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# Risk Assessment Results in Biogas Production from Agriculture Biomass

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***Abstract*****—**The use of renewable energy sources incl. biogas has become topical in accordance with the increasing demand for energy, decrease of fossil energy resources and the efforts to reduce greenhouse gas emissions as well as to increase energy independence from the territories where fossil energy resources are available.

As the technologies of biogas production from agricultural biomass develop, risk assessment and risk management become necessary for farms producing such a renewable energy. The need for risk assessments has become particularly topical when discussions on changing the biogas policy in the EU take place, which may influence the development of the sector in the future, as well as the operation of existing biogas facilities and their income level.

The current article describes results of the risk assessment for farms producing biomass from agriculture biomass in Latvia, the risk assessment system included 24 risks, that affect the whole biogas production process and the obtained results showed the high significance of political and production risks.

***Keywords*****—**Biogas production, risks, risk assessment.

## I. Introduction

CURRENTLY (according to the data of 2013) in Latvia there are 38 biogas production facilities with a total capacity of 42.93 $MW_{el}$; of the facilities, 32 produced biogas from agricultural biomasses. Biogas production from agricultural biomasses was started in Latvia in 2008, and the support policy of the entire EU as well as that of Latvia has changed during these five years – currently the consideration of the amount of financial support for renewable energy production and the promotion of the production of energy that is generated not only from renewable energy sources, but also in accordance with the principles of bioeconomics – its production is resource-efficient, competitive, and innovative, it does not reduce food supply, and it is compatible with environmental protection [1] is emphasized; besides, energy production has to be sustainable and both electricity and heat generated at cogeneration plants have to be used efficiently. These changes along with a limited experience of the whole sector and of individual production plants cause risks to the producers and obstruct the further development of the sector. Therefore an assessment of risks and the possible risk management alternatives as well as the factors hindering further development of the sector was needed and can be used in the practical risk management of the biogas production.

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## II. Materials and Methods

The author of the paper identified risks in biogas production based on an analysis of the scientific literature [2]-[5] and by consulting experts – two biogas producers and a LBA representative. To obtain data for the risk assessment, the author conducted a survey of experts, which consisted of 4 question blocks: general information about the farm; biogas production; risk assessment; and socio-demographic information.

15 experts from farms producing biogas from agricultural raw materials were involved in the survey. Based on the technological specifics and differences in biogas production, representatives of power plants producing biogas from sewage or household waste were not involved. Therefore, the target group consisted of 32 farms, and the risk assessment survey covered 47% of the target group. The survey was conducted from February to April 2013. In the block of general information, the experts provided the following information: the structure of their farm, the production sectors the farm is engaged in, the area of UAA, and the number of productive livestock.

The risk assessment methodology was based on the risk definition – *risk is a combination of the probability of occurrence of an event and the level of significance of a negative effects caused by it* [6]-[13], indicating that for the determination of risk level, one should assess two parameters – probability of risk occurrence and the severity of losses caused by the risk occurrence. The probability of risk occurrence (Table I) was determined on a five-point scale. To raise the objectivity and comparability of the risk assessment, each point was assigned a meaning ranging from 1 – a very low probability that the risk occurs and it could happen only under special circumstances to 5 – it is almost certain, that the risk will occur at least once a month.

TABLE I
Scale for the Probability of Risks and Its Characteristics

| Probability | Scale | Characteristics of probability |
|---|---|---|
| Almost certain | 5 | It is almost certain, that the risk will occur at least once a month. |
| Highly probable | 4 | It is very possible that it will happen within a month |
| Probable | 3 | It could happen within a year |
| Unlikely | 2 | It could happen, but it is unlikely |
| Improbable | 1 | It could happen, but only under rear circumstances |
| No relation to the particular enterprise | 0 | The enterprise does not perform activities related to the occurrence of this risk |

The severity of risks (Table II) was rated on a scale from 1 to 5 and the also the severity scale were explained. In this case, all possible kinds of losses are converted into financial losses; it enables obtaining comparable data and reduces the subjectivity of the expert's opinion. According to the definition of risks, a risk significance level was obtained by multiplying both parameters – probability of risk occurrence and risk severity.

