

The Performance and Efficiency of the Energy Management Program (EMP) Implemented at Hospital Pulau Pinang

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Abstract: *The rising energy consumption in healthcare facilities worldwide presents a critical challenge. Hospitals and medical centres are significant energy consumers due to their 24/7 operations and the need for strict environmental controls. The objective is to analyse the performance and efficiency of the energy management program (EMP) at Hospital Pulau Pinang (HPP). The analysis aims to provide a comprehensive evaluation of the program's performance and suggest actionable insights for future improvements. HPP implemented an EMP on 1 October 2019. The program is scheduled to conclude on 31 March 2025. The EMP aims to achieve guaranteed annual energy savings of 5,664,691 kWh from the baseline energy consumption, with an estimated annual cost savings of RM 2,375,426.74. The program includes several initiatives, such as retrofitting LED lights, installing chillers, and implementing a Building Automation System. The targeted energy savings from each initiative are as follows: Lighting savings account for 15,729 kWh monthly and 188,743 kWh yearly; Chiller Block B savings account for 310,348 kWh monthly and 3,724,170 kWh yearly; Chiller Block ACC savings account for 145,981 kWh monthly and 1,751,777 kWh yearly. As of 31st May 2024, HPP had achieved savings of 588,477 kWh monthly and cumulative savings of 32,678,939.89 from January 2017. In conclusion, HPP managed to achieve the objective of the EMP. Optimizing energy consumption in healthcare facilities through EMP at HPP enhances operational efficiency and supports broader economic and environmental goals. By overcoming associated challenges through strategic initiatives and collaborations, the global healthcare sector makes significant strides towards sustainability.*

Keywords: Energy Management Program (EMP), Healthcare Facilities, Energy Consumption, Sustainability, energy savings

1.0 INTRODUCTION

Energy Performance Contracting (EPC) has made it to the headline for the past decade with Malaysia following suit very soon after in 2016. This started with the efforts taken by the then Minister of Energy, Green Technology, Science, Climate Change, and Environment Minister of Malaysia, also The Honourable Minister Yeo Bee Yin who mentioned a few methods which have been sought by the government of Malaysia to encourage energy efficiency. Some of the approaches taken include retrofitting with energy efficient lightings and appliances, as the Energy Efficiency and Conservation Act was drafted, which put in a review to improvise on the National Energy Efficiency Action Plan 2016-2025 (Goh, Chai & Goh 2019).

EPC is an approach which utilises market-based technology and capital in order to improve on energy efficiency in industry, buildings, and other areas. It has been noted that there is a large room for improvement and development in this area of market in Malaysia (Goh, Chai & Goh 2019). The implementation of EPC in the Malaysia government sector has been approved by the government since 2013 January. It takes with it marking the deepest footprint in reducing carbon emission and encouraging energy efficiency among government sectors in Malaysia. This concept is a profit-sharing agreement between the Energy Service Company (ESCO) and the building owner, where the initial cost in the energy efficiency improvement projects is borne by ESCO. ESCOs have been required to register with the Minister of Finance to ensure the successful implementation of the concept. This registration is made mandatory to implement the EPC projects in government sector buildings which are under the Green Technology Service Code. The Ministry of Finance has also required ESCOs which apply for registration in the said code to register with the Energy Commission. Since 2013, Malaysia's energy-efficiency projects and initiatives have developed at a fast pace since 2013, which encompass the number of energy service companies or ESCOs, and the total amount of invested capital in energy performance contract management (Rupadi & Norazrin 2017).

This rapid development of the country's energy-efficient service industry was initially focussed in the industrial sector, as this sector remains the main sector of energy consumption, which account for 2/3 of Malaysia's total energy consumption. However, there is more than one single model for EPC in this country, and energy-saving benefits remain as the main factor with energy saving benefit-sharing contracts liable for national tax and financial incentives. As Malaysia remains as the stage for rapid economy development with low energy prices throughout, thus the energy service industry was previously in its infancy. Hence, most industrial sectors regard energy-saving improvement activities as one of the ways to reduce costs with further impact on industries to expand their production, hence increasing profits. Due to its infancy in this developing nation, there is lack of initiative and enthusiasm to carry out energy efficiency investment projects (Goh, Chai & Goh 2019).

