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DEVELOPMENT OF A BIOMASS PRODUCTION NETWORK IN THE PREFECTURE OF KORÇA AND THE REGION OF WESTERN MACEDONIA A PEST ANALYSIS

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Abstract

In this study, we tried to understand the current situation of biomass production in the two cross-border regions that include the Prefecture of Korçë and the Region of Western Macedonia with the aim of promoting the development of a biomass production network in the region. For the purposes of this study we decided to use biomass combustion in the wider sense of the term encompassing all biomass conversion technologies in order to provide a more complete picture of the biomass energy generation in the two cross-border regions of Prefecture of Korça and Region of Western Macedonia. The biomass users for energy generation can be classified as household users and industrial users. The category of industrial biomass users can be further subdivided into biomass heat generation plants, biomass electricity generation plants or biomass Combined Heat and Power (CHP) plants which are a combination of the two, producing electricity and thermal energy simultaneously. The objects of this study are biomass combustion companies which generate energy for sale beyond fulfilling their own needs. This category includes district heating systems and biomass power plants. As the focus of this study is on private energy

companies in the two cross-border regions and their possible cooperation, the public enterprises falling in this category are excluded.

Keywords: biomass, thermal energy, powerplants, energy sale, economy

INTRODUCTION

Biomass sources for energy generation

The biomass sources that can be used for energy generation can be classified into six categories, based on their properties (Khan et al. 2009): Forestry products, waste, and residues, which can be subdivided into: Stem-wood logs and wood chips, primary forestry residues: Logging residues, stumps, secondary forestry residues: wood processing by-products and residues, bark, cutter chips, and sawdust. Tertiary residues: demolition wood (e.g., from furniture) Agricultural residues and wastes (also called herbaceous species), which are subdivided into three categories:

• Primary (or direct harvest-related) residues, e.g., straw and vineyard residues

• Secondary residues, which are generated after processing harvested material: Bagasse (residue from sugar production from sugarcane) Molasses and vinasse, nutshells. Press cakes or pulp (from, e.g., olive and other vegetable oil processing) Rice husks. Tertiary residues: manures from (domesticated) animals, such as chickens, cows, and pigs—dung and litter

Benefits of biomass energy generation

The principal advantages of using biomass as a source of energy include its smaller negative impact on environment compared to fossil fuels and its relatively high availability. Bioenergy delivers substantial and cost-effective greenhouse gas reductions (Thornley et al. 2015).

Biomass is considered CO2-neutral because its proper combustion adds to the atmosphere the same amount of carbon dioxide that was recently removed from atmosphere by photosynthesis. In contrast, burning fossil fuels such as oil, coal, and natural gas adds more carbon dioxide to the atmosphere than is being removed because it releases carbon dioxide contained in the fossil fuels that was removed from the atmosphere a long time ago. Thus, biomass combustion does not contribute to the aggravation of the greenhouse effect. Furthermore, biomass is highly flexible both in its production and usage. As explained above a wide range of materials can be used for its production. In addition, the energy stored in it can be converted into electricity, heat and kinetic energy. However, it is often available in the form of a low bulk density solid, which means that biomass usually has less energy than a similar volume

of fossil fuels. Biomass has much higher oxygen content than fossil fuels which lowers its combustion value to roughly half of its fossil counterparts.

From a fuel's point of view the material content of biomass can be classified as organic components (like cellulose, hemicelluloses, lignin, fat, waxes, etc.), ash components (the nonorganic components in the organic structure inside the biomass or dissolved in internal water), and the water content itself. Biomass generally needs some processing before it can be used for energy generation.

BIOMASS COMBUSTION IN THE TWO CROSS-BORDER REGIONS

Prefecture of Korça

Of all the various biomass sources that can be used for energy generation only wood biomass is actually used for energy production in the Prefecture of Korça. Firewood remains the main fuel for heating and cooking in the Prefecture of Korça accounting for 96.35% of the total energy used for heating with about 90 - 93% of their amount used by households and the remaining used by businesses operating in the services and industry sectors (Instat 2015). In the last couple of years there has been observed a greater use of the wood pellets particularly by households.

At the moment there are no biomass combustion facilities as per our definition in the Prefecture of Korça. The establishment of landfill of Maliq most likely will be the first step towards using biomass for energy generation beyond fulfilling own needs. The project could result in considerable amounts of biogas production from the organic municipal waste.

Region of Western Macedonia

The biomass used for energy generation in the Region of Western Macedonia consists largely of wood biomass. Wood biomass in the form of firewood and wood pellet is used primarily for thermal energy generation by households (Grammelis et al. 2010). Wood waste is used mainly from wood processing companies to fulfill their needs for thermal energy.

