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Application Design of Embodied Energy Calculation for Building Materials in Indonesia

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ABSTRACT
This paper describe software design of embodied energy (EE) calculation for building materials. Materials' EE is an issue in green building which refers to energy released in building- lifecycle of a material usage. Therefore, EE value becomes very important in measuring how much energy will be consumed and how environment can be damaged, since the planning phase of the building. The materials' EE calculation is called Material Unit Analysis (MUA). It was developed base on Work Unit Price Analysis or *AHSP* method as a construction material calculation method in Indonesia. Application design of EE calculation for building materials software use the flowchart as programming. The main programmes are software and simulation section of EE calculation. Software section display some function are ; the materials' EE inventory data, unit conversion and input new materials which is not in EE inventory data. The simulation section could show the materials' EE calculation results in three display, are in: each material unit, building components or total building. Hopefully, materials' of EE calculation software application will ease the calculation system. The designers are willing to do the EE value calculation, and using it as an environmental consideration in the design decisions.
Keywords - Application, Building Material, Calculation, Design, Embodied Energy

I. INTRODUCTION

This paper will decsribe application design and development the Embodied Energy (EE) Calculation for building material. EE calculation software application could make the materials' EE calculation tool usage easier. It will be encourage designers to calculate EE material value for their building planning. It is a mitigation efforts for use no harm materials for environment in the future.

Development activities were consumed a large of energy and contribute Emission Carbon (EC) increasing. It mean would effect to environment temperature increasing which is called greenhouse effect. Most country in the world start to use Clean Develoment Mechanism (CDM) implementation as global agreement to reduce EC and make the world greener [1,2]. Energy policy for building concern to manage the energy efficient, are ; 1) Energy efficient of Building Planning, 2) Integration of City Planning. Both of all were support the implementation as energy efficient building standard and environment friendly [2].

An energy mitigation of building could use technology aspect as an approach to implement energy mitigation through EE material calculation of building. The application was created as application software and it developed base on *Analisis Harga Satuan Pekerjaan (AHSP)* method developing. Materials' EE value calculation has developed as a tool to count the EE material value of the object. It promote for stakeholder to involve as their role and responsibility to early energy

mitigation. [3]. Material measurement of building would not figure out of all building energy consumption, but it would represent for most part of a large the building energy consumption [4].

1.1 Embodied Energy Analysis

The energy that accompany its activities in each or total phase of lifecycle building is called Embodied Energy (EE). EE in buildings represents the non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site, and construction. EE has direct energy that used to transport building products to the site, and then to construct the building; and indirect energy that used to acquire, process, and manufacture the building materials, including any transportation related to these activities [5].

EE in planning phase will cover all activities for materials building procurement in pre-construction phase or called as craddle to the gate [6]. Materials' EE value was resulted through EE material calculation process. Most in Indonesia, construction work planning use *AHSP* method which is issued by *Badan Standarisasi Nasional (BSN)*. *AHSP* or Work Unit Price Analysis (WUPA) have some component of construction work, are : materials, labour and equipment. WUPA will breakdown all component of construction work as

Bill of Quantity (BoQ). BoQ consist some component, are : coefficient, unit, work specification and work volume. It will through selection process to find material aspect only as Material Unit Analysis (MUA) method as describe in **Figure 1** below. The material aspect consist are ; coefficient, unit, material specification and material volume. The material is known as static component but others as dinamic component in construction work [7]. All of the material selected process is described as seen in **Figure 1** below.

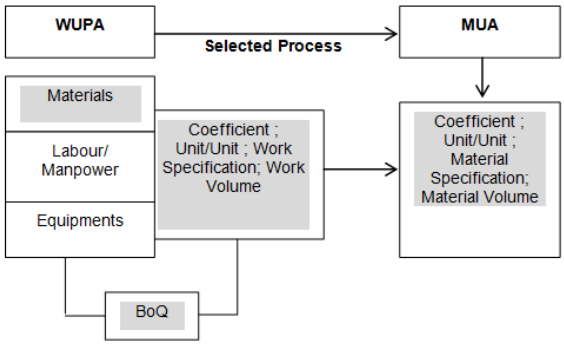


Fig. 1

The material aspect is described in material specification and material volume as seen in **Table 1** below.

Table 1.

