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3rd 2021 EIconCIT Welcome Editorial Remarks

The 2021 3rd East Indonesia Conference on Computer and Information Technology (2021 3rd EIconCIT) was held in April 9-11, 2021 in Surabaya, Indonesia as virtual conference with the support of IEEE Indonesia Section. This conference is held with partnership with East Universitas Mulawarman, Universitas Muslim Indonesia, Universitas Negeri Malang, Universitas Islam Negeri Maulana Malik Ibrahim Malang, Universitas Ahmad Dahlan, Universitas Hasanuddin, Universitas Cokroaminoto Palopo, Politeknik Negeri Samarinda, Politeknik Negeri Bali.

This year conference takes on the theme of “*The Future of Innovation and Digital Transformation Technology*”. We are pleased to announce the 2021 3rd EIconCIT of Proceeding have been finalized and submitted to IEEE Publisher.

The 3rd 2021 EIconCIT generally attracts more than 288 authors from 12 countries. Number of papers accepted to be published is 85 papers out of 238 papers submitted with 35.7% of acceptance rate. Additionally, we would like to warmly thank all the authors who have presented their presentations to the lively exchange of scientific information that is so vital to the endurance of scientific conferences.

We would like to thank to all keynote speakers; Assoc. Prof. Dr. Rayner Alfred (Universiti Malaysia Sabah), Emeritus Prof. Kondo Kunio (Tokyo University of Technology), Assoc. Prof. Leonel Hernandez (Corporación Universitaria Reformada , Barranquilla, Colombia), and Assoc. Prof. Dr. Endang Setyati (Institut Sains dan Teknologi Terpadu Surabaya) who gratefully delivered their speech and shared knowledge.

Also, we would like to thank to all reviewers who have contributed their valuable advices and encouraging comments and all the members of 2021 3rd EIconCIT Editorial Team who have made this publication possible. We really hope you enjoy the Proceeding and look forward to seeing you in the next conference.

The next event, the 2022 4th EIconCIT, will be hosted by Universitas Islam Negeri Maulana Malik Ibrahim Malang and Universitas Negeri Malang, in 2022. We invite and welcome all participant to come in Malang, East Java, Indonesia.

May 2021

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Table of Content

No	Title	Page
1.	A Performance of ES920LR LoRa for the Internet of Things: A Technology Review	1
2.	A Performance Evaluation of ZigBee Mesh Communication on the Internet of Things (IoT)	7
3.	Designing Information Security Risk Management on Bali Regional Police Command Centre Based on ISO 27005	14
4.	Monitoring Design of Temperature and Humidity Issues in IoT-Based Train Passenger cars	20
5.	Predicting Frequently Asked Questions (FAQs) on the COVID-19 Chatbot using the DIET Classifier	25
6.	Analysis Classification Opinion of Policy Government Announces Cabinet Reshuffle on YouTube Comments Using 1D Convolutional Neural Networks	30
7.	Analysis of the Spread of COVID-19 in Local Areas in Indonesia	36
8.	A Comparison of Naive Bayes Methods, Logistic Regression and KNN for Predicting Healing of Covid-19 Patients in Indonesia	41
9.	Time Series Forecasting for the Spread of Covid-19 in Indonesia Using Curve Fitting	45
10.	A New Approach for Spear phishing Detection	49
11.	Detection of Online Prostitution Account in Twitter Platform Using Machine Learning Approaches	55
12.	Application of Deep Learning for Early Detection of COVID-19 Using CT-Scan Images	61
13.	Control Design of Information Security Related to Privacy in The Smart SIM Business Process	66
14.	Bus Scheduling in The City of Surabaya Using Smooth Transition Method and Equal Average Load	73
15.	Indonesian Abstractive Summarization using Pre-trained Model	79
16.	Banana Ripeness Classification Based on Deep Learning using Convolutional Neural Network	85
17.	Smart Watering Plant Design in Apartment Lifecycle using Mobile Application	90
18.	Development of an online PTT voice transmission system between cell phones, computers, and embedded systems over the internet	95
19.	Sentiment Analysis of Indonesia's National Economic Endurance using Fuzzy Ontology-Based Semantic Knowledge	99
20.	Accuracy Comparison of Home Security Face Recognition Model in The Several Lighting Condition Using Some Kinect Produced Image	105
21.	Sheep Face Classification using Convolutional Neural Network	111
22.	Unsupervised Corpus Callosum Extraction for T2-FLAIR MRI Images	116
23.	Sentiment Analysis on Covid19 Vaccines in Indonesia: From the Perspective of Sinovac and Pfizer	122
24.	Data Augmentation and Faster RCNN Improve Vehicle Detection and Recognition	128
25.	Automation and Optimization of Course Scheduling Using the Iterated Local Search Hyper-Heuristic Algorithm with the Problem Domain from the 2019 International Timetabling Competition	134
26.	4G LTE Experience: Reference Signal Received Power, Noise Ratio and Quality	139
27.	Batik Clothes Auto-Fashion using Conditional Generative Adversarial Network and U-Net	145
28.	Multi Camera Positioning Behaviour Based on A Director Style Using Fuzzy Logic for Machinima	151
29.	Talent management in agile software development: The state of the art	156
30.	Scheduling control of air-conditioning system based on electricity peak price	161
31.	Design of Sign Language Recognition Using E-CNN	166
32.	Optimization of the 5G VANET Routing Protocol on AODV Communication with Static Intersection Node	171
33.	Monitoring and Controlling Smart Hydroponics Using Android and Web Application	177
34.	Predicting Student's Failure in Education Based on Dropout Status	183
35.	3D Printer Operational Robustness on Polylactic Acid based Product Printing	189
36.	Helmet Usage Detection on Motorcyclist Using Deep Residual Learning	194
37.	Short Message Service (SMS) Spam Filtering using Machine Learning in Bahasa Indonesia	199
38.	Improving Machine Learning Accuracy using Data Augmentation in Recruitment Recommendation Process	203
39.	Evaluation of the Customs Document Lane System Effectiveness: A Case Study in Indonesia	209

