INTEGRATION OF RISKS AND POLITICAL CHANGES IN DYNAMIC MODELLING OF BIOGAS PRODUCTION

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Abstract. Promoting biogas production to generate energy is associated with several EU policy initiatives such as increasing the output of electricity and thermal energy, energy independence, and the reduction of GHG emissions. To reach both, the international and the national policy targets, all EU member states use several support mechanisms. In Latvia four support mechanisms are used – obligatory state purchase of electricity, guarantee of a set price, release from paying the electricity tax for the energy, produced from the renewable resources and public (EU structural fund) funding for investments. In few recent years in Latvia, the support mechanisms described above had created a motivating support system for joining the biogas production sector, but due to the pressure of enterprises and households the government intends to change the support policy and the amount of the support for electricity production from biogas. It creates instability and increases political risks for biogas producers thus obstructing the development of the sector. The current article reviews the integration of the risk assessment results and changes in the governmental support policy for biogas production in the dynamic model of the farm level biogas production and estimates the impact of political risks and current changes in the support policy.

Keywords: biogas production, dynamic modelling, support measures, political risks.

Introduction

Historically, economic development has always been closely associated with the availability and price of the energy resources. Yet, in the period from the end of the 20th century to the present, sustainability of energy resources – gradual replacement of fossil energy resources with renewable sources and higher efficiency in the use of energy – has been also emphasised. In the EU, including Latvia, the need for more extensive use of local renewable energy sources is also affected by the wish to gain greater energy independence. Tackling the problems related to a wider use of renewable energy is integrated in the policy and legal documents of the EU and Latvia, which involves introducing financial assistance to sell the electricity generated from renewable energy sources at higher prices and co-financing the construction of energy production facilities.

The mentioned support instruments have significantly promoted the use of renewable energy sources, including biogas, for energy production in Latvia since 2008 when the first biogas production plant for production of biogas from agriculture biomass was built.

Owing to the support mechanisms for biogas production in the EU and Latvia, 53 biogas facilities with a total capacity of 55.42 MW_{el} operated in Latvia in 2014; of these facilities, 45 produced biogas from biomasses of agricultural origin (Fig. 1) [1; 2]. However, an analysis of the development of such energy facilities in Latvia suggests that producers of renewable energy have faced both, institutional and technological problems, as well as problems with selling the produced electricity, which all cause risks to the whole energy production process.

Materials and methods

To analyse the process of biogas production, the authors elaborated a farm level dynamic model that includes risks affecting the biogas production process. From the authors' point of view, biogas production may be perceived as an integrated part of a farm production cycle; therefore, the farm that produces biogas is viewed from the perspective of the systems theory [3-6]. The author depicted the systemic approach and the interrelation among the farm economic activity processes by dynamic modelling, developing a model of a farm that produces biogas.

Hypothetically, a biogas production system was defined based on the survey of the experts – 15 biogas producers that answered to the questions about their farming and biogas production structure and evaluated the potential risks on their production plants (the evaluation was carried out from February to April, 2013).

Fig. 1. **Location of biogas facilities in Latvia in 2014 (source: authors' construction based on MoE and Environment State Bureau data, 2014)**

The structural scheme of the model for biogas production from agricultural biomass (Fig. 2) shows the division of the biogas production process into 4 blocks: the first block involves biomass production from products of plant, livestock origin, and waste. The second block involves biogas production and cogeneration, which results in heat and electricity; the third block is the total income block. Along with electricity and heat, digestate, which forms in the biogas production process, also generates income. But the fourth block involves all the risks influencing biogas production and affecting individual processes in all the other blocks.

