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Assessment Studies for Specific Biogas Sites in the target region of Greece

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Contents

Summary

Biogas can be produced of nearly all kinds of organic materials. Nowadays in Europe, there are quite a few biogas process volumes at the current wastewater treatment plants, landfill gas installations, and industrial biowaste processing facilities. However, the largest volume of produced biogas will be, by 2020, originate from farm biogas and from large co-digestion biogas plants, integrated into the farming – and food – processing structures[1].

In Greece the picture is different as the produced biogas derives mainly from landfills, wastewater treatment plants and a couple of industrial applications. Although Greece has a promising potential of organic wastes and especially animal manure currently there is no farm scale biogas plant. It is worth mentioning that taking into account only the breeding animals in Greece (cattle and pigs) and based on different assumptions, several authors have estimated that the theoretical annual manure production comes up to 10-17 million tones[2].

Currently, in Greece there are about 33,000 calf-breeding farms with 723,000 breeding animal heads, 36,500 pig-breeding farms with 140,600 sows, 2,500 olive oil mills, 25 secondary olive residues treatment facilities and a considerable number of food industries. According to estimates made by CRES[3], and based on a conservative scenario, it is estimated that the AD of manure and organic wastes from the slaughter houses and milk factories could feed CHP plants of total installed capacity of 350 MW and a mean annual electricity production equal to 1.121,39 GWhe.

In Greece there are several suitable sites for biogas exploitation. Three of them were chosen, based mainly to the BIG>EAST Guidelines, results obtained within the project and CRES experience and continues work on biogas exploitation in Greece. Generally, promising areas for Biogas exploitation in Greece can be considered the following:

- Crete island (Region)
- Lakonia (Prefecture)
- Evia island (Prefecture)
- Aitoloakarnania (Prefecture)
- Preveza (Prefecture)
- Thessaly (Region)
- Central Macedonia (Region)

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1 Nielsen J. and P. Oleskowicz-Popiel (2007): The future of Biogas in Europe: Visions and Targets until 2020, European Biogas Workshop The Future of Biogas in Europe – III, Esbjerg, Denmark.

2 Nielsen J. and P. Oleskowicz-Popiel (2007): The future of Biogas in Europe: Visions and Targets until 2020, European Biogas Workshop The Future of Biogas in Europe – III, Esbjerg, Denmark.
Zafiris C. (2007): Biogas in Greece: Current situation and perspectives, European Biogas Workshop The Future of Biogas in Europe – III, Esbjerg, Denmark.
Boukis I. and A. Chatziathanassiou (2000): State of Biogas production, energy exploitation schemes and incentives in Greece, 1st World Conference on Biomass for Energy and Industry, pp. 1346-1349.
University of MISKOLC (2008): A computer aided database "Estimation of the existing biomass potential for the conversion into biomethane taking into account the shares of all existing competitors", report of REDUBAD EIE-06-221 project, www.redubar.eu

3 Zafiris Christos (2007). Biogas in Greece. Current situation and prospectives. European Biogas Workshop proceedings "The Future of Biogas in Europe – III", University of Southern Denmark Esbjerg, Denmark 14-16 June 2007.

The basic characteristics of the three selected biogas sites are given below. More details can be found in the next chapters.

Biogas site 1: REGION OF STEREA ELLADA (Schimatari)

The livestock-farming plays an important role in the economical activity of the Prefectures of Viotia and Evia. The intensive livestock-farming is concentrated near the Metropolitan area of Athens namely the South East of Viotia and central Evia (near Chalkida) and it consists mainly by poultry and pig farms and then cattle breading. Viotia but mostly Evia is an interesting Prefecture concerning the number of pig farms, the maximum farm capacity (number of sow places), manure production and thus for future biogas exploitation.

Based on the mapping of the two Prefectures (Evia and Viotia) a promising site for biogas exploitation based mainly on pig manure can be located in the greater area between Evia island and the mainland. The planned biogas plant shall be operated with the input material of liquid manure from pigs, cows and chicken manure, fat, blood from slaughterhouse, dairy waste (Whey), katsigaros (waste of olive oil production) and food waste. The input materials come from agricultural and industrial companies in the nearby area of the plant. The plant can be located to the mainland in the greater area of Schimatari - Inofyta.

The plant is based on co-digestion of different types of feedstock in a two step process – first step thermophilic digester made at silo digesters at approx. 50-52^{o}C, and secondary digesters made at storage tanks operated on lower temperature (in practice 40-45^{o}C). The total amount of CH_4 production is approx. 3.7 Mm^3 (approx. installed capacity 1.7 MWe). In this case it is assumed that the biogas is utilised in a gas engine for the production of electricity for sale to the grid (14 GWh/year) and for heat production (16 GWh/year). The heat is mainly used for the process (approximately 60%) and no external heat sale is assumed (an alternative is the excess heat to be used in the nearby area, e.g. for space heating or other uses of the military campus). The plant as proposed will require a site of approx. 2.6 ha.

Biogas site 2: REGION OF DYTIKI ELLADA (Agrinio)

Aitoloakarnania is one of the biggest Prefectures in Greece and can be characterized as an agricultural area. The main agricultural products are olive oil, maize, tobacco, cotton. Based on the mapping of the Prefecture a significant biogas potential in the region comes mainly from manure in the area of Agrinio and dairy waste (whey) with co-digestion of maize silage, thus a biogas plants can be located in the greater area of Agrinio city.

The planned biogas plant shall be operated with the input material of liquid manure from pigs, dairy waste (whey), maize silage, katsigaros (waste of olive oil production) and fat, blood from slaughterhouses. The input materials come from agricultural and industrial companies in the vicinity of the plant. The farmers' harvest is directly brought to the place of the plant and discharged into the reception bunker. The plant can be located in the nearby area of Agrinio city (eg. Spolaita or Stratos community at a distance of 10km approx. NW of Agrinio city).

The plant is based on co-digestion of different types of feedstock in a two step process – first step thermophilic digester made at silo digesters at approx. 50-52^{o}C, and secondary digesters made at storage tanks operated on lower temperature (in practice 40-45^{o}C). The total amount of CH_4 production is approx. 9.7 Mm^3 (approx. installed capacity 4.4 MWe). In this case it is assumed that the biogas is utilised in a gas engine for the production of electricity for sale to the grid (36.7 GWh/year) and for heat production (41.8 GWh/year heat production). The heat is mainly used for the process (approx. 36%) and no external heat sale is assumed (an alterna-

tive is the excess heat to be used in the greenhouses in the nearby area). The plant as proposed will require a site of approx. 3 ha.

Biogas site 3: REGION OF THESSALIA (Trikala)

Trikala Prefecture is located in the centre of Greece and is about 331km far away from Athens. Based on the mapping of the Prefecture significant biogas potential comes mainly from manure and such a central AD plant can be located in the vicinity of Trikala city (eg. Municipality of Pialion). There is also the alternative of co-digestion with energy crops-agricultural residues (eg. maize silage) or agro-industrial residues (eg. Wastes form slaughterhouses or olive oil mills).

The plant is based on pig manure and a small proportion of maize silage co-digestion in a two step process – first step thermophilic digester made at silo digesters at approx. 50-52^{o}C, and secondary digesters made at storage tanks operated on lower temperature (in practice 40-45^{o}C). The total amount of CH_4 production is approx. 2 Mm^3 (approx. installed capacity 0.95 MWe). In this case it is assumed that the biogas is utilised in a gas engine for the production of electricity for sale to the grid (7.9 GWh/year electricity production) and for heat production (9 GWh/year). The heat is mainly used for the process (approx. 40%) and no external heat sale is assumed. The plant as proposed will require a site of approx. 2 ha.

In all the case studies the solid fertiliser (the fibre fraction) will sold as solid fertilizer and the liquid fertiliser will be supplied to farms where it can be utilised. Furthermore, the owner of the plant can be a private investor, a consortium or even a Public Private Partnership (PPPs).

Results within Step 1: Selection of the Region

Description of the selected regions for potential Biogas Sites

Greece is located to the south-eastern edge of Europe, occupies an area of 132,000 km^2 and has a population of 10.96 million according to the 2001 census (66% of which live in urban areas). Greece has peculiar geomorphology divided into the mainland with large mountainous areas and a vast number of islands reasons that affects to the development of energy infrastructure. The main economic activities in Greece are shipping and tourism. A large portion of the population is employed in the public sector and services, 20% in industry and 12% in the industrial sector.[4]

The term «biogas» hides a wide range not only in the ways in which it is valorised but also the technologies in which it is produced. In general all kind of organic substances can be used for biogas exploitation. The plant different feedstock affects also the biogas yield due to differentiations in the energy content. Biogas can be produced using digesters or collected by the landfill sites.

Feedstock for Anaerobic Digestion plants can be derived mainly from three major categories (sources of wastes):

- Municipal waste (eg. landfill gas and wastewater treatment plants)
- Industrial waste (eg. dairy industries, food/beverage industries, slaughterhouses)
- Agricultural waste & energy crops (eg. cattle-pig-poultry manure, energy crops, agricultural residues).

The produced municipal solid wastes are disposed in landfills where organic matter is decomposed producing landfill gas. Thus, landfill gas is one of the most attractive systems for producing electricity and heat and is already a well known and established technology in Greece. Furthermore, biogas coming from the anaerobic digestion of wastewater sludge has been utilized for energy production.

Biogas production from some kind of industrial wastes seems to be an attractive alternative for the Greek industrial sector too. In some cases like in food industries the influences contain high amounts of easy biodegradable organic compounds, so they can be used for biogas production and use the thermal or electrical energy produced. In this way anaerobic digestion can be considered more as an energy production method than as a treatment one.

In Greece, sheep, goats and lambs breeding represent the highest percentage of livestock and its breeding is mainly done by shepherds. The largest portion of Greek livestock farming is extensive where the produced manure is spread on the grazing land[5]. Taking into account that the livestock farming is extensive the potential users of biogas production are mainly livestock units and especially medium and large ones. It is worth mentioning that although Greece has a promising potential of organic wastes and especially animal manure currently there is no

[4] Ministry of Development (2007). 1st report for the long term Energy Policy in Greece 2008-2020, part 1, Athens August.

[5] Chatziathanassiou A., I. Boukis (2000). Constrains and Strategy for the Development of Anaerobic Digestion in Livestock Farming in Greece. !st World Conference on Biomass for Energy and Industry, Sevilla Spain 5-9 June 2000.

farm scale biogas plant. Furthermore, a CAD plant is a viable option and a promising solution.

Currently, in Greece there are about 33,000 calf-breeding farms with 723,000 breeding animal heads, 36,500 pig-breeding farms with 140,600 sows, 2,500 olive oil mills, 25 secondary olive residues treatment facilities and a considerable number of food industries[6].

Generally in Greece, the Anaerobic Digestion technology is used mainly as a waste treatment method but not accompanied with biogas and energy production (at least not in a wide extent at the moment). The general approach is that the waste are disposed after some treatment (aerobic or anaerobic) than the adaptation of a well know and integrated technology (AD) for parallel biogas production and the substrate use as fertilizer too. Furthermore, the wastes disposal (eg manure) creates so far only a few problems compared to what happen to the other EU Member States (eg. West Europe). Thus, the implementation of biogas schemes for reduction of water and soil pollution is not so imperative in Greece until now.

According to the Special Spatial Plan for RES the most suitable sites for biogas plants are considered those located near to the "feedstock" production and availability. The Plan excludes some areas and land uses. Furthermore, according to the requirements of the EU Nitrate Directive 91/676/EEC (JMD 195652/1906/1999, OJG 1575B), seven sensate areas toward nitrogen pollution from agricultural run-offs have been established (Thessaly plain, Kopaida plain, Argolida plain, Pinios basin, Thessaloniki plain, Strimonas basin, Preveza-Arta plain). In these areas the implementations of special Action Programmes has been planned and are obligatory to all the farmers of these areas.

