INSIGHT OF POLICY SUPPORT FOR ENERGY EFFICIENCY INVESTMENT: CASE STUDY OF HOTEL SECTOR IN THAILAND

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
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Field of Study	Environment, Development and Sustainability
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การศึกษานี้วิเคราะห์เส้นโค้งต้นทุนของมาตรการอนุรักษ์พลังงานเพื่อหาระดับต้นทุนของมาตรการอนุรักษ์พลังงาน และพิจารณาโอกาสในการเปลี่ยนแปลงนโยบายเพื่อเพิ่มการลงทุนมาตรการอนุรักษ์พลังงานสำหรับภาคโรงแรมของประเทศไทย โดยการศึกษานี้ได้ดำเนินการเป็นสองส่วน

ส่วนที่หนึ่ง มาตรการอนุรักษ์พลังงาน ต้นทุนการลงทุนและปริมาณพลังงานที่ประหยัดได้ของแต่ละมาตรการอนุรักษ์พลังงาน และข้อมูลที่เกี่ยวข้อง ข้อมูลเหล่านี้ได้นำมาจากโครงการของกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงานจำนวน 3 โครงการ ได้แก่ (1) โครงการเงินหมุนเวียนเพื่อการอนุรักษ์พลังงานโดยสถาบันการเงิน (2) โครงการส่งเสริมการลงทุนด้านอนุรักษ์พลังงานและพลังงานทดแทนด้วยเงินทุนหมุนเวียน (3) โครงการส่งเสริมการอนุรักษ์พลังงานในรูปแบบมาตรการอุดหนุนผลการประหยัดพลังงาน ผลวิจัยของเส้นโค้งต้นทุนของมาตรการอนุรักษ์พลังงานบ่งชี้ว่า มาตรการอนุรักษ์พลังงานจำนวน 12 มาตรการมีความคุ้มค่า โดยมีต้นทุนเฉลี่ยตลอดอายุตั้งแต่ 1.07 ถึง 3.50 2018 บาท/หน่วย และมีจำนวน 3 มาตรการที่ยังไม่คุ้มค่า โดยมีต้นทุนเฉลี่ยตลอดอายุตั้งแต่ 4.46 ถึง 5.47 2018 บาท/หน่วย ทั้งนี้พบว่าต้นทุนเฉลี่ยของโรงแรมขนาดกลางและขนาดย่อมนั้นสูงกว่าโรงแรมขนาดใหญ่ ซึ่งมีต้นทุนเฉลี่ยตลอดอายุอยู่ที่ 2.68 และ 2.44 2018 บาท/หน่วย ตามลำดับ เมื่อพิจารณาผลการวิเคราะห์ความอ่อนไหวพบว่า กรณีมุมมองรัฐบาลในระดับปานกลาง (อายุการใช้งาน 10 ปีและอัตราคิดลดจริง 7%) ส่งผลให้ต้นทุนเฉลี่ยลดลง 26% และกรณีมุมมองรัฐบาลที่อนุรักษ์นิยมสูง (อายุการใช้งาน 20 ปีและอัตราคิดลดจริง 7%) ต้นทุนลดลงเกือบครึ่งหนึ่ง (46%) เมื่อเปรียบเทียบกรณีฐานในมุมมองเอกชน (อายุการใช้งาน 10 ปีและอัตราคิดลดจริง 15%)

ส่วนที่สอง การศึกษาได้พัฒนาข้อเสนอแนะเชิงนโยบายซึ่งได้มาจากการวิเคราะห์ผลของเส้นโค้งต้นทุนของมาตรการอนุรักษ์พลังงาน และการวิเคราะห์ ความท้าทายและโอกาสของโครงการกรณีศึกษาข้างต้น มีข้อเสนอแนะ ดังนี้ มาตรการที่ยังไม่คุ้มค่าจำนวน 3 มาตรการ ได้แก่ ปั๊มความร้อนเพื่อทดแทนอุปกรณ์ทำน้ำร้อนไฟฟ้า อุปกรณ์ควบคุมความเร็วรอบมอเตอร์ ที่ใช้งานในห้องครัว และเครื่องปรับอากาศประสิทธิภาพสูง (แบบแยกส่วน) ยังคงต้องการโครงการสนับสนุนเพื่อเพิ่มความเชื่อมั่นทางเทคนิคและเพื่อลดต้นทุนจากการใช้งานมากขึ้นในตลาด มูลค่าเงินลงทุนมาตรการอนุรักษ์พลังงานจากมุมมองของภาคเอกชนยังคงสูงอยู่ นโยบายสนับสนุนทางการเงินควรได้รับการออกแบบให้เหมาะกับกลุ่มเป้าหมายทางการตลาดทั้งในด้านความสามารถในการจัดหาเงินทุนของบริษัทและระดับความพร้อมของเทคโนโลยีเพื่อเพิ่มความสำเร็จในการส่งเสริมการอนุรักษ์พลังงาน

สาขาวิชา สิ่งแวดล้อม การศึกษา และความยั่งยืน	ลายมือชื่อนิสิต..
ปีการศึกษา 2563	ลายมือชื่อ อ.ที่ปรึกษาหลัก.................................

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KEYWORDS: COST CURVE/ LEVELIZED COST/ POLICY SUPPORT/ ENERGY EFFICIENCY INVESTMENT/ HOTEL SECTOR/ THAILAND

ATHITA VIVATPINYO: INSIGHT OF POLICY SUPPORT FOR ENERGY EFFICIENCY INVESTMENT: CASE STUDY OF HOTEL SECTOR IN THAILAND. ADVISOR: ASSOC. PROF. CHANATHIP PHARINO, Ph.D., 72 pp.

This study used the cost curve of energy efficiency measures to find the level of the cost of energy efficiency measures comparing with the energy price and the opportunities for policy change for enhancing energy efficiency implementation for the Thai hotel sector. The study was conducted in two parts.

First, energy efficiency measures, investment costs, energy savings and related information were derived from three Department of Alternative Energy Development and Efficiency's projects, which are (1) Energy Efficiency Revolving Fund, (2) Energy Service Company Revolving Fund, (3) DEDE Demand Side Management Bidding. The cost curve of energy efficiency measures indicates that 12 energy efficiency measures are cost-effective, with the cost range of 1.07 to 3.50 THB/kWh, and 3 measures are not cost-effective, with the cost range of 4.46 to 5.47 THB/kWh. The average cost of the SME hotel sector is higher than the large hotel sector, which is 2.68 and 2.44 THB/kWh respectively. The moderate government aspect scenario (10 years lifetime and 7% real discount rate) results in a 26% decrease in average costs and the high conservative government aspect scenario (20 years lifetime and 7% real discount rate) decreases by almost half the cost (46%) comparing the private sector aspect base case (10 years lifetime and 15% real discount rate).

Second, policy suggestions were drawn from the result of the cost curve of energy efficiency measures and the discussion around the current situation, the challenge and opportunity of three programs and concluded from the suggestions from the interviewees. Three cost-inefficiency measures, including heat pump that substitute existing electric hot water equipment, variable speed drive in kitchen application and high-efficiency air conditioning (split type), still need the supporting program to enhance their technical confidential and to decrease their cost. The sensitivity analysis shows that the energy efficiency investment costs when seeing from the private point of view are still high. Many interviewees from various sectors suggest that the financial policy support should be designed tailor to market segments in both financing capacity and maturity of technology dimensions to enhance successful energy efficiency supporting program implementation.

Field of Study: Environment Development and Sustainability | Student's Signature......................
Academic Year: 2020 | Advisor's Signature.....................

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INTRODUCTION

1.1. Background and Rationale

Hotel is the top-three sub-sectors of energy-intensive and carbon-intensive in Thailand building sector, which the largest contribution is from office building, department store and hotel, respectively. The energy consumption of hotels in Thailand is approximately 16% of total energy consumption in the building sector (ICF International, 2013). The hotel has consumed both electricity and fossil fuel, such as LPG, diesel and fuel oil that raises the carbon intensity of 0.24 tCO_2/sq-m, which is higher than the average in building sector of 0.19 tCO_2/sq-m (ICF International, 2013). Li, Kritsanawonghong, and Gao (2014) shown the energy intensity of 148 designated hotels in Thailand that is 518 kWh/sq-m. Then, there is the high energy efficiency improvement potential of 36 – 53% of present energy consumption when comparing with energy benchmarks of a hotel in Singapore, which is 244 – 329 kWh/sq-m (Building and Construction Authority, 2017). In addition, the tourism sector contributes to over 17% of Thailand's national GDP (Krungsri Research, 2017). Reducing energy consumption in the hotel sector is not only reducing energy demand and carbon emission but also enhancing economic development for the country through the tourism sector. Realization of energy efficiency implementation by the hotel sector will benefit both the hotel owner and the country.

Many studies provide information about the energy consumption behavior, energy consumption intensity, and potential of energy saving for the hotel sector. However, the information of the cost curves of energy efficiency measures has not been reported elsewhere and the policy gap and opportunity analysis on hotel energy efficiency policy is still limited. The cost curves of energy efficiency measures can be used as background information for the hotel owner to decide which measures are economically feasible to implement. Energy efficiency measures that have lower cost curves than energy price should be selected to implement by the hotel owner. In addition, this study applies policy gap analysis to energy efficiency policies focusing on the challenges posed by existing policies and the opportunities for policy change to more effectively promote energy efficiency in the hotel sector.

1.2. Research Questions

1.2.1. What is the level of the cost of energy efficiency measures of the hotel sector compared with the present energy price?

1.2.2. What are the policy gaps and opportunities for policy change for enhancing energy efficiency implementation in the hotel sector?

1.3. Research Objectives

1.3.1. To investigate cost curves of energy efficiency measures for a hotel in Thailand

1.3.2. To examine and develop a policy recommendation for promoting energy efficiency investment of the hotel sector in Thailand

1.4. Expected Results

1.4.1. Cost curves of energy efficiency measures for a hotel in Thailand that the hotel owner has information for easier deciding to implement the measures which have cost lower than the energy price.

1.4.2. Policy recommendation for a policymaker to increase energy efficiency implementation.

1.5. Scope of the Study

1.5.1. This study studies the cost curves of energy efficiency measures for the hotel sector in Thailand

1.5.2. Data for cost curve calculation is derived from THREE public support programs including (1) Energy Service Company Revolving Fund, (2) Energy Efficiency Revolving Fund, (3) DEDE Demand Side Management Bidding

CHAPTER II
LITERATURE REVIEW

2.1. Energy Efficiency Definition

Energy efficiency means using the energy required lessor for the same level of energy services (ADB, 2015; EIA, 2017). Energy efficiency measures are often a cost-effective alternative to increasing energy security and climate change mitigation with the same level of economic development requirements. A distinction can be described between energy efficiency and energy conservation. Energy efficiency measures, such as replacing higher energy efficiency industrial production equipment and machinery, reduce energy input while maintaining the same level of output (ADB, 2015). Energy efficiency can be distinctive described that is using less energy required technology to perform the same service. Using a LED light bulb that requires less energy instead of using a compact fluorescent bulb to produce the same amount of light is an example of energy efficiency (EIA, 2017). Energy conservation invokes a behavioral change that results in the use of less energy, on the other hand, help reduce the amount of energy used. Turning the lights off when not in use and recycling plastic bottles are both ways of conserving energy. This study considers energy efficiency and energy conservation measures similarity, both result in energy savings (ADB, 2015).

2.2. Energy Consumption and Carbon Emission of the Hotel Sector

Hotel is the top-three sub-sectors of energy-intensive and carbon-intensive in Thailand building sector, which the largest contribution is from office building, department store and hotel, respectively (ICF International, 2013). From ICF International (2013) study, the hotel sector's energy intensity was 787.45 MJ/sq-m and carbon intensity was 0.24 tCO_2/sq-m as shown in Figure 2-1.

Building type	Number of Buildings for which data is available	Total energy consumption		Energy Intensity	Carbon intensity
		Tera Joules	toe	MJ/sq-m	tCO2/sq-m
Hotel	77	3,942.30	93,322	787.45	0.24
Hospital	81	3,447.98	81,621	515.87	0.11
Department store	180	9,543.34	2,25,910	826.74	0.14
Education	106	3,364.44	79,643	180.47	0.03
Office	264	9,514.66	2,25,231	1,958.76	0.33
Others	29	838.57	19,851	548.25	0.1

Figure 2-1 Energy intensity and carbon intensity of commercial building in Thailand (ICF International, 2013)

Hotel in Thailand comprises both designated and SME sectors, which they have different energy consumption characteristics. Hotel is the sector that has consumed both electricity and fossil fuel, such as LPG, diesel and fuel oil, which electricity is the main energy source in this sector. Tangon, Chontanawat, and Chiarakorn (2018) has shown that the designated hotel mainly consumed electricity, which was 69 - 94% of total energy consumption. For SME hotel, Wongsapai, Fongsamootr, and Chaichana (2017) has shown that electricity was 86 - 99% of total energy consumption.

There is a high technical energy efficiency improvement potential for the hotel sector in Thailand. Li et al. (2014) has shown the energy intensity of 148 designated hotels in Thailand, which consumed both electricity and fossil fuel, that is 518 kWh/sq-m. In Singapore, the energy benchmark of the hotel sector is 244 – 329 kWh/sq-m (Building and Construction Authority, 2017). By comparing the Singapore benchmark and the Thailand hotel energy consumption, it has been found that the energy efficiency improvement potential is 36 – 53%.

In addition, the hotel sector has had high carbon intensity of 0.24 tCO_2/sq-m which was higher than the average in the building sector of 0.19 tCO_2/sq-m. The high carbon intensity because the hotel sector consumes both electricity and fossil fuel, which fossil fuel causes higher emissions.

2.3. Thailand Energy Efficiency Barriers

Energy efficiency barriers are defined as obstacles that hinder the investments of energy efficiency technologies (Yang & Yu, 2015). Many studies have studied and concluded the various barriers to energy efficiency deployment in Thailand. The barriers can be classified into five broad categories (Wang, Stern, Limaye, Mostert, & Zhang, 2013). These barriers are various from such as imperfect information, rigid bureaucratic processes, subsidized energy prices, consumer preferences for non-energy efficiency attributes, low management priority on energy efficiency, lack of awareness, limited M&V capacity, limited energy efficiency expertise, the uncertainty of new technologies, lack of internal energy efficiency policies, and lack of access to financing.

Table 2-1 Thailand energy efficiency barriers

Category	Typical barriers
Policy and regulatory barriers	• Lack of successful cases that can provide information about energy-efficient technologies, energy management system, and cleaner production (Deshpande, 2015; Hasanbeigi, Menke, & du Pont, 2010) • Lack of information about government regulation and incentives (Hasanbeigi, Menke, & du Pont, 2010) • Lack of realistic energy price trend (Hasanbeigi, Menke, & du Pont, 2010) • Difficulties in the procedure of public-support implementation and long-time bureaucratic process (Hasanbeigi, Menke, & du Pont, 2010) • High subsidy in the energy sector (Deshpande, 2015)

Category	Typical barriers
End-user barriers	• Focusing mainly on maximizing production rather than efficient production (Chemhengcharoen, Bonnet, & Puhl, 2014; Hasanbeigi, Menke, & du Pont, 2010) • Lack of energy efficiency mindset of business owners (Deshpande, 2015) • Lack of awareness programs to the private sector (Deshpande, 2015) • Lack of internal technical knowledge of energy efficiency (Chemhengcharoen et al., 2014)
Barriers related to equipment and service providers	• Lack of energy monitoring systems (Chemhengcharoen et al., 2014) • Lack of external information and expertise on energy efficiency (Chemhengcharoen et al., 2014; Deshpande, 2015) • Uncertainty about new technologies (Hasanbeigi, Menke, & du Pont, 2010)
Institutional barriers	• Limit bottom-up communication of energy efficiency improvement to the managing level (Chemhengcharoen et al., 2014) • Lack of responsible person to take care of central energy consumption information (Chemhengcharoen et al., 2014) • Lack of proper monitoring and verification (M&V) framework (Deshpande, 2015)
Financing barriers	• Lack of financial internal resources for investment (Chemhengcharoen et al., 2014). • Lack of financial incentives (Hasanbeigi, Menke, & du Pont, 2010)

Source: Chemhengcharoen et al. (2014); Deshpande (2015); Hasanbeigi, Menke, and du Pont (2010)

2.4. Existing Study of Energy Efficiency in the Hotel Sector in Thailand

Peer review studies have provided information mainly on present energy consumption, energy intensity, potential energy saving, and energy consumption characteristic of the Thailand hotel sector. The summary of the existing study shows in Table 2-2. Energy intensity leads to understanding the status quo for the hotel sector. Potential energy saving can be derived from comparing to the benchmark or summing-up savings from each energy efficiency measure. Energy consumption characteristics can be used to identify potential energy efficiency measures.

Chirarattananon and Taweekun (2003); Pantong, Chirarattananon, and Chaiwiwatworakul (2011) have used program simulation to calculate and to show energy consumption, energy intensity and potential energy saving for the designated hotel by 4 energy efficiency measures with many scenarios, which concerned only electricity saving. These studies have shown the possibility of energy efficiency improvement in the hotel sector.

ICF International (2013); Li et al. (2014); Tangon et al. (2018) have studied by using bottom-up energy audit data to show present energy consumption, energy intensity for the designated hotel. These studies have provided policymaker for a situation of energy consumption in the hotel sector which can be developed as the energy consumption benchmark for the hotel sector.

