BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, December 2013. Vol. **10**(2), 499-507

Solar-Macro-Alage Based Biogas Hybrid System for Future Offshore Installation

O. Sulaiman Olanrewaju[1], S.A. Kader[2] and W.B Wan Nik[3]

[1,2] Marine Technology Center, University Technology Malaysia, Skudai, UTM Skudai, 81310 Johor, Malaysia.
[3]Faculty of Science and Technology, University Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

DOI: http://dx.doi.org/10.13005/bbra/1159

(Received: 12 May 2013; accepted: 25 July 2013)

Marine algae biomass energy source is increasing getting approval from policy maker and community. Beside production of seaweed for biomass energyhas potential economic benefits in Malaysia. Prototype plantations have been deployed in coastal areas and therefore are competing for limited space with other shoreside activities such as recreation and industry. If seaweed can be cultivated in relatively deeper waters away from populated areas, production may be expanded using larger areas not presently exploited for other purposes. Prototype systems aquaculture plantations have so far relied on ad hoc, field developed mooring systems, rather than engineering design principles. Such systems may not be sufficiently reliable for deepwater deployments, where repairs are more costly and resources are scarce. Considerable experience and hands-on knowledge has been obtained, the design concepts can be used as a basis for further improvements. The paper describe integrative approach to ocean energy by combining capability of solar and biogas.

Key words: Alternative energy, Sustainability, Hybrid, Solar, Biomass, Energy.

The reality of integration of science and system lies in holistically investigation of efficiency of hybridizing alternative energy source with conventional energy source. This can be achieved with scalable control switching system that can assure reliability, safety and environmental protection. Option for such sustainable system is required to be based on risk, cost, efficiency benefit assessment and probabilistic application. Greenhouse gas (GHG) pollution is linked to energy source. Large amount of pollution affecting air quality is prone by reckless industrial development. GHG release has exhausted oxygen, quality of minerals that support human life on earth, reduction in the ozone layer that is protecting the planetary system form excess sunlight.

Hybrid use of alternative source of energy remains the next in line for the port and ship power. Public acceptability of hybrid energy will continue to grow especially if awareness is drawn to risk cost benefit analysis result from energy source comparison and visual reality simulation of the system for effectiveness to curb climate change contributing factor, price of oil, reducing treat of depletion of global oil reserve. Malaysia tropical climate with reasonable sunlight fall promise usage of source of sun hybrid candidate energy, also hydrolysis from various components to produce fuel cell and hybridization with conventional system and combined extraction of heat from entire system seem very promising to deliver the requirement for future energy for ports. The paper hope to contribute to the ongoing strives towards

* To whom all correspondence should be addressed.
Tel.: +60177244339; Fax : +607 557 4710;

reducing greenhouse gases, ozone gas depletion agents and depletion of oxygen for safety of the planet in order to sustain it for the right of future generation.

Energy and Environment

Extensive reliance on energy started during industrial revolution. For years there has been increased understanding of the environmental effects of burning fossil fuels has led to stringent international agreements, policies and legislation regarding the control of the harmful emissions related to their use. Despite this knowledge, global energy consumption continues to increase due to rapid population growth and increased global industrialization. In order to meet the emission target, various measures must be taken, greater awareness of energy efficiency among domestic and industrial users throughout the world will be required, and domestic, commercial and industrial buildings, industrial processes, and vehicles will need to be designed to keep energy use at a minimum. Figure1 shows that the use of fossil fuels (coal, oil and gas) accounted continue to increase.

The global requirement for sustainable energy provision is become increasingly important over the next fifty years as the environmental effects of fossil fuel use become apparent. As new and renewable energy supply technologies become more cost effective and attractive, a greater level of both small scale and large scale deployment of these technologies will become evident. Currently there is increasing global energy use of potential alternative energy supply system options, complex integration and switching for design requirement for sustainable, reliable and efficient system.

Most renewable energy development and supply are in small-scale, particularly on islands and in remote areas, where the import of energy sources through transport, pipeline or electricity grid is difficult or expensive. Individual buildings, industries and farms are also looking to the possibility of energy self-sufficiency to reduce fuel bills, and make good use of waste materials which are becoming increasingly difficult and expensive to dispose of various studies have been carried out into the extensive use of new and renewable resources, to generate electricity, on a small scale, for rural communities, grid-isolated islands and individual farms. Recent studies focus on security of supply and hybrid system.

