Optimizing Energy Use in Fisheries in Southeast Asia

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In terms of geographical features, the total length of the coastlines of Southeast Asia is estimated to be about 112,699 km while the total EEZs is about 9,407,999 km^2. The continental shelf which is the stretch of sea beds adjacent to each country also known as territorial waters is 3,523,398 km^2. This scenario makes fishing an important activity especially in the coastal areas of Southeast Asia except Lao PDR being land-locked which is solely engaged in inland capture fisheries and aquaculture. In the region, fossil fuels are used not only for commercial fishing boats such as the super-trawlers, but also for powered small-scale boats especially those that operate beyond the countries' EEZs. This specifically means that fossil fuel inputs are now increasingly being used to harvest the fishery resources in order to increase fishery production. The increasing use of fossil fuels by fishing boats led to increased emission of CO_2 which is the carbon footprint of fishing boats. Since the boat's carbon footprint is directly proportional to the amount of fuel burned, it is therefore necessary to reduce the use of fossil fuel to minimize the fishing boat's carbon footprint and subsequently reduce the emission of CO_2 a major greenhouse gas (GHG) that contributes heavily to global warming.

The seas of Southeast Asia form part of the South China Sea, constituting about 2.5% of the world's oceans, and bordered by Brunei Darussalam, Cambodia, China, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand and Vietnam. The seawaters which surround the Southeast Asian countries include the Andaman Sea, Gulf of Thailand, Strait of Malacca, Indian Ocean (eastern part), South China Sea, Philippine Sea, Celebes Sea, Java Sea, Arafura Sea, Makassar Strait, and Timor Sea. On the other hand, Lao PDR is the only country in the Southeast Asian region which is land-locked but is endowed with enormous internal water areas from the Mekong River which forms a large part of its western boundary with Thailand.

The region's EEZ and internal waters (**Table 1**) offer great potentials for exploitation by the fisheries sector, which plays an important role in supplying protein to the populations, generating income and employment, and stimulating economic growth. In 2007, the total fishery production of the Southeast Asian countries was 25,211,212 mt valued at US$ 23,938 million. The quantity exported by the countries was 7,369,862 mt valued at US$ 14,395 million (**Table 2**).

Table 1. Geographical features of the Southeast Asian countries

Countries	Length of coastline[a] (km)	Exclusive Economic Zone (EEZ)[b] (km^2)	Continental shelf[b] (km^2)	EEZ + internal waters[b] (km^2)
Brunei Darussalam	161	10,090	8,509	15,855
Cambodia	443	62,515	62,515	243,550
Indonesia	81,000	6,159,032	2,039,381	8,019,392
Lao PDR	-	-	-	236,800
Malaysia	4,675	334,671	323,412	665,474
Myanmar	2,832	532,775	220,332	1,209,353
Philippines	17,460	1,590,780	272,921	1,890,780
Singapore	224	1,067	1,067	1,772
Thailand	2,614	299,397	230,063	812,517
Vietnam	3,260	417,663	365,198	748,875
TOTAL	**112,669**	**9,407,990**	**3,523,398**	**13,844,368**

Sources:
[a] *SEAFDEC Fishery Statistical Bulletin for the South China Sea Area: 2007*
[b] *United Nations Law of the Sea (1982)*

Creel (2003) established that about 50% of the world's population lived within 200 km from the coastline, a figure which could double by 2025. In 2007, the population of Southeast Asia was reported at 560 million (SEAFDEC, 2010) which means that about 280 million people are living in the region's coastal areas. From the point of view of sustainability, the concentration of peoples in coastal areas could put the ecosystem which provides the much needed economic benefits, at risk. The concentration of peoples in the region's coastal areas also led to the increasing number of fishers. Records have shown that there were more than 4,193,000 fishers in the region of which more than 3,052,000 were full-time; 805,000 were part-time mainly engaged in fisheries; while more than 336,000 were part-time partly engaged in fisheries (SEAFDEC, 2010).

Correspondingly, the number of fishing boats is also large as reported in SEAFDEC (2010). Specifically, the report indicated that in 2007, the Philippines reported the highest number of boats at 788,526, followed by Indonesia with 590,314 boats of which 241,889 were non-powered boats and 348,040 were powered comprising 185,509 out-board powered and 162,531 in-board powered boats less than 5 gross tons. In total, the number of fishing boats in Southeast Asia, both powered and non-powered could be about 1,500,000 (**Table 3**).

