



## Evaluation of energy conservation measures in designated buildings comply with Energy Conservation Promotion Act B.E. 2535 (Amended B.E. 2550) during 2010-2019

Chaisumet Luengyotluechakul<sup>1</sup>, Narawat Wongkham<sup>2</sup>, Pornrapeepat Bhasaputra<sup>2</sup>, and Woraratana Pattaraprakorn<sup>1</sup>

<sup>1</sup>Department of Chemical Engineering, Faculty of Engineering, Thammasat University, Pathumthani, Thailand

<sup>2</sup>Department of Electrical and Computer engineering, Faculty of Engineering, Thammasat University, Pathumthani, Thailand

### Abstract

The Ministry of Energy of Thailand has seen the country's energy consumption trend increasing. Therefore, an energy conservation plan was issued to set goals and action plans for energy conservation over a period of 20 years starting from 2011 in accordance with the energy conservation law of the Energy Conservation Promotion Act of 1992. The amended version of 2007 stipulates that an energy management report should be submitted regularly. The report contains interesting information to study measures that should promote effective energy conservation results.

This research presents the amount of energy use and measures that should be promoted from data collected from the Energy Conservation Report sent to the Department of Alternative Energy Development and Efficiency over the past 10 years from 2010 to 2019, totaling 26,595 volumes. There is an economical effect on investment in each type of measure followed by 1. The housekeeping measures (HK) result is by determining the right on-off time is 45.84%, 2. The Machine change (MC) measure result is by changing from tungsten-halogen bulbs to LED bulbs is 0.797 %, 3. The Produce Improvement (PI) measure by using the variable speed system (VVVF) on the motor of the cold-water pump is 0.797 %. And other processes result by Enable-Disable Control is 2.34 %.

**Keywords:** Designated Buildings, Energy Conservation, Energy Conservation Measures, 10-year success

### 1. Introduction

The Ministry of Energy has developed the 20 years Energy Efficiency Plan (2011-2030) (EEDP 2011) to set the short-term 5 years and the long-term 20 years period energy conservation goals. These include the economic sector, transport sector, industrial sector, business building sector, and the residential sector. To achieve the objectives, develop strategies and recommendations to promote energy conservation. By 2030, it seeks to lower energy intensity by 20% compared to 2005 (Ministry of Energy, 2011). The plan was assessed by the Department of Energy in 2015 (Energy Efficiency Plan; EEP 2015).

Due to the economic expansion trend of Thailand and infrastructure investment plans according to government policy, The Ministry of Energy has deployed 5 main energy plans following (1) Thailand's Electric Power Development Plan (PDP) (2) Energy Efficiency Plan (EEP) (3) Renewable Energy Development Plan and Alternative Energy (AEDP), (4) Thailand's natural gas procurement plan and (5) oil and fuel management plan, the Ministry of Energy has set targets under the energy conservation plan framework during the year. 2015-2036 to reduce energy intensity by 30 percent by 2036 compared to 2005 (Ministry of Energy, 2015) and later due to the current energy consumption situation. and energy demand that tends to rise, Thailand has therefore formulated various plans or policies that are consistent with the 20-year national strategy, covering a period of 2018 – 2037, the Ministry of Energy agrees that 4 plans should be improved, namely, (1) Energy Efficiency Plan, (2) Alternative and Alternative Energy Development Plan, (3) Natural gas management plan, and (4) fuel management plan in accordance with the plan for efficient energy resource management and will lead to solving the country's energy problems and set goals under the framework of the Energy Efficiency Plan during the year 2018-2037 (2018-2037) to reduce energy consumption intensity by 30 percent in 2037 compared to the Year 2010 (Ministry of Energy, 2018).



When considering energy consumption classified by economic sector, it was found that the industrial sector has the highest energy consumption and has the highest energy consumption continuously for 10 years. This research is interested in studying the appropriate measures in the control building as part of this industry branch (Department of Alternative Energy Development and Efficiency, 2014; Department of Alternative Energy Development and Efficiency, 2019).

**Table 1** Energy Consumption (Ktoe) 2010-2019

<b>Economic Sectors</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
Agriculture	3,499	3,686	3,790	3,906	3,957	3,891	2,987	2,652	2,876	2,940
Industry	25,571	24,845	26,910	27,193	28,110	28,438	29,466	28,459	30,440	31,144
Residential	10,963	11,040	11,305	11,367	11,459	11,099	11,071	10,870	11,001	11,171
Commercial	5,621	5,511	6,081	5,805	5,477	5,952	6,215	6,452	6,549	6,846
Transportation	24,594	25,480	26,230	26,943	26,801	28,501	30,190	32,319	33,086	33,607

The renewable energy development plan that took place between 2011 and 2018 was born as a result of the enactment of the Energy Conservation Promotion Act, B.E. 1992 (Ministry of Energy, 1992).

