REGARDLESS OF THE ATTRACTIVE MARKET CONDITIONS, THE ROMANIAN BIOGAS SECTOR DID NOT ADVANCE. AN INDUCTIVE APPROACH

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Abstract - Romania is one of Europe's traditional producers of energy from renewable sources. After the regime change 1989 nothing happened in this market until 2008 when the Romanian renewable sector went through a remarkable boom. 5.000 MW new capacities were installed mainly in wind, PV and biomass plants but almost none in biogas plants. There is plenty of substrate available, some of it for free, and the support mechanism is also very generous when it comes to biogenic gas, so how come today there are less than 15 MW installed in biogas capacities? This question lies at the base of our research covering several company intern and extern aspects. This particular article addresses the risks induced by technology vs. the market risks on the basis of a study case from Romania. We analyse the profitability indicators of the first landfill gas recovery facility from Romania which was after implementation less profitable than expected.

Keywords: biogas, landfill gas recovery, Romania, case study, profitability, simulation.

1. INTRODUCTION

Romania is one of Europe's traditional producers of energy from renewable sources. Solar thermal appliances were the hit of the 70's and 80's, every agricultural university used to have its own biogas station and biomass heating and cooking appliances are today still spread all over the country accounting for over 7% of the primary energy consumption while about 6% are covered by the Romanian hydropower stations, heritage of the communistic regime. In 2008, a year after joining the EU, Romania has implemented a support mechanism for electricity produced from renewable sources from a variety of sources. Afterwards everything happened very quickly: first the wind farms, then the PV fields, a hand full industrial scale biomass plants, a few new small hydroelectric plants on the rivers still unexploited but almost no biogenic gas plants. The first modern biogas plant connected to the network in Romania, which today produces electricity from waste deposit gas close to Bucharest, was not commissioned until 2011. Although some gas recovery facilities were constructed prior in water treatment plants, the captured gas was not used for electricity generation or they were not connected to the electricity grid.

The use of biogas has an old tradition in Romanian history. Research for the production of biogas from anaerobic sources began in the 50s. The research was mainly based on laboratory tests with active methanogenic bacteria, which should produce biogas from various organic substrates.

After 1980, research and experiments focused mainly on manure and sewage sludge as substrates for biogas production. In the 80s, some authors mention a generation volume of 85,000 m^3 biogas per day produced in biogas plants used in sewage treatment plants. In the same period there were also some biogas plants to treat organic waste from the food industry, farms and distilleries [1]. According to Mateescu et al. [2] these covered a large variety of capacities from 14 m^3 to 500 m^3. Unfortunately, interest in this sector has decreased significantly in the 90's. Authors explained this throwback by socio-economic circumstances, political conditions in Romania and the lack of know-how. This lack of interest has led to a lack of investment in this sector. Not only that there were no new investments in the field, but maintenance for existing capacities has not been performed. Research in this field was also abandoned by academics in Romania, but also by the business sector. By 2007 there were also few incentives granted by the State so that at least foreign companies with tradition in the biogas field would consider entering the Romanian market.

In order to break this vicious circle, in 2008 the Romanian Government has initiated a support scheme for the production of electricity from renewable energy sources. The promotion of renewable energy production is ensured by a combined system relying on compulsory quotas and green certificates. The law obliges all electricity suppliers to meet annually prior set quotas of E-RES in their energy mix. This means that a certain percentage of the amount of electricity supplied to the end consumer should come from renewable sources. The E-RES producer receives for every MWh feed into the system next to the market price for electricity (when he trades the energy) a certain amount of green certificates - for biogas up to 3 certificates [3].

The E-RES producer will get according to this law 2 certificates for biogas and 1 certificate for sludge or deposit gas for 20 years. Additionally he can get 1 certificate if the electricity is produced in cogeneration. The supplier reaches the set quota by purchasing green certificates. The remuneration for the energy producer consists of the current price for electricity and an additional compensation received for the traded green certificates. The certificates may be traded on a specialised market in the price range € 27-55/piece + Euro-inflation. The current minimum value for certificates is 29.3 € / MWh and the maximum value 59.6 € / MWh.

The average electricity prices for E-RES producers as well as the medium certificate price vary; Table 2 shows their evolution in the time-period 2011-2014. According to these figures a biogas electricity producer using cogeneration would have earned 2014 between 122.9 € / MWh (worst case scenario) and 213.8 € / MWh (best case scenario), with a media of 143 € / MWh. These values still place Romania among the most active supporters of biogas in Europe [3].

