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FEMIP

Potential for Biofuel Production
in FEMIP countries

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Biofuel Production in
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FTF/REG/04/2006**

Executive Summary

For the

European Investment Bank

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Job No. 2368/May 2009

Executive Summary

The study is financed under the FEMIP¹ Trust Fund. This Fund, which was established in 2004 and has been financed – to date – by 15 EU Member States and the European Commission, is intended to support the development of the private sector via the financing of studies and technical assistance measures and the provision of private equity. The authors take full responsibility for the contents of this report. The opinions expressed do not necessarily reflect the view of the European Investment Bank.

Feedstock production potential

The FEMIP countries² encompass a land area of some 421 million hectares, of which just over 5% or 23.9 million hectares in 2007 were used for crop production. Desert occupies approximately 90% of total FEMIP land area, ranging from 20% in Lebanon, 59% in Israel to 95% in Algeria, Egypt and Jordan. Analysis of the physical and agro-climatic conditions prevalent in the FEMIP region indicates that only a relatively small proportion of land area is currently suited to biofuel feedstock production.

Cereals are the dominant crop in the FEMIP countries covering 15.5 million hectares (65% of total harvested area), while oil crops (mainly in the form of olives and seed cotton) cover 2.5 million hectares (11% of harvested area). Typical crop yields vary across the region depending on whether the crops are irrigated or not. Rain-fed yields are generally low, whereas under irrigation crop yields can be much higher. A key issue for biofuel feedstock production is therefore the availability of water. With the possible exception of Lebanon, average annual rainfall is insufficient to satisfy even the average water requirements of crops suitable for use as biofuel feedstock currently cultivated in the region.

All FEMIP countries suffer from severe water shortages and many are close to the internationally accepted 'water poverty' limit of 500 m³/capita/year. They have rising populations demanding more water per capita. They rely on irrigated agriculture to boost national crop production which in many cases consumes more than 80% of the water resources available for economic growth, employment and food security. There are therefore severe constraints on the potential to increase irrigated areas. FAO estimates the existing irrigated area at 7.06 million hectares and considers that there is the potential for all the FEMIP countries at 8.75 million hectares – an increase of some 1.68 million hectares (24%). The greatest suggested irrigation potential lies in Egypt, where there appears to be room for a further 1.15 million hectares.

¹ FEMIP - Facility for Euro-Mediterranean Investment and Partnership.

² FEMIP countries - Algeria, Egypt, Gaza/West Bank, Israel, Jordan, Lebanon, Morocco, Syria, Tunisia.

This data on irrigation potential implies that water resources would be available but this is not guaranteed. Despite the apparent potential identified by FAO in Egypt total renewable water resources are already unsustainably over-exploited, although it would appear that there may be water available for some further development in Morocco, Syria and Tunisia. This highlights that more detailed in country studies will be essential to confirm the availability of both land and water in locations that are suitable for biofuel feedstock crops.

Some desalination is currently taking place in FEMIP countries, but this technology is currently too expensive to consider for agricultural use. There would appear to be potential to irrigate some 300,000 hectares in the FEMIP countries with re-used water. If this potential were realised and used for biofuel feedstock crop production, it is estimated that sufficient quantities of bio-ethanol and bio-diesel could be produced in the FEMIP region to satisfy demand for *either* a 4.6% bio-ethanol blend by volume *or* a 1.1% bio-diesel blend by volume in domestic road transport fuel consumption. However, it should be noted that, particularly in closed basin systems like the River Nile, upstream waste-water collection and treatment does not create new water supply, and re-distribution to new areas would in reality deprive existing downstream water users of valuable supply. On this issue considerable research would also therefore need to be undertaken to identify and mitigate potential externalities in the form of loss of downstream water availability before investing in waste-water collection, treatment and potential irrigation schemes for biofuel feedstock and forest biomass production.

Marginal land in the FEMIP region is in reality currently used for agriculture – cultivating crops when rainfall conditions allow, but most often, for grazing animals such as cattle, sheep, goats and camels, even if this grazing is seasonal or only takes place in good rainfall years. Therefore, the report notes that the potential for growing biofuel feedstock on so-called ‘marginal’ land should not be overstated. Where water resources have been diverted to new areas and uses, tree crops have successfully been cultivated in Egypt and other FEMIP countries for the purpose of the safe use of primary treated municipal waste-water and combating desertification. These have the potential to produce cash crops (fruit, nuts, timber), biomass for fuel and also potentially to provide a source of ligno-cellulosic feedstock for ethanol production.

Public promotion policies

There is strong political support in the FEMIP countries for the development of the region’s energy sector and policies; in 1995 the Euro-Mediterranean Partnership was

established. For the FEMIP countries, this provides a medium to secure technical assistance for the development of the energy sector, while providing 'favourable' conditions for EU investment in energy (including renewables) infrastructure in the FEMIP region consistent with the EU strategy for securing future energy supplies. There are commitments across the FEMIP region to increase energy security, improve competitiveness of energy supply, as well as protection of the environment. These are reflected in the countries' political support to renewable energy. However, specific commitments concerning biofuel use and production in the FEMIP region are limited, with only Israel being on the point of introducing policies to encourage biofuel use.

There are a number of different measures along the value chain from feedstock production to end use of the biofuel where support for the sector can be provided. In Israel it is intended that support be provided by means of excise tax exemptions/reductions; lowering of duties on imported feedstock, mandatory blending rates and adaptation of the rules governing engine standards to enable biofuel to be used.

All of the FEMIP countries (except for Gaza/West Bank) are Non-Annex 1 parties to the Kyoto Protocol, meaning that in practice they are not subject to Greenhouse Gas (GHG) emission restrictions. However, when a greenhouse gas emission reduction project is implemented in Non-Annex 1 countries, the project would receive Carbon Credits, which can then be sold to Annex I buyers. This provides an incentive for foreign investment in greenhouse gas emission reduction projects in the FEMIP countries, including investments in biomass production projects, renewable energy projects and potentially biofuel production.

