FRAMEWORK ANALYSIS OF FISH WASTE TO BIO-DIESEL PRODUCTION – AQUAFINCA – CASE STUDY

Tony Piccolo (MBA – Energy and Sustainable Development)

TONY PICCOLO
tony.piccolo@gmail.com
www.aquaticbiofuel.com
+39 338 1965884

INTRODUCTION:

The use of animal fat to produce bio-diesel is not a new technology, however the adaptability of this technology to aquatic resources has only attracted public interest recently. The stress on land based products to produce biofuels is becoming quite significant and will be even more so in years to come. Therefore looking at aquatic resources for energy production makes not only ecological sense but economic sense too. The conversion process is simple after the fish oil has been produced from the left over waste of the fishing industry the oil is cleaned purified and with the addition of some caustic soda and methanol the bio-diesel is produced. 1kg of fish waste can produce up to 1.13lts of bio-diesel.

BIO-DIESEL PRODUCTION:

The bio-diesel produced from fish waste would be a non-toxic and fully biodegradable renewable fuel that can easily be adapted without any modification to current diesel engines. Bio-diesel is particularly good for the environment as opposed to standard fuel or diesel because it reduces the air toxins, CO_2, particulates, black smoke and other hydrocarbons. The fish oil is similar to a vegetable oil or animal oil and it reacts with an alcohol (methanol), the catalyst used is generally caustic soda. This produces a pure bio-diesel or B100 (100% bio-diesel) with a valued by product glycerin. Glycerin is an important by-product, and is currently further being enhanced and could become a new source of income for bio-diesel producers. It is a colour-less, odorless, slimy liquid which is used for pharmaceutical, food and cosmetic purposes. Up to now market conditions have impeded this valuable by product to be sold commercially, however, world wide researchers and experts are looking at ways to enhance the product and find more ways to utilise it in order to make it economically and commercially viable.

Some fish oils contain essential fatty acids like omega 3, which is a highly valued commodity especially in the pharmaceutical industry. Therefore care has to be taken on which types of fish is used when producing the fish oil. Below you will find a table of fish species and their content of Omega 3 fatty acids per 100 gr. One of the lowest in Omega 3 content but high in oil is catfish.

One other note of care is the acid content of the oil extracted. For example, salmon oil is high in acid and this acid needs to be removed. Therefore an additional step in removing this acid is required. Sulfuric acid is added to reduce the acid value of the oil. Once this has been done the process of trans-esterification can begin.

Table 1: Fish species and their Omega 3 fatty acid content

Fish species	**Omega 3 (EPA+DHA) content (g) per 100 g of fish**
Tuna (fresh)	0.28-1.51
Atlantic salmon	1.28-2.15
Mackerel	0.4-1.85
Atlantic herring	2.01
Rainbow trout	1.15
Sardines	1.15-2
Halibut	0.47-1.18
Tuna (canned)	0.31
Cod	0.28
Haddock	0.24
Catfish	0.18
Flounder or sole	0.4
Oyster	0.44
Shrimp	0.32
Scallop	0.2
Cod liver oil capsule	0.19
Omacor (Pronova)	0.85

Source: adapted from the guidelines of the American Heart Association.

The Technology and plants:

The technology used in the production of bio-diesel from fish waste is adaptable and transferable in many other parts of the world including developing regions in Africa, Asia and Latin America as well as small fishing communities and small islands who rely heavily on oil imports. It can provide labor, and produce local energy free from green house gases and emissions. With little investment in already existing fishing communities local energy can be produced at very little cost.

Currently several large fish waste to bio-diesel plants exist **Aquafinca** in Honduras, Finland's **VTT Technical Research Center,** the largest applied research organization in Northern Europe together with its partner Hiep Thanh Seafood JSC in Viet Nam have launched **ENERFISH** which will run as an experimental project until 2011, ENERFISH began bio-diesel production from fish waste (cat fish) in May 2009, and plans to produce 120,000 litres of bio-diesel a day.

An initial feasibility study was conducted by the **Sustainable Community Enterprises** in Vancouver, Canada in 2007. the SCE was awarded a grant to study the production of fish oil into bio-diesel. In a previous study conducted in 2005 however, it was concluded that it was not economically viable. The 2007 demonstrated 2 options for bio-diesel production one was a self-built base trans-esterification system and the other a fully automated acid/base two stage model with water wash. The latter was almost 3 times more expensive to purchase but benefits were higher. The feedstock would come from 2 different salmon processing plants and the bio-diesel production plant would be located at a different area, increasing therefore costs of production.