The integration and control strategies for all of these components must be carefully considered and implemented, and this complexity has been seen as a barrier to renewable energy system deployment. There are many possible supply combinations that can be employed, and the optimum combination for a given area depends on many factors. The balances being considered can be complex, and this highlights the need for a decision support framework through which the

Table 1. Carbonhydrate composition of macro algae

Bown algae	Green algae	Red algae
Laminarin	Starch	Carrageenan
Manintol	Cellulose	Agar
Alginate	Cellulose	
Fucodine	Lignin	
Cellulose		

Table 2. Full Scale Wave

Return Period (Year)	Full Scale Wave Height (m)	Full Scale Wave Period (s)
90%	4.599	9.711
95%	4.850	10.25
1/12th	0.6	1.295
1-Yr	5.110	10.79
10-Yr	10.7	12.82
100-Yr	7.3-13.6	11.1-15.1

Table 3. Overall Savings

	Without Solar PV system	With Solar PV system	Savings
Annual Generator Output	21206.5 kWh	9233.0 kWh	11973.5 kWh
Liters of Fuel required by generator	6361.95 liters	2769.9 liters	3592.1 liters
Fuel Cost	RM12723.90	RM5539.80	RM7184.20
Annual Average Cost	RM1139930.9	RM1134128.5	RM5802.40

relative merits of many different scenarios and control strategies for a chosen area can be quickly and easily analysed.

The renewable hybrid age require utilities, local authorities and other decision makers to be able to optimization that beat constraints, potentials, and other energy requirements from port powering. This to aid the transition between the current situation and a future, mostly renewable, electricity supply with substantial self sufficient distributed generation. When intermittent electricity generating sources are used in a sustainable energy supply system, it is important to consider how well the profiles of demand and supply of electricity match. It is advisable to seek the best possible match by using varying amounts of a range of different intermittent sources. It is prudent to use as diverse a mix of generators as possible.

The sizing and type of storage system required depends on the relationship between the supply and demand profiles. For excess amount electricity produced this could be used to make hydrogen via the electrolysis of water. This hydrogen could then be stored, used in heaters or converted back into electricity via a fuel cell later as required. Using excess electricity, this hydrogen could be produced centrally and piped to for port or produced at vehicle filling stations for haulage, or at individual facilities in the port.

Solar energy system

Harnessing energy from sun require production, distribution, control and consumer utilization at low cost. Risk work for the system should address the back drop and hybrid system alternative energy system that can be installing as auxiliary for synchronization through automatic control system that activate storage supply whenever supply is approaching the minimum setup limit. Prior to installing solar, it is important to collect, analyze data and information to determined initial condition necessary to start the project and come with acceptable design. Such data should be used for simulation and construction of prototype model of the system that include existing system, central receiver, collectors, power conversion, control system, sunlight storage, solar radiation to supply

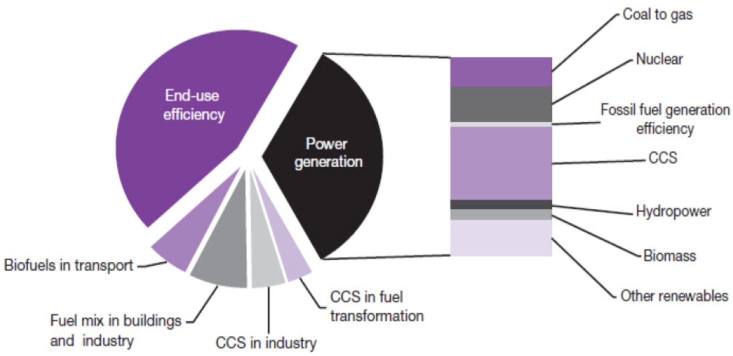

Fig. 1. GHG Emissions Reductions through 2050, by Consuming Sector [EIA, 2007]

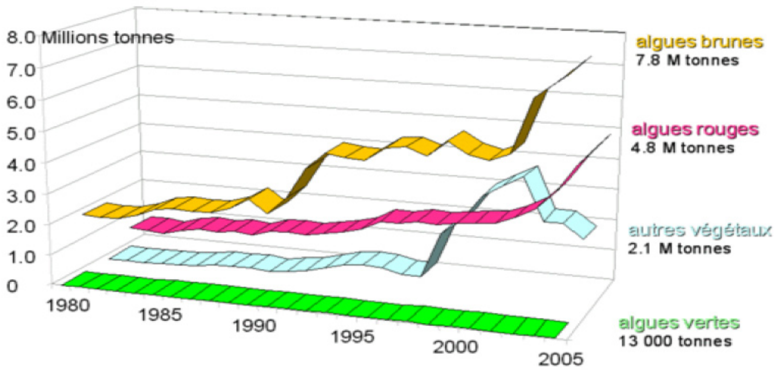

Fig. 2. Algae production (FAO, 1987)

a solar system to convert sunlight to electricity and distribute through existing channel.