TABLE II
SCALE FOR RISK SEVERITY ASSESSMENT AND ITS CHARACTERISTICS

| Loss | Scale | Characteristics of financial loss |
|---|---|---|
| Very significant loss | **5** | More than 25% of total budget |
| Significant loss | **4** | 10–25% of total budget |
| Moderate loss | **3** | 5–10% of total budget |
| Minor loss | **2** | 1–5% of total budget |
| Insignificant loss | **1** | Less than 1% of total budget |
| No relation to the particular enterprise | **0** | The enterprise does not perform activities related to the occurrence of this risk |

In the **risk assessment block**, the experts assessed 24 risks (Table III) that were divided into 6 groups: personnel, production, property, logistics, environmental, and political or legislative risks.

TABLE III
RISK CLASSIFICATION FOR THE ASSESSMENT OF RISKS IN BIOGAS PRODUCTION FROM BIOMASS OF AGRICULTURAL ORIGIN

| Risk code | Characteristics of the risk | Risk group |
|---|---|---|
| *P1* | Personnel's lack of responsibility | |
| *P2* | Personnel's low qualification and lack of experience | Personnel risks |
| *P3* | Violations of occupational safety rules | |
| *R1* | Low quality of biomass | |
| *R2* | Instability of microbiological processes in the bioreactor | |
| *R3* | Operational problems of the machinery servicing the biogas facility | |
| *R4* | Failures in the operation of cogeneration equipment | Production risks |
| *R5* | Interruptions in the consumption of biogas | |
| *R6* | Interruptions in the connection to the electricity distribution network | |
| *R7* | Interruptions in the consumption of heat | |
| *R8* | Delayed equipment service and availability of spare parts | |
| *Ī1* | Low external security of the bioreactor and other equipment | |
| *Ī2* | Fire and lightning risks | |
| *Ī3* | Risk of unavailability of financial resources, including loans, for investment in the farm | Property risks |
| *Ī4* | Financial obligation risk (problems with covering existing financial obligations) | |
| *L1* | Irregular supply of biomass | |
| *L2* | Problems with digestate storage | |
| *L3* | Problems with biomass storage | Logistics risks |
| *L4* | Accidents when transporting biomass | |
| *L5* | Accidents when transporting digestate | |
| *V1* | Problems with utilising digestate as a fertiliser for fields (effect of weather conditions, complaints by the local residents, etc.) | Environmental risks |
| *V2* | Environmental risks in utilising digestate as a fertiliser for fields | |
| *Pol1* | Changes in the energy policy | Political risks |
| *Pol2* | Changes in purchase prices of heat or electricity | |

## III. RESULTS AND DISCUSSION

In the **block of questions on biogas production**, the experts answered questions on experiences in biogas production, the effect of seasonality, raw materials used to produce biogas and their origin, as well as the use of heat. Replies on the question about experiences in biogas production revealed that the majority of the farms produced biogas for one year (the modal value), 4 years was the longest period of biogas production, while 3 of the farms produced biogas for less than one year. It is a short period, therefore, their knowledge about this industry and related risks sometimes is insufficient and it is not possible to objectively refer to mistakes of other producers if trying to manage risks on a farm.

An analysis of the percentage distribution of the quantity of biomasses used for biogas production showed that livestock residues dominate, as 61% of the biomass used for biogas production was by-products of the livestock sector; biomass of plant origin was used almost half as much – 36%, while wastes of various kinds accounted for only 2% of the quantity of biomasses. Such a percentage distribution of biomasses may be explained by the need to ensure an optimal combination of biomasses for biogas production, which, according to the literature review, consists of 60% of livestock manure and 40% of biomass of plant origin and biomasses of other kinds [14]. Such a combination of biomasses ensures both a high yield of gas and a high content of methane in biogas, which allows maximising the output of electricity and heat from biogas. Yet, the use of maize silage or another kind of silage, green biomass, or good quality grain does not comply with the principles of bioeconomics and "green" energy, as biomass is produced for its further use for biogas production instead of obtaining it from wastes of other economic activities.