Based on a series of factors in Greece there are several suitable sites for biogas exploitation. Three of them were chosen, according mainly to the BIG>EAST Guidelines CRES experience and continues work on biogas exploitation schemes in Greece and the preliminary results obtained within this project (Task 2.3). Potential areas for Biogas plants in Greece can be considered the following (from South to North):

- Crete island (Region)
- Lakonia (Prefecture)
- Evia island (Prefecture)
- Aitoloakarnania (Prefecture)
- Preveza (Prefecture)
- Thessaly (Region)
- Central Macedonia (Region)

[6] Zafiris C (2007). Biogas in Greece: Current situation and perspectives. European Biogas Workshop The Future of Biogas in Europw – III, 14-16 June 2007, Esbjerg, Denmark.

Biogas Site 1: *REGION OF STEREA ELLADA (Schimatari)*

The Region of Sterea Ellada is found in the centre of the country (**see Map below**), has a total extent of 15,549Km^2 represented approximately the 11.8% of the country surface and consists of five Prefectures (Viotia, Evia, Evrytania, Fthiotida, Fokida). The population of the Region is 605,329 inhabitants (5.52% of the Greece population according to the population census of 2001) and the most of them are living in the main urban centers of the Region (urban population represents 46% of the total inhabitants), namely Chalkida (53,584 inhabitants), Lamia (46,406 inhabitants), Thebes (21,211 inhabitants), Livadeia (20,061 inhabitants), Amfissa (6,946 inhabitants) and Karpenisi (6,592 inhabitants). Lamia is the administrative centre of Sterea Ellada.

Map of Sterea Ellada (Source: Europa.eu)

According to the Agriculture – Livestock census 1999/2000 the basic land uses are presented in **Table 1**.

Table 1: Distribution of the Country's area by basic land cover / land use categories (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

Land use / Region	STEREA ELLADA	GREECE
AGRICULTURAL AREAS	**6,331.3**	**65,136.4**
Arable land	1,785.6	21,181.4
Permanent crops	798.6	7,491.8
Pastures - transitional woodland/shrumb	13.1	880
Pastures - shrumb and/or herbaceous vegetation associations	938.4	9,151.7
Rastures - Open spaces with little or no vegetation	313.7	4,420.5
Heterogenous agricultural areas	2,481.9	22,011
FORESTS AND SEMI-NATURAL AREAS	**8,910.2**	**62,478.1**
Forests	2,970.8	22,411.6
Transitional wood land / shrumb	1,526.7	11,606.9
Shrumb and/or herbaceous vegetation associations	3,944.5	23,949.7
Open spaces with little or no vegetation	468.2	4,509.9
SURFACES UNDER WATER	**141.2**	**1,789.6**
ARTIFICIAL SURFACES	**111.6**	**2.577.7**
TOTAL	**15,554.3**	**131,981.8**

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

The flat part of the Region is about 20.8% of the total extent and the rest is mountainous (47.4%) and semi-mountainous (31.8%). The Region has well developed agriculture, live-

stock-farming and tourist resources. The distribution of utilized agricultural area by basic categories of land use in Sterea Ellada is given in **Table 2**. Holdings and number of animals by kind is given in **Table 3**. Like in most of the rest of the country the tertiary sector has the biggest development and plays an important role in the economy of the Region. Although it faces continues decreasing, the primary sector is still the basic source of income and economic activity.

Table 2: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

STEREA ELLADA	Holdings	Areas
Annual crops	39,706	1,910
Vineyards (grapes and raisins)	15,969	62
Areas under trees	64,341	929
Other areas	22,868	605

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 3: Holdings and animals by kind (Farm Structure Survey 2005)

STEREA ELLADA	Holdings	Number of heads
Cattle	2,211	66,886
Sheep	24,999	1,526,299
Goats	18,050	505,834
Pigs	8,419	136,840
One – hoofed	2,596	3,421
Rabbits	4,956	140,752
Poultry	53,134	2,472,404
Beehives	689	55,232

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

According to the statistical data of 2001 the main agricultural products are tomato, cotton, tobacco, potato olive oil and wheat. The animal products are important too as the Region produce 13% of the country production of meat, 15.6% of the total honey production and 28.1% of the fishes[7].

The livestock-farming plays an important role in the economical activity of the Region but not the primary one. The main form of farming represents the extensive sheep breeding in the mountainous regions and mainly in Evia and Fthiotida Prefectures. The intensive livestock-farming is concentrated near the Metropolitan area of Athens namely the South East of Viotia and central Evia (near Chalkida) and it consists mainly by poultry and pig farms and secondary by cattle breading. The last years the intensive animal breading is rather stable. Viotia but mostly Evia is an interesting Prefecture concerning the number of pig farms, the maximum farm capacity (number of sow places), manure production and future biogas exploitation. Among the leader Prefectures in that prospective is Evia, Trikala and Preveza.

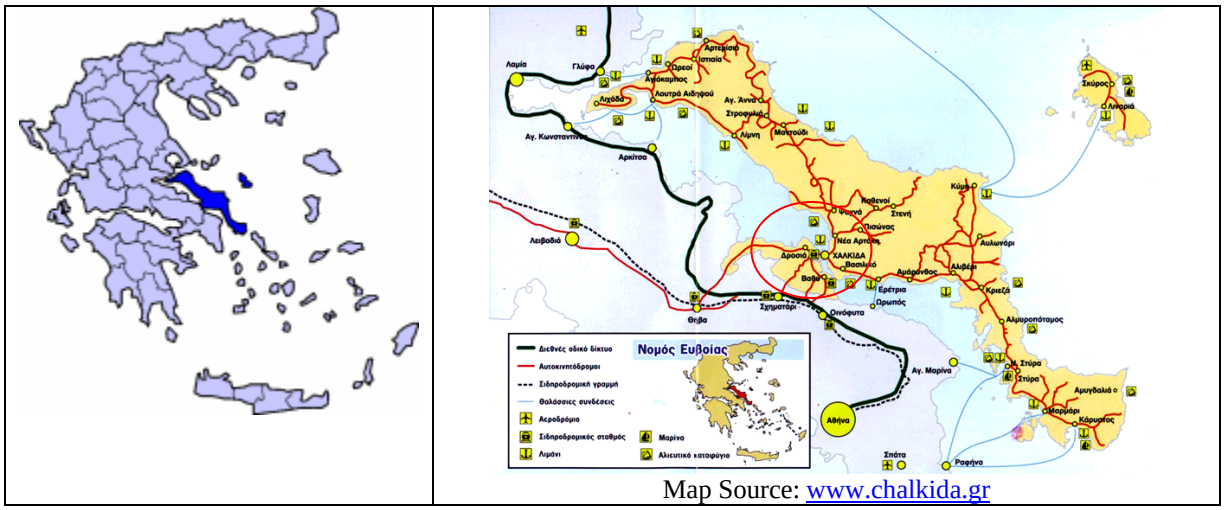
According to the results of the Agricultural-Livestock census 1999-2000 the holdings with utilized agricultural area were 79,332 and the utilized agricultural land was 350,637.5 ha (average area per holding 4.42ha or 44.2 stremmas).

Based on the mapping of the two Prefectures (Evia and Viotia) a promising site for biogas exploitation based mainly on pig manure can be located in the greater area between Evia island and the mainland (**see map below**). Evia is the largest island of Greece too close to the mainland, separated by the Euboic sea. The electrical system of the island is connected to the

[7] www.stereaellada.gr

mainland national grid. Viotia has a well established electrical system as it belongs to the mainland and is served by the mainland national grid. The current and planned Hellenic interconnected electric power transmission system in the area for the period 2008-2012 is presented in **Figure 1**.

It is worth mentioning that in Evia there are big industrial units of mining recourses treatment and in the axis of Chalkida-Thebes in Viotia Prefecture a lot of manufactures and industries are installed due to the vicinity to Athens and the provisions that exclude their installation in Attica Region.



Map Source: www.chalkida.gr

Tables 4, 5, 6 and 7 give the main figures for the Prefectures of Evia and Viotia concerning the basic land uses, distribution of utilized agricultural area by basic categories of land use, main crops, production and number of animals by kind respectively.

Table 4: Distribution of the Country's area by basic land cover / land use categories (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

Land use / Region	EVIA	VIOTIA
AGRICULTURAL AREAS	**1,707.0**	**1,602.9**
Arable land	85.8	836
Permanent crops	322.3	171.8
Pastures - transitional woodland/shrumb	3.8	2.1
Pastures - shrumb and/or herbaceous vegetation associations	169.7	246.9
Rastures - Open spaces with little or no vegetation	128.7	49.8
Heterogenous agricultural areas	996.7	296.3
FORESTS AND SEMI-NATURAL AREAS	**2,379.4**	**1,288.5**
Forests	739.9	231.2
Transitional wood land / shrumb	454.3	126.3
Shrumb and/or herbaceous vegetation associations	1,042.1	898.7
Open spaces with little or no vegetation	143.1	32.3
SURFACES UNDER WATER	**16.9**	**27.4**
ARTIFICIAL SURFACES	**61.0**	**34.5**
TOTAL	**4,164.3**	**2,953.3**

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

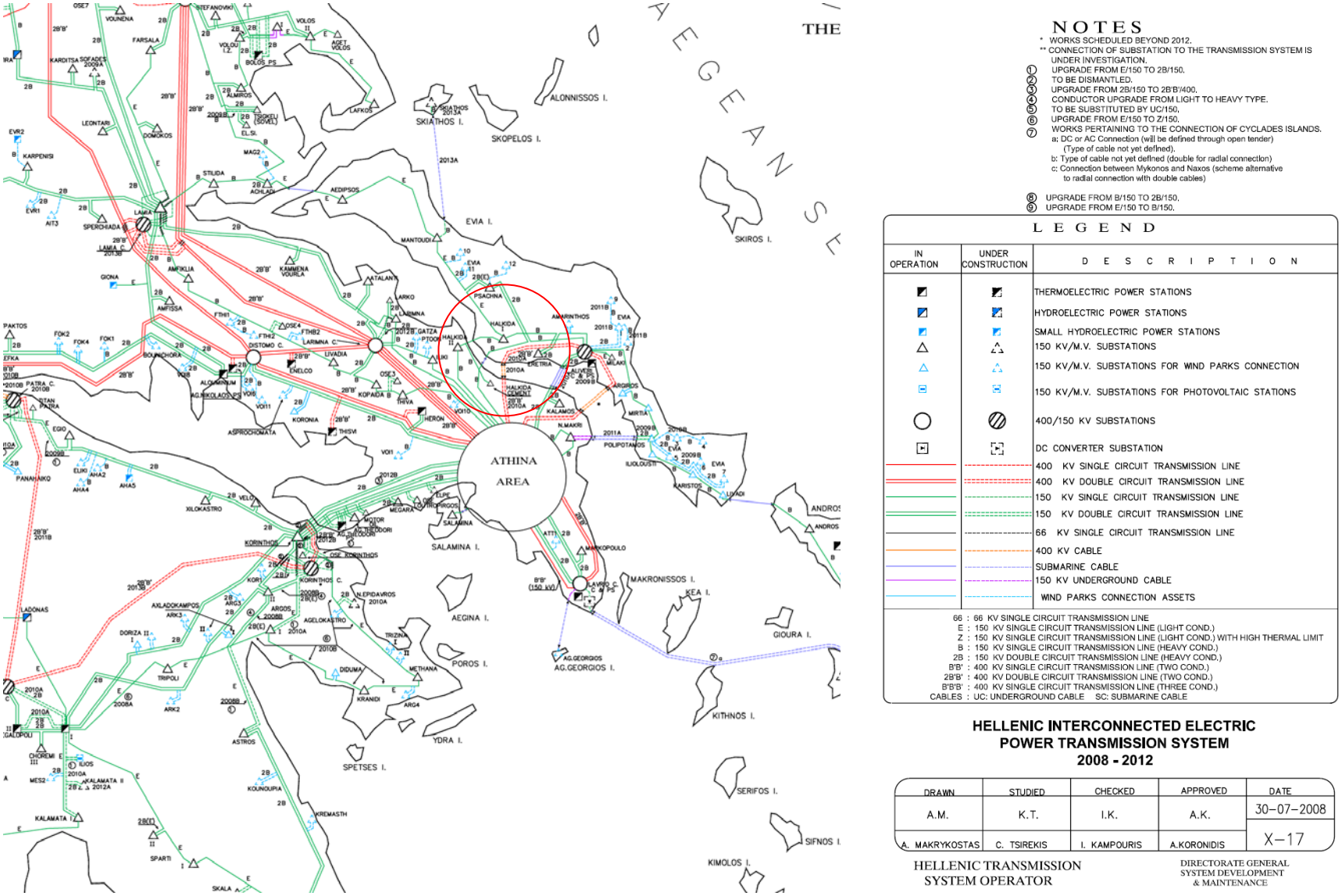


Figure 1: Hellenic interconnected electric power transmission system for the period 2008-2012 (www.desmie.gr)

