Trends and developments in the renewable energy sector in Ukraine

With a special focus on opportunities and threats for using biomass in the energy transition

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Report

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Summary

The government of Ukraine has adopted the Renewable Energy Directive (RED) with clear goals and a roadmap to facilitate its energy transition towards renewable sources. This is done because of both climate concerns as well as reasons related to Ukraine's foreign policy which led the government to decide that Ukraine should work more on its own energy independence. Currently the percentage of renewable energy sources in Ukraine is among the lowest of the entire Europe and there is only slow development in terms of the growth of the sector, even though there is a lot of available biomass, given the large and flat surface of the country with a well-developed agricultural sector.

Barriers exist mainly on policy level, in terms of unfavourable legislation for example in terms of bioethanol production. High excise taxes make bioethanol production unprofitable for example. There is development in terms of legislation in most areas aiming to stimulate the energy transition, but unfortunately new laws are not always properly implemented, giving possibilities for less than fair business practices. Besides that, the currently underdeveloped market offers difficulties for investors as well as that there are mainly old and therefore less efficient equipment and production facilities, which are in need of serious reconstruction, and, of course, extra investment. Another problem is the wide-spread pollution, which can be a big trouble for investors and entrepreneurs, who will be obliged to pay for clean-up of sites. Furthermore, there is the problem of regional power company monopolisation, all of which are the property of a small number of Ukrainian businessmen. It is questionably in how far it is in the interest of most of these regional power companies, to implement RED policies as fast as possible, because they have a good profit in the current situation. Big changes in the energy sector could very well bring extra costs and a potential decrease in profits. All RED projects in Ukraine are projects designed for long-term investments and a long payback period. At the same time, the (political) situation in the country is not so stable and this high uncertainty, makes any long-term-oriented project too risky for entrepreneurs. Besides these barriers in legislation and economic and societal structure, there are several more technical barriers that limit the implementation of effective energy transition to more renewable sources.

Despite these barriers, there are plenty opportunities for the implementation of new technologies, and to illustrate this, a business case calculation is included for the direct processing of sugar beets into bioethanol with the help of the Betaprocess. Betaprocess is a new technique developed by the company Dutch Sustainable Development, using a vacuum shock explode cells, which helps to greatly speed up the fermentation process. With Betaprocess, bioethanol can be produced significantly faster and cheaper than with conventional techniques. Chapter 3 deals with the parameters and calculations of the possible implementation of Betaprocess in Ukraine and shows that this technique can be profitably implemented in the Ukrainian market, given the current market conditions. Still, some questions remain, especially about the ability and refinery capacity in Ukraine to blend bioethanol with fossil fuels. Alternatives like the usage of molasses from white sugar production for producing bioethanol are also investigated, but the specific business case cannot be calculated very much in detail for this type of production, given the lack of research data. One of the most pressing matters in terms of the bioethanol production is the problem of the high excise taxes, making it currently difficult to develop a good market for it. Sugar beets do have the advantage that they play an important role in crop rotation schemes positively influencing soil fertility. Producing bioethanol from sugar beets gives good options for new usage of sugar beets, even though the use of sugar beets for white sugar production is under pressure because of societal debates about the role of sugar in diabetes.

Biomass in one form of the other may have a great potential for Ukraine to become more energy independent, but there are of course limits to how much biomass can be "harvested". Too much of it will lead to soil degradation, a situation that has been occurring in Ukraine since the breakup of the Soviet Union. Some people blame the moratorium on land sale in Ukraine for this, leading to many lease contracts, in which the leasing companies do feel hesitation to invest in the soil quality of the land. Chapter 4 offers a model which shows the potential land degradation and offers a number of solutions to alleviate these problems, the most important of which are: No-till planting – no ploughing, harvesting straw only once every 2 or 3 years, planting a green manure crop after harvest, using stems, leaves for the soil. 2/3 nutrients left in the field + 1/3 of organic matter, returning ash from straw burning to the field, requiring balanced fertilisation from farmers, apply other organic fertilizers: biogas digestate, manure etc. and usage of maize straw instead of wheat straw. Application of these measures can lead to better estimates on how much biomass is available for use and how much residue should be left on the fields for long term sustainable use, but further research in the context of Ukraine is needed to find out exact numbers.

