RISK MANAGAMENT IN RENEWABLE ENERGY PRODUCTION

Sandija Rivža, Pēteris Rivža
Latvia University of Agriculture
Sandija.Rivza@llu.lv

Abstract
Even though the activities of an individual have always been subject to risks, the understanding of risk and its role in the society at the turn of the 20th and 21st century have become the issue of theoretical and practical importance and are closely connected with the ideas of two sociologists, U. Beck (1999) and A. Giddens (2002). The issue of risk management has not lost its topicality, therefore an increasing number of studies apply risk evaluation and risk management methods. A wider attention to the renewable energy production is drawn in the context of forecasted exhaustion of the fossil energy resources, the increase in their prices and energy dependence. Consequently, the scope of research in the field of renewable energy production has broadened. This paper summarizes the risk management studies in renewable energy production and proposes risk classification, risk management cycle and risk management options for the management of renewable energy production risks in Latvia.
Key words: risk, risk classification, risk management cycle.

Introduction

European Union (EU) consistently works on setting up a common energy policy with an important place allocated to the renewable energy production, energy efficiency, sustainable use of resources, and energy security and independence. The new Directive on renewable energy (Directive 2009/28/EC of the European Parliament and of the Council) sets ambitious targets for all Member States: the share of energy from renewable sources in EU reaching 20% by the year 2020 (8.5% in the year 2005), and a 10% share of renewable energy specifically in the transport sector (Directive 2009/28/EC, 2009). To reach this common goal, each member state has to increase the amount of renewable energy production and exploitation as a source for electricity, heating, cooling, and transportation. In the year 2010, renewable energy composed 37% in the total structure of energy in Latvia, with a target of reaching 40% in the year 2020.

Although researchers of the Latvia University of Agriculture have a certain experience in working with risk determination and assessment issues in various fields of agriculture, veterinary medicine, food science, etc., the field of renewable energy production is rather new and is scantily explored, therefore we should adopt the experience of other countries, for example, the USA (Rausser, M. Papineau, 2008) and the UK (Froggatt, Lhan, 2010), and of organizations such as United Nations Environment Program (Financial Risk Management.., 2004).

The research aim is to summarize risk classification and risk management approaches in the context of renewable energy production.

Materials and Methods

There are several definitions of the notion of risk in scientific literature (Hardaker, Huirne, 2004; Renn, 2008; Pettere, Voronova, 2004; Šuškeviča, 2005; Baoding, 2011; Definitions of Risk, s.a.; etc.). Some authors define it as a probability, others as consequences (positive or negative), some authors consider that risk is the combination of probability and consequences. The authors of the present paper define the term 'risk' in the following way: risk is the multiplication of the probability of an event occurrence and its significance level of potentially unfavourable consequences. There is no unanimous opinion neither regarding the definition of 'risk' nor regarding the classification of risks. Risks are difficult to group because of their close mutual links and substitution. John Maynard Keynes (1930; 1937) was the first scientist who attempted to divide risks into three groups:

- risk of a loan taker;
- risk of a creditor;
- inflation risk (Arhipova, Arhipovs, 2005b).

Different risk classifications and risk groups appear in the publications. Regarding the location of risks, they are divided into internal and external (Pettere, Voronova, 2004). Likewise A. Giddens (1999) applied a similar risk division, grouping them into external risks and manufactured risks caused by one's own activities. The risk as a decision is considered to be an internal risk, but the risk as an event refers to external risks.

As far as the origin of risks is concerned, risks are divided into subgroups, which, according to the aim of the classification, might be either all-embracing or specific. For example, 'RiskMetrics Group' has identified a broad spectrum of 12 risks that includes market, management, environment, social, accounting legislative, credit risks, etc. (RiskMetrics Group, 2008). Recently the research on financial risk management has become more common including market risks, liquidity risks, credit risks, operational risks, legal risks, etc. (Crouhy, Mark, 2000).

Table 1.

