Available online at www.sciencedirect.com

SciVerse ScienceDirect

AASRI Procedia 2 (2012) 235 – 240

AASRI Procedia

www.elsevier.com/locate/procedia

2012 AASRI Conference on Power and Energy Systems

Conceptual Applications of the Risk Management Measures in Dynamic Models for the Farms Producing Biogas from Agriculture Biomass

Sandija Rivza[a*], Peteris Rivza[a]

Latvia University of Agriculture, Liela street 2, Jelgava, LV 3001, Latvia

Abstract

As technologies of renewable energy production evolve, its sustainability aspects have become topical at the moment. Dynamic modeling allows designing the whole production system as well as testing the technological and economic aspects of this system for its efficiency and sustainability in a defined period of time. The dynamic model described in the article was set up for a farm that produces biogas from agriculture biomass. The dynamic model includes a full cycle of agricultural production and consists of several mutually connected blocks: production (grain, biomass, milk, meat, biogas, heat, electricity), finances (investments, income, outcome, subsidies, loans), resources (arable land, farms, bioreactor, technical equipment, workforce), and risks. The model was created within the Powersim Studio 7 software and was tested using the data obtained at the Latvia University of Agriculture (LLU) Study and Research farm ,,Vecauce'' biogas production plant. Risks in the model are divided into 5 groups: personnel, production, environment, property and legislative (changes in the energy purchase tariffs) risks. They are assumed as probable variables with a normal distribution that is determined by an average value and a standard deviation. They are connected to the processes that they affect to calculate the impact of risks to the farm actions.

Keywords: farm optimization; dynamic model; risk management; biogas production; renewable energy

[*] Corresponding author. Tel.: +371 26387278; fax: +371 63005685.
E-mail address: Sandija.Rivza@llu.lv.

2212-6716 © 2012 Published by Elsevier B.V. Selection and/or peer review under responsibility of American Applied Science Research Institute
Open access under CC BY-NC-ND license. doi:10.1016/j.aasri.2012.09.040

1. Introduction

Following the world tendencies, the topicality of renewable energy production in Latvia is increasing. Currently, most of the electricity from renewable resources in Latvia is made from hydropower plants, but 1% of electricity is produced by cogeneration of biomass (Energy strategy 2030, 2011), which is seen as a perspective source for increasing renewable energy production under the conditions of Latvia. The development of cogeneration plants is largely encouraged by funding from the EU structural funds, Cohesion fund, and European Agriculture fund for rural development available from the government of Latvia and the EU in the past few years as well as for the coming year (2013).
At the moment there are 23 biogas production plants working in the territory of Latvia with the total power capacity of 29.92 MW. Till the year 2030 it is planned to increase the total production capacity up to 90 MW (by producing biogas from various biomasses) (Energy strategy 2030, 2011). With the expansion of biogas production from agriculture biomass, sustainability aspects, risk assessment and risk management become topical in farms that produce this kind of energy.
In this article the experience in setting up an all-embracing risk evaluation in farms that produce biogas as well as the attempt to create a dynamic model connected to the risk management mechanisms is reflected.

2. Materials and Methods

A farm that produces biogas is viewed from the systems theory perspective (Blumberga, et.al., 2010). In the study described in this article, firstly, the outside environment and its impact on a farm was determined: laws, regulations, subsidies, quotas, etc. The research was based on the data of a farm that is engaged both in crop production and dairy-farming; biogas production is an auxiliary sector. The crop production sector firstly serves to provide fodder for dairy cows – biomass for silage and heylage. Likewise crop production provides the biogas reactor with maize or grass biomass (Kalnins, 2009). The additional free arable land is fully used for grain production and growing of rape. The optimization of arable land is made by the following linear optimization task:

to find x_{ijt} values to maximize the income from crop-production:

$$z = \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{t=1}^{T} c_{ijt}\, a_{ijt}\, l_{ijt}\, x_{ijt} \rightarrow \max$$

by conditions that

$\sum_{i=1}^{n}\sum_{j=1}^{m} a_{ijt} l_{ijt} x_{ijt} \geq A_{jt}, \quad t = 1,2,3,...,T$ - the minimal demand for crop production is secured;

$\sum_{i=1}^{n} l_{it} x_{ijt} \leq L_t$ - arable land constraint in t year;

$\sum_{t=1}^{T} x_{ijt} \leq 2 * (T/3)$ - constraint for crop production;

crop culture change in the field at least every 3 years:

$$x_{ijt} = \begin{cases} 1, if\ in\ t-year,\ i-field,\ j-culture\ is\ sowed \\ \hline 0-the\ oposite \end{cases}$$

The need for crop production A_{jt} is determined by the need for fodder and biogas production that is simulated in the dynamic model.

