Feasibility study on an effective and sustainable bio-ethanol production program

by

Least Developed Countries as alternative to cane sugar export

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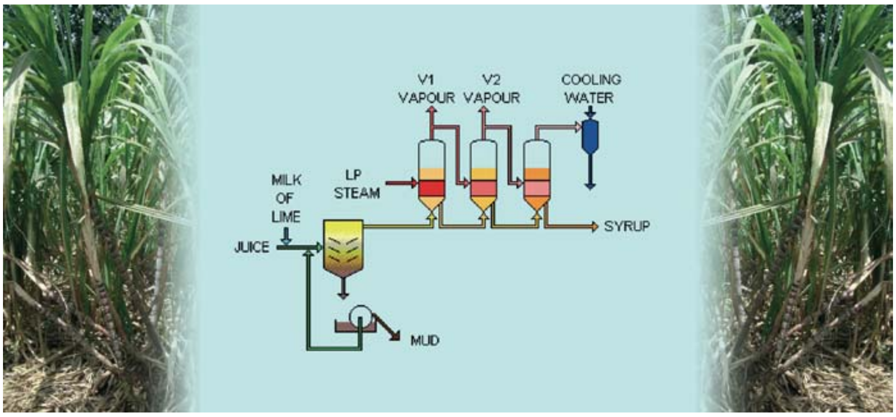

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Executive summary

The Everything But Arms ("EBA") initiative formulated by the EU will result in 2009 in an open market for Least Developed Countries ("LDC's") exporting Everything But Arms, including commodities such as cane sugar to the EU. As a consequence of recent EU proposals to reform the EU sugar regime it is expected that prices will drop from currently € 523/ton to € 329/ton in 2009 for raw sugar.

In view of these developments the Dutch Ministry of Agriculture ("LNV") raised the question whether bio-ethanol produced from sugarcane in LDC's could be a feasible alternative for the production of cane sugar.

The DSD ("Dutch Sustainable Development") Group has been tasked to perform a desk-study on the economic and technical feasibility of producing bio-ethanol from sugarcane by LDC's.

Bio-ethanol can be used as a substitute for fossil fuels and if mixed with gasoline is suitable for use in motor engines. The mixture results in a fuel with a cleaner combustion. The Kyoto protocol requires signatory nations to reduce greenhouse gas emissions by at least 5% during the period 2008-2012. The use of bio-ethanol is an excellent opportunity to support Kyoto requirements.

Although it is recognized that bio-ethanol can be produced from different arable crops such as sugarcane, sugar beets, maize or grains, this report investigates sugarcane only in view of the changing sugar regime in the EU.

LDC's face on the one hand a future reduction of cane sugar income due to reduced prices catched in the EU and on the other hand possess a commodity with an increasing potential, if transferred to bio-ethanol, to serve as an alternative for fossil oil as oil prices tend to increase.

The Brazilian bio-ethanol program has seen rapid developments resulting in an enormous effective production capability with stand alone bio-ethanol distilleries and rising demand for the need of bio-ethanol. It is recommended for LDC's to use existing sugar processing facilities whereby parallel to cane sugar production bio-ethanol is produced using thick juice during the harvest period and molasses during the off-season period. This concept results in a modest investment profile with an estimated investment ranging between € 10 and € 15m for a capacity averaging to 80.000 litres/day. This proposition is expected to be acceptable for all concerned stake holders. The rest products can also be used for the generation of heat and electricity required for the production of cane sugar and bio-ethanol.

The production costs for raw sugar in certain LDC's range between € 300 and € 400/ton. The current world market price for raw sugar amounts to an average of € 150/ton. It seems that no special reason be available to continue to produce cane sugar for export means with the exception of the export to the EU.

The world price for bio-ethanol is difficult to establish as it is not a world wide traded commodity such as cane sugar. If the production costs of bio-ethanol are compared to the price for gasoline at consumer level it is estimated that with an average consumer price level of € 0,42/litre (excluding taxes and duties) economic bio-ethanol production can be achieved. It is however important that governmental support is given to stimulate the use of bio-ethanol.

Additional advantages in using bio-ethanol relate to other less-quantifiable aspects such as reduced need for foreign currency, spin-off industrial applications, the outlook for stable and less political dominated delivery schemes, environmental advantages supporting Kyoto requirements.

For the selection of LDC's capable to produce bio-ethanol it is required that LDC's comply with the following selection criteria:

- LDC's have a surplus of cane sugar;
- LDC's are dependant of imported oil and
- LDC's have a potential for an economic production of bio-ethanol.

The selected LDC's with bio-ethanol capabilities are Malawi, Zambia, Ethiopia, Mozambique and Sudan. Malawi, Ethiopia and Mozambique are recommended as final candidate for a bio-ethanol production pilot project.

Beyond the study report it is recommended to proceed with the development and installation of a demonstration facility producing bio-ethanol in a selected LDC.

Chapter 1
Introduction

1.1 Conflicting policies

Governments are concerned with economic development of third world countries. The United Nations have denominated a 'Least Developed Country' (LDC) category for those countries (presently 50) that are considered structurally handicapped in their economical development process (see Appendix 1 for an overview of the LDC´s). On an international level it has been agreed between the developed countries to reduce world-wide poverty in 2015 by 50%, by means of an open and honest trading system.

LEAST DEVELOPED COUNTRIES
In response hereto the EU has formulated the Everything But Arms (EBA) initiative. Through this initiative, LDC's can export certain commodities tax and duty free to the EU in order to increase substantially the amount of trade with the LDC's, enhancing their export earnings and encouraging the diversification of their economies.

However, due to a WTO dispute case filed by Brazil, Australia and Thailand, against the EU export subsidies for sugar above the levels defined in the Uruguay Round Agreement, the EU is likely to be forced to reform its sugar regime resulting in substantial price reductions in the EU market. This effect would imply a lower return for LDC's importing to the EU and does impede the development potential of the EBA initiative.

COMMON AGRICULTURAL POLICY
Next to these developments, it is expected that the envisaged open-ended imports resulting from the EBA initiative could also interfere with the Common Agricultural Policy so called ("CAP") of the EU commission. The aim of the CAP in the EU is to provide the farmers with a reasonable standard of living. This is partly accomplished through the regulation of the agricultural market securing minimum prizes for foodstuffs within a fixed amount of production. As a result, the prices paid for agricultural products in the EU are well above world market prices. To keep the market stable, countries outside the EU (which in general can produce much cheaper) have difficult access to the internal EU market.

The EBA initiative could impede the CAP policy, because of the potentially big amount of agricultural goods entering the EU internal market. The 'duty and quota-free' market access for sugar will only begin in year 2009.

Nevertheless raw sugar can already be exported duty-free by the LDC's to the EU market within the limits of a tariff quota. This quota will be increased each year by 15% from 74,185 tons (white-sugar equivalent) in 2001/2002 to 197,355 tons in 2008/2009. After that, unlimited access is allowed.

DUTCH SUSTAINABLE DEVELOPMENT GROUP
The DSD Group recognizes the conflicting interests resulting from the EBA initiative, in particular in the area of sugar as well as arising from the WTO dispute. The Dutch Ministry of Agriculture, Nature and Food Quality have requested the DSD Group to investigate whether it can be an option for LDC countries to produce bio-ethanol out of sugarcane whereby an economical sustainable source of income in the concerned LDC's could be maintained or even be improved.

Through this opportunity, the potentially unlimited export of (rough) cane sugar could be reduced and the LDC's could potentially have more benefit from sugarcane.

AFRICAN, CARIBBEAN AND PACIFIC COUNTRIES
In addition hereto, a development which may impede on the longer-term the EU sugar program is the negotiation which the EU started in September 2002 with the 77 ACP (African Caribbean and Pacific Countries, the former colonies) countries. Under these Agreements, the same access provided to the LDC's will likely be extended to all ACP countries. These countries currently produce 6 million tons of sugar and they could potentially provide all of it to the EU on short notice for relatively high prices while covering their own consumption from the world market for relatively low prices. Nowadays the ACP countries are allowed to export almost 1.3 million tons of raw sugar to the EU at guaranteed prices.

1.2 Bio-ethanol, an interesting alternative

This study focuses, as mentioned earlier, on the feasibility for locally produced bio-ethanol from sugarcane in LDC's. Bio-ethanol can be produced from other sources as well such as sweet sorghum or corn, but in view of the potential sugar reform policy in the EU, this study addresses sugarcane only.

Why bio-ethanol, what makes this commodity so interesting? This paragraph intends to provide an answer to this question in the perspective of different global developments.

1.2.1 A regulated sugar market in reform

Sugar is one of the most policy regulated of all commodities. Producers in some countries, for example the EU, receive more than double or even triple the world market price due to government guaranteed prices, import controls and production quotas. This quota will be defined per Member State. The quota corresponds, in principle, to the demand on the internal market and to the export of excess quota sugar with export refunds, respectively. For sugar produced outside the quota there is no support, nor can it be freely marketed within the EU. This sugar is declassified and considered C-sugar and must be exported without refund in the expense of the sugar industry and beet producers.

In the process, lower-cost developing country producers have been underprivileged of export opportunities. Efforts to reduce protection have been opposed from well-funded and entrenched supporters of existing policies, while consumers who pay high prices have voiced little opposition because of the small share of their food budgets spent on sugar. However, internal changes in the EU sugar and sweeteners markets and international trade (WTO) commitments make changes unavoidable.

The main reform of the EU sugar regime is a lower institutional price for sugar. The current intervention price is to be replaced by a reference price. The proposal of former EU commissioner Fischler in 2004 is to lower this price by 33% in steps, thus the price would be finally € 421/t for white sugar in comparison with € 632/t nowadays, see table 1.1.

Table 1.1: Proposed EU price for raw sugar

	Reference Period	2005/2006	2006/2007	2007/2008
Institutional Sugar Price (EUR/t)	632	506	506	421
Cumulative reduction in institutional price	0.0%	-20.0%	-20.0%	-33.0%

This proposal has major consequences for the LDC's. Preferential market access is very lucrative at present, due to the high price for sugar in the EU and well-protected sugar market. The forthcoming reforms on the EU sugar regime may have a major impact on the sugar exports of the LDC's.

A drastic cut in the intervention price for sugar may consequently result in a major drop in the potential LDC country earnings from sugar exports to the EU. Bio-ethanol production in LDC's could lead towards higher incomes.

1.2.2 High energy demand and oil prices

The growth of the world population and the striving for a higher standard of living is responsible for a growing need for energy. Next to that the energy demand from countries such as China and India will imply a considerable claim on the availability of fossil fuels. It is expected that the world demand for energy will rise during the next 25 year with roughly 60% (Rabobank, 2004). Two-third of the increase in global energy demand will come from developing countries. By 2030, they will account for almost half of the total demand, in line with their more rapid economic and population growth (IEA, 2004). Sufficient oil reserves exist worldwide to satisfy the projected demand only during the next three decades.

The current supply of fossil fuels come to a great extend from limited sources in unstable regions, like the Middle East or Russia. The oil and gas prices trend to significant increase from current levels: the oil price is projected to reach a long term price level of € 45/barrel in 2015 (EU, 2003) whereas the price today is almost € 50/barrel. Many developing countries do not have self supporting oil industries and therefore have to pay for it on the world oil market with hard currency. They could better use this money for the development of their countries and would gain an advantage if used to stimulate alternatives for conventional energy sources, such as bio-ethanol. Against this background changes in the manner on which we fulfil our need for energy are absolutely necessarily. The strong rise in demand for energy and the finite availability of supplies of fossil fuels forces us to seek for alternative means of energy. One opportunity could be bio-ethanol.

1.3 Study objective

As an alternative to the production of cane sugar from sugarcane the production of bio-ethanol from sugarcane can be considered. Bio-ethanol can be applied for domestic use within the LDC's. Bio-ethanol can be added to fossil fuels as natural supplement, by doing so less fossil fuel is necessary and the fuel becomes cleaner. It is expected that the Kyoto agreements will lead to an increasing demand for bio-ethanol in the next years. Also, the production of bio-ethanol from cane sugar could lead to higher gains and economic growth for the LDC's compared to the export of cane sugar.

The resulting objective of this study is defined as:

'To investigate if there is a political, technical and economic basis for the economic production of bio-ethanol from sugarcane in Least Developed Countries.'

It is a challenge to investigate whether in LDC's similar or different processes can be implemented to achieve economic opportunities for producing bio-ethanol from sugarcane on a lesser scale due to their inherent geographical circumstances.

1.4 Study approach

The study has been executed as a desk study of existing literature and with the information supplied from various specialist sources. No field research has been done.

The Brazil situation, due to the fact that on the bio-ethanol program a lot of experience and information is available to review its history, pitfalls and successes, has been analysed and considered as reference basis for an evaluation of the feasibility of bio-ethanol production and consumption in LDC's.

The report has been written following the structure as described hereinafter.

Prior to the assessment whether bio-ethanol can be produced in LDC's, the characteristics of bio-ethanol are analysed and to what extend it can be used. This analysis is described in Chapter 2.

Chapter 3 examines the current sugar and bio-ethanol markets. This Chapter examines the first criteria referring to the existing regulations which would impede a free choice whether to produce cane sugar or alternatively bio-ethanol. Maybe it is more interesting to export cane sugar through the benefits as a result of the EBA initiative then to seek for alternatives such as bio-ethanol production.

The second criteria relate to the required technology for bio-ethanol production and the amount of foodstuff needed for the production. This is described in Chapter 4. Also, the cost of the total process of harvesting, production and distribution of sugarcane is examined in this Chapter.

The third criteria relates to the economical feasibility analysed in Chapter 5. This Chapter addresses the question whether the production of bio-ethanol is an economic option next to the continued production of sugarcane.

After these three criteria have been examined in relation to the subject of the study a recommendation of selected countries for which the production of bio-ethanol is considered feasible is made and described in Chapter 6.

Chapter 7 provides conclusions obtained from the study, whereas Chapter 8 defines recommendations for the implementation of the study results.

Chapter 2
Bio-ethanol production and trading; an opportunity for LDC's ?

2.1 Introduction

This Chapter investigates the opportunities for LDC's to produce and trade bio-ethanol in view of current market and political developments.

2.2 Why bio-ethanol?

Bio-ethanol can be used as a substitute to fossil fuels for certain applications, in particular as a replacement of several substances currently added to fuel. If mixed with gasoline for use in automotive engines a great potential exists for the application of bio-ethanol.

