ENERFISH

Integrated Renewable Energy Solutions for Seafood Processing Stations

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2	Technische ûberwachungsverein Rheinland	TÜV	Germany
3	Technofi	Technofi	France
4	National Energy Foundation	NEF	Great Britain
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7	Preseco	Preseco	Finland
8	Vahterus	Vahterus	Finland
9	ECC	ECC	Vietnam
10	RCEE Energy and Environment JSC	RCEE	Vietnam
11	AF Industry JSC	AFI	Vietnam

Executive Summary

i) Biodiesel from fish-waste

If the biodiesel would be sold in the market and used to replace petrodiesel, the total annual income (including CRE's (small) and the sold biodiesel (large)) would accumulate to 4.1 – 4.4 million €., making the waste to biodiesel a good investment . This implies no additionality and non-eligibility for CDM funding.

ii) Biogas from glycerol.

This type of project, biogas from wastewater sludge to electricity, is not common practice in Vietnam, and it would be a considerably high investment generating a relatively small income.
Asian technology (eg ERDI/Thai) could be substantially less expensive, and thus the availability and costs of such technology should be investigated in the further stages of project development, such as in a feasibility study.

Summary

i) Biodiesel from fish-waste

If the biodiesel would be sold in the market and used to replace petrodiesel, the emission reductions would be in the order of 13 850 t CO_2e/year, if an emission factor of 2.92 t CO_2/t for petrodiesel is used. This would mean a CER income of roughly 138 500 €/year, and the total annual income (including the sold biodiesel) would accumulate to 4.1 – 4.4 million €. This income is uncertain, because the market price and demand cannot be guaranteed in advance.
The Preseco biodiesel process used in the ENERFISH project generates higher quality biodiesel, and can be directly applied to diesel engines. Two projects using the AM0047 methodology (biodiesel to be used in host country) are in validation, situated in China and India. Neither one of the projects in validation involve biodiesel production from fish waste oils/fats. This means that a fish waste biodiesel project implemented (in other seafood processing facilities) could be first of its kind in the world, which is a good argument for additionality.
However, this sort of project is not additional because of its high commercial value, sothat it would be excluded from CDM funding.

ii) Biogas from glycerol.

This type of project, biogas from wastewater sludge to electricity, is not common practice in Vietnam, and it would be a considerably high investment generating a relatively small income.
Asian technology could be substantially less expensive, and thus the availability and costs of such technology should be investigated in the further stages of project development, such as in a feasibility study. If the costs are assumed to be 5.5 M€ (Finnish technology), and the annual electricity costs savings and CER income from the biogas plant account to 161 170 €, the payback period would be roughly 34 years (no discount factor applied). Without the CER income the payback period is notably longer, about 65 years.
However, for instance The Chiang Mai based ERDI institute (Thailand) has designed numerous similar biogas plants in Thailand, reducing the costs by a factor 5-6, (due to the design being made for tropical countries involving less insulation) making the project (more) feasible.

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1.1 Introduction

In 1989, the IPCC (Intergovernmental Panel on Climate Change) [1] was created after the warnings sent by many specialists of the climate who suspected that massive anthropogenic release in the atmosphere of gases such as carbon dioxide and methane could cause a rise in mean temperatures and change our climate, i.e. result in global warming. The IPCC was set up, as an independent body, by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) in order to give to the international community a clear scientific view on human-induced climate change. The mission of the IPCC was and is still today to "assess the scientific, technical and socio-economic information that relates to human-induced climate change". The most important documents published by the IPCC are the assessment reports. The first assessment report (FAR) published in 1990 [1] provided a clear scientific evidence for human-induced climate change and it played an important role in the creation of a common political platform, the United Nations Framework Convention on Climate Change (UNFCCC) [2], the key international treaty to reduce global warming and cope with the consequences of climate change. It was signed during the 1992 Earth Summit in Rio de Janeiro by 166 countries. The IPCC Second Assessment Report (SAR, 1995) [2] provided further knowledge which helped to set up the Kyoto Protocol in 1997 during the third Conference of Parties (COP) of the UNFCCC. In this protocol, some countries (industrialized countries) committed themselves to stabilize their emissions of GHG[1] (greenhouse gases) emissions in the atmosphere whereas in the UNFCCC they were only encouraged to do so. The Kyoto protocol was considered as a political turn point with important consequences on the economies of the participating countries since reducing emissions implicitly meant to reduce industrial activities or to promote (invest in) energy efficiency and clean (green) technologies for energy production, manufacturing, agriculture, etc.

1.2 - The UNFCCC and the Kyoto protocol

There are three families of tools which can be used to mitigate GHG emissions: regulations, taxes and emission trading.

- Historically, regulatory tools have been used to ban CFCs[2] from all human-made products, for example the Montreal protocol (depletion of the ozone layer) in 1987. CFC emissions are inherent to few industrial activities, and therefore are easy to track; GHG emissions have multiple and diffuse sources. Tracking GHG emissions would be too complex and inefficient in economic terms.

- Tax-based tools were considered by the European Commission in 1992 before the EU-ETS[3] was in place. Due to tax harmonization problems, a consensus was never reached at the EU level. Some European countries have however implemented this tool which proved to be quite efficient. The main difficulty with such measures is to find the right taxation level and therefore the right prices for GHG emissions without obvious market signals.

- The third tool is the creation of a market where the price of GHG emissions is set by a cap-and-trade mechanism. This tool has already been used in the US for sulfur dioxide (SO_2)

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[1] GHG: 6 gases according to the IPCC. These are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (C_nF_{2n+2}), hydrofluorocarbons ($C_nH_mF_p$) and sulfur hexafluoride (SF_6).
[2] CFCs: chlorofluorocarbons.
[3] EU-ETS: European emission trading scheme.

mitigation (acid rains): in the nineties, power plants had emission caps and could participate in trading mechanisms for compliance. This is the tool that has been chosen by the international community in the UNFCCC and later on the Kyoto protocol.

1.2.1 - The UNFCCC

The United Nations Framework Convention on Climate Change, which entered into force on 21 March 1994, puts forward an international framework where parties agree to address the issue of climate change and therefore enact effective legislations (legal instruments) in order to mitigate GHG emissions and bring back their concentrations to a level where anthropogenic activities do not interfere with the climate system (article 2 of the convention). The parties (countries) are sorted into three different groups (cf. Table 1) with different levels of commitment (articles 3 and 4).

- Annex I countries which are OECD[4] countries plus CIS, where the CIS (Commonwealth of Independent States) countries are referred to as EIT (economies in transition) that is the former Soviet Union and all central and eastern European nations. These parties must reduce their GHG emissions to the 1990 level (article 4.2b).

- Annex II countries (OECD only) have the obligations of Annex I countries. They must also provide financial support to monitoring of GHG emissions (article 4.3) and technology transfer (clean technologies, cf. article 4.5) to non-Annex I countries.

- Non-Annex I countries, which represent all developing countries, must cooperate in the monitoring process by providing all assistance which is required.

Parties of the UNFCCC also agree to cooperate in research and systematic observation (article 5) and in education, training and public awareness (article 6). The remaining articles (7 to 26) deal with the governance issues (secretariat, bodies, financing, etc.). Agreements have been reached on the methodologies for reviewing and reporting inventories of countries (an inventory means a data base where, for each year, GHG emissions are reported by source for each GHG, a source being any activity which releases GHG in the atmosphere), especially issues related to LULUCF[5] and sinks (a sink means any process or mechanism which removes GHGs from the atmosphere; it should not be confused with a reservoir which is a component or a set of components of the climate system which stores GHGs, the ocean for example for carbon dioxide).

Today, the membership of the UNFCCC is nearly universal, i.e. 192 countries have signed the convention.

1.2.2 - The Kyoto protocol

The Kyoto Protocol which was adopted in 1997 and which came into force in 2005 defines all means and targets to implement the UNFCCC. The Kyoto protocol binds the 38 most developed nations, referred to as the Annex B countries, cf. Table 1, to a cap-and-trade system for the six major GHGs with the target of reducing by 5.2% the overall emissions, based on the levels of 1990, in the commitment period 2008 to 2012 (article 3 of the protocol). The reduction targets are unevenly distributed: each Annex B country has emissions quotas called AAs, i.e. assigned amounts. The emissions of each country are estimated in metric tons of carbon dioxide equivalent

[4] OECD: Organisation for Economic Cooperation and Development.
[5] LULUCF : Land Use, Land-Use Change, and Forestry.

