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THE POLISH BIOMASS INDUSTRY: THE CASE OF BOBOLICE

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Abstract: *The renewable energy industry has recently gathered momentum due to green awareness, the need to diversify energy sources and the rise in oil and gas prices. In many ways, the Polish biomass industry has greater potential than others new EU members (post-2004). Poland's size, as well as its large population – the sixth largest in Europe – has attracted the attention of investors. Furthermore, the country's agricultural characteristics, high dependence on foreign sources of energy, as well as its abundant use of polluting energy sources such as coal, make Poland the perfect place to invest in the biomass industry. This research analyses the potential of the Polish biomass industry via the case of Bobolice, a town in Northern Poland. The study claims that companies wishing to evaluate potential projects will raise the project's chances of success if they operate in areas where the population is larger than 4500 inhabitants, in areas where heating is consumed annually for about 7 months and where there is a variety of facilities, other than homes, which require heating.*

Keywords: Biomass, Renewable Energy, Investment, Poland, Environment

Introduction

The renewable energy industry has been gathering momentum recently due to green awareness, the need to diversify energy sources and the rise in oil and gas prices. The European Union, which has set an ambitious target to enlarge the market segment of renewable and green energy at the expense of fossil oil, is largely behind the idea of supporting the industry. The fact that the Central and East European countries have joined the Union has, to a great extent, raised the biomass industry's potential to become the main source of generation of renewed energy. The new EU members' agricultural characteristics, as well as the general aspiration to strengthen the peripheral areas and the agricultural sector in those countries, has rendered biomass particularly interesting. In many ways, the Polish biomass industry has more potential than that of the other countries that joined the EU in 2004. Poland's size, as well as its large population – the sixth largest – has attracted the attention of

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investors. Furthermore, the country's agricultural characteristics, high dependence on foreign sources of energy, as well as its abundant use of polluting energy sources such as coal, make Poland the perfect place to invest in the biomass industry. And finally, Poland's proximity to Germany and Scandinavia has influenced the Polish government to commit to renewable energy and to encourage foreigners to invest in it.

This research will analyze the potential of the Polish biomass industry via the case of Bobolice, a town in Northern Poland. It will present the fundamental elements that model the industry and the matters that the considerations of entrepreneurs who wish to invest in the market. The aim of the research is also to present guiding principles for the evaluation of the economic potential of villages throughout Poland for which biomass plants are planned.

General Description

The town of Bobolice is about 40 kilometers away from the city of Koszalin, in West Pomeranian Voivodeship. It has approximately 350 square kilometers of municipal territory and is surrounded by vast agricultural land and forests. The town has a population of about 4,500 16 percent of which is unemployed. Most of the people in the town work in agriculture, in factories that export metal to Sweden and in providing services to the surrounding villages. The town has several advanced education and sports facilities, for which people need to pay. In terms of infrastructure, the town has an electricity and heating system which is inferior to the systems found in rural areas in Western Europe. Indeed, most of those systems were installed at the end of the 1970s and there are still people who heat up their own water in their homes.[1]

Bobolice has a boiler system that has been in use for the past 30 years. Although there is constant upkeep work on the system, the city council wishes to replace the current boiler with apparatus based on biomass sources, which can generate heat and electricity via cogeneration. The council intends to build a facility which will supply MW 3.8 of heat, in addition to the gas that will be used in cases of very cold winters. The aim of the boiler is to provide heat to most of the city's inhabitants, as well as to public establishments such as the local high school that has 500 pupils, the primary school with its 300 pupils, kindergartens and a regional sports cen-

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ter. Other than that, the city council intends to build a hotel and more sports and leisure centers, all of which will be connected to the central boiler. The new boiler will also be able to produce "green electricity" which will be sold to the energy companies operating in the area.

Table 1: The town's oil sources and consumption characteristics in 2009[552]

No.	Municipal Objects	Heat Energy Consumption GJ/year	Installed Capacity of Boilerhouse MW	Power Demand	Yearly Consumption of Natural Gas m3/year	Yearly Consumption of Coal Ton/year	Primary Energy in Fuel GJ/Year	Basic Boilerhoue Efficiency-percent	Cost of Fuel Zl/year	Cost of Fuel in 1GJ of Heat
1	Residential buildings	7,412	1.16	1.09	0.00	596.50	13,123	56.48	149,125	20.12
2	Public Institutes and private houses	4,670	1.00	0.80	0.00	300.00	6,600	70.76	75,000	16.06
3	Sport facilties and Education centers	950	1.00	0.70	46,000	0.00	1.63	58.25	69,900	73.58
4	Shopping stores, Storage facilities	2805	0.66	0.66	91,000	0.00	3.19	88.07	136,500	48.66
5	Total	15,837	3.82	3.82	137,000	896	19,127.82	273.56	430,525	158.42