Wood biomass is used also by some business entities operating in the Region of Western Macedonia, particularly those engaged in wood processing that use the wood waste that results from wood processing to generate energy. ALFAWOOD – PINDOS S.A. and ZIOGAS Co. - two wood processing companies - are examples of such businesses. As the energy produced from biomass is destined for own use these cases are excluded from our study (outside the focus of this study).

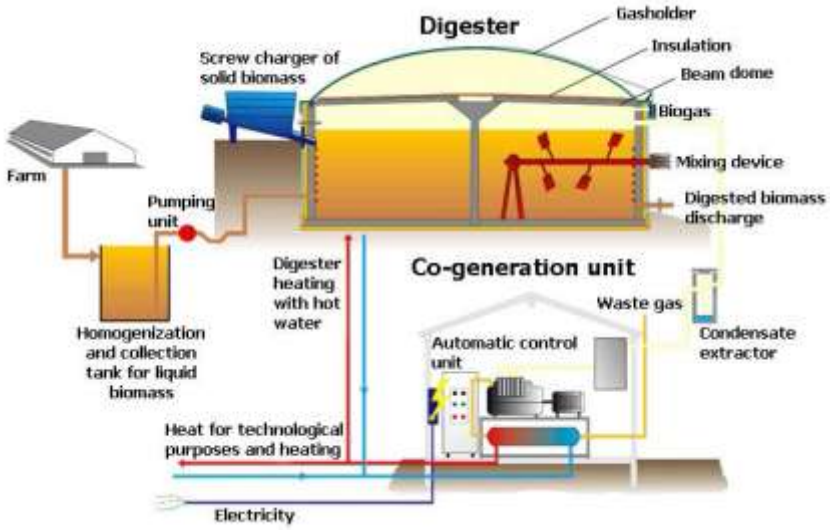
Currently there are only two biomass CHP units operational in the Region of Western Macedonia, Matesion Co. in Kozani (120 KWel) and Mantmouazel S.A. in Kastoria (240 KWel), producing biogas from various organic waste.

The information regarding the existence of these 2 biogas plants was obtained by a study on the location and the identification of the Pilot Projects – Regional Examples of biomass and bioenergy production, prepared by the Greek partners of the GABE project.

We used the information provided by them on Matesion Co. unit and also contacted via phone with the company to obtain additional information. We visited Mantmouazel S.A. to obtain the relevant information.

The two projects represent the first private investments in the field of bioenergy production in the Region. They use the same biomass conversion technology as Matesion Co. is the technology provider and constructor of Mantmouazel's unit. The biomass sources used for the production of biogas include animal waste (manure) and a variety of agricultural waste with the former accounting for the biggest share. They are converted to biogas and compost using anaerobic digestion. The biogas produced feeds an internal combustion engine (electric power generator) to produce heat and electricity. Heat is used for the producers' own technological and heating purposes while electricity is sold to the Greek electricity supply company (PPC S.A) though long term contracts of 20-years duration. Compost, being a very good organic fertilizer, is sold to the farmers and breeders in the region. Schematically, the biomass conversion to biogas is shown in the figure below:

Figure 1 Biogas production from animal manure and agricultural waste



Source. www.zorg.ua

MATESION Co.

MATESION Co. offers a wide range of project design and consulting services. The biogas unit is located in a parcel in Ag. Dimitrios, in Kozani, occupying an area of 5,293 m^2. Some of the most important components of the biogas plant are shown in the figures below

Figure 2 Homogenization tank, digester tank

Photos taken on site by the authors

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Mantmouazel S.A.

The company MANTMOUAZEL S.A. is engaged in the fur farming and leather processing and only recently operates a biogas unit. The biogas unit of Mantmouazel S.A. is located in the Chiliodentro Kastoria, Perioki: Dhromos Argos Orestikoi, Kiliodhendro Agrotica 204. It is also located in a parcel with an approximate area of 20,000 m^2.

Some other biomass to energy projects are in different phases of completion. The most "ready" bioenergy installation is located in the Municipality of Servia – Velvento. Its main parts are: an anaerobic digestion and CHP unit, and a pellet production unit (10,000 ton/year). The anaerobic digestion unit exploits animal waste and agricultural residues, producing biogas used for electricity generation and heat (1MWel + 1,25MWheat). The pellet production unit uses forest (ligneous) biomass for pellet production, which can be sold in market to household or industrial users. The waste heat produced by the CHP unit is used for forest biomass drying during the pellet production process. One or more biomass boilers using biomass or wood pellet

as fuel can be added to meet the area's heating needs (Kouras et al. 2014). This investment was submitted to JESSICA, but actually is frozen due to the crisis.