No	Title	Page
40.	A Policy Strategy Evaluation for Covid-19 Pandemic in the City of Surabaya Using Vensim Ventana Dynamic System Simulation	215
41.	System Evaluation of RFID-Based User Localization	222
42.	Mobile Network Experience in Forest Research and Conservation Areas	227
43.	Analysis of User Acceptance for Rumah Belajar Mobile Application	232
44.	Multivariate Data Model Prediction Analysis Using Backpropagation Neural Network	239
45.	Information Extraction from ICMD Documents to Determine the Ratio Factors Function Performance using Fuzzy	244
46.	Energy Efficient Fog Computing with Architecture of Smart Traffic Lights System	248
47.	Developing Machine Learning Framework to Classify Harmonized System Code. Case Study: Indonesian Customs	254
48.	Position Control Using Linear Quadratic Gaussian on Vertical Take-Off Landing	260
49.	The Mobile Payment Adoption: A Systematic Literature Review	265
50.	CBES: Cloud Based Learning Management System for Educational Institutions	270
51.	Technology Acceptance Model in One Stop Service Systems during the Covid-19 Pandemic	276
52.	Communication Media Rankings to Support Socialization at PPATK	281
53.	Measuring the UX of Mobile Application Attendance Lectures Feature Using Short-User Experience Questions (UEQ-S)	286
54.	Cloud-based COVID-19 Patient Monitoring using Arduino	292
55.	Performance Analysis of GPU-CPU for The Face Detection	297
56.	Bank Account Classification for Gambling Transactions	302
57.	How to the Need for Personal Protective Equipment (PPE) during the current Covid 19 Pandemic: Smart Products Solution	309
58.	Detecting Social Media Influencers of Airline Services Through Social Network Analysis on Twitter: A Case Study of the Indonesian Airline Industry	314
59.	Classification of Male and Female Sweat Odor in the Morning Using Electronic Nose	320
60.	Recent Trends and Opportunities of Remote Multi-Parameter PMS using IoT	325
61.	Categorization of Exam Questions based on Bloom Taxonomy using Naïve Bayes and Laplace Smoothing	330
62.	Social Media Emotion Analysis in Indonesian Using Fine-Tuning BERT Model	334
63.	Customer Complaints Clusterization of Government Drinking Water Company on Social Media Twitter Using Text Mining	338
64.	Improvement of Xception-ResNet50V2 Concatenation for COVID-19 Detection on Chest X-Ray Images	343
65.	Analysis of End-user Satisfaction of Zoom Application for Online Lectures	348
66.	Intelligent Decision Support Systems of Medicinal Forest Plants for Skin Disease	354
67.	Ontology-Based Sentiment Analysis on News Title	360
68.	Prediction the Condition of Tuberculosis Patients Who Can Recover Normally Using a Support Vector Machine with Radial and Polynomial Kernels	365
69.	Fuzzy Logic and IoT for Smart City Lighting Maintenance Management	369
70.	Decision Support System Two-Dimensional Cattle Weight Estimation using Fuzzy Rule Based System	374
71.	Performance Comparison of Naïve Bayes and Neural Network in Predicting Student Violation	379
72.	Detection Jellyfish Attacks Against Dymo Routing Protocol on Manet Using Delay Per-Hop Indicator (Delphi) Method	385
73.	Network Traffic WLAN Monitoring based SNMP using MRTG with Erlang Theory	391
74.	Strawberry Ripeness Identification Using Feature Extraction of RGB and K-Nearest Neighbour	395
75.	A backpropagation neural network algorithm in agricultural product prices prediction	399
76.	Recognition of Indonesian Sign Language Alphabets Using Fourier Descriptor Method	405
77.	Measurement of Iodine Levels in Salt Using Colour Sensor	410
78.	Tiny Encryption Algorithm on Discrete Cosine Transform Watermarking	415
79.	Lung X-Ray Image Enhancement to Identify Pneumonia with CNN	421
80.	Applying Hindsight Experience Replay to Procedural Level Generation	427
81.	The Edge Feature Subtraction for Completing Video Matting	433
82.	A fuzzy Mamdani Approach on Community Business Loan Feasibility Assessment	438
83.	Multi-Branch Company Enterprise Resource Planning Solution using Open ERP System in Indonesia	443

