HELLENIC REPUBLIC
MINISTRY OF DEVELOPMENT
DIRECTORATE GENERAL FOR ENERGY
RENEWABLE ENERGY SOURCES AND ENERGY SAVING DIRECTORATE

1st NATIONAL REPORT REGARDING PROMOTION OF THE USE OF BIOFUELS OR OTHER RENEWABLE FUELS FOR TRANSPORT IN GREECE FOR THE PERIOD 2005 – 2010

(ARTICLE 4 OF DIRECTIVE 2003/30/EC)

ATHENS, JULY 2004

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1. INTRODUCTION

Directive 2003/30/EC of the European Parliament and the Council of 8 May 2003 aims at promoting the use of biofuels or other renewable fuels to replace diesel or gasoline for transport in each Member State, with a view to contributing to objectives such as meeting climate change commitments, as well as promoting environmental-friendly security of supply and renewable energy sources. In this context, Member States should ensure that a minimum share of biofuels or other renewable fuels is placed on their markets and, to that effect, they shall set national indicative targets.

In an effort to implement this Directive in the national legislation so that biofuels or other renewable fuels are introduced in the Greek transport fuel market, the Hellenic Ministry of Development has started an intensive elaboration with local stakeholders (Ministry of Economy and Finance, General State Chemical Laboratory, refineries, fuel trade companies, companies interested in biofuels production, Ministry of Rural Development and Foods and other Ministries and Institutions that could be involved in this matter), as well as experts from other European countries and DG TREN of European Commission, assisted by the Laboratory of Fuel Technology and Lubricants of the National Technical University of Athens and the Center of Renewable Energy Sources (CRES). The main issues to be considered are the following:

- the current status of the biofuel market and the readiness of Greece to produce biofuels at local level and distribute them through the existing fuel market infrastructure,
- the status of the current National Legislation regarding the use of transport fuels and additional legislative initiatives needed to promote biofuels,
- the potential to produce biofuels from agricultural crops produced domestically,
- the measures needed for the promotion of biofuels including the assessment of various detaxation scenarios for the gradual introduction of biofuels in the local fuel market.

This continuing elaboration concluded so far that two biofuels are more promising for Greece: biodiesel and bioethanol, which are analyzed in the following chapters.

2. BIODIESEL

2.1. Current Situation

The consumption of automotive diesel fuel used in transport in Greece for year 2002 amounted to 1.925.000 tons, while data for year 2003 are not yet available.

Until now in Greece there has been no consumption of biodiesel as automotive fuel, in the form of domestic production or imports. There is the exception of the period 1998-2000 where small quantities of biodiesel were imported by a fuel trade company for a demonstration field test, selling blends of 5% and 7% biodiesel in automotive diesel from its outlets in the region of Thraki, with very promising results.

Regarding local biodiesel production, currently two plants are under construction, one in Kilkis with an estimated startup in December 2004 and a maximum annual capacity of 40.000 tons, whereas a second one of equal capacity is under construction in Volos with estimated startup in May 2005. Both companies received financial aid from the Operational Programme for Competitiveness (OPC). According to their production planning, the plant in Kilkis is estimated to produce 40.000 tons of biodiesel during the year 2005, whereas the plant in Volos is estimated to produce 15.000 - 20.000 tons for the same period, which means a total local production of 55.000 - 60.000 tons of biodiesel for the year 2005. Some additional small quantities of imported biodiesel are also anticipated. It should be noted that the biodiesel distributed in the Greek fuel market shall meet the EN 14214 specifications.

Furthermore, several other companies have expressed their interest to the Ministry of Development, to build their own small and medium scale biodiesel production plants (annual capacity 10.000 – 30.000 tons) in various regions of Greece. Since they are in the initial stage of planning no further details are available, but, provided that construction starts before end of 2004, their production start-up could be anticipated for the second half of 2005.

2.2. Estimation of Biodiesel Required

In order to estimate the quantities of biodiesel required for the period 2005 - 2010 to satisfy the needs of Greece, according to the principles set in Directive 2003/30/EC, the following procedure is followed:

- The consumption of automotive diesel for the period 2005 - 2010 is estimated using regression analysis based on the automotive diesel consumption for the period 1992 – 2002. Details may be found in Appendix - 1.
- The lower calorific value (LCV) of automotive diesel is considered to be 10.200 kcal/kg, whereas the LCV of biodiesel is taken as 9.050 kcal/kg (which is the average of various grades of biodiesel produced by sunflower oil, corn oil, olive oil and used fried oils respectively, since these raw materials are available in Greece and could be used for biodiesel production).
- The density of automotive diesel is considered to be 845 kg/m^3.

The results for the indicative percentages of biodiesel used every year are presented in Table 1.

Table 1: Amount of Biodesel required per penetration percentage annually

Year	Estimated Automotive Diesel Consumption (000 tons)	Percentage of Biodiesel used	Biodiesel Required (tons)
2005	2.084	2,00%	**46.976**
2006	2.125	3,00%	**71.851**
2007	2.167	4,00%	**97.695**
2008	2.208	4,50%	**111.986**
2009	2.249	5,00%	**126.739**
2010	2.290	5,75%	**148.407**

2.3. Implementation Planning

From the experience gained in other European countries which already use biodiesel, it is known that biodiesel presents no handling and transportation problems when introduced in the local fuel market (refineries & fuel trade companies), especially as blends of up to 5% by volume (v/v) with diesel, where also no technical obstacles arise for older diesel-fueled cars.

Based on that fact, during the initial stage of biodiesel penetration in Greek market, Greece is considering to have the biodiesed blended with automotive diesel in the local refineries, following regulations set in the standard EN 590:2004, i.e. mixtures of FAME biodiesel up to 5% v/v with regular automotive diesel, while biodiesel shall meet the requirements of EN 14214. According to this approach, the mixture percentage will be set each year by the Ministry of Development and the Ministry of Economy & Finance, according to the quoted available quantities of biodiesel in the local market. Then this mixture will be distributed through the existing automotive diesel fuel market infrastructure.

In order to consider higher concentrations of biodiesel in diesel, Greece is aiming to carry out additional studies on diesel-fueled targeted fleets, in order to assess the mid- and long-term full engine effects. Since most of the diesel-fueled vehicles in Greece are old with engines meeting Euro-0 or Euro-1 standards, there is the concern that some problems may arise in the elastomers or other parts of the engines.

Regarding feedstock for biodiesel production, the two plants under construction will mainly use imported oils (rapeseed oil, soybean oil, etc), as well as some domestically produced oils (cotton seed oil, used fried oils, etc). At a later stage, they are planning to organize local cultivation of various oleiferous crops. The involvement of the Ministry of Rural Development and Foods (former Agriculture) is of paramount importance, in order to assist Greek farmers to re-organize their cultivations with the introduction of energy crops suited to the local conditions.

3. BIOETHANOL

3.1. Current Situation

The consumption of automotive gasoline fuels in Greece for year 2002 amounted to 2.572.000 tons for unleaded and 920.000 tons for LRP, i.e. total gasoline at 3.492.000 tons, while data for year 2003 are not yet available.

So far, there has been no consumption of bioethanol as automotive fuel in Greece, in the form of domestic production or imports and thus, the existing bioethanol production is directed exclusively to the alcoholic-beverage industry. However, quite recently, interest has been expressed by a company to build the first plant for automotive bioethanol production in the country. However no furthers details are available, since they are yet in the initial stage of planning,.

This prospect will certainly assist Greek farmers in the introduction of alternative cultivations of energy crops, as explained in detail in the next chapter.

3.2. Estimation of Bioethanol Required

In order to estimate the quantities of bioethanol required for the period 2005 - 2010 to satisfy the needs of Greece, according to the principles set in Directive 2003/30/EC, the following procedure was followed

- The consumption of automotive gasolines for the period 2005 - 2010 is estimated using regression analysis based on the gasoline consumption for the period 1990 - 2002. Details may be found in Appendices 2-4.
- Since the excise tax for LRP is different from unleaded gasoline, regression analysis and forecast calculations are performed separately for each one.
- The lower calorific value (LCV) of gasoline is considered to be 10.444 kcal/kg, whereas the LCV of bioethanol is taken as 6.429 kcal/kg.
- The density of gasoline is considered to be 766 kg/m^3.

The results for the indicative percentages of bioethanol used every year are presented in the Tables 2a-2c.

