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# JENOSYS: Application of a Web-Based Online Energy Performance Reporting Tool for Government Buildings in Malaysia

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***Abstract*****—**One of the areas that present an opportunity to reduce the national carbon emission is the energy management of public buildings. To our present knowledge, there is no easy-to-use and centralized mechanism that enables the government to monitor the overall energy performance, as well as the carbon footprint, of Malaysia's public buildings. Therefore, the Public Works Department Malaysia, or PWD, has developed a web-based energy performance reporting tool called JENOSYS (JKR Energy Online System), which incorporates a database of utility account numbers acquired from the utility service provider for analysis and reporting. For test case purposes, 23 buildings under PWD were selected and monitored for their monthly energy performance (in kWh), carbon emission reduction (in $tCO_2eq$) and utility cost (in MYR), against the baseline. This paper demonstrates the simplicity with which buildings without energy metering can be monitored centrally and the benefits that can be accrued by the government in terms of building energy disclosure and concludes with the recommendation of expanding the system to all the public buildings in Malaysia.

***Keywords*****—**Energy-efficient buildings. energy management systems, government buildings, JENOSYS.

## I. Introduction

CLIMATE change, global warming and greenhouse gas emissions have become contentious issues that are being discussed and debated around the world. One of the main contributions to the global carbon emissions comes from buildings, where the energy proportion from buildings is 40% from total energy consumption as reported by United Nations Environment Programme Sustainable Buildings & Climate Initiative [1]. In tackling the issues at the global level, Malaysia has announced, in Paris in 2015, its pledge to reduce its national carbon footprint by 45% by the year 2030, a revised target from previous 40% reduction by the year 2020 set in 2009, using a 2005 baseline.

In the Eleventh Malaysian Plan (11 MP), measures to identify potential improvements and appropriate approaches to ensure efficient use energy in buildings, industries and households have been formulated. These measures include capacity building, such as increasing the number of Registered Electrical Energy Managers (REEM), implementing Energy Performance Contracting (EPC) for government buildings, enhancing awareness among users through energy labelling, as well as promoting energy management standards such as ISO 50001 for buildings and Minimum Energy Performance Standards (MEPS) for appliances [2].

The Ministry of Energy, Green Technology and Water (MEGTW) has launched a number of initiatives to complement the strategies in order to achieve 8% national energy saving by 2025, as stated in the National Energy Efficiency Action Plan (NEEAP) [3].

The Public Works Department Malaysia (PWD) has implemented a number of strategies to incorporate the NEEAP, namely;

i. MS 50001 certification for the PWD main office in Kuala Lumpur in 2015;
ii. Launching of the Guideline for Establishing Energy Management System (EnMS) in Government Buildings in 2014, with the revised edition in 2017;
iii. Establishment of EnMS in PWD Mechanical Engineering State Offices (PWD MESO); and
iv. Launching of the PWD Sustainable Green Mission 2.0 policy in 2017; and
v. Launching of the web-based JKR Energy Online System (JENOSYS).

The aim of this paper is to highlight the features of the web-based energy reporting developed by PWD, named JKR Energy Online System or JENOSYS, for the government buildings in Malaysia.

## II. Related Works and Initiatives

The implementation of energy management initiatives for government buildings in Oman was investigated by Saleh et al. [4], using the Sultan Qaboos University's (SQU) library located in the capital city of Muscat as a case study. The methodology involved collection of preliminary data on equipment energy use followed by a detailed energy audit. The field data measurement was then validated with DesignBuilder, a whole-building performance simulation program. The authors have proposed several energy management opportunities (EMOs), which consists of 1) switching off the HVAC systems outside the occupancy hours; 2) increasing the thermostat set-point, 3) reducing the air

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infiltration by using sealant around the window frames and doors, and 4) reducing the lighting intensity as well as using LED instead of the current fluorescent lighting. The investigation concluded that with the combination of EMOs, the energy consumption can be reduced by as much as 38.5%. This study, however, does not cover the energy monitoring systems used in the campus.