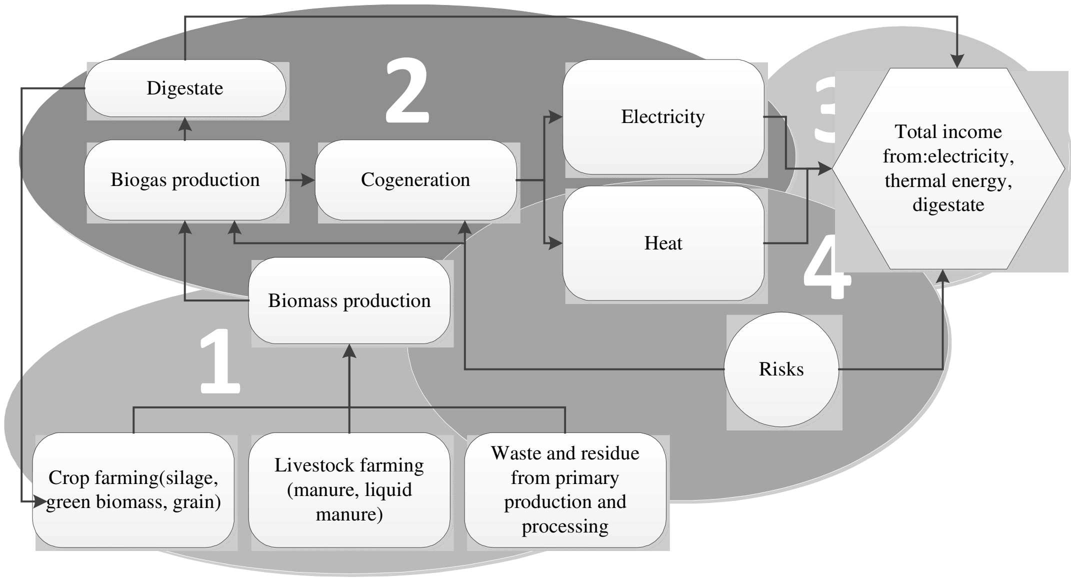

Fig. 2. **Structural scheme of the model for biogas production from agricultural biomass**

The **aim of the model** is to depict a system that is subject to the effects of various risks, inc. political changes and to identify the overall significance of these effects and that of individual risk groups. **Hypothesis**: the integration of risks into the dynamic model raises its stochastic characteristics and allows the model to approximate a real biogas production process.

The flow diagram for the biogas model is shown in Fig. 3, for modelling, the authors used several data sources. Mainly, the quantitative indicators of the biogas production process on the LLU training and research farm "Vecauce" were used: the amount of crop biomasses grown and the amount of manure from livestock. Several theoretical indicators that determine the biogas production process, for instance, the yield of biogas from a particular kind of biomass, energy output, and heat to electricity ratio were obtained by summarising the theoretical information on these processes [7-10]. As mentioned earlier, the risk level values were calculated based on the survey of the experts.