($MTCO_2e$ or tCO_2e)[6]. Each emitted $MTCO_2e$ corresponds to one carbon credit, i.e. an assigned amount unit (AAU), which is the right to emit one metric ton. The total number of credits (AAs) which corresponds to the Kyoto target for each country and for the 5 year period, AA_{08-12}, is calculated as follows:

$$AA_{08-12} = E_{90} \times 5 \times R,$$

where E_{90} represent the baseline year that is the GHG emissions in 1990 computed according to article 3 (3.7 and 3.8) of the protocol. This quantity is close to the 1990 GHG emissions excluding LULUCF. R sets the individual target. R and E_{90} are given in Table 1: R is, for example, 0.87 for Austria and 1.08 for Australia which means that Austria has to reduce its GHG emissions by 13% whereas Australia can increase them by 8% compared to the 1990 level. The EU agreed to an 8% decrease but even though each EEC country is assigned a 0.92 coefficient, the EU has a burden sharing agreement (BSA) where the targets are spread unevenly, see Table 1. The coefficient R should be the BSA one for the EU 15 countries.

The choice of year 1990 as a reference year has had important consequences. For the EIT countries, whose economies were much stronger at the beginning of the nineties than they are now, this base-

Table 1. Annex I and II countries (UNFCCC) and Annex B countries with associated targets (Kyoto protocol). BSA: burden sharing agreement of the EU. E_{90}: emissions for base year (1990) in $MtCO_2e$. (a) Countries that are undergoing the process of transition to a market economy. (b) Countries added to Annex I by amendment (decision 4/CP.3 adopted at COP 3). (c) The USA has not ratified the Kyoto protocol. UK: United Kingdom of Great Britain and Northern Ireland, EEC: European Economic Community. Note that the EU (called EEC at the time of signature of the UNFCCC) signed collectively but member states also signed on their own account. Source: [2].

Annex I	Annex II	Annex B	Target	BSA	E_{90}
Australia	Australia	Australia	1.08		548.7
Austria	Austria	Austria	0.92	0.87	79
Belarus (a)					
Belgium	Belgium	Belgium	0.92	0.925	145.7
Bulgaria (a)		Bulgaria	0.92		132.6
Canada	Canada	Canada	0.94		594
Croatia (a,b)		Croatia	0.95		
Czech Republic (a,b)		Czech Republic	0.92		194.2
Denmark	Denmark	Denmark	0.92	0.79	70
Estonia(a)		Estonia	0.92		42.6
EEC	EEC	EC	0.92		4266
Finland	Finland	Finland	0.92	1	71
France	France	France	0.92	1	563.9
Germany	Germany	Germany	0.92	0.79	1232.4
Greece	Greece	Greece	0.92	1.25	107
Hungary (a)		Hungary	0.94		115.4
Iceland	Iceland	Iceland	1.10		3.4
Ireland	Ireland	Ireland	0.92	1.13	55.6

[6] tCO_2e : for a specific GHG, called "X", y tCO_2e of X = y x GWP(X), y in tonnes, where GWP is the Global Warming Power, *cf.* [1,2].

Italy	Italy	Italy	0.92	0.935	516.8
Japan	Japan	Japan	0.94		1261.3
Latvia [a]		Latvia	0.92		26
Liechtenstein [b]		Liechtenstein	0.92		0.23
Lithuania [a]		Lithuania	0.92		49.4
Luxembourg	Luxembourg	Luxembourg	0.92	0.72	13.2
Monaco [b]		Monaco	0.92		0.11
Netherlands	Netherlands	Netherlands	0.92	0.94	213
New Zealand	New Zealand	New Zealand	1.00		61.9
Norway	Norway	Norway	1.01		49.6
Poland [a]		Poland	0.94		563.4
Portugal	Portugal	Portugal	0.92	1.27	60.1
Romania [a]		Romania	0.92		278.2
Russian Federation [a]		Russian	1.00		3323.4
		Federation	0.92		72.1
Slovakia [a,b]		Slovakia	0.92		20.4
Slovenia [a,b]	Spain	Slovenia	0.92	1.15	289.8
Spain	Sweden	Spain	0.92	1.04	72.2
Sweden	Switzerland	Sweden	0.92		52.7
Switzerland		Switzerland			
Turkey			1.00		920.8
Ukraine (a)	UK	Ukraine	0.92	0.875	780
UK	USA	UK	0.93 [c]		
USA		USA			

-line year means a surplus of AAUs without any effort to mitigate GHGs emissions: this surplus is referred to as "hot air". For some countries, like the Russian Federation, Ukraine or Belarus, it can represent today more than 50% of their emission allowances. Figure 1 shows normalized GHG emissions profiles for EITs (Russian Federation, Ukraine and Belarus) and USA, Canada, France and the EU 15. The hot air issue is clearly seen in Figure 1 (left). It appears that it will be difficult for countries like the USA and Canada to meet their Kyoto targets, Figure 1 (right). The financial crisis and the economic recession should lead to a temporary decrease which should be enough for the EU (the cap for each country in Figure 1 is not 1 but R: it is 0.92 for the EU which means that the EU 15 is slightly short of carbon credits so far).

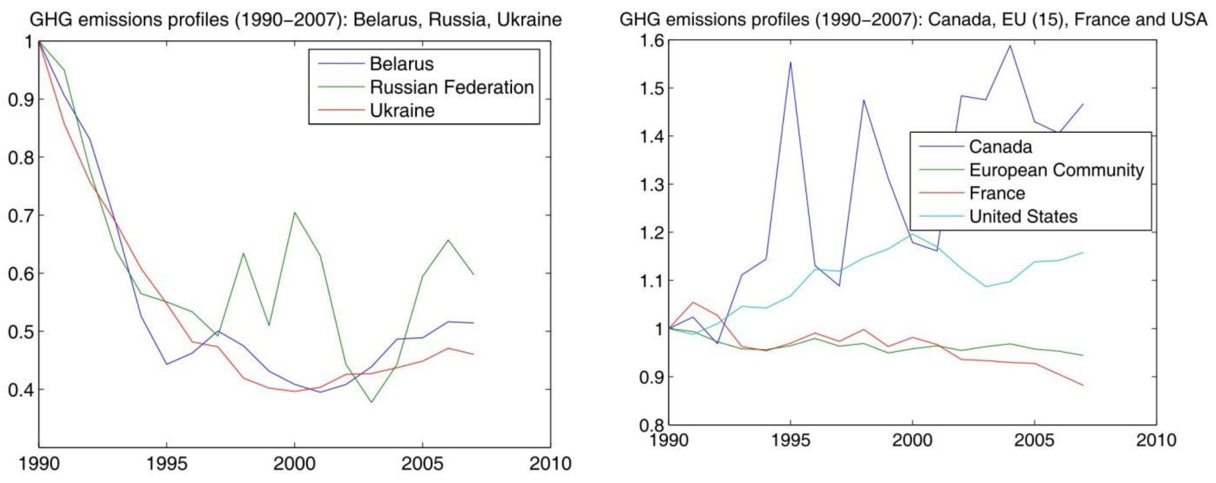

Figure 1: normalized GHGs emissions profiles (1990-2007). Left: normalized GHGs emissions profiles for EIT (Russia, Ukraine, and Belarus). Right: normalized GHGs emissions for the USA,

Canada, France and the EU 15. The cap is represented by the value 1 multiplied by R since the GHG emissions have been normalized with the 1990 values for each country. The data includes LULUCF. Source: [2].

The Kyoto protocol entered into force in February 2005 after ratification of Russia in October 2004, which was and is still the largest source of hot air. The USA remains the only Annex B country which has not ratified the protocol after Australia finally signed it in 2007 following a change in government.

The tools at hand in the Kyoto Protocol for GHG emissions mitigation are market-based (international emissions trading -IET-, cf. article 17) and project-based: clean development mechanism (CDM, cf. article 12) and joint implementation (JI, cf. article 6) projects. These tools, referred to as the flexibility mechanisms, can be used by companies, businesses, NGOs, etc., under the authority and responsibility of the respective governments. The principles are as follows:

- CDM: clean development mechanism. It gives the possibility to developed countries (Annex I) to invest in developing countries (non-Annex I) in projects where there are emissions reductions (this is mainly achieved by investments in clean technologies, for example in the energy sector) in comparison to a reference project. The gained carbon credits are added to the account of the investing countries. The carbon credits gained are called CERs (Certified Emission Reduction): 1 CER represents the reduction of 1 tCO_2e[7].