Approaches of Risk Classification

No.	Risk classification feature	Types of risks
The cause (source) of risk		
1.	Type of business	1.1. Financial (credit) risk 1.2. Production risk 1.3. Investment risk 1.4. Innovation risk 1.5. Market risk 1.6. Legislative risk 1.7. Insurance risk 1.8. Transport risk
2.	Cause of risk	2.1. Business risk 2.2. Risk of manager's personality 2.3. Risk of insufficient information
3.	Location of the cause	3.1.Internal risk 3.2. External risk
4.	Type of the cause	4.1. Objective risk 4.2. Subjective risk
The risk force subject		
5.	Scale	5.1. Local (endemic) risk 5.2. Regional risk 5.3. National risk 5.4. International risk 5.5.Global risk
6.	Included economic subjects	6.1. Individual risk 6.2. Group risk
The risk conditions		
8.	Insurance opportunities	8.1. Insured risk 8.2. Risk without insurance
9.	Impact time period	9.1. Short-term risk 9.2. Long-term risk
10.	Time criterion	10.1. Past risk 10.2. Current risk 10.3. Future risk
11.	The significance level of risk consequences	11.1. Acceptable risk 11.2. Critical risk 11.3. Disaster risk
12.	Diversification level	12.1. Common risk 12.2. Specific risk
13.	Forecast opportunity	13.1. Forecast risks 13.2. Risk which is impossible to forecast

Source: created by the authors on the basis of Pettere, Voronova, 2004; Stanka, 2004; Crouhy, Mark, 2000; Olivier, s.a.; Merna, Al-Thani, 2005

Besides the above mentioned classifications, risks could be grouped according to the scale, insurance opportunities, economic subjects, operational length, time criterion, legal criterion, etc. (Pettere, Voronova, 2004). After having examined risk classification approaches, the authors of the present paper created their own risk classification consisting of three groups (Table 1):

1. risk classification according to the cause (the source);
2. risk classification according to the risk force subject;
3. risk classification according to the risk conditions.

Each of the groups contains subgroups or risk classification features that serve as the basis for the selection of the group.

The type of risk classification depends on the aim, the branch, and the context of risk management. Apart from the ones described above, there is a risk classification approach, which is based on risk force subject. The PEST analysis method is the most commonly used method; it comprises political, social and technological aspects. The PESTEL method includes environmental and legislative aspects in

Table 2.

General classification of risks in renewable energy production

Risk group (cluster)	Risk
1.Personnel	1.1. Responsibility of the personnel 1.2. Qualification and experience 1.3. Work safety
2.Production	2.1. Quality of resources 2.2. Stability of production cycle 2.3. Regular supply of resources 2.4. Connection with the state electricity network 2.5. Utilization possibilities of the produced heat and their stability 2.6. Accessibility of service for technical equipment
3.Property	3.1. The outer security of the energy production plant and other production facilities 3.2. Credit risk 3.3. Fire security
4.Environment	4.1. Storage of production resources 4.2. Transportation of production resources 4.3. Storage of waste from production of energy 4.4. Further use of waste from production of energy
5.Legislative	5.1. Changes in energy policy 5.2. Changes in the purchase tariffs

Source: made by the authors

addition to political, social and technological aspects (SWOT&PEST Analysis, s.a.). The method STEEP is less common, it contains political, economic, social, environmental and technological factors (Mazareanu, 2007). The method STEEPLED comprises political, economic, social, environmental, legislative, ethic and technological factors (STEEPLED Analysis, s.a.). The analysis of risk management research in the field of producing renewable energy shows that the risk classification in this field is mostly related to the cause of risk. The dominating groups among others are technological, environmental, legislative, financial and investment risk groups (Olivier, s.a.; Financial Risk Management, 2004; Froggatt, Lhan, 2010.; Ferraris, s.a.); less common are such groups as social, macroeconomic, resource, short-term and long-term operating risks and reputation risks (Financial Risk Management, 2004; Froggatt, Lhan, 2010; Aragonés-Beltrán, Pastor-Ferrando, 2009). The above mentioned principles have been used in the present research to design the risk assessment system by classifying the risks into 5 basic groups on the basis of the cause of risks – personnel, production, property, environmental, and legislative risks.