The construction of a 500KW biogas plant that will use cattle manure and abattoir waste as substrates located in Ptolemaida is under construction as declared in the press release dated November 2014 of the German biogas plant manufacturer WELTEC BIOPOWER. (http://www.electricenergyonline.com/detail_news.php?ID=506179&titre=WELTEC+builds+Biogas+Plants+in+Greece&cat=;83;59)

Another project that is in an advanced stage of implementation is the Municipal Solid Waste (MSW) treatment facility in the Region of Western Macedonia established by E.P.A.DY.M. S.A. with shareholders HELECTOR S.A. and AKTOR Concessions S.A.. The Project relies on the aerobic treatment of the organic fraction of the waste and is to be undertaken by the German company Herhof GmbH which is 100% affiliate of HELECTOR S.A.

As per the latest information provided by the Greek partners of this project the 3 District Heating Systems that are currently operative in the Region of Western Macedonia (in the cities of Kozani, Ptolemais, Amyntaion) want to include biomass in their mix. One of them is performing the study for a new biomass boiler and one other has done it already and even made a non-binding procurement for such a plant.

PEST ANALYSIS

Political factors

Albania

There is an improvement of the political climate in Albania. The local elections held in June 2015 were not accompanied with major contestations reflecting the country's greater democratic maturity. They can be considered a step forward towards establishment of a normal political climate in the country. As contracting party to the Energy Community Treaty, Albania has made binding commitments to implement the relevant EU Acquis on energy, environment and RES (Energy Charter Secretariat, 2013). Significant progress has been made in transposing the Community *acquis* on renewable energy into the national legislation. In line with the EU's Renewable Energy Directive 2009 the country has taken important steps to promote the use of renewable energy. The Law "On Renewable Energy Resources" that was approved in 2013 is fully approximated with the European Parliament Directive 2009/28/EC. It is the central piece of legislation for promoting the use of energy from renewable sources in Albania. To achieve the declared 2020 national renewable energy target of 38% the producers of renewable energy are given a preferential treatment. The law gives priority dispatch to producers of electricity from renewable sources. It guarantees transmission and distribution of the electricity they generate if

they benefit from the Feed-in Tariff mechanism and have signed a power purchase agreement (PPA) with the utility company which is obliged to purchase the electricity generated from renewable energy sources. Simplified licensing procedures and authorizations for producers of renewable energy are already approved by the Council of Ministers. In addition, companies investing in construction of renewable energy plants are entitled to an exemption from custom duties on the import of all machinery and equipment used for the construction of the renewable energy plants (KPMG 2014). Energy Efficiency Law (still in draft version) is another important legal initiative that promotes RES. It foresees the establishment of a National Energy Efficiency Fund to provide grants (subsidies), loans, financial guarantees or other types of financing for the implementation of energy efficiency projects.

Greece

The Greek parliament approval of the economic reforms required by the country's international creditors and supported by the left-wing government avoided the country going into early elections. However, the longevity of the current government is closely linked with the success of the proposed reforms. The recent months have been a very difficult period for the government but the most crucial challenges lie ahead.

Greece is an EU member country and consequently the national policies to a large extend are dictated by the EU policies. Under the Renewable Energy Directive **(**Directive 2009/28/EC) all EU Member States have taken on binding national targets for raising the share of renewable energy in their energy consumption by 2020. The Renewable Energy Sources Law (3851/2010), which entered into force in Greece in June 2010, sets the RES targets for Greece: RES electricity share (40%), RES heating and cooling share (20%), and RES transport share (10%) in order to achieve the national target of 20% contribution of the energy produced from RES to the gross final energy consumption (NREAP Greece 2010). To achieve the national RES targets it introduced a favorable framework for the development of Renewable Energy Sources (RES) projects in Greece particularly by:

- accelerating and simplifying the licensing procedures for RES projects
- improving the procedure for connection of renewable energy projects to the grid.

Reserved connection capacities are provided for new installations producing electricity from renewable energy sources (NREAP Greece 2010)

- improving the feed-in tariff scheme applicable to electricity generated from renewable sources

Further incentives are provided by Law 4146/2013 "Creation of a Business-Friendly Environment for Strategic and Private Investments" which is the primary investment incentive

law currently in force. It is gradually phasing out Law 3908/2011. The types of aid foreseen by the law include:

- **Tax relief** providing exemption from payment of income tax on pre-tax profits which result, according to tax law, from any and all of the enterprise's activities.
- **Subsidy** with the State providing a sum of money to cover part of the subsidized expenditure of the investment.
- **Leasing subsidy** with the State paying a portion of the installments under a leasing agreement to acquire new machinery and/or other equipment.
- **Soft loans** by ETEAN (National Fund for Entrepreneurship and Development).

The aid referred to above is aggregated for the purpose of determining the total amount of aid allocated to the investment project. In this case the benefit of the funding above is included in total aid, which may not exceed the limits delineated on the Regional State Aid Map.