- AJI: activities implemented jointly, referred to as JI. It gives the possibility to developed countries (Annex I) to invest in another developed country (Annex I) in projects where there are emissions reductions compared to a reference project. The gained carbon credits by the investing country are offset by a corresponding debit in the host country. The JI mechanism generates consequently zero carbon credits at the Annex I level. The carbon credits gained by the investing party are called ERUs (Emission Reduction Units): 1 ERU represents the reduction of 1 tCO_2e.

- IET (International Emissions Trading): under the current compliance period (2008-2012), Annex B countries that emit less than their quotas can sell carbon credits to nations that exceed their quotas. Transfers and acquisitions of the carbon units (AAUs) are tracked and recorded through registry systems and an international transaction log ensures secure transfer of emission reduction units between countries.

As we shall see in Section 1.2.3, the emission allowances generated by the flexible mechanisms (AAUs, CERs, and ERUs) have different rights and obligations associated with them.

Keeping in mind the basics of the flexibility mechanisms which have just been presented, one can explain why the USA has not ratified the protocol. The reasons of the USA to stay outside the protocol are mainly twofold: firstly, the USA are reluctant to limit their economic growth (which is at the moment directly related to GHG emissions) when countries like China and India which have become main GHG emitters have no targets (since 2005, China has larger yearly GHG emissions than the USA; this is not true however for the yearly emissions per capita). Secondly, the hot air issue is considered by the USA as an issue which is still to be solved: if the US were to adopt the protocol, the probable excess of emissions that they would have at the end of 2012

[7] The CDM is efficient in countries with low carbon intensity of the economy, that is, where few GHG emissions are needed to produce one unit of GDP.

would correspond to the Russian hot air. In addition, the Russian surplus is probably too big for good market conditions, i.e. the market is long, that is the caps were probably too generous.

The above mentioned issues raise serious concerns about the future of the Kyoto protocol after the first commitment period (end of 2012) since no agreement was reach at the last COP in Copenhagen last year.

1.2.3 - Specificity of the allowances

The main specificity of the different products is their bankability. AAUs are bankable[8]. CERs and ERUs are bankable in the limit of 2.5% of AA $_{08\text{-}12}$ at the end of the true-up period that is in 2015 when the accounting and verification of the first Kyoto commitment period has to be performed.

CERs and ERUs are fungible, which means that they are recognized by other trading schemes of Annex B countries, the EU-ETS for example. CERs and ERUs could be used as a fungibility link between the EU-ETS and other schemes (the Australian Carbon Pollution Reduction Scheme - CPRS- for example) since both trading schemes should not recognize their respective trading units (EUAs and AEUs)[9]. CERs and ERUs can be seen as the way to have an international price signal. There is however a point to be made concerning this view: experts are reluctant to see CERs as a good price signal since they are not based on a cap-and-trade system but rather on a baseline-and-credit mechanism. AAUs are backed by a cap-and trade system which makes them a better candidate to an international price signal. This is, however, not true in practice since CERs are today traded almost all over the world and are de-facto recognized as the best fungibility link.

AAUs are usually traded between countries and this causes some rigidity in the market because of liquidity issues. This means that the price of AAUs cannot be considered as a real market price. In addition, one could argue on the prices of ``different" AAUs: indeed Russian AAUs should be priced differently from for example Japanese AAUs because they correspond to hot air for Russia and voluntary measures to mitigate GHGs emissions for Japan. This issue has not been settled yet. The fact that some countries like Canada and Japan refuse to buy AAUs from Russia makes the AAUs a rather weak fungibility link.

1.2.4 - CDM: mechanisms and key figures

We recall that Annex B countries can invest in projects in developing countries where there are emissions reductions. The gained CERs can be used by the investing countries for example to comply with the Kyoto caps; they can also be used in cash to improve the profitability of the projects. The CDM is built on three main principles: cost effectiveness, "mitigate locally and act globally" and additionality.

- Cost effectiveness means that it is cheaper (in terms of investment) for a developed country to mitigate in a developing country, since the carbon intensity of the host's economy is lower.

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[8] Bankability refers to the "carry-over" function of the allowance transfer mechanisms: carry-over means to transfer a unit issued under a commitment period to the next commitment period, *i.e.* the carry-over of the Kyoto units after 2012. The AAUs can be carried over. CERs and ERUs can be carried over in the limit of 2.5% of AA $_{08\text{–}12}$. AAUs, CERs and ERUs are therefore bankable.

[9] EUA and AEU: European Union Allowance and Australian Emissions Unit, i.e. right to emit 1 tCO_2e in the EU-ETS (EUA) or in the CPRS (AEU).

- "Mitigate locally and act globally" means that the climate change issue is global, i.e. the release of 1 tCO_2e in Vietnam has the same effect on the climate system as the emission of 1 tCO_2e in Finland for example.

- The additionality principle is closely linked to the baseline-and-credit approach of the CDM. A CDM project needs to generate more emission reductions than it would otherwise have occurred (additionality), meaning that one has to compare the project to a reference project which corresponds to a business as usual one (the baseline). If there is indeed a reduction of emissions, the economics of the greenest project are boosted by an extra source of funding (CERs are traded against cash which represent a credit; they can also be used to meet the reduction targets). This baseline-and-credit scheme has a major drawback: the need for a regulator that checks that the reference project is a real one and that the claimed emission reductions are real. This considerably slows down the process and increases the "political" risk.

Figure 2 display the key steps of a CDM project. The secretariat of the CDM is overseen by the CDM executive board (CDM EB) which is a 10 person board. For each country, the projects must be registered by the Designated National Authorities (DNA). The DNA is the official body of the host country which checks that the projects are in line with the Kyoto framework. In order to carry out all operational work, the CDM EB has accredited Designated Operational Entities (DOE). The DOEs, which can be domestic or international organizations, are responsible for all activities related to the approval of the projects (Bureau Veritas Certification Holding SAS, for example, is a DOE). Once the project has been approved by the DNA, the DOE executes the validation and registration processes. After implementation and monitoring, the DOE verifies the emissions measurements and certifies the project. The CDM EB can then proceed with the issuance of the CERs through a CDM registry.

The CERs arising from a CDM project are called primary CERs. In order to finance the project development costs, these CERs are usually sold by the stakeholders of the project to third party investors before issuance through Emission Reduction Purchase Agreements (EPRA), i.e. forward contracts. The investors take the risk of default that is the failure of the time consuming validation process and the issuance of the CERs. This is one of the reasons why these products are traded at a discount in the market (compared to the spot price). When issued, the CERs can be traded in a secondary market (they are called secondary CERs). These CERs do no longer contain any project risk. They can be used by Annex B countries to comply with the Kyoto caps (in this case they end up in the national registries of the countries).

There are today over 4200 projects in the CDM queue of which 1873 are registered and 109 are requested registration. The expected number of CERs represents more than 2.9 $GtCO_2e$: the registered projects so far should account for 1.67 $GtCO_2e$ whereas the ones requesting registration should represent 40 $MtCO_2e$. Today, the total number of issued CERs by host countries is approximately 340 millions, that is 340 $MtCO_2e$ whereas the total number of CERs that were requested is roughly 356 $MtCO_2e$. The 2.9 $GtCO_2e$ of CERs which should be issued in the first commitment period added to the already estimated 7.9 $GtCO_2e$ surplus of the Annex B countries make the market roughly 11 $GtCO_2e$ long, for a market which should be around 60 $GtCO_2e$.