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Average price of coal		[zł/t]	250.00
Average price of natural gas		[zł/m3]	1.50
LHV (low heat value) of coal		[MJ/kg]	22.00
LHV of natural gas		[MJ/m3]	35.00
sales price of heat energy		[zł/GJ]	40.98
Price of ordered heat power		[zł/MW/m-c]	9,726.42
year turnover from heat sale		[zł/year]	1,094,916.38

Calculation of heating prices and payment collection systems

The payment collection system for heating and the formula used to set consumer prices are similar in most of the towns and villages in the North-Western parts of Poland. The heating prices in Bobolice are set at the beginning of each year according to the price of coal and an assessment of the weather forecast for the winter months. A rise in the price of coal, therefore, raises the cost of heating, whilst a decrease in price lowers it. However, only the towns and councils whose heating consumption is below MW 5 are able to set consumer heating prices. In accordance with that provision, the Bobolice council decided that the consumer price for 1 Giga Joule of heating would be 48.90 Zloty including V.A.T. in 2009. The basic assumption of entrepreneurs who wish to work in that market, therefore, is that they need to preserve the correlation between consumer prices and coal prices in Poland in order to ensure that local consumers buy their energy products.

The payment for heating in Bobolice is made to a local company on a monthly basis but the local council suggests that groups of buildings buy electricity at reduced rates if payment is made in advance and over a long term. According to interviews with the management companies, there is not usually any problem to collect dues from the local population but a number of entrepreneurs in the biomass business consider the current collection system to be the main problem in a project such as theirs. They fear that, if the council comes into financial difficulties, it will not forward the payment to the company carrying out the project but will prefer to use the money to cover its deficit (Official documents supplied by

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Bobolice energy committee).

Bobolice's Sources of raw material

In order to assess whether the project in Bobolice is feasible, the sources of raw material at the town's disposal need to be examined. An analysis of the economic potential of a facility that produces energy from renewable sources requires an assessment of the raw material sources available within a radius of 50 kilometers. An assessment of the biomass potential is made by dividing the proposed area to agricultural areas, forest areas, grazing areas, and areas without agricultural potential. The next stage is to analyze the amount of raw material that can be produced from these areas, and how accessible that material is.[3]

During the project, the availability of a number of energy sources in the area was analyzed. The use of secondary agricultural products, such as straw, is a potential source of energy due to its easy availability and relatively low cost. Poland has a straw surplus of 4–11 million tons a year, and the price of a ton of straw on the local market was 45.05 Zloty a ton, not including transportation, in 2009.[4]

Despite straw's potential as a cheap, easily available source of raw material, a number of impediments arose in the Bobolice area when relying on that source, such as difficulty in concluding long term contracts with farmers, dependence on yearly crops, high transportation costs due to numerous collection points, and also low energy value that requires vast amounts of raw material. Finally, some of the facility owners refuse to use straw because of its high chlorine content which causes corrosion in the machinery.

Tree Waste

It is estimated that about 2.5 million cubic meters of tree waste can be harvested in Poland every year, and those numbers could change in the future due to the rise in the number of trees planted in the past decades. There is no data available as to the distribution of tree waste per area[5] but, based on an examination of the more forested areas of the country, it is likely that there is a significant amount of tree waste in Poland. It has always been customary for

tree waste harvesting to be under the supervision of the State Forests National Forest Holding, and most of the raw material is then sold to carpentries. Bobolice is surrounded by woodland and it is the council's responsibility to take part in tree waste harvesting. The price of tree waste includes the cost of manpower and transportation, and the State Forests National Forest Holding's approval must be obtained in order to use the tree waste for commercial purposes. If such permission is forthcoming, it is estimated that the amount of dry tree waste produced could reach 150 tons a year, and that the cost would be between 80 and 120 Zloty per ton.