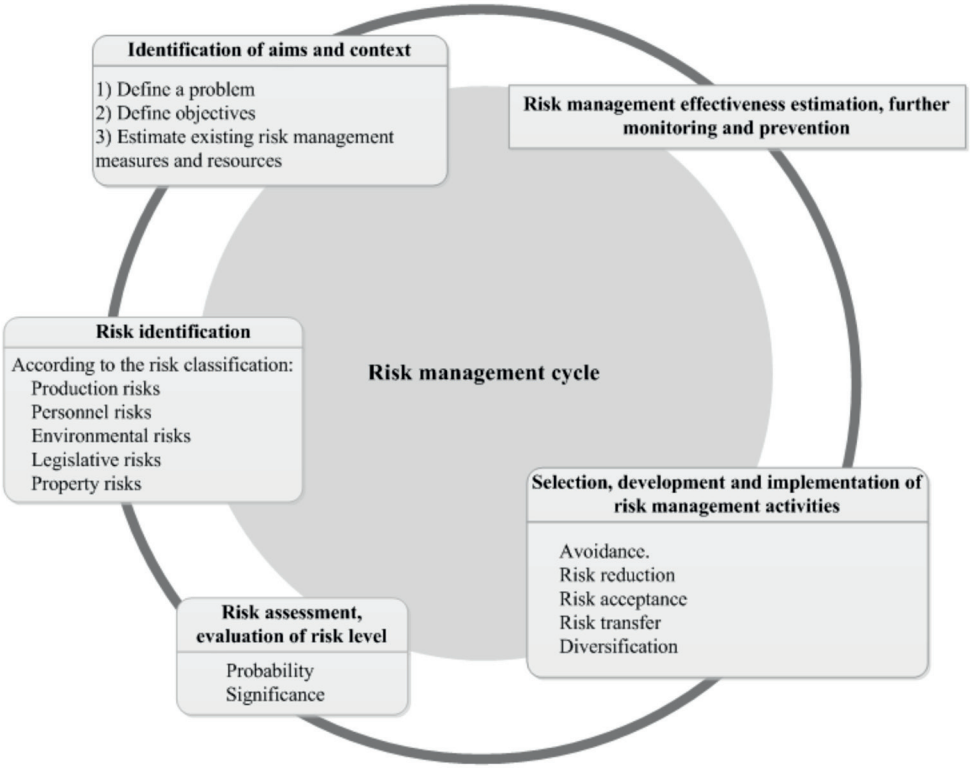
According to the literature review, the authors tried to create a general classification of risks in renewable energy production, which could be extended or modified according to the specifics of the particular field of renewable energy production. For example, in biogas production, under the Production group there would be such risks as 'Quality of biomass' instead of the generalized 'Quality of resources', but in the Environmental risk group 'Utilization possibilities of the produced heat and their stability' instead of 'Further use of waste from production of energy', etc.

Results and Discussion

Risks are manageable using various methods, which allows forecasting the probability of risks and taking measures to minimize the risk level. Risk management is a set of methods, approaches and actions with the help of which it is possible to forecast risks at a certain level and to develop action plans for risk prevention or for reduction of negative consequences (Rurāne, 2002). Risk management in a company should be implemented as an ongoing process or the so-called risk management cycle. The risk management cycle (see Fig. 1) comprises 4 basic elements: identification of aims and context, identification of risks, assessment of risks (assessment of risk level), and implementation of risk management activities. Risk monitoring and prevention are implemented in all stages of the cycle; risk monitoring and the analysis of effectiveness of the implemented activities are important, particularly, after the completion of risk management activities.

Several approaches might be applied to risk assessment and risk level evaluation that can be divided into 3 groups: qualitative, quantitative and semi-quantitative (Šantare, Rivža, 2007).

