Development of Web Programming for Calculation of Energy Efficiency Design Index (EEDI)

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Abstract: Transportation is one of the biggest contributors to air pollution. To create a clean environment from pollution in sea transportation, International Maritime Organization (IMO) issued a regulation in the form of energy efficiency design index (EEDI) that applies to ships over 400 GT. The calculation is based on the divisor between CO2 emissions and transportation work. But to calculate the overall energy efficiency design index requires several parameters that are quite detailed. These parameters will be the basis for increasing efficiency according to sufficient load capacity and will make an innovation for the creation of a blue economy. Therefore, to make it easier to find an optimal and fast design process, web programming will be created and developed for the calculation of the energy efficiency design index which can later be accessed via the internet and hopefully can be used for ship designers.

1 INTRODUCTION

In this era of globalization, the world's industry is developing very fast. The development of the industrial world known as the Industrial Revolution. According to (Schwab, 2017), the development of the industry is divided into 4 industrial revolutions, Industrial Revolution 1.0 to 4.0. The emergence of the industrial revolution began with the discovery of steam engines in the 18th century so that goods could be mass-produced. The 2.0 Industrial Revolution began in the 19-20 century with the use of electricity that could make production cheaper. With computers and automation systems found around 1970, the 3.0 Industrial Revolution emerged. The 4.0 Industrial Revolution through intelligence engineering and the Internet of Things occurs movement and connectivity between humans and machinery in various areas that cause such activities can also accelerate human work (Mukhopadhyay and Suryadevara, 2014; Prasetyo and Trisyanti, 2018). The impact of the rapidly expanding industrial revolution one is with the demand of the customers that will increase. Because the development will also increase fossil-fired machines used in the production of an item. The many uses of these fossil machines will cause increased air pollution. Closely related to the world of shipping, the automatic capacity of the ship can also increase according to the supply needs in an area. Because this increased capacity can also cause the use of larger diesel engines too. It can also increase emissions or air pollution.

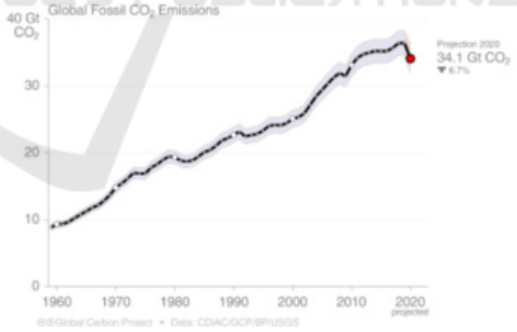

Figure 1: Global CO2 emission (Global Carbon Project, 2020).

To create a healthy environment caused by this industrial revolution, green economy is introduced by UNEP. The green economy is based on economic production, by minimizing emissions, reducing resource consumption, and reducing environmental cost (Bauer, 2014). Transportation is one of the biggest contributors to air pollution, one of which is sea transportation. To reduce pollution on vessels, the International Maritime Organization (IMO) issued a

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regulation in the form of energy Index design Efficiency (EEDI). This Regulation applies to new vessels above 400 GT which is a building contract placed on or after 1 January 2013or without the existence of a contract of construction, the keel placed or that at the same stage of constructions on or after 1 July 2013 or shipments on or after 1 July 2015 (International Maritime Organization, 2011). As well as being useful for minimizing emissions, it also raises innovations that will be used to increase ship efficiency. The increasing efficiency of this vessel will save fossil fuels that will benefit the owner of the ship itself as well as the environment. Mutually beneficial factors between ship owners and the environment because the innovations that have been made are also included in the concept of the Blue Economy (Pauli, 2010).

In this 4.0 industrial revolution in addition to increased demand for capacity, it is also necessary to quickly process the ship design. One of the most important ship designs is designing a propulsion or machining system of ships. In the process of constructing a new vessel of the construction of the vessel, holding the role of 70% both in terms of Finance and in terms of job execution (Cahyasasmita and Utama, 2014; International Maritime Organization, 2009). Therefore, since the initial selection of the engine is to be.