No	Title	Page
84.	SDN: A Different Approach for the Design and Implementation of Converged Networks	450
85.	Answer Ranking with Weighted Scores in Indonesian Hybrid Restricted Domain Question Answering System	456

Scheduling Control of Air-Conditioning System Based on Electricity Peak Price

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Abstract—Today, due to large population growth and rising income, the number of air conditioning units installed globally has increased to high levels. Meeting the increased demand for air conditioning has required billions of dollars of infrastructure investment and produced billions of tons of carbon dioxide emissions. The proposed study describes scheduling control of air conditioning systems based on peak electricity price. To achieve this goal, a demand response model was applied to set up scheduling according to the peak price through a load aggregator. The aggregator allows negotiation of the electricity price with market operators located within their corporate borders. The proposed method can concurrently accommodate on-site renewable energy sources. Finally, an analysis example simulates if the proposed scheduling is effective to avoid electricity peak price.

Keywords—*air conditioning, aggregator, peak price, scheduling*

I. INTRODUCTION

Increasing population contributes to increase demand for home air conditioning (AC) units to be installed. Energy demand for the AC will be one of top drivers of electricity demand and prices globally. The implication is not just for the electricity providers and consumers but also for the environment. The utility needs a billion dollars for infrastructure investment to meet the demands of the AC. In addition, the government need a new policy to solve the problem of carbon dioxide emissions produced by the AC. Therefore, growing of electricity demands of the AC is one of the most critical blind spots today and in the future.

According to [1] the AC contributes around 30% of peak demand during the summer season. In Singapore, the AC system contributes 24–60% of electricity demand in building [2]. The total electricity use for cooling of buildings accounts for around 20% worldwide [3]. Author in [4] investigates consumption of electricity for households average spend at 35–40%. In addition, urban electricity consumption during a summer day accounts for more than 40% in China [5]. Based on the data above, the cooling energy use in building is growing faster than other energy service. Some research have been conducted to solve electricity peak demand for the AC, For example: level data analysis [6], electricity peak cut method [7], centralized and decentralized strategies [8]. This example describes some solutions to meet peak demand due to the AC load. However, each study illustrates different

method with a different result, as illustrated in the following explanation.

