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An empirical analysis of biogas investments in large-scale agricultural companies in Ukraine

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1 Introduction

1.1 Background of the Research Topic

"In a very fundamental way, sustainability depends on long-term economic success. It´s the only way to fund whatever degree of environmental commitment a company chooses to make."

Esty, Winston (2009, p. 251)

Globally biogas together with other renewable energies plays an important role in the reduction of fossil fuel consumption. Ukraine could export inland generated renewable energy, thus contributing to meeting global climate goals, however, the need for reliable domestic energy supply is becoming a more important political issue in this country (Arzinger 2009, p. 5). Ukraine has limited fossil-fuel resources and is dependent on imported natural gas, which has made the country reliant on its neighbouring states (European Bank for Reconstruction and Development (EBRD) 2014, p. 5). In recent years imported gas has accounted for up to 70 % of Ukraine´s total gas consumption (International Renewable Energy Agency (IRENA) 2015, p. 12). Natural gas is also a main energy source in the country´s total energy supply and is one of the reasons for Ukraine´s current energy-security problems. Moreover, the energy density of Ukraine´s economy is three to four times higher than that of Western European countries (Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2014; Kirchner, Zachmann 2009; Naumenko et al. 2012; Radeke 2012; Kirchner 2013; International Finance Corporation (IFC) 2010). Needless to say, this situation is particularly challenging in the context of the economic slowdown and geopolitical uncertainty Ukraine is currently facing.

Given Ukraine´s natural and climate resources, biogas represents an opportunity for improving the country energy supply (International Finance Corporation (IFC) 2015, p. 7). The potential of biogas and other renewable energies in Ukraine can be exploited to decrease its dependency on imported natural gas. Recent studies suggest that biomass has the greatest energy potential among all other types of renewables because of Ukraine´s high agricultural output (Organisation for Economic Development and Cooperation (OECD) 2012, p. 18). Agricultural residues and waste, e.g. manure, account for close to 60 % of the biomass potential (International Renewable Energy Agency (IRENA) 2015, p. 22). In this respect biogas is a key technology for biomass utilization in Ukraine´s agricultural sector. Regarding the economic efficiency of biogas investments, large-scale agricultural companies, called "agroholdings" in Ukraine, represent a good potential for biogas production.

Agroholdings are a relatively new type of enterprise in Ukraine´s agricultural sector. They emerged over the last 20 years during the transformation processes, e.g. collapse of the state-owned farms. So far scholars have provided only a general definition of "agroholding" as a vertical incorporation of several enterprises in the agricultural value chain (Wandel 2011, p. 62). The current development of agroholdings is negatively influenced by the uncertain geopolitical situation in Ukraine. Considering this and unpredictable energy prices agroholdings might look for reliable and independent energy supply. One option may be energy generation from biogas. However, biogas use in the agricultural sector should not be seen only as an additional source of power generation. Biogas creates a synergy effect, including economic, environmental and social advantages: economic advantages are connected to stable energy generation, positive environmental aspects of biogas are associated with prevention of methane emissions from agricultural waste, the social component of biogas includes improving relationships with local communities and new job creation in rural areas (Geletukha, G., et al. 2013d, p. 32-33; 42). Despite the attractiveness of biogas utilisation for agroholdings, biogas is reliant on governmental support in Ukraine (Masini, Menichetti 2013, p. 511).

To stimulate investment in the biogas sector, the government of Ukraine has implemented a set of economic incentives: a preferential feed-in tariff (called a "green tariff" in Ukraine) for electricity generated from biogas, tax benefits and obligating the Wholesale Electricity Market of Ukraine to purchase the entire electricity from biogas (Energy Charter Secretariat 2013, p. 86; Arzinger 2011, p. 23). Notwithstanding many advantages of biogas for agricultural companies, only a few Ukrainian agroholdings have thus far invested in biogas projects (Kucheruk 2013, pp. 4–5; Matveev 2013, p. 11).

1.2 Research Scope and Research Questions

The aim of the present work is to analyse Ukrainian agroholdings´ willingness-to-invest in biogas and to contribute to the understanding of their decision-making behaviour in the context of biogas investments. Taking into account the fact that biogas investments are often characterised by high up-front costs (Reise et al. 2012, p. 134) this dissertation focuses on large agroholdings, considered capable of financing such projects. Due to their leading role in the investment decision-making, top-managers of agroholdings were selected as an appropriate information source to study the willingness-to-invest in biogas. To this end, I have conducted a survey in which top-managers were asked personally about their willingness-to-invest in biogas, actual investment performance and attitudes towards biogas technologies.

Based on a literature review and identified research gaps (see Chapter 3), the present work incorporates adoption and organisational theories in the analysis of factors influencing the willingness-to-invest in biogas and addresses the following research questions:

- Which factors have a significant influence on the top-managers´ willingness-to-invest in biogas?
- Is there a difference in the influencing factors of top-managers with previous biogas investments compared to those which have not yet made this kind of investment?
- Does an existing willingness-to-invest in biogas lead to actual biogas investments?

To answer these research questions, a theoretical model has been designed consisting of four groups of factors: a) perceived investment attributes of biogas, b) organisational factors of the agroholdings, c) personal factors of the decision-maker and d) the external business environment. The model is empirically examined using primary data collected from a sample of large Ukrainian agroholdings.

1.3 Structure of the Work

The dissertation is organised as follows:

- Chapter 2 provides the context for the empirical research by giving an overview of the recent biogas implementation in Ukraine´s agricultural sector.
- Chapter 3 offers a theoretical background for the study and reviews relevant literature within the framework of the present dissertation. The literature review includes research on the adoption of innovative agricultural technologies, organisational decision-making regarding investments in agriculture and behavioural economics of organisations.
- In the next chapter the conceptual model explaining the investment behaviour of agroholdings regarding biogas investments will be developed.
- The research design of the present study which combines qualitative and quantitative techniques is provided in chapter 5.
- The next chapter illustrates the empirical research methods adopted in this work.
- Chapter 7 presents the results of descriptive statistics and the findings of the empirical model examination.
- In Chapter 8 the results will be discussed and summarised. Finally, limitations of the present survey will be presented and recommendations for future research will be proposed. I also draw conclusions of the doctoral thesis and provide potential applications of these findings to theory and practice.

2 Recent Biogas Implementation in Ukraine´s Agricultural Sector

This chapter provides the context for the empirical research by giving an overview of the recent biogas implementation in Ukraine´s agricultural sector. First, I will present a literature review of biogas potential and use in Ukraine. Second, the existing policy and legal framework for biogas support in Ukraine will be provided. Third, I will illustrate the current share of biogas production in Ukraine´s total energy supply and investment barriers to a larger increase of biogas utilisation. Finally, the formation and recent development of agroholdings will be presented.

2.1 Present Status of Biogas in Ukraine

The application of biogas in the agricultural sector should not be seen as only an additional source of power generation. Biogas creates a synergy effect, including economic, environmental and social advantages (Geletukha, G., et al. 2013d, p. 32-33; 42). Economic advantages are connected to stable energy generation during the year. It allows covering grid peaks in the periods of unstable energy supply, caused e.g. by deficit of imported natural gas or coal. Biogas can produce electrical and thermal energy in agroholdings located in the areas of low access to the national grid. Biogas may improve the company energy security through natural gas substitution and energy diversification. Electricity produced from biogas may also be sold at a favourable feed-in tariff[1], generating additional cash flow. In the case of organic waste fermentation, biogas can cover a part of the waste treatment cost. Fermented biogas substrate is a high-valuable organic fertilizer. The application of these fertilizers improves soil fertility and, as a result, crop yields. Positive environmental aspects of biogas are associated with prevention of methane emissions from agricultural waste. It also avoids discharging of harmful substances, e.g. ammonia, hydrogen sulphide, from organic waste into air, soil and groundwater. Undesirable smells from agricultural waste, e.g. pig and cattle manure, which may lead to conflicts with local citizens, will be reduced too. The social component of biogas includes improving relationships with local communities and contributing to new job creation in rural areas. In the following sections the reader will see how biogas advantages are currently exploited in Ukraine by providing an analysis of biogas implementation.

2.1.1 Literature Review on Biogas Implementation

In the first section scientific publications on implementation of biogas in Ukraine´s agricultural sector will be reviewed. Unfortunately, thus far scholars have not paid much attention to biogas. Therefore, studies investigating overall implementation of renewable energy in Ukraine will also be included. In the second section, publications on biomass use in Ukraine will be presented. Finally, I will review scientific reports on biogas implementation in Ukraine´s agricultural sector.

2.1.1.1 Analysis of Renewable Energy Potential

An increasing number of scholars have begun to investigate renewable energy in Ukraine. These studies usually focus on the potential of renewables for energy generation and existing barriers to their implementation. The most recent study was published by the International Renewable Energy Agency (IRENA) in 2015. IRENA issued a series of roadmaps for 26 different countries to show how they can boost renewable energy production. The report on Ukraine provides detailed background information on the energy sector. The results suggest that Ukraine can increase the share of renewables in the country´s energy mix while gaining socio-economic and environmental benefits. Kudrya (2013; 2012a; 2012b; 2012c) has estimated the potential of renewables in Ukraine and has analysed energy generation in post-Soviet[2] countries. Deloitte (2012) and the Organisation for Economic Development and Cooperation (OECD) (2012) explored the market conditions for renewables from investors´ perspective. The authors of these two studies used data from different sources to present a concise report for developers. They recommended implementing European best policy practices to evolve Ukraine´s renewable energy sector.

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[1] Feed-in tariff for renewable energy is called “green tariff” in Ukraine (see Section 2.1.3).

[2] Post-soviet or CIS (Commonwealth of Independent States) countries: Armenia, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

The European Bank for Reconstruction and Development (EBRD) has launched a financial programme for renewable energy called "Ukraine Sustainable Energy Landing Facility" (USELF). For this purpose EBRD commissioned a Strategic Environmental Review (SER) for investors in renewables to provide guidance for specific renewable energy projects. The SER also identified potential constrains and opportunities regarding implementation of such projects. Numerous German authors used the experience of the European policy makers for the analysis of renewables support system in Ukraine (Meissner, Ueckerdt 2010; Strubenhoff et al. 2009; Strubenhoff, Movchan, Burakovsky 2008). They identified the barriers associated with gaps in the laws regulating the Ukrainian energy sector. Table 2.1 summarises the main publications in the field of renewable energies in Ukraine.

Table 2.1: Overview on publications in the field of renewable energy in Ukraine

Author(s)	Focus of the study	Context and problems
International Renewable Energy Agency (IRENA) 2015	Analysis of the present renewable energy situation in Ukraine and implementation options for 2030.	• Potential and current status of renewables • Investment barriers
Kudrya 2013, 2012a, 2012b, 2012c, n.y.a, n.y.b[3]	Scientific analysis of renewable energy potential in Ukraine.	• Potential of renewables in Ukraine and other post-Soviet countries • Description of current technologies
Deloitte 2012	Economic analysis from investor´s perspective.	• Potential and current status of renewables • Policy framework
Organisation for Economic Development and Cooperation (OECD) 2012	Publication on policy framework in Ukraine from the EU perspective.	• Policy framework • Investment barriers
Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2012, 2011f, 2011g	Environmental impacts from transition to renewables in Ukraine.	• Analysis of natural and business environments for projects developers
Meissner, Ueckerdt 2010	Analysis focused on the policy improvement.	• Policy framework • Investment barriers
Strubenhoff et al. 2009; Strubenhoff, Movchan, Burakovsky 2008	Study of the legal and policy framework.	• Policy framework
Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2011e, 2011d, 2011c	Analysis of wind, solar and small hydro power sectors in Ukraine.	• Potential and current status of renewables • Policy framework
European-Ukrainian Energy Agency (EUEA) (2011)	Analysis of the solar energy sector in Ukraine.	• Potential and current status of renewables • Policy framework

[3] n.y.a, n.y.b – no year of publication was mentioned for two publications of this author ("a" and "b" accordingly).

Based on the publications summarised in this section, several conclusions can be reached. Ukraine´s climate conditions and available biogenic resources offer good commercial opportunities for renewable energy generation. However, the availability of economic incentives for renewable energy producers is essential to boost investment in sustainable energy projects. To ensure economic benefits from renewable energy investments precise and stable policies in the energy sector are needed. Thereby, biomass is expected to become the main source of renewable energy in Ukraine. To exploit the biomass potential for energy generation affordable financing programmes for sustainable energy projects in Ukraine should be created. The next section examines studies on biomass utilisation in Ukraine.

2.1.1.2 Literature Review on Biomass Use

There are several examples in the literature on analysis of biomass utilization in Ukraine. Comparative studies on biomass use versus fossil fuels have recently been published (Geletukha, G., et al. 2016, 2015a, 2015b, 2015c, 2014b, 2014c, 2013a, 2013b, 2013c, 2011, 2006b, 2002, 2010). These studies suggest that biomass has the greatest potential among all renewable energies in Ukraine, because of Ukraine´s high agricultural output (Organisation for Economic Development and Cooperation (OECD) 2012, p. 18). Some scholars indicate that biomass energy may already be competitive vis-a-vis natural gas and coal in Ukraine (Geletukha, G., et al. 2010, p. 1). However, existing legal and political barriers may hamper the uptake of biomass in the country´s energy mix[4]. Ukraine annually produces 110 to 120 m tons of biomass feedstock, e.g. crop and animal waste (see Figure 2.1). Most of this feedstock will be further processed or wasted and only a small share of biomass is used for energy generation.

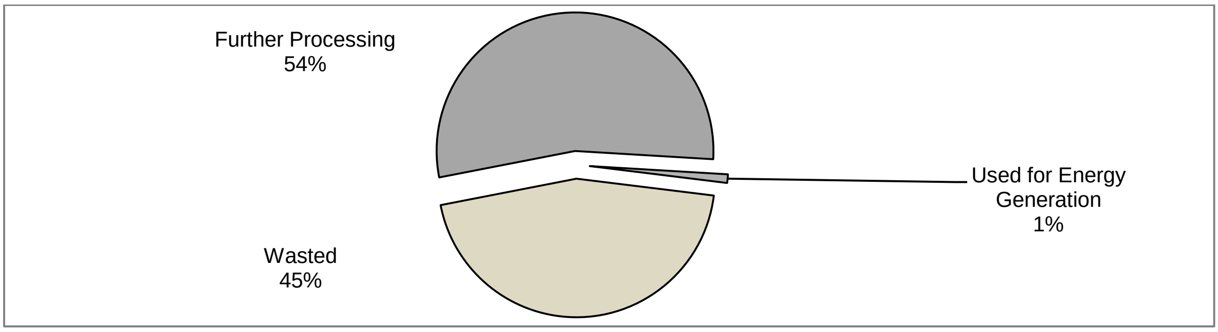

Figure 2.1: Structure of biomass use in Ukraine, 2015
(Based on International Finance Corporation (IFC) (2015, p. 25))

The International Finance Corporation (IFC) (2015) explored current market conditions for biomass-to-energy production in Ukraine and conducted a survey among market players in different sectors of the Ukrainian biomass industry. The surveyed companies included pellet producers, agricultural companies and municipal heat suppliers. The authors pointed out that only 11 % of agricultural producers, despite their direct access to biomass, use it for energy generation (Figure 2.2).

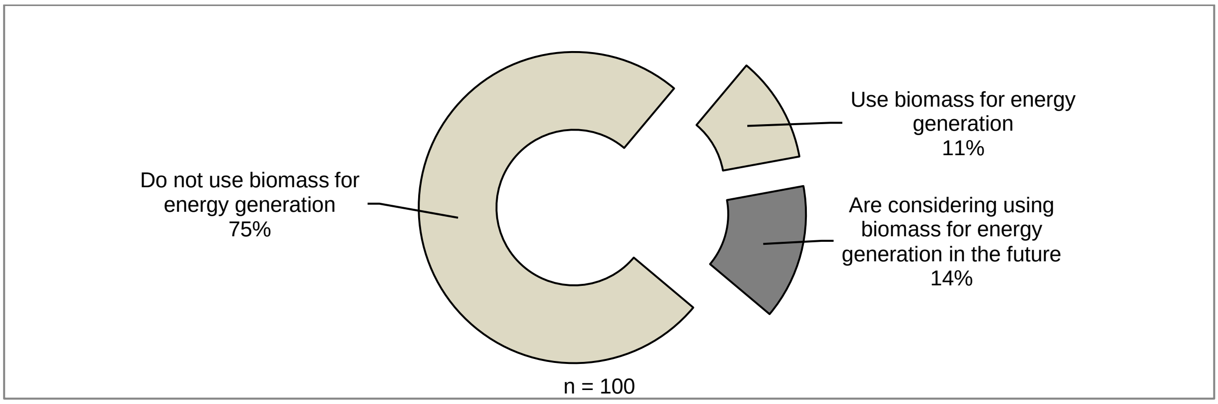

Figure 2.2: Biomass use for energy generation in Ukrainian agricultural companies, 2015
(Based on International Finance Corporation (IFC) (2015, p. 25))

[4] Existing investment barriers to renewable energy in Ukraine will be presented in Section 2.1.5.

They also emphasized the importance of removing existing barriers and improving the legal framework in Ukraine. This view is shared by Strubenhoff (2009), who also identified uncertainty in small and middle sized enterprises in the implementation of the legal support scheme for biomass[5]. Lakemeyer (2007) investigated the competitiveness of different crops and raw materials for energy production in Ukraine. In this work a special emphasis was put on the economics of biomass–to-energy use. The author recommended utilizing low-cost raw materials, e.g. straw, wood residues and manure, to support the energy supply in rural areas of Ukraine.

Apart from general studies on biomass utilisation, numerous articles have been published about biomethane, straw and municipal solid waste use. Geletukha, G., et al. (2014a) explored the prospects for biomethane production in Ukraine for domestic and EU markets. The researchers concluded that at current natural gas prices, biomethane generation would not be profitable, if undertaken. Yet, the authors saw advantages of biomethane production beyond the economic. The potential of straw use for the paper industry was explored by the International Finance Corporation (IFC) (2013d). The authors interlinked positive impacts of the straw-to-cellulose processing for agricultural and paper industries.

Kuznetsova (2010; 2012a) applied a cost-benefit analysis of straw use for heat and pellet production. The author concluded that both options may be profitable for Ukrainian agricultural companies. However, farmers often express concerns about the need to leave straw on fields for soil fertility preservation. Table 2.2 summarises relevant publications in the field of biomass use in Ukraine.

Table 2.2: Overview on publications in the field of biomass use in Ukraine

Author(s)	Focus of the study	Context and problems
Geletukha, G., et al. 2016, 2015a, 2015b, 2015c, 2014b, 2014c, 2013a, 2013b, 2013c, 2011, 2010, 2006b, 2002	Development of biomass industry in Ukraine	• Potential and current status of biomass use • Investment barriers
International Finance Corporation (IFC) 2015	Biomass-to-energy projects	• Analysis of current market conditions for biomass-to-energy purposes
International Finance Corporation (IFC) (2013e)	Potential of agricultural waste recycling	• Biomass use for energy and non-energy purposes
Strubenhoff 2009	Biomass market conditions	• Potential and current status of biomass use • Investment barriers
Lakemeyer 2007	Crops, straw, wood	• Competitiveness of different crops for energy production
Geletukha, G., et al. 2014a	Biomethane	• Potential of biomethane production • Investment barriers
International Finance Corporation (IFC) 2013d; International Finance Corporation (IFC) 2012b	Straw, municipal solid waste	• Potential of straw use in different industries • Investment barriers
Kuznetsova 2012a; Kuznetsova; 2012b; Kuznetsova 2010	Straw, wood, sunflower husk	• Profitability analysis of pellet production from straw, wood and sunflower husk

[5] The legal framework for renewable energies will be provided in Section 2.1.1.1.

Energy generation from biomass is of strategic importance for countries focusing on agriculture, such as Ukraine. Due to Ukraine´s growing agricultural production, unutilised biomass is available in high quantities. An extension of biomass use for energy generation in the agricultural sector would strengthen Ukraine´s energy supply and contribute to the implementation of farm-based, environmentally-friendly bioenergy systems. One option for biomass utilisation is biogas production. In the next section studies on biogas implementation in Ukraine will be presented.

2.1.1.3 Literature Review on Biogas Implementation

Currently there are few publications regarding biogas generation and its profitability in Ukraine. The newest ones are from Geletukha, G., et al. (2013; 2013e), commissioned in cooperation with the Fachagentur Nachwachsende Rohstoffe and GFA consulting group. The authors compared the legal framework and recent number of biogas plants in Ukraine and Germany. They pointed out the role of governmental support and existing barriers in Ukraine´s biogas sector. Another example of cooperation between Ukrainian and German companies is a publication by Arzinger, Biogasrat (2012). Similar to Geletukha, G., et al. (2013) the authors analysed German policy making experience in the biogas and biomethane sectors.

As part of a financial support programme, the Ukraine Sustainable Renewable Energy Lending Facility (USELF) (2011a) provided a report on biogas implementation in Ukraine. In this publication the biogas potential and available agricultural resources for biogas utilisation are estimated from investors´ viewpoint. The first attempt to analyse economic performance of biogas production in Ukrainian agroholdings was made by Kuznetsova, Kutsenko (2010). The authors calculated the profitability of biogas plants under the green tariff and use of own waste as a basic substrate, and showed that in this case the payback period of a biogas investment may equal up to four years. Table 2.3 summarizes the literature on biogas implementation in Ukraine.

Table 2.3: Overview on publications in the field of biogas implementation in Ukraine

Author(s)	Focus of the study	Context and problems
Geletukha, G., et al. 2013d, 2013e	Biogas	• Potential and current status • Investment barriers
Kucheruk 2013; Matveev 2013	Biogas	• Comparison of biogas implementation in Ukraine and Germany • Analysis of existing projects in Ukraine
Arzinger, Biogasrat 2012	Biogas and biomethane	• Comparison of biogas implementation in Ukraine and Germany • Investment barriers
Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2011a	Biogas	• Potential and current status of biogas • Investment barriers
Kuznetsova, Kutsenko 2010	Biogas	• Estimation of the biogas profitability under the green tariff and use of own waste as a basic substrate

2.1.2 Biogas Potential in Ukraine

Given Ukraine´s natural and climate resources, biogas represents an opportunity for improving the country´s energy supply (International Finance Corporation (IFC) 2015, p. 7). Exploiting the biogas potential may decrease Ukraine´s dependency on imported natural gas, thus making Ukraine´s energy supply more secure. As of 2015, the total renewable energy potential in Ukraine was estimated at 68.6 million tonnes of oil equivalent (Mtoe) (International Renewable Energy Agency (IRENA) 2015, p. 5; 21). This equalled to half of the country´s energy consumption in that year.

Between 2000 and 2015 over 50 scientific publications on renewable energy potential were issued in Ukraine. A review of these publications shows a wide range of calculations of this potential. Figure 2.3 illustrates the estimated potential among the major forms of renewables[6]. The black vertical lines represent the standard deviation. The ends of the black lines demonstrate the maximum and minimum values. The red line shows Ukraine´s Total Primary Energy Supply (TPES, 105.7 Mtoe in 2014 (State Statistics of Ukraine 2016, pp. 1–2)).

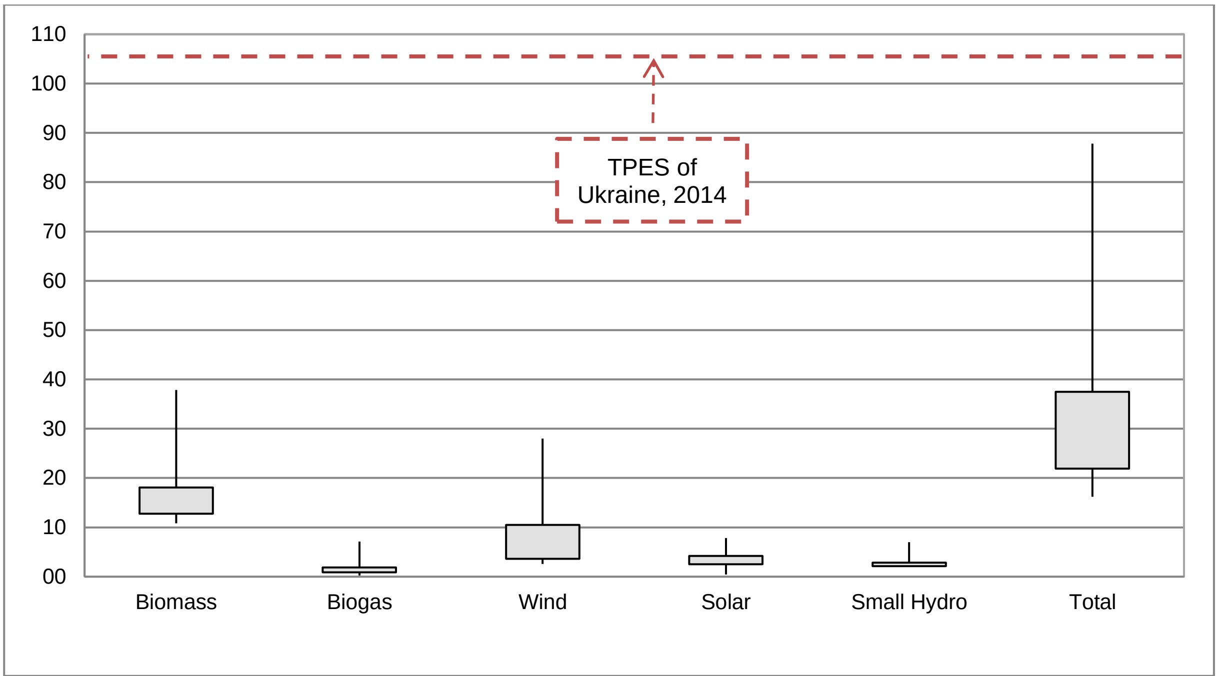

Figure 2.3: Estimated Ukraine´s renewable energy potential, Mtoe
(Author´s calculation based on Geletukha, G., et al.; International Renewable Energy Agency (IRENA); European Bank for Reconstruction and Development (EBRD), Geletukha, G., et al.; International Finance Corporation (IFC); Matveev; Arzinger, Biogasrat; Kudrya; Deloitte; Kudrya; Organisation for Economic Development and Cooperation (OECD); Ukraine Sustainable Renewable Energy Lending Facility (USELF); Kirchner; Kuznetsova, Kutsenko; Meissner, Ueckerdt, Geletukha, G., et al.; Kudrya (2015a; 2015; 2014; 2013; 2013e; 2013e; 2013; 2012; 2012b; 2012; 2012c; 2012; 2011b; 2010; 2010; 2010; 2006a; 2004; n.y.a))

As shown in Figure 2.3, the total renewable energy potential in Ukraine spreads from 16.2 to 87.8 Mtoe p.a., representing a range between 15 % and 84 % of the TPES respectively. If one takes an arithmetic mean of these values (52.0 Mtoe or 54.5 %), about half of Ukraine´s energy supply could be generated from renewable sources alone. This confirms the thesis of International Renewable Energy Agency (IRENA) (2015), reported above. Biomass represents up to 40.0 Mtoe or over one third of the total renewable energy potential. Considering Ukraine´s agricultural output, some experts argue that biomass represents two thirds of the country´s renewable energy potential (Organisation for Economic Development and Cooperation (OECD) 2012, p. 18). The bar representing the biogas potential is the smallest one because the estimated biogas potential includes only animal manure as substrate type. Other biomass types suitable for biogas combustion (e.g. silage maize) are included in the overall biomass potential.

However, agricultural residues and waste (e.g. manure) account for nearly 60 % of the biomass potential (International Renewable Energy Agency (IRENA) 2015, p. 22). Thus, biogas is one of the key technologies for biomass utilization in

[6] The potential of geothermic was not included in the calculation.

Ukraine´s agricultural sector. Due to high methane yield, cattle and pig manure are efficient feedstock types for biogas combustion. Another suitable feedstock is chicken dung (Kuznetsova, Kutsenko 2010, p. 9). With regard to the economic efficiency of biogas production, manure collection is a key issue to be addressed. In Ukraine, approximately 50 % of the feedstock population is on small-scale farms and private households. Therefore, areas containing large livestock populations have a better potential as locations for biogas plants (Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2011a, pp. 5–6). According to a number of estimations, from 3 %[7] to 10 %[8] of Ukrainian agricultural enterprises would be able to fuel biogas plants with own manure. Geletukha, G., et al. (2013d) estimated the theoretical biogas market size in Ukraine to be about 800 plants ranging between 100 KW_{el} and 20 MW_{el} and total installed capacity of about 700 MW_{el} (Geletukha, G., et al. 2013d, p. 56). Conversely, Meissner, Ueckerdt (2010) saw the potential for 2,990 plants with a total capacity of 405 MW_{el} and 731 MW_{th} (Meissner, Ueckerdt 2010, p. 18). In this respect, the size and structure of agricultural companies are important factors for the economic performance of biogas.

Therefore, livestock breeding companies (dairy, chicken and pig farms), meat processing plants and sugar mills, which generate large amount of organic waste, represent a good potential for biogas production (Geletukha, G., et al. 2013d, p. 56). Economies of scale may favour high livestock numbers, resulting in better biogas profitability (Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2011a, p. 6). If the feedstock and manure amount of 2016 in Ukraine were converted into oil equivalent, the potential energy output from biogas could reach 4.62 Mtoe p.a. or approximately 4 % of Ukraine´s TPES in 2014 (Figure 2.4). According to Kuznetsova, Kutsenko biogas could provide annually from 4 % to 7 % of Ukraine´s electricity consumption (Kuznetsova, Kutsenko 2010, p. 5).

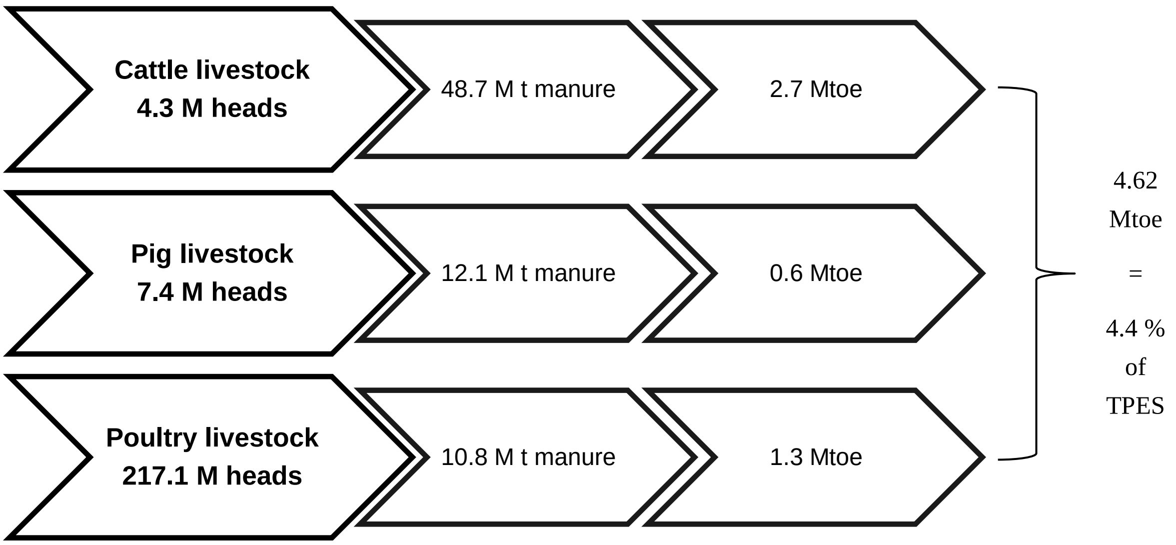

Figure 2.4: Estimation of biogas potential by feedstock type
(Based on finance.ua (2016) and International Finance Corporation (IFC) (2013e, p. 16))

To estimate the biogas potential for agroholdings, it is useful to analyse their energy consumption and livestock population. Unfortunately, no official data for agroholdings´ energy consumption and for their livestock are available. However, Kucheruk (2013) and Geletukha, G., et al. (2013) provided some estimations in this field, considering all animal farms (large and small) in Ukraine. Taking into account other suitable waste types, e.g. bagasse from sugar mills, the authors assessed the biogas potential in Ukraine´s agricultural sector and proposed the following numbers (Table 2.4).

[7] 3 % of agricultural companies in Ukraine would be able to run a 500 KW_{el} and upwards biogas plant (Meissner, Ueckerdt 2010, p. 18).

[8] 10 % of agricultural companies in Ukraine would be able to run a 100 KW_{el} and upwards biogas plant (Geletukha, G., et al. 2013d, p. 56).

Table 2.4: Biogas potential in Ukraine´s agricultural sector
(Based on Kucheruk (2013, p. 9); Geletukha, G., et al. (2013d, p. 56))

Company type	**Total number of companies**	**Total biogas plants**		**Installed power capacity, MW_{el}**		
		Units	**Installed capacity, MW_{el}**	**< 1.0**	**1.0 to 5.0**	**> 5.0**
Cattle farms	5,079	453	97	449	4	0
Pig farms	5,634	65	15	63	2	0
Poultry farms	785	150	143	119	24	7
Sugar mills	60	50	354	0	26	24
Others (e.g. breweries)	109	66	72	47	18	1
Total	**11,667**	**784**	**681**	**678**	**74**	**32**

As shown in Table 2.4, over 11,000 enterprises are considered in the calculation of Kucheruk and Geletukha, G., et al. The authors saw a high potential in the sugar industry, in which over 350 MW_{el} of biogas plants in the range of 1.0 to 20.0 MW_{el} could be installed. During the times of the Soviet Union, the sugar production in Ukraine was increasing and, therefore, many sugar plants were built. Although they consumed large amounts of energy, in those days energy was relatively cheap. In recent years Ukraine´s sugar sector has been declining because of the low sugar prices. Obviously, the high energy consumption of these mills, which now represent a majority of the operating sugar companies in Ukraine, will not help overcome the economic crisis. Consequently, many of them have been shut down[9]. Kucheruk and Geletukha, G., et al. also saw a potential for 631 biogas plants under 1.0 MW_{el} on animal farms, which confirms the fact, reported above, that a large part of animal livestock in Ukraine is located on small-scale farms and private households.

Despite the attractiveness of biogas utilisation for agricultural companies in Ukraine, biogas is dependent on governmental support (Masini, Menichetti 2013, p. 511). In the next section the reader will see which actions the Ukrainian government is taking to exploit Ukraine´s biogas potential and support investment in the biogas sector.

[9] This information was derived from interviews with industry experts in Ukraine (see Chapter 5).

2.1.3 Policy and Legal Support of Biogas

2.1.3.1 Policy Framework

The government of Ukraine has committed itself to moving towards a more energy efficient economy, evidenced by various policy incentives for renewable energy. Between 1997 and 2015 a number of stimuli were implemented to encourage the transformation of Ukraine´s energy sector (Geletukha, G., et al. 2015a, p. 13). Additionally, energy and climate targets for 2030 were set. The existing policy framework can be categorized into four key economic sectors: energy supply, industry, buildings and transport. Together they determine three types of energy actions: increase the share of renewable energies in the country´s energy supply, decrease the energy consumption per unit GDP (Gross Domestic Product) and decrease the CO_2 - emissions of Ukraine´s economy. The main objectives of Ukraine´s government are to achieve a 12.6 % share of renewables in the overall energy balance[10] and to reduce the energy consumption per unit GDP by 54 % from the 2008 level. The third target is to cut CO_2 - emissions by 50 % compared to the 1990 levels.

In September 2010 Ukraine signed the Protocol on Accession to the Energy Community Treaty (Energy Community 2010, pp. 1–6). In 2011 the country became a full member of the Energy Community (Verkhovna Rada 2011, p. 1; Energy Community 2014, p. 1). This membership obligates the state to cover 11 % of its final energy consumption (Kobets 2013, p. 9) and 12 % of its electricity supply from renewable sources by 2020 (Clifford Chance 2013, p. 1). In response to this obligation, in 2014 the government adopted the National Renewable Action Plan (NREAP), which sets the target of an 11 % share of renewables in the final energy consumption by 2020 (Cabinet of Ministers of Ukraine 2014, p. 3). This plan was first drafted in 2012 (State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) 2012, p. 1) and later improved in 2014 (State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) 2014, p. 1). According to the NREAP, the expected share of biomass in Ukraine´s heat supply from renewables will be 85 % (International Finance Corporation (IFC) 2015, p. 37).

The second political programme is the Energy Strategy of Ukraine for 2030, first introduced in 2006 (Cabinet of Ministers of Ukraine 2006, p. 1). Due to increasing natural gas prices between 2006 and 2013, the Energy Strategy had to be revised in 2013. The primary goals of the Energy Strategy are to improve the state energy security and to reduce the consumption of imported natural gas. The strategy foresees a 50 % increase in the total electricity demand by 2030. Therefore, the objective is to meet this demand through a reliable energy supply. Additionally, the energy consumption per unit GDP is to be decreased by 54 % in 2030, compared to the energy consumption of 2008 (Cabinet of Ministers of Ukraine 2013, p. 120). Another target is the 50 % reduction of greenhouse-gas emissions by 2050 from the 1990 levels. The Energy Strategy provides a guideline of how to achieve the targets, but not actions (Ecofys 2013, p. 7). Additionally, Ukraine will develop exploitation of domestic natural gas and coal. Installed renewable energy capacity is planned to achieve 12.6 % in the overall amount of installed capacity of power plants in Ukraine, which equals to 8 GW_{el} or 14 TWh of electric power p.a. (Cabinet of Ministers of Ukraine 2013, p. 6; 126). According to the strategy, the structure of installed renewable capacities should be as shown in Table 2.5.

Table 2.5: Projected installed capacity of renewables in the Energy Strategy of Ukraine for 2030
(Cabinet of Ministers of Ukraine (2013, pp. 51–54))

Renewable energy type	Projected installed capacity for 2030
Biomass/Biogas electricity	1-1.5 GWel
Biomass/Biogas heat	10-15 GWth
Wind energy	3-4 GWel
Solar energy	4 GWel
Small hydro power	1-1.5 GWel

[10] It means in the overall amount of installed capacity of energy generation facilities in Ukraine.

As shown in Table 2.5, new installation of biogas power is expected in heat and electricity generation. However, the Energy Strategy does not provide clear targets for biogas in the country´s energy mix. Geletukha, G., et al. (2013c) reestimated the numbers in the strategy for biomass and came to the result that the biomass share in the total energy consumption will account for 1.78 % in the period between 2015 and 2030.

To harmonize the implementation of the Energy Strategy and NREAP, the government of Ukraine set an additional political programme, called the State Target Economic Program of Energy Efficiency and Renewable Energy for 2010-2016. The programme was first approved in 2010 (Cabinet of Ministers of Ukraine 2010, p. 1) and amended in 2016 (Cabinet of Ministers of Ukraine 2016, p. 1). The main objectives of this strategy for 2016, which were not changed by the amendment, are as follows (Energy Charter Secretariat 2013, pp. 67–69):

- to achieve a 10 % share of renewable energy in the state energy balance
- to reduce the consumption of imported natural gas by 25 %[11]
- to decrease the energy intensity per unit GDP by 20 % compared with 2008

The three governmental strategies presented build the political basis for renewable energy implementation in Ukraine, particularly for biogas, and set the main targets for the energy sector. Table 2.6 provides an overview of the three state programmes.

Table 2.6: Overview of the state programmes supporting renewable energy implementation in Ukraine (Cabinet of Ministers of Ukraine (2014, 2013, 2016))

State program	Time span	Goals		
		Renewable energy	**Energy efficiency**	**CO_2 - emissions**
State Target Economic Program of Energy Efficiency and Renewable Energy	2010-2016	10 % in the state energy balance	20 % decrease in the energy consumption per unit GDP, compared with 2008	not specified
National Renewable Energy Action Plan (NREAP)	2010-2020	11 % in the Total Final Energy Consumption (TFEC)	9.2 Bil m³ p.a decrease of the natural gas consumption	not specified
Energy Strategy of Ukraine	2010-2030	12.6 % in the overall energy balance	54 % in the energy consumption per unit GDP, compared with the level of 2008	50 % reduction of CO_2 – emissions by 2050 compared with the level of 1990

[11] No year for the comparison of gas consumption is stated.

2.1.3.2 Legal Framework

To achieve the goals set out in the aforementioned state programmes, several legislative mechanisms have been implemented (Geletukha, G., et al. 2013d, p. 35). The supporting mechanisms for biogas are (Energy Charter Secretariat 2013, p. 86; Arzinger 2011, p. 23):

- the setting a preferential feed-in tariff (called "green tariff" in Ukraine) for electricity generated from biogas[12]
- tax benefits and customs exemptions
- obligating the Wholesale Electricity Market of Ukraine to purchase biogas electricity

The setting a green tariff for electricity generated from biogas

On April 22, 2009 the Parliament of Ukraine passed an amendment to the "Law of Ukraine on Electricity" and introduced the principal support measure for biogas, the "green tariff". The Law defines the preferential tariff on electricity generated from renewables as: "*The green tariff is a special tariff for electricity generated by alternative energy sources (wind, solar, biomass and small hydro power, excluding electricity generated with blast-furnace and coke oven gases but including electric energy generated by small hydro power plants (HPP))*" (Verkhovna Rada 2009b, p. 1).

Originally the Law contained several inaccuracies, the first being the definition of biomass as agricultural waste and residues, but excluding products of agriculture and forestry (e.g. energy crops, pellets, etc.). In addition, the Law included a local content requirement (LCR), according to which up to 50 % of the biogas plant equipment had to be manufactured by Ukrainian companies (Geletukha, G., et al. 2013d, p. 35). Otherwise the biogas producer would not obtain the license for the green tariff. Moreover, biogas plants commissioned before 2013 were not allowed to obtain the green tariff. As these terms created legislative barriers, the implementation of the green tariff did not result in the biogas sector growing between 2009 and 2015, but in its stagnation (Dentons 2015b, p. 1). Due to the geopolitical situation, the government called a state of emergency in the energy sector in winter 2015. From January to March 2015 this led to temporary cuts of green tariff payments up to 50 % (Cabinet of Ministers of Ukraine 2015, p. 1). These actions may have had a negative impact on the investment attractiveness of the biogas sector (Windpower 2015; TSN.UA 2015; renewablesinternational.net 2015; BIN.ua 2015). Nevertheless, in summer 2015 the Parliament adopted a new Law on Introduction of Changes to the legislation in Ukraine´s energy sector, which was signed by the president (Administration of the President of Ukraine 2015). Additionally, the state of emergency was cancelled and the green tariff payments restored (UNIAN 2015). The new Law tackled existing legal barriers and resolved major problems faced by the biogas industry (International Finance Corporation (IFC) 2015, p. 37):

- revising the definition of biomass in line with the EU Directive 2009/28/EC, which considers both agricultural products and waste as biomass for energy generation
- removing the Local Content Requirement (LCR) for the plant equipment

The green tariff serves as a legal basis of the biogas support scheme. The green tariff is granted for electricity but not for heat power generation. A basic level of the green tariff for biogas is 12.39 €cent/KWh (net price). The tariff is established for a 20-year time period up to January 1, 2030, with a gradual reduction over time (Arzinger 2011, p. 31). The gradual tariff cut is settled for biogas plants commissioned in:

- 2014 – cut by 10 %
- 2019 – cut by 20 %
- 2024 – cut by 30 %

Figure 2.5 illustrates the green tariff reduction between 2015 and 2029.