Table 2a: Amount of Bioethanol required per penetration percentage annually for Leaded/LRP Gasoline

Year	Estimated Leaded/LRP Gasoline Consumption* (000 tons)	Percentage of Bioethanol used	Bioethanol Required (tons)
2005	652	2,00%	25.562
2006	537	2,50%	21.809
2007	422	3,00%	20.566
2008	307	4,00%	19.949
2009	192	5,00%	15.595
2010	77	5,75%	7.192

* It should be noted that LRP gasoline may be phased out earlier than predicted.

Table 2b: Amount of Bioethanol required per penetration percentage annually for Unleaded Gasoline

Year	Estimated Unleaded Gasoline Consumption (000 tons)	Percentage of Bioethanol used	Bioethanol Required (tons)
2005	3.055	2,00%	99.258
2006	3.263	2,50%	132.520
2007	3.470	3,00%	169.112
2008	3.677	4,00%	238.934
2009	3.885	5,00%	315.562
2010	4.092	5,75%	382.232

Table 2c: Amount of Bioethanol required per penetration percentage annually for Total Gasoline

Year	Estimated Total Gasoline Consumption (000 tons)	Percentage of Bioethanol used	Bioethanol Required (tons)
2005	3.707	2,00%	**120.442**
2006	3.800	2,50%	**154.329**
2007	3.892	3,00%	**189.678**
2008	3.984	4,00%	**258.883**
2009	4.077	5,00%	**331.157**
2010	4.169	5,75%	**389.424**

3.3. Implementation Planning

After detailed elaboration, some potential technical obstacles in the introduction of bioethanol as mixture with gasoline have emerged.

Firstly, bioethanol when blended in gasoline tends to separate in the presence of water. The degree of separation depends on the quantity of water present in the mixture, the aromatics present in the gasoline, the ambient temperature, etc. This is of paramount importance for the Greek fuel distribution network, since the local fuel distribution system on the islands and some coastal areas consists of a common pipeline for the transfer of all liquid fuels from the carrier ship to the local central fuel tanks. During this procedure a water-pillow is used to separate the various fuel products. This fact increases the possibility of presence of significant amounts of water in the gasoline/bioethanol mixture when transferred through this system.

In addition, a known issue when mixing bioethanol with gasoline is the increase of Reid Vapour Pressure (RVP), resulting in gasoline blend to be out of specification according to EN 228:2004, especially during summer when the RVP limit is lower.

In view of this situation, it has been decided that bioethanol be converted into ETBE (Ethyl Tertiary Butyl Ether) in the refineries, using the existing MTBE (Methyl Tertiary Butyl Ether) production units, which need only minor alterations and replacement of methanol feed-in with bioethanol. Then ETBE is added into gasoline, replacing MTBE.

ETBE blend with gasoline does not present any of the previously mentioned technical obstacles and is widely used in most Southern European countries (Spain, Italy and France). Furthermore, ETBE can be added into gasoline up to 15% v/v, compared to 5% v/v of bioethanol, according to EN 228:2004.

Another issue that care should be taken of is attempts of adulteration of automotive bioethanol (that would receive special detaxation status) with the cheaper chemically produced ethanol, which is chemically identical and very difficult to be identified especially in mixtures. This issue is resolved with the denaturation of automotive bioethanol with ETBE inside the production plant.

Above prospect is commonly accepted by local refineries and fuel trading companies, as well as General State Chemical Laboratory, as the best way to introduce bioethanol into gasoline market.

4. RESOURCES FOR BIOFUELS IN GREECE

4.1. Introduction

This section presents the available resources in Greece for the production of liquid biofuels, namely biodiesel and bioethanol. It provides information on the type and available quantities of resources per biofuel.

4.2. Background to the Greek Agriculture

Agriculture is an important sector of economic activity in Greece accounting for 6% of GDP and 20% of employment. Agriculture's contribution to GDP has been declining, while agricultural employment expressed as a share of total employment has shrunk by a 5 percentage since the early 1990s.

From the total area of Greece of 13,2 Mha (million hectares), the land devoted to agriculture constitutes 9,2 Mha, from which 5,2 Mha are pastureland, 3,9 Mha are cultivated with various crops and about 0,5 Mha are left fallow every year. From the cultivated land area, 2,78 Mha are arable and approximately 0,5 Mha is fallow land.

The agricultural sector receives high financial support, the majority of which comes from the EU Common Agricultural Policy (CAP) schemes. Cotton, wheat, olive oil and tobacco are the most heavily protected products, attracting most of the support allocations, while the remaining funds aim at production restructuring under the European Agricultural Guidance and Guarantee Fund (EAGGF). Most of the national funds are earmarked for investments, including improvements of rural infrastructure and comparable grants for farm modernisation programmes eligible for EU support. A significant part of these funds also consists of support to young farmers, early retirement of farmers and preservation of the countryside. In addition to such direct support, substantial indirect support comes from national sources to fund a non-contributory scheme for farmers' pensions.

The Greek agricultural sector suffers from structural weaknesses which result in poor international competitiveness. Structural impediments to enhance productivity are mostly due to the large number of small inefficient farms, of a size being just 25% of the EU average.

4.3. Average Yields of Crops Suitable for Biofuel Production

Table 3 gives the yields of several crops cultivated in Greece suitable for biodiesel or bioethanol production.

Table 3: Biofuel yields for agricultural crops in Greece

Biofuel	Raw material	Yields (kg/ha)	Yields in biofuel (lt/ha)
Biodiesel	Sunflower	1.200 – 3.000	430 - 1.100
	Rapeseed	1.200 - 2.500	430 - 900
Bioethanol	Wheat	2.500 – 5.000	750 - 1.500
	Corn	9.000	2.700
	Sugar beets	50.000	5.000
	Sweet sorghum	60.000 - 90.000	6.000 - 9.000

4.4. Potential Crops for Biodiesel Production in Greece

In Greece, four oleiferous crops (groundnut, sesame, soybean and sunflower) are currently cultivated for their seeds. Among them, groundnut, sesame and soybean are cultivated in a relatively small area, while sunflower is cultivated in relatively larger area in the northern part of the country. These crops are traditionally used mainly for oil extraction and edible seed.

In the last few decades, the area cultivated with groundnut, sesame and soybean has significantly declined, while sunflower presented an upward trend since 1993. Meanwhile, rapeseed cultivation is still at demonstration scale.

4.4.1. Sunflower

In 2001, about 13% (7,6 Mtons) of the world total seed oils production was sunflower oil, with EU being one of the leading producers. Its oil content ranges from 25 to 48% and crude protein from 15 to 20% (suitable for cattle feeding). The oil content of the Greek cultivated varieties ranges from 40 to 45% and crude protein from 15 to 20%. The respective seed yields range from 1,3 to 3 tons/ha.

Sunflower is the leading farming among the four oleiferous crops cultivated today in Greece and is mainly grown in the northern regions of the country (Macedonia and Thraki). It should be noted that the area cultivated and seed production have shown a significant growth over the last decade.

4.4.2. Groundnut

Groundnut is worldwide grown as an annual crop mainly for its seed. The seed oil content ranges from 40 to 50% and protein from 25 to 40%. Its unshelled seed yields range from 0,3 to 4 tons/ha, depending upon variety, soil, climate and applied cultivation practices. The average seed yield for the Greek climate is 2,6 tons/ha.

In Greece, groundnut is exclusively grown in spring for its seeds, which are consumed mainly as dry nuts and seeds. Its cultivation is dominant in the southern part of the country (Peloponnisos) and to a minor extent to the north (Macedonia). It should be noted that the area cultivated and seed production have dramatically decreased over the last decade.

4.4.3. Sesame

Sesame is mainly grown for its seed production, while its cake is used as a protein-rich animal feedstock. The sesame seed oil content ranges from 44 to 63% and protein from 19 to 26%. Average seed yields range from 0,5 to 2,5 tons/ha depending upon variety, climate and applied cultivation practices. For profitable commercial production 2 tons/ha is required, this level being achieved in many countries.

Sesame cultivation is spread all over Greece with focus on the Southern and Eastern Aegean islands. It should be noted that the area cultivated and seed production dropped dramatically over the last decade.