2.0 Objective

The Energy Performance Contracting (EPC) for Hospital Pulau Pinang, Pulau Pinang commences on 1 October 2019, with the contract ending on 31 March 2025. The installation works took 9 months, and the period of energy savings is observed beginning from 1 July 2020. The objective of this Energy Management Program (EMP) at Hospital Pulau Pinang is to achieve guaranteed annual energy savings of 5,664,691 kWh from the baseline energy consumption, with an estimated annual cost savings of RM 2,375,426.74.

3.0 METHODOLOGY

The implementation of energy savings measures (ESM) for the Energy Performance Contracting (EPC) project in Hospital Pulau Pinang to enhance efficiency and reduce energy consumption. These measures included:

- a) Lighting - Retrofit of 1,368 4ft 10W LED to replace 1,368 4ft fluorescent tubes
- b) ACMV - Installation of 1 nos of 500 RT Magnetic Bearing, Oil Free VSD Chiller and motorized valves at AHUs in Blok B.
- c) ACMV - Installation of 2 nos of 250 RT Magnetic Bearing, Oil Free VSD Chiller in Ambulatory Care Centre (ACC) Block.
- d) Building Automation System (BAS) - BAS components relevant to energy savings measure was installed to complement retrofit of chiller plant.

4.0 RESULTS

The Energy Performance Contracting (EPC) project at Hospital Pulau Pinang aimed to achieve significant energy savings through various Energy Savings Measures (ESM). Each measure contributed to overall energy efficiency improvements, and the targeted energy savings categorised as follows in Table 1. Table 2 presents a summary of the accumulated targeted savings, contractual calculation savings, and energy avoidance savings for the year 2024. Tables 3, 4, and 5 present the breakdown of target savings, contractual savings, and avoided energy (kWh) by ESM from January to December 2024, respectively. Figure 1 and Table 6 summarize accumulated targeted, contractual calculation savings, and avoided energy savings from July 2020 to June 2021.

Table 1: Energy savings from each Energy Savings Measures (ESM)

Description	Monthly	Yearly
Contractual Fee (RM)	197,792.13	2,373,505.53
Lighting Savings (kWh)	15,729	188,743
Chiller Blok B Savings (kWh)	310,348	3,724,170
Chiller ACC Savings (kWh)	145,981	1,751,777
Total Guaranteed Savings (kWh)	472,058	5,664,691

Table 2: Summary of Accumulated Targeted, Contractual Calculations Savings, and Energy Avoided Savings for year 2024

Month	Target Savings based on Guaranteed Savings	Savings based on Contractual Method	Savings based on Calculation	Savings based on Energy Avoidance Calculation
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January	3,335,658	3,073,190	4,063,329
February	3,771,459	3,479,184	4,607,011
March	4,252,268	3,910,962	5,240,846
April	4,718,075	4,310,726	5,864,634
May	5,198,884	4,705,451	6,453,111
June	5,664,690	5,086,745	6,985,249
July	480,809	425,238	496,202
August	961,618	852,074	1,107,640
September	1,427,424	1,278,385	1,676,854
October	1,908,233	1,733,120	2,287,717
November	2,374,040	2,177,343	2,872,313
December	2,854,849	2,642,195	3,472,988

Table 3: Breakdown of Target Savings (kWH) from January 2024 to December 2024 by ESM

Target Savings (kWH)					
Month	No of Days	Lighting	Chiller ACC	Chiller Blok B	Total
January	31	15,729	148,781	316,299	480,809
February	28	15,729	134,383	285,690	435,801
March	31	15,729	148,781	316,299	480,809
April	30	15,729	143,982	306,096	465,809
May	31	15,729	148,781	316,299	480,809
June	30	15,729	143,982	306,096	465,809
July	31	15,729	148,781	316,299	480,809
August	31	15,729	148,781	316,299	480,809
September	30	15,729	143,982	306,096	465,806
October	31	15,729	148,781	316,299	480,809
November	30	15,729	143,982	306,096	465,806
December	31	15,729	148,781	316,299	480,809

Table 4: Breakdown of Contractual Savings (kWH) from January 2024 to December 2024 by ESM

Contractual Savings (kWH)					
Month	No of Days	Lighting	Chiller ACC	Chiller Blok B	Total
January	31	21,139	126,836	315,020	462,996
February	28	21,139	104,085	280,770	405,994
March	31	21,139	100,282	310,357	431,778
April	30	21,139	85,052	293,572	399,763
May	31	21,139	72,488	301,098	394,726
June	30	21,139	66,339	293,816	381,294
July	31	21,139	91,686	312,413	425,238
August	31	21,139	92,347	313,350	426,836
September	30	21,139	107,262	297,909	426,311
October	31	21,139	119,928	313,668	454,735
November	30	21,139	121,879	301,204	444,223
December	31	21,139	130,170	313,543	464,852