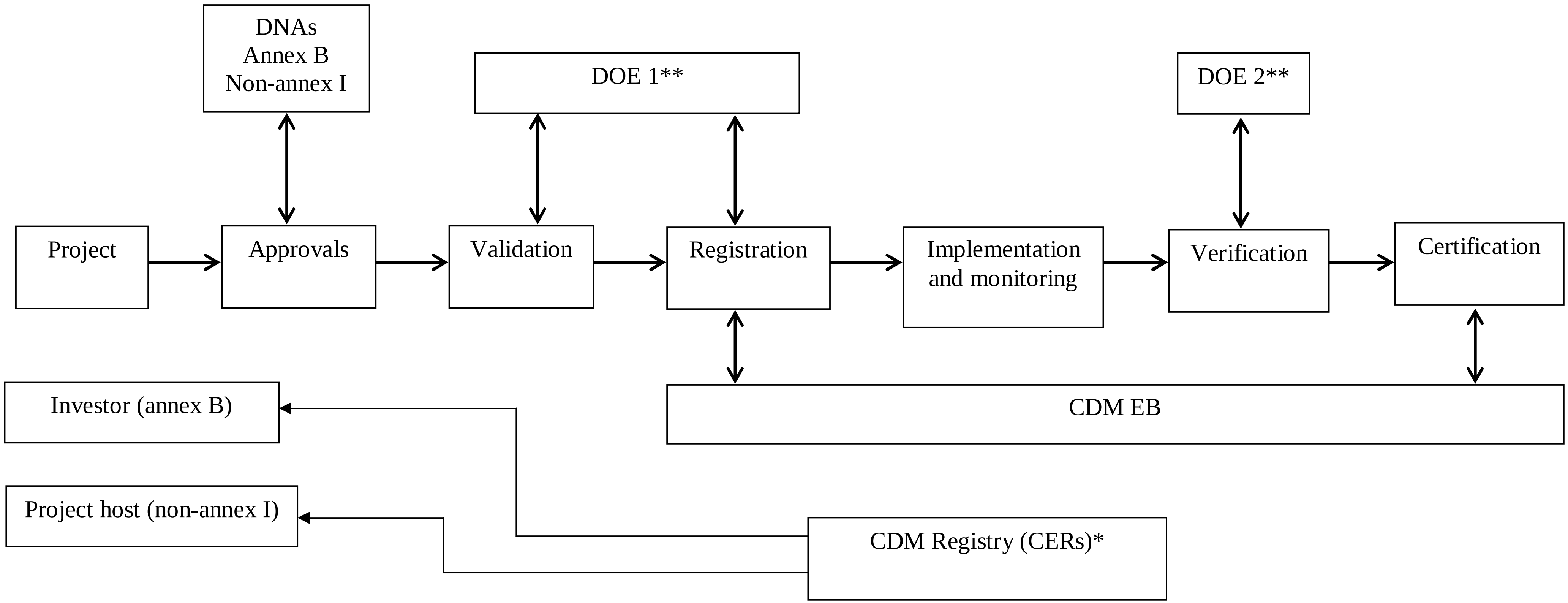

Figure 2: the CDM project cycle. (*): 2% of CERs are kept by the CDM EB as a fee. (**): the validation and registration must be carried out by two different DOEs.

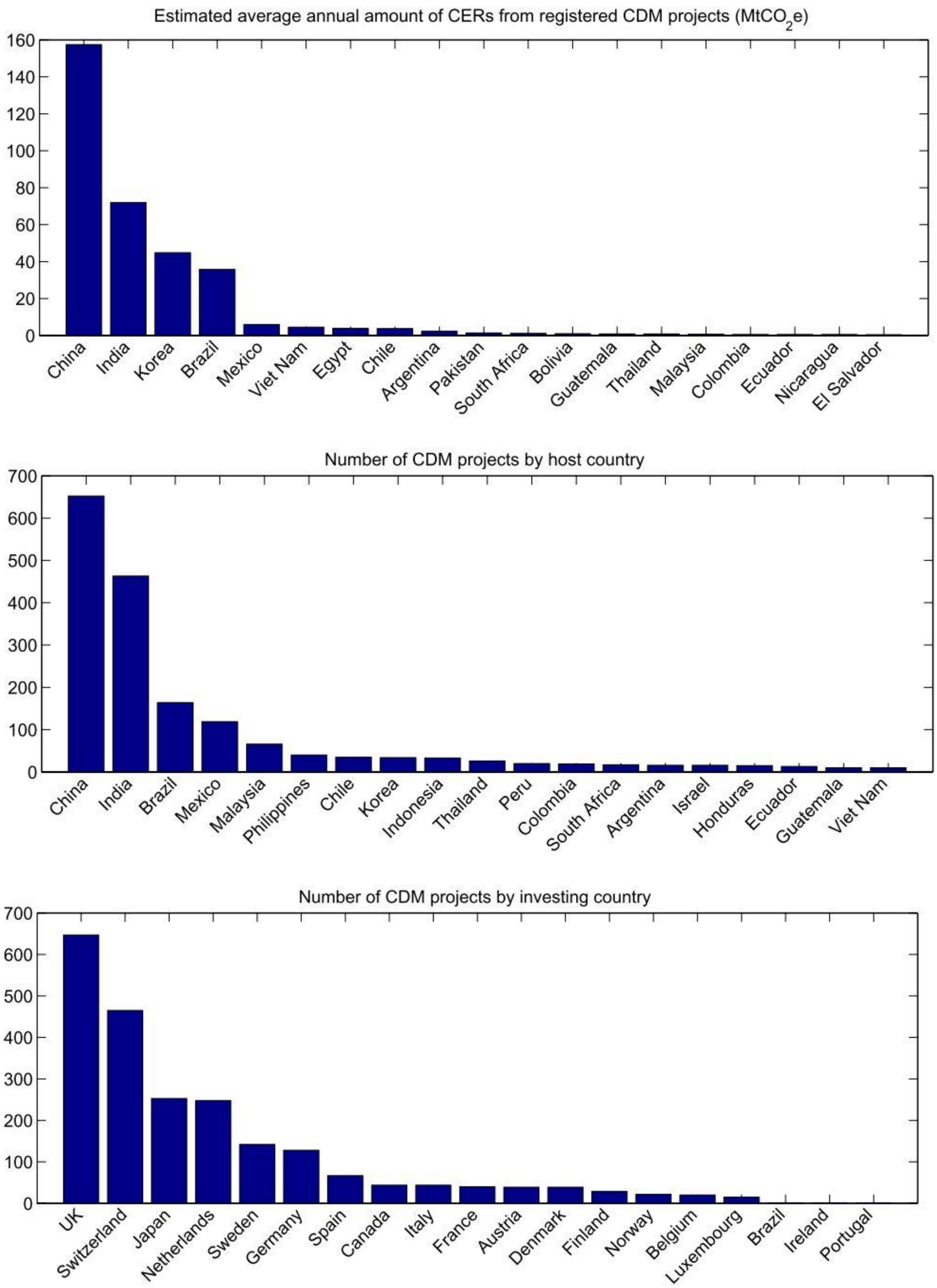

Figure 3: number of CDM projects by host (top). Middle: number of CDM projects by investor. Bottom: expected average of CERs per year in the first commitment period by host country. Source: UNFCCC [2].

Figure 3 displays the number of CDM projects by host and investor. It can be seen, as expected, that China and India represent 60% of the CDM projects by host. Surprisingly, Japan and Canada, the two Annex B countries with the largest potential shortfall of AAUs are not the main investors. This is not reflected in this chart (primary CERs) because CERs can be purchased on the secondary market. Vietnam is hosting a significant number of projects, especially in terms of the amount of issued CERs per project.

Overall, 60% of the projects are in the energy sector, 18% in the waste handling and disposal sectors. Manufacturing industries and agriculture represent approximately 5% each. China represents 50% of the CERs.

1.2.5 – Spot and futures prices of CERs

Table 2 puts forward the volumes and the values of carbon markets in 2007 and 2008. The markets are divided into three main categories: project based transactions, secondary CDM and allowances markets. The data shows that the EU-ETS is by far the main market in terms of value and volume (64% in volume and 73% in value of the total in 2008). The CDM markets (both primary and secondary CERs) complete the picture (30% in volume and 26% in value of the total in 2008), the other markets are marginal (6% in volume and 1% in value of the total in 2008).

Climate exchanges have been established to provide a spot market in allowances, as well as futures markets to help discover a market price and maintain liquidity. Carbon prices are normally quoted in Euros per ton of carbon dioxide or its equivalent (tCO_2e). There are currently several exchanges trading in carbon allowances in the EU (spot and futures markets), the main ones being BlueNext in France [4] for spot products and the European Climate Exchange (ECX) in London [5] for derivatives, i.e. futures. Market players are private companies eligible to the EU-ETS as well as brokers, speculators and market makers. The spot markets give the possibility for eligible companies to buy emission allowances (mainly EUAs and CERs) in case of under-coverage and to sell emission allowances in case of surplus quantities in order to comply with the allocation obligations and to optimize their production processes. The futures on EUAs and CERs (derivatives market) permit price hedging for emission allowances and enable to implement efficient CO_2 risk management and to ensure planning capability regarding the costs of EUAs and CERs.

Table 3: volumes ($MtCO_2e$) and values (MUSD: millions of US dollars) of carbon markets in 2007 and 2008. Source: [3].