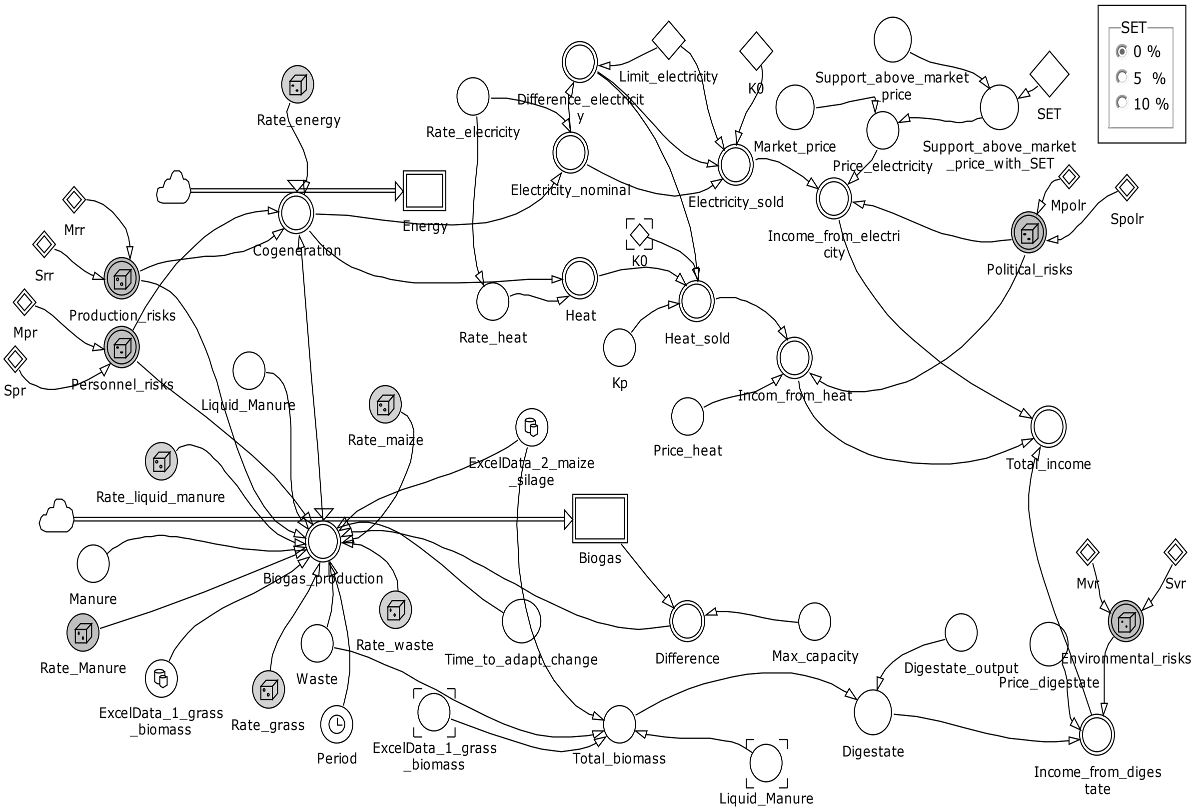

Fig. 3. **Flow diagram for the dynamic model in biogas production**

For the integration of risks in the biogas production process simulated in the dynamic model, three scenarios are set:

A0 – influence of all risks is included;

A1 – only the influence of political risks is included;

A2 – risk influence is not included.

The elaboration of the mentioned scenarios and their inclusion in the simulation reflects the overall risk effects and effects of a separate risk group on the process of biogas production. Thus allowing to estimate the potential risk influence and chose rational risk management alternatives. Political changes in the model are included dually – as a risk evaluation scenario and as two scenarios for the tax on subsidised electricity (SET) with a rate of 10 and 5 per cent. The SET is a new initiative of the Government of Latvia approved by the Cabinet of Ministers on September 17th, 2013 and introduced since the beginning of 2014. At present, the size of the tax is set at 10 % of the subsidies paid to renewable energy producers under the mandatory purchase obligation; for producers of electricity from natural gas, the tax rate is set at 15 %, while a 5 % tax rate is set for exceptional renewable energy producers, that fulfils the requirements regarding use of heat, choice of biomass etc. [11]. For biogas production, the tax rate is differentiated depending on the electric capacity installed at the facility, the type and origin of biomass, as well as the ratio of heat efficiently utilised. In 2014 17 biogas producers are charged a 5 % SEN rate, and 36 biogas producers – a 10 % SEN rate [12].

The SET rate is included in the model with a switch, therefore, in opposite to the risk influence scenarios, it is possible to change the SET scenarios, and choose one of the SET rates in each simulation attempt.

By validating the model, the model output data were compared with the two indicators of the real system: electricity generated and sold under the mandatory purchase obligation in 2012, kWh per year, and income from this electricity [13]. These indicators were chosen for the validation, as the data are precisely recorded when selling electricity under the mandatory purchase obligation.

After analysing the output data, it can be concluded that for the first year of simulation, the most precise data were obtained from scenario A2, which does not include the effect of risks; the deviation of this scenario from a real system data is only 2 % for both parameters. But in the further simulation, according to the dynamic hypothesis, the data produced by this scenario are rather optimistic, and significantly differ from the base results.

However, in the scenarios that involve risks, the risk effect initially seems to be insignificant, but this effect is included as a variable with normal distribution and changes from year to year; therefore, it has to be analysed for a longer period. It can be concluded that the model is useful in forecasting and in general, it produces credible data that, if certain risks are included in the simulation, maximally approximate a real system.