Table 2-2 Summary of an existing study of energy efficiency in the hotel sector

Literature	Description	Energy consumption behavior	Energy consumption intensity	Potential of energy saving
Chirarattananon and Taweekun (2003)	• Designated • Simulation • Electricity	• Building envelope, Air conditioning system, Lighting system, Operational schedule	171 kWh/m^2-year	• peak power demand 22.74% • load sensed by cooling coil 16.80% • electric energy consumption 22.58%
Pantong et al. (2011)	• Designated • Simulation • Electricity	• Building envelope, Air conditioning system, Lighting system, Operational schedule	271.2 kWh/m^2-year	• COD 199.0 kWh/m2-year • HEPS 159.9 kWh/m2-year • ECON 116.4 kWh/m2-year • NZEB 96.8 kWh/m2-year
ICF International (2013)	• Designated (77)	-	787.45 MJ/m^2-year	-
Li et al. (2014)	• Designated (148) • Electricity and heat	• Electricity and heat consumption • Building characteristic (HVAC area, scale, operating time)	1,863 MJ/m^2-year or 518 kWh/m^2-year	-
Tangon et al. (2018)	• Designated (63) • Electricity (Main 69-94%)	• Hotel parameter (no. of room, worker density and occupancy rate) • Electricity equipment	321.84 kWh/m^2-year	-
Prukvilailert and Wangskarn (2011)	• SME • Electricity and heat • Most 5 EE measures each electricity and thermal	• Electricity and heat consumption	1,221.41 toe/year	84.04 toe/year (6.9%)
Wongsapai et al. (2017)	• SME (165) • Electricity and heat	• Electricity and heat consumption	707 GJ/year-SME	147.07 GJ/year-SME (20.8%)

Note: Building energy code level (COD), Higher energy performance standard level (HEPS), Economic level (ECON) (5 years payback), Net-zero energy buildings level (NZEB) (New technology)

In recent years, some studies considered the energy efficiency potential in the SME sector. The studies have provided information about energy consumption and potential energy saving by using bottom-up energy audit data. These studies have shown the potential for energy efficiency improvement in the hotel sector.

However, these studies mainly provide technical information for energy efficiency improvement in the hotel sector. There is a lack of techno-economic information for the hotel owner to use for deciding to invest in energy efficiency measures. DEDE has done well in support investment for energy efficiency improvement. There are evidence of the investment costs and energy savings in the hotel sector under DEDE's programs. Using this data to create a cost curve can be an advantage for the hotel owner to use as the information for deciding to invest in potential energy efficiency measures.

2.5. Public Support Programs in Energy Efficiency Investment

Three existing financial support programs that enhance energy efficiency investment. This study examined the financial support measures. These three programs used market mechanisms to promote more energy efficiency enhancement which used less public funds when comparing with direct subsidy program.

2.5.1. Energy Service Company Revolving Fund (ESCO Fund)

The Energy Service Company Revolving Fund (ESCO Fund) was established by DEDE. The ESCO Fund is a financial incentive for promoting private investment in energy efficiency and renewable energy, with THB 2,000 million allocated from the ENCON Fund. The ESCO Fund was operated for 4 phases (2008-2017), initially launched in October 2008, with a capital of THB 500 million each phase. ESCO Fund's main financial products for the private sector include equity investment for renewable energy and equipment leasing for energy efficiency, with further venture capital for ESCOs, carbon credit trading, credit guarantee facility and technical assistance. The fund is managed by the government-appointed, non-profit two entities for the identification and appraisal of projects, which are Energy Conservation Foundation of Thailand (ECFT) and Energy for Environment Foundation (EforE).

The ESCO Fund offers six funding assistance instruments for project developers, which are equity investment, equipment leasing, ESCO venture capital, carbon credit facility, credit guarantee facility, and technical assistance. The instrument that directly supports energy efficiency investment is equipment leasing.

Under the ESCO Fund from 2008 to 2017, 1,119 million THB of government funding was invested in 148 energy efficiency and renewable energy projects, with a total investment of approximately 6,121 million THB. ESCO Fund with a total of 4 phases contributes private investment of a total 6,121.18 million THB compared to an expected total investment of 5,000 million THB. It leads to reduce the energy consumption of a total of 66.67 ktoe per year compared to an expected energy saving of 40 ktoe per year. ESCO Fund has succeeded in engaging energy efficiency and renewable energy investment, especially within phase 1 – 2, that 63 – 94% of the fund budget was used. While ESCO Fund phase 3 was suddenly closed before the designed timeline due to the unexpected political situation. ESCO Fund phase 4 seems to be limited success in allocation fund with a total 30 months of operation, only 34% of fund budget was used.

2.5.2. Energy Efficiency Revolving Fund (EERF)

Energy Efficiency Revolving Fund (EERF) is a simple soft loan, providing capital investment with a maximum interest rate of 4 percent for a maximum loan period of 7 years. For phase 1-5, Eleven commercial banks have participated as the implementing partners of EERF. For phase 6, eight commercial banks have participated and a maximum interest rate of 3.5 percent for a maximum loan period of 5 years. The scheme is monitored by DEDE.

Under the EERF from 2003 to 2013, 6,799 million THB of government funding was invested in 4,011 energy efficiency and renewable energy projects, with a total investment of approximately 12,831 million THB. EERF with a total of 5 phases leads bank investment of a total 7,621 million THB. It leads to reduce energy consumption of total 311.3 ktoe per year or 4,961 million THB per year. EERF has succeeded in engaging energy efficiency and renewable energy investment (Beerepoot, Laosiripojana, Sujjakulnukij, Tippichai, & Kamsamrong, 2013). For phase 6, 2015 to 2019, the government budget is 4,489 million THB. In July 2018, DEDE has approved 2,797 million THB to 153 projects (DEDE, 2018).

2.5.3. Demand Side Management Bidding (DSM Bidding)

Demand Side Management Bidding (DSM Bidding) provides subsidies through a bidding mechanism to encourage business operators to invest in higher energy efficiency machines/equipment to achieve energy savings higher than the subsidy ratio. The program was operated for 2016 – 2017, which is monitored by DEDE. There is a total of 258 projects that have been involved in this program.

Industrial and commercial companies or ESCO companies can apply to the program. There are only two measures that can be implemented to receive support, which are LED replacement and variable speed drive or inverter measures. Subsidies are provided based on actual units of energy savings achieved in a year. With the bidding mechanism, companies requesting the lowest weighted subsidy rate will be subsidized first. The beneficiaries can be both designated and SME companies. For the designated company, the ceiling of subsidy is 1 THB per kWh for 1 year. For SME companies, the ceiling of subsidy is 2 THB per kWh for 1 year.

CHAPTER III
METHODOLOGY

3.1. Cost Curves of Energy Efficiency Measures

3.1.1. Data Analysis

Cost curve analysis was constructed with the following steps. First, the levelized costs of energy efficiency measures were calculated from the input of energy savings, capital cost, and measure lifetime, which were derived from three DEDE's projects. Second, by having all these data, the cost curve was derived. The least-cost option was chosen first, then following with the higher-cost option. Finally, the cost curve was compared with electricity and fossil fuel prices.

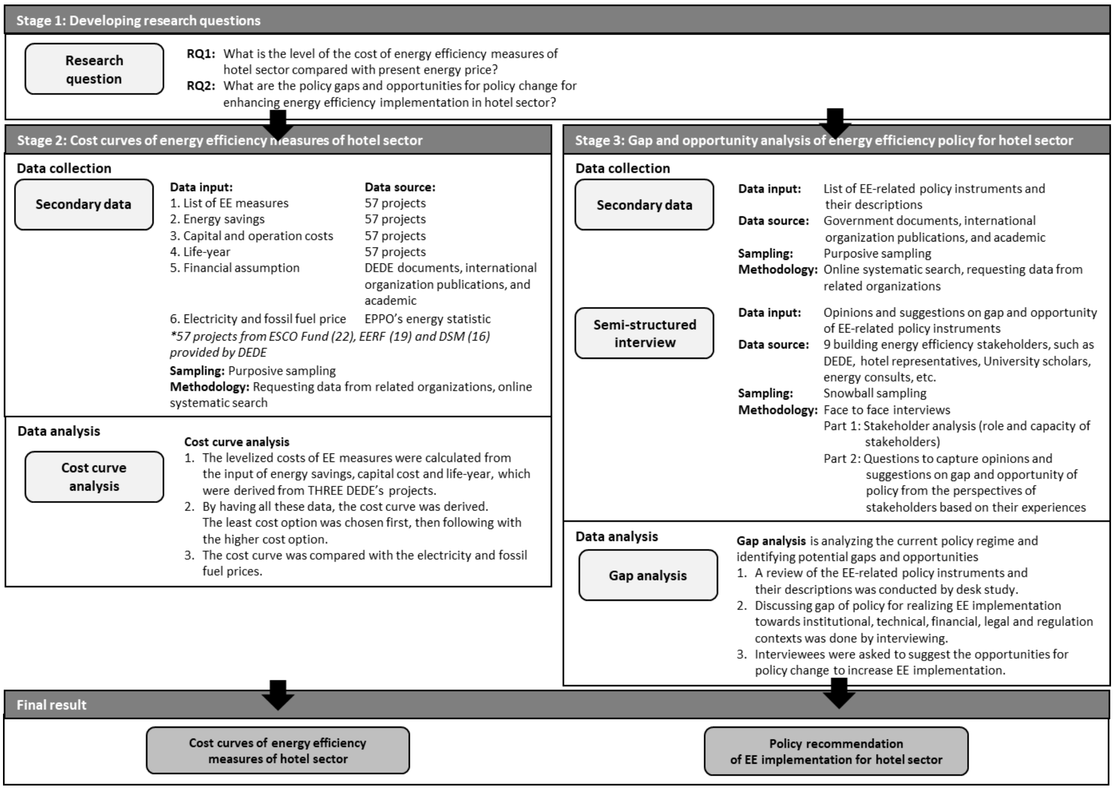

Figure 3-1 An overview diagram of the research methodology

3.1.2. Data Collection

Secondary data which included a list of energy efficiency measures, energy savings, capital cost, and measure lifetime were derived from 57 projects, which were public supported by ESCO Fund program (22 projects), EERF program (19 projects) and DSM

Bidding program (16 projects) under DEDE. These data were raw data for calculating the levelized costs and constructing the cost curve of energy efficiency measures. The data was collected in the year 2018 and the time range of data was 2006 to 2018. This study excluded the effects of the COVID-19 situation and the latest enforcement of the Building Energy Code law for the new building.

Financial assumptions were derived from DEDE documents, international organization publications, and academic. Electricity and fossil fuel prices were derived from PEA tariff and EPPO energy statistic.

Purposive sampling was used because of studying a particular program that needed the all-relevant evidence to be included in the study.

Data collection methodology was done by requesting data from related organizations and online systematic search.

3.2. Gap and Opportunity Analysis of Energy Efficiency Policy

3.2.1. Data Analysis

Policy gap and opportunity analysis was done with these 3 steps. First, a review of the energy efficiency-related policy instruments and their descriptions was conducted by desk study. Second, discussing the gaps of policy for enhancing energy efficiency implementation towards institutional, technical, financial, legal and regulation contexts was done by semi-structured interview. Finally, interviewees were asked to suggest the opportunities for policy change to increase energy efficiency implementation.

3.2.2. Data Collection

The data collection of this section comprised of two major parts which were: (1) secondary documents and (2) semi-structured interviews carried out with stakeholders and energy efficiency experts from various institutions in Thailand. The combination of two data collection was the evidence for policy gap and opportunity analysis.

3.2.2.1. Secondary Data

Secondary data was collected to retrieve evidence for policy gap and opportunities analysis. Secondary data also allowed to collect both qualitative and quantitative data for integrating analysis with the aim for in-depth understanding. The data dimensions were explored with the focus on ‘how’ and ‘why’ intervention from program influence to outcomes.

Purposive sampling was used because of studying a particular program that needed the all-relevant evidence to be included in the study. The aim of sampling was not to find out how often something occurs in a population, but rather what occurred, why it occurred, and what relationship exists among observed events (California Department of Health Services, 1999).

Documents, which contained relevant information on cases were systematically collected. Existing case studies, websites, government documents, international organization publications, and academic publications were considered.

Data collection methodology was done both online and offline. An online systematic search was done from sources, i.e., ‘Google, Science Direct, Springer Link, IEEE Xplore, Google scholar, Thailis, Thai Journal Online, www.dede.go.th, www.eppo.go.th, and www.thaiesco.org’. Offline data gathering was retrieved from requests from related government organizations.

Collected Data

A list of data dimensions that were collected was shown in Table 3-1.

Table 3-1 Data dimensions to be collected each case

Factors	Discussion topics
Institution structure	• Structure of the steering process • Structure of inhouse-fund manager
Design	• Reasons for establishing the fund • Size of the fund • Interest rates • Target group • Project eligible for funding • Maximum loan size • Repayments • Operational costs of the scheme
Operation	• Application process (financial and technical assessments) • Steering process • Participation by program operators • Participation by beneficiaries • Promoting the fund • Monitoring the performance of the Fund (such as number of inquiries and how they heard about the fund, number of days to approve projects, etc.)
Performance	• Number of projects • Program support investment and total investment • Energy savings • Number and variety of energy efficiency measures

Source: EFA and DMG (2005); UNDP (2017)

Data Sources

From initial data surveying, the example secondary documents to provide information for the analysis was shown in Table 3-2.

Table 3-2 Example of data sources

Program	Example of Data sources
EERF	• Thailand's Energy Efficiency Revolving Fund: A Case Study, Energy Futures Australia Pty Ltd, Danish Management Group (Thailand) Co Ltd, APEC Energy Working Group, 2005 • Revolving and ESCO Funds for Renewable Energy and Energy Efficiency Finance, Center for Clean Air Policy, 2012 • Public efforts to mobilize private energy efficiency finance: lessons learned from the energy efficiency revolving fund of Thailand, Verena Streitferdt, Surapong Chirarattananon, 2014 • On the Dynamics of Low Carbon Green Growth in Thailand, Investing in Low-Carbon Energy Systems Implications for Regional Economic Cooperation, Qwanruedee Chotichanathawewong, 2016
ESCO Fund	• E for E and the Management of Energy Efficiency and Renewable Energy Projects under ESCO Fund, Energy for Environment Foundation, 2014 • Technical Proposal for ESCO Revolving Fund 2015, Energy for Environment Foundation, 2015 (Thai version) • Optimising energy efficiency finance in emerging economies in Southeast Asia, Verena Streitferdt, 2016
DSM Bidding	• Announcement of qualification, criteria and application process for DSM Bidding program, DEDE 2016 • Application manual of DSM Bidding program, DEDE 2016

3.2.2.2. Semi-Structured Interview

Semi-structured interviews were conducted to collect stakeholders' responses about the gaps of policy for enhancing energy efficiency implementation towards institutional, technical, financial, legal and regulation contexts. In addition, interviewees were asked to suggest the opportunities for policy change to increase energy efficiency implementation. The interview allowed to collect primary data from an actor perspective who had been involved in the program. Interviewees were also expected to be consulted and provided their opinion of recommendations for promoting energy efficiency investment.

Snowball sampling was used by starting with identifying a few respondents that are the one who knows a lot about the programs and then ask them to recommend others they know who also are the stakeholder positions or who would be valuable to interview (Bhattacherjee, 2012; California Department of Health Services, 1999).

The semi-structured interview was conducted with building energy efficiency stakeholders, such as DEDE, hotel representatives, University scholars, energy consults, etc. **Nine interviewees** were completed for this study, which the organization's list shows in Table 3-3.

Face-to-face interviews were conducted based on scheduled appointments, which the introduction of the study and semi-structured interview questionnaire were sent to them in advance before the interviewing schedule.

Collected Data

The questionnaire protocol was generally prepared to ensure that similar information was collected from all respondents (California Department of Health Services, 1999). **The semi-structured interview questionnaire was shown as Appendix A.** Semi-structured interview questionnaire which included primarily open-ended questions was prepared by separating it into 2 sections.

- **SECTION 1:** Stakeholder analysis
- **SECTION 2:** Questions to capture opinions and suggestions on gap and opportunity of policy from the perspectives of stakeholders based on their experiences

Data Sources

Table 3-3 List of interviews

No.	Code	Organization
1	G1	Department of Alternative Energy Development and Efficiency, Ministry of Energy
2	G2	Department of Alternative Energy Development and Efficiency, Ministry of Energy
3	G3	ESCO Fund Manager
4	G4	EERF Operator
5	G5	DSM Bidding Operator
6	P1	Hotel owner
7	P2	Hotel owner
8	I1	University scholar
9	I2	Independent consultant

3.3. Data Reliability

To ensure reliability in this study, triangulation with multiple data types and data sources was considered. Triangulation was often used to eliminate the bias of data before influencing to results of analysis (Goodrick, 2014). Triangular was conducted in two dimensions by (1) multiple data types, which are primary data from interview and secondary data from related documents, and (2) multiple data sources, which were interviewing various stakeholders i.e. policymakers, program operators, and private sectors who received the loan fund and collecting documents for more than 3 sources each case to ensure a broader range of case context and writer/stakeholder attitude (Yin, 2003).

CHAPTER IV
RESULT AND DISCUSSION

This chapter presents 3 main parts of results, including (1) the cost curve of energy efficiency measures, (2) current situation and challenge and opportunity analysis of three public support programs and (3) policy recommendations for enhancing energy efficiency implementation for the hotel sector are described respectively.

4.1. Cost Curve of Energy Efficiency Measures

The cost curve of energy efficiency measures shows the levelized cost of energy efficiency measures in ascending from the lowest cost to the highest cost of investment. The levelized cost is the investment cost that is annualized over measure lifetime per saved energy. The cost curve is shown comparatively with energy prices both electricity and fuel that allows finding the cost-effective measures which their levelized costs are lower than energy price. The private sector can use this information to decide to invest the cost-effective measures instead of purchasing energy.