Table 1 Regional State Aid Map and aid rates for the region of Western Macedonia

Region	**Prefecture**	**Zone**	**Percentage of aid**		
Western Macedonia			Large enterprises	Medium-size enterprises	Small and micro enterprises
	Grevena	C	30%	40%	50%
	Kozani	B	30%	35%	40%
	Florina	C	30%	40%	50%
	Kastoria	C	30%	40%	50%

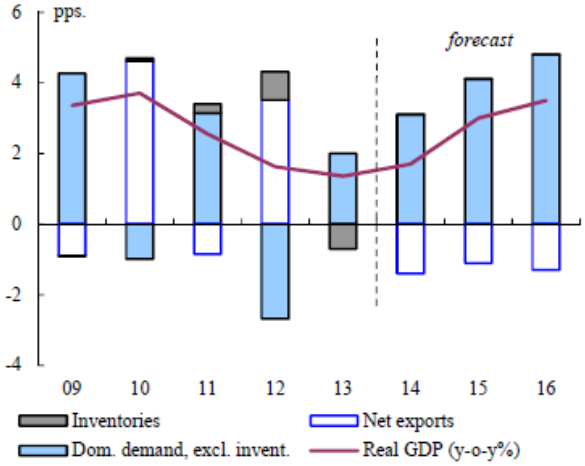
L.4146/2013 followed by an amendment introduced through Art.68 of L.4155/2013 narrowed RES investment subsidies only to hydro, pumped hydro, hybrid, biomass and biogas stations for all the investment plans submitted after the 01.01.2014. However, all RES technologies are eligible for tax incentives (Second Progress Report on the Promotion and Use of Energy from Renewable Sources in Greece 2014).

In both countries the approval of stimulating renewable energy policies is likely to have a significant positive influence on the development of the biomass market.

Economic factors

Both, the latest European Commission and the World Bank economic forecasts for Albania seem favorable. Economic growth is projected to rise to 3 percent in 2015 and 3.5 percent in 2016 supported in particular by a rising domestic demand.

Figure 3 Albania – Real GDP growth and contributions



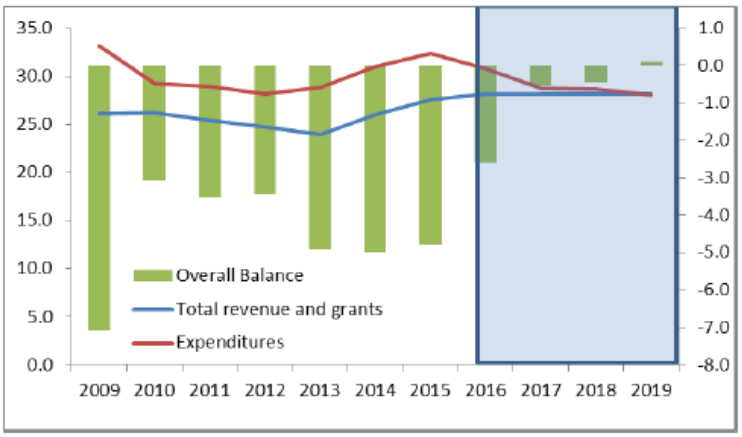
Source: European Economic Forecast Winter 2015

The private consumption is expected to increase due to the positive effects of the fall in international oil prices and sluggish increase in food prices on consumer's purchasing power. The domestic private investment is also expected to increase due to repayment by government of arrears to business, expected credit expansion and business climate improvement.

The expected NPLs (non-performing loans) resolution and bankruptcy law improvement are believed to be the main drivers behind credit expansion as the banks will be more willing to lend once they have cleaned up their balance sheets. The NPLs have fallen slightly in 2015 and are expected to fall further as arrears are repaid. In addition, a significant amount of troubled loans is expected to be written off to comply with the regulations of Bank of Albania. Despite the difficulties faced the banking sector remains stable and profitable. The interest rates are expected to remain low influenced by the low policy rate adopted by the Bank of Albania. Bank of Albania is likely to keep its policy rate low as inflation is predicted to move slowly towards the target of 3%. The ALL to EUR exchange rate is stable and is expected to remain so in the foreseeable future. There seems to be an improvement in the business climate reflected in the better standing in ease of doing business in the Doing Business 2015 report attributed largely to the modernization of the legal and regulatory framework for business. A strong inflow of FDI is expected as the implementation of the TAP project advances. They are believed to mitigate the anticipated widening of the current account deficit. The public finances are expected to improve due to the fiscal measures included on the annual budget law for 2015 and the fiscal consolidation program that began in 2014. As a result a further narrowing of the fiscal deficit to 4.8 percent of GDP in 2015 is anticipated. In addition, Albania's public debt is projected to fall below 60 percent by 2019. However, the serious financial difficulties of the energy sector