[12] Green tariff for heat power generation from biogas is currently under development by the Cabinet of Ministers of Ukraine (Geletukha, G., et al. 2015a, p. 13).

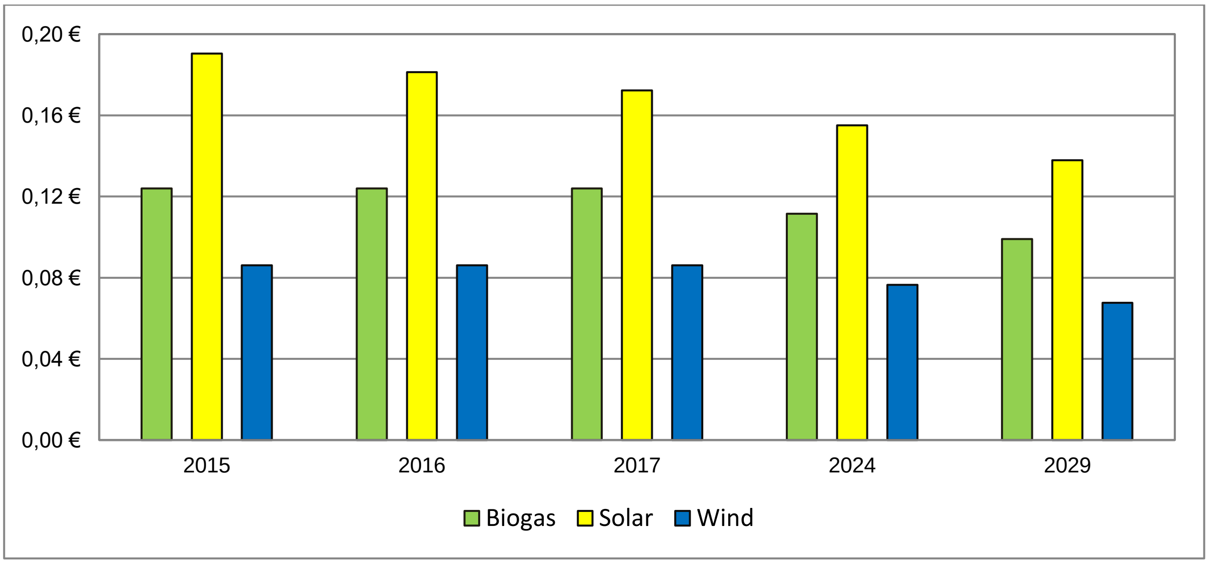

Figure 2.5: The basic green tariff rate for biogas, solar and wind from 2015 to 2029 (year of plant installation), €/KWh (Dentons (2015a, p. 1))

Figure 2.5 includes the green tariff rates for wind and solar too. The solar tariff is higher than that for biogas and the tariff for wind is the lowest. The explanation for the differences in the tariff rates is that the total costs per generated kWh electricity have been estimated the highest for solar energy, while that for wind are the lowest.

Apart from the relatively low green tariff rate for biogas[13], obtaining it is another important issue. The experts interviewed (see Section 5.1) claimed that this procedure can be complicated and time consuming (Figure 2.6). The permissions require at least ten steps and approximately 100 permission forms (International Finance Corporation (IFC) (2014, p. 1)). These procedures and obtaining the necessary permissions create bureaucratic barriers for biogas implementation.

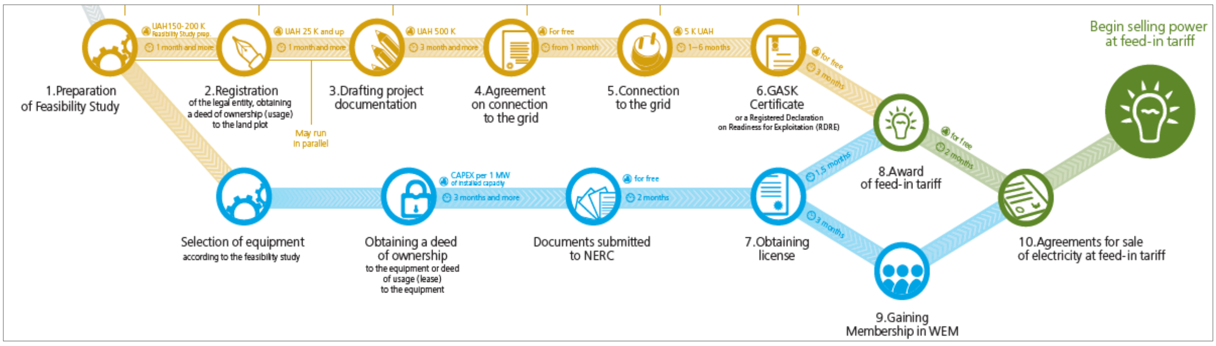

Figure 2.6: The scheme for the obtaining of the green tariff[14]
(International Finance Corporation (IFC) (2014, p. 1))

The green tariff can only be granted after the completion of a biogas plant. The National Regulatory Commission for Energy and Utilities of Ukraine approves the plant completion on a case-by-case basis (Energy Charter Secretariat 2013, p. 87). Despite the complicated obtaining and the relatively low level of the green tariff, its implementation has been an important signal for the energy sector (Deloitte 2012, p. 5). Whether and how Ukrainian agroholdings respond to the green tariff in terms of biogas investments is analysed in Section 7.2.1 and Section 7.2.2.

[13] The tariff in Ukraine is low compared to that in the EU, e.g. in Germany, where the tariff was 20-25 €cent/kWh before 2014.

[14] Abbreviations in Figure 2.6: NERC – National commission on regulation of power sector; WEM – wholesale electricity market; GASK – state architecture and building control.

Tax benefits and customs exceptions

The current legislation provides several tax incentives for production and use of electricity from biogas, including exemption from income tax for 10 years and decreasing the land taxation. It also repeals custom duties and the Value Added Tax (VAT) for the import of biogas generating equipment (Table 2.7).

Table 2.7: Legal tax incentives for biogas production
(Arzinger 2011, pp. 28–30; Deloitte 2012, pp. 20–22; Geletukha, G., et al. 2013d, pp. 34–37)

Type of tax benefit	Specification
Exemption from income tax for 10 years for:	• Electricity, generated from biogas • Combined electricity and heat production from biogas (co-generation activity) • 80 % of the company income, gained out of sales of own produced raw materials/equipment, which will be further used for biogas generation
Decrease in land taxation up to:	• 25 % of the standard level of land tax • 3 % of the normative value of lease payments (12 % rate is normally applied)
Repeal of custom duties and VAT for:	• Import of equipment and materials, which produce or consume energy, generated from biogas

Obligating the Wholesale Electricity Market of Ukraine to purchase biogas electricity

The aforementioned “Law of Ukraine on Electricity” obliges the Wholesale Electricity Market of Ukraine to purchase the entire electricity generated from biogas plants at the green tariff rate (Verkhovna Rada 2009a, p. 1). The Law also provides the option to sell electric power at contractual prices directly to final consumers or to local energy supplying companies, called “oblenergos” in Ukraine (Figure 2.7). These two alternative ways of selling electricity from biogas should create a more flexible market position for biogas producers, because they no longer have to sell the electricity exclusively to the state owned Wholesale Market of Ukraine.

The Law sets some limitations on the oblenergos to buy electricity at prices, which are higher than the wholesale price. Additionally, the compensation mechanism of the green tariff payments for oblenergos is not clearly stated in the Law (Kuznetsova, Kutsenko 2010, p. 13). So oblenergos are not provided with sufficient funding to cover the price difference between the wholesale price and the green tariff.

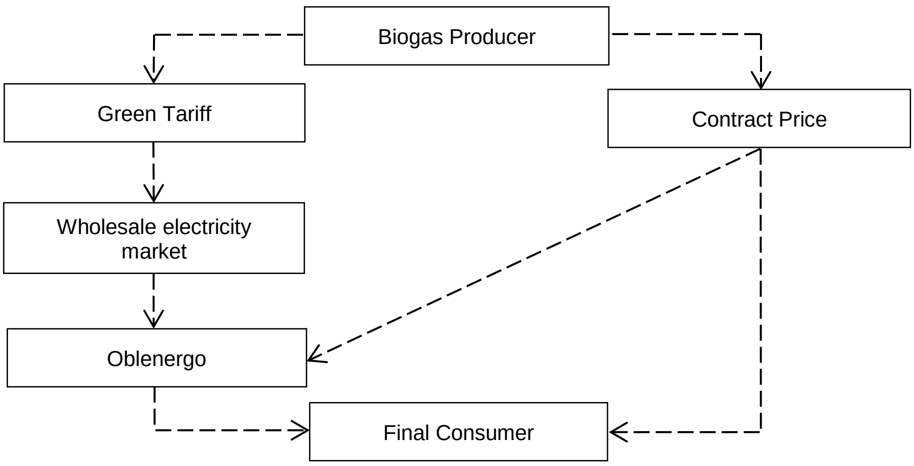

Figure 2.7: Scheme of electricity sale for green tariff
(Based on the Law of Ukraine “On electricity” (Verkhovna Rada 2009a, p. 1))

The policy and legal background, recently introduced by the government, shows that Ukraine has made progress in planning the future of its energy sector. The state programmes and legislative incentives, presented in this section, should ensure economic benefits from biogas production for agricultural companies (European-Ukrainian Energy Agency (EUEA) 2012, p. 1). In the next section the current development of the biogas sector under the present support measures will be analysed.

2.1.4 Current Biogas Share in Ukraine´s Total Energy Supply

In 2014 Ukraine´s Total Primary Energy Supply (TPES) reached 1,229.1 TWh[15] (State Statistics of Ukraine 2016, pp. 1–2). Coal accounted for 33.7 % of the country´s total energy generation. Natural gas was estimated at 31.6 % and was "a chief contributor to the country energy security problem" (International Renewable Energy Agency (IRENA) 2015, p. 12). Nuclear power and oil accounted for 22.0 % and 10.1 % respectively. The remaining 2.6 % were from the renewable energy sources (Figure 2.8).

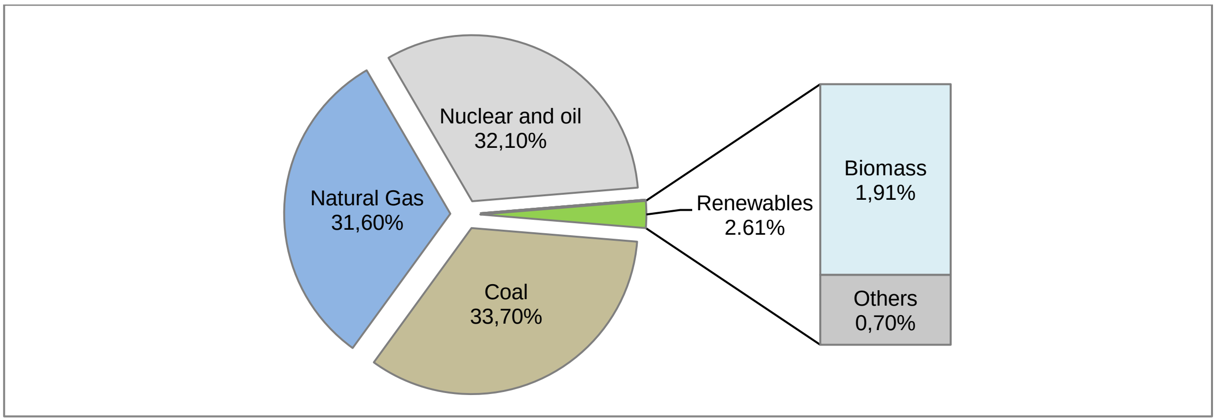

Figure 2.8: Structure of the Total Primary Energy Supply (TPES) in Ukraine by energy source, 2014
(Author´s calculation based on State Statistics of Ukraine (2016, pp. 1–2))

Biomass had a 73.5 % share in Ukraine´s renewable energy supply in 2014, but the statistical data do not provide a breakdown of biomass sources in the TPES (e.g. for biogas). Nevertheless, Geletukha, G., et al. estimates the biogas share for 1.0 % in the total use of biomass in the TPES for the years 2011 and 2012 (Geletukha, G., et al. 2013d, p. 47). In Ukraine biomass has mostly been used for heat power[16]. However, as described in Section 2.1.1.2 (see Figure 2.1), only 1.0 % of the biomass available in Ukraine will be used for energy purposes. According to the official statistical data, the biomass share in the electricity supply from renewables accounted for 6.0 % in 2014, while at the same time, the biogas share equalled 2.0 % (State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) 2016, pp. 1–4).

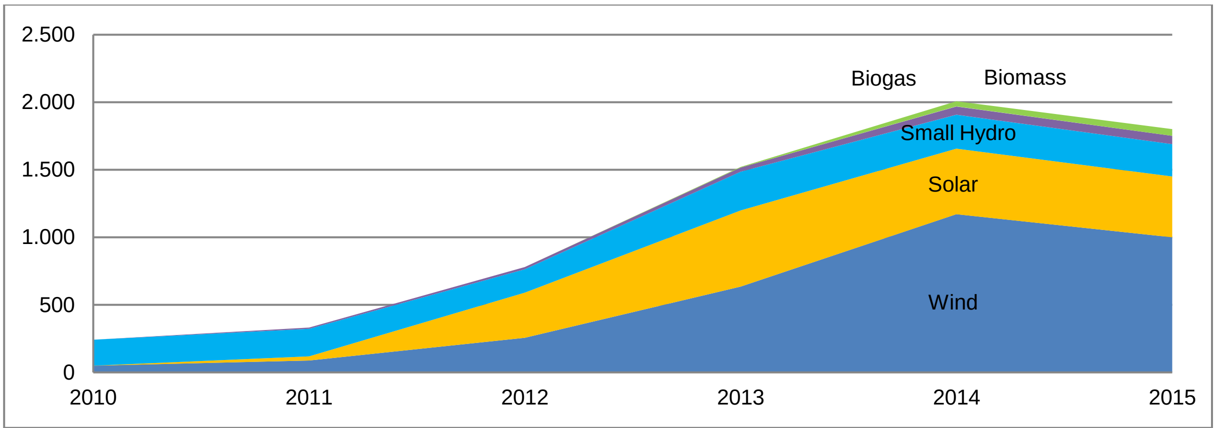

Figure 2.9: Electric power generated from renewable sources between 2010 and 2015 in Ukraine, M KWh
(Author´s calculation based on National Energy and Utilities Regulatory Commission (2016, pp. 48–50); State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) (2016, pp. 1–4))

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[15] The original energy unit in the document "thousand tonnes of oil equivalent (ktoe)" has been recalculated in TWh: 1 ktoe = 0.01163 TWh.

[16] An overview on biomass use in the industrial and household sectors of Ukraine is given by Geletukha, G., et al. 2015a, p. 8. It is worth mentioning that high reliance on biomass as a primary source of energy may lead to environmental problems in Ukraine, such as wood degradation (International Energy Agency (IEA) 2012, pp. 47–48).

As shown in Figure 2.9, electricity generation from renewables was increasing between 2010 and 2014. The decline in 2015 can be explained by the fact that a substantial part of wind and solar plants are located on the Crimea. After the peninsula was annexed by Russia in 2014, these plants were switched off from the Ukrainian grid. At the same time, while the share of biomass and biogas remained nearly constant, the largest portion of electricity was produced from wind and solar. The relatively high share of solar energy is associated with a higher green tariff level before 2015 (see Figure 2.10), while the tariffs for biogas and wind energy were lower.

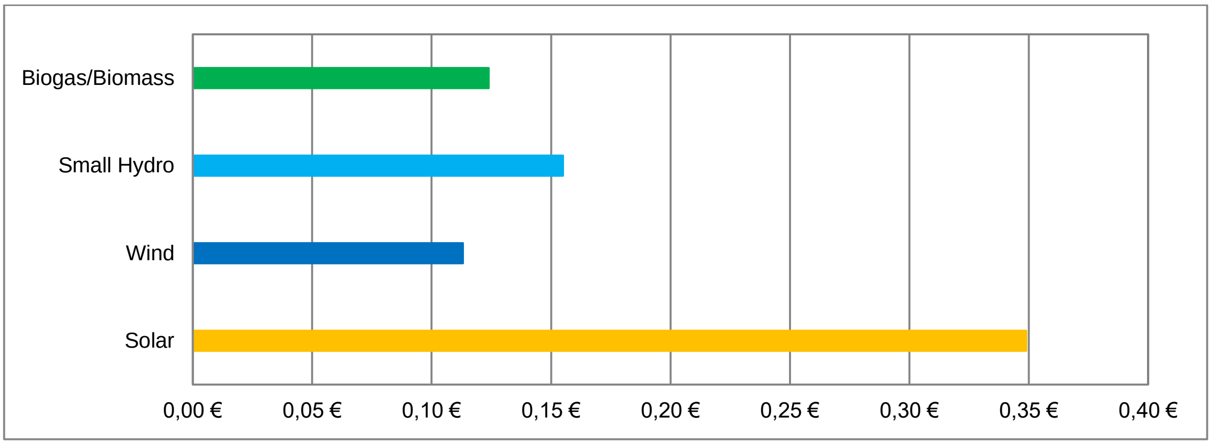

Figure 2.10: Green tariff rate for major types of renewable energies between 2009 and 2014 in Ukraine, €/KWh (Based on Kudrya (2013, p. 3))

The total amount of installed biogas capacity in 2015 equalled 13.9 MW_{el}, whereas the amount of all renewables accounted for 1,462 MW_{el}. (State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) 2016, pp. 1–4). According to the National Energy and Utilities Regulatory Commission (2016), the total installed capacity of renewable power plants for electricity generation with green tariff in 2015 in Ukraine was 993.8 MW_{el} (Figure 2.11).

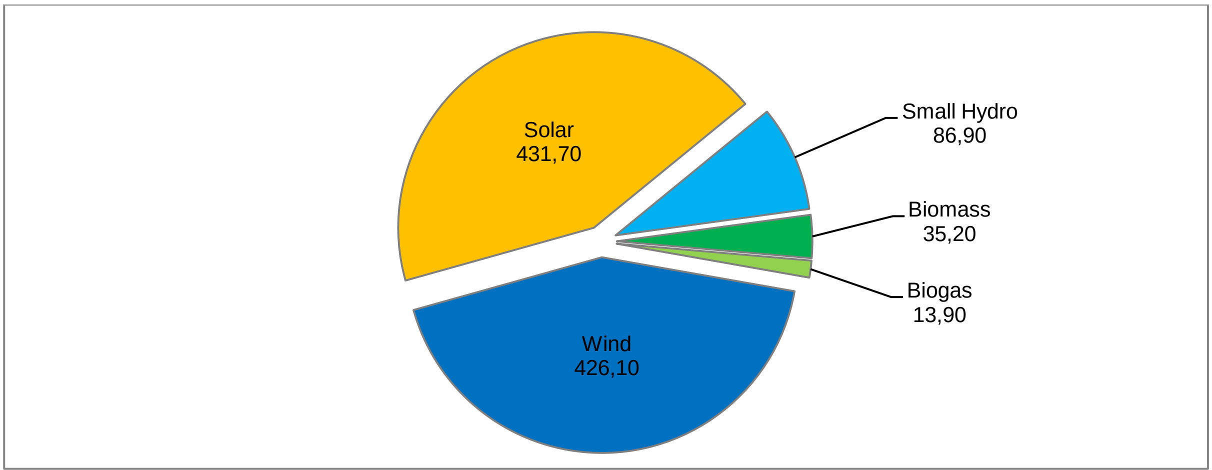

Figure 2.11: Structure of renewable energy capacities for electricity generation with green tariff in Ukraine, MWel, 2015 (Based on National Energy and Utilities Regulatory Commission 2016, pp. 48–50; State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) (2016, pp. 1–4))

In 2015, the total installed capacity of electric power plants in Ukraine (conventional and renewable) equaled 46,88 MW_{el} (National Energy and Utilities Regulatory Commission 2016, p. 17). Calculating the share of renewables in the overall balance of operating power plants in 2015, a 2.1 %[17] share of renewable energies can be estimated. Despite the target of a 10 % share of renewables in 2016 (see Section 2.1.3.1), the 2.1 % share in 2015 is below this 10 %. One explanation of this result is existing investment barriers to renewable energy implementation in Ukraine, which will be presented in Section 2.1.5. Figure 2.12 shows the current and planned installed capacity of renewables, broken down by energy source. The column for 2030 incorporates the data shown in Table 2.5.

[17] 993.8 MW_{el} (renewables)/46,880 MW_{el} (total) = 2.1 %.

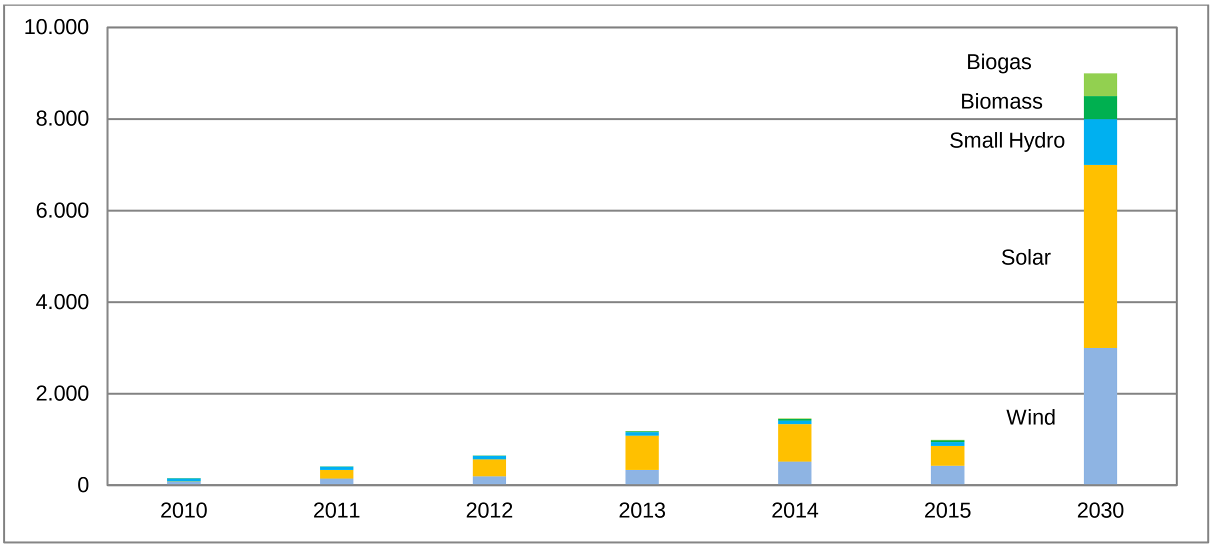

Figure 2.12 Current and planned amount of installed capacity of renewables from 2010 to 2015 and in 2030 in Ukraine, MW_{el} (Author´s representation based on (National Energy and Utilities Regulatory Commission 2016, pp. 48–50; State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) 2016, pp. 1–4; Cabinet of Ministers of Ukraine 2013, p. 51)

As shown in Figure 2.12, the amount of installed renewable plants was growing until 2014. As of April 2015, there were nine biogas plants in Ukraine producing electricity under the green tariff (State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) 2016, p. 1). Additionally, there were a few biogas plants operating without the green tariff. The geographical distribution of the total amount of operating biogas plants in Ukraine is illustrated in Figure 2.13.

Figure 2.13: Geographical location of all operating biogas plants in Ukraine, 2016
(SEC "Biomasse" 2016)

As shown in Figure 2.13, biogas plants are distributed nearly equally throughout Ukraine. A higher concentration of biogas facilities can be observed in the Kyiv region. In this area several biogas plants fuelled by municipal solid waste have recently been built. A few projects of this type were realised between 2000 and 2008 in Ukraine under the Kyoto Protocol. During the times of the Soviet Union, there were numerous biogas stations operating on municipal solid waste. However, not many of them remain operational today (Geletukha, G., et al. 2013d, p. 53).

At the total number of operating biogas plants in Ukraine approximately ten biogas projects are owned by large-scale agricultural companies (Table 2.8). Among them are agroholdings with large animal populations (poultry, cattle and pig farms) and one sugar mill. All of these biogas plants operate without the green tariff, primarily because the companies´ applications for obtaining the green tariff license have been rejected by state authorities. The reasons for the rejection remain unknown.

Table 2.8: List of existing and planned biogas plants in Ukraine´s agricultural sector in 2015
(Based on Kucheruk 2013, pp. 4–5; Matveev 2013, p. 11; International Renewable Energy Agency (IRENA) 2015, p. 12)

Agroholding type	**Start-up year**	**Substrate type**	**Power capacity, KW_{el}**
Operating biogas plants			
Pig Farm	1993	Pig manure	n.s.
Pig farm	2003	Pig manure, fat from poultry slaughter	180
Cattle and pig farm	2009	Cattle and pig manure	250
Milk cow farm	2009	Cattle manure	625
Poultry farm	2012	Poultry manure	5,000
Pig farm	2013	Pig/poultry manure and agro-waste	1,000
Sugar mill	2013	Bagasse	1,000
Cattle Farm	2014	Cattle manure	n.s.
Sugar mill	2015	Bagasse	n.s.
Fruit juice producer	2014	Processed fruits and vegetables	2,400
Plants currently under construction or planned			
Poultry farm	not specified	Poultry manure	4,000
Poultry farm	not specified	Poultry manure	3,000
Sugar mill	not specified	Bagasse	n.s.
Pig farm	not specified	Pig manure	125
Agricultural company	not specified	Cattle manure and corn silage	1,360
Agricultural company	not specified	Silage and vine vinasse	125
Agricultural company	not specified	not specified	1,200

As described in this section, the current development of Ukraine´s biogas sector remains moderate. There are reasons hampering a larger production of biogas in an agriculture-oriented country such as Ukraine. These reasons will be analysed in the next section.

2.1.5 Investment Barriers to Biogas Implementation

To exploit the existing biogas potential in Ukraine´s agricultural sector, several investment barriers need to be overcome (Organisation for Economic Development and Cooperation (OECD) 2012, p. 18). In this section the existing barriers to biogas implementation in Ukrainian agroholdings will be analysed. Based on the study of Negro et al. (2007) and interviews with industry experts (see Section 5.1), the main political, economic and sector-specific obstacles in Ukraine´s biogas sector are identified (Table 2.9).

Table 2.9: Investment barriers to biogas plants in Ukraine´s agricultural sector

Barrier	Explanation	Source
Political barriers		
Changing policy landscape	The laws and policies in Ukraine have been repeatedly changed (see Section 2.1.3.1). An unpredictable policy environment and ad-hoc measures have negative consequences for biogas investment.	• International Renewable Energy Agency (IRENA) 2015, p. 1; • Balmann 2014, p. 28; • Meissner, Ueckerdt 2010, p. 30; • Strubenhoff et al. 2009, p. 173;
Inefficient govern-mental support	Absence of specific objectives, funding sources and timelines for biogas implementation from the state side.	• International Finance Corporation (IFC) 2015, p. 34, Geletukha, G., et al. 2013b, p. 44, 2013d, p. 72; International Finance Corporation (IFC) 2015, p. 18;
Corruption and bureaucracy	Administrative procedures (obtaining of the green tariff, tax exemptions, permissions (see Section 2.1.3.1)) and corruption remain important barriers for a larger production of biogas.	• Organisation for Economic Development and Cooperation (OECD) 2012, p. 18; Nivievskyi, Strubenhoff 2006, p. 11; Kirchner, Knuth 2011, p. 2, Geletukha, G., et al. 2013d, p. 71, 2013d, p. 72, 2013d, pp. 71–72, 2013d, p. 72, 2013b, p. 46;
Low green tariff rate	According to experts´ estimations, the current level of green tariff leads to a payback period for biogas projects, which exceeds a 10 year mark. As a result, projects with higher return rates may be privileged by the agroholdings.	• Geletukha, G., et al. 2013d, p. 69; • Kudrya 2013, p. 3;
Lack of regulatory framework for grid connection and construction works	A lack of cost-recovery mechanisms and procedures for grid connection. Additionally, there is no legal regulation for connecting to the national gas system.	• Geletukha, G., et al. 2013d, p. 71, 2013d, p. 72; • Organisation for Economic Development and Cooperation (OECD) 2012, p. 18; • International Renewable Energy Agency (IRENA) (2015, p. 35);
Economic barriers		
High investment costs	Biogas technologies require high initial investments, creating market-entering barriers for many agroholdings.	• International Finance Corporation (IFC) 2015, p. 18; • International Renewable Energy Agency (IRENA) 2015, p. 1;
Lack of capital	Due to the uncertain economic situation from 2014 to 2016 in Ukraine, capital resources of agroholdings remain low. Financial institutions often prefer non-agricultural investments.	• International Finance Corporation (IFC) 2015, p. 18; • Nivievskyi, Strubenhoff 2006, p. 11; • Strubenhoff 2011, p. 1;

Barrier	Explanation	Source
Absence of biogas market	The undeveloped market of biomass supply in Ukraine creates uncertainty in substrate availability.	• Geletukha, G., et al. 2013b, p. 45; International Finance Corporation (IFC) 2015, p. 18;
Low importance of energy costs	The energy costs of some agroholdings may be low compared to other costs. This may lead to a lower importance of energy costs.	• Hertel 2014, p. 211;
Opportunity costs	Investments in biogas compete with other (usually more profitable) agroholdings´ businesses, e.g. crop production.	• Hertel 2014, p. 211;
Sector specific barriers		
Perception of company future	Uncertainty about the company´s business future may lead to low interest in long-term investments.	• Hertel 2014, p. 211;
Deficit of professionals in the field of biogas and agriculture	There is a lack of experienced developers and technicians to implement biogas projects.	• Meissner, Ueckerdt 2010, p. 36; • Strubenhoff et al. 2009, p. 174; • Nivievskyi, Strubenhoff 2006, p. 11;

The factors described in Table 2.9 create barriers to a larger deployment of biogas investments in Ukraine´s agricultural sector. Additionally, the current development of Ukrainian agroholdings is an important factor influencing the biogas implementation in Ukraine. The current situation in Ukraine´s agricultural sector and the present status of agroholdings will be examined in the next section.

2.2 Current Status of Agroholdings in Ukraine

Over the last 20 years an increase in investments in Ukraine´s agricultural sector has been observed. These investments are often made by a new type of large-scale agricultural company, called “agroholdings”. In this section the literature on the phenomenon of large vertical integrated agroholdings and their status in Ukraine´s agricultural sector will be examined.

2.2.1 Forming of Large-Scale Agricultural Companies

The emergence of large-scale agricultural companies was explored by Wandel (2011) and Balmann et al. (2013). Wandel (2011), investigating the origin of agroholdings in the Russian Federation, analysed factors determining the formation and development of agroholdings. Wandel also formulated a general definition of an “agroholding” as a vertical incorporation of several enterprises in the agricultural value chain (Wandel 2011, p. 62). The author pointed out a need for future research on such phenomenon as large farms, above all because of their relevance for economic theory of industrial organisations. As an important factor of their emergence he identified transition processes from the command to the free-market economy in post-Soviet countries (Wandel 2011, pp. 643–644). The consequences of the transformation processes[18] in Eastern Europe and Central Asia have been investigated in numerous publications (Kimhi, Leman 2013; Stange 2010; Zinych 2009; Zinych, Odening 2009; Biesold 2004; Schulze op. 2003; Heinrich, Hinners-Tobrägel 2002; Poganietz 2000; Tillack, Schulze ©1997). All these authors concluded that the transfer of property rights from the state to private hands increased manager´s focus on profitability and economic efficiency.

Koester (2005) analysed reasons behind the domination of large farms in Russia´s agricultural sector with an eye toward transition processes. He concluded that agroholdings´ domination of the sector was based to a lesser extent on comparative advantages (economies of scale), and was instead “a consequence of embedded institutions and [an] inadequate institutional framework” (Koester 2005, p. 112). Balmann (2014) provided an international overview of existing agroholdings in Latin America, Asia and RUK (Russia, Ukraine and Kazakhstan). He emphasized the importance of professional management in agroholdings for gaining long-term benefits from large arable areas. Focusing on Ukrainian agroholdings, he investigated advantages and disadvantages of company size from an entrepreneurial viewpoint and concluded that factors in the formation of large farms may include corruption, a lack of infrastructure and market imperfections. The most recent study on the formation of agroholdings was published by Granzhan (2015), who conducted a qualitative analysis of the main agricultural regions in Ukraine, developed a classification of agricultural enterprises and explored the structural changes, caused by transformation of the agricultural sector.

In addition to the research investigating the formation of agroholdings, scholars have also studied agroholdings´ strategic management (Gerasin et al. 2003), operations management (Luka 2003) and financial analysis (Pirscher, Tillack 2000; Galushko, Bruemmer 2003). Several authors found that farm size alone has little impact on the agroholdings´ profitability (Demyanenko 2003; Protchenko, Pugachov 2003). To a much greater extent, the profitability appears to depend on the effective strategic and operations management of agroholdings. The scientists also identified agroholdings´ high production inefficiency in crop and arable farming as a challenge (Balmann, Kataria K. et al. 2013). The researchers acknowledged the need to improve the labour productivity of agroholdings to become competitive in an international context. Finally, the scholars identified the tendency of agroholdings to intensify vertical integration to produce goods and services with a higher added value (Kovalchuk 2014). Kovalchuk suggested that the absence of governmental support forces agroholdings to seek financing abroad; therefore, recently the need for foreign investment in Ukraine has become urgent. In the next section the current development of Ukrainian agroholdings will be investigated.

2.2.2 Current Development of Agroholdings

Agroholdings are a relatively new type of enterprise in Ukraine´s agricultural sector. Official statistical data on agroholdings are not easily available, and there is no official information to describe the vertical integration of

[18] Under the transformation processes scholars understand the collapse of collective farms (kolkhozes) in the post-Soviet countries.

agroholdings, their investment activity, energy management, etc. The information in this section is based on the annual publication of the Ukrainian Agribusiness Club (2015). This report summarises the recent development of Ukraine´s agricultural sector. To gain a better understanding of the present situation relating to agroholdings, the Ukrainian Agribusiness Club took a historical perspective and suggested three stages in the development of agroholdings in Ukraine:

- 2005-2009: This period was characterised by the rapid growth of agroholdings. Newly created companies tried to cultivate as much arable land as possible. Another trend was attracting external financial resources for company´s development. Several agroholdings undertook Initial Public Offering (IPO) on European stock exchanges: Warsaw, London, Frankfurt (Balmann 2014, p. 26). Capital gained through the IPOs equalled to $ 1.4 Bn or 25 % of all IPOs of Ukrainian companies. However, the development of agroholdings was negatively affected by the global financial crisis between 2008 and 2009.
- 2010-2014: The second stage was characterised by improving the agroholdings´ operational efficiency and slowing down the arable land growth. Figure 2.14 illustrates the decline of land cultivated by agroholdings after 2013. Due to the worsening economic situation in this period in Ukraine, attracting investment became difficult. Many agroholdings diversified their businesses and invested in production of agricultural goods with higher added value. Because of the increasing energy prices, several agroholdings invested in pellet and biogas production, biomass use and energy efficiency (Latifundist.com 2013). However, the trend toward sustainable investments has not become a mainstream in Ukraine´s agricultural sector.
- 2014-present: This period has been negatively affected by the geopolitical uncertainty in Ukraine. A portion of agroholdings´ arable land has been left uncultivated and capital investments have been placed on hold due to the Crimea annexing and the military conflict in East Ukraine. However, due to the export orientation of agroholdings and national currency devaluation, profitability of the agroholdings´ main business - crop cultivation - has increased (Ukrainian Agribusiness Club 2015, p. 21).

In 2014 the agroholdings´ utilized agricultural area (UAA) was approximately 5.64 M ha and equalled to 26 % of the UAA of all agricultural producers in Ukraine (Figure 2.14). The UAA of agroholdings climbed between 2007 and 2013, and declined from 2013 to 2015.

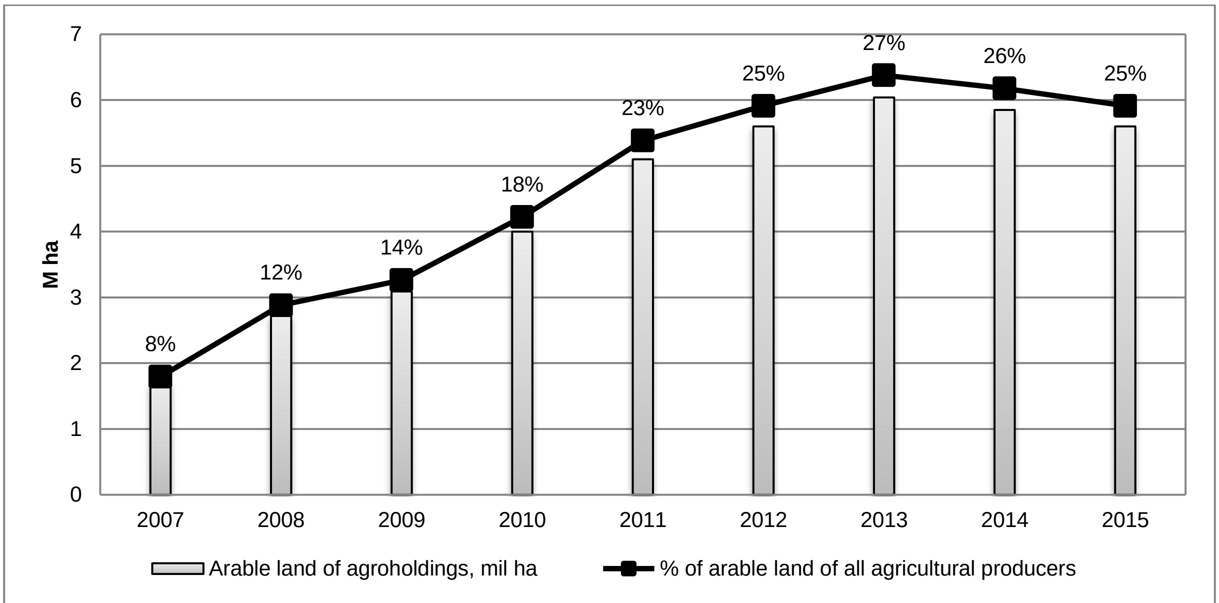

Figure 2.14: Agroholdings´ arable land between 2007 and 2015 in Ukraine, M ha
(Author´s calculation based on Ukrainian Agribusiness Club (2015, p. 6))

The Ukrainian Agribusiness Club estimated the overall number of agroholdings at 112 in 2014 (Ukrainian Agribusiness Club 2015, p. 12). However, neither this organisation nor the State Statistics of Ukraine provide a clear number of the currently operating agroholdings and their definition. In terms of Ukraine´s gross agricultural production, agroholdings had a 22.1 % share in 2014 (Figure 2.15), which was the lowest share among the three main categories of agricultural producers in Ukraine: agroholdings, small farms and private households[19]. While small farms were responsible for 33.2 % of production, the largest share was obtained by private households in rural areas with 44.7 %. The share of agroholdings in crop production equalled to 19.6 %, while small farms and private households took the first position with 39.7 % and 40.4 %, respectively. In animal production, agroholdings´ share equalled to 28.1 %, and this share is reported to have grown since 2014. However, this growth does not compare to an increase of agroholdings´ absolute animal production. Against the background of a strong overall decline of the animal population in Ukraine, the agroholdings´ animal production might be decreasing too, although slower than the animal production of small farms and private households. This may explain the relatively high share of agroholdings (28.1 %) in Ukraine´s animal production.

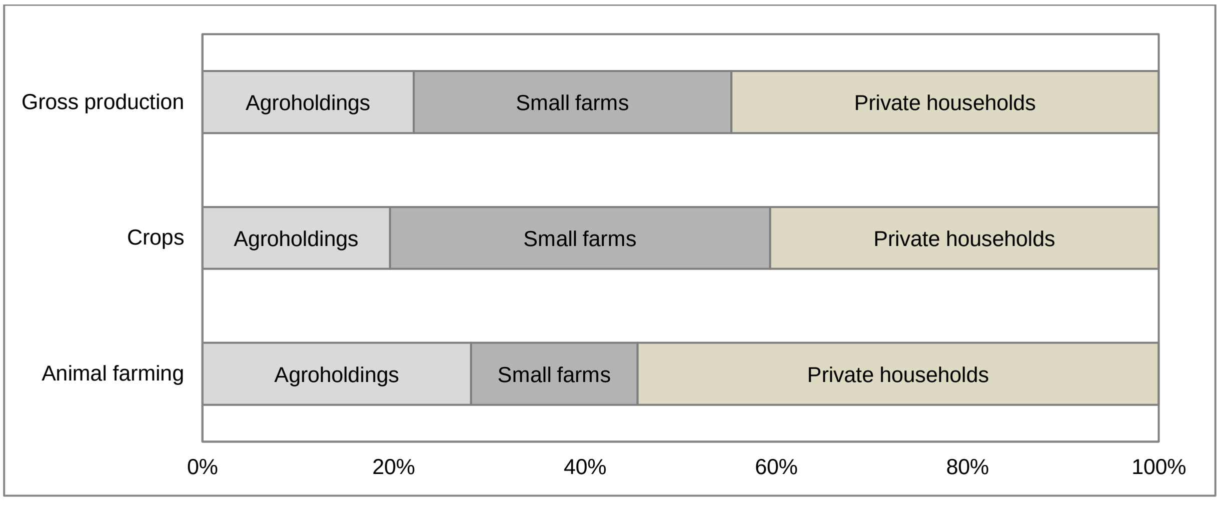

Figure 2.15: Agroholdings´ share in gross production of agricultural goods in Ukraine, 2014
(Author´s calculation based on Ukrainian Agribusiness Club (2015, p. 12))

Considering the agroholdings´ gross agricultural production, crops retained long-term leadership with 63.0 % in agroholdings´ total revenues, while animal husbandry had a share of 37.0 % in 2014, indicating that agroholdings´ key business activity is arable farming (Figure 2.16). However, the data on agroholdings´ gross production does not include any figures of food processing and other businesses agroholdings may have.

