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Energy Consumption and Intensity at Building Construction Industry

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ABSTRACT

Based on the research at developing country, 30 to 40% of natural resources were exploited by construction industry which are 50% of energy be used for heating and cooling the building. If energy demand can be reduced or industry delayed, energy usage will be reduced. As a result, that energy consumption guideline must be established to control the usage of energy. The objective of this research is to know the energy consumption and intensity at construction industry. For this research, it will focus on the specification of the project site based on contract sum, location, and environment before know on how to reduce energy. The case study for this research covers several high-rise building construction industries. Selected data have been taken from the case study which are manpower, energy used, plant machinery and master work program. All the data given have been analyst and come out with their total floor area result have been tabulated. Technically, construction can be divided into six stages which are initial construction, coordination, implementation, critical, testing and commissioning and handover stage. At the end of the research, a new method to measure Energy Consumption Guideline for Building Construction Industry have been established.

1. Introduction

Construction industry is a major consumer of non-renewable resources and a massive producer of waste. Based on the research at developing country, 30% to 40% of natural resources were exploited by construction industry which are 50% of energy will be used for heating and cooling the building. This similar percentage is expected in the developing country such as Malaysia [1,2]. Malaysia is categorized as a developing country; a lot of projects are in progress and on planning to build. A lot of electricity energy to be used to complete the entire project.

The developer team's attitude plays an important role towards creating sustainable living. Campaign had been going to educate and reminds all the team to control the usage of energy. Not only will it save the electrical bill, but also the environment impact. However, the main problem is the developer or contractor don not have awareness on how to reduce or overcome the energy

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resources. For them, the progress to complete the project on time is most important than the environment impact after used a lot of energy in one time. These issues if not tackled strategically will further aggravate and exert challenges toward sustainable construction in the following way [3,4].

2. Methodology

In this research, it consists of three phases which are background of construction, data collection of construction and optimization phase. Every phase is very important into making this research become successful. For the background of construction phase, it will focus on the history of energy trend in building construction industry. It will cover on the background of the project such as location, total usage of energy and quality product handover. Five projects have been selected as a case study. The projects have been selected based on several criteria and all the data have been collected and interpret at data collection of construction phase. The data will come out from several medium such as site daily of the project, machinery, manpower, monthly report and TNB bill meter [5-12]. Based on the data given, the main factor that affects the energy usage will be analyzed. By comparing between five projects (refer to Table 1), it will show the difference of energy usage. At the end of this research, energy consumption guideline for building construction industry will be proposed [13-23].

Table 1
Case study: Characteristic of the five projects in construction industry

	Project A	Project B	Project C	Project D	Project E
Location	Johor Bahru, Johor	Johor Bahru, Johor	Kuala Lumpur	Kuala Lumpur	Shah Alam, Selangor
Description	Mix development (Apartment services and hotel)	Mix development (Apartment services and retail)	Apartment services	Hotel	Mix development (Apartment and retail)
Contract period	33 Months	34 Months	28 Months	36 Months	33 Months
Completion Date	4 October 2017	25 November 2018	31 March 2017	30 September 2018	14 August 2017
Floor	832569 sqft	880597 sqft	1101497 sqft	1011807 sqft	912582 sqft

3. Results

Figure 1 show the stage of construction. Stage of construction are divided into 6 stage which is initial construction stage, coordination stage, implementation stage, critical stage, testing and commissioning stage and handover stage.

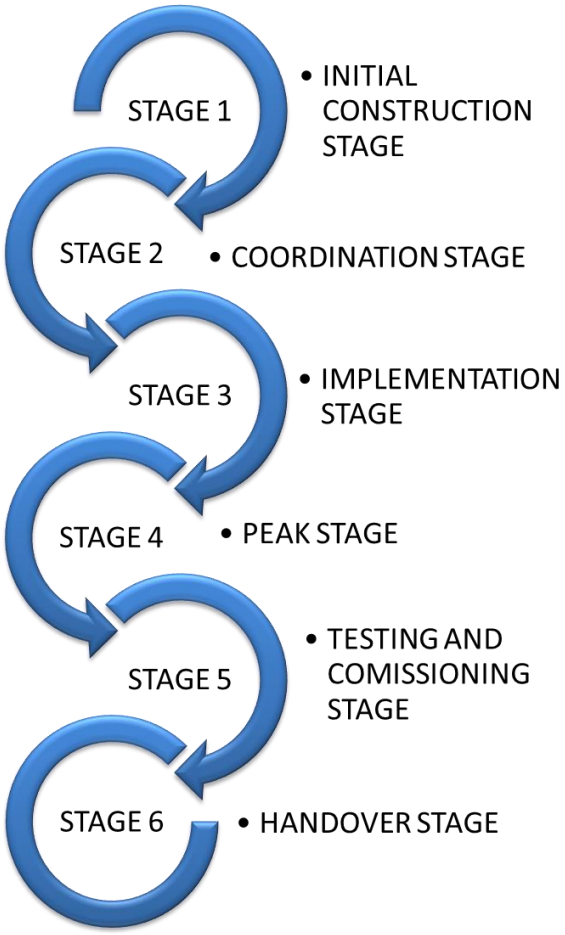

Fig. 1. Six common stage of construction process in Malaysia

3.1 Stage 1: Initial Construction Stage

Initial construction stage can also define as mobilization stage. During this stage, most of the temporary work will be take place such as, installation of tower crane, set up site office and yard for bar bending work. For the site progress, only structure work activity is taking place.