This section consists of six topics including (1) the data overview is described to lay the background for calculating the levelized cost of energy efficiency and constructing the cost curve, (2) the cost curve of energy efficiency measures for thermal energy savings measures and electricity saving measures are illustrated, (3) the simple average levelized cost of energy efficiency measure between for large company sector and SME company sector are compared and analyzed, (4) the sensitivity analysis is simulated to show the result when using government point of view on the assumptions for calculating, including the discount rate and measure lifetime, (5) the hotel age is described to show a characteristic of the hotel who has potential to implement energy efficiency projects and (6) investment opportunity for chain hotel and independent hotel are described.

4.1.1. Data overview

The data was collected from DEDE including capital investment cost and energy savings of energy efficiency measures of the hotel sector in the year 2006 to 2018. There was a total of 112 datasets from 57 energy efficiency installation projects from 56 hotels[1]. Each investment project typically consisted of 2 to 3 measures that were

[1] There is the hotel who involved in both ESCO Fund and DSM Bidding programs. Then, the total projects are 57 projects but the number of hotels is only 56 hotels.

implemented at the same time. In this study, there were 3 thermal energy savings measures and 12 electricity energy savings measures.

This section provides overview information on the data inputs and the assumptions that were used in deriving the cost curve of energy efficiency measure, including (1) capital investment cost, (2) energy savings, (3) discount rate, (4) measure lifetime, (5) constant cost, (6) analysis method and (7) energy price.

Capital investment cost

This study used only the initial capital investment cost to calculate the levelized cost of energy saved. It excluded the operation and maintenance and interest rate costs. The investment cost included value-added tax (VAT) of 7%.

The operation and maintenance cost along measure lifetime was excluded in calculating due to there is no data available in any program reports. Although it typically includes capital cost, operation and maintenance cost and other related costs when calculating the cost of energy source, other papers sometimes excluded operation and maintenance cost when the data was unavailable (Brunke & Blesl, 2014; Danish Energy Agency, 2018; Hasanbeigi, Menke, & Therdyothin, 2010). While, Toleikyte, Kranzl, and Müller (2018) used only initial capital cost in their calculation.

There is another important cost which is the measure and verification (M&V) cost in energy efficiency practice. In this study, the capital cost under ESCO Fund and DSM Bidding programs included M&V cost due to the program requests the beneficiary to implement M&V process to verify the energy savings, so the M&V cost was counted in the capital cost. While there was no restricted requirement for M&V process under EERF program, so the M&V cost was excluded.

Therefore, the cost that was included in this study were the capital cost and the M&V cost and excluded operation and maintenance cost.

Energy savings

Energy savings that was used in calculating the levelized cost of energy saved was unavoidably both ex-post savings and ex-ante savings characteristics due to the criteria of three programs.

The participated companies under ESCO Fund and DSM Bidding were required to implement M&V procedure and to report the savings result, which was called ex-post savings. For EERF, there was no requirement for M&V procedure and the participated companies were requested to submit the estimated savings to DEDE for evaluating the eligible measures, which was assumed as ex-ante savings. The ex-ante savings was relied on claimed savings from the product supplier.

Discount rate

In this study, the discount rate was used in the meaning of the opportunity cost of investments. This study used a 15% real discount rate to reflect the private sector risk associated with deciding energy efficiency investment (Preechametta, Junanantatham, Siriprachai, Cintakulchai, & Aroonruengsawat, 2003). The real discount rate was used due to the inflation was already considered in using constant THB.

The discount rate is typically used to reflect the investment requirement from a different perspective (Hoffman et al., 2018). The discount rate of 3% as a reference from an economical assessment of environmental damages was used when the study was concerned with government impact (Toleikyte et al., 2018). For the private sector, they often decide to invest energy efficiency project when the project payback period is no longer than 5 years with economic measure lifetime within 10 years, which it causes the internal rate of return of 15% (Brunke & Blesl, 2014). While Hasanbeigi, Menke, and Therdyothin (2010); Worrell, Martin, and Price (2000) have used 30% real discount rate in calculating to reflect barriers to energy efficiency investment of cement sector in Thailand and the USA, respectively.

The 15% real discount rate was used in this study to reflect the desired perspective from the private's point of view to decide to invest the energy efficiency project. Besides, a sensitivity analysis was studied with 7% real discount rate (represented 7 years payback period, 10 years measure lifetime) to reflect the government point of view in supporting energy efficiency investment. This sensitivity analysis can show the gap in energy efficiency cost between private and government perspectives.

Measure lifetime

There is no rule of thumb on measure lifetime. While the government sector has expected on technical-based measure lifetime that was about 15 – 20 years, the private sector has preferred to use economic measure lifetime. The levelized cost will be lower when a longer measure lifetime is used to spread the cost. This study used 10 years for measure lifetime to reflect private expectation. It excepted only the light emitting diode (LED) measure that the technical lifetime is only not more than 5 years or 50,000 working hours so the measure lifetime for LED to use in this calculation was used only 5 years.

It is to be noted that both economic and technical lifetime are estimated numbers. It will be good that the government can improve data collection on the real measure lifetime.

This study used 10 years for measure lifetime to reflect the private sector's point of view. Furthermore, a measure lifetime of 15 years was used to show the levelized cost of energy efficiency in the government's point of view. This sensitivity analysis was not expected to find the trend of the levelized cost but to show how the cost difference between private and government perspectives.

Constant cost

This study used the year 2018 as the base year. This study conducted a calculation based on the constant 2018 THB. The consumer price index (CPI), which is derived from the Ministry of Commerce (MOC) online database, was used to convert the investment cost each year to be the constant 2018 cost.

The levelized cost of energy efficiency from other papers that were collected to compare with this study were converted to be THB by the exchange rate at the year of the reference studies and adjusted to be constant 2018 THB. The exchange rate for converting each currency is derived from the Bank of Thailand (BOT) online database.

Analysis method

To create a cost curve of energy efficiency, it started from calculating the levelized cost of energy efficiency from the data input described above for all measures. Then, the levelized cost was arranged in ascending order to create the cost curve. The thermal energy savings and electricity savings measures were ranked separately for easier to compare to fuel price and electricity price. The cost-effective measures were the measures that the levelized cost was lower than the energy price.

The levelized cost is sometimes called the cost of conserved energy that shows the cost of investment per saved energy. To calculate the levelized cost, the capital cost for each measure in the year of installation was converted to constant 2018 THB by using CPI that provided by MOC online database (Ministry of Commerce, 2020). Then, the constant 2018 capital cost was annualized over the measure lifetime by using the discount rate. Then annualized capital cost was divided by annual energy savings, which there were separately thermal energy savings and electricity savings according to the energy efficiency measures.

Levelized cost of energy efficiency:

$$\text{Levelized Cost of Energy Efficiency} = \frac{\text{Capital Recovery Factor } \times \text{Capital Cost}}{\text{Annual Energy Savings (in kWh)}}$$

Capital Recovery Factor:

$$\text{Capital Recovery Factor} = \frac{\mathrm{r}(1+\mathrm{r})^{N}}{(1+\mathrm{r})^{N}-1}$$

r = the discount rate

N = the measure lifetime in years

Energy price

This study used the simple average retail electricity charge from the schedules 2, 3 and 4 tariff rates. These data were provided by Provincial Electricity Authority (PEA) to reflect the character of hotels in this study, including both large and SME hotels. This electricity price was included Fuel Adjustment Charge (Ft) in the year 2018 and VAT to be consistent with the capital cost of investment that also included VAT.

This electricity tariff has been announced since November 2018 which the simple average electricity price was 3.77 THB/kWh. It is the simple average electricity price from the schedules 2, 3 and 4 tariff rates. The simple average electricity price excludes service charge, energy demand charge and power factor charge which charges depend on energy user characteristics. This study used the simple average electricity price for comparing with the levelized cost of energy efficiency due to there was a lack of consistent primary data of electricity price for the hotel sector.

For fuel price, this study used average retail liquefied petroleum gas (LPG) and fuel oil prices (price at Bangkok) in the year 2018 that was provided by EPPO online database. The fuel prices were also included VAT. This study used the LPG price of the cooking sector and the fuel oil price of 600 grade according to the application of the hotel sector. There was no primary data of fuel prices available from the participated hotels so this study used the country-average price. There is a limit on using the country average price that is ignoring the difference in fuel price according to the regions. The private sector can compare the levelized cost of energy efficiency data from this study with their specific energy price for deciding on energy efficiency investment.

4.1.2. Cost curve of energy efficiency measure

The cost curve of energy efficiency measures for the hotel sector in Thailand was presented. The levelized costs of energy efficiency measure, which were the annualized investment cost over measure lifetime per energy savings, were arranged ascending from the lowest cost to the most expensive cost for constructing the cost curve of energy efficiency measures. The cost curve of energy efficiency measures was compared with energy prices to find the cost-effective measures in which the levelized cost of measure is lower than energy price. Thermal energy savings and electricity savings measures were separately studied and compared with fuel oil, LPG and electricity prices.

The levelized cost of energy efficiency measures was shown in the interquartile range for presenting maximum, minimum, median and simple average from each measure's dataset. Danish Energy Agency (2018) has shown the levelized cost of energy efficiency measures by maximum and minimum data range to represent different options in energy efficiency implementation. Hoffman et al. (2018); Molina (2014) have studied to find the levelized cost of US Utility energy efficiency programs which they have shown the results by interquartile range to present both the variation and central tendency across their program sample. To provide the private sector as much as information for risk assessment of energy efficiency investment, this study provided including simple average, median and interquartile range.

In this sector, the cost curves of energy efficiency measures for both thermal energy and electricity savings and comparison of the levelized cost for the hotel sector with the other studies were described.

4.1.2.1. Thermal energy savings

From 56 hotel case studies under this study, it can conclude that there were three thermal energy savings measures in the Thai hotel sector including heat pump (thermal), boiler and solar collector which were used in hot water generating system. The simple average levelized cost of energy efficiency for heat pump (thermal), boiler and solar collector were 1.07, 1.23 and 1.97 THB/kWh, respectively (see Table 4-1 and Figure 4-1).

The lowest cost option was the heat pump that substituted existing equipment using thermal fuel such as fuel oil and LPG. The most expensive cost option was a solar collector and it was cost-effective when only replacing fuel oil consumption due to higher energy price. Heat pump and boiler were cost-effective whether to compare with LPG and fuel oil energy prices which the energy prices were 1.66 and 2.73 THB/kWh, respectively.

The simple average and the median value of the levelized cost of energy efficiency under thermal energy measure was equal according to a small number of samples, then an analysis on an opportunity for investment cost reduction was limited.

Table 4-1 Levelized cost of energy efficiency measures for the Thai hotel sector (2018THB/kWh)

	Average	Median	Minimum	Maximum
Thermal energy				
Heat pump (thermal)	1.07	1.07	0.78	1.35
Boiler	1.23	1.23	1.08	1.39
Solar collector	1.97	1.97	1.38	2.56
Electricity				
Variable speed drive (AC)	0.83	0.77	0.29	1.33
Thermostat	1.31	1.29	0.99	1.66
Chiller control	1.93	1.93	1.93	1.93
LED	1.98	0.99	0.20	6.60
Freezer temperature control (E-Cube)	2.20	2.14	0.97	3.39
Insulation	2.62	2.62	2.62	2.62
Chiller	2.65	2.64	1.05	5.31
Voltage regulator	3.05	3.03	0.60	5.38

	Average	Median	Minimum	Maximum
Refrigerant pressure control (5-Plus)	3.50	3.41	3.16	4.04
Heat pump (electricity)	4.46	4.70	3.85	4.82
Variable speed drive (kitchen)	4.66	4.57	2.06	7.04
High efficiency air conditioning	5.47	5.27	3.82	6.64
Overall	2.65	2.56	0.20	7.04
Energy price				
LPG	1.66			
Fuel oil	2.73			
Electricity	3.77			

4.1.2.2. Electricity savings

From 56 hotel case studies under this study, it can conclude that there were twelve electricity saving measures. The simple average levelized cost of energy efficiency measures was a range from 0.83 to 5.47 THB/kWh, which the simple average levelized costs of energy efficiency measures were shown as follow; variable speed drive (air conditioning) 0.83 THB/kWh; thermostat 1.31 THB/kWh; chiller control 1.93 THB/kWh; LED 1.98 THB/kWh; freezer temperature control (E-cube) 2.20 THB/kWh; insulation 2.62 THB/kWh; chiller 2.65 THB/kWh; voltage regulator 3.05 THB/kWh; refrigerant pressure control (5-plus) 3.50 THB/kWh; heat pump (electricity) 4.46 THB/kWh; variable speed drive (kitchen) 4.66 THB/kWh; high-efficiency air conditioning 5.47 THB/kWh, further detail shown in Table 4-1.

The lowest cost option was variable speed drive in an air-conditioning application which the simple average levelized cost was 0.83 THB/kWh. The highest cost option was high-efficiency air conditioning (split type) which the simple average levelized cost was 5.47 THB/kWh.

There were nine cost-effective measures for the Thai hotel sector because the investment cost over a lifetime was lower than the electricity price which was 3.77 THB/kWh, see Figure 4-1.

The popular implementing measures were LED lighting (30 hotels) and Chiller (27 hotels) from a total of 56 hotels in this study. LED measure was the highest implementing measures which it may cause from high technical confidence, easy verifying occurred savings, hotel-specific characteristic of frequently lighting system replacement and available dedicated program support for LED (DSM Bidding program). Chiller measure was another popular implementing measures. The chiller was decided to install according to it was the main energy consumption equipment in the hotel, the existing chiller was used for more than 15-20 years and it was commercially used that there was a low technical risk.

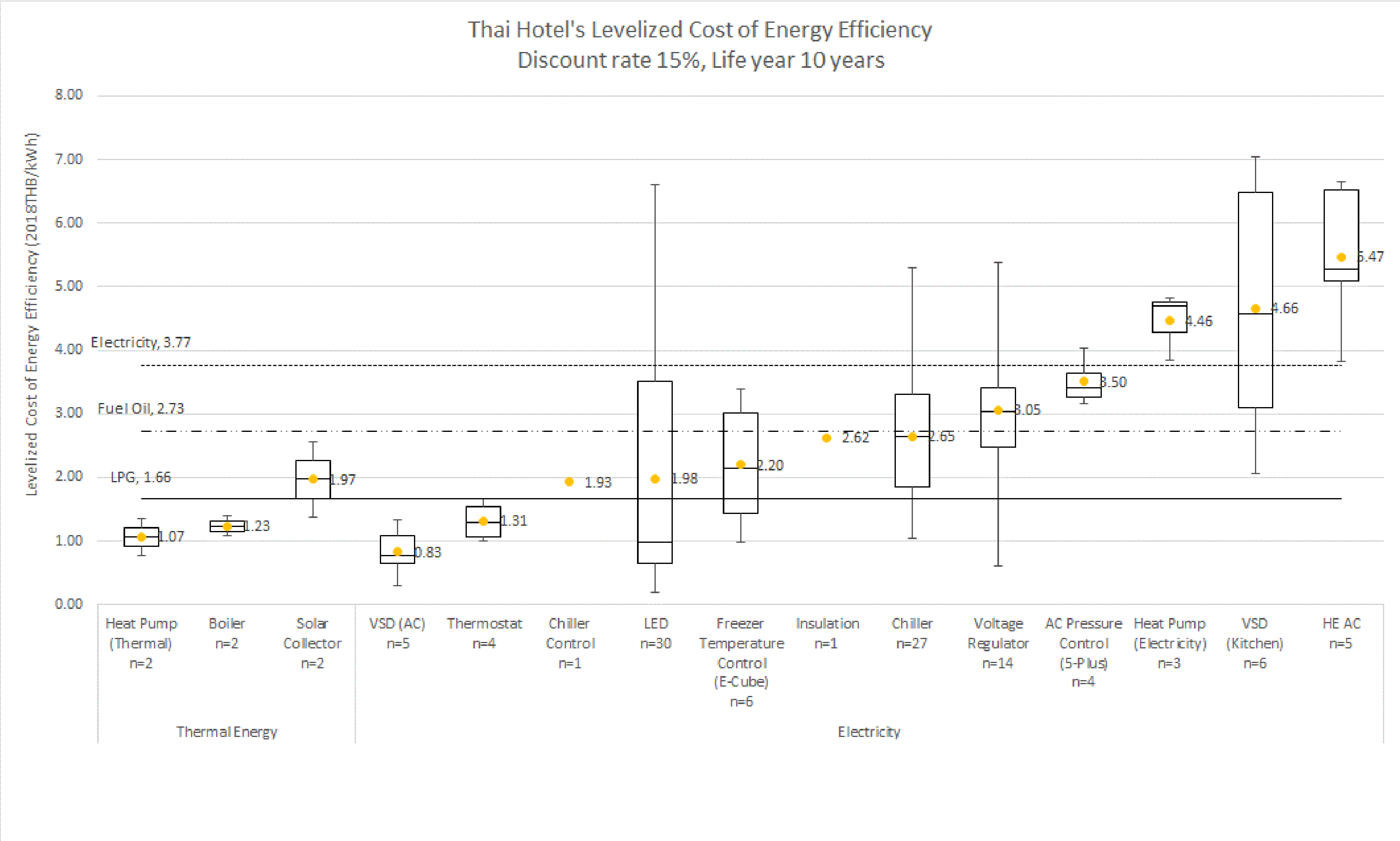

Figure 4-1 Levelized cost of energy efficiency measures for the Thai hotel sector

The levelized cost of LED measure was ranged from 0.20 to 6.60 THB/kWh. The highest cost has occurred from the hotel that invested LED measure in the year 2018 under EERF program. The wide range of cost of LED measure may cause from the various application options such as replacing downlight, T5 lighting, and high bay types which the LED high bay was still a high cost. In addition, LED measure has had a specific characteristic that the price was still high at the beginning of its emerging in the market in the past and the lower price was found in the present project.