2.2.1 Bio-ethanol as substitute for gasoline

Technically speaking, bio-ethanol is capable to replace 100% of all fuel for motor cars. This conversion has been applied for several years in Brazil, where a motorcar can be bought which runs on 100% ethanol. This however requires specifically adopted car engines. The development required hereto implies significant investments by motorcar manufactures and is only worthwhile in case the use of these engines would be encouraged on a world wide basis. An option which is better achievable for the short and medium term is to mix bio-ethanol (<20%) with gasoline. Up to 25 % blended gasoline can be applied in existing motor engines without the need to change the engine. The latest development is the definition of the flex-car capable to run on any mixture between bio-ethanol and gasoline. Brazil, together with car manufacturers has recently announced a program whereby a flex-car development is endorsed and whereby the first series are already running.

As an example what the use of bio-ethanol could save on fossil fuel consumption if blended as car gasoline can be calculated as follows: The production of 1 HA sugarcane with a yield of 80 ton results in the production of an average of 6.200/6.300 litre of bio-ethanol. Compared to a car with an average use of 1:12 and an average annual mileage of 30.000 km's would mean that 2 1/2 cars per year could run on bio-ethanol.

2.2.2 Bio-ethanol is greenhouse neutral

In countries where sugarcane is grown and harvested, the amount of carbon dioxide removed from the atmosphere during its grown process equals the amount of carbon dioxide released when the same sugarcane crop is processed into its final products and consumed.

The net result is greenhouse neutral; sugarcane, during its growth, absorbs carbon dioxide from the atmosphere. When the sugarcane is processed into sugar, ethanol and other products, the process is reversed.

2.2.3 Kyoto protocol

The Kyoto Protocol's major feature is the definition of mandatory targets on greenhouse-gas emissions accepted by the world's leading economies[1].

These targets range from -8 percent to +10 percent of the countries' individual 1990 emissions levels "with a view to reducing their overall emissions of such gases by at least 5 percent below existing 1990 levels in the commitment period 2008 to 2012."

In almost all cases -- even those set at +10 percent of 1990 levels, the limits call for significant reductions in currently projected emissions. Future mandatory targets are expected to be established for "commitment periods" after 2012. These targets are to be negotiated well in advance of the periods concerned.

The Protocol establishes three innovative "mechanisms" known as:
- joint implementation,
- the clean development mechanism and
- emission trading.

These mechanisms are designed to stimulate Annex I Parties[2] to cut the cost of meeting their emissions targets by taking advantage of opportunities to reduce emissions, or increase greenhouse gas removals that cost less in other countries than at home.

JOINT IMPLEMENTATION

Under joint implementation, an Annex I Party may implement a project that reduces emissions (e.g. an energy efficiency scheme) or increases removals by sinks (e.g. a reforestation project) in the territory of another Annex I Party, and count the resulting emission reduction units (ERUs) against its own target.

CLEAN DEVELOPMENT MECHANISM

Under the clean development mechanism (CDM), Annex I Parties may implement projects in non-Annex I Parties (e.g. LDC's) that reduce emissions and use the resulting certified emission reductions (CERs) to help meet their own targets.

The CDM also aims to help non-Annex I Parties to achieve sustainable development and contribute to the objective of the Protocol. Per project, it has to be approved by a executive board if a project is a CDM-project.

EMISSIONS TRADING

Under emissions trading, an Annex I Party may transfer some of the emissions under its assigned amount, known as assigned amount units (AAUs), to another Annex I Party that finds it relatively more difficult to meet its emissions target. It may also transfer CERs or ERUs that it has acquired through the CDM, joint implementation or sink activities in the same way. It is therefore not possible to trade emissions between the EU and the LDC's.

[1] EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland, Canada, Hungary, Japan, Poland, Croatia, New Zealand, Russian Federation, Ukraine, Norway, Iceland

[2] Annex I Parties: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America.

International cooperation, and the provision of support to developing countries and to countries with economies in transition, is crucial to ensure the implementation of the Protocol by all parties. Therefore, the Least Developed Country Fund is set up. This is a fund to enable the world's poorest nations to carry out national programs of action to adapt to the effects of climate change.

The EU is establishing a greenhouse gas emissions trading scheme for the cost-effective reduction of such emissions in the Community. This scheme should enable the Community and the Member States to meet the commitments to reduce greenhouse gas emissions made in the context of the Kyoto Protocol.

Installations operating in the energy sector, iron and steel production and processing, the mineral industry and the paper and card industry will automatically be subject to the emission trading scheme. Directive 2004/101/EC reinforces the link between the Union's emission allowance trading scheme and the Kyoto Protocol by making the latter's "project-based" mechanisms (Joint Implementation and the Clean Development Mechanism) compatible with the scheme. This will enable operators to use these two mechanisms in the allowance trading scheme to fulfill their obligations.

The result will be lower compliance costs for installations in the scheme. It is estimated that annual compliance costs in the period 2008-2012 for all covered installations in the enlarged Union will be reduced by more than 20%. This Directive thus recognizes joint implementation (JI) and clean development mechanism (CDM) credits as equivalent to EU emission allowances.

2.2.4 Finiteness of fossil fuels

Another important issue relating to fossil fuels is that its availability is finite. Recently the price of fossil fuel is increasing since the beginning of the 21th century (from € 15 per barrel to € 45 per barrel or even more).

That means that net fossil fuel importing countries are confronted with increasing need for hard currency. The availability of locally produced bio-ethanol could therefore improve the trade balance.

From publications presented during the Seminar on the Renewable Energy Valley at Den Helder (October 8th 2004) it is concluded that the production of oil and gas from already discovered fields is decreasing rapidly from currently 4.5 m barrels/day to less than 1.0 m barrels/day in 2018 (in oil/equivalent).

2.2.5 EU developments on bio-ethanol

Another aspect affecting the demand for bio-ethanol is the situation in the EU. In 2005 gasoline mixed with 2 % bio-ethanol requires 48,8 million hl bio-ethanol and in 2010 if mixed with 5% would equal to 121,9 million hl, which equals 19,5 mt sugar. The current EU production of sugar equals 20,0 mt. The conclusion can be drawn that the domestic EU production of bio-ethanol out of sugar-beet is inadequate to comply to the expected demand.

These figures seems to indicate that it is not possible to produce all the bio-ethanol in the EU and therefore a market need to be established for the import of bio-ethanol from other countries and/or the production of bio-ethanol from other species. The EU has initiated a study referring to opportunities of developing bio-fuels in general.

2.3 Requirements for production and trading of bio-ethanol

Bio-ethanol can be produced from several species. As an example, the production of 100 litre bio-ethanol equals the following equivalents:

- 1.270 kg sugarcane, or
- 1.030 kg sugar beets, or
- 360 kg molasses, or
- 268 kg maize, or
- 260 kg grains.

In view of the purpose of this report it has been decided that only sugarcane as feedstock for the production of bio-ethanol is investigated. Although we are aware of the fact that in particular in the northern hemisphere mainly grains are used for bio-ethanol production.

For the production of cane sugar and bio-ethanol it is required that sugarcane be harvested near the processing facility, due to the limited conservation time of sugarcane after harvest. The production of bio-ethanol requires a distillery next to the sugarcane factory in view of the use of tick juice resulting from the processing of sugarcane into cane sugar, which can not be transported. Based on this requirement, factories can be selected which are capable to implement an investment in a distillery in combination with the sugar processing factory in view of minimum quantities concerned and processes required.

Next to the specific processing requirements of bio-ethanol, storage - and logistic requirements apply as well for the production of bio-ethanol. Adequate storage facilities at the factory where the bio-ethanol is processed are required for the storage of bio-ethanol.

In case bio-ethanol is also exported, the factory and distillery has preferably to be located in the neighbourhood of a harbour in order to keep transport costs down. Based on the Brazil analysis where a strong dominating government policy stimulated the bio-ethanol consumption it is a necessary condition that LDC governments strongly define proper instruments as to stimulate bio-ethanol consumption and to support the production of bio-ethanol.

2.4 Conclusions

The Brazilian PROALCOOL program has shown that bio-ethanol is an interesting substitute to save on fossil fuel consumption if blended with gasoline for use in automotive applications and stimulates economical developments. The use of bio-ethanol supports the reduction in greenhouse-gas emissions as required under the Kyoto Protocol.

Also from various studies it is widely demonstrated that the finiteness of fossil fuels need the search for renewable energy sources. The use of bio-ethanol is an interesting opportunity.

From a production point-of-view the requirements for the processing of bio-ethanol from sugarcane have been analysed and it has been concluded that the production of bio-ethanol can be achieved within reasonable and acceptable constraints.

Chapter 3
The contemporary sugar and bio-ethanol markets; future developments

3.1 Introduction

In this Chapter an analyses has been made of the market potential for the production of sugar and bio-ethanol in the LDC's with a view to substitute sugar production for bio-ethanol production in one or more LDC's. First, the market for sugar is described. This market is divided in the regulated and the free world market. Second, the market for bio-ethanol is explored. Today's potentials and future developments have been reviewed.

3.2 The sugar market

Sugar in general is one of the most policy regulated of all commodities and the European Union, Japan, and the United States are among the most regulated regions. Producers in these countries receive more than double the world market price due to government guaranteed prices, import controls and production quotas. More than 80% of the world production is regulated, only the remaining 20% is produced without regulations. It is therefore necessary to make a division between the regulated market and the unregulated world market.

3.2.1 The regulated market

The regulated sugar market accounts for more than 60% of the world sugar market. The EU is not only a regulated market but also an important single market for exports of LDC's. In 2000 more than 50% of LDC sugar exports were sold on the EU market, compared to 37% in 1999. In 2000, the EU took around 70% of LDC agricultural exports.

Among 15 out of 50 LDC's, are dependent on this market, as over 50% of their exports are directed to the EU (UNU/WIDER, 2003). Therefore the main part of this paragraph is dedicated to the EU. Firstly, a brief description of the internal EU market is given. Secondly, the relation between the EU and the LDC's is described. The paragraph ends with an outlook to the future EU market.

THE INTERNAL EU-MARKET

The EU sugar policy stipulates production quotas, import controls and export refunds (subsidies) to support sugar beet production in the EU who produce well above world market prices. The program is financed primarily by EU consumers who pay more than world market prices. The total A/B quota amounts to 17.4 million tons for EU 25 and is divided into:

- A-quota (82 %) and
- B-quota (18%)

These A and B quota, set per Member State, correspond in principle to the demand on the internal market and to the export of excess sugar quota with export refunds. Sugar produced outside the quota is not supported, nor can it be sold within the EU.

This sugar is declassified and considered C-sugar and must be exported without refund on the expense of the sugar industry and beet producers.

The intervention price at which intervention agencies are obliged to buy-in eligible sugar offered to them has been frozen since 1993/94 at € 631.90 per ton for white sugar and € 523.70 per ton for raw sugar. These prices have been more than double the world market prices during most of the past 20 years. Import duties and restriction of available quantities, which are other tools of the regulation, keep market prices above the level of intervention. Some non-EU countries have preferential access to the EU-market. These countries can sell their sugar on the EU-market at the high internal prices. This is the subject of the next section.

PREFERENTIAL ACCESS

Preferential access to the EU sugar market and its high prices have been used as development assistance since the initial 46 countries (currently 77 countries) from Africa, the Caribbean and the Pacific (ACP) signed the first Lomé Convention in 1975 and became eligible to sell sugar to the EU at internal prices. The Sugar Protocol of the Lomé Convention provided for imports of specified quantities of cane sugar, raw or white, which originate in the ACP states at guaranteed prices. Unlike most Articles of the Lomé Convention, the Sugar Protocol does not expire and cannot be changed unilaterally. The original quantities specified amounted to 1.3 million tons of white sugar equivalents. This amount has remained constant during reallocation of quotas among existing members when a country could not meet its quota deliveries. The benefit of this regulation is high. The difference between the intervention price and the price on the world market is almost € 38 per 100 kg (€ 52 against € 14) (SBC, 2005).

The EBA initiative allows duty-free access to the EU sugar market for the LDC's and this initiative could become an EU commitment with the biggest unilateral content. The EU initiative to eliminate duty and quota for essentially all products except arms and ammunition originating from the LDC's took effect in March 2001 (EU, 2001). The 'duty and quota-free' market access for sugar will only begin in year 2009. Nevertheless, in the transition period until the full liberalization of sugar, raw sugar can be exported duty-free by the LDC's to the EU market within the limits of a tariff quota. These limits will be increased yearly by 15% from 74,185 tons (white-sugar equivalent) in 2001/2002 to 197,355 tons in 2008/2009, see the table below.

Table 3.1: Summary sugar exports from LDC´s to the EU

Production year	In ton	Excess imports	Total LDC imports
2001/2002	74.185	0	74.185
2002/2003	85.313	0	85.313
2003/2004	98.110	0	98.110
2004/2005	112.826	0	112.826
2005/2006	129.750	0	129.750
2006/2007	149.213	37.303	186.516
2007/2008	171.594	61.550	233.146
2008/2009	197.334	94.097	291.431
from 1 July 2009	free	n/a	???????

Source: Sweetener Analysis/LMC, October 2004

The quota for the year 2003/2004 is detailed per country as presented in the next table.

Table 3.2: Quota per country

x ton	2002/2003 (Actual)	2003/2004 (Scheduled)
Bangladesh	0	8.989
Burkina Faso	7.237	7.672
Ethiopia	14.689	15.249
Malawi	10.661	10.959
Mozambique	8.384	10.116
Nepal	8.970	8.667
Sudan	17.037	16.979
Tanzania	9.317	9.940
Zambia	9.017	9.538
Total	85.313	98.110

Source: LMC International

Certain LDC's have also an ACP status. These countries can export to the EU under two trade agreements and can potentially export more sugar to the EU than other countries qualifying under only one trade agreement.

An overview of this group and other possible combinations of trade agreements is detailed in Appendix 1.

The consequences of the EBA initiative on the amount of sugar traded to the EU are not clear. The EU Commission gave estimation that sugar imports from the LDC's would gradually increase to 900,000 tons in the medium term (ENARPRI, 2003). According to a study conducted by UNCTAD in 2002 (UNU/WIDER, 2003), it is estimated that sugar exports from the LDC's to the EU market would increase by only 50,000 to 100,000 tons. A recent study of the University of Hohenheim indicated an amount of even 2.7 mt. (see Appendix 7).

The lower estimate is based on the fact that due to infrastructure costs, constraints (in particular for land-locked producers) and the unfavourable investment climate (including political stability) facing the LDC's at present, production is kept low. The result may be an indication that the non-trade barriers are quite substantial in blocking the sugar exports from the LDC's to the EU even after the duty and quota-free market concession from the EU to the LDC's. The two predictions do not produce similar figures, indicating the uncertainties facing the future of EBA imports.

The difference in figures can be explained through the possibility of swaps of produced sugar to sugar exports. It is possible for LDC's to export all local produced sugar to the EU after 2009, when unlimited market access for sugar will begin. This is an amount averaged at 3 million tons. The domestic need for sugar can be fulfilled with sugar imports from the world sugar market, at world market price levels. In this case the LDC's earn the EU sugar price for their exports and pay the lower world market sugar price for their import needs. This form of triangular trade is difficult to investigate due to a lot of uncertainties such as exchange rate, double transport costs, world market price, etc..