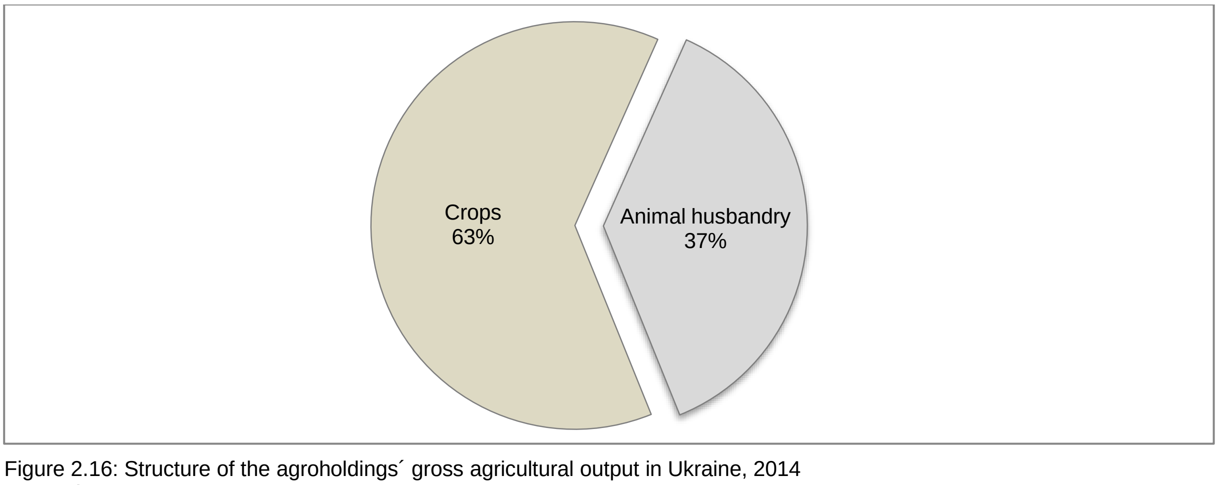

Figure 2.16: Structure of the agroholdings´ gross agricultural output in Ukraine, 2014
(Author´s calculation based on Ukrainian Agribusiness Club (2015, p. 16; 51))

By further analysing the agroholdings´ gross agricultural output I observed that in 2014 cereals (wheat, maize, barley) equalled to 62.4 % of agroholdings´ revenues in arable farming, while the share of oil seeds (sunflower, soya, rape) was

[19] There is no clear legal distinction between these three classes of agricultural producers in Ukraine.

29.7 % (Figure 2.17). Other crops, e.g. sugar beet, had 8.0 %. Regarding the animal business, the production of poultry[20] with a 56.9 % revenue share dominated, while pig and dairy farming (milk and beef) had 25.5 % and 17.5 %, respectively.

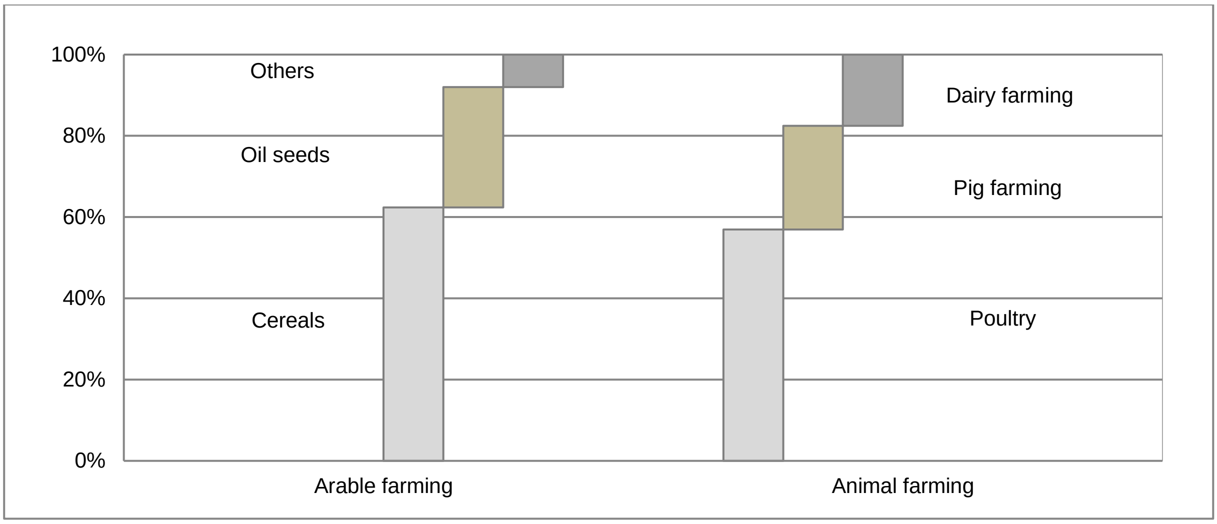

Figure 2.17: Agroholdings´ production structure in arable and animal farming, 2014
(Author´s calculation based on Ukrainian Agribusiness Club (2015, p. 17; 52))

[20] The value of eggs is not included, because the data did not provide it. If the revenue from egg production were included, the share of poultry business might have been larger.

3 Theoretical Background

This section provides the theoretical foundation for the present work. Three conceptual frameworks, relevant for the empirical study, will be presented: adoption of innovative agricultural technologies, organisational decision-making regarding investments in agriculture, and behavioural economics of organisations. The first section reviews how scholars have investigated the process of new technology adoption in agriculture, relating to biogas technologies. Second, theoretical approaches explaining organisational decision-making will be presented. Third, I will explore how behavioural economics may be applied to study the organisational investment behaviour regarding biogas.

3.1 Adoption of Innovative Agricultural Technologies

3.1.1 Foundation of Adoption Theories

A new technologies adoption in agriculture has been at the centre of agricultural economic studies for the last half century (Sauer, Zilberman D. 2010, p. 2). These studies have been reviewed and interpreted through a cross-disciplinary framework to give practical guidance for research and policy making (Pannell, Marshall 2006, p. 1407). Since the pioneering work of Griliches (1957), a number of scholars have been investigating different aspects of technology adoption in agriculture (Yaron et al. 1992, p. 361). Feder, Umali (1993) and Sunding, Zilberman D. (1999) reviewed the literature on this topic. Putler, Zilberman D. (1988) explored computer use by farmers in California. Foltz, Chang (2002) and Barham et al. (2004) studied the adoption of hormone use (recombinant bovine somatotropin) in US dairy farms. Abdulai, Huffman (2005) explored the crossbred-cow technology adoption in Tanzania. Sauer, Zilberman D. (2010) investigated the automatic milking systems adoption in Northern Europe. These studies showed the positive influence of farm size on the probability of new technology adoption.

Another stream of studies investigated the farmer´s risk perception concerning new technologies. Yaron et al. (1992) analysed the influence of price uncertainty on Israeli farmers. Kim, Chavas (2003b) explored the farmer´s risk exposure with respect to future corn yields in the U.S.A. Koundouri et al. (2006) worked out a theoretical model for irrigation technology in Greece and Crete. All these authors found that farmer´s risk perception plays an important role in agricultural technology adoption. They concluded that technological progress significantly contributed to the reduction of the farmer´s perceived risk. Other authors point to the importance of information and learning-by-doing effects in the adoption decision (Baerenklau 2005; Mcwilliams, Zilbermanfr 1996; Foster, Rosenzweig 1995; Manski 1993; Durlauf 1986-<2015 >; Brock, Durlauf 1983-<2007>). They suggested that there remains a lack of empirical research on the adoption decision, including social interactions in behavioural models.

As biogas can be considered both an agricultural and an environmental innovation, literature on adoption of environmental technologies is also relevant for the present study. Numerous researchers explored this field and provided insights into the impacts of organisational and external factors on adoption of environmental technologies (Lin, Ho 2011; Weng, Lin 2011; Voss et al. 2008; Henriques, Sadorsky 2007; Rothenberg, Zyglidopoulos 2007; del Brío, Junquera 2003; Salim, Rafiq 2012). These studies confirmed the influence of organisational and external dimensions on the adoption decision.

Yet another stream of literature models the adoption decision based on a selection threshold for farmers, which refers to the farm size, the level of human capital on farms and the agricultural technology that may be adopted on a farm (Dridi, Khanna 2005; Moreno, Sunding 2005; Smith et al. 2004; Khanna 2001; Smale et al. 1994). These studies showed that the adoption decision related not only to the threshold criteria, but also to the sequential decision process. A five-stage model in the innovation decision process was designed by Rogers (2003) (Figure 3.1).

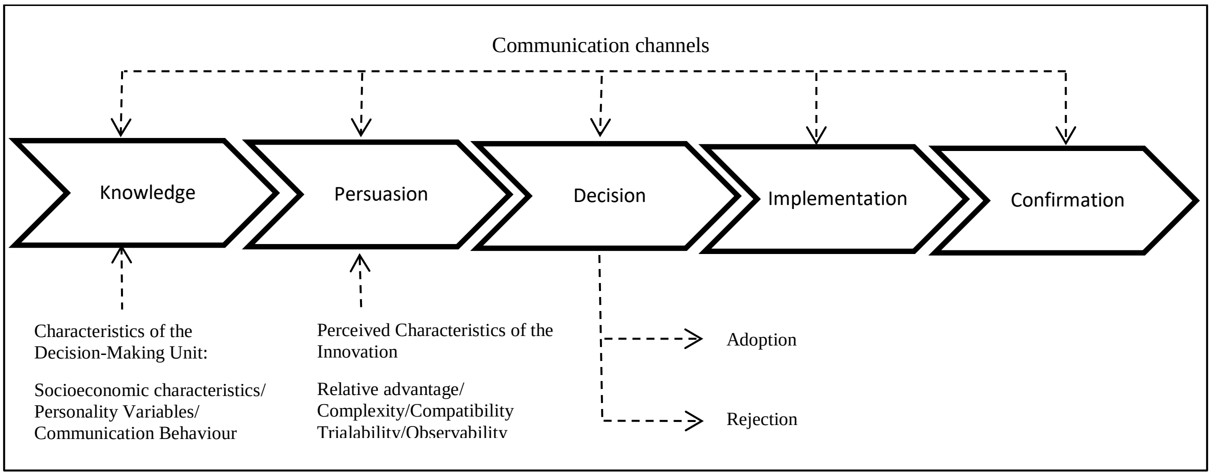

Figure 3.1: Five stages in the innovation-decision process
(Rogers 2003, p. 170)

Classical models of adoption decision process suggest that adopters first develop an interest in a new product by gaining knowledge about it (Herbig, Day 1992, pp. 4–15). Through this knowledge and other specific decision-influencing factors, people form attitudes, which impact their decision to adopt or reject a new technology (Gilbert, Cordey-Hayes 1996, p. 301). At every step of the model, communication channels, e.g. social networks, mass media, and so on can influence the decision of potential adopters (Goes, Park 1997, p. 673). Additionally, Rogers incorporates into his model characteristics of the decision-making unit and perceived characteristics of innovation, which will also be incorporated in the present study (see Section 4.1.1).

Depending on the point in time of new technology adoption, Rogers classified adopters into five main categories, illustrated in Figure 3.2. Rogers assumed that adoption distributions might be expected to be normal and used two parameters of a normal distribution - the mean (x) and the standard deviation (σ) - to divide the distribution into five areas. Then the author functionally named these five areas as innovators, early adopters, early and late majority, and laggards. Based on the mean and the standard deviation, Rogers suggested, the distribution area could be divided into any number of categories. In the case of biogas adoption in Germany, some researchers identified three types of farmers: "Pioneers or Idealists", "Switchers" and "Rationalists" (Trojecka 2007, pp. 123–125). In the context of the present study the adopter categorisation by Rogers helps identify more innovative top-managers of agroholdings, who adopt biogas technologies earlier than the majority of agricultural companies in Ukraine.

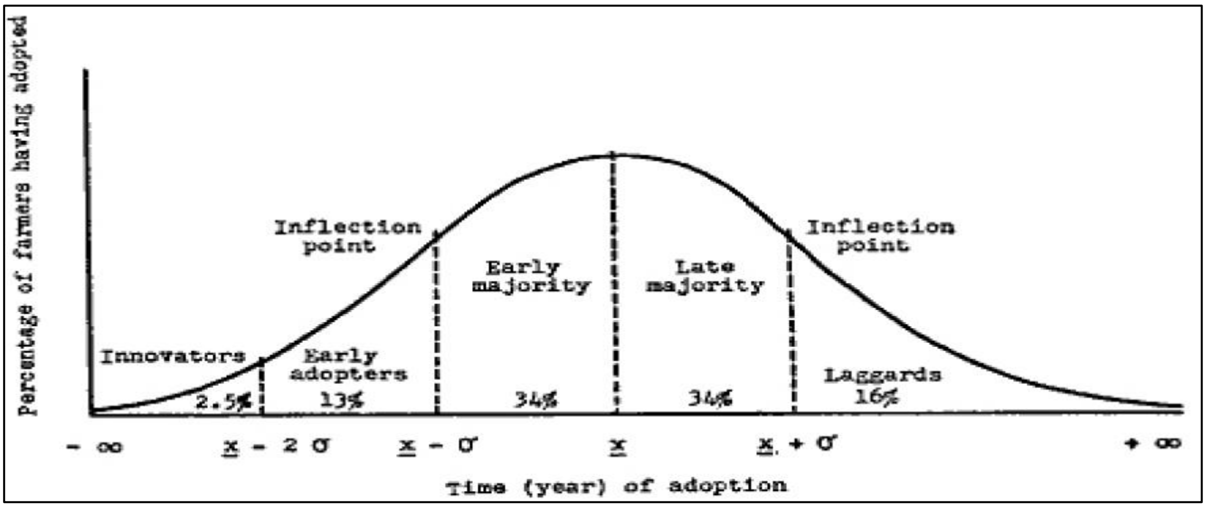

Figure 3.2: Adopter categorization based on the time of adoption
(Rogers 1958, p. 351)

The availability of a new technology in agriculture does not guarantee its adoption (Peter et al. 2002, p. 513). Therefore, it is necessary to understand the factors that influence the decision-maker during the five adoption steps (see Figure 3.1). These factors will be presented in the next section.

3.1.2 Determinants of Innovation Adoption

Numerous researchers have investigated a number of factors influencing the adoption of agricultural and environmental innovations (Gadenne et al. 2009; Jungklaus 2010; Hertel 2014; Etzion 2007; Gonzalez-Benito, Gonzalez-Benito 2006). According to their studies the adoption decision is affected by technological, organisational and environmental dimensions (Figure 3.3). In each of the three dimensions, adoption is based on the individual's subjective perceptions and, to a lesser extent, on the objective facts (Pannell, Marshall 2006, p. 1408).

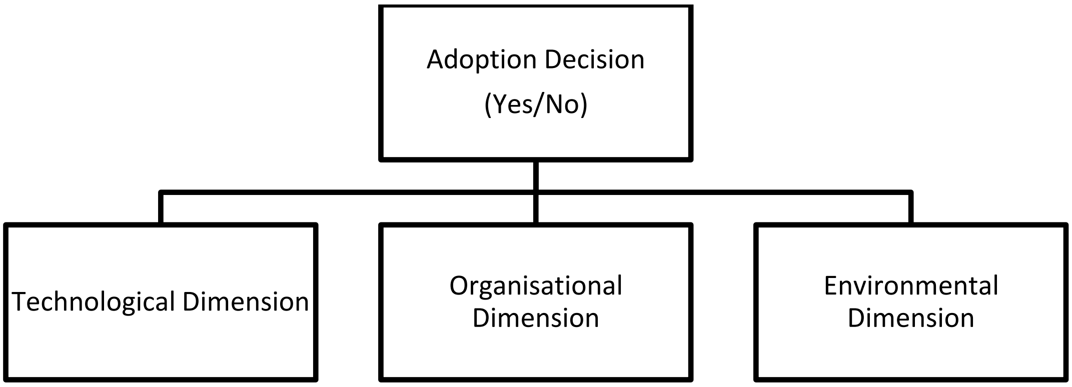

Figure 3.3: Dimensions of innovation adoption
(Based on Weng, Lin (2011, p. 9155))

Rogers (2003) developed a theory around the technical dimension (Rogers 2003, p. 15). Organisational dimension relates to internal characteristics of the organisation and individual variables of the decision-maker (Hertel 2014, pp. 54–60). Environmental factors relate to the business environment of a company and include political stability, stage of economic development, etc. (Peter et al. 2002, p. 516).

Technological Dimension

Technological characteristics of an innovation may affect its actual adoption (Weng, Lin 2011, p. 9156). The subjective perception of these characteristics, named by Rogers "attributes of innovation", helps explain different rates of technology adoption (see Figure 3.4). Tornatzky, Klein (1982) and Guettler (2001) found significant impact of relative advantage, compatibility and complexity on the speed of new technology adoption. These findings are in line with Arts et al. (2011). In the present dissertation two attributes, "relative advantage" and "complexity", will be incorporated into the empirical study and their definition will be further explained in Sections 4.1.1.3 and 4.1.1.5, respectively. Rogers defines "compatibility" as the degree to which a new technology is consistent with the technologies the adopter already uses; "trialability" is the degree to which an innovation can be tested by the adopter on the instalment plan; and "observability" is the degree to which the results of the innovation adoption can be perceived by others (Rogers 2003, p. 240, 258)

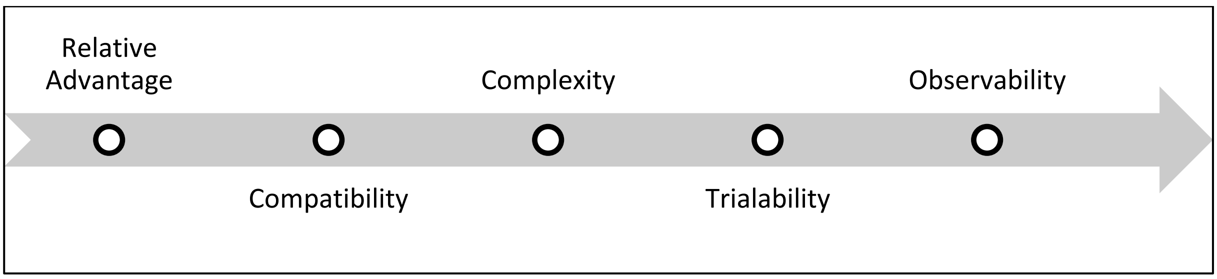

Figure 3.4: Perceived attributes of innovation
(Based on Rogers (2003, p. 15))

Organisational Dimension

The organisational context includes a variety of company characteristics. Numerous scholars have discussed the impacts of different organisational factors on the adoption rate of new technologies (Lin, Ho 2011; Weng, Lin 2011; Etzion 2007; Gonzalez-Benito, Gonzalez-Benito 2006; Jeyaraj et al. 2006; Pohl 1996; Damanpour 1991; Tornatzky, Fleischer 1990; Kimberly, Evanisko 1981).

In their studies, human resources, top-management´s leadership skills and organisational size are the most significant determinants. Pohl structured the factors of organisational context into three levels: organisational variables, the buying-center´s structure and characteristics of the decision-maker (Pohl 1996, p. 71). Organisational variables consist of the company´s internal economic situation, structure and size, as well as of the company´s industry and location. Because important organisational decisions are usually made by a group of high-ranking employees, the structure of this group, called the buying-center, impacts the adoption decision process. According to the individuals´ role within the buying-center, Webster, Wind (1972b, p. 77) differentiate between decision-makers, who actually make the decision about the new technology adoption, influencers, who significantly impact the first group, gatekeepers, who look for relevant information regarding a new technology, as well as users and buyers. Personality variables, such as her socioeconomic characteristics, the individual´s position in the company, as well as his or her risk-taking attitudes represent the third level of the organisational determinants. Figure 3.5 illustrates the organisational dimension factors relevant for the present study. In the context of the present dissertation, this classification helps better understand new technology adoption in Ukrainian agroholdings by identifying decision-influencing factors at the organisational level. The application of these factors to the present work the reader will find from Section 4.1.2 to Section 4.1.4.

Organisational Variables
- Economic Situation
- Structure
- Size

Buying-Center´s Structure
- Decision-Makers
- Influencers
- Gatekeepers

Characteristics of the Decision-Maker
- Personality Variables
- Position in the Company
- Risk Taking Attitudes

Figure 3.5: Organisational dimension of innovation adoption
(Based on Pohl (1996, pp. 70–73))

Environmental Dimension

In the present study environmental factors refer to the organisations´ external business environment. The external factors, e.g. environmental uncertainty and governmental support, have been widely discussed in scientific literature (Tornatzky, Fleischer 1990; Jeyaraj et al. 2006; Etzion 2007; Weng, Lin 2011; Gonzalez-Benito, Gonzalez-Benito 2006). Peter et al. (2002) suggest that environmental characteristics are reflected by the business system itself and include the stage of economic development, political stability, trade regulations and so on. Environmental uncertainty and resource availability are often regarded by scholars as primary environmental factors, affecting technical innovation (Weng, Lin 2011, p. 9157). In this context scholars often use the term “diffusion” for innovation research in the macroeconomic context. Rogers defined diffusion as “… a process by which an innovation is communicated … over time … among the members of a social system” (Rogers 2003, p. 9). In contrast to adoption, diffusion focuses on the overall market and innovation itself, rather than on the behaviour of individuals (Hertel 2014, p. 40). Distinction patterns of these two central dimensions of innovation research are illustrated in Table 3.1.

Table 3.1: Distinction between the terms “adoption” and “diffusion” of innovations
(Hertel 2014, p. 40)

Aspect	Adoption	Diffusion
Perspective	Individual – microeconomic perspective	Overall market – macroeconomic perspective
Examination site	Individual	Market, innovation
Time dimension	First notice to adoption	Market introduction to market penetration

During the last three decades there has been a great number of publications on diffusion of renewable energy (Sick 2014; Toka et al. 2014; Negro et al. 2012; Peres et al. 2010; Rao, Kishore 2010; Dinica 2009, 2008; Mahapatra, Gustavsson 2008; Dinica 2006; Tsoutsos, Stamboulis 2005; Rogers 2003; Jacobsson, Johnson 2000).

Scholars suggest that most of these studies are primarily focused on industrialized countries, while very few investigate renewables in developing regions (Pfeiffer, Mulder 2013; Brunnschweiler 2010). In the latter countries the uptake of renewables decreases, if the consumption of electricity and fossil fuels grows. On the other hand, a higher per capita income and the implementation of supporting economic incentives accelerate the diffusion of renewable technologies in developing countries (Pfeiffer, Mulder 2013, p. 285). Sick (2014) investigated the impact of energy prices for fossil fuels on the renewables diffusion in developed countries. The author found no significant correlation between investments in renewables, e.g. wind, solar, biomass, and natural gas prices in developed countries (Sick 2014, p. 207). Madlener, Schmid; Negro, Hekkert; Schmid, Madlener (2009; 2008; 2008) explored diffusion patterns for biogas under the impact of preferential feed-in tariffs. The authors indicated a positive magnitude and direction of the feed-in tariff influence on biogas adoption.

Environmental uncertainty and the government´s role have been often regarded as primary influencing factors for the renewables´ adoption (Aragon-Correa, Sharma 2003; Rothenberg, Zyglidopoulos 2007; Scupola 2014; Lee 2008). Governmental intervention plays an important role in the renewables´ diffusion. Policies introduced for renewable energy promotion should reduce investor risks and increase investor confidence. However, as shown in Section 2.1.5, a changing policy framework may be perceived as a potential risk by market players. Therefore, the relationship between the policies and renewables´ diffusion is not straightforward (Menichetti 2010, p. 38). Negro et al. (2012) pointed out that the lack of stable policies for the renewables´ promotion is a key problem. Rao, Kishore; Dinica (2010; 2008) explored the barriers resulting from unstable governmental support in different countries, including Spain. Tsoutsos, Stamboulis (2005) suggested that a clear strategy for renewables´ promotion should be incorporated into policy making to reduce investor uncertainty. On the technological level the degree of technology development and norms (standards) for its implementation are important (Liftin 2000, p. 46). Access to funding and the investment climate are main indicators of the external business environment on the macroeconomic level (Conzelmann 1995, p. 64; Klump 2011, p. 134). Public opinion or the opinion of competitors on a new technology may also impact the adoption rate (Weber 2010, p. 72). This theoretical approach helps to explain the influence of the business environment in Ukraine on the biogas technologies´ adoption by Ukrainian agroholdings. Figure 3.6 illustrates the environmental determinants of innovation adoption.

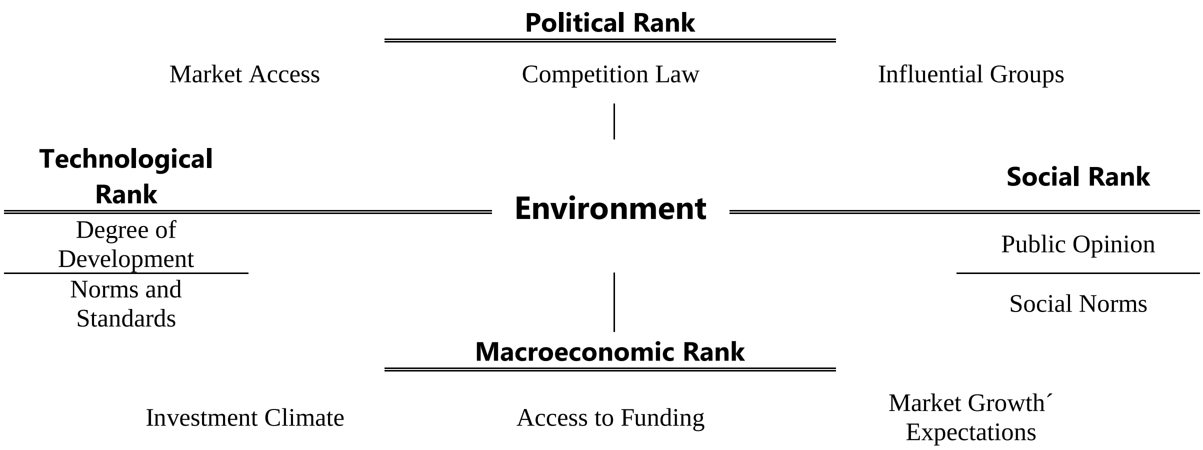

Figure 3.6: Environmental dimension of innovation adoption
(Based on Weber (2010, p. 71))

Despite the abundant literature on adoption of agricultural innovations, few studies have analysed simultaneously the impacts of technological, organisational and environmental dimensions on the adoption decision (Weng, Lin 2011, p. 9155). Drawing on the adoption theories, the present work attempts to contribute a new model to explain the decision to adopt biogas technologies, including all three dimensions. As the investigation unit of the present study are agroholdings, which represent large agricultural organisations, the reader should gain insights into the organisational decision-making in agriculture. The next section provides a theoretical framework for organisational decision-making related to new technologies in agriculture.

3.2 Organisational Decision-Making in Agriculture

3.2.1 Foundation of Decision Theories

The decision-making environment in agriculture is complex (Ilbery 1978, p. 448). Some scholars suggest that external pressures on farmers regarding their organisational decision-making may be greater than that in other industries (Errington 1991; Napier, Forster 1982; Potter 1985). A literature review shows that there are several publications in the field of decision-making in agriculture (Barlett 1980; Austin et al. 1998b; Austin et al. 1998a; Willock, J., et al. 1999; Berger Thomas 2001; Edwards-Jones 2006; Sachs 1973; Gasson et al. 1993). As in other businesses, an agricultural producer is interested in maximizing his profits. Decisions, which are mostly dominated by farmers´ financial constraints, are usually better predicted by traditional economic theories (Edwards-Jones 2006, p. 785). A great number of studies have focused on farmers´ economic concerns (Lynne, Rola 1988; McClymont 1984; Antle, Crissman 1990; Robinson et al. 1987; Wise, Brannen 1983).

Nevertheless, because of tendencies towards more environmentally-friendly agriculture, farmers´ decisions may be based not solely on profit goals (Anosike, Coughenour 1990; Gartrell, Gartrell 1985; Herath et al. 1982; Turvey 1991). In the context of the present work, these theoretical approaches provide a foundation for decision-influencing factors, impacting biogas investments of Ukrainian agroholdings.

Numerous scholars have concluded that decision-making in agriculture is a combination of farmer´s motivation, external factors and farm organisational characteristics (Lynne et al. 1995; Jacobsen et al. 1994; La Due et al. 1991; Solano et al. 2003; Olsen, Lund 2011). Hence, the traditional economic approaches have been supplemented by a psychological theories (Edwards-Jones 2006, p. 783). Willock, J., et al. (1999) published a model of farmer´s decision-making, which incorporated psychological factors (Figure 3.7).

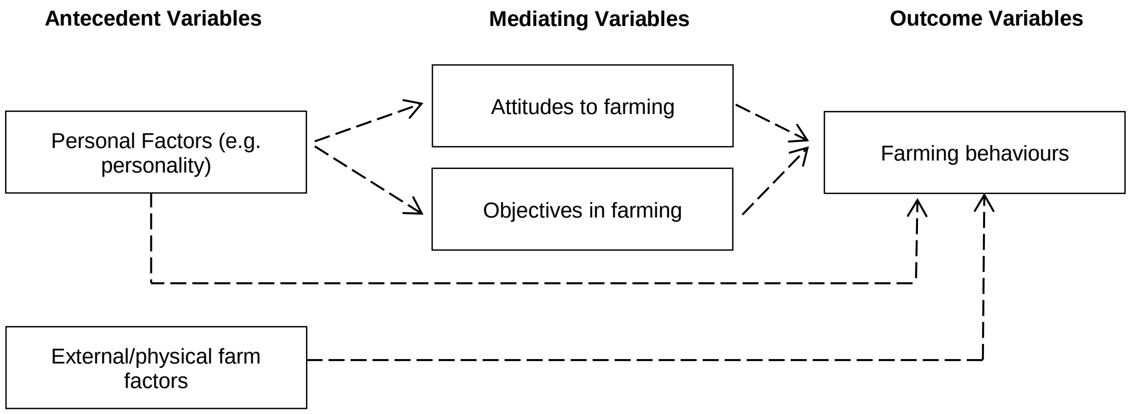

Figure 3.7: Farmer´s decision-making model
(Based on Willock, J., et al. (1999, p. 6))

In this model personal factors and the farming environment are the most distant antecedent variables from the dependent one (farming behaviours). This model suggests that farmer´s attitudes are linked to farmer´s behaviour, which includes farmer´s orientation toward production, environmentally oriented farming and the stress degree in farming (Willock, J., et al. 1999, p. 7). The model also shows a potential relationship between personal factors, attitudes to farming and behaviour. Before this model was published, psychologists had known about these interactions and had incorporated these sorts of relationships into a larger theory, which implies that attitudes interact with other individual factors to influence behaviour, calling this concept "Theory of Planned Behaviour" (see Figure 3.8), introduced by Ajzen (1991).

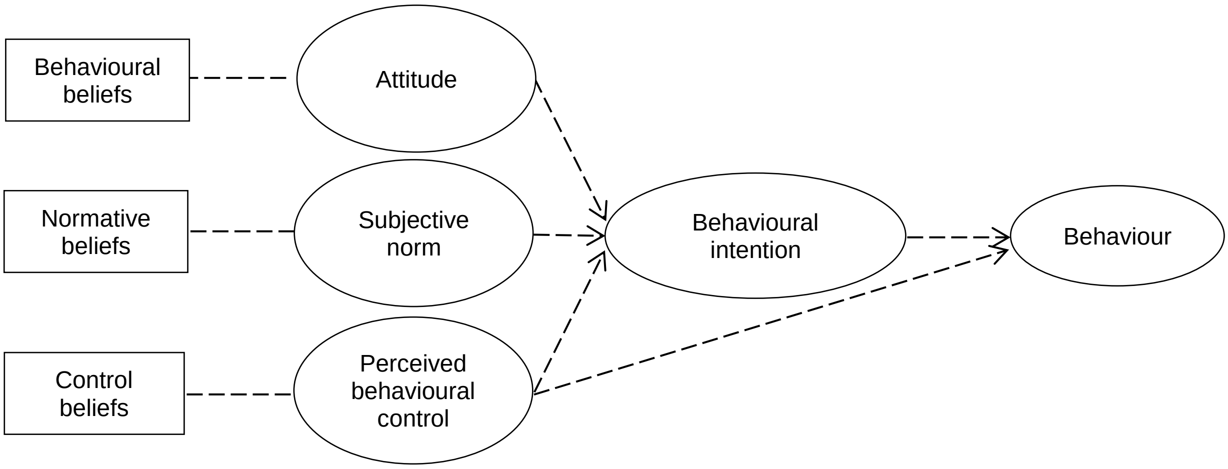

Figure 3.8: The Theory of Planned Behaviour
(Ajzen (1991, p. 182))

This theory is designed both to predict and explain human behaviour in different and specific contexts. Being an extension of the original Theory of Reasoned Action (Fishbein, Ajzen 1975; Ajzen, Fishbein ©1980), the authors added a third predictor variable, perceived behavioural control, to reflect the degree of control an individual perceives to have over the behaviour under investigation (Parker et al. 1995, p. 128). According to the Theory of Planned Behaviour, the individual´s intention to perform a given behaviour is the most proximal predictor of an actual behaviour (Hagger. M.S., Chatzisarantis 2006, p. 731). The intention summarises three sets of motivational forces, reflected in behavioural, normative and control beliefs which influence the behavioural outcome (Johansson, Laike 2007, p. 437).

Eagly, Chaiken define an attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly, Chaiken 1993, p. 1). In other words, an attitude refers to the degree of a person´s favorable or unfavorable evaluation of the particular behaviour. The second predictor and also a social factor in the model is subjective norm, which explains the social pressure, perceived by the individual, to perform or to reject the behaviour (Ajzen 1991, p. 188). The social pressure in this context means that the people in the person´s social environment, e.g. family and friends, desire the person to perform a certain behaviour (Johansson, Laike 2007, p. 438). And the third predictor of the individual´s behaviour is the construct of perceived behavioural control, added by Ajzen to the earlier Theory of the Reasoned Action. The perceived behavioural control refers to the person´s beliefs of whether she has the resources and capacity needed to perform the behaviour (Hagger. M.S., Chatzisarantis 2006, p. 732). Additionally, the perceived behavioural control is assumed to reflect the individual´s past experience and also her anticipated barriers for the enacting of the particular behaviour. Although in some cases perceived behavioural control may predict the person´s outcome behaviour directly, according to the Theory of Planned Behaviour, the behaviour is a joint function of the intention and the perceived behavioural control (Ajzen 1991, p. 185). Despite the fact, that the intention and the perceived behavioural control are found to explain a "considerable proportion of variance in behaviour" (Ajzen 1991, p. 206), the strength and direction of relationship between the model variables - attitude, subjective norm and perceived behavioural control - is still uncertain, revealing the areas for improvement of the present theory.

Beedell, Rehman (2000) used this theory to investigate farmers´ decision-making on the adoption of environmentally-friendly approaches. The authors found that farmers with a greater environmental awareness were more influenced in their decision-making by conservation-related attitudes and less by management concerns than other farmers in the survey. Applying this theory Willock et al. (1999) explored environmentally-oriented behaviours of farmers, and Zubair, Garforth (2006) studied sustainable forestry systems in Pakistan. However, Burton (2004) criticised their models for overemphasizing the role of attitudes in decision-making.

In the present work internal and external factors influencing decision-makers in the context of biogas investments will be analysed simultaneously, and the Theory of Planned Behaviour will be adopted to investigate the relationship between the intention to invest in biogas and actual biogas investment of Ukrainian agroholdings (see Section 7.2.3), therefore, addressing the third research question, described in Section 1.2.

Groenwald (1987) and Willock, J., et al. (1999) suggested that agricultural business is basically understood by researchers as a small farm production, where decisions are made by one person (farmer). Agroholdings, which are the focus of the present study, are large business organisations, where decisions are made and influenced by various employee groups (see Section 2.2). In this case, models of organisational decision-making are helpful to explain biogas investments.

3.2.2 Models of Organisational Decision-Making

Questions of how business organisations are expected to make decisions - in contrast to how they actually do it - form a large stream of research literature (March, Lingen 1990; George, McKeown 1985; Nelson, Winter 1982; Simon 1979; Cyert et al. 1970a; Taylor 1970; Weber 1970; Frese et al. 2011; Rosenstiel, Nerdinger 2011; Spieß 2008; Ortmann 2000). In neoclassical organisational theories the decision-maker identifies and implements optimal solutions, which are primarily based on profit maximisation (Cyert, March 1992, p. 215).

Modern organisational behavioural theories assume that managers simplify the decision-making in a number of ways. For example, they choose an optimal solution from available alternatives rather than trying to find the best imaginable profitable one. Additionally, they may follow rules-of-thumb in decision-making (Cyert, March 1992, p. 216). Indeed, behavioural theories do not refer to any deviation from profit maximisation goals, but rather to the inconsistency in the decision-making process (Granoszewski 2013, p. 113). It can be assumed that organisational decision-making of agroholdings in the context of biogas investments is not uniquely determined by profit maximisation, but also by the need to recycling manure, control pollution, etc. Here, a group of organisational characterstics, such as the size and structure of an agroholding, seems to be decision-relevant. Additionally, numerous individuals are involved in the decision process, which directly impact the final decision (see Section 3.1.2). Based on these considerations and the subject of the present dissertation, the decision-making models of Backhaus, Voeth (2010), Webster, Wind (1972a) and Sheth, Sharma (1973) have been chosen. The first model of Backhaus, Voeth (2010) incorporates five groups of variables (see Figure 3.9).

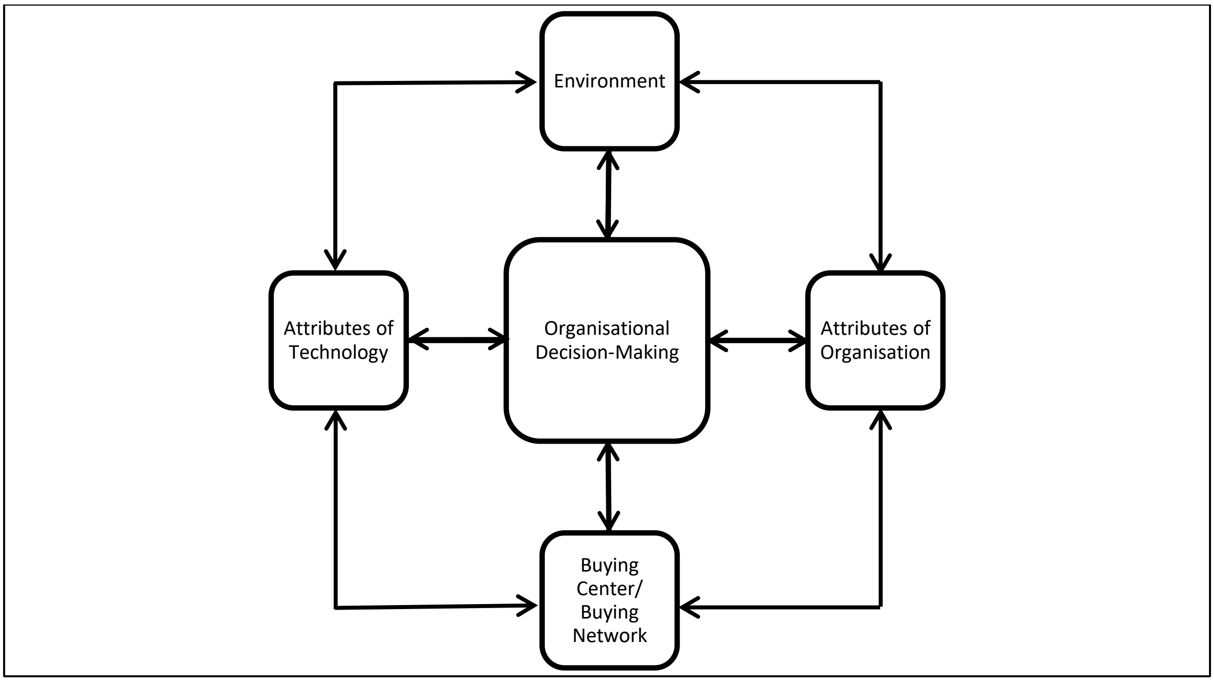

Figure 3.9: Determinants of organisational decision-making
(Based on Backhaus, Voeth (2010, p. 38))

The buying-center consists of all individuals, who belong to the organisation or are outsiders, involved in the company´s decision-making process. Backhaus, Voeth indicated that with the growth of the buying-center its role in the decision-making process increases (Backhaus, Voeth 2010, p. 37). The factors related to the environment and to the attributes of technology and organisation reflect the factors, which have been introduced in the adoption theories (see Section 3.1.2). The central construct of the model – organisational decision-making – is divided into four stages (Backhaus, Voeth 2014, pp. 44–45):

1. Preliminary enquiry, which includes a feasibility study;
2. Proposal preparation, in which the supplier develops his offer;
3. Negotiation with the client, during which the proposal evaluation by the potential consumer takes place;
4. Project realisation and guarantee provision, which complete the decision-making process in the model.

Furthermore, organisational decision models are classified into total models, which include all relevant factors, and partial models, which analyse specific decision variables (Hertel 2014, p. 20). Webster, Wind (1972a) proposed a total model, which consists of four groups of variables (Figure 3.10).