3.2 Stage 2: Coordination Stage

At this stage, most of the trade already awarded and start the work such as architectural and mechanical and electrical work. Coordination work will be taken place at this stage to avoid site issue later. Other than that, a lot of samples, method statement and shop drawing need to get approval before start work at site. Coordination will lead by MEP team to make sure the height clearance can be achieved and any changes due to design need to inform consultant immediately. Activity that will take place at this stage are:

i. First fix installation for electrical work
ii. Installation of ducting for mechanical services at lower level
iii. Skim coat work started at lower level
iv. Concreting for structural work
v. Coordination for architectural and mechanical and electrical work
vi. Temporary work such as: set up concrete pump and placing bomb

3.3 Stage 3: Implementation Stage

Implementation stage can be defined as where the all the activity is ready to start. At this stage number of workers will be increased rapidly. Activity that will take place at this stage are:

i. Pulling cable for electrical work and ELV work.
ii. Installation of ducting for mechanical services at above floor.
iii. Installation of pipe for cold water, sanitary and fire protection system.
iv. All initial work for architectural trade such as for painting, brick wall, tiling, and door frame.
v. Concreting for structural work (65% already complete).
vi. Temporary work such as: set up passenger hoist.

3.4 Stage 4: Peak Stage

Stage 4 is categorized as the beginning of the final work before handover to the client. Mechanical and electrical work and architectural work will be the higher no of activity and worker and this stage. Activity that will take place at this stage are:

i. Installation final fix for electrical work such as dB, light fitting, MSB, transformer, and generator set.
ii. Installation final fix for ACMV (air conditional and mechanical ventilation) services such as air conditional, VRV, and FCU.
iii. Installation of sanitary wares, bulk meter, waste pipe for cold water and sanitary work.
i. Installation of sprinkler, wet riser, hose reel, fire extinguisher and all fire compartment for fire protection system.
ii. Installation of pump and all fitting for swimming pool and water feature services.
iii. Installation of gas detector, and valve for natural gas system.
iv. Installation of lift come with finisher.
v. Architectural work – Brick wall, tiling, ceiling, door lead, painting, vanity top and sanitary ware, ironmongeries, kitchen cabinet, waterproofing, railing.
vi. ID Work such as marble at common area and furniture.
vii. Landscape work – Planting, irrigation system, finishing for walk way area/ driveway.
viii. Concreting for structural work (85% already complete).
ix. Temporary work such as: monitor on usage of big equipment such tower crane and mobile crane.

3.5 Stage 5: Testing and Commissioning Stage

Refer to the Figure 2, Stage 5 will be the will testing and commissioning stage. List of the activity to be conducted during the testing and commissioning such as:

i. Mechanical work testing such as air-conditional, VRV, FCU, air collar system, ducting for ventilation system and exhaust fan.
ii. Testing of the permanent lift include also escalator.
iii. Testing of the MSB, transformer and switchgear.
iv. Testing of generator set. (600kVA, 1200kVA and 1500 kVA).
v. Plumbing system – check on the water heater and pump system.
vi. Fire Protection System - To run all the fire systems such as the wet riser, and sprinkler system to make no leakage and the system integrated into the fire console system.

vii. Testing on CCTV, SMATV, PA system and intercom for all the units.
viii. Testing on swimming pool and water system.
ix. Testing on natural gas system.
x. Testing on the landscape system such as the irrigation system.
xi. Testing on all the dB panels such as fire alarm system.
xii. Testing on the light fitting such as LED light and façade lighting.

3.6 Stage 6: Handover Stage

At this stage, some of the testing is still conducted but since it comes from two difference resources incoming power supply, it can't capture the actual amount of energy used. Some activities conducted at this stage are:

i. BOMBA inspection and handover.
ii. IWK inspection and handover.
iii. TNB handover.
iv. JKKP inspection for lift and escalator.
v. Water Meter handover to SYABAS/SAJ (depending on the location).
vi. Majlis inspection for landscape and common access.

Calculation for energy used by stage:

$$\text{Energy used by stage} = \frac{\text{Energy used per total area}}{\text{month (by stage)}}$$

Table 2 shows the ratio of the energy used per floor plan. Based on Table 2 it can be concluded that the energy increases at every stage but at the final stage it decreases rapidly. For Stage 1, the highest energy used is at Project B which is 0.034 and the lowest at Project E. While for Stage 2 the lowest energy used is Project C which is 0.022 and the highest is 0.047. For Stage 3, the highest energy is 0.0746 in Project B and the lowest energy is 0.0305 for Project C. Stage 4 shows the highest energy at Project E which is 0.076 and the lowest energy is 0.057. Meanwhile, for stage 5, the highest energy is at Project A which is 0.153 and the lowest energy is 0.125. For the final stage, the highest energy is 0.064 at Project C and the lowest energy is 0.024 at Project B.