4.4.4. Soybean

The world soybean production amounted to 156 Mtons in 1999-2000, with yields ranging between 2,3 to 4 tons/ha. This production represents about 52% of total global oilseed production. About 11% of soybean oil is produced in the EU-15. Soybean is mainly cultivated for its seeds that are utilized commercially for human consumption, animal feed and extraction of oil. Its seeds usually contain 15-22% oil, while the protein ranges from 40 - 50%. Average soybean seed yields range from 1,5 to 3,5 tons/ha.

In Greece, soybean is grown in the western (Ipiros) and the southern region (Peloponnisos) of the country, while a small amount comes from the northern region. It should be mentioned that the area cultivated and seed production dropped dramatically over the last decade, while a respective increase in imports has taken place.

4.4.5. Rapeseed

In 2001, about 12% (13,5 Mtons) of the world oil production was rapeseed oil, of which 26% was produced in EU. The world production of rapeseed was 38,5 Mtons in 2001-2002, with France and Germany being the leading producers, accounting for 11% and 9% of the world production, respectively.

Rapeseeds usually contain 30-50% oil (up to 60% has been observed), while the rape cake contains a considerable amount of crude protein (10-45%).

In Greece, rapeseed can be cultivated as a winter or spring annual crop. At the moment, no statistical data are available, since its cultivation has been conducted on experimental and demonstration scale only. The ability to grow at low temperatures is the most important feature of rapeseed compared to the other oleiferous crops grown in Greece.

Results from an experiment conducted by CRES and lasting four years (1997-2000) have shown high average yields up to 17 tons dry biomass/ha and 0,7-3 tons seed/ha, depending on the prevailing soil/climate conditions.

Figure 1 shows the regions where sunflower is cultivated, as well as rapeseed experimental sites.

4.4.6. Cotton

Cotton constitutes one of the most dynamic crops in Greece. It is cultivated in central and southern Greece. The area cultivated and seed production has almost doubled over the last decade. It is used in the textile, plastic materials, oil production and soap industries, as well as animal feed and fertilizer. However, cottonseed oil is considered a potential feedstock for biodiesel production in Greece.

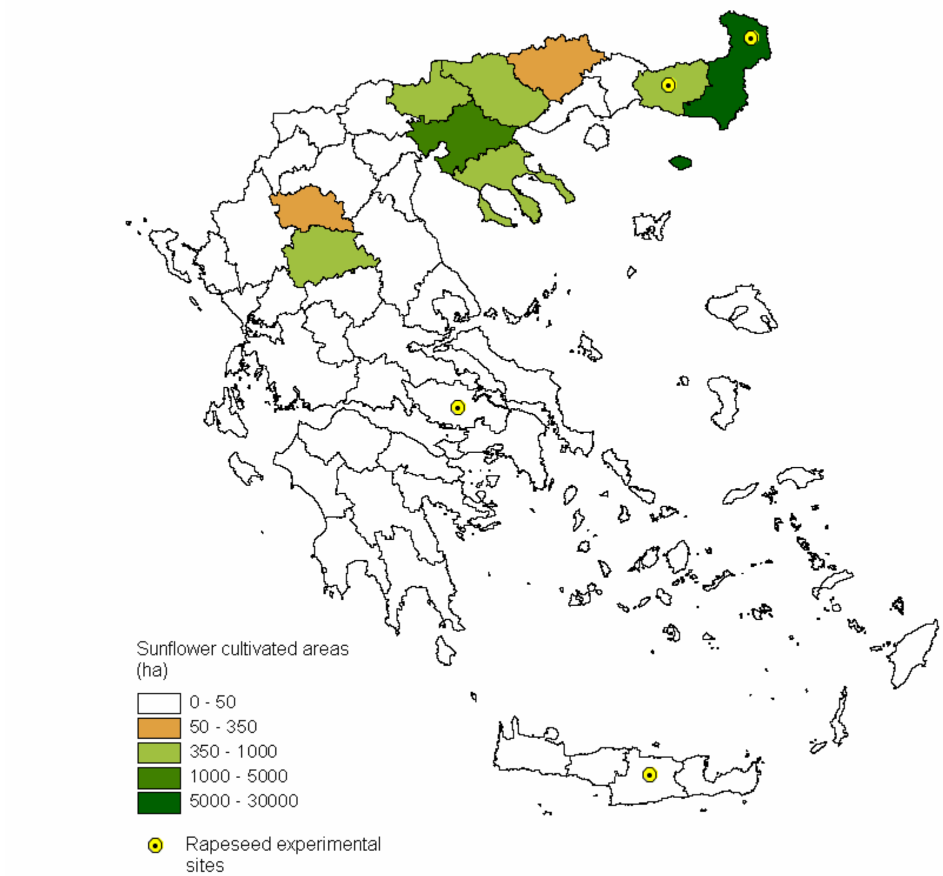


Figure 1: Regions of sunflower cultivated area (ha) in Greece and location of rapeseed experimental sites.

4.4.7. Other Oleiferous Crops

According to recent preliminary studies carried out by CRES and NTUA, tobacco seed oil and tomato seed oil have given very promising results as alternative feedstock for biodiesel production in Greece. It should be noted that both seeds are produced in sufficient quantities every year as by-products of tobacco cultivation and tomato juice industry respectively.

4.4.8. Properties of Seed Oils

A summary of the physical and chemical properties of various seed oils produced in Greece is presented in Table 4. It is notable that heating values are in the range of 30 to 40 MJ/kg which are low compared to diesel fuels (about 45 MJ/kg).

Table 4: Physical and chemical properties of various seed oils produced in Greece

Properties	Sunflower	Corn	Soybean	Sesame	Cotton	Rapeseed	Peanut
Density (kg/l)	0,916	0,909	0,914	0,913	0,916	0,915	0,903
Heating value (MJ/kg)	39,6	39,5	39,6	39,3	39,5	39,7	39,8
Kinematic Viscosity at 38°C (mm^2/sec)	33,9	34,9	32,6	35,5	33,5	37	39,6
Iodine mumber	125,5	122,6	112,5	106,6	105,7	130	80-106
Cetane number	37,1	37,6	37,9	40,2	41,8	37,6	41,8
Flash point (°C)	274	277	254	260	234	246	271
Pour point (°C)	-15	-40	-12,2	-9,4	-15	-31,7	-6,7
Cloud point (°C)	7,2	-1,1	-3,9	-3,9	1,7	-3,9	12,8
Ash (% wt)	<0,01	0,01	<0,01	<0,01	0,01	0,054	0,005
Sulphur (% wt)	0,01	0,01	0,01	0,01	0,01	0,01	0,01

The chemical and physical properties of the crude seed oils can be improved through transesterification, bringing about a lowering of viscosity and a small increase in cetane number and heating value, close to those of diesel fuel.

Additionally, the chemical properties of various biodiesel qualities produced from different seed oils available in Greece, as compared to the EN 14214 Standard values, are listed in Table 5.

Table 5: Physical and chemical properties of biodiesel from various seed oils produced in Greece

Properties	Sunflower oil	Corn oil	Soybean oil	Cotton oil	Rapeseed oil	EN 14214 standard
Density (kg/l)	0,860	0,886	0,885	-	0,882	0,860-0,900
Kinematic Viscosity at 38°C (mm^2/sec)	4,6	4,5	4,08	-	4,58	3,5-5
Iodine number	125,5	115	133,2	105,7	97,4	max 120
Cetane number	49	65	45	51,2	52,9	min 51
Flash point (°C)	183	111	178	110	170	min 120

4.4.9. Imports and Exports of Oleiferous Seeds and Oils

Although Greece has negligible production for some of the previously mentioned oleiferous crops (e.g. soybean and rapeseed), it has significant imports and exports of various oleiferous seeds and oils suitable for biodiesel production.

Tables 6 and 7 show imports, exports and the corresponding average prices of the most important oleiferous seeds and oils for the period 2000-2003.

Concerning oleiferous seed imports during the same period, soybean seeds represent the highest quantities with an increase from 250.000 to 390.000 tons. Sunflower seed imports are also important, but they have decreased from 75.000 to 40.000 tons. Moreover, cottonseeds have the highest import average price (1,71 - 1,85 €/kg); this price is very high compared to the other oleiferous seeds prices, which vary between 0,20 to 0,55 €/kg. This is due to the great importance of cotton cultivation in Greece (19,35% of the total agricultural crops).