FUTURE DEVELOPMENTS

The EBA initiative allows immediate expanded access to the EU sugar market by the LDC's and unlimited access by 2009. Further, the EU has been expanded with 10 new

countries in 2004, and many of these countries are sugar beet producers. An additional three countries, also sugar beet producers, will join at a later time.
It is expected that these newly joined countries will increase production and exports because of the better returns.

If consumption in these countries does not increase apace with production, EU intervention stocks could be forced to absorb the surplus.

An additional longer-term development influencing the EU sugar program is the Economic Partnership Agreements (EPA's), which the EU started negotiating with all 77 ACP countries.

Under these Agreements, similar access provided to the 50 LDC's will likely be extended to all ACP countries. These countries currently produce 6 million tons of sugar and they could potentially provide all of it to the EU on short notice for relatively high prices while covering their own consumption from the world market for relatively low prices. Nowadays the ACP countries are allowed to export almost 1.3 million tons of raw sugar to the EU.

An external pressure to reform the EU sugar regime is a WTO complaint filed by Brazil, Australia and Thailand in 2002, which charges that the EU sugar regime subsidizes exports beyond those allowed by WTO commitments. A finding against the EU could lead to an immediate reform of the sugar regime. In order to maintain the EU-market in place it requires a reform. In order to accomplish an acceptable EU sugar market, former EU commissioner Fischler has issued a proposal described in the next paragraph.

The main reform of the EU sugar regime is the fact that lower intervention prices for sugar need to be implemented. A proposal hereto, issued by former EU commissioner Fischler is to lower the price by 33 – 37 %, resulting in a new price of € 421/t for white sugar and € 329/t for raw sugar, compared with respectively € 632/t and € 523/t nowadays.

This proposal has consequences for the LDC countries as well. Preferential market access is very lucrative at present, owing to the relatively high price for EU sugar and well-protected sugar market (€ 380/t, as described earlier). The forthcoming reforms on the EU sugar regime may have a major impact on the sugar exports of the LDC's. A cut in the institutional price for sugar may result for the LDC's in a big decline on the income based on sugar exports to the EU (also 33%-37%).

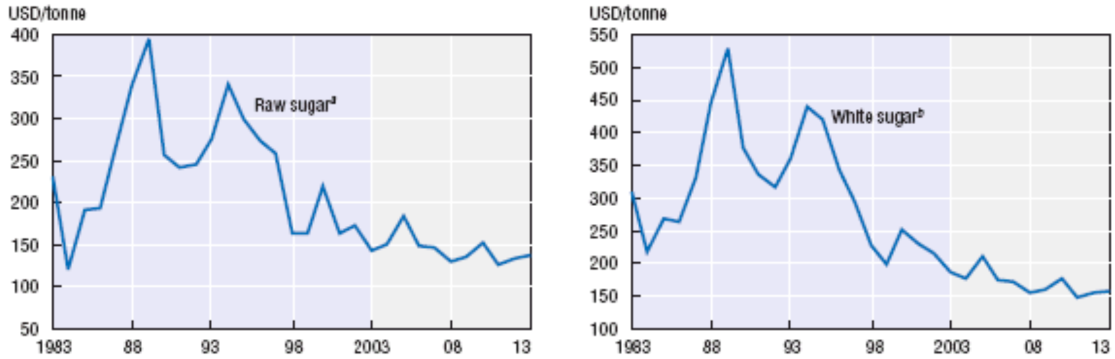
3.2.2 Unregulated world market

The unregulated world market accounts for 20 % of the world production and 40 % of the world trade of sugar. This paragraph provides a brief overview of the present market and future developments.

CURRENT MARKET

International prices for sugar are of significant importance and are extremely volatile, following an erratic path, as shown in figure 3.1. The average for the first quarter 2003 is down to € 170/t (OECD, 2004).

Figure 3.1: The world sugar price through time



a) Raw sugar world price, New York No. 11, f.o.b., bulk spot price, September/August.
b) Refined sugar price, London No. 5, f.o.b. Europe, spot price, September/August.

Source: OECD, 2004

The so-called world sugar price is in fact a residual market price at which surplus sugar is traded internationally. This price does not reflect costs of production, but is based on supply and demand and trade deals in that residual market. Only three (3) countries (Australia, Brazil and Cuba) have sugar sectors which can trade at world market price levels. These three countries together, count for 20% of world production and 40% of world trade. At current world prices, most of the sugar industries in the developing countries would be unable to compete, as a result of their higher production costs.

World prices are low mainly because of the ten-fold increase in exports from Brazil (over 10 million tons) in the last 10 years. This trend is continuing, with Brazil targeting to expand its production even further to take as target 50% of the world sugar market (Koo & Taylor, 2004).

FUTURE DEVELOPMENTS

World sugar production is expected to continue to expand faster than global consumption in most years up to 2013. The resulting mismatch leads to some accumulation of global stocks that overhang the market and a continuing, although smaller, structural surplus in sugar. Although the use ratio of the global stocks is expected to fall by 2013, it will remain too high to have much impact on prices.

With ample sugar supplies available, and Brazil's reserve capacity to increase production, world sugar prices are projected to remain low over the period to 2013/14. The world prices of raw and white sugar are projected to remain within a range of USD 7-9 cents/lb (€ 130-170/t) and USD 8.5-10.5 cents/lb (€ 150-190/t), respectively, up to 2013/14. This level of nominal world prices implies a continuing decline in real sugar prices (OECD, 2004).

In case of full liberalization of the world sugar market, one general conclusion from recent studies is that protection in the world sugar market is imposed by developed countries at great cost to themselves and by developing countries with an economic potential to expand exports.

A number of developing countries have preferential access to the EU through the ACP/LDC Sugar Protocol. These countries receive the relatively high internal price on exports allowed by quotas and this preferential access is valued at about $0.8 billion per year when compared to world market prices.

However, the value of this preferential access is less than it appears, because many of these producers have high production costs and would not produce at world market prices. The net loss to these exporting countries from full liberalization is estimated to total $0.45 billion per year (Mitchell, 2004).

3.2.3 Major findings

The current sugar market makes it possible for LDC's to export sugar with substantial benefits. However, changes in the market are in progress, certainly in the EU. The precise manner of these reforms is not clear, but some conclusions can be drawn. Only some countries can trade sugar profitable at world markets (e.g. Brazil) and these are not the LDC's, with the exception of Mozambique and Ethiopia. They are dependent of the preferential access to the EU. With lower intervention prices in the future, the benefits are vanishing.

For example, a country as Malawi (a LDC country) is producing raw sugar around € 350/t. Today, the selling price for raw sugar is € 523/t (EU price), but the future price could be around € 329/t. So, a decrease averaged at € 194 in income is at hand. Possible gains with different production costs in LDC's are visualized in following table.

Table 3.3: Overview of possible gains for raw sugar from sugarcane

	Revenue	Profit (Production cost (200/t)	Profit (Production cost (300/t)	Profit (Production cost (400/t)
World market price	€ 150/t	€ - 50/t	€ - 150/t	€ - 250/t
EU price today	€ 523/t	€ 323/t	€ 223/t	€ 123/t
EU 33 % price cut	€ 329/t	€ 129/t	€ 29/t	€ - 71/t

The income out of sugar production in LDC's appears to be under pressure. A description of the bio-ethanol market is the subject of the next paragraph.

3.3 The bio-ethanol market

The bio-ethanol market is a relatively new market, with no clear trade agreements or future markets such as the sugar market. This paragraph describes the current market and the future developments on the bio-ethanol market. It intends to provide a view on the potential benefits of bio-ethanol and reviews the developments at the world market with a subsection on the EU.

3.3.1 The current market for bio-ethanol

A benefit-cost evaluation is complicated due to several difficult-to-quantify benefits, while costs are dominated by fairly well quantified – and often fairly high – production costs. Estimating the value of the benefits is one of the most difficult and uncertain aspects of analyzing the bio-ethanol market.
However, this calculated cost might be much lower when considered in the context of other non quantifiable benefits, such as:

- improvements in energy security,
- reductions in pollutant emissions,
- fuel octane enhancement and
- improved balance of trade (IEA, 2004).

Because these benefits are difficult to quantify, the market price for bio-ethanol does not adequately reflect them. This disadvantages bio-ethanol relative to fossil fuels. In most countries, liquid bio-ethanol production costs currently are high – up to three times the cost of fossil fuels. But a conclusion that bio-ethanol is “expensive” ignores the substantial soft benefits and the fact that these benefits are increasing as new, more environment-friendly processing techniques are developed.

In some countries, such as Brazil, bio-ethanol production costs are much lower than in other countries and are very near the cost of producing fossil fuel. This will also likely to occur in recent years in other countries, as production costs continue to decline. The costs of producing bio-ethanol are much lower in tropical and subtropical countries, especially developing countries with low land and labour costs, compared to developed, temperate climate countries (e.g. the EU). However, there is a mismatch between those countries where bio-ethanol can be produced at lowest cost and those where demand for bio-ethanol is rising most rapidly.

In spite of the difficulties with measuring the real benefits of bio-ethanol, a market price is established. Bio-ethanol is globally traded for € 250 – 300/t (F.O. Licht, Berg, 2004), but the price is instable and no clear prediction can be given on how this price will develop. This is depending on the production costs and global demand. But the price for bio-ethanol is higher than the world price of sugar (€ 150 per ton) and just below the EU sugar price after the nearby regime reform.

A more extended economical analysis is also performed in this report in Chapter 5 analyzing the economical feasibility of bio-ethanol in LDC countries.

The main objective of the 1995 Framework Agreement is the preparation of negotiations for an Interregional association Agreement between the EU and Mecursor, which should include a liberalization of trade in goods and services aiming at free trade, in conformity with WTO rules, as well as an enhanced form of co/operation and a strengthened political dialogue. The negotiations are ongoing but currently do not form a trade barrier for bio-ethanol in the EU. Countries and companies can trade freely in bio-ethanol. As bio-ethanol is no arms or ammunition, it is a commodity which can also be traded freely by the LDC’s under the EBA initiative.

3.3.2 Future developments

The major incentive for a growing bio-ethanol market is the finitude of the oil reserves and the sharp rising prices of conventional fuel. An interesting alternative could therefore be bio-ethanol.

Bio-ethanol production in the EU has not really taken off yet. However, it may do so in the next couple of years. The main drivers will be two EU bio-fuel Directives. The first Directive stimulate the use of bio-ethanol, natural gas, hydrogen and other alternative fuels up to 20% of the use of gasoline by 2020.
National “indicative targets” are now to be set to ensure that 2% of total transport fuel consumption (by energy content) is derived from bio-ethanol by 2005 and 5.75% by 2010. Member States are now developing bio-fuels strategies to meet these targets.

The second Directive relevant for bio-ethanol is the one on taxation of energy products. Under this directive Member States will be able to exempt bio-ethanol, such as ethanol, from the tax on mineral oil products (IEA, 2004).
If historical trends were to continue, future annual growth rates in the use of bio-ethanol would amount average to 7% for Europe, 2.5% for North America and Brazil, and 2.3% globally. This would lead to a global increase from an average of 30 billion litre in 2003 to over 40 billion litre by 2020. However, given recent policy initiatives and changes in trends, a different picture could emerge: a quadrupling of world production to over 120 billion litre by 2020. On a gasoline energy-equivalent basis, this represents about 80 billion litre, accounting for about 6% of world engine gasoline use in 2020, or about 3% of total road transport energy use (IEA,2004). This would mean a significant increase in the demand to be covered with increasing production. Brazil can't accomplish this increase at its own, especially not at its today's cost level.

The best production areas are already in use, thus production at different locations would lead to higher production prices. This, together with the higher demands, will lead tot higher prices of bio-ethanol on the world market. But improved production techniques and economies of scale lead to lower production costs, so the future of market prices of bio-ethanol is not clear. But it is certain that demand will rise and market prices probably will rise or stay at today's level.

Another development is the changing position of oil companies in the bio-ethanol market.

These companies are becoming major players in the market, because of the fact that they are accepting bio-ethanol as a commodity and an important substitute for fossil fuels. To be competitive, it is not cost effective to buy it on the world market and consequently wish to produce bio-ethanol by themselves. In this case, the oil companies can be an accelerator in the development in the world bio-ethanol market.

3.4 Conclusions

After our analysis of the sugar and the bio-ethanol markets, some conclusions can be drawn.

- First, the price paid for raw sugar produced in the LDC's shall become lower through the EU regime change. The difference between today's and tomorrows price levels is not yet determined, but this difference could probably amount to an average of 35% (proposal of former EU commissioner Fischler).

- Second, demand for bio-ethanol shall grow through the different policies promoting the use of bio-ethanol and the finitude of the oil reserves.

- Third, the price for bio-ethanol on the world market is higher than the price of sugar on the world market and just below the proposed EU price for raw sugar. Thus, bio-ethanol certainly has potential as an alternative product from sugarcane.

- Finally, the world of fossil fuels is changing rapidly and it is a fact that one has to accept that alternative energy sources need to be developed and encouraged, such as bio-ethanol.

Chapter 4
Analyses of sugarcane production- and processing within LDC's in relation to bio-ethanol production

4.1 Introduction

This Chapter provides an analysis of the production methods required for the processing of bio-ethanol in a way considered feasible for LDC's and their existing possibilities. We review as a basis the situation existing in Brazil and assess its relevance for the LDC's.