Table 5: Breakdown of Energy Avoided (kWH) from January 2024 to December 2024 by ESM

Energy Avoided (kWH)					
Month	No of Days	Lighting	Chiller ACC	Chiller Blok B	Total
January	31	21,139	112,566	468,176	601,881
February	28	21,139	83,848	438,694	543,681

March	31	21,139	96,620	519,076	633,835
April	30	21,139	84,478	518,171	623,788
May	31	21,139	68,091	499,248	588,477
June	30	21,139	55,265	455,733	532,138
July	31	21,139	53,400	421,663	496,202
August	31	21,139	101,316	488,982	611,437
September	30	21,139	90,982	457,093	596,215
October	31	21,139	115,537	474,187	610,862
November	30	21,139	107,605	455,853	584,597
December	31	21,139	117,111	462,425	600,675

Table 6: Summary of Accumulated Targeted, Contractual Calculations Savings, and Energy Avoided Savings for July 2020 until June 2021

Year	Month	Accumulated Savings (kWh)			Accumulated Variance (A vs B)		Accumulated Variance (A vs C)	
		Target Savings based on Guaranteed Savings (A)	Savings based on Contractual Calculation Method (B)	Savings based on Energy Avoidance Calculation (C)	%	kWh	%	kWh
2020	July	480,809	469,446	575,751	-2.4%	- 11,363	19.7%	94,942
	August	961,618	933,008	1,144,494	-3.0%	- 28,610	19.0%	182,876
	September	1,427,424	1,367,875	1,678,555	-4.2%	- 59,550	17.6%	251,130
	October	1,908,233	1,841,241	2,190,239	-3.5%	- 66,993	14.8%	282,006
	November	2,374,040	2,322,697	2,795,425	-2.2%	- 51,343	17.7%	421,385
	December	2,854,849	2,820,000	3,430,411	-1.2%	- 34,849	20.2%	575,562
2021	January	3,335,658	3,318,887	4,019,795	-0.5%	- 16,771	20.5%	684,137
	February	3,771,459	3,819,671	4,658,349	1.3%	48,212	23.5%	886,890
	March	4,252,268	4,310,399	5,326,360	1.4%	58,131	25.3%	1,074,091
	April	4,718,075	4,778,837	5,932,889	1.3%	60,762	25.7%	1,214,814
	May	5,198,884	5,271,303	6,613,006	1.4%	72,419	27.2%	1,414,122
	June	5,664,690	5,739,592	7,218,026	1.3%	74,902	27.4%	1,553,336

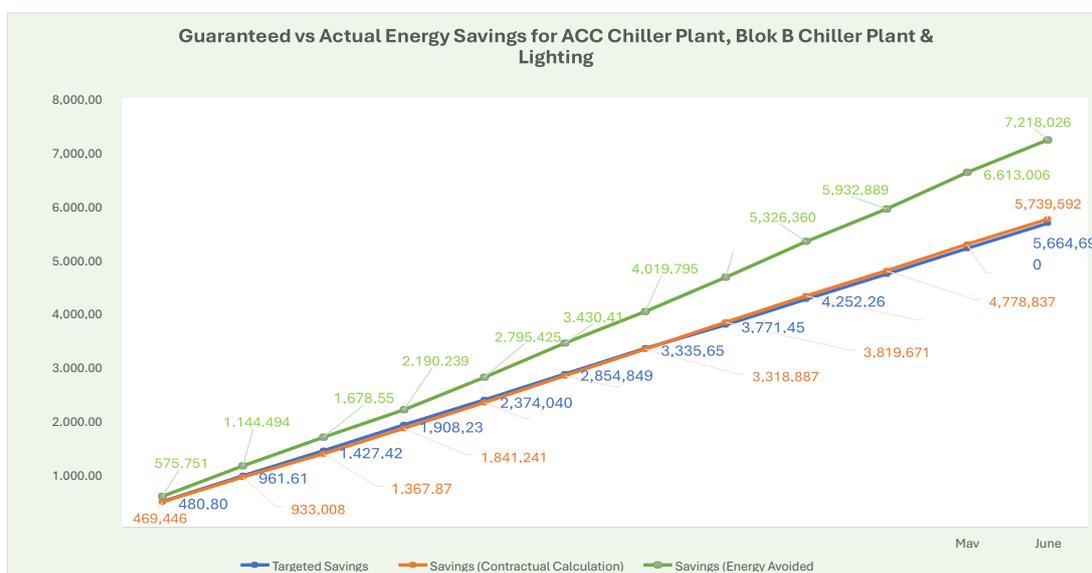


Figure 1: Summary of Accumulated Targeted, Contractual Calculations Savings, and Energy Avoided Savings for July 2020-June 2021