Table 5: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

	EVIA	VIOTIA
Annual crops	259	732
Vineyards (grapes and raisins)	23	32
Areas under trees	321	187
Other areas	9,397	1,664

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 6: Main crops and production in Evia and Viotia, areas in stremmas and production in tn/year for the year 2005

	EVIA		VIOTIA	
	Areas	tn/year	Areas	tn/year
Soft wheat	4,355	599	50	15
Durum wheat	123,688	22,516	293,113	77,408
Burley	39,911	7,458	10,390	2,158
Oats	21,081	3,802	4,055	1,298
Rye	2	-	-	-
Maize	12,853	8,088	27,342	29,416
Rice	-	-	-	-
Tobacco	-	-	3,865	1,083
Cotton	15,824	4.870	293,642	98,267
Sunflower	-	-	-	-
Sugarbeets	-	-	-	-
Vineyards	36,358	41,424	37,667	20,361
Olive plantations	290,255	38,267	194,118	23,115
Potatoes	24,298	37,864	16,649	35,521
Fallow	166,134	-	8,128	-

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 7: Animals by kind (Agriculture - Livestock Survey 2005), number of heads

	EVIA	VIOTIA
Cattle	2,253	4,596
Sheep	201,629	118,398
Goats	163,700	103,170
Pigs	77,311	16,291
One – hoofed	1,504	95
Rabbits	33,651	7,578
Poultry	780,578	1,301,450
Beehives	32,914	7,383

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

According to the Agriculture – Livestock Survey of 2005 the main agricultural products are olive oil, durum wheat, cotton and vineyards. The animal products are important too mainly in the Prefecture of Evia. Viotia produce 22,559 t milk, 14,374 t meat and 1,402 t cheese. On the contrary Evia produce 37,680 t milk, 34,426 t meat and 4,164 t cheese.

Biogas Site 2: *REGION OF DYTIKI ELLADA (Agrinio)*

The Region of Dytiki Ellada (**see map below**) is one of the 13 Regions of Greece covers an area of 11,350 Km^2 (8,6% of the total area of Greece) and consists of three Prefectures (Aitoloakarnania**,** Achaia, Elia). These three Prefectures lie from the western part of the mainland to the northwest part of the Peloponnese having extensive coastal areas along the Ionian Sea and the Gulfs of Ambrakia, Patras and Corinth. According to the 2001 census, the population of the Region is 740,506 inhabitants (7% of the country's total population). The most of the inhabitants are living in the main urban centers of the Region namely Patras (163,446 inhabitants), Pyrgos (34,902 inhabitants), Mesolongi (17,988 inhabitants), Agrinio (54,253 inhabitants). Patras is the administrative centre of Dytiki Ellada.

Map of Sterea Ellada (Source: Europa.eu)

According to the Agriculture – Livestock census 1999/2000 the basic land uses of the Region are presented in **Table 8**.

Table 8: Distribution of the Country's area by basic land cover / land use categories (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

Land use / Region	DYTIKI ELLADA	GREECE
AGRICULTURAL AREAS	**5,305.1**	**65,136.4**
Arable land	1,110.4	21,181.4
Permanent crops	541.4	7,491.8
Pastures - transitional woodland/shrumb	20	880
Pastures - shrumb and/or herbaceous vegetation associations	399.4	9,151.7
Rastures - Open spaces with little or no vegetation	146.8	4,420.5
Heterogenous agricultural areas	3,087.1	22,011
FORESTS AND SEMI-NATURAL AREAS	**5,512.3**	**62.478,1**
Forests	1,542.2	22,411.6
Transitional wood land / shrumb	1,157.7	11,606.9
Shrumb and/or herbaceous vegetation associations	2,332.6	23,949.7
Open spaces with little or no vegetation	479.8	4,509.9
SURFACES UNDER WATER	**332.6**	**1,789.6**
ARTIFICIAL SURFACES	**168.1**	**2.577.7**
TOTAL	**11,318.1**	**131,981.8**

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Most of the area is mountainous (45.3 %) and semi-mountainous (25.6 %), whereas only 29.1 % is flat. The primary sector is well developed, and it includes traditional agricultural products (eg. tobacco, cotton, wheat, rice, citrus, apples, peaches, potatoes, tomatoes, corn), animal farming products fishing and aquaculture products. The distribution of utilized agricultural area by basic categories of land use in Dytiki Ellada is given in **Table 9**. Holdings and number of animals by kind is given in **Table 10**.

Table 9: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

DYTIKI ELLADA	Holdings	Areas
Annual crops	42,187	1,353
Vineyards (grapes and raisins)	22,862	142
Areas under trees	76,863	872
Other areas	38,587	800

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 10: Holdings and animals by kind (Farm Structure Survey 2005)

DYTIKI ELLADA	Holdings	Number of heads
Cattle	2,211	66,886
Sheep	24,999	1,526,299
Goats	18,050	505,834
Pigs	8,419	136,840
One – hoofed	2,596	3,421
Rabbits	4,956	140,752
Poultry	53,134	2,472,404
Beehives	689	55,323

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Based on the results of the Agricultural-Livestock census 1999-2000 the holdings with utilized agricultural area were 92,099 and the utilized agricultural land was 316,772.3 ha (average area per holding 3.44ha or 34.4 stremmas).

Aitoloakarnania covers and area of 5,461 Km^2 with two dominated towns (Agrinio ant its capital Mesolongi). The borders of the Prefecture is Arta, Karditsa, Evrytania and Fokida. According to the 2001 census, the population of the Prefecture is 222,984 habitants (population density of 41 habitants/Km^2).

Aitoloakarnania is the largest Prefecture in the country and is a predominantly agricultural area. Agrinio is the biggest city of the Prefecture and is an important tobacco-producing centre.

Map source: www.ditikiellada.gov.gr

Tables 11, 12, 13 and 14 give the main figures for the Prefectures of Aitoloakarnania concerning the basic land uses, distribution of utilized agricultural area by basic categories of land use, main crops and production and number of animals by kind respectively.

Table 11: Distribution of the Country's area by basic land cover / land use categories (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

Land use / Region	AITOLOAKARNANIA
AGRICULTURAL AREAS	**2,120.7**
Arable land	654.1
Permanent crops	166.6
Pastures - transitional woodland/shrumb	15.8
Pastures - shrumb and/or herbaceous vegetation associations	292.4
Rastures - Open spaces with little or no vegetation	87.3
Heterogenous agricultural areas	904.5
FORESTS AND SEMI-NATURAL AREAS	**2,987.3**
Forests	883.2
Transitional wood land / shrumb	599.0
Shrumb and/or herbaceous vegetation associations	1,282.9
Open spaces with little or no vegetation	222.2
SURFACES UNDER WATER	**278.7**
ARTIFICIAL SURFACES	**36.2**
TOTAL	**5,422.9**

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 12: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

	AITOLOAKARNANIA
Annual crops	560
Vineyards (grapes and raisins)	5
Areas under trees	310
Other areas	398

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 13: Main crops and production in Aitoloakarnania, areas in stremmas and production in tn/year for the year 2005

	AITOLOAKARNANIA	
	Areas	**tn/year**
Soft wheat	6,930	1,478
Durum wheat	26,460	5,177
Burley	8,216	1,769
Oats	59,774	10,913
Rye	124	5
Maize	138,199	143,694
Rice	8,000	3,811
Tobacco	93,341	25,869
Cotton	63,345	23,204
Vineyards	6,817	3,193
Olive plantations	220,757	72,402
Potatoes	10,572	10,086
Fallow	250,216	-

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 14: Animals by kind (Agriculture - Livestock Survey 2005), number of heads

	AITOLOAKARNANIA
Cattle	51,050
Sheep	883,505
Goats	279,974
Pigs	100,567
One – hoofed	537
Rabbits	35,397
Poultry	892,819
Beehives	26,911

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

According to the Agriculture – Livestock Survey of 2005 the main agricultural products are maize, olive oil, tobacco and cotton. The animal products are important too as the Prefecture produces 74,093 t milk, 19,553 t meat and 6,953 t cheese. According to data gathered for the Prefecture concerning the cattle and pig farms, slaughterhouses and milk factories the theoretically available biomass for biogas exploitation in Aitoloakarnania is presented in **Table 15**.

Table 15: Theoretically available biomass (organic wastes) in Aitoloakarnania

Recourses	**Units***	**Capacity ***	**Organic wastes (tn/year)**	**Installed capacity (MW)**
Cattle	1,050	34,113 cattle	847,708	16.25
Pig farms	41	8,035 sows	129,583	2.12
Slaugherhouses	5	2,550 tn/year (Cat. 2) 1,850 tn/year (Cat. 3)	4,400	0.6
Milk factories (milk processing for cheese production)	3			
Total			**981,691**	**18.97**

* Source: Ministry of Agricultural Development and Food

Based on a more detailed mapping of the Prefecture a significant biogas potential in the region comes mainly from manure and wastes in the area of Agrinio with co-digestion of maize silage, thus a biogas plants can be located in the greater area of Agrinio city. The area is served by the mainland national grid. The current and planned Hellenic interconnected electric power transmission system in the area for the period 2008-2012 is presented in **Figure 2**.