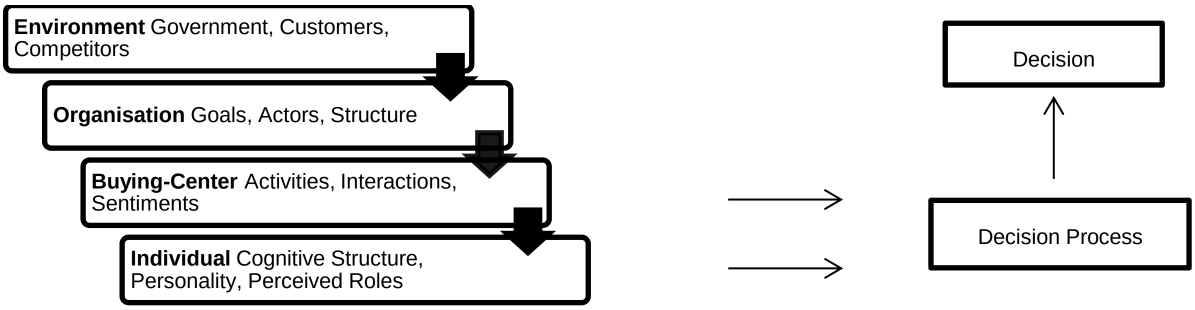

Figure 3.10: Webster-Wind model of organisational decision-making
(Based on Webster, Wind (1972a, p. 15))

This model provides a theoretical framework rather than an explanatory approach, because many of its factors cannot be operationalised for empirical examination (Hertel 2014, p. 22). Sheth, Sharma (1973) proposed a new conception of organisational behaviour (see Figure 3.11), which has been criticised for the lack of empirical application (Backhaus, Voeth 2010, p. 94):

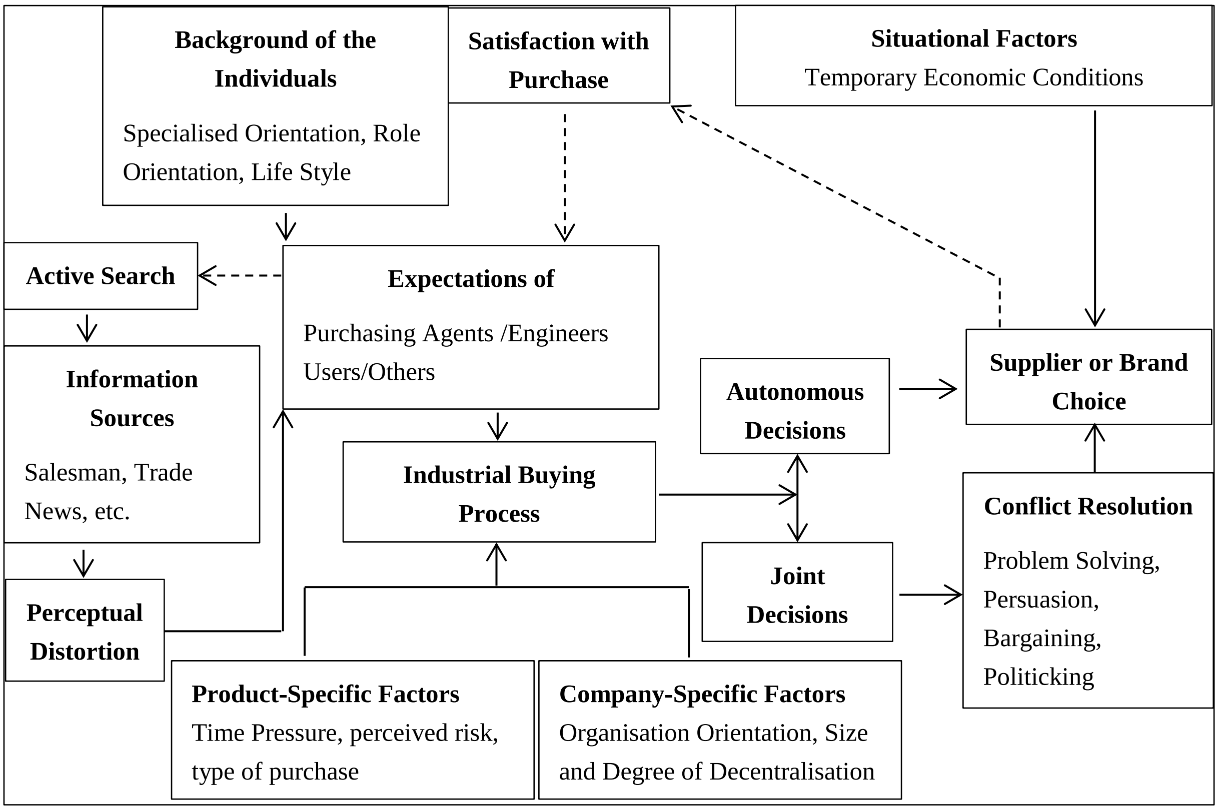

Figure 3.11: Sheth-Sharma model of organisational decision-making
(Based on Sheth, Sharma (1973, p. 51))

As described in the literature review, a mere techno-economic analysis of organisational decision-making is not sufficient to explain the final decision in the context of new technology adoption. Yet, for several decades scholars noted that an incorporation of behavioural and social aspects is needed. The merging of economics and psychology into one discipline has become very popular in the scientific field and is called “behavioural economics”. The next section analyses how behavioural economics can be applied to agricultural organisations in the context of their investment decisions in biogas.

3.3 Behavioural Economics of Organisations

Traditional economic theories see human beings as Homo economicus, who make rational decisions and apply extended processing power to any information. He maximizes self-interest in an environment, where market, institutions and other individuals are rational (Yazdipour ©2011, p. 23). Rationality of humans is at the heart of the classical economic theories, related to market efficiency and finances (Menichetti 2010, p. 43). However, real humans do not provide evidence of complete rationality and, in addition, live in a world of uncertainty (Yazdipour ©2011, p. 191). Over the years an increasing number of scholars have questioned the capability of the classical economic theories to answer diverse economic phenomena. A new research area, which originally arose as an alternative to traditional approaches, is called "behavioural economics" (Thaler 2016, p. 1577).

3.3.1 Key Research Areas of Behavioural Economics

Behavioural economics is a relatively new field which aims to define explanations of people´s decisions in the real world. It combines behavioural and psychological theory with economics and finance. Once considered a "paradigm-shifting revolution within economics" (Thaler 2016, p. 1577), behavioural economics is now become mainstream (Baker, Nofsinger ©2011a, p. 3). From the methodological perspective, behavioural economics is an advance technique of conventional economics, which uses qualitative and quantitative methods of social science (Yazdipour ©2011, p. 235). Table 3.2 outlines the main research fields and applications of behavioural economics.

Table 3.2: Key themes and applications of behavioural economics
(Based on Baker, Nofsinger (©2011a, pp. 4–8))

Key Themes	Applications
Heuristics	Investors
Mental shortcuts simplify the complex methods ordinarily required for making decisions.	In the field of portfolio investments biases of individual investors have been documented. Behavioural economics studies how investors can improve their financial decisions.
Framing	Corporations
Depending on the way the question is framed, people make different decisions, while the point of the question itself remains constant.	In business organisations, one or a few people make decisions impacting big financial resources. Therefore, their mistakes have direct impact on the company´s performance and markets. Conventional theory suggests that individuals´ mistakes do not influence the market.
Emotions	Markets
People´s emotions, needs, fears, etc. influence decision-making.	The way in which individual factors and errors affect markets is a key research topic of behavioural economics.
Market Impact	Regulations
Standard theory argues that market players´ mistakes do not affect market prices. Behavioural economics studies impacts of individuals´ cognitive errors on market and prices.	Heuristics impact average citizens as well as politicians who make laws and policies. Effective policy design can help people make better economic decisions.

The concept of "bounded rationality" is a basis of behavioural economics. This phenomenon will be explained in the next section.

3.3.2 Bounded Rationality in Organisational Decision-Making

The term “bounded rationality” was coined by Simon (1957). The basic assumption of this theory is that the human thinking process does not work like a computer. Individuals are constantly influenced by different factors, and they may act in a seemingly irrational manner. As a result, their investment decisions may violate traditional concepts of risk aversion and have negative impact on the organisation´s business performance (Baker, Nofsinger ©2011b, p. 3). Scholars used to study business organisations. Behavioural research explores how socialisation, networks and identity shape employee behaviour (Camerer et al. 2004, p. 235). Conventional studies on decision-making in organisations are based on publicly available data, which reflect the results of past decisions. In contrast, interview-based behavioural surveys attempt to identify the reasoning of actual decisions. Scholars suggest that such surveys may deliver a more realistic picture of business behaviour (Schwartz ©2011, p. 375). The present work focuses on the decision-making of agroholdings´ top-managers regarding biogas. Camerer et al. (2004) reviewed publications on chief executive officers (CEOs) of large corporations in the U.S and concluded that top-managers may be as biased and irrational as the average of the population. For example, top-managers may tend to underestimate risks, sometimes leading them to taking risky projects with higher returns. Shleifer posits that “the perception of risk is one of the most intriguing open areas in behavioural finance” (Shleifer 2000, p. 181). An executive risk estimation is influenced by his or her overconfidence and “better-than-average” effects[21] (Camerer et al. 2004, pp. 259–261). Additionally, often risk cannot be quantified with precision (Altman ©2011, p. 194).

In a series of experiments in the 1970s, Kahneman, Tversky further refined the bounded rationality approach. The scholars applied cognitive psychology methods to show that people make systematically biased decisions (Thaler 2016, p. 1581). They found out that humans tend to rely on heuristics when making decisions under uncertainty. In 1979, in a second publication Kahneman, Tversky identified numerous behaviours which were inconsistent with the conventional expected utility theory[22] (Menichetti 2010, p. 44):

- certainty effect: people tended to underweight merely probable outcomes compared with certain obtainable outcomes;
- reflection effect: when choosing between negative opportunities, people seemed to be risk-taking, and, when selecting between positive perspectives they were risk averse;
- isolation effect: to simplify the choice, people ignored all details of every alternative under consideration, and concentrated on the features that distinguished the alternatives.

To better understand these identified phenomena, Kahneman, Tversky incorporated these aspects into a new model of decision-making under uncertainty and called it “prospect theory”. The theory is a representation of individuals´ behaviour in a world of uncertainty. Its main focus lies on how people evaluate risky alternatives and engage in risky choice behaviour (Altman ©2011, p. 191). Kahneman (2003) identified the implementation of short-term emotional variables as determinants of decision behaviour a critical point of the prospect theory. Kahneman, Tversky introduced a value function which consists of positive and negative values (see Figure 3.12). The function demonstrates changes in states of wealth from a given subjective reference point. In contrast, the traditional subjective expected utility theory includes only positive values, where gains and losses are equal to the utility value. In prospect theory losses are weighted 2 to 2.5 times higher than gains. In the context of the present work this can mean that top-managers of Ukrainian agroholdings may find probable losses from a biogas investment more important than profits from it, if they perceive the probability of losses as being higher than that for profits.

[21] Managers, if asked about their skills compared to the median person in their group, rated themselves as „above average“ (Camerer et al. 2004, p. 260).

[22] The explanation of the expected utility theory is beyond the scope of the present work.

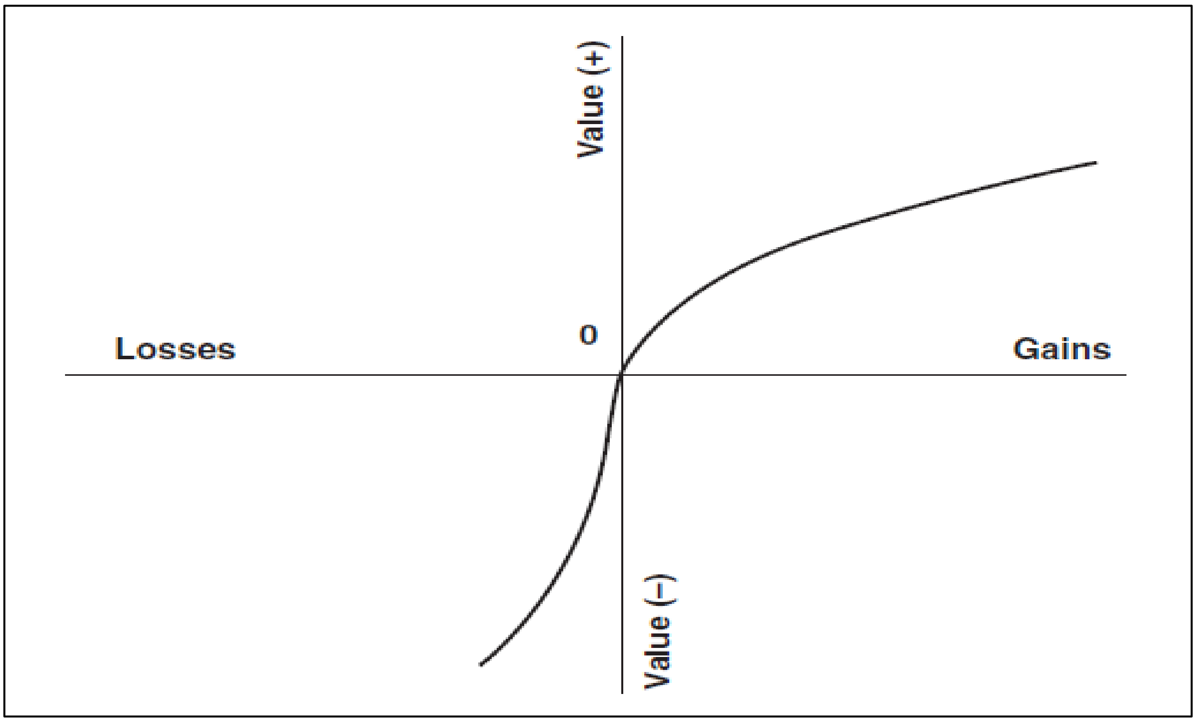

Figure 3.12: Kahneman-Tversky value function
(Altman ©2011, p. 201)

Admires of traditional economic theories did not except Kahneman, Tversky´s findings, referring the deviations from the conventional paradigm to the inappropriate methodology and variables definition (Menichetti 2010, p. 46). Economists saw the findings of behavioural scientists as generating lists of biases and errors and they criticised behavioural research for not providing coherent models for basic theories, e.g. a rational-agent model (Kahneman 2003, p. 1449). Gigerenzer assumed that the behavioural economic theory highlighted the importance of cognitive factors rather than provided a theory of decision-making under uncertainty. Einhorn, Hogarth (1986) determined three elements of risky decision-making behaviour, where both conventional and behavioural theories are weak:

1. The nature of uncertainty in choice: gambling, often used in behavioural experiments for modelling risky decisions, is not an ideal example for real-life situations;
2. The effects of context: changes in the context variables impact the risk evaluation in the experiment;
3. The relationship between probabilities and outcomes: payoffs affect the weighting of uncertainty, e.g. under ambiguity.

While numerous scholars have applied behavioural theories to explain farmers´ decisions (Willock et al. 1999; Beedell, J. D. C. and Rehman, T. 1999), several studies have investigated behavioural factors affecting renewable energy investments (West et al. 2010; Menichetti 2010; Masini, Menichetti 2013, 2010; Wüstenhagen, Menichetti 2012). These studies have confirmed measurable impacts of cognitive factors on investment decisions regarding renewables. Devine-Wright; Wolsink (2007; 2007) examined how people form views on renewable technologies. Hekkert et al.; Wüstenhagen et al.; Stephens, Jiusto (2007; 2007; 2010) explored how the perceived potential influence of renewable energies affects their actual implementation. Safarzynska, van den Bergh, Jeroen C.J.M.; Haegstad Flam (2011; 2009) as well as Reise et al. (2012) and Frör (2008) used bounded rationality to study energy technology choices. Additionally, the bounded rationality method has gained recognition in other scientific fields: economics (van Zandt 1999), operations management (Bendoli 2006; Gino, Pisano 2008; Loch, Yaozhong 2005), strategic management (Bromiley 2005) and sustainability marketing (Beretti et al. 2009). In the next chapter a theoretical model, explaining the top-managers´ decision-making, will be provided.

4 Conceptual Model of Agroholdings´ Investment Behaviour in Biogas

A literature review has provided the groundwork for developing a conceptual model for the present study. Furthermore, a series of exploratory interviews with renewable energy experts in Ukraine was conducted to refine the theoretical model and to examine which factors are indeed decision-relevant for Ukrainian agroholdings in the context of biogas investment (see Section 5.1). The model consists of two stages of the variables, defined from the literature analysis and the expert interviews. The first stage examines which factors influence the willingness-to-invest in biogas. This stage consists of four general categories of decision-relevant aspects: perceived investment attributes (Section 4.1.1), organisational (Section 4.1.2), personal (Section 4.1.3) and external business environment factors (Section 4.1.4). The second stage investigates relationships between the intention to invest in biogas (willingness-to-invest) and actual biogas investments (Section 4.1.5). In this chapter the formation and argumentation of the hypotheses, the variables´ operationalisation as well as the development of the conceptual model will be presented.

4.1.1 Perceived Investment Attributes

The first set of factors is related to perceived characteristics of investments in biogas projects, which include Rogers´ attributes of innovation: “relative advantage” and “technological complexity” (see Section 3.1). Numerous scholars have found individual perception of investment attributes to be important in influencing the adoption process (Sia et al. 2004; Lin, Ho 2011; Tornatzky, Klein 1982; Weng, Lin 2011). The factors “compatibility”, “observability” and “trialability” are seen as less relevant in the context of the present study, because of their limited application for biogas. In contrast, the factors “payback period”, “investment costs” and “perceived risk”, which were defined in the expert interviews (see Section 5.1), form an important part of the theoretical framework of the present study.

4.1.1.1 Payback Period

The payback period is generally defined as the time required for the investment to recoup its initial costs. Thus, the payback period is an indicator for the project profitability expressed in years. Profit maximisation is an important factor of decision-making in agriculture, as well as in other businesses (Sachs 1973; Gasson et al. 1993; Cary et al. 2001). Pannell, Marshall (2006) found that a lack of financial benefits reduces investment probability. Additionally, Cancian (1979) suggested that the relationship between the profit expectations and the adoption probability is not linear. Thus far, only a few authors have examined the economic performance of biogas production and support the choice of this influencing factor (Gebretzhabler 2010; Keymer 2009; Heißenhuber, Berenz; Heißenhuber, Berenz; Wulf et al. 2006). Kuznetsova, Kutsenko; Kuznetsova (2010; 2010) analysed the payback period for biogas plants under the green tariff and the use of own waste in Ukraine, and estimated that the payback for Ukrainian agroholdings may be up to four years. In contrast to these findings, Geletukha, G., et al. (2013) calculated that under the current green tariff rate the payback exceeds 10 years in Ukraine. According to the experts interviewed, a six-year payback period seems to be a “psychological threshold” for Ukrainian agroholdings. If the project exceeds this mark, the agroholding will probably reject it and will search for something more profitable. Therefore, the length of the payback period is an important factor and a “six year +”-payback appears to have a negative influence on the top-managers´ willingness-to-invest in biogas, as indicated by the hypothesis and item, used in the empirical survey (Table 4.1).

Table 4.1: Payback period
(Author´s concept)

Num.	Hypothesis
1.	The longer the payback period for a biogas investment, the lower is the willingness-to-invest in biogas.

Item	Author
If the payback period for biogas exceeds six years, then such a project is not interesting for us.	Pannell, Marshall (2006)

4.1.1.2 Investment Costs

Investments in biogas technologies are often characterised by high up-front costs (Reise et al. 2012). Large capital investments plus a long payback period reduces investment attractiveness of biogas for Ukrainian agroholdings. Additionally, Pannell, Marshall (2006) pointed out that the costs of a traditional technology, which in the present case biogas would replace, e.g. natural gas heating, is also decision-relevant. Moreover, a high outlay, required for biogas plants, is a major barrier for a broader market penetration of this technology in Ukraine (International Finance Corporation (IFC) 2015; International Renewable Energy Agency (IRENA) 2015). Consequently, it is expected that the top-managers of agroholdings, which perceive biogas investment costs as being high, will tend to reject biogas investments. Therefore, the following hypothesis and statement are proposed:

Table 4.2: Investment costs
(Author´s concept)

Num.	Hypothesis
2.	The higher the investment cost of a biogas plant, the lower is the willingness-to-invest in biogas.

Item	Author
Biogas requires large capital investments.	Reise et al. (2012)

4.1.1.3 Relative Advantage of Biogas

Rogers defined this factor as "… the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers 2003, p. 229). In the context of the present study, this factor reflects a perception of top-managers that biogas is more advantageous than the technology it replaces. The perceived relative advantage of a new technology is positively related to its adoption (Tornatzky, Klein 1982; Rogers 2003). Companies are more likely to invest in biogas technologies, if they are able to provide a higher performance and economic gains than the previous technology (Weng, Lin 2011). The rejection of a new technology is often explicable in terms of its failure to provide relative advantages, e.g. economic ones, for the investor (Pannell, Marshall 2006). Relative advantage depends on the investor´s particular goals and the context where a new technology will be used. Pannell, Marshall (2006) developed a list of factors affecting the perception of relative advantages by farmers.

Considering the benefits of biogas use for agroholdings[23], three levels of perceived relative advantages of biogas are defined: advantage of biogas use compared to natural gas, improving the company´s financial situation through biogas investments and consideration of biogas as an attractive investment. Furthermore, a positive influence of perceived biogas advantages on the top-managers´ willingness-to-invest in biogas is expected (Table 4.3).

Table 4.3: Relative advantage of biogas
(Author´s concept)

Num.	Hypothesis
3.	The higher the perception of biogas relative advantages, the higher is the willingness-to-invest in biogas.

Item	Author
Biogas has more advantages for us than using natural gas.	Tornatzky, Klein (1982); Rogers (2003)
Biogas can improve the financial situation of our company.	
We consider biogas to be an attractive investment.	

[23] For the advantages of biogas use in the agricultural sector see Section 2.1.

4.1.1.4 Perceived Risk of Biogas Investments

The perceived risk concept has been used by scholars since the late 1960s, when it was first brought to the attention of the scientific community (Mitchell 1999). Cunningham conceptualised the definition of perceived risk as “the amount that would be lost … if the consequences of an act were not favourable” (Cunningham 1967, p. 37). He also identified five categories of risk which a potential investor should be aware of: social, financial, physical, time and functional. While scholars debate on the existence of objective (“real world”) and subjective (“perceived”) risks, only the latter term is used in the present study. Since the emerging of the risk concept, scholars have developed different models for risk measuring: basic (two-component), complex and multi-attitude risk models (Mitchell 1999). Peter, Ryan (1976) proposed a simple equation for risk measurement in the two-component model of Cunningham[24]:

$$Risk = Probability\ of\ Negative\ Consequences\ Occuring\ x\ Importance\ of\ Negative\ Consequences;$$

Newall (1977) designed a simple risk-based model for buying behaviour consisting of three groups of factors (Figure 4.1):

Figure 4.1: A simple risk-based model of buyer behaviour
(Based on Newall (1977, p. 167))

In general, authors found that farmers´ risk perception plays a significant role in decision-making to invest in a new technology. Scholars also developed risk types specially related to agricultural production (Iatsiv 2011):

- **financial**: interest and exchange rates, liquidity, cash flow;
- **strategic**: regulatory, competitors, industry dynamics, customer changes;
- **hazard**: natural events, environment, employees;
- **operational**: supply chain, technology breakdowns.

Several authors investigated the impact of risk and uncertainty on renewable energy adoption (Meijer et al. 2007; Apak et al. 2011; Chassot et al. 2014). They underlined the negative impact of perceived policy risks relating to investments in renewables. Menichetti (2010) found that the changing policy framework is perceived by investors as a potential risk. As most renewable energies are regulated under policy schemes, the political risk is of high importance for the further implementation of renewables. To the best of the author´s knowledge no studies have examined the risks of biogas investments in Ukraine. Nevertheless, International Finance Corporation (IFC) (2015) studied risks associated with biomass use in Ukraine. In this work the shortage of biomass supply of required quality was a key concern of the heat-supplying companies. The second perceived risk was unstable energy output, caused by different biomass quality and heat content. Additionally, companies were concerned about the quality of equipment used for the biomass-to-energy generation.

Based on the arguments given above, perceived risk of agroholdings, associated with biogas investments, is a decision-influencing determinant in the present study. Therefore, a high perceived risk regarding biogas investments is expected to negatively impact the top-managers´ willingness-to-invest in biogas (Table 4.4).

[24] The methods of risk measurement were discussed by Arztner et al. 1999.

Table 4.4: Perceived risk of biogas investments
(Author´s concept)

Num.	Hypothesis	
4.	The higher the perceived risk of a biogas investment, the lower is the willingness-to-invest in biogas.	
Item		**Author**
Please, evaluate an overall risk of a biogas investment for your company. [From very high to very low]		Mitchell (1999); Newall (1977); Esty, Winston (2009)

4.1.1.5 Technological Complexity

Complexity is the degree to which a new technology is perceived as being difficult to understand and use (Peter et al. 2002). An innovation with high complexity contains a lot of knowledge, which requires additional time to obtain. It makes a complex technology relatively difficult to adopt (Weng, Lin 2011). The greater its complexity, the greater the required information to be certain about the outcomes of the use of a technology (Pannell, Marshall 2006). Technological complexity may also increase the requirements of the ongoing operations, which reduces technology´s relative benefits. Another negative impact of complexity is that it may increase the risk of technical failure related to the technology use. Alternatively, a new technology may not be complex in itself, but its adoption may add to the overall complexity faced by the company (Pannell, Marshall 2006). In general, the complexity of biogas production perceived to be higher is hypothesised to be negatively correlated with the technology adoption and the top-managers´ willingness-to-invest in biogas (Table 4.5).

Table 4.5: Technological complexity
(Author´s concept)

Num.	Hypothesis	
5.	The higher the perceived complexity of biogas production, the lower is the willingness-to-invest in biogas.	
Item		**Author**
Biogas is a complicated technological process.		Pannell, Marshall (2006)

4.1.2 Organisational Factors of the Agroholding

The organisational context consists of a variety of company characteristics. Numerous scholars have discussed the impacts of different organisational factors on the decision to use new technologies (Lin, Ho 2011; Weng, Lin 2011; Etzion 2007; Gonzalez-Benito, Gonzalez-Benito 2006; Jeyaraj et al. 2006; Pohl 1996; Damanpour 1991; Tornatzky, Fleischer 1990; Kimberly, Evanisko 1981). In their studies human resources, top-management´s leadership skills and organisational size are the most relevant determinants. Considering the context of the present study, the following factors will be incorporated into the empirical model: the economic situation of the agroholding, energy costs, perceived need for waste recycling and company size.

4.1.2.1 Economic Situation of the Agroholding

The internal economic situation of the company impacts its ability to invest in new agricultural technologies. Farmers, fully satisfied with their finances, are not likely to invest in new projects (Granoszewski, Spiller 2012). However, companies which are struggling with financial obstacles often lack resources for new projects and are unable to make new investments (La Due et al. 1991). In empirical research scholars sometimes apply objective indicators such as company total revenue, net profit, market share or return on investment to measure business performance (Krueger 1988; Murphy, Trailer 1996). However, there are several problems with the comparison of these numbers in Ukraine´s agricultural sector. For example, agroholdings may pass through different investment cycles or apply differing profit & loss calculation methods and etc.

As a consequence, researchers also work with subjective measurements of a company economic situation (Dawes 1999; Dess, Robinson 1984; Covin, Slevin 1994). Based on Kollmann, Herr (2008) and Gupta, Govindarajan (1984), three dimensions of the perceived economic situation of agroholdings are defined: overall satisfaction, ability to invest in new projects and business results in the last three years (Table 4.6). Referring to Granoszewski, Spiller (2012) a perceived positive economic situation in an agroholding is expected to negatively influence the top-managers´ willingness-to-invest in biogas (Table 4.6).

Table 4.6: Economic situation
(Author´s concept)

Num.	Hypothesis
6.	The better the economic situation in the agroholding, the lower is the willingness-to-invest in biogas.

Item	Author
We are satisfied with the financial situation of our company.	Granoszewski, Spiller (2012); Kollmann, Herr (2008)
Our financial situation does not allow investing in new projects.	
Key results of our business (revenue, profit) from 2012 to 2014 were excellent.	

4.1.2.2 Energy Costs

The influence of perceived energy costs on the top-managers´ decision-making concerning biogas emerged during the expert interviews (see Section 5.1). The experts suggested that rising energy prices motivate agricultural producers to better use their own resources. Sick (2014) investigated impacts of energy prices, e.g. natural gas, on renewable energy diffusion in developed countries and did not find a significant correlation between investments in renewables, e.g. biomass, and gas prices. Hertel (2014) discovered a significant positive influence of energy costs on the attitudes towards adoption of energy efficient technologies in horticulture. In the context of the present study, two dimensions of this factor are considered: satisfaction with the current energy costs of the agroholding and willingness-to-decrease company´s expenses on energy. A positive impact of high importance of agroholdings´ energy costs on the top-managers´ willingness-to-invest in biogas is expected (Table 4.7).

Table 4.7: Energy costs
(Author´s concept)

Num.	Hypothesis
7.	The higher the importance of energy costs in the agroholding, the higher is the willingness-to-invest in biogas.

Item	Author
We are satisfied with the level of our heating and electricity costs.	Hertel (2014)
We are looking for possibilities to decrease our heating and electricity costs.	

4.1.2.3 Perceived Need for Waste Recycling

As presented in Section 2.1.2, agricultural companies generating a sufficient amount of organic waste represent a good potential for biogas production in Ukraine. During the expert interviews (see Section 5.1) it emerged that agroholdings, which invested in biogas between 2000 and 2014, were influenced by the need for waste recycling. In many cases, a poor waste treatment caused several problems for the agroholdings: penalty payments for missing waste recycling, conflicts with local citizens because of undesirable smells, soil pollution and etc. Because arable land usually belongs to the local citizens, who, moreover, often are agroholding employees, such local conflicts may negatively impact the agroholdings´ business performance. Local citizens are able to discontinue the lease contracts, therefore, leaving the agroholding without land. As expressed by the interviewed top-manager of the largest chicken meat producer in Ukraine “the biggest problem in our business is not money, but where to bring our chicken waste”.

Although no references in literature relating to the relationship between agricultural waste and biogas investments were found, a positive impact of perceived need for waste recycling on the top-managers´ willingness-to-invest in biogas is expected. Following this argumentation, a new item is introduced (Table 4.8).

Table 4.8: Perceived problem of waste recycling
(Author´s concept)

Num.	Hypothesis	
8.	The higher the perceived need for waste recycling, the higher is the willingness-to-invest in biogas.	
Item		**Author**
Recycling of production waste is a problem for our company.		Author´s concept based on expert interviews
Production waste of our company has led to conflicts with local citizens.		

4.1.2.4 Company Size

The influence of company size on biogas investments was explored by Granoszewski, Spiller (2012). The authors found that arable land size had a significant positive influence on the farmer´s decision behaviour. These results are consistent with the pioneering studies of Schramm (1977), who showed that entrepreneurs in general pay high attention to the size of their companies in a decision-making process. These findings were confirmed by Yaron et al. (1992) who discovered that company size had a positive influence on the adoption rate of new agricultural technologies on farms. Voss et al. (2008) concluded that mainly larger farms in Germany decided to invest in biogas.

As presented in Section 4.1.1.2, investments in biogas technologies are often characterised by high up-front payments (Reise et al. 2012). Therefore, primarily large agricultural companies in Ukraine will be able to finance biogas projects. Thus, it is argued that the company size has a positive impact on the top-managers´ willingness-to-invest in biogas (Table 4.9).

Table 4.9: Company size
(Author´s concept)

Num.	Hypothesis	
9.	The larger the agroholding´ size, the higher is the willingness-to-invest in biogas.	
Item		**Author**
What number of hectares does your company cultivate in 2014/2015 financial year? [ha]		Voss et al. (2008) Reise et al. (2012)

4.1.3 Individual Factors of the Decision-Maker

Personality can play an important role in organisational decision-making. If one views decision-making as a social process, one might expect the decision to be affected by personality, social networks and personal circumstances. However, some scholars criticise that almost every measurable characteristic of an individual has already been statistically proved to be related to decision-making (Pannell, Marshall 2006). This section reflects the factors which are related to the individuals involved in the agroholdings´ decision-making regarding biogas investments. Based on the expert interviews (see Section 5.1), two individual factors - the decision-maker´s risk aversion and innovativeness have been chosen for the empirical study.

4.1.3.1 Risk Aversion

Risk aversion reflects an individual´s tendency to take or avoid risks in decision-making (Pannell, Marshall 2006). The higher the individual´s risk aversion, the higher the tendency to invest in a new technology which is perceived to reduce risk (Shapiro et al. 1992). In contrast, if the innovation is perceived to increase risk, a risk averse individual will tend not to invest in this innovation (Ghadim et al. 2005).

Economic studies have indicated that decision-makers in agricultural companies vary widely in the degree of risk aversion (Abadi Ghadim A.K., Pannell 2003; Bardsley, Harris 1987; Bond, Wonder 1980). Voss et al. (2008) found that risk averse farmers in Germany tend to reject biogas investments; that findings have been confirmed by Granoszewski, Spiller (2012). Sauer, Zilberman D. (2010) also confirmed a strong relationship between farmers´ risk aversion and decision-making on the example of the adoption of automated milk systems. These results have been supported by Kim, Chavas (2003a) using the example of an irrigation technology adoption. Willock et al. (1999) suggested that farmers´ risk-taking attitudes are of major importance for explaining decision-making. Scholars identified attitudes towards sustainability and profit maximising as important facets of farmers´ risk aversion (Pile 1991; Driver, Onwona 1986; Salamon, Davis-Brown 1986).

In the context of investments in renewable energies Ghosh et al. (1994) found that risk aversion has a significant impact on decision-making. Their results contrast with Masini, Menichetti (2013), who did not confirm the significance of the relationship between the investor´s risk aversion and investments in renewables. Based on these results, a negative impact of risk aversion on the top-managers´ willingness-to-invest in biogas is expected (Table 4.10). Therefore, two dimensions of risk aversion are defined: a choice between two projects with different perceived risk levels and a willingness to take higher risks to gain higher profits.

Table 4.10: Risk aversion of the decision-maker
(Author´s concept)

Num.	**Hypothesis**	
10.	The higher the risk aversion of the decision-maker, the lower is the willingness-to-invest in biogas.	
Item		**Author**
When making decision regarding new investments we choose a project with a lower risk.		Voss et al. (2008); Sauer, Zilberman D. (2010)
To achieve higher profits we are ready to take higher risks in business.		

4.1.3.2 Innovativeness

Concerning the use of new technologies in organisations, researchers have found a relationship between the decision-maker´s innovativeness and innovation adoption (Marcati et al. 2008). Scholars define innovativeness as "[…] the degree to which an individual is relatively earlier in adopting an innovation than other members of his system" (Rogers, Shoemaker 1971, p. 27). In the concept of innovativeness, decision-makers are categorised according to the point in time when an innovation was first adopted[25] (Rogers 1958).

The authors of the concept suggest that people apply their innovativeness equally to every adoption decision (Pannell, Marshall 2006). However, this long-standing theory has been criticised in the scientific literature (Goldsmith, Hofacker 1991). People who adopt an innovation earlier may be indifferent to other innovations.

The role of innovativeness in agriculture has been widely investigated by scholars (Voss et al. 2008; Granoszewski, Spiller 2012; Austin et al. 1998b; Willock et al. 1999; Driver, Onwona 1986; Roehrich 2004; Manning et al. 1995). Voss et al. (2008) found that an individual´s innovativeness had a positive influence on biogas investments of German farmers. This view was not supported by the findings of Granoszewski, Spiller (2012), who did not find a significant relationship between the farmer´s innovativeness and his decision concerning biogas investments. Despite these contradictory empirical findings, it is expected that the top-manager´s innovativeness has a positive impact on his willingness-to-invest in biogas (Table 4.11).

[25] The categorisation of adopters can be found in Section 3.1.1.

Table 4.11: Innovativeness of the decision-maker
(Author´s concept)

Num.	Hypothesis	
11.	The higher the innovativeness of the decision-maker, the higher is the willingness-to-invest in biogas.	
Item		**Author**
We are always among the first in Ukraine who apply and use modern agricultural technologies.		Willock, J., et al. (1999)

4.1.4 External Business Environment

In addition to the organisational and individual factors, the external business environment of the organisation has to be examined in the research framework. The literature analysis and interviews with industry experts (see Section 5.1) have suggested those factors in the context of biogas investments in Ukraine: the aspects of the green tariff, business uncertainty, capital availability and natural gas price.

4.1.4.1 Perception of the Green Tariff

The effectiveness of governmental policies on renewable energy investments depends on a large set of policy measures. This set consists of a combination of the state-guaranteed incentive levels, administration and predictability. Nevertheless, the correlation between the policy support and investments in renewables is not straightforward (Menichetti 2010). Because the policy framework can change, it directly affects the investment profitability and increases the investor´s perceived risk. Numerous scholars have found that high feed-in tariffs had a positive role in lowering investors´ risks in renewable projects (Lipp 2007; Menanteau 2003; Mitchell, Connor 2004; Mitchell et al. 2006; Bahrs et al. 2007; Ehlers 2008). Other researchers concluded that feed-in tariffs are the most effective support instrument, when compared to market-based approaches (Block 2006; Butler, Neuhoff 2004; Contaldi et al. 2007; Couture, Gagnon 2010). In contrast, Liebreich (2009) and Lesser, Su (2008) indicated negative impacts of feed-in tariffs for the entire society, e.g. if set too high, they may offset the benefits of renewables for the society by reducing living standards.

Despite the green tariff implementation for biogas in Ukraine in 2009, this political measure has not led to large investments in biogas (see Section 2.1.4). Moreover, the tariffs were temporarily cancelled and further decreased in 2015[26]. Despite the thus far limited biogas adoption in Ukraine, a positive relationship between the perception of the green tariff and the top-managers´ willingness-to-invest in biogas is expected (Table 4.12).

Table 4.12: Perception of green tariff
(Author´s concept)

Num.	Hypothesis	
13.	The more positive the perception of the green tariff for biogas, the higher is the willingness-to-invest in biogas.	
Item		**Author**
Investments in biogas without state guaranteed feed-in tariff are not interesting for us.		Menichetti (2010); Liebreich (2009)

[26] The information about the temporary cancellation of the green tariff payments in Ukraine was presented in Section 2.1.3.2.

4.1.4.2 Business Uncertainty

Business uncertainty has often been regarded as a primary influencing factor for investments in innovative technologies (Aragon-Correa, Sharma 2003; Rothenberg, Zyglidopoulos 2007; Scupola 2014; Lee 2008). Weng, Lin (2011) defined business uncertainty as frequent and unpredictable changes of the external business factors, perceived by the decision-maker. Li, Atuahene-Gima (2002) viewed business uncertainty as the most relevant external factor affecting companies´ business decisions. In the case of high external uncertainty, businesses will address environmental changes by rapidly gathering new information (Gupta, Govindarajan 1984). To maintain companies´ competitive advantages, businesses will pay more to increase the rate of technical innovation (Damanpour 1991; Kimberly, Evanisko 1981). Some scholars found that companies are more likely to invest in environmental innovations under uncertainty (Aragon-Correa, Sharma 2003; Rothenberg, Zyglidopoulos 2007).

The current business uncertainty in Ukraine is considered high due to the geopolitical situation between 2014 and 2016 (eurointegration.com.ua 2014; telegraf.com.ua 2015; business.vesti-ukr.com 2015; Lavrynovych & Partners 2015; Apostrophe.com.ua 2014; forbes.ua 2014). This uncertainty is reflected in the negative development of the investment climate in Ukraine´s agricultural sector (Deutsch-Ukrainischer Agrarpolitischer Dialog 2016), however, the investment conditions in the agricultural sector of Ukraine have always been far from favourable (bbc.co.uk 2013a, 2013b; International Finance Corporation (IFC) 2012a; European Business Association (EBA) 2009, 2007; Nivievskyi, Strubenhoff 2006). Additionally, the Crimea annexing and the military conflicts from 2014 to 2016 in East Ukraine may have negatively affected biogas investments. Therefore, it is expected that the agroholdings will behave cautiously with new biogas investments and that the top-managers´ willingness-to-invest in biogas is negatively impacted by the perceived business uncertainty in Ukraine (Table 4.13).

Table 4.13: Business uncertainty
(Author´s concept)

Num.	Hypothesis	
14.	The worse the perceived business uncertainty in Ukraine, the lower is the willingness-to-invest in biogas.	
Item		**Author**
We are not sure in the development of economic situation in Ukraine and we are now cautious with new investments.		Li, Atuahene-Gima (2002)

4.1.4.3 Capital Availability

The capital needs may be high when investing in renewable energies (Peter et al. 2002). Langniss (1996) suggested that well-designed financial programmes are essential for dissemination of investments in renewable energies. Thus, a lack of long-term capital may be a key barrier to biogas investments. Shaper, Christian et al. (2008) mentioned that 98.5 % of biogas producers in Germany use credit financing for their projects. Zinych, Odening (2009) found that financial resources are the main determinant for the development of Ukrainian agricultural companies and capital availability together with high interest rates have been a critical constraint in Ukraine´s agricultural sector.

From 2011 to 2014 the interest rates for businesses fluctuated between 10 % and 30 % (Ukrainian Agribusiness Club 2014a, p. 10; 26). In contrast, the average interest rates in Germany and France ranged from 3 % to 7 % (Agro Energy Group LLC 2014). Due to the aforementioned business uncertainty, banks and financial institutions have almost stopped financing Ukrainian business[27] (ostro.org 2015).

[27] Nevertheless, there are special financial programmes which support renewable energy implementation, particularly biogas, in Ukraine: International Finance Corporation (IFC) 2013a, 2013b, 2013c; epravda.com.ua 2014; Ukraine Sustainable Renewable Energy Lending Facility (USELF) 2014; Romanov 2012; European Bank for Reconstruction and Development (EBRD) 2015; Binder 2013; Lauert 2013; Ogarenko 2013. A description of these financial programmes, their effectiveness and role in the renewable energy implementation in Ukraine is beyond the scope of the present work.

A majority of experts interviewed have stressed negative impacts of the low capital availability on biogas investments in Ukraine. Based on these considerations, a negative influence of the high interest rates on the top-managers´ willingness-to-invest in biogas is expected (Table 4.14).

Table 4.14: Capital availability
(Author´s concept)

Num.	Hypotheses	
15.	The higher the perceived interest rate in Ukraine, the lower is the willingness-to-invest in biogas.	
Item		**Author**
Interest rates in Ukraine make biogas investments not attractive for us.		Zinych, Odening (2009)

4.1.4.4 Natural Gas Price

Agroholdings use natural gas for different purposes: from drying cereals after the harvesting to heating pig and chicken farms. The experts interviewed suggested that the uncertainty in the gas supply and its price fluctuations have motivated agroholdings to look for other reliable and independent energy supplies. In a survey conducted by the Ukrainian Agribusiness Club in 2014, 47 % of Ukrainian agricultural producers cited the energy price increase as one of the main obstacles for their business. Figure 4.2 illustrates the price development of natural gas in Ukraine between 2006 and 2015. The price decrease from 2012 to 2015 coincided with the national currency devaluation (Grivna), so that agroholdings are currently paying a higher price in Grivna compared to 2012.