Timber

Poland's timber export industry is ranked 17th in the world and 3rd in Europe. The Polish wood industry has grown in recent years because of renewable energy and the rising number of carpentries. In order to satisfy demand, the number of trees planted between 2000 and 2006 increased by 28 percent. In 2008, the biomass industry was making use of 4.8 percent of the wood supply but that supply will become limited in the years to come, due to demand from other industries that require wood, such as the building and paper industries. The use of wood as the main component of the biomass industry is therefore anticipated to continue to decrease, as it did from 95 percent in 2008 to 75 percent in 2010. Indeed, due to the extensive demand for timber in other industries, it became more expensive in West Pomeranian Voivodeship than other sources of energy such as straw, tree waste and energy crops. In 2009, for example, the price of a ton of wood pellet in the Bobolice area was 180 Zloty including transportation, which significantly raised the anticipated cost of operating the biomass facility. Although the price tendered to the biomass project entrepreneurs was higher than the average Polish market price – which was 138 Zloty per ton, not including transportation – and despite the relatively low market prices, it was decided that this kind of raw material would only be used in the initial years of the project until local raw materials, and particularly energy crops, became available. Indeed, fear of an increase in wood pellet prices due to mounting consumption, as well as an aspiration to encourage local employment, prompted the Council and the investors to opt for local raw materials that are not

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dependent on other industries.[6]

Energy crops

According to Polish government publications, Poland has an area of 2.6 million hectares of energy crops but maximal growth of energy crops is not realistic. Indeed, the Swedish case shows that only one fifth of agricultural areas allotted to energy crops are in use. Under the assumption that Poland uses 5 percent of its agricultural areas, it will be able to use 190,000 hectares at the most. An even more pessimistic estimate is that Poland will be able to make use of 59,000 hectares due to farmers' lack of familiarity with energy crops and due to the agricultural community's fear of a lack of long term commitment on the part of the EU.[7]

The EU has a number of distinguishable energy crops such as willows, poplars, eucalyptus trees, sorghum and grass. The economic benefit of those crops depends on the quality of the soil, the time it takes to grow them and the way they are harvested. Generally speaking, the costs of energy crops are higher than other crops because most farmers are not familiar with them and it therefore costs more to implement them. When assessing risk factors, the fact that farmers need to know that a crop is at least as economically advantageous as traditional crops – and mainly corn – in order to take it on must be taken into account. There is therefore fear that energy crops not be financially viable at times of price increases.[8]

In recent years, the willow has become one of the most important sources of energy in the Polish biomass industry. Indeed, the willow is a unique species which has a 20–25 year lifespan and the ability to produce 8–12 tons of dry biomass per hectare. Willow cultivation is done mainly between November and April and is suited to the cold North European climate. According to a number of researches, willows reach full maturity within four years but biomass can already be produced after two years, although the product is less abundant in such cases. Research made in the Warsaw area and at Koszalin University shows that a hectare of willow land can produce 6.43 tons of dry biomass in the first year and 10,994 tons after three years. On the other hand, willows have a number of significant disadvantages, such as the high cost of planting them as compared with other plants, due to farmers' lack of experience with

them and their need to get expert advice. Furthermore, the cost of harvesting and drying the raw material is not only considered to be more expensive but also requires special tools.[9]

Table 2: Comparative cost of the various components in willow cultivation according to research made in Sweden, Poland and Denmark

Country	Establishment	Fertilization	Harvest
Sweden	26	30.2	43.8
Poland	27–31 percent	16.4–21 percent	26.2–21 percent
Denmark	33 percent	34 percent	33 percent

1,000 hectares of willows are required in order to supply the Bobolice municipality's yearly biomass consumption. That amount of raw material is estimated to be sufficient for a facility with an output of MW4 that operates, on average, 4,800 hours per year. Koszalin University, which is 20 kilometers away from Bobolice, owns 80 hectares of willows that are in their fourth year and are 15–30 kilometers away from Bobolice. There is also a new willow farm, on an area of 40 hectares, in the first stages of development 12 kilometers away from Bobolice, as well a local company, with which long term agreements can be made, that owns a willow forest that spreads over 600 hectares 50 kilometers away. Furthermore, there are several vacant state-owned agricultural areas with medium to low quality soil where willow farms can be established. The use of state-owned land for the cultivation of willows can help to solve the problem of unemployment in Bobolice and enable the continuation of traditional agriculture such as wheat and corn etc. According to local estimates, dry willow will cost the consumer 120–130 Zloty per ton including transportation, thanks to the short distances from the cultivation areas.