Feedstock and practices

Agriculture continues to play an important role in the economies of the FEMIP countries, ranging from an estimated 2.4% of 2007 GDP in Israel, to 25.0% in Syria. However, apart from Syria and Tunisia, the majority of FEMIP countries are net importers of agricultural produce and more particularly significant net importers of potential biofuel feedstock (or in the case of *sugar cane* and *beet* of the end product of that feedstock, i.e. sugar). Export volumes of potential biofuel feedstock are relatively limited, with the most significant being *wheat* (predominantly from Syria) and *seed oils*.

Given the limited volume of potential biofuel feedstock exports, the potential to divert these commodities into domestic biofuel production is limited. In total, some 1.52 million tons of feedstock exports in the form of *grains*, *oilseeds* and *seed oils*, with

a value of €206.6 million could be replaced by some 512,000 m³ of bio-ethanol and 62,000 m³ of biodiesel production with a total value of €234.5 million, with an additional 489,000 tons of DDGS and 102,000 tons of *oilseed meal* co-product returned to the domestic and/or export livestock feed sector. This volume of potential biofuel production would be sufficient to substitute some 3.3% of gasoline and 0.2% of diesel consumption by volume for road transport in FEMIP countries.

The general lack of surplus water resources in FEMIP countries implies that to increase bio-ethanol production over and above the levels potentially achievable by diverting feedstock exports, would result in some displacement of other agricultural crops. However in future, second generation biofuel could offer the potential to increase biofuel production without displacing current crop production volumes. This having been said, the areas required to achieve modest biofuel blending targets are also relatively modest and would not therefore significantly endanger food production objectives. However, other external effects of existing crop (including feedstock) production practices would need to be mitigated, notably those related to potential over-exploitation of water resources resulting in lowering of groundwater, increased risk of salt water incursion, degradation of water quality and soil erosion.

In the short term, the most promising non-domesticated feedstock crop suitable for cultivation in the FEMIP region appears to be *castor beans* for biodiesel production and researchers believe that commercial seed lines should be available on the market within 2-3 years. Further research into cultivation commercial seed lines of *jatropha* is still required. Beyond this there appears to be some scope for *tropical sugar beet* as this crop is reported to be being used as the basis for ethanol production in other countries and appears to have attractive cultivation characteristics for the FEMIP region, notably a lower water requirement than sugar cane. Similarly *sweet sorghum* which is already to an extent being grown in the region could well be an attractive feedstock, especially given the fact that ethanol production would produce feed by-products. A high medium to long term potential is also seen for *pongam trees* which appear well adapted to FEMIP conditions and produce suitable oil as well as biomass. Other crops which are considered to have potential but are as yet untested in the region are *Chinese pistachio* and the *yellowhorn tree*. The latter plant, as well the *Chinese dwarf cherry* are also potential multi-use plants which could provide seed for biodiesel, fruit for ethanol, and biomass for ligno-cellulosic ethanol production. Similarly *algae* produced in ponds might well produce a suitable feedstock for biodiesel once this technology becomes more price competitive. Further attention should also be given to the potential use of *non-edible dates* for ethanol production especially given the fact that these are grown on significant areas.

Second generation biofuel technologies are currently expensive and there is a need for significant cost reduction to compete with conventional fossil fuels and 1st generation biofuel. Significantly, fossil gasoline and diesel fuels continue to receive implicit direct or indirect subsidies in a number of FEMIP countries, and while such direct or indirect subsidies exist, the economic viability of both 1st and 2nd generation biofuel will remain doubtful. Ligno-cellulosic ethanol production technology is still at the demonstration stage, although it is considered likely that commercial scale plants will come on stream over the next decade. Research on *sweet sorghum* in the FEMIP countries would be a particular priority in this regard. In addition, in FEMIP countries notably Egypt, there is particular interest in using forest plantations as a means of addressing a number of key environmental priorities, including the safe use of primary treated municipal waste-water and for combating desertification. These environmental aims are also compatible with biomass feedstock production for possible future ligno-cellulosic ethanol production.

Domestic production and use of biofuel

There is currently no commercial biofuel production in any FEMIP country. There are two companies operating beverage (not fuel) grade ethanol plants in Egypt and Morocco and there is one demonstration biodiesel plant in Israel, although there is no current or planned commercial production. There are also currently only three proposed plants for biofuel in the region, in Algeria, Egypt and Israel, but it is not clear when production is likely to proceed particularly as there is no developed downstream production chain.

Although a number of FEMIP countries, and in particular Algeria, are producers of fossil fuels and derived products, biofuel would be able to contribute to reducing dependence on fossil fuel production and/or imports especially in significant net importing countries such as Morocco, Israel, Jordan and Lebanon. The introduction of a mandatory 1% by volume biofuel blending target for road transport fossil gasoline and diesel consumption would require some 152,000 m³ of bio-ethanol and 361,000 m³ of biodiesel across the FEMIP countries. However, as has been observed in other countries, it appears that a clear government framework, probably including mandatory biofuel blends, would be required to encourage infrastructure investment in the necessary distribution and retail chain for biofuel by the fossil fuel sector.

There is interest in the development of biogas plants for electricity generation in a number of FEMIP countries. In addition, there could also significant biogas transport fuel potential available from putrescible waste streams, such as livestock waste and wheat straw, which assuming it could all be collected could theoretically generate an estimated 15.0 billion Nm³/year of CH₄-enriched biogas (bio-methane) for use as

transport fuel, sufficient to power a fleet of some 9.8 million vehicles in FEMIP countries.