Contribution of Fisheries to Greenhouse Gas Emission

The fishing sector is an important but rapidly growing source of greenhouse gas emission and thus, should be

Table 2. Southeast Asian fisheries production and trade of fishery commodities: 2007

Countries	Total Fisheries Production		Export of Fishery Commodities		Imports of Fishery Commodities	
	Qty (mt)	Value ('000 US$)	Qty (mt)	Value ('000 US$)	Qty (mt)	Value ('000 US$)
Brunei Darussalam	3,227	11,464	93	5	14,043	13,355
Cambodia	525,100	58,038	55,812	32,566	4,200	8,222
Indonesia	7,510,767	7,683,427	854,601	2,258,919	145,230	142,750
Lao PDR	143,847	296,962	-	-	-	-
Malaysia	1,654,221	1,855,326	286,404	752,393	453,197	633,667
Myanmar	2,808,037	1,862,403	343,874	549,120	2,428	466,159
Philippines	4,710,952	3,912,137	173,076	569,790	200,136	149,483
Singapore	8,026	23,319	[a]2,855,492	482,435	[b]2,763,427	862,554
Thailand	3,675,382	3,986,931	1,964,685	5,965,978	1,379,598	1,743,482
Vietnam	4,315,500	4,544,750	835,826	3,783,834	50,435	364,018
TOTAL	**25,211,212**	**23,937,795**	**7,369,862**	**14,395,040**	**5,012,694**	**4,383,690**

Source: *SEAFDEC Fishery Statistical Bulletin for the South China Sea Area 2007*
Notes:
[a] *More than 96% of the export quantity of Singapore comprised the ornamental or aquarium fishes*
[b] *More than 91% of the import quantity of Singapore comprised the ornamental or aquarium fishes*
\- *means no data available*

Table 3. Number of fishing boats in the Southeast Asian region

Countries	Non-powered boats	Out-board powered boats	In-board powered boats	Total
Brunei Darussalam[1]	305	2,841	38	**3,184**
Indonesia	241,889	185,509	162,531	**590,314**
Malaysia	2,645	18,458	18,118	**34,221**
Myanmar[1]	15,219	14,289	1,863	**31,371**
Philippines	-	-	-	**788,526**
Singapore[1]	0	130	12	**142**
Thailand	-	-	-	**13,056**
Vietnam[1]	-	-	-	**12,920**
TOTAL	**260,058**	**221,227**	**182,562**	**1,473,734**

Sources:
SEAFDEC Fishery Statistical Bulletin for the South China Sea Area 2007
SEAFDEC Fishery Statistical Bulletin of Southeast Asia 2008
Notes:
[1] *Data were reported for 2008, while the rest of the data were reported for 2007*
\- *means no data available*

made part of the international climate change mitigation framework. Some 2.5 million out of 4.3 million vessels used in fisheries are powered by fossil fuel burning engines that consume some 42-45 million tons of fuel per year. Considering the current volatility of fuel prices, this concern is very significant for the future viability of small-scale fisheries and related livelihoods. Together with labor, fuel is the most important cost in capture fisheries and a major constraint to the economic sustainability of fisheries.

This scenario is especially present in developing countries where access to and promotion of fuel reducing technologies are extremely limited. The link between energy use, costs and greenhouse gas (GHG) emission suggests that fisheries can make an important contribution to GHG reduction through the adoption of energy savings technologies and practices that reduce reliance on fossil fuel and eventually achieve improved national financial economy. It should be considered that fossil fuels are now widely used from the powered small-scale boats to the commercial fishing boats such as the super-trawlers. This specifically means that fossil fuel inputs are now increasingly being used by many countries in the region for intensifying fishing operations to attain increased fishery production. The increasing use of fossil fuels by fishing boats has led to the increased emission of CO_2 which is the carbon footprint of fishing boats per unit of output. The emission comes primarily from burning the fuel by the boat engine and also from other fishing activities such as towing and hauling the fishing gear, refrigeration of the catch and other related activities.