The dynamic model of a farm consists of several mutually connected modules: resources, production, finances, and risks. Resources include 5 blocks (see Fig. 1): arable land, production premises, technical equipment and vehicles, personnel, and optimization of crop production sector. The module „Resources'' is located in the MS Excel software, including the optimization block. Information exchange between MS Excel and Powersim Studio is done by using Studio Dataset. The second module – Production – includes the following blocks: grain production, rape production, biomass production, reproduction of milking cows, milk production, biogas production, and heat and electricity production. All these blocks have Powersim Studio dynamic flow modules that, of course, are mutually connected. For example, biogas production block includes biogas production flow module that accordingly is connected with the milking cow module, biomass production module as well as with heat and electricity production module (see Fig. 2).
Finance module includes 3 blocks: income, costs and profit. Data for assumptions of income and costs are gathered form the production block modules.

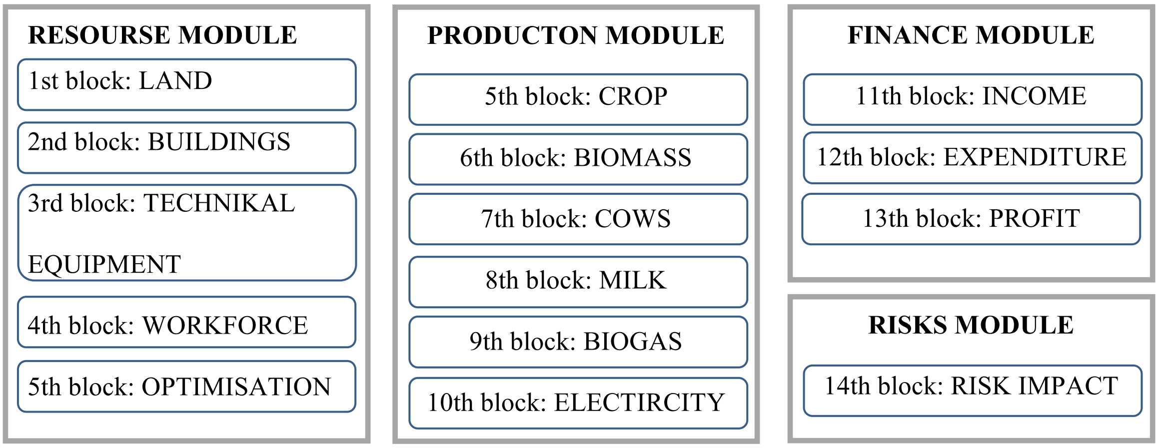

Fig.1. Structural scheme of the farm dynamic model

The last of the modules Risk module is linked with the variables of the Production module which allows calculating the impact from risks to the production process. Literature review on risk management in renewable energy production shows, that risks are mainly classified by the cause of the risk. Dominant and specific risk groups can be noticed. Technological, environment, legislative, financial and investment risks (Olivier, s.a., Financial Risk Management, 2004; Froggatt, Lhan, 2010; Ferraris, s.a.,) are frequently seen in the risk management studies of this certain field. Based on this summarization, the risks in this research are divided into 5 groups or clusters: personnel, production, property, environment, and legislative (changes in the energy purchase tariffs) risks.
Risks are assumed as probable variables with a normal distribution that is determined by an average value and a standard deviation, estimated by experts. The authors of this article have considered the following definition of the term „risk'': *Risk is the multiplication of the probability of an event occurrence and its significance level of potentially unfavourable consequences* (based on: Hardaker, Huirne, 2004; Renn, 2008). Therefore, in this case, the risks included in the dynamic simulation give only a negative effect and do not reflect any positive consequences.
The biogas plant of the study and research farm „Vecauce'' of LLU served as the basis for the biogas production module. It was built using *WEL tec BioPower GmbH* technology (Agricultural Biogas.., s.a.). This technology is characterized by biogas production in a mezofil fermentation process; the brutto capacity of the fermenter is 2 006 m³. As a substrate in the fermenter, cattle manure, maize silage, grain and other substrates

are used; for the post-fermentation, a 4 100 m³ tank was built. A container-type TES with the electric power capacity of 260 kWel (for the production of electricity) and heat production capacity of 310 kWter (for production of heat) was used for biogas procession into electric energy and heat.
The gas engine was produced by the company *Libherr* (Diesel engines.., s.a.), but the generator - by *Marelli* (Gasoline Engine Control.., s.a.). Gas consumption was 140 Nm³/h, and temperature of the hot water was 70/90 ºC. The forecasted annual production of electricity was 2 184 MWh. For the technological use in the plant, 110 – 120 kW of heat is required or about 30% from the total amount of the produced heat in the plant.
Production of biogas is limited by the maximal capacity of the bioreactor and the amount of manure form the dairy cow farm. The amount of manure for biogas production is determined by the number of dairy cows in the farm, in the MPS ,,Vecauce'' there are 500 dairy cows. The amount of biomass for biogas production can be supplied according to necessity by increasing the production fields of maize or grass, jet the priority of the simulation is to secure dairy cows with the fodder from the agricultural production of the farm.