As amended by Energy Conservation Promotion Act (No.2), B.E. 2550 (2007) to conserve energy in machinery or equipment and to promote the use of energy-efficient materials, the Cabinet, under the recommendation of the National Energy Policy Council, shall have the power to issue the Material Regulations as follows:

1) To designate machinery or equipment as having high efficiency, according to the types and sizes of the machinery and equipment, the quantities of energy consumption, the rate of energy loss, and the efficiency in energy consumption.

2) To determine which materials, by types, qualities, and standards, are materials used for energy conservation. Producers and distributors of high-efficiency machinery, equipment, or materials to be used for energy conservation under Clause one hereof, shall have the right to ask for support and assistance under Section 40 (ECP Act B.E. 2535; Ministry of Energy, 1992).

Also, in order to be able to identify the regulatory groups, a royal decree (1995) has been issued designating designated buildings as follows:

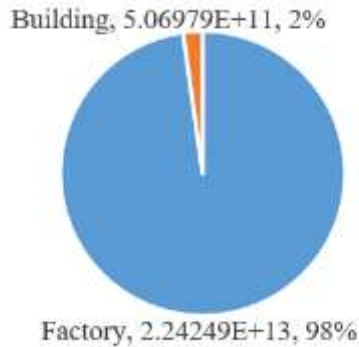
1) A building (Factory) or buildings (Factory) under the same address that are allowed by any energy distributor to install an electricity metering device, or to install one or more transformers whose combined capacity is 1,000 kilowatts or 1,175 kilovolt-amperes and up.

2) A building (Factory) or buildings (Factory) under the same address that consumes commercial energy including electricity and steam as from January 1 to December 31 of the past year in the total volume of energy of 20 million megajoules or more of electrical energy equivalent (Ministry of Energy, 1995).

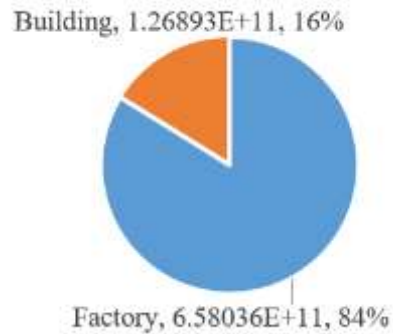
During the interesting period of 10 years in this study, the proportion of total energy consumption of the controlled building compared to the total power consumption (Buildings and factories) Buildings use a lot less energy than factories because the number of factories is 37,914 factories, but the total number of buildings is only 20,474 buildings. A total of 58,388 laws are included in both factory and buildings directed during this period.

The energy consumption of controlled buildings as shown in orange color in the past 10 years between 2010-2019 was divided into 92.68% of electricity consumption and 7.32 percent of the use of heat energy, showing the behavior of most of the energy consumption. Controlled buildings consume a large portion of the electricity consumption as shown in Figure 1, and when dividing the energy consumption for each year, the proportion of electricity and thermal energy consumption for each year is similar. Although this behavior has not changed over a period of 10 years as shown in Figure 2.

[502]

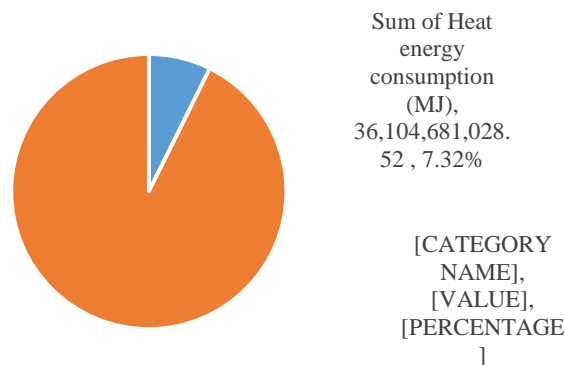


**Figure 1** Proportion of consumption of controlled buildings in the past 10 years



**Figure 2** Proportion of electricity consumption of designated buildings in the past 10 years

The number of designated buildings and factories in the system is constantly increasing every year. However, the number of energy management reports submitted to the Department of Alternative Energy Development and Efficiency each year has continued to increase in years 1-7 but has declined steadily in the last 3 years, as shown in Figure 3 and Table 1. As designated buildings and some designated factories filed for a waiver for more energy conservation, this is a channel through which designated buildings and designated factories that are expected to consume less than 20 million megajoules of energy that year can apply for a waiver. legal the total number of energy management reports submitted in the 10 years from 2010 to 2019, a total of 26,595 buildings were diagnosed as controlled buildings, and 19,642 reports were submitted according to the law, representing 73.8% compliance with the law.