It has been established that the boat's carbon footprint is directly proportional to the amount of fuel burned, *i.e.* one gallon of gasoline (≈ 3.79 liters) could generate a carbon footprint of footprint of about 9.0 kg CO_2 (IPCC, 2009). It is therefore necessary to minimize the fishing boat's carbon footprint in order to reduce the emission of CO_2 which is a major greenhouse gas (GHG) that contributes heavily to global warming. Two ways to reduce the boat's carbon footprint had been identified: reduce fossil fuel consumption, and offset boat's carbon footprint by reducing carbon footprint in other fishing activities onboard as well as onshore, which could include changing fishers' lifestyles onboard. Reducing the over-all boat's carbon footprint would therefore lead to reducing the impact of fisheries on the environment. Moreover, CO_2 emission could also be managed through good engine maintenance, responsible fishing operations, and proper handling of fuel through the practice of safe fueling procedures.

Therefore, reducing dependence on fossil fuels requires a combination of measures to be taken by fisheries stakeholders. This includes developing an appropriate baseline of energy use and energy practices, creating an appropriate policy framework for energy use, investing in research and development of Low Impact Fuel Efficient (LIFE) capture technologies, and promoting and raising awareness of proven, cost effective technologies available to the fishers.

Management Direction of Energy Use in Fisheries in Southeast Asia

Capture fisheries

Fishing activities using powered boats and with engines whether inboard or outboard had been conducted in the region's coastal waters as well as in the respective countries' EEZ and internal waters. Considering the big number of powered fishing boats in operation in the region's seawaters, it has become imperative to reduce fuel consumption in order to contribute to savings on operations costs as well as reducing the CO_2 being released to the environment. Reduction in fuel consumption of fishing boats engaged in capture fisheries can be managed through the improvement of fishing methods, control of the lights used in fishing or light intensity, as well as the reduction of fishing capacity or number of fishery vessels based on respective appropriate policies of the Southeast Asia countries. However, in order that such measures become effective in reducing energy use in fisheries, these should be accompanied with good engine maintenance including regular or annual maintenance to improve the performance of engines, and use of alternative energy source for example the use of sails for small fishing vessels, natural gas such as the liquefied petroleum gas (LPG) or compressed natural gas (CNG) or the liquefied natural gas (LNG) commonly used in natural gas vehicle (NGV) as alternative fuel for engines to reduce pollution and CO_2 released from vessel's engine, and smart design of fishing gears and fishing vessels to reduce resistance during fishing operations or reduce travel time from shore to fishing grounds.

Fish handling and post-harvest technology onboard fishing boats

The development of sustainable fisheries post-harvest technology is vital for advancing the production of fish and fishery products in the region in terms of safe and good quality standards, to help place ASEAN fish and fishery products in the world market, and eventually boost the flow of foreign currency into the region's economies, as well as increasing the availability of fish and fish products for human consumption.

Sustainable development in fisheries post-harvest technology can therefore, be achieved through minimizing the fuel consumption for refrigeration or that of the boat's auxiliary engine through good fish handling processes and preservation, and proper use of ice and chilled sea water which SEAFDEC has already promoted in the Southeast Asian countries. Furthermore, the traditional method for fish processing such as the use of solar energy should also be advanced to reduce the use of charcoal and fuel in processing.

Aquaculture

Intensive aquaculture, which is mostly done as national operation and well within national policy frameworks in the region, is also confronted with many constraints that impede its sustainable development. Widely fluctuating oil prices led to increased costs of inputs and other operating costs such as feeds and transportation, making it difficult for fish farmers to continue their operations. Although aquaculture production has increased, farm gate prices of aquaculture products continue to decrease. This situation results in less profits for fish farmers and the whole aquaculture operation is becoming more risky. In order to cope up with the situation, approaches following environment friendly aquaculture should be applied in extensive and semi-intensive aquaculture systems which should also be enhanced and applied more in intensive culture systems that consume a lot of energy. Specifically, research on suitable and cost-effective substitutes for fish meal by using low-cost agricultural products should be pursued and/or intensified. This will reduce pressure on capture fisheries and reduce carbon footprint not only from aquaculture operations but in capture fisheries as well.