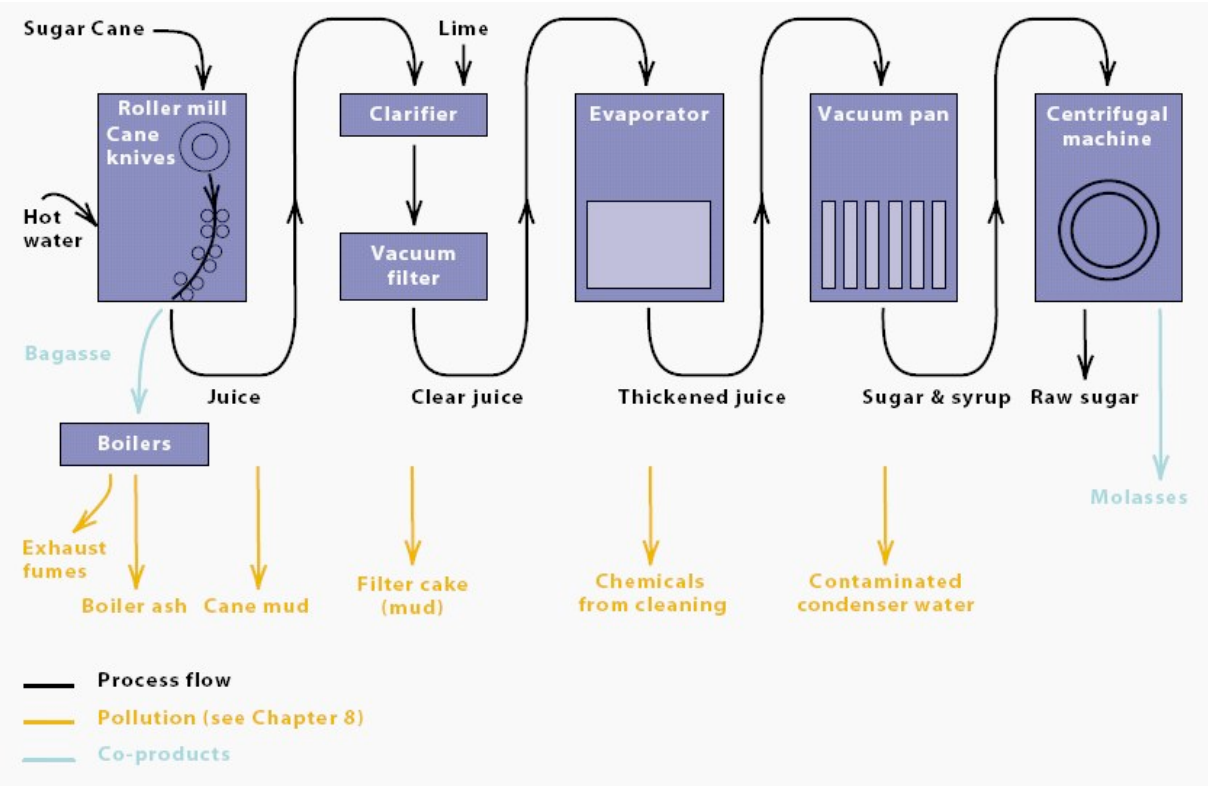
4.2 Brazilian ethanol program

Brazil introduced a national ethanol program (PROALCOOL) in 1975. The major target of this program was to reduce the oil import as the dependence of Brazil on imported oil was high. The result was a huge domestic demand for sugarcane. Before that time the sugarcane producers frequently faced excessive production and huge price fluctuations. With the PROALCOOL program the situation on the domestic sugarcane market became stable with rising production and prices set by the government. During mid 1980 oil prices tended to decline and the Brazilian debt crises dried up financial resources to support the PROALCOOL program. In combination of an inadequate fuel-ethanol supply, a loss of consumer confidence resulted which caused a decline in the demand for bio-ethanol. In an attempt to improve on the program, the government has decided to rule for liberalization of the prices but with one restriction as to their right to define the blend ratio to gasoline. Recent years indicate that this government policy is rather successful and production has been increased considerably.

4.3 Required techniques and processes

As a reference we have investigated the typical process for the production of sugarcane capable also for the production of bio-ethanol as applied in Brazil. A typical process flow for the production of cane sugar is shown hereby.

Figure 4.1: Process flow from sugar cane to cane sugar



Source: UNEP – Industry & Environment Overview Series

Bio-ethanol can be produced using differing methods. We have analysed the following scenarios:

(i) bio-ethanol directly produced on a stand-alone basis;
(ii) bio-ethanol produced in stead of cane sugar applying the same process;
(iii) bio-ethanol produced next to cane sugar.

Scenario (i) means a green field developed factory containing a dedicated process whereby the sugarcane is directly used for the production of bio-ethanol. The function of the distillery is integrated in the total process. The process flow differs from the other two scenarios (see Appendix 3). The estimated investment costs amount to an average of m$100-$120.

Scenario (ii) is a variant to scenario (iii) whereby the existing process facility can be switched from cane sugar production to bio-ethanol production and vice versa. The operator needs to make a choice whether to start the processing of cane sugar or for bio-ethanol. This scenario requires moderate investments amounting to 60-70 m$ (200.000 litres/day).

The success of this scenario depends also on the price level of sugar as well as of bio-ethanol and is only feasible if implemented on a large scale operation.

Scenario (iii) can be implemented in existing factories whereby a distillery is added to the existing facilities. A detailed process flow is attached as Appendix 4.

The essence of this scenario (iii) is that bio-ethanol can be processed year round. During the harvesting period raw cane juice can be used, next to the production of cane sugar also for the bio-ethanol production. During the sugarcane processing, molasses as by-product is obtained. The molasses can be stored and used during the off-season for the processing into bio-ethanol. For a detailed cost comparison of the applied basic materials we refer to Appendix 5.

The sugarcane processing is energy consuming. Due to recent technological developments it is worthwhile to investigate the possibility to seek for biomass driven power plants for the generation of the heat and electricity. During the process bagasse is obtained as waste material which can be used as biomass. Next hereto, the rest material from the cane harvest, such as leaves, head of the plant (25 – 30 cm) can also be used as biomass for the generation of heat and electricity. Any surplus energy could be supplied to the public electricity network.

This scenario (iii) has advantages above scenario (ii) for the LDC countries in view of the existing facilities be available and moderate investments required estimated at an average of € 10-15m for a distillery with a daily capacity of 80.000 hl/day.

4.4 Required raw material

4.4.1 General

Bio-ethanol can be produced out of several agricultural crops such as maize, grains, sweet sorghum, sugar beets, cane sugar. A recent EU funded (LAMNET program) research program investigated the possibilities to combine from several crops all waste products for use in the processing of bio-ethanol. One of the studies concluded that sweet sorghum is a very useful plant, whereby the complete plant can be used without leaving any waste.

An overview of cost levels of bio-ethanol produced from different crops is presented herewith:

Table 4.1: Bio-ethanol crops & yield & costs

Type	M^3 ETOH/ha	Cost $/$m^3$
Sugar beet (€ 15 / t)	2,500 – 3,000	300 – 400
Sugar cane	3,500 – 5,000	~ 160 (best)
Corn	2,500	250 – 420
Wheat	0.5 – 2.0	380 – 480
Potatoes	1.2 – 2.7	800 – 900
Sweet Sorghum	3.0 – 5.0	200 – 300
Cassave	1.5 – 6.0	700
Synthesis ETOH	-	540 (min)

Source: Microdistillery – LAMNET project ICA4-CT-2001-10106

It is concluded that bio-ethanol produced from sugarcane is an attractive proposition. In view hereof and with the changing EU regulations relating to the sugar regime it has been decided for the purpose of this report to concentrate only on bio-ethanol produced from sugarcane and not from other crops.

Sugarcane is grown as a crop and used for sugar production and in some cases also for ethanol production. Sugarcane grows very simple and the growing process has no special requirements for the soil. The crop is simple protected against diseases and insects.

For the sugarcane processing only the stem or stalks are used from the harvested plant. Leaves and the top of the plants are considered waste and are left or burned at the field. A detailed mass-balance is presented in Attachment 6.

The sugarcane can be harvested from a plantation during a period of seven consecutive years following good farmer's practise. During this period the sugarcane can be harvested every 10 – 24 months depending on the climatologic conditions. It must be noted that in Brazil a situation exists whereby during 500 years or more the same land is used for sugarcane fields, without any loss of quality or quantity of the sugarcane being harvested. To the contrary even increasing quantities are experienced. It is good practice however that the bagasse is being returned at the field. The stalks have an average yield between 12-14% sugar.

Table 4.2: The yield of sugar cane

	Yield x tonnes/ha
Australia	100
Brazil	75
India	70
South Africa	70
Thailand	45
Avg LDC	40

Source: Various internet sites

4.4.2 Production systems

Sugarcane is being cultivated by several types of land ownerships:

1) Small producers

In Asia (India, Thailand, Philippines) sugarcane is produced on small fields owned by small farmers. For example India has around 7 million small farmers with an average of around 0,25 ha sugarcane fields. Thailand has around 1 million farmers with less than 1 ha sugarcane fields each. Due to this situation only small quantities with differing quality are supplied to the factory. Next to this, the organization to collect and transport the sugarcane is a huge problem. The harvesting is mainly made by hand as no suitable equipment is available.

2) Big companies

In Australia and South Africa the harvesting and processing of sugarcane takes place on big scale farms with more than 100 ha planted sugarcane. These farms are mechanically well equipped for the planting as well as for the harvesting and require per ha less personnel than with the small producers up to even less than 15 employees per 100 ha.

3) Plantations

These integrated estates, owned by rich farmers, are intensive monoculture with areas above 10.000 ha, mostly situated around the sugar factories. This type of organization is located in the Caribbean, Central-America and several African countries. In Brazil more than 70% of the sugarcane production is grown on plantations. Most of the plantations are well structured and equipped. When the mechanization is not well structured, around 50 till 70 employees per 100 ha are necessary. The social situation for employees is in some cases rather bad.

In countries like Kenya and Tanzania and in several Latin American countries an organization called ''nucleus estate'' is used.

This means that the area and the plantations around the sugar factory are owned by the sugar factory and are exploited by the factory. Small cane growers can deliver their cane sugar only in case there is a shortage of products for the continuity of the process. For these farmers no guarantee is given for supply contracts, neither any other guarantee.

4.4.3 Harvest and logistics

After harvesting it is necessary that the transport to the factory is as short as possible. All rest products remain on the field and will be burned or used as fertiliser for the soil. The transported stalks of the sugarcane plant have to be processed in the factory within 24 hours, but in any case not later than 48 hours. Therefore the distance for transport to the factory is in an optimum situation not longer then 20 km.

4.5 Cost of production analysis

Out of 1 ton cane sugar 6,2 hl bio-ethanol can be produced. The cost of production of ethanol out of sugar beets varies between € 0,47 and € 0,86 per litre, with an average of € 0,49 per lit (source: Ecofys). The cost of production of bio-ethanol out of cane sugar is averaged at € 0,42, see Appendix 6.

In recent years the production costs of ethanol has been 2-times higher than the production costs of fossil fuel (source Nedalco, "Oogst 16 mei 2003"). But with increasing oil prices it is expected that the difference will decrease or even disappear.

The costs for the production of ethanol out of grain is averaged at € 0,53 per litre and when biomass is used, the cost of ethanol production can drop to an average of € 0,46 per litre.

The investment of an ethanol distillery unit combined to the sugar factory is estimated at € 10 - 15m for a capacity of 80.000 litres/day.

In our selected scenario bio-ethanol can be produced during the campaign period next to the processing of sugarcane into cane sugar. The cane juice obtained during the process can apart for cane sugar also be used for bio-ethanol production. Due to the nature of the juice it can however not be stored for later use but must be processed instantly. This would limit the bio-ethanol production during the off season. At the end of the sugarcane process molasses are collected as a by-product. Molasses can be stored in silos and can also be used for the production of bio-ethanol. With this scenario production of bio-ethanol can be accomplished throughout the year and thus could become an interesting proposition.
A financial trade-off will be made in Chapter 5.

In a subsequent phase however the exact ratio between cane sugar versus bio-ethanol out of the thick juices and the quantity of molasses need to be analysed and calculated in order to define an optimum scenario for the processing of bio-ethanol next to the processing of cane sugar.

4.6 Conclusions

In view of our analyses we conclude that sugarcane is an interesting alternative for the production of bio-ethanol.

A necessary condition is that all related activities have to be organized in a logic and cost effective way such as harvesting, logistic organization, processing and transportation.

On one hand we see high scale sugar processing capabilities arising in countries such as Brazil, but also in Sudan and Bangladesh and on the other hand we identify the need for smaller processing capabilities in certain countries due to its limited harvesting and milling capabilities.

Chapter 5
The economic feasibility of bio-ethanol production in LDC's

5.1 Introduction

This Chapter will focus on the economical feasibility for bio-ethanol production out of sugarcane for LDC's and starts with a brief examination of the main economic factors influencing the pricing on the bio-ethanol markets.

5.2 Bio-ethanol market pricing influences

As in any other market, market prices for bio-ethanol from sugar are a product of supply and demand. On the supply side the profitability of the ethanol producers depends heavily on the price of the feedstock, (in our case sugar cane). Besides normal price fluctuations due to changing production costs, this price is also influenced by the prices for by-products and substitutes which can be made from sugarcane. Thus when examining the economic feasibility of ethanol production from sugarcane one of the key factors is the price of sugar. Rising sugar prices therefore increase the (opportunity) costs for ethanol from sugarcane, which lead to lower potential profit margins for ethanol producers using sugarcane as a feed stock.

The demand for bio-ethanol results heavily from the demand for fuel for cars and other combustion engines. As is shown in Chapter 2, anhydrous bio-ethanol can be blended with (fossil) fuel and can thus be sold at local gasoline pumps. However it should be taken into account that the energy density of ethanol (23.4 MJ/ litre) is lower than that of gasoline (32.4 MJ / litre). The IEA did a cost comparison on the basis of per litre of gasoline equivalent in direct recognition of the fact that the unit cost of ethanol per litre was inflated by a factor of 1/0.684=1.46 to arrive at cost for ethanol in terms of litre of gasoline equivalent. However the advantages of greater volumetric efficiency and octane number improvement offset the lower calorific value of alcohol (26.6 MJ/kg versus petrol 44.0 MJ/kg). With appropriate engines pure alcohol delivers 18% more power per litre than gasoline, but it is consumed at a rate which is 15 - 20% higher. This means that the two factors effectively cancel, leaving neither fuel with a clear advantage from an energy point of view.

However in this report we assume that it is not feasible for LDC's to adjust their engines to specifically optimise them for the use of bio ethanol, since this would mean a considerable investment. So the 18% more power per litre will not be made, leaving the 15-20% higher consumption rate. Based on these findings we assume that 1,2 litre of bio-ethanol fuel can be sold as an equivalent for 1 litre of unleaded gasoline fuel.

This possible substitution means that the relationship between ethanol and gasoline prices is a determining factor for ethanol demand. If there is no (governmental) restriction, or incentive for fuel distributors in choosing between bio-ethanol or gasoline, they will choose the cheapest alternative, thus optimising their potential profit margins. Given the fact that when using non adapted engines 15 to 20 % more bio-ethanol is needed to achieve the same performance as gasoline fuels, this would mean that in a free ethanol market the price/ value of bio-ethanol would have to be equal to or lower then approx 80% of the price of unleaded gasoline to make it interesting for buyers to choose for this product.

Having defined the two key factors on the demand and supply side on the market for bio ethanol made from sugarcane we will now review if there is a potential for LDC's to benefit economically from the production of bio-ethanol from sugarcane.

5.3 Potential benefits for LDCs: supply side

As stated above a key factor for determining the economical benefits for LDC's for production of bio-ethanol from sugarcane is the comparison with sugar prices. As was stated in Chapter 4, LDC's currently export a substantial amount of their sugar to the EU. This is due to the fact that they can sell their sugar at a preferential price level well above current world market sugar prices. However the EU (pressured by the WTO) is currently undergoing a major reform of their sugar market, which could lead to a significant drop of the EU sugar prices. If the current proposed reforms are implemented by the EU this will lead to a price of € 329 per ton in 2009.