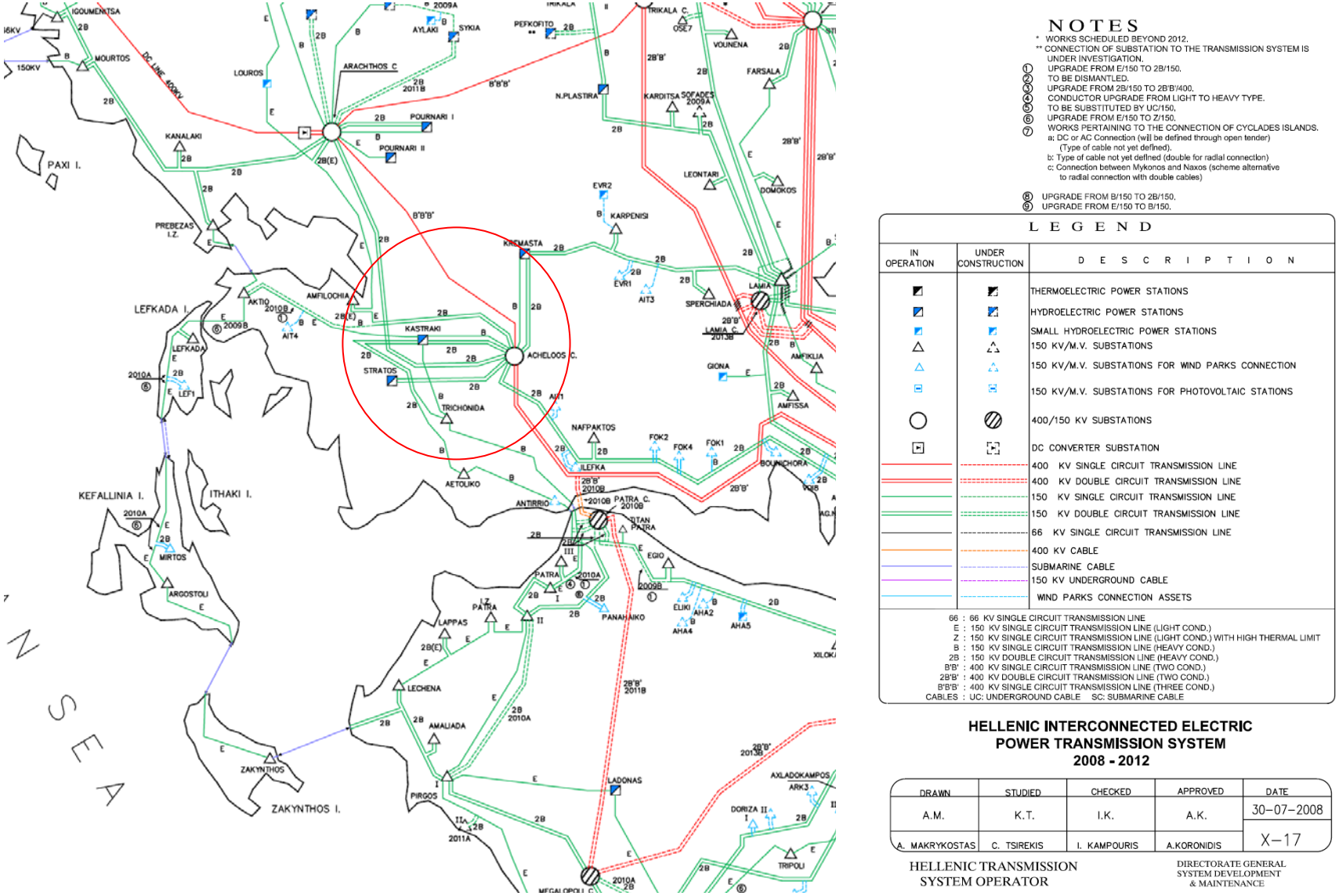


Figure 2: Hellenic interconnected electric power transmission system for the period 2008-2012 (www.desmie.gr)

Biogas Site 3: *REGION OF THESSALIA (Trikala)*

The Region of Thessaly (**see map below**) occupies the central-eastern part of continental Greece and consists of four Prefectures (Karditsa, Trikala, Larisa and Magnesia). The Region covers and area of 14,036 Km^2 (10,6% of the total area of Greece). According to the last population census (2001), the population of the Region is 753,888 inhabitants (7% of the country's total population). The most of the inhabitants (44%) are living in the main urban cities of the Region like Volos, Larisa, Trikala and Kartditsa, and 40% are agrarian population showing a decline over the years. Larisa is the administrative centre of Thessalia.

Map of Thessalia (Source: Europa.eu)

According to the Agriculture – Livestock census 1999/2000 the basic land uses are presented in **Table 16**.

Table 16: Distribution of the Country's area by basic land cover / land use categories (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

Land use / Region	THESSALIA	GREECE
AGRICULTURAL AREAS	**7,552.7**	**65,136.4**
Arable land	4,282.8	21,181.4
Permanent crops	211.7	7,491.8
Pastures - transitional woodland/shrumb	25.2	880
Pastures - shrumb and/or herbaceous vegetation associations	1,254.1	9,151.7
Rastures - Open spaces with little or no vegetation	281.6	4,420.5
Heterogenous agricultural areas	1,497.3	22,011
FORESTS AND SEMI-NATURAL AREAS	**6,170.6**	**62,478.1**
Forests	2,192	22,411.6
Transitional wood land / shrumb	1,336.1	11,606.9
Shrumb and/or herbaceous vegetation associations	2,336	23,949.7
Open spaces with little or no vegetation	306.5	4,509.9
SURFACES UNDER WATER	**81.7**	**1,789.6**
ARTIFICIAL SURFACES	**241.6**	**2.577.7**
TOTAL	**14,046.6**	**131,981.8**

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

The Region of Thessalia, is characterized by a highly variable landscape.

The primary sector plays an important role in the economic development of the Region and almost all the Prefectures of the Region can be characterized as agricultural areas. It is notable that the agricultural sector contributes by 66% in the Region income. This gave advantage also to the employment in the primary sector.

Animal-farming also present developmental tendencies, that were expressed with the increase of animal production and the animal capital of pigs and cattle at the previous decade, but it has big margins of improvement, mainly in the sector of breeding sheep and goats[8].

The distribution of utilized agricultural area by basic categories of land use in Thessalia is given in **Table 17**. Holdings and number of animals by kind is given in **Table 18**.

Table 17: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

THESSALIA	Holdings	Areas
Annual crops	57,266	3,332
Vineyards (grapes and raisins)	10,519	39
Areas under trees	29,594	458
Other areas	32,033	281

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 18: Holdings and animals by kind (Farm Structure Survey 2005)

THESSALIA	Holdings	Number of heads
Cattle	2,090	104,632
Sheep	12,978	1,245,334
Goats	8,875	493,205
Pigs	5,307	169,333
One – hoofed	1,956	4,106
Rabbits	2,131	64,355
Poultry	40,402	1,925,364
Beehives	936	77,952

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Based on the results of the Agricultural-Livestock census 1999-2000 the holdings with utilized agricultural area were 78,215 and the utilized agricultural land was 411,015.6 ha (average area per holding 5.26ha or 52.6 stremmas).

Trikala Prefecture is located in the centre of Greece and is about 331km far away from Athens. The population of the Prefecture is 138,956 inhabitants (2001 census), 57,914 of them are living in the capital Trikala. The Prefecture can be characterized an agricultural area based on the fact that is located in the fertile plain of Thessaly. Although the Prefecture and the city of Trikala is far away for the national road Athens – Thessalonica the improvement of existing ones and construction of new roads give a better prospective for development and a more competitive role in the Region.

[8] http://www.thessalia-region.com

Map source: www.trikala.gr

Tables 19, 20, 21 and 22 give the main figures for the Prefectures of Trikala concerning the basic land uses, distribution of utilized agricultural area by basic categories of land use, main corps and production and number of animals by kind respectively. According to the Agriculture – Livestock Survey of 2005 the main agricultural products are cotton, maize and durum wheat. The animal products are important too. Trikala produces 42,851 t milk, 12,455 t meat and 25,962 t cheese.

Table 19: Distribution of the Country's area by basic land cover / land use categories (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

Land use / Region	TRIKALA
AGRICULTURAL AREAS	**1,430.4**
Arable land	520.3
Permanent crops	8.8
Pastures - transitional woodland/shrumb	19.3
Pastures - shrumb and/or herbaceous vegetation associations	447.3
Rastures - Open spaces with little or no vegetation	124
Heterogenous agricultural areas	310.7
FORESTS AND SEMI-NATURAL AREAS	**1,890.0**
Forests	861.6
Transitional wood land / shrumb	526.2
Shrumb and/or herbaceous vegetation associations	339.7
Open spaces with little or no vegetation	162.5
SURFACES UNDER WATER	**27.1**
ARTIFICIAL SURFACES	**38.6**
TOTAL	**3,386.1**

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 20: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000), areas in thousand stremmas

	TRIKALA
Annual crops	468
Vineyards (grapes and raisins)	5
Areas under trees	19
Other areas	108

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 21: Main crops and production in Trikala, areas in stremmas and production in tn/year for the year 2005

	TRIKALA	
	Areas	**tn/year**
Soft wheat	19,562	6,919
Durum wheat	70,419	23,474
Burley	18,534	6,160
Oats	2,447	675
Rye	230	39
Maize	119,390	141,663
Tobacco	8,310	2,747
Cotton	134,493	49,533
Sunflower	296	33
Sugarbeets	2,220	15,236
Vineyards	7,259	4,278
Olive plantations	14,397	2,119
Potatoes	3,118	5,315
Fallow	41,667	-

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

Table 22: Animals by kind (Agriculture - Livestock Survey 2005), number of heads

	TRIKALA
Cattle	35,716
Sheep	311,252
Goats	105,737
Pigs	81,086
One – hoofed	706
Rabbits	17,944
Poultry	389,752
Beehives	9,210

Source: General Secretariat of National Statistical Service of Greece, www.statistics.gr

According to data gathered for the Prefecture concerning the cattle and pig farms, slaughterhouses and milk factories, the theoretically available biomass for biogas exploitation in Trikala is presented in **Table 23**.

Table 23: Theoretically available biomass (organic wastes) in Trikala

Recourses	**Units***	**Capacity ***	**Organic wastes (tn/year)**	**Installed capacity (MW)**
Cattle	653	25,946 cattle	644,758	12.36
Pig farms	110	9,474 sows	152,790	2.51
Slaugherhouses	2	1,066 tn/year (Cat. 2) 845 tn/year (Cat. 3)	1,911	0.25
Milk factories (milk processing for cheese production)	6			
Total			**799,459**	**15.12**

* Source: Ministry of Agricultural Development and Food

Based on a more detailed mapping of the Prefecture significant biogas potential comes mainly from manure and such an AD plant can be located in the vicinity of Trikala city (eg. Municipality of Pialion). There is also the alternative of co-digestion with agricultural residues-energy crops (eg. maize silage) or agro-industrial residues (eg. waste form slaughterhouses, olive oil mills, dairy wastes). The area is served by the mainland national grid. The current and planned Hellenic interconnected electric power transmission system in the area for the period 2008-2012 is presented in **Figure 3**.