Reducing the Use of Fossil Fuel in Fisheries

There are many ways of reducing the use of fossil fuel in fisheries and fishing operations. These could include changing the hull design, range of engine power and operation, and engine design, engine operation and maintenance, and modification of fishing gear and methods, as shown in **Box 1**. Engines used in fishing boats are classified as heavy duty, and thus are meant to operate in loaded condition for long periods. Automatic engines are generally classified as light duty, and their fuel options such as the use of unmodified vegetable oils, may not be applicable for heavy duty engines. In marine context, engines reliability has significant implication for safety, therefore, fuel/engines strategy must carry less risks of failure.

Natural gas is an interesting option for a reduction of fuel cost and its use can reduce greenhouse gas emissions (CO_2) due to lower carbon to hydrogen ratio than diesel fuel. LPG is a generic name for hydrocarbons mainly propane and butane, and when these mixtures are lightly compressed and cooled they change from a gaseous state to liquid. This is an advantage for the utilization of LPG because the liquid fuel, having an acceptably similar volumetric energy-density to diesel can be comfortably stored at ambient temperature in conventional pressure vessels. Natural gas can be stored as liquid (LNG) or in compressed form (CNG), although such storage and associated refueling facilities are not widely available. The cost of converting low pressure natural

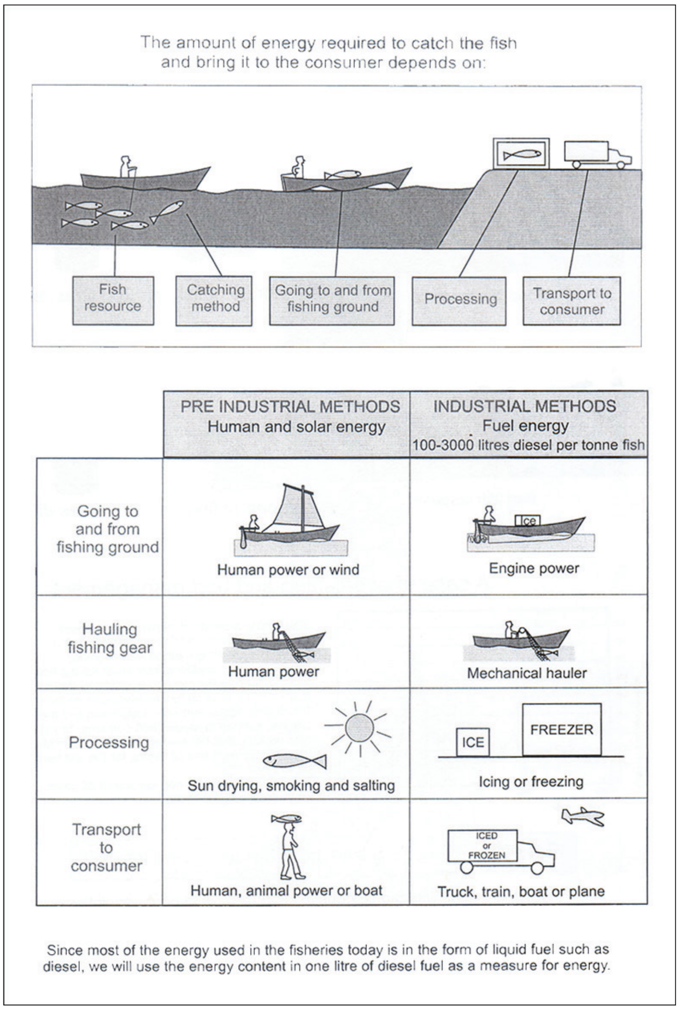

Fig. 1. Energy use in fisheries

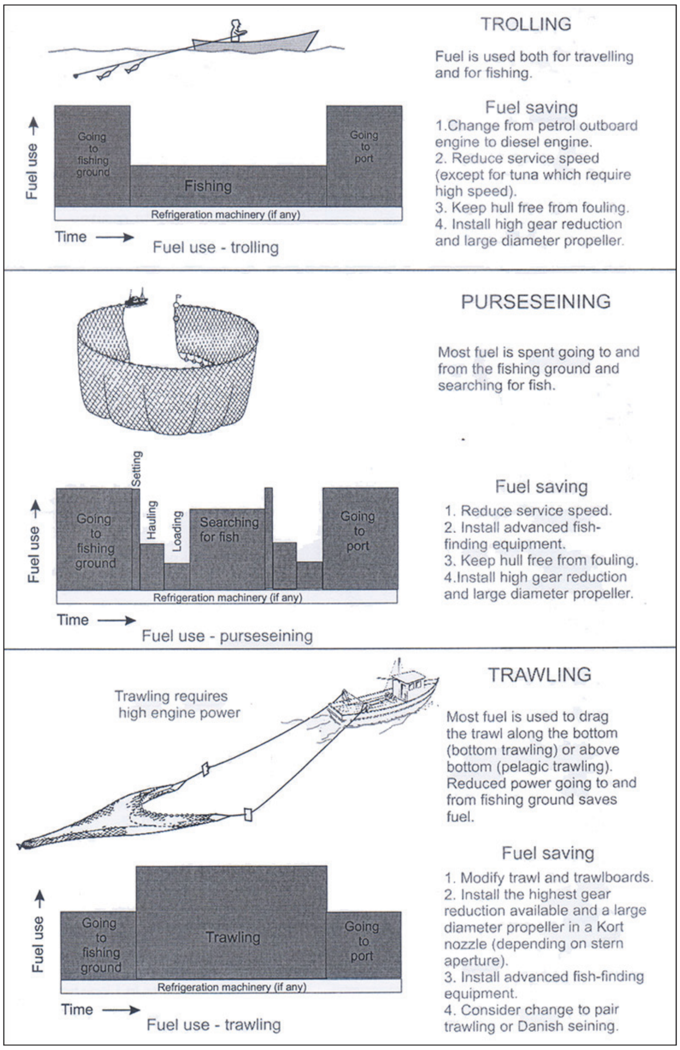

Fig. 2. Active Fishing Methods

gas to CNG and LNG is significant. Particularly, LNG and on-board storage tanks for fuels are far from straight forward, and for CNG storage at 200 bar is well-established technology which is already applied worldwide.