Contents

Chapter 1

Introduction

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1.1 Background and relevance

As in most countries in the world, there is a quite intensive and well-developed debate in Ukraine about the energy sector, energy usage and the necessary transition towards more renewable types of energy. One of the consequences of it is that Ukraine is one of the partner countries in the Paris agreement and committed itself to reducing the amount of greenhouse gas emissions in the future. That means that a transformation towards renewable energy is needed, even though currently in Ukraine only a low percentage of energy is generated by sustainable sources. The general picture is that in Ukraine the development of the renewable energy sector is going not as fast as could have been. In other words, there are several barriers present that hinder the energy transition. One of the issues behind such a barrier may be a limited access to technology, or problems with legislation or other issues which may be unknown so far, but certainly relevant for foreign investors. The Ukrainian government adopted the so-called Renewable Energy Directive (RED), set goals for the energy transition and support the transition itself. In some areas progress was made, for example in the growing number of biomass fired boilers, but still Ukraine remains one of the European countries with the lowest percentage of renewable energy production.

Therefore, in order to identify currently existing barriers and help to find possible applications of new technologies in Ukraine, the Dutch Enterprise Agency (Rijksdienst voor Ondernemerschap) commissioned this study. It was done within the framework of the Partners in Business on Bioenergy program. The focus of this study is on analysing the renewable energy sector, with special attention for biomass, in the form of biomass-based heating and biomass for biofuels. Of course, other parts of the renewable energy sector such as solar and wind energy are also taken into consideration. The second part consists of a case study to determine the business case for direct processing of sugar beets with Betaprocess as a possible application of biomass to biofuel production in Ukraine. The third study is aiming at determining the amount of biomass that can safely be taken from the fields, without negatively affecting the fertility of the soil.

These sub-studies mentioned in the previous paragraph offer a better understanding of the renewable energy market in general and biomass/biofuel applications in particular. This study sheds light on several important questions that entrepreneurs and/or other foreign investors may have about investing in Ukraine. Even though it is well-known that doing business in Ukraine is challenging, it is also very important to have a clear picture of the opportunities that this country offers, within the limits that nature sets, in order to avoid negative consequences like soil degradation.

1.2 Research questions

The objective of this report is to find out about which opportunities and barriers exist in the Ukrainian transition towards renewable energy generation, to calculate the profitability of new biomass-processing technologies as well as finding out limitations of biomass usage. Therefore the report is divided in three parts, the first part focuses on opportunities and barriers of the Renewable Energy Directive implementation in Ukraine. The second part focuses on identifying and calculating a business case for the innovative technology of direct processing of sugar beets in order to produce bio-ethanol and the third part focuses on the consequences of biomass removal for the soil quality.

The central research question of the first sub-study is:

Why is the implementation of the RED in Ukraine stagnating and which opportunities and barriers for the further development of this market can be identified?

The central research question of the second sub-study is:

What does the business case for direct processing of sugar beets in Ukraine look like and can this direct processing be profitably implemented in the context of Ukraine?

The central research question of the third sub-study is:

What are the effects of crop residue removal on the soil and the effect of methods to alleviate negative effects on soil quality?

1.3 Outline of the report

This report consists of three separate chapters about strongly connected topics related to understanding and facilitating the energy transition towards renewable sources in Ukraine. All of the studies were done in the Spring of 2018. The first study, chapter 2, offers insight in trends and developments in the renewable energy market in Ukraine. A description of the structure of the Ukrainian energy sector is provided in chapter 2.2. The study also deals with the reasons for the relatively slow development of the Ukrainian renewable energy sector. Chapter 2.3 & 2.4 describe the barriers that exist in terms of legislation, economic or social structure of society as well as technical ones. The chapter ends with a conclusion about the situation in Ukraine and gives potential investors and/or entrepreneurs who are thinking about entering the Ukrainian market several recommendations in order to facilitate their access to the market.