Photovoltaic (PV) solar system use silicon photovoltaic cell to convert sunlight to electricity using evolving unique characteristic of silicon semiconductor material and accommodating market price of silicon is god advantage for PV fuel cell. Silicon is grown in large single crystal, wafer like silicon strip are cut with diamond coated with material like boron to create electrical layer, through doping the elementary energy particle of sunlight – photon strike the silicon cell. They are converted to electron in the P-N junction, where the accepts the electron and the n reject the electron thus setting into motion direct current and subsequent inversion to AC current as needed. Electrical conductor embedded in the surface layer in turn diverts the current into electrical wire. Consideration for solar power unit Parameters are [4]:

i. Collector module need to face south for case of photovoltaic, this depends on modular or

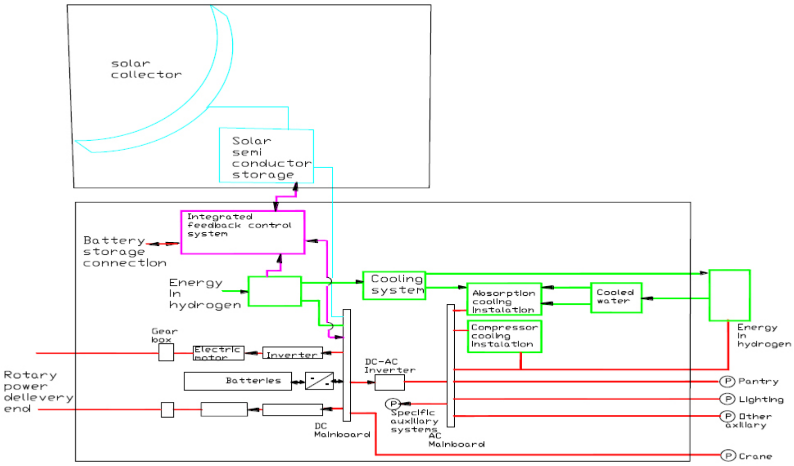

Fig. 3. Hybrid configuration

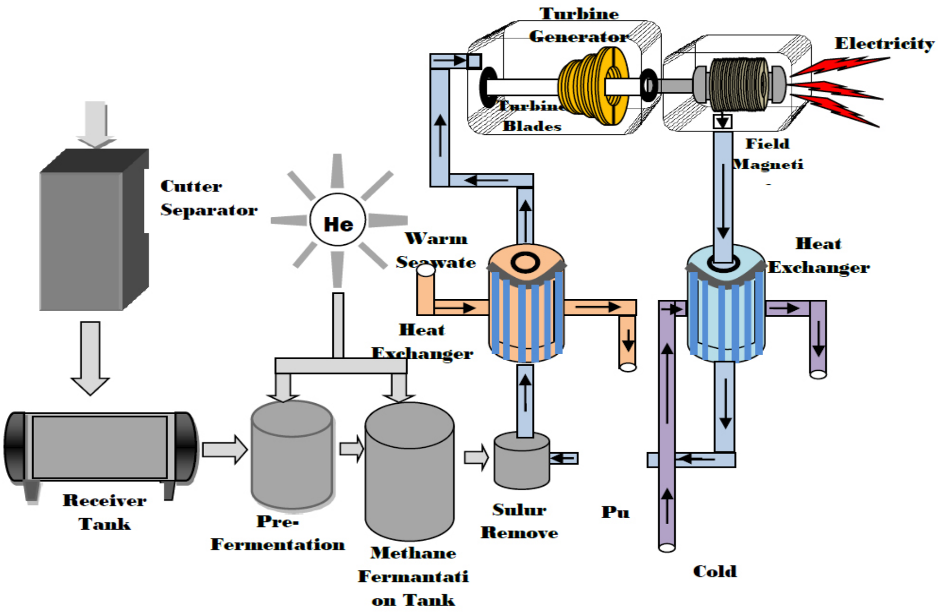

Fig. 4. A typical biogas anaerobic digestion of macro algae plant

central unit's modular
ii. Module storage unit need maintenance
iii. The system need power inverter if the load requires AC current
iv. Highlight of relevant procedural differences from regular projects of this type will be needed
v. Discuss requirements benefits and issues of using new procedures, and incorporating that into the total cost
vi. Procedure to build on will be described, hybrid system and integration system will be described and analyzed from the results and
vii. System successful complied with all regulations
viii. Efficiency penalty caused by extra power control equipment