**Figure 3** Proportion of electricity and heat energy consumption of the total controlled building in 2010-2019.

Energy Conservation Measures of Designated Buildings Controlled buildings that have been operating under the law for the past 10 years have A total of 303 energy conservation measures have been implemented. These measures can be divided into 4 main processes. 1) Housekeeping Measure (HK) to maintain the efficiency of machinery and equipment is always good as this measure does not invest, takes less time in implementation, and is popular in operation. 2) Machine change (MC) modifies some machinery and equipment to have a higher efficiency to a certain extent, however, this measure requires a higher investment. 3) Produce Improvement (PI) to adjust the whole production process for maximum performance, this measure requires the highest investment capital. 4) Other measures to collect data from the many buildings that the supervises include some of the processes that can be identified, or the data



sender is uncertain which process will be included. Item 4 was added to facilitate the management of DEDE's information (Department of Alternative Energy Development and Efficiency, 2007).

## 2. Objectives

- 1) To analyze the use of energy consumption in designated buildings under the Energy Conservation Promotion Act (No. 2) (2007) during the 10 years from 2010 to 2019. Begin with an action verb to describe the behavior at the appropriate level of learning.
- 2) To analyze the measures that have been applied to the top 10 most designated buildings in designated buildings under the Energy Conservation Promotion Act (No. 2) (2007) during the 10 years from 2010 to 2019.
- 3) To analyze and find appropriate measures to conserve energy in designated buildings under the Energy Conservation Promotion Act (No. 2) (2007)

## 3. Materials and Methods

The Department of Alternative Energy Development and Efficiency provided the data for this investigation (DEDE). Because the building must comply with the law, it is required to submit an energy management report to the DEDE by March 31 of each year, beginning with the 2009 annual report. Currently, the report has been filed for ten years, from 2010 to 2019, and there is a wealth of information to research on energy conservation, including energy usage, business type, and location of operation. Measures performed to conserve energy, investments made in energy conservation, and so on.

The information used in this research was acquired from designated buildings that follow the law, appoint an energy manager, and submit an annual report to the Department of Alternative Energy Development and Efficiency (DEDE). In 2009, the annual report was submitted for the first time. The report has been presented for the last ten years, from 2010 to 2019. Energy conservation studies reveal a wealth of information, including energy use, business type, and location of operation. Measures are made to conserve energy and invest in energy conservation. The Department of Alternative Energy Development and Efficiency has classified the reference industries according to Types of Thailand Industrial Standards (Thailand Standard Industrial Classification: TSIC) using classification criteria and coding according to international industry standard classification (International Standard Industrial Classification of All Economic Activities 1968: ISIC) of the United Nations (United Nations) for the benefit of administration such as supervision, promotion, advice, statistical collection of designated buildings and factories. and other relevant economic statistics as well as being able to compare data with other countries in the international system in addition, various departments can also be used for manpower planning, education, training, and national development planning (National Statistical Office, 2009). The Department of Alternative Energy Development and Efficiency classifies 20 types of designated buildings and factories. It is divided into controlled buildings as follows: 1) Hotel 2) Hospital 3) Cattle farm 4) Shopping centers 5) Educational institutions 6) Offices 7) Other buildings by the number of energy management reports submitted to the Department of Alternative Energy Development and Efficiency for 10 years from 2010-2019, including the number of legal reports submitted. 26,595 cases can be shown as the proportion of energy use of the controlled factories in the years 2010-2019 classified by building type as shown in Figure 4 and Table 2.

Between 2010 and 2019, the number of designated buildings entering the mandatory energy management system increased each year, with office buildings and retail malls accounting for the majority of the total. This reflects a rise in the number of regulated buildings, which will result in higher energy usage.

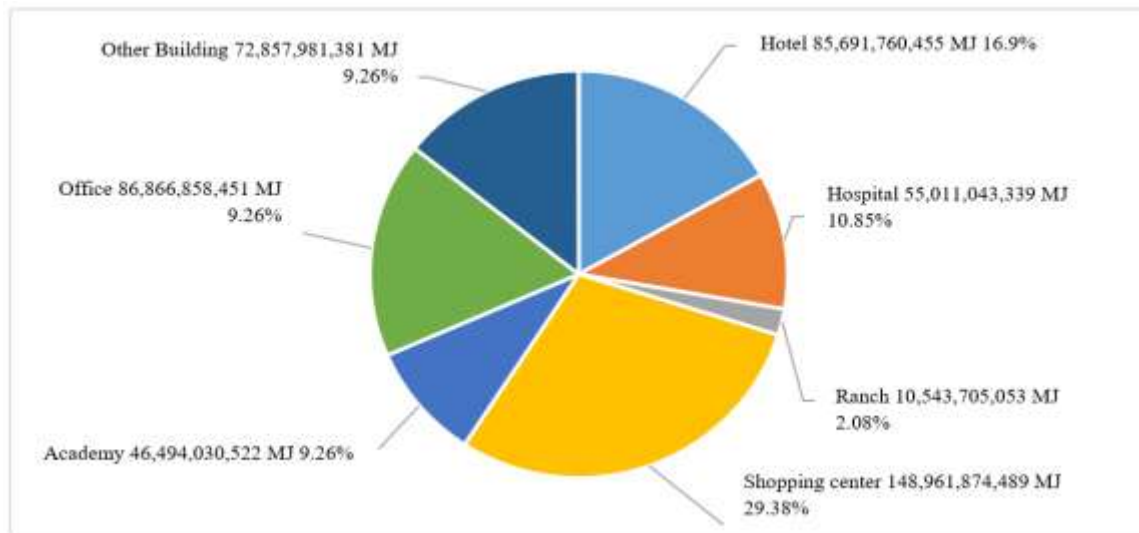
Basic statistical approaches should be used to assess these data. Using the Department of Energy Development and Efficiency's selection method for energy conservation measures, which utilizes the



