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The Potential of Demand Response Measures of Commercial Buildings in Thailand

Witchuda Pasom[a], Apichit Therdyothin[a*], Adisak Nathakaranakule[a], Cherdchai Prapanavarat[b], Bundit Limmeechokchai[c]

[a]*School of Energy, Environment and Materials, King Mongkut's University of Technology Thonburi, Thailand*
[b]*Department of Electrical Engineering, King Mongkut's University of Technology Thonburi, Thailand*
[c]*Department of Mechanical Engineering and Manufacturing Systems, Sirindhorn International Institute of Technology, Thailand*

Abstract

The aim of this research is to estimate the potential of demand response measures applying to commercial building in Thailand based on the actual test result from 3 existing buildings in Bangkok. The potential measures can be divided into 2 main categories namely self-generation using existing standby generators and reducing their actual demand using various techniques. The initial estimation point out that the maximum of 2.1 MW can be reduced from these 3 tested building. However, the actual experiment shows that only 1.76 MW can be achieved. The difference of the peak reduction mainly comes from not only the in-accurate estimation of the standby generator ability in both capability and durability but also the effect on the comfort condition in the building. Therefore, the appropriate estimated level of demand reduction from the building should approximately 83% of technical potential. The final recommendation from the building owner is the building should adopt DR scheme and able to reduced their demand to some extent. However, it depends on the level of benefit offered to the building.

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Keywords: Peak demand reduction, Demand side management, Demand response

1. Introduction

The energy security of the electricity system is crucial to the development of the national economy for the developing country including Thailand. Especially during the summer when the peak of the system is

* Corresponding author. Tel.:+66 085444777
E-mail address: apichit.the@gmail.com

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high and the generating capacity of the country are hardly cope with. Building the new power plant is seemed to unacceptable not only investment cost but also the environment point of view. Therefore, enhancing the behaviors of electricity user like demand response is considered. Many countries found that these measures are acceptable by their customer. Generally this type of measures have lower cost than building new peak power plant [1-2].

2. Methodology

In this study, many demand response measures have been actually tested and verified in 3 existing building. The buildings comprise of hospital building and 2 shopping malls. The baseline of electricity using pattern of all major equipment in the building has been collected. These data have been used to estimate the potential of peak demand reduction during the tested period [3-5]. The electricity consumption data can be used to evaluate the baseline of the building and some specific system to get the actual peak reduction during tested period (1 pm - 4 pm).

The testing process can be device into 2 main parts. The first part is monitoring the overall electricity use pattern that will be used to formulate the base line for the test day [6]. The second part is the result of the test day that will be used to compare with the formulated based line to identify the peak reduction.

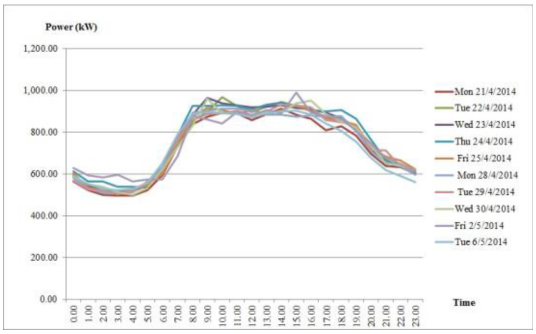
During the tested period the condition in the building and the response of the customer has been monitor. The test will be stopped if they consider condition go beyond the pre specified maximum value.

3. Results

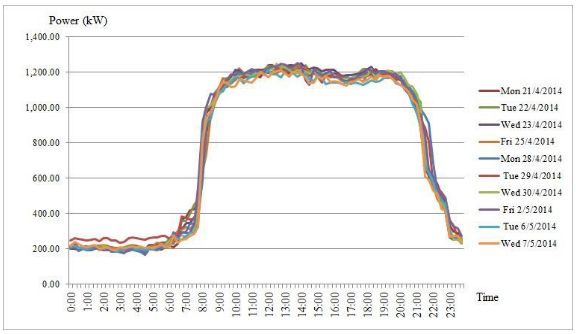
To formulate the base line for each individual building, we need to monitor the electricity consumption pattern of the building for 10 days prior the test day. In the test day, the overall electricity consumption of the building will be measured together with the various high consume equipment and system. During the test hour, 1 pm to 4 pm of the test date, the actual electricity consumption of the building will be compared with the formulated base line to evaluate the real value of the peak reduction. The finding can be summarized as follows.