The second study, chapter 3, offers a concrete business case in bioenergy, in order to show from a business perspective, the opportunities in processing biomass that certainly exist in the Ukrainian market. Chapter 3 deals with the direct processing of sugar beets with the help of the innovative Betaprocess technology. Chapter 3.2 consists of a brief explanation about this specific technology and the business case in the Ukrainian context is described and calculated in chapter 3.3. The rest of the chapter deals with possible alternatives for such a production method. The entire third chapter is a good example to illustrate the large potential in biomass to energy processing in Ukraine.

Even though Ukraine offers a lot of potential in using its large quantities of biomass, it is also necessary to look at the limits of such soil usage. It is well-known that overusing biomass will eventually lead to soil degradation. Chapter 4 deals with this issue and offers a couple of models to simulate the effects of year on year agricultural activities on the soil quality. The results of such studies can be used as input for policy makers to think about rules and regulation of the use of biomass.

Chapter 2

Development of renewable energy policy and markets in Ukraine

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2.1 Introduction

2.1.1 Background

Ukraine is a country that has always been quite dependent on foreign partners for delivering its energy needs. Traditionally this has been the Russian Federation over the last couple of decades, but the political troubles between the two countries saw a shift in thinking about the energy issue in Ukraine, in terms of becoming more energy independent. One of the options is to increase production of domestic oil and gas resources, but this will be not enough to cover Ukraine's energy demand. Plus, given the threatening situation around climate change and exhaustion of the planet's limited fossil resources, a lot of attention also goes to the development of renewable energy, for example wind and solar energy, but also biomass. Since Ukraine has a large surface with a lot of arable land at its disposal, it means that its potential for using biomass is also large.

Even though the renewable energy sector can in principle address a lot of important political issues, its development is however rather slow. Ukraine is the country with one of Europe's lowest percentages of energy generated by renewable sources and what is more, the growth rates of this sector are rather low, even though there is a political will to support this sector. This seems to be a paradoxical situation which is difficult to understand. It is unclear what causes the situation that RED implementation in Ukraine lags behind.

Several journal articles, background stories, policy documents and legislative texts on the situation in Ukraine are available, which shed light on the issue. Some of the important sources for this study include:

- Information published at the official website of the Ministry of Energy, Verkhovna Rada (Parlement) and President of Ukraine
- Marketing research and sector development reports (from different organizations active in the renewable energy sector), which were done in the period 2000 -2017 about the economic situation in Ukraine in relation to the RED
- Different kind of Renewable Energy Development Strategy policy documents, which have been published on Internet
- information from Ukrainian mass media, including radio, TV and magazines

About 80% of the sources used in this study, were in the Ukrainian or Russian language, including the interviews that have been done within the framework of this study. Quotes from different sources are translated by the authors themselves.

2.1.2 Objectives

The main objective of this study is to find out and present the most pressing barriers and problems which hold back the renewable energy transition and the Renewable Energy Directive (RED) policy implementation in Ukraine. The conclusions from this study can be used by policy makers to identify points of intervention to break the stagnation in the growth of the renewable energy sector. At the same time, it gives foreign (Dutch) entrepreneurs some insight in the specifics of the Ukrainian renewable energy market and recommendations for becoming active in Ukraine as technology provider or investor.

2.2 Analysis of the Energy Sector in Ukraine

2.2.1 The structure of energy sector

Structurally, Ukraine's energy sector consists of two large subsectors: the fuel and electric power industry (Figure 2.1)[1]. The fuel subsector consists of seven main components: natural gas, oil, coal, biomass to fuel, natural gas transportation and storage, crude oil transportation and storage and refinery. The electric power industry subsector consists of five main components: nuclear, thermal (including cogeneration facilities and block power stations), hydro, other renewable energy sources and power electricity networks. The main components of the subsectors were classified depending of the type of the energy sources and/or type of business activity.