Bonilla et al. [5] used virtual instrumentation as a form of practical, low-cost tool to manage building energy use in a study in Mexico. They have proposed a flexible, user-friendly and low-cost remote monitoring system called Virtual Energy Management System (VMS). The tool is based on virtual instrumentation and the graphical user interface is developed on the LabVIEW 2013® virtual programming platform. The VMS developed would display and record the information of electrical parameters, electricity costs and carbon footprint to assist the user in visualizing the monitoring display and accessing records from the internet. Furthermore, the VMS software was designed to be used by employees and building managers to minimize the number of working personnel. The data was validated with the building actual energy use by the Autonomous University of the State of Baja California (UABC) located in Mexicali, Mexico. The results have shown that the total investment cost of a monitoring tool for Building Energy Management System (BEMS) can be reduced by 40% for small and medium buildings.

A similar work on using a simulation and control model for building energy management was done by Fanti et al. [6]. The authors used MATLAB/Simulink program to model the load and the user interface for the appliances was designed using Petri Net framework. In the proposed control strategy, the comfort conditions are respected for each of the appliances on the basis of the user preferences. The actual case study and the effectiveness of the simulator were validated against the actual usage of appliances. The results have shown that the simulation closely represents the real system: the simulation determines an energy cost equal to €3.3 and the measures obtained by the smart meter report an average cost of €3.15 with a consequent relative error of 4.8%.

From the Malaysia context, a review on building energy for sustainable development was conducted by Shaikh et al. [7]. In this review, it acknowledges the importance of pushing the user behaviour towards practicing energy efficiency in buildings, both from the users and tenant's points of view. It also highlights the 20% energy reduction in buildings through a retrofitting strategy initiated by the Government of Malaysia, while savings of 10% and more can be accrued by low or no cost energy saving measures. The scope of the review did not cover the mechanism by which this saving can be monitored and reported, especially in the government offices where tenancy rate or property market aspects may not be given high priority.

Apart from the works mentioned above, there is virtually no study conducted on using a web-based tool to monitor the energy performance for government buildings in Malaysia. Hence, the result from this paper will contribute to the body of knowledge regarding on-line building energy reporting tools, the use of which is applicable to hot and humid countries. The details of JENOSYS frameworks and feature are explained in Part III.

## III. JENOSYS FRAMEWORK

The JENOSYS framework was designed to ease the user to view, via the internet, the result of energy performance of their building in terms of energy saving in kWh, energy saving in utility cost (Malaysian Ringgit, RM) and the annual building energy intensity (BEI) in kWh/m$^2$/year. The following sub-sections describe the process flow and features of JENOSYS.

### *A. Process Flow*

The data acquisition and monitoring between JENOSYS and other external parties such as utility provider and external data manager are as shown in Fig. 1.