There were three cost-inefficiency measures in the Thai hotel sector in which the levelized cost was higher than electricity price, including heat pump that substitute existing electric hot water equipment, variable speed drive in kitchen application and high-efficiency air conditioning (split type). Variable speed drive in kitchen application was the emerging measure in the market that has been implemented in EERF phase 6 which caused still high investment cost. High-efficiency air conditioning (split type) was a high price and its energy savings from the hotel sector may be small according to the low usage hours.

The simple average levelized cost was higher than the median value for LED measure which can interpret that there is an opportunity for decreasing investment cost by a greater scale of implementation in the market. There was a similar situation that the average cost of residential sector support programs in the United States of America was higher than the median value, the authors have suggested that there was a potential for cost reductions (Hoffman et al., 2018). While chiller and voltage regulator measures have had a close gap between the simple average and the median values which it can interpret that their costs were commercially stable according to long time experience. The remaining measures have had a too-small sample to analyze and conclude.

4.1.2.3. Comparison with other studies

Many authors have studied the levelized cost of energy efficiency measures in cement and pulp and paper industrial sectors in many countries including the USA and Thailand (Hasanbeigi, Menke, & Therdyothin, 2010; Sathitbunanan & Ritthong, 2017; Worrell et al., 2000). Danish Energy Agency (2018) also has provided a guideline for calculation the levelized cost of energy efficiency and renewable energy for helping to compare and select the optimal cost of future energy supply, which energy efficiency has been seen as the source of power generation.

The levelized costs of energy efficiency measures from the studies were converted to constant 2018 Thai baht by converting with the exchange rates at the year of study and then convert to the constant 2018 by CPI. From the surveying on the studies, it was found that 2 measures can be comparable, including variable speed drive and LED lighting measures.

For variable speed drive measure, it was found that the simple average levelized costs of variable speed drive in an air-conditioning application for the Thai hotel sector (0.83 THB/kWh) was similar to the average costs for variable speed drive in cement production process were 0.65 THB/kWh (Worrell et al., 2000) and 1.10 THB/kWh (Hasanbeigi, Menke, & Therdyothin, 2010). While the average levelized costs of variable speed drive in kitchen application seemed to be dramatically higher than other applications both air-conditioning application and cement production process, the average levelized cost was higher almost six times. The range of variable speed drive cost data for the Thai hotel sector (n=5) was 1.04, which was similar characteristic from the Thai cement industry in that the range of cost data was 1.33 (n=4) (Hasanbeigi, Menke, & Therdyothin, 2010).

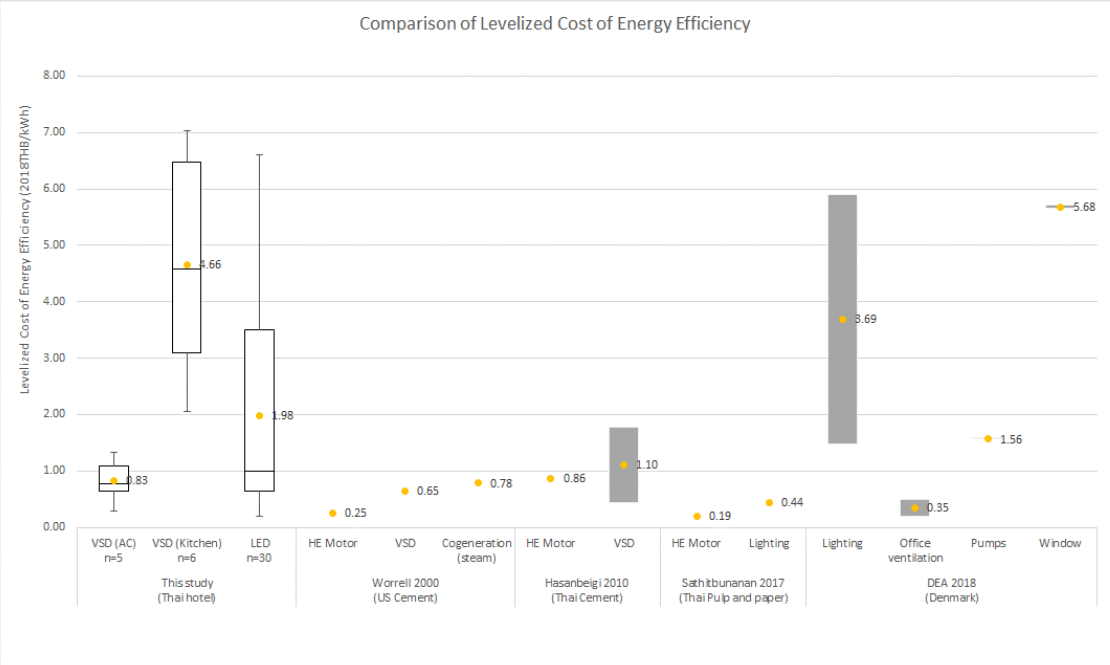

Figure 4-2 Comparison of the levelized cost of energy efficiency measures for the hotel sector with the other studies

The costs for lighting measures were widely various, including 1.98 THB/kWh from the hotel sector in this study and 0.44 THB/kWh from the pulp and paper sector study (Sathitbunanan & Ritthong, 2017). The lighting investment cost in the pulp and paper sector was similar to the lowest cost of LED in this study, which was 0.20 THB/kWh. This is possible according to the wide range of application options for lighting measure, which it was shown in the Danish Energy Agency (2018) study that the range was from 1.48 to 5.90 THB/kWh.

4.1.3. Size of hotel

Besides, the cost curve of energy efficiency measures for the overall Thai hotel sector was presented, the cost curves for measures that were implemented by large and SME scale companies were present separately to show different investment costs to save the same amount of energy. The inequity investment cost according to the scale of business would be tailored supported by the government to overcome specific market characteristics. This was the background data for the policy analysis section, in which policy support should be designed based on financing capacity to access the fund from the private financial instrument.

In the energy government organization, the company was defined by its energy intensity according to the ENCON Act law. EPPO has used the number of rooms to group the hotels to represent the different service area which related to energy consumption in the DSM bidding program in the year 2008. The upper 150-rooms hotels were expected to have high technical energy savings potential which was more than 100,000 kWh per year. However, the data of hotels under this study showed that there was no clear relation between their neither energy intensity nor the business size and the number of rooms which the detail was shown in Table 4-2. In addition, the financial constraints to invest in energy efficiency projects were usually based on the financing capacity of a company to access the fund. So, the company was grouped according to the business size which is large and SME sectors instead of the energy consumption dimension for this study.

For the energy intensity dimension, the company was defined to be DF&Bs and non-DF&Bs according to their energy consumption when consumed electricity demand greater than 1.0 MW or annual energy use of more than 20 TJ per year. The data of DF&Bs company list was derived from DEDE online database.

Table 4-2 The relationship between energy consumption, business size and number of rooms

	Number of rooms		
	Average	Minimum	Maximum
Energy intensity dimension			
DF&Bs (n=37)	315	125	672
non-DF&Bs (n=19)	127	38	271
Financing capacity dimension			
Large (n=18)	407	166	672
SME (n=38)	185	38	672

For the financial capacity dimension, they were defined by income and labor. The manufacturing sector and trade and service sector were defined by different criteria. The hotel sector was under the trade and service sector which was defined when income less than 1.8 MB as 'Microenterprise', 1.8 to 50 MB as 'Small enterprise' and 50 to 300 MB as 'Medium enterprise', more detail as Table 4-3. The data of the company's income was derived from DBD online database.

Table 4-3 The definition of small and medium enterprises

	Micro-Enterprise		Small Enterprise		Medium Enterprise	
	Annual Income (MB)	Employment (Person)	Annual Income (MB)	Employment (Person)	Annual Income (MB)	Employment (Person)
Manufacturing	≤ 1.8	≤ 5	≤ 100	≤ 50	≤ 500	≤ 200
Service and Merchandising	≤ 1.8	≤ 5	≤ 50	≤ 30	≤ 300	≤ 100

The average cost of energy efficiency measures for the large hotel sector was 2.44 THB/kWh with a range of 0.20 to 7.04 THB/kWh. The average cost for the SME hotel sector was higher than the large sector in which the average cost was 2.68 THB/kWh with a range of 0.24 to 6.67 THB/kWh. This meant that to conserve 1 kWh, the SME hotel sector has to invest higher than the large sector, which may be caused by the higher transaction cost for a smaller project. This trend was similar to the US Utility program cost study in which the residential sector had a higher cost than the commercial and industry sector (Hoffman et al., 2018).

The coefficient of quartile deviation for the large sector was 0.53 and for the SME sector was 0.46 which shown that the cost of investment in the large sector was more dispersed than the SME sector. The widest range of costs was under LED measure in the large sector that it may cause from the various application options such as replacing normal lighting, downlight, and high bay types which the LED high bay was still a high cost.

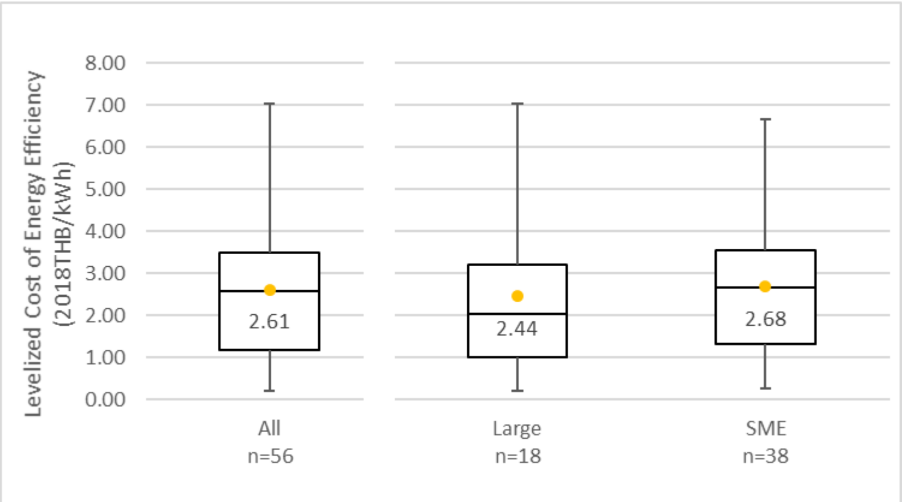

Figure 4-3 The average cost of energy efficiency measures
for large and SME hotel sectors.

The data showed that the SME hotel sector was the main beneficiary for these three programs which includes 38 hotels (68%) from the total 56 hotels. This can be concluded that the policy support programs were success to support small company in hotel sector who has low financing capacity.

4.1.4. Sensitivity

The sensitivity analysis simulated three scenarios to show the average cost of energy efficiency measures that not only private sector aspect but also government aspect which provided an opportunity to see the mismatch point of views.

Table 4-4 Sensitivity analysis for the levelized cost of energy efficiency in the Thai hotel sector in the base year 2008 with different measure lifetime and discount rate respective to private and government aspects (2018THB/kWh)

	Scenario		
	M10R15	M10R7	M20R7
Thermal energy			
Heat pump (thermal)	1.07	0.76	0.50
Boiler	1.23	0.88	0.58
Solar collector	**1.97**	1.41	0.93
Electricity			
Variable speed drive (AC)	0.83	0.59	0.39
Thermostat	1.31	0.94	0.62
Chiller control	1.93	1.38	0.91
LED	1.98	1.62	1.62
Freezer temperature control (E-Cube)	2.20	1.57	1.04
Insulation	2.62	1.87	1.24
Chiller	2.65	1.89	1.25
Voltage regulator	3.05	2.18	1.45
Refrigerant pressure control (5-Plus)	3.50	2.50	1.66
Heat pump (electricity)	**4.46**	3.19	2.11
Variable speed drive (kitchen)	**4.66**	3.33	2.21
High-efficiency air conditioning	**5.47**	**3.91**	2.59
Overall	2.61	1.92	1.42

M10R15: Measure lifetime 10 years, Discount rate 15%
M10R7: Measure lifetime 10 years, Discount rate 7%
M20R7: Measure lifetime 20 years, Discount rate 7%

The base case used the discount rate of 15% with 10 years measure lifetime (M10R15) which reflected 5 years payback period expectation. The base case represented for private sector point of view. From the government point of view, the discount rate of 7% with 10 years measure lifetime (M10R7) to reflect 7 years payback period and the technical measure lifetime of 20 years (M20R7) were used to calculate the levelized cost of energy efficiency measures. The overall average costs under the M10R15 (base case), M10R7 and M20R7 scenarios were 2.61, 1.92 and 1.42, respectively, which the detail is shown as Table 4-4.

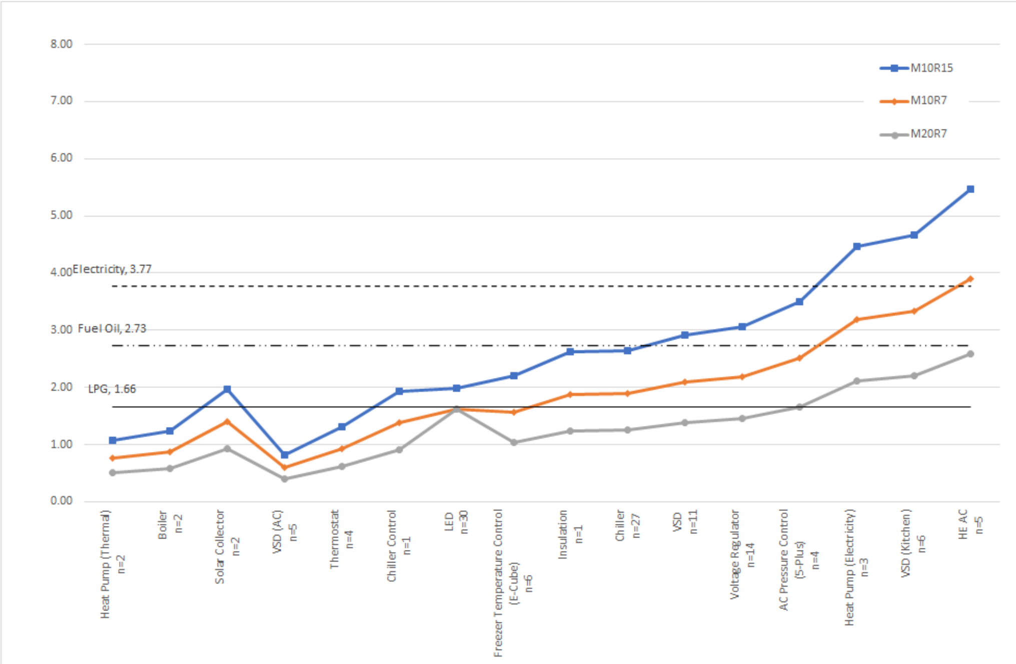

Figure 4-4 Sensitivity analysis for the levelized cost of energy efficiency in the Thai hotel sector in the base year 2008 with different measure lifetime and discount rate respective to private and government aspects

The M10R7 scenario caused the decreased cost by 26% that heat pump (electricity) and variable speed drive (kitchen) measures which were cost-ineffective in the base case became attractive to invest. The M20R7 scenario decreased almost half of the cost (46%) compared to the base case which all measures were cost-effective.

In the other words, it can interpret that policymaker tend to think that all energy efficiency measures are cost-effective while the private sector often requires a high internal rate of return to manage associated risks. The base case (M10R15) shown that some measures still needed more policy support to enhance their implementation.

4.1.5. Hotel age

The average hotel age from hotels that involved in these three programs was 27 years with the range from 3 to 64 years. For EERF, ESCO Fund and DSM Bidding programs, the average hotel ages were 25, 32 and 22 years, respectively. It was concluded that the hotels that invested in energy efficiency projects were quite old hotels. This was confirmed by the hotel technical department manager who was one of the interviewees in this study, which he said that *most hotels have a trend to think to invest in energy* *efficiency when they are old and need to renovate which energy efficiency measures will be invested at the same time of the renovation* (P2).

Table 4-5 The average hotel age from the hotels involved in the three programs

	Hotel age		
	Average	**Minimum**	**Maximum**
EERF	25	8	42
ESCO Fund	32	13	64
DSM Bidding	22	3	55
Overall	**27**	**3**	**64**

4.1.6. Chain hotel and independent hotel

Investment cost per project data shown that the simple average investment costs were 1.69 Million THB/project from the chain hotel sector and 4.10 Million THB/project from the independent hotel sector. The number of chain hotels involved in these three programs was 14 hotels while the independent hotel sector was higher which was 42 hotels.

The data reflected that the independent hotels have received financial support from government projects higher portion than the chain hotels. The reason may be that the chain hotels have internal financing capacity which they can invest the energy efficiency project by themself which caused the lower involving portions. The independent hotels were included large and SME hotels that may rely on external financing. In addition, there is an opportunity for the chain hotels to combine small projects from subordinate hotels to be a large project that may reduce transaction costs which may enhance more cost-effectiveness for investing in energy efficiency projects.