As was shown in Chapter 2, most LDC's produce sugar against a production costs in the range of € 300,- to € 400,- per ton, where transportation costs make up a huge amount of these world market cost prices (esp. so for landlocked LDC's). This would mean that LDC's would only make a marginal benefit (if any) when selling to the EU at a price of € 329 per ton. Since the current sugar world market prices are even well below the level of € 329 this distribution channel is also not a viable alternative for sugarcane producing LDC's.

The future for export of the sugarcane industry in these LDC's therefore seems to be very gloomy. Domestic use of sugarcane resources drops the necessary logistical cost dramatically compared to selling the surplus on the world markets. Since labour and land costs are often very cheap, logistical costs make up a relatively high portion of the overall cost price of cane sugar for LDC's when selling on the world markets. Producing bio-ethanol for domestic use from their surplus cane sugar therefore might be an interesting alternative for LDC's in order to put their surplus cane sugar to an economically viable use.

If the LDC's (and possibly the same would apply for APC countries) would manage to lower their cost price for cane sugar or would continue to produce a surplus and export these surpluses to the EU markets, this could have disastrous effects for EU sugar producers. Using this surplus to produce bio-ethanol could address this potential threat to the EU markets.

If it would be possible to lower this potential surplus of the LDC &ACP cane sugar with 50 % by transforming it into bio-ethanol, this would mean that the current production level in the EU of ca. 16 mt of sugar-beets could be maintained under the reforming program of the Commission, (see Appendix 7). Reduction of this surplus by producing bio- ethanol for domestic use in LDC's (and potentially also ACP countries) seems therefore very interesting for EU sugar producers.

5.4 Potential benefits for LDC's: demand side

LDC's need access to a steady supply of energy sources in order to facilitate demand for energy by their domestic industry and to facilitate their domestic transportation system.

Currently the energy demand is relatively low when compared to more developed nations, since both industry and transportation systems are underdeveloped in most LDC's. However in order to develop it, it is expected (as was stated in Chapter 1) that energy demand will rise significantly in the upcoming years. To such a level that it is expected that developing countries will account for half of the total world energy demand by 2030. Aside from the upward price effect this increasing demand will have on gasoline prices, this also means that LDC's need to gain access to an already overcrowded gasoline market to ensure a steady supply of fuel to facilitate their growth. Another factor that needs to be taken into consideration is that the international gasoline market is trading in US$. This means that LDC's require a substantial amount of foreign currency in order to buy gasoline on the world market. Almost all LDC's are currently lacking the foreign currency resources to make the necessary payments.

Given these factors and trends on the international gasoline market the production of bio-ethanol by LDC's seems to be a very appealing alternative to fuel their local industry and transportation system. The development and use of locally-produced, renewable fuels, would mean a reduction of demand for imported gasoline. Since the bio-ethanol could be produced locally from sugarcane, this would also mean a reduction in necessary payments in scarce foreign currencies.

Having stated the major potential benefits for the production of bio-ethanol from sugarcane for LDC's we will now examine the economical feasibility for the separate LDC's to see if any LDC country fit the necessary criteria for an economical feasible production of bio-ethanol from domestic use.

Certain important factors have influenced the continued demand for bio-ethanol such as its capability to replace fossil fuels and lower production costs due to the development of the processing technology (R&D programs) during the last 5 – 10 years. It is expected that an interesting market will arise in the near future. Brazil produces (figures 2004) already ca. 18 mio m3, equal to 50% of the world ethanol production. In the future (2015) Brazil plans to produce yearly around 30 mio3.

It is expected that only 10% of produced bio-ethanol will come available for export means.

5.5 Selection of LDC's

As stated above the most important trigger for LDC's to switch from the production of sugar to bio-ethanol from sugarcane is the threat that they will lose an economical viable export market for sugar due the reduction of EU prices for sugar. Therefore we first need to establish which LDC's currently export sugar to the EU. Leaving the substitution of export and import by some LDC's out of consideration this means that we need to focus on the LDC's that have a current net trade surplus in sugar. As is shown in table 5.1 not all of the 50 LDC's qualify for the selected requirements; most of them don't even produce sugarcane. Only 23 countries qualify for current sugar production, including seven (7) countries in need of rehabilitation.

Table 5.1: Status of LDC's producing sugarcane

	Functioning	Rehabilitation	Not functioning
Net importers	Bangladesh Burkina Faso Burundi CAR Chad Congo DR Mali Nepal Rwanda Senegal Uganda	Hati Laos Madagascar Togo Tanzania Afghanistan	Angola Benin Cambodia Guinea Sierra Leone Somalia
Net exporters	Ethiopia Malawi Myanmar Sudan Zambia	Mozambique	

Source: LMC International

Of the six net exporters it is discouraged to do business in Myanmar because of its current troublesome political and social climate caused by the military junta governing this country. Myanmar will therefore not be taken into consideration in this report as a potential candidate for production of bio-ethanol from sugar cane.

5.5.1 Supply

For the five remaining sugar exporting LDC's we need to establish the current export volumes of sugar. These volumes are shown in table 5.2 below.

Table 5.2: Summary of production and consumption surplus

LDC's	No. of factories	Production	Utilization (%)	Imports	Exports	Net trade	Consumption
Malawi	2	260.822	99%	1.555	66.890	65.335	126.237
Zambia	1	190.757	?	1.701	86.280	84.579	111.334
Ethiopia	4	258.449	99%	11.540	61.882	50.342	213.805
Mozambique	4	84.333	92%	33.084	36.322	3.239	90.467
Sudan	5	656.952	98%	47.838	117.839	70.001	466.258

Source: Figures are in ton and based on the ISO report 2003 and of the Kenana Sugar Co. (Sudan).

All of these countries are located in Africa. It should be taken into consideration that if these countries start to develop economically, it is expected that their own domestic demand for sugar start to rise as well.

In the near future it is expected that the EU will gradually remove sugar quotas and to drop the institutional price for sugar. The 2009/10 EU price for sugar imports for LDC's is rated at € 329 per ton of raw sugar and will be quota free. If the LDC's will still be able to produce sugar for the world market well below the price of € 329 there is no immediate trigger to switch production for the surplus.

The second step therefore is to identify what the production costs for the five selected countries are. The production costs of cane sugar exported to the EU and to the world market are estimated at:

If one compares cost levels in various countries it is seen that a difference with Ethiopia occur.

Table 5.3: Comparison of production costs

LDC's	Cost prices cane sugar for export (including transportation costs)
Malawi	300-400
Zambia	300-400
Ethiopia	200-300
Mozambique	300-400
Sudan	300-400

Source FO Licht

The difference between Ethiopia and the other countries arises from a difference in geographical condition, field production, utilization, scale of the factories and effective harvesting and processing.

The figures above include transportation costs, which are considerably influencing cost prices for landlocked countries as Malawi and Zambia. After the separation of Eritrea, Ethiopia is also a landlocked state, but it uses neighbouring Djibouti for relatively easy access to the Red Sea/ world markets.

Given the EU price of € 329 per ton of sugar, currently only Ethiopia seems to have a direct economical viable reason to export sugar to the EU after 2009 and therefore has no immediate trigger to switch production from sugar to bio-ethanol for its sugar surplus. The other four countries need to find a way to either drastically lower their production costs or find an economical viable alternative for the use of their (current) sugar surplus.

5.5.2 Demand

As stated above the domestic demand for bio ethanol in the selected LDC's can be derived from the demand for gasoline in these countries. The oil production and consumption for the five selected LDC's is shown in the table below:

Table 5.4: Oil consumption and production

LDC's	Consumption (in barrels/day)	Production (in barrels/day)
Malawi	5.400	-
Zambia	11.000	-
Ethiopia	23.000	-
Mozambique	8.500	-
Sudan	50.000	229.100

Figures based on CIA fact book 2001

It should be noted that 1 barrel of oil equals 159 litres, which can provide (roughly) 100 litres of refined fuels. The table shows that out of the five selected LDC's only Sudan is currently producing a substantial amount of oil. This even to the extent that oil is produced by Sudan for export markets. Sudan is therefore not a very likely candidate to start producing bio ethanol out of its sugar cane surplus for domestic use, since it already has a (relatively) cheap surplus resource of oil available to meet domestic demand.

5.5.3 Bio-ethanol; cost of production

As stated in the paragraph on the factors influencing the demand side of the bio-ethanol market, fuel distributors will be inclined to buy bio-ethanol for blending with gasoline if the price of ethanol is lower or equal to 80% the price of gasoline. Therefore in order to gain a good insight in the economic feasibility of the production of bio-ethanol from sugar cane we will need to examine the cost associated with the production of bio-ethanol.

A wide variety of research results on this topic have been published throughout the years. These results differ frequently as far as the costs for the production of bio-ethanol are analysed. The production costs for bio-ethanol depends with the location (for instance associated land and labour costs in the US are very different from those in Brazil!). These research reports show one common element, which affects heavily the production costs for ethanol, being the feedstock which is used for the production.

Nowadays, new technologies allow for the production of ethanol from agricultural residues (straws, corn stalks and cobs, bagasse, cotton gin trash, palm oil wastes, etc.), crops grown specifically for their biomass (grasses, sweet sorghum, fast growing trees, Kenaf, etc.), paper (recycled newspaper, paper mill sludge's, sorted municipal solid waste, etc.), wood wastes (prunings, wood chips, sawdust, etc.) and green wastes (leaves, grass clippings, vegetable and fruit wastes, etc.).

These new production methods are also significant for the production cost of bio ethanol from sugar cane: for example, where one acre of sugar cane produces about ten tons of edible sugar and three tons of molasses, it also produces (in the form of leaves and stalks) an additional twenty to twenty-five tons of non-edible materials which were left over in field after the harvest of the stalks. With the new technologies these by-products could be easily and efficiently transformed into ethanol.

In our discussion with experts in the field of setting up sugar and bio-ethanol production facilities in LDC's we have found that production costs for bio- ethanol from sugar cane of € 0,42 is feasible. The supporting cost calculations are shown in Appendix 4. This cost price calculation is based on the preferred production method for bio-ethanol from sugar cane using molasses and cane B-syrup/ thick juice, as main ingredients.

Other research data from various research conducted in this area seems to confirm the established cost price of € 0,42. A short overview of these research results on bio ethanol production costs is given in the table below:

Table 5.4: Research results bio-ethanol production costs

Source	Cost price of 1 litre of ethanol
IEA, 1994	€ 0,20 - € 0,30
Australian Bureau of resource and economics, 2001	€ 0,30 - € 0,60
Energy division of Hawaii State Department of Business, Economic Development & Tourism, 1994	€ 0,32 - € 0,58
Unica, 2000	€ 0,25 (ex-factory Brazil)

Based on these findings it seems save to assume an average out of factory production costs of bio-ethanol from sugarcane ranging between € 0,30 and € 0,50 per litre.

Since 20% more bio-ethanol then gasoline is needed to get the same performance in non adapted engines a mark up of 20% is added to this cost price to get a fair comparison with gasoline prices. Adding this 20% mark up to the calculated price range results in a price range of € 0,36 (low end) and € 0,60 (high end).

Given the fact that 1 barrel of oil produces approximately 100 litres of refined fuels the calculated price range for bio-ethanol would be comparable to a cost price per barrel of € 36 to € 60 per barrel. A range that is competitive to the current oil prices over € 50 per barrel (and rising!).

5.5.4 Fuel prices per country

Fuel prices differ greatly per country. These differences are caused by a difference in distribution costs and availability/ access to the product but are for the most part caused by the different taxing policies that governments in the various countries use to influence the use of gasoline. These differences in prices can be very significant (eg. one litre of fuel costs approx. € 0,09 in Libya, but over € 1,20 in most Western European countries).

In order to investigate the economic feasibility of the bio-ethanol production the calculated prices for bio-ethanol have to be compared to the average selling prices for gasoline in the selected LDC's.

The table below represents the current average price per litre of fuel for the selected LDC's.

Table 5.5: Average fuel prices

Average retail fuel prices per litre	2004
Malawi	€ 0,80
Zambia	€ 0,92
Ethiopia	€ 0,50
Mozambique	€ 0,73
Sudan	€ 0,40

Source: Metschies, G (2004) International Fuel Prices 2005, Data Preview

These prices are retail prices paid by customers at their local petrol station. To make a fair comparison we will have adjust the price range of bio-ethanol of € 0,36 (low end) to € 0,60 (high end) to match retail prices.

In order to do this another 30% (an industry average) is added on the price for fuel distribution costs and another 20% for profit margin for fuel distributors. This results in the following distribution and selling prices for bio-ethanol:

	Low end	High end
Production cost:	€ 0,36	€ 0,60
Distribution cost (30%)	€ 0,108	€ 0,18
	€ 0,468	€ 0,78
Profit margin (20%)	€ 0,094	€ 0,156
Selling price bio-ethanol at pump (per litre)	€ 0,562	€ 0,936

Following this table, Malawi, Zambia and Mozambique have a selling price for fuel lower or equal to the estimated selling price range for 1 litre of bio-ethanol of € 0,56 - € 0,93. Ethiopia and Sudan have a lower selling price for fuel, which makes it therefore less feasible for these countries to produce bio-ethanol for domestic use.

However more detailed knowledge of the supporting cost components of the fuel prices in each country is necessary to determine the actual competitiveness of the bio-ethanol fuel compared to gasoline. Many LDC's apply tax incentives (so tax benefits instead of extra added taxation as is common in the West!) on the use of fuel, in order to stimulate and support the overall use of machinery. Stimulation of the mechanisation of the agricultural sector is for instance an important reason for governments to try to keep fuel prices low. Another factor influencing the taxing policy of governments is the availability of a cheap alternative energy source. Of the investigated LDC's Zambia has the highest price for oil. Zambia also has very large coal supply. It seems therefore likely that the relatively high price for gasoline fuel reflects the Zambian government's intention to support the use of coal as much as possible. This presumption also advocates the use of bio-ethanol for all countries which lack any oil supplies. Bio-ethanol can be produced locally, so if this would result in a alternative for imported fuels, this could result into a drastic change in the taxing policy of the selected LDC's. As stated before, more research is necessary on the local taxing policy on fuels in each selected country.

The findings in this paragraph show that even without in depth knowledge of the local tax regime on fuels bio-ethanol is an interesting alternative for certain LDC's. And it is an alternative fuel of its use is worthwhile to explore for all countries that lack domestic oil production. From the selected LDC's only Sudan seems a very unlikely candidate to switch from oil to bio- ethanol.