The study concluded and determined a price of $1.10 per litre of bio-diesel. The self made system produced 250,000 litres of bio-diesel per year and payback time is 4.2 years whereas the other system produced about 227,100 litres and payback time is 7.7 years. Transport of the waste was an important contributing factor to the overall cost, so the cost would diminish if the processing facility would be located at one of the processing companies

In 2007 **The National Technological Centre for the Canning of Fish Products in Spain (Anfaco-Cecopesca)**, was looking into ways in which fish fat which is found in waste water generated by the canning industry can be used for the manufacture of bio-diesel. A regional government grant of EUR 111 119 (US$ 152 134.45) was given to the project which was being carried out in Galicia. At present, these fats are not used for any industrial purpose, but they could have potential value, especially as they can be easily separated from waste water using physical methods. The research is in its preliminary phase.

AQUAFINCA – San Pedro Sula, Honduras

Aquafinca is a tilapia farm situated about 200km from the administrative capital of Honduras, San Pedro Sula. The farm produces roughly 100 tonnes of tilapia a day of which about half is waste i.e. offal, bones, skin/scales, etc.

Aquafinca is fully sustainable with the ability to be energy self-sufficient. It can produce energy for the whole company, providing imports of methanol from the USA arrive regularly. The fish scales/skin which is a separate by-product is sold to China for the production of gelatin.

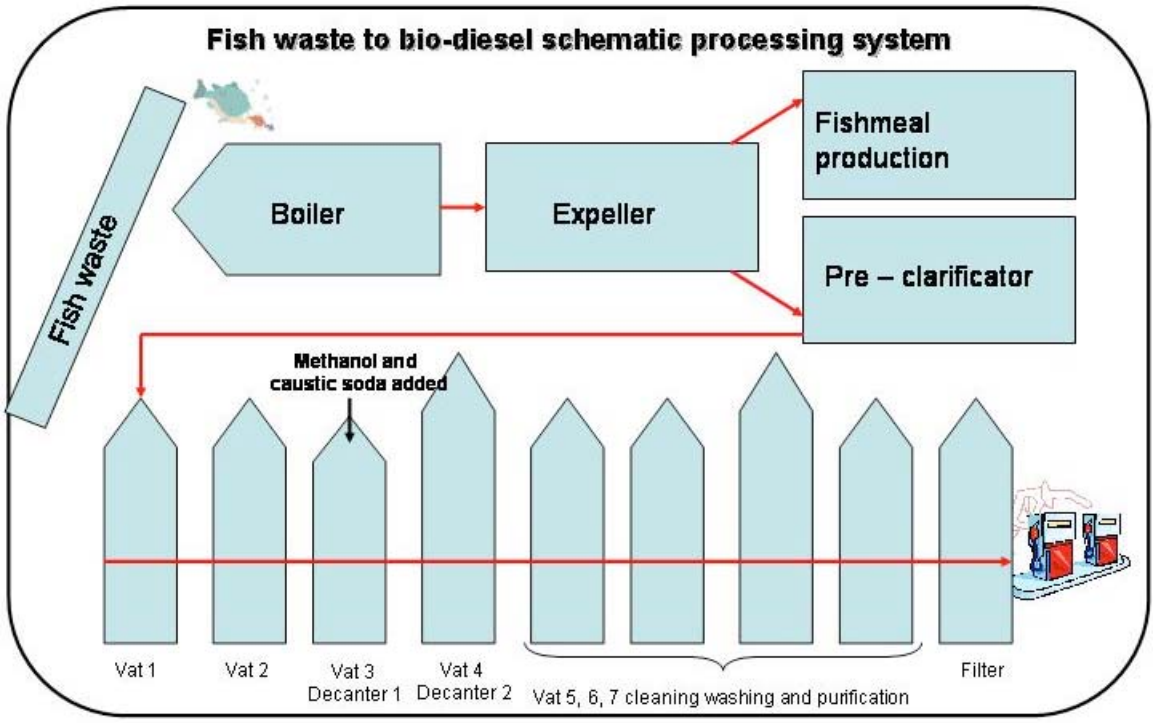
Aquafinca runs on a total of 10 generators which provide power for the whole plant plus electricity for housing, there are 50 people employed on the plant and work on 3 shifts cycles. The plant uses up 1368kw a day and produces 11,000 litres of fish oil. From that 6000 litres of bio-diesel are made, glycerine (valuable by-product), and roughly 10 tonnes of fishmeal.