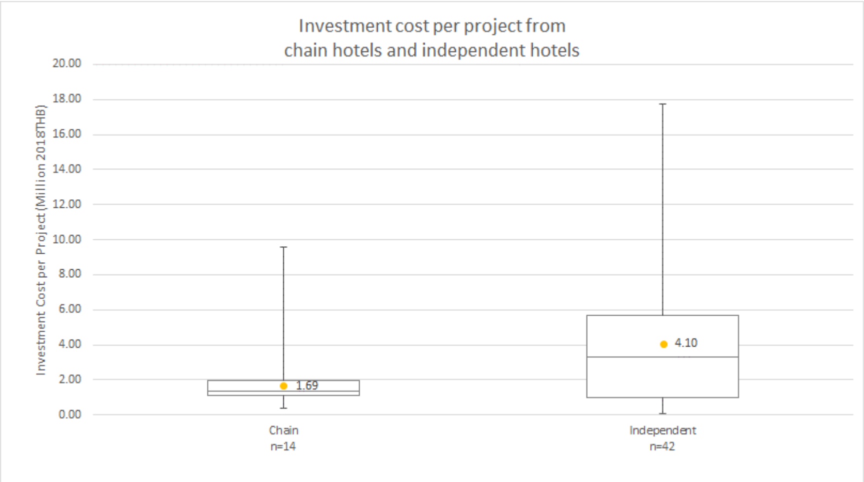

Figure 4-5 Investment cost per project from the chain and independent hotels

4.1.7. Summary for the cost curve study

The cost curve of energy efficiency measures presents the levelized costs of energy efficiency measures in ascending arrangement to illustrate the most cost-effective and to help to compare with energy price.

There were three measures of thermal energy savings in Thailand's hotel industry, including the heat pump (thermal), boiler and solar collector. The simple average levelized costs of energy efficiency for heat pump (thermal), boiler and solar collector were 1.07, 1.23 and 1.97 THB/kWh, respectively. All three thermal energy savings measures were cost-effective which solar collector was suitable to implement when substituting fuel oil consumption and heat pump and boiler were comparable with both LPG and fuel oil energy prices.

There were twelve measures of electricity savings for Thailand's hotel sector that the lowest average levelized cost was 0.83 THB/kWh from variable speed drive (AC) and the highest average levelized cost was 5.47 THB/kWh from high-efficiency air conditioning (split type). There were nine cost-effective measures under Thailand's hotel sector, including variable speed drive (in air conditioning system), thermostat, chiller control, LED, freezer temperature control (E-Cube), insulation, chiller, voltage regulator, refrigerant pressure control (5-Plus). The most popular implementation measures were LED lighting (30 hotels) and chiller (27 hotels) among a total of 56 hotels in the study. There were three cost-ineffective measures in Thailand's hotel sector where the levelized cost was higher than the price of electricity, including heat pumps, variable speed drive in kitchen and air conditioning (split type).

It was found that variable speed drive's levelized cost in an air-conditioning application for Thailand's hotel industry, which was 0.83 THB/kWh, was similar in the cement production process that was 1.10 THB/kWh (Hasanbeigi, Menke, & Therdyothin, 2010) and 0.65 THB/kWh (Worrell et al., 2000). Variable speed drive's levelized cost in kitchen application was six times higher than in air-conditioning application and cement production process. LED lighting measure was a wide range of levelized costs, including 1.98 THB/kWh for the hotel sector and 0.44 THB/kWh for the pulp and paper industry study (Sathitbunanan & Ritthong, 2017). The levelized cost of LED in the pulp and paper industry was similar to the lowest cost in this study hotel sector, which was 0.20 THB/kWh. The wide range of application options for lighting measure reflected the widest range of costs, which was a similar trend that the cost range of lighting measure was from 1.48 to 5.90 THB/kWh in the Danish Energy Agency (2018) study.

The SME hotel sector's average cost was higher than the large hotel sector which the average costs were 2.68 and 2.44 THB/kWh, respectively. It was interpreted that the SME hotel sector has to spend higher than the large sector to conserve the same one kWh, which may result from the higher transaction cost of a small project. The data showed that the hotels under the SME sector were the major beneficiary of these three programs, including 38 SME hotels (68%) among a total of 56 hotels.

The M10R7 (moderate government aspect) scenario resulted in a 26% decreased average costs which resulted that the heat pump (electricity) and variable speed drive (kitchen) measures have become attractive for investment. The M20R7 (high conservative government aspect) scenario decreased by nearly half the cost (46%) comparing to the base case, which resulted that all measures were cost-effective. In the other words, it can conclude that policymaker tend to assume that energy efficiency measures are typically cost-effective whereas some measures still required more policy support to widespread their implementation when seeing from the private sector aspect.

4.2. Current Situation and Challenge and Opportunity Analysis

4.2.1. EERF

EERF is a 'credit-line' that provides funding for energy efficiency/renewable energy investments that provides zero- or low-interest capital to commercial banks for the provision of a "soft loan" to the company. EERF received the total initial funding from the ENCON Fund, which amounted to 12,332 million Baht (MB) from 2003 to 2019 (DEDE, 2016b).

Institution structure

There were three stakeholders under EERF program which were including DEDE, program consultant and commercial banks. DEDE had a responsibility to govern the overview of the program and coordinate disbursement of the fund from ENCON Fund to participated in commercial banks. Program consultant had a responsibility to administrate the program, assess an application, update the database, promote the program by a seminar with at least 5 times and a minimum of 750 attendees, manage disbursement and repayment, assess technical part of the proposal and conduct M&V process for the beneficiaries with 55 projects (DEDE, 2015). The private banks had a responsibility to assess financing capacity, assess the financial part of the proposal and process the documents for received the fund from the ENCON Fund via DEDE.

Design

The government established the EERF to enhance the implementation of energy efficiency investment by allowing energy end-users to access external upfront costs with a low-interest rate. The low-interest rate instrument helps to reduce the friction of a company's energy efficiency investment decisions. In addition, participated banks were also intended to benefit from capacity building in the area of energy efficiency lending experience (APEC, 2005).

The total budget fund was 12,332 MB and the actually allocated fund was 10,114 MB which caused that the participation rate to was 82%. The maximum loan was 50 MB for each project initially designed for medium-sized investments (APEC, 2005). The initial interest rate was designed at a fixed rate of 4% or less for management fees and bank risk costs (APEC, 2005). In Phase 6, DEDE set the interest rate at a maximum of 3.5% to encourage greater investment in energy efficiency. In practice, banks have offered an interest rate with a maximum of 3.5% effective rate for five years loan (KBank, 2015). The government has assigned the principal fund with 0.5% interest rate to the bank since phase 3.

DF&B was the target at the beginning of the first phase (APEC, 2005) and non-DF&Bs, ESCO and new buildings were later expanded targets (DEDE, 2016b). Eligible measures were the energy efficiency/renewable energy where the payback period does not exceed seven years.

Operation

The approval process required duration of two months, which banks and DEDE preferred one month each (DEDE, 2016b). The loan fund was released from ENCON Fund via DEDE to banks by one month (DEDE, 2016b). Banks evaluated financial potential through an “asset-based” practice that requires strong collaterals and balance sheets (APEC, 2005). Program contractor, hired by DEDE, evaluated the technical potential of projects. The banks lent to borrowers, with a grace period of up to a year. Borrowers returned the principal with interest to the banks. The banks returned the principal and interest to DEDE within seven days of receiving the customer. For risk management, DEDE enabled the bank to terminate the contract for a defaulted project and start a new contract at a commercial interest rate. DEDE can fine banks when late repayment occurring with 14% interest rate (APEC, 2005).

Performance

EERF enhanced energy efficiency and renewable energy investment for a total of 295 projects under phase 1-5. Total investment which stimulated by the program under phase 1-5 was 15,959 MB, which EERF allocated 7,205 MB. Energy cost savings was 6,806 MB and energy consumption reduction was 320 ktoe/year which was occurred from EERF phase 1-5. Unfortunately, there was no available public data for total investment and energy saving from phase 6. In phase 6, EERF has allocated funds around 2,909 MB for 162 projects which the data has been shown as of September 2018.

Thirteen energy efficiency measures were implemented under the program, including 5-plus technology (refrigerant pressure stabilizer), chiller, chiller control, e-cube technology (freezer temperature control), high-efficiency air conditioning, heat pump (replacing electricity equipment), heat pump (replacing thermal energy equipment), insulation, LED, thermostat, voltage regulator and variable speed drive.

Table 4-6 EERF performance

	Unit	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6[a]
Promoting year	-	2003-2006	2006-2009	2007-2010	2009-2012	2010-2013	2015-2019
No. of projects	Projects	78	85	104	11	17	162
EERF budget	MB	2,000	2,000	2,942.5	400	500	4,489
EERF allocation	MB	1,902	1,805	2,853	383	262	2,909
Total investment	MB	3,427	3,536	6,388	1,272	1,336	n/a
Energy cost savings	MB	1,394	1,415	1,092	1,053	1,852	n/a
Energy savings	ktoe/y	97.6	102.45	98.01	13.21	8.73	n/a
No. of banks	Banks	6	n/a	n/a	n/a	13	8
Interest rate to banks	% p.a.	0%	0%	0.5%	0.5%	0.5%	0.5%
Interest rate to borrowers	% p.a.	4%	4%	4%	4%	4%	3.5%

[a] as of September, 2018

Table 4-7 Average initial investment cost per project for the hotel sector under EERF

	Constant Investment Cost (MB2018)		
	Average	Minimum	Maximum
Large	4.37	0.06	20.50
SME	2.93	0.03	17.76

The average investment costs were 4.37 MB for the large hotel sector and 2.93 MB for the SME hotel sector.

Gap and opportunity analysis

Table 4-8 Gap and opportunity analysis

	EERF	
	Challenges	Opportunities
Institutional	• ESCOs are limited access to loan funds due to they are mostly small companies and have weak financial profiles (Streitferdt, 2016).	• The suitable target is a large company that has a strong financial profile and medium-SME which there were 4 large companies (21%) and 10 medium SME companies (53%) from the total of 19 hotels involved in the program. • Banks take care of the financial assessment and repayment process that helps the public to reduce duty and budget (APEC, 2005), however, the public still needs to take care of technical assessment and administration (G4).
Technical	• The allowing five years lending period that is shorter than seven years payback period hinders the final decision to invest in energy efficiency measures.	

	EERF	
	Challenges	Opportunities
Financial	• EERF is limited success to transform to be private energy efficiency financing, in which commercial banks create their energy efficiency portfolio and take care throughout the process (Streitferdt, 2016). • Customers take both technical and financial risks because the program does not require for Energy Performance Contract (EPC) and M&V, and banks will assign new interest at a commercial rate for any default customer (APEC, 2005). • Energy savings costs were seen as invisible income (Streitferdt & Chirarattananon, 2014). • A small investment fund that the average was 2.9 for SME and 4.4 for Large which is a mismatch with the design of 50 MB for medium-sized energy efficiency project.	• The government provides credit-line to commercial banks, for which the public has no risk of principal fund loss (APEC, 2005). • The soft loan allows companies to decide to invest easier because it provides up-front cost with 3.5% effective interest rate that is lower than the commercial rate of 6.5% effective rate.
Legal and regulation	• Lack of demand for energy efficiency investment according to lack of law enforcement (Streitferdt & Chirarattananon, 2014). • Avoid of long-time disbursement process and heavily documentation was mentioned to be improved (G4). • There is a low dissemination of the program (Streitferdt, 2016).	

4.2.2. ESCO Fund

ESCO Fund was designed to provide various financial instruments to mitigate energy efficiency/renewable energy financial barriers. There were six tools which two main tools were equity investment for renewable energy and equipment leasing for energy efficiency measure and renewable energy, further tools were including venture credit guarantee facility, capital for ESCOs, carbon credit facility and technical assistance. Energy efficiency projects were supported by an equipment leasing instrument, which was analyzed in this study.

Institution structure

There were three stakeholders under the ESCO Fund program which were Investment Committee (IC), DEDE and Fund managers. The IC, composed of qualified persons from the public and private sectors, appointed by DEDE and chaired by the Director-General of DEDE, will approve the allocation of investments and regulate fund managers. Fund managers are responsible for financial and technical assessments, as well as tasks related to marketing, project coordination, law, accounting and databases.

Design

The lease of energy efficiency/renewable energy equipment was designed to be a “soft loan” using the associated energy efficiency/renewable energy equipment as collateral and the company's authorized manager as guarantor (EforE, 2014). The public provides upfront funding for upfront costs and allows savings to be used as reimbursements. DEDE established the ESCO Fund to improve opportunities for low-collateral developers by moving from an “asset-based” assessment to a “project-based” assessment, enabling the public to take risks in the event of default. ENCON Fund allocated the total initial funding of 2,000 MB for ESCO Fund. The maximum loan size was 10 MB per company for Phase 1 - 2. The maximum loan size was expanded to 25 MB in phase 4 to meet leasing renewable energy equipment such as Biogas gas engine and solar rooftop. The interest rate was designed to be 4% flat rate as the same EERF but while private bank provides up to 4% fixed effective rate, ESCO Fund charge up to 7.42% effective rate for 5 years loan. The interest rate is 3.5% flat rate for five years loan, at the final phase.

The target group was as same as EERF program which was DF&Bs, non-DF&Bs and ESCOs to receive the fund for implementing the energy efficiency project. In addition, ESCO Fund also aimed to promote ESCOs’ services for being acceptable and high quality for energy end-users (EforE, 2014). ESCOs were provided initial funds for arranging finance for customers with guaranteed-saving projects or implementing shared-saving projects.

The equipment cost and associated cost were eligible to receive under ESCO Fund program, which its portion should be less than 20% of the total cost. The associated cost can be including installation cost, O&M cost, engineering fee, M&V cost, and insurance fee (EforE, 2014). In addition, the EPC guarantee by ESCOs was required to implement with the project that receives the fund from the program, which EPC contract restricted any occurred shortfall of energy savings must be charged from ESCOs.

Borrowers have to repay principal and interest to fund managers within five years. The fund manager had an opportunity to use the return of investment as an expense for the monitoring period and return all principal and interest to ENCON by the end of the monitoring period.

Fund managers charge up to 25 MB of performance-based management fees during the promotional period. During the monitoring period, they can charge expenditures up to half the return on investment received.

Operation

Strict technical assessment under a 'project-based' basis was conducted to reduce the default risk (Jue, Johnson, & Vanamali, 2012). Approval procedure was conducted through 3 steps including, an in-house committee under fund manager organization, DEDE's working group, and Investment Committee (IC) which about four months duration was required (EforE, 2014). To facilitate the company who implement energy efficiency measure, ESCO Fund allowed to offer up to six months grace period for both principal and interest (EforE, 2014).

Fund managers are responsible for both financial and technical assessments, complementing with marketing, project coordination, legal, accounting, and database tasks. According to a 'project-based' basis, strict technical assessment is needed to minimize default risk (Jue, Johnson, & Vanamali, 2012). An approval process is conducted through 3 steps, an in-house fund management committee, DEDE's working group, and Investment Committee (IC) that requires about four months (EforE, 2014). The IC, comprising qualified persons from both public and private sectors, appointed by DEDE, and chaired by DEDE Director-General, will approve granting investment and regulate fund managers. Borrowers have to repay principal and interest to fund managers within five years. Fund managers charge performance-based management fees within the promoting period as up to 25 MB. For the monitoring period, they can charge the expenses up to half of the received investment return.

Performance

ESCO Fund provided a total of 1,119 MB to implement 148 projects, with the fund stimulated a total investment of 6,121 MB. It caused energy savings of a total of 66.67 ktoe/year. There were six energy efficiency measures for the hotel sector which included Boiler, Chiller, LED, Solar Collector, Voltage Regulator, VSD. Chiller was the most popular measure that 14 projects (37% of total projects) were implemented.

Table 4-9 ESCO Fund performance

	Unit	Phase 1	Phase 2	Phase 3	Phase 4	Total
Promoting Year	-	2008–2010	2010–2013	2013–2014	2015-2017	
Monitoring Year	-	2010-2015	2013-2018	2015-2020	2017-2022	
ESCO Fund budget	MB	500.00	500.00	500.00	500.00	2,000.00
ESCO Fund allocation	MB	314.74	471.67	161.85	170.83	1,119.09
No. of projects	Projects	32	69	26	21	148
Total investment	MB	3,512.69	2,058.80	179.85	369.84	6,121.18
Energy savings	ktoe	20.61	30.73	2.20	13.13	66.67
Interest rate	-	4%	4%	4%	3.5%	-

Table 4-10 Average initial investment cost per project for the hotel sector under ESCO Fund

	Constant Investment Cost (MB2018)		
	Average	Minimum	Maximum
Large	4.07	0.61	11.53
SME	4.01	0.34	10.99

The average investment costs were similar between large and SME hotel sectors which were 4.07 and 4.01 MB, respectively.

Gap and opportunity analysis

Table 4-11 Gap and opportunity analysis

	ESCO	
	Challenges	Opportunities
Institutional	• Equipment leasing is distractive by ESCOs due to they are reluctance to implement shared-saving guarantee for their customers.	• Energy efficiency equipment leasing is designed friendly for low collateral capacity companies, that financial assessment is based on technical feasibility (EforE, 2014). • There are best practices that are suitable for a small company such as eligible project cost including both equipment cost itself and associated cost, no lending fee, the grace period for both principal and interests up to six months (EforE, 2014), which can be replicated by financial institute who is designed to provide financing to a limited financial capacity company (CCAP, 2012; Streitferdt, 2016).
Technical	• Further, the maximum loan fund is limited to 25 MB per company, which is only enough to implement a small project at a time. • There are some challenges about the process of the program, which are low program dissemination, long-time approval process, limited quality of ESCOs, high equipment quality and price requirements, and lack of standard M&V plan (CCAP, 2012).	• There is an opportunity for implementing new energy efficiency technology because the program uses project-based assessment, which can be a case study for widely use and banks to provide a loan (CCAP, 2012).
Financial	• Government has to take a risk on default projects to enhance financial access of low collateral capacity proponents. • However, the public can receive an investment return of at least 1.75% (a half of the interest rate) which can be used to manage the defaulted portion (G1).	• It mitigates high up-front investment cost barriers. According to strict technical requirements which are equipment certificate, EPC guarantee and standard M&V implementation, the program helps customers to reduce technical risk (EforE, 2014).