The design of the propulsion system is closely related to the calculation of the energy efficiency index design (EEDI) for new ships (International Maritime Organization, 2012). Before calculating EEDI, it takes the main engine power parameters to be adjusted to the propeller. In the design of the initial design is calculated in complex beforehand to be able to push the ship according to the desired speed of the ship. Even to predict in detail can use software or conduct experiments directly. In addition to the main engine power parameters, the selected machining power data is also required.

After going through a lengthy process in predicting the main engine, along with other parameters, an EEDI calculation can be performed to determine and predict the emissions released in accordance with the capacity and speed desired by the ship. If the EEDI results obtained do not meet the requirements, then go back to the previous calculation (spiral design) (Papanikolaou, 2014). If the traditional propulsion system still has an EEDI that does not meet the requirements, it can be interpreted that the efficiency of the ship is still low and has high emission gas. To overcome this, optimization efforts can be made to increase the efficiency of the ship (Ančić and Šestan, 2015).

The energy efficiency design index can also be said as verification for a new ship design so that it has sufficient efficiency to minimize emissions and fuel. The industrial revolution 4.0 demands that every process be carried out quickly and accurately. Although as a verification, EEDI has a fairly complex calculation and varies for each type of ship, fuel, the amount of power produced and several other parameters (International Maritime Organization, 2011, 2012). Besides technical data, documents or certificates are also needed for the approval of classification bodies (International Maritime Organization, 2013). Lifting activity is one of important part in the engineering sequence.

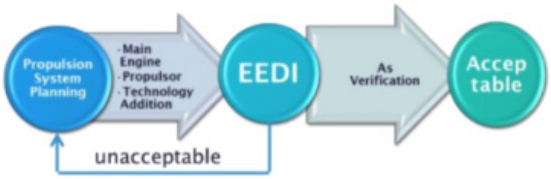

Figure 2: EDDI as verification.

An integrated system is needed to create, share and exchange design, manufacturing, operating and maintenance information. The required system must minimize redundancy in sharing and exchanging technical information (Kim et al., 1998; Lee et al., 2006; Suh et al., 2000). Therefore, it would be very helpful if the energy efficiency index design calculations can be done quickly and precisely according to predetermined standards to expedite the approval of the classification body both the calculations and the documents required. For this reason, a web-based development program can be made to meet and help these needs that can be easily accessed by those in need.

2 LITERATURE REVIEW

In this literature review will discuss the calculation of energy efficiency index design and web programming. The following basic data is needed to achieve EEDI:

2.1 Energy Efficiency Design Index

The Energy Efficiency Design Index (EEDI) is a measure of ship CO2 emissions in grams per ship's capacity-mile (the smaller the EEDI the more energy efficient ship design) and is calculated by a formula based on the technical design parameters for a given

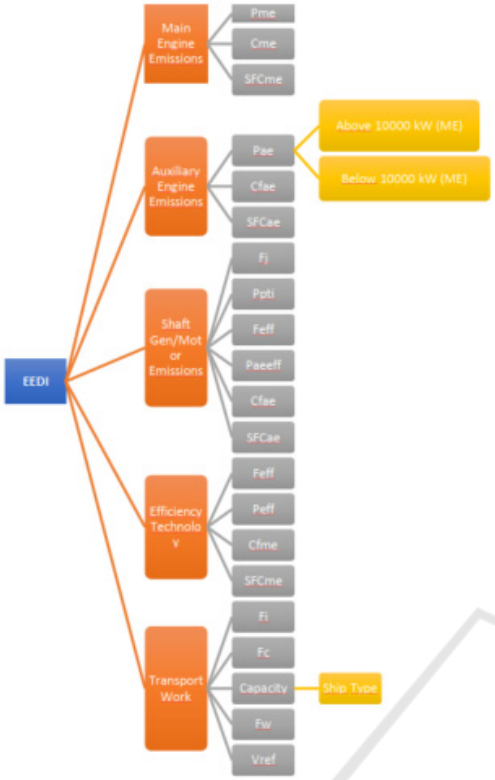

Figure 3: Basic data and parameter.