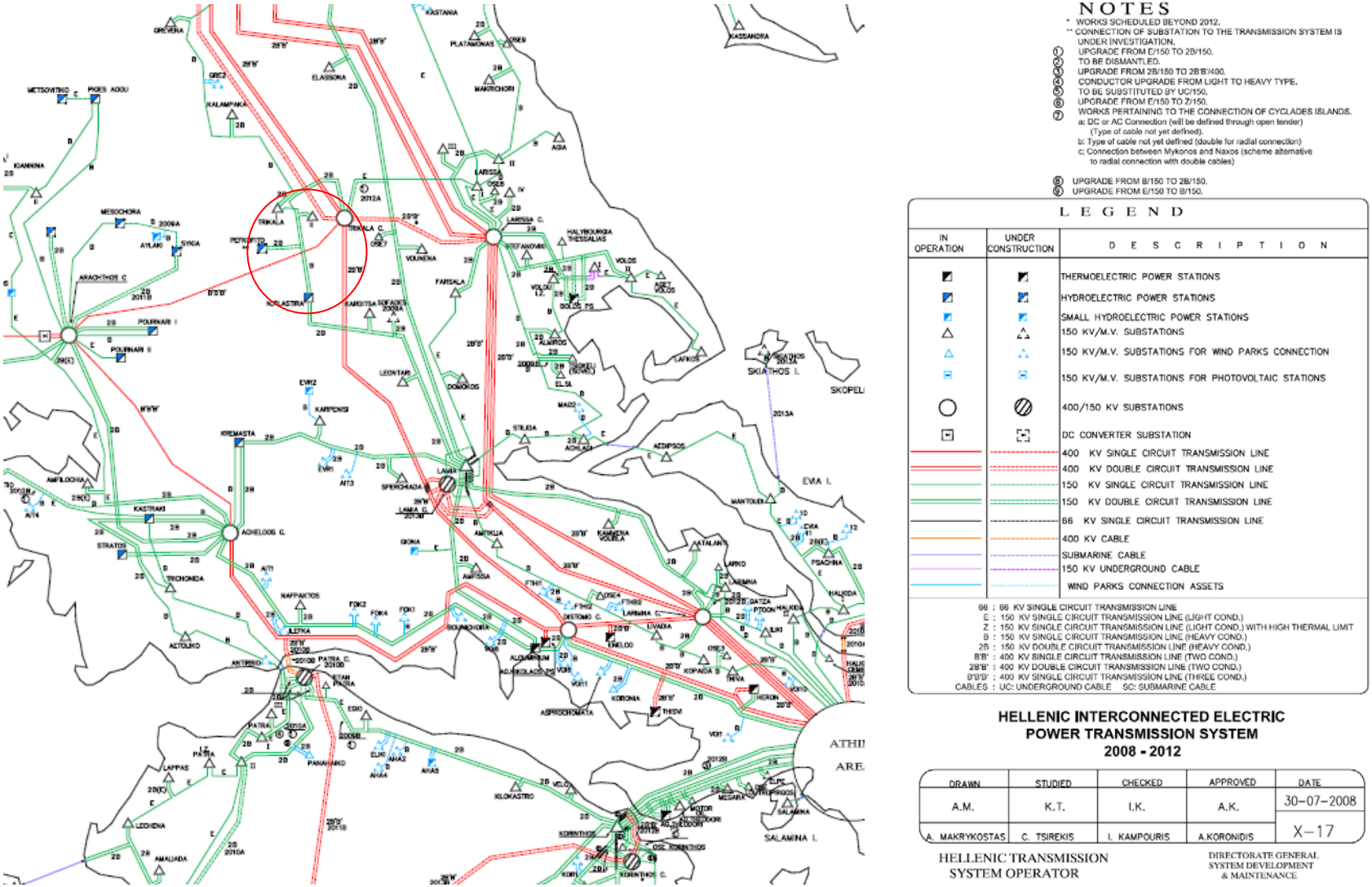


Figure 3: Hellenic interconnected electric power transmission system for the period 2008-2012 (www.desmie.gr)

Biomass supply

The objective of this chapter is to provide an overall overview of the biomass supply that could be used as feedstock in the biogas installations in the three selected sites. The work is based on a mapping of the biogas resources in the local area, BIG>EAST guidelines and results and data and experiences from plants of similar type and size in operation (mainly in Denmark).

Biogas Site 1: *REGION OF STEREA ELLADA (Schimatari)*

The planned biogas plant shall be operated with the input material of liquid manure from pigs, cows and chicken manure, fat, blood from slaughterhouse, dairy waste (Whey), katsigaros (waste of olive oil production) and food waste. The input materials come from agricultural and industrial companies in the nearby area of the plant. The plant can be located to the mainland in the greater area of Schimatari – Inofyta (**see map below**).

It is assumed that more than 85% of the manure available in the area is transported to the biogas plant for digestion and separation. The plant is a co-digestion plant utilising besides the manure wastes residuals from nearby industries and nearby military campus (waste from larger kitchens). The amount of these biomasses used in the calculation is based on mapping made in the area. The availability of pig manure from Evia and Viotia and cow farms in Viotia that can be used as feedstock in the biogas plant is provided in the following tables.

Pig farms	Year Sows (YS)	Fattening Pigs (FP)	Slurry Production YS (tn/y)	Slurry Production FP (tn/y)	Slurry Production Total (tn/y)
in Biotia (10 farms)	3,300	66,000	17,800	35,420	53,220
In Evia (14 farms)	10,236	204,720	55,212	109,866	165,079
Total	**13,536**	**270,72**	**73,012**	**145,286**	**218,299**

Cow farms in Biotia	Bulls (heads)	Cows (heads)	Total (Bull/Cows)	Young Cows	Slurry Production Bull/cow (tn/y)	Slurry Production Y.Cows (tn/y)	Slurry Production Total (tn/y)
2	96	286	382	257	7,640	1,248	**8,888**

The gas potential is calculated form Danish standard figures of potential gas yield from different biomasses as achieved in lab tests and on commercial operating plants. Based on the above estimations and other feedstock availability in the area the following biomasses and potential biogas production is calculated below.

Other feedstock like fat, blood from slaughterhouse, dairy waste (Whey), katsigaros (waste of olive oil production) and food waste were added in small proportion in order to increase the biogas yield. The biogas generated by fermentation shall be utilised in a combined heat and power station and the generated power shall be supplied into the public network.

Schimatari site	Biogas production					
Input	t input/y	% TS	VS/TS	t VS	GVS	m^3 CH_4/y
Pig manure Sows	65,000	5.6	80	2.912	290	844,480
Pig manure Fatteners	125,000	6.2	80	6.200	290	1,798,000
Cow manure	8,000	10	80	640	210	134,400
Chicken manure	2,400	50	80	960	290	278,400
Stomach content	512	22	85	96	460	44,042
Fat	323	12	95	37	650	23,934
Blood	845	8	95	64	350	22,477
Whey	2,100	5	95	100	330	32,917
Oil mill waste	1,400	25.4	58	205	700	143,500
Food waste	730	35	90	230	350	80,482
Total	206,310	7		11,443		3,402,633
Added storage	10%					340,263
Total production of methan						**3,742,896**

Transport/logistic

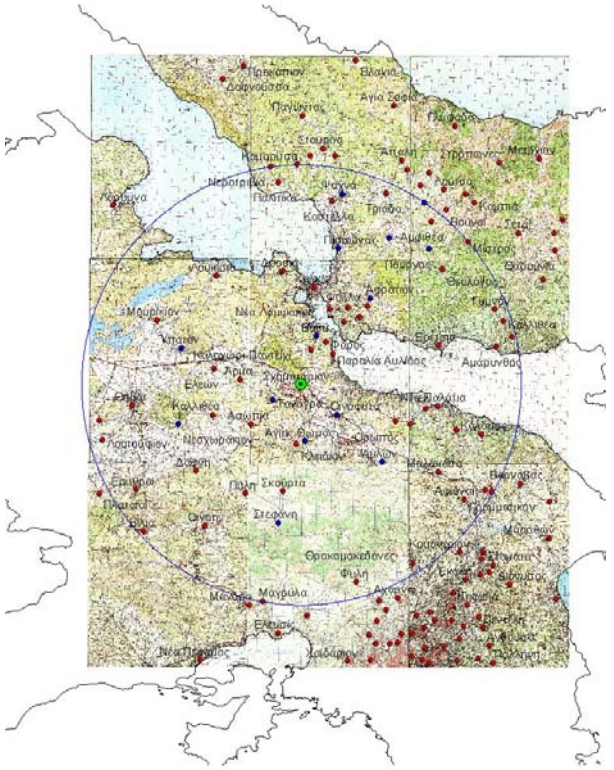
The manure is picked up from the farms and transported to the biogas plant in a tanker. It is important that the farms have best possible pick up facilities so that the connection and pumping time is minimised. It is anticipated that each farm is equipped with a pre-tank containing approx. 60-80 m^3. This tank is provided with a connection pipe so that it takes a minimum of time to connect and soak up the manure.

The transport can be made in own tankers or the service can be purchased from an external contractor. It is assumed that the trucks can carry a payload of 30 t similar to trucks used on Danish biogas plants.

The transport of approx. 200,000 t of manure to the plant and 190,000 t liquid fertilizer per year from the plant to the farms can be done by two trucks operating approx. 11-12 hours per working day.

It is assumed that the industries supplied the waste products to the plant themselves or by contractors.

Source: Google



Map Source: Hellenic Military Geographical Service

Biogas Site 2: *REGION OF DYTIKI ELLADA (Agrinio)*

The planned biogas plant shall be operated with the input material liquid manure from pigs, dairy waste (whey), maize silage, katsigaros (waste of olive oil production) and fat, blood from slaughterhouse. The input materials come from agricultural and industrial companies in the vicinity of the plant. The farmers' harvest is directly brought to the place of the plant and discharged into the reception bunker. The plant can be located in the nearby area of Agrinio city (**see map below**).

It is assumed that approx. 80% of the manure and waste available in the area is transported to the biogas plant for digestion and separation. Besides this the plant is planned to utilise energy crops (mainly maize silage) produced by the local farmers and sold to the plant. The plant is a co-digestion plant utilising besides the manure residuals from nearby industries (dairies and slaughterhouses) and energy crops in a mixture too. The amount of these biomasses used in the calculation is based on mapping made in the area. The availability of pig manure and Cheese dairies wastes in Agrinio vicinity is provided in the following table.

Pig farms	Year Sows (YS)	Fattening Pigs (FP)	Slurry Production YS (tn/y)	Slurry Production FP (tn/y)	Slurry Production Total (tn/y)
31	9,360	192,600	51,944	103,362	155,306

Cheese dairies	Milk Processing (tn/day)	Milk Processing (tn/y)	Main product (tn/y)	Liquid wastes (tn/y)
27	656	239,440	59860	167,608

The gas potential is calculated form Danish standard figures of potential gas yield from different biomasses as achieved in lab tests and on commercial operating plants. Based on the above estimations and other feedstock availability in the area the following biomasses and potential biogas production is calculated:

Agrinio site	**Biogas production**					
Input	t input/y	% TS	VS/TS	t VS	GVS	m^3 CH4/y
Pig manure	124,000	6,5	80	6,448	290	1,869,920
Dairy waste	134,000	6	90	7,236	330	2,387,880
Energy crops	35,000	31	95	10,307	350	3,607,625
Stomach content cows/lamp/goat	137	20	80	22	400	8,768
Stomach waste pigs	200	22	90	40	460	18,216
Katsigaros	25,000	8.7	72	1,566	600	939,600
Fat	161	12	95	18	650	11,930
Blood	530	8	95	40	350	14,098
Total	319,028	9		25,678		8,858,037
Added storage	10%					885,803
Total production of CH_4						**9,743,841**

Other feedstock like wastes form slaughterhouse and energy crops were added in small proportion in order to increase the biogas yield. The biogas generated by fermentation shall be utilised in a combined heat and power station and the generated power shall be supplied into the public network.