Natural gas in Ukraine is provided by imports and domestic production. The annual volume of gas production ranges from 18 to 21 bcm/year in the past 15 years and almost has not changed in the past decade. About 85% of production is performed by state enterprises. The total gas consumption in Ukraine has fallen from 57,6 bcm in 2010 to 33,8 bcm in 2015 or by 23,8 bcm (-41,3%). The largest reduction in gas consumption the last 5 years occurred in industry, where the gas consumption was falling from 23,0 bcm in 2010 to 11,8 bcm in 2015 (-48,7%). Gas usage for the operating needs of gas producers and system operators has declined by 6% from 3.6 to 3.3 bcm. Operating needs of Ukraine's gas transmission system operator Uktransgas are related to the volume of gas transported from the Russian Federation to the EU, Moldova and Turkey. In 2015, the transmitted volumes increased by 4,9 bcm (8%) from 62,2 bcm in 2014 to 67,1 bcm in 2015[2].

Crude oil production and the refining industry of Ukraine experience a lack of investments in order to implement new technologies, minimize raw material losses, attain European quality standards and increase the export of petroleum products. It has been planned that (foreign) investors will provide reconstruction of existing refineries, but this has not happened so far due to weak incentives for investments[3].

The structure of mine assets of state coal mining companies indicates the aging of main assets. About 40% of all mines have been in operation for over 70 years. The coal industry remains a subsidized industry. The situation was severely complicated in the recent years, due to military events in the East of Ukraine and destruction of coal mining industry infrastructure. This leads to imminent closing down of mines, first those that were destroyed or damaged.[4] Because of the military activities and uncertainty of the future of coal mining in Eastern Ukraine, priority is shifted to the development of the Lviv-Volyn coal basin, development of brown coal deposits and combustible shale deposits in Central Ukraine, as well as conducting an independent audit of mine assets and creating an open registry of coal reserves.

The biomass to fuel component within the first subsector has several specific issues that are discussed later on in this chapter (See chapter 2.3).

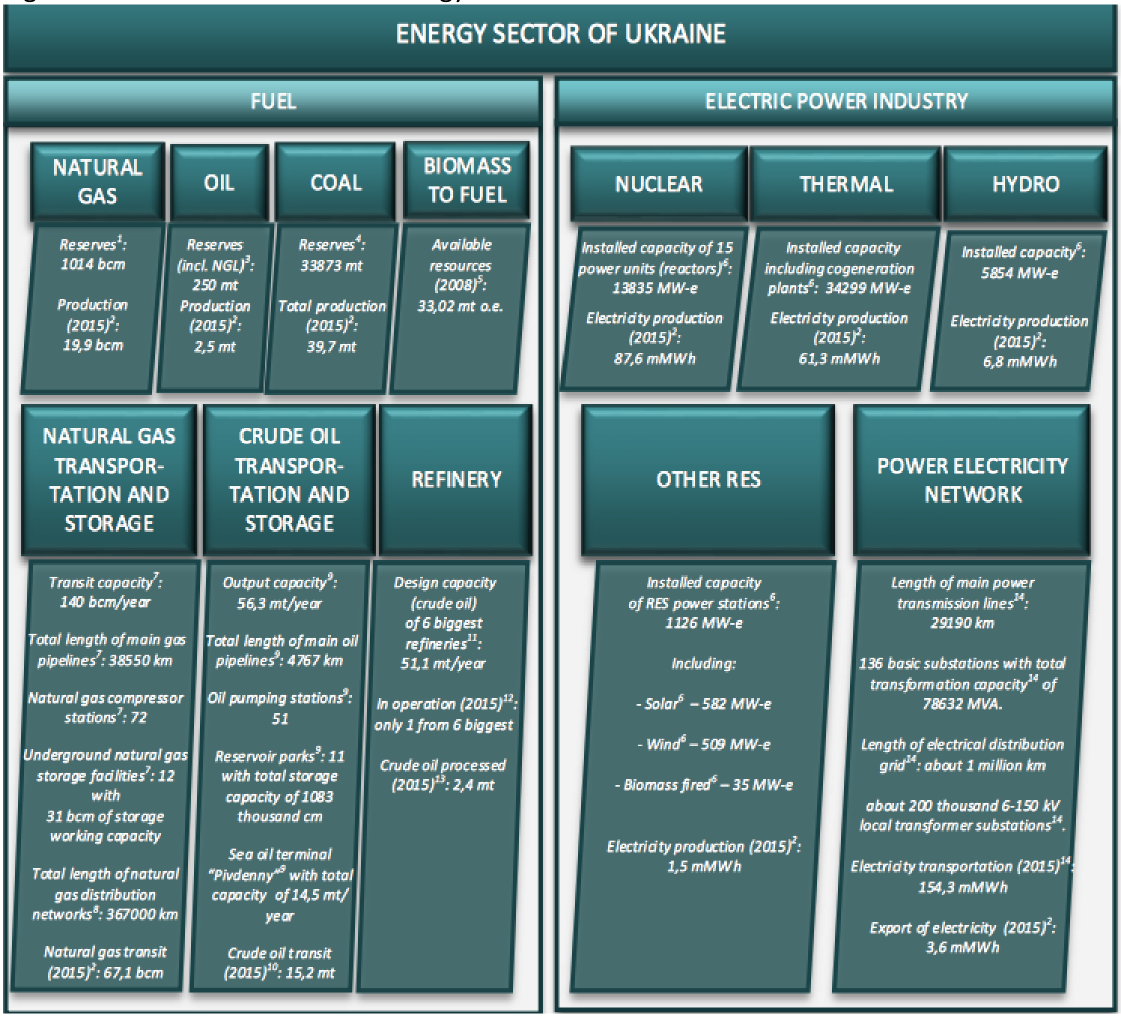
[1] Institutional Reform of Ukraine's Energy Sector in the Context of its Integration into the EU Market Information source: http://archivesicdt.demkk.hu/documents/publications/Final-Report_Institutional-Reform-Ukraines-Energy-Sector%5B00%5D_ENG.pdf