represent a major risk for the country's public finances. The situation and future prospects of the Albanian Electricity Sector presented below refer to the World Bank's analysis of the Albanian Energy Sector in the document entitled ALBANIA World Bank Group Partnership Program Snapshot April 2015. The Albanian electricity sector is characterized by increasing demand for electricity and uncertain supply due to almost total dependence on hydropower generation which is conditional on weather conditions. It is not financially self-sustaining because of high distribution losses, low collection rates and high arrears thus being a substantial burden for the government finances. Government has taken vigorous measures to improve the situation and turn (make) the sector financially self-sustaining. It initiated an enforcement program in 2014 to reduce electricity theft and increase revenue collection. New cost-reflective tariffs are introduced since January 2015 followed by the approval of a power sector recovery plan supported by IMF.

Figure 4 Fiscal Revenues, Expenditures and overall balance as % of GDP



Source: Ministry of Finance; World Bank staff calculations

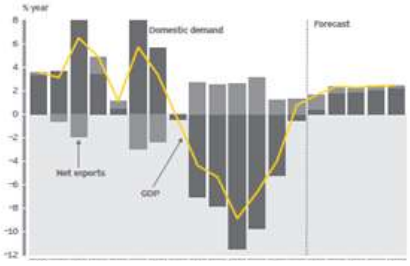
To a certain extend the Albania's economic prospects depend on the resolution of the Greek crisis considering the interconnection of the two economies (Elbasani and Elbasani 2010). It poses several risks to Albania's economy with the Albanian cross-border regions being particularly vulnerable to the economic hardship in Greece (ACIT 2012). Unfortunately, the official economic data for the Prefecture of Korça are very limited to provide further insights on the economic development of the region. The latest INSTAT data published in the REGIONAL STATISTICAL YEARBOOK 2015 show that the GDP for the Prefecture of Korça was approximately 521 million euro in 2012. It shows a rising trend, albeit a small one, from 2008 to 2012. In 2012 the per capita GDP for the prefecture of Korça was 70% of the country's average classifying the region in the lowest GDP per capita category. Services (40.4 % of the Gross Value Added) and agriculture and fishery (38.7% of the Gross Value Added) were the most

important economic sectors in the prefecture of Korça in 2012. Industry and Construction accounted for approximately 10% of the Gross Value Added each. In 2014 the number of active enterprises in the Prefecture of Korça was 7311 with 90% of them having 1-5 employees.

Greece x years of recession, 2014 proved

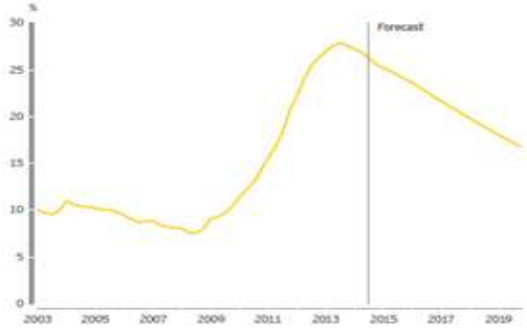
The economic outlook for Greece is encouraging assuming that the country implements the required reforms. However, considering the most recent events that have accompanied the lengthy negotiations on the bailout plan the situation presented below may refer to a rather optimistic scenario. After a six-year recession that began in 2007 the country recorded a positive real GDP growth in 2014. Although GDP grew by only 0.8% in 2014 it may have signaled the beginning of the economic recovery for Greece. According to the EY Eurozone Forecast of March 2015 GDP is expected to increase to 1.7% in 2015 and 2.4% in 2016. The European Commission forecasts for 2015 and 2016 are a bit higher, 2.5% and 3.6% respectively, assuming that the country implements the agreed upon reforms. The driving forces behind real GDP growth are believed to be increasing consumption and business investment. Consumption is expected to grow with a diminishing rate due to the large unemployment and output gap which exert a negative influence on wage growth. It will take several years for the high unemployment rate of more than 25% to fall to its pre-crisis level. The European Commission predicts the unemployment rate will fall to 22.0% in 2016. Business investment is expected to increase strongly as firms move to replace capital that has been allowed to depreciate during the recession if the political environment remains stable. Net exports have had a positive contribution but their positive influence on growth is predicted to fall due to the expected rise of imports that is likely to accompany economic recovery. It's hard for exports to grow at the same pace as the structural reforms to enhance the country's competitiveness need time to produce the desired results. The European Commission forecast rests on more optimistic assumptions predicting a reduction of the current account deficit to 0.9% of GDP in 2016. Figure 1 below shows the forecasted GDP growth for Greece and its key contributors while figure 2 shows unemployment forecast for Greece.