ship (International Maritime Organization, 2019). In EEDI calculation, CO2 emission is divided into 4 main parameters. The parameters are emissions produced by the main engine, emissions produced by auxiliary engines, emissions produced by shaft generators or motor shafts, and technology efficiency used in propulsion systems. While for transport work (ship's capacity-mile) there are 4 main parameters. The parameters are capacity factor, cubic capacity correction factor, capacity, ship speed, and weather factor. The following formula per parameter is used to calculate EEDI:

2.1.1 Main Engine Emissions

$$\sum_{i=1}^{nME} P_{ME(i)}.C_{ME(i)}.SFC_{ME(i)} \quad (1)$$

P_{ME} is 75per cent of the rated installed power (MCR for each main engine. C_{ME} is conversion factor between fuel consumption and CO_2 emission of main engine. Conversion factor is given in Table 1. SFC_{ME} is specific fuel oil consumption.

Table 1 Conversion factor between fuel consumption and CO2 emission.

Type of fuel	Reference	Carbon Content	CF (t-CO2/tfuel)
Diesel/Gas oil	ISO 8217 Grades DMX through DMB	0.8744	3.206
Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.8594	3.151
Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.8493	3.114
Liquefied Petroleum Gas (LPG)	• Propane	0.8182	3.000
	• Butane	0.8264	3.030
Liquefied Natural Gas (LPG)		0.7500	2.750

2.1.2 Auxiliary Engine Emissions

$$P_{AE}.C_{FE}.SFC_{AE} \quad (2)$$

P_{AE} is power of auxiliary engine. For calculation of P_{AE}, divided into two depending on the main engine power. For ship power with a main engine power of 10.000 kW or above, P_{AE} is defined as:

$$\left(0.025\left(\sum_{i=1}^{nME} MCR_{ME_i} + \frac{\sum_{i=1}^{nPTI} P_{PTI_i}}{0.75}\right)\right) + 250 \quad (3)$$

For ship power with a main engine power below 10,000 kW, P_{AE} is defined as:

$$0.05\left(\sum_{i=1}^{nME} MCR_{ME_i} + \frac{\sum_{i=1}^{nPTI} P_{PTI_i}}{0.75}\right) \quad (4)$$

$P_{PTI(i)}$ is 75 per cent of the rated power consumption of each shaft motor divided by the weighted average efficiency of the generator(s). If there is not shaft motor PPTI(i) is 0 (Bøckmann and Steen, 2016). CFAE is conversion factor between fuel consumption and CO_2 emission of auxiliary engines given in Table 1. SFC_{AE} is specific fuel oil consumption of auxiliary engine.

2.1.3 Shaft Generator/Motor Emission

$$\left(\prod_{j=1}^{M} f_j . \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{n_{eff}} f_{eff}(i) . P_{AE_{eff}(i)}\right) C_{FAE} . SFC_{AE} \quad (5)$$

f_j, is a correction factor to account for ship specific design elements. f_j is divided into three types: for ice class ship, for ice shuttle tanker with propulsion redundancy, and for other ship.

The power correction factor for ice-classed ship should be taken as the greater value of f_j0 and f_j min, as tabulated in Table 1 but not greater than f_j max= 1.0.

For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7. For correction factor for power fj ice-class ship see MEPC 212 (63) Annex 8, Page 9 (International Maritime Organization, 2012). For shuttle tankers with propulsion redundancy should be fj = 0.77. This Correction factor applies to Shuttle tankers with propulsion redundancy between 80,000 and 160,000 deadweight. The Shuttle Tankers with Propulsion Redundancy are tankers used for loading of crude oil from offshore installations equipped with dual-engine and twin-propellers need to meet the requirements for dynamic positioning and redundancy propulsion class notation (International Maritime Organization, 2012). For other shiptypes fj= 1.0.

f_{eff} is avaibility factor of each innovative energy efficiency technology. f_{eff} for waste energy recovery system should be (1.0). $P_{AEeff(i)}$ is auxiliary power reduction due to innovative electrical energy efficient technology measured at $P_{ME(i)}$.