Hydrogen is a clean fuel that can be produced from fossil fuels, biomass or electricity, but the potential for reduced greenhouse gas emissions depends on the production method used. Production from fossil fuels could involve capture and sequestration of the fossil carbon, but the cost of production, storage and utilization on board are relatively high at present. Ethanol is an alcohol and an oxygenated organic carbon compound. It is the intoxicating component of alcoholic beverages and is also used as solvent (methylated spirits). Ethanol as a renewable fuel that produces less fossil CO_2 than conventional fuels and could easily blend with gasoline but not with diesel. Although alcohols can be used in diesel engines, the process would however require engine modification for extensive engine adaptation.

SEAFDEC Projects on Energy Use in Fisheries in Southeast Asia

SEAFDEC had implemented since 1998 the Project on Responsible Fishing Technologies and Practices (Fishing in harmony with nature) in collaboration with the SEAFDEC Member Countries. One of activities under this project is the promotion alternative sources of energy for fishing in coastal areas in Southeast Asia, which include experiments and trials on the use of sails for small fishing boats. In addition, a formula to determine the size of a sail with respect to the size of the boat was established.

In Thailand, results of the experiments indicated that the average speed of a boat must be about 15-20 km/hr. Experiments were also conducted in Myanmar in late 2008 after the Cyclone Nagris hit the country's Irrawaddy Delta. Evaluation and assessment of the experiences in these countries were conducted while promoting the use of wind energy was continued in the other Southeast Asian countries. Furthermore, the SEAFDEC Training Department also proposed to conduct a project on optimizing energy use in capture fisheries in Southeast