Transport/logistic

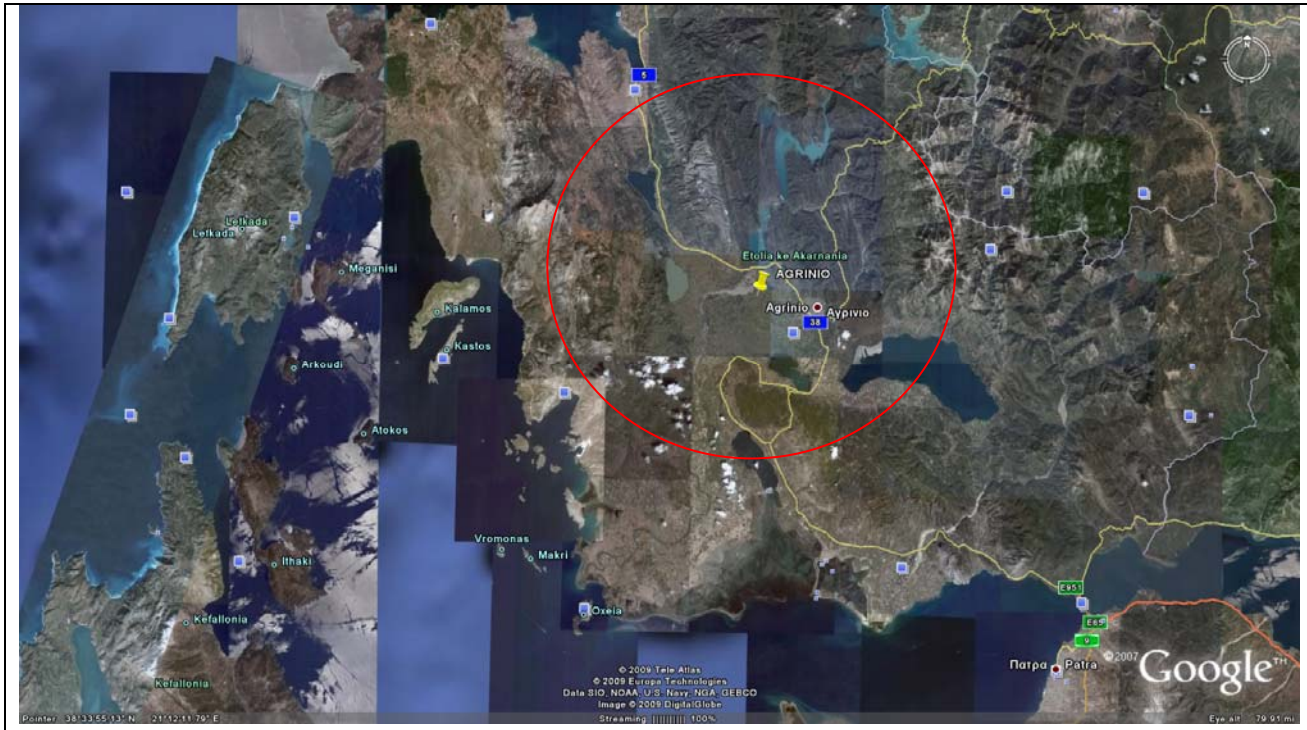
The manure is picked up from the farms and transported to the biogas plant in a tanker. It is important that the farms have best possible pick up facilities so that the connection and pumping time is minimised. It is anticipated that each farm is equipped with a pre-tank containing approx. 60-80 m^3. This tank is provided with a connection pipe so that it takes a minimum of time to connect and soak up the manure.

The transport can be made in own tankers or the service can be purchased from an external contractor. It is assumed that the trucks can carry a payload of 30 - 33 t similar to trucks used on Danish biogas plants.

The transport of approx. 320,000 t of manure to the plant and 280,000 t liquid fertilizer per year from the plant to the farms can be done by two trucks operating approx. 12-13 hours per working day. To do this it requires three drives to man the trucks plus extra personal to cover holidays and other periods when the drivers are off duty.

It is assumed that the industries supplied the waste products to the plant themselves or by contractors.

Silage is produced on the farms and partly stored on the farms and on the biogas plant. The final set up of silage storage facilities can be made in parallel with the project negotiations' on the conditions for supply of silage.



Source: Google Earth

Biogas Site 3: *REGION OF THESSALIA (Trikala)*

The planned biogas plant shall be operated with the main input of liquid manure from pigs. The manure comes from the pig farms in the vicinity of the plant (farms located in the extent of Municiplaity Pialion). The plant can be located in the nearby area of the Filyra community which belongs to the Municipality of Pialion (**see map below**) as is well known that there are a lot of pig farms in the area (see tables below concerning pig farms).

The amount of the biomasses used in the calculations is based on mapping made in the area. It is assumed that approx. 80% of the manure available in the area is transported to the biogas plant for digestion and separation. Besides this the plant is planned to utilise maize silage produced by the local farmers and sold to the plant. The plant is a co-digestion plant utilising besides the pig manure residuals or energy crops from nearby pig farms arable land in a mixture. The following Table gives the summarized data of the existed pig farms in the Municipality of Pialion (Communities of Eleftherohori, Pialia, Fiki and Filyra) based on data gathered by the Ministry of Agricultural Development and Food showing the theoretical availability of pig manure in the vicinity of Filyra community.

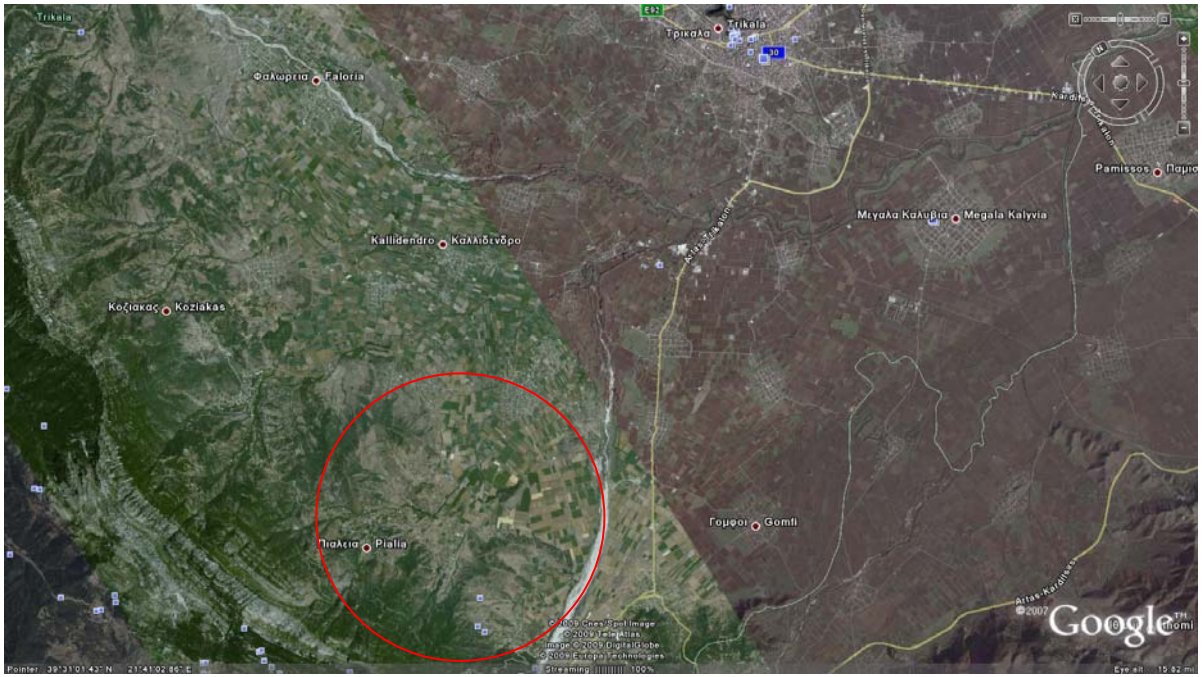
Community	Number of pig farms	Number of pig sows
Elefterohori	17	1,443
Pialia	44	2,313
Fiki	16	1,105
Filyra	32	2,048
Total	**109**	**6.909**

Pig farms	Year Sows (YS)	Fattening Pigs (FP)	Slurry Production YS (tn/y)	Slurry Production FP (tn/y)	Slurry Production Total (tn/y)
109	6,909	142,166	38,342	76,296	114,638

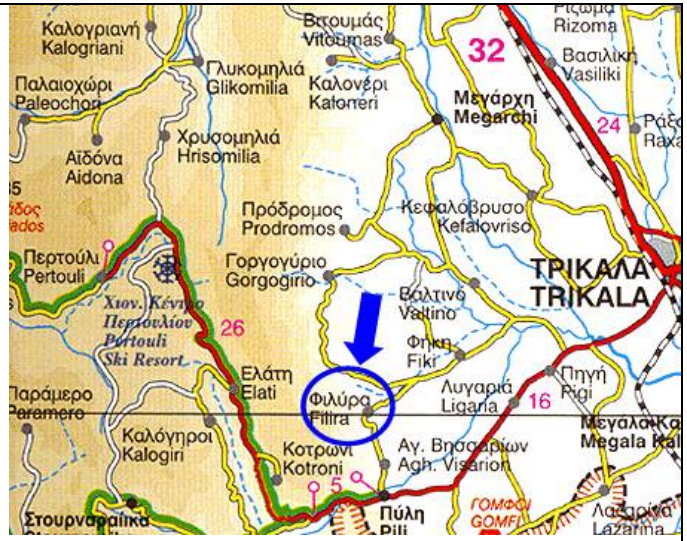
Except to this scenario a viable solution would be a mixture of pig manure with other residuals from nearby industries. The gas potential is calculated form Danish standard figures of potential gas yield from different biomasses as achieved in lab tests and on commercial operating plants. Based on the above estimations of feedstock availability in the area the following biomasses and potential biogas production is calculated:

Trikala site	**Biogas production**					
Input	t input/y	% TS	VS/TS	t VS	GVS	m^3 CH4/y
Pig manure	91,710	6,5	80	4.769	290	1,382,987
Energy crops - residues	5,000	31	95	1,472	350	515,375
Total	96,710			6.241		1,898,362
Added storage	10%					189,836
Total production of CH_4						**2,088,198**

The biogas generated by fermentation shall be utilised in a combined heat and power station and the generated power shall be supplied into the public network.



Source: Google Earth



Map source: filyra.tripod.com

Biogas Digestate Utilisation

Leakage of nutrients

Normal handling of manure results in a leakage of nutrients to the water environment and to the air. Raw manure contains a high proportion of organic nitrogen that will denitrify under non controlled circumstances. If the organic nitrogen is denitrified in a period where there is rain and no crops on the fields the nitrogen will be washed out into the water environment. By digesting the manure the organic nitrogen will be changed into free nitrogen in the digester and therefore direct assessable to the crops and leakages can be avoided.

The composition of nutrients in normal raw manure is not optimal for crops like serial, maize and grass. The phosphor content is too high in relation to the nitrogen content often meaning an overdosing with phosphor. Phosphor can to an extent accumulate in the soil but it the phosphor level is too high it will wash out into the water environment. By separating the digestate the liquid will have a better N/P ration and the main amount of phosphor will be in the fibre that can be utilised on drops with a high P demand (which very often are using chemical fertiliser to day).

EU nitrate Directive

For the agriculture the biogas and separation installation provides optimised handling of manure. The process means that the manure will be improved as fertiliser, much lower environmental pressure and reduction of odour. Besides this the biogas plant can act as a distribution agent for surplus nutrients so that these can be transferred from the animal producers to arable farmers and among these also wine- and fruit growers. The raw manure as well as the digestate must be utilised in relation to the EU nitrate directive (Council Directive 91/676/EEC). In accordance to this Directive 170 kg of N can be spread per ha.

Fertilizer

Today the manure and in some extend the stomach waste is utilised as fertiliser. After introducing the biogas plant it will be possible to utilise also nutrients in organic waste that not are utilised as fertiliser today and hereby subsidising chemical fertilisers.

Beside the rise in the amount of fertiliser an improved quality of the fertiliser in the digestion process will mean savings in fertiliser. The digestate and separated manure is a much better fertiliser because most of the organic nitrogen is changed into ammonia nitrogen in the process, this ammonia nitrogen is directly assessable for the crops so that the efficincy raise. Besides this separation will take out the rest of the organic nitrogen so that the liquid only contains ammonia nitrogen and because the liquid fertiliser is very thin and therefore very quickly soaks down to the roots preventing evaporation of nitrogen.

The fibre fraction is a phosphorus rich “compost-like” product which is perfect for wine and fruit. There is some nitrogen content that will be utilised but the efficiency is uncertain because it is mainly organic bounded and the time of denitrification in uncertain. The efficiency of the phosphor is as high as in chemical fertiliser.

Besides these advantages the separated digestate will be easier and cheaper to spread because it is very liquid and the storage tanks do not require mixing before spreading.

The liquid fertilizer will be carried back form the biogas plant at the farms. There will be enough storage capacity on the farms that will meet the EU and national requirements before

spreading in the field. Another option is that the biogas plant will storage the liquid fertilizer at the site of the plant.

The solid fertiliser (the fibre fraction) will be sold as solid fertiliser.