2.1.4 Efficiency Technologies

$$\sum_{i=1}^{n_{eff}} f_{eff(i)} . P_{eff(i)} . C_{FME} . SFC_{ME} \quad (6)$$

f_{eff}, C_{FME}, SFC_{ME} have been explained above. While $P_{AEeff(i)}$ is the output of the innovative mechanical energy efficient technology for propulsion at 75 per cent main engine power.

2.1.5 Transport Work

$$f_i . f_c . \text{Capacity} . f_w . V_{ref} \quad (7)$$

f_i is capacity factor and should be assumed to be one (1.0) if no necessity of the factor is granted. There are three capacity factors that are required according to the type of ship: for ice-classed ships, for ship specific voluntary structural enhancement, for bulk carriers and oil tanker (International Maritime Organization, 2012).

f_c is the cubic capacity correction factor and should be assumed to be one (1.0) if no necessity of the factor is granted. There are two cubic capacity factors that are required according to the type of ship: for chemical tanker and for gas carriers having direct diesel driven propulsion system constructed (International Maritime Organization, 2012).

For calculating EEDI, the capacity of the ship is also defined according to the type of ship. For bulk carriers, tankers, gas tankers, ro-ro cargo ships, general cargo ship, refrigerated cargo carrier and combination carriers, deadweight should be used as Capacity. For passenger ships and ro-ro passenger ships, gross tonnage in accordance with the International Convention of Tonnage Measurement of Ships 1969, Annex I, regulation 3 should be used as Capacity. For containerships, 70 per cent of the deadweight (DWT) should be used as Capacity.

f_w is coefficient indicating the decrease of speed in representative sea conditions of wave height, wave, frequency and wind speed. While V_{ref} is ship speed.

2.1.6 Main Formula EEDI

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} . C_{ME(i)} . SFC_{ME(i)}\right) + (P_{AE} . C_{FAE} . SFC_{AE}) + \left((\prod_{j=1}^{M} f_j . \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{n_{eff}} f_{eff}(i) . P_{AEeff(i)}) C_{FAE} . SFC_{AE}\right) - \left(\sum_{i=1}^{n_{eff}} f_{eff(i)} . P_{eff(i)} . C_{FME} . SFC_{ME}\right)}{f_i . f_c . \text{Capacity} . f_w . V_{reff}} \quad (8)$$

The explanation above is the parameters used and needed to calculate EEDI. Calculation and formula This is a combination of main engine emission, auxiliary engine emissions, shaft generator or shaft motor emissions, additional technology efficiency, and transport work. To obtain the Energy Efficiency Design Index use the following formula (International Maritime Organization,2012):

2.2 Web Programming

There are several types of web programming such as PHP, MySQL, and Javascript. But what is recommended for this case is to use PHP web programming because it has advantages compared to another web programming (Nixon, 2014). The advantage of PHP is its use is relatively easy, PHP only requires HTML and CSS to support the creation of web programming. PHP is a free application because it has many PHP communities. The advantage of this large number of communities is that

when you have a few problems with PHP, finding a solution is relatively easy. PHP is also special programming for making the web, so it is very suitable in this case. Most websites today also use PHP, including large websites like facebook, yahoo,Wikipedia, Flickr.

The benefits of the system developed are the reduction in management costs by the systematic and integrated management of a large amount of data created during the entire life cycle of the ship, the reduced number of paper documents and drawings, increased consistency and integrity between each department in the organization. In addition, because the system developed is based on the internet, users can utilize information regardless of time and place, reducing the time needed to collect data and analysis for decision making (Lee et al., 2006).

2.3 PHP Web Programming

HP is a server-side scripting language designed to make the web. On HTML pages embed PHP code. PHP code is executed on the server side not on the client computer. And the results displayed are pure HTML code (Astamal, 2009).

This programming language uses a server-side system. Server-side programming is a type of programming language that later scripts / programs will be run / processed by the server. The advantages are easy to use, simple, and easy to understand and learn.

