2017 in the South Sulawesi region. This means any price more than $50 per MWh is called a price spike. The average of the electricity prices under $50 per MWh is called the non-spike price, which was $20.69 per MWh in this period. In addition, the temperature data on June 29, 2017 was selected for the outside temperature \( (T_o) \).

4. Discussion

4.1 Description of Methodology

Consumers should start to apply DSR program to optimise the AC as soon as they receive information from the aggregator. Due to the peak session periods (e.g., 18:00 to 21:00), the consumer is required to participate in the DSR program starting from 18:00 to 19:30. The case study reported in this paper illustrates the optimisation of AC if a spike may only occur during one and half hour. This model is appropriate only when we know the spike may only occur during these time.

Numerical modeling is a possible solution to minimize the energy cost by controlling the room temperature with consideration of varying electricity market prices and outside temperature. In this simulation, the maximum and minimum permitted temperature were 25 \( \circ \)C and 19 \( \circ \)C. There were 20 switch edges characterizing the switching decisions, we could compute the energy cost of the AC. The numerical minimization was applied to find a set of edges which satisfied the constraints and provide minimum cost. The process was required to do optimization of the cost.

The energy cost was calculated when AC was on. And the cost was zero when AC was off. This method continued until AC was expired. To make the temperature comfortable for the consumer, the room temperature was only allowed to be between 19 \( \circ \)C and 25 \( \circ \)C. This means the temperature was not allowed to reach the maximum and minimum permitted temperature. For the purpose of the simulation, the starting point temperature was chosen as 22 \( \circ \)C with AC turned off. Table 2 summarizes the parameters of the typical room and AC used in this optimization.

<table>
<thead>
<tr>
<th>No</th>
<th>Parameter</th>
<th>Room A</th>
<th>Room B</th>
<th>Room C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heat transfer coefficient from floor wall and ceiling (W/m(^2)-(\circ)C)</td>
<td>0.8</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>Total areas (m(^2))</td>
<td>14.40</td>
<td>8.64</td>
<td>8.06</td>
</tr>
<tr>
<td>3</td>
<td>Heat capacity of the room (J/(\circ)C)</td>
<td>20</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Heat transfer from the air conditioning (W)</td>
<td>900</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>5</td>
<td>Temperature reference ((\circ)C)</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>Maximum temperature ((\circ)C)</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>Minimum temperature ((\circ)C)</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>Duration of time hour</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>Rating power of air conditioning (P)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>Number of switching</td>
<td>18</td>
<td>16</td>
<td>14</td>
</tr>
</tbody>
</table>

Data above taken from a residential house in Makassar City in South Sulawesi Indonesia.

4.2 Cost Function of the Price Spike without DSR Program

The aim of the controller is to maintain the temperature of the room in some temperature threshold in order to keep it within comfortable limits. In this simulation, the starting point of 22 \( \circ \)C was chosen with AC turned off. The lower and upper temperature were 20 \( \circ \)C and 24 \( \circ \)C. AC was turned on once the temperature rose to the selected maximum. AC was turned off once the temperature dropped to the selected minimum, then the temperature could increase and rise to the selected maximum. The typical operation of AC is continuous without the control of DSR program. In this case, the consumer did not consider a price...
spike. On the other hand, a price spike in the electricity market may occur in the one and a half hour spike. Figs. 3 and 4 illustrates the cycling temperature and the market cost if a spike may occur in these time.

In this simulation, there are 20 switch edges to compute the energy cost for AC. If $S_s$ is the electricity price when a spike occurs, Pen is the penalty, then the total market cost for the spike case $(MC_{A,B,C})$ is

$$MC_{A,B,C} = \min_{n} \int_{t=1}^{t=n} \left[(S_s(t)P(t)D(t)U(t))dt\right] + \text{Pen}. \quad (6)$$

Equations (1) to (6) are used to compute the results of simulation without the DSR program when the one and a half hours spike may occur form 18:00 to 19:30 during the peak period, as shown in Figs. 3 to 5.

According to the result of optimization, the electricity market cost of the Room A was higher than other rooms because of the nominal price of the spike and duration of the spike. The market cost of Room A $(MCA)$, Room B $(MCB)$, and Room C $(MCC)$ are defined for the market cost without DSR program, then the market costs of every room are presented in Table 3.

### 4.3 Cost Function of the Price Spike Under DSR Program

The control system optimizes the room temperature of AC is to save the energy cost for consumers, at the same time maintain the temperature between the permitted maximum and minimum temperature in order to provide a comfortable room temperature for the consumer. In this optimization, the maximum and minimum temperature were 25 °C and 19 °C. Temperature starting form 22 °C was chosen. Under the DSR program, the cost function of the price spike is calculated as follows:

$$MC_{A,B,C} = \min_{n} \int_{t=1}^{t=n} \left[(S_s(t)P(t)D(t)U(t))dt\right] + \text{Pen}. \quad (6)$$

Fig. 5. Cycling temperature and market cost without DSR model (Room C): (a) temperature and (b) market cost.

As shown in Figs. 3 to 5, the calculation of the electricity cost during this period is based on AC status. The electricity cost increased when the temperature was reduced by AC on. Furthermore, there was no electricity cost when AC was off or electricity costs were not calculated when AC was off. The electricity cost calculation started from switch number 1 to number 2. Then, AC was turned off again when switching number 2 to number 3. The type of operation was continuous all the time. The consumer/aggregator pays the cost according to the normal price before and after a spike occurs. The price spike was only calculated when the spike happened from 18:00 to 19:30. In this case, three kinds of different characteristic rooms were considered as Rooms A, B, and C.