Coefficient	Unit	Material Specifica -tion	Material Volume
70	unit	Brick	Suitable for each building unit
18,95	Kg	Portland Cement	
0.038	m^3	Sand	

MUA method calculate materials' EE value. It could be used for count singular material or total material of the building. First, breakdown material specification of building and list the material specification. Materials' EE calculation model will process each material building for material volume. There was various material unit and it need to convert into energy unit by materials' EE value unit (EE = MJ/Kg). materials' EE calculation by MUA method need the Inventory of EE Material Data to complete EE material value of building/object. It refer to credible sources is like Inventory of Carbon and Energy (ICE) which is issued by Bath University, United Kingdom [8]. The ICE that used by many institution all over the world [4].

1.2 Energy Unit Conversion

MUA resulting for various unit in wall component work per m^2. It desribe as seen in **Table 1** above. All of material building referred to EE Material Inventory Data and will found that some specification material has not materials' EE value yet [8]. In spite, there were some various unit have to change to same unit. All of EE material value which is have mass unit or energy unit do not have to change but the other have to change it.

MUA have concern to material unit/component building because it has various unit for each material specification in the object. Material unit have to convert to energy unit for calculation easily. The conversion process of material unit through all material unit converting process and result in kilogram (kg). It will ease EE material calculation in energy unit (EE = MJ/kg). The ilustration of conversion process to energy unit (MJ/Kg), e.g. MUA result showed the data volume wood material of the object in m^3. The wood material unit would convert into kilogram (kg). The basic formula of volume (m^3) = mass (kg) / specification mass of wood (kg/m^3). The formula of mass (kg) = volume (m^3) * specification mass of wood (kg/m^3). So, mass of wood in the object will result in kilogram base on number of material volume. The result of the mass of wood material = xx kg. Kg have equal with Newton.meter (N.m). N.m should divide by per 10 kg to equal with 1 Joule. Then, Joule could be convert to MJ/kg with divided by 1000. It is called Singular Material Calculation Method [9].

List of Symbols	
M	Mass of materials
J	Unit of energy
Kg	Unit of mass
m^3	Unit of volume
N	Unit of force
m	Unit of lenght

II. SOFTWARE PROGRAMMING DESIGN OF EMBODIED ENERGY CALCULATION

Materials' EE calculation would develope as application base on web. Its processing requires a programming and design application. This application use a simple programming as a flowchart for materials' EE calculation base on computer application. The outline sequence for the work as input-process-output as diagram form. It describe all process step by step of operation system in computer [10, 11]. Flowchart of EE calculation for building material as seen in **Figure 2** below.

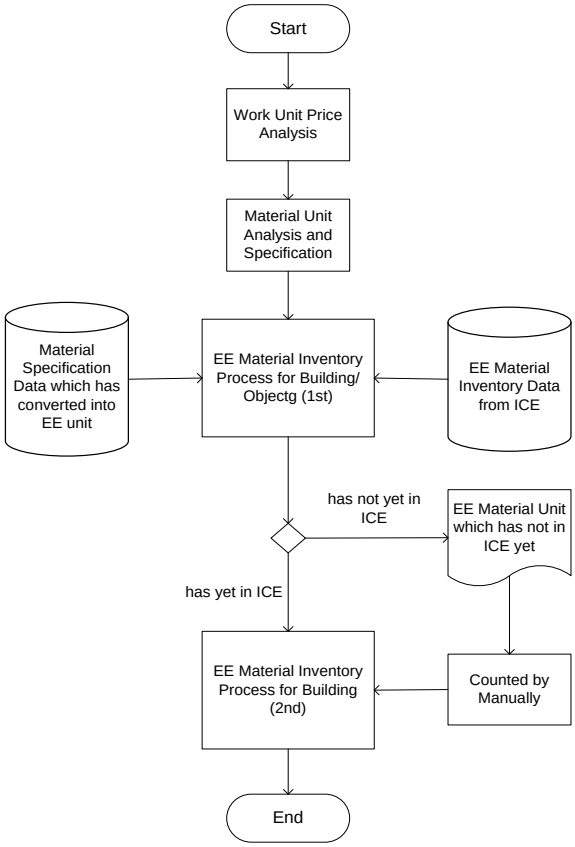


Fig. 2

To create a software application have to follow all phase in design application :

1) Flowchart as programming showed the first concern for data storage of materials' EE value as important thing in process.
2) Second, all of material unit conversion to energy unit is done. In this case, the materials' EE material calculation model ready to process in programming system by flowchart.
3) The process refer to every step and then stored in data storage.
4) The flowchart illustrated how the model development an operating system in the application of EE material calculation.
5) The calculation applied a mathematical model to clarify the operating system was built.
6) Then use operating system as input-process-output.