5.6 Other considerations

5.6.1 Environmental benefits

Besides the potential purely economic benefits for LDC's to produce bio-ethanol fuels there are potential environmental advantages as well. As stated in previous Chapters, the use of bio-ethanol fuels instead of fossil based fuels could provide significant reductions in greenhouse gas emissions as well as reduction of dependence in energy supply. For Central America countries studies revealed scenario's with possible reductions ranging between 3 and 23 % (source: International Sugar Journal 2005, Vol. 107 no. 1275, March 2005).

Not only will this benefit the environment in the LDC's directly, but since the Kyoto protocol allows developed nations to reduce their emission levels by investing in reduction in other (lesser developed) countries as well, this presents a very interesting opportunity for LDC's to gain funds necessary for investments in bio-ethanol production.

It also opens up a potential international market for bio-ethanol fuels, since a lot of developed nations are examining the potential reduction of greenhouse gasses that can be achieved by blending bio fuels into fossil based gasoline fuels. However it should be noted that it's currently very difficult to put a price tag on these potential developments in the market. Bio fuels are at the moment one of the options to achieve CO2 reduction, but strong government support in developed nations for choosing for bio fuels is necessary to realize the potential economical gains.

In order to provide an indication of the economic value of the environmental benefits of bio-ethanol fuels we provide the following example:

*Study reports based on the Brazilian ethanol program have found a CO2 reduction of 2,82 Kg CO2 per litre of anhydrous bio-ethanol. Average world market prices related to CO2 reduction under the Kyoto protocol vary between € 5,- to € 10,- per ton CO2 reduction. When a price is used of € 7,50 per reduced ton of CO2, and given the amount of reduction of 2,82 Kg CO2 per litre of anhydrous bio ethanol, this would lead to an extra economic benefit of (€ 7,50 / 1000) * 2,82 = € 0,02115 per litre, or approximately € 0,02 per litre of bio- ethanol. This is, besides the benefits of cleaner and less polluted air in the LDC's, using bio fuels, a benefit that is not easily translated into economic values.*

As the example shows, the current economic value of CO2 reduction support the wish to make the bio fuels more attractive compared to fossil fuels, but the calculated potential price reduction by using bio fuels is at the moment marginal (€ 0,02). When extrapolating this reduction to a price per barrel this could result in a € 2,- reduction per barrel, deducted from the price range of € 36,- to € 60,- per barrel.

5.6.2 Other potential spin offs

The production of bio-ethanol offers a range of other spin-off effects besides the ones already previously mentioned above, such as: employment creation, agro-industry diversification and electrical power production by cogeneration. These spin-offs can also stimulate the development of these nations. Stimulation of local agriculture products and additional markets generates extra revenues for farmers and decreases their dependencies and exposure to world market prices (of sugar) by giving them an alternative market to sell their products.

This could consequently lead to the increase in the stability of the purchasing power in agricultural areas, which in most LDC's make up a large portion of the economy.

Other applications of ethanol:

- Chemical industry: Ethanol is a versatile product necessary for the establishment of a powerful chemical industry. It is used to produce a long list of industrial chemical products and by-products. It is a highly performing solvent for agro industries preparations.
- Medical: there is a market in LDC's for ethanol which is actually imported from overseas for hospitals, clinics operational needs and for industrial maintenance purposes.
- Alcohol: ethanol is used for the production of various types of liquor.

Potential spin-offs vary per country and depend strongly on the local circumstances and market opportunities. It is therefore very difficult to quantify these effects, but they are definitively very interesting to take into consideration, when examining the economic feasibility of bio-ethanol production in a particular country in more detail.

5.7 Conclusions

Based on the tentative findings in this study the production of bio-ethanol fuels in LDC's is an appealing alternative for countries which currently produce (and export) a surplus of sugar.

Two main factors make this an economically interesting alternative:

1. Current sugar export opportunities for the selected LDC's will strongly diminish with the proposed EU sugar reforms. This leaves these countries with the necessity to drastically restructure their current sugar cane producing industry or find an alternative use/ market for the output of this sector.
2. Research has shown that bio-ethanol can be produced from sugarcane (using molasses and cane B-syrup/ thick juice) against an economically competitive price. Even without taking other potential benefits into account which could also contribute to the economic development of the LDC's.

As shown in this Chapter, six LDC's currently produce a surplus of sugar. Of these six countries,

- Malawi,
- Mozambique,
- Zambia, and
- Ethiopia

have conditions that make them suitable candidates for starting bio-ethanol fuel production. Additional research and investigations are necessary to examine local conditions in these countries in order to gain detailed insight in the potential benefits that could be achieved for the various countries.

In interpreting these results, one should bare in mind that the findings in this Chapter are made under a number of assumptions and simplifications which had to be made during this research due to the complexity of the areas in which the research was conducted. The main reason for this is the poor predictability of the main factors influencing the economic feasibility of bio-ethanol fuel production. Predicting future oil and gasoline prices and prices for raw sugar is very difficult, and expert opinions on this topic vary greatly. The potential economic value of environmental benefits is also very difficult to predict.

Another problem when conducting research on the economic feasibility for bio-ethanol production in LDC's is the lack of study results on this topic with a focus on LDC's. Most studies have focused on ethanol production in Brazil, the US and Western Europe.

If and how the results for these more developed countries can be fitted into the unique situation of LDC's needs further investigation.

The cost analyses are based on large scale ethanol production as currently undertaken in Brazil and the US and some other countries. For an interpretation of these findings in relation to LDC country use it is therefore necessary to bare in mind the scale of the distilling facilities in these countries. The large production units used in these countries achieve significant economies of scale and throughput, utilizing state of the art technology and using bagasse as a major part of the fuel source for distillation.

Chapter 6
Recommended LDC's; their opportunities and constraints

6.1 Introduction

In order to select certain LDC's capable for bio-ethanol production we have identified the following three selection criteria:

Criteria 1: LDC country must have a sugarcane production surplus;
Criteria 2: LDC country must have a net import requirement for oil;
Criteria 3: Economic feasibility of production of bio-ethanol.

6.2 Selection criteria

6.2.1 Criteria 1

Next to the required production surplus, we have also reviewed the expected export quota from these countries to the EU, including the total amount of sugar. In the season 2003/2004 the total quota for export to the EU is averaged at 98.110 ton. An overview of countries and their sugar factories in provided in Appendix 8.

Although Tanzania, Burkina Faso and Bangladesh are net-importers, they do export to the EU. These countries are using ''swaps'': local production based on their quota which will be exported to the profitable EU market. The shortage on the home market is compensated with the import of cheap world market sugar.

It is expected that in the long term the export to the EU from the LDC's without swaps will amount to an average of 1 million ton and with swaps included an average of 6 till 7 million ton will be expected, depending of the price reduction program chosen.[3]

Based on criteria 1, the following countries have been selected:

- Ethiopia,
- Malawi,
- Mozambique,
- Senegal,
- Sudan,
- Tanzania and
- Zambia.

6.2.2 Criteria 2

In case a LDC country should also have a net oil import the following countries have been selected:

- Ethiopia,
- Malawi,
- Mozambique,
- Senegal and
- Tanzania.

[3] Statement made by mr. Hugues Beyler from CGB/France during presentation at Sugar and Ethanol Brazil.

Zambia and Sudan provide for there own energy resources and do not import oil and fuel. As a consequence it is not likely that these countries will act as a candidate for bio-ethanol production.

Sudan has his own oil production and Zambia produces coal.

An important factor also is the acceptance and the interest of the local Government in these countries. The Government has to pursue the need for the change in using bio-fuels via possible tax facilities.

6.2.3 Criteria 3

Upon review of the economic feasibility of producing bio-ethanol, the following countries have been selected:

- Ethiopia,
- Malawi,
- Mozambique.

Based on existing survey information it is concluded that two low cost-producers do exists: Ethiopia and Brazil. This means that Ethiopia is one of the countries that, based on these criteria, has been selected as one of the most interesting countries. Ethiopia has good quality sugarcane with high yields per hectare and is well organized. Another aspect is that all plantations are owned by the sugar factories and all sugar factories are owned by the Government. So changes need to be endorsed on governmental level.

In applying the three selection criteria it is considered that Ethiopia is the LDC country with the biggest potential for bio-ethanol production and with Malawi or Mozambique as next candidates. It must be noted that Governmental support in Ethiopia is likely to be provided due to the extreme low gasoline prices.

Chapter 7
Conclusions and recommendations

7.1 Introduction

The objective of the study reported has been defined as:

'To investigate if there is a political, technical and economic basis for the economic production of bio-ethanol from sugarcane in Least Developed Countries.'

From the literature survey and impressions from specialist information it has been concluded that opportunities exist in certain selected LDC's and ACP countries to stimulate local bio-ethanol production and consumption. This Chapter contains a listing of conclusions and recommendations.

7.2 Conclusions

7.2.1 Technological

From a technological point of view the following conclusions can be drawn:

- **It has been identified that with the use of existing processes and technology a distillery for the production of bio-ethanol can be added to existing production facilities for cane sugar production in certain LDC's;**

- **The most cost-effective scenario, requiring no new technology, is to produce bio-ethanol next to cane sugar at existing facilities extended with a distillery. The extra investment is estimated between € 10-15 m for a capacity of an average of 80.000 litre/day;**

- **During the study it became clear that if all related activities such as harvesting, logistic organization, processing and transportation have been organized in a logic and cost effective way bio-ethanol production can easily be implemented;**

- **Yield optimisation (quality and quantity) can be achieved through the use of research effort available at Brazilian research institutions;**

- **On one hand we see high scale sugar processing capabilities arising in countries such as Brazil, but also in Sudan and Bangladesh and on the other hand we identify the need for smaller processing capabilities in certain countries due to its limited harvesting and milling capabilities.**

7.2.2 Economical

From an economical point of view the following conclusions can be drawn:

- **It is established that the price of production of bio-ethanol is economical in case world market prices for oil amount to at least ca. $45 per barrel, which is generally considered very realistic;**

- **LDC's with a surplus of sugar (net exporter) in combination with strong imports of import fossil fuels are considered candidate countries for bio-ethanol processing. These countries are: Ethiopia, Malawi, and Mozambique;**

- **Required investment in a distillery production to an existing running cane sugar factory is estimated to amount to € 10m- € 15m;**

- **Based on the current production level in the EU, ranging to ca. 16 million ton of sugar-beets, it is estimated that the export from LDC's and ACP countries of raw sugar should be reduced by ca. 50% in order to maintain that status under the reforming program of the EU. This offers a great opportunity to promote and support the transfer to bio-ethanol production in selected LDC's and ACP countries;**

- **Suppose it could be established that only 50% of the expected LDC &ACP cane sugar to the EU would be transferred to domestic bio-ethanol, the current production level in the EU ranging to ca. 16 million ton of sugar-beets could be maintained under the reforming program of the EU;**

- **The consumer price of bio-ethanol must be ca. 20%-30% lower than the price for gasoline due to its extra consumption in motor engines requiring a production price (excl. distribution and margin) ranging between € 0,35 and € 0,55 per litre;**

- **The cost price for the production of bio-ethanol can positively be influenced due to the use of waste and biomass for the energy production;**

- **Environmental effects are significant if the reduction of fossil-fuel consumption and pollution is reduced;**

- **Spin-off applications might be available once bio-ethanol is produced, such as chemical, medical and industrial applications.**

7.2.3 Political

From a political point of view the following conclusions can be drawn:

- **Implementation of bio-ethanol has an effect on the energy matrix of the concerned country. This fact requires detailed analyses and study as to the effect of it and its related macro-economic implications;**

- **The use of bio-ethanol would stimulate lower green house emissions supporting international agreements related hereto;**

- **Governmental support through tax incentives and investment credits is necessary for a successful implementation of bio-ethanol production and consumption;**

- **The use of bio-ethanol leads to a positive effect on the trade balance of a LDC as the demand for strong currency is decreased;**

- **For the implementation of an effective bio-ethanol programme the support and stimulation of the EU as well as of the governments of the LDC's selected is very important.**

Chapter 8
Recommendations

8.1 Introduction

Based on the conclusions that bio-ethanol production from cane sugar offers an interesting opportunity for the EU as well as for LDC's, the DSD Group recommends to proceed with an implementation scheme aiming to establish one or more demonstration facilities for bio-ethanol production in selected LDC's.

8.2 Implementation scheme

The following planning is proposed:

Phase 1: **Pre-Feasibility study; completed with this report**

Phase 2; **Feasibility Study**
Phase 2A: **Final selection LDC/ACP country(ies) for a demonstration plant.**
Typical tasks to be performed include:

- detail verification selection country(ies);
- field research for selection;
- consensus with government selected country;
- consensus selected existing plant;
- selection of interested stakeholders such as NGO's, sugar producers, oil companies, emission traders, banking institutes, etc.
- support from interested EU countries

Duration: It takes four months after go-ahead to realise phase 2A.

Phase 2B: **Definition of Business Plan.**
Typical tasks to be performed will include:

- process definition,
- technology definition,
- equipment selection,
- organisation;
- cost price calculation including investments;
- financing;
- partners;

Duration: Completion is scheduled four months after completion phase 2A.

Phase 3: **Development and installation of demonstration plant**
The goal is to build and install a bio-ethanol demonstration plant.

Duration: Completion is scheduled nine months after go-ahead.

Phase 4: **Spin-off to other countries, know-how transfer**

The advantage for a demonstration plant is that the (agricultural) stakeholders in the EU as well as domestic partners obtain the opportunity to gain experience in internationalisation of their investment portfolio.

It is important that during the next 2 phases enough support from Governmental side is required to prepare and present the project. The result might be that on the longer term the EU sugar beet growers and the growers of sugarcane in the ACP and LDC countries each have achieved and implemented sound and financially attractive production capabilities which an outlook to improve economic and socially well being.

In order to stimulate the success of the integrated demonstration plants, it is recommended to liaise with the "klimaatplan" as defined by the "Kerken in aktie/ICCO" and other international NGO's with experience in the field of the stimulation of local enterprises.

The present situation of regulating the WTO arrangements, the changing needs for energy transition and EU directives to stimulate the economy of the EBA countries is an excellent opportunity to combine efforts of all stake holders involved.

With the support of the Dutch Government, especially the Ministry of Agriculture, Nature and Food Quality, DSD has prepared this report. It is not a report based on extensive and expensive field research but it aims to stimulate thinking and acting on alternative methods to cope with world wide differing environmental changes one is confronted with. We consider that enough positive results have been identified during this study which is worthwhile for a follow up.