	ESCO	
	Challenges	Opportunities
	• Project cost is higher than purchasing equipment alone that it is including equipment, O&M, M&V and insurance costs to meet technical requirements (CCAP, 2012). • The 3.5% flat rate for five years loan is equal to 6.54% effective rate, which causes insufficient encouraging to implement an energy efficiency project.	
Legal and regulation	• There is a low dissemination of the program (Streitferdt, 2016).	

4.2.3. DSM Bidding

DSM Bidding is a performance-based energy efficiency investment grant, which award on the basis of actual energy savings generated over a year at the proposed bidding rate (DEDE, 2016a). This program has been in place from 2016 to 2017. A total of 512.13 MB has been allocated from ENCON for DSM Bidding.

Institution structure

There were three stakeholders to govern the program including the support steering committee, DEDE and program operator who has been hired by DEDE. The support steering committee has had duties including defining policies and guidelines for the implementation of the project, defining the support criteria and conditions, considering the selection of project participants, considering approving the fund for project participants and giving advice to the program operator in solving various problems (DEDE, 2016c; Kasetsart University, 2016a). DEDE has overall supervised and monitored the implementation of the project. DEDE's in-house finance department had also a responsibility to process disbursement to project participants by coordinating with the program operator (G5). Program operator comprised of three sections which were technical, administrator and M&V sections. The duties were managing the project in accordance with the objectives and goals, coordinating with project participants, being a consultant for project participants, verifying the achieved energy savings, preparing the verified energy savings report for the support steering committee, preparing related documents for disbursement and reporting the operation results of the project to DEDE.

Design

The program was created to encourage companies to implement energy efficiency measures and to build technological confidence (DEDE, 2016a). The subsidy mechanism was used to increase the attractiveness of the investment of energy efficiency measures, where the government bears part of the costs, thus reducing the resistance of the energy efficiency investment. The bidding mechanism allowed the government to support only the lowest requested subsidy rate and no more than the ceiling rate. The widespread implementation of the energy efficiency measures from the attractive cost of the investment increased energy efficiency awareness, price reduction and real energy savings demonstration which indirectly increased technological confidence.

An eligible project must have energy savings potential higher than 50,000 kWh per year. There are requirements for the equipment’s certification for ensuring quality. Conducting M&V plan as a provided guideline is requested.

The total budget fund was 521.125 MB and the maximum subsidy size was 100 MB per enterprise (DEDE, 2016a). Energy end-users both DF&Bs and non-DF&Bs and ESCO who intend to install Light Emitting Diode (LED) lighting and a high-efficiency variable speed air conditioning system were eligible for involving to bid the incentive rate (DEDE, 2016a). There are two ceiling rates, 1 bath/kWh savings for DF&Bs and 2 baht/kWh savings for non-DF&Bs (DEDE, 2016a). ESCOs may apply when authorized by the energy facility owner, which the ceiling was depending on the type of energy facility. The bidder who offered the lowest rate was awarded first and then the highest rate was awarded respectively. If the applicant was offered at the same rate, prior applying was considered as a priority. The project that has an energy saving potential greater than 50,000 kWh per annual was eligible to apply. Equipment certification was required in place for quality assurance. Implementation of the M&V process in accordance with the program’s guidelines was needed.

Operation

There were two rounds for submitting the bid, in which the first round was from July to August 2016 (contract from September 2016) and the extended round was on October to December 2016 (contract from February to November 2017) (Kasetsart University, 2016b). Energy end-users submitted a proposal for bidding. The program operator, DEDE and support steering committee coordinated to manage the bidding process, which was an assessment of its eligibility and proposed rate. Successful proponents were announced and the contract was signed with DEDE. Proponents implemented energy efficiency measures and executed M&V process. The program operator audited the M&V process to certify the energy savings achieved and remitted the funding to the bidders. Project participants submitted the documents for the disbursement process within 2 months after receiving an approved letter for a verified energy savings report.

The program was initially planned to implement for 12 months (DEDE, 2016a). Project participant was intended to complete the process within 8 months after the winning bidders' list was announced (DEDE, 2016c). However, there was a late disbursement process according to the required complex documents, which caused around 2 years duration in receiving the fund (P1).

The measures that were eligible to implement under this program were certified by the required minimum standard, the Thai Industrial Standards (TIS), minimum warranty requirement and M&V process guideline. A seminar to promote the program was held in August 2016 which there were 100 attendances from DEDE, the private sector and ESCOs (Kasetsart University, 2016b). The program operator has also conducted a meeting with industrial sector associates to promote the program (G5).

Performance

DSM Bidding provided an investment subsidy for 201 projects. The total budget allocation was 168.42 MB. The program resulted in energy savings of 11.62 ktoe and cost savings of 545.6 MB. There were only two energy efficiency measures under this program which were LED and variable speed air condition measures.

Table 4-12 DSM Bidding performance

	Unit	Phase 1
Year	-	2016 – 2017
No. of projects	Projects	201
Budget	MB	512.13
Allocation	MB	168.42
Total investment	MB	n/a
Energy cost saving	MB	545.60
Energy saving	ktoe/y	11.62

Table 4-13 Average initial investment cost per project for the hotel sector under DSM Bidding program

	Constant Investment Cost (MB2018)		
	Average	Minimum	Maximum
Large	1.16	0.10	2.63
SME	0.44	0.11	1.09

There was evidence for the hotel sector that the average investment costs per project were 1.16 2018MB for a large company and 0.44 2018MB for the SME company which were very small funds, detail shown as Table 4-13.

Challenge and opportunity analysis

Table 4-14 Challenge and opportunity analysis of DSM Bidding program

	DSM Bidding	
	Challenges	Opportunities
Institutional	• It may require higher administration cost according to meet the comprehensive M&V process to ensure achieved energy savings.	• A suitable target is strong financial companies who can invest in high up-front cost measures themselves. • The program has done well on risk management for government to ensure achieved energy savings, including a purchase order confirmation, random site visit, minimum standard requirement and comprehensive M&V process, which the practice was also implemented in the ProKilowatt program (Radgen, Bisang, & Koenig, 2016).
Technical	• The openness of technology should not limit to only two well-known measures, which are LED lighting and variable speed air conditioning.	• Suitable measures can be wide including simple measures until complex measures such as improving energy consumption throughout the production process, which is required to implement with standard M&V for ensuring energy savings.
Financial	• The award payment at once after completing projects is not friendly for winning bidders when energy efficiency measures are high investment costs and complex technology. • There is a suggestion to be ensured that the total requested incentive should be over 1.2 times of budget for a successful competitive bidding mechanism (Radgen et al., 2016). • The allocated fund was high up to 40% of investment cost, which was caused by the low participation rate under this DSM Bidding program. However, the subsidy portion can be reached 35% of the investment cost for implementing comprehensive measure under the US Efficiency Bid program (Mueller, Patnode, Bradford, Leuthauser, & Ahlberg, 2007)	• DSM Bidding, a performance-based subsidy, allows a market mechanism to establish an economical subsidy rate, which is more cost-effective than a cost-based subsidy.
Legal and regulation	• The ceiling should be improved each round according to such as previous average cost, present energy efficiency investment cost and other transaction costs (Radgen et al., 2016). • The program was a delay from the expected duration according to the long-time disbursement process (G5, P1).	• Performance-based subsidy was political acceptance by the private sector (Radgen et al., 2016).

4.2.4. Summary of stakeholders' opinions and suggestions

Table 4-15 Summary of stakeholders and energy experts' opinions and suggestions

Topic	Opinions and suggestions
Institutional	• University scholar has suggested that the green fund which is the crowding fund for investing in energy efficiency project may be another possible source of fund for enhancing energy efficiency investment (I1). • Government officer has advised that the government can work together with the private bank by providing energy efficiency loan fund as the top-up fund with the general loan fund that private bank offers to the customer because energy efficiency investment cost is seemed to be a small portion for the private sector (G1). The government sector is willing to provide technical information such as a bundle of potential measures for each industrial cluster (G1). • Privat bank officer has recommended that hotel who has potential to invest energy efficiency measure is the moderately old hotel which has an age over 7 to 8 years (G4). A further challenge for the hotel sector is that hotel usually decides to invest in energy efficiency project when the hotel has to renovate (G4). • Private bank officer has also suggested the idea for enhancing small scale energy efficiency project such as providing energy efficiency lending portfolio for bundling measures for each industrial cluster or providing debt portion for ESCOs company who do the shared savings scheme with the 100 Million THB portfolio (G4). • From a private bank's point of view, the bank had defined the SME sector by income which company has an income lesser than 400-500 Million THB (G4) that this concept is different from a government point of view which defines small company from who consumes low energy consumption. • ESCO Fund program has been a good example in term of that government-provided dedicated program to meet niche market such as a company that has ignored by a private bank (G1), however with the changing market context from the design stage of the program, ESCO Fund may transform to other services such as technical facilitator or sinking fund (I2, P2). In addition, risk management of default funds should more study before extending the implementation of the ESCO Fund program (G1). • Financial support is the main offer that the private sector still needs, while a technical consultant to help hotel investigate the potential energy efficiency project can be hired by the company themself (P1). • DSM Bidding program which is a subsidy mechanism can be implemented specifically for the target sector that is still a low investment in energy efficiency project (I2). • Energy efficiency policy support programs that were implemented in Thailand targeted the same market segments which included DF&Bs, non-DF&Bs and ESCOs and also the same widely energy efficiency technologies, which led the limited successful program implementation (I2, G2). DSM Bidding program also has been faced the competitive program which is the tax incentive by BOI (2006-2020) (G5) because the large company who has corporate tax high enough to claim the 50% cost subsidy preferred to apply for the tax incentive program.
Technical	• Many interviewees have advised that M&V process is important (I2, G1, G3). Government officer has offered that the program support for subsidizing M&V cost for very small energy efficiency project is possible to be provided (I2). ESCO fund manager has also suggested that there are the needs for energy measurement equipment rental service and a list of M&V professionals (G3). In addition, a standardized energy performance contracts should be concisely designed by a lawyer and online published for available access for anyone (G3).

Topic	Opinions and suggestions
	• Private bank officer has advised that there is the need of intensely technical facilitator which is provided from the government sector who help the energy user to develop energy efficiency project at the beginning stage (G4). • The well-known technology is already a low perceived risk for the private sector and excluding strict technical guarantees can reduce the transaction cost that is usually combined in the project cost (P2). • Providing separate support programs for which well-known or complex technologies is suggested by many interviewees. One interviewee has suggested that *'if possible, the government could help to identify the top three high technical potential energy efficiency measures to implement for each industry and building sectors and banks can use their customer database to approach the potential energy user'* (G4). • There are different energy efficiency technologies among the size of the business, for the example hotel sector, central chiller implementation for large hotel and high-efficiency air conditioner split type for medium to small hotel (G4, G3), which could be suggested separately.
Financial	• An Independent energy expert has suggested that the government may improve the tool that is equity investment for ESCO company which has not been implemented in ESCO Fund program to enhance more energy efficiency investment opportunity (I2). • Many interviewees have suggested that the low-interest rate mechanism may be used to enhance energy efficiency investment for the SME sector. An energy expert has proposed that the SME sector may receive lower rate such as a further 0.5% together with a credit guarantee mechanism (I2). Government officer has offered to provide lower than 3.5% for some industrial and building sectors to introduce emerging technology or new market in a short time (G1).
Legal and regulation	• The private sector has advised that enhancing program dissemination via television, newspaper and line message media may help to reach the deciding person who is usually elderly people (P2). The government can improve the process to be faster by using innovation that it is one of a suggestion by the private sector (P2). • The cost of lost funds and the reasons for default projects under ESCO Fund should be studied to be information for risk management by the government sector to provide other programs (I2, G1). • The long-time disbursement process under EERF and DSM Bidding program has been requested to improve by many stakeholders (G4, G5, P1).

4.2.5. Environmental benefits from the case studies in energy efficiency policy

Based on the energy efficiency projects under the hotel sector, these three governmental supporting programs resulted in the total energy savings of 37.68 Million kWh per year which it was equal to reducing greenhouse gas emission by the total of 18,835 tCO_2eq per year. Greenhouse gas emission factor for Thailand electricity system, grid mix was provided from Thailand greenhouse gas management organization (public organization) (TGO) which was 0.4999 $kgCO_2eq/kWh$.

Table 4-16 Greenhouse gas emission conservation from the hotel sector that implemented energy efficiency projects under these three programs

		EERF	ESCO Fund	DSM Bidding
Energy savings from the hotel sector	Million kWh/y	16.33	14.86	6.49
GHG emission factor for Thailand electricity system	$kgCO_2eq/kWh$	0.4999	0.4999	0.4999
GHG emission conservation from hotel sector	tCO_2eq/y	8,165	7,428	3,242
Total GHG emission conservation from hotel sector	tCO_2eq/y		18,835	

Emission factor for Thailand electricity, grid mix (TGO, 2020)

4.3. Policy Recommendations

Policy recommendations were derived based on the secondary data and the semi-structured interview from stakeholders of three programs and energy experts. Policy recommendations were drawn from the result of the cost curve of energy efficiency measures and the discussion around the current situation, the challenge and opportunity of three public support programs and concluded from the suggestions from interviewees.

The results from the study indicated that there are some policy suggestions for enhancing more energy efficiency implementation for the hotel sector including;

- There were three cost-inefficiency measures in the Thai hotel sector in which the levelized cost was higher than electricity price, including heat pump that substitute existing electric hot water equipment, variable speed drive in kitchen application and high-efficiency air conditioning (split type). These measures still needed the supporting program to enhance their technical confidence and to decrease their cost by transforming to commercial application.
- There were three well-known measures including chiller, LED and voltage regulator, which their highest costs from some hotels (the maximum cost in the range of levelized costs) were still higher than electricity price. They were also needed tools to help their penetrating in the market to reduce cost.
- The M10R7 and M20R7 scenarios, which represented a government point of view, caused a decreased cost by 26% and the scenario decreased almost half of the cost (46%) compared to the base case, which represents the private point of view. The energy efficiency investment costs were still high from the private point of view. It needed more study about policy support to enhance their implementation.
- Financial policy support should be designed and signaled tailor to market segments. Energy efficiency policy support programs that were implemented in Thailand targeted the same market segments which included DF&Bs, non-

DF&Bs and ESCOs and also the same widely energy efficiency technologies, which led the limited successful program implementation (I2, G2).

- Providing separate support programs for which well-known or complex technologies is suggested by many interviewees. One interviewee has suggested that *'if possible, the government could help to identify the top three high technical potential energy efficiency measures to implement for each industry and building sectors and banks can use their customer database to approach the potential energy user'* (G4). The well-known technology is already a low perceived risk for the private sector and excluding strict technical guarantee can reduce the transaction cost that is usually combined in the project cost (P2).
- Offering EERF with a comprehensive TA unit program may need to study more to be the program that supports SME in investment in energy efficiency project because EERF and ESCO Fund have offered evidence that SME still needs dedicated external fund with low-interest rate for investing energy efficiency projects. Many interviewees also mentioned that there is a need for an energy efficiency facilitator to help the private sector to develop since the beginning of project development (G4, I1, G2). In addition, the result of different investment costs between large and SME companies shown that the SME hotels had to invest 10% higher than large hotels to conserve the same of 1 kWh. This result confirmed that SME has had to pay higher investment cost which if the government may help to tailor-designed the program to mitigate this barrier to the SME sector.
- Due to the COVID-19 situation, the tourism sector has been decreased income. In this situation, hotels may take the opportunity to implement energy efficiency measures that are low hanging fruit measures and low investment costs to help reducing the operating costs.

CHAPTER V
CONCLUSION

Several studies provide information on the behavior of energy consumption, the rate of energy consumption, and the energy savings potential of the hotel sector. The information on the cost curves of the energy efficiency interventions has not been published elsewhere, however, and the policy gap and incentive analysis on the energy efficiency policy for hotels remains small. As context information for hotel owners, the cost curves of energy efficiency interventions can be used to determine which measures are economically feasible. Energy efficiency technologies with lower levelized costs than energy costs should be preferred for the hotel owner to be invested. Furthermore, this study applies policy gap analysis to energy efficiency policies, focusing on the obstacles raised by current policies and the potential for policy change to promote energy efficiency more effectively in the hotel sector.

Cost curve of energy efficiency measures

To explain the most cost-effective and to help compare energy rates, the cost curve of energy efficiency measures presents the levelized costs of energy efficiency measures in ascending arrangements. In the Thai hotel industry, three measures of thermal energy savings have been implemented, including heat pumps (thermal), boilers and solar collectors. For heat pump (thermal), boiler and solar collector, the average levelized energy efficiency costs were 1.07, 1.23 and 1.97 THB/kWh, respectively. Three thermal energy efficiency measures were cost-effective when the solar collector by replacing the consumption of fuel oil and the heat pump and boiler by comparing with both LPG and fuel oil energy prices.