This kind of support scheme is however associated with higher risks than schemes relying on feed in tariffs [4]. Cleijne and Ruijgrok underlined that for electricity producers trading in green electricity, the price development of electricity - determined by supply and demand of electricity on the one hand and by fossil fuel prices on the other – constitutes a risk source which directly affects prices [5]. Obviously the same applies for green certificates which underlie also the free market mechanisms.

Even though the Romanian support scheme for renewable electricity generation was in place for three years, until 2011 there were no investments in the biogas field. The following table presents the production of energy from biogas and electricity installed capacity benefiting from the support scheme in force starting with 2011.

Tabel 1: Biogas plants in Romania

	2011	2012	2013	2014	2015
Number of plants	1	3	5	10	13
Installed capacity(MWel)	1.9	5.0	6.9	12.1	16.1
Energy generated (MWh)	13,231	18,610	35,995	39,655	-

Sorces: Transelectrica, ANRE

Baran [6] argued that the lack of investment in this area can be explained due to the need for higher efficiency in plants so that plants can work economically given current energy prices. Internal risks such as low plant performance, maintenance risks and risks related to operating costs are also addressed by other international studies [7].Top technology providers on the other hand, argue that given the market conditions in Romania, investments in waste gas or sewage sludge gas plants can break even after 2 to 3 years, so the case of the technology provider Haase Energietechnik from the further on described business case.

2. METHODOLOGY

In order to complete our research we decided to analyse a representative study case as well. Research based on case studies represents a widely accepted alternative method of research. According to Duxbury [8] it offers an accepted framework for building real-world theory, based on direct observations, and not retrospective, surveys, or laboratory tests. Like recommended by Eisenhardt and Graebner we accessed a rich variety of data sources, including interviews, historical data, data obtained from official reports and personal observations [9]. We believe that interviews are a very effective way to gather large amounts of empirical data, especially when the phenomenon of interest is rare. This particular research based on a singular case study, is presenting qualitative data in narrative format, interspersed with quotes on key informants and other documents. The formulation of the theory is achieved through the close link between empirical evidence and theories emerging. Studies based on one case have the advantage that they can describe a phenomenon in detail, what we have tried to achieve within this paper.

On basis of the particular case studied and the official data available concerning the market evolution, we developed a simple calculation model for the profitability indicators of investments in landfill gas recovery facilities easily transposed on any other project. We used this model in order to determine the influence of market factors and of technological factors on the return of investment.

3. CASE STUDY ON THE LANDFILL GAS RECOVERY FACILITY IN CHIAJNA, ILFOV

Fig. 1 Landfill gas recovery facility, Chiajna [10]

The first plant using biogas from organic waste to produce electricity and heat in Romania was completed 2011 by IRIDEX GROUP (Bucharest) in collaboration with HAASE Energietechnik GmbH (Neumunster, Germany). The analysed facility is installed near to the landfill Chiajna (located 11 km from downtown Bucharest), and is built and managed by IRIDEX GROUP (Romanian Capital, Turnover 2014 – 40 Mil. Eur).

1999, when the landfill Chiajna was put into service, it was the first Romanian municipal landfill operated and owned by a company with private capital. Since 2006, Iridex Group had started working on a project aiming to generate energy from landfill gas. At the beginning

Iridex tried a collaboration with a service provider from Bucharest and a Norwegian investor. Haase Energietechnik, a leading German technology and service provider specialized on landfill technology became then the technology partner of the project. Unfortunately, the partners didn't reach an agreement in the negotiations concerning project size, costs, revenues and profit distribution. Negotiations have been concluded and the landfill owner decided to develop, finance and operate the project by himself. On this basis, negotiations between IRIDEX and Haase were taken up again and successfully completed in February 2010, when the agreement was signed between the two companies and one year later their landfill gas facility was put into practice.

3.1 TECHNICAL ASPECTS

In the case of landfills, the waste's organic fraction is first decomposed aerobic (by using oxygen embedded microorganisms to form carbon dioxide and water) followed after depletion of oxygen by a phase of anaerobic digestion. The anaerobic decomposition comprises the acido- and acetogenesis resulting in hydrogen (H2), ammonium (NH3), carbon dioxide (CO2) and organic acids as well as the methanogenesis, phase in which methane bacteria are using hydrogen and organic acids to produce methane (CH4), the main component of biogas. This stage starts according to Moisa after approx. 9 months of storage but usually continues for 30-40 years. The highest volume of biogas generated is expected to be reached at the end of the storage period of the landfill Chiajna, 2019 [10].

The Chiajna landfill is taking up an area of approx. 20 ha. The time limit set for the operation of the 2009 built landfill is 20 years. In 10 years of operation the amount of waste deposited in the landfill has reached approx. 3.0 Mil. T, and it is expected to reach by 2019 its maximal capacity of 4.3 Mil. T household waste.