- Qualitative research methods are applied to assessment either of economic results or forecast of possible consequences which do not have quantitative features and scales. These methods are evaluated by discrete quantity 1 and 0, 'yes'or



Source: created by the authors on the basis of Trigilio, 2006; Olivier, s.a.; Guide to Risk.., 2004; Špoģis, 2005

Figure 1. **Risk Management Cycle**

'no', etc. Intellectual, dispositive and other types of risks belong to this group (Špoģis, 2005). This type of risks is assessed by means of decision making (hierarchy analysis method, analytical network method) (Saaty, 2010) and expert methods (Delphi method) (Pettere, Voronova, 2003).

- Forecasts of consequences and economic assessment of risk factors might be based on the data accumulated by entrepreneurs, publications and statistics. If the amount of the available data is sufficient, it is possible to apply quantitative methods based on the probability theory, mathematical statistics and other appropriate methods (Špoģis, 2005).
- Semi-quantitative risk management methods are used to express the qualitative assessment of experts with a quantitative indicator, i.e. risk level, and it is determined applying the risk analysis taxonomy. This method is used to assess a wide range of risks.

The methods of risk assessment in the field of renewable energy depend on the aim and context of the specific risk assessment. The research is frequently related to investment risks, therefore quantitative risk assessment methods are most commonly used; however, semi-quantitative methods can also be applied.

After the identification, the measures should be developed and implemented to further management of the identified and assessed risks. The development of measures is based on the analysis of risk management options. Theoretical sources (Sparrow, 2000; Trigilio, 2006; Olivier, s.a.; *Guide to Risk..*, 2004; Špoģis, 2005; Pettere, Voronova 2003) mention 5 options.

1. Avoidance is a commonly used option in risk management and it means the avoidance of the risks causing significant destructive consequences. This option envisages elimination of the causes that could lead to serious losses in an enterprise. Thus, production and economic conditions are created to prevent the probability of risk occurrence – either discontinuing the production and leaving the area of business subject to risks, or making political decisions of banning certain business activities (e.g., production of nuclear energy in a country) etc.
2. Risk reduction – this option reduces the likelihood of the risk occurrence or the amount of risk consequences, or the risk level (both probability of risk occurrence and the amount of risk consequences). The application of this option is necessary when:
   - risk occurrence probability or loss occurrence probability is sufficient enough and there are safe methods to reduce the loss;
   - the amount of possible loss is negligible.

The method envisages the development of preventive measures decreasing the probability of risk occurrence and warns (if performed regularly) about the

emergence of risk causes. The application of this option is reasonable if costs do not exceed the gains.

3. Risk acceptance – this option includes accepting the losses of the risk consequences and covering the expenses from resources of an enterprise. This option is applied when:
   - probability of loss occurrence is negligible;
   - the amount of potential losses is not large (they can be paid from regular financial gains).
4. Risk transfer – one party which is subject to risk finds a partner that can take the responsibility of possible risks. The consequences of risks are transferred to an insurance company or another company or organization on the basis of a contract.
5. Diversification – revenues are obtained from different mutually unrelated business activities (European Commission, 2001). Revenues from one or several business activities cover the losses of unfortunate business in the given time period. The risk of the business failure is reduced. The diversification as the risk reduction strategy increases the total production costs, since purchase and maintenance of various equipment and machinery increase the amount of the fixed costs in the company (Šantare, Rivža, 2007).

Initial research of risk management assessment options (Rivža, 2011) in the context of renewable energy production shows that specific features of a risk group should be taken into account when selecting a preferable risk management option. For example, property risks require risk transfer by means of property insurance, but legislative risk management requires risk monitoring since there is no other option from the point of view of a renewable energy producer. As regards production, personnel or environmental risks, they refer to risk reduction and, in some cases, risk acceptance.

Conclusions

The type of risk classification depends on the aim and the context of risk management. Risks can be divided into three classification groups: according to the cause (the source), according to the risk force subject, and according to the risk conditions.

Risk classification in this field is mostly related to the cause of risk. The dominating groups among others are technological, environmental, legislative, financial and investment risk groups, less common are such groups as social, macroeconomic, resource, short-term and long-term operating risks and reputation risks.