Table 6: Greek imports of oleiferous seeds and oils for the period 2000-2003

Year	**2000**		**2001**		**2002**		**2003**	
Product	**Tons**	***Avg. price (€/kg)***	**Tons**	***Avg. price (€/kg)***	**Tons**	***Avg. price (€/kg)***	**Tons**	***Avg. price (€/kg)***
Oleiferous seeds								
Soybean seeds	243.991	*0,22*	375.635	*0,23*	334.912	*0,23*	391.337	*0,24*
Rape seeds	143	*0,26*	21	*0,32*	24	*0,54*	91	*0,39*
Sunflower seeds	73.948	*0,22*	58.407	*0,24*	28.250	*0,30*	42.890	*0,25*
Cotton seeds	3.721	*1,75*	8.896	*1,83*	12.263	*1,71*	7.869	*1,85*
Seed oils								
Soybean oil	2.016	*0,43*	1.048	*0,51*	1.262	*0,95*	2.252	*0,59*
Palm oil	30.093	*0,43*	44.496	*0,38*	41.186	*0,40*	50.330	*0,43*
Sunflower oil	19.602	*0,50*	27.532	*0,57*	36.066	*0,68*	56.778	*1,61*
Cottonseed oil	194	*0,72*	454	*0,60*	5.985	*0,60*	487	*0,88*
Rapeseed oil	150	*0,70*	99	*0,93*	48	*1,25*	82	*0,81*

Concerning seed exports for the same period, cottonseeds represent the highest quantities, although they have decreased from 200.000 to 165.000 tons. It is notable that their export average price (0,13 - 0,27 €/kg) is much lower than their respective import price.

Concerning vegetable oil imports for the same period, palm oil and sunflower oil are the highest at 50.000 tons each in 2003, although sunflower oil is characterized by the highest average price. In addition, imported quantities of these two products have increased over the last four years.

Concerning seed oil exports for the same period, soybean oil is the highest, its exports having increased from 16.000 to 23.000 tons, while its average export price is 0,50 €/kg. These large quantities of exported soybean oil can be justified by the increased imported quantities of soybean seeds.

Table 7: Greek exports of oleiferous seeds and oils for the period 2000-2003

Year	2000		2001		2002		2003	
Product	**Tons**	***Avg. price (€/Kg)***	**Tons**	***Avg. price (€/Kg)***	**Tons**	***Avg. price (€/Kg)***	**Tons**	***Avg. price (€/Kg)***
Oleiferous seeds								
Soybean seeds	2	*0,72*	1.630	*0,24*	1.148	*0,28*	19	*0,78*
Rape seeds	0	*0,49*	-	-	-	-	-	-
Sunflower seeds	174	*1,01*	774	*0,74*	788	*0,65*	2.274	*0,37*
Cotton seeds	203.372	*0,13*	191.394	*0,16*	193.273	*0,27*	164.468	*0,20*
Seed oils								
Soybean oil	16.178	*0,49*	17.266	*0,43*	21.659	*0,47*	22.875	*0,50*
Palm oil	1.592	*0,38*	746	*0,54*	1.695	*0,55*	1.347	*0,57*
Sunflower oil	6.501	*0,53*	2.951	*0,54*	3.396	*0,70*	7.077	*0,62*
Cottonseed oil	12.701	*0,43*	8.651	*0,42*	9.087	*0,52*	7.749	*0,60*
Rapeseed oil	241	*0,46*	1.391	*0,57*	559	*0,57*	-	-

Another important issue is that the average price of exported sunflower oil is much lower than the corresponding price of the imported one, while, as mentioned before, Greece has sufficient sunflower seeds production and imports. These market characteristics make sunflower oil a good candidate for biodiesel production in Greece. Furthermore, soybean oil and palm oil may also be considered as feedstock for biodiesel production, although they have important alternative uses.

4.5. Potential Crops for Bioethanol Production in Greece

Bioethanol can be produced from carbohydrates such as sugar, starch and cellulose by fermentation using yeast or other organisms.

Resources for ethanol production may include grains, sugar beets, potatoes or other starchy crops. Among the crops currently cultivated in Greece, there are several options, such as cereals (durum and soft wheat, oats, barley, maize) and sugar beets. Considerable research efforts have also been made during the last decade on sweet sorghum as a potential bioethanol resource.

Figures 2 and 3 illustrate the cultivated area and the respective production of the potential crops for bioethanol production for each Greek administrative region.

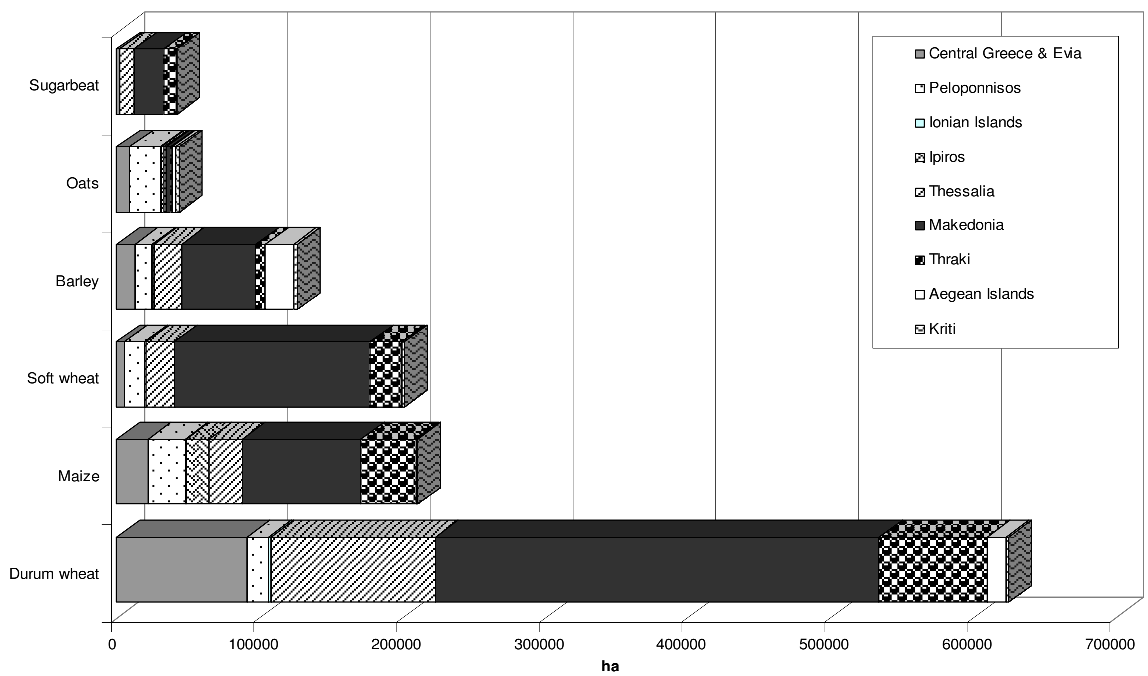


Figure 2: Cultivated area in hectares of the potential crops for bioethanol production per Greek administrative region.