Year ->	2007		2008	
Market	volume	value	volume	value
Project-based transactions				
Primary CDM	552	7 433	389	6 519
JI	41	499	20	294
Voluntary market	49	263	54	397
Sub-total	636	8 195	463	7 210
Secondary CDM				
Sub-total	240	5 451	1 072	26 277
Allowances Markets				

EU-ETS	2 060	49 065	3 093	91 910
New South Wales (Australia)	25	224	31	183
Chicago Climate Exchange (US)	23	72	69	309
RGGI (US)	-	-	65	246
AAUs	-	-	18	211
Sub-total	2 108	49 361	3 276	92 859
Total	2 984	63 007	4 811	126 345

There are two main CER products traded in the EU-ETS: BlueNext Spot CER (BNS CER), launched August 2008, which is a spot contract for CERs and ICE ECX Futures CER (ECX Futures Dec yy) which is a derivative with delivery in December each year. The price tick is 0.01 euro per ton and the volume tick is 1000 tons.

Figure 3 displays the spot prices for EUAs and CERs (BNS EUA 08-12 and BNS CER). It shows that CERs trade lower than EUAs. There are several reasons for that. In the case of primary CERs, the discount is a direct consequence of the risk of the CERs not making the CDM approval process and not being issued. In the present case, i.e. secondary CERs for which delivery is guaranteed by the seller, the discount is due to the trading limits (the CERs are not bankable in the same terms as the EUAs, cf. the 2.5% limit after 2012). One might argue that this will not always be the case since CERs are a fungibility link: as more trading schemes become available around the world, CERs might gain in value since there are today the only trading unit which is or shall be recognized by the coming exchanges.

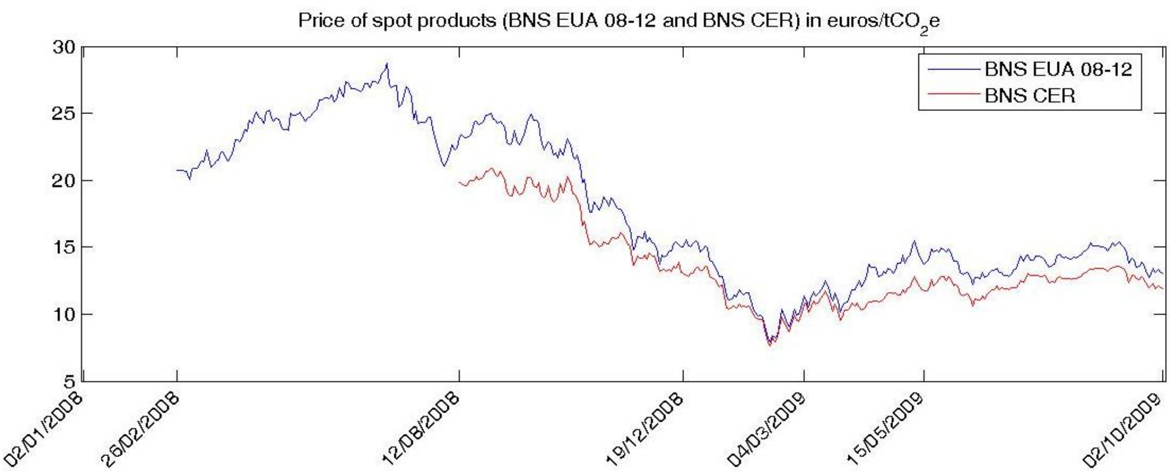

Figure 3: spot price for BNS EUA and BNS CER in Euros/tCO_2e. Source: [4].

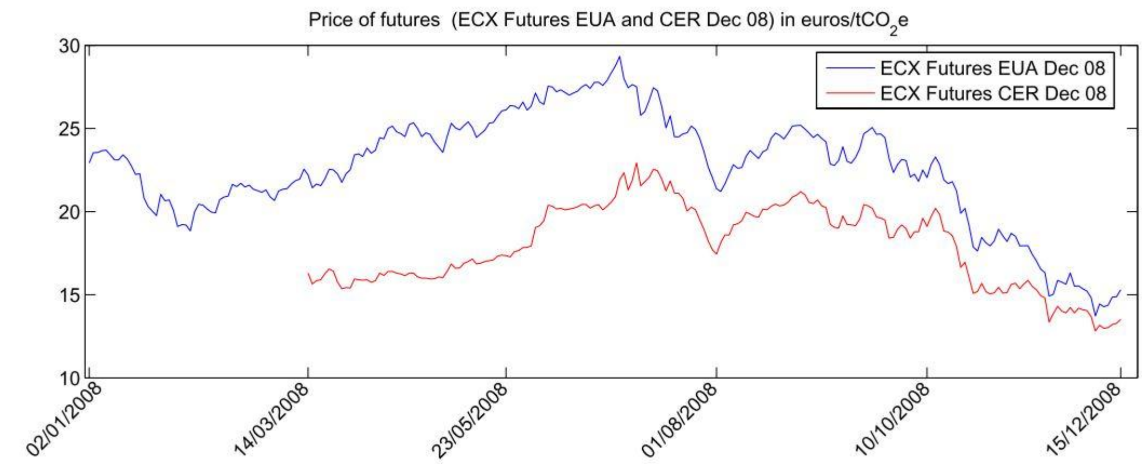

Figure 4: price for ECX Futures (EUAs and CERs) in euros/tCO$_2$e. Source: [5].

Figure 3 shows that the carbon price dropped during fall 2008 from 20-25 to 8 euros/tCO_2e and has stayed since then in a 10 to 15-Euro interval. The 2008 fall decrease was due to the consequences of the financial crisis: the economic recession which followed the financial crisis lowered the demand in allowances whereas the offer stayed the same. The demand stayed quite high for energy producers (electricity) but not for industries which had to cut their productions. According to economists, the right price of emission allowances should be 15 to 20 euros and there is no clear explanation why it has been so low up to now [6]. A possible explanation is the credit crunch: many industries which cannot find cash on the market to finance their activities resort to the carbon markets. This short term strategy is possible due to the EU-ETS calendar, that is, companies can get in February their allowances for the coming year before compliance for the former year in April. A company can borrow up to one year of allowances and cash them in the market (up to 2012). This type of behavior has increased the offer and consequently the spot prices both for EUAs and CERs have decreased.

Figure 4 puts forward the price trajectories for the ECX Futures (EUA and CER) which matured December 2008. As in the case of the spot products, the EUA-based futures traded higher than the CER-based ones for the same reasons that were exposed earlier. The spread between the prices of EUAs and CERs called for arbitrage. One could sell EUAs and buy CERs for compliance in 2008, and pocket the difference. Many large market players (installations, etc.) that could trade futures in large quantities took advantage of this price differential. In spring 2008, they could sell EUA Futures and buy CER Futures and pocket a 9 euros/tCO_2e difference, and still be able to comply by 30th April 2009, cf. Figure 5. By the end of December 2008, just before delivery, these market players had arbitraged away most of the EUA/CER price differential (the price differential was then between 1 and 2 Euros/tCO_2e).

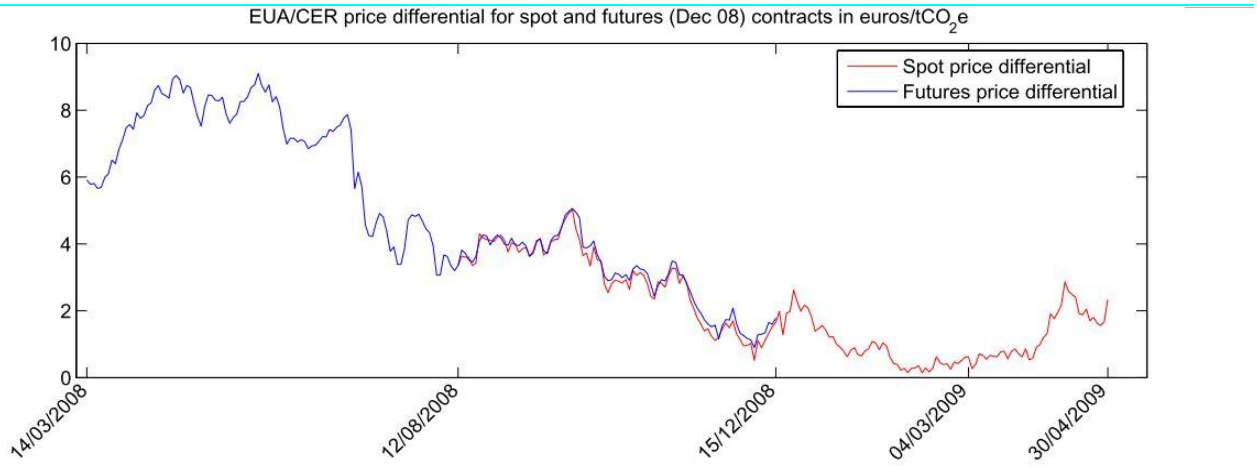

Figure 5: EUA/CER price differential for spot and futures (Dec 08) contracts in Euros/tCO_2e. Source: [4 and 5].