criteria to compare the savings in energy conservation on investment to compare measures that are the most worthwhile investment, the first 5 most from the measures that are classified into 4 measures are used.

**Table 2** Thailand Standard Industrial Classification: TSIC and energy consumption of the Controlled Building in 2010-2019

	Thailand Standard Industrial Classification: TSIC	Type of TSIC
1	Hotels	Building
2	Hospitals	Building
3	Ranches	Building
4	Shopping centers	Building
5	Academy	Building
6	Offices	Building
7	Other buildings	Building



**Figure 4** Proportion of energy use of controlled factories in 2010-2019 classified by building type

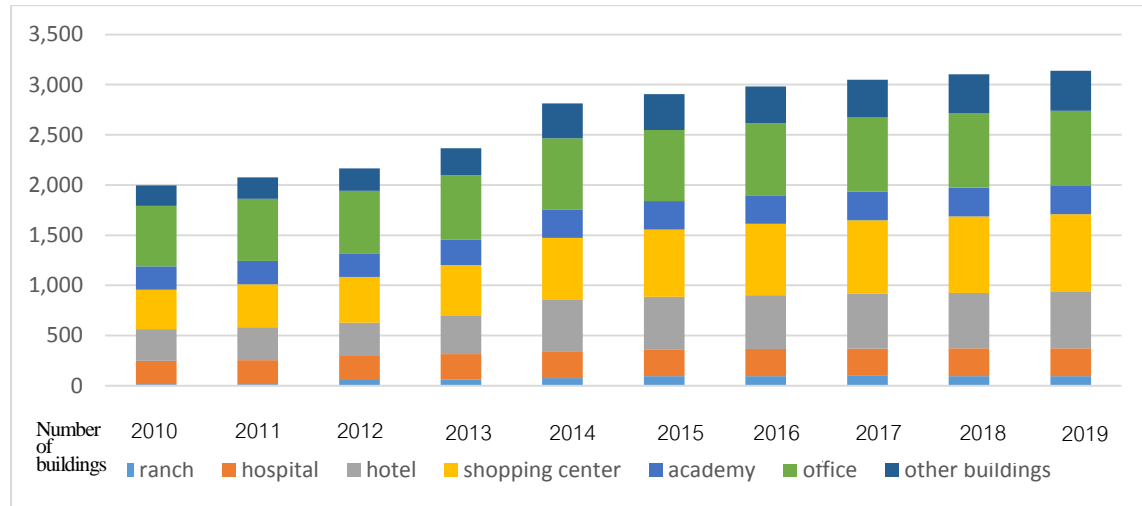


Figure 5 Number of designated buildings in 2010-2019 in each industry type

#### 4. Results and Discussion

Under the Energy Conservation Promotion Act, B.E. By starting to submit an energy management report in 2010 for the first time, this research would like to present me an analysis of the data in various aspects. That affects energy conservation by referring to the database of the Department of Alternative Energy Development and Efficiency By using the data for a period of 10 years from 2010 to 2019, the results of the research present the following information.

