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Developing Model and Scenarios of Energy Conservation Using System Dynamics (Study Case : Institute of Technology Sepuluh Nopember, Surabaya)

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ABSTRACT

Electricity is one of human's need to operate all the electronic appliances. Electricity that we used is generated from crude oil and coal. Both are non-renewable natural resources and limited in availability. While electricity is also the next generation's need. Therefore, we need an effort to guarantee the availability of electricity in the future. One of effort to guarantee the availability of electricity in the future is energy conservation effort. Energy conservation is the effort of using energy efficiently and rationally. In other words, energy conservation is energy saving. Energy conservation can be done in higher education because it has many populations and they use electricity in their main activities. Study about electricity saving are studied to identify the effort. From the study, one of the effort is to reduce the duration of use. So this research aims to know how much saving are obtained if we reduce the duration of use by using system dynamics.

Keywords : System Dynamics, Duration of use, Energy Conservation

I. INTRODUCTION

Electricity is one of human's daily need. People use electricity to run their electricity appliances. For example : electricity for lighting, for turning on the computer, etc. Electricity is mainly generated from combustion of crude oil and coal. The availability of those natural resources become limited so there's a need to reduce the use of them.

Higher education is one of the user of electricity. We can consider it as a small city because it has a big area, consist of many population and many activities that have direct and indirect impact on environment [1]. The use of electricity has an impact to environment because of the gas emissions that created from the use of crude oil and coal to produce electricity. So that's why higher education also has a responsibility to sustain the environment.

One of effort to reduce the use of non-renewable natural resources is to conserve the energy. The simplest thing to do is by reducing the use duration of electrical appliances. Therefore this research is aimed to know how much electricity consumption is reduced by reducing the use duration of electrical appliances. This research is using system dynamics method to show what variables are related with electricity consumption [2]

II. LITERATURE REVIEW

A. Energy Conservation

The simple definition of energy conservation is energy saving. Energy conservation is needed to do because of some reasons [3]:

- The dependency with fossil energy to generate electricity is still high while the availability of fossil energy is now limited.
- The linkage with environmental issue that is mitigation of climate change and national commitment to reduce gas emissions around 26 % by 2020.

- The utilization of renewable energy and energy conservation implementation is still not optimal.

The installation of sensors is the example to conserve energy. [4] used sensors to control use of electrical appliances at retail outlets. Those sensors are used for :

- Controlling air conditioning (AC) without decrease the comfort level
- Controlling air flow rate of ceiling fans
- Controlling the intensity of illumination

The result of the experiment is reducing the electricity use around 5%.

B. Institute of Technology Sepuluh Nopember (ITS)

ITS is a science and technology higher education located in Surabaya, Indonesia. To support the activities in it, ITS has two power house named Rektorat and Kampus. ITS only has one stand meter, so we only know the total electricity consumption in ITS. There's no stand meter in each building in ITS so we don't know how much each building consume electricity each month.

III. SIMULATION DESIGN

A. Causal Loop Diagram (CLD)

The data that received from ITS is only the list of appliances. Therefore, to calculate the electricity consumption , the first thing to do is to seek the electrical power of the electrical appliances. After that, the list of appliances are categorized into 9.

TABLE 1
APPLIANCES CATEGORIES

Category
Lab equipments
Printer and scanner
Household appliances
Audio video and film equipments
24 hours appliances
Office appliances
Computer appliances
Air conditioning (AC)
Lighting

After the appliances are categorized then the causal loop diagram is created.