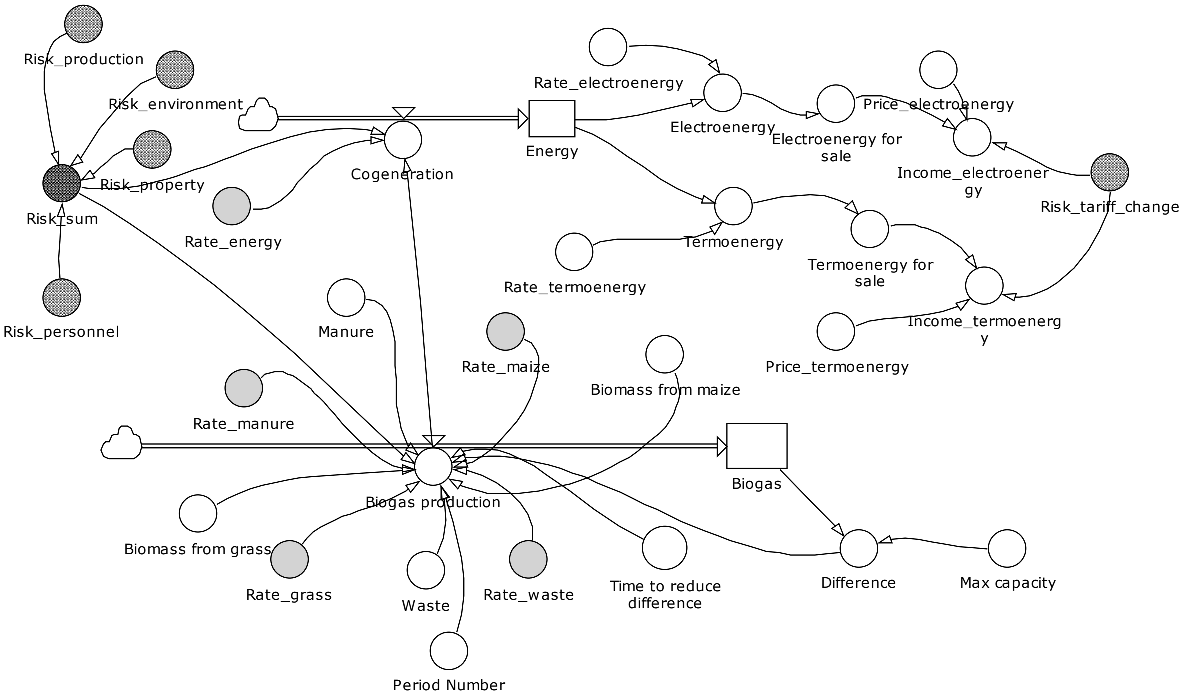

Fig. 2. Flow diagram of the biogas production dynamic model
In the flow diagram, the variables that determine biogas production are shown. These variables are modulated in other blocks of Production module, for example, biomass from maize and biomass from grass are modulated in the block ,,Biomass''. Biogas outcome is assumed as a probable variable with a normal distribution, that is determined by an average value and a standard deviation. Likewise the risk variables are determined by the experts and connected to the Production block variables that are affected by these risks.

3. Results and Discussion

Each of the blocks of the Production module gives an outcome in the process of simulation: grain yield, biomass yield, number of dairy cows, amount of milk produced, etc., as well as income and costs of the production in the farm. All production costs and income of the farm are summarized in the Finance module, which gives a possibility to estimate the profit of the farm. For example, production of electricity from biogas is characterized by the following charts: produced electricity and income from sale of the produced electricity.

