Biogas in Greece: National State of the Art

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1. INTRODUCTION

Biogas is being promoted in the electricity market to reduce both dependence on imports and exposure to international energy markets, as well as to reduce GHG emissions in the atmosphere. The electricity market in Greece, from 1950 to 1994, was dominated by the Public Power Corporation (PPC), which was the only company producing, transmitting and distributing electrical energy in Greece. The PPC generation system consists of the interconnected mainland system (some nearby islands are also connected there), the systems of Crete, Rhodes, and the independent systems of the remaining islands. From 1994 it was allowed to auto-producers and independent producers to generate electrical energy from renewable energy sources while from 2001 the deregulation of the electrical energy market was established.

Even though the government favours the use of natural gas in power generation, low-quality lignite domestically extracted still accounts for 30.72% of Greece's total energy needs in 2005 and contributes 55.9% to the national electricity production (Ministry of Development, 2005).

Greece successfully introduced natural gas into its energy mix in 1996. In 2005, natural gas imported from Russia and Algeria in the form of LNG was estimated to account for 6.6% of gross energy consumption and gas consumption is growing fast. It has already a good footing in power production and has replaced some oil use in the industrial sector. In 2005, natural gas contributed 12.9% to the electricity production in Greece. In the future, most growth in gas demand is expected to come in power generation and in the residential and services sectors. The current gas infrastructure is sufficient to meet demand for several years.

Renewable energy sources –wind energy, small hydro, biomass and photovoltaics- contributed 3.1% to the Greek electricity production in 2005. Biogas accounted for 3.2% of RES contribution, with an installed capacity of about 24 MW, coming from the exploitation biogas energy of landfill generated in Sanitary Landfills (SL) and biogas generated in Municipal Wastewater Treatment Plants (MWTP) in the region of Attiki.

2. BIOGAS CURRENT SITUATION AND POTENTIAL RESOURCES

During the 80's a few efforts for biogas energy exploitation were attempted in Greece, the feedstock being mainly animal wastes and wastes from food processing industries. Some of the efforts were demonstration projects, which were finally abandoned because of a number of reasons, the most important being the lack of proper legislation, financial incentives and lack of public awareness. Nowadays the situation had changed and there are a number of legislative measures and financial instruments available to support biogas investments in Greece and a series of information campaigns to initiate public awareness and stakeholders' involvement in biogas.

The installed power capacity produced from biogas in 2005 was 24 MW, which corresponded to primary biogas production of 1,507.2 TJ. For 2006 the respective figures

were 36.39 MW and 2,905.80 TJ. The biofuel is coming from the exploitation of biogas generated in Sanitary Landfills (SL) (2,268.84 TJ in 2006) and biogas generated in Municipal Wastewater Treatment Plants (MWTP) (636.97 TJ) mainly in the region of Attiki (Table 1). As noted in Table 1, only the large-scale anaerobic digestion (AD) plants of Psyttalia and A. Liosia produce power and heat, while the rest produce only power.

So far a number of additional requests for permits have been submitted to the Regulatory Authority for Energy (RAE) and approved for about 11 MW of additional electricity generation in the coming years. This figure is relatively low compared to the potential energy generation from SL and MWTP.

Table 1: Anaerobic plants in Greece

Plant	Feedstock	Amount (m^3/day)	Gas production (Nm^3/day)	Primary production of biogas (TJ/y)	Installed Capacity (MW)	Produced Electricity (MWh_e)	Produced Heat (MWh_{th})	Produced Heat (TJ/y)
1. MWTP of Chania	Sewage sludge	17,000	1,085	9.12	0.21	130		2.2
2. MWTP of Heraklion	Sewage sludge	23,000	3,200	26.90	0,19	465		4.3
3. MWTP of Volos	Sewage sludge	27,000	1,500	12.61	0,35	240		4.12
4. MWTP of Psyttalia	Sewage sludge	760,000	70,000	588.34	7,14	28,000	40,300	145.22
5. SL of A.Liosia	Landfill gas		164,000	1,107.41	13,8	264,000	0	0
6. SL of A.Liosia (Expansion)	Landfill gas		112,000	756.28	9,7	190,000	84,500	304.49
7. SL of Tagarades	Landfill gas		60,000	405.15	5,0	95,600	0	0
TOTAL			**411,785**	**2,905.80**	**36,39**	**578,435**	**124,800**	**460.32**

Regarding the potential resources for biogas production in Greece, sheep, goats and lamps breeding represents the highest percentage of livestock but this is mainly shepherded and thus the produced manure is spread on the grazing land (Bookis, I. 1997). 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.

The potential users for biogas production through AD would be focused on intensive livestock, such as medium scale livestock units (Table 2).