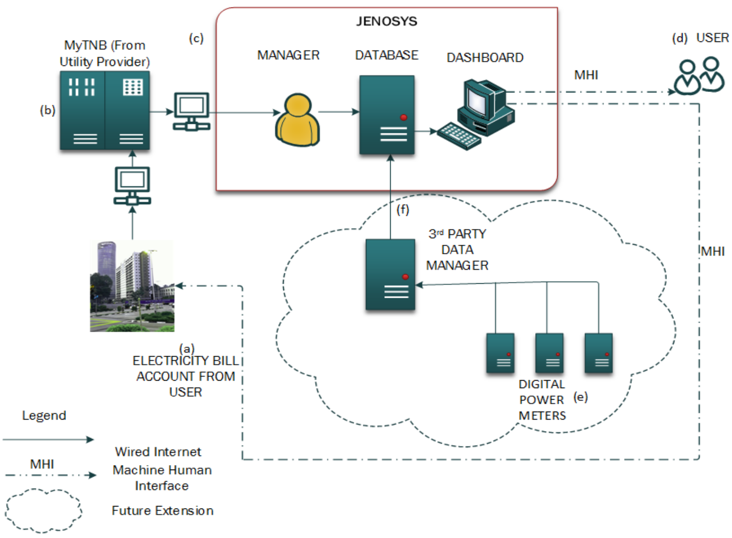


Fig. 1 Interface between JENOSYS and External Parties

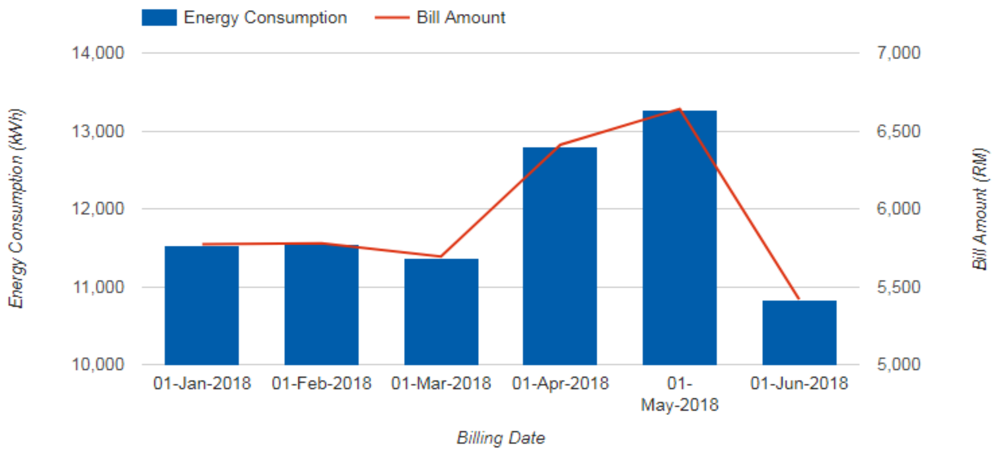


Fig. 2 User account form MyTNB showing billing history

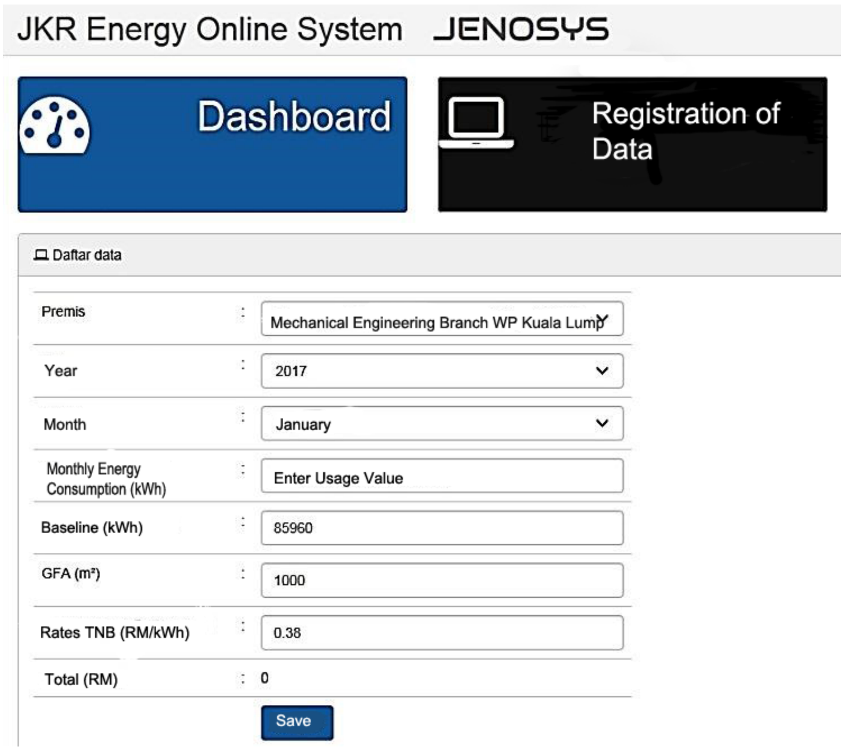


Fig. 3 JENOSYS interface for data input

The electricity utility bill of a user building, (a), is acquired through the MyTNB portal, (b), from which the user can access the consumption data, as shown in Fig. 2. MyTNB is developed by Tenaga Nasional Berhad (TNB), the government-linked utility provider.

The data are then fed into the JENOSYS, (c). The overall consumption is extracted from the database to be displayed on the dashboard for monitoring purpose by users, (d). For future extension of JENOSYS involving buildings equipped with digital power meters, (e), the energy consumption data would be consolidated at a 3rd party Data Manager, (f), and transferred to JENOSYS. The interface of JENOSYS for the purpose of feeding data from MyTNB is shown in Fig. 3.