Biogas Site 1: *REGION OF STEREA ELLADA (Schimatari)*

The raw manure supplied into the plant requires approx. 7,900 ha in relation to the nitrate directive. Even if the plant is supplied with nutrients in the organic waste the requirement after digestion and separation will be lower because nitrogen is removed in the fibre fraction. The requirement for land for using the liquid after the process will be approx. 6,300 ha meaning a saving of approx. 1,600 ha spreading area. This will reduce pressure on land in the area and reduce costs for transport and spreading. The solid fertiliser (the fibre fraction) will be sold as solid fertiliser.

According to Table 5: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000) the ultimate speading area of the Prefectures of Viotia and Evia comes to 991 thousand stremmas of annual crops.

Biogas Site 2: *REGION OF DYTIKI ELLADA (Agrinio)*

The raw manure supplied into the plant requires approx. 6,900 ha in relation to the nitrate directive. After digestion the liquid is spread in relation to the nitrate directive now requiring approx the an area of 5,500 ha which means a saving of approx. 1,300 ha spreading area. This will reduce pressure on land in the area and reduce costs for transport and spreading. On this area the total nutrient demand can be covered by using the separated digestate. It is obvious to utilise part of the nutrients for fertilising the crops supplied. The solid fertiliser (the fibre fraction) is sold as solid fertiliser.

According to Table 12: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000) the ultimate speading area of the Prefecture of Aitoloakarnania comes to 560 thousand stremmas of annual crops.

Biogas Site 3: *REGION OF THESSALIA (Trikala)*

The raw manure supplied into the plant requires approx. 2,500 ha in relation to the nitrate directive. After digestion the liquid is spread in relation to the nitrate directive now requiring approx an area of 2,000 ha which means a saving of approx. 500 ha spreading area. This will reduce pressure on land in the area and reduce costs for transport and spreading. The solid fertiliser (the fibre fraction) is sold as solid fertiliser.

According to Table 20: Distribution of utilised area by basic categories of land use (Agriculture - Livestock Census 1999/2000) the ultimate speading area of the Prefecture of Trikala comes to 468 thousand stremmas of annual crops.

Results within Step 2: Selection of the biogas neighbourhood

Sale of energy in the neighbourhood of the biogas plant

Biogas Site 1: *REGION OF STEREA ELLADA (Schimatari)*

The total amount of CH_4 production is approx. 3.7 Mm^3 (approx. installed capacity 1.7 MWe). In this case it is assumed that the biogas is utilised in a gas engine for the production of electricity for sale to the grid and for production of heat. The heat is mainly used for the process and no external heat sales are assumed (there is a possibility the excess heat to be used in the nearby area, eg for space heating ot other uses of the military campus). The following energy production can be expected:

Energy production					
Gas produktion used on site	37.204.395	kWh/y	at	9,94	kWh/m3 CH4
equal to	4.247	kW			
Minmum engine capacity	1.695	kW electric	at		
Utilisation					
Electricity production engine	14.102.326	kWh/y	at	39,9%	efficiency
			and	5%	of the time out
Total electricity production	14.102.326	kWh/y			
Heat production	16.072.299	kWh/y	at	43,2%	efficiency
Used in the process	9.573.547	kWh/y	at	38	Deg C heated
For other use	6.498.751	kWh/y	equal to	742	kW
Utilised	-	kWh/y	equal to	0%	of heat

As it can be seen an electricity production of approx. 14.1 GWh per year can be expected. The plant uses some electricity for operation (separation equipment, pumps, mixers, blowers etc.). This is estimated to approx. 0.9 GWh (equal to approx. 6% of the total electricity production). This leaves approx. 13.2 GWh for sale to the grid.

It is expected that the engine is out for service in approx. 5% of the time of the year (equal to approx. 18 days). During service the gas is burned in a boiler for producing heat for the plant and possible surplus gas is flared off.

As it can be seen the process heat demand is relatively large (approx. 60% of the heat production from the engines). The reason is that the biomass has relative low energy content/high water content.

Biogas Site 2: *REGION OF DYTIKI ELLADA (Agrinio)*

The total amount of CH_4 production is approx. 9.7 Mm^3 (approx. installed capacity 4.4 MWe). In this case it is assumed that the biogas is utilised in a gas engine for the production of electricity for sale to the grid and for production of heat. The heat is mainly used for the process and no external heat sales are assumed (an alternative is the excess heat to be used in greenhouses in the nearby area). The following energy production can be expected:

Energy production					
Gas produktion used on site	96.853.778	kWh/y	at	9,94	kWh/m3 CH4
equal to	11.056	kW			
Minmum engine capacity	4.411	kW electric			
Utilisation					
Electricity production engine	36.712.424	kWh/y	at	39,9%	efficiency
			and	5%	of the time out
Total electricity production	36.712.424	kWh/y			
Heat production	41.840.832	kWh/y	at	43,2%	efficiency
Used in the process	14.804.080	kWh/y	at	38	Deg C heated
For other use	27.036.752	kWh/y	equal to	3.086	kW
Utilised	-	kWh/y	equal to	0%	of heat

As it can be seen an electricity production of approx. 36.7 GWh per year can be expected. The plant uses some electricity for operation (separation equipment, pumps, mixers, blowers etc.). This is estimated to approx. 1.4 GWh (equal to approx. 5% of the total electricity production). This leaves approx. 35.0 GWh for sale to the grid.

It is expected that the engines are out for service in approx. 5% of the time of the year (equal to approx. 18 days). During service the gas is burned in a boiler for producing heat for the plant and possible surplus gas is flared off. The process heat demands approx. 36% of the heat production from the engines.

Biogas Site 3: *REGION OF THESSALIA (Trikala)*

The biogas production of approx. 2 Mm^3 CH_4 equals approx. 0.95 MW biogas. In this case it is assumed that the biogas is utilised in a gas engine for the production of electricity for sale to the grid and for production of heat. The heat is mainly used for the process and no external heat sales are assumed. The following energy production can be expected:

Energy production		
Energy production	20,756,688 kWh/y	9.94 kWh/m^3 CH_4
equal to	2,370 kW	
Electricity production	7,867,823 kWh/year	39.9% efficiency & 5% of the time out
Heat production	8,966,889 kWh/year	43.2% efficiency
Used in the process	3,586,756 kWh/year	38 Deg C heated
For other uses	kWh/year	equal to 614kW
Urilised	-	-

As it can be seen an electricity production of approx. 7.9 GWh per year can be expected. The plant uses some electricity for operation (separation equipment, pumps, mixers, blowers etc.). This is estimated to approx. 0.4 GWh (equal to approx. 5% of the total electricity production). This leaves approx. 7.5 GWh for sale to the grid.

It is expected that the engines are out for service in approx. 5% of the time of the year (equal to approx. 18 days). During service the gas is burned in a boiler for producing heat for the plant and possible surplus gas is flared off.

The process heat demands approx. 40% of the heat production from the engines. No sales of heat are included at this stage.

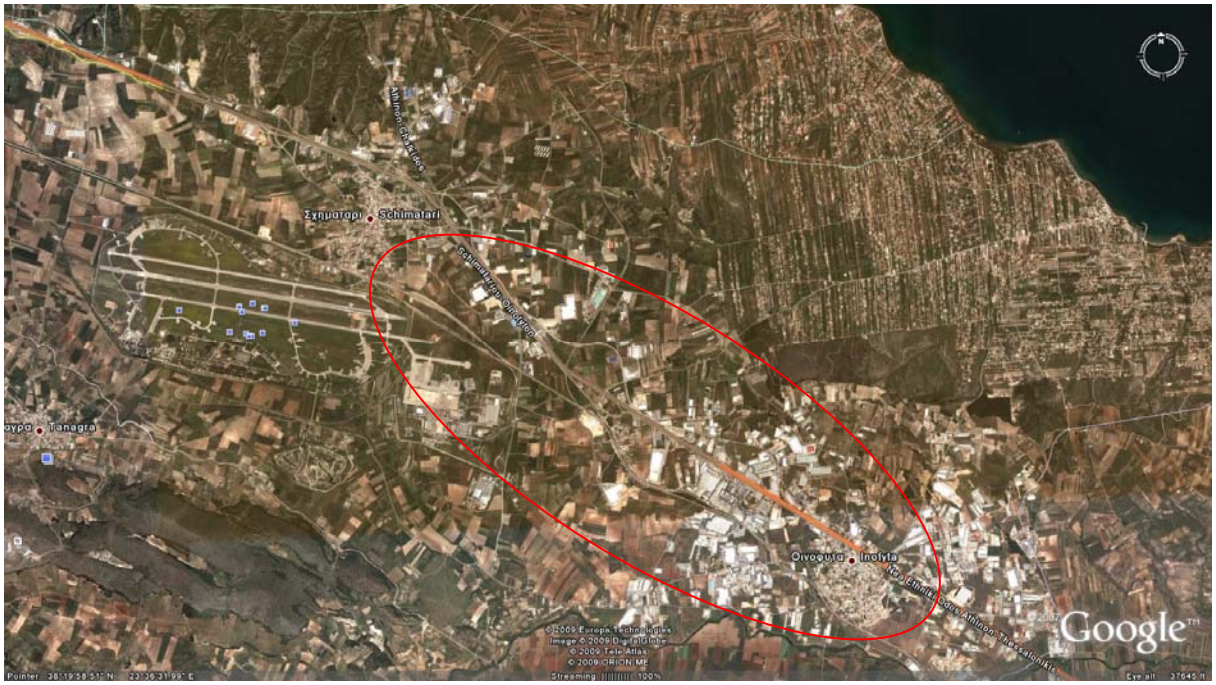
Results within Step 3: Selection of the Biogas Site itself

Requirements towards the biogas plant site

Biogas Site 1: *REGION OF STEREA ELLADA (Schimatari)*

As it is already mentioned the planned biogas plant shall be operated with the input material of liquid manure from pigs, cows and chicken manure, fat, blood from slaughterhouse, dairy waste (Whey) katsigaros (waste of olive oil production) and food waste. The input materials come from agricultural and industrial companies in the nearby area of the plant. The plant can be located to the mainland in the greater area of Schimatari - Inofyta (**see map below**).

The biogas plant can be located in a near distance of the national road Athens – Thessalonica (mainly industrial land use). The area is served by a 150 kV and 400 kV transmission line (see Figure 1) and there are a lot of manufactures and industries in the vicinity of Schimatari and Inofita.



Source: Google Earth

Overall plant set-up

The manure is picked up from the farms and transported to the biogas plant. It is assumed that the industries supplied the waste products to the plant themselves or by contractors.

The plant is provided with the following reception tanks:

Reception tank for manure:	Approx. 2,000 m^3 covered concrete tank provided with mixers
Reception tank for Cat. 3 waste:	Approx. 100 m^3 covered concrete tank provided with mixers
Reception tank for waste where sanitation is not required (whey, vegetable waste etc.):	Approx 200 m^3 covered concrete tank provided with mixers.

By an estimated retention time of approx. 16 days in the primary digesters the volume of the primary digesters will be approx. 9,000 m^3. It is assumed that this is made in two times 4,500 m^3. Alternatively it can be made as three times 3,000 m^3. It is recommended to make the tanks as high silo tanks (a little higher than the diameter) to easy mixing and to save space and that they are provided with top mounted mixers.

The secondary digesters can be made as non insulated concrete manure tanks provided with a double membrane. It is recommended that the retention time is a little longer than in the primary digesters. Besides serving as a secondary digester the volume under the membrane serves as gas storage (approx. 1,000 m^3 gas storage capacities in each tank). It is assumed that all gas passes these three tanks and that a biological gas purification (removal of H_2S) is made under the membrane.