For Thailand's hotel sector, there were twelve measures of electricity savings that the lowest average levelized cost was 0.83 THB/kWh from variable speed drive (AC) and the highest average levelized cost was 5.47 THB/kWh from high-efficiency air conditioning (split type). There were nine cost-effective measures, including variable speed drive (in air conditioning system), thermostat, chiller control, LED, freezer temperature control (E-Cube), insulation, chiller, voltage regulator, refrigerant pressure control (5-Plus). The widely recognized implementation measures were LED lighting (30 hotels) and chiller (27 hotels) among a total of 56 hotels in the study. There were three cost-ineffective measures where the levelized cost was higher than the price of electricity, including heat pumps, variable speed drive in kitchen and air conditioning (split type).

The levelized cost of variable speed drive in the air-conditioning application for the hotel industry in Thailand, which was 0.83 THB/kWh, was found to be comparable in the cement production phase, which was 1.10 THB/kWh (Hasanbeigi, Menke, & Therdyothin, 2010) and 0.65 THB/kWh (Worrell et al., 2000). The levelized cost of variable speed drive in kitchen application was six times higher than in the application of air conditioning and cement production process. The LED lighting was a large range of levelized costs, including 1.98 THB/kWh for the hotel industry and 0.44 THB/kWh for the pulp and paper industry (Sathitbunanan & Ritthong, 2017). In the pulp and paper industry, the levelized LED cost was comparable to the lowest cost in this study hotel market, which was 0.20 THB/kWh in 2018. In the Danish Energy Agency (2018) report, the broad range of application options for lighting measurement represented the widest range of costs, which the cost range of lighting measurement from 1.48 to 5.90 THB/kWh, that was similar to this study.

The average cost of the SME hotel sector was higher than the average cost of the large hotel sector, which was 2.68 and 2.44 THB/kWh respectively. It was interpreted that to conserve the same and one kWh, the SME hotel sector had to invest more than the large sector, which could result from the higher transaction costs of a small project. The data showed that the key beneficiaries of these three programs were hotels in the SME market, including 38 SME hotels (68%) out of a total of 56 hotels.

The M10R7 (moderate government aspect) scenario resulted in a 26% decrease in average costs, resulting in attractive investment measures for the heat pump (electricity) and variable speed drive (kitchen) measures. Compared with the base case, the M20R7 (high conservative government aspect) scenario decreased by almost half the cost (46%), which resulted in all interventions being cost-effective. In other words, it can be inferred that policymakers appear to assume that energy efficiency measures are usually cost-effective, while there have been some measures that, when viewed from the private sector aspect, also need more policy support to broadly implemented.

Policy recommendations

The study results showed that there are some policy recommendations for improving the implementation of more energy efficiency for the hotel sector, including;

- Three cost-inefficiency measures in the Thai hotel sector, including heat pump that substitute existing electric hot water equipment, variable speed drive in kitchen application and high-efficiency air conditioning (split type), still needed the supporting program to enhance their technical confidential and to decrease their cost by transforming to commercial application.
- Three well-known measures including chiller, LED and voltage regulator were also needed tools to help their penetration in the market to reduce cost because their maximum cost in the range of levelized costs was still higher than electricity price.

- Financial policy support should be designed and signaled tailor to market segments in both financing capacity and maturity of technology dimensions to enhance successful program implementation
- Due to the COVID-19 situation, hotels may take the opportunity to implement energy efficiency measures to save the energy and help reducing the operating costs.

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APPENDIXES

APPENDIX A

SEMI-STRUCTURED INTERVIEW QUESTIONNAIRE

INTRODUCTION

1. Interviewer introduction.
2. **Purpose of visit:** Conducting Semi-Structured interviews of relevant stakeholders, which are such as DEDE, program operators, beneficiaries, independent consultants, and academia.
3. **Survey aim:** To collect data and to learn from their experiences, opinions, know-how and recommendations by conducting policy gap and opportunity analysis in the context of institutional, technical, financial, and legal and regulation to find a current gap and to identify possible policy change for increasing energy efficiency implementation.
4. **Confidentiality:** The answers will remain confidential and will be used only for research purposes. The results will be used to support policymaker.

This research studies THREE public support programs for EE investment including (1) Energy Service Company Revolving Fund, (2) Energy Efficiency Revolving Fund, (3) DEDE Demand Side Management Bidding. This research needs to learn from the experiences opinions, and know-how of the experts to find out focusing on the challenges posed by existing policies and the opportunities for policy change to more effectively promote EE in the hotel sector. There are 2 sections within this questionnaire.

SECTION 1: Stakeholder analysis

1. Name of stakeholders, organization, and position

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2. General role

3. Years of experiences

4. Relevant projects

5. Role and responsibility in the programs

SECTION 2: Identifying Gaps, Opportunities, and Policy recommendation, with regards to the context of Institutional, Technical, Financial, and Legal and regulation.

1. What are your opinions **on the challenges posed by existing policies** for enhancing EE implementation in the hotel sector?

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2. What are your opinions **on the opportunities for policy change** to more effectively promote EE in the hotel sector?

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3. What are further recommendations **to diminish the challenges** and **maximize the available opportunities**?

Categories	**Recommendations**
Institutional	
Technical	
Financial	
Legal and regulation	

APPENDIX B

DATA INPUT AND CALCULATION
LEVELIZED COST OF ENERGY EFFICIENCY

No.	Measure Code	Program Code	Estrablished Year	No. of Year	Hotel Code	Building Type	Province	Region	Rooms	Business Type	Year of Installation	Initial Investment Cost (MB)	Electricity Savings (Million kWh/yr)	Thermal Energy Savings (Million MJ/yr)	Lifetime (Yr)	Constant Investment Cost (MB2018)	Annualized Investment Cost (MB2018/yr)	LCOEE (B2018/kWh)
1	Solar Collector	ESCO	1964	598	Hotel 1	DF&Bs	BKK	BKK	380	Medium	2010	5.12	0.83		10	5.76	1.15	1.38
2	Solar Collector	ESCO	1978	584	Hotel 2	DF&Bs	BKK	BKK	672	Medium	2010	9.78	0.86		10	10.99	2.19	2.56
3	VSD	ESCO	1963	599	Hotel 3	Non DF&Bs	SKA	Southern	184	Small	2010	0.50	0.38		10	0.56	0.11	0.29
4	VSD	ESCO	2006	556	Hotel 4	Non DF&Bs	SKA	Southern	210	Small	2010	0.43	0.15		10	0.49	0.10	0.65
5	Voltage Regulator	ESCO	1987	575	Hotel 5	DF&Bs	RYG	Eastern	240	Medium	2013	5.10	0.72		10	5.24	1.04	1.45
6	Chiller	ESCO	1987	575	Hotel 5	DF&Bs	RYG	Eastern	240	Medium	2013	5.46	0.73		10	5.62	1.12	1.53
7	LED	ESCO	1965	597	Hotel 6	DF&Bs	BKK	BKK	392	Large	2013	2.44	0.30		5	2.51	0.75	2.52
8	LED	ESCO	1986	576	Hotel 7	DF&Bs	BKK	BKK	672	Large	2013	0.60	0.05		5	0.61	0.18	3.75
9	Voltage Regulator	ESCO	1986	576	Hotel 7	DF&Bs	BKK	BKK	672	Large	2013	2.57	0.17		10	2.64	0.53	3.08
10	Chiller	ESCO	1986	576	Hotel 7	DF&Bs	BKK	BKK	672	Large	2013	9.49	0.99		10	9.76	1.95	1.97
11	VSD	ESCO	1969	593	Hotel 8	DF&Bs	CBI	Eastern	533	Large	2013	1.96	0.52		10	2.02	0.40	0.77
12	Chiller	ESCO	1980	582	Hotel 9	DF&Bs	BKK	BKK	170	Large	2013	7.33	0.53		10	7.55	1.50	2.83
13	Chiller	ESCO	2001	561	Hotel 10	Non DF&Bs	NKI	Northeastern	198	Small	2013	6.64	0.36		10	6.83	1.36	3.83
14	Voltage Regulator	ESCO	1988	574	Hotel 11	DF&Bs	BKK	BKK	318	Large	2013	2.90	0.30		10	2.98	0.59	2.00
15	LED	ESCO	1988	574	Hotel 11	DF&Bs	BKK	BKK	318	Large	2013	1.24	0.54		5	1.28	0.38	0.71
16	Chiller	ESCO	2006	556	Hotel 12	Non DF&Bs	BKK	BKK	76	Medium	2013	4.33	0.31		10	4.45	0.89	2.83
17	LED	ESCO	2006	556	Hotel 12	Non DF&Bs	BKK	BKK	76	Medium	2013	0.75	0.08		5	0.77	0.23	2.79
18	LED	ESCO	2001	561	Hotel 13	Non DF&Bs	CBI	Eastern	60	Medium	2013	1.92	0.15		5	1.97	0.59	3.90
19	Chiller	ESCO	1993	569	Hotel 14	DF&Bs	PBI	Central	193	Medium	2013	5.64	0.38		10	5.81	1.16	3.06
20	Voltage Regulator	ESCO	1993	569	Hotel 14	DF&Bs	PBI	Central	193	Medium	2013	0.97	0.07		10	1.00	0.20	2.95
21	Chiller	ESCO	1965	597	Hotel 15	DF&Bs	BKK	BKK	196	Medium	2013	6.50	0.51		10	6.69	1.33	2.62
22	Voltage Regulator	ESCO	1965	597	Hotel 15	DF&Bs	BKK	BKK	196	Medium	2013	1.04	0.06		10	1.07	0.21	3.31
23	Voltage Regulator	ESCO	1987	575	Hotel 5	DF&Bs	RYG	Eastern	240	Medium	2013	3.06	1.05		10	3.15	0.63	0.60
24	Chiller	ESCO	1987	575	Hotel 5	DF&Bs	RYG	Eastern	240	Medium	2013	4.01	0.31		10	4.13	0.82	2.61
25	Chiller	ESCO	1998	564	Hotel 16	DF&Bs	BKK	BKK	234	Medium	2013	9.62	0.53		10	9.90	1.97	3.72
26	Voltage Regulator	ESCO	1998	564	Hotel 16	DF&Bs	BKK	BKK	234	Medium	2013	0.93	0.08		10	0.96	0.19	2.32
27	LED	ESCO	1998	564	Hotel 16	DF&Bs	BKK	BKK	234	Medium	2013	0.33	0.14		5	0.34	0.10	0.74
28	Chiller	ESCO	1986	576	Hotel 17	DF&Bs	BKK	BKK	407	Large	2013	11.20	0.90		10	11.53	2.30	2.57
29	Voltage Regulator	ESCO	1986	576	Hotel 17	DF&Bs	BKK	BKK	407	Large	2013	2.02	0.14		10	2.08	0.41	2.98
30	LED	ESCO	1986	576	Hotel 17	DF&Bs	BKK	BKK	407	Large	2013	1.77	0.23		5	1.82	0.54	2.37

No.	Measure Code	Program Code	Estrablished Year	No. of Year	Hotel Code	Building Type	Province	Region	Rooms	Business Type	Year of Installation	Initial Investment Cost (MB)	Electricity Savings (Million kWh/yr)	Thermal Energy Savings (Million MJ/yr)	Lifetime (Yr)	Constant Investment Cost (MB2018)	Annualized Investment Cost (MB2018/yr)	LCOEE (B2018/kWh)
31	Chiller	ESCO	1993	569	Hotel 18	Non DF&Bs	MKM	Northeastern	77	Small	2013	4.99	0.29		10	5.14	1.02	3.48
32	Voltage Regulator	ESCO	1993	569	Hotel 18	Non DF&Bs	MKM	Northeastern	77	Small	2013	0.45	0.03		10	0.46	0.09	3.45
33	VSD	ESCO	1997	565	Hotel 19	Non DF&Bs	SKA	Southern	144	Small	2014	0.59	0.09		10	0.59	0.12	1.33
34	Boiler	ESCO	1986	576	Hotel 7	DF&Bs	BKK	BKK	672	Large	2014	4.07		2.74	10	4.11	0.82	1.08
35	Chiller	ESCO	1991	571	Hotel 20	DF&Bs	KSN	Northeastern	140	Small	2014	5.49	0.33		10	5.55	1.11	3.30
36	Boiler	ESCO	1991	571	Hotel 20	DF&Bs	KSN	Northeastern	140	Small	2014	2.45		1.28	10	2.48	0.49	1.39
37	Chiller	ESCO	1955	607	Hotel 21	Non DF&Bs	CRI	Northern	271	Medium	2017	9.49	0.36		10	9.59	1.91	5.31
38	Chiller	ESCO	2001	561	Hotel 22	Non DF&Bs	SKA	Southern	175	Small	2017	4.65	0.28		10	4.70	0.94	3.38
39	LED	DSM	2007	555	Hotel 23	DF&Bs	BKK	BKK	403	Large	2017	0.10	0.06		5	0.10	0.03	0.54
40	LED	DSM	1995	567	Hotel 24	DF&Bs	BKK	BKK	270	Large	2017	1.08	1.66		5	1.09	0.32	0.20
41	LED	DSM	2005	557	Hotel 25	DF&Bs	BKK	BKK	205	Medium	2017	1.08	0.37		5	1.09	0.33	0.88
42	LED	DSM	1994	568	Hotel 26	DF&Bs	BKK	BKK	446	Large	2017	0.37	0.17		5	0.37	0.11	0.64
43	LED	DSM	2007	555	Hotel 27	DF&Bs	BKK	BKK	166	Large	2017	0.95	0.34		5	0.96	0.29	0.84
44	LED	DSM	1987	575	Hotel 28	DF&Bs	SKA	Southern	269	Medium	2017	0.15	0.19		5	0.15	0.05	0.24
45	LED	DSM	2002	560	Hotel 29	DF&Bs	PTN	Southern	125	Medium	2017	0.19	0.12		5	0.19	0.06	0.48
46	LED	DSM	2016	546	Hotel 30	DF&Bs	CRI	Northern	256	Medium	2017	0.68	0.19		5	0.69	0.21	1.10
47	LED	DSM	2016	546	Hotel 31	DF&Bs	CMI	Northern	200	Medium	2017	0.60	0.27		5	0.60	0.18	0.67
48	LED	DSM	1986	576	Hotel 17	DF&Bs	BKK	BKK	407	Large	2017	1.11	0.29		5	1.12	0.33	1.17
49	LED	DSM	1964	598	Hotel 32	DF&Bs	BKK	BKK	381	Large	2017	1.87	0.30		5	1.89	0.56	1.85
50	LED	DSM	1980	582	Hotel 33	DF&Bs	BKK	BKK	565	Large	2017	1.23	0.57		5	1.25	0.37	0.66
51	LED	DSM	2004	558	Hotel 34	DF&Bs	BKK	BKK	505	Large	2017	2.60	1.30		5	2.63	0.78	0.60
52	LED	DSM	2008	554	Hotel 35	DF&Bs	SNI	Southern	203	Large	2017	1.03	0.43		5	1.04	0.31	0.72
53	LED	DSM	1984	578	Hotel 36	Non DF&Bs	SKA	Southern	50	Small	2017	0.11	0.12		5	0.11	0.03	0.28
54	LED	DSM	2001	561	Hotel 37	DF&Bs	CBI	Eastern	494	Medium	2017	0.22	0.11		5	0.22	0.07	0.61
55	Chiller	EERF	1982	580	Hotel 38	DF&Bs	SKA	Southern	430	Medium	2006	7.24	1.42		10	8.98	1.79	1.26
56	Chiller	EERF	1989	573	Hotel 39	DF&Bs	PKT	Southern	383	Large	2006	5.52	0.79		10	6.85	1.37	1.73
57	Chiller	EERF	1977	585	Hotel 40	Non DF&Bs	PKT	Southern	180	Medium	2006	5.35	0.64		10	6.64	1.32	2.06
58	Chiller	EERF	1987	575	Hotel 41	Non DF&Bs	LPG	Northern	100	Small	2006	2.50	0.19		10	3.10	0.62	3.29
59	Chiller	EERF	1989	573	Hotel 42	DF&Bs	NMA	Northeastern	184	Medium	2006	4.65	0.49		10	5.77	1.15	2.34
60	Chiller	EERF	1986	576	Hotel 43	DF&Bs	PKT	Southern	350	Medium	2006	6.25	0.94		10	7.76	1.55	1.65
61	Insulation	EERF	1986	576	Hotel 43	DF&Bs	PKT	Southern	350	Medium	2006	2.38	0.22		10	2.95	0.59	2.62
62	Chiller	EERF	2001	561	Hotel 44	Non DF&Bs	CBI	Eastern	69	Small	2009	12.00	0.86		10	13.94	2.78	3.22
63	Heat pump (Thermal)	EERF	1977	585	Hotel 40	Non DF&Bs	PKT	Southern	180	Medium	2009	5.00		3.09	10	5.81	1.16	1.35
64	Chiller	EERF	1989	573	Hotel 45	Non DF&Bs	LPG	Northern	235	Small	2009	3.00	0.57		10	3.49	0.69	1.22
65	Chiller Control	EERF	1978	584	Hotel 46	Non DF&Bs	PLK	Central	100	Small	2009	2.80	0.34		10	3.25	0.65	1.93
66	VSD	EERF	1978	584	Hotel 46	Non DF&Bs	PLK	Central	100	Small	2009	0.27	0.06		10	0.32	0.06	1.08
67	LED	EERF	1978	584	Hotel 46	Non DF&Bs	PLK	Central	100	Small	2009	0.02	0.01		5	0.03	0.01	1.19
68	Chiller	EERF	1988	574	Hotel 47	Non DF&Bs	SNI	Southern	200	Large	2013	9.53	1.86		10	9.81	1.95	1.05
69	Chiller	EERF	1991	571	Hotel 48	DF&Bs	KBI	Southern	221	Medium	2013	17.25	1.34		10	17.76	3.54	2.64
70	Heat pump (Thermal)	EERF	1989	573	Hotel 42	DF&Bs	NMA	Northeastern	265	Medium	2013	2.20		2.07	10	2.26	0.45	0.78