The methods of risk assessment in the field of renewable energy depend on the aim and context of the specific risk assessment. The research is frequently related to investment risks, therefore quantitative risk assessment methods are most commonly used; however, semi-quantitative methods can also be applied.

References

1. Aragonés-Beltrán P., Pastor-Ferrando J.P., Chaparro-González F., Bautista R.P. (2009) Selection of Photovoltaic Solar Power Plant Projects Using ANP. In: *Proceedings of the International Symposium on the Analytic Hierarchy Process* (Online). Pittsburgh, Pennsylvania, USA. p. 11. Available at: http://www.isahp.org/2009Proceedings/Final_Papers/4_Aragones-Beltran_SOLAR_REV_FIN.pdf
2. Arhipova I., Arhipovs S. (2005) Riska vadības metodoloģija. No: red. P. Rivža. *Riski lauksaimniecībā un privātajā mežsaimniecībā:* monogrāfija. Jelgava: Latvijas Lauksaimniecības universitāte, Rīgas Tehniskās universitātes Datorzinātnes un informācijas tehnoloģiju fakultāte, 64.-79. lpp.
3. Baoding L. (2011) *Uncertainty Theory* (Online) Department of Mathematical Sciences. Available at: http://www.orsc.edu.cn/~liu/ut.pdf
4. Beck U. (1999) *What Is Globalization?* Cambridge: Polity Press. p. 180.
5. Crouhy M., Mark R., Galai D. (2000) *Risk Management*. USA: McGraw-Hill, p. 35-39.
6. *Definitions of Risk* (Online). Business Dictionary (s.a.) Available at: http://www.businessdictionary.com/definition/risk.html
7. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources European Parliament, **2009** (Online) Available at: http://eurlex.europa.eu/lexuriserv/lexuriserv.do?uri=celex:32009l0028:en:not
8. Ferraris I., De la Canal M.D., Labriola C. (s.a.) *Risk Analysis in Renewable Energy: Assessment of the Vulnerability of the Environment and Community*. (Online) Available at: http://www.icrepq.com/icrepq07/363-ferraris.pdf
9. Financial Risk Management Instruments for Renewable energy projects. Summary document. United Nations Environment Programme. Words and Publications, Oxford, UK, 2004, ISBN: 92-807-2445-2
10. Froggatt A., Lhan G. (2010) *Sustainable Energy Security. Strategic Risks and Oppurtunities for Business:* White Paper. Lloyds 360^0 risk insight. London: Chatman House. p. 48.
11. Giddens A. (2002) *Runaway World*. Croydon, Surrey: Bookmarque Ltd., p. 6-20.
12. *Guide to Risk Management* (2004) Australian Capital Territory Insurance Authority. (Online) Available at: http://www.treasury.act.gov.au/actia/Risk.htm
13. Hardaker J., Huirne R.B.M., Anderson J.R., Lien G. (2004) Coping with risk in agriculture. Cambridge: CABI. p. 332.
14. Mazareanu V. (2007) Risk Management and Analysis: Risk Assessment (Qualitaive and