For simulation relevant system input data considerations are:
i. Collector length , width, depth
ii. Plate length , long wave emissivity, conductivity
iii. Solar panel absorbance
iv. Tubes number, spacing
v. Storage tank volume, wall conductivity, wall thickness, surface area, initial and return temperature, room temperature

PV parameters are
i. Cell: type, umber of cell in series and parallel
ii. Power: nominal, maximum current, maximum voltage, short circuit current, open circuit voltage
iii. Standard test temperature condition, standard test isolation condition
iv. Panel height

Sola collector can be plate or dish type. Stefan' law relates the radiated power to temperature and types of surface:

$$\frac{P}{T} = \varepsilon\sigma T^4$$

Where P/A is the power in watts radiated per square meter, is surface emissivity, is Stefan-Boltzmann constant= 5.67×10e8 W/m².K^4

The maximum intensity point of the spectrum of emitted radiation is given by:

$$\lambda_{max} = \frac{2898}{T(K)}$$

Macro algae as Biomass energy production

There is renew interest in founding alternative energy source due to devastating effect of carbon release energy source which in turn destroy ozone layer by forming chlorofloro carbon termed as global warming and price hike of petroleum in the world. The renewabe energy source is the solution which boimass as a fuel play important rule using macro algae. Macro algae are multicellular organism that synthesis their own food. They have no true roots, stems and leaves and are usually found in damps area like ocean and coastal waters,with large amount of carbonhydrate and low lipid content. The following are advantages of macro algae as fuel [4]:
1. Reliability on oil is reduced,
2. Promoting diverse energy resources
3 Establishment of new industry.

Biodiesel can be used directly in a diesel engine with little or no modifications, and burns much more cleanly and thoroughly than diesel, giving a substantial reduction in unburned hydrocarbons, carbon monoxide and particulate matter. The main barriers to the implementation of alternative fuels is the requirement for a choice of fuel at a national level, the necessity to create a suitable refuelling infrastructure, the length of time it will take to replace or convert existing vehicles, and the need for a strong public incentive to change.

Harvesting seaweed from wild population is an ancient practices dating back to the fourth and sixth centuries in Japan and China, respectively, but it was not until the mid-twentieth century that methods for major seaweed cultivation were developed. Seaweed has traditionally been grown in nearshore coastal waters, with some smaller operations on land. Offshore systems which are the focus of this study are an emerging seaweed culture technology. The seaweed extract, (Carrageenan) is an important hydrocolloids product for food additive ingredient and it is highly demanded in the world market. Seaweed is also used for biomass energy production as well as pharmaceutical and medicinal product The demand for seaweed has created huge market for this raw material, especially, the Cottonii seaweed also known as Kappaphycus (Euchema spp). For exemple, under the Malaysian Government NKEA, there is need to produce 1 million tonnes seaweed every year, currently there is no proper system or platform to deliver this demand[5].

The green algae (Chlamydomonas reinhardtii) seaweed is used as biomass, hydrogen fuel source, as it can produce superior amount of vegetable oil and heat compare with terrestrial crop. Marine algae are used as food supplement that provide the body with additional fuel and immune body system regulatory response. It contains extensive fatty acid profile including Omega 3 and Omega 6 and it contain abundant vitamins, mineral, and trace elements. Chondrus crispus know as carrageen is an excellent stabilizer in milk, gelatin and cosmetic product. Algae are used as fertiliser for livestock and soil; Algae are also used for waste water pollution control. Figure shows available resources of macro algae. The estimated world value of macro algae products per annum was approximately 6 billion US Dollars with Asian market supplying up to 5 billion USDollars for human consumption and the rest from other continent. In the year 2006, the production level increase to15,075,612 metric tonworth of 2.098 10^-3 metric ton per Dollar (FAO,2008a).