Table 2
Reading of energy per area by stage

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Project A	0.017	0.039	0.066	0.067	0.153	0.053
Project B	0.034	0.038	0.075	0.065	0.129	0.024
Project C	0.018	0.022	0.030	0.060	0.125	0.064
Project D	0.019	0.030	0.039	0.057	0.120	0.045
Project E	0.000	0.047	0.067	0.076	0.136	0.030

Based on the Figure 2, the highest energy used is at stage 5. The reason why this phenomenon happens is because all the projects conducted testing and commissioning at one time. Some of the activities need to be run for more than 24 hours such as lighting at the carpark area and air conditioning at typical unit. It will take more power requirement especially during day time. The closer to the dateline the more activity need to be done, the more energy they use. Other tests that will be conducted at this stage are air conditional and mechanical ventilation system, natural gas and

water heater system. Table 3 shows the energy consumption guideline for building construction industry.

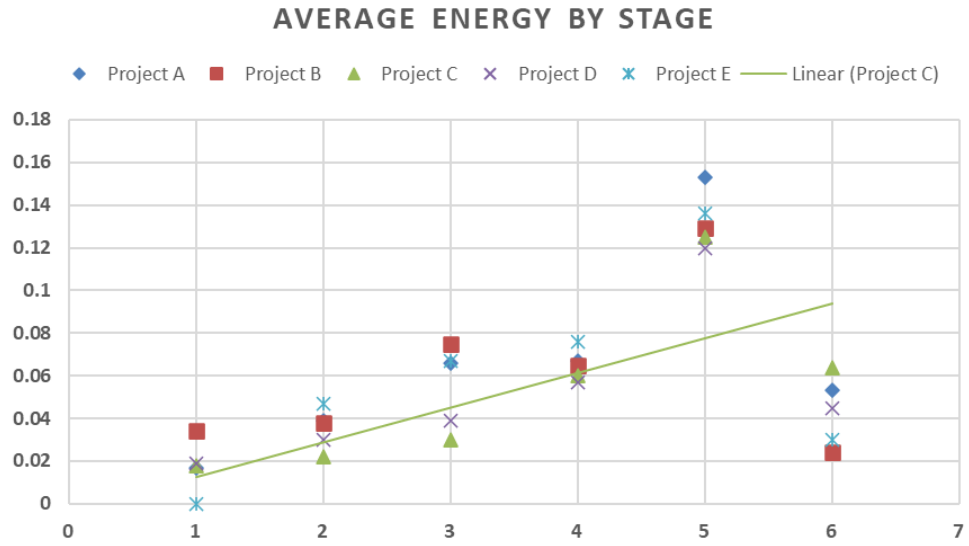

Fig. 2. Average energy by stage of construction

Table 3
Energy consumption guideline for building construction industry

Stage	Activity	Energy per area (kWh/ft^2)
Stage 1: Initial construction	i. Temporary work ii. Structural work	0.017
Stage 2: Coordination	i. Structural work ii. MEP work iii. Architectural work	0.035
Stage 3: Implementation	i. Structural work ii. MEP work iii. Architectural work iv. Landscape Work v. ID work	0.055
Stage 4: Critical	i. Structural work ii. MEP work iii. Architectural work iv. Landscape work v. ID work vi. Façade work	0.065
Stage 5: Testing and commissioning	Testing and commissioning work	0.125
Stage 6: Handover	Handover to building owner	0.033

The Guideline standard for building construction works is divided into two main components:

i. Activity

The activity will be captured in the work program activity that will be controlled by planner/ project manager of the main contractor. This work program will be the guideline of all parties such as main contractor and client to ensure the project will be handover on time.

ii. Energy per floor area
Before work commencement, all the contractor should be known on the power requirement of the site used. In order to control the energy usage, all the meter data should be taken every month.

4. Conclusions

Based on the five projects, the data have been collected for the plant machinery, energy and number of activities for each project and all the data have been analysed. From the result, it has been seen that Project C have the highest amount on the energy, manpower and number of activity than the other project. For the plant machinery, Project A has the highest number than the others project.

From the table energy by the stage, it shows that Stage 5 is the most used of energy than the other stages. Project A shows the highest amount of energy used which is 0.15285 kWh/ft^2. The table can be concluded for usage of energy will be high on the last 3 of 4 months before handover. Based on all the data it can be assumed that, even though Project C have the highest number of manpower and number activity, it can't affect the overall energy usage. As the conclusion, the energy used at construction affected by the total floor area. Based on the Energy Consumption Guideline for Building Construction Industry, it shows that at stage 5 will be high energy demand. The contractor must control the energy usage and make sure it around 0.125 kWh/ft^2. The construction team should have a good planning to ensure the project use the energy perfectly in order to achieved project dateline.

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