Of the 100 tonne catch a day roughly 54 tonnes are waste this includes heads, bones, tail etc which goes to make the fish oil and fishmeal. Of that 54 tonnes

65% of the total biomass is water = 35.1 tonnes
20% is solid biomass which goes into making fishmeal = 10.8 tonnes

15% is made into fish oil = 8.1 tonnes, roughly 5 tonnes of these is converted into bio-diesel and the rest is sold as pure fish oil. 5 tonnes which equals roughly 5000 litres + 20% added methanol comes to a total of 6000 litres

Figure 1: Bio-diesel schematic processing system



Pic 1: Fish waste as it arrives at the bio-diesel plant

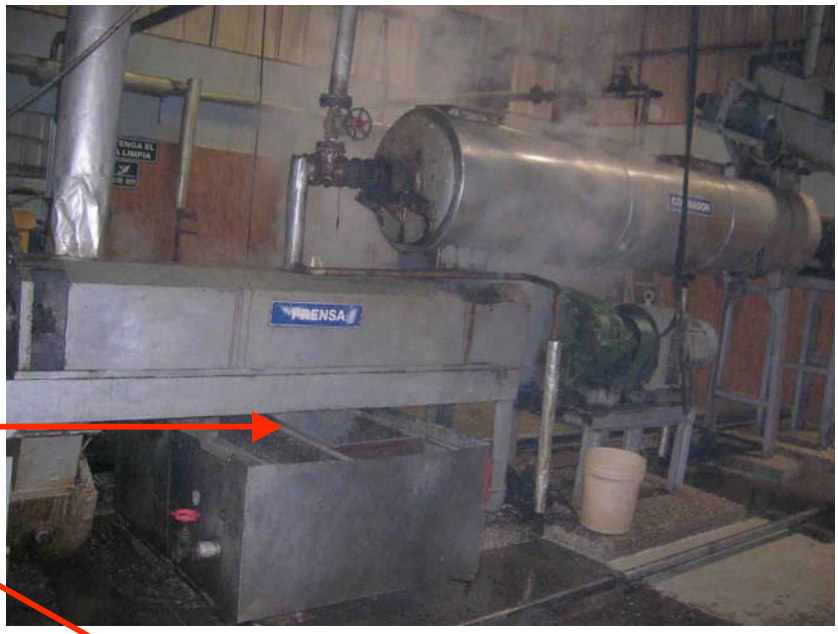
Pic 2: Fish waste includes head, bones fins, tail. Skin is removed, dried and sold separately as a valued by-product

Pic 3: Cooker at 100^{o} C moves very slowly takes about 4mins

Expeller

Pic 4: Expeller: Separates liquid from biomass

Liquid being squeezed out and solid biomass remains in the prensa (expeller)



The liquid that falls from the expeller contains abut 54% water, 4% solids and 42% oil. The biomass goes to fishmeal production and takes a different direction. At this point the liquid that falls to the bottom shown above has to go through a cleansing clarification process to remove and separate the 3 products. It goes to a “pre-clarificator” pic 5.

Pic 5 “Pre-clarificator”

The pre-clarificator separates the oil from the water and from the biomass (solid)

Pic 6: The liquid is now ready to go to the fish oil production plant.

Vat 1 raises the oil at an ideal temperature and basically acts as a heater.
Vat 2 is the reactor, and is the vat that separates the glycerine from the oil (glycerine is the by-product of the process) (however all particles are separated but mixed). At this point the methanol (about 20%) is added and so to is caustic soda (catalyst) to assist the separation process and it all goes to the decanter 1(vat 3), where the oil in the vat is distinctly separated from the glycerine.

Pic 7: Final product after decanter 1 (Vat 3)

Pic 8: Cleaned and purified oil to the left and un-cleaned and dirty (containing glycerine in bottom) oil on the right.

The oil then goes through a first purifying process, and oil is separated once more from impurities.