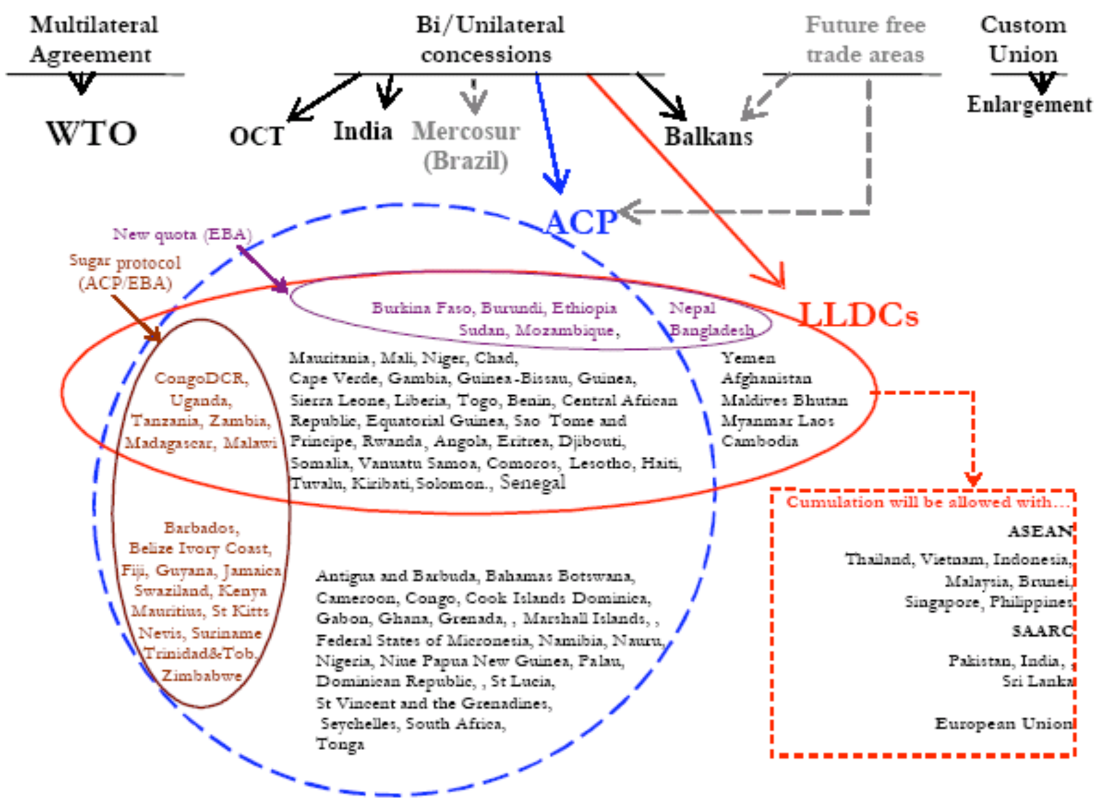
DSD proposes to continue the project and as part of the next phase select one country to identify a pilot project for local bio-ethanol production and consumption.

Appendix 1 List of Least Developed Countries

Africa		**Asia**	**Oceania**	**Mid and south America**
Angola	Madagascar	Afghanistan	Kiribati	Haiti
Benin	Malawi	Bangladesh	Solomon Islands	
Burundi	Mali	Bhutan	Samoa	
Burkina Faso	Mauritius	Cambodia	Timor/Lese	
Central-Africa Republic	Mozambique	Laos	Tuvalu	
Comores	Niger	Maldives	Vanuatu	
Democratic Republic Congo	Uganda	Myanmar		
Djibouti	Rwanda	Nepal		
Equatorial-Guinea	Sao Tome en Principe	Yemen		
Eritrea	Senegal			
Ethiopia	Sierra Leone			
Gambia	Sudan			
Guinea	Somalia			
Guinea-Bissau	Togo			
Cape Verde Islands	Tsjaad			
Lesotho	Tanzania			
Liberia	Zambia			

Appendix 2 Overview of sugar trade agreements with the EU

From: Sugar sector reform (COM N° 2004/499, 14 July 2004) Background Note N° 4



1. The LDCs – ACP included in the sugar protocol - This group had in the average year 2000/'02 about 770 thousand tons of sugar production, 23% of which is already exported and some countries (e.g. Madagascar) have to compensate their export with imports to fulfil their domestic needs. For other countries significant developments of sugar exports do not appear plausible in the short run mainly due to their land locked position which heavily reflects on transportation costs. This is, for instance, the case of Malawi and Zambia where production costs of are among of the lowest in the world, but the transport from the zone of production to the closest international shipping facilities – e.g. the port of Beria in Mozambique- adds over 150 EUR/ton. On the other side for Tanzania a liberalization towards attractive markets may offer opportunities for some export increases to given that their higher production costs could be compensated by an easier access to the sea.

2. The LDCs – ACP not included in the sugar protocol, but with an EBA quota – This is the subgroup of the LDCs with the higher current production and future potential, also due to their competitive production cost. Its composition is highly diversified. On the one hand, countries as Burundi and Burkina Faso, are net-importers and have a scarcely developed sugar industry.
On the other side, Sudan, Ethiopia and Mozambique seem closer to the possibility to take advantage of the opportunities offered by the market. Sudan, which has the largest EBA quota (17 thousand tons), reached a point of self-sufficiency in 1980 and since then its production – favourably located in the region between the two branches of the river Nil which grants full irrigation - keeps rising. Currently, the full FOB costs at the sugar terminal in Port Sudan (1.200 Km away from the production area) are still heavily influenced by the transport costs (about 100 EUR/ton). The country has projects to expand production both on the basis of an increase of the efficiency of the existing assets and on the realization of three new plantations/sugar factories.

Among the latter only one is close to his finalization. In Ethiopia, which has the second largest EBA quota, the sugar industry is still 100% in public hands. Exports are shipped from Djibouti, which still does not have a sugar facility. However, the low production costs and the potential of this country, together with the right market incentives could encourage the realization of new sugar production projects. Finally, in Mozambique after the war in 1992 the privatisation of the sugar industry has attracted investors from South Africa and Mauritius, which re-launched sugar production. The country has a 8,4 thousand tons preferential quota with the EU (EBA) and a 13,7 with the US. Sugar is shipped mainly from the port of Maputo, with the advantage of reducing transportation fee (transport and fobbing is estimated around 50 EUR/ton).

3. The LDCs – ACP without sugar quotas of any kind - The majority of the countries in this subgroup does not produce sugar or have a very limited production which often does not cover domestic needs. Senegal is the sole not a negligible producer is, but its poor conditions make implausible an expansion of sugar production in the near future.

4. The LDCs – non ACP with an EBA sugar quota - The two countries of this group, Nepal and Bangladesh, have a production of about 110 thousand tons each and currently do not show interest for further expansion of sugar production. However, their proximity with India – the second largest world with over 18 mio tons in 2000/’02 and one of the countries allowed for “cumulation” under the EBA agreement - suggests to be prudent at least until the EBA initiative will enter in the phase of its full implementation.

5. The LDCs – non ACP without sugar quotas of any kind - With the exclusion of Myanmar none of the countries in this sub-group is a sugar producer. However, Yemen has a large potential for sugar refinement which stresses once again the importance of a clear definition of the rules of origin in the implementation of the EBA. For the remaining ACP non LDCs further opportunities of increasing sugar export to the EU are less close in time, being linked to the development of the EPAs, the Economic Partnerships Agreements, which currently under negotiation and that should imply, among other, a certain degree of liberalization of the EU agricultural markets. Within the ACP non LDCs 2 sub-groups of countries can be identified.

6. The ACP non LDC in the sugar protocol - This sub-group includes those countries which are well known for being large sugar producers and whose production development has been largely driven by the possibility of supplying the EU market at the guaranteed price. For many of these countries (Mauritius, Fiji, Jamaica, etc.) sugar production is already close or even above the reasonable economic potential and the effort is now in the direction of lowering production costs so to be more competitive on the international market.

7. The ACP non LDC without sugar quotas - The sugar production of this sub-group over 3 million tons, is quite relevant, but in reality more than 80% is produced by South Africa, which also has the largest and most efficient export infrastructure of Austral Africa. In principle, South Africa should not be part of the EPAs negotiations, being a bilateral trade agreement with the EU already in place since the year 2000. However, the vicinity with other ACP suggests that some attention has to be put on potential triangular trade.

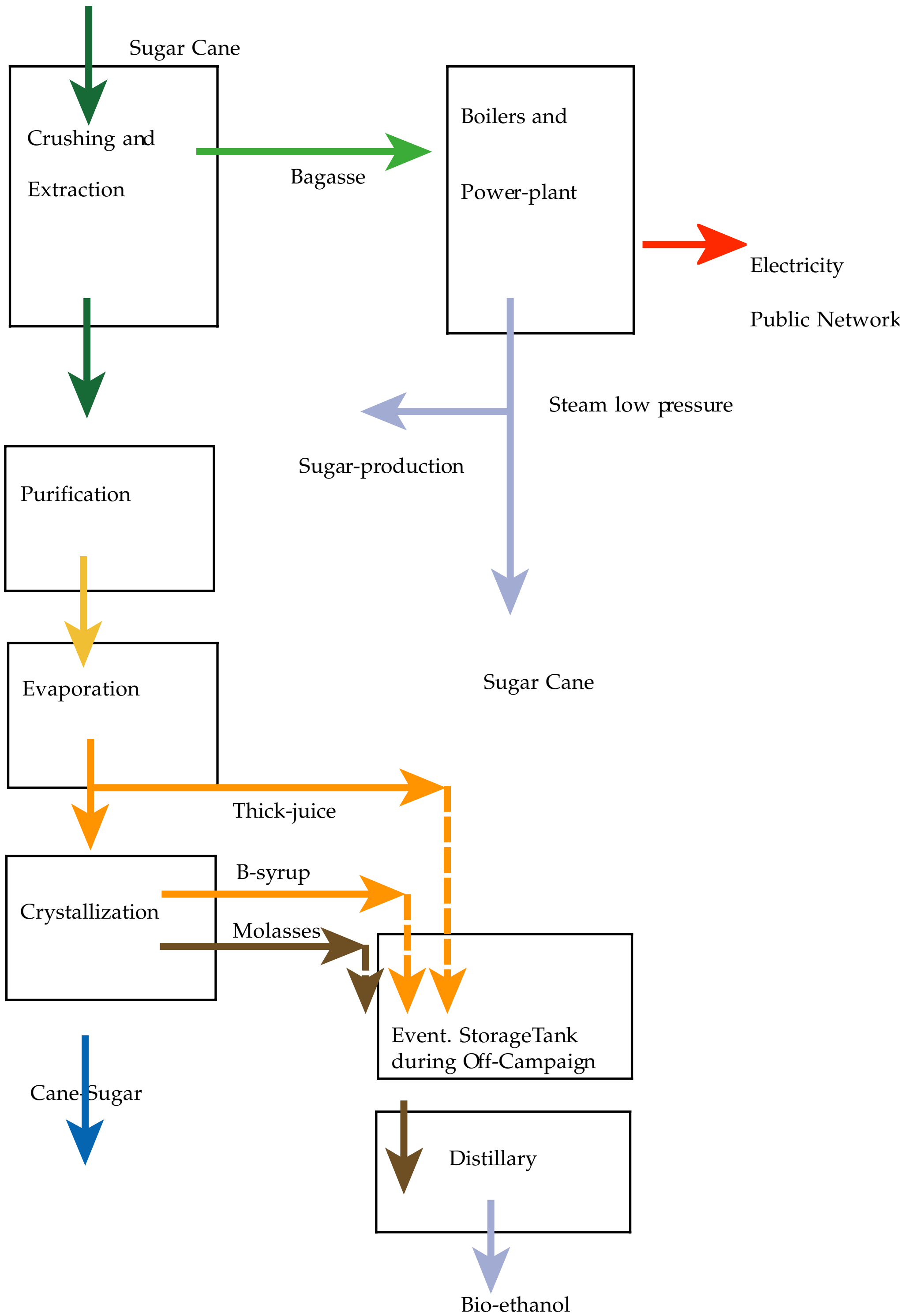
8. The Balkans, Albania, Bosnia-Herzegovina, Croatia, the FYRM, Serbia and Montenegro produce about 320 thousand tons of sugar per year and offer an example of the difficulties that may be associated with the respect of the rules of origins. In the couple of years after liberalization exports of sugar from the western Balkans to the EU rose abnormally (from 613 tons in 2000 to 228 thousand in 2002) and the EU, after investigation, had to temporarily suspend trade.

9. Brazil and India are the biggest world sugar producers. In particular, Brazil exports more than 50% of its production (9,5 million tons) and its potential for expansion is proved by its incessant seeks for new export markets (e.g. the WTO sugar panel). Different is the situation of India, which is using its 18,3 million tons of sugar production mainly for domestic uses (15,9 million tons). However, as it has already been discussed, the presence of such a big producer among the “cumulation” countries of the EBA agreement suggests a great deal of care and prudence when the rules of origins and cumulation are decided and implemented.

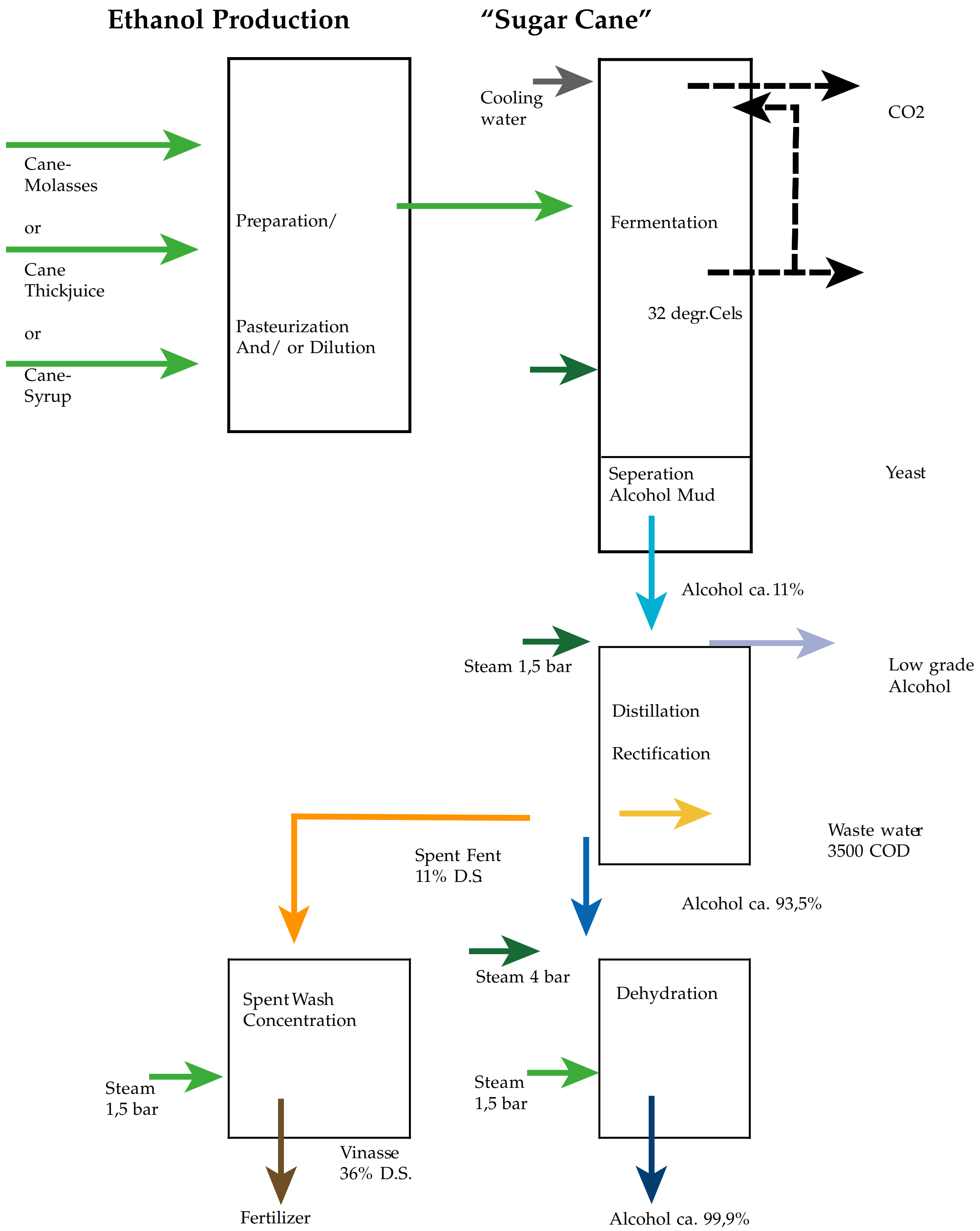
10. Relating to the "other" cumulation countries the same considerations apply. These countries produce, all together, over 14 million tons of sugar. Further, among them there are countries as Thailand whose participation in the WTO sugar panel against the EU testimonies the strong interest in gaining new sugar market for export.