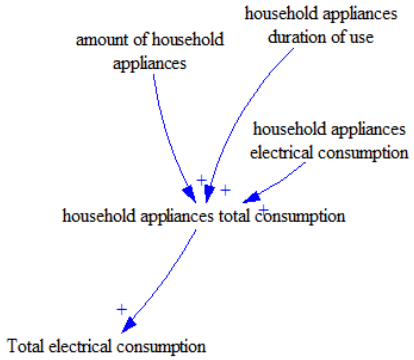

Figure 1. Sub household appliances CLD

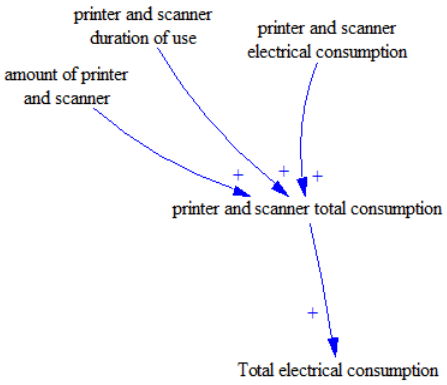

Figure 2. Sub printer and scanner CLD

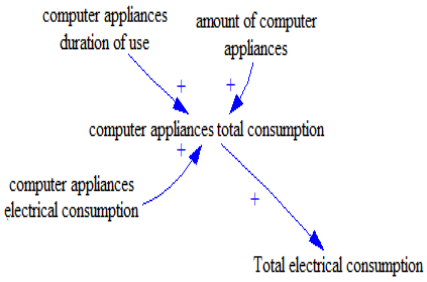

Figure 3. Sub computer appliances CLD

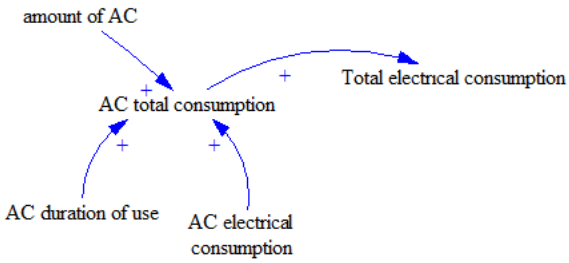

Figure 4. Sub AC CLD

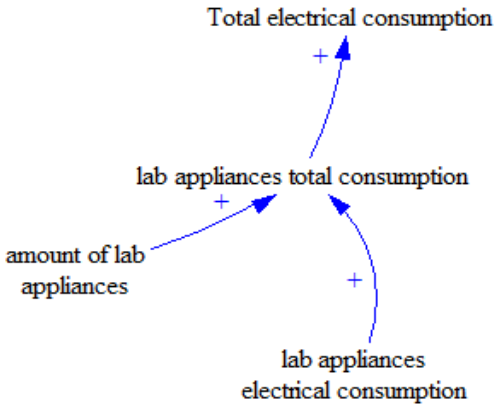

Figure 5. Sub lab appliances CLD

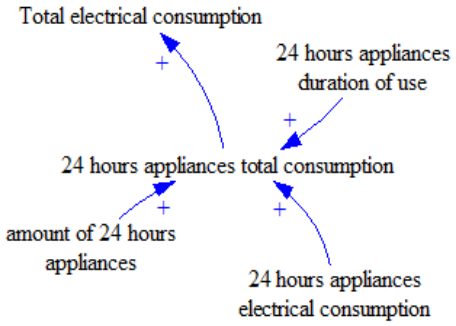

Figure 6. Sub 24 hours appliances CLD

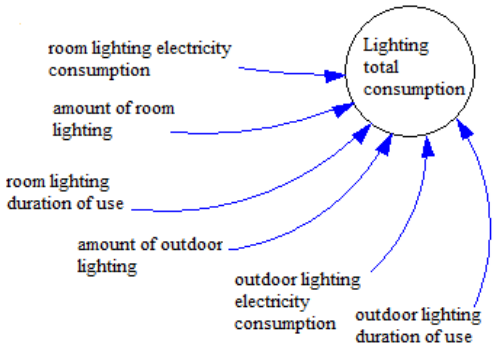

Figure 7. Lighting CLD

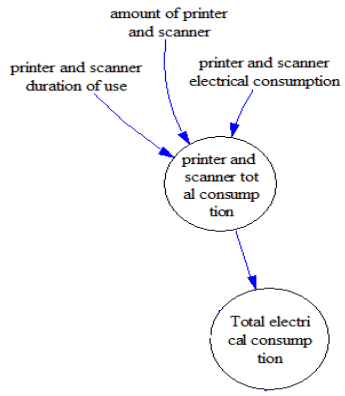

Figure 8. Printer and scanner consumption SFD

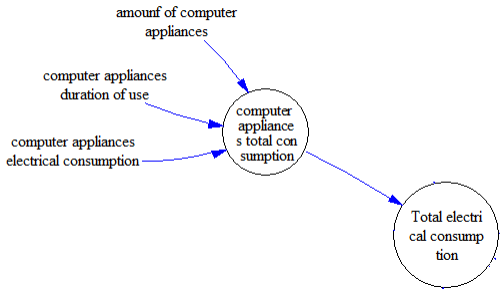

Figure 9. Computer consumption SFD

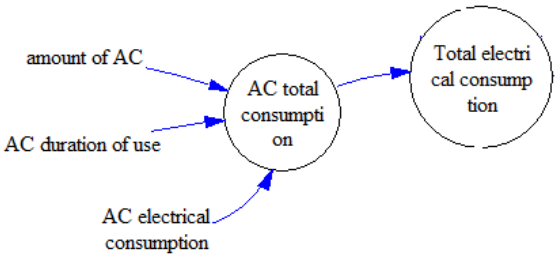

Figure 10. AC consumption SFD

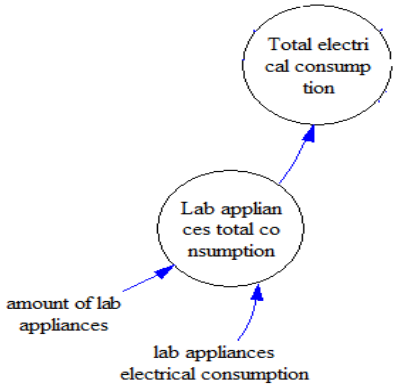

Figure 11. Lab appliances consumption SFD

B. Stock and Flow Diagram (SFD)

After we create the causal loop diagram next we create the stock and flow diagram.