3.1 Electricity consumption pattern of the building for 10 days prior to the test day

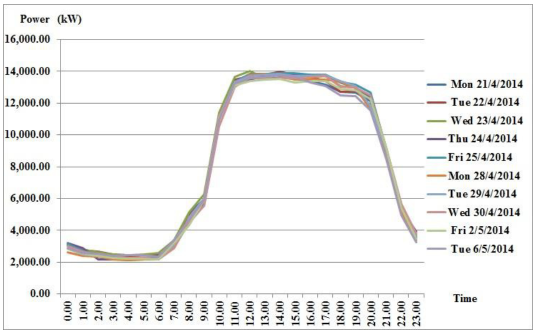
The electricity consumption pattern of each building for 10 days prior to the test day has been recorded and show in figure 1 (a), (b), (c).



(a)



(b)



(c)

Fig. 1. The 24 hours consumption pattern of each building. (a) Hospital (b) Shopping mall 1 (c) Shopping mall 2

From figure 1 (a) show the electricity consumption pattern of the tested hospital. The peak demand of their hospital was 956 kW. While the demand during night time was nearby 600 kW, due to the high number of the impotent. The demand service from 7 am due to the preparation of staff for the incoming out-patient. The demand was quality stable during the day and start decreasing after 7 pm. While all activity for out-patient ended. The average power and energy consumption of main build system could be summarized as in table 1.

Table 1. Ratio of power consumption in hospital building.

System		Power (kW)	% Power	Energy (kWh/y)	% Energy
1	Chillier	373	40.2	2,759,400	40.3
2	Pump water cooling system, cooling tower.	110	11.8	964,914	14.1
3	Lighting	90	9.7	665,409	9.7
4	Other	353	38.2	2,446,936	35
Total		**927**	**100**	**6,836,660**	**100**

The air-conditions system consumed more than half of all the building consumption while the various equipment consumes 35% of energy and lighting was 9.5%

From figure 1 (b) and (c) show the characteristics of two shopping mall that very difference in size. However the electricity consumption ours quite the same. The demand starts increasing from 7am while some shopping mall staff coming in and start preparing for their customers. The demand peak a high level at the opening hour of the mall and more or less the same until the closing time. During the night time, the demand was very low to approximate 20% of daytime, mostly from the secrete lighting and some refrigerators in the mall. The ration of power and electrical energy in each main system has seemed show in table 2 and 3 for small and large shopping mall respectively.

Table 2. Ratio of power consumption in shopping mall 1.

System	Power (kW)	% Power	Energy (kWh/y)	% Energy
1. Chiller	313	25.2	1,172,325	15.9
2. Pump water cooling system and cooling tower	82.7	6.7	394,695	5.4
3. Lighting	248.3	19.9	1,450,155	19.7
4. Cold storage	58.2	4.7	367,008	5.0
5. Pumps	10.6	0.8	59,843	0.8
6. AHU,FCU, Escalators and other	529	42.6	3,905,973	53.1
Total	**1,242.69**	**100**	**7,350,000**	**100**

The highest peak in the cooling system of the building, including air conditioning and lighting systems. In Cold AHU FCU, Pumps and Escalators are used less power.

From figure 1 (c) the building has a maximum power of 10,852 kW on all electricity consumption behaviours over the last 7 days showed that the use of electricity during the hours of 9am -10pm. The use of high power all the time, because the mall is open. During at 10pm electricity consumption decreased due to power will only prepare areas for activities in the plaza only. The use of electricity for 7 days with the same format as in figure 1 (c). Note that the use of electricity on Saturday and Sunday will be lower than on weekdays. Because the building was closed due to the air to one set down.
From measurements of the main equipment to evaluate its power consumption and power demand of each system in Table 4.