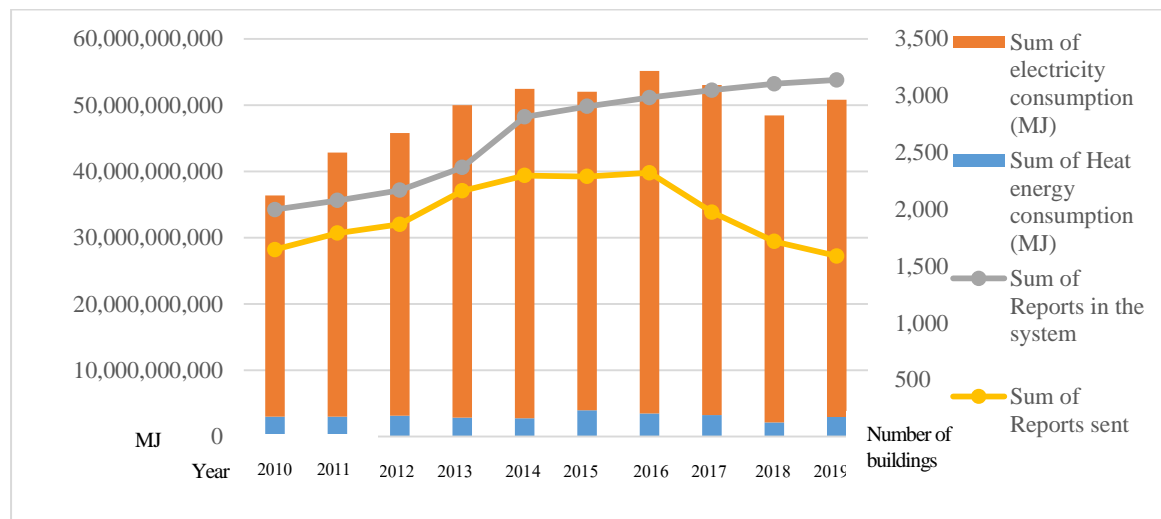


Figure 6 The energy consumption of the designated building and the number of reports 2010-2019

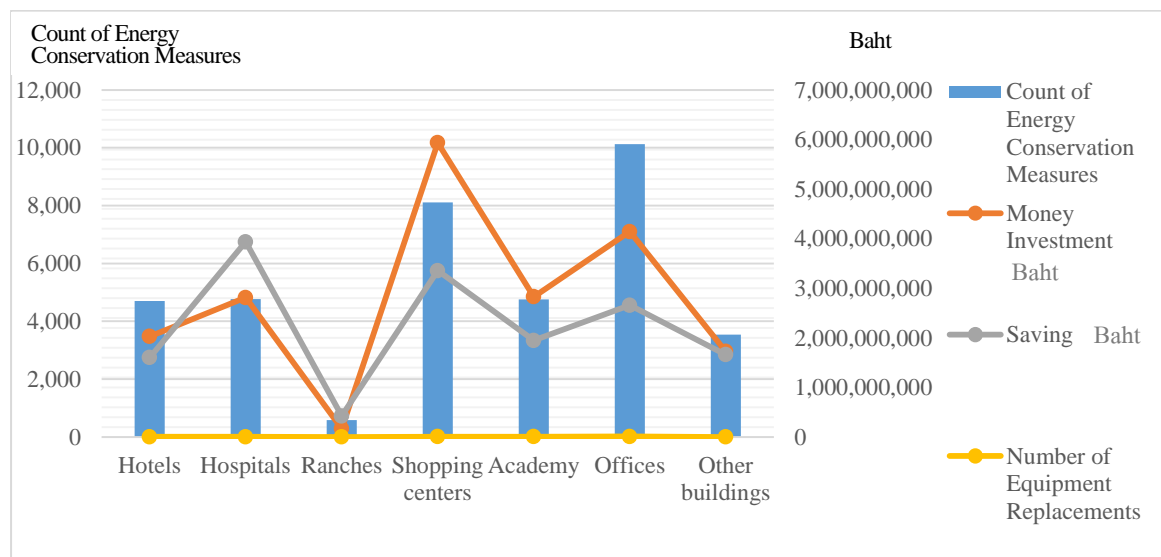


**Table 3** The amount of energy consumption of the designated building in 2010-2019 and the number of reports submitted

Year	Sum of Heat energy consumption (MJ)	Sum of electricity consumption (MJ)	Reports in the system	Reports sent
2010	2,991,321,166.62	33,358,979,331.29	1,996	1,644
2011	2,968,929,718.37	39,843,591,881.62	2,077	1,789
2012	3,126,362,913.51	42,675,678,908.24	2,166	1,866
2013	2,808,089,366.51	47,179,655,143.81	2,367	2,161
2014	2,720,059,192.40	49,743,951,354.97	2,812	2,297
2015	3,957,857,400.24	48,073,567,883.06	2,905	2,288
2016	3,437,315,927.55	51,709,649,592.08	2,982	2,320
2017	3,195,014,251.94	49,842,464,333.98	3,048	1,974
2018	2,121,027,334.41	46,317,319,418.02	3,104	1,716
2019	2,920,743,273.45	47,890,286,412.44	3,138	1,587
Sum	30,246,720,545.02	456,635,144,259.51	26,595	19,642

**Energy Conservation Effects of designated Buildings**

Energy conservation performance of designated buildings during 2010-2019, if considering each type of industry according to (Thailand Standard Industrial Classification: TSIC) that the Department of Alternative Energy Development and Efficiency uses to classify each type of building by 1) Hotels, 2) Hospitals, 3) Ranches, 4) Shopping centers, 5) Academy, 6) Offices, 7) Other buildings. Between 2010 and 2019, there were 36,586 measures implemented, with a total investment in energy conservation of 19,638,177,227.28 Baht, the number of replacement devices of 28,563,294 devices, and energy conservation results of 15,582,353,481.44 Baht, which can be classified by type of industry as shown in Figure 6 and Table 3.