Unfortunately, no legal framework, which would differentiate the support for biogas production, was created when the production of biogas started and a production support system was being established; instead, financial support was linked to the quantity of electricity produced, and, logically, for the purpose of profit maximisation, biogas producers use particularly this kind of biomass. This consideration should be taken into account if designing a future support policy for biogas use, and in case granting permits for the construction of biogas facilities is restarted, the support amount has to be differentiated depending on the kind of biomass used for biogas production and the possibilities for an efficient use of heat.

After analysing the origins of biomasses (Fig. 1), the author concludes that biomass is mainly produced on the farm – 11 of the farms grow maize and produce maize silage and 9 use cow manure; it is a positive fact that biogas facilities are constructed in the vicinity of livestock farms, which allows processing the manure produced on these farms.

A trend is observed to diversify the acquisition of biomass – on some farms, one kind of biomass, for instance, maize silage is both produced on the spot, purchased, and acquired free of charge from other producers of agricultural products; for free farms usually acquire waste products that need to be recycled– food and agricultural wastes, food processing waste, low quality silage or grain. It is often cheaper to producers to transport their by-products and wastes to a biomass facility rather than to recycle them into other products. Such cooperation ensures that agricultural production approximates the principles of bioeconomics and provides environmental gains to both biogas producers and farms that dispose of waste; therefore, such cooperation should be especially supported by subsidising energy production.

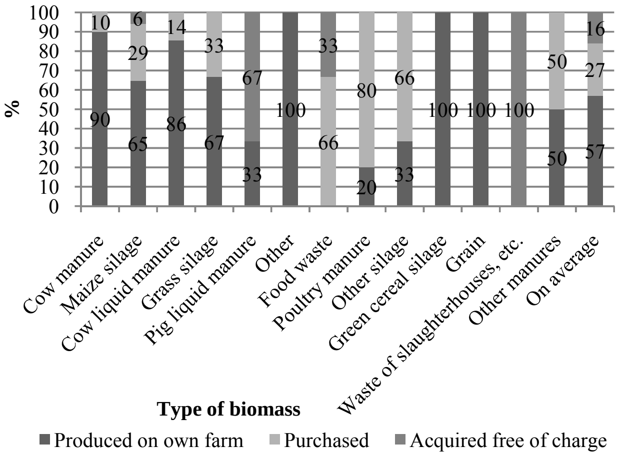


Fig. 1 Percentage distribution of the kinds of biomasses by origin and way of production for biogas production on the surveyed biogas farms in Latvia in 2013

After examining the percentage distribution of use of heat (Fig. 2), one can conclude that, on average, equal amounts of heat – 26% – are used for the process of biogas production and for heating other buildings.

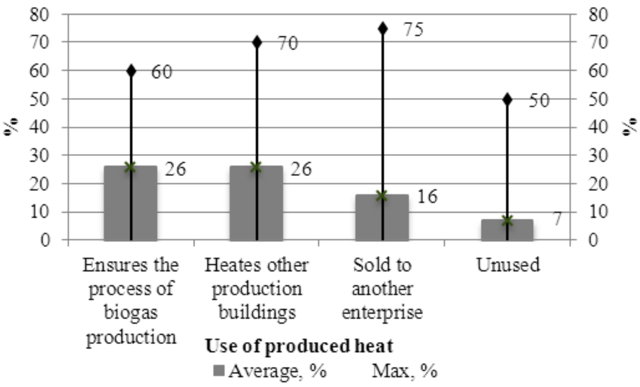


Fig. 2 Percentage distribution of the uses of heat generated in the cogeneration process on the surveyed biogas farms in Latvia in 2013

A smaller amount or, on average, 16% is sold to another enterprise, while on average 7% of heat is not utilised. However, an analysis of the dispersion and maximum values of indicators shows that the largest dispersion in the use of heat generated is observed for the item "sold to another enterprise", 75%; besides, on average, this item accounts for only 16% of the heat produced. It may be explained by the fact that several biogas facilities do not sell their heat generated at all, while others sell all their heat that is not necessary for the biogas production process. It can be concluded that most of the heat generated is efficiently used, and the biogas facilities that could not sell their heat before or utilise it for other economic activities seek to create such opportunities.