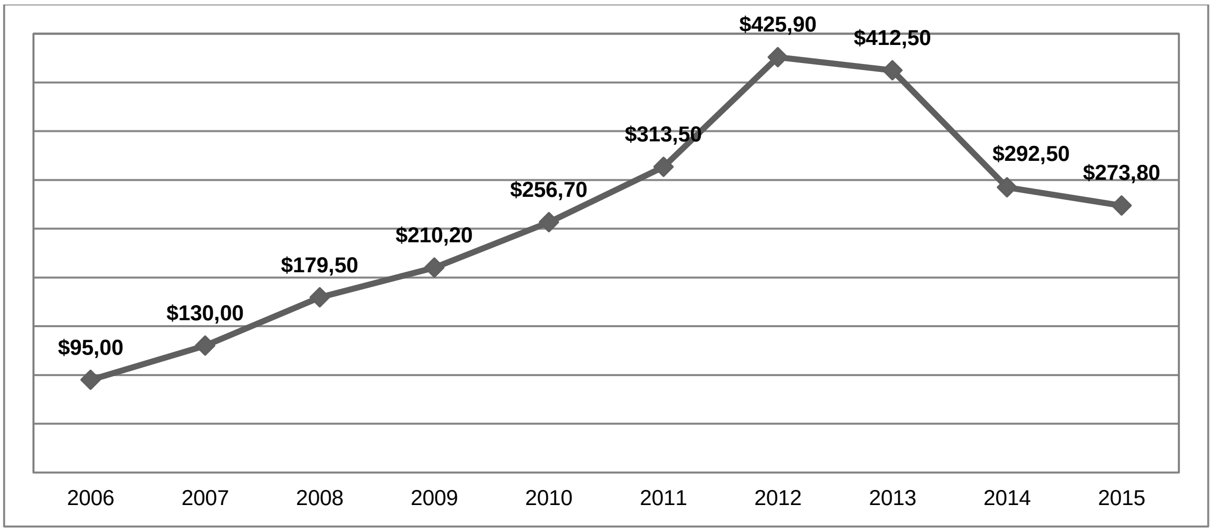

Figure 4.2: Development of the natural gas price between 2006 and 2015 in Ukraine, $/1.000 m³ gas
(Center EIR 2016)

Although scholars have not found a significant correlation between the natural gas price and biogas investments in developed countries (Sick 2014), a positive impact of high natural gas prices on the top-managers´ willingness-to-invest in biogas is expected (Table 4.15).

Table 4.15: Natural gas price
(Author´s concept)

Num.	Hypotheses	
16.	The higher the perceived natural gas price, the higher is the willingness-to-invest in biogas.	
Item		**Author**
Today´s natural gas price makes biogas an attractive investment.		Author´s concept based on expert interviews

4.1.5 Willingness-to-Invest in Biogas and Actual Biogas Investment

The Theory of Planned Behaviour, described in Section 3.2.1, suggests the relationship between an intention and an actual behaviour. Benninghaus (1976) examined over 100 research studies on this topic. The researcher argued that in approximately 30 % of these publications the correlation between intention and behaviour was greater than 0.30. Manstead, Parker (1995) evaluated over 150 scientific papers to investigate this type of relationship and found that a correlation between these two factors equalled 0.62. Six, Eckes (1996) categorised research in this field and concluded that the correlation equalled 0.40. In contrast, Hertel (2014) failed to find a significant correlation between these two variables.

To examine the relationship between the agroholdings´ interest on biogas investment and real biogas investment in the sample, the variables “willingness-to-invest” and “actual biogas investments” were incorporated into the theoretical model. A positive influence of the willingness-to-invest on actual biogas investment is expected (Table 4.16).

Table 4.16: Willingness-to-invest in biogas and actual biogas investment
(Author´s concept)

<table>
<tr><th>Num.</th><th colspan="2">Hypotheses</th></tr>
<tr><td>17.</td><td colspan="2">The higher the willingness-to-invest in biogas, the higher is the probability of an actual biogas investment.</td></tr>
<tr><th colspan="2">Item</th><th>Author</th></tr>
<tr><td colspan="2">We will invest in biogas in the following three years.</td><td rowspan="2">Ajzen (1991)</td></tr>
<tr><td colspan="2">What kinds of renewable energies have you invested in today?</td></tr>
</table>

4.1.6 Empirical Model and Research Hypotheses

The literature review has provided the basic knowledge for developing the conceptual model presented in Figure 4.3. Furthermore, a series of exploratory interviews with renewable energy experts in Ukraine (see Section 5.1) was conducted to refine the theoretical model.

The perceived investment attributes payback period, investment costs, relative advantage, perceived risk and technological complexity were defined from the literature analysis and confirmed during the expert interviews as decision-relevant. Additionally, the organisational factors economic situation, energy costs, company size, and the business environment factors green tariff, business uncertainty and capital availability, as well as the personal factors of the decision-maker risk aversion and innovativeness were determined from the scientific literature and further confirmed in the expert interviews. The factors perceived need for waste recycling and the perceived height of the natural gas price were developed from the results of the expert interviews.

The two-stage model examines which factors have influence on the top-managers´ willingness-to-invest in biogas and on actual biogas investments. The first stage of the model examines which factors have influence on the willingness-to-invest in biogas. This stage consists of four general categories of decision-relevant aspects: perceived investment attributes (see also Section 3.1 and Section 4.1.1), organisational (Section 3.1.2, 3.2 and Section 4.1.2), personal (Section 3.2, 3.3 and Section 4.1.3) and business environment factors (Section 3.1, 3.2 and Section 4.1.4).

The second stage investigates relationships between the intention to invest in biogas (willingness-to-invest) and actual investments in biogas (Section 3.2.1 and Section 4.1.5). It is expected that actual biogas investments are significantly influenced by the top-managers´ willingness-to-invest in biogas.

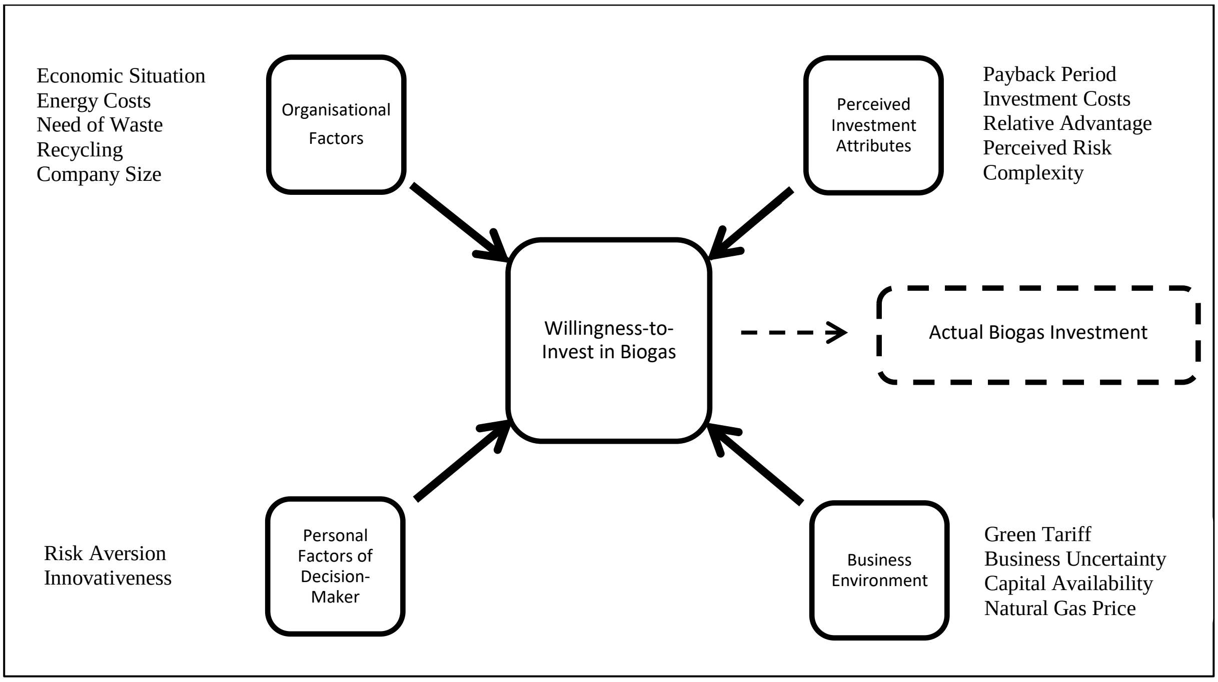

Figure 4.3: Conceptual model

The model variables were operationalised combining quantitative and qualitative scales, as appropriate. Interview partners were asked to express their individual agreement with the statements reflecting the model variables. For these statements a 5-point Likert scale was used: from 1 – “agree strongly” to 5 – “disagree strongly”. The statements were developed from the literature review and the results of the expert interviews. The next chapter illustrates the research design and how the theoretical preliminary work has been implemented in the empirical study.

5 Research Design

The present chapter describes the research design developed under the framework of the doctoral thesis. The research design aims at addressing the research questions (see Section 1.2) and at translating the conceptual model into empirical steps. Scholars suggest that a well-articulated research design is a fundamental step in structuring a scientific survey (Yin 2003; Black 1999). Maxim (1999) assumed that it helps enhance the robustness of the results by minimizing the measurement errors. The research design of the present study includes a combination of qualitative and quantitative methods. As argued by Snow, Thomas (1994), this combination should be selected due to the complexity of the research questions and the variables to be investigated. Figure 5.1 shows the main steps of the research design of the present study.

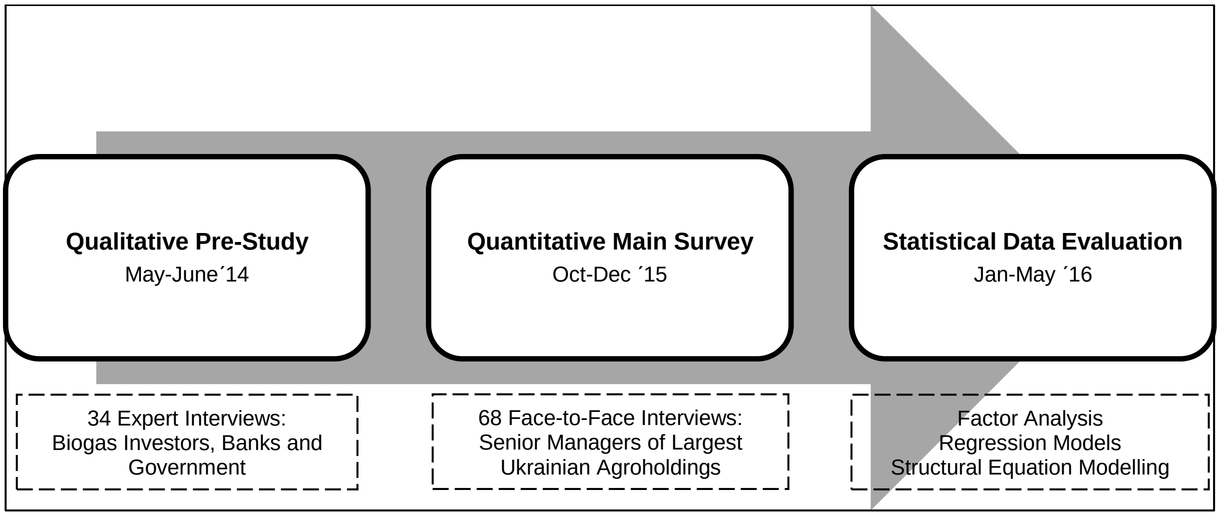

Figure 5.1: Main steps of the research design

As a first step, a qualitative preliminary study was conducted. At this stage qualitative methods, such as a literature analysis, expert interviews and a questionnaire pre-test were applied. The preliminary study was made to gain a solid understanding of the main problems, related to the biogas implementation in Ukraine´s agricultural sector. Special attention was devoted to the literature review to identify the decision-influencing variables. Then, to test and refine the conceptual model, interviews with selected experts in the field of renewables in Ukraine were conducted. The purpose of the expert interviews was to gain an in-depth understanding of the biogas industry and to set up a database for the main survey. Additionally, the content validity of various model constructs had to be assured in the preliminary study. Finally, a pre-test questionnaire was filled out during the interviews and it helped refine the questionnaire structure, eliminate unnecessary and reformulate unclear questions. The second step was to launch an interview-based survey questionnaire. The main survey was administered to a sample of top-managers of large Ukrainian agroholdings. Despite a limited access to senior managers of Ukrainian agroholdings, 68 top-managers out of approximately 112 operating agroholdings[28] in Ukraine were interviewed (Ukrainian Agribusiness Club 2015, p. 12).

Finally, the data collected were analysed by means of the appropriate statistical methods to best answer the research questions (see Section 6.1). Furthermore, during all three stages of the research design the doctor thesis was disseminated to scholars and practitioners in Ukraine and Germany through academic conferences[29], which made it possible to present the research findings and to improve the quality of the present work by gaining useful feedback. A more in-depth description of the survey process is provided in the next sections.

[28] The current development of agroholdings, including their overall amount, was presented in Section 2.2.2.

[29] Between 2014 and 2016 this project was presented on five international and national conferences in Ukraine and Germany, thoroughly collecting and implementing the participants´ feedback into the data processing. This helped ensure quality of the present doctor thesis.

5.1 Qualitative Preliminary Study

Due to the lack of available data on biogas investments in Ukraine´s agricultural sector, a qualitative pre-study approach was chosen. The aim of the preliminary study was to elucidate "why questions" relating to biogas investments in Ukraine. For instance, I was interested in the barriers to and driving forces for agricultural producers regarding biogas projects. Additionally, I wanted to examine the theoretical model and refine the questionnaire. Based on Ehlers (2008), expert groups in four sectors, responsible for biogas implementation in Ukraine, were selected. First, agroholdings, which had already operated biogas plants, were determined. Second, the key financial institutions, which provide capital for renewable projects, were found. Third, I spoke to state authorities and non-governmental organisations (NGOs), which support the development of renewable energies in Ukraine. Finally, major Ukrainian professional associations in the field of renewables were contacted. The administration of the preliminary study took place in Ukraine between May and June 2015. In total, 34 face-to-face interviews were conducted, which have since been further evaluated by applying qualitative research methods (Naderer, Balzer 2011; Kuckartz 2012; Mayring 2010). A semi-structured interview guide, designed after Gläser, Laudel (2008); Mayring (2007), was used. Table 5.1 provides the description of the expert groups interviewed in the preliminary study.

Table 5.1: Structure of the interviewed expert groups (n = 34)

1. Agroholdings with operating biogas plants	
Company type	**Description of the biogas project**
Poultry farm	5,000 KW_{el} biogas
Pig farm	1,000 KW_{el} biogas
Sugar mill	1,000 KW_{el} biogas
Cattle farm	n.s.
Juice producer	Biogas plant has been implemented into the company water treatment system.
2. Financial institutions, supporting biogas investments	
World Bank	Finances projects in all major forms of renewable energy in Ukraine
European Bank of Reconstruction and Development (EBRD)	Finances investments in renewables, energy efficiency and agricultural sector in Ukraine
International Finance Corporation (IFC)	Finances investments in renewables, energy efficiency and agricultural sector in Ukraine
Ukrainian Sustainable Energy Landing Facility (USELF)	Finances only renewable energy investments in Ukraine
3. State authorities and NGOs, promoting biogas implementation in Ukraine	
State Agency of Energy Efficiency of Ukraine (SAEE)	Regulation of legal and policy framework for renewables
Ministry of Ecology of Ukraine	Implementation of projects after the Kyoto Protocol
Ministry of Regional Development of Ukraine	Implementation of joint ventures in the field of renewables
International Chamber of Commerce of Ukraine (ICC)	Policy consulting in the field of renewables
Global environmental facility of the United Nations (UNIDO/GEF)	Due-diligence and financing of renewable energy projects
4. Professional associations	
Uabio	A major association of biomass industry in Ukraine
Ukrainian Wind Energy Association (UWEA)	Wind park developing
Bioenergy Association of Ukraine (BAU)	Union of Ukrainian pellet producers

5.2 Quantitative Main Survey

A key step of the research process was the quantitative survey. To this end, a list of target agroholdings, identified through data collection, was set up. Additionally, a semi-structured questionnaire, based on the findings of the preliminary study, was prepared. In the following sections the questionnaire structure[30] and the data collection process will be described.

5.2.1 The Questionnaire Structure

The questionnaire covered three main areas: prior and future biogas investments in agroholdings, top-managements´ attitudes towards biogas projects and energy management in agroholdings (Figure 5.2). The purpose of the questionnaire was to elicit the decision-influencing factors regarding biogas investments. The other purpose was to evaluate how many agroholdings have already invested and will probably invest in biogas in the next five years.

1. Section — **Prior and future biogas investments of agroholdings**

- Structure of the past and planed future investments of agroholdings
- Currently used capital sources
- Perceived capital availability for new investments

2. Section — **Attitudes towards biogas investments of decision-makers**

- Evaluation of the interest on biogas investments
- Identification of the factors preventing biogas projects
- Assessment of state support measures for biogas

3. Section — **Energy management in agroholdings**

- Perceived increase of energy costs
- Currently used energy sources
- Investments in energy supply

Figure 5.2: The questionnaire structure

In particular, the first part aimed at determining biogas investments in agroholdings. The managers were solicited to provide a structure of past investments and expected future investments in agroholdings, including their key business areas (see Section 7.1.2). In fact, this research targeted a diversified group of agroholdings, which have different hierarchies and are involved in different stages of the agricultural value chain. Therefore, it was neither possible nor appropriate to provide a common structure of investments for the agroholdings studied. To avoid potential misunderstandings, their investment activities were divided into four categories: investments in biogas, investments in renewable energies (excluding biogas), investments in key business areas and investments in new businesses or markets (excluding renewables and biogas). In addition, the interview partners were asked about the capital sources of these investments and the perceived capital availability for new projects.

The second section of the questionnaire was dedicated to assessing the top-managements´ attitudes towards biogas investments (see Section 7.1.3). Moreover, the respondents were asked to evaluate the interest of their companies in investments in renewable energies, including biogas. Then, the interview partners were asked to assess factors limiting their biogas investments. Additionally, the senior managers were questioned to evaluate the state support mechanisms of biogas, described in Section 2.1.3. The top-managers were expected to specify the minimal green tariff rate, acceptable for them to invest in biogas. However, a majority of the respondents knew neither the current green tariff rate for biogas nor the minimal satisfactory tariff rate for their business.

The purpose of the third section was to assess the energy management in agroholdings: the perceived increase of energy costs, currently used sources of heat power and the preferences for an investment in a desirable energy source.

[30] The full version of the questionnaire is provided in Section 11.1.

When the questions investigating the energy efficiency measures in agroholdings were asked, the senior managers were requested to express their degree of agreement with several statements relating to their attitudes towards the need for improving company energy management. Finally, the questionnaire included a series of farmographic questions covering the agroholding profile. The respondents specified key areas of their businesses, total revenue, arable land and livestock availability. To determine that an impact of the interview partner on the investment decisions existed, he or she was asked for his or her position in the agroholding and his role in the decision-making process. Table 5.2 summarises the model variables and the items used for the statistical data analysis.

Table 5.2: Operationalisation of the model variables

Variable	Items	Source
Payback Period	If the payback period for biogas exceeds six years, then such a project is not interesting for us.	Pannell, Marshall (2006)
Investment Costs	Biogas requires large capital investments.	Reise et al. (2012)
Relative Advantage	Biogas has more advantages for us than using natural gas.	Tornatzky, Klein (1982); Rogers (2003)
	Biogas can improve the financial situation of our company.	Tornatzky, Klein (1982); Rogers (2003)
	We consider biogas to be an attractive investment.	Tornatzky, Klein (1982); Rogers (2003)
Perceived Risk	Please, evaluate an overall risk of a biogas investment for your company. [From very high to very low]	Mitchell (1999); Newall (1977); Esty, Winston (2009)
Technological complexity	Biogas is a complicated technological process.	Pannell, Marshall (2006)
Economic Situation	We are satisfied with the financial situation of our company.	Granoszewski, Spiller (2012); Kollmann, Herr (2008)
	Our financial situation does not allow investing in new projects.	Granoszewski, Spiller (2012); Kollmann, Herr (2008)
	Key results of our business (revenue, profit) from 2012 to 2014 were excellent.	Granoszewski, Spiller (2012); Kollmann, Herr (2008)
Perceived Need for Waste Recycling	Recycling of production waste is a problem for our company.	Author´s concept based on expert interviews
	Production waste of our company has led to conflicts with local citizens.	Author´s concept based on expert interviews
Company Size	What number of hectares does your company cultivate in 2014/2015 financial year? [ha]	Voss et al. (2008) Reise et al. (2012)

Variable	Items	Source
Risk Aversion	When making decision regarding new investments we choose a project with a lower risk.	Voss et al. (2008); Sauer, Zilberman D. (2010)
	To achieve higher profits we are ready to take higher risks in business.	Voss et al. (2008); Sauer, Zilberman D. (2010)
Innovativeness	We are always among the first in Ukraine who apply and use modern agricultural technologies.	Willock, J., et al. (1999)
Green Tariff	Investments in biogas without state guaranteed feed-in tariff are not interesting for us.	Menichetti (2010); Liebreich (2009)
Business Uncertainty	We are not sure in the development of economic situation in Ukraine and we are now cautious with new investments.	Li, Atuahene-Gima (2002)
Capital Availability	Interest rates in Ukraine make biogas investments not attractive for us.	Zinych, Odening (2009)
Natural Gas Price	Today´s natural gas price makes biogas an attractive investment.	Author´s concept based on expert interviews
Willingness-to-invest in biogas	We will invest in biogas in the following three years.	Ajzen (1991)
Actual biogas investment	What kinds of renewable energies have you invested in today?	Ajzen (1991)

5.2.2 Data Collection and Data Preparation

As a first step of data collection, a database of target agroholdings was set up. Because contact details of agroholdings and their senior managers are not publicly available in Ukraine, gathering this information was a challenge. Therefore, multiple sources were used, including professional agricultural associations in Ukraine, direct contacts on conferences, company websites and other specialised directories. Additional sources of information included ratings of the largest Ukrainian agroholdings[31], provided by Agro times (2015), Latifundist.com (2015) and the Ukrainian Agribusiness Club (2014b). Overall, a list of about 120 companies from every part of Ukraine was collected. Due to the difficult political situation in East Ukraine and the Crimean peninsula, the companies from these regions had to be excluded from the sample.

The data collection took place between October and December 2015 in Ukraine. First, a written or a web-based form of data collection was considered. However, when asking about internal company information, e.g. investment volumes, managers may become reluctant to fill-in questionnaires. After consultations with industry experts, I decided to conduct personal interviews with the top-managements of agroholdings, since this would allow the senior managers to examine the credibility of the interviewer and to gain additional information managers could have been interested in. From October to December 2015, 68 face-to-face interviews with the top-managers of agroholdings from the collected database were conducted.

The senior managers, selected for the main survey, received individual invitations via email with complete information concerning the research project. Then, a personal appointment at the time and location best suited for the interview partner was agreed on personally per telephone. As recommended by Huber, Power 1985, in order to limit the impact of self-assessment and to secure the accuracy of responses, a completely confidential processing of the collected information was guaranteed, and I promised to share the final results with the managers. Given the confidential character of the data collected, all model variables had to be measured by questionnaire. This represents a limitation of the present study. In an ideal case, to measure investment activity of agroholdings, objective data on the investment performance of these companies should have been used. Due to the reluctance of senior managers to disclose some specific information on their businesses, generally perceptual values had to be applied in the main study.

The collected data have been transferred into the statistical software IBM SPSS 23 and SmartPLS 2.0 and further evaluated using three different quantitative methods. Which kind of statistical techniques have been applied for the data analysis will be explained in the next chapter.

[31] The agroholdings were rated by the total revenue and the amount of arable land.

6 Quantitative Research Methodology

Two statistical research methods were adopted to evaluate the empirical model: multinomial regression (linear and logistic) analysis and structural equation modelling. In order to simplify the regression analysis and to investigate interrelationships between independent variables, a factor analysis was applied in the first stage of the data analysis. The selection of these statistical techniques was largely determined by the limited sample size (n = 68). The second criterion was the research questions, as both regression analysis and structural equation modelling are often applied to analyse influences between a set of dependent and independent variables (Schendera 2008; Hair 2014a; Backhaus et al. 2006).

The purpose of the multivariate regression analysis was to evaluate the statistical robustness of the conceptual model, explaining the willingness-to-invest in biogas of Ukrainian agroholdings (see Chapter 4). Additionally, the two following objectives have been set:

1. To assess the magnitude and direction of influence of particular independent variables, incorporated into the model, on the target variable (willingness-to-invest in biogas);
2. To study the characteristics best suited to differentiate agroholdings with biogas investments compared to those which have not invested in biogas thus far.

Moreover, one of the structural equation modelling approaches, called the Partial Least Squares (PLS) method, has been used to answer the following questions:

3. To provide intermediate evaluation of the empirical model by analysing the impact of every factor group on the willingness-to-invest in biogas;
4. To identify the relationship between the willingness-to-invest in biogas and actual biogas investments.

The selected statistical methods helped answer the specific research questions of the present work (Table 6.1).

Table 6.1: Application of the statistical methods in relation to the research questions

Research question		Multivariate data analysis techniques
1.	Which factors have a significant influence on the top-managers´ willingness-to-invest in biogas?	Multivariate linear regression
2.	Is there a difference in the influencing factors of top-managers with previous biogas investments compared to those which have not yet made this kind of investments?	Binomial logistic regression
3.	Does an existing willingness-to-invest in biogas lead to actual biogas investments?	Structural equation modelling

The following sections provide a description of the chosen quantitative methods and the way they have been applied in the present study.

6.1 Explorative Factor Analysis

Factor analysis is the first multivariate method applied in the present work. Explorative factor analysis is a statistical technique used to examine the interrelationships among a set of variables (Afifi et al. 2004, p. 391). The purpose of the factor analysis is to discover which variables in the original set form unique subsets, relatively independent from each other (Tabachnick, Fidell 2007, p. 607). The resulting coherent subsets of variables, obtained in the factor analysis, are called factors. Mathematically, the extracted factors are linear combinations of original variables (Backhaus et al. 2008, p. 330). In the context of the present study, the purpose of the factor analysis is to reduce a large number of identified decision-influencing variables to a smaller number of factors. Figure 6.1 illustrates the fundamental idea of this statistical method.

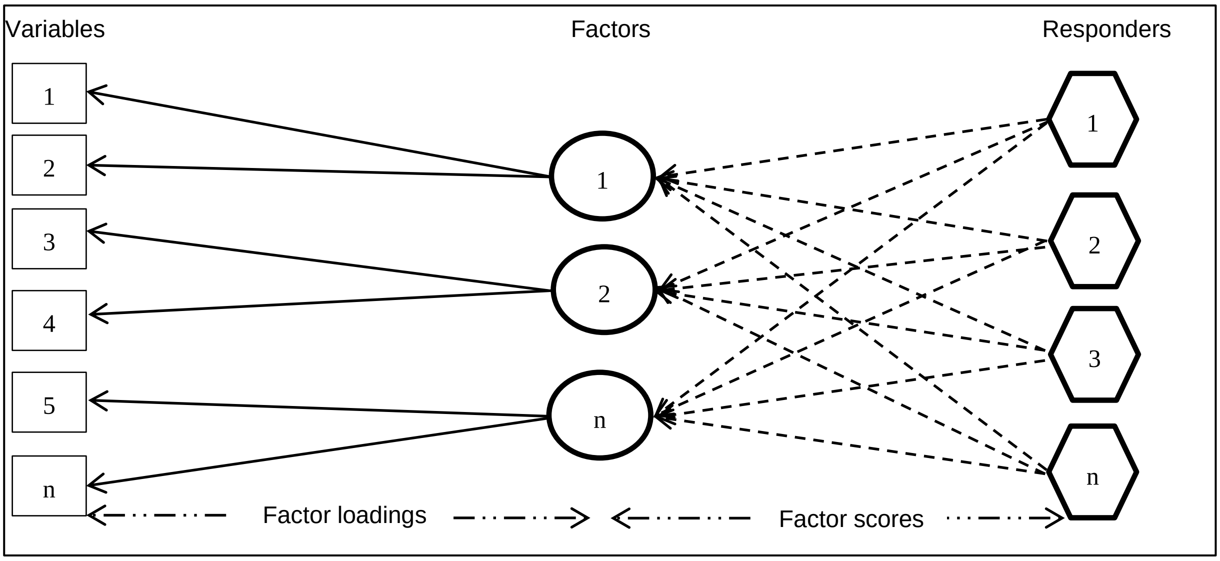

Figure 6.1: Basic idea of the factor analysis
(Based on Backhaus et al. (2008, p. 323))

Performing a factor analysis on the data obtained is an iterative process, conducted in a sequence of four major steps (Hatcher, O'Rourke 2014, ©2013[32]):

1. Analysis of the correlation matrix;
2. Initial extraction of the factors;
3. Rotation;
4. Assigning factor scores.

Factor analysis is very sensitive to the correlations between the variables in the original set. Thus, an appropriate selection of variables is of high importance. The variables have to be scaled metrically and standardised[33] (Afifi et al. 2004, p. 393). Next a correlation matrix including all variables to be analysed will be produced. The quality of the initial data can be examined with the coefficients of this matrix. For this purpose scholars apply “measure of sampling adequacy” also called Kaiser-Mayer-Olkin-criteria (KMO). The value of this criteria ranges between 0 and 1, whereas values lower than 0.5 are boarder-line unacceptable (Backhaus et al. 2008, p. 336). In this case the variables with KMO < 0.5 should be eliminated from the set analysed.

The second step of the analysis involves the initial extraction of factors. There exist numerous procedures for factor extraction: principal components, principal factors, irritated components, image factoring, maximum likelihood factoring, etc. (Tabachnick, Fidell 2007, p. 633).

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[32] No page reference is possible because this is an online source.

[33] In this case the mean of the variable is equal to 0 and its standard deviation is equal to 1.

The goal of the principal components method, applied in the present work, is to maximise the extracted variance with as few factors as possible. To measure the variance scholars use two values: communality and eigenvalue. While both indicate the extent of the variance, explained by the factors, they are different. The eigenvalue shows the amount of variance which is accounted for by a given factor, whereas communality represents the variance extent of one variable, explained by all factors (Brosius 2011, p. 799). After extracting the initial factors, one should examine their quality criteria. For this scholars adopt several methods: KMO-criteria, the scree test, proportion of variance accounted for and interpretability criteria (Hatcher, O'Rourke 2014, ©2013). The first two, usually applied by scientists, will be explained. According to the KMO-criteria, the extracted factors with eigenvalues lower than 1 have to be eliminated from the factor model. In this case, the factor would explain a smaller variance range than a variable itself (Klein 2010, 2010, p. 40). The size of the relationship between extracted factors and original variables is expressed by the factor loading (see Figure 6.1), which equals to their correlation coefficient. The second method is graphical. With the scree test one plots eigenvalues and looks for a break between factors with larger and smaller eigenvalues (Backhaus et al. 2008, p. 353). The number of factors can be also determined by the user. Computer tools, used for factor analysis, provide numerous functions for this procedure.

After initial factors have been extracted and their number defined, the analyst interprets the factors. The interpretation of factor patterns is easier when the analysed variables have high loadings on an extracted factor, while the loadings of remaining variables are near-zero (Hatcher, O'Rourke 2014, ©2013). However, the initial results may be difficult to interpret. To improve the interpretability of results, scholars perform a linear transformation of the factor pattern, called rotation, applied to maximise correlations between factors and variables and to minimise low ones (Tabachnick, Fidell 2007, p. 620). There are two main rotation types: orthogonal and oblique. In orthogonal rotation the factors are uncorrelated. The purpose of this method is to maximise the variance of loadings on each factor and, therefore, to ease interpreting the results. Among numerous orthogonal rotation techniques the most common are varimax, quartimax and oblimax methods (Brosius 2011, p. 805). If the researcher assumes that factors are correlated, oblique rotation can be applied. However, this technique may bring practical disadvantages in interpreting the results (Tabachnick, Fidell 2007, p. 638).

Once the factor analysis is complete, factor scores respondents have for each factor can be obtained (see Figure 6.1). Factor scores represent a participant´s actual characteristic of a given factor and may be saved in the statistical programme for further analysis (Backhaus et al. 2008, p. 358). To examine the quality of the final results, Cronbach alpha criterion may be applied. This technique measures the reliability (or consistency) of the extracted factors (Brosius 2011, p. 823). In the context of the present work, the results of the factor analysis will be used for the multivariate regression analysis. The next two sections describe how these techniques will be applied.

6.2 Multivariate Linear Regression

Multivariate linear regression analysis is a statistical technique in which one variable is explained by a combination of several other variables. Mathematicians define three typical purposes of a regression analysis: modelling the relationship between Y (dependent variable) and x (independent variable), prediction of the dependent variable (forecasting) and testing of hypotheses (Chatterjee, Simonoff 2013, p. 4). The linear equation of regression is expressed as follows (Fahrmeir et al. 2009, p. 60):

$$\hat{Y} = b_0 + b_1x_1 + b_2x_2 + \ldots + b_jx_j;$$

where:

$\hat{Y}$ = predicted (fitted) value of Y (dependent variable)
b_0 = Y-intercept (the value of Y when all x values are zero)
$x_1 \ldots x_j$ = independent variables (from 1 to j)
$b_1 \ldots b_j$ = regression coefficients, assigned to the independent variables during regression

A method for the estimation of regression model is called least squares, which aims at minimising the sum of squared deviations of the observed values of the dependent variable from its estimated expected values. The difference between the observed and the estimated expected values of the dependent variable is called the residual (Chatterjee, Simonoff 2013, p. 21). A primary goal of the regression model is to estimate the unknown parameters $b_1 \ldots b_j$. Table 6.2 provides the most relevant quality criteria of a regression analysis, their acceptable values and practical relevance.

Table 6.2: Quality criteria for the analysis of linear regression model
(Based on Schendera (2008, pp. 35–67))

Quality criteria	Acceptable range of values	Description
Examining the quality of the model		
Coefficient of determination (R^2 or “goodness of fit”)	R^2 values preferably high. In general, $R^2 \geq 0.5$ is favoured (in some research fields $R^2 < 0.5$ is also acceptable).	Estimates the variance of the dependent variable, which is explained by the regression model.
F-Statistics	F values preferably high. In some cases the F-value can be compared to standard table F-values (Backhaus et al. 2008, p. 74).	This is a test of the overall significance of the regression model. It helps answer the question whether any of the independent variables have predictive power for the dependent one.
Standard error of the estimate	Value preferably small.	Represents the variation unexplained by the regression model.
Examining the regression coefficients		
T-value	Value preferably high and statistically significant.	It is a test of significance of individual regression coefficients. This value shows whether a particular independent variable has predictive power on the dependent one.
Beta-value (standardized regression coefficient)	Value preferably high and statistically significant.	Represents the change in the dependent variable associated with a change of a particular independent variable in one unit.

The quality criteria of a regression analysis depend on the basic assumptions of the model and data and should be checked for accuracy before performing a regression analysis. Table 6.3 shows the most relevant premises, their explanation and acceptable values (Schendera 2008, pp. 132–139).

Table 6.3: Assumptions of the regression model
(Based on Fahrmeir et al. (2009, pp. 64–72))

Model assumption	Acceptable range of values	Description
Ratio of cases to independent variables in the model	$N \geq 50 + 8\,M$; M = a number of independent variables in the regression model; N = sample size	Required sample size depends on various issues, e.g. the desired explanation power of a model or a number of predictors. As a rule-of-thumb scholars recommend at least ten cases per one independent model variable.
Absence of outliers among the model variables (dependent and independent) and in the solution	Screening test prior to a regression estimation or residual analysis after an initial run	Regression coefficients are sensitive to the extreme cases (outliers) in the data sample. Outliers impact the regression estimation and the precision of regression weights. Therefore, the outliers should be detected and deleted or the variables transformed.
Absence of multicollinearity	Variance Inflation Factor $VIF \leq 1.896$ or graphical test	Multicollinearity means that independent model variables are highly correlated with each other. This phenomenon leads to wrong interpretation of regression coefficients.
Homoscedasticity, linearity and normality of residuals	Examination of residuals, scatterplots or Goldfeld/Quandt-test	The variance of residuals should be constant (homoscedasticity). The violation of this assumption leads to inefficient estimation of model parameters.
Absence of autocorrelation	Graphical screening test or Durbin-Watson-test	Residuals should be uncorrelated with each other. The violation of it results in wrong assessment of the model strength.
Normality of residuals	Examination of residuals or scatterplots	Residuals should follow a normal distribution curve. Otherwise hypothesis tests may be misleading.

6.3 Binomial Logistic Regression

Logistic regression is a special type of regression model which allows to predict a discrete outcome, such as a group membership, from a set of variables (Tabachnick, Fidell 2007, p. 437). In contrast to standard linear regression models, logistic regression predicts not the outcome itself, but the probability of its occurrence (Backhaus et al. 2008, p. 245). Logistic regression is often used whenever an individual or an object (the result of an action) is to be classified into one of several groups (Afifi et al. 2004, p. 282). Because of its functionality this method has been widely used in medicine (probability of catching a disease), finance (probability of bankruptcy) and consumer research (buying or not buying a product). Contrary to the linear analysis, the logistic method examines nonlinear relationships between the outcome (dependent variable) and a combination of its predictors[34] (independent variables). Mathematical formula below describes these relationships (Tabachnick, Fidell 2007, p. 438):

$$P_z = \frac{e^{\alpha+\beta_1 x_1+\cdots+\beta_n x_n}}{1+e^{\alpha+\beta_1 x_1+\cdots+\beta_n x_n}};$$

where P_z is a probability that a Z_{th}-outcome is in one of the analysed categories, and Z is a linear regression equation (see Section 6.2) of the dependent variable Z and predictors “x_1 ... x_n”: $Z = \alpha + \beta_1 x_1 + \cdots + \beta_n x_n$. To produce a new interpretation, this formula has been modified, defining an odds ratio:

$$odds = \left(\frac{P_z}{1-P_z}\right).$$

As probability values vary from 0 to 1, and a linear combination of variables is not expected to be limited to these numbers, scholars perform an odds ratio formula by taking a logarithm of odds:

$$\ln(odds) = ln\left(\frac{P_z}{1-P_z}\right) = \alpha + \beta_1 x_1 + \cdots + \beta_n x_n = Z.$$

The Z values, estimated by this logistic regression equation, are called Logits (Backhaus, Voeth 2010, p. 249). These values vary between plus infinity and minus infinity. After further algebraic procedures the Z values may be converted into probabilities [0;1] of being in one of the analysed groups. The goal of the logistic model is to determine the optimal linear combination of independent variables (predictors) for obtaining the observed outcome (Tabachnick, Fidell 2007, p. 439). This is followed by the estimation of regression coefficients $\beta_1...\beta_n$ through a procedure called a maximum likelihood. The underlying principle is to estimate β-coefficients with the values, which give the data collected the highest probability of occurring (Chatterjee, Simonoff 2013, p. 156). Figure 6.2 shows the types of relationships between the values in the logistic regression model.

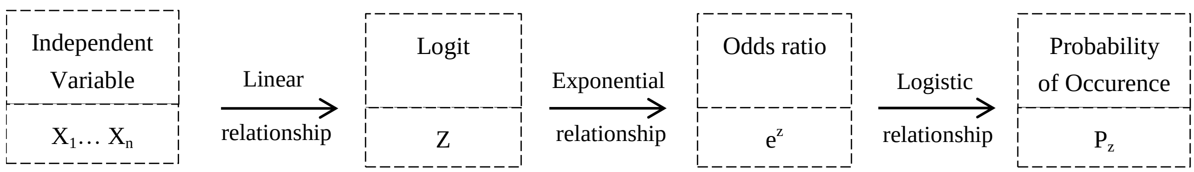


Figure 6.2: Types of relationships between the values in the logistic regression model
(Based on Backhaus et al. (2008, p. 251))

The Logit values Z represent a linear combination of predictors. Therefore, they can be interpreted analogically to the linear regression coefficients. The odds ratio shows the change in odds of belonging to one of the outcome categories, when one of the predictors changes by one unit (Tabachnick, Fidell 2007, p. 461). The Logit values show the direction in which the probability of occurrence changes (positive or negative). The odds ratios quantify the influence of predictors on the dependent variable. For the estimation of the model quality, mathematicians apply three types of criteria: log-likelihood functions, goodness-of-fit values and information criteria tests. Table 6.4 describes these quality criteria types and gives acceptable ranges of their values.

[34] A regression model may also contain only one predictor. However, in the present work I was more interested in the analysis of relationships between a set of predictors and two dependent variables.