**Figure 7** Number of designated buildings in 2010-2019 in each industry type

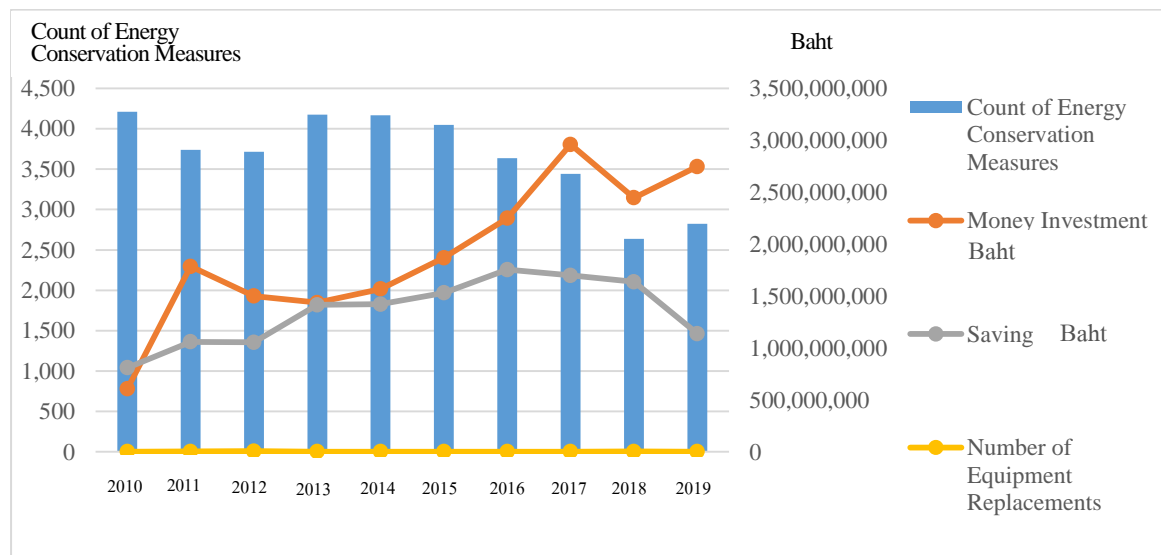


**Table 4** Thailand Standard Industrial Classification: TSIC and energy consumption of the designated Building in 2010-2019

	Thailand Standard Industrial Classification: TSIC	Count of Energy Conservation Measures	Money Investment (Baht)	Number of Equipment Replacements	Saving (Baht)
1	Hotels	4,705	2,027,835,741.69	1,528,017	1,601,643,397.64
2	Hospitals	4,773	2,811,475,729.99	2,758,754	3,936,617,724.52
3	Ranches	579	166,275,159.23	263,816	423,379,312.78
4	Shopping centers	8,106	5,935,450,863.35	5,534,499	3,355,857,562.20
5	Academy	4,760	2,829,766,705.39	6,560,641	1,946,955,965.40
6	Offices	10,127	4,142,959,779.42	10,734,328	2,657,919,783.85
7	Other buildings	3,536	1,724,413,248.21	1,183,239	1,659,979,735.05
	Sum	36,586	19,638,177,227.28	28,563,294	15,582,353,481.44

When considering the results of annual energy conservation between the years 2010 and 2019, it shows a reduction in the number of measures indicating that the control building has a better understanding of energy conservation, and therefore appropriate measures can be selected and proven to be economically effective. Thus, limiting the selection measures to only those that are good Increased investment and savings

Considering the investment and the savings, the average investment for energy conservation is increasing every year. There may be some years that the average investment in controlled buildings is much higher because of large investments like installing solar. cells in a large area. Besides, the savings, on average, increased during the years 2010-2016 and decreased in 2017-2019 because most of the controlled factory buildings have already implemented most of the energy conservation measures and have not been able to implement the measures. that has a very economical effect later, as shown in Figure 7 and Table 4.



**Figure 8** Number of designated buildings in 2010-2019 in each industry type



**Table 5** Thailand Standard Industrial Classification: TSIC and energy consumption of the designated Building in 2010-2019

Year	Count of Energy Conservation Measures	Money Investment (Baht)	Number of Equipment Replacements	Saving (Baht)
2010	4,209	605,866,890.52	2,343,973	809,014,530.74
2011	3,740	1,785,384,482.36	3,023,459	1,059,750,303.41
2012	3,715	1,499,888,312.79	6,153,385	1,053,861,463.23
2013	4,173	1,635,971,290.86	2,564,176	1,415,279,574.68
2014	4,166	1,567,919,960.14	1,808,448	1,421,678,939.64
2015	4,047	1,868,523,770.73	2,648,394	1,531,159,115.88
2016	3,635	2,248,063,392.19	2,412,595	1,753,434,913.50
2017	3,443	3,110,339,566.87	1,984,831	3,762,794,646.84
2018	2,637	2,570,078,561.12	3,369,136	1,637,370,407.40
2019	2,821	2,746,140,999.70	2,254,897	1,138,009,586.12
Sum	36,586	19,638,177,227.28	28,563,294	15,582,353,481.44

Since the measures implemented by the designated buildings are many and each building may have different names, the DEDE, therefore, defines the measures that the DEDE has established as a standard for the implementation of various measures. It is understandable to choose the measure name. The measures that the DEDE has determined, there are up to 303 measures. Considering that, the measures that the designated buildings have been used the most over a period of 10 years are shown in Table 5.