As a matter of fact, small market players who could not trade large quantities of futures could have resorted to the spot market. This did not happen: due to the late connection of the ITL and the CITL[10] in October 2008, CERs and some EUAs could not be delivered in time.

The price differential between EUA-based products and CER-based products should change in the near future as more exchange go live, CERs being today the main fungibility link. The differential should vary depending on the compliance calendars of the other trading schemes. It should reach a maximum value during the 2012-2015 time period. At the end of 2015, only few CERs in each EU-ETS national registry will be bankable; this should lower their value.

2. Biodiesel from Fish waste at the Hiep Thanh seafood processing plant

2.1 Objectives and description of project activity

The Hiep Thanh Seafood Joint Stock Company operates a large fish processing facility by the Hau Giang River, which is a distributary to the Mekong River, in southern Vietnam. The facility produces mainly pangasius (Pangasius hypophthalmus) fillets for export. The company also owns a 70 ha pangasius raising farm on the other side of the river, where the fish are raised before they are processed in the plant, and a fish food factory. An energy audit was done at the Hiep Thanh Seafood Joint Stock Company by Pöyry Energy Oy accompanied by VTT Technical Research Centre of Finland and Motiva Oy in October 2008. The underlying project idea note (PIN) is based on the energy audit calculations in the audit report and further data gathered during the ENERFISH project.
The monthly average input of fresh pangasius in the fish processing plant is 3 360 tonnes, which generates an average output of 1 008 tonnes of frozen fillets. The annual production of fillets is

[10] The ITL and CITL are the transaction logs of the Kyoto protocol and the EU-ETS respectively.

approximately 12 100 tonnes (production in 2007). Monthly about 2 352 tonnes, which is nearly 70 %, of the fresh pangasius processed in the plant ends up as waste, when the fillets are removed. The annual amount of fish waste is about 28 470 tonnes.
Currently the fish waste is sold in the market. However, in the energy audit it was noticed, that it would be possible to produce biodiesel from the fish waste. The fish waste contains significant amounts of animal fats (fat content of pangasius is 22 %), which make a good source for diesel making purposes.
The biodiesel could be used in the seafood processing plant to make electricity at the spot (in a diesel engine/generator) or sold in the market where it would replace petrodiesel.
As the biodiesel production at Hiep Thanh Seafood is part of the ENERFISH project, the project idea presented in this PIN is just for information purposes. This information could be used in similar seafood plants in other parts of Vietnam or other countries. Furthermore the possibility of programmatic CDM (if possible after 2012) should be considered at that stage.

The objective of this project activity is to produce biodiesel from fatty fish waste at the Hiep Thanh seafood processing plant. The biodiesel process involves fish oil separation from the waste, and esterification of the oil to separate biodiesel and glycerol into two layers (see more detailed process description in ENERFISH Deliverable D3). From the 28 470 tonnes of fish waste annually generated at the plant, an estimated 4 745 tonnes of biodiesel could be produced. The daily amount of fish oil separated from the waste would be 17 tonnes, of which 13 tonnes of biodiesel could be produced. The biodiesel could be used to make electricity, or sold to the market to replace petrodiesel in other types of diesel engines. One ton of biodiesel would generate an estimated 4 MWhel of electricity, so the annual potential of electricity would be 18 980 MWhel. In the ENERFISH project it has been planned, that a diesel engine with a capacity of 1.1 MWel would be connected to the biodiesel process, so that the electricity currently used in the plant could be self-produced. The seafood processing plant uses around 16 980 MWh of electricity annually (estimated use in 2008), so the potential generation of 18 980 MWhel would be enough for the electricity needs of the seafood plant, and the remaining electricity could be fed to the net or used otherwise.

The price for electricity is approximately 42.7 €/MWh (2009 average price), so the potential generation of electricity would create an income of 810 446 € per year. If the electricity produced from biodiesel would be used to replace electricity purchased from the grid, the emission reductions would be in the order of 11 830 t CO_2e/year, if a grid emission factor of 0.623304 is used. This would mean a CER income of roughly 118 300 € annually, assuming a price of 10 € per CER. The total annual income would therefore be 928 746 €.

However, alternatively the biodiesel could be sold to the Vietnamese market for a price of 800 - 900 €/ton.
The CDM methodology ACM0017 (replaced AM0047) on the production of biodiesel for use as fuel [7] stipulates the following:

i)Biodiesel Plant and Products:

a) The petrodiesel, the biodiesel and the blended biodiesel comply with national regulations (if existent) or with suitable international standards such as ASTM D6751, EN14214, or ANP42. ENERFISH guarantees standard EN14214;

b) The project activity involves construction and operation of a biodiesel production plant. ENERFISH does this.

c) The by-product glycerol is not disposed of or left to decay. It should be either incinerated or used as raw material for industrial consumption. ENERFISH Deliverable D2 gave an overview of possible applications of the by-product glycerol. For smaller scale glycerol production, the concept of co-fermenting crude glycerol with waste water sludge, biodiesel soap water and other locally available organic waste streams is a sustainable concept combining both glycerol utilisation and local waste management to produce local fuel (biogas). This possibility will be the subject of paragraph 3 below.

d) If biomass or biofuels are used at the site of the biodiesel production plant or the oil production plant(s) for fuel combustion (e.g. for heat or electricity generation), then at least 95% of the biomass and biofuel used in these plants should be either biomass residues from the dedicated plantations established under the project activity or biodiesel generated in the project activity biodiesel production plant. The amount of biodiesel used should not be included in the quantity of biodiesel for which emission reductions are claimed. ENERFISH fulfills this demand.

ii)Consumption of biodiesel:

(a) The (blended) biodiesel is supplied to consumers within the host country who use the (blended) biodiesel for fuel combustion in existing stationary installations (e.g. diesel generators) and/or in vehicles;

(b) The consumer and the producer of the (blended) biodiesel are bound by a contract that allows the producer to monitor the consumption of (blended) biodiesel and that states that the consumer shall not claim CERs resulting from its consumption;

(c) No modifications in the consumer stationary installations or in the vehicles engines are necessary to consume/combust the (blended) biodiesel. In case of stationary installations, biodiesel or blended biodiesel with any blending fraction between 0 and 100% can be used. In case of vehicles, only blended biodiesel can be used and the blending proportion must be low enough to ensure that the technical performance characteristics of the blended biodiesel do not differ significantly from those of petrodiesel. This condition is assumed to be met if the blending proportion is up to 20% by volume (B20).[11] If the project participants use a blending proportion of more than 20%, they shall demonstrate in the CDM-PDD that the technical performance characteristics of the blended biodiesel do not differ significantly from those of petrodiesel and comply with all local regulations. Blending is done by the producer, the consumer or a third party who is contractually bound to the producer to ensure that blending proportions and amounts are monitored and meet all regulatory requirements;

(d) In case of vehicles, the consumer (end-user) of the blended biodiesel is a captive fleet of vehicles;

[11] 2004 Biodiesel Handling and Use Guidelines, U.S. Department of Energy.

(e) Only biodiesel consumed in excess of mandatory regulations is eligible for the purpose of the project activity.[12]

So assuming these CDM conditions regarding consumption will be fulfilled, selling the biodiesel to the market would generate a total annual income of 3.98 – 4.27 million €, if there would be demand for the biodiesel for a price of 800 – 900 €/t.

It can thus be concluded, based on the annual income potential, that the option of selling the biodiesel to the market would be more profitable than producing electricity for own use.

The market demand for fish based biodiesel is however not known at the PIN development stage. If the biodiesel would be sold in the market and used to replace petrodiesel, the emission reductions would be in the order of 13 850 t CO_2e/year, if an emission factor of 2.92 t CO_2/t for petrodiesel is used. This would mean a CER income of roughly 138 500 €/year, and the total annual income would accumulate to 4.1 – 4.4 million €. This income is more uncertain, because the market price and demand cannot be guaranteed in advance.

The baseline scenario is that the fish waste is continued to be sold to the market, as it is has been the most economical option for Hiep Thanh in the current circumstances.