Transportation

Transportation is a significant factor in the assessment of whether the biomass industry is financially advantageous. According to several models, cutting back on transportation expenses can reduce energy production costs by 0.5 cents per kw/h in a biomass facility. There are several factors that influence transportation con-

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siderations and, consequently, the final cost, such as lack of accessibility to an agricultural area, weather conditions, dispersed raw material areas, the amount of humidity in the raw material, keeping to working schedules, and fuel costs. On the other hand, transportation costs from facilities close to rivers and the sea can be significantly reduced by shipping the raw materials. Placing facilities close to railroads can also reduce transportation costs. The cost of transportation, however, is also influenced by raw material show that transportation costs rise significantly where collection of raw materials is not within a compression ability. Raw material such as straw, for example, is cheaper to transport because it is easy to compress. Many researches also 60 kilometer radius of the facility. Furthermore, it is important that there be collection points no further than 49 kilometers away from one another in order for transportation to operate more easily. And finally, areas without easy road access will raise transportation costs because of the need for smaller vehicles.[10]

An analysis of transportation costs shows that Bobolice enjoys a number of advantages. Most of the raw materials needed for the establishment of the project are within a 20–25 kilometer radius and transportation costs make up 7–10 percent of the cost of the raw material, which is 20 to 30 Zloty per ton of willow. The remaining 25 percent of raw material is within a radius of 50 kilometers, which only raises transportation costs slightly. Furthermore, if additional villages in the area opt for biomass facilities based on agriculture, a large amount of the raw material can be transported by boat because Koszalin and the towns surrounding it are only 15 kilometers away from the Baltic Sea. Nonetheless, a number of problems have arisen in the collection and transportation of the raw materials, such as the difficult access for heavy vehicles to the willow fields belonging to the University. Moreover, most of the towns and villages do not have tools suitable for harvesting willows and for making willow chips. In order to produce biomass from willows, entrepreneurs will therefore have to buy advanced mechanical tools, which will increase expenses in the first few years.

Storage

Storage conditions are very important to the quality of the raw material, as well as to end prices of biomass. In most cases, drying

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is done naturally by placing the raw material in covered storage facilities, and in some cases, particularly in Germany, there is a tendency to improve the raw material by active drying. Companies that deal in biomass naturally prefer storage areas to be near the biomass burning facility in order to save on transportation costs. Raw material such as timber, however, is difficult to store in large amounts, and most of it is therefore stored for relatively short periods of 4 months or less. On the other hand, relying on agricultural raw materials calls for longer storage periods if the harvesting season is short. Furthermore, sources of raw material such as wood pellet require complicated storage procedures and longer drying time. However, most of the facilities investigated claimed that, insofar as straw and wood chips are concerned, storage costs are minimal compared to the other expenses. And finally, straw storage proved to be inefficient in most cases due to the fact that it loses its energetic value if exposed to pests.[11]

Unlike fuel, biomass undergoes natural processes when in storage, which reduces its energetic value. Some of the raw materials in the industry contain chemicals, metal, copper and zinc, which can cause erosion during storage or processing. In most cases, the humidity of the raw material is influenced by a number of factors, such as the type and size of the raw material, the harvesting season, the harvesting age, the wind speed and the relative humidity in the area of the biomass facility. There are, therefore, some who believe that biomass drying should be done immediately after the harvesting, before it is transferred to the boilers, in order to reduce humidity and avoid damage to the raw material. That process reduces transportation costs due to the removal of the humidity and other by-products from the raw material, but drying the raw material in the collection area can cause the loss of significant amounts of it, while drying it in the area of the facility helps to enlarge the amounts that can be used.[12]

Poland's experience with facilities that dry the humid raw material is very limited. To date, there are no such facilities in Bobolice other than traditional crop storage barns. The area of the heating facility can contain raw material for seven weeks, after which more raw material needs to be brought in. Most of the agricultural areas, as well as the existing willow fields, have old storage facilities which are very cheap to run and cost no more than 2–5 percent of the en-

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tire cost of the raw material. They are only a few kilometers away from the raw material areas and transportation costs are therefore not high. Furthermore, most of the raw material for industry is produced in the spring and summer months which helps to minimize humidity.

Cost, advantages and disadvantages of biomass facilities

The most important factor in the success of the project is the positioning of the facility in relation to the raw material areas: the nearer the facility to the raw material area, the higher the chances of success. Other than that, the ability to diversify raw material sources lessens dependence on one single source and reduces the negative influence of commodities market fluctuations on the financial viability of the facility.[13] Furthermore, the power system and its installation had a significant influence on the cost of the facility, and the cooperation of the local council and its willingness to help with the project proved to have great influence on its establishment. Indeed, the fact that the Council is an elected one means that its members must approve and convince the inhabitants of the town that the facility is a reliable, efficient solution in the long term, which can reduce heating costs and be a source of income for farmers and local people. And finally, a long line of permits are required from various sources, such as the Polish Power Grid Company, the Polish Committee for Standardization, the Ministry of the Environment, as well as building permits.