Table 2: Biomass potential (of the main organic wastes) in Greece

Category	Units *	Capacity *	Organic wastes (t/y)	Installed capacity (MW)
Cattle	32.875	727,040 cattle	14,540,800	278
Sows	36.593	140,645 sows	2,268,220	37
Slaughterhouses	101	77,242 t/y (Cat 2) 127,690 t/y (Cat 3)	204,932	28
Milk factories (milk processing for cheese production)	548	160,362.4 t/y goat milk 447,705.2 t/y sheep milk	425,647	7.21
Σύνολο			**17,439,599**	**350.21**

* Source: Ministry of Agricultural Development and Food

According to Table 2 and based on a conservative scenario, about 17,400,000 tons of main organic wastes are annually produced in Greece. 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 350MW. A mean annual electricity production equal to 1.121.389 MWh_e/y (38,5% efficiency 5% maintenance) and 1.349.000 MWh_{th}/y or 4861 TJ/y (44% efficiency) of thermal energy.

Following the previously mentioned data, eight centralised anaerobic digestion (CAD) plants, of 5-20 MW installed capacity, could be constructed in Greece, in areas of high organic waste potential that is associated with high environmental risks created from their uncontrolled disposition. An advantage noted is their close proximity (all proposed plants are in a radius of 20-25 km) that lowers the transportation costs of the organic wastes to the centralised AD plants.

3. LEGAL FRAMEWORK AND SUPPORT MEASURES

The following legislative framework on RES, including biogas, is currently in place:

- **Law 2244/94**, regarding revisions on the electricity production code from RES, and the implementing Ministerial Decision 8295/95, which broke new ground for the promotion of RES in Greece. This law remained in force only until the end of 2000, when it was replaced by the law 2773/99 for which it still acts as reference.
- **Law 2773/99** regarding the liberalisation of the electricity market in Greece. Key features include:
  a) priority to the electricity produced from RES to cover the demand of electricity
  b) a ten year contract to the producers of electricity from RES at a price which will be 90% of the existing medium voltage tariff, at maximum, for the energy produced.
- **Development law 2601/98**, replacing 1892/90, which was the main funding tool of RES applications.
- **Law 2941/2001** regarding the simplification of procedures for establishing companies, licensing Renewable Energy Sources plants, etc.
- **Law 3017/2002** related to the ratification of the Kyoto Protocol to the Framework-convention on climate change",

The new developments in the legislative framework are the following:

- **Law 3299/2004** on promotion of investment. Subsidies vary from 40- 55% according to region, and the type of the enterprise (in case of SMEs and specific regions they can reach up to 55%) (www.elke.gr is the official site of the Hellenic Centre for Investment). Support on capital cost (up to 40%) for biodiesel plants was included in the 3rd Community Support Framework (Energy), which ended last year. The 4th Framework is under development and respective provisions are expected to be put forth.
- The Biofuels directive 2003/30 has been adopted by the Greek government late 2005, as **law 3423/2005**. According to this, biodiesel will be the main biofuel for the Greek transport sector with bioethanol playing a less important role until 2008. The amount of biodiesel required to satisfy the indicative target of 2% (on a lower calorific basis) for the year 2006 has been estimated to be circa 80.000 tonnes while the amount to satisfy the indicative target of 5.75% for the year 2010 has been estimated to be c. 148.000 tonnes.
- The Directive 2001/77 on electricity from RES has been adopted by the Greek government in June 2005, as **Law 3468/06**. According to this, a target of 20.1% RES contribution incl. large-scale hydro on electricity production in 2010 has been set. The main scope of this new law is to simplify the permitting system for the RES investments in Greece (i.e. licensing procedures). A point of strong interest is the new electricity feed-in-tariffs system, applicable for the sales of RES-produced electricity to the grid. Electricity produced by biomass is set at 73 euro/MWh.
- Join **Ministerial Decrees** 54409/2623(27/12/2004) ruling the Emissions Trading schemes

- Specific Spatial Planning Framework and Sustainable Development for RES. According to this plan, for biomass and biogas exploitation, favorable areas are considered these located in near proximity to agricultural lands where biomass is produced, waste treatment plants, food industries, animal breading farms. Minimum distances from the nearby land uses are set. The plan is under public consultation.

The financial measures set for RES applications, including biogas are the following:

- The Operational Programme of Energy (OPE) (1994-2000) of the 2nd Community Support Framework (CSF) is the most important financing instrument for RES promotion in Greece. Currently, the funding mechanisms of the Operational Programme of Competitiveness (OPC) of the 3rd CSF, initiated in 2000-2006 by the Ministry of Development, gave a further impulse to RES projects, with a total budget of about 777.6 MEURO (public funding of about 268.4 MEURO). Biomass share was 60.7 MEURO, out of which the 31.4 MEURO were spent on biogas projects.
- A provision has been applied to give the 3% of the electricity sales in favor of the municipalities, in order to curtail any public opposition in areas with high RES potential. A significant budget has been earmarked for the upgrading of the electricity network in areas of high wind or biomass potential.

It is expected that with the forthcoming 4th CSF private investors will take advantage of the funding mechanisms and the upgrading of the network and will invest.