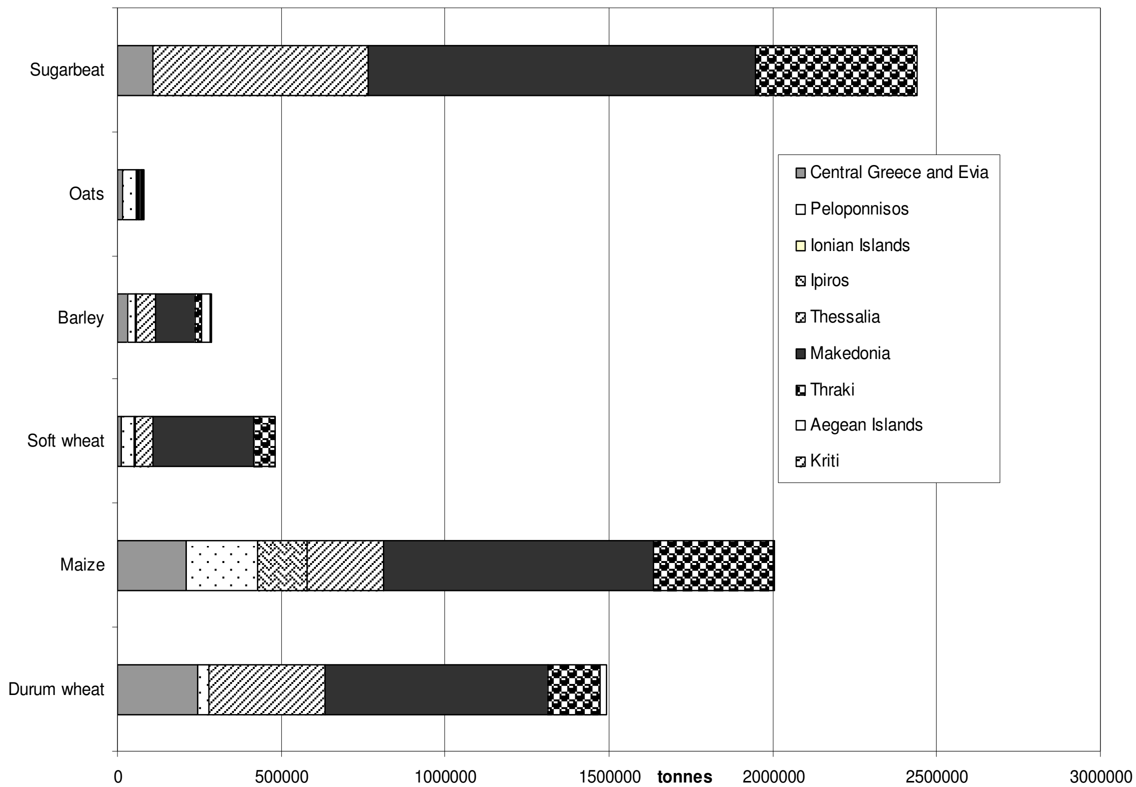


Figure 3: Respective production in tons of the potential crops for bioethanol production per Greek administrative region.

4.5.1. Wheat

Wheat is an annual grass belonging to the family of cereals and can be seen as a representative for several grain crops (barley, rice etc). World-wide it is the most important cereal crop with a total grain production of 585 Mtons/year.

In Greece, wheat (durum and soft) is the most widely cultivated annual crop with grain production of 2 Mtons/year and respective cultivated area of 827.000 ha.

During the last decade the cultivated area with wheat has been reduced in Western Europe, but wheat grain production has remained rather constant indicating a slight increase in yields. The same pattern stands for Greece, where a reduction of approximately 0,15 Mha has been noted.

Wheat yields in Greece and in other Southern European countries are much lower (2,7 - 5 tons/ha in Greece) than the yields achieved in Central Europe. In general, yields depend upon climate and soil conditions, as well as other factors such as variety of cultivar, size of kernel, etc.

4.5.2. Maize

Maize is an annual plant which also belongs to the cereal grain crop category. Its height varies greatly, according to plant growth conditions and genetics practices applied. Maize is highly efficient under conditions of elevated temperatures and solar radiation. The nutritional value of maize is lower than most other cereals but, after wheat and rice, is the most important cereal in the world. Western European countries are the largest importers of maize, since this crop is not cultivated as widely as wheat.

The highest proportion of maize production is directly used for animal feed. Furthermore, significant amounts of corn are yearly used for human consumption, in fresh, canned or frozen forms. Finally, maize corn can be converted into various industrial products, including starch, syrup, dextrin, corn oil, etc. These substances are used in the printing, confectionery, leather tanning, plastics, food, brewing, soap, paint, and textile industries.

In Greece, the total cultivated area with maize is approximately 0,21 Mha with an average yield of 10,6 tons/ha, which is among the highest in European countries; the average yield of maize in Central Europe is 8,02 tons fresh matter/ha. The total usable production of maize in Greece is 2 Mtons/year, most of which is directly used as animal feed.

Maize propagates by seeds, and its cultivation requires similar operations to those for wheat cultivation. Seed rates of 11,5-16 kg/ha are considered normal.

4.5.3. Sugar Beet

Cultivated forms of sugar beet are biennial plants, which are grown for their roots. The beet roots contain up to 20% (on fresh weight basis) sugar, thus making sugar beet the second most important source of sugar in the world, after sugar cane. This sugar content can be recovered by appropriate processing of the beet roots. During processing, several by-products can also be obtained, like molasses, dried pulp and filter cake.

Molasses are usually combined with beet pulp to provide animal food or used as fermentation feedstock in chemical and pharmaceutical industries for bio-products such as citric acid and its esters.

Sugar beet is cultivated in all countries of Central and Southern Europe. In Greece the average yield is about 57,5 tons fresh matter/ha. Due to the high moisture content of the roots (85%), the average dry yield of sugar beet is 9,5 odt/ha/year.

4.5.4. Sweet Sorghum

During the last decade, several experiments have been performed in seven different locations throughout Greece, testing yield performance and energy content of sweet sorghum grown under several rates of irrigation and nitrogen fertilisation. The most important findings of this research were:

1. Fresh biomass yields ranged between 100 to 120 tons/ha, depending on the site and the variety tested, with a stem percentage of 85-90 % of total fresh weight, while the various irrigation and nitrogen fertilization rates did not bring about pronounced differences.
2. Sugar percentage in sweet sorghum fresh stems ranged from 10 to 12 % wt.
3. The harvesting period could be extended from early September to late November without significant losses in the contained sugars.
4. Bioethanol production ranges from 6.500 to 8.000 lt/ha, in the case of sugar fermentation, and surpassing, in some cases, 10.000 lt/ha through one step fermentation of sugars and cellulose.
5. The bagasse (the solid residue left after fermentation) could provide energy of 0,5-0,8 toe, capable not only to meet the total energy requirements for ethanol production, but also to produce some extra electricity that could be sold.

Furthermore, CRES in collaboration with the Laboratory of Biosystems Technology and the Laboratory of Thermodynamics and Transport Phenomena of NTUA had carried out a research programme on one step (simultaneous) fermentation of cellulose and sugars for bioethanol production. Three scenarios were tested, namely:

1. from a simple water extraction of fresh sweet sorghum stems, harvested in several dates, with the sole addition of yeast
2. from sorghum juice (obtained by pressure and the addition of yeast) and sorghum bagasse (mixed with yeast and Fusarium) and
3. from direct fermentation of ground stems (mixed with yeast and Fusarium).

4.6. Conclusions

Summarizing the above information, it is concluded that both the qualitative (fuel properties) and quantitative (land use, yielding capacities, prices, etc) data presented indicate that future biofuels (biodiesel and bioethanol) production in Greece can be supported to a major extent from indigenous resources. More specifically:

Biodiesel

Oleiferous crops (groundnut, sesame, soybean, sunflower and others) are currently cultivated in Greece for their seed production, used mainly for oil extraction and edible seed. Among them, groundnut, sesame and soybean are cultivated in a relatively small area. On the other hand, the total cultivated area of sunflower is much higher, since the crop is traditionally used for food. Cottonseed oil represents a promising raw material for biodiesel production. Rapeseed is still on an experimental and demonstration scale, however it presents good adaptability and high yields. From preliminary studies, also tobacco seed oil and tomato seed oil look very promising as alternative feedstock for biodiesel production.

Bioethanol

Cereals (durum and soft wheat, barley and, in a smaller extent, oats), maize and sugar beets are the traditional crops that could be redirected wholly or partially to bioethanol production in Greece. However, based on the yielding capacity shown in Table 3, it is evident that the most promising option is sweet sorghum.

5. NATIONAL RESOURCES ALLOCATED TO THE PRODUCTION OF BIOMASS FOR ENERGY USES OTHER THAN TRANSPORT

5.1. Introduction

Renewable energy sources (RES) contributed 4,2% (1,28 Mtoe) to the Greek Total Primary Energy Supply (TPES) in 2002, as shown in Table 8. Out of this, energy production from biomass accounted for 78% (1 Mtoe), from which domestic use of wood (burned in open heaths for cooking, water and space heating) accounted for 71% (0,7 Mtoe). The remaining 29% (0,3 Mtoe) was produced by the combustion of wood by-products and agricultural residues, as well as biogas from landfills, agro-food industries and municipal wastewater treatment plants.

It should be noted that several plants producing heat and/or electricity using biogas from landfills, wastewater treatment plants or other sources have so far been constructed or are being planned for implementation in the near future; detailed analysis follows.