Firstly, Ref [6] illustrates level data analysis to reduce demand of the AC during summer days. This research investigates some data by monitoring significant level consumption appliance in Sydney, Australia. The contribution of the AC was analysed during the peak summer demand. To achieve the goal, K-mean clustering method was applied to define the load of the AC for several households during peak periods. The load profile combined with some scenarios has been applied to estimate possible demand reduction for the AC. The result of this research found that around 9% of total peak demand can be minimized.

Secondly, the electricity peak cut method has been considered to reduce peak demand of the AC [7]. The proposed method simulates peak-cut operation in building during the summer season. In this paper, control of cooling power method is used to monitor the power consumption every thirty minutes. The cooling power controlled under demand response to define a target value of power considering the outside temperature. The results indicated the proposed scheme can reduce the electricity demand and maintain a comfortable room temperature for consumers.

Thirdly, Author in [8] illustrates centralized and decentralized strategies to reduce peak demand for the AC. This paper illustrates the potential control of the AC to reduce peak electricity demand in Austin, Texas, USA. In this study, an economic model predictive control was applied to simulate variation of wholesale electricity market prices for around 900 homes. To achieved this goal, centralized and decentralized strategies were applied to shift electricity consumption. As a result, both methods can reduce the peak by 8.8% and 3.1% for centralized and decentralized, respectively.

However, the proposed method was not similar to the previous method mentioned above. This method develops scheduling control of the AC based on the electricity price. To control the AC, a load aggregator is needed to schedule the AC to be switched on and off for an appropriate time. The aggregator load is only a consideration for the electricity peak price. The rest of this paper is organized as follows: section 2 is the literature review, section 3 is methodology, section 4 is analysis and results and section 5 concludes the conclusion.

II. LITERATURE REVIEW

Previously, some research has prompted discussion of the electricity peak price, demand response model and load aggregator.

A. Electricity peak price

In general, the electricity price is an accumulating cost spent by the utility to build, maintain and operate generation electricity and transmission/distribution. The electricity price varies based on the local or government policy. The electricity price can also differ depending on the customer-base, typically by residential, commercial and industrial connections. Therefore, the electricity price can vary by locality within a country.

In addition, electricity peak price occurs in the summer season when the total demand is highest due to increased cost for generation to meet peak demand. According to [9] electricity peak price is an abnormal price value which significantly impacts consumers. Author in [10] investigated that an abnormal price can rise to 100 or 1000 times higher than a normal price. The electricity price spike can occur with some factors, such as: transmission and generation contingency, peak demand, cost of power plant and environment factor e.g., temperature. Fig. 1 illustrated an example of the electricity peak price and peak demand that occurred in Queensland between 19 January to 20 January 2021.

B. Demand response model

Ref [11] DR is a program to reduce electricity consumption when the electricity price is expensive. The DR program serves consumers with a competitive market price, enhanced reliability of the system, and mitigates potential market power, etc. Accordingly, the benefits of the DR program can be categorized as: economic, pricing, risk management and reliability, impact to market efficiency, a lower cost electrical system and cost, customer service and the environment.

Previously, some studies have discussed the DR program to reduce electricity peak demand. For example: Ref [12] investigated the DR program for home energy management. The proposed model applied Reinforcement Learning (RL) and Fuzzy Reasoning (FR) to evaluate the energy management system for residential homes. In this study, there are 14 household appliances to control under this system. As a result, the proposed model can smoothly reduce power consumption. Other research has been developed by [13] to mitigate the supply-demand imbalance in the electricity market. In this paper, an incentive-based program is used to develop multiple energy carriers considering the behavioural coupling effect of consumers. This research also extends to evaluate the effect of energy storage units. As a result, the total cost can be cut down and can improve the utilization of energy storage units.

Author in [14]-[16] illustrates that the DR program is divided to two main programs: time based and incentive-based programs. These kinds of time-based programs are divided into four categories, namely: time of use (TOU), real-time pricing (RTP), critical peak pricing (CPP) and critical peak rebates. In addition, the specific model of incentive-based programs contains some categories, such as: direct load control, the emergency demand response model, capacity market program, interruptible/curtailable service, demand bidding and ancillary markets. Fig. 2 illustrated the categories of the DR program.