Biofuel production costs

Estimated biofuel production costs vary significantly between countries and by feedstock type. In most FEMIP countries, the gross production cost of biofuel is significantly higher than in the main biofuel producing countries worldwide, substantially due to high feedstock costs. These generally high feedstock costs are only partially offset by lower labour and energy costs compared to other countries. In particular, the EU-27 has a comparative advantage in biodiesel production over all the FEMIP countries except Egypt, while none of the (low cost) bio-ethanol producing FEMIP countries which use sugar cane as a feedstock can compete with Brazil on a production cost basis.

Estimated costs of *biodiesel* production are presented in the Annex below (see Figure 1 and Table 1 below). Analysis suggests that biodiesel production is not competitive with the regional fossil fuel supply cost in any FEMIP country and would require a direct or indirect subsidy to render it competitive. Estimated costs of *bio-ethanol* production are also presented in the Annex below (see Figure 1 and Tables 2 and 3). In most FEMIP countries, the cost of producing bio-ethanol exceeds the retail cost of gasoline, with the following exceptions: bio-ethanol from wheat in Israel, Morocco and Gaza/West Bank; and bio-ethanol from sugar beet, maize and sugar cane in Morocco. In the case of Morocco, this is because gasoline prices are relatively highly taxed compared to the other FEMIP countries. Compared to the regional supply cost of gasoline, bio-ethanol production is not competitive in any FEMIP country and would also require a direct or indirect subsidy to render it competitive.

Estimated costs of producing *second generation biofuel* (i.e. ligno-cellulosic ethanol and syndiesel) were compared to current typical first generation ethanol and biodiesel costs (see Table 6 below). It was noted that in particular ligno-cellulosic ethanol production costs would in future be competitive with ethanol produced from first generation feedstock. The key issue here would be to develop an adequate supply chain to generate the very substantial volumes of biomass required. Cellulosic feedstock costs were found to be substantially lower than those for first generation feedstock (except tallow). Conversion costs for cellulosic ethanol are not substantially higher than those for grain based ethanol, although syndiesel conversion costs are higher than those for conventional biodiesel.

The budgetary cost of introducing mandatory biofuel blending targets depends on the domestic biofuel production cost relative to the supply cost of fossil fuels and the extent to which governments subsidise or conversely tax fossil fuels. Thus in Egypt, for example, which theoretically would have relatively competitive production of bio-ethanol but also subsidises fossil fuels, the estimated annual budgetary cost of a 1% by volume blend ranges from some €2.4 million per year for bio-ethanol made from sugar beet to some €21.0 million for a 1% by volume biodiesel blend. In Morocco where fuels are taxed but costs of production are also generally higher, the picture is more variable as the budgetary cost will consist significantly of revenue foregone from duty and thus the estimated cost for a 1% biofuel blend by volume varies from some €4.7 million for ethanol from sugar beet to over €38.0 million for biodiesel from sunflower oil.

Due to the relatively high costs of feedstock in FEMIP countries, domestic biofuel production based on imported feedstock could be considered, particularly to take advantage of usually port based oil refineries to undertake blending close to the point of biofuel processing. However, for bio-ethanol, importing grain feedstock for conversion to ethanol is not economically advantageous because, without border protection which would impose a cost on consumers, it would be cheaper to import ethanol from Brazil or elsewhere where it is competitively produced rather than producing it in the region. In contrast, importing oilseeds or seed oils for biodiesel production could be advantageous as the feedstock constitutes a high proportion of gross biodiesel production costs and some FEMIP countries have advantages in terms of energy and/or labour costs which may make the processing option particularly attractive. In addition, importing and crushing the oilseed would produce oilseed meals which would reduce the need for some imports of livestock feed.

FEMIP biofuel for international trade

Jordan and Egypt enjoy duty free preferential access to the EU for bio-ethanol exports, while all FEMIP countries have a tariff preference set at zero for biodiesel exports. Technically therefore, there is potential for FEMIP biofuel exports to the EU, which is likely to be expanded as part of the negotiations on the Europe-Mediterranean Free Trade Area (EU-MFTA). However, it should be noted that any exports would have to satisfy new sustainability criteria adopted by the EU.

World bio-ethanol and biodiesel demand is forecast to increase over the next decade and hypothetically there could be opportunities for FEMIP exports to major import markets. However, given the current state of and outlook for biofuel policy and production development in FEMIP countries it is considered highly unlikely that

the FEMIP region as a whole will develop into a significant net exporter in the projection period. Instead, if policies promoting the domestic use of biofuel are introduced, the FEMIP region is most likely to be a net importer for the foreseeable future, or at least until such time as the production of alternative feedstock not using scarce land and fresh water resources are deemed to be viable. The infrastructure for feedstock imports are already largely in place as the FEMIP countries are substantial importers of grains and oilseeds, which raises the prospect of having port located refineries, which would potentially benefit from the synergies to be derived from being located close to petrochemical complexes where biofuel blending would take place. Alternatively, biofuel (e.g. bio-ethanol from Brazil) could be imported directly, particularly in the case of Israel which is already a net fuel importer. However, if a domestic biofuel market were to develop in FEMIP countries, apart from the refineries themselves, this would require substantial additional investment in transport and blending equipment (pipelines, specially adapted tanker trucks or rail freight containers) as well as new storage and terminal capacity and investment in suitable equipment at retail outlets.

Socio economic effects

The FEMIP region is characterised by large rural populations (on average 45%) and with unemployment running at around 10% or above (generally higher for females). Therefore, there is often a large pool of labour in rural areas which could be drawn on to produce biofuel. However, an assessment of the expected employment and social effects of biofuel production in the FEMIP region is problematic, not least due to the absence of any biofuel production currently. In terms of employment, assuming that feedstock production was not displacing current food production, research suggests that for each 1% by volume of the petrol market displaced by domestic bio-ethanol production in the FEMIP region as a whole some 5,000 jobs (or 7,575 jobs for a 1% blend by energy content) would be created. Similarly a 1% by volume blend of biodiesel would create 5,080 jobs (or 5,639 jobs for a 1% by energy blend). In aggregate taking a 1% by volume blend for biodiesel and bio-ethanol this amounts to some 10,080 jobs.