Figure 5 Greece – Contributions to GDP growth



Source: Oxford economics

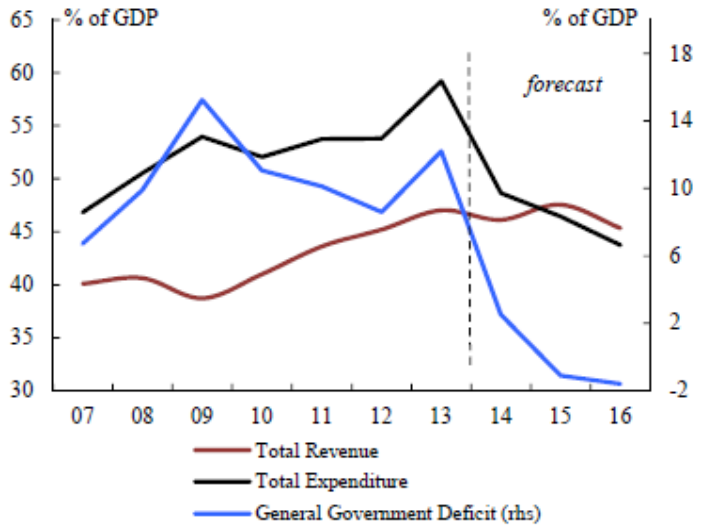
Figure 6 Unemployment



Source: Oxford economics

A major concern for the policymakers is the huge government debt that accounts for more than 170% of the country's GDP. Serious questions have been raised by an IMF study on the sustainability of the Greek debt. The European Commission is also highly concerned regarding the sustainability of Greece's public debt and believes that strong commitment by the Greek authorities to the required reforms would be the key to its gradual decline to acceptable levels within an en extended period of time of more than 15 years. It also predicts a falling government deficit mainly due to the reduction of government expenses as shown in the figure below.

Figure 7 Greece - General Government Revenue, Expenditure and Balance



Source: European Commission

Inflation is expected to become positive in 2016 as recovery accelerates. However, the recovery may slow down considerably if the uncertainty on the direction of policies continues.

The temporary closure of banks in Greece and the imposed capital controls have added more strain to the struggling Greek economy. The latest regional economic data provided by Eurostat show that the economic activity in the region of Western Macedonia has contracted as a result of the crisis. The region's gross domestic product in 2013 was less than three quarter of the amount recorded in 2007 that corresponds to the beginning of the crisis. A similar situation emerges when looking at the gross value added at basic prices. It begins to fall after 2009 with the value recorded for 2013 approximately 73% of the 2007 value. A sharper decline in gross fixed capital formation in the region of Western Macedonia is observed, with the 2011 value slightly higher than half the 2007 value. The contracting of regional economic activity has seen its unemployment rate more than double between 2007 and 2012. The most recent Eurostat data indicate that the unemployment rate for the 20-64 years age group was more than 27% showing signs of improvement from the peak unemployment rate of 31.5% recorded in 2013. 6,000 – 7,000 workers are employed in the energy sector. Western Macedonia is considered the energy "heart" of Greece covering more than 50% of the country's electricity demand during the last decade (Technical Chamber of Greece Department of Western Macedonia 2014). The importance of the Region of Western Macedonia for energy production is closely linked to the substantial domestic lignite reserves located in the region that are estimated to be between 1.5 and 1.8 billion tons. The lignite deposits of the region contain the largest calorific value countrywide ranging from between 1,261 to 1,615 kilocalories per gram (kcal/gr) in the Ptolemaida area and 1,927 to 2,257 kcal/gr in the Florina area (Chatzitheodoridis et al. 2010). In addition, lignite cost is lower than that for other energy fuels (less than 15 €/ton according to Grammelis et al. 2010) making it very competitive. 5 power plants located in the region rely on low-cost domestic lignite producing approximately 4.2-4.5GW of electric power per year. The construction of a new 660MW lignite-fired power plant (Ptolemaida 5) is expected to start soon following PPC's submission of documents to the local authorities to obtain the building permit. EUROCOAL experts believe that lignite will maintain its strong position in the regional energy market due to its large availability, low extraction costs and stable prices. Furthermore, it offers possibilities for co-combustion with other fuels such as biomass reducing CO_2 emissions. With some modifications some of the existing lignite-fired plants can be converted to biomass-fired plants. The results of Margaritis et al. (2014) study on introduction of Renewable Energy Sources (RES) in District Heating Systems of Kozani and Ptolemaida are encouraging. The latest data provided by Koroneos et al. (2014) show that in 2011 electricity production from renewable energy sources in the Region of Western Macedonia accounted for only 6% of the total energy consumption and that oil represented the most important energy fuel in the region (64%) followed by electricity (21%). The predicted increase in the price of oil could mean an

opportunity for further development of biomass combustion despite the decline of the Feed-In Tariff (FIT) for biomass generated energy specified in the Bill entitled “Provisions on the rectification of the Special Account of article 40 of law 2773/1999 and other provisions” published by the Ministry of Environment, Energy & Climate Change (YPEKA) in 7/3/2014 (Margaritis et al. 2014). However, the natural gas transmitted by the TAP project that will cross the region of Western Macedonia will most likely provide strong competition to biomass combustion.