Overall the results about the biogas production process in the farm provide background information for the further analysis of the risks affecting this process.

After analysing the data obtained from the risk assessment, it can be concluded that the modal value of severity of all the risks is equal to 5, i.e. the risk severity level mentioned most often is stated as a very significant loss of more than 25% of the enterprise's total budget, while the average value derived from the model values of all risk severity ratings is equal to 3, i.e., on average, at biogas facilities, risks cause a loss of 5 – 10% of the enterprise's total budget. However, the modal and average levels of probability of risk occurrence are homogenous, 3 and 2.4, respectively, i.e. the occurrence of risks is possible, and the risks could happen within a year.

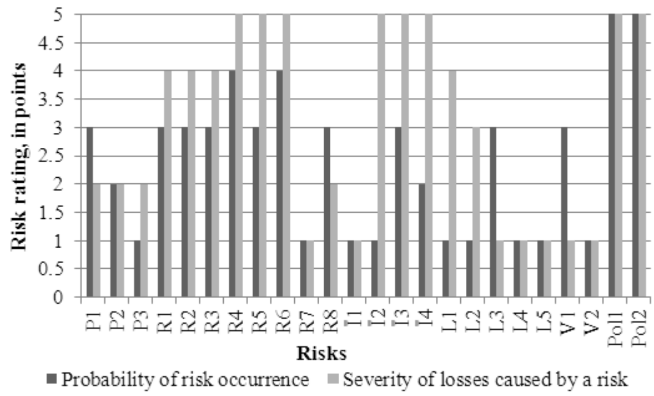


Fig. 3 Severity and probability of risk occurrence in biogas production, on a scale from 1 to 5, for the surveyed biogas farms in Latvia in 2013

According to the experts, (Fig. 3) the most significant risks were as follows: three production risks, most of the property risks (three), and all the political risks. Among the production risks: failures in the operation of cogeneration equipment (R4); interruptions in the consumption of biogas (R5); and interruptions in the connection to the electricity distribution network (R6). Among the property risks: fire and lightning risks (Ī2); and risk of unavailability of financial resources, including loans, for investment in the farm (Ī3); and financial obligation risk (problems with covering existing financial obligations) (Ī4). Both risks in the political risk group were recognised as very significant: changes in the energy policy (Pol1); and changes in purchase prices of heat or electricity (Pol2). On the whole, it can be concluded that such an assessment is objective and the mentioned risks, in the worst scenario, could cause such losses. Since there is a relatively small experience in biogas production, there is a chance that producers focus on their daily problems, and they have not yet faced environmental and logistics risks that might occur in the future; therefore, they are not aware of the significance of these risks. In the rating of risk occurrence, both political risks were recognised as the most probable: changes in the energy policy and changes in purchase prices of heat or electricity. It is a negative fact, as it reflects the instability of political decisions and legislation process in Latvia. Even objectively knowing that the legal acts and political decisions binding upon biogas facilities do not cause risks so often, the higher level managers and professionals engaged in the field of biogas production have such an opinion. This risk assessment reflects subjective opinions of the experts, as described in risk assessment theory. If semi-quantitative and qualitative risk assessment approaches are employed, i.e., data are obtained from experts, it has to be taken into account that experts use the rational choice approach to risk assessment – rational choice theory is based on an assumption that individuals are able to act strategically, associating their decisions with consequences. [15], [16] The experience in tackling a specific risk is accumulated; however, the negative aspects of such an assessment is the effects of subjectivity and stereotypes on experts' opinions, thus their negative experiences in other fields are transferred to an assessment of specific risks.