[2] http://www.naftogaz-europe.com/subcategory/en/GasConsumption

[3] Victor Logatskiy, Leading Expert, Energy Programmes, Razumkov Centre energy sector of Ukraine in 2014-2016: review and swot analysis. http://old.razumkov.org.ua/upload/1467706848_file.pdf

[4] http://www.naftogaz-europe.com/subcategory/en/GasConsumption

Figure 2.1. Structure of Ukraine energy sector



The second Energy subsector about electricity and power generation consists of five subsectors, which are briefly discussed here. The installed capacity of Ukraine's power stations (including CHP and block stations) is 55114 MW-e at the end of 2014[5]. Table 2.1 offers an overview over the different installed types of power generators. Table 2.2 shows an overview of the actual electricity production in 2015, which was in total 157.2 mMWh.

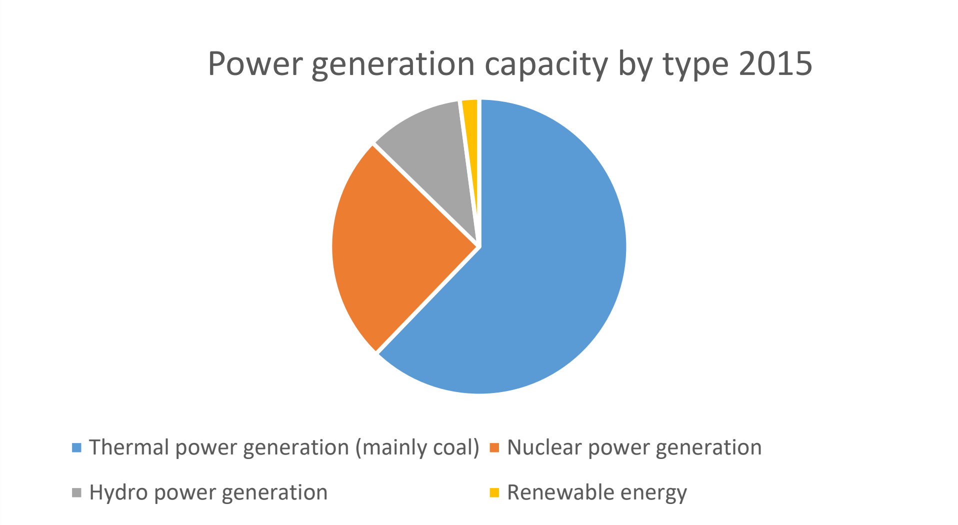
Table 2.1: Electricity generation capacity by type in Ukraine in 2015