The targeted energy savings from each initiative are as follows: Lighting savings account for 15,729 kWh monthly and 188,743 kWh yearly; Chiller Block B savings account for 310,348 kWh monthly and 3,724,170 kWh yearly; Chiller ACC savings account for 145,981 kWh monthly and 1,751,777 kWh yearly. As of 31st May 2024, Hospital Pulau Pinang had achieved savings of 588,477 kWh monthly and cumulative savings of 32,678,939.89 from January 2017.

5.0 DISCUSSIONS

For August 2022, data for CSB is estimated using average hourly data from 20th to 24th August due to data loss. For October 2022, data for CSB is estimated using average hourly data from 15th to 21st October due to data loss. For November 2022. Data for power is using individual DPM for each equipment. For Chiller 2, DPM data is phase-corrected. For December 2022, cooling load data for CSB from 21st December onwards is estimated using similar chiller plant power consumption. For January 2023, cooling load data for CSB from 1 January – 17 January is estimated using similar chiller plant power consumption. There is a reduction in cooling load in ACC building due to closure of OT (21 January 2023 to 4 February 2023). For October 2023, data for CSB estimated using average hourly data from 6th – 11th October. For October 2023, data for ACC estimated using average hourly data from 19th – 31st October. For November 2023, data for ACC is estimated using average hourly data from 19th – 30th November. For November 2023, data for CSB is estimated using average hourly data from 18th to 29th August due to data loss.

The summary of accumulated targeted, contractual calculations savings, and energy avoided Savings for the Year 2024 provides a comparative analysis of energy savings across three different calculation methods: target savings based on guaranteed savings, savings based on contractual calculation method, and savings based on energy avoidance calculation. From the data, a general upward trend is observed in the first half of the year (January to June), with energy savings reaching their highest values in June across all three methods. Target Savings based on Guaranteed Savings increased from 3,335,658 kWh in January to 5,664,690 kWh in June, while contractual calculation method savings followed a similar pattern, rising from 3,073,190 kWh to 5,086,745 kWh. The energy avoidance calculation consistently reported the highest values, peaking at 6,985,249 kWh in June, suggesting that this method accounts for a broader range of energy savings factors. However, starting in July, there is a significant drop in energy savings across all three methods, with Target Savings declining to 480,809 kWh and remaining relatively lower for the rest of the year. A similar trend is observed in both the contractual and energy avoidance calculations. The lower savings in the latter half of the year may be attributed to seasonal variations, changes in energy demand, or operational factors impacting efficiency.

Table 3 shows the breakdown of target savings (kWh) from January 2024 to December 2024 by ESM presents the distribution of targeted energy savings across three key components: Lighting, Chiller ACC, and Chiller Blok B. The data indicates a consistent allocation of energy savings throughout the year, with minor variations in months with 30 days. Across all months, Lighting savings remain constant at 15,729 kWh, suggesting a fixed contribution from lighting efficiency measures. Chiller ACC and Chiller Blok B account for the majority of the energy savings, with their values fluctuating slightly depending on the number of days in each month. In months with 31 days, total target savings reach 480,809 kWh, while in months with 30 days, the total savings slightly decrease to 465,809 kWh or 465,806 kWh due to the reduced operational days. The Chiller Blok B consistently contributes the largest portion of savings, followed by Chiller ACC, emphasizing the significant impact of chiller system efficiency in achieving energy targets. These findings suggest that optimizing chiller operations remains a key priority for maximizing energy savings.

Table 4 present the breakdown of Contractual Savings (kWh) from January 2024 to December 2024 by ESM presents the distribution of energy savings under the contractual calculation method across Lighting, Chiller ACC, and Chiller Blok B. Unlike the target savings, contractual savings exhibit more fluctuations throughout the year, particularly in the chiller components. Lighting savings remain constant at 21,139 kWh per month, indicating a fixed estimation for lighting efficiency improvements. However, Chiller ACC and Chiller Blok B savings vary significantly, with their contributions fluctuating across different months. The highest total contractual savings occur in January (462,996 kWh) and December (464,852

kWh), while the lowest is recorded in June (381,294 kWh). A notable trend is the gradual decrease in chiller savings from January to June, reaching the lowest values mid-year before increasing again in the second half of the year. This pattern could be influenced by seasonal variations in cooling demand, operational efficiency adjustments, or variations in energy consumption patterns.