Consequently to the highest evaluated severity and probability levels, political risks had the highest significance level, reaching a score of 25 (Fig. 4) – such risks are considered extreme risks and immediate actions should be taken for their management. Yet, as the author mentioned before, in this case the particular group risks mainly indicate the subjectivity of the experts' opinions and point to instability and distrust in political decisions in Latvia. Although the future support policy for renewable energy production was unclear at the moment of conducting the risk assessment (February till March of 2013), the author of the thesis did not see legally justified possibilities for affecting the electricity purchase price for biogas facilities that have already concluded a contract on electricity sales under the mandatory purchase obligation; half a year after the risk assessment was completed, the political rhetoric was focused on introducing a new tax on the subsidised amount of price paid to electricity producers under the mandatory purchase obligation [17]. The introduction of such a tax reduces real incomes from electricity and confirms concerns about changes in the support policy. The political risks are also associated with the opinion of renewable energy producers, expressed by the public and media, which was inconsistent and which, to a great extent, resonated in political discussions, thus raising concerns about the possible change in the support policy. The effect of the political risks on this economic activity is considerable due to the fact that largely income from the biogas production depends on the mandatory purchase price, and the additional income of biogas facilities is relatively small.

The next highest score for the risk level belongs to the group of production risks, 12.25; such risk level corresponds to significant risks, and immediate actions have to be taken for their management. To the groups of property, personnel, and logistics risks, whose risk level ranges from 3.6 to 7.75 and corresponds to moderately significant risks, attention should be paid as well. The group of environmental risks has a score of 2, ranking the risks of this group in the group of tolerable risks; no active actions are required for the management of such risks, the risk level has to be monitored and prevention should be done if necessary. The low score for the risk level of this risk group could be also related to the short period of operation of biogas facilities', as no accidents occurred in relation to the particular risk groups, and the potential severity of these risks has not been comprehended. Accordingly, a risk assessment should be performed repeatedly – after a longer period of operation of the biogas facilities.

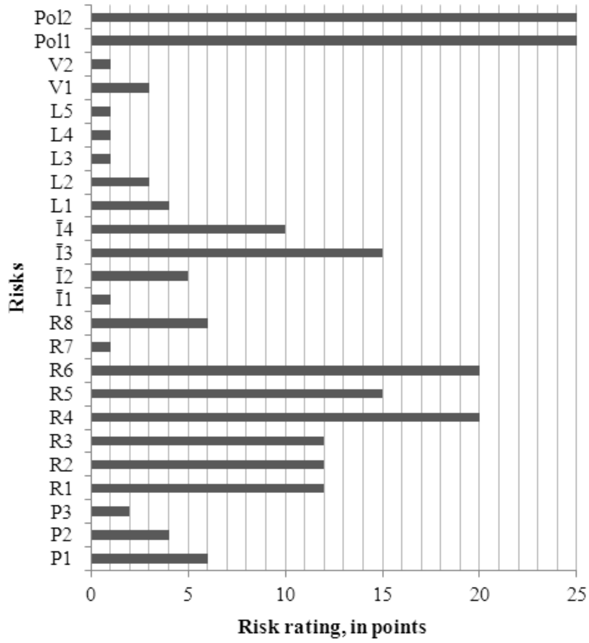


Fig. 4 Significance level of risks in biogas production, on a scale from 1 to 5, for the surveyed biogas farms in Latvia in 2013

To analyse the homogeneity of the experts' ratings, the author calculated the average, maximum, and minimum values for the experts' ratings of risk level, thus constructing Fig. 5 that presents the dispersion of the experts' ratings of risk level.