While it is clear that there are potential employment benefits to the introduction of biofuel most authors stress that the institutional arrangements and production technologies which are adopted to produce biofuel are critical to the socio-economic impact they are likely to have and that generally more positive results in socio-economic terms are likely to be obtained if smallholders are involved in the production process. This having been said, in view of the economies of scale obtainable frequently large scale plantations may well be the most economically competitive option for producing feedstock and in other regions these have been

associated with land evictions, child labour and poor treatment of workers in terms of wages and working conditions. These are however not the inevitable consequence of biofuel production and they can be mitigated by good governance. With respect to the gender differentiated impact of biofuel it has been noted that since feedstock production generally requires improved access to production inputs such as land, machinery and other inputs such as fertiliser and pesticides, women may be disadvantaged because of a lack of ownership of land and therefore an inability to generate the collateral needed to obtain credit for the purchase of inputs. It should be noted, however, that this situation is not specific to biofuel production, but rather arises from the culture and customs (e.g. land property and inheritance rights) in the FEMIP region. The limited evidence available suggests this is strongly the case in some FEMIP countries and therefore this is an issue which will need to be borne in mind carefully when schemes are drawn up so as to avoid further marginalisation.

Reviewing the effects of energy crops on land ownership and size distribution the limited evidence available for the FEMIP region suggests that generally rural land ownership structures tend to be dominated by a large number of very small holdings owning a relatively small share of the arable land. It is not possible to identify precisely how energy crop production would affect such structures as the effect would depend on what biofuel is generated and how biofuel production will take place. Thus if the rights and interests of smallholders are protected and they became involved in contract farming it is possible that over time the landholding structure indicated above would become more equal. On the other hand, there are risks that the scale requirements, in particular of bio-ethanol production, tend to work in favour of larger scale units and unless sufficient safeguards are built into the development process this could entrench rather than reduce ownership disparities.

To conclude with respect to the likely beneficiaries of biofuel production and consumption experience from other regions suggests that many of the benefits of biofuel production may accrue downstream from agriculture. Nevertheless, to the extent that biofuel production leads to higher prices for feedstock, this will benefit the supply end of the chain in the form of landowners and those involved in production as well as those supplying inputs to the primary production sector. While this is of benefit to producers, this benefit must be balanced against possible losses arising to consumers from higher food prices. The major concern with the potential development of biofuel production in the FEMIP region would be the potential displacement of food crops that feedstock production for biofuel might require in countries which are all net food importers. It has been estimated that the bulk of output required to meet a minimum level of demand could be met from a relatively small amount of land, particularly in the case of bio-ethanol from sugar-based feedstock due to the high yields potentially achievable under irrigation in FEMIP

countries. It is therefore considered that that neither of these effects will in themselves be particularly significant in most of the FEMIP countries concerned unless very ambitious targets were to be introduced.

Annex: Results of biofuel production cost analysis

The estimated net cost per litre of *biodiesel* production (incl. capital cost) in fuel equivalent ranges from €0.42/litre in Egypt to €1.84/litre in Israel (see Figure 1 and Table 1 below). Compared to the regional supply cost of fossil diesel, calculated at €0.28/litre (i.e. the breakeven point between biodiesel and diesel), biodiesel production is not competitive in any FEMIP country and would require a direct or indirect subsidy of between €0.11/litre and €1.56/litre to render it competitive. In comparison, the estimated net cost per litre of biodiesel production (incl. capital cost) in fuel equivalent using domestically grown castor bean oil ranges from €0.26/litre to €0.33/litre and from €0.41/litre to €0.49/litre using domestically grown jatropha oil for (see Table 5 below). However, as previously stated the key factor would be to develop commercial seed lines of jatropha and castor beans.

The estimated net cost per litre of *bio-ethanol* production (incl. capital cost) in fuel equivalent ranges from €0.39/litre in Egypt to €1.57/litre in Israel (see Figure 1 and Tables 2 and 3 below). In most FEMIP countries, the cost of producing bio-ethanol exceeds the retail cost of gasoline, with the following exceptions: bio-ethanol from wheat in Israel, Morocco and Gaza/West Bank; and bio-ethanol from sugar beet, maize and sugar cane in Morocco. In the case of Morocco, this is because gasoline prices are relatively highly taxed compared to the other FEMIP countries. As a result, compared to the regional supply cost of gasoline, calculated at €0.30/litre (i.e. the breakeven point between bio-ethanol and gasoline), bio-ethanol production is not competitive in any FEMIP country and would require a direct or indirect subsidy of between €0.09/litre in Egypt and €1.27/litre in Israel to render it competitive.