Social factors

Prefecture of Korça

The latest INSTAT data show a steady decline in the total population of the Prefecture of Korça during the period 2001-2015. The total population in 1 January 2015 was 224,165 which accounts for 85% of the total population in 2001. The declining trend is observed in both urban and rural population of the Prefecture or Korça. The percentage decline is higher for rural population. Depopulation of certain rural areas may have played a role in this. The decreasing population is likely to have a negative effect on the efforts to promote establishment of biomass-fired plants for electricity generation in the Prefecture of Korça.

Region of Western Macedonia

The total population of the region of Western Macedonia also shows a declining trend. The latest Eurostat data show that the 2014 population of the region was 278,214 showing a 5% decline from the number recorded in 2000. The region of Western Macedonia is a low density populated region. The population density for the region of Western Macedonia was 30.4 inhabitants for square kilometer in 2013 (Eurostat). The Eurostat data show a steady rise in the percentage of population aged 25-64 with upper secondary or tertiary education attainment in the region of Western Macedonia. It rose from 40.2% in 2000 to 57.4% in 2014. This could have a positive effect on energy production from biomass as more educated people are likely to be more sensitive to environmental problems. The rising awareness for environmental pollution in the Region of Western Macedonia as a result of lignite utilization could favor biomass combustion for energy generation in the region.

Technological factors

R&D capacities

Most of the regional R&D activities in the Region of Western Macedonia are focused on energy related issues such as energy saving, clean energy production etc. (Reid et al. 2012).

The Department of Mechanical Engineering at the University of Western Macedonia which is particularly involved on biomass conversion technologies (Tzolakis and Agaleridou 2010) could play an important role on promoting biomass combustion. Other important research centers with increased knowledge on biomass combustion include CERTH/CPERI, the Centre for Research & Technology Hellas (CERTH) /Chemical Process & Energy Resources Institute (CPERI). They can offer valuable research expertise in advanced processes for biomass conversion such as gasification and pyrolysis (Ketikidis et al. 2012). The Cluster of Bioenergy and Environment of Western Macedonia developed as a not-for-profit company with members from the Triple Helix of the Region: public sector, enterprises and research and development and innovation actors can play a key role in coordinating efforts to enhance biomass utilization for energy generation.

Co-firing

Development of large scale wood biomass to energy conversion projects in the Region of Western Macedonia is largely influenced by the life cycle of the already active (and under projection) lignite power plants which offer great potential for biomass co-firing.

Actually in the Region of Western Macedonia there are five electricity power plants that produce 45% of total electrical power production of Greece (Vatalis et al. 2014). Relevant information regarding these plants is provided in the table below.

Table 2 Lignite power plants in the Region of Western Macedonia, Installed Capacity, CO2 emissions and end of life cycle

	Power Plant	MW	Emissions t(CO_2/year)	end of life cycle
1	AgiosDimitrios, I	300		2029
	AgiosDimitrios, II	300		2029
	AgiosDimitrios, III	310		2030
	AgiosDimitrios, IV	310		2030
	AgiosDimitrios, V	375		after 2030
	Subtotal Ag. Dimitrios	1595	13.629.229	-
2	Ptolemais I	70		2013
	Ptolemais II	125		2013
	Ptolemais III	125		2015
	Ptolemais IV	300		2015
	Subtotal Ptolemais	620	3.487.897	-
3	Kardia I	300		2016 -2019 opt-out
	Kardia II	300		2016 -2019 opt-out
	Kardia III	325		2016 -2019 opt-out
	Kardia IV	325		2016 -2019 opt-out
	Subtotal Kardia	1250	9.815.429	-
4	Amyntaio I	300		2016 -2019 opt-out
	Amyntaio II	300		2016 -2019 opt-out
	Subtotal Amyntaio	600	5.124.545	-
5	MelitiFlorina	330	1.995.721	after 2050
	Total	4.395	34.052.821	-

Source: Vatalis et al. 2014

A new 660 MW lignite-fired power plant of Ptolemais V (Unit 5) designed to provide 140 MWth of thermal energy is under projection. This gives the Region of Western Macedonia an undisputed large potential for co-firing lignite with biomass in the lignite-power plants.