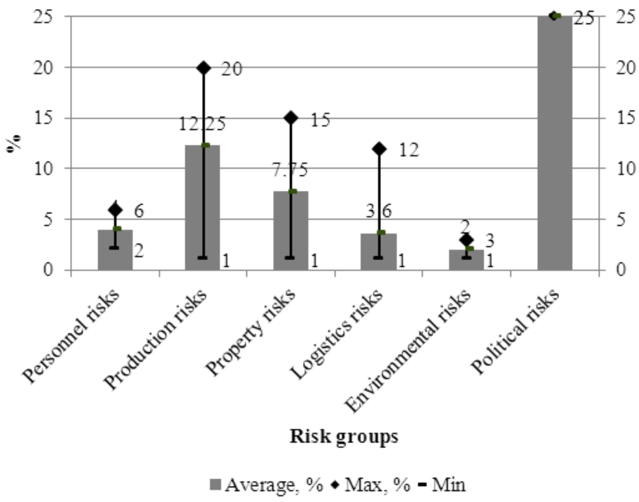


Fig. 5 Dispersion of the significance level of the risk groups in biogas production, on a scale from 1 to 5, for the surveyed biogas farms in Latvia in 2013

The greatest dispersion is observed for the group of production risks; this group includes a risk – interruptions in the consumption of heat –, which is a tolerable risk with a score of 1, while there are two risks that may be viewed as extreme, with a score of 20 – operational problems of the machinery servicing the biogas facility and interruptions in the connection with the electricity distribution network. Such results show the experts' particularisation of each risk and give a confidence about the objectivity of the reflection of a real situation in the risk assessment.

Answering the final question in the risk assessment block, the experts advised the most appropriate risk management instrument for each risk by choosing one of the following 5: A – risk avoidance, B – risk reduction, C – risk-taking, D – risk transfer, and E – diversification.

The data (Fig. 6) show that the risk management alternatives suggested by the experts for each risk group differ rather significantly, for instance, environmental, personnel, and production risks are mainly advised to be reduced, as these risks can be relatively simply reduced at a low cost, whereas an entirely opposite assessment was given to the group of political risks, as these risks, from the perspective of a biogas producer, cannot be influenced and reduced. For the management of political risks, a third of the respondents proposed taking the risk, while the same number of respondents advised diversifying economic activity. Thus, even if negative changes take place in the energy policy, which cause risks to biogas production, other economic activities would assist in compensating for and depreciating the accrued losses. The author believes that such an opinion of the experts reflects the practical risk management possibilities and show that the experts suggested different risk management techniques for each risk group, while examining their potential effectiveness and the possibilities for their use to manage specific risks.

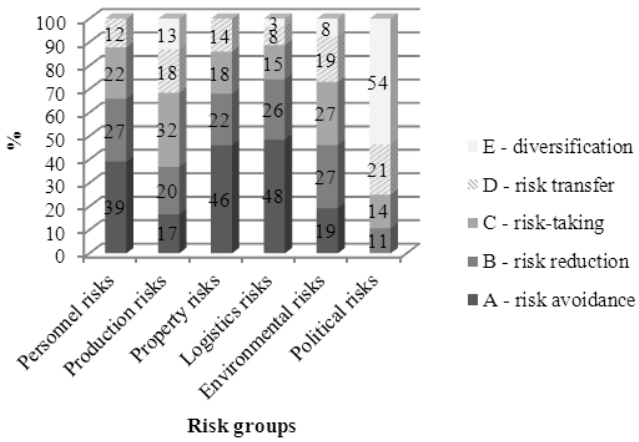


Fig. 6 Percentage distribution of the risk management alternatives in biogas production for the surveyed biogas farms in Latvia in 2013

In the risk assessment survey, the factors hindering further development of entrepreneurship were also assessed, and these factors were classified into 3 groups: economic, political, and social or personality influence factors:

- economic factors involve both microeconomic and macroeconomic factors, such as price, demand, availability of premises, equipment, and employees;
- political factors includes factors as guaranteed purchase prices and their stability, legislative changes, increase of electricity production capacities or availability of permits for the installation of new equipment, and availability of national and EU support;
- social factors refer to the potential internal risks that could result from the social influence factors included in the survey. Social risks are one of the least researched risk groups. They, to a great extent, depend on the individual's approach to knowledge. Since the (internal) risks caused by one's own activity often remain unnoticeable, the social risk position has to be formed by creating networks of knowledge with other individuals who have a wider access to necessary information about risks [18].