Table 8: RES contribution in Greek energy balance for 2002

Energy Balance 2002	ktoe	%
Solid Fuels	**8.980**	**29,45%**
Liquid Fuels	**16.985**	**55,71%**
Gaseous Fuels	**1.801**	**5,91%**
RES:	**1.284**	**4,21%**
Solar	*102*	*0,33%*
Wind	*151*	*0,50%*
Biomass - Industry	*243*	*0,80%*
Biomass - Household	*705*	*2,31%*
Biomass - Transport	*0*	*0,00%*
Biogas	*48*	*0,16%*
Small Hydro (up to 10 MW)	*35*	*0,11%*
Large Hydro (over 10 MW)	**614**	**2,01%**
Pumped Storage	**154**	**0,51%**
Imports - Exports	**672**	**2,20%**
TOTAL	**30.490**	**100,00%**

5.2. Biomass for Heat Production

Biomass heat production is mainly applied to the agricultural and forestry industries using the respective residues (food industry, cotton ginning, wood processing, olive pomace and pits, rice husks, fruit kernels, etc.).

There are also three plants in the sewage treatment sector. Table 9 presents the plants that use biomass for heat production per resource type.

Table 9: Plants producing thermal energy from biomass per sector in Greece in 2002

Type	**Consumption (tons)**	**Thermal energy produced (TJ)**
FUEL WOOD COMBUSTION		
Domestic use	1.298.520	29.388
BIOGAS COMBUSTION		
Food industry residues		27
Sewage treatment plants		779
Total		*806*
RESIDUE COMBUSTION		
Wood residues	85.774	1.166
Cotton ginning residues	24.637	306
Dry olive kernels	500.000	8.372
Husks/Kernels	677	13
Rice residues	5.799	92
Straw	0	0
Total	*616.887*	*9.949*
TOTAL	**1.915.407**	**40.143**

In detail:

- Several cotton ginning factories use their residues to produce the heat required for cotton drying and space heating of their facilities. The total thermal energy produced has been estimated to 306 TJ/year.
- The olive kernel wood produced in the olive kernel factories is being used for greenhouse heating, space heating, etc. The total thermal energy produced has been estimated to 8.372 TJ/year.
- Fruit kernels produced by fruit canneries and shells from almond, walnut and hazelnut peeling plants are being used for greenhouse and residential heating. The annual thermal energy production has been estimated to 12,6 TJ/year.

- Rice husk is used to produce the heat needed by the rice processing factories. The annual thermal energy production has been estimated to 92 TJ/year. There is also a factory using rice husk for power generation with an installed capacity of 0,44 MW_e.

5.3 Biomass for Electricity Production

From 1950 to 1994 Public Power Corporation (PPC) was the only utility producing and distributing electricity in Greece. The PPC power system consists of the interconnected mainland system (with some nearby islands are also connected), the systems of Crete and Rhodes and the other autonomous systems of the remaining islands. Since 1994 it was allowed to auto-producers and independent producers to produce electricity using RES, whereas the deregulation of the electricity market initiated in 1999.

The first attempts in Greece to produce electricity from biomass were focused to projects that were undertaken for environmental reasons (sewage treatment plants, gas from sanitary landfills). There are two plants (one of demonstration scale) using landfill gas that produce only electricity (see Table 10) and several others that also produce heat (co-generation units, see Table 11).

Table 10: Plants producing electricity from biomass in Greece in 2002

Company	Fuel	Installed capacity (MW_e)	Electricity produced (MWh/y)
Municipality of Thessaloniki	Landfill gas	0,24	720
Consortium, Ano Liosia (municipal & private)	Landfill gas	13,80	89.995
TOTAL		**14,04**	**90.715**

Co-generation (CHP) plants using biomass with a 22 MW_e total capacity are already installed, while future projects for additional 58 MW_e have already been granted power generation authorization by the Ministry of Development following a recommendation of the Regulatory Authority for Energy (RAE), as shown in Table 12.

Meanwhile, industries are trying for the first time anaerobic digestion for the production of electricity, while other technologies are also taken under consideration.

Table 11: Co-generation (CHP) plants using biomass in Greece in 2002

Company	Fuel	Installed electrical capacity (MW_e)	Installed thermal capacity (MW_{th})	Electricity produced (MWh/y)	Thermal energy produced (MWh/y)
Water Entity, Psyttalia	Sewage treatment (ST) biogas	7,37	10,20	35.000	204.639
Municipality Entity, Volos	ST biogas	0,35	0,70	20	2.917
Municipality Entity, Heraklio	ST biogas	0,19	0,53	258	2.972
Municipality Entity, Chania	ST biogas	0,17	0,29	44	1.000
Agrino	Rice industry residues	0,16	4,30	0	20.611
TOTAL		**8,24**	**16,02**	**35.322**	**232.139**

Table 12: Biomass CHP projects that have received power generation authorization

Region	Installed capacity (MW_e)	Fuel	Technology
Tebloni, Corfu	3,00	Landfill gas	2*1,35 MW engines
Thermi, Thessaloniki	8,00	Landfill gas	6*1,35 MW engines
Liosia, Attiki	9,50	Landfill gas	7*1,4 MW engines
Grevena	0,37	Wood residues	Combustion
Metamorfosi, Attiki	0,67	ST biogas	Anaerobic digestion
Patra, Achaia	0,90	ST biogas	Anaerobic digestion
Sparti, Lakonia	3,00	fruit peels and fibres	Anaerobic digestion
Fillipiada, Preveza	4,09	pig manure	Anaerobic digestion
Xanthi	9,50	Municipal solid waste (MSW)	Gasification
Rodos, Dodekanisa	0,50	MSW	Gasification
Meligalas, Messinia	8,14	Prunings	Gasification, 6*1,356 MW engines
Meligalas, Messinia	5,00	Dried olive stones	Fluidized bed combustion, steam turbine
Heraklio, Crete	5,42	Dried olive stones	Fluidized bed combustion, steam turbine
TOTAL	**58.09**		

6. PROMOTION POLICIES AND MEASURES

6.1 Legislative and institutional issues

Directive 2003/30/EC will be incorporated into national legislation at the instigation of the Ministry of Development, included in the ongoing amendment of Law 3054/2002 concerning the use and distribution of fuels in the market, thus allowing the use of biofuels. It is anticipated that definite decisions will be announced in autumn 2004 together with the setting of national indicative targets for the first phase of biofuels implementation.

Meanwhile, the General State Chemical Laboratory (GSCL) has already started the incorporation in the national legislation of standards EN 590:2004 concerning automotive diesel fuel requirements and test methods, EN 228:2004 concerning automotive gasoline fuel requirements and test methods and EN 14214 concerning automotive FAME biodiesel specifications. This procedure is expected to be completed by the end of 2004, allowing the use of biodiesel in the Greek fuel market.

Regarding bioethanol, GSCL seems reluctant to issue specifications before the EN standard is released by CEN, which is expected by late 2005. Therefore, introduction of bioethanol in the Greek gasoline market is expected to take place in 2006 or later.

6.2 Taxation Issues

In order to secure the competitiveness of biofuels vis-à-vis the conventional fuels, a detaxation policy may be applied according to the provisions of Directive 2003/96/EC.

Various detaxation scenarios, ranging from full to zero detaxation of biofuels, are currently examined, taking into account the effect of the introduction of biofuels on automotive diesel and gasoline retail prices. The total fiscal impact of biofuels detaxation could be as high as € 740 million for the period 2005 - 2010.

An elaborate analysis is needed, since the addition of biofuels to automotive fuels alters the economics and the operating features of automotive fuels.

The benefits to the agricultural sector from the cultivation of energy crops to produce biofuels will also be evaluated. Additionally, positive environmental impacts will be evaluated, since less CO_2 will be emitted to the atmosphere by the use of biofuels. Emission reductions must be quantified under the Kyoto protocol agreement. Furthermore, new jobs due to the introduction of biofuels will be assessed.

7. CONCLUSION

- The consumption of automotive fuels used for transport in Greece for year 2002 reached 1.925.000 tons for diesel, and 3.492.000 tons for total gasoline (2.572.000 tons for unleaded and 92.000 tons for LRP gasoline). The corresponding data for year 2003 are not yet available.
- Among the possible biofuels covered by the Directive 2003/30/EC which can be used as automotive fuels, in pure form or in mixtures, the most promising for Greece are biodiesel and bioethanol.
- Biodiesel can easily be accommodated to the existing automotive diesel fuel infrastructure, since it presents no problems during transportation and handling.
- Bioethanol in mixtures with gasoline poses technical obstacles, the most important being separation in presence of water under cold conditions and high vapour pressure (RVP) mainly in summer-specification gasolines. For this reason, it is planned to convert in refineries bioethanol into ETBE (Ethyl Tertiary Butyl Ether) and use this as a blending component into gasoline, replacing MTBE (Methyl Tertiary Butyl Ether).
- The amount of biodiesel required for year 2005, in order to meet the indicative target of 2% (on a lower calorific value basis), is estimated to 47.000 tons, whereas for year 2010, it amounts to 148.000 tons for a corresponding indicative target of 5.75%.
- Two biodiesel production plants are now constructed in Greece, one in Kilkis and the other in Volos. These plants will have a maximum capacity of 40.000 tons/yr each. Furthermore, several other companies have expressed their interest to build additional biodiesel plants in Greece.
- The amount of bioethanol required for year 2005, in order to meet the indicative target of 2% (on a lower calorific value basis), is estimated to 120.000 tons, whereas for year 2010, it amounts to 390.000 tons for a corresponding indicative target of 5.75%.
- There is no indigenous bioethanol production, although a company has recently informed the Ministry of Development for its intention to build an automotive bioethanol plant in Greece.