Results and discussion

Based on the data obtained in the dynamic modelling, changes in the output of biomass and the economic indicators – income from electricity, heat, and digestate and the total income – were analysed. As several stochastic variables create changes in the obtained results in each simulation, to determine the average values and the distribution interval of the results, the authors accumulated simulation results for 97 [14] simulation attempts. Fig. 4 shows the average results for the income from electricity for the three scenarios included in the model.

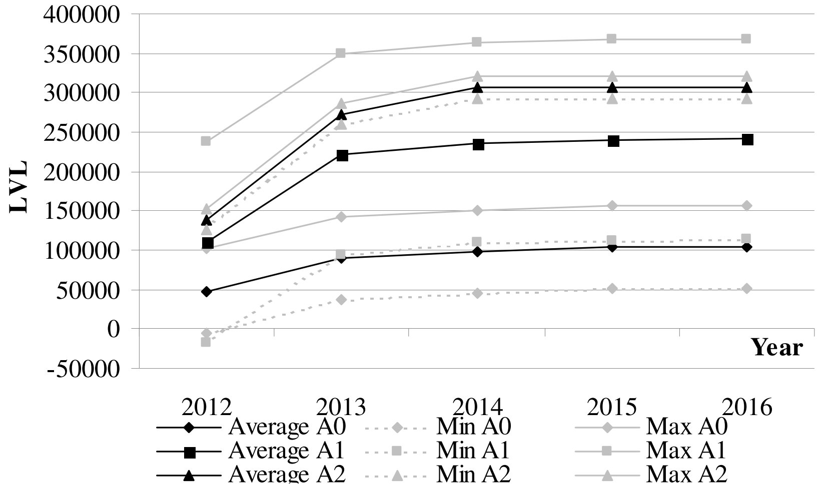

Fig. 4. **Average income from selling electricity for the three (A0..A2) scenarios included in the module, LVL per year, *N*=97**

For this variable, the highest average results are reached in the scenario A2, but the highest distribution of results – in the scenario A1, its minimal limit reaches the average level of the results for the scenario A0, but the maximal limit exceeds both, the average and the maximal level of the results for the scenario A2.

After analysing the total income from selling electricity, heat and digestate (Fig. 5), it can be concluded that similarly as in the results reflected in Fig. 4, the lowest results are for the scenario A0, while scenario A1 produces volatile results, bet the results of the scenario A2 show the closest homogeneity and overall, the highest results. In both cases, the results for the scenario A1 may be explained by the fact that these indicators are affected by the political risks, which, according to the experts, have a high influence; these risks are included in the model as a variable with normal distribution. Therefore, it can be assumed, that the years when the indicator sharply decreases are the periods when the risk makes its impact at the maximum value of the variable, which corresponds to the model hypothesis.

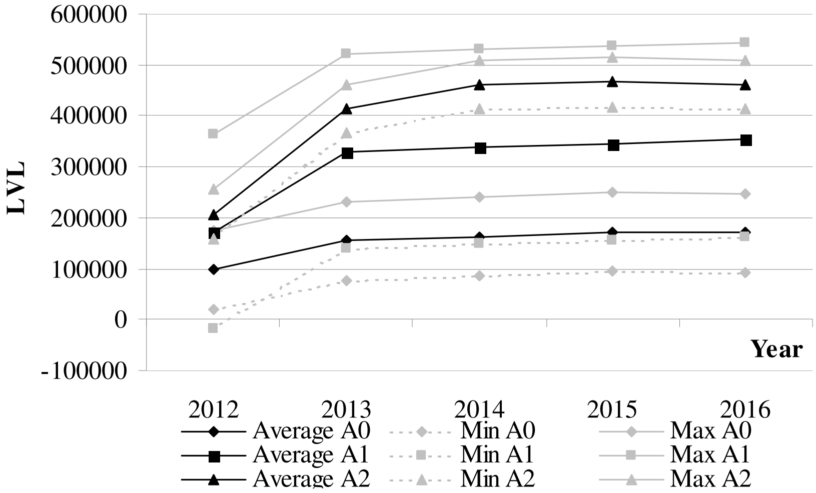

Fig. 5. **Average total income for the three (A0..A2) scenarios included in the module, LVL per year, *N* = 97**