According to the result of optimization, the electricity market cost of the Room A was higher than other rooms because of the nominal price of the spike and duration of the spike. The market cost of Room A $(MCA)$, Room B $(MCB)$, and Room C $(MCC)$ are defined for the market cost without DSR program, then the market costs of every room are presented in Table 3.

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Market Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room A $(MC_A)$</td>
<td>5.32</td>
</tr>
<tr>
<td>Room B $(MC_B)$</td>
<td>5.23</td>
</tr>
<tr>
<td>Room C $(MC_C)$</td>
<td>3.94</td>
</tr>
<tr>
<td>Total cost $TMC_n$</td>
<td>14.49</td>
</tr>
</tbody>
</table>
program the cycling temperature room was bigger than without DSR program. This is to given more options and more flexibilities for the optimization. In addition, since the price spike may occur form 18:00 to 19:30, the consumer is required to optimize to minimize expected energy costs.

Under the DSR program, the control system applied the pre-cooling method to avoid high costs when a spike happens. Similar to the previously described method, AC was turned on once the temperature rose to the maximum permitted temperature. Then, it was turned off when the temperature dropped to the minimum permitted temperature. The control system kept the room temperature between the maximum and minimum permitted temperature.

If $S_i$ is the electricity price when a spike occurs, $Pen$ is the penalty, then the total market cost for the spike case ($MC_{S_A,B,C}$) can also be determined by (6).

Equations (1) to (6) were used to compute the numerical results of optimization of AC when the one and a half hour spike occurred at the peak season, as shown in Figs. 6 to 8 and Table 3.

Fig. 6 illustrates the numerical results of AC optimization when a price spike may occur in the middle of the day for half an hour. The cost can be minimized by maintaining the temperature of the room between the lower and upper temperature. The typical operation is similar to the previously described method (i.e., the method without DSR program) as discussed above. In the meanwhile, the AC controller apply the pre-cooling method before a spike happens to avoid the price spike that may occur at the peak season. This is because the substantial risk of the price spike. In all, the room temperature would be cooler in the period leading up to the higher price time.

As Figs. 6 to 8 indicate, a pre-cooling method was applied at switch number 4 before a spike happened. The temperature during the pre-cooling period dropped to a lower level, such as

![Fig. 6. Cycling temperature and market cost under DSR model (Room A): (a) temperature and (b) market cost.](image)

![Fig. 7. Cycling temperature and market cost under DSR model (Room B): (a) temperature and (b) market cost.](image)

![Fig. 8. Cycling temperature and market cost under DSR model (Room C): (a) temperature and (b) market cost.](image)

19 °C for Room A, B, and C, which was cooler than the temperature during the spike period. AC status starting from the spike period was off until the duration of the spike had nearly expired. And the control system turned on AC only for a short time during the spike period. But the room temperature only rose to higher than 22 °C.

The calculation of the cost was based on AC status, and the electricity cost was only calculated when AC was switched on. The market cost of the price spike was paid only when AC is on during the spike period. In addition, the consumer paid a normal price when the AC was on during no-spike periods. The market cost for Rooms A, B, and C, respectively, and the penalty ($Pen_{S_A,B,C}$) and the total cost for Rooms A, B, and C (TMCs) that occur as a result of the optimisation are given in Table 4.
4.4 Benefit of DSR

Based on the results of the optimisation shown, the consumer and aggregator could gain collective benefits when the consumer controls AC using the DSR program. The collective benefit (CB) is expressed by

$$CB_{A,B,C} = TMC_s - TMC_n.$$  \(7\)

The percentage of CB is illustrated by

$$\%CB = \frac{CB}{TMC_n} \times 100\%.$$  \(8\)

Equations (7) and (8) were used to compute CB. Table 5 summarises CB for the consumer and aggregator when the consumer was required to be the member of the aggregator. CB of 22.71% can be achieved for the consumer and aggregator, in addition, this model will also assist the utility to decrease electricity demand when a peak season occurs.

Table 5: CB comparison

<table>
<thead>
<tr>
<th>Room</th>
<th>MC_{A,B,C} ($)</th>
<th>Pen_{A,B,C} ($)</th>
<th>CB ($)</th>
<th>CB (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.84</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>3.71</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>3.65</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMCs ($)</td>
<td>11.20</td>
<td>—</td>
<td>3.29</td>
<td>22.71</td>
</tr>
</tbody>
</table>

It is clear from the results presented in Table 5 that the collective benefits obtained by the consumer and aggregator was $3.29 (22.71%) when the DSR program is applied. In addition, the benefit impact to the utility includes the decreased electricity demand when a peak season. Therefore, DSR program will help balance the supply and demand to ensure the reliability, efficiency, and responsiveness of the electrical power system.

5. Conclusion

This paper discussed the proposed DSR program for AC to minimize the energy cost for consumers. To apply this system, the consumer was required to be the member of the aggregator as the third party to negotiate the electricity price between utility and consumer. CB of 22.71% can be achieved for the consumer and aggregator, in addition, this model will can assist the utility to decrease electricity demand when a peak season occurred.

6. Acknowledgment

This research was supported by Ministry of Research, Technology and Higher Education of the Republic of Indonesia.

References


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