In ENERFISH Deliverable D1 this baseline scenario resulted in the parametrization of the electricity/CHP versus biodiesel option as depicted in Figure 7 and 8 below:

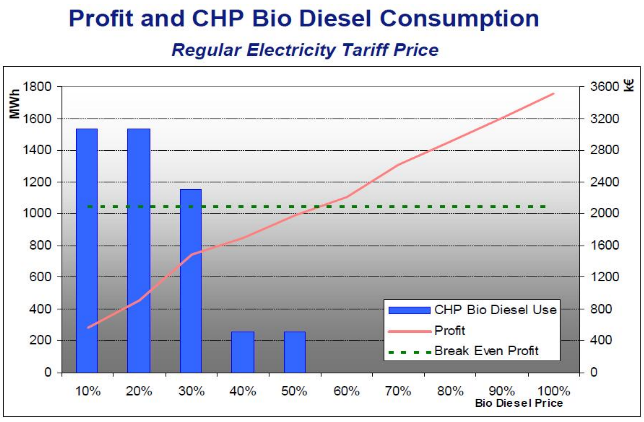

Figure 7 Profit and CHP Biodiesel consumption (regular electricity price)

12 Regulations that have been implemented since the adoption by the COP of the CDM M&P (decision 17/CP.7, 11 November 2001) need not be taken into account.

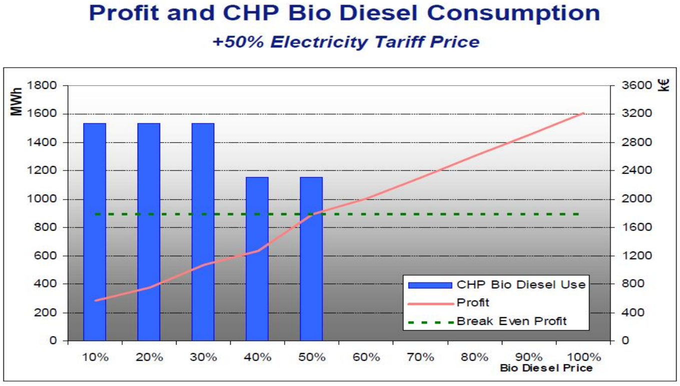

Figure 8 As figure 7 (50% electricity tariff price)

The figures are based on some more conservative estimates than the above (biodiesel 650 Euros/t), but still the figures show a remarkable profit of 1.5 Million euro's year (base case Figure 7) as compared to the business as usual scenario (dotted line). Assuming a price of 400.000,- Euro as investment value for the biodiesel plant, it is clear that the investment has a pay-back period of less than one year.

2.2 Additionality

In assessing the possibility to realize a project as ENERFISH as a CDM project, the concept of additionality must be addressed.

The additionality requirement is important because the CDM is an offsetting mechanism. This means that emission reductions achieved through CDM projects in developing countries permit industrialized countries to emit more greenhouse gases than stipulated in their assigned Kyoto targets. If a project that would also be implemented without the incentive provided by the Certified Emission Reduction Units (CERs) is registered as a CDM project, the use of the CERs results in an increase of global GHG emissions: the CERs enable industrialized countries to increase their GHG emissions above their assigned Kyoto target, whereas the emission reductions in the developing country would occur anyway.
The current guidelines on demonstrating additionality of small-scale projects (<60kton CO2 /year) are very short and vague. They do not explicitly require that credible alternatives be identified, that barriers be credible, and that documentation be provided for the existence of the barrier. The CDM Executive Board should revise the guidelines and clarify what documentation needs to be provided [8].
The Preseco biodiesel process used in the ENERFISH project generates high quality biodiesel, and can be directly applied to diesel engines. There are currently no registered biodiesel projects in the world . However, two projects using the AM0047/ACM001 methodology are in validation, situated in China and India (checked 1.2.2011 at cdm.pipeline.org). Neither one of the projects in validation involve biodiesel production from fish waste oils/fats. This means that a fish waste biodiesel project implemented in another seafood processing facility could be first of its kind in the world, which is a good argument for additionality.
However, since the ENERFISH project is not situated in an LDC/SID and moreover does not deliver distributed electricity to households, the overriding argument against additionality is the

profitability of the project. With or without CER income any project like ENERFISH would be undertaken.
Another argument against additionality is the common practice argument as indicated below.

The Mekong Delta is an important area for fish farming and processing and therefore large quantities of fish waste are produced as well.

Agifish (http://www.agifish.com.vn/home_en/modules/news/) is one of the Vietnamese catfish producers. The company has agreed to set up a joint venture with Saigon Petro in order to establish large-scale production facilities of biofuel from catfish gut. Two local refrigeration firms are involved in the project as well. The production capacity of the plant is planned to be 30 000 tonnes of fuel a year and it would be located in An Giang province. A feasibility study is being prepared and negotiations on investments are underway. Possible plant-sites are still being evaluated as well. The processing equipment is planned to be imported. Converting fish waste to valuable fuel could generate major opportunities for rural communities by providing income as well as securing energy supply. However, according to Agifish representative, Vietnamese biodiesel producers have not yet received any state funding for biodiesel production (Piccolo 2008; Vietnam News 2008 in Deliverable D2).

Minh Tu Ltd Co. is another Vietnamese company that plans producing fish oil based biodiesel. In 2006, the company successfully investigated the possibilities to manufacture biodiesel. The company has invested in building a facility and partners with domestic companies as well as a Cambodian company. It is estimated, that the facility could produce as much as 2 million litres of biodiesel a year. The company affirms that 50/50 blends of biodiesel and mineral diesel would be feasible. Minh Tu Ltd Co. purchases its raw material through local agencies and the company has a stable supply of 50 tonnes of catfish fat a day. The price of catfish fat has recently risen steeply which presents a challenge to biodiesel industry. This is due to the fact that local enterprises are exporting large volumes of catfish fat. Therefore, Minh Tu Ltd co. is considering the use of jatropha oil for the production of biodiesel (Vietnam News 2008 in Deliverable D2) .

According to Vietnamese biodiesel producers, there are some tedious procedures and legal limitations for biodiesel which hinder the use of biodiesel. Yet, there are no clear national requirements on biodiesel quality. However, a draft of biodiesel quality standard has been prepared. (Vietnam News 2008 in Deliverable D2)

A Project summary

Key information

Project title	Biodiesel from fish waste at the Hiep Thanh seafood processing plant
Project type and category	small scale CDM
Project proponent	Hiep Thanh Seafood Joint Stock Company
Contact person	Mr. Nguyen Thanh Danh
Host Country	Socialist Republic of Vietnam
Targeted greenhouse gases	CO_2
Estimated crediting period	2011-2020 (10 years without renewal)
Estimated emission reductions	Total by 2012: 17 745 – 20 775 tCO_2e (expected CER generation start July 2011) Total by 2020: 112 385 – 131 575 tCO_2e	Annual average: 11 830 to 13 850 tCO_2e/year (estimates depending on biodiesel end use)

B Greenhouse gas emission reductions

Information on emission reductions

Indicative CER price	Unit price: 10 EUR/tCO_2e	Total value: 177 450 – 207 750 EUR (by 2012) T T Total value: 1 123 850 – 1 315 750 EUR (by 2020)
Estimated CERs over crediting period and by 2012	Total: 112 385 – 131 575 tCO_2e Total by 2012: 17 745 – 20 775 tCO_2e	From: 2011 to: 2020 (i.e. 10 years) Annual average: 11 830 - 13 850 tCO_2e/year
Applicable baseline and monitoring methodology	ACM0017: Production of biodiesel for use as fuel Additionality questionable	

3. Biogas from wastewater sludge at the Hiep Thanh seafood processing plant

3.1 Objectives and description of project activity

As mentioned in section 2.3 for smaller scale glycerol production, the concept of co-fermenting crude glycerol with waste water sludge, biodiesel soap water and other locally available organic waste streams is a sustainable concept combining both glycerol utilisation and local waste management to produce local fuel (biogas).

Thus the baseline scenario has to be more accurately defined in the possible detailed project development stages, but here it is assumed that in the absence of the project activity the wastewater sludge, glycerol and biodiesel process wastes are treated in anaerobic conditions where they would generate methane emissions to the atmosphere. In the baseline situation all the electricity consumed in the seafood processing plant would be bought from the grid, and thus produced by mainly fossil fuels.