**Table 6** Thailand Standard Industrial Classification: TSIC and energy consumption of the Designated Building in 2010-2019

	Number of Equipment Replacements	Saving (Baht)
Changing from fluorescent lamps (FL) to LED lamps		3,565
Proper maintenance (Window/Split Type)		2,947
Determining the right on-off time		2,931
Using a new set of air conditioners with high efficiency (High EER) to replace the old set		2,038
proper maintenance		1,912
Determining the time to turn off and turn on the device appropriately		1,806
Using the on-off control switch		1,233
changing the type of lamp		1,216
reduce the number of bulbs		1,071
Reduce the working time of machines or equipment		914

When considering the factors affecting energy conservation that can be obtained from the energy management report can be shown in Table 6, showing a list of measures total number of measures taken over 10 years Total investment of that measure number of devices operated.

In Table 6, it can be concluded that the top 10 measures used by the regulated buildings were implemented using housekeeping (HK) measures or machine or equipment maintenance measures. Five of the 34 measures were machine change measures (MC). Modify parts of machinery and equipment, 2 out of 59 measures are Produce Improvement (PI) measures, 1 out of 103 measures to modify the whole production process, and 1 out of 109 other types of measures because each type of measure has investment capital. that are significantly different. Therefore, the authors would like to divide the analysis by type of measures as follows:

**Table 7** The results of the housekeeping measures (HK)

Name of Conservation Measures	Count of Energy Conservation Measures	Money Investment (Baht)	Saving (Baht)	Saving/ Investment
1. proper maintenance (Window/Split Type)	2,947	618,085,578.73	3,250,253,638.68	5.258582
2. Determining the right on-off time	2,931	24,761,420.62	1,135,115,397.86	45.8421
3. Proper maintenance	1,912	377,939,832.89	749,318,735.69	1.98264
4. Determining the time to turn off-on the device	1,806	41,352,830.26	275,717,144.12	6.667431
5. Reduce the number of bulbs	1,071	11,278,668.97	169,782,585.74	15.05342

From Table 7, it can be concluded that Proper timing of opening-closing measures has the greatest savings/investment effect, which indicates Investments in the implementation of this measure can yield the most economical return of 45.84%.

From Table 8, it can be concluded that the measure of the conversion from tungsten halogen lamps to LED lamps has the greatest savings/investment effect, indicating Investments in the implementation of this measure yield the highest savings of 0.797 %.

From Table 9, it can be concluded that the Measure of the use of a variable speed system (VVVF) on the motor of the cold-water pump has the greatest saving/investment effect. The investments in the implementation of this measure yield the highest savings of 0.797 %.

From Table 10, it can be concluded that the on-off control measures had the greatest savings/investment effect, indicating that Investments in the implementation of this measure can yield the highest savings of 2.34 %.

**Table 8** Action results of the Machine change (MC) measure

Name of Conservation Measures	Count of Energy Conservation Measures	Money Investment (Baht)	Saving (Baht)	Saving/ Investment
1. Changing from fluorescent lamps (FL) to LED lamps	3,565	2,531,509,704.03	1,541,804,973.21	0.609
2. Using a new set of air conditioners with high efficiency (High EER) to replace the old set	2,038	1,876,274,201.54	514,170,792.22	0.274
3. Changing from a 36 Watt T8 fluorescent tube to a T5 tube	761	276,008,663.9	205,582,064.5	0.745
4. Changing from tungsten halogen bulbs to LED bulbs	740	239,364,162.4	190,786,055.6	0.797
5. The use of a new high-efficiency air conditioner to replace the old one.	697	1,347,264,797	337,761,814.3	0.251

**Table 9** Implementation results of the Produce Improvement (PI) measure

Name of Conservation Measures	Count of Energy Conservation Measures	Money Investment (Baht)	Saving (Baht)	Saving/ Investment
1. Using the on-off control switch	1,233	8,465,010.36	115,219,097.54	0.609
2. Reduce the wattage of the lamp.	692	181,188,230.2	146,409,050.5	0.274
3. Use a timer to control the on-off control.	358	19,317,630.05	36,380,123.63	0.745
4. Using the variable speed system (VVVF) on the motor of the cold-water pump.	256	124,471,539.2	108,419,444.1	0.797
5. Optimizing the working load	219	38,948,647.76	94,382,130.75	0.251