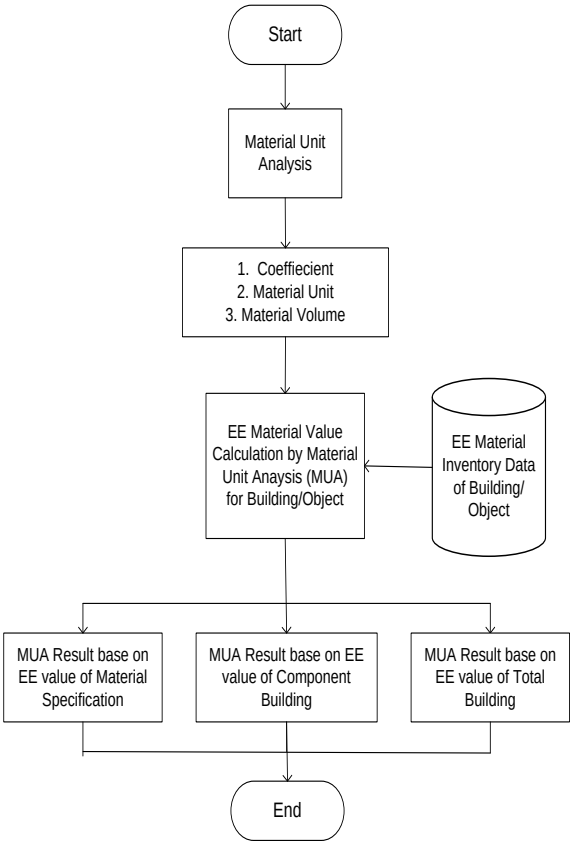


Fig. 3

Flowchart describe the EE material value result and will divide into three option, are ; 1) result of specification material, 2) result of component building, 3) result of total building. The options could be choiced if it necessary.

The application will need data input one by one manually, then computer application will do calculation process once, and finally will show the result in three option which needed by user. EE Material Model Calculation as shown in **Figure 3**.

III. APPLICATION DESIGN OF EMBODIED ENERGY CALCULATION

3.1 Dialogue Design

Each sections of flowchart are interconnected and constructed sequentially. It started by input data, the calculation process and finally output are displayed. All sections must be link each other and operating system that will be recognized by programming. This dialogue where each part is illustrated clearly and order as Chart Dialogue Design has shown in **Figure 4** below.

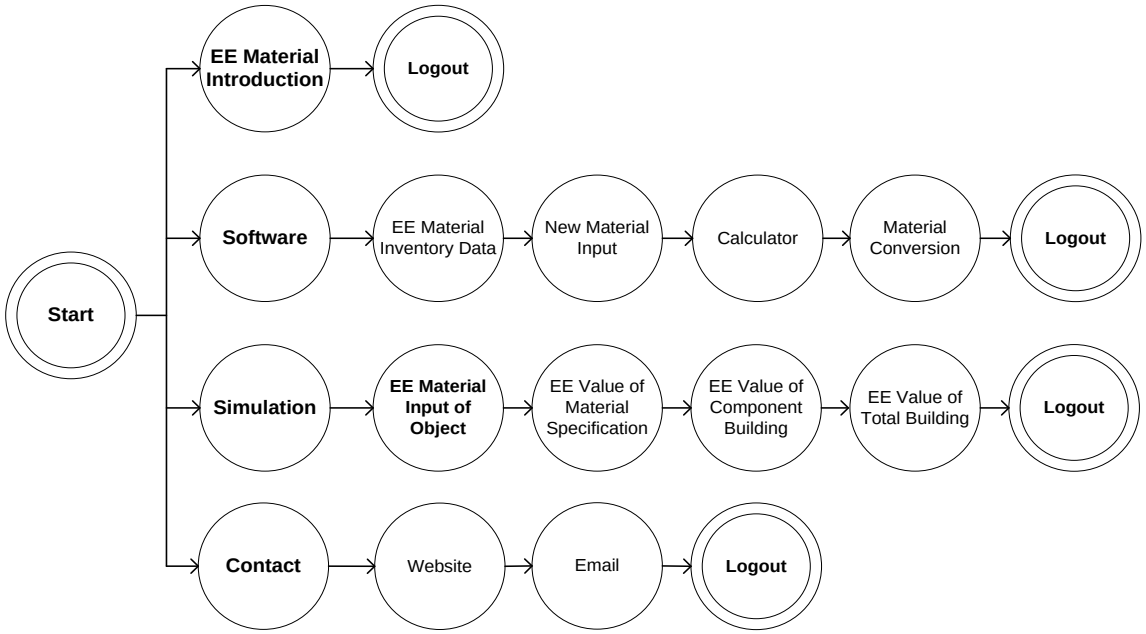


Fig. 4.