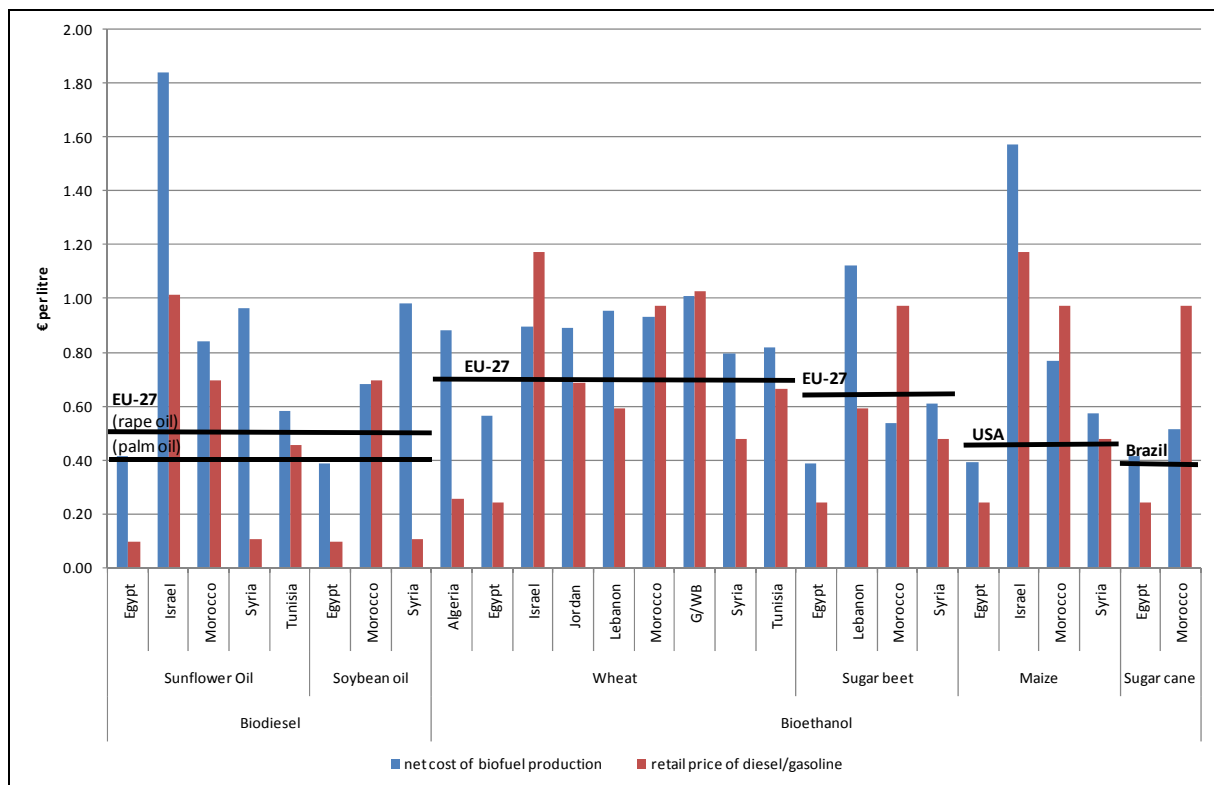


Figure 1: Cost³ of producing biofuel in FEMIP countries using domestic feedstock (net cost (incl. capital)) in fuel equivalent) and the retail price of diesel and gasoline (€/litre)

Note: Detailed supporting data for FEMIP countries biofuel production costs including assumed feedstock prices shown in Tables 1 to 3 below; and gasoline and diesel retail price data is presented in Table 4

Source: Agra CEAS calculations based on F.O. Licht (2004; 2007; 2009); Smeets et al. (2005); OECD (2006); GTZ (2007); FAO (2009); World Bank and OECD Indicators; European Commission data.

³ Disclaimer: No commercial production of biofuel for fuel use currently takes place in the FEMIP region. Therefore the analysis was developed on the basis of a number of realistic assumptions. These assumptions are set out in detail in the report, but may be summarised as follows:

- **Capital costs:** the technology used to produce biodiesel from vegetable oils and ethanol from sugar and grain crops is virtually the same irrespective of the country of production. Thus, the cost of constructing a biofuel plant is assumed not to vary significantly between countries.
- **Feedstock costs, by-product values and conversion ratios:** domestic feedstock prices for the individual FEMIP countries are 10-year average producer prices (1997-2006) in local currencies from FAO and national data sources, converted to Euro at the average 2006 exchange rates. The feedstock oil prices were calculated based on historic average margin of seed oil prices over oilseed prices using FAPRI oilseed complex market data series. Feedstock conversion factors for the amount of feedstock (tons) required to produce a cubic metre (m³) of biofuel were based on the latest F.O. Licht (2009) survey of biofuel production costs. By-product prices for the individual FEMIP countries were based on FAO price data and the relationship between by-product prices and feedstock in those countries where there is a functioning market for these products. For glycerine and vinasse, a notional price was used based on international values. We have assumed a crush margin value of zero, which reflects the extremely volatile nature of oilseed and seed oil markets and fluctuating international crush margins.
- **Operating costs and conversion ratios:** as the technology used to produce biodiesel from vegetable oils and ethanol from sugar and grain crops is virtually the same irrespective of the country of production, operating costs were assumed not to vary by country; operating costs varied by feedstock used only. Variations in labour costs were based on the most recent (2007) World Bank Development Indicators and OECD data. Variations in energy prices were based on the most recent (2008) electricity and gas tariffs for the individual countries as reported by the European Commission. Energy conversion factors were based on those reported in the latest F.O. Licht (2009) survey of biofuel production costs.

Table 1: Cost³ of producing bio-diesel in FEMIP countries using domestic sunflower and soybean oil as feedstock