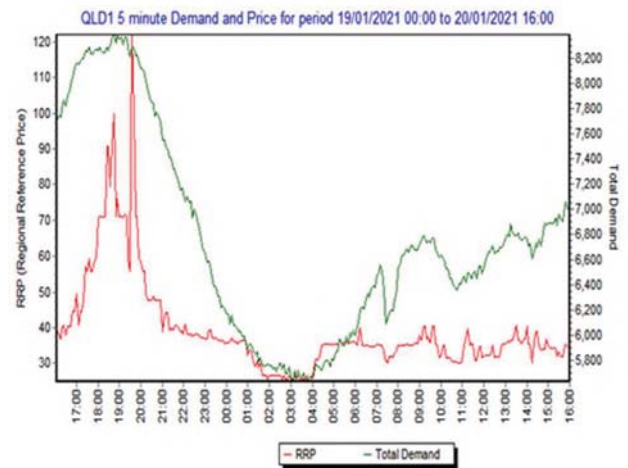


Fig. 1. An example of electricity peak price

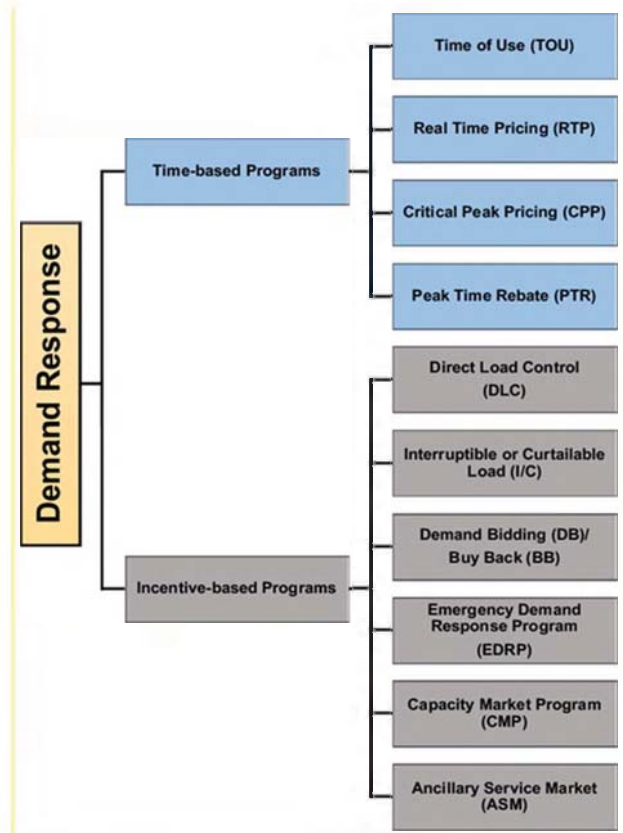


Fig. 2. Categories of DR program [14-16]

C. The load aggregator

According to [11] the load aggregator (LA) is an agent who manages the DR program. Ref [17], [18] LA is independent organisation which integrates the response between the consumer and the electricity market operator. The LA can be defined as a company which provides electricity service for consumers who want to purchase electricity by negotiation [17]. According to [19], [20] the LA task is to offer load reduction to consumers and compete with a set of generating companies in a market environment to maximize its profit. Fig. 3 illustrated the load aggregator.

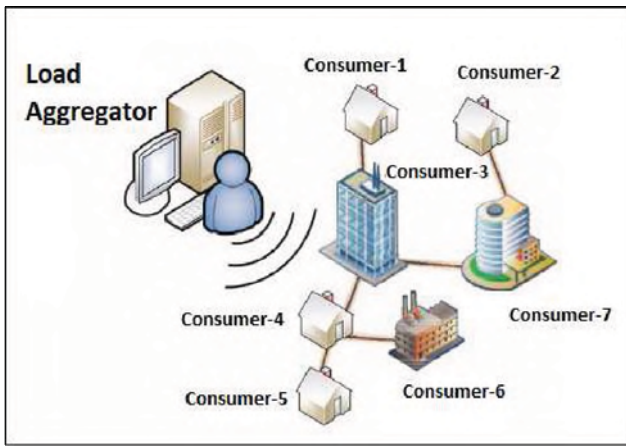


Fig. 3. Load aggregator [21]

III. PROPOSED MODEL

To achieve this goal, the following illustrates architecture design and load aggregator model.