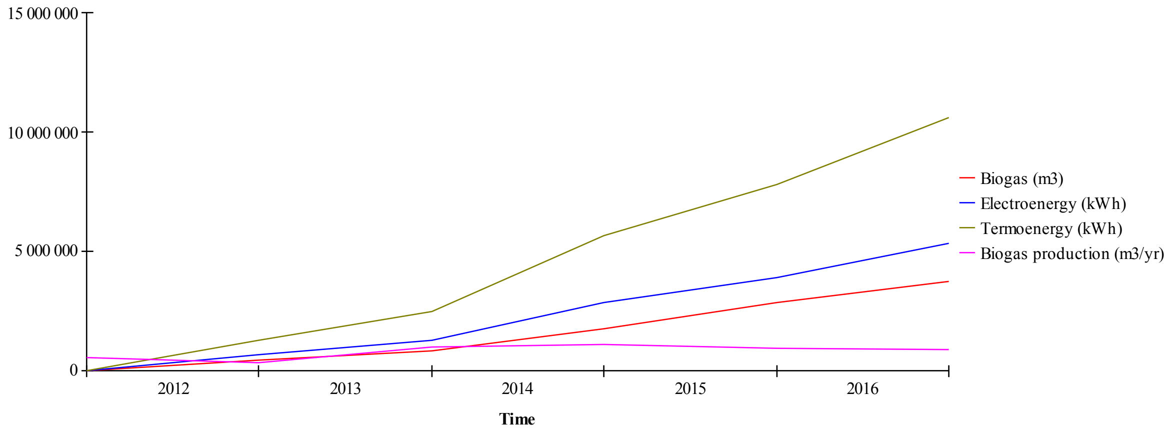

Fig. 3. Biogas production result chart

4. Conclusions

For farms in Latvia biogas production from agriculture biomass is a new type of economic activity that is currently supported from the state through purchase tariffs and from the EU in the form of co-funding for investments.

The dynamic module allows covering the whole cycle of biogas production and procession as well as distribution of the produced energy, by including agricultural and dairy production, biogas production itself and the subsequent cogeneration of heat and energy. Thus it allows improving the whole production cycle of the farm and testing the sustainability and economic efficiency of the renewable energy production in a defined period of time. After creating the conceptual model it needs to be calibrated carefully according to the parameters of the specific farm with the aim to increase the reliability and applicability of the simulation results.

Dynamic simulation also provides an opportunity to estimate the risk impact on the production outcome or on the separate parts of the production process and subsequently plan the possible risk management alternatives such as risk transfer, risk reduction, etc.

5. Acknowledgements

Publication and dissemination of research results has been made due to the funding of the ERAF Project Promotion of scientific activities of LLU”, Contract No. 2010/0198/2DP/2.1.1.2.0/10/APIA/VIAA/020

References

[1] Blumberga A., Blumberga D., Bažbauers G., Dāce E., Bērziņa A., Žogla G., Moxnes E., Davidsen P.I. Sistēmiskas domāšanas integrēšana vides politikā (Integration of System Thinking in Environmental Policy) Rīga, RTU, 2010, p. 225.
[2] Enerģētikas stratēģija 2030 (Energy strategy 2030)(2011) [Online]. Ekonomikas ministrija [Accesed: 11.01.2012.]. Retrieved: http://zrea.lv/upload/attach/ LR_Energetikas_strategija_2030_14-12-2011.pdf
[3] Kalniņš A. Biogāzes ražošanas saimnieciskie un vides ieguvumi (Economical and environmental benefits from biogas production). Rīga, 2009., 148.lpp.

[4] Agricultural Biogas Plants by WELTEC BIOPOWER. [Online]. [Accesed: 11.01.2012.]. Retrieved: http://www.weltec-biopower.com/Agricultural-Biogas-Plants.363.0.html
[5] Diesel engines by Liebherr [Online]. [Accesed: 15.02.2012.]. Retrieved:http://www.liebherr.com/CP/en-GB/products_cp.wfw/id-16546-0
[6] Gasoline Engine Control systems by Marelli [Online]. [Accesed: 15.02.2012.]. Retrieved: http://www.magnetimarelli.com/business_areas/powertrain
[7] Olivier T., Andlug Consulting, Rödl & Partner, (b.g.) *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
[8] *Financial Risk Management Instruments for Renewable energy projects*. (2004) Summary document. United Nations Environment Programme. Words and Publications, Oxford, UK.
[9] 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.
[10] Ferraris I., De la Canal M.D., Labriola C. (b.g.)*Risk Analysis in Renewable Energy: Assessment of the Vulnerability of the Environment and Community*. [Online] Available at: ttp://www.icrepq.com/icrepq07/363-ferraris.pdf
[11] Hardaker, J., Huirne, R.B.M., Anderson, J.R., Lien, G. (2004) *Coping with risk in agriculture.* Cambridge: CABI. p. 332.
[12] Renn O. (2008) *Concept of Risk: An Interdisciplinary Review*. In: Proceedings of the ISA Conference, Barcelona, September 2008, pp. 3-10. Retrieved: http://www.riskanduncertainty.net/TG04/Ortwin_Renn_concepts.pdf. Access: 10 July 2011.