Biofuel: Feedstock: Country:	Bio-diesel							
	Sunflower oil					Soybean oil		
	Egypt	Israel	Morocco	Syria	Tunisia	Egypt	Morocco	Syria
Plant size (m ³ /year biodiesel)	227,000	227,000	227,000	227,000	227,000	227,000	227,000	227,000
Plant cost (€ million)	42	42	42	42	42	42	42	42
Interest rate (%)	6%	6%	6%	6%	6%	6%	6%	6%
Depreciation period (years)	10	10	10	10	10	10	10	10
Annual capital cost (€/litre biodiesel)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Feedstock conversion (tons oil/m ³ biodiesel)	0.91	0.91	0.91	0.91	0.91	0.93	0.93	0.93
Feedstock price (€/ton oil)	363.99	1,765.72	781.69	905.58	524.03	326.85	610.45	903.44
Feedstock costs (€/m³ biodiesel)	331.23	1,606.80	711.34	824.07	476.87	303.97	567.72	840.20
Labour cost (€/m ³ biodiesel)	5.06	7.72	4.87	4.92	5.28	5.06	4.87	4.92
Processing costs (excl. labour & energy) (€/m ³ biodiesel)	63.88	63.88	63.88	63.88	63.88	63.88	63.88	63.88
Processing costs (excl. energy) (€/m³ biodiesel)	68.93	71.60	68.75	68.80	69.16	68.93	68.75	68.80
Energy use: heat (MBTU/m ³ biodiesel)	-	-	-	-	-	-	-	-
Energy price: natural gas (€/MBTU)	-	-	-	-	-	-	-	-
Energy use: electricity (kWh/m ³ biodiesel)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Energy price: electricity (€/kWh)	0.04	0.10	0.10	0.04	0.09	0.04	0.10	0.04
Total energy costs (€/m³ biodiesel)	2.00	5.00	5.00	2.00	4.50	2.00	5.00	2.00
Gross production costs (€/m³ biodiesel)	402.16	1,683.40	785.09	894.87	550.53	374.90	641.47	911.00
Animal feed co-product conversion (tons per ton feedstock)	-	-	-	-	-	-	-	-
Animal feed co-product value (€/ton co-product)	-	-	-	-	-	-	-	-
Glycerine value (€/m ³ biodiesel)	49.34	49.34	49.34	49.34	49.34	49.34	49.34	49.34
Vinasse value (€/m ³ biodiesel)	-	-	-	-	-	-	-	-
Total by-product credit (€/m³ biodiesel)	49.34	49.34	49.34	49.34	49.34	49.34	49.34	49.34
Net production costs (€/m³ biodiesel)	352.83	1,634.07	735.75	845.54	501.19	325.57	592.13	861.67
Net cost of biofuel (€/litre)	0.35	1.63	0.74	0.85	0.50	0.33	0.59	0.86
Net cost of biofuel (incl. capital cost) (€/litre)	0.37	1.66	0.76	0.87	0.52	0.35	0.61	0.88
Net cost of biofuel - fuel equivalent (€/litre)	0.39	1.82	0.82	0.94	0.56	0.36	0.66	0.96
Net cost of biofuel (incl. capital cost) - fuel equivalent (€/litre)	0.42	1.84	0.84	0.96	0.58	0.39	0.68	0.98

Source: Agra CEAS calculations based on F.O. Licht (2004; 2007; 2009); Smeets et al. (2005); OECD (2006); GTZ (2007); FAO (2009); World Bank and OECD Indicators; European Commission data.

Table 2: Cost³ of producing bio-ethanol in FEMIP countries using domestic wheat as feedstock

Biofuel: Feedstock: Country:	Bio-ethanol								
	Wheat								
	Algeria	Egypt	Israel	Jordan	Lebanon	Morocco	G/WB	Syria	Tunisia
Plant size (m ³ /year bio-ethanol)	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Plant cost (€ million)	135	135	135	135	135	135	135	135	135
Interest rate (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%
Depreciation period (years)	10	10	10	10	10	10	10	10	10
Annual capital cost (€/litre bio-ethanol)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Feedstock conversion (tons feedstock per m ³ bio-ethanol)	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79
Feedstock price (€/ton feedstock)	228.28	105.07	131.45	186.21	200.06	225.99	202.88	194.47	178.17
Feedstock costs (€/m³ bio-ethanol)	636.90	293.16	366.76	519.52	558.17	630.50	566.04	542.57	497.10
Labour cost (€/m ³ bio-ethanol)	9.02	8.53	13.02	8.47	9.55	8.22	13.02	8.30	8.91
Processing costs (excl. labour & energy) (€/m ³ bio-ethanol)	107.71	107.71	107.71	107.71	107.71	107.71	107.71	107.71	107.71
Processing costs (excl. energy) (€/m³ bio-ethanol)	116.73	116.24	120.74	116.19	117.26	115.93	120.74	116.01	116.62
Energy use: heat (MBTU/m ³ bio-ethanol)	10.15	10.15	10.15	10.15	10.15	10.15	10.15	10.15	10.15
Energy price: natural gas (€/MBTU)	0.25	0.11	16.93	7.94	9.53	4.06	12.17	0.18	4.41
Energy use: electricity (kWh/m ³ bio-ethanol)	-	-	-	-	-	-	-	-	-
Energy price: electricity (€/kWh)	-	-	-	-	-	-	-	-	-
Total energy costs (€/m³ bio-ethanol)	2.51	1.07	171.94	80.60	96.72	41.19	123.58	1.79	44.78
Gross production costs (€/m³ bio-ethanol)	756.14	410.47	659.43	716.30	772.14	787.63	810.36	660.37	658.49
Animal feed co-product conversion (tons per ton feedstock)	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343	0.343
Animal feed co-product value (€/ton co-product)	262.52	120.84	151.17	214.14	230.07	259.89	233.32	223.64	204.90
Glycerine value (€/m ³ bio-ethanol)	-	-	-	-	-	-	-	-	-
Vinasse value (€/m ³ bio-ethanol)	-	-	-	-	-	-	-	-	-
Total by-product credit (€/m³ bio-ethanol)	251.23	115.64	144.67	204.92	220.17	248.70	223.28	214.02	196.08
Net production costs (€/m³ bio-ethanol)	504.91	294.83	514.76	511.38	551.97	538.92	587.08	446.36	462.41
Net cost of biofuel (€/litre)	0.50	0.29	0.51	0.51	0.55	0.54	0.59	0.45	0.46
Net cost of biofuel (incl. capital cost) (€/litre)	0.58	0.37	0.59	0.59	0.63	0.62	0.66	0.52	0.54
Net cost of biofuel - fuel equivalent (€/litre)	0.77	0.45	0.78	0.77	0.84	0.82	0.89	0.68	0.70
Net cost of biofuel (incl. capital cost) - fuel equivalent (€/litre)	0.88	0.56	0.90	0.89	0.95	0.93	1.01	0.79	0.82

Source: Agra CEAS calculations based on F.O. Licht (2004; 2007; 2009); Smeets et al. (2005); OECD (2006); GTZ (2007); FAO (2009); World Bank and OECD Indicators; European Commission data.