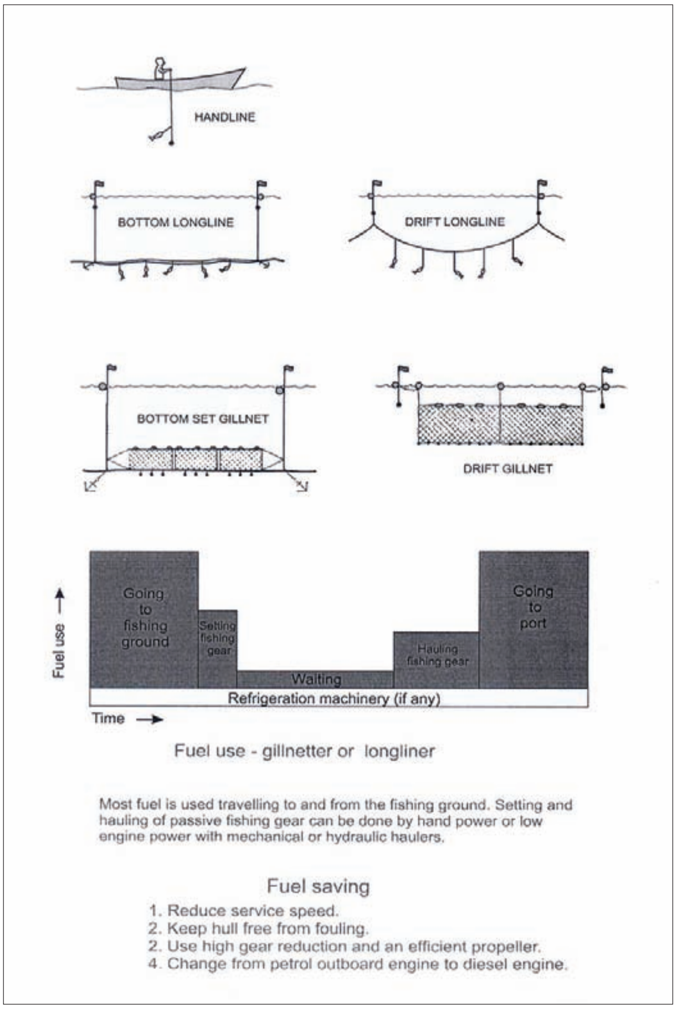

Fig. 3. Passive Fishing Methods Adapted from Gulbrandsen, 2010

Asia, which is aimed at reducing the use of fossil fuels and developing appropriate baseline energy use, creating appropriate policy framework for energy use to determine and estimate the amount of fuel consumption and CO_2 emission in fishing boats in Southeast Asia, and mitigating fuel consumption and energy use in capture fisheries. The promotion of the appropriate energy saving technologies and low impact fuel efficiency fishing (LIFE Fishing) in Southeast Asia will be implemented together with raising awareness and building human capacity in the region

Box 1. Ways and means of reducing the use of fossil fuel in fisheries

Hull design

The reduction in engine power can be achieved by increasing the length of the waterline (LWL), making it possible to obtain a sharper bow and thereby reduce the resistance when other dimensions are kept the same. Although the weight of a boat itself is increased by the prolonged length, the overall effect on the hull resistance is beneficial. A limiting factor is the increased cost of the hull, which must be balanced against the fuel saving. Finally, the reduction of boat weight and utilization of sustain boat displacement should be considered.

Engine power and operation range

By engine power, means the way power delivery is measured, since for fishing boats only the rating power is continuously measured. An internal combustion engine does not operate at its peak throughout the whole range of rev/min of output. From a specific fuel consumption curve, the specific fuel consumption in the range 70 – 80 % of maximum rev/min shows that an engine burns fuel most efficiently.

Engine design

- **Economical engine power and optimized fuel consumption**
  The accepted guidelines for trawlers on economical engine power to reduce fuel consumption for small fishing vessels, suggested that a vessel should not be equipped with engines larger than 5 Hp/ton displacement (continuous duty DIN 6270 “A”) and that it should be operated in service condition at about 3 Hp/ton actual output at maximum of about 80% revolutions/min.
- **Power margin definition**
  Power margin is the excess capacity of a propulsion engine for sailing a boat at designed service speed. Therefore, it is necessary, but the question is how big such power margin should be. The recommended optimized margin requires about 1.6 to 1.7 of continuous rating power.
- **Definition of engine size**
  Engine power used for fishing boats is defined as the ship’s displacement at service condition speed multiplied by economic service rate power per ton and margin power.
- **Reduction gear and propeller**
  It is clear that a large reduction gear ratio can contribute to considerable fuel saving while the boat speed is kept constant. Higher thrust is available by adopting larger reduction ratios while fuel saving is in the inverse proportion to speed. In this case, higher reduction gear ratio means larger propeller diameter and increased draught. In shallow harbor entrances, this might be a limiting factor unless a certain type of limiting propeller is used. As a general rule, the maximum available reduction gear ratio should be chosen.