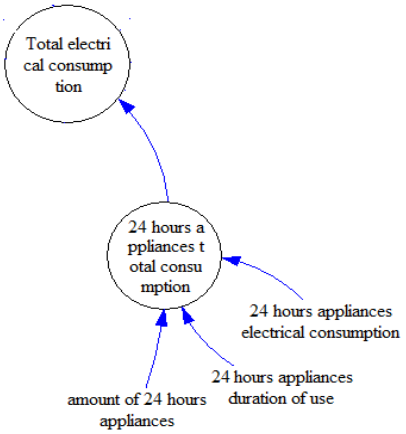

Figure 12. 24 hours appliances consumption SFD

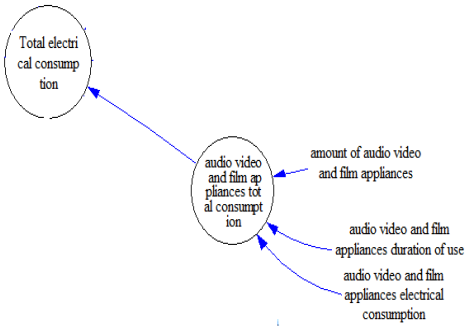

Figure 12. Audio video and films appliances consumption SFD

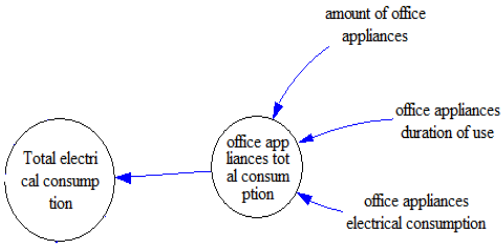

Figure 13. Office appliances consumption SFD

The mathematical model for total electrical consumption:

Total electrical consumption = printer and scanner total consumption + computer appliances consumption + AC consumption + lab appliances consumption + 24 hours appliances consumption + audio video and film appliances consumption + office appliances consumption +household appliances

IV. VALIDATION

There are two validation that are used: means comparison (E1) and amplitude variations comparison (E2). The model is valid if E1 ≤5% and E2 ≤ 30%.

$$E1 = \frac{|\bar{S} - \overline{A}|}{|\overline{A}|}$$

From the calculation, E1 = 0,00045.

$$E_2 = \frac{|S_s - S_a|}{S_a}$$

From the calculation, E2 = 0,23.