The idea of using algae for energy production has been around for over 50 years, the concept of using lipids derived from algal cells to produce liquid fuels arose more recently. Macro-algae are extensively grown and used as food in Asia Countries, or as source of chemicals. They are usually collected from natural water basins where they are seasonally available. Only recently they have been considered for energy production, and the potential of some Pacific Ocean strains

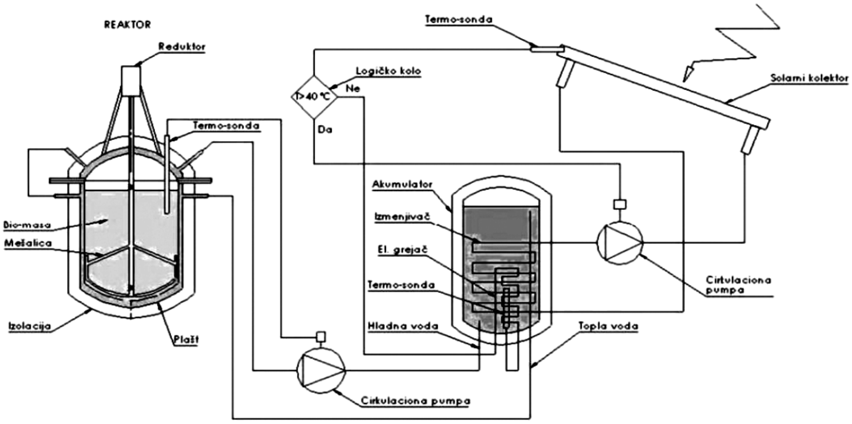

Fig. 5. Sola Biogas Hybrid power plant

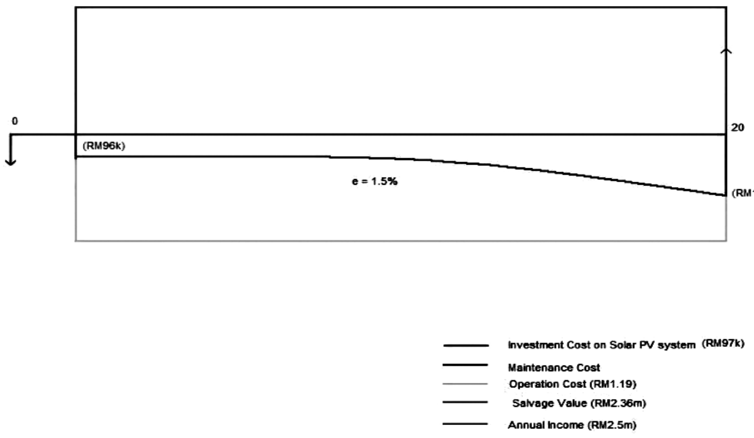

Fig. 6. Cash flow for vessel with solar PV system

has been preliminarily studied. The Life Cycle Assessment (LCA) methodology for the energy production from macro-algal biomass is especial tp be evaluated.

The world population is increasing at an alarming rate and so is the liquid fuel demand in the transport sector. Global warming, depletion of fossil fuels and increasing price of petroleum-based fuels are gaining great concern and the exigency of the situation has forced the search for alternative, sustainable, renewable, efficient and cost-effective energy sources with lesser greenhouse gas emissions[4-5]. Biomass can serve as an excellent alternative source to meet the present and future fuel demands.

Macrocystispyrifera to produce acetone during World war1 form butanol has properties of energy density, low corrosively, hydrophobicity and ability to blend with gasoline, considered desirable in an advanced biofuel is of current interest. Biofuel energy conversion technology involves[6]:

Anaerobic digestion to biogas; this is production of methane gas from biomass

Hydrolysis of organic matter.

Synthesis of acetic acid from hydrolysis products,

Methane gas generation by methanogenic bacteria.sugars(High temperature acids or enzymes) and fermentation of sugars to ethanol.

Fermentation to alcohols involves hydrolysis of organic material to simple sugars (High temperature acids or enzymes) and fermentation of sugars to ethanol.

Hydrothermal liquefaction

When ash content is removed from wet macro algae (volatile solid) the chemical composition of the biomass can be evaluated. The composition of seaweed depends on season, geographical site location and the part of plant involved[5, 6].

Hybrid system

With a focus on developing applications for clean, renewable, non-fossil fuel, energy systems. Our final emphasis is on maritime related activities, however, as marine engineers we are devoted to promoting all types of alternative & sustainable energy technologies.Various types of engine, turbine and fuel cell may be run on a variety of fuels for combined heat and power production. Hybrid system can provide control over power needs, green and sustainable energy that delivers a price that is acceptable and competitive. The power plants can be located where it is needed less high power lines are required, not only reducing costs but assisting health by reducing magnetic fields that people are so worried about, Global warming is addressed d by direct action by providing power that does not release any emissions or discharges of any kind. The technology associated with the design, manufacture and operation of marine equipment is changing rapidly. The traditional manner in which regulatory requirements for marine electrical power supply systems have developed, based largely on incidents and failures, is no longer acceptable. Current international requirements for marine electrical power supply equipment and machinery such as engines, turbines and batteries have evolved over decades and their applicability to new technologies and operating regimes is now being questioned by organizations responsible for the regulation of safety and reliability of ships. Figure 4 and 5 shows hybrid configuration for conventional power, solar and hydrogen, and Figure 3 shows physical model of hybrid of solar, wind and hydrogen being experimenting in UMT campus[3].