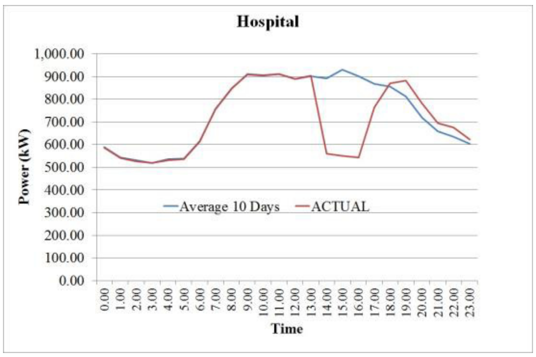
Table 3. Ratio of power consumption in Shopping mall 2

System	Power (kW)	%Power	Energy (kWh/y)	% Energy
1. Chillier	3,376	31.1	18,377,795	25.6
2. Conditioning System (Pump + Cooling Tower)	1,199	11.1	8,345,712	11.6
3. Public and office lighting	549	5.1	13,086,759	18.3
4. Elevators, escalators, AHU, general store and other	5,727	52.7	31,858,734	44.5
Total	**10,852**	**100**	**71,669,000**	**100**

The building is located at the peak of the cooling system, including the air conditioning system. And the use of electricity in most of the shops, lighting, elevators and escalators, respectively

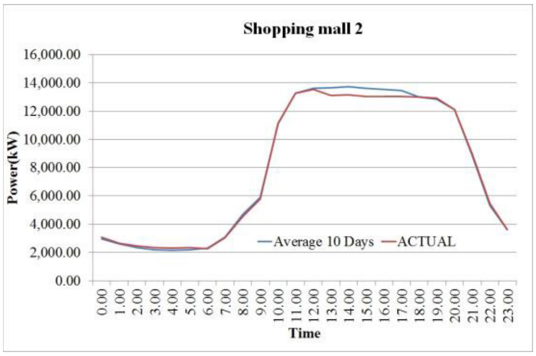
3.2 Electricity consumption pattern of the building in the test day

The 10 day electricity consumption pattern of the building has been used to predict the typical demand pattern of the test day. However, their typical pattern will be slightly adjusted by the level electricity demand before test time of test day. Their adjusted pattern will be used as a baseline to calculate the peak reduction of that building.
During the test time, several measures have been implemented simultaneously. The actual demand was measured in paste with all main equipment in the building. The actual demand was commercial with the predicted base time in fig 2 (a), (b) and (c) for hospital, small shopping mall and large shopping mall respectively.



(a)

(b)



(c)

Fig. 2. The power reduction from DR tested. (a) Hospital (b) Shopping mall 1 (c) Shopping mall 2

Hospital

Figure 2 (a) show the actual demand of the Hospital significantly reduce from the baseline while was mainly come from the seeming of standby generator to cut down the peak of the hospital. Moreover, the temperature in the building was a litter bit increase to reduce the demand of the air conditioning system. The result show that their hospital can reduce up 36.5% of peak consumption. However, the rough calculation show that the cost of running the standby generator was 7.8 Bath/kWh (base on diesel price at 29.99 Bath/lite) which quite high compare to average electricity price a 3.9 Bath/kWh.

Shopping mall 1

The measures applied to the shopping mall 1 including running the standby generator for 3 hours, limited the door opening of the freezer, set demand limit of the chiller to 80% of maximum demand. These can reduce 318 kW of peak demand or equal to 26.7% of actual demand. The profile of electricity used during the test hours is shown in fig 2 (b). The cost of running a standby generator of this building is about 10.0 Baht/kWh.