A number of advantages and disadvantages emerged during the analysis of the facility's potential. A significant disadvantage is the state of dilapidation of the power grid, which needs to be replaced. Furthermore, the sports facilities and the main electricity consumers are one kilometer away from the boiler and the cost of connecting them to the heating facility has become very expensive. Moreover, the site of the facility is old and neglected and must therefore be destroyed and replaced by a new site that includes a covered storage area. On the other hand, the town's heating consumption is higher than it is in other areas of Poland and the facility's profits should be higher than elsewhere. Furthermore, unlike other villages and towns in the area, most of the residents are connected to

the central heating system and there is a higher heating consumption compared to other towns due to a number of facilities such as school, sports facilities and a hotel, that are considered to be energy "gobblers". All those elements make the project profitable despite the difficulties in setting it up.

Table 3: Estimated expenses for the installation of the facility

Cost E. U. r	Specification of the Project	No.
2,200,000	Thermal oil boiler for biomass utilization capacity 4,5 MW + hydraulic biomass feed system + exhaust gas system with dust filtration and electro filters + ash removing system	1
74,000	Pump system for thermal oil circulation	2
53,000	Pump system for hot water circulation to central heating city net	3
29,300	Electrical power control box and low voltage connection to grid	4
99,000	Automation and control systems + central visualization SCADA system	5
165,000	Hot water buffer vessels with total capacity ~200m3	6
164,000	Heat exchanging and measuring units (7 sets) to connect municipal objects	7
	Services:	
440,000	Constructional works related to: biomass boiler building + ORC module building + warehouse of biomass + internal roads and drives	1
530,000	External central heating pipe net connecting ORC power plant (located on the territory of old coal boiler house on Fabryczna Str.) with other consumers	2
184,000	Installation works of all equipment of ORC power plant (including start-up, commissioning and training of personnel)	3
75,000	Installation works of all equipment of ORC power plant (including start-up, commissioning and training of personnel)	4
35,000	Project management	5
100,000	Investment cost risk found	6
4,293,000	Total Net in euros	

Estimates annual cost and revenues of biomass

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FACILITY:

Value	Unit	Specification	No.
16,743,870	Zl	Investment Cost	1
0.67	MW	Nominal Electrical Output Power of ORC unit	2
3.06	MW	Nominal Heat output Power of ORC unit	3
4.29	MW	Initial heat Power in Biomass flow	4
14,000	kJ/kg	LHV(low heat Value) of Biomass	5
1.10	t/h	Max Demand of Dry Biomass	6
4,800	H	Amount of hours of operation per year related to nominal capacity	7
	t/h	Yearly Demand of Biomass (dry)	8
130	Zl/t	Estimated Price of Biomass	9
418,596.75	2.50 percent	Annual constant costs of exploitation and services administration and bookkeeping + insurance and land taxes	11
3216	MW/h	Annual production of electricity	12
14,688	MW/h	Annual Production of heat	13
52,876	GJ	Annual Production of heat	14
180	Zl/MWh	Sales Price of Electricity	15
248.00	Zl/MWh	Sales price of "green certificate"	16
45	Zl/GJ	Sale price of heat	17
1,376,448	Zl/year	Annual turnover on electricity sales	18
2,379,456.00	Zl/year	Annual turnover of heat sales	19
3,755,904	Zl/year	Annual turnover in total	20
3,337,307.25	Zl/year	Economic Effect	21

Conclusion

Poland's agricultural structure, as well as its need to reduce the use of coal as its main source of energy, makes it a country with good potential for a biomass market. In order to establish an effective and advantageous industry, however, a number of elements that are crucial to its future success must be evaluated. The case of the town of Bobolice indicates the main considerations that companies seeking to invest in the field should make. The research shows that the

availability of cheap raw material within a radius of 50 kilometers from the facility is conducive to the success of the project. A lack of available, cheap raw material would raise the facility's production costs and make it financially unviable. The research also shows that raw materials, such as tree waste and willows, are worth using because of their easy availability, their low cost and their contribution towards creating jobs. Furthermore, energy crops such as willows do not require high quality soil and therefore do not detract from the number of lands used for food. Moreover, the success of the project depends on continuing EU and Polish government commitment to the green energy industry. Indeed, the Polish government's support via the "Green Certificate" system has a great influence on income from electricity and heating facilities that operate via renewable energy sources. In addition, companies wishing to evaluate potential projects will raise the project's chances of success if they operate in areas where the population is larger than 4,500 inhabitants, in areas where heating is consumed annually for about 7 months and where there is a variety of facilities, other than homes, which require heating. All those factors will make for the biomass industry in Poland to be a financial success.

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