*B. Features*

Basically, the JENOSYS dashboard consists of the histogram chart displaying the monthly building energy consumption against the energy baseline, the Building Energy Intensity, the monthly and cumulative energy savings, as well as the percentage and cumulative percentage energy saving for the building. The histogram chart of a typical monthly building energy consumption with baseline is shown in Fig. 4.

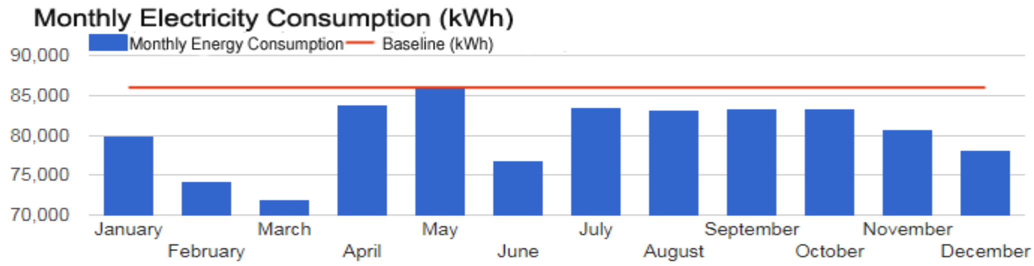


Fig. 4 Histogram Chart of Typical Monthly Building Energy Consumption with Baseline (Redline)

The JENOSYS manager calculates the energy baseline using the monthly energy bills received from the building user. The system then automatically calculates the energy saving in a month and cumulative energy savings for a year chosen earlier by the end user as illustrated in Fig. 5.

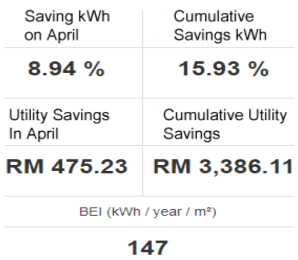


Fig. 5 Dashboard for Building Energy Intensity, Monthly Cumulative Energy Saving, Cumulative Energy Saving, Percentage Monthly Energy Saving and Cumulative Percentage Energy Saving

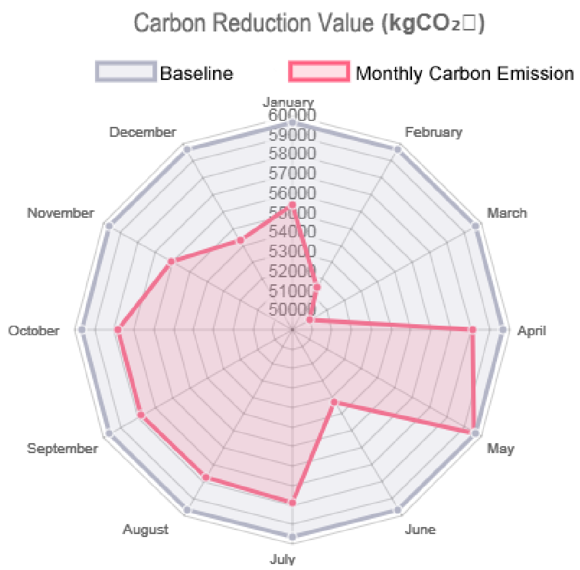


Fig. 6 Spider web diagram showing monthly carbon emission for a building (red area) against the baseline (gray area)

The energy savings will also be translated into a form of percentage and cumulative percentage summary results for the convenience of the end user.

Another feature of the JENOSYS dashboard is the carbon emission indicator for the electricity consumption, which is calculated monthly and compared against the baseline carbon emission, as shown in Fig. 6.

The methodology on calculating all the parameters such as building energy intensity, and $CO_2$ emission is explained in Part IV.

## IV. Methodology

The total building energy intensity, BEI, for a building is calculated using (1).

$$BEI = \frac{TBEC}{GFA} \quad (1)$$

where, TBEC = Total Building Energy Consumption (kWh), GFA = Gross Floor Area, ($m^2$).