Engine operation and maintenance

When an engine is badly operated or not well maintained, the loss in efficiency will be as high as 30 to 40 %. Thus, it is necessary to operate the engine at properly maintained condition, such as maintaining the engine at ambient temperature through the use of cooling systems and ventilations. Cleaning operation of the engine must be carried out by replacing injectors/filters, strainers regularly, and performing engine periodical check maintenance and inspection of the transmission system. Most especially, lubrication oil must be changed at certain grades and at intervals recommended by the engine manufacturer. To avoid dirt and water contaminating the fuel, an extra fuel oil filter and a water separator should be installed between the daily fuel tank and the engine.

Modification of fishing gear and methods

The amount of fuel used to catch and land a ton of fish varies greatly with the type of fishing gear and methods as well as the fish resource including the distance to fishing grounds. The strength of the fish source (good fishing grounds) is of major importance in terms of fuel use. A poor resource or poor fishing ground means more fuel used per ton of fish landed.

Alternative fuel use

Alternative fuels to petro-diesel include bio-diesel, LPG, LNG, CNG, ethanol, and hydrogen. A right choice of fuel may reduce fuel costs and improve business liability, as well as reduce greenhouse gas emission. This issue could have a bearing on the net cost of converting an alternative fuel (Sterling and Goldsworthy, 2006).

Alternative energy use

Utilization of alternative energy relates to moving away from the use of chemical energy in the form of fuel and the conversion of the heat of combustion into mechanical work using a heat engine. Among the alternatives that have practical possibilities are wind, solar and wave energies. However, there are two issues related to harnessing such energy, namely: collection and conversion of the energy to more usable form and storing the energy until it is required in fishing operations. For all these forms of energy, it seems unlikely that either or all of them combined would be able to satisfy the total energy demand of a typical fishery operation at least in the foreseeable future. Nonetheless, utilization of both wind and solar energy in fishing could be easily conceptualized based on the already proven and well-known technologies, although the practicalities and performance of such systems on fishing boats would depend on the exact application of the correct or emerging technologies used. Nevertheless, the utilization of wave energy could not yet be easily conceptualized as of the moment.

(Suthipong *et al*., 2010). As envisaged, the proposed project could contribute to the reduction of the use of fossil fuel in fisheries and fishing operations, and eventually reduce CO_2 and greenhouse gas emissions. Finally, the ultimate goal of reducing the cost of fishing would directly benefit the fishers.

ASEAN Plan of Action in Regional Energy Policy and Planning (APAREPP):2010 – 2015

Regional energy policy and planning are crucial to attaining shared goals of enhancing greater energy security and environmental sustainability in the context of open market competition and sustainable development in the ASEAN region. In the ASEAN countries, the issue on energy use in fisheries has become one of the most critical areas that would need government policy interventions. Overall, energy policies should critically address key areas of energy supply development, energy demand, oil operational reserves, transformation, transport and distribution sectors, and environmental protection. These areas need to be planned properly to evolve a dynamic and responsive energy policy to ensure a secure, affordable, reliable and competitive energy supply in the context of sustainable development in the ASEAN region.

As new energy landscapes and challenges arise, ASEAN views the need for ASEAN countries to move beyond independent energy policies and planning to an inter-dependent, inter-country and outward looking policies for greater economic integration and narrowing the development gap. Thus, ASEAN energy security policy and planning should ensure the consolidated and harmonized standards of policy and planning activities on energy security in the Member Countries. An end goal is to enhance the individual national energy policy and planning activities of the ASEAN countries for integration and mainstreaming into a cohesive and effective regional energy policy analysis and planning towards sustainable development (**Box 2**). The objective of the plan of action is to enhance cooperation on regional energy policy analysis and planning towards sustainable development and to effectively manage the implementation of APAREPP.

Box 2. Strategic goals of APAREPP

- To effectively manage the implementation, monitoring and evaluation of the progress of APAREPP programs;
- To develop tools and instruments for monitoring the APAREPP;
- To strengthen collaborative efforts towards regional energy policy and planning for sustainable development; and
- To strengthen capacity building by formulating sound regional energy policies and coordinated courses of action to meet the overall goal of the APAREPP.

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