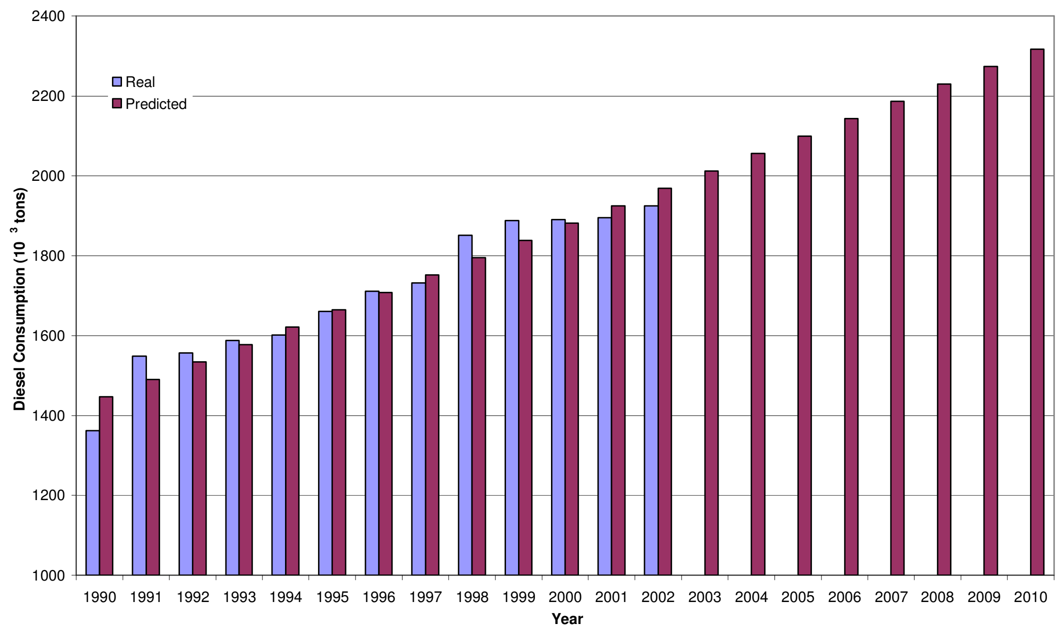
- There are several agricultural resources in Greece that could produce biodiesel and bioethanol.
- The procedure for incorporating in the national legislation the necessary technical specifications EN 590:2004 for automotive diesel, EN 228:2004 for gasoline and EN 14214 for automotive biodiesel is expected to be completed by year end. Bioethanol specifications will be issued by CEN by late 2005, therefore introduction of bioethanol in the Greek gasoline market is expected to take place in 2006 or later.
- Various taxation scenarios are currently being evaluated by the Ministry of Development and the Ministry of Economy & Finance. Full and partial detaxation of biofuels are considered, aiming to secure the biofuels penetration .
- By autumn 2004, the policy measures for the promotion of biofuels are expected to be finalized and they will be announced together with the national indicative targets for the first phase of implementation of Directive 2003/30/EC.

APPENDICES

**Prediction Models for the Estimation
of Automotive Fuels Consumption in Greece
up to the year 2010**

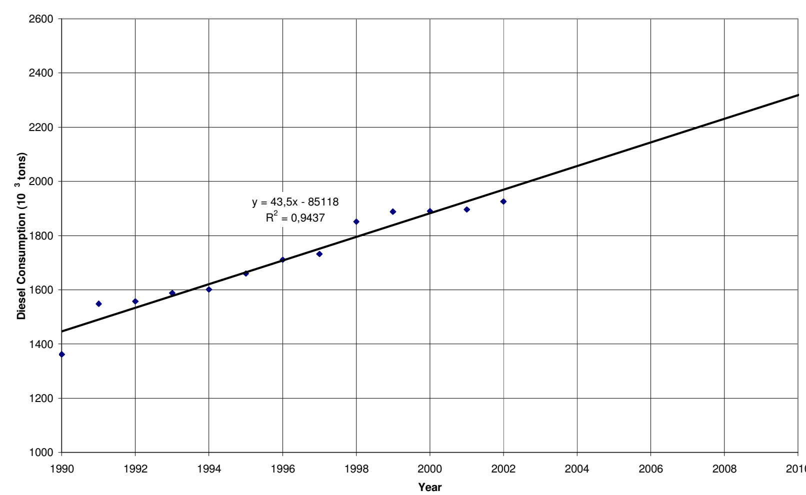
Estimation of Automotive Diesel Consumption in Greece up to the year 2010

Year	Automotive Diesel Consumption			
	Actual	Predicted	Residuals	Standardized Residuals
1992	1557	1548	-9	0,2856
1993	1588	1589	1	-0,0508
1994	1601	1631	30	-0,9794
1995	1660	1672	12	-0,3947
1996	1711	1713	2	-0,0733
1997	1732	1754	22	-0,7387
1998	1851	1796	-55	1,8197
1999	1888	1837	-51	1,6807
2000	1890	1878	-12	0,3903
2001	1896	1919	23	-0,7686
2002	1925	1960	35	-1,1708
2003		2002		
2004		2043		
2005		2084		
2006		2125		
2007		2167		
2008		2208		
2009		2249		
2010		2290		



Regression Statistics	
Multiple R	0,9762
R Square	0,9529
Adjusted R Square	0,9477
Standard Error	32,0435
Observations	11

Coefficients		Standard Error	t Stat	P-value
b	-80576,4	6101,289	-13,2065	3,39E-07
a	41,22727	3,055223	13,49403	2,82E-07