Quantitative) (Online). In: Proceedings of the Scientific Annals of the "Alexandru Ioan Cuza" University of Iasi, p. 42-46. Available at: http://anale.feaa.uaic.ro/anale/resurse/06_Mazareanu_V_-_Risk_management_and_analysis-risk_assessment.pdf
15. Merna T., Al-Thani F. (2005) *Corporate Risk Management. An Organisational Perspective.* West Sussex, England: John Wiley & Sons Ltd. p. 440.
16. Olivier T., Andlug Consulting, Rödl & Partner (s.a.) *Scoping Study on Financial Risk Management Instruments for Renewable Energy Projects. United Nations Environment Programme* (Online): Reference document. Marsh and Mc Lennan Companies. p. 142. Available at: http://www.sefi.unep.org/fileadmin/media/sefi/docs/publications/RiskMgt_full.pdf
17. Pettere G., Voronova I. (2003) *Riski uzņēmējdarbībā un to vadība*: mācību līdzeklis. Banku augstskola. Rīga: apgāds ``Rasa ABC``. 176 lpp.
18. Rausser G., Papineau M. (2008) Managing R&D Risk in Renewable Energy. University of California, Berkeley (Online) Available at: http://escholarship.org/uc/item/41j9f6ks#page-1
19. Renn O. (2008) *Concept of Risk: An Interdisciplinary Review*. (Online): In: Proceedings of the ISA Conference, Barcelona, September 2008, p. 3-10. Available at: http://www.riskanduncertainty.net/TG04/Ortwin_Renn_concepts.pdf
20. Risk Management Tools for EU Agriculture with a special focus on insurance (2001) (Online): Working Document. European Commission, Brussels. p. 84. Available at: http://ec.europa.eu/agriculture/publi/insurance/text_en.pdf
21. *RiskMetrics Group* (2008) (Online). RiskMetrics Group. Available at: http://www.riskmetrics.com/our_company
22. Rivža S., Rivža P. (2011) Risk assessment in renewable energy production using ANP. In**:** *Proceedings of the International Symposium on the Analytic Hierarchy Process (ISAHP)*: Online proceedings. AHP Academy, Cassino (Online). Available at: http://204.202.238.22/isahp2011/dati/pdf/135_0176_Rivza.pdf. ISSN 1556-8296.
23. Rurāne M. (2002) *Uzņēmējdarbības organizācija un plānošana*. Rīga: Biznesa Augstskola Turība. 330. lpp.
24. Saaty T.L. (2010) *Principia Mathematica Decernendi: Mathematical Principles of Decision Making*. Pittsburgh, PA, USA: RWS Publications, p. 1-28.
25. Šantare D., Rivža S. (2007) Risku un krīžu vadīšanas teorijas iespējas un metodes. No: Lauksaimniecības un pārtikas risku vadīšana: monogrāfija. Red. Pēteris Rivža. Jelgava: Latvijas Lauksaimniecības universitāte, Latvijas Republikas Zemkopības Ministrijas Pārtikas un veterinārais dienests, Rīgas Tehniskās universitātes modelēšanas un imitācijas katedra, pp 44-70.
26. Sparrow A. (2000) *A theoretical framework for operational risk management and opportunity realisation*: New Zealand Treasury Working Paper 00/10. (Online). New Zealand Treasury. p. 31. Available at: http://www.treasury.govt.nz/publications/research-policy/wp/2000/00-10/twp00-10.pdf
27. Špoģis K. (2005) Risku ekonomiskās iespējas vai draudi un to seku novērtēšana. No: *Riski lauksaimniecībā un privātajā mežsaimniecībā:* monogrāfija. Red. Pēteris Rivža. Jelgava: Latvijas Lauksaimniecības universitāte, Rīgas Tehniskās universitātes Datorzinātnes un informācijas tehnoloģiju fakultāte, 385.-389. lpp.
28. Stanka A. (2004) Riski, to izvērtēšana un vadība. No: *Uzņēmējdarbība lauku ilgtspējīgā attīstībā.* Jelgava: Jelgavas tipogrāfija, 170.-192. lpp.
29. *STEEPLED Analysis* (s.a.)(Online). Malabar Consulting. Available at: http://malabarconsulting.co.uk/wp-content/plugins/downloads-manager/upload/STEEPLED%20Analysis.pdf
30. Šuškeviča J. (2005) *Riska vadības rokasgrāmata.* Rīga: Dienas bizness, 12.-38. lpp.
31. *SWOT & PEST analysis* (s.a.) (Online). Centre of Competitive Intelligence for Business Success. Available at: http://www.marketing intelligence.co.uk/help/Q%26A/question24.htm
32. Trigilio S. (2006) *Applying the Principles of Risk Managament to Nuclear Plant Safety* (Online). International Foundation for Protection Officers. p. 12. Available at: http://www.ifpo.org/articlebank/Trigilio_Nuclear_Power.pdf

Acknowledgement
This publication is prepared within the framework of the ESF Project „Attraction of human resources to the research of the renewable energy sources", Contract No. 2009/0225/1DP/1.1.1.2.0/09/APIA/VIAA/ 129.