The Chart Design Management Views as seen in **Figure 5.**

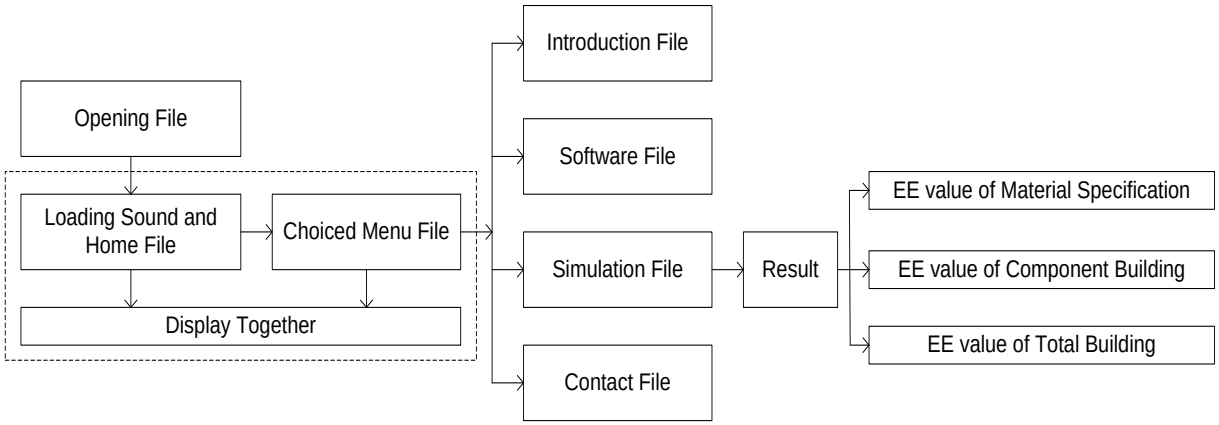


Fig. 5.

3.2 Layout Design View by Applications

Materials' EE calculation application view is made simple for the features as well as summaries that are considered important. In the layout of the Layout Design View as shown in **Figure 6**.

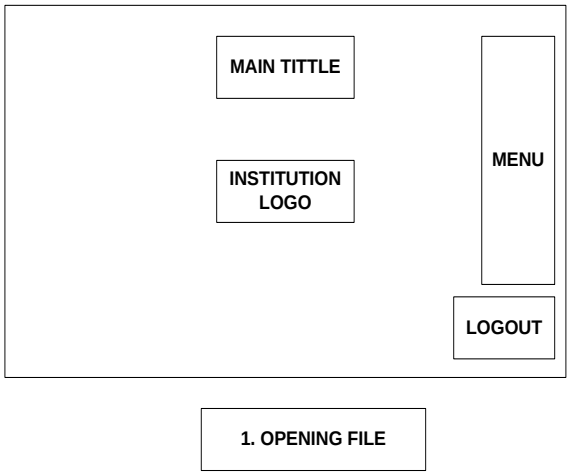


Fig. 6.

3.3 View Display by Application

Views display by application create in five section and interconneted by menu button. First, user should know the name of website which have EE material calculation application. It will be at http://ar.itb.ac.id/gbrc/eec. Section 1 display the opening section and show MAIN PROGRAM and its atributes are like logo institution, features icon and some figures. Icon consists of Home, Introduction, Basic Calculation (software), Simulation, and Contact. Home inform what the features can be seen on this section. Icons will clicked by user to go the the feature or program. In every page will appear home and logout icon. Opening Section as shown in **Figure 7**.

The important section in this application are Software Section **(Figure 8)** and Simulation Section **(Figure 9)**. Both as core of application which is calculating process or result display.

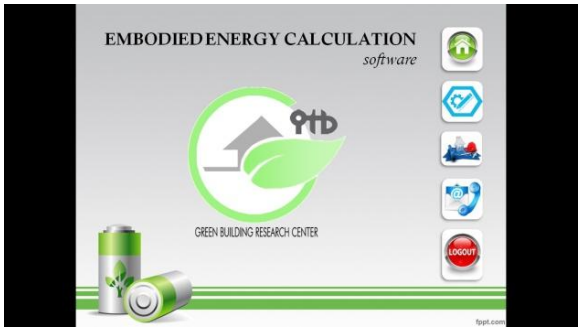


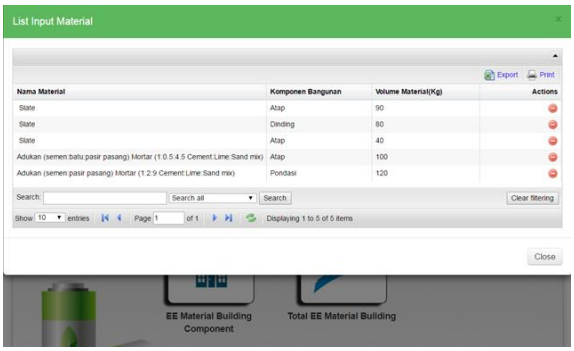
Fig. 7.