Table 3: Cost³ of producing bio-ethanol in FEMIP countries using domestic sugar beet, maize and sugar cane as feedstock

Biofuel: Feedstock: Country:	Bio-ethanol									
	Sugar beet				Maize				Sugar cane	
	Egypt	Lebanon	Morocco	Syria	Egypt	Israel	Morocco	Syria	Egypt	Morocco
Plant size (m ³ /year bio-ethanol)	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000
Plant cost (€ million)	70	70	70	70	63	63	63	63	66	66
Interest rate (%)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Depreciation period (years)	10	10	10	10	10	10	10	10	10	10
Annual capital cost (€/litre bio-ethanol)	0.06	0.06	0.06	0.06	0.04	0.04	0.04	0.04	0.04	0.04
Feedstock conversion (tons feedstock per m ³ bio-ethanol)	9.26	9.26	9.26	9.26	2.44	2.44	2.44	2.44	11.70	11.70
Feedstock price (€/ton feedstock)	15.32	63.94	30.20	37.24	93.43	408.40	184.13	135.59	14.72	20.38
Feedstock costs (€/m³ bio-ethanol)	141.88	592.05	279.64	344.88	227.98	996.49	449.28	330.84	172.26	238.42
Labour cost (€/m ³ bio-ethanol)	8.53	9.55	8.22	8.30	4.65	6.51	4.52	4.56	9.14	8.26
Processing costs (excl. labour & energy) (€/m ³ bio-ethanol)	107.71	107.71	107.71	107.71	61.02	98.65	98.65	98.65	60.86	60.86
Processing costs (excl. energy) (€/m³ bio-ethanol)	116.24	117.26	115.93	116.01	65.67	112.11	112.11	112.11	69.99	69.12
Energy use: heat (MBTU/m ³ bio-ethanol)	10.15	10.15	10.15	10.15	9.89	16.18	16.18	16.18	-	-
Energy price: natural gas (€/MBTU)	0.11	9.53	4.06	0.18	0.08	12.70	3.04	0.13	-	-
Energy use: electricity (kWh/m ³ bio-ethanol)	-	-	-	-	-	-	-	-	-	-
Energy price: electricity (€/kWh)	-	-	-	-	-	-	-	-	-	-
Total energy costs (€/m³ bio-ethanol)	1.07	96.72	41.19	1.79	0.78	205.57	49.25	2.14	-	-
Gross production costs (€/m³ bio-ethanol)	259.19	806.02	436.77	462.68	294.43	1,314.16	610.64	445.08	242.25	307.54
Animal feed co-product conversion (tons per ton feedstock)	0.06	0.06	0.06	0.06	0.313	0.313	0.313	0.313	-	-
Animal feed co-product value (€/ton co-product)	119.78	228.07	257.63	221.70	93.43	408.40	184.13	135.59	-	-
Glycerine value (€/m ³ bio-ethanol)	-	-	-	-	-	-	-	-	-	-
Vinasse value (€/m ³ bio-ethanol)	-	-	-	-	-	-	-	-	5.95	5.95
Total by-product credit (€/m³ bio-ethanol)	66.55	126.71	143.14	123.17	71.36	311.90	140.62	103.55	5.95	5.95
Net production costs (€/m³ bio-ethanol)	192.64	679.31	293.63	339.51	223.08	1,002.26	470.01	341.53	236.31	301.59
Net cost of biofuel (€/litre)	0.19	0.68	0.29	0.34	0.22	1.00	0.47	0.34	0.24	0.30
Net cost of biofuel (incl. capital cost) (€/litre)	0.25	0.74	0.36	0.40	0.26	1.04	0.51	0.38	0.27	0.34
Net cost of biofuel - fuel equivalent (€/litre)	0.29	1.03	0.44	0.51	0.34	1.52	0.71	0.52	0.36	0.46
Net cost of biofuel (incl. capital cost) - fuel equivalent (€/litre)	0.39	1.12	0.54	0.61	0.39	1.57	0.77	0.57	0.42	0.51

Source: Agra CEAS calculations based on F.O. Licht (2004; 2007; 2009); Smeets et al. (2005); OECD (2006); GTZ (2007); FAO (2009); World Bank and OECD Indicators; European Commission data.

Table 4: Retail petrol and diesel fuel prices, 2006¹ (€/litre)

	Diesel	Subsidy/ tax element	Gasoline	Subsidy/ tax element	Overall subsidy/ tax classification (diesel and gasoline)
Algeria	0.15	0.40	0.26	0.24	Very high fuel subsidy ²
Egypt	0.10	0.45	0.24	0.26	Very high fuel subsidy ²
Israel	1.01	-0.46	1.17	-0.67	Very high fuel taxation ⁵
Jordan	0.36	0.19	0.69	-0.19	Fuel taxation ⁴
Lebanon	0.49	0.06	0.59	-0.09	Fuel taxation ⁴
Morocco	0.69	-0.14	0.97	-0.47	Fuel taxation ⁴
Gaza/West Bank	0.78	-0.23	1.03	-0.53	Very high fuel taxation ⁵
Syria	0.10	0.45	0.48	0.02	Fuel subsidies ³
Tunisia	0.45	0.10	0.66	-0.16	Fuel taxation ⁴

Notes: ¹Annual average price in 2006. Average 2006 US\$:€ 0.79703. More recent prices were not considered appropriate given that neither 2007 nor 2008 were typical years in terms of energy prices.