It can be concluded that integration of the risk influence into the dynamic model reduces the results, and the model data approach the real performance results of the farm. The risks in the model are included as stochastic values with normal distribution and their parameters (the mean value and the standard deviation) were obtained from the experts' risk assessment. Therefore, by changing these coefficients, it is possible to forecast the performance results of the farms and their relation to the existing risks. If a potential loss or a lower profit is expected, it is possible to choose the risk management alternatives more successfully and to consider which risks have to be transferred (for instance, which risks have to be insured) or reduced, but which risks should be up-taken, thus considering the potential consequence of risk occurrence.

After analysing the average results obtained (Fig. 6), the authors conclude that on the whole the risk level scenarios make a greater effect on the model results in contrast to the application of the SET rates and changes in these rates.

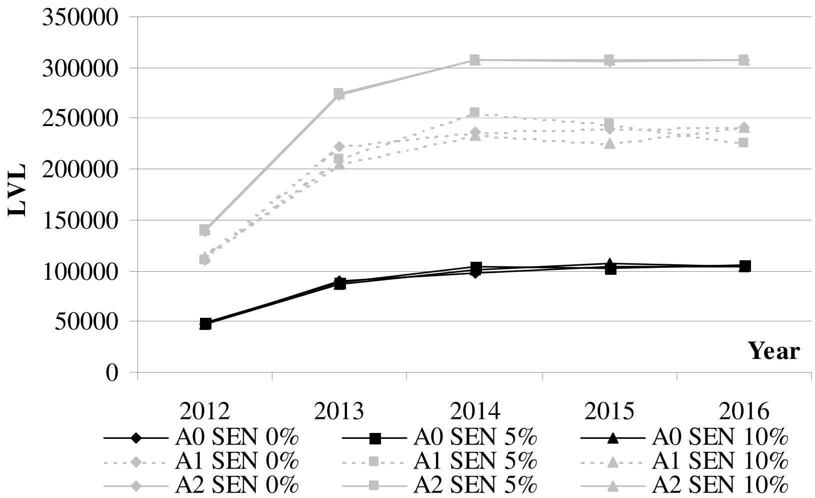

Fig. 6. **Average income from selling electricity after SET is applied for the three (A0..A2) scenarios included in the module, LVL per year, *N* = 97**

Since there are also other stochastic variables along with the risk level scenarios in the model, no directly proportional income reduction is observed when decreasing the amount of support; yet the incomes tend to decline. These results reflect the ability of the elaborated model to react to the additionally introduced conditions and successfully show the proportion of the losses from the risk variables and the SET. Corresponding to the expert evaluation, political risks have a high evaluation of the significance level, therefore the effects on the results of the model for this and other risk groups are relatively higher than the effect of the SET. Although also the implementation of the SET is considered a political risk, the effect of the SET on the annual income from the sold electricity will not bring the forecasted losses of the political risk group, in a long-term it can influence both, the profitability of the biogas production facilities and to increase the concerns about the further realization of the energy policy, its instruments and the predictability of these instruments.

Conclusions

1. Political decisions and the historically elaborated support system have significantly affected the biogas production sector in Latvia, but as it is intended by the MoE to reduce the amount of support and to hinder the rapid development of this sector, political risks are the ones that are currently evaluated as the most influential.
2. The approach used for dynamic modeling in this paper allows to include the risk levels and political changes in the performance of the farm level production process of biogas, thus allowing to estimate the effect of production, property, political, environmental and other risks as well as to detect the influence of particular changes in the support policy.
3. The obtained results show that integration of the risk influence into the dynamic model reduces the results, and the model data approach the real performance results of the farm. The results reflect the ability of the elaborated model to react to the additionally introduced conditions and successfully show the proportion of the losses from the risk variables and the SET, thus allowing using this model as a tool for forecasting the effect of political changes and other risks to the financial results of farm level biogas production.

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