The monthly carbon emission for each building in JENOSYS is calculated using (2).

$$CO_2\ emission\ (kg\ CO_2eq) = TBEC\ x\ 0.694\ (\frac{kg}{kWh}) \quad (2)$$

The figure 0.694 is the $CO_2$ baseline for the year 2014 for peninsular Malaysia, calculated by the Sustainable Energy Development Authority (SEDA) Malaysia.

There are 12 states in Peninsula Malaysia, and each state has its PWD MESO. A typical PWD MESO consists of at least one administrative block and a maintenance workshop block for doing government vehicles and heavy plant repairs. All the offices were chosen as a pilot to assess the practicality in data acquisition. The utility bills for all the offices are acquired from MyTNB utility accounts. The monthly energy performance data were captured and analyzed for its cumulative savings and the equivalent carbon emission. The exercise started at the beginning of year 2016. The average energy consumption for that year was chosen as the baseline for each building.

## V. Results and Discussion

The energy performance and the carbon impact of all the office buildings are shown in Table I.

i. The characteristic and function of the case study buildings can be categorized as the normal office and workshop building. These buildings have different types of billing method, where a number of buildings share a bulk energy meter, while a few PWD MESOs have individual meter for each building. This represents a difficulty in identifying which building takes priority; having a bulk meter may give the data of the total energy consumption of the whole complex but it masks the most significant energy user. However, for the sake of consistency, the analysis is taken as a single reading of utility cost (in Malaysian Ringgit, RM) and usage (kWh). This was simplified based on the Single Energy Usage (SEU) of each building owner due to difficulty in gathering the data on SEU for each system such as air-conditioning, lighting, and plug loads.

ii. Preliminary result from JENOSYS has shown that the cumulative energy saving for the case study buildings are 184,757 kWh per year with the $CO_2$ emission of 128,221.36 tonnes $CO_2$ per year (see Table I).

iii. From the monitoring, the user can notice the uniqueness of each building in terms of energy profile. This is due to:

a. Different tariffs used in different locations of the buildings;

b. Different categories of buildings within the same perimeter (such as administrative building and maintenance workshop block); and

c. Varying frequency of operations of the workshops between the PWD MESO (a few are active at the beginning of the year, while others are active at the end of the year).

TABLE I
PRELIMINARY SAVING IN KWH AND $CO_2$ EMISSION FOR THE CASE STUDY BUILDING

| Case Study Building | Cumulative Savings for 2017 (kWh) | Equivalent Carbon Emission ($kgCO_2e$) |
|---|---|---|
| A | 66,772 (6.47%) | 46,339.77 |
| B | -14,509 (-4.32%) | - |
| C | 12,674 (5.12%) | 8,795.76 |
| D | -25,151 (-10.91%) | - |
| E | 3,522 (1.75%) | 2,444.27 |
| F | 26,402 (15.11%) | 18,322.99 |
| G | 14,795 (7.69%) | 10,267.73 |
| H | -9,387 (-4.10%) | - |
| I | 54,825 (21.57%) | 38,048.55 |
| J | -8,614 (-6.44%) | - |
| K | -32,384 (-7.19%) | - |
| L | 5,767 (1.76%) | 4,002.30 |
| TOTAL | 184,757 | 128,221.36 |

**Note:** The negative sign indicates no saving incurred.

## VI. CONCLUSION AND FURTHER RECOMMENDATION

The features of the web-based JENOSYS, as well as its framework and preliminary result have been discussed. Despite difficulties in gathering data on precise energy usage for each HVAC plant, lighting and plug loads, and just relying on bulk meter readings via utility bills, the results have shown that comparison of energy performance for the case study buildings is possible. The web-based reporting has proven useful for the decision maker of a public office to evaluate and monitor the energy performance for each state in Malaysia. JENOSYS has the potential as an easy-to-use, national level web-based building energy disclosure tool for government buildings in Malaysia.

It is recommended that JENOSYS be extended beyond PWD, which will cover buildings owned or rented by other ministries. It is also recommended that the manual energy data acquisition be replaced by automated data input from utility company. Additional features such as a summary page showing the comparison of energy performance, energy savings and carbon emission between buildings under a government agency category, rather than categories of buildings, would be incorporated in the future for easier and quicker monitoring and corrective action.

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