Table 6.4: Quality criteria for the analysis of logistic regression model
(Based on Backhaus et al. (2008, pp. 256–288))

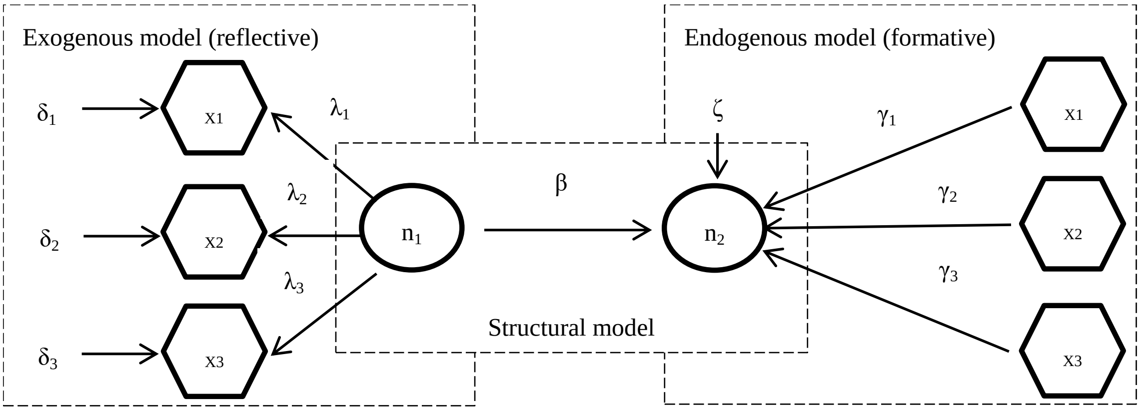
Quality criteria	Acceptable range of values	Description
Log-Likelihood function		
Deviance statistic	Value near 0, significance near 1	Comparison with a “perfect” hypothetical model.
Likelihood-ratio test	Chi-square value preferably high, significance level < 0.05	Characterises the significance level of the model. Shows the applicability of results on the whole population.
Pseudo R²		
McFadden	> 0.2 acceptable, > 0.4 good	Suggests the level of improvement of the zero-model over the full model.
Cox and Snell	> 0.2 acceptable, > 0.4 good	Provides a comparison of Likelihood values. It also weights the R² over a sample size.
Nagelkerke	> 0.2 acceptable, > 0.4 good	Shows the extent of the variance of dependent variable through independent variables.
Classification results		
Hosmer-Lemeshow	Chi-square value preferably high	Examines the deviation between predicted and observed values.
Press´s Q-test	Chi-square value preferably high, significance level < 0.05	Examines the model with Chi square value.

The next step of the model fit is to examine the classification accuracy of the logistic model. The measure of predictive accuracy corresponds to the percentage of cases correctly classified and is called the hit ratio (Hair 2014b, p. 335). The comparison standards for the hit ration are the maximum and proportional chance criteria. The first one is calculated as the percentage of respondents in the largest group. The latter value considers the group sizes and is calculated as $a^2 + (1-a)^2$, where a is the share of the largest group (Backhaus et al. 2008, p. 267). With acceptable model fit and hit ratios, the analyst can next turn his attention to assessing logistic coefficients to identify significant relationships affecting the group membership. First, the estimated coefficients can be evaluated for statistical significance. If the coefficient is significant, it can be interpreted in terms of its influence on the estimated probability of an outcome investigated, and thus the prediction of the group membership. For this purpose the Wald statistic is applied in a similar manner to the t-test in a linear regression (see Table 6.2). As a rule-of-thumb, coefficients with the largest Wald value should be considered significant and can be further interpreted to identify the direction and magnitude of the relationships each variable has on the predicted probabilities and group membership. For these purposes researchers examine the original regression coefficients B and the exponentiated coefficients Exp (B), which are a transformation (antilog) of the first (Hair 2014b, p. 325). To assess the direction of relationships of each factor, statisticians can examine both coefficients. Starting with the initial coefficients B the direction can be interpreted from the coefficient sign. However, the exponential coefficients Exp (B) reflect the direction differently, because they are logarithms of the original coefficients B and, therefore, do not have negative values. If a coefficient B is 0.0 (no effect on the dependent variable), its logarithm is 1.0. In this case, exponential coefficients equal 1.0 and correspond to the relationship between an independent and dependent variables with no direction. Thus, Exp (B) > 1.0 expresses a positive relationship and Exp (B) < 1.0 reflects a negative one. In addition to the direction of relationships between model variables, researchers quantify the magnitude of these relationships. The change in the probability of the studied event given a one-unit change in the independent variable is shown by the magnitude, which is directly reflected by exponential coefficients and can also be assessed as a percentage change (Hair 2014b, p. 329):

$$\text{Percentage change} = (\text{Exp (B)} - 1.0) \times 100.$$

6.4 Structural Equation Modelling

The last method of multivariate data analysis applied in the present study is a combination of statistical techniques, which allows a simultaneous examination of relationships between a set of dependent and independent variables and is called structural equation modelling (Tabachnick, Fidell 2007, p. 676). In particular, structural equation modelling involves factor and regression analysis, explained in Section 6.1 and 6.2. The major questions which structural equation modelling helps to answer are testing theories, reliability of indicators and group differences. As this technique incorporates regression analysis, structural equation modelling should fulfill similar requirements to data: sufficient sample size, multivariate normality of responses, absence of multicollinearity and outliers[35]. The general aim of structural equation modelling, analogous to that of regression analysis, is to estimate to which degree a theoretical model is supported by the sample of data collected. Figure 6.3 illustrates an exemplary structural model.



n_1, n_2	=	constructs
x_1 ... x_3	=	manifest variable
λ_1 … λ_3	=	factor loading
δ_1 … δ_3	=	error of the indicator

β	=	path coefficient
ζ	=	error of the construct
γ_1 … γ_3	=	factor weight

Figure 6.3: Path diagram of a structural model
(Based on Backhaus et al. (2011, p. 66))

Basically, there are two possibilities for statistical application of structural equation modelling: the variance-based approach and the covariance-based (Haenlein, Kaplan 2004, p. 285). Numerous computer programmes are applied for the structural equation modelling analysis: LISREL, AMOS, PLS. While LISREL is still the most widely-used software for structural equation modelling, a growing number of scholars are adopting a variance-based technique of Partial Least Squares. The main goal of the Partial Least Squares approach is to minimize the variance of the measurement error of all dependent variables in the model. An important advantage of this technique compared to LISREL and AMOS is the ability to distinguish between formative and reflective relationships of factors (see Figure 6.3). If a change in a latent model variable causes a change in the measured indicator, this relationship can be defined as "reflective". In contrast, if a change of the indicators lead to a change of the latent variable, this variable can be called "formative" (Hertel 2014, pp. 95–96). The definition of the causal direction in the structural model depends on the analyst and involves subjective decisions at various steps. The other advantage of Partial Least Squares is that it allows small sample sizes to be analysed. Scholars estimate a minimal requirement on data size at $n > 30$ (Hertel 2014, p. 110). Based on these considerations, Partial Least Squares is the method employed in the present study due to the limited sample size ($n = 68$).

[35] For further requirements on data sample see Section 6.2.

For obtaining valid results, a set of quality criteria of the measurement model has to be fulfilled. Because of its multilevel modelling nature, an evaluation of a structural model consists of three steps: evaluation of reflective and formative model constructs and evaluation of the general structural model. Due to the similarities of the quality indicators to that of regression analysis (see Section 6.2), they will not be repeated in this section. Table 6.5 represents the widely used measurement criteria for Partial Least Squares models.

Table 6.5: Quality criteria for the structural equation modelling
(Based on Weiber, Mühlhaus (2010); Huber (2007); Chin et al. (2006); Bliemel (2005))

Quality criteria	Acceptable range of values	Description
Reflective constructs		
Average variance extracted (AVE)	AVE ≥ 0.5	Shows the ratio between extracted variance and estimation error.
Discriminant validity	$AVE > \lvert r_{max} \rvert^2$	Demonstrates differences in the estimation of constructs.
Indicator loading; t - value	Outer loading ≥ 0.7, t-value ≥ 1.65	Examines the variance of the indicator explained by the construct (see also Section 6.1).
Composite reliability	Cronbach alpha α ≥ 0.7	Measures the reliability (or consistency) of the extracted factors (Section 6.1).
Formative constructs		
Regression coefficient	Coefficient preferably high; if β < 0.1 the construct should be eliminated	Shows the value and direction of influence of the construct on the target value (dependent variable(s), see also Section 6.2).
t-value	t-value ≥ 1.66 (significant by p-value[36] 0.10), t-value ≥ 1.98 (significant by p-value 0.05), t-value ≥ 2.63 (significant by p-value 0.01)	For explanation see Section 6.2.
Multicollinearity	VIF ≤ 4.0	For explanation see Section 6.2.
Structural model		
R^2 or "goodness of fit"	R^2 values preferably high. In general, $R^2 \geq 0.5$ is favoured (in some research fields $R^2 < 0.5$ is also acceptable)	For explanation see Section 6.2.
Total effect (f^2)	$f^2 \geq 0.35$ - large, $0.15 \leq f^2 < 0.35$ - intermediate, $0.02 \leq f^2 < 0.15$ - small	Shows the impact of exogenous constructs on endogenous constructs.
Predictive validity	Stone-Geisser $Q^2 > 0$	Examines the forecasting capacity of the reflective measurement model.

[36] p-value – significance level.

7 Empirical Results

The empirical results of this study are presented in this chapter. First, descriptive statistics for the sample analysed will be introduced. More specifically, after describing the agroholdings´ profiles the chapter investigates their prior and future biogas investments. Additionally, top-managers´ attitudes towards biogas investments and company internal situation will be analysed. Finally, items associated with the individual factors of decision-makers will be discussed. The set of descriptive statistics serves as the fundament for a better interpretation and understanding of the results of the multivariate analysis, presented in Section 7.2.

7.1 Descriptive Statistics

7.1.1 Characteristics of the Sample

Table 7.1 displays descriptive statistics of the sample and shows that the group of top-managers interviewed is diversified with respect to the legal form, key business areas and arable land. The agroholdings in the sample are primarily limited or public liability companies (58.9 % and 27.9 % respectively) and 52 % of them have multiple business areas. In addition to arable and animal farming, 44.1 % of companies are food producers, e.g. meat, dairy or sunflower oil. The diversified business structure supports the common definition of an agroholding as a vertical incorporation of several enterprises in the agricultural value chain (Wandel 2011, p. 62). The total arable area of agroholdings in the sample equals 3.5 M ha, which represents 62.1 % of arable land of all agroholdings and approximately 16.1 % of land of all agricultural companies in Ukraine[37] (including small farms). Due to the lack of official data the classes of arable land and total revenue of agroholdings were developed after the expert interviews (see Section 5.1). The percentages of these classes could not be compared to the average structure of agricultural companies in Ukraine. Respondents are mainly senior executives of agroholdings: 87.0 % of the interviewed managers were in the executive level of agroholdings. The high-ranking profile of the managers interviewed should ensure a certain level of accuracy in the responses, supporting the reliability of the data collected.

Table 7.1: Descriptive statistics of the research sample (n = 68)
(Author´s calculation)

	N	%
Legal form of the enterprise		
Individual private farm	9	13.2 %
Limited liability company	40	58.9 %
Public liability company (including others)	19	27.9 %
Key business areas (multiple answer possible)		
Arable farming	65	95.6 %
Animal farming	50	73.5 %
Food production	30	44.1 %
Others (e.g. fertiliser production)	36	52.9 %
Arable land (ha)		
<10.000	28	41.0 %
>10.000-50.000	24	35.0 %
>50.000	16	24.0 %
Total arable land of the sample	3.5 M ha	62.1 % of the arable land of all agroholdings

[37] Total arable land of all agroholdings = 5.64 ha (2014); total arable land of all agricultural producers = 5.64 / 26 % = 21.69 M ha (2014, see Section 2.2.2).

	N	%
Total revenue ($ p.a. in average from 2012 to 2014)		
<1.000.000	1	1.5 %
>1.000.000-10.000.000	24	35.3 %
>10.000.000-50.000.000	21	30.9 %
>50.000.000	22	32.3 %
Responder´s position in the agroholding		
Executive level	59	87.0 %
Non-executive level	9	13.0 %

7.1.2 Prior and Future Biogas Investments of Agroholdings

A descriptive analysis of the responses revealed past and future investments of agroholdings in biogas. The data indicated that more than half of the agroholdings have already invested in some form of renewable energies (Table 7.2). Of the agroholdings interviewed 48.5 % invested in biomass, primarily to reduce the natural gas consumption and to generate own energy. Therefore, older gas boilers were replaced by straw, wood or pellet heating in areas, where these energy sources were easily available in Ukraine. In the sample 14.7 % of agroholdings were already biogas producers. These projects generally aimed at waste recycling on large animal farms, sugar mills or food processing plants. Investments in other types of renewables, e.g. solar, wind or biofuels have been undertaken by 11.8 % of the companies interviewed. These investments were small-scaled and, to a larger extent, considered by agroholdings as “experiments” (statement of the interviewed top-managers). Over 40 % of agroholdings in the sample have not yet made any renewable energy investments.

Table 7.2: Firms exposure to prior investments in renewable energy (n = 68)
(Author´s calculation)

	N	%
Prior renewable energy investments		
Yes	40	59.0 %
No	28	41.0 %
Investments by technology (multiple answers possible)		
Biogas	10	14.7 %
Biomass	33	48.5 %
Solar, Wind, etc.	8	11.8 %

Additionally, the respondents were asked about their general interest in future investments in biogas and other forms of renewable energies. The results show that agroholdings are generally interested in biomass and biogas technologies (see Figure 7.1). Solar power also received relatively high attention among the surveyed companies. Top-managers characterised solar heating as a cheap source of warm water in summer, which is needed in large amounts for workers during intensive field operations such as harvesting. However, the number of the top-managers, not interested in biomass, biogas or solar technologies, is also relatively high. Generally, this lack of interest can be explained by the fact that the agroholdings perceive initial costs of the renewable technologies as relatively high and the senior managers do not see how they can recoup their initial investments in a short or middle term. Wind energy was not associated with high interest, primarily because the responders already knew about the relatively high initial costs of wind turbines. Similarly, energy plants (short rotation forestry) were not seen as interesting investment, which may be explained by the fact that a majority of managers reported they had not heard about energy plantations previously.

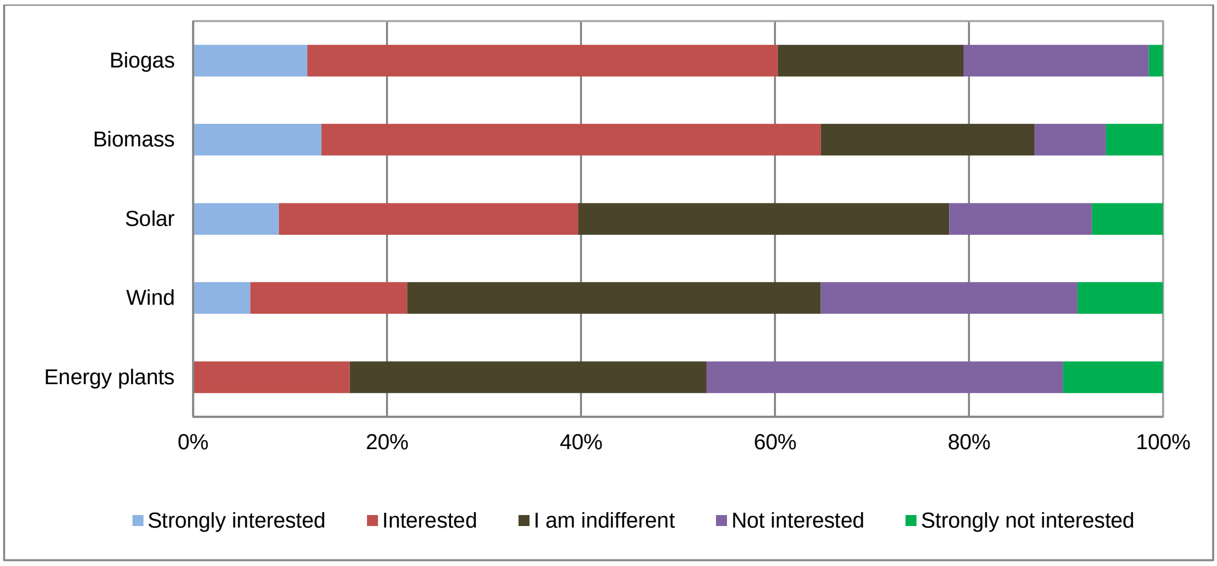


Figure 7.1: Agroholdings´ general interest in future investments in renewable energy (n = 68)
(Author´s calculation)

The next step of the study was to compare previous investments of agroholdings in the last five years and the plans for the next five years, 2009-2014 and 2015-2020, respectively. A five-year corridor was chosen as a middle- to long-term horizon, reflecting strategic decisions of the top-management on agroholdings´ development for 2020. Therefore, the executives´ plans for investments in the following years (2015-2020) were compared with the actual investments between 2009 and 2014. The total number of investments of agroholdings was, thereby, classified into four segments: key business areas (crop or animal farming, food processing, etc.), new businesses (excluding investments in renewable energies and biogas), renewable energies (excluding biogas) and biogas investments. Every top-manager was asked to disclose at least approximate information on every of the four proposed investment directions. Some responders were not sure in their statements concerning both past and future investments[38]. Figure 7.2 illustrates the percentage of investments in each of the four segments, which the top-managers chose for 2009-2014 and 2015-2020, respectively.

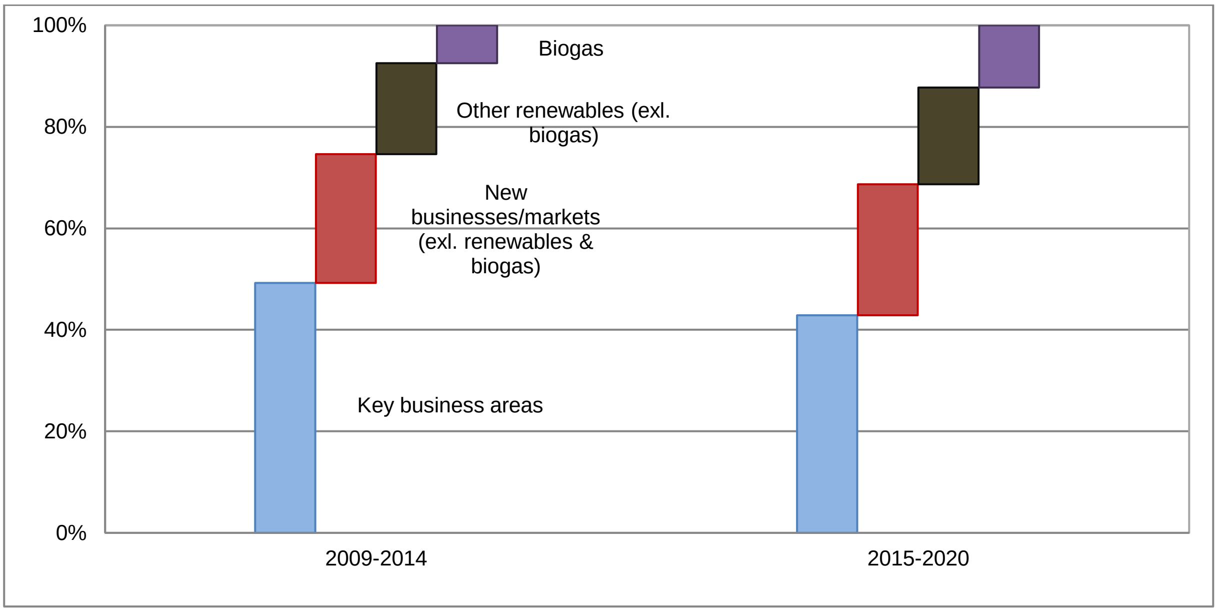


Figure 7.2: Agroholdings´ investments between 2009 and 2014 and from 2015 and 2020 (multiple answers, n = 68)
(Author´s calculation)

[38] This confirms the hypothesis that top-managers face limitations of information regarding investment decisions of their companies, supporting the concept of “bounded rationality”, described in Section 3.3.2.

First, the results revealed no significant differences in the top-managers´ preferences for investments in the compared time horizons (Figure 7.2). The highest portion of investments from 2009 to 2014 was made in key business areas (49.3 %). This proportion may decrease to 42.9 % between 2015 and 2020. Next, 25.9 % of investments of agroholdings are likely to be devoted to opening new businesses/markets from 2015 to 2020, compared to 25.4 % between 2009 and 2014. Here one should consider the role of the Russian embargo on the majority of Ukrainian agricultural goods and services in the years 2014 and 2015. While the Russian market is virtually closed to agroholdings at the moment, the top-managements may be in need of new markets, e.g. the European, or may have to start new businesses to remain economically viable. Despite this situation, the proportion of investments in new businesses/markets was not found to grow significantly. Additionally, due to the instability of Ukrainian economy, e.g. in terms of national currency devaluation and high inflation, domestic markets in Ukraine were not considered by the top-managers as attractive area for new investments. The share of investments in renewable energies (excluding biogas) may increase from the current 17.9 % to 19.0 % between 2015 and 2020. In terms of biogas, the growth from 7.5 % of total investments from 2009 to 2014 was estimated to 12.2 % between 2015 and 2020. This may indicate an increasing interest on biogas investments among large Ukrainian agricultural companies. However, the realisation of this interest depends on Ukraine´s future geopolitical situation.

The Figure 7.2 does not show the overall amount of investments in M USD in the four defined segments, which would provide a more accurate estimation of whether Ukraine´s agricultural sector, together with the renewable energy sector, will attract more or less investments in the future. Unfortunately, there are no official data available on the investment volumes of Ukraine´s agroholdings in general, and no data on the agroholdings´ investments in specific areas, e.g. renewable energy. In the next section top-managers´ attitudes towards biogas investments underlying their decision-making will be analysed.

7.1.3 Decision-Makers´ Attitudes Towards Biogas Investments

In order to evaluate the managers´ attitudes regarding investments in biogas, a statement battery using a 5-point Likert scale was formulated. Statements presented in Figure 7.3 reflect the attitudes towards biogas in the context of the model variables "relative advantage" (Section 4.1.1.3), "investment costs" (Section 4.1.1.2), "payback period" (Section 4.1.1.1), "green tariff" (Section 4.1.4.1), "interest rates" (Section 4.1.4.3), "natural gas price" (Section 4.1.4.4) and "technological complexity" (Section 4.1.1.5). The Figure 7.3 illustrates the arithmetic means of the answers to the respective statements.

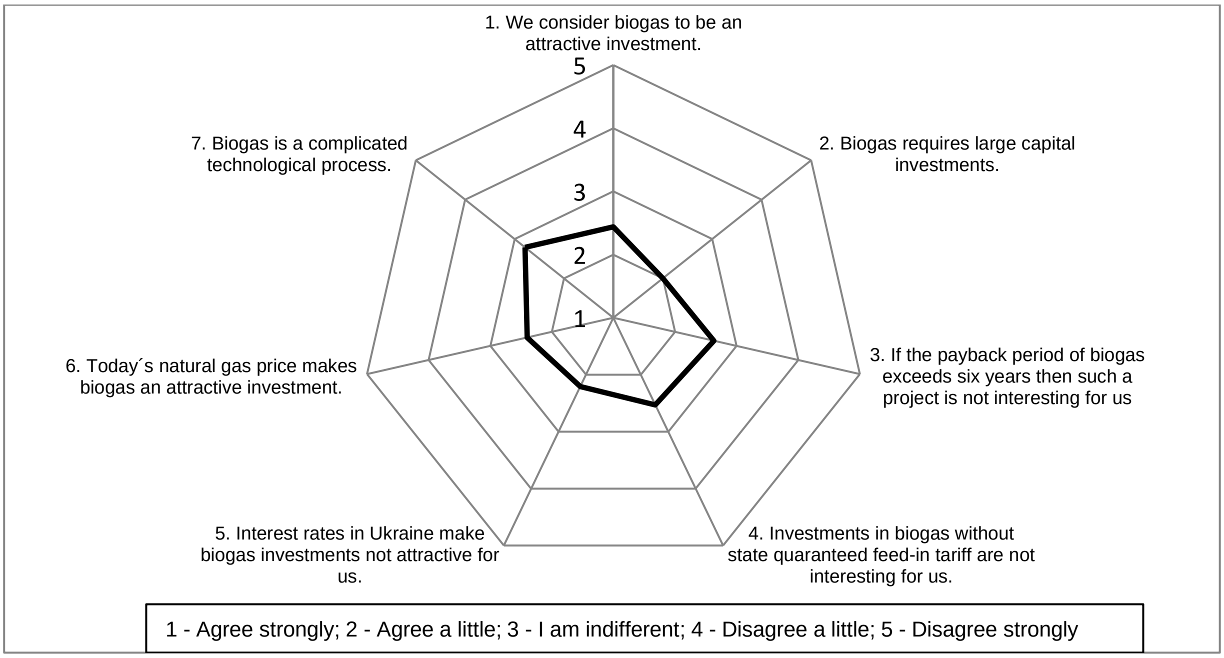


Figure 7.3: Attitudes of the interviewed top-managers towards biogas investments (n = 68, arithmetic mean)
(Author´s calculation)

The results show that the answers of the respondents range in average between low agreement (2 – “Agree a little”) and indifference (3 – “I am indifferent”). Most of the responders agree that biogas generation would require high initial investments (statement 2, mean 2.0), and that current interest rates in Ukraine would make biogas investments uninteresting for their business (statement 5, mean 2.21). Furthermore, the top-managers expressed an indifferent position to the statements regarding investment attractiveness of biogas (statement 1, mean 2.44), and the influence of the current natural gas prices (statement 6, mean 2.4), as well as the statements related to the need of the green tariff for biogas (statement 4, mean 2.53), a six-year payback period for a biogas investment (statement 3, mean 2.63) and the perceived technological complexity of biogas (statement 7, mean 2.79).

After the attitudes regarding biogas investments of the interviewed managers were analysed, an additional analysis of the organisational factors “internal economic situation”, “energy costs” and “need for waste recycling” was carried out (see Figure 7.4). The results reveal that 60.0 % of the executives in the sample considered their total revenue and net profit between 2012 and 2014 as “excellent”. It is worth adding that the responders expressed this positive perception of the key business results at the time of the recession and geopolitical uncertainty in 2015 in Ukraine. Due to the low growth of Ukraine´s agricultural sector from 2012 to 2014, the objective business results of the agroholdings in these years might have been different from the expressed perception of the interviewed top-managers[39]. However, 47.0 % of the responders were satisfied with the financial situation of their companies in 2015. Furthermore, 67.6 % of the interview partners expressed their discontentment with the energy costs. Therefore, it can be assumed that biogas and biomass investments between 2009 and 2014 (Table 7.2 and Figure 7.2) may not have been sufficient to reduce heating and electricity costs. Nevertheless, the price increase for energy in 2015 may have caused this dissatisfaction as well[40]. Finally, 25.0 % of the respondents expressed some difficulties associated with the company production waste. One explanation may be that though 73.5 % of agroholdings in the present sample practice animal farming, most of them are mainly concentrated on crops (see Figure 2.16 in Section 2.2.2). As a consequence, animal husbandry of agroholdings in the sample may not generate large amounts of animal waste.

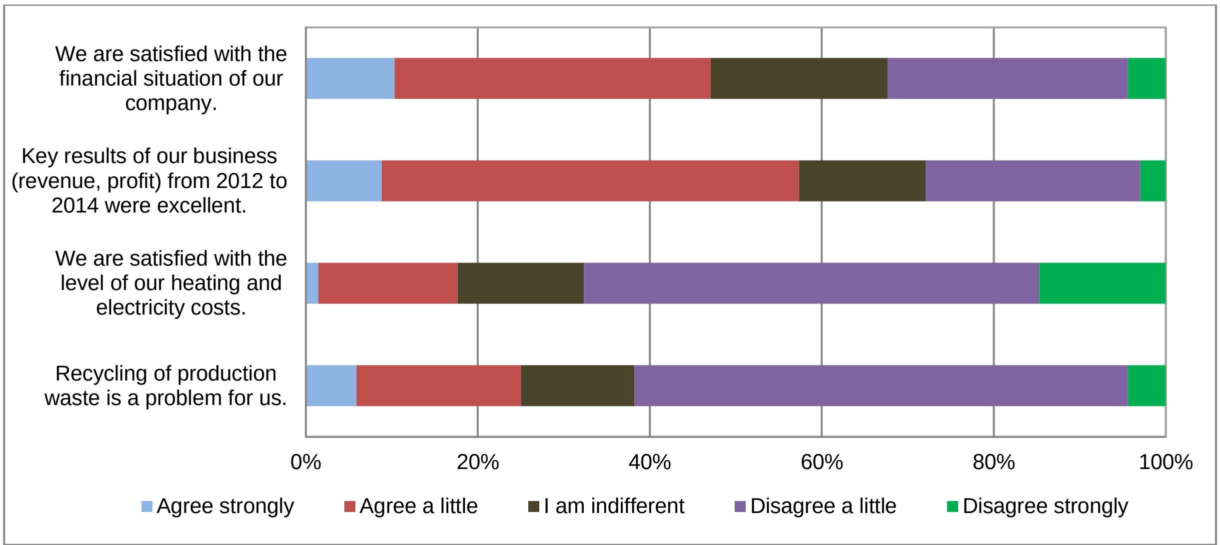


Figure 7.4: Analysis of organisational factors of agroholdings (n = 68)
(Author´s calculation)

The study also intended to provide some insights concerning individual business attitudes of the senior managers. These factors were risk-taking attitudes and innovativeness (Figure 7.5). First, 61.8 % of the respondents would not be ready to take higher business risks for the sake of higher profits. Second, 44.1 % of the interviewed top-managers choose projects with a lower risk, when making new investment decisions.

[39] For the development of agroholdings in Ukraine from 2009 to 2014 see Section 2.2.2.

[40] Development of payments for consumed natural gas was described in Section 4.1.4.4.

These two findings may indicate risk aversion in the senior management of Ukrainian agroholdings. This confirms the conventional economic theory, presented in Section 3.3, which postulates that agents tend to avoid risks when making important business decisions. Additionally, 75.0 % of the top-managers in the sample consider themselves to be among the first in Ukraine who apply and use new agricultural technologies. Obviously, so many companies cannot be “among the first”, confirming the “better-than-average” effects, stated in Section 3.3.2. One explanation for these answers could be that high-ranking executives want to be associated with application of new technologies. This may help create a positive image of a successful and prospering business organisation. In addition, the executives could have meant only certain production segments where they may use modern technologies, e.g. GPS or no-till in crop farming, but not their general tendency to always adopt the newest agricultural technologies, when such technologies appear on the Ukrainian market. Another explanation could be that the senior managers interviewed compared their companies only on the regional level, where they may not have strong and innovative competitors. Finally, the respondents could have given socially desirable answers to this question. However, an overall examination of the adoption of new technologies, employed in Ukrainian agroholdings, is beyond the scope of the present work.

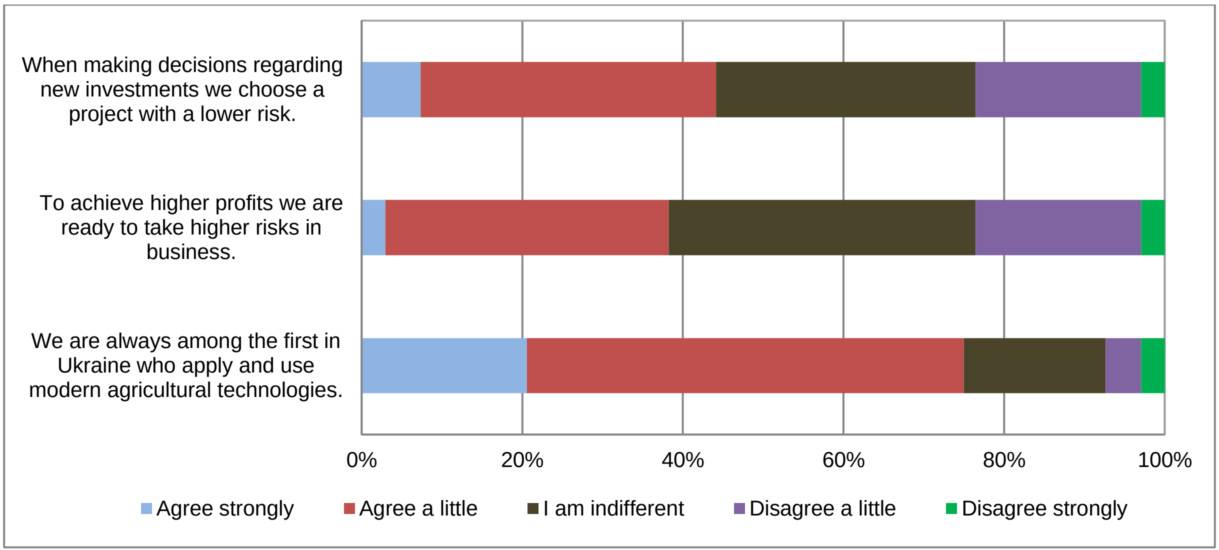


Figure 7.5: Individual business attitudes of the interviewed top-managers (n = 68)
(Author´s calculation)

7.2 Results of the Empirical Model

The previous sections have provided descriptive statistics of the sample, as well as the analysis of agroholdings´ prior and future biogas investments. In this section the conceptual model has been tested against the data collected in order to analyse, whether the hypothesis formulated in Chapter 4 can be confirmed. For these purposes four quantitative statistical methods, described in Chapter 6, have been applied. In the present section the central findings of the work are reported, based on the research questions, presented in Section 1.2.

7.2.1 Explanatory Power of the Influencing Factors on the Willingness-to-Invest in Biogas

The conceptual model of the agroholdings´ investment decision-making, presented in Section 4.1.6, includes a relatively large set of independent variables. On the other hand, statistical techniques used in the present work require a sufficient number of cases for reliable results, which is not completely covered by the sample of 68 cases (see Section 6.2 and Section 5.2). Therefore, model variables which originally consisted of multiple statements ("relative advantage of biogas", "economic situation", "energy costs", "perceived need for waste recycling" and "risk aversion") were factor analysed using orthogonal rotation. The results of the factor analysis fulfill the quality criteria (KMO > 0.603, Cronbach α > 0.530, factor loadings > 0.768) and explain 72.24 % of the total variance[41]. The procedure yielded a five-factor solution, representing the original model variables (Table 7.3).

Table 7.3: Results of the explorative factor analysis (KMO = 0.603, variance extracted = 72.24 %)
(Author´s calculation)

Factor 1	**Relative Advantage of Biogas**	**Cronbach α = .773**	**Factor Loading**
RA_1	Biogas has more advantages for us than using of natural gas.		.797
RA_2	Biogas can improve the financial situation of our company.		.850
RA_3	We consider biogas to be an attractive investment.		.800
Factor 2	**Economic Situation**	**Cronbach α = .777**	**Factor Loading**
ES_1	We are satisfied with the financial situation of our company.		.810
ES_2*[42]	Our financial situation allows investing in new projects.		.770
ES_3	Key results of our business (revenue, profit) from 2012 to 2014 were excellent.		.836
Factor 3	**Energy Costs**	**Cronbach α = .534**	**Factor Loading**
EC_1	We are satisfied with the level of our heating and electricity costs.		.772
EC_2*	We are not looking for possibilities to decrease our heating and electricity costs.		.839
Factor 4	**Perceived Need for Waste Recycling**	**Cronbach α = .530**	**Factor Loading**
PW_1	Recycling of production waste is a problem for our company.		.839
PW_2	Production waste of our company has led to conflicts with local citizens.		.768
Factor 5	**Risk Aversion**	**Cronbach α = .543**	**Factor Loading**
AV_1	When making decision regarding new investments we choose a project with a lower risk.		.818
AV_2*	To achieve higher profits we are not ready to take higher risks in business.		.798

[41] Separate steps of the conducted factor analysis the reader can find in Section 11.2.

[42] Items marked with "*" have been transformed (see Section 11.2).

Factor 1 “relative advantage of biogas” represents the expected additional value of biogas use for an agroholding. The second factor “economic situation” reflects the companies´ financial status, perceived by the top-manager. The factor “energy costs” describes to what extent the top-management of an agroholding is satisfied with its payments for electricity and heating. It also includes whether the management is trying to improve the internal energy situation of an agroholding. The fourth factor shows the top-manager´s perceived need to recycle company production waste. It also contains the impact of production waste on relationships with local communities. Factor 5 “risk aversion” represents the basic risk-taking attitudes of the agroholdings´ management concerning business decisions.

The multivariate regression model was used to analyse the determinants influencing the executives´ willingness-to-invest in biogas. First, please, recall that the present study depicts a business context of large agricultural enterprises. The top-managers of these companies tend to minimise the financial risks of their investments by grounding their choices on available factual information. They seek for projects promising a satisfactory profitability level axed on acceptable risk as a prerequisite for the investment decision. Against this background, the multivariate regression model has provided some additional findings. In particular, significant causal relationships between the top-managers´ attitudes towards biogas and the top-managers´ willingness-to-invest in biogas were identified, thus addressing the research questions. Taking into account the sample size of 68 respondents the linear model satisfies the statistical quality criteria ($R^2 = .531$; F-test = 3.932 with $p < 0.001$). This confirms the robustness of the developed conceptual model. The results of the analysis are presented in Table 7.4.

Table 7.4: Explanatory power of the influencing factors on the willingness-to-invest in biogas ($R^2 = 531$; ***$p \leq 0{,}01$; **$p \leq 0{,}05$; *$p \leq 0{,}1$)
(Author´s calculation)

Variable	Regression coefficient Beta	Standard error	T	Sig.	Variation inflation factor
Perceived investment attributes					
Payback period	**-.249**	.110	-2.261	**.028****	1.342
Investment costs	**.293**	.117	2.511	**.015****	1.515
Relative advantage	**.340**	.128	2.661	**.010*****	1.810
Perceived risk	-.034	.104	-.330	.743	1.203
Technological complexity	-.062	.113	-.552	.583	1.423
Organisational factors					
Economic situation	.075	.120	.628	.533	1.602
Energy costs	**-.368**	.109	-3.387	**.001*****	1.313
Perceived need for waste recycling	.127	.105	1.211	.231	1.221
Company size	**-.239**	.118	-2.031	**.047****	1.536
Individual factors					
Risk aversion	-.038	.118	-.319	.751	1.542
Innovativeness	.091	.117	.783	.437	1.510
Business environment factors					
Green tariff	.125	.110	1.136	.261	1.348
Business uncertainty	-.121	.140	-.866	.390	2.182
Capital availability	.022	.118	.184	.855	1.533
Natural gas price	-.062	.141	-.438	.664	2.201

As shown in Table 7.4, the perceived investment attributes of biogas represent the strongest predictor of the dependent variable. As hypothesised, a payback period (Beta = -.249, T = -2.261, sign. = .028) exceeding a six-year mark has a negative impact on the willingness-to-invest in biogas, which could be an indication that the economic success of a biogas investment is a “conditio sine qua non” (Masini, Menichetti 2013, p. 520) for the decision-maker. In other words, the top-management seems to have stronger preferences for a technology which has already proven its financial efficiency. It also represents the top-managers´ striving for profit maximisation by recouping their initial investments as soon as possible. These findings are in line with the works of Sachs (1973), Gasson et al. (1993), Cary et al. (2001) and Geletukha, G., et al. (2013).

In addition to the significant influence of the perceived payback period, the perceived investment costs of biogas plants also have a significant impact on the dependent variable (Beta = .293, T = 2.661, sign. = .015). The significance of the factor “investment costs” regarding the willingness-to-invest in biogas generally supports the findings of Reise et al. (2012), Granoszewski, Spiller (2012), International Finance Corporation (IFC) (2015) and International Renewable Energy Agency (IRENA) (2015) that the level of investment costs for biogas projects is of central importance for agricultural companies interested in this technology both in Germany and Ukraine. However, the positive sign of the beta coefficient of the factor “investment costs” appears in contrast to the hypothesised effect (see Section 4.1.1.2), in accordance to which the willingness-to-invest in biogas was expected to increase with perceived reducing investment costs of biogas plants. This result may be explained by the operationalisation of this variable: the direction of meaning in the statement “Biogas requires large capital investments” does not state clearly which capital investments are large.

The degree of the perceived relative advantages of biogas has the strongest positive impact on the top-managers´ willingness-to-invest in biogas (Beta = .340, T = 2.661, sign. = .010). These results confirm that of Tornatzky, Klein (1982), Rogers (2003) and Weng, Lin (2011). On the other hand, contrary to Meijer et al. (2007), Apak et al. (2011) and Chassot et al. (2014), the influence of the perceived risk and that of technological complexity have been found as being not statistically relevant in the present study.

In contrast to the hypothesised effect, the variables “energy costs” (Beta = -.368, T = -3.387, sign. = .001) and “company size” (Beta = -.239, T = -2.031, sign. = .047) are negatively associated with the willingness-to-invest in biogas. One explanation for this result related to the factor energy costs might be that approximately 60 % of the companies interviewed had already invested in energy management measures before the interview took place in autumn 2015, mainly without biogas investments (see Table 7.2). These investments might have reduced their energy costs largely by using wood biomass or straw for heating. Another reason could be that some of the companies studied might not consider biogas as an energy-cost-decreasing option, as shown in Figure 7.6.

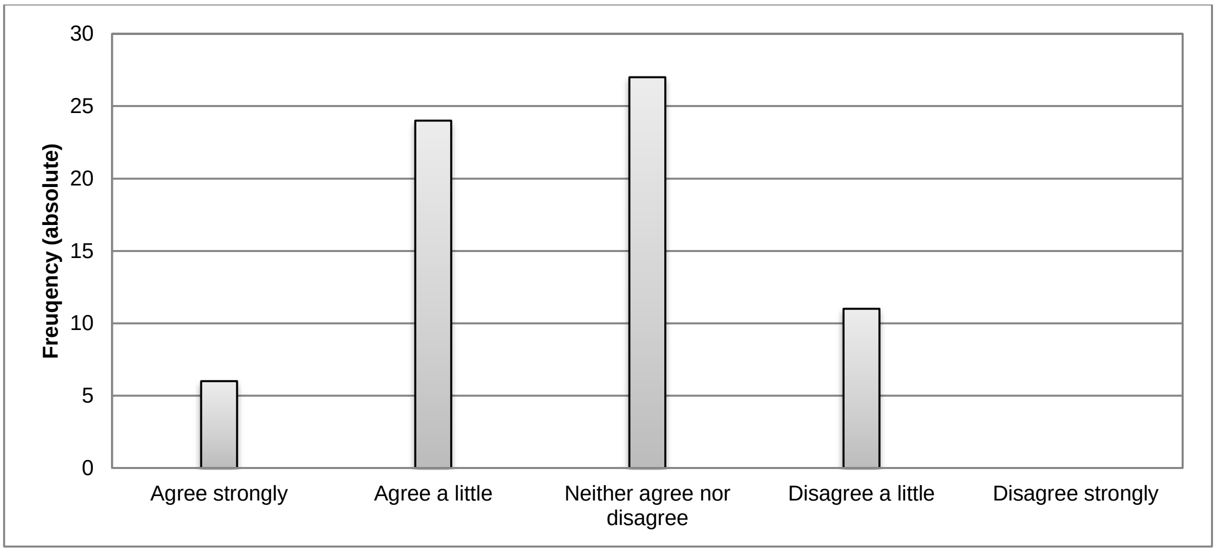


Figure 7.6: Agreement to the statement "Biogas investments can significantly decrease our heating and electricity costs" (n = 68)
(Author´s calculation)

The negative sign of the beta coefficient of the factor "company size" means that with decreasing arable land the willingness-to-invest in biogas increases. This might be because large-scale agroholdings are primarily concentrated on crop production and, thereby, may overlook promising applications of biogas for them. Conversely, smaller companies often have relatively high livestock populations, resulting in larger waste amounts suitable for biogas production. Therefore, smaller agroholdings showed a higher interest on biogas investments in this study. The not significant beta coefficient of the factor perceived "internal economic situation of the agroholding" does not support the findings of Granoszewski, Spiller (2012). One explanation is that a majority of the managers interviewed, when considering a new biogas investment, look first at whether a new biogas project fulfils a desired profitability rate and whether the top-management can finance the new investment (initial costs).