The combine system componntes are:

Solar collector

Anaerobic reactor in the form of a vessel with a double wall and an electric mixer,

Water thermal energy storage with an electric heater

Heat exchanger,

Circulation water pump

Control and regulation module

Reliability of Ocean Deployment

Aquaculture activities are inherently done at close proximity to coastline and near shore. Issues and environmental impact concerns and challenges necessitate the need for offshore aquaculture that required reliable structural integrity and mooring system design for ultimate state limit, fatigue state limit and accidental and progressive state limit against environmental loading and accidental loading. To avoid mooring system failure, selecting an appropriate breaking strength and limit state for mooring lines is necessary; this project involved a mooring system design that accounted for forces and environmental loadings.

Design for offshore floating structure of seaweed farming is required to meet the operating conditions, strength and serviceability requirements, safety requirements, durability, visually pleasing to the environment and cost-effective. An appropriate design service life is prescribed depending on the importance of the structure and the return period of natural loads. Its service life is generally expected to be as long as 50 to 100 years with preferably a low maintenance cost. The structure will be operating 200 meters from the shore as a result; the structure is likely to experience more energizes wave action and stronger wind associated with deep water region. This design also considered 1-2 boat lanes within the structure blocks which is about 5 meters wide at the original size. In the structural design of floating offshore structures, the external load and major load effect, such as cross sectional forces, are determined from the rigid body motions. The dimensions of structural members and arrangement are subsequently determined so that the structure has sufficient strength and stiffness against the given loads and loads effects. The hydrodynamic loads measured will be used to build approximate scale models of the seaweed. The model seaweed will mimic the Froude-scaled properties (mass, dimensions, added mass and damping) of the seaweed measured previously. Suitable material such as plastic ribbon, rubber tubing or even young seaweed seedlings will be used to build a sufficiently quantity of scaled seaweed[3,4].

The weather in Malaysia is mainly influenced by two monsoon regimes, namely, the Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March. However the east coast of peninsular Malaysia is the area that exposed directly to the strong sea currents and periodic monsoon season which is prevalent off the east coast. Furthermore, with the existence of nature elements of the deep and open water environment, seaweed farming is hard to be applied in this area. Regular waves were considered and generated by the wave maker for a few tests. Random waves spectrum was based on the Jonswap spectrum (for less than 1Yr or for 1Yr or greater, respectively. Froude scaling was applied to establish the relationship between full scale wave height (Hp) and period (Tp) and the corresponding model scale wave height (Hm) and period (Tm), where Hm = Hp/50 and Tm = Tp/ „©50 (Table 1). Incident waves will be measured and analyzed prior to the tests. Two wave probes will be installed for calibrations: one in front of the carriage at the basin centreline and one to the side of the nominal position of the model. Wave force vector is generally expressed as the sum of linear wave force proportional to wave height and the slowly varying drift force proportional to the square of the wave height[7].

Mooring design for offshore platforms makes use of software tools which have been benchmarked against model tests, computational data and full scale measurements for their given applications. Hydrodynamic loading on the platform, risers and mooring system itself due to waves and currents are calculated using a variety of tools such as potential flow, CFD and empirical data.

Cost and Energy Saving

In Table 3 shows the overall savings that can be concluded from the above analysis. Installation of solar PV system would save 11973.5kWh per year, where it saves 3592.1 liters of fuel. As fuel cost RM2.00 per liter, RM7184.20 is saved. The difference of Annual Average Cost between vessel with solar PV system and without solar PV system is RM5802.40.

In Figure 6 shows the cash flow diagram for vessel without solar. In this Figure, all the costs are sum up to get the present cost except for the salvage value as it is profitable only after 20 years of usage.

CONCLUSION

Macro algae based biogas has potential to dominate future biogas market, for region with abundant sunlight. Macroalge has very high calorific energy value, and large deployiment of offshore system can capture more carbon from atmosphere and additional carbon cfredit for use of algae product for biomass. The reliability of power can be augmented by incorporating hybrid of solar system to offshore energy system. The system can use with existing offshore system as well as new system.

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