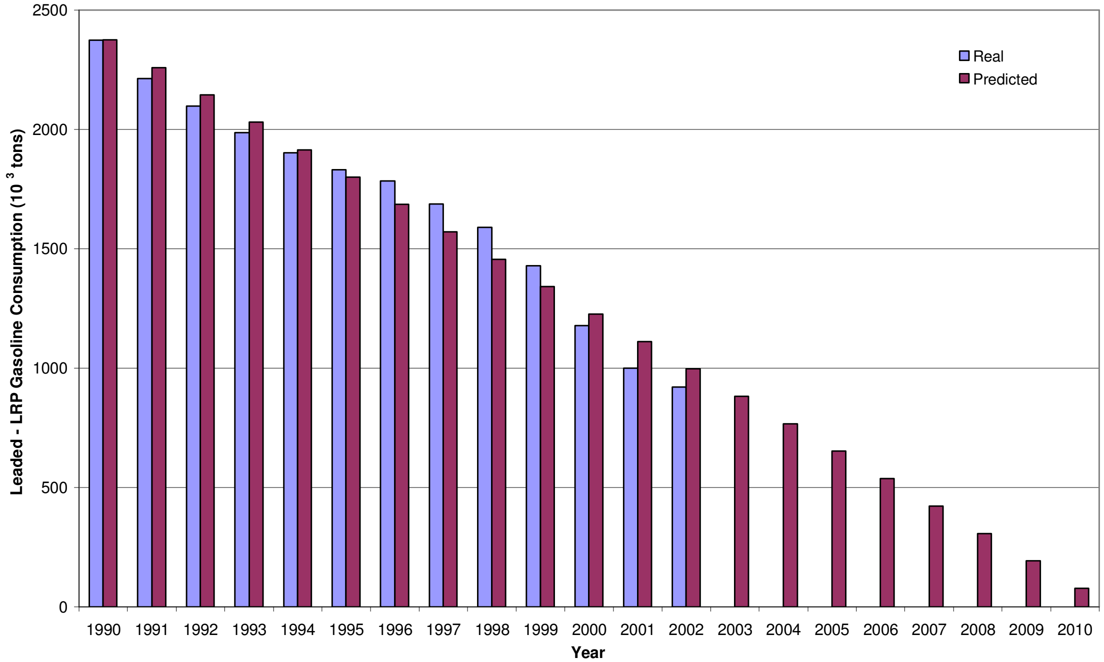


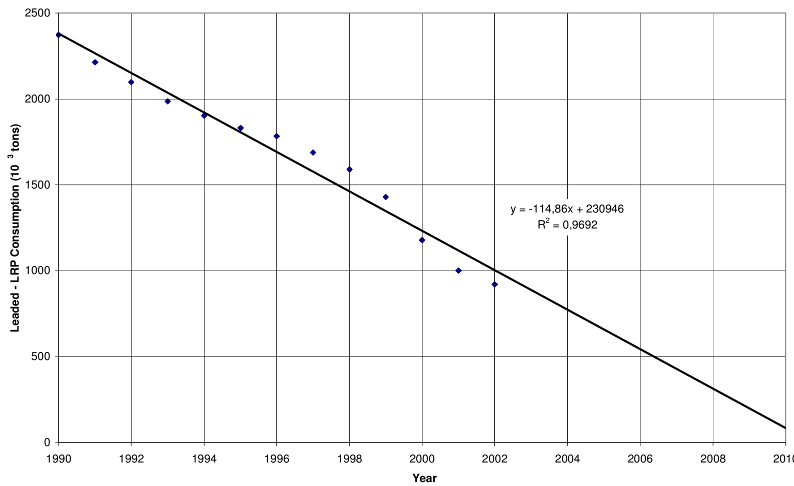
Estimation of leaded/LRP Gasoline Consumption in Greece up to the year 2010

Year	Leaded/LRP Gasoline Consumption			
	Real	Predicted	Residuals	Standardized Residuals
1990	2373	2375	2	-0,0963
1991	2213	2260	47	-0,6622
1992	2098	2145	47	-0,6640
1993	1986	2030	44	-0,6282
1994	1902	1915	13	-0,2414
1995	1831	1800	-31	0,3084
1996	1783	1685	-98	1,1466
1997	1688	1571	-117	1,3955
1998	1590	1456	-134	1,6068
1999	1428	1341	-87	1,0158
2000	1178	1226	48	-0,6783
2001	1000	1111	111	-1,4699
2002	920	996	76	-1,0329
2003		881		
2004		767		
2005		652		
2006		537		
2007		422		
2008		307		
2009		192		
2010		77		

Regression Statistics	
Multiple R	0,9845
R Square	0,9692
Adjusted R Square	0,9664
Standard Error	83,3173
Observations	13

Coefficients		Standard Error	t Stat	P-value
b	230946,4	12327,1	18,73486	1,08E-09
a	-114,857	6,17589	-18,5977	1,16E-09



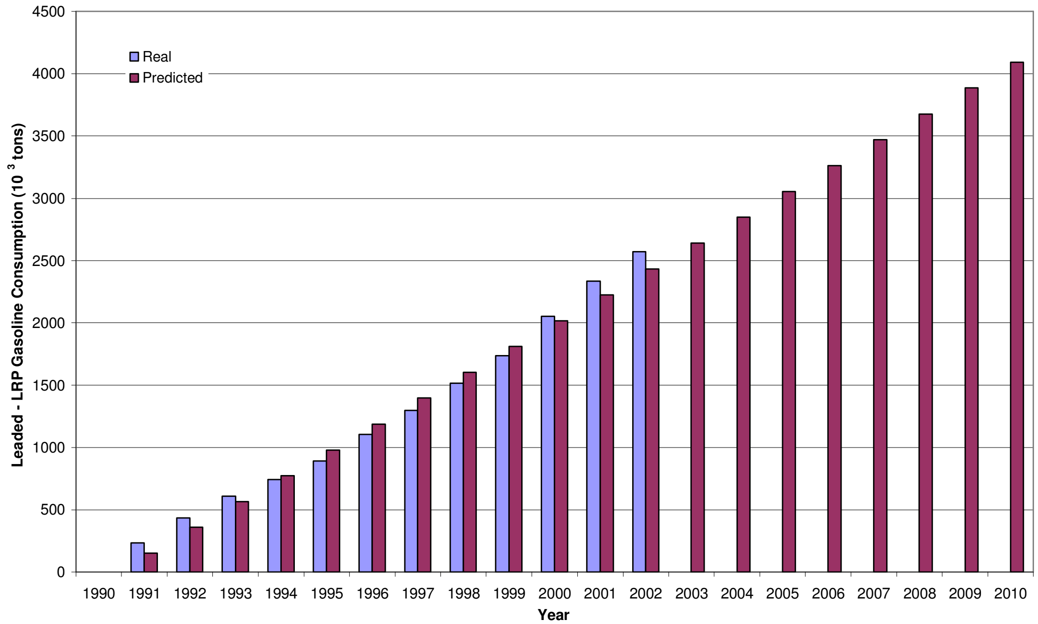


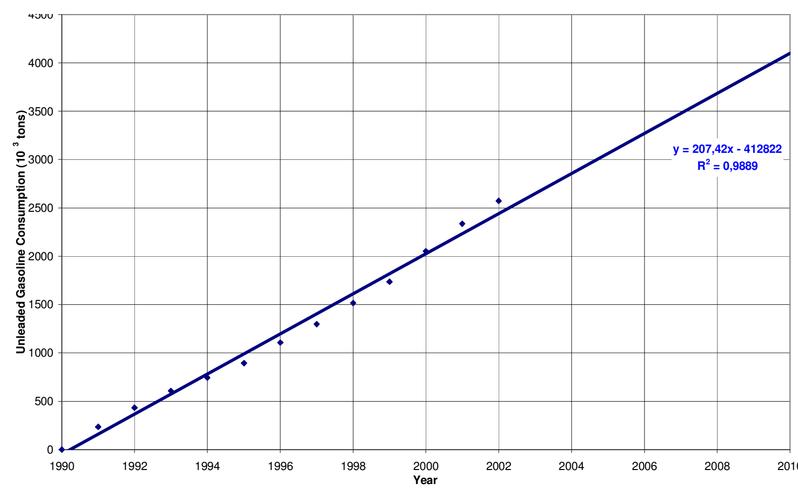
Estimation of Unleaded Gasoline Consumption in Greece up to the year 2010

Year	Unleaded Gasoline Consumption			
	Real	Predicted	Residuals	Standardized Residuals
1990	0		0	0,5848
1991	234	151	-83	0,8956
1992	434	359	-75	0,8088
1993	608	566	-42	0,4179
1994	743	773	30	-0,4291
1995	893	981	88	-1,1008
1996	1107	1188	81	-1,0238
1997	1297	1396	99	-1,2276
1998	1516	1603	87	-1,0922
1999	1737	1811	74	-0,9334
2000	2052	2018	-34	0,3248
2001	2336	2225	-111	1,2204
2002	2572	2433	-139	1,5546
2003		2640		
2004		2848		
2005		3055		
2006		3263		
2007		3470		
2008		3677		
2009		3885		
2010		4092		

Regression Statistics	
Multiple R	0,9944
R Square	0,9889
Adjusted R Square	0,9879
Standard Error	89,3027
Observations	13

	Coefficients	Standard Error	t Stat	P-value
b	-412822	13212,65	-31,2444	4,28E-12
a	207,4231	6,619555	31,3349	4,15E-12





Estimation of the Total Gasoline Consumption in Greece up to the year 2010

Year	Predicted Total Gasoline Consumption		
	Leaded/LRP	Unleaded	TOTAL
1990	2375		**2375**
1991	2260	151	**2411**
1992	2145	359	**2504**
1993	2030	566	**2596**
1994	1915	773	**2689**
1995	1800	981	**2781**
1996	1685	1188	**2874**
1997	1571	1396	**2966**
1998	1456	1603	**3059**
1999	1341	1811	**3151**
2000	1226	2018	**3244**
2001	1111	2225	**3337**
2002	996	2433	**3429**
2003	881	2640	**3522**
2004	767	2848	**3614**
2005	652	3055	**3707**
2006	537	3263	**3799**
2007	422	3470	**3892**
2008	307	3677	**3984**
2009	192	3885	**4077**
2010	77	4092	**4170**