² **Very high fuel subsidy** – the retail price of fuel (average of diesel and gasoline) is below the price of crude oil on the world market.

³ **Fuel subsidies** – the retail price of fuel is above the price of crude oil on the world market and below the price level of the USA (i.e. diesel US\$0.69/litre (€0.55/litre); gasoline US\$0.63/litre (€0.50/litre)). Fuel prices in the USA are average cost-covering retail prices including industry margin, VAT and include approximately \$0.10 for two road funds (federal and state). This fuel price being without other specific fuel taxes may be considered as the international minimum benchmark for a non-subsidised road transport policy.

⁴ **Fuel taxation** – the retail price of fuel is above the price level of the USA and below the price level of Luxembourg (i.e. diesel US\$1.14/litre (€0.91/litre); gasoline US\$1.29/litre (€1.03/litre)). The fuel prices in Luxembourg reflect an orientation level in the EU. Prices in EU countries are subject to VAT, an EU minimum taxation of €0.287/litre on unleaded gasoline and €0.245/litre on diesel, as well as other country-specific duties and taxes.

⁵ **Very high fuel taxation** – the retail price of fuel is above the price level of Luxembourg.

Source: GTZ (2007)

Table 5: Estimated cost³ of producing bio-diesel in FEMIP countries using domestic castor bean and jatropha oil as feedstock

Country:	FEMIP			
Biofuel:	Biodiesel			
Feedstock:	Castor bean oil		Jatropha oil	
	Low feedstock price	High feedstock price	Low feedstock price	High feedstock price
Plant size (m ³ /year biodiesel)	227	227	227	227
Plant cost (€ million)	42	42	42	42
Interest rate (%)	6%	6%	6%	6%
Depreciation period (years)	10.0	10.0	10.0	10.0
Annual capital cost (€/litre biodiesel)	0.02	0.02	0.02	0.02
Feedstock conversion (tons oil per m ³ biodiesel)	0.91	0.91	0.91	0.91
Feedstock price (€/ton oil)	205.00	275.00	352.00	431.00
Feedstock costs (€/m³ biodiesel)	186.55	250.25	320.32	392.21
Labour cost (€/m ³ biodiesel)	5.57	5.57	5.57	5.57
Processing costs (excl. labour & energy) (€/m ³ biodiesel)	63.88	63.88	63.88	63.88
Processing costs (excl. energy) (€/m³ biodiesel)	69.45	69.45	69.45	69.45
Energy use: heat (MBTU/m ³ biodiesel)	-	-	-	-
Energy price: natural gas (€/MBTU)	-	-	-	-
Energy use: electricity (kWh/m ³ biodiesel)	50.00	50.00	50.00	50.00
Energy price: electricity (€/kWh)	0.07	0.07	0.07	0.07
Total energy costs (€/m³ biodiesel)	3.70	3.70	3.70	3.70
Gross production costs (€/m³ biodiesel)	259.70	323.40	393.47	465.36
Animal feed co-product conversion (tons per ton feedstock)	-	-	-	-
Animal feed co-product value (€/ton co-product)	-	-	-	-
Glycerine value (€/m ³ biodiesel)	49.34	49.34	49.34	49.34
Vinasse value (€/m ³ biodiesel)	-	-	-	-
Total by-product credit (€/m³ biodiesel)	49.34	49.34	49.34	49.34
Net production costs (€/m³ biodiesel)	210.36	274.06	344.13	416.02
Net cost of biofuel (€/litre)	0.21	0.27	0.34	0.42
Net cost of biofuel (incl. capital cost) (€/litre)	0.23	0.30	0.37	0.44
Net cost of biofuel - fuel equivalent (€/litre)	0.23	0.30	0.38	0.46
Net cost of biofuel (incl. capital cost) - fuel equivalent (€/litre)	0.26	0.33	0.41	0.49

Source: Agra CEAS Consulting

Table 6: Estimated 2nd generation bio-ethanol and syndiesel production costs

Biofuel	Feedstock	Year	Plant size	Feedstock cost	Conversion cost	Co-product credit	Total cost	
			m ³	€/GJ biofuel	€/GJ biofuel	€/GJ biofuel	€/GJ biofuel	€/litre
Bio-ethanol	Cellulosic biomass	2015	90,000	9.57	9.57	-	19.14	0.41
		2022	360,000	9.57	6.83	-	16.06	0.34
	Sugar cane (Brazil)	2008	250,000	5.26	4.78	-	10.05	0.21
	Wheat (EU)	2008	250,000	24.74	7.18	4.10	27.81	0.59
Syndiesel	Cellulosic biomass	2015	80,000	8.20	11.62	-	20.16	0.69
		2022	280,000	8.20	5.47	-	13.67	0.61
Bio-diesel	Palm oil (Indonesia/Malaysia)	2008	220,000	36.73	1.85	1.16	17.84	0.59
	Rapeseed oil	2008	220,000	27.68	1.85	1.16	28.29	0.94

Note: Feedstock costs are 2008 average prices and could be adjusted for different feedstock prices. Lignocellulosic feedstock cost is \$105/dry ton (equivalent to \$5.8/GJ). This is an indicative average wood fuel price for the UK in 2008. Average 2008 US\$:€ 0.68341.

Source: E4tech (unpublished data).

FEMIP for the Mediterranean



Facility for Euro-Mediterranean Investment and Partnership



The FEMIP countries² encompass a land area of some 421 million hectares, of which just over 5% or 23.9 million hectares in 2007 were used for crop production. Desert occupies approximately 90% of total FEMIP land area, ranging from 20% in Lebanon, 59% in Israel to 95% in Algeria, Egypt and Jordan. Analysis of the physical and agroclimatic conditions prevalent in the FEMIP region indicates that only a relatively small proportion of land area is currently suited to biofuel feedstock production.

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