The main components of the landfill gas recovery facility in Chiajna are [10]:

- The biogas capture network
    - 60 biogas collection wells, 90 cm in diameter, drilled into the landfill body, with depths between 15 and 25 m, fitted with perforated polyethylene pipes and gravel filters.
    - Special well heads with flexible connectors for coupling to the connection pipes.
    - Polyethylene pipelines connecting wells with each collection unit.
    - 4 units for biogas collection connected to groups of 15 wells, with the possibility of measuring quantitative and qualitative parameters of biogas per well.
- Biogas transport network
    - Network of polyethylene pipes on the margins of the landfill which connect landfill biogas collection units to the central unit.
    - Condensate separators in the low level points of the transmission pipelines.
    - The central unit for the production of electricity and heat from biogas
- Central condensate separation.
    - Desulfurization unit with activated carbon, which reduces the amount of H2S in biogas to fit the engine's limits to ensure the proper functioning of the CHPs.
    - Booster station.
    - Flame (burner) for surplus biogas.
    - 2 CHP units, in containers, each having an installed capacity of 1.2 MW.
    - (Heat exchanger to supply heat distribution network).
    - Transformer to connect to the medium voltage electrical grid.

2013 the average level of biogas captured varied between 1,600 Nm3 / h and 2000 Nm3 / h (Iridex estimates deviate from those of Haase Energietechnik). Representatives of Iridex anticipate an increase in output to 2.700Nm3 / h by 2019. Nowadays the company generates electricity that could cover the needs of approx. 5,000 households.

3.2 THE INVESTMENT'S PROFITABILITY

The plant supplies the local networks with green electricity since 2011, the year when Iridex Group Import Export also became a beneficiary of the support scheme in place. Considering that Iridex decided not to use the generated heat, the company receives only one green certificate for each MWh feed into the grid. Iridex generates revenue by selling the electricity and green certificates earned. The company was the first of the 13 companies in Romania who currently benefit from the green certificate support scheme for electricity generated from biogas.

Iridex's investment volume for the acquisition and implementation of the technical components listed above is estimated at € 3 Mil. The annual operation costs for the plant are estimated at € 200,000 with general revisions costing up to 20% of the initial investment every 5 years. The life span of the plant is considered at 18 years with a residual value of € 600,000.

The initial business plan relied on an annual constant income of 1.8 Mio. € leading to a full recovery of the investment in approx. two years. Having experience in markets with feed-in-tariffs support systems, and considering the very slow development of the Romanian renewable energy market in the period 2008-2011, Iridex's consultant and technology provider Haase Energietechnik underestimated the rapid evolution of the market in the years after the investment.

Following major investments in renewable projects, the medium prices for electricity on the wholesale market as well as the transaction prices for green certificates dropped each year. Meanwhile the electricity price for the end consumer rose to the point that the Government decided to intervene and lower the compulsory yearly quota for renewable energy in the energy mix. This decision lead to a blockage of the certificates market: 2015 1/3 of the green certificates issued will presumably remain unsold and the green certificates transactions happening are at minimum prices. The following table presents the evolution of medium energy and certificates prices for the past 4 years, prices used in the rentability calculations presented further down.

Table 2: Evolution of average electricity and green certificate prices on the specialized market

Medium Transaction Prices	2011	2012	2013	2014
Eur/Mwh	37.1	37.0	35.3	35.0
Eur/GC	56.7	53.0	44.7	36.0

Source: ANRE, OPCOM

Starting with 2015, market experts expect the green certificates price to remain constant at their minimum legal value and the electricity price to slowly rise. In our calculation we adopted a conservative position choosing a worst case scenario from this point on: constant certificates and electricity prices.

We addressed the project's profitability using 4 common indicators:

- The net present value as calculated according to the formula

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o \quad (1)$$

where:
- Ct = net cash inflow during the period t
- C0= total initial investment costs
- r = discount rate, and
- t = number of time periods;

- The internal rate of return (IRR) as approximated by MS Excel 2010 on the basis of the NPV;
- The profitability index calculated considering the NPV and the initial investment;
- The recovery period.

The following table presents the main indicators of profitability obtained through calculations set out in Annex 1. The first column shows the optimum situation - constant market conditions and maximum technological parameters (80,000 hours / year). Under ideal circumstances, Iridex would probably choose to pay of its accessed investment credit of 3 Mio. Eur in two years. The internal rate of return amounts to 119% and the investment is recovered in two years and six months. Applying the real evolution of market conditions in the last four years and an estimate of their evolution in the coming years under a constant production, the profitability index drops from 3.16 to 2.37 and the internal rate of return at 92%.