PHP can help to develop web-based applications that are quite complex, reliable, and fast. Depending on business specifications, hosting usage, level of experience, application requirements, and timeframe development. In addition, there are many PHP frameworks to choose from (Oktavian, 2010).

The way PHP works is as a programming language for developing web-based applications. Because in addition to PHP web programming can also be used to develop desktop-based applications and CLI (Command Line Interface).

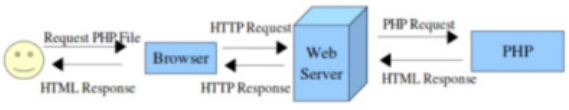

Figure 4: PHP Works.

From the picture above it can be explained PHPworks (Astamal, 2009):

1. The user requests a PHP page
2. The browser sends an HTTP Request to WebServer
3. WebServer sends the PHP file request to the PHP processor. PHP processor can be a module (part of the webserver) or separate (as CGI / FastCGI)
4. He request is processed by the PHP processor then the results are sent back to the webserver
5. The web server repackages the results by adding an HTTP header and sending it back to the browser.
6. The browser processes the HTTP packet and displays it as HTML to the user.

Variables are very important elements in a programming language. Almost every programming language knows what is called variable. Variable itself is a form of temporary data storage in computer memory that will be further processed. Conditions for making variables:

1. Variables can consist of letters, numbers and underscore (_) and of course the dollar ($).
2. Variables cannot begin with numbers.
3. Variables are case sensitive meaning to distinguish between lowercase and uppercase letters.
4. The $ name variable is not the same as $ NaMe.

For that reason, be careful in writing variable names.

2.3.1 PHP Variable

There are several variables in PHP; type variables, constants, variable and constant theory, and comments. In PHP we don't need to declare variable types explicitly, the cool term is dynamic typing. Because PHP can automatically determine the type of variable based on the values that exist in that variable. The following are some data types that are covered by PHP; integer, string, double, boolean, array, and object.

Almost the same as a variable, constants are also used for temporary storage of values. But the difference between constants and variables is that your constants cannot change its value if it has been declared. The method of declaration is also different from the variable. The constant is used the define keyword to declare a variable. Constants also do not start with a $ (dollar).

2.3.2 Comment

The commentary on the script aims to tell the reader, whether it's someone else or yourself. Usually, comments are used to explain the purpose of writing the script, who the author is, when it was written and so on. Comments are also useful for yourself when someday you forget why you wrote this file, what it's

for and many others. PHP will ignore all the text in the comments. It will not affect the running of a script.PH P recognizes three types of comment styles. First the C language model (many lines / multi line), usually can be placed at the top of the script. Second is C ++, and third is a shell script model (Oktavian,2010).

2.3.3 Operator

Operators are symbols that can be used to manipulate values and variables. In the previous section we have used several operators including =, ==, <, +, * and others. Words like “is”, “or”, “then”, etc. should not be capitalized unless they are the first word of the subtitle. There are several types of operators: arithmetic operators, combination operators, comparison operators, logical operators, increment/decrement operators, and string operators (Astamal, 2009).

2.3.4 Control Structure

Control Structure is a structure in a programming language that allows us to control the flow of the execution of a program or script. The control structure includes the structure of conditions and the structure of repetition or looping (Astamal, 2009). The condition structure consists of several statements, namely:

if...
if...else...
if...elseif...else...
switch...case...break...

While the repetition structure consists of:

for...
while...
do...while...
foreach...

3 METHOD

The method used for web programming-based EEDI calculations is to use a PHP Web programming application. By installing the webserver and phpmyadmin then create a database in mysql. After all is done then make the form in accordance with the concepts that have been made.

The concept of the form created is based on user convenience. To calculate the main EEDI formula is quite easy, but to get the value of each parameter is rather complicated because each type of ship is different also the value of the required parameters. So, to simplify the calculation and user convenience later the formula will be divided into two, namely the main formula and the basic data formula which must be calculated first. To verify the built-in web calculator use excel calculations or calculations from MEPC 214 guidelines (63).