In contrast to the findings of the expert interviews, the factor "perceived need for waste recycling" did not show statistically significant influence on the top-managers´ willingness-to-invest in biogas. This finding may have several explanations. First, mainly large agroholdings in Ukraine, which were addressed in the present work, do not generate large amounts of organic waste due to their concentration on crop cultivation. Therefore, the aspect of waste recycling could be a significant factor mainly in agroholdings with high animal population. Second, biogas is not the only option for waste recycling: composting of waste has been used by several agroholdings, which required smaller initial investments than that for biogas.

Furthermore, the expected impact of the individual characteristics of the managers interviewed could not be confirmed in the present analysis. Neither the factor "risk aversion" of the decision-maker nor his "innovativeness" have a significant influence on the dependent variable. The findings on risk aversion differ from that of other scholars (Shapiro et al. 1992; Willock, J., et al. 1999; Sauer, Zilberman D. 2010; Kim, Chavas 2003b; Ghosh et al. 1994) and confirm that of Masini, Menichetti (2013). Nevertheless, this result may also be associated with the limited sample size of 68 companies interviewed. Additionally, despite the low statistical significance level for these two factors, the initial hypothesised negative influence of the first factor "risk aversion" and the positive impact of the second factor "innovativeness" were confirmed in the analysis. It should be taken into account that in the present work large agricultural companies, where decisions are usually made by a buying-center (see Section 3.2.2), have been investigated. In this case the influence of the individual characteristics of one executive at a large agroholding on an investment decision of the company may be smaller compared to family farms, where one person (farmer) makes such decisions. However, the role of individual characteristics in decision-making of large agricultural companies needs to be researched more deeply. This includes, e.g. collecting more detailed information concerning top-managers´ background. A categorisation of senior managers regarding their preferences for new technologies, the way they manage the company and make important investment decisions is also an informative and useful aspect to be explored in future studies.

The variables related to the external business environment did not demonstrate statistically significant coefficients. One explanation regarding the green tariff could be that the interviewed agroholdings might reject the necessity of relying on governmental payments in the case of long-term investments. In fact, a 20-year horizon promised for the green tariff in Ukraine may, in contrast to Western European countries, increase the perceived risk of agroholdings´ top-management because of the general political instability in Ukraine. Therefore, the top-managers do not seem to trust with regard to renewable energy and biogas technologies, that the government will fulfill its promises to potential biogas investors to provide green tariff payments in the amount and at the rate, fixed in the law (see Section 2.1.3).

Additionally, the present research has also revealed that top-managers have limited knowledge relating to the legal framework for biogas support and bounded practical experience with renewables. The questions in the questionnaire regarding the green tariff, its desirable duration and overall estimation of the legal framework for biogas in Ukraine were not answered by the majority of managers. They might not yet have become familiar with this topic, which is not surprising, since Ukraine´s biogas sector has only emerged recently. Thus, at the moment of the interview, the green tariff did not gain a high magnitude of influence concerning the top-managers´ willingness-to-invest in biogas.

In addition, the variable "business uncertainty" did not show significant coefficients related to the top-managers´ willingness-to-invest in biogas. Thus, these findings do not confirm the studies of Li, Atuahene-Gima (2002), Aragon-Correa, Sharma (2003), Rothenberg, Zyglidopoulos (2007). The recent business uncertainty in Ukraine does not seem to motivate agroholdings to invest in technological innovations for maintaining their competitive advantages, as argued by Damanpour (1991) and Kimberly, Evanisko (1981). Although the negative impact of the geopolitically uncertain situation in Ukraine is obvious, the statistically insignificant coefficients of this factor might find its explanation in the fact that life in Ukraine used to take place under a "stable instability". The ad-hoc political decisions regarding agricultural policies, high inflation, volatility of the prices for commodities and national currency devaluation have been realities for Ukrainian businesses for years.

Following this argumentation the statistically insignificant influence of the capital availability on the willingness-to-invest in biogas can be also interpreted. Despite its clear negative impact on investments in Ukraine´s agricultural sector, demonstrated in numerous studies (Zinych 2009; Zinych, Odening 2009), capital availability may not have a definite relationship to biogas investments. If interest rates in Ukraine were lower, the agroholdings would probably allocate acquired financial resources in areas where their capital needs are more obvious and acute: modernisation of agricultural machinery and buildings, paying off previous debts, building cash reserves, etc. Thus, it can be assumed that biogas projects would not directly benefit from an improved capital availability, because the capital loaned for acceptable interest rates would be invested in buying new tractors and harvesters or paying back existing debts, which had previously been taken at higher interest rates.

Finally, the almost neutral statistical influence of natural gas prices, contrary to the findings of the expert interviews, might be explained similar to the factors "energy costs" and "perceived need for waste recycling". First, crop producers use relatively small amounts of natural gas. So, increasing gas prices may not be considered by the top-managements as highly relevant in the agroholdings´ annual financial statement. Second, due to the price increases between 2006 and 2012, a majority of agroholdings might have already adapted to this situation during this time period. Thus, "the current natural gas price" as was asked in the questionnaire (see Section 11.1), did not significantly influence the top-managers´ willingness-to-invest in biogas. These findings also support the results of Sick (2014).

Based on the findings of the linear regression analysis the initial model hypotheses were examined (Table 7.5). The non-confirmation of a large number of the hypotheses could be explained by the relatively low sample size (n = 68) and also by the special context of the present study (large agricultural companies in Ukraine). A majority of the sources used for developing the model hypotheses have investigated either small family farms or investments in renewable energy in developed countries. In contrast, the influence of the factors examined in the present dissertation on biogas investments in the context of Ukrainian agroholdings may be different from one in developed countries and on small family farms. These contextual and practical differences should be taken into account when interpreting the findings of the present study.

Table 7.5: Summary of the hypothesis examination
(Author´s calculation)

Num.	Hypotheses	Result
1.	The longer the payback period for a biogas investment, the lower is the willingness-to-invest in biogas.	Accepted
2.	The higher the investment cost of a biogas plant, the lower is the willingness-to-invest in biogas.	Cancelled
3.	The higher the perception of biogas relative advantages, the higher is the willingness-to-invest in biogas.	Accepted
4.	The higher the perceived risk of a biogas investment, the lower is the willingness-to-invest in biogas.	Cancelled
5.	The higher the perceived complexity of biogas production, the lower is the willingness-to-invest in biogas.	Cancelled
6.	The better the economic situation in the agroholding, the lower is the willingness-to-invest in biogas.	Cancelled
7.	The higher the importance of energy costs in the agroholding, the higher is the willingness-to-invest in biogas.	Cancelled

Num.	Hypotheses	Result
8.	The higher the perception of the waste problem, the higher is the willingness-to-invest in biogas.	Cancelled
9.	The larger the agroholding size, the higher is the willingness-to-invest in biogas.	Cancelled
10.	The higher the risk aversion of the decision-maker, the lower is the willingness-to-invest in biogas.	Cancelled
11.	The higher the innovativeness of the decision-maker, the higher is the willingness-to-invest in biogas.	Cancelled
12.	The more positive the perception of the green tariff for biogas, the higher is the willingness-to-invest in biogas.	Cancelled
13.	The worse the perceived business uncertainty in Ukraine the lower is the willingness-to-invest in biogas.	Cancelled
14.	The higher the perceived interest rate in Ukraine, the lower is the willingness-to-invest in biogas.	Cancelled
15.	The higher the perceived natural gas price, the higher is the willingness-to-invest in biogas.	Cancelled

In the next section the second research question will be addressed: is there a difference in the influencing factors of top-managers with actual biogas investments compared to the executives not familiar with this kind of investment.

7.2.2 Differential Factors Between Investors and Non-Investors in Biogas

In order to identify the differences between two groups of agroholdings – investors and non-investors in biogas – a binomial logistic model was tested. The present logistic regression differs from the linear analysis in that its purpose is to predict the probability of the occurring events. The logistic model generates coefficients of the independent variables, which represent the magnitude and direction of influence on the probability of the group membership (Hair 2014b, p. 317).

The independent variables of the present logistic model reflect the predictors of the multiple linear regression model (see Section 7.2.1). As dependent variable a dichotomous value of an investment in biogas was used, which has two categories: 0 – have not yet invested in biogas and 1 – have already invested in biogas. The next step of the analysis is to examine the classification accuracy of the logistic model (Table 7.6).

Table 7.6: Classification table
(Author´s calculation)

Observed		Predicted		
		Actual biogas investments		Percentage of right predictions
		no	yes	
Actual biogas investments	no	56	2	96.6
	yes	4	6	60.0
Total percentage				91.2

The hit ratio of the present model is 91.2 % (Table 7.6). The comparison standards for the hit ration are the maximum and proportional chance criteria. The maximum proportional chance criteria of the sample analysed equals 85.3 %[43]. Thus, the proportion chance criterion of the present model (91.2 %) is above this level. The latter value (proportional chance criteria) considers the group sizes and is calculated using $a^2 + (1-a)^2$, where a is the share of the largest group (Backhaus et al. 2008, p. 267). In this case it equals 74.9 %[44], which is below the result of the present logistic model (91.2 %). Overall, 96.6 % of non-investors and 60.0 % of investors in biogas could be predicted correctly by the logistic model. After the results of a model fit and hit ratios, the logistic coefficients of the model variables are analysed to identify significant relationships affecting the group membership. The findings of the logistic regression model are reported in Table 7.7[45].

Table 7.7: Differential factors between the top-managers-investors and non-investors in biogas (Nagelkerke R^2 = .525; -2 Log-Likelihood = 32.812; Chi-square = 23.978; ***p ≤ 0.01; **p ≤ 0.05; *p ≤ 0.1)
(Author´s calculation)

Variable	B	Standard error	Wald	Sig.	Exp (B)
Perceived investment attributes					
Payback period	-.006	.742	.000	.994	.994
Investment costs	**-1.570**	**.912**	**2.965**	**.085***	**.208**
Relative advantage	-.375	.849	.195	.659	.687
Perceived risk	.334	.649	.265	.607	1.396
Technological complexity	.611	.632	.934	.334	1.842
Organisational factors					
Economic situation	-.354	.683	.268	.605	.702

[43] 68 respondents overall, including 58 non-investors in biogas. 58/68 = 85.3 %.

[44] 85.3 %² + (1 – 85.3 %)² = 74.9 %.

[45] All calculation steps of the logistic regression can be found in Section 11.4.

Variable	B	Standard error	Wald	Sig.	Exp (B)
Energy costs	-.244	.611	.160	.689	.783
Perceived need for waste recycling	-.188	.638	.087	.768	.828
Company size	**1.299**	**.661**	**3.867**	**.049****	**3.666**
Individual factors					
Risk aversion	.313	.713	.193	.660	1.368
Innovativeness	**.943**	**.596**	**2.503**	**.114**	**2.567**
Business environment factors					
Green tariff	**-1.472**	**.631**	**5.446**	**.020****	**.229**
Business uncertainty	-.182	.818	.049	.824	.834
Capital availability	.205	.752	.074	.785	1.228
Natural gas price	-.435	.671	.420	.517	.647

The Nagelkerke R^2 of the present model exceeds .50, indicating that the logistic model accounts for over half of the variation between the two groups analysed: investors and non-investors in biogas. Coupled with the statistically significant regression coefficients, the present model is acceptable in terms of statistical and practical significance.

If a coefficient is statistically significant, it can be interpreted in terms of its influence on the estimated probability of a biogas investment, and, thus, the prediction of the group membership (investor or non-investor in biogas). For this purpose the Wald statistic is applied in a similar way to the t-test in the linear regression. As shown in Table 7.7, there are four coefficients with the largest Wald values: investment costs, company size, innovativeness and green tariff. The significance level of the variable "innovativeness" is above 0.1, which can be associated with the sample size of 68 respondents. Therefore, all four coefficients are considered to be significant and are further interpreted and examined to identify the direction and magnitude of the relationships each variable has on the predicted probabilities and the group membership. For these purposes the original regression coefficients B and the exponentiated coefficients Exp (B) will be analysed.

Positive values of the variables "company size" (B = 1.229, Exp (B) = 3.666, Wald = 3.867) and "innovativeness" (B = 0.943, Exp (B) = 2.567, Wald = 2.503) indicate a positive relationship between these independent variables and the predicted probability of a biogas investment. As the values of either company size or innovativeness of the agroholdings´ top-management increase, the predicted probability of the group membership also increases, thus increasing the likelihood that an agroholding will be categorised as a biogas producer. If the factor "company size", defined as the number of hectares cultivated in financial year 2014/2015 by the agroholding, increases in one unit, the probability of a biogas investment in this agroholding increases with the factor 3.666. It should be noted that the factor 3.666 is the Exp (B) is the logarithm of the regression coefficient B, and this logarithm shows the influence of the variable "company size" on the probability [0;1] of the belonging to the group of biogas investors, but not on a biogas investment itself. If the factor "innovativeness" of the top-manager, measured with the help of a five-point Likert scale, increases by one unit, the probability of belonging to the group of biogas investors increases with the factor 2.567. The positive relationship between the innovativeness of the agroholdings´ top-managers and the actual decision to invest in biogas, found in the present analysis, accord with earlier research (Rogers, Shoemaker 1971; Willock, J., et al. 1999; Marcati et al. 2008; Hertel 2014; Schramm 1977; Voss et al. 2008) but differ from those reported by Granoszewski, Spiller (2012).

Additionally, two other variables “green tariff” (B = -1.472, Exp (B) = .229, Wald = 5.446) and “investment costs” (B = -1.570, Exp (B) = .208, Wald = 2.965) have a negative sign. If the agreement to the statement “Investments in biogas without state guaranteed feed-in tariff are not interesting for us” relating to the green tariff or to the statement “Biogas requires large capital investments” increases in one unit, the probability of a biogas investment decreases by 77.1 %[46] and 79.2 %, respectively. For a real-life interpretation one can imagine a situation when some negative information concerning either the green tariff in Ukraine (e.g. decline in green tariff payments, described in Section 2.1.3.2) or growing required capital investments reaches the top-management of an agroholding. This information would have a significant negative impact on the probability of a new investment in biogas in this company.

At first glance the green tariff should be positively associated with actual biogas investments as a guarantee for the producer to cover his financial risks. This would support the majority of scholars who indicated a positive influence of feed-in tariffs on renewable energy investments (Block 2006; Butler, Neuhoff 2004; Contaldi et al. 2007; Couture, Gagnon 2010). However, almost none of the actual biogas owners in Ukraine had obtained a license for the green tariff at the time of the interview. Due to the fact that some part of the top-managers interviewed had tried unsuccessfully to receive this grant for several years, it is understandable that the perception of the green tariff has a significant negative impact on the current biogas investors in the sample[47]. Therefore, these findings are consistent with that of Liebreich (2009) and Lesser, Su (2008), who identified negative impacts of feed-in tariffs on the development of renewable energies.

In the case of investment costs the algebraic sign of the coefficient is negative. This may indicate a different perception of investment costs of biogas plants by the top-managers with actual biogas investments compared to those not familiar with this kind of investment in the sample analysed. Thus, biogas investors in the present study could have underestimated the initial investment costs of the biogas plants. Reise et al. (2012) also concluded that German farmers operating biogas plants have often underestimated their investment costs. Consequently, the final project costs might have been considerably higher that the initial forecast. As unexpected cost increases are undesirable for biogas investors, this might lead to the negative sign of the factor “investment costs” and decreasing the probability of belonging to the group of biogas investors.

In this and the previous sections significant differences between the direction and magnitude of factors influencing the intention to invest in biogas and observed behaviour relating to biogas investments have been indicated. The question whether the willingness-to-invest in biogas leads to actual biogas investments and how this phenomenon can be explained will be addressed in the next section.

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[46] 77.1 % = (1 - Exp (B)) * 100 = (1 - 0.229) * 100.

[47] For the regulation procedures concerning green tariff obtaining see Section 2.1.3.2.

7.2.3 Relationships between the Willingness-to-Invest in Biogas and Actual Biogas Investment

Structural equation modelling was applied to investigate the relationship between the intention to invest in biogas and the observed behaviour concerning biogas investment. As described in Section 6.4, this statistical technique allows the researcher to examine multi-level relationships between independent and dependent variables. The set of independent variables, explaining the willingness-to-invest in biogas and tested in Section 7.2.1 and Section 7.2.2, have been adapted for the structural equation modelling (Figure 7.7). The variable “actual biogas investment” is taken from the logistic regression analysis, presented in the previous section.

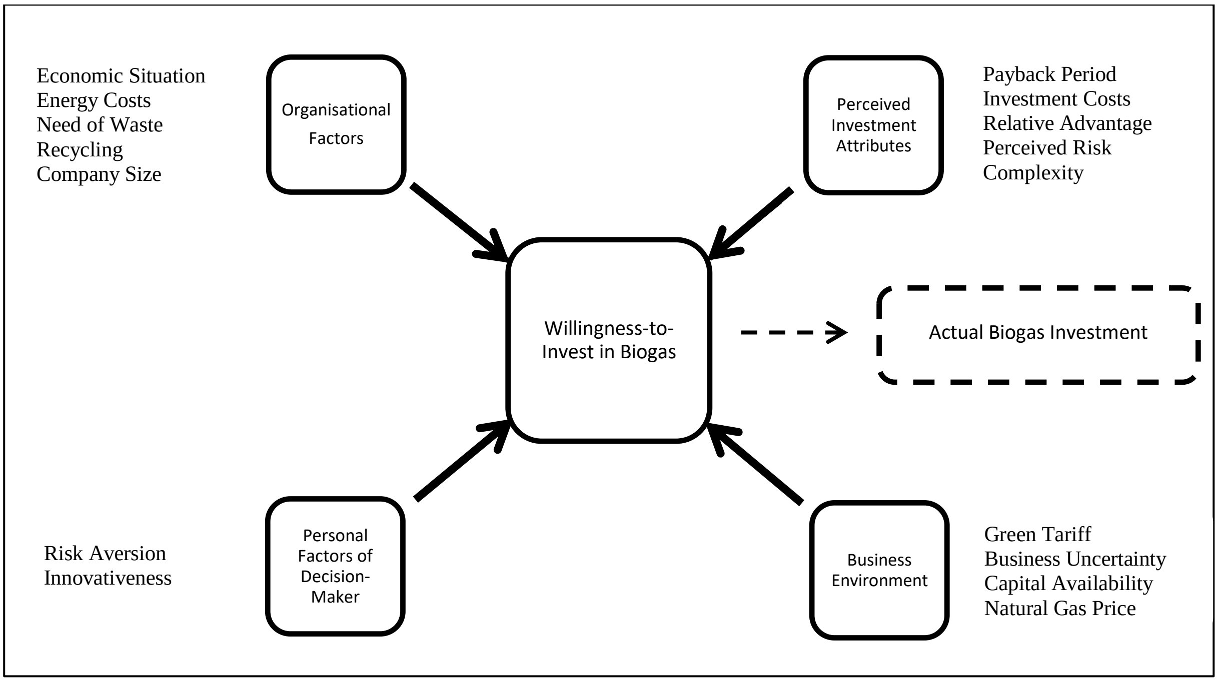

Figure 7.7: Structural equation model explaining the relationships between the willingness-to-invest in biogas and actual biogas investment

To obtain valid results, the measurement model must fulfill a set of quality criteria described in Section 6.4. The validity check of the formative model variables provides the values shown in Table 7.8.

Table 7.8: Quality criteria for the formative constructs (significance level α = 0.05)
(Author´s calculation)

Construct	Indicator	Regression coefficient	t-value	Variation inflation factor
		≥ 0.1	**≥ 1,65**	**≤ 4.0**
Perceived investment attributes	Payback period	-0.172	0.275	1.093
	Investment costs	0.148	0.568	1.253
	Relative advantage	**0.776**	**1.774**	1.133
	Perceived risk	0.386	1.239	1.126
	Technological complexity	0.283	0.835	1.259
Organisational factors	Economic situation	-0.294	1.059	1.165
	Energy costs	**0.745**	**3.469**	1.016
	Perceived need for waste recycling	**-0.715**	**3.048**	1.083
	Company size	-0.238	1.065	1.098
Individual factors	Risk aversion	-0.279	0.636	1.026

Construct	Indicator	Regression coefficient	t-value	Variation inflation factor
	Innovativeness	**-1.006**	**2.386**	1.026
Business environment factors	Green tariff	0.485	1.008	1.062
	Business uncertainty	0.391	0.949	1.056
	Capital availability	0.068	0.280	1.113
	Natural gas price	0.776	1.061	1.016

The results indicate that two of the three quality criteria (regression coefficient and variation inflation factor) concerning the formative model variables are fulfilled by all indicators, accept the factor “capital availability”. The third criterion “t-value”, which shows the indicators´ statistical significance, is fulfilled by the factors “relative advantage”, “energy costs”, “perceived need for waste recycling” and “innovativeness”. Because the indicators of the formative constructs are specified by their content, these indicators cannot be eliminated owing to their low t-values (Huber 2007). In addition, the application of the structural equation modelling in the present work serves to answer the third research question of whether the willingness-to-invest in biogas actually leads to biogas investment, and not to analyse the influence of the indicators on the latent variables. Therefore, all indicators of the formative model variables remain in the measurement model.

At the next stage of the statistical model estimation R^2-values of the structural equation for the entire model, the path coefficients and the t-values of the latent variables are analysed. Table 7.9 reports the main results of the structural equation model.

Table 7.9: Results of the structural equation modelling
(Author´s calculation)

Endogenous construct	R^2	Q^2	Exogenous construct	Regression coefficient	t-value	Variation inflation factor
	≥ 0.2	**≥ 0**		**≥ 0.1**	**≥ 1.65**	**< 4.0**
Actual biogas investment	0.007	-0.005	Willingness-to-Invest in biogas	-0.086	0.848	1.000
Willingness-to-Invest in biogas	0.336	0.147	Perceived investment attributes	0.250	1.342	1.151
			Organisational factors	-0.256	1.995	1.290
			Individual factors	0.114	1.042	1.099
			Business environment factors	0.209	0.769	1.370

As shown in Table 7.9, based on the data collected the relationship between the willingness-to-invest in biogas and de facto biogas investment explains only 0.7 % of the variance of actual biogas investments ($R^2 = 0.007$), and turns out to be statistically insignificant (regression coefficient = - 0.086, t - value = 0.848). Additionally, the value of - 0.005 for Stone - Geisser´s Q^2 criterion does not fulfill the requirement for a predictive validity of the measurement model.

These findings contrast to that of Benninghaus (1976), Manstead, Parker (1995), Six, Eckes (1996) and do not support the Theory of Planned Behaviour, presented in Section 3.2.1. On the other hand, these results support that of Hertel (2014), who did not find a statistically significant relationship between the intention to use energy-saving technologies and de facto investment in such technologies in Germany´s horticultural sector. One explanation might be that biogas, despite its deep market penetration in the European market, is a new technology for the Ukrainian agroholdings analysed, which emerged in the recent years.

Therefore, these agroholdings might be at an early stage of their development, trying to build a solid fundament for their key businesses, e.g. crop production. In this case, the top-managers might first be interested in well-established and proven agricultural technologies, designed to e.g. yield increases and crop protection. Consequently, despite showing interest in biogas plants indicated in Section 7.1.2 (see Figure 7.1), the senior executives do not make actual biogas investments.

By the further analysis of the model results one can see a significant overall influence of the organisational factors on the willingness-to-invest in biogas (regression coefficient = -0.256, t - value = 1.995). These results indirectly support that of the linear regression analysis, where the factors "energy costs" and "company size" had a negative significant influence on the dependent variable (see Section 7.2.1). In contrast, the other three model constructs "perceived investment attributes", "individual factors" and "business environment factors" do not provide significant coefficients. An explanation may be that, if analysed as an aggregated group of independent variables, these constructs do not represent a significant predictor of the willingness-to-invest in biogas, while in a separate analysis in the multiple linear regression model their coefficients are statistically significant. To the best of the author´s knowledge, no scientific studies were identified in which the influence of group of factors in the context of the present work has been investigated simultaneously. Therefore, the results of the structural equation model could not be directly compared to that of other authors. The explanatory power of the perceived investment attributes, explored in the previous sections, were not confirmed by the results of the structural equation model (regression coefficient = 0.250, t - value = 1.342). The business environment (regression coefficient = 0.209, t - value = 0.769) and the individual factors (regression coefficient = 0.114, t - value = 1.042) do not provide statistically significant coefficients.

In the last step of the model analysis the total effects of the variables "perceived investment attributes", "organisational", "individual" and "business environment factors" on the probability of actual biogas investment will be examined. As shown in Table 7.10, the connections (total effects) of all four model variables to the actual biogas investment cannot be considered high and are below 0.02[48].

Table 7.10: Total effects within the structural equation model
(Author´s calculation)

Total effects	Actual Biogas Investment
f ≥ 0.02	
Perceived investment attributes	- 0.022
Organisational factors	0.022
Individual factors	- 0.010
Business environment factors	- 0.018

The variable "perceived investment attributes" has a negative total effect of - 0.022, lowering the probability of actual biogas investment. The same is true for the variables "individual factors" of the decision-maker and the perceived "business environment factors", resulting in the negative total effects of - 0.010 and - 0.018, respectively. In contrast, the increasing total effects on the probability of actual biogas investment are shown by the variable "organisational factors", which has a value of 0.022.

The next chapter discusses the empirical findings of the present work. Furthermore, conclusions will be derived and implications of the findings for theory and practice will be given. Afterwards, the limitations of the present study will be described. Finally, Chapter 8 provides recommendations for future research in the field of organisational decision-making relating to investments in renewable energy in the agricultural sector.

[48] For the requirements on the height of the total effects in structural equation modelling see Table 6.5 in Section 6.4.

8 Discussion

8.1 General Discussion of the Results

The results show that the conceptual model is able to capture the determinants influencing the adoption process in the context of biogas investments, as well as the direction and magnitude of the relationships between variables, therefore, providing answers to the research questions.

First, the results of the descriptive data analysis demonstrate that more than half (59.0 %) of the interviewed agroholdings´ top-managers have already invested in some form of renewable energy and 14.7 % of the executives are biogas investors, while 48.5 % of the interview partners have invested in biomass combustion, e.g. wood or straw. Because these types of biomass utilisation are not subsidised in Ukraine, a relatively high number of existing investors in biomass in the present sample may indicate a proven economic viability and an already high competitiveness of biomass combustion versus fossil fuels in Ukrainian agricultural companies.

Second, the findings concerning new investments reveal that the executives interviewed are generally interested in biomass, biogas and solar power investment, while wind energy and energy plants have not gained their attention. To transform this interest into investments of Ukrainian agroholdings in renewable energy generation, the state support mechanisms should be concentrated especially on the preferred types of renewable sources.

Third, the overall investment preferences of the agroholdings analysed are not expected to change significantly between 2015 and 2020, compared to the years from 2009 to 2014: a large portion of investment in the years ahead may be allocated in agroholdings´ key business areas, e.g. crop production. This tendency can be partly explained by the current economic uncertainty in Ukraine, because of which the top-managers interviewed are rather looking for possibilities to withstand the existing financial shortages in the country and are not sure about the geopolitical conditions their companies may be facing in the near future in Ukraine. Therefore, future research should investigate overall investment strategies of large agricultural companies more deeply to explain companies´ reactions to the economic uncertainty.

Furthermore, the analysis of the managers´ attitudes regarding biogas investments shows that the executives have expressed an indifferent position concerning the influence of the current natural gas prices, the green tariff for biogas and the six-year payback period on their willingness-to-invest in biogas. These results may be explained by the limited practical experience with biogas technologies of the top-managers interviewed, since more than 85 % of the respondents were unfamiliar with biogas investments at the time of the interview. In addition, this indifferent position may be explained by the overall market uncertainty in Ukraine, concerning high inflation, national currency devaluation and political instability. The senior executives simply do not know how the situation regarding the natural gas prices and the green tariff for biogas may change in the future and what effects these changes may have on the attractiveness of investing in biogas. Moreover, the green tariff design may appear unprofitable and the permission procedures regarding green tariff granting may be complex for the top-managers interviewed, leading them to rejecting this support scheme for biogas.

Additionally, the analysis reveals that the perceived investment attributes “payback period”, “investment costs” and “relative advantage of biogas” represent the strongest predictor of the willingness-to-invest in biogas. Different methods for the calculation of a project´s payback period or the number of investment costs are applied in Ukrainian agroholdings, which depends on specific financial standards the companies in Ukraine use. Therefore, the factors “payback period” and “investment costs” represent the top-managers´ subjective perception of these two financial parameters and their definition may differ from agroholding to agroholding. Although implicitly these findings suggest that top-managers of agroholdings consider the proven financial reliability of biogas technology and its comparable benefits as a necessary condition to invest in biogas, the impact of the decision-maker´s individual factors, confirmed in other scientific studies investigating farm production in highly industrialised countries, is not verified by the findings of the present study. Here, two additional points should be also taken into account to explain the difference between the results of this analysis and previous research.

First, considering the fact that the present study investigated large and relatively young agricultural companies, where investment decisions are made collectively, the influence of individual factors of one person in a decision-making unit (buying-center, see Section 3.2.2) is much lower than that on small farms, where decisions are usually taken by a farmer and, maybe, his family. The second point is, in the context of the current economic situation in Ukraine the top-managers are forced to think primarily in terms of the profit maximisation to ensure the existence of their companies in times when the state is struggling with financial difficulties. In contrast, in Western European countries the farms are usually provided with state financial support and good capital availability, which allows farmers to build financial reserves and ground their investment decisions not solely on financial goals. Moreover, several agroholdings in the sample analysed are publicly owned companies, which mutually impacts the top-managements´ financial decisions in terms of guarantying profitability of investments undertaken to the stakeholders and private investors.

The results also show that in the sample analysed the willingness-to-invest in biogas increases with the reduction of arable land. One reason for this result might be that large-scale agroholdings primarily concentrate on crop production, while smaller agricultural producers in the present study often run animal farming with high livestock populations and also generate large amounts of waste, suitable for biogas production. Therefore, the policies supporting biogas generation in Ukraine should be designed differently for smaller and larger agroholdings to ensure the best use of the advantages of biogas generation by companies of different sizes in terms of a total revenue and arable land.

Furthermore, perceived importance of energy costs for the top-manager, contrary to the hypothesis, is negatively associated with his willingness-to-invest in biogas. This phenomenon may have two explanations. First, over half of the senior managers interviewed had already invested in energy efficiency measures, mainly in biomass heating, before the interviews took place in autumn 2015. Due to this fact, their energy costs could have already been decreased compared to the times when natural gas was a relatively cheap energy source in Ukraine. A second explanation might be that biogas plants may not be recognised as an energy-saving technology by the executives interviewed.

Moreover, the need for waste recycling, which could be a potential motivation for a biogas investment, is relevant only for a small portion of the senior executives interviewed, thus not confirming the findings of the expert interviews. Consequently, if the biogas production in Ukraine is to be increased and such advantages of biogas as recycling of organic waste is to be exploited, the policies for biogas promotion - green tariff, capital funding, tax exemptions, etc. - should primarily target agricultural companies generating large amounts of organic waste. In this case, the height of the green tariff for biogas should imply the cost savings from waste recycling for agroholdings with high livestock population. In addition to the biogas support for waste recycling, the composting of waste should be better promoted to such agroholdings, which cannot afford capital-intensive biogas investments, but are still in need for waste recycling.

The results also demonstrate significant factors for differentiating between the senior managers-investors and non-investors in biogas. The variable “company size” has a positive impact on actual biogas investment, while in the case of the willingness-to-invest in biogas this factor influenced the dependent variable negatively. This means that the probability to belonging to the group of biogas producers increases with increasing arable land, cultivated by an agroholding. The opposite impact of the available arable land of an agroholding on the interest in investing in biogas and actual biogas investment may have two consequences. First, there might be a gap between an intention to adopt biogas technologies and an observed behaviour, resulting in de facto investment in biogas generation. Unfortunately, the relationship between attitude and intention has been investigated in scientific literature much more often than that between intention and observed behaviour (Hertel 2014, p. 166). Although several authors conducted meta-analyses of this kind of a relationship and found significant correlation between the intention and the behaviour (Kim, Hunter 1993; Manstead, Parker 1995; Six, Eckes 1996; Kraus 1995), the contexts of these studies were different from biogas investments in agriculture. However, Arts et al. (2011) and Hertel (2014) also did not confirm a significant influence of the intention on the observed behaviour. Second, these findings may also indicate that larger Ukrainian agroholdings use innovative agricultural technologies earlier than smaller agricultural companies in Ukraine.

Furthermore, the results indicate a positive influence of the top-managers´ innovativeness on the probability of biogas investment. This phenomenon means that, if the top-manager considers his agroholding as an innovative agricultural company, the probability of biogas investment in such agroholdings increases. In future research top-managers of large agricultural companies should be categorised in terms of their innovativeness and interest in new agricultural technologies for developing targeted marketing campaigns to promote innovative technologies to innovative managers. Such categorisation seems to be also relevant for advertising and selling strategies of agricultural machinery, equipment, fertilisers and other agricultural input factors in Ukraine.

Next, the variables “green tariff” and “investment costs” show negative significant coefficients in relation to the actual biogas investments. Despite the fact that renewably energy investments all over the world have been driven primarily by investor return on investment (ROI), and thereby relatively high levels of the preferential feed-in tariffs have been guaranteed to ensure that investments are undertaken, the influence of the green tariff for biogas in Ukraine is perceived as a negative factor by biogas investors in the present sample. As a result, when increasing the negative perception of the green tariff or investment costs by one unit, this leads to the decline in the probability of a biogas investment by 77.1 % and 79.2 %, respectively. These findings mean that, if some negative information related to the green tariffs, such as decline in payments, reaches top-managers of Ukrainian agroholdings, this would likely decrease the probability of new biogas investment in these companies. As a consequence, the government of Ukraine should improve the policy design for the green tariff and eliminate existing administrative barriers.

Finally, the results show that the relationship between the willingness-to-invest in biogas and the actual biogas investments has a low explanatory power. This could be explained by the fact that biogas generation is a relatively new technology in Ukraine´s agricultural sector, despite the broad diffusion of biogas plants in Europe. As a result, Ukrainian agroholdings may pay more attention to well-established technologies which help develop their core businesses, e.g. crop farming, by increasing crop yields or daily weight gains of livestock. The present findings may also indicate that in many cases investment decisions of Ukrainian agricultural companies may be significantly influenced by capital constraints, the political situation, legal framework, restrictions concerning qualified workforces and so on. As a consequence, investments in innovative agricultural technologies in Ukraine´s agricultural sector remain on a relatively low level.

8.2 Contribution of the Present Work to Theory and Practice

This dissertation makes a contribution to the literature in the fields of adoption theories, agricultural economics and energy policy making in transition countries and renewable energy investments:

First, the present work provides empirical results on the decision-influencing factors related to investment in biogas technologies in large-scale agricultural companies, thus corroborating the existing scientific literature by delivering empirical evidence on an under-investigated research topic.

Second, the present study analysed the top-managements´ attitudes toward renewable energy policy, particularly in the field of biogas generation in Ukraine. Since Ukraine´s biogas sector is regulated under several policy and legal schemes, understanding the impact that the existing policies have on the willingness-to-invest in biogas and actual biogas investment of Ukrainian agricultural companies may help policy makers design more effective support mechanisms to increase the diffusion of biogas technologies in Ukraine. The findings related to the effects of the feed-in tariffs for biogas can be partly used for investigating and comparing the influence of policy measures for biogas production in developed and developing countries as well as in transition countries.

Third, the descriptive analysis of agroholdings conducted in the present work provides additional findings on their current situation in Ukraine, their past and future investments, the attitudes of the top-managements towards investments and companies´ performance and the interest of senior executives in sustainable energy generation.

Fourth, the development and examination of the conceptual model, which incorporates institutional and individual elements into the analysis of investment decision-making, contributes to the scientific theory in this field. It provides a more accurate description of the influence of decision-relevant factors on the intention to invest in a new technology.

Additionally, as was mentioned earlier in this work, a majority of scholars have so far focused on small farm production, where decisions are usually made by one person and, maybe, his or her family. By expanding the scope to large-scale agricultural companies, this dissertation contributes to evaluating and extending previous findings.

Moreover, the present work provides methodological instruments for other researchers on how the executive level of large business organisations can be attracted to the participation in a scientific survey, how these methods can be applied in practice and how to collect data not publicly available.

Fifth, by applying different multivariate statistical techniques, e.g. factor analysis, regression models and structural equation modelling, the work allows the comparison of advantages and disadvantages of the application of these methods for conducting research in areas with limited data availability.

Sixth, the study contributes to extending the adoption and organisational decision-making theories by analysing simultaneously the influence of three different dimensions - technological, organisational and environmental - on the decision to adopt a new agricultural technology. By providing empirical evidence on how and to what extent an adoption decision concerning biogas technologies may deviate from or support the expectations of traditional and behavioural economic theories, the present study contributes to this stream of scientific literature.

Seventh, the present work is relevant for the interviewed top-managers of the agroholdings. Their subjective, often restricted information and knowledge level concerning the functioning of the biogas industry, revealed during the interviews, may create additional perceived risk for renewable energies, hampering the adoption of technologies for sustainable energy generation in countries which do not provide subsidisation for renewable energy generation. In fact, at the present time in several East European countries many people tend to believe that only developed and rich countries, which are subsidising their agricultural production anyhow, are able to adopt renewable energies. As a result, many agricultural companies in transition countries do not consider renewable energy to be competitive with traditional energy sources without continuous subsidisation. This might lead to privileging short-term returns over projects which will bring multiple yields in a longer time horizon in such countries.

Finally, the study is relevant for practitioners in Ukraine´s renewable energy market, including companies interested in developing projects in the field of sustainable energy generation, professional organisations supporting the development of renewable energies in Ukraine, foreign investors considering the attractiveness of Ukraine´s energy sector, as well as European producers of biogas plants planning to enter the Ukrainian market: the analysis of potential decision-influencing factors, presented in this work, may help different parties, including private investors, to develop a more balanced view on policy and technological risks, but also a view on opportunities in Ukraine´s agricultural and energy sectors.

8.3 Limitations of the Present Work

Like most scientific research, the present work has its limitations which might hinder generalisation of the results to other countries, farm operations and situational context. The first limitation is that the present study is restricted to the special political and geographical context of Ukraine. The findings of the present work may be difficult to generalise and the results might be different in other political and geographical contexts due to different conditions regarding the legal framework in other regions of the world, different country-specific limiting conditions, as well as investors´ attitudes.

In order to better understand these differences and their impact on biogas investment in agricultural sectors of other countries, as well as to validate the results and conclusions of the present study, it would be worth conducting a similar survey in countries where large agroholdings operate. In particular, interesting studies could be conducted in countries like Brazil, China, the Russian Federation, the USA and India, all of which are currently attracting new investments in energy and agriculture. Such future works could provide some useful insights for international institutions, as well as for policy makers and professional organisations in the field of biogas.

The present study is also based on a specific empirical context (biogas investments and large-scale agricultural companies). Because the sample is skewed toward large-scale export-oriented crop producers, the results may be difficult to apply to smaller farms.

The second limitation pertains to the relatively small sample size. Although the present survey represents 60.7 % of all operating agroholdings in Ukraine, which cultivate 16.1 % of land of all Ukrainian agricultural enterprises (see Section 7.1.1), the number of 68 cases has influenced the statistical estimations. Obviously, some of the phenomena investigated could be sample size-dependent. The limited sample size prevented a better differentiation among the various types of the agricultural companies studied. Additionally, a relatively large number of decision-influencing factors has been included in the conceptual model. Despite the fact that the assumptions of the regression analysis (multicollinearity, autocorrelation, etc.) have been controlled, the use of a larger sample would be necessary to validate these findings. Thus, a higher number of respondents along with fewer variables would also increase the statistical power and the informational value of the conceptual model.

The third limitation is that given the confidential character of the data collected, all model variables had to be measured using the questionnaire. Due to the reluctance of senior managers to disclose some objective information on their businesses, mainly perceptual values had to be applied in the main study. In an ideal case, to measure and explain the investment activity of agroholdings more objective data of economic performance of these companies should have been used. However, a majority of the agroholdings in the sample are relatively young companies: the oldest agroholdings have operated in Ukraine since the early 2000s and the youngest companies since 2014. This limited the possibility to receive investment performance data for a long-term time period. Thus, future research should focus on agricultural companies with a longer history and investment experience. This could provide several advantages: first, a study of long-performing agroholdings would allow an in-depth investigation of companies´ actual investment preferences across a long time period; second, the information provided by agroholdings could be cross-checked against the official statistical information, companies´ financial statements and publications in professional journals.

Fourth, due to the lack of established theories explaining the willingness-to-invest in biogas and actual biogas investments on the part of large-scale agricultural companies, the theoretical foundation of the present work is limited. As a consequence, based on the findings of the previous scientific works and the results of the qualitative preliminary study, a specific theoretical framework was developed for this dissertation. However, this framework does not establish a new theory, regarding the issues investigated, which than can be applied to other empirical contexts and research questions without adaptation. The aim of this theoretical framework is to explain the behaviour of large-scale agroholdings in the context of biogas investments and empirically test the significance and strength of influence of the decision-relevant factors, defined in the study. Therefore, future research could aim at developing and applying a new conceptual theory with a strong theoretical foundation to test this theory empirically.

Fifth, the use of face-to-face interviews for the data collection has also created several limitations. For example, the influence of the interviewer on the interview partner by answering questions could not be completely excluded from the study. Additionally, the respondents could have provided socially desired answers to present their companies and themselves under a more positive light. Moreover, in the present study only one interviewer conducted all interviews both in the preliminary study and in the main survey. This created additional limitation of the data collection, because the interviewer´s biases and influence was spread on every interview partner at the same way. Alternatively, several interviewers could have been used to conduct the interviews to exclude the possibility of the interviewer influence on senior managers. Nonetheless, it was difficult to find partners in Ukraine who were able and ready to collect the data in the way it was planned and designed by the author of the present work.