No.	Measure Code	Program Code	Estrablished Year	No. of Year	Hotel Code	Building Type	Province	Region	Rooms	Business Type	Year of Installation	Initial Investment Cost (MB)	Electricity Savings (Million kWh/yr)	Thermal Energy Savings (Million MJ/yr)	Lifetime (Yr)	Constant Investment Cost (MB2018)	Annualized Investment Cost (MB2018/yr)	LCOEE (B2018/kWh)
71	Chiller	EERF	1989	573	Hotel 42	DF&Bs	NMA	Northeastern	265	Medium	2013	6.32	0.96		10	6.50	1.30	1.34
72	Chiller	EERF	2002	560	Hotel 49	DF&Bs	CBI	Eastern	222	Medium	2018	3.71	0.19		10	3.71	0.74	3.96
73	Chiller	EERF	2002	560	Hotel 49	DF&Bs	CBI	Eastern	222	Medium	2018	0.63	0.05		10	0.63	0.13	2.69
74	Voltage Regulator	EERF	1985	577	Hotel 50	DF&Bs	PKT	Southern	524	Large	2018	4.09	0.19		10	4.09	0.81	4.19
75	HE AC	EERF	1985	577	Hotel 50	DF&Bs	PKT	Southern	524	Large	2018	20.50	0.63		10	20.50	4.08	6.52
76	LED	EERF	1985	577	Hotel 50	DF&Bs	PKT	Southern	524	Large	2018	2.85	0.13		5	2.85	0.85	6.60
77	Heat pump (Electricity)	EERF	1985	577	Hotel 50	DF&Bs	PKT	Southern	524	Large	2018	7.35	0.30		10	7.35	1.46	4.82
78	E-Cube	EERF	1985	577	Hotel 50	DF&Bs	PKT	Southern	524	Large	2018	0.06	0.01		10	0.06	0.01	1.75
79	VSD	EERF	1985	577	Hotel 50	DF&Bs	PKT	Southern	524	Large	2018	0.48	0.01		10	0.48	0.10	7.04
80	Voltage Regulator	EERF	1988	574	Hotel 51	Non DF&Bs	PKT	Southern	75	Medium	2018	1.37	0.05		10	1.37	0.27	5.02
81	HE AC	EERF	1988	574	Hotel 51	Non DF&Bs	PKT	Southern	75	Medium	2018	4.21	0.13		10	4.21	0.84	6.64
82	LED	EERF	1988	574	Hotel 51	Non DF&Bs	PKT	Southern	75	Medium	2018	0.48	0.04		5	0.48	0.14	3.77
83	Heat pump (Electricity)	EERF	1988	574	Hotel 51	Non DF&Bs	PKT	Southern	75	Medium	2018	1.36	0.06		10	1.36	0.27	4.70
84	E-Cube	EERF	1988	574	Hotel 51	Non DF&Bs	PKT	Southern	75	Medium	2018	0.03	0.00		10	0.03	0.01	3.39
85	VSD	EERF	1988	574	Hotel 51	Non DF&Bs	PKT	Southern	75	Medium	2018	0.49	0.01		10	0.49	0.10	6.67
86	Voltage Regulator	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	2.81	0.10		10	2.81	0.56	5.38
87	LED	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	0.69	0.04		5	0.69	0.21	4.86
88	5-Plus	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	2.66	0.13		10	2.66	0.53	4.04
89	Thermostat	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	0.59	0.07		10	0.59	0.12	1.66
90	HE AC	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	0.83	0.03		10	0.83	0.17	5.27
91	E-Cube	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	0.05	0.01		10	0.05	0.01	0.97
92	VSD	EERF	2011	551	Hotel 52	Non DF&Bs	KBI	Southern	170	Medium	2018	0.46	0.03		10	0.46	0.09	3.24
93	LED	EERF	2004	558	Hotel 53	DF&Bs	PNA	Southern	153	Medium	2018	1.06	0.05		5	1.06	0.32	6.06
94	5-Plus	EERF	2004	558	Hotel 53	DF&Bs	PNA	Southern	153	Medium	2018	4.33	0.27		10	4.33	0.86	3.16
95	Thermostat	EERF	2004	558	Hotel 53	DF&Bs	PNA	Southern	153	Medium	2018	0.62	0.13		10	0.62	0.12	0.99
96	E-Cube	EERF	2004	558	Hotel 53	DF&Bs	PNA	Southern	153	Medium	2018	0.05	0.01		10	0.05	0.01	1.34
97	VSD	EERF	2004	558	Hotel 53	DF&Bs	PNA	Southern	153	Medium	2018	0.76	0.03		10	0.76	0.15	5.91
98	HE AC	EERF	2004	558	Hotel 53	DF&Bs	PNA	Southern	153	Medium	2018	1.34	0.07		10	1.34	0.27	3.82
99	Voltage Regulator	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	3.24	0.21		10	3.24	0.65	3.12
100	LED	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	1.63	0.12		5	1.63	0.49	3.89
101	5-Plus	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	4.31	0.24		10	4.31	0.86	3.51
102	Thermostat	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	1.00	0.13		10	1.00	0.20	1.51
103	Heat pump (Electricity)	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	2.51	0.13		10	2.51	0.50	3.85
104	E-Cube	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	0.08	0.01		10	0.08	0.01	2.54
105	VSD	EERF	1988	574	Hotel 54	DF&Bs	PKT	Southern	275	Large	2018	0.85	0.08		10	0.85	0.17	2.06
106	Voltage Regulator	EERF	2004	558	Hotel 55	DF&Bs	SNI	Southern	183	Medium	2018	2.33	0.16		10	2.33	0.46	2.93
107	LED	EERF	2004	558	Hotel 55	DF&Bs	SNI	Southern	183	Medium	2018	1.22	0.08		5	1.22	0.36	4.71
108	5-Plus	EERF	2004	558	Hotel 55	DF&Bs	SNI	Southern	183	Medium	2018	2.57	0.15		10	2.57	0.51	3.31
109	Thermostat	EERF	2004	558	Hotel 55	DF&Bs	SNI	Southern	183	Medium	2018	0.07	0.01		10	0.07	0.01	1.08
110	E-Cube	EERF	2004	558	Hotel 55	DF&Bs	SNI	Southern	183	Medium	2018	0.06	0.00		10	0.06	0.01	3.18
111	VSD	EERF	2004	558	Hotel 55	DF&Bs	SNI	Southern	183	Medium	2018	0.25	0.02		10	0.25	0.05	3.05
112	HE AC	EERF	2010	552	Hotel 56	Non DF&Bs	TRT	Eastern	38	Small	2018	1.90	0.07		10	1.90	0.38	5.09

APPENDIX C

ENERGY PRICE

The retail price of petroleum products in Bangkok

UNIT:BATH/LITRE

PRODUCTS	4. FUEL OIL		5. LPG				
	600 (2%S)	1500 (2%S)	LOW INCOME HOUSEHOLD (B/Kg)	COOKING (B/Kg)	INDUSTRY (B/Kg)	AUTOBILE (B/Kg)	AUTOBILE (BAHT/L)
2018 (MIN)	25.92	24.06	18.63	21.13	21.13	21.13	11.41
(WT.AVG)	28.20	26.15	18.78	21.28	21.28	21.28	11.49
(MAX)	31.04	29.23	19.08	21.58	21.58	21.58	11.65
-JAN (MIN)	23.97	22.26	17.32	19.82	19.82	19.82	10.70
(WT.AVG)	26.22	24.01	17.88	20.38	20.38	20.38	11.01
(MAX)	29.01	27.67	18.79	21.29	21.29	21.29	11.50
-FEB (MIN)	23.74	22.03	17.32	19.82	19.82	19.82	10.70
(WT.AVG)	25.99	23.78	17.32	19.82	19.82	19.82	10.70
(MAX)	28.78	27.44	17.32	19.82	19.82	19.82	10.70
-MAR (MIN)	23.97	22.26	17.32	19.82	19.82	19.82	10.70
(WT.AVG)	26.22	24.01	17.32	19.82	19.82	19.82	10.70
(MAX)	29.01	27.67	17.32	19.82	19.82	19.82	10.70
-APR (MIN)	24.32	22.61	17.32	19.82	19.82	19.82	10.70
(WT.AVG)	26.57	24.36	17.85	20.35	20.35	20.35	10.99
(MAX)	29.36	28.02	18.45	20.95	20.95	20.95	11.31
-MAY (MIN)	26.09	22.57	18.65	21.15	21.15	21.15	11.42
(WT.AVG)	28.36	24.33	19.34	21.84	21.84	21.84	11.79
(MAX)	31.18	27.99	21.45	23.95	23.95	23.95	12.93
-JUN (MIN)	26.38	24.67	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	28.67	26.45	19.37	21.87	21.87	21.87	11.81
(MAX)	31.51	30.17	19.37	21.87	21.87	21.87	11.81
-JUL (MIN)	26.96	25.25	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	29.26	27.04	19.37	21.87	21.87	21.87	11.81
(MAX)	32.11	30.78	19.37	21.87	21.87	21.87	11.81
-AUG (MIN)	26.96	25.25	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	29.26	27.04	19.37	21.87	21.87	21.87	11.81
(MAX)	32.11	30.78	19.37	21.87	21.87	21.87	11.81
-SEP (MIN)	26.96	25.25	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	29.27	27.05	19.37	21.87	21.87	21.87	11.81
(MAX)	32.13	30.80	19.37	21.87	21.87	21.87	11.81
-OCT (MIN)	27.96	26.25	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	30.29	28.06	19.37	21.87	21.87	21.87	11.81
(MAX)	33.17	31.83	19.37	21.87	21.87	21.87	11.81
-NOV (MIN)	27.81	26.10	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	30.11	27.89	19.37	21.87	21.87	21.87	11.81
(MAX)	32.96	31.62	19.37	21.87	21.87	21.87	11.81
-DEC (MIN)	25.87	24.22	19.37	21.87	21.87	21.87	11.81
(WT.AVG)	28.22	29.79	19.37	21.87	21.87	21.87	11.81
(MAX)	31.12	26.02	19.37	21.87	21.87	21.87	11.81

Source: EPPO online database, 2018

The retail electricity price

Schedule 2 Small General Service

Applicable to businesses, businesses with residential, industrials, government institutions, local authorities, state enterprises, embassies, establishments related to foreign countries or international organizations, and so on, including their compound with the maximum of an average integrated demand of energy in 15 minutes lower than 30 kW., through a single Watt-hour meter.

Monthly Rate

2.1 Normal Rate	Energy Charge (Baht/kWh)	Service Charge (Baht/Month)
2.1.1 At voltage level 22 - 33 kV.	3.9086	312.24
2.1.2 At voltage level lower than 22 kV.		46.16
First 150 kWh. (0 – 150 th)	3.2484	
Next 250 kWh. (151 st – 400 th)	4.2218	
Over 400 kWh. (401 st and over)	4.4217	

2.2 Time of Use Rate (TOU)	Energy Charge (Baht/kWh)		Service Charge (Baht/Month)
	Peak	Off-Peak	
2.2.1 At voltage level 22 - 33 kV.	5.1135	2.6037	312.24
2.2.2 At voltage level lower than 22 kV.	5.7982	2.6369	46.16

Note: 1. As for tariff No. 2.2, if the customer installs a meter on a low voltage side of his/her transformer, another 2% of kWh will be added to the energy consumption to compensate for the losses in the transformer.

2. Tariff No. 2.2 is an optional rate, in order that the customer is obligated to pay for any additional cost specified by PEA. After the minimum use of 12 months, the customer can require to be in tariff No. 2.1

3. If the maximum of an average integrated demand of energy in 15 minutes is equal to 30 kW. or over, the customer will be classified under the schedule 3 – 5 depend on the case.

Schedule 3 Medium General Service

Applicable to businesses, industrials, government institutions, local authorities, state enterprises, embassies, establishments related to foreign countries or international organizations, and so on, including their compound with the maximum of an average integrated demand of energy in 15 minutes in any period of time from 30 kW. to lower than 1,000 kW., and an average energy consumption in the last 3 consecutive months are not over 250,000 kWh. per month, through a single demand meter.

Monthly Rate

3.1 Normal Rate	Demand Charge (Baht/kW)	Energy Charge (Baht/kWh)	Service Charge (Baht/Month)
3.1.1 At voltage level 69 kV. and over	175.70	3.1097	312.24
3.1.2 At voltage level 22 - 33 kV.	196.26	3.1471	312.24
3.1.3 At voltage level lower than 22 kV.	221.50	3.1751	312.24

3.2 Time of Use Rate (TOU)	Demand Charge (Baht/kW)	Energy Charge (Baht/kWh)		Service Charge (Baht/Month)
	Peak	Peak	Off-Peak	
3.2.1 At voltage level 69 kV. and over	74.14	4.1025	2.5849	312.24
3.2.2 At voltage level 22 - 33 kV.	132.93	4.1839	2.6037	312.24
3.2.3 At voltage level lower than 22 kV.	210.00	4.3297	2.6369	312.24

Minimum Charge: The minimum charge cannot be lower than 70% of the maximum demand charge in the last 12 months, ending in the current month.

Note: 1. If the customer installs a meter on a low voltage side of his/her transformer, another 2% of kW and kWh will be added to the energy consumption to compensate for the losses in the transformer.

2. Tariff No. 3.1 is for customer who classified under tariff No. 3.1 before November 2015. The customer may switch to tariff No. 3.2 by paying for any additional cost specified by PEA, and cannot be able to switch back to tariff No. 3.1.

3. The maximum 15 minutes integrated demand is lower than 30 kW., this rate will still be applied. If the demand drops to lower than 30 kW. for 12 consecutive months and still be lower than 30 kW. in the 13th month, the customer will be reclassified under tariff No. 2.1 or No. 2.2 depend on the case. The customer who has classified under TOU rate, and has paid, will not have to pay an additional cost.

Schedule 4 Large General Service

Applicable to Businesses, industrials, government institutions, local authorities, state enterprises, embassies, establishments related to foreign countries or international organizations, and so on, including their compound with the maximum of an average integrated demand of energy in 15 minutes in any period of time from 1,000 kW. and over or an average energy consumption in the last 3 consecutive months are over 250,000 kWh per month through a single demand meter.

Monthly Rate

4.1 Time of Day Rate (TOD)	Demand Charge (Baht/kW)			Energy Charge (Baht/kWh)	Service Charge (Baht/Month)
	Peak	Partial	Off-Peak		
4.1.1 At voltage level 69 kV. and over	224.30	29.91	0	3.1097	312.24
4.1.2 At voltage level 22 - 33 kV.	285.05	58.88	0	3.1471	312.24
4.1.3 At voltage level lower than 22 kV.	332.71	68.22	0	3.1751	312.24

Peak : 06.30 p.m. – 09.30 p.m. everyday
Partial : 08.00 a.m. – 06.30 p.m. everyday (Demand charge is considered only the excess demand over peak period)
Off-Peak : 09.30 p.m. – 08.00 a.m. everyday

4.2 Time of Use Rate (TOU)	Demand Charge (Baht/kW)	Energy Charge (Baht/kWh)		Service Charge (Baht/Month)
	Peak	Peak	Off-Peak	
4.2.1 At voltage level 69 kV. and over	74.14	4.1025	2.5849	312.24
4.2.2 At voltage level 22 - 33 kV.	132.93	4.1839	2.6037	312.24
4.2.3 At voltage level less than 22 kV.	210.00	4.3297	2.6369	312.24

Minimum Charge: The minimum charge cannot be lower than 70% of the maximum demand charge in the last 12 months, ending in the current month.

Note: 1. Tariff No. 4.1 is for customer who classified under tariff No. 4.1 before November 2015. The customer may switch to tariff No. 4.2 by paying for any additional cost specified by PEA, and cannot be able to switch back to tariff No. 4.1.

2. The maximum 15 minutes integrated demand is lower than 1,000 kW., or the monthly energy consumption is not over 250,000 kWh., this rate will still be applied. If the demand drops to lower than 30 kW. for 12 consecutive months and still be lower than 30 kW. in the 13th month, the customer will be reclassified under tariff No. 2.1 or No. 2.2 depend on the case. The customer who has classified under TOU rate, and has paid, will not have to pay an additional cost.

Source: PEA, November 2018

BIOGRAPHY

Ms. Athita Vivatpinyo was born in 1987 in Thailand. She has been a master student at Environment, Development and Sustainability program, Chulalongkorn University. She graduated bachelor's degree in environmental engineering from Chiang Mai University in 2010. In the last semester of her degree, she has been an exchange student at Osaka University, which she has done a mini-research about balancing the risk of chlorination. She has worked as a sales support engineer in the water and wastewater system business for one year after graduation. She has decided to change her job field from engineering-business to engineering-research due to her interesting career path. She has been working at Energy for Environment Foundation in a technical officer position that given her an opportunity to work both in engineering and policy-related officer fields. Due to her career experience, she is interested in policy, energy and the environment. She has published the conference proceedings that the title is “Challenges of Energy Efficiency Promoting Policy in Thailand” which was presented in the International Conference on Sustainable Energy and Green Technology 2018.