Fig. 8

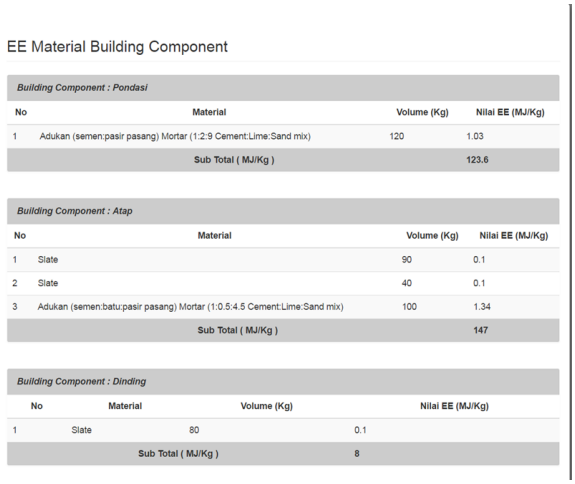
Fig.9

Simulation Section (**Figure 8**) have four icon, and each button has each program, are ; input data, input new inventory data, calculator, unit conversion. User could input data one by one and follow the form in this icon. Data will sent and save in data storage, ready for calculating by program. User could input data of new material which is not in the list of inventory EE material data. User input new data one by one and follow the form in this icon. Data will sent and save in data storage. Operator will check the new data and process it. User could use the new data if it was in inventory EE material in application.

Simulation section (**Figure 9**). This is a core program in application. The page have four icon, and each button has each program, are ; Unit EE Material Input data, EE Material Specification, EE Material Building Component, Total EE Material Building. First icon is Unit EE Material Input data to input material data of object which will calculate. It is a simulation of EE material calculation with an ob object. The next icon have fuction to display result of EE material calculation for an object. It will shown in three result display type, are ; 1) as material specification list and each EE material value in volume, 2) as building component and its volume, and 3) as total material building volume. As seen in **Figure 10 (a-c)** below.



(a) Display of each material specification and its EE value



(b) Display of each material volume of building component and sub-total EE value

(c) Display of total EE value for building / object

3.4 Result of EE Material Calculation Application

The EE calculation application was early development. The application should to be tested and checked error system. This application is not as easy as planned at the beginning. The test found that conversion process for material cannot did automaticly. Material unit have to convert as

singular material unit and result some numeric as consequence of conversion process. The conversion process must through a special process and is not connected with the operating system of EE material calculation model. When it connected will face many various unit and built as the simple operating system not.

The obstacle in using in the Inventory EE material. EE material Inventory data is expected to cover all the user requirement. EE material data source refer to the ICE, UK, in spite, the terms of the materials used are different in Indonesia terms. It must make adjustments to the terms commonly used in BSN, to allow user find the necessary data. Completeness of data can be performed manually by the operator only. When there is new material input, new EE material value should be a special process that is not connected with the operating system of EE material calculations application. The main problem in this calculation system is material conversion to energy unit in obtain a more comprehensive EE inventory data. This application should have complete EE material value more to cover all building type.

In the next development, the obstacles of operating system application of EE material calculation shoud be repair. The input-process-output should make operator and user could do easily. Furthermore, this application should develop as an integrated application with other requirement, e.g costing calculation. There is many possibility to develop this application to respon user's requirement.

IV. CONCLUSION

This paper presents the software design of materials' EE calculation base on computer application. The application used simple flowchart as programming and have materials' EE inventory data collecting. The final result divided into 3 choices of EE material value displaying, are ; 1) as material specification list and each EE material value in volume, 2) as building component and its volume, and 3) as total material building value in volume.

Next, this computer application should develope base on android system. The aim of software application development is to ease materilas' EE calculation by user. Hopefully, user encouraged to contribute EE material decreasing in their project. This application should develop as an integrated application with other requirement, e.g costing calculation.

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