Despite the limitations described above, the advantages of conducting personal interviews for data collection concerning investments of large companies are: ensuring the quality of the data and the answers received, supporting the complete fulfilment of the questionnaire and providing useful feedback for improving the quality of the survey. In addition to other research recommendations, described above, applying a web-based or a written form of a questionnaire, posted to a broader range of agricultural companies, is recommended to validate the present findings.

Several limitations related to the statistical methods, applied in the present work, will also be discussed in the following:

Concerning the multinomial linear regression analysis, a methodological limitation relates to the fact that the variables used in the theoretical model are self-assessed and measured by a five-point Likert scale. This choice was largely influenced by the results of the expert interviews, which revealed that Ukrainian agroholdings would not disclose objective data for scientific purposes beyond a first-order assessment on the ranking scale (agree, indifferent, disagree, etc.). Although the regression analysis excluded the evidence of typical method-related problems (see Section 6.2), the use of objective measures of agroholdings´ performance is necessary to confirm the results. Moreover, the regression model includes the relatively large set of independent variables, tested on the limited sample size. Generally, the recommended proportion between the number of cases and a model variable is nearly five to one (Hair 2014b, p. 318), which is not fulfilled in the present study. Therefore, future research studies in the field of biogas investment should investigate a smaller number of independent variables, using the statistically significant variables in the present analysis on a greater number of agricultural companies.

As far as the binomial logistic analysis is concerned, the model includes more non-investors in biogas than investors. Additionally, for the total number of 16 model variables 68 cases were used. In an ideal case, the groups investigated should have been nearly equal and the number of cases per model parameter should not have been less than ten in every group analysed (Hair 2014b, p. 329). Although nearly all biogas investors in Ukraine took part in the present survey, their total number was not enough to fulfill these statistical requirements. This limitation needs to be taken into account when interpreting the findings of the logistic model.

The application of structural equation modelling to analyse investments in environmentally-friendly technologies and to investigate the relationship between an intention and an observed behaviour has been found in other scientific works (Hertel 2014). However, the results of the Partial Least Square approach applied in the present dissertation have a relatively low explanatory power of the conceptual model, explaining the causal relationship between the willingness-to-invest in biogas and actual biogas investments ($R^2 = 0.7$ %). Thus, the informational power of the model reveals some limitations in this respect. Although the Partial Least Square modelling allows analysing small sample sizes ($n > 30$), the limited number of cases in the present study ($n = 68$) has influenced the results of the structural equation modelling as well as in the regression analysis. Moreover, the presence of a reverse relationship between actual biogas investments and the willingness-to-invest in biogas in the future cannot be excluded a priori. Thus, agroholdings which have previously invested in biogas may show less interest in new biogas investments, because their previous biogas projects have exploited the potential of biogas application for these agroholdings. Furthermore, it can be also expected that over time those agroholdings which invested in biogas technologies earlier will also tend to invest in other renewable energies, e.g. in solar power or wood heating, but will not show interest in new biogas investments. Therefore, future research should examine the relationship between actual biogas investments and the willingness-to-invest in other renewable energy sources.

8.4 Recommendations for Policy Makers and Future Research

While working on the present doctoral thesis, a series of recommendations for policy and additional suggestions for future research have been developed. First, the main recommendation for policy making derived from the empirical results are that more targeted support mechanisms for biogas generation in Ukraine´s agricultural sector should be designed and implemented, which must take into account the degree of the sector´s development, Ukraine-specific investment conditions and the level of biogas technology maturity. At the same time, the design of the policy framework should consider specific needs of the target group: agricultural producers.

So far, Ukraine´s policy making seems to have been largely influenced by European support schemes, e.g. high feed-in tariffs, which cannot be transferred into Ukraine´s agricultural industry without adaptation. Therefore, to design policies which will attract more attention of the agricultural business sector, agricultural companies should be involved in the development of renewable energy programmes and respective support mechanisms in Ukraine from the beginning.

Second, the introduction of existing support mechanisms for renewable energy generation in Ukraine was largely determined by the obligations of Ukraine´s accession to the Energy Community Treaty in 2010 (see Section 2.1.3.1).

However, the decision to produce sustainable energy, despite the obvious need to become more independent from natural gas imports, has never been discussed with Ukrainian people. As a result, renewable energies do not appear to be accepted by the population and industrial sector, which actually do not want to be forced to pay much higher prices for consumed renewable energy. Most people in Ukraine are not motivated to fulfill the requirements of the Energy Community, which should be met by Ukraine´s government. As expressed by one of the interview partners “the government should communicate with us and give us clear signals that they want us to produce renewable energy, in particular, biogas”. Thus, a broader societal and political dialogue involving social and business sectors is recommended to raise the support of Ukraine´s society to transform the country´s energy sector.

Third, while feed-in tariffs are the most favoured policy instrument in Western European countries to promote renewable energy generation, the results of the present study have revealed a low importance of green tariffs for biogas investment in Ukraine´s energy sector. Moreover, when European investors ask for the continued support over a timeframe of 20 years, Ukrainian agricultural companies do not seem to trust the guarantees of Ukraine´s government to provide payments for the same time period. Thus, a mere increase of the green tariff does not seem to significantly support a broader deployment of biogas in Ukraine´s agricultural sector. Therefore, the government should invest more time and effort in building its trustworthiness in the business sector, which would have positive effects exceeding the effects related only to a larger diffusion of biogas technologies in Ukraine. The Ukrainian government should ensure both the business sector and the society that the use of public subsidies for renewable energy promotion is effective, efficient and transparent.

Fourth, it became clear that worldwide governmental spending in the renewable energy sector has been largely dedicated to subsidising electricity generation from renewable sources. However, in countries with cold winters, e.g. in Ukraine, more heat power is needed than in Western European countries. Therefore, renewable heat energy should gain more political attention than merely the current support of renewable electricity production. Through heat power generation from renewable sources Ukraine could probably replace more fossil fuels, e.g. imported natural gas, than it currently needs for the electricity supply. Such substitution would lead to a more reliable heat supply in winter and could also result in a more rapid modernisation of Ukraine´s energy sector. Additionally, the benefits of biogas use should not be solely devoted to replacing natural gas: the government should bundle the advantages of biogas use, described in Section 2.1, both for the agricultural companies, rural development and the social sector in their politics, to maximise positive effects of every support measure for biogas combustion.

Fifth, to mobilise investment of Ukrainian agricultural producers in biogas generation the governmental support should be linked to energy efficiency measures, such as building insulation, lighting replacement, purchasing energy-saving machinery, etc. This would increase positive effects from biogas generation by reduced energy consumption in large agricultural companies operating in different business areas.

Other uncertainties, partially undermining the effects of biogas production, are related to the fixing of green tariffs in Euro. Due to the on-going national currency devaluation, the government must pay more tax-payer money in Grivna[49] to cover the difference resulting from its devaluation versus the USD and Euro. This fact, again, is negatively influencing acceptance of renewable energy generation by the population. Additionally, because of the relatively high initial costs of biogas plants, mainly large companies are able to finance them and to reap benefits from the governmental support of biogas production. Small and middle-size Ukrainian farms would require first an easier access to capital markets to raise financial sources needed for biogas investments.

Turning attention to suggestions for further research, several ideas are developed:

In particular, screening scientific literature, in which renewable energy investment have been investigated, it became evident that governmental support of renewable energy generation in highly industrialised countries has been largely directed to achieving certain amounts of electricity produced and capacities installed. As a result, most research in this

[49] Grivna is Ukraine´s national currency.

field has concentrated on evaluating the impacts and effectiveness of different support mechanisms, aimed at widespread diffusion of several renewable energy technologies. In contrast, less attention has been dedicated to the analysis of policy effectiveness in the field of research and development regarding more efficient and inexpensive ways to generate power from renewable sources, as suggested by Nemet, Kamen (2007) on the example of the U.S. energy research.

Indeed, as could be demonstrated in this study on the example of Ukraine´s agricultural sector, for worldwide expansion of biogas, wind and solar power, especially in transition countries, the market availability of cheaper energy generating facilities seems to be a research priority. Moreover, in order for renewables to become a self-sustaining market, competitive with fossil fuels without continuous governmental subsidisation, policy makers, investors, producers and customers need to better understand the primary issues regarding the energy sector and identify optimal solutions acceptable to all parties involved. This could further accelerate the cost reduction for renewable energy generation, bridge the current competitiveness gap between conventional and renewable energies, and lead to a greater diffusion of renewable technologies in countries which cannot provide financing for renewables at the levels comparable with Western European economies. However, currently the main manufactures and key players of the renewable industry do not appear to be motivated to reduce the initial prices of biogas plants, wind turbines and solar plants, because the continuing subsidisation allows earning profits for both producers and buyers of renewable power facilities. Within this framework, scientific research incorporating behavioural economics and organisational theories in the assessment of technology-push political programmes could provide additional findings.

Another aspect for future research, identified during this project, is that a market breakthrough of sustainable energy technologies does not depend merely on one special factor, e.g. governmental subsidies. Instead it depends on a complex combination of different factors, including effective public-private partnerships, developed infrastructure, e.g. greed connection, and a dynamic industrial environment for projects in the field of research & development regarding renewable energy generation. In addition to further research projects, activities related to inform different stakeholder groups, e.g. environmental organisations, state authorities, industry enterprises, are needed to positively influence private consumers to support renewable energy production. Nevertheless, this may be a long-term process, requiring coordinated strategies on the part of different institutions. These points could be addressed in future research as well.

9 Summary

In the context of sustainable energy supply in Ukraine, biogas technologies are regarded with increasing interest as an effective instrument for replacing natural gas. Because of the limited domestic fossil-fuel resources, Ukraine imports natural gas, oil and coal, resulting in the country´s reliance on its neighbouring states, which has become particularly challenging concerning Ukraine´s current recession and the geopolitical obstacles the state has been experiencing since 2014.

Over the last 15 years the potential of biogas generation in Ukraine has gained increasing attention from scholars, who published over 50 studies in the field of biogas production and renewable energy generation, focusing among other issues on existing investment obstacles for biogas implementation in Ukraine. Due to the on-going development of Ukraine´s agricultural sector, resulting also in the increase of biomass supply, suitable for biogas combustion, experts suggest that biomass represents the greatest potential among all types of renewable energy sources in Ukraine (Organisation for Economic Development and Cooperation (OECD) 2012, p. 18). Because agricultural residue and waste account for over half of the overall biomass supply, biogas is a key technology for biomass utilisation in Ukraine´s agricultural sector. Thus, agroholdings might represent a good potential for future increase of Ukraine´s biogas production.

In Ukraine´s agricultural sector agroholdings emerged over the last two decades during the transformation processes, triggered by the collapse of the collective farms int the late 1990s. Despite the fact that there is still no unified definition of agroholdings, scholars define such companies as a vertical incorporation of several enterprises in the agricultural value chain (Wandel 2011, p. 62). Ukrainian agroholdings are mainly concentrated on crop production in the cultivated area of approximately 5 M ha. In spite of the recent geopolitical uncertainty in Ukraine, which is negatively impacting the development of agroholdings, their top-managements are considering the feasibility of reliable and independent energy generation, one of which is biogas production. Despite the principle attractiveness of biogas for agroholdings, biogas is reliant on governmental support (Masini, Menichetti 2013, p. 511).

Since 2009 the Ukrainian government has introduced several financial incentives for biogas generation, committing itself to reform the domestic energy sector and to increase the energy efficiency of Ukraine´s economy. The main support mechanisms, guaranteed by the law, include the preferential green tariff for electricity generated from biogas, tax benefits and obligating the Wholesale Electricity Market of Ukraine to purchase the entire electricity from biogas (Energy Charter Secretariat 2013, p. 86; Arzinger 2011, p. 23). Despite this promising outlook, Ukraine´s biogas potential is far from being exploited, because meanwhile there are only nine biogas plants, which produce electricity for the green tariff. Therefore, to achieve a higher level of biogas utilisation, several investment barriers need to be overcome (Organisation for Economic Development and Cooperation (OECD) 2012, p. 18). Based on the existing research and expert interviews, key barriers in politics, legal, economic and social spheres have been identified within this study. The key obstacles are related to high investment costs of biogas plants, lack of capital and insufficient governmental support (low green tariff).

The performed analysis of the scientific literature regarding investment decision-making in the context of biogas emphasises several important aspects. First, it highlights that decision-making regarding investments in innovative agricultural technologies is affected by different factors. Some scholars divide the decision-relevant aspects into technological, organisational and environmental dimensions (Gadenne et al. 2009; Jungklaus 2010; Hertel 2014; Etzion 2007; Gonzalez-Benito, Gonzalez-Benito 2006). Other researchers explain decision-making as a combination of farmer motivation, external factors and farm organisational characteristics (Lynne et al. 1995; Jacobsen et al. 1994; La Due et al. 1991; Solano et al. 2003; Olsen, Lund 2011). Despite the abundant literature on this topic, little empirical study has analysed the simultaneous impact of all three dimensions. Additionally, the magnitude and direction of impact of the decision-relevant factors have not been thoroughly assessed in scientific literature.

Second, decision-making research in agriculture has basically focused on small farms, where individual farmers make investment decisions (Groenwald 1987; Willock et al. 1999). In contrast, agroholdings, analysed in the present doctoral thesis, are large organisations, where decisions are made and influenced by different employee groups.

According to the neoclassical organisational theories decision-makers choose optimal solutions, grounding them mainly on profit maximisation (Cyert, March 1992, p. 215). In contrast, modern organisational behavioural theories assume that organisations identify and implement an optimal solution from available alternatives rather than try to find the best imaginable and profitable one. Thus, it is concluded that organisational decision-making of Ukrainian agroholdings regarding biogas investment is determined not only by profit maximisation, but in this context a group of organisational features also influence the final decision of senior managers. Moreover, the decision of whether to accept or reject a new investment project is directly impacted by numerous individuals involved in the decision process.

Third, cognitive factors influence the decision to invest in new agricultural technologies. Numerous scholars have applied behavioural theories to explain farmers´ decisions (Carr, Tait 1991; Wilson 1997; Austin et al. 1998a; Austin et al. 2005; Willock et al. 1999; Beedell, J. D. C. and Rehman, T. 1999), and many studies have examined behavioural factors affecting renewable energy investments (West et al. 2010; Menichetti 2010; Masini, Menichetti 2013, 2010; Wüstenhagen, Menichetti 2012; Devine-Wright; Wolsink (2007; 2007); Hekkert et al.; Wüstenhagen et al.; Stephens, Jiusto (2007; 2007; 2010)). The authors conclude that, apart from financial goals, psychological factors influence decision-making regarding investments in renewable energies. Therefore, it is assumed in this study that in addition to an economic evaluation of biogas investments non-financial factors have impact on the investment decision.

Thus far, there is a lack of empirical research examining organisational decision-making in agriculture regarding investments in innovative agricultural technologies. This study contributes to filling this gap. The aim of the present work was to simultaneously investigate the influence of three dimensions – technological, organisational and environmental – on the top-managers´ decision-making behaviour in Ukrainian agroholdings in the context of biogas plants. Building upon the literature review including adoption and organisational theories, energy policy, market reports on agroholdings and renewable energies in Ukraine and cognitive psychology studies a conceptual model has been designed to address three research questions of the present work:

- Which factors have a significant influence on the top-managers´ willingness-to-invest in biogas?
- Is there a difference in the influencing factors of senior executives with previous biogas investments compared to those which have not yet made this kind of investment?
- Does an existing willingness-to-invest in biogas lead to actual biogas investment?

The theoretical model examined the direction and strength of influence of different factors on the likelihood of investing in biogas and whether, in turn, the influence of these factors is reflected in investments of Ukrainian agroholdings in biogas. Four main categories of decision-relevant factors were included as independent variables in the model: perceived investment attributes, organisational, individual and business environment factors. The dependent variables were “willingness-to-invest in biogas” and “actual biogas investment”.

The methodological approach applied to collect the data and to examine the conceptual model, included qualitative and quantitative measurement techniques and allowed to obtain statistically and practically relevant results. As for the data collection, the agroholdings´ top-managers were interviewed personally, thus, allowing them to determine the interviewer´s trustworthiness. A written or a web-based form of data collection was rejected after consultations with experts in Ukraine´s agricultural and renewable energy sectors, who suggested that the senior executives of Ukrainian agroholdings might not disclose internal company information such as investment details and might not fill-in the questionnaire.

Related to the data analysis, three main statistical techniques were adapted to serve specific research purposes. The multivariate regression was used to address the first research question, concerning significant determinants of the top-managers´ willingness-to-invest in biogas. The binomial logistic model was employed to measure the statistically significant differences between the senior executives-investors and non-investors in biogas.

The structural equation modelling approach investigated the statistical relationship between the intention regarding biogas investment (willingness-to-invest) and the observed investment behaviour (actual biogas investment).

The results derived from the statistical analyses show that the top-managers´ interest on potential biogas investments is determined by three project parameters: expected payback period, investment volumes needed to conduct a biogas project and comparable advantages of biogas use versus other energy sources. However, actual investment decisions related to biogas projects are negatively influenced by the top-managers´ perception of the green tariff, giving a signal to Ukrainian policy makers to improve this support mechanism. Additionally, the probability of a biogas investment is higher in larger agroholdings compared to the smaller agricultural companies in the sample analysed. Finally, the results reveal that there is a low coherence between the intentions to invest in biogas technologies and actual investments made in the agroholdings studied.

To summarise, the recommendations for policy derived from the present study are that more attention should be brought to communicating renewable energy programmes to business organisations in Ukraine. On a more general level, biogas generation should be considered an important part of Ukraine´s sustainable energy supply system. Because biogas allows adaption of production to demand, biogas generation has an important advantage compared to other renewable energy sources, such as wind and solar. This benefit should be considered by Ukrainian policy makers when designing the support instruments for renewable energy generation.

In any case, it took the renewable energy movement more than 20 years to gain ground in the European Union, thus the path to sustainable energy generation in less developed regions, e.g. Ukraine, will certainly be long.

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The author is grateful to those 102 top-managers of the Ukrainian agroholdings and experts in the field of renewable energy in Ukraine, who took part at the preliminary and main surveys. This project was possible only because of their active participation and their interest on sustainable energy generation and biogas technologies. Finally, my thanks go to my parents, Lyudmila and Igor, for their continuous support, dedication and commitment to my work.

During the entire process of developing this thesis, the work was present at five international and national conferences in Ukraine and Germany: at the 6th "Large Farm Management Conference 2015", organised by the Ukrainian Agribusiness Club, at the Conference "Renewable energy for Ukraine´s agricultural sector 2015" from the Ukrainian agro confederation, at the seminars "Organic agriculture for large Ukrainian agribusiness companies 2016" from the Research Institute of Organic Agriculture (FiBL, Switzerland) and "Sustainable energy generation for Ukraine 2016" from Renewable Energy Academy AG (Renac AG, Berlin), and the EAAE-Conference "Days of agricultural economics in Ukraine" 2016 in Kyiv, Ukraine.

11 Appendix

11.1 The Questionnaire of the Main Survey

HSWT I Wissenschaftszentrum | Petersgasse18 | 94315 Straubing

Survey of University of Applied Sciences Weihenstephan-Triesdorf

Development of Biogas in Ukraine´s Agricultural Sector

Dear project participants,

the achievement of Ukraine´s independency on natural gas, in our opinion, is impossible without participation of agricultural companies. One of the opportunities of natural gas replacement in our country is biogas production.

The goal of the project, PhD thesis of Dmytro Romets, is to determine the willingness-to-invest in biogas by Ukrainian agroholdings and to identify factors that have the greatest impact on their decision.

Your participation in the project is fully anonymous and protected by the German Law of personal data protection. The interview will last 30 minutes.

We are grateful for your participation in the project. If you have any questions, please, feel free to contact Dmytro Romets who will gladly provide you with additional information.

Best regards,

Prof Dr Klaus Menrad PhD Dmytro Romets

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1.1. Investment attractiveness of biogas

What kinds of renewable energies have you invested in for today?

☐	Biogas	☐	Energy plants (miscantus, willow, etc.)
☐	Biomass (chopped wood, pellets, sunflower husk, etc.)	☐	Wind energy
☐	Solar energy	☐	Other renewables
☐	Biofuels (biodiesel, ethanol, etc.)	☐	We have not invested into renewable energies yet.

Please, evaluate the existing legislation of Ukraine in the field of biogas.

1-very bad; 2-bad; 3-satisfactory; 4-well; 5-very well.

1 **2** **3** **4** **5**

How do you feel about future investments of your company in biogas?

Very likely	Likely	I am indifferent	Unlikely	Very unlikely
☐	☐	☐	☐	☐

Please, evaluate the general interest of your company on investments in the following renewable energies.

	Strongly intereste d	Intereste d	I am indifferent	Not interested	Strongly not interested
Biogas	☐	☐	☐	☐	☐
Biomass (chopped wood, pellets, sunflower husk, etc.)	☐	☐	☐	☐	☐
Solar energy	☐	☐	☐	☐	☐
Biofuels (biodiesel, ethanol, etc.)	☐	☐	☐	☐	☐
Energy plants (miscantus, willow, etc.)	☐	☐	☐	☐	☐
Wind energy	☐	☐	☐	☐	☐

Which reasons prevent your company from investments into biogas?

	Agree strongly	Agree a little	I am indifferent	Disagree a little	Disagree strongly
Environmental uncertainty	☐	☐	☐	☐	☐
Investments into other businesses are more attractive	☐	☐	☐	☐	☐
Low profitability of biogas investments	☐	☐	☐	☐	☐
No interest in biogas investments	☐	☐	☐	☐	☐
High need for capital	☐	☐	☐	☐	☐
No loan capital	☐	☐	☐	☐	☐
Other factors: ____________________	☐	☐	☐	☐	☐

How will biogas develop in Ukraine in the following 10 years?

Very many companies will invest into biogas	Many companies will invest into biogas	Few companies will invest into biogas	Very few companies will invest in biogas	No one will invest into biogas
☐	☐	☐	☐	☐

Specify the minimum “green tariff” (GT) level on biogas that you invest in this business.

☐	< 0,12	€/KWh	☐	We are ready to invest into biogas without GT.
☐	0,12 - 0,15	€/KWh		
☐	0,16 - 0,2	€/KWh	☐	No interest on investments into biogas regardless of GT.
☐	> 0,2	€/KWh		

For how many years would you sign a contract with the state on electricity production from biogas?

☐	< 10	years	☐	We do not trust existing government, so we would not sign such kind of a contract with it.
☐	10 - 20	years		
☐	> 20	years	☐	We are ready to invest into biogas even without a contract.

What part of investment into biogas with the amount of $ 2.5 M can your company finance with own capital? [%]

0% 10 20 30 40 **50%** 60 70 80 90 **100%**

Please, evaluate an overall risk of a biogas investment for your company.

Very high	High	Average	Low	Very low
☐	☐	☐	☐	☐

Will you invest in biogas in the following three years?

Yes, necessarily	Rather yes	Neither yes nor no	Rather no	No, in no case
☐	☐	☐	☐	☐

Please, express your opinion regarding the following statements.

	Agree strongly	Agree a little	I am indifferent	Disagree a little	Disagree strongly
We consider biogas to be an attractive investment.	☐	☐	☐	☐	☐
Biogas requires large capital investments.	☐	☐	☐	☐	☐
Today´s natural gas price makes biogas an attractive investment.	☐	☐	☐	☐	☐
Interest rates in Ukraine make biogas investments not attractive for us.	☐	☐	☐	☐	☐
Investments in our main businesses are more attractive for us that one into biogas.	☐	☐	☐	☐	☐
Investments in biogas without state guaranteed feed-in tariff are not interesting for us.	☐	☐	☐	☐	☐
Biogas can improve the financial situation of our company.	☐	☐	☐	☐	☐
If the payback period for biogas exceeds six years then such a project is not interesting for us.	☐	☐	☐	☐	☐
Biogas production is a complicated technological process.	☐	☐	☐	☐	☐
The biogas we produce can be used within the company (for heating and electricity).	☐	☐	☐	☐	☐

1.2. Corporate energy efficiency

How did your heating and electricity costs change in 2012-2014? Change in % 2014 to 2012.

Increased significantly	Increased	Did not change	Reduced	Reduced significantly
(increase > 21%)	(increase> 0 - 20%)		(reduce> 0 - 20%)	(reduce> 21%)
☐	☐	☐	☐	☐

Which energy sources do you use for heating of production facilities, corn silos, offices etc.?

☐	Natural gas	☐	Chopped wood (graft, sawdust, pellets, etc.)
☐	Biogas	☐	Straw in bales/ straw pellets
☐	Sunflower husk	☐	Other sources ________________________

What steps will your company take in the case of a sharp price increase for heating and electricity? Please, describe your actions in brief.

What kind of energy would you invest in for providing your company with heat and electricity?

	Very possible	Possible	Neither possible nor impossible	Less possible	Very less possible
Natural gas	☐	☐	☐	☐	☐
Biogas	☐	☐	☐	☐	☐
Sunflower husk	☐	☐	☐	☐	☐
Chopped wood (graft, sawdust, pellets, etc.)	☐	☐	☐	☐	☐
Straw in bales/ straw pellets	☐	☐	☐	☐	☐
Other sources ________________	☐	☐	☐	☐	☐

Please, express your opinion regarding the following statements.

	Agree strongly	Agree a little	I am indifferent	Disagree a little	Disagree strongly
We are satisfied with the level of our heating and electricity costs.	☐	☐	☐	☐	☐
Biogas can significantly decrease our heating and electricity costs.	☐	☐	☐	☐	☐
We are looking for the possibilities to decrease our heating and electricity costs.	☐	☐	☐	☐	☐
The current state support of biogas in Ukraine hampers biogas more than supports.	☐	☐	☐	☐	☐
Biogas has more advantages for us than using of natural gas.	☐	☐	☐	☐	☐
We have already managed to significantly reduce our heating and electricity costs.	☐	☐	☐	☐	☐
We will invest in biogas in the following three years.	☐	☐	☐	☐	☐

1.3. Corporate investment activity

Specify the approx. investment volume into the company business directions listed below that was invested in 2009-´14 and will be invested in 2015-´20? [$ total amount]

2000-2014

	$0	> $0-500.000	>$500.000 -1.000.000	>$1.000.000-5.000.000	$5.000.000-10.000.000	>$10.000.000
Biogas	☐	☐	☐	☐	☐	☐
Renewable Energies (RE, without biogas)	☐	☐	☐	☐	☐	☐
Investments into the main businesses (without RE and biogas)	☐	☐	☐	☐	☐	☐
Opening of new businesses/markets (without RE and biogas)	☐	☐	☐	☐	☐	☐
Investments into company energy efficiency	☐	☐	☐	☐	☐	☐

2015-2020

	$0	> $0-500.000	>$500.000 -1.000.000	>$1.000.000-5.000.000	$5.000.000-10.000.000	>$10.000.000
Biogas	☐	☐	☐	☐	☐	☐
Renewable Energies (RE, without biogas)	☐	☐	☐	☐	☐	☐
Investments into the main businesses (without RE and biogas)	☐	☐	☐	☐	☐	☐
Opening of new businesses/markets (without RE and biogas)	☐	☐	☐	☐	☐	☐
Investments into company energy efficiency	☐	☐	☐	☐	☐	☐

Evaluate the total success of your investments in 2009-´14.

Results significantly exceeded expectations	Results exceeded expectations	Results were equal to expectations	Results were worse than expectations	Results were much worse that expectations
☐	☐	☐	☐	☐

Which sources of capital were the investments in 2009-´14 financed from?

☐ Own company capital

☐ Ukraine´s banks loans

☐ Foreign banks/donors loans (IFC, EBRD, etc.)

☐ Other sources (Eurobonds, funds of private investors, etc.)

How easy it is for your company to get loan capital for new projects.

Very easy	Easy	Satisfactory	Difficult	Very difficult
☐	☐	☐	☐	☐

Please, express your opinion regarding the following statements.

	Agree strongly	Agree a little	I am indifferent	Disagree a little	Disagree strongly
We are satisfied with the financial situation of our company.	☐	☐	☐	☐	☐
Key results of our business (revenue, profit) from 2012 to 2014 were excellent.	☐	☐	☐	☐	☐
We are always among the first in Ukraine who apply and use modern agricultural technologies.	☐	☐	☐	☐	☐
To get more profit we are ready to take higher risks in business.	☐	☐	☐	☐	☐
Financial difficulties hold us back from applying new technologies.	☐	☐	☐	☐	☐
Our financial situation does not allow investing in new projects.	☐	☐	☐	☐	☐
When making decision regarding new investments we choose a project with a lower risk.	☐	☐	☐	☐	☐
We are not sure in the development of economic situation in Ukraine and we are now cautious with new investments.	☐	☐	☐	☐	☐
The achievement of Ukraine´s independency on imported gas is important for us.	☐	☐	☐	☐	☐
Recycling of production waste of production waste is a problem for us.	☐	☐	☐	☐	☐
Production waste of our company has led to conflicts with local citizens.	☐	☐	☐	☐	☐

Structure of the company

What kind of legal form does your company have?

☐ Private Farm ☐ Closed Stock Company

☐ Limited Liability Company ☐ Public Joint Stock Company

☐ Joint Stock Company ☐ Other ________________________________

Specify the main directions of your business.

☐ Plant growing ☐ Food processing

☐ Stock breeding ☐ Other ________________________________

What number of hectares does your company cultivate in 2014/2015 financial year? [ha]

____

Name the average yield crops between 2012 and 2014. [t/ha]

Wheat (spring/winter)	____________	Rape	____________
Maize	____________	Sugar beat	____________
Sunflower	____________	Potato	____________
Soy	____________	Other ____________	____________

Do you apply new agricultural technologies, listed below?

	Yes	No
Precision Farming	☐	☐
Zero Tillage	☐	☐
Irrigation Systems	☐	☐

Specify the average number of livestock in your company. [heads]

Pigs	____________
Cattle (without dairy cows)	____________
Dairy cows	____________
Poultry	____________

Specify the directions of your business on food processing.

☐ Pork production ☐ Sunflower/rape oil

☐ Beef production ☐ Sugar production

☐ Milk and dairy production ☐ Other ____________________________

☐ Production of poultry meat, eggs, etc.

Specify the total annual average revenue of your company in 2012-2014. [$ per year]

☐ < $ 100.000

☐ > $ 100.000 - 500.000

☐ > $ 500.000 - 1.000.000

☐ > $ 1.000.000 - 5.000.000

☐ > $ 5.000.000 - 10.000.000

☐ > $ 10.000.000 - 50.000.000

☐ > $ 50.000.000 - 100.000.000

☐ > $ 100.000.000

What part of the gross production did you export in average in 2012-2014? [%]

0% 10 20 30 40 **50%** 60 70 80 90 **100%**

1.4. Personal Questions

Specify the post where you work.

Which role in the company do you play in decision-making?

☐ I make decisions.

☐ My opinion influences those who make such decisions.

☐ My opinion does not influence those who make such decisions.

☐ Other ____________________

Who are you on education?

☐ Agronomist

☐ Economist

☐ Engineer

☐ Jurist

☐ Other _____________________

Year of your birthday?

11.2 Factor Analysis

Table 11.1: List of items

Factor 1	**Relative Advantage**
RA_1[50]	Biogas has more advantages for us than using of natural gas.
RA_2	Biogas can improve the financial situation of our company.
RA_3	We consider biogas to be an attractive investment.
Factor 2	**Economic Situation**
ES_1	We are satisfied with the financial situation of our company.
ES_2*[51]	Our financial situation allows investing in new projects.
ES_3	Key results of our business (revenue, profit) from 2012 to 2014 were excellent.
Factor 3	**Energy Costs**
EC_1	We are satisfied with the level of our heating and electricity costs.
EC_2*	We are not looking for possibilities to decrease our heating and electricity costs.
Factor 4	**Perceived Need for Waste Recycling**
PW_1	Recycling of production waste is a problem for our company.
PW_2	Production waste of our company has led to conflicts with local citizens.
Factor 5	**Risk Aversion**
AV_1	When making decision regarding new investments we choose a project with a lower risk.
AV_2*	To achieve higher profits we are not ready to take higher risks in business.

[50] “RA_1” is item code.

[51] Items marked with „*“ have been transformed.

Table 11.2: List of transformed (“*”) items

Factor 2	**Economic Situation**
ES_2	Our financial situation does not allow investing in new projects.
ES_2*	Our financial situation allows investing in new projects.
Factor 3	**Energy Costs**
EC_2	We are looking for possibilities to decrease our heating and electricity costs.
EC_2*	We are not looking for possibilities to decrease our heating and electricity costs.
Factor 5	**Risk Aversion**
AV_2	To achieve higher profits we are ready to take higher risks in business.
AV_2*	To achieve higher profits we are not ready to take higher risks in business.

Table 11.3: Correlation matrix

Factor 1	Relative Advantage	RA_1	RA_2	RA_3
RA_1	Correlation Pearson	1	,548**	,467**
	Significance		.000	,000
RA_2	Correlation Pearson	,548**	1	,582**
	Significance	.000		,000
RA_3	Correlation Pearson	,467**	,582**	1
	Significance	,000	,000	
Factor 2	**Economic Situation**	**ES_1**	**ES_2***	**ES_3**
ES_1	Correlation Pearson	1	,472**	,713**
	Significance		.000	.000
ES_2*	Correlation Pearson	,472**	1	,411**
	Significance	.000		.000
ES_3	Correlation Pearson	,713**	,411**	1
	Significance	.000	.000	
Factor 3	**Energy Costs**		**EC_1**	**EC_2***
EC_1	Correlation Pearson		1	,366**
	Significance			.002
EC_2*	Correlation Pearson		,366**	1
	Significance		.002	
Factor 4	**Perceived Need for Waste Recycling**		**PW_1**	**PW_2**
PW_1	Correlation Pearson		1	,369**
	Significance			.002
PW_2	Correlation Pearson		,369**	1
	Significance		.002	
Factor 5	**Risk Aversion**		**AV_1**	**AV_2***
AV_1	Correlation Pearson		1	,374**
	Significance			.002
AV_2*	Correlation Pearson		,374**	1
	Significance		.002	

Table 11.4: KMO- and Barlett-Test

Kaiser-Meyer-Olkin-criteria.		,603
Bartlett-Test	Chi-Square	210,883
	df	66
	Significanse after Bartlett	,000

Table 11.5: Rotated component matrix

	Components				
	1	2	3	4	5
RA_1	,797				
RA_2	,850				
RA_3	,800				
ES_1		,810			
ES_2_trans		,770			
ES_3		,836			
EC_1				,772	
EC_2_trans				,839	
PW_1			,839		
PW_2			,768		
AV_1					,818
AV_2_trans					,798
Extraktionsmethode: Hauptkomponentenanalyse. Rotationsmethode: Varimax mit Kaiser-Normalisierung.					
a. Die Rotation ist in 5 Iterationen konvergiert.					

Table 11.6: Extracted variance

Components	Rotated sum of squared factor loadings		
	Sum	% of the variance	Cumulated %
1	2,171	18,090	18,090
2	2,150	17,918	36,008
3	1,478	12,315	48,322
4	1,458	12,149	60,471
5	1,412	11,768	72,240
Extraktionsmethode: Hauptkomponentenanalyse.			

11.3 Multivariate Linear Regression

Table 11.7: List of regression model variables

Variable	Code	Statement
Perceived investment attributes		
Payback period	PB	If the payback period for biogas exceeds six years then such a project is not interesting for us.
Investment cost	IC	Biogas requires large capital investments.
Relative advantage	F1_RA	Biogas has more advantages for us than using of natural gas. Biogas can improve the financial situation of our company. We consider biogas to be an attractive investment.
Perceived risk	PR	Please, evaluate an overall risk of a biogas investment for your company. [From very high to very low].
Technological complexity	TC	Biogas is a complicated technological process.
Organisational factors		
Economic situation	F2_ES	We are satisfied with the financial situation of our company. Our financial situation allows investing in new projects. Key results of our business (revenue, profit) from 2012 to 2014 were excellent.
Energy costs	F3_EC	We are satisfied with the level of our heating and electricity costs. We are not looking for possibilities to decrease our heating and electricity costs.
Perceived need for waste recycling	F4_PW	Recycling of production waste is a problem for our company. Production waste of our company has led to conflicts with local citizens.
Company size	CS_1	What number of hectares did your company cultivate in 2014/2015 financial year?
Individual factors		
Risk aversion	F5_AV	When making decision regarding new investments we choose a project with a lower risk. To achieve higher profits we are not ready to take higher risks in business.
Innovativeness	IN	We are always among the first in Ukraine who apply and use modern agricultural technologies.
Business Environment		
Green tariff	FT	Investments in biogas with state guaranteed feed-in tariff are interesting for us.
Business uncertainty	BU	We are not sure in the development of economic situation in Ukraine and we are now cautious with new investments.
Capital availability	IR	Interest rates in Ukraine make biogas investments not attractive for us.
Natural gas price	NG	Today´s natural gas price makes biogas an attractive investment.
Dependent variable		
Willingness-to-Invest	WTI	Will you invest in biogas in the following three years?

Table 11.8: Model quality criteria

R	R^2	Adjusted R^2	Standard error	Durbin-Watson-Test
.729	.531	.396	.77698350	2.153

Table 11.9: Analysis of the variance (ANOVA)

Model		Square sum	df	Mean of the squares	F	Sig.
1	Regression	35.607	15	2.374	3.932	.000[b]
	Not standardised residues	31.393	52	.604		
	Total	67.000	67			

Table 11.10: Coefficients

Model	Not standardised coefficients		Standardised coefficients	T	Sig.	Collinearity diagnosis	
	Regression coefficient b	Standard error	Beta			Tolerance	VIF
PB	-,249	,110	-,249	-2,261	,028	,745	1,342
IC	,293	,117	,293	2,511	,015	,660	1,515
F1_RA	,340	,128	,340	2,661	,010	,552	1,810
PR	-,034	,104	-,034	-,330	,743	,831	1,203
TC	-,062	,113	-,062	-,552	,583	,703	1,423
F2_ES	,075	,120	,075	,628	,533	,624	1,602
F3_EC	-,368	,109	-,368	-3,387	,001	,762	1,313
F4_PW	,127	,105	,127	1,211	,231	,819	1,221
CS_1	-,239	,118	-,239	-2,031	,047	,651	1,536
F5_AV	-,038	,118	-,038	-,319	,751	,649	1,542
IN	,091	,117	,091	,783	,437	,662	1,510
FT	,125	,110	,125	1,136	,261	,742	1,348
BU	-,121	,140	-,121	-,866	,390	,458	2,182
IR	,022	,118	,022	,184	,855	,652	1,533
NG	-,062	,141	-,062	-,438	,664	,454	2,201

11.4 Binomial Logistic Regression

Table 11.11: List of variables

Variable	Code	Statement
Perceived investment attributes		
Payback period	PB	If the payback period for biogas exceeds six years then such a project is not interesting for us.
Investment cost	IC	Biogas requires large capital investments.
Relative advantage	F1_RA	Biogas has more advantages for us than using of natural gas. Biogas can improve the financial situation of our company. We consider biogas to be an attractive investment.
Perceived risk	PR	Please, evaluate an overall risk of a biogas investment for your company. [From very high to very low].
Technological complexity	TC	Biogas is a complicated technological process.
Organisational factors		
Economic situation	F2_ES	We are satisfied with the financial situation of our company. Our financial situation allows investing in new projects. Key results of our business (revenue, profit) from 2012 to 2014 were excellent.
Energy costs	F3_EC	We are satisfied with the level of our heating and electricity costs. We are not looking for possibilities to decrease our heating and electricity costs.
Perceived need for waste recycling	F4_PW	Recycling of production waste is a problem for our company. Production waste of our company has led to conflicts with local citizens.
Company size	CS_1	What number of hectares did your company cultivate in 2014/2015 financial year?
Individual factors		
Risk aversion	F5_AV	When making decision regarding new investments we choose a project with a lower risk. To achieve higher profits we are not ready to take higher risks in business.
Innovativeness	IN	We are always among the first in Ukraine who apply and use modern agricultural technologies.
Business environment		
Green Tariff	FT	Investments in biogas with state guaranteed feed-in tariff are interesting for us.
Business uncertainty	BU	We are not sure in the development of economic situation in Ukraine and we are now cautious with new investments.
Capital availability	IR	Interest rates in Ukraine make biogas investments not attractive for us.
Natural gas price	NG	Today´s natural gas price makes biogas an attractive investment.
Dependent variable		
Actual biogas investment	ABI	What kinds of renewable energies have you invested in for today? [Biogas, Biomass, Wind, etc.]

Table 11.12: Coding of the dependent variable

Initial value	Internal value
no	0
yes	1

Table 11.13: Omnibus-tests of the model coefficients

		Chi-square	df	Sig.
Step 1	Step	23.978	15	.065
	Block	23.978	15	.065
	Modell	23.978	15	.065

Table 11.14: Summary of the model

Step	-2 Log-Likelihood	Cox & Snell R^2	Nagelkerke R^2
1	32.812	.297	.525

Table 11.15: Hosmer-Lemeshow Test

Step	Chi-square	df	Sig.
1	1,716	8	,989

Table 11.16: Variables in the model

		Regression coefficient B	Standard error	Wald	df	Sig.	Exp(B)
Step 1	PB	-,006	,742	,000	1	,994	,994
	IC	-1,570	,912	2,965	1	,085	,208
	F1_RA	-,375	,849	,195	1	,659	,687
	PR	,334	,649	,265	1	,607	1,396
	TC	,611	,632	,934	1	,334	1,842
	F2_ES	-,354	,683	,268	1	,605	,702
	F3_EC	-,244	,611	,160	1	,689	,783
	F4_PW	-,188	,638	,087	1	,768	,828
	CS_1	1,299	,661	3,867	1	,049	3,666
	F5_AV	,313	,713	,193	1	,660	1,368
	Innov	,943	,596	2,503	1	,114	2,567
	FT	-1,472	,631	5,446	1	,020	,229
	BU	-,182	,818	,049	1	,824	,834
	IR	,205	,752	,074	1	,785	1,228
	NG	-,435	,671	,420	1	,517	,647
	Constant	-3,109	,784	15,718	1	,000	,045

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