Appendix 3 Production process flow (scenario ii)

Production "Cane sugar"



Appendix 4 Production process flow (scenario iii)



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Appendix 5 Cost production cane sugar

Cost price Calculation

Investment	€ 10.000.000						
Profit on investment	15%				€ 1.500.000		
	13%					€ 1.250.000	
	10%						€ 1.000.000
Maintenance on investment	2%				€ 200.000		
Labour (6 man/shift, 5 shifts)	€ 8.000		30	man	€ 240.000		
Fixed costs					€ 1.940.000	€ 1.690.000	€ 1.440.000
Production per year	28.000.000	ltr					
Cost price fixed costs					**€ 0,069**	**€ 0,060**	**€ 0,051**
- Steam	€ 300	ton	80	kg/ton			
- Heavy Oil	€ 0,30	kg	2,8	kg/litre	€ 0,07		
- Electricity	€ 0,15	kWh	0,15	kWh/litre	€ 0,02		
- Process water	€ 2,00	qm	12	litre/litre	€ 0,02		
- Several chemicals	??				€ 0,05		
					€ 0,1637		
Costs per litre excl. Raw Material					**€ 0,2330**		

Raw material	**Unit price**		**Material/ equivalent**		**Molasses**	**Cane B-syrup Thick-juice**	**Cane-Sugar**
- Costs per litre excl. raw mat.					0,233	0,233	0,233
- Molasses	55,00	tonnes	3,4	kg/litre	0,187		
- Cane-sugar B-syrup	69,00	tonnes	2,7	kg/litre		€ 0,186	
- Cane sugar	300,00	tonnes	1,65	kg/litre			€ 0,495
Costs incl. Raw Material					0,42	0,42	0,73

Remarks:

Depending the wanted return on investment prices can decrease

			Molasses	Cane B-syrup Thick-juice	Cane-sugar
Return on investment	15%	Maximum price	€ 0,420	€ 0,419	€ 0,728
Return on investment	10%	Minimum price	€ 0,402	€ 0,401	€ 0,710

Costs for Distribution	??		
Cost for mixing with gasoline	??		
CO2 reduction benefit	€	0,02	litre

Appendix 6 Mass Balance report

Ethanol Production **Mass-Balance**

Production / Raw material	**General**		**Cane-sugar**	
Ethanol production	80.000	litre/day		
Production time	350	day		
Production over the year			28.000.000	
Cane sugar-campaign			210	days
Production during cane-campaign			16.800.000	litres
Production during inter-campaign				
Production during inter-campaign			11.200.000	litres
			11.200	qmtr
Storage need for inter-campaign				
Storage calculated in sugar	1	litre. ethn.	1,65	kg. sugar
Thick-juice, 68% Brix, 62,5 Pol			43.482	tonnes
B-Syrup, 68% Brix, 61,0 Pol			44.552	tonnes
Molasses, 80% Brix, 48,5 Pol			47.629	tonnes
Storage capacity syrup or molasses			50.000	tonnes
			36.000	qmtr
Tank diameter 5 mtr height			95	mtr
Storage capacity in cane-sugar			18.480	tonnes

Raw-material and Auxillary material for Ethanol Production

Raw - Material	Molasses			
Alcohol Production	80.000	ltr/day		
Raw-Material	125.000	kg/day		
-Thick-juice	211.200	kg/day	8.800	kg/hr
- B-Syrup	216.393	kg/day	9.016	kg/hr
- Molasses	272.165	kg/day	11.340	kg/hr
Nutrient salts	300	kg/day		
Amonium sulphate	800	kg/day		
sulphuric acid	800	kg/day		
Process water	300	qm/day	13	qm/hr
Cooling water 25 dgr. Celsius	3000	qm/day	125	
Saturated steam 6 bar	240	tonnes/day	10	tonne/hr
Electricity				
- installed power	350	kW		
- needed energy	8.000	kWh/day	333	KWh

Appendix 7 Overview EU production scenarios

EU sugar production and consumption (in million tonnes)	**2004/5**	**2009/10 F.O.Lichts**	**2009/10 Univ. of Hohenheim**	**Processing into bio ethanol**	**2009/10 optimum via local pro cessing into bio ethanol**
Domestic consumption	16.3	16.1	16.1		16.1
- Imports total	1.9	2.4	4.3		1.0
Of which:					
ACP – countries	1.3	1.3	1.6	0,9	0.7
EBA – initiative (=LDC)	0.3	0.8	2.7	2,5	0.2
Balkan	0.3	0.3	0.3		0.1
TOTAL production domestic use	**14.4**	**13.7**	**11.8**		**15.1**
+ Exports total	5.6	0.9	0.9		0.9
Of which:					
Subsidized	2.5	0.5	0.5		0.5
In products	0.5	0.4	0.4		0.4
C-sugar	2.6	0.0	0.0		0.0
= EU sugar production	**20.0**	**14.6**	**12.7**		**16.0**
Of which:					
A + B sugar	17.4	14.6	12.7	-1,4	16.0
C sugar	2.6	0.0	0.0		0.0

Appendix 8 Key data sugar factories in LDC countries 2003/04

Key data sugar factories in LDC countries 2003/04

Countries	Total factories	Tot. Cap. ton cane/day	Avg. cap. ton cane/day	Ownership	Cane-supplier	Avg. prod. x 1.000 ton/year
Bangladesh	15	21.040	1.403	State	Independent	149
Burkina Faso	1	2.680	2.680	Priv. + gov.	Estate	35
Burundi	1	1.350	1.350	State	Estate	21
Centr. Afr. R	1	450	450	Private	Estate	12
Chad	1	2.000	2.000	Private	Estade	32
Congo DR	1	5.000	5.000	Private	Estade	67
Ethiopia	4	12.470	3.118	State	Estate	281
Laos	1	200	200	Private	Independent	1
Madagascar	4	8.000	2.000	State	Estate	51
Malawi	2	11.200	5.600	Private	Estate	225
Mali	1	1.000	100	Private	Estate	32
Mozambique	4	14.400	3.600	Private	Est./Indep.	92
Myanmar	8	9.100	1.138	State	n.a.	100
Nepal	7	1.120	1.600	Priv./State	Independent	95
Rwanda	1	60	600	Private	Estate	4
Senegal	1	5.500	5.500	Private	Estate	93
Sudan	5	46.500	9.300	Priv./State	Estate	714
Tanzania	4	9.080	2.270	Private	Estate	144
Togo	1	500	500	Private	Est./Indep.	4
Uganda	3	8.900	2.967	Priv./State	Estate	143
Zambia	1	n.a.	n.a.	Private		207

Source:

The 15 sugar factories in Bangladesh are small and have an average capacity less than 1.500 ton cane per day. These factories are delivered via independent, small farmers, it is expected that there are more than 400.000 cane sugar growers.

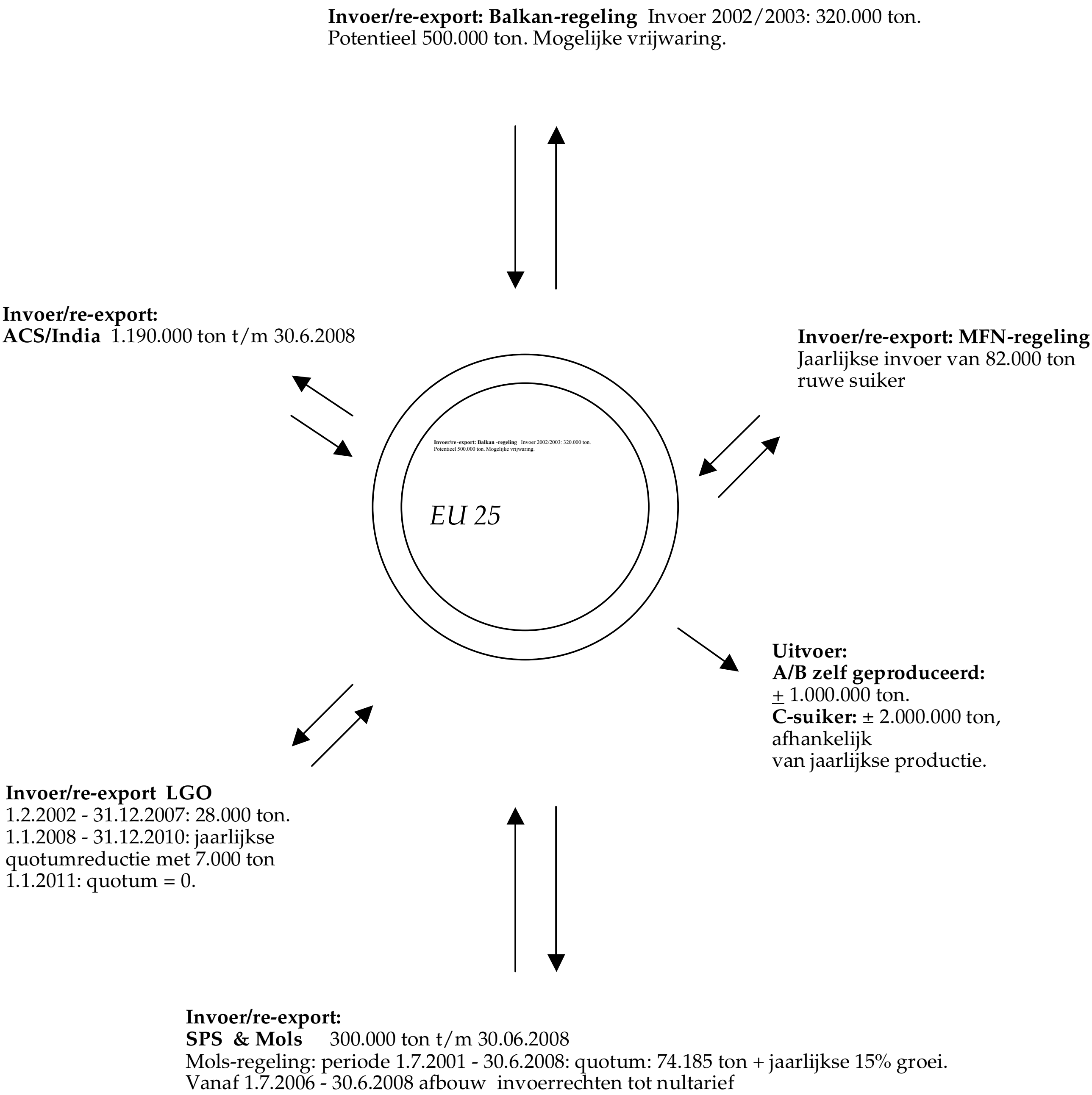
The biggest sugar industry in a LDC country is in Sudan. In Sudan five sugar factories are operating, one as part of a private company (Kenana) and four state owned companies (Sudanese Sugar Company).

Appendix 9 Publications & references

The following publications and/or references have also been used for the preparation of the report:

- F.O.Licht publications;
- Presentations presented during the Sugar and Ethanol Brazil conference held in Sao Paulo 14-16 March 2005;
- Meeting with UNICA (Sao Paulo Sugar Cane Agro industry Union) representative;
- Meetings with representatives from Denini, Praj Industries and Chematur Engineering;
- Presentations during Symposium Energy Valley, Den Helder, October 2004 ;
- Rabobank International: The World of Sugar and Sweeteners, Market study, October 1999;
- EU Lamnet information;
- Sugar Journal publications;
- LMC publications;
- SHELL publication on discovered production fields;
- EU publications (DG Agri/DG Developing countries).

Appendix 10 Annual in- and export of sugar in the EU



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Appendix 11 Profile DSD Group

The DSD (Dutch Sustainable Development) Group is a consultancy agency active on the sustainable agriculture and bio/fuels market. The DSD Group is a co-operation between Swilion Business Development B.V. and Teamwork Technology B.V.

The DSD Group has managed and successfully implemented a number of projects in various developing countries, such as Indonesia, South Africa, Senegal, Brazil, India and the Caribbean. The involvement of the DSD Group in the projects ranged from the total responsibility for the management and execution of the entire project to the responsibility for the realisation of specific parts of a project in cooperation with partners.

The DSD Group and its affiliated companies can assign an experienced project team which will cover all relevant aspects necessary for the successful realisation of the proposed activity. The assigned persons all have experience with (inter-)national projects on various fields. His project team consists of:

- project managers;
- financial and controlling managers;
- agricultural experts;
- information specialist;
- experts on sustainable energy;
- process technology experts;
- back office support;
- legal and contractual experts.

Based on these expertises the DSD Group is capable to offer her unique capabilities in areas such as:

- establishing local partnerships and cooperating with local partners and connections to organise and manage factories for the production of bio-fuels, such as bio-diesel and bio-ethanol;
- transfer of know-how of process techniques and logistic procedures;
- prepare business plans, including investment and financing plans and investment propositions;
- project management and financial control;
- the development of the agricultural chain: ranging from breeding to production techniques;
- establishment and organising of distribution channels for bio-fuels.

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TEAM WORK TECHNOLOGY

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