4 RESULT

The results displayed in this chapter are a website created for the purposes of calculating the energy efficiency index design. The concept form that has been created is the main formulation of EEDI. This main formula is divided into 5 (five) parameter parts: main engine emissions, auxiliary engine emissions, shaft generator or shaft motor emissions, additional technology efficiency, and transport work.

Lifting of objects generally takes place at shipbuilding industry, construction sites, factories and other industrial situations such as offloading with a forklift truck, containers at a warehouse or at a commercial area. There are many goals in lifting for good practice and correct lifting method such as move large objects efficiently, safely and reduce manual handling operations (Chevron, 2009). The major accident usually happens due to incorrect lifting method. The process of carrying out correct and safe lifting operations involves a range of requirements which must be considered during the arrangement of lifting operation (Milton, 2012).

In this study, lifting process was conducted in the shipbuilding industry with ship block as object.

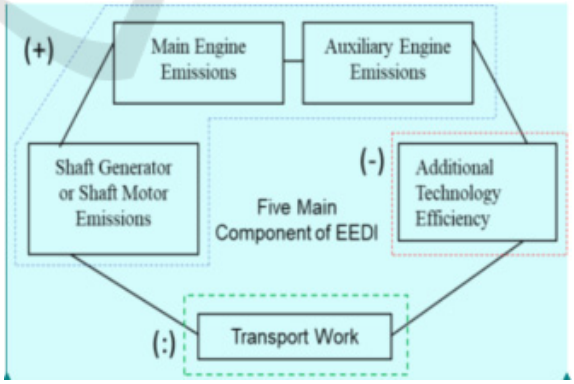

Figure 5: Five Components of EEDI.

The first page when opening a web address is to register first, after registering must be verified to enter into the calculation of energy efficiency index design.

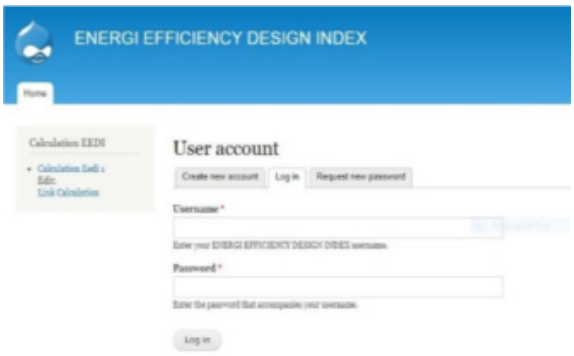

Figure 6: Log In.

Figure 7: Log In success.

Figure 8: Edit profile.

Figure 6 shows that the log in that was done was successful. After the user has successfully entered the website, the user can also change their respective profiles which can be seen in Figure 8. After successfully entering the form, the user can perform EEDI calculations by inputting values in accordance with predetermined parameters. To enter into the calculation form, users can enter via “add content” in “Navigation”.

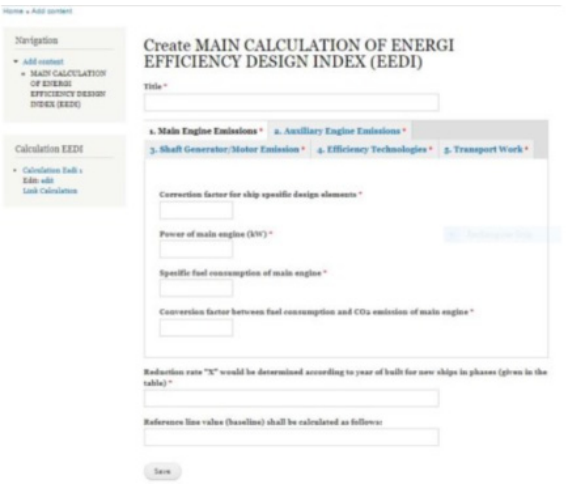

Figure 9: Form of Main Calculation EEDI.

From Figure 9 we can see the calculation of the main formula of EEDI which is divided into 5 parameters so that users can easily categorize the calculations and enter the required input parameter values. After completing entering all the values needed to calculate EEDI can be saved.