Biomass co-firing consists of burning biomass along with coal in coal-fired power plants. It involves replacing a certain percentage of coal with biomass to reduce carbon emissions mitigating environmental degradation. The technology is already established in Northern Europe and the United States with some 230 power and combined heat and power (CHP) plants using co-firing The major advantages this technique offers compared to power plants burning 100% biomass are lower capital investments needed (a relatively modest incremental investment is needed to retrofit existing coal plants), higher efficiency, improved economies of scale and lower electricity costs (IEA-ETSAP and IRENA (2013). Co-firing at low percentages of biomass (typically below 5-10%) does not seem to cause problems to biomass combustion equipment (Werther 2009). The utilization of existing power plants is a major advantage as the additional investments of the co-combustion equipment are significantly lower (for pulverized coal-fired plants in some examples as low as 300 Euro/kW_{el}; the investments of standalone biomass plants amount from 2,500 to 3,000 Euro/kW_{el}). In addition, electrical efficiency is higher compared to the use of biomass in small standalone plants and because of the higher efficiencies the reduction of CO_2 emissions and other greenhouse gases (GHG) is larger for biomass co-combustion. It also seems to result in an improved combustion due to the higher volatile matter content of biomass. Several biomass sources could be used as fuels without increasing the risk of corrosion of combustion equipment. These benefits are likely to outweigh additional costs for transportation, preparation and on-site handling of biomass that are typically required (VGB PowerTech e.V. 2008). The positive results of woody biomass co-firing with lignite at low co-firing ratios in Kardia power plant indicate that it is quite feasible. The only concern relates to the biomass availability in the region of Western Macedonia to supply the existing lignite power plants (Kouras et al. 2014). Similar conclusions were derived in earlier co-firing tests in the same plant using cardoon to co-fire lignite (Karampinis et al. 2012). Positive results were also obtained for a variety of woody biomass fuels in both Kardia and Meliti power plants in the framework of the DEBCO project (DEBCO final report 2012).

Region of Western Macedonia

The region of Western Macedonia holds great potential for the development of RES technologies due to its favorable geographical position and weather conditions, and energy related research centers located in the region. Several hydropower plants are in use or under construction, the largest located in the Polyfytos area. PV parks of 23.7 MW and wind farms of

total installed capacity of 24 MW are operative as well (Koroneos et al. 2014). The region is particularly suitable for PV installations being listed among the regions with the highest solar irradiation in the country with around 1800 kWh/m2a (JRC, 2013). A 200 MW photovoltaic park (Project ILIAKO VELOS ENA) at the Western Macedonia Lignite Centre in the Municipality of Kozani with a €500 million budget is under development.

TAP will play a key role in the development of the gas market in both cross border regions possibly slowing the development of biomass combustion projects on the two cross-border regions.

CONCLUSIONS

Biomass combustion sector in the two cross-border regions of Prefecture of Korça and Region of Western Macedonia is at early stage of development. Currently, there are no biomass-to-energy conversion units operational in the Prefecture of Korça. In addition, there is no such unit under construction or planned to be established in the near future. The biomass combustion sector is more developed in the region of Western Macedonia. 2 biogas plants using animal manure and organic waste are fully functional. They are located in Kozani and Kastoria with a power generating capacity of 120 KWel and 240 KWel, respectively. Both have signed long-term contracts with the Greek electricity distribution company PPC to sell the electricity produced. Three more biomass conversion plants are in different stages of completion.

Even the 3 existing DHS (in Kozani, Ptolemaida, Amyntaion) are considering using biomass for energy generation. The Region of Western Macedonia has great potential for the development of biomass co-firing with lignite. It is widely regarded as the energy “heart” of Greece contributing about half of the total electricity production of the country. A new lignite fired power plant (Ptolemaida V) is being projected adding to the existing stock of 5 lignite power plants. Considering the lower cost of lignite it is likely to remain the main combustion fuel used for electricity generation in the Region of Western Macedonia. Some woody biomass types have been successfully co-fired with lignite in the existing power plants (Kardia, Meliti). The lower capital investment required coupled with higher electricity production efficiency give the existing plants significant advantages making the establishment of large scale 100% wood biomass power plants in the Region of Western Macedonia less attractive.

In both countries the favorable legal framework that aims to increase the RES share in energy consumption (deriving from the EU Directive 2009/29/EC) is the principal driver behind the development of biomass combustion sector. It has also promoted the implementation of other RES technologies in the two cross-border regions. These technologies together with the

TAP natural gas network can provide competition to biomass combustion. Therefore, joint efforts by all interested parties are needed to promote the biomass combustion sector in the region. The presence of specialized research organizations on biomass conversion technologies in the Region of Western Macedonia is a major advantage that if properly “utilized” can give a significant contribution to the development of biomass combustion sector in both cross-border regions. The expected economic recovery will create the necessary pre-conditions for materializing these initiatives. Way forward it will be better than future studies to be made so we can have a much better understanding as well as a greater number of this typical plants to be studied given the high renewable energy that such plants can generate.

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