Table 5 shows the breakdown of energy avoided (kWh) from January 2024 to December 2024 by ESM presents the distribution of energy savings achieved through avoided energy consumption across Lighting, Chiller ACC, and Chiller Blok B. This method generally reports the highest savings compared to the target and contractual calculation methods, indicating a broader consideration of operational and efficiency factors. Lighting savings remain constant at 21,139 kWh per month, similar to contractual savings. However, Chiller ACC and Chiller Blok B savings fluctuate throughout the year, reflecting seasonal and operational variations in cooling demand. The highest total energy avoided is recorded in March (633,835 kWh), followed by April (623,788 kWh) and August (611,437 kWh), while the lowest occurs in July (496,202 kWh) and June (532,138 kWh). The Chiller Blok B consistently contributes the largest portion of avoided energy savings, highlighting its major role in overall energy efficiency. A noticeable decline is observed from January to June, followed by a recovery in the second half of the year, suggesting a potential correlation with cooling demand variations and operational adjustments.

Table 6 shows the summary of accumulated targeted, contractual calculations savings, and energy avoided savings for July 2020 to June 2021 provides a comprehensive overview of energy savings over a one-year period. The data reflects savings based on three different methodologies—targeted savings, contractual calculation method, and Energy Avoided Calculation—offering insights into variations in recorded energy efficiency improvements. Following the reporting period, savings figures were updated in September 2021 to align with a revised calculation method based on Measurement and Verification (M&V) principles. This adjustment ensures greater accuracy and consistency in savings assessment. Additionally, savings figures from July 2021 were updated to correct lighting savings, addressing discrepancies in previous calculations. During the transition to the updated methodology, data loss occurred for BTU readings between 28 November 2021 and 29 November 2021 due to a temporary connection issue. As a corrective measure, hourly averages were used to estimate missing values, ensuring continuity in reported savings.

Figure 1 shows the summary of Accumulated Targeted, Contractual Calculations Savings, and Energy Avoided Savings for July 2020–June 2021 provides a clear view of energy savings across three methodologies over a one-year period, offering valuable insights into energy efficiency performance. These savings figures serve as benchmarks for energy optimization efforts, reflecting the effectiveness of targeted actions and the overall energy consumption reduction across the facility. However, during this period, data losses occurred for key meters, notably the CSB BTU meter and the ACC BTU meter. Specifically, data loss was recorded from 20 March 2022 to 25 March 2022 for the CSB BTU meter, from 27 March 2022 to 31 March 2022 for the ACC BTU meter, and again for the ACC BTU meter from 1 April 2022 to 15 April 2022. In response to these gaps, cooling load data was estimated by comparing it to similar energy consumption levels, ensuring minimal disruption to the overall savings calculations. Additionally, further data loss for the CSB BTU meter occurred from 2 Mei 2022 to 18 Mei 2022, and for both the CSB BTU meter and DPM from 24 June 2022 to 28 June 2022. These gaps were addressed by using hourly averages to estimate the missing data and accurately calculate the savings. This approach ensured that data continuity was maintained, even in the absence of direct readings, allowing for consistent and reliable savings reporting.

6.0 CONCLUSIONS

The Energy Management Program (EMP) at Hospital Pulau Pinang (HPP), initiated in October 2019 and running until March 2025, has been a pivotal step in enhancing energy efficiency in healthcare facilities. The program has driven significant energy savings through initiatives like retrofitting lighting, installing energy-efficient chillers, and implementing a Building Automation System (BAS), achieving a monthly reduction of 588,477 kWh by May 2024, contributing to over 32.6 million kWh in cumulative savings since January 2017. These savings, driven mainly by chiller systems, were recorded using various calculation methods—targeted, contractual, and energy-avoided savings. Despite fluctuations in savings due to seasonal cooling demands and operational factors, including challenges such as data loss in critical metering systems, the program successfully maintained accurate energy savings calculations. By addressing these challenges through data estimation methods and maintaining operational efficiency, HPP's EMP

has achieved substantial environmental and economic benefits, setting a replicable example for energy management in healthcare globally.

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