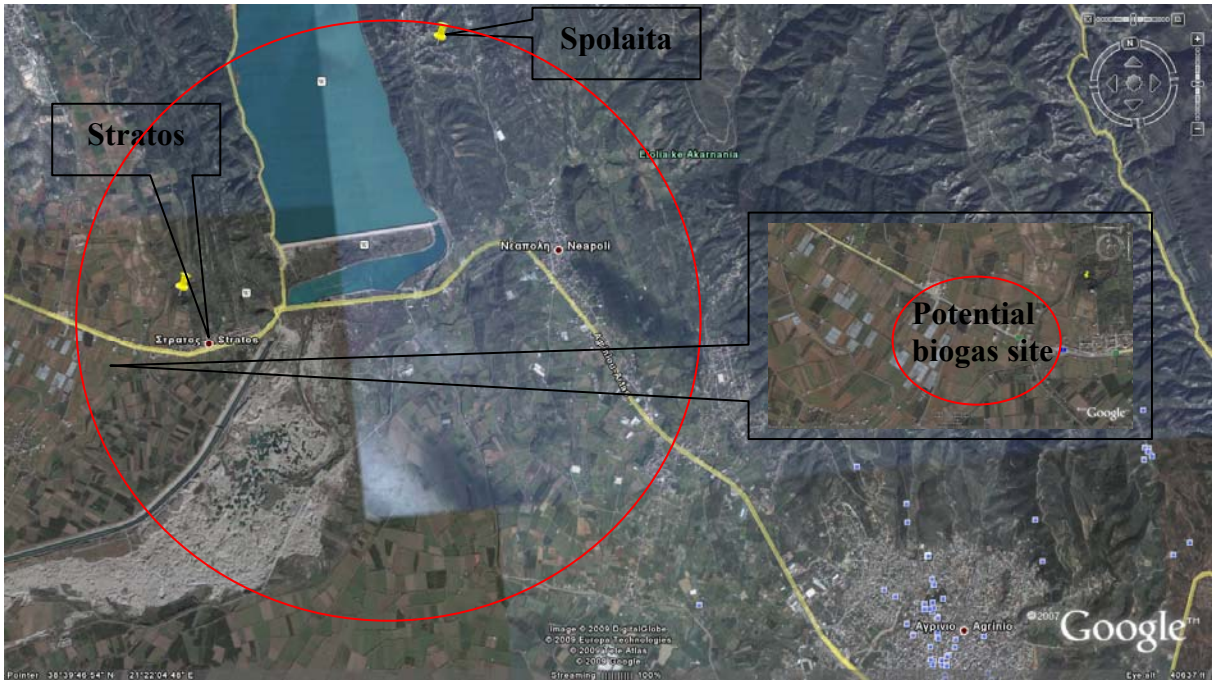
Furthermore, it is assumed that the digested liquid fertiliser is supplied to farms where it can be utilised. An approx. 3,500 m^3 buffer tank for this is included on the site.

The plant as proposed will require a site of approx. 150*175 m (approx. 2.6 ha). The size enables possible later expansion with one more digester and secondary digester.

Biogas Site 2: *REGION OF DYTIKI ELLADA (Agrinio)*

The planned biogas plant shall be operated with the input material liquid manure from pigs, dairy waste (whey), maize silage, katsigaros (waste of olive oil production) and fat, blood from slaughterhouse. The input materials come from agricultural and industrial companies in the vicinity of the plant. The farmers' harvest is directly brought to the place of the plant and discharged into the reception bunker. The plant can be located in the nearby area of Agrinio city (eg. Spolaita or Stratos community in a distance of 10km approx. NW of Agrinio), (**see map below**).

The area is served by a 150 kV transmission line (see Figure 2) and is near to the road Agrinio – Ioannina..



Source: Google Earth

Overall plant set-up

The manure is picked up from the farms and transported to the biogas plant. It is assumed that the industries supplied the waste products to the plant themselves or by contractors.

Silage is produced on the farms and partly stored on the farms and on the biogas plant. The final set up of silage storage facilities can be made in parallel with the project negotiations' on the conditions for supply of silage (see estimation below). The silage supplied into the plant and stored on a plate. From here it is loaded by a front loader into a feeding device (quick mixer). If all silage must be stored at site this requires a plate of approx. 7-9 ha. If this can not be fitted into the site decentralised storage at the farms are required.

It is assumed that the plant is provided with the following reception tanks:

Reception tank for manure:	Approx. 1,000 m^3 covered concrete tank provided with mixers
Reception tank for Cat. 3 waste:	Approx. 100 m^3 covered concrete tank provided with mixers
Reception tank for waste where sanitation is not required (whey and katsigaros):	Approx 1,000 m^3 covered concrete tank provided with mixers.

By an estimated retention time of approx. 14 days in the primary digesters the volume of the primary digesters will be approx. 12,000 m^3. It is assumed that this is made in three times 4,000 m^3. It is recommended to make the tanks as high silo tanks (a little higher than the diameter) to easy mixing and to save space and that they are provided with top mounted mixers.

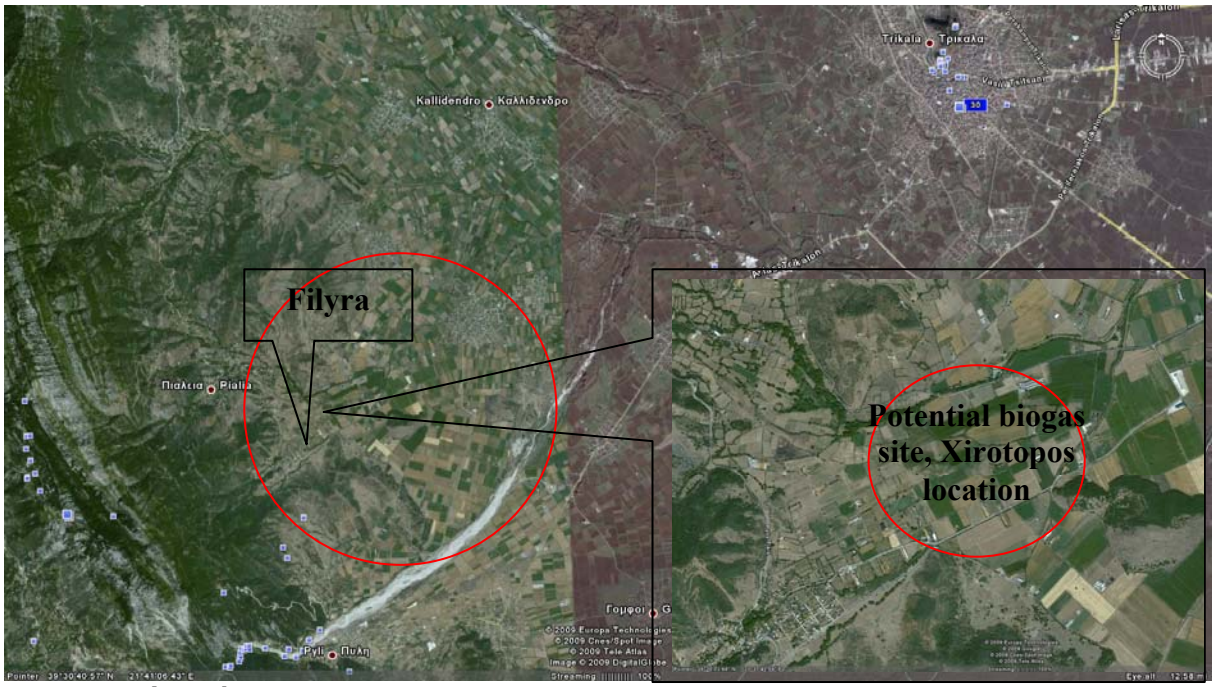
The secondary digesters can be made as non insulated concrete manure tanks provided with a double membrane. It is recommended that the retention time is a little longer than in the primary digesters. Besides serving as a secondary digester the volume under the membrane serves as gas storage (approx. 1,000 m^3 gas storage capacities in each tank). It is assumed that all gas passes these tanks and that a biological gas purification (removal of H_2S) is made under the membrane.

It is assumed that the digested liquid fertiliser is supplied to farms where it can be utilised. An approx. 3,500 m^3 buffer tank for this is included on the site.

The plant as proposed will require a site of approx. 150*200 m (approx. 3 ha) plus possible area for the silage storage (depending on the logistic in relation to supply of silage).

Biogas Site 3: *REGION OF THESSALIA (Trikala)*

The planned biogas plant shall be operated with the input material liquid manure from pigs and maize silage. The input material comes from agricultural companies in the vicinity of the plant (pig farms located in the extent of Pialion Municipality) and the nearby arable land. The farmers' harvest is directly brought to the place of the plant and discharged into the reception bunker. The plant can be located in the nearby area of the Filyra community which belongs to the Municipality of Pialaion (**see map below**), due to high concentration of pig farms, existence of infrastructures and its vicinity to Trikala (approx. 15km SW). Alternative the biogas plant can be located to any of the other communities of the Municipality of Pialion.



Source: Google Earth

Overall plant set-up

The manure is picked up from the farms and transported to the biogas plant in a tanker. It is assumed that the plant is provided with the following reception tanks:

Silage is produced on the farms and partly stored on the farms and on the biogas plant. The final set up of silage storage facilities can be made in parallel with the project negotiations' on the conditions for supply of silage (see estimation below). The silage supplied into the plant and stored on a plate. From here it is loaded by a front loader into a feeding device (quick mixer). If all silage must be stored at site this requires a plate of approx. 1-1.3 ha. If this can not be fitted into the site decentralised storage at the farms are required.

Reception tank for manure:	Approx. 1,000 m^3 covered concrete tank provided with mixers

By an estimated retention time of approx. 15 days in the primary digesters the volume of the primary digesters will be approx. 4,000 m^3. It is recommended to make the tanks as high silo tanks (a little higher than the diameter) to easy mixing and to save space and that they are provided with top mounted mixers.

The secondary digesters can be made as non insulated concrete manure tanks provided with a double membrane. It is recommended that the retention time is a little longer than in the primary digesters. Besides serving as a secondary digester the volume under the membrane serves as gas storage (approx. 1,000 m^3 gas storage capacities in the tank). It is assumed that all gas passes the tank and that a biological gas purification (removal of H_2S) is made under the membrane.

It is assumed that the digested liquid fertiliser is supplied to farms where it can be utilised. An approx. 3,500 m^3 buffer tank for this is included on the site.

The plant as proposed will require a site of approx. 200*100 m (approx. 2 ha), plus possible area for the silage storage (depending on the logistic in relation to supply of silage).

In all the case studies the owner of the plant can be either a private investor or consortium or even a Public Private Partnership (PPPs). Till now in Greece it seems that private investment with funds is a more flexible solution. The ownership has to be clarified in the planning and the structure of agreements between the plant and the ones dealing with the plant have to be structured. The important issue in setting up the organisation is that the ones that have an influence on normal operation also take the risk and gain the advantages.

Results within Step 4: Optimising the soft requirements for selected sites

The Guidelines of the BIG>EAST project and the main principles for the identification of biogas sites were applied to three specific areas in Greece (SCHIMATARI, AGRINIO, TRIKALA). The result of this analysis was the assessment of the suitability for biogas production and utilization in these areas. Following to this step, 2 Biogas Show Cases are selected and will be used to motivate and convince the decision makers in order to support new biogas plants in Greece.

These Show cases are the sites of SCHIMATARI and AGRINIO. It is worth mentioning that there is investment interest in all the identified sites for biogas exploitation. In the framework of the calls for permits to generate electricity by Independent Power Producers (IPPs) by the Hellenic Regulation Authority for Energy (RAE) an application was submitted in December 2008 for a biogas plant with installed capacity of 1,36MWe in the Community of Fiki (Trikala Prefecture)[9].

A detailed analysis concerning the plant layout and characteristics of the two Show Cases will follow in Deliverable 6.4.

[9] www.rae.gr

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