In the energy audit it was discovered that the seafood processing plant uses a significant amount of water in the fish filleting process; water consumption in the plant was 360 000 m³ in 2007, of which 324 000 m³ ended up as wastewater. The daily amount of waste water generated by the plant is currently approximately 900 m³, and the daily amount is going to be at least 50 m³ greater when fish waste biodiesel production is also implemented at the plant.
The wastewater characteristics (before treatment) are as follows:

Table 4. Waste water characteristics before treatment

Parameter	amount	unit
BOD	3,320	mg/l
COD	3,730	mg/l
TS	3,114	mg/l
TSS	2,680	mg/l
VSS	2,602	mg/l
Alk	14	mg/l
TKN	127	mg/l
pH	6.51	mg/l
flowrate	1,300	m3/d

The waste water is currently treated in a wastewater treatment facility connected to the plant (with a capacity of 1 000 m³/d) before it is led to the Hau Giang River. The wastewater treatment for the seafood processing plant consists of two systems: in the first system the wastewater is aerated with compressed air, and in the second one the floating and sinking particles are separated before the water is led to the river. The biodiesel plant (implemented by the ENERFISH project) also produces wastewater and crude glycerol, which are not treated in the wastewater treatment facility, but directed to the biogas plant .

The wastewater treatment for the seafood processing plant consumes approximately 441 MWh and the proposed biogas plant 240 MWh of electricity annually. The total energy consumption of the plant is currently around 16,7 GWh/a (without the biodiesel and biogas plants).

The objective of the project activity proposed is to reduce methane emissions and generate electricity by recovering biogas from the sludge generated in the wastewater treatment facility and the waste water, protein and glycerol generated in the biodiesel production. The Finnish company Preseco has designed the specifications for the biogas plant for the VietAudit 2 project (see Vietaudit final report).

Preseco has calculated that the biogas process would consume 240 MWh of electricity, 2 654 m³ of fresh water and 4 tonnes of chemicals per year. There would be a total wastewater sludge input of 25 891 tonnes per year to the biogas process.

Of the total input the waste water from the biodiesel unit and oil separation would make about 82 %, fish protein about 14 %, glycerol about 3 % and the wastewater sludge from the treatment plant only about 0.06 %.

The biodiesel project by ENERFISH is therefore a key component in the implementation of the biogas project. The total input of 25 891 t/a would generate 103 Nm³ of biogas per hour. The methane content of the biogas is expected to be 65 %. This means that a total of 66.95 Nm³/h of methane would be generated from the wastewater sludge and other input.

In one year the amount would be 586 482 Nm³, which corresponds to 384.7 t CH4, if a methane density of 0.656 kg/m³ (methane density at 25˚C, close to annual average temperature in Vietnam) is applied.

According to the CDM methology a Methane Correction Factor (MCF) shall be used to determine a more realistic amount of methane released to the atmosphere by the way the sludge is treated in the absence of the biogas project. It is assumed in this PIN (not enough information currently available) that the sludge is treated in an anaerobic digester for sludge without methane recovery, which has an IPCC default MCF factor of 0.8. This means that in the absence of the project, the amount of methane that would be released annually to the atmosphere is approximately 307.76 t CH4. Methane has a global warming potential of 21, which means that it is a 21 times more potent greenhouse gas than carbon dioxide. The methane emissions avoided by the proposed biogas project would be equivalent to 6 463 t CO_2e/year.

The electricity generated from biogas is renewable, and reduces greenhouse gas emissions, because it replaces energy purchased from the grid. Generating own electricity also reduces electricity costs, because less electricity needs to be bought from the grid. The average price for grid electricity is 42.6 €/MWh (2009 average price), so generating 1 977 MWh of electricity annually by biogas, 84 220 €/year can be saved from the electricity purchase costs. Grid electricity in Vietnam grid emission factor is expected to be 0.623304 t CO_2e per MWh of electricity.

Calculating with this emission factor (taken from recent Vietnamese PDDs) the potential electricity generation of 1 977 MWh/a would reduce carbon dioxide emissions by 1 232 tonnes per year.

Combining the emission reductions of the methane avoidance and electricity generation, a total of circa 7 695 t CO_2e/year can be reduced. Assuming a CER price of 10 €, this would mean an income of 76 950 € per year. The CER amount is quite roughly calculated (and the CER price uncertain) at this stage, and would need to be calculated in more detail in the possible PDD development stage.

Investment costs for the biogas plant are expected to amount to 5-6 million €, if Finnish technology is used. Asian technology could be substantially less expensive, and thus the availability and costs of such technology should be investigated in the further stages of project development, such as in a feasibility study.

If the costs are assumed to be 5.5 M€ (Finnish technology), and the annual electricity costs savings and CER income from the biogas plant account to 161 170 €, the payback period would be roughly 34 years (no discount factor applied). Without the CER income the payback period is notably longer, about 65 years. If the total CER revenue potential up to 2020 is 731 020 €, it means that around 13 % of the investment could be covered with the CER revenues. According to these calculations, the investment seems quite expensive in comparison to the income it would generate; hence the costs and benefits of the biogas plant would have to be analyzed very carefully before making any investment decisions.

3.2 additionality

The type of the project proposed here has not been done before in Vietnam, so there would be several barriers to the implementation of the project.

There are several wastewater sludge biogas CDM projects in the registration process in Vietnam (conditionally registered if corrections are made), and in the validation process, but none of them uses wastewater sludge from animal waste as the source of biogas. All of the proposed biogas CDM projects in Vietnam are based on starch production and generate thermal energy instead of electricity. There are no registered CDM projects yet using the methodologies AMS-III.H and AMS-I.D together, which means generating electricity from wastewater sludge biogas.

Three such projects (located in China, Thailand and Indonesia) are currently in the validation process, and one Chinese project is placed under review by the CDM Executive Board because of insufficient justification of the benchmark used in its benchmark analysis.

This type of project, biogas from wastewater sludge to electricity, is not common practice in Vietnam, and it would be a considerably high investment generating a relatively small income. Therefore this project is not feasible at this moment.

A Project summary

Key information

Project title	Biogas from wastewater sludge at the Hiep Thanh seafood processing plant	
Project type and category	CDM	
Project proponent	Hiep Thanh Seafood Joint Stock Company	
Contact person	Mr. Nguyen Thanh Danh	
Host Country	Socialist Republic of Vietnam	
Targeted greenhouse gases	CH_4, CO_2	
Estimated crediting period	2011-2020 (10 years without renewal)	
Estimated emission reductions	Total by 2012: 11 542 tCO_2e (expected CER generation start July 2011) Total by 2020: 73 102 tCO_2e	Annual average: 7 695 tCO_2e/year

B Greenhouse gas emission reductions

Information on emission reductions

Indicative CER price	Unit price: 10 EUR/tCO_2e	Total value: 115 420 EUR (by 2012) Total value: 731 020 EUR (by 2020)
Estimated CERs over crediting period and by 2012	Total: 73 102 tCO_2e Total by 2012: 11 542 tCO_2e	From: July 2011 to: Dec 2020 (i.e. 9,5 years) Annual average: 7 695 tCO_2e/year
Applicable baseline and monitoring methodology	AMS-III.H. Methane recovery in wastewater treatment (version 13 or latest) + AMS-I.D. Grid connected renewable electricity generation (version 14 or latest) Not feasible due to high investment.	

4. Conclusions

i) Biodiesel from fish-waste

If the biodiesel would be sold in the market and used to replace petrodiesel, the emission reductions would be in the order of 13 850 t CO_2e/year, if an emission factor of 2.92 t CO_2/t for petrodiesel is used. This would mean a CER income of roughly 138 500 €/year, and the total annual income (including the sold biodiesel) would accumulate to 4.1 – 4.4 million €.
With an investment of around 400.000,- €, this means this sort of project is not additional, and therefore not eligible for CDM funding.

ii) Biogas from glycerol.

This type of project, biogas from wastewater sludge to electricity, is not common practice in Vietnam, and it would be a considerably high investment generating a relatively small income. Asian technology could be substantially less expensive, and thus the availability and costs of such technology should be investigated in the further stages of project development, such as in a feasibility study. If the costs are assumed to be 5.5 M€ (Finnish technology), and the annual electricity costs savings and CER income from the biogas plant account to 161 170 €, the payback period would be roughly 34 years (no discount factor applied). Without the CER income the payback period is notably longer, about 65 years.
However, for instance The Chiang Mai based ERDI institute (Thailand) has designed numerous similar biogas plants in Thailand, reducing the costs by a factor 5-6. This is due to the design being especially made for tropical counties (involving less insulation), making the project more feasible.

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