After examining the factors that hinder the development of entrepreneurship (Table IV), the author concludes that the most essential effect on the further development of entrepreneurship, according to the experts, is made by the political risks. It is confirmed by what the author stressed regarding the expectations of changes in legal acts and the problem of instability, as well as the low trust of entrepreneurs in political decisions and their stability.

TABLE IV
SUMMARY, CLASSIFICATION, AND AVERAGE RATINGS, ON A SCALE FROM 0 TO 5, OF THE FACTORS HINDERING THE FURTHER DEVELOPMENT OF ENTREPRENEURSHIP FOR THE SURVEYED BIOGAS FARMS IN LATVIA IN 2013

| Factors hindering the development of entrepreneurship | Factor group | Rating |
|---|---|---|
| Lack of financial resources | Economic | 5 |
| Lack of premises/equipment | | 2 |
| Lack of demand for heat generated | | 2 |
| Price of heat generated | | 3 |
| Lack of demand for other products (if produced) | | 2 |
| Price of other products (if produced) | | 2 |
| Lack of employees | | 3 |
| ***Average rating of the economic factors:*** | | ***2.7*** |
| Guaranteed electricity purchase prices | Political | 5 |
| Changes in guaranteed electricity purchase prices (instability) | | 5 |
| Changes in the legislation | | 5 |
| Availability of permits | | 5 |
| Availability of EU support for investment in the farm | | 5 |
| National support for economic activity (subsidies, etc.) | | 5 |
| ***Average rating of the political factors:*** | | ***5*** |
| Lack of entrepreneurial ability | Social | 3 |
| Lack of knowledge and information on possibilities for entrepreneurship development | | 2 |
| ***Average rating of the social factors:*** | | ***2.5*** |

The data obtained in the risk assessment survey reflect the roles of legislative and political risks and affecting factors in entrepreneurship and its further development. Without creating a stable, well-structured, and predictable sectoral policy, entrepreneurship, according to the experts, is subject to very significant risks. Such an assessment indicates the sector's great dependence on political decisions, as this sector receives national and international financial aid through two support mechanisms: the EU's support for investment and feed-in purchase prices of electricity generated under the mandatory purchase obligation; besides, entrepreneurial actions in the sector may be started only if a MoE permit for increasing electricity production capacities and a permit for the installation of a new equipment is granted (in accordance with Cabinet Regulation No 883 of $11^{th}$ of August, 2009). For this reason, the operation of the biogas production sector's enterprises significantly depends on political priorities that are presently unclear.

## IV. CONCLUSIONS

In the risk assessment, the highest risk level was obtained for the political group risks, reaching a score of 25, thus pointing to political instability and distrust in political decisions in Latvia. The results of the risk assessment survey reflect the role of legislative and political factors in entrepreneurship and its further development. Without a stable, well-structured, and predictable sectoral policy, entrepreneurship, according to the experts, is subject to significant risks. Such an assessment indicates the sector's great dependence on political decisions due to the historically evolved support system.

An analysis of the risk management alternatives for each of the risk groups shows significant differences among the alternatives suggested by the experts for each of the risk groups – they advised to reduce mainly the environmental, personnel, and production risks, as these risks can be relatively simply reduced at a low cost, whereas an entirely opposite assessment was given to the group of political risks, as these risks, from the perspective of a biogas producer, cannot be influenced. For the management of political risks, a third of the respondents proposed taking the risk, while the same number of respondents advised diversifying economic activity.

After analysing the factors hindering the development of entrepreneurship, it can be concluded, that according to the experts the most significant effects on the further development of entrepreneurship are made by political factors, thereby indicating the expectations of changes in legal acts and the problem of instability, as well as the low trust of entrepreneurs in political decisions and their stability.

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