**Table 10** Other processes

Name of Conservation Measures	Count of Energy Conservation Measures	Money Investment (Baht)	Saving (Baht)	Saving/ Investment
1. Changing the type of lamp	1,216	505,813,508.46	59,308,337.99	0.117
2. Changing the lamp model	884	295,002,272.9	37,739,926.28	0.128
3. Enable-Disable Control	616	8,595,748.24	20,104,159.23	2.339
4. Other ways to maintain lighting	491	149,958,837.4	20,914,795.67	0.139
5. Other Ways to Maintain Air Conditioning or Cooling and Ventilation	266	160,415,220.6	75,543,468.76	0.47

## 5. Conclusion

A total of 19,642 reports were filed as a result of the implementation of energy savings in designated buildings from 2010 to 2019. A total of 30,246,720,545.02 and 456,635,144,259.51 MJ are amounts of heating and electricity energy, respectively. Total energy conservation was achieved after 36,586 energy-saving measures were implemented, 28,563,294 energy conservation equipment was replaced, and total energy conservation was achieved. The total amount is 15,582,353,481.44 Baht.

When analyzing the main sorts of measures, it is possible to summarize which ones should be encouraged. From the five most regularly used measures in each category, which are the results of the housekeeping measures (HK), it can be determined that the proper time-saving measures have the greatest saving/investment effect, which represents the greatest cost-effective return on investment in the execution of this policy is 45.84 percent.

According to the findings of the Machine Change Measure (MC), the conversion from tungsten halogen lamps to LED lamps had the largest savings/investment effect. The return on investment for implementing this solution was the highest, at 0.797 percent. The variable speed regulation (VVVF) system, which was fitted to the chilled water pump's motor, was successful in implementing the Produce Improvement (PI) measure. The largest Saving/Investment reflects investments in the application of this strategy that result in the greatest savings of 0.797 percent.

Acquiring recommended measures in each type of measure based on the proposed research for the government's benefit in establishing policies to encourage such measures. Including the building that is



interested in energy conservation measures with the maximum conservation effect on investment for the benefit of the building's own energy conservation investment as well as the development plan country.

## 6. Acknowledgements

Technical data and assistance from energy efficiency technologies for the department of electrical and computer engineering, Faculty of Engineering, Thammasat University, and Department of Alternative Energy Development and Efficiency, Ministry of Energy are gratefully acknowledged

## 7. References

- Ministry of Energy. (2011). Thailand 20-year energy efficiency development plan (2011 - 2030). Retrieved January 12, 2022, [http://www.eppo.go.th/images/POLICY/ENG/EEDP\\_Eng.pdf](http://www.eppo.go.th/images/POLICY/ENG/EEDP_Eng.pdf).
- Ministry of Energy. (2015). Energy Efficiency Plan; EEP 2015 (2015 - 2036). Retrieved January 12, 2022, <http://www.eppo.go.th/images/POLICY/PDF/EEP2015.pdf>.
- Ministry of Energy. (2018). Energy Conservation Plan 2018-2037 (EEP 2018). Retrieved January 12, 2022, [http://e-lib.dede.go.th/mm-data/BibA11693\\_EEP2018.pdf](http://e-lib.dede.go.th/mm-data/BibA11693_EEP2018.pdf).
- Department of Alternative Energy Development and Efficiency. (2014). Thailand Energy Efficiency Situation. Retrieved January 13, 2022, [https://www.dede.go.th/ewt\\_news.php?nid=47340](https://www.dede.go.th/ewt_news.php?nid=47340).
- Department of Alternative Energy Development and Efficiency. (2019). Thailand Energy Efficiency Situation. Retrieved January 13, 2022, [https://www.dede.go.th/ewt\\_news.php?nid=47340](https://www.dede.go.th/ewt_news.php?nid=47340).
- Ministry of Energy. (1992). Energy Conservation Promotion Act. B.E. 2535 (1992). Retrieved January 13, 2022, <http://www.eppo.go.th/images/law/ENG/nation2.pdf>
- Ministry of Energy. (1995). ROYAL DECREE ON DESIGNATED BUILDINGS B.E. 2538 (1995). Retrieved January 13, 2022, [http://berc.dede.go.th/wp-content/uploads/2021/09/Royal\\_Decree\\_Building.pdf](http://berc.dede.go.th/wp-content/uploads/2021/09/Royal_Decree_Building.pdf)
- Department of Alternative Energy Development and Efficiency. (2007). Energy conservation tips for executives, 5. Retrieved January 13, 2022, [http://www2.dede.go.th/km\\_berc/menu4\\_varasan.html](http://www2.dede.go.th/km_berc/menu4_varasan.html).
- National Statistical Office (2009). Classification of Thai Industrial Standards 2009. Retrieved January 13, 2022, <http://riped.utcc.ac.th/wp-content/uploads/2016/03/LFS-Industry-Code-2013.pdf>.