The project has also faced technological problems which affected substantially the number of hours the power plant worked. We adapted the ideal conditions situation with the real working hours. For the calculation of working hours from this point onward we used an average of 60,000 operating hours annually, a number on which the active support scheme in Germany, the greatest biogas energy producer worldwide, is grounded [11]. We find that the impact of the technological factor under constant market conditions on profitability indicators is higher so far than that of the market factors in optimal operating conditions. We extended the investment credit payback period to 3 years and obtained an internal rate of return of 69% with a recovery period of 3 years and 6 months. Under real technological and market conditions, the investment in this project is recovered after 4 years and 5 months, the internal rate of return lies at 44% and the profitability index is 1.67.

Table 3: Variation of profitability indicators depending on market and technological conditions

Indicator	Constant market conditions and optimal technologic al functioning	Market fluctuations and optimal technological functioning	Constant market conditions and technologica l difficulties	Market fluctuations and technological difficulties
Net Present Value (EURO)	6,470,610	4,107,127	3,790,274	2,018,941
Internal Rate of Return	119.50%	92.01%	69.51%	44.04%
Profitability Index	3.16	2.37	2.26	1.67
Recovery Period (Years)	2.46	2.61	3.49	4.40

Source: own calculations

In order to respond to the gas flow growth, Iridex recently decided to install a 3rd cogeneration unit with an electrical power of 1.2 Mwel. This time they plan to equip the unit also with a heat exchanger of 1.25 MWth. The project is in implementation stage. Depending on the amount of biogas, the facility will be extended to 5 cogeneration units with a total installed capacity of up to 6 MWel and 4 MWth. Representatives Iridex expect the facility to operate at full power around the time of closure of the landfill (2019), then it will gradually decrease reaching in 2029 its current dimension (2.4 MWel).

3.3 IRIDEX AND HAASE – THE ENTREPRENEURIAL INITIATIVE

Analysing the entrepreneurial initiative of Iridex Group through by the main features of its business models, confirmed that the company implemented an entrepreneurial model in Chiajna rather than a classic business model. Not only the fact that innovation is a main part of the company's mission but also the company's declared reasons for its decision to activate outside its core business, qualifies its business model as entrepreneurial. The main triggers for developing this project were [10]:

- Environmental standards in force & ecological reasons: "Prevention of gases resulting from the anaerobic digestion of organic waste which could harm the environment to reach the atmosphere,"
- Exploiting New Opportunities & Economic profitability: "The production of electricity and heat from renewable sources."
- Reduction of operating risks in its main business "To increase safety of operation of the landfill."

When analyzing the role that partnerships played in this business model, it is worth to turn our attention towards the German technology supplier HAASE Engergietechnik GmbH (BMF Engergietechnik HAASE

GmbH), Iridex's main partner in this project. Haase Energietechnik is providing services and technologies for the management of leachate and landfill gas since 1986. In Germany the company is holding not only an extensive know-how regarding technology but also regarding operating and service structures and count among the market leaders both in terms of leachate management and recovery of landfill gas and biogas. The company also has a lot of experience at European level, in areas such as development and implementation of projects, general contracting and construction and operation of plants. Although market leader in several European countries, Haase Energietechnik is in Romania mainly active as a technology provider. In Chiajna Haase Energietechnik provided the technology, the design and site supervision and the ongoing technical maintenance and optimization.

The calculation presented in the chapter above is partially based on Haase Energietechnik's model, who recommends an annual capitalization of the investment cost (initial cost, gas collection system construction, gas recovery facility construction) of between 50% and 65% of annual costs. They also recommend their partners to engage investment credits with longer pay back times – ideally 10 years. Considering Iridex's economic strength, their overall cash flow and their decision to internally finance the project, we chose to reduce the payback time to the minimum. The operating costs have to be kept according to Haase at approx. 30% of the annual costs of the project.

Trying to better understand the small number of entrepreneurial initiatives in this field, we interviewed Haase's representatives regarding the main factors of impact on entrepreneurship and the overall development of this sector as well as about the main risks they are facing. They identified following determinant factors:

- The availability of resources:
    - ecological landfills of volumes allowing recovery facilities with installed electrical capacity exceeding 2MW,
    - substrate quality.
- Contractual options available;
- Availability of capital;
- Approvals and permits (construction, operation, trading);
- Technology (for biogas capture and recovery);
- Institutional culture;
- Income structure.