Because the E1 and E2 are qualified, so the model is valid.

V. SIMULATION SCENARIOS

From the stock and flow diagram, some scenarios are run to know how much reduction of electrical consumption if the duration of use is reduced. For the base model, the duration of use is set from 8-24 hours. The scenarios are run for printer and scanner appliances and AC. For the scenario model, the duration of use is set from 0-8 hours.

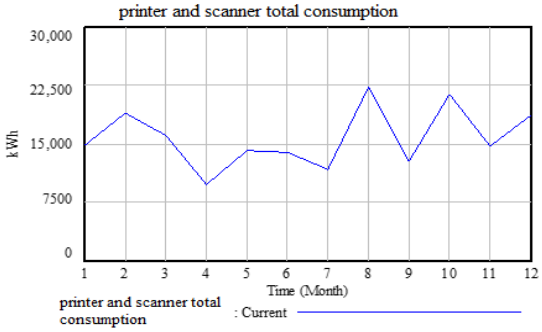

Figure 14. Base model of printer and scanner total consumption

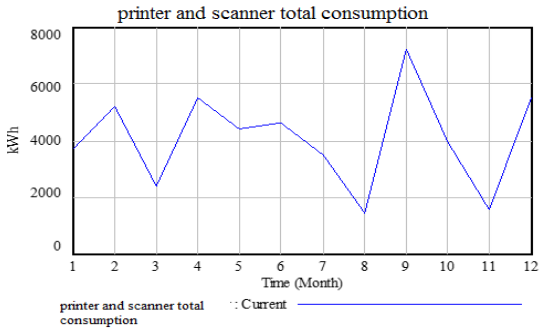

Figure 15. Scenario model of printer and scanner total consumption

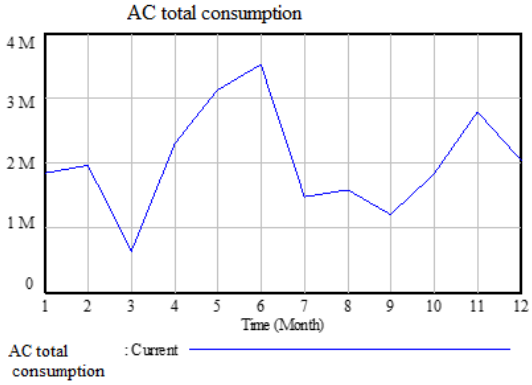

Figure 15. Base model of AC total consumption

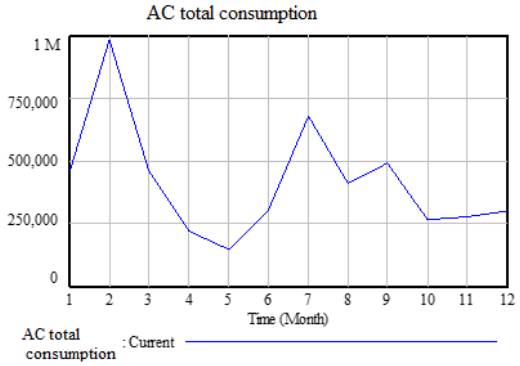

Figure 16. Scenario model of AC total consumption

VI. CONCLUSION

Based on the scenarios, it can be concluded that one of effort to conserve energy, we should reduce the use duration. Reduction of use duration means that after we use the electrical appliances or if we go away for a long time, those should be turn of completely. Because the electrical appliance is still draw the electrical power in standby mode.

VII. REFERENCES

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