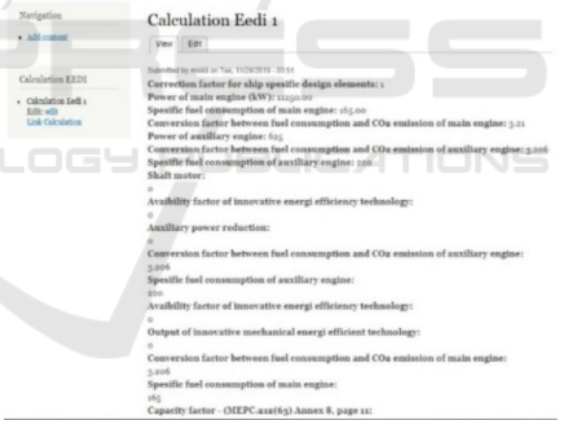

Figure: 10 View parameter input.

After the value of the entered parameter has been saved, it can be seen the input summary seen previously on the "Calculation EEDI" form. In addition, the calculation can also be edited on the "edit" form.

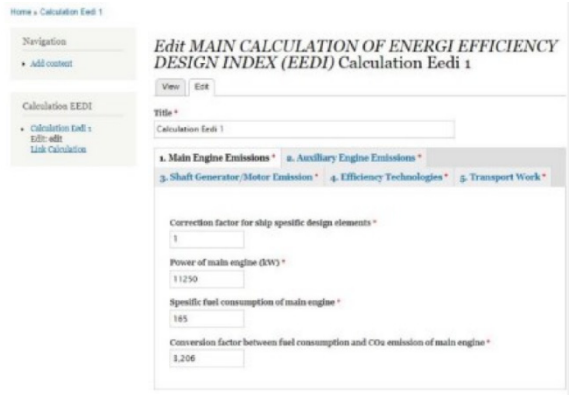

Figure 11: Edit calculation.

For the final results the value of the EEDI calculation can be seen in the "link calculation". In addition to the results of the final values from the EEDI calculations, also displays accepted or not accepted.

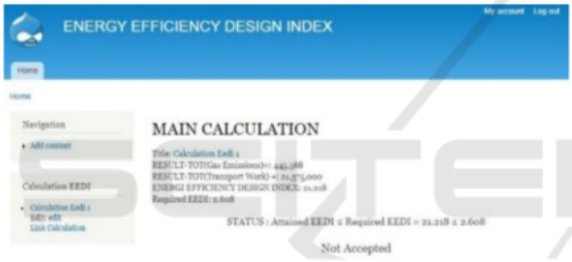

Figure 12: Final calculation.

5 CONCLUSION AND SUGGESTIONS

From the results discussed above a calculation has been developed from the energy efficiency design index (EEDI) based on web programming using PHP. To make it easier for users, a concept form is made to make it easier. From the EEDI formula, 5mainforms have been made, namely main engine emissions, auxiliary engine emissions, shaft generator or shaft motor emissions, additional technology efficiency, and transport work. The resulting value is the energy efficiency index design that can be directly viewed on the web calculator. It also shows the value of EEDI that is acceptable or unacceptable.

Many benefits derived from the transformation of calculations using web programming are reducing the number of paper documents and drawings increases consistency and integration between each department in the organization. In addition, users can utilize information released from time and place, reducing the time needed to collect data and analysis for decision making. Web-based development can be a solution to the problems of the maritime world in the industrial revolution 4.0 era.

For further sustainability, basic data calculations that are quite complicated can be further developed. This basic data calculation is used for the initial calculation before inputting the value into the main EEDI formula. This EEDI calculation is used specifically for ship designers. The next hope is that this web programming-based calculation can be further developed into the Ship Energy Efficiency Management Plan (SEEMP) which can be used by a wide range of stakeholders to facilitate the rapid certification process. In addition to calculations, technical and documents can also be developed.

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This research is an initial idea and is expected to be implemented to be further developed for the better. The author is open to receiving suggestions and criticism. Hopefully this research is useful, and other good research ideas emerge.

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