The main risks investors are facing in landfill gas exploitation are:

- Wrong estimates on the amount of gas available;
- Fluctuations in prices for heat and power;
- The general trend of increasing operating costs (staff, equipment, auxiliary costs).

The challenges encountered in the implementation of the project from Chiajna were both according to project representatives and to other sources of legal and technical nature. From a technical standpoint, the facility originally designed had to be upgraded regarding the gas pretreatment (cleaning). The landfill gas captured had a higher concentration of tracer gas than anticipated. From the administrative point of view, the project implementation was delayed by the difficulties to obtain the technical approvals for connection to the electricity grid.

After implementation the permanent maintenance of the installation was not performed properly so the working times of the cogeneration units were influenced heavily. From administrative point of view, the changes to the support scheme for energy from renewable sources also influenced the evolution of the market and market prices in the detriment of Iridex.

In our interviews with the representatives of Haase Energietechnik we also asked them about the value added of this kind of business. They stressed repeatedly that as long as the gas exists and doesn't need to be generated, for instance in the detriment of food safety, the social value of a biomethane recovery systems can not under any circumstances be questioned. Analysing power plants on a whole life basis, renewable energy plants will contribute long term utmost to sustainable development. Assessing the effectiveness of a particular technology should not be limited to the operation period of the plant. Nuclear technology, for example, is considered to be an effective technology that results in a low-cost energy. Costs of neutralization and disposal of nuclear waste however are not taken into account in these assessments. Energy from biomethane recovered from landfills or municipal sewage treatment plants does not have any disadvantages. The most important aspect of this source of energy is the availability of free gas "The gas is there, flowing daily from a free source. The sooner the source is accessed the better, best case scenario projects are early initiated and

4. CONCLUSIONS

While specialised literature and several studies conducted within our academic circle [12] [13] [14] [15] in the past revealed the deep impact of external factors on the development of renewable energy entrepreneurial initiatives as well as on the whole sector, within this particular approach we can observe that the impact of internal factors is far more relevant.

First of all, although almost all modern renewable projects in Romania were developed as a consequence of the implementation of the renewable support scheme, we find that Iridex has been looking to develop a gas recovery facility to generate electric and thermal energy from waste deposit gas since 2006, two years before the support scheme for renewable electricity generation was put in place. The intention to exploit new business opportunities was mainly founded on the availability of resources of internal nature. We could be tempted to attribute their intrapreneurial decision to the obligations resulting from the standard environmental regulations. They were obliged to implement a gas recovery and treating system in order for the gas not to escape in the atmosphere, which they have had implemented prior to the complex gas recovery facility which was put in place 12 years after the completion of the landfill. Later on, when implementing and operating the facility, internal factors had a higher impact on the profitability indicators of the plant than external factors. According to our calculations the technological factors (investment value, hours of operation, maintenance, capital repairs) and the available financing options had a deeper effect on the analysed indicators. Within the applied profitability calculation model we can observe that even though market development also plays an important part in the profitability of a plant, in this particular case it is not as important as that of technology and the company's size and capitalization.

The implementation of the Romanian support scheme for renewable energies of course contributed to IRIDEX's decision to revive their diversification plan. The mere existence of a support scheme is the main determinant for the whole investment to make economically sense (without it the recovery time exceeds 13 years). Also the obstacles generated by the legal and institutional environment influenced the implementation of the project and finally the changes in the support legislation determined the green certificates market to crash and also affected the company's profitability indicators substantially. Still, when analyzing the project's time span the internal factors were more determinant for the investment.

In the past, before any investments were done in this field, Băran underlined the higher importance technology plays within the biogas sector. The results of the above described calculation support his theory. Other representatives of the sector also emphasized the higher role technology and know-how play in this particular renewable field. However these aspects necessitate further research, maybe of quantitative nature within more developed markets (in Romania there are only 13 biogas plats).

In emerging markets like Romania, strategic partnerships - a key element of entrepreneurial business models – can compensate the lack of experience and know-how. Strategic partnerships can also open completely new perspectives for the sector, also in other areas, except for gas from waste deposits and sewage sludge.

When looking at the sources for the energy capture, there comes the necessity of concluding long-term supply contracts for gas or biodegradable resources (biodegradable waste, animal residues, energy crops). Despite low yields in agriculture and high fragmentation of farms and livestock, Romania has a naturally high potential for biogas production. All these can be taken into account as well. Besides the raw materials available from agriculture and animal husbandry, biodegradable waste available in the food industry, municipal landfills and sewage plants is ideal for producing generous amounts of gas for the energy production. These sources should be addressed with priority, leaving place for agricultural biogas plants in the future, when know-how levels are higher.

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