A. Architecture design

Fig. 4 illustrated the architecture design of the proposed method. In the DR model, the control system was required to be switched on and switched off for the AC. The other function of the control system is to make connected information from the user and aggregator regarding the scheduling control of the AC and/or monitoring electricity price at any time. To implement the control system that a shell script under Linux operation system is used to execute with each interaction. The control design contains a programmable internet router, web-relay and software application and external switches. Every consumer applied a home computer to set up their preference of energy sources and scheduling for the AC. In this research, there are two kinds of energy source to support this model: generation from the power grid and on-site renewable energy. The primary energy is implemented when the electricity price is lower. In contrast, on-site renewable energy as a secondary power is connected to the AC when the electricity price is higher than normal. The control system arranges the time to connect to the primary grid and/or secondary power is based on the electricity price information from the aggregator. The pseudo code of the controller is illustrated in Fig. 5.

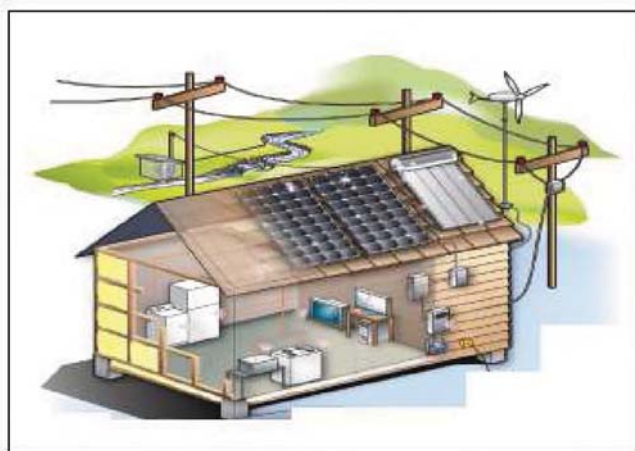


Fig. 4. Architecture design

```

echo $name
echo $startAfter
echo $finishBefore
if {$startAfter -lt $nowSec -b $finishBefore}; then
    air condition1)relay1=1
    air condition2)relay2=1
    air condition3)relay3=1
    air condition4)relay4=1
else
    air condition1)relay1=0
    air condition2)relay2=0
    air condition3)relay3=0
    air condition4)relay4=0
fi
done

```

Fig. 5. Pseudo code for control loop

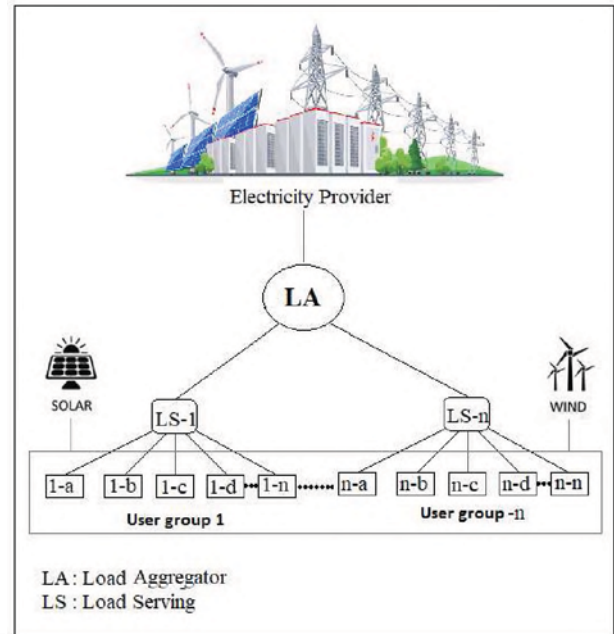


Fig. 6. The load aggregator model

B. The load aggregator model

The load aggregator model is presented in Fig. 6. The DR model proposed is divided to become multi-tiered where load aggregator is responsible for managing the overall network and particularly to schedule control of the AC. In the proposed method, the control system within a certain geographical area can be considered as the second tier of the overall network. The second-tier network will introduce more flexibility to network management. To simplify, peer to peer communication will be able to be applied for sharing information regarding the electricity consumption and network usage information. This kind of peer-to-peer communication is based on the consumer group, for example: geographical area, e.g., house in the same street or suburb, institutional consumer e.g., school or university, small-industrial consumer, farm consumer, etc. Therefore, the aggregator as a representative of consumer control station only concentrated to manage the local needs of the second-tier ad hoc networks, not to manage smart controlling of each individual house. In addition, on-site renewable energy is just controlled by the individual consumer. If the consumer participates in the DR program, the consumer consumption $d(t)$ for a maximized benefit can be calculated according to [15], [22]:

$$d(t) = do(t) \left\{ 1 + \beta(t, t) \frac{[r(t) - ro(t)]}{ro(t)} \right\} \quad (1)$$