In vat 4 (decanter 2) below the oil already separated from the glycerine once again goes through a purifying process, where it is completely separated from the impurities and cleaned.

Pic 9: Washing of the bio-diesel and further purification

Pic 10: Filter final stage before entering the storage and pumping filling stations

The final stages of the process are the washing of the bio-diesel with water vapour at 95^{o}C, and then the drying process to dry the bio-diesel from the water vapour used for cleaning in the previous stage. The bio-diesel is purified once again and filtered.

Pic 11: The bio-diesel is checked for quality control

Pic 12: After quality control the bio-diesel is stored in these green tanks ready for distribution

Pic 13: From the green tank above it goes directly to distribution in the eternal pump.

BUILDING A FISH WASTE TO BIO-DIESEL PLANT:

OBJECTIVES AND PROJECT IMPLEMENTATION:

The main objective of a plant is to produce bio-diesel from fish waste as well as its valued by-product glycerin. Depending on the fish waste available in the area a rough calculation can be made on how much bio-diesel can be produced under optimal conditions. Specific to tilapia and Aquafinca they are able to use about 54% of the fish as waste and roughly 15% of that can be "squeezed" out as fish oil. Conditions and results may vary according to the fish used and waste produced.

In order to fulfill the objectives the following is required:

- Suitable location needs to be found to set up the bio-diesel plant. A location with easy and simple access to fish waste would be ideal to minimize costs of transport and in order to lower the carbon footprint of the plant due to emissions from transportation. An environmental impact assessment would have to be made on the chosen location, taking into consideration the whole plant cycle.

- Abundant waste should be available, either near a fishing port or inside or close to a fish filleting processing aquaculture farm.

- Easy access to methanol to ensure continuous production of the bio-diesel. Aquafinca purchase their methanol from the US and had problems when availability became scarce. A good source of methanol and caustic soda and other materials is of high importance.

- A market for glycerin in order to ensure quick income from the production and the sale of the by-product.

- Human resources – a fulltime project/plant manager to overlook the production and depending on availability of raw material and production 8 – 10 people working on the plant.
- Storage facilities for the fish oil, the methanol and a storage or pumping station for the final product.

INPUTS:
Fish waste, methanol, caustic soda, sulfuric acid (if required).

OUTPUTS:
Bio-diesel, glycerin, fishmeal, water (with nutrients) which can be recycled,

COSTS AND MAINTENANCE:

There are 2 options for building a fish waste to bio-diesel plant. A self built option which would cost around $130,000 US, and the ready bought option around $350,000 US, other expenses like pre-treatment (if required) and operating costs would vary from $7,000 US to around $17,000 US, depending on the plant chosen.[1] Human resources costs would also have to be considered, this would depend on location and labor costs.

ENVIRONMENTAL CONCERNS:

Some GHG emissions could come from the transport of the fish waste to the processing plant but if that processing plant was nearby that would not be a problem or if the lorry/truck transporting the waste was using a low carbon fuel or the bio-diesel produced from the plant, again this would lower emissions.

There is strong potential for this technology to be transferred to other parts of the developing world, particularly in small island communities that rely on fossil fuel oil for their liquid fuels. Depending on the amounts of fish catch the waste can be transformed into fish oil and thence into bio-diesel. The energy produced would be free from GHG's.

The effects of global warming can already be felt, from sea level rising to changed patterns of agriculture, extreme weather patterns and climate change. Such a project would fall under mitigation of global warming because it involves directly taking action to reduce greenhouse gas emissions. It would also contribute to the Kyoto Protocol initiative to reduce GHG emissions.

CONCLUDING REMARKS:

Large scale projects like the ones mentioned have been running quite successfully throughout the world particularly in developing countries. The process to extract the fish oil from the raw left over materials and then converting that oil to bio-diesel is energy intensive, however, some of the bio-diesel produced can be used to run the machinery, this would make the process self-sustainable and totally greenhouse gas emission free.

Fishing ports could se up cooperatives to collect all the fish waste and produce the fish oil, fishmeal and bio-diesel. This would mean the construction of only one big plant instead of many smaller ones, reducing costs and increasing quantity and potential.

Tony Piccolo
tony.piccolo@gmail.com
+39 338 1965884
www.aquaticbiofuel.com

[1] "A feasibility study for fish oil bio-diesel production" Sustainable Communities Enterprise for Clayoquot Biosphere Trust.