Shopping mall 2

The measures that applicable for the shopping mall 2 is running of standby generator shut down one chillier and a storage water pump. The peak of the building can be reduced by 1.09 MW or equivalent to 26.7% of the actual peak demand. The cost of electricity generated is 9.17 Baht per kWh.

The actual of performance of the building, to reduce the peak demand can be summarized as in Tab 4.

Table 4. Peak power reduced during the experimental period.

Measures	DR (kW)		% Actually	Remark
	Target	Actual		
1. Backup generator during system peak.	1,524.25	1,122.57	73.65	
• Hospital	568	331.43	58.35	
• Shopping mall	956.25	791.14	82.73	
2. Peak reduction	605.37	636.52	105.15	
• Limit to the door opening of the freezer and slid down the compressor	58.16	3.6	6.19	Has enabled a freezer
• Using demand limit of chiller	34.66	36.6	105.60	
•Shutdown 1 chiller	475.25	507.97	106.88	Turn off the water pump system for chillier.
•Shutdown 1 pump	-	64.85		A measure that would do more
Rising the temperature in the building	37.3	23.5	63.00	
Total	**2,129.62**	**1,759.09**	**82.60**	

The actual running of standby generator to cut down the demand of the building show a high potential of peak canting. However, the actual reduction due to these standby generator still lower than our estimation. Same problem found were lack of experience in seeming standby set cannot maintain the temperature of the system when running at a high capacity for a long period, other several measures has been tested. The result show that the overall demand reduction was 636 kW, while was higher than estimated value at 605 kW due to adjusting of the limit of chiller that can go beyond our expectation at 5%.

The total peak reduction in these 3 buildings is 1,759 kW, that 64% is the result of running the standby generator while others 36% from various peak reduction measures.

Many problems are faced during the testing hour for example, the temperature inside the standby generator room and of the generator itself rising up to the level that considered too dangerous to continue the test. This cause the shopping mall to stop its generator before the test is finished. There are reports of problems about the maximum generating capacity of the generator which found that even the newest one can't run at its rated capacity for 3 hours. Moreover, the running of this exercise shows that the utility in the building is not well maintained and prepare enough for this activity.

4. Discussion

Demand response in Thai building seems to have high potential but main reduction is from running a standby generator which has high running cost. Therefore, the cost of applying a demand response program in Thailand may face high running cost. In the individual point of view of the building owner, implementing this demand respond may cause some effect on their customer. Therefore, the incentive that they should get must be high enough. Of the measures taken to see the obstacles and problems as follows.

1. Generator to load some effect of increasing the temperature of the engine so it will not be complete after 3 hours.
2. The generator load in some buildings and voltage sags, resulting in some devices such as escalator stopped.
3. Close Cellar measures cannot be closed for 3 hours because the trade is not sufficient to assess the needs of the customers needs to open a frozen-in-progress.
4. Adjust the demand limit of cold water affects the change in temperature changes. It is not appropriate to use an area with a lot of service users.

Acknowledgment

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Reference

[1] Parsa,M.,Moghaddam, abdollahi, A. Rashidinejad, M. 2011. Flexible demand response programs modelling in competitive electricity markets. Applied Energy 88: 3257-3269

[2] Faria, P. and Vale, Z. 2011. Demand response in electrical energy supply: An optimal real time pricing approach. Energy 36: 5374-5384

[3] Witchuda Pasom et al., 2014. "Potential of demand response in Thailand" 5th International Conference on Sustainable Energy and Environment. (SEE 2014): 2-5

[4] Jacopo Torriti, Mohamed G. Hassan, Matthew Leach, 2010. Demand response experience in Europe: Policies, programmes and implementation. Energy 35 (2010):1575–1583

[5] Peter Cappers, Charles Goldman, David Kathan.2010. Demand response in U.S. electricity markets: Empirical evidence. Energy 35 (2010) 1526–1535

[6] Clifford Grimm DTE Energy. 2008 Evaluating baseline for demand response programs, 2008 AEIC Load Research Workshop San Antonio, Taxas February 25-27 2008