Where:

$do(t)$: Nominal demand level (kWh)

$\beta(t)$: Elasticity parameter

$r(t)$: The rate of customer pays for electricity at the time t (kWh)

$ro(t)$: Nominal rate for electricity consumption (\$/kWh)

IV. ANALYSIS AND RESULT

In this paper, we analyzed the change of the electricity price based on the time of operation of air conditioners. There are three analyses of different scenarios applied on this proposed model. The first is keeping a comfortable living space. To analyze the effect of the proposed scheme on electricity energy savings the electricity price in Queensland has been used. Fig. 7, 8 and 9. illustrated an example of the impact scheduling control of the AC under DR model. In this case there are three scenarios have been conducted to avoid electricity peak price, namely:

A. Scenario A

Based on the information from the aggregator, residential consumers set-up the air conditioner based on the periodic times, e.g., switch on for 3 hours and then switch off for the next 3 hours. If the consumer was required to turn on the AC, the recommended times to switch on are 03:00 to 06:00, 09:00 to 12:00, 15:00 to 18:00 and 21:00 to 23:00. These schedules were set-up by the load aggregator for all consumers who wanted to participate in the DR program. Fig. 7 illustrates the operation system of this scenario.

B. Scenario B

Like the previous method, the load aggregator provides another option to set-up scheduling for the AC. In this scenario, the load aggregator sets-up the time to be three times periodically to turn on the AC, namely: 03:00 to 07:00, 11:00 to 16:30 and 21:00 to 24:00. Therefore, as a member of the DR program that all consumers should follow the scheduling to avoid the peak electricity price. As a result, the consumer will be rewarded by the load aggregator. Fig. 8 illustrates the operation of this scenario.

C. Scenario C

Another time option is provided by the load aggregator for all consumers. For example: 01:30 to 08:30 and 10:30 to 16:30. In this scenario only two times are provided periodically to turn on the AC. However, every period takes a longer time than the other scenarios. This option is recommended to all consumers who want to participate in DR program. Consequently, the consumer can avoid peak electricity price and get a reward from the load aggregator. Otherwise, a penalty will be applied. Fig. 9 illustrates the operation of this scenario.

D. Integrated onsite renewable energy

As a second power, on-site renewable energy will be connected to charge the AC if consumers need to turn on during a Switch OFF period. On site renewable energy is used to ensure that the AC can function for only several times. As a backup power for each individual home that the control system can arrange the schedule automatically. The appropriate time will be arranged based on commands from the control system. However, as a member of the DR program, that consumer should be participated to switch the AC ON/OFF based on the schedule from the load aggregator.



Fig. 7. Operation scenario A



Fig. 8. Operation scenario B



Fig. 9. Operation scenario C

As a member of the DR program, consumers will get a reward if they participate on the schedule program. In contrast, the penalty will accumulate when the consumers turn on the AC during the switched off period. To optimize the scheduling, the load aggregator arranges the schedule considering some parameters, such as: outside temperature, electricity peak price and peak season.

CONCLUSION

Based on the results, this research illustrated that the impact scheduling control of the AC under the DR model. In this research, there are three scenarios that have been created and scheduled under the load aggregator. Scenario A is designed to allow consumers to switch on and switch off the AC for 3

hours, namely: 03:00 to 06:00, 09:00 to 12:00, 15:00 to 18:00 and 21:00 to 23:00. Scenario B illustrated the consumer is required to participate in the DR program three times a day, namely: 03:00 to 07:00, 11:00 to 16:30 and 21:00 to 24:00. Scenario C gives another option to switch on the AC only twice periodically, namely: 01:30 to 08:30 and 10:30 to 16:30. To anticipate if consumers want to apply the AC during off periods, then the on-site renewable energy can be connected to charging as back-up power even for only a few times. As a result, the proposed method is an effective way to avoid the peak electricity price.

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