4. RISKS AND BARRIERS

There are a number of key risks and barriers that can threaten investment in biogas projects and thus prevent more rapid uptake of desirable technologies. Barriers associated with investment opportunities, on a macro-economic level, were categorised according to distinct but interrelated topics and include:

- Cognitive barriers, which relate the low level of awareness and understanding of the financing schemes and risk management infrastructures
- Political barriers, associated with regulatory and policy issues (lack of gate fees, lack of regulatory price for heat)
- The small-scale of projects,
- Resource availability and supply risk, either in terms of assessing the resource or contracting the supply (reduction of gas quantity and quality due to changes in organic feedstock)
- High investment costs
- Planning opposition associated with odor problems

Biogas projects suffer significantly from resource supply risk and small scale. One issue that comes up repeatedly when seeking finance for biogas and cogeneration projects is security of supply and fuel price volatility.

Large plants owners are not properly aware of the technologies for manure treatment and potential biogas-to-energy applications, while, on the other hand, small plants cannot in general effectively combine forces with other producers to form clusters of enterprises and create viable biogas plants.

The few potential investors that are fully aware of all the benefits of biogas exploitation mentioned are discouraged to proceed to similar investment due to the high investment cost and the low public subsidy (grant). The financial return for an AD plant is insufficient to repay the investment outlay, because financial analyses do not include the socio-economic costs and environmental benefits (external costs).

Although new laws and ministerial decrees have been adopted, which improve the institutional and the legal framework for such investments, these investments are resource-limited, i.e. the "polluter pays principle" is not applied practically, which would greatly improve operational costs by imposing gate fees to polluters and help remove uncertainties for the power plant owners.

Liberalisation of the energy market, that would initiate investments, is not fully implemented in Greece and PPC still retains the leading position in power generation and supply.

5. PERSPECTIVES AND SUCCESS CONDITIONS

A realistic scenario was produced (Ministry of Development, 2005) to assess the demand for installed power capacity from RES that is needed to reach the target of 20.1% contribution of RES in the internal electricity market. According to this scenario, the requirements in installed capacity by 2010 from biomass are 103 MW, which corresponds to 0.81 TWh and accounts for 1.19% of the RES share (Table 3). The scenario was based on the assumption that the share of various RES types will not vary significantly in the next four years; thus the biomass-produced electricity will derive mainly from biogas. This assumption is considered as realistic given that rapid technological evolution that would lead to significant changes in the economic viability of the various technologies is not expected.

Table 3. RES installation requirements to meet the 2010 target.

	Requirements in installed capacity by 2010, in MW	**Energy gene-rated in 2010 in TWh**	**Percentage share of every renewable energy source in 2010**
Wind parks	3,372	7.09	10.42
Small-scale hydro	364	1.09	1.60
Large-scale hydro	3,325	4.58	6.74
Biomass	103	0.81	1.19
Geothermal	12	0.09	0.13
Photovoltaics	18	0.02	0.03
Total	**7,193**	**13.67**	**20.10**

Referring to the success conditions, some corrective actions that may be undertaken to improve and speed up the current licensing process of RES, including biogas, are outlined below:

- Strict adherence to the deadlines set for the various RES applications which are rarely respected by the public electricity company, by the relevant departments of the Ministry of Development and the Ministry of Environment, Civil Planning and Public Works, by the regional and prefecture authorities, etc.
- Substantial reduction in the number of public- sector entities (departments, committees, agencies, etc.) required to approve environmental licensing of RES installations, so as to initiate investments.
- Detailed examination of the possibility to incorporate all RES –licensing procedures into a 'one-stop shop' mechanism, under the supervision of the Ministry of Development.
- Creation of national clusters consisted of representatives from SMEs, technology suppliers, specialized contractors, equipment manufactures, financing providers, policy makers (Ministries, Local Authorities) etc. that would assure constant and

efficient linking between different policies – on energy, environment, etc – and marketing activities on biogas deployment. The aim of such clusters would be to determine synergies, dependencies and interactions between the involved key players for each stage of a biogas plant life cycle and find out which productive systems can be derived.

- Increase of the percentage of the public funding on the investment capital costs from the 40% that is now to 50%, mainly for the advanced bioconversion technologies.
- Improvement of the biogas market conditions (increases of demand and thus increases of the selling price of the energy products). This could be achieved through the increase of the amount of the de-taxed biofuels and the price of the biogas-produced electricity to the grid (73 euro/MWh set at present to the 150 euro/MWh).

6. CONCLUSIONS

Biogas currently exploited is mainly in the form of landfill gas and sewage sludge generated gas. However, Greece has a high organic waste potential that currently is not exploited. Eight CAD plants could be constructed, with a total installed capacity of 350 MW, in areas of high organic waste potential.

The legislative framework and financing mechanisms are constantly being improved, but the still high investment costs coupled with the lack of public awareness on biogas production advantages, the lack of implementation of a 'gate-fee', as well as the lack of socio-economic costs and environmental benefits (external costs) reflected in economic analysis of a CAD plant hinder the biogas deployment in Greece.

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