Type	Installed power generating capacity	Percentage
Thermal power	34299 MW-e	62.2%
Nuclear power	13835 MW-e	25.1%
Hydro power	5854 MW-e	10.6%
Other sources, including renewables	1126 MW-e	2.1%
Total	55114 MW-e	100%

Source: Ukrstat, 2017

[5] *United Energy System of Ukraine: Capacity at the end of 2014.* *http://2014.ukrenergo.energy.gov.ua/ukrenergo/control/uk/publish/article?art_id=182509&cat_id=171201)*

Figure 2.2: Relative share of installed power generation capacity in Ukraine



Source: Ukrstat, 2017

Table 2.2: Electricity production in million MWh in Ukraine in 2015

Type	Electricity production	Percentage
Thermal power	61.3 mMWh	39.0%
Nuclear power	87.6 mMWh	55.7%
Hydro power	6.8 mMWh	4.3%
Other sources, inclusing renewables	1.5 mMWh	1.0%

Source: Ukrstat, 2017

The total power losses in transmission and distribution networks was measured at 35,4 MWh or 22,5% in 2015. The high level of power losses in Ukraine's UPS networks is caused by their long period of exploitation, limited financing of reconstruction, modernization and little new construction of transmission and distribution electricity grids. The wholesale electricity market is the only institutionally organized electricity market in Ukraine. As of September of 2016, the current market model of does not foresee the development of direct bilateral agreements with the sector's customers, segments of a balancing market and an auxiliary services market[6].

2.2.2 Renewable energy sector in Ukraine – overview

This section consists of a more detailed description of the renewable energy situation in Ukraine. Currently, the share of renewable energy in domestic energy supply is insignificant (see table 2.2), but the *Energy Strategy to 2035* projects that it will grow.[7] Most of the country's renewable energy today is concentrated in hydropower and biomass-fired heating boilers. There are also several wind power plants and geothermal heating systems. Ukraine has developed some renewable energy technologies, but their quality and reliability need to be improved (see chapter 2.3 for more details). The most significant challenges in expanding renewable energy are cost competitiveness and financing of technologies and projects. Existing subsidies for traditional energy and other market distortions heighten these challenges. Ukrainian policy makers have introduced a number of

[6] Ukraine energy policy review 2006. Information source: http://www.iea.org/publications/freepublications/publication/ukraine2006.pdf

[7] Energy strategy of Ukraine towards 2035, White book of Ukrainian energy policy "security and competitiveness" http://www.enercee.net/fileadmin/enercee/images-2016/Ukraine/Energy_strategy_2035_eng.pdf

incentives to stimulate renewable energy production and use, but most have yet to be implemented. More effective policies and regulations are needed to enhance the use of renewable energy and fully capture its environmental, economic and social benefits. In 2014, renewable energy, including large hydro, accounts for some 0.9% of total primary energy supply (TPES) in Ukraine.[8]

Most renewable energy technologies are capital intensive, and high cost is the main constraint to the expansion of renewable energy sources (except in the case of large hydro). For example, the wind power tariff in Ukraine is UAH 0.24 (USD 0.05)/kWh, while the nuclear tariff is only UAH 0.08 (USD 0.016). Direct and hidden subsidies for traditional energy, as well as other market distortions, effectively work against broader use of renewables. Some forms and uses of renewable energy are however already economically viable in Ukraine.

A positive and perspective vision on the development of Renewable Energy sources is described in "Energy Strategy of Ukraine for the period until 2035". From this vision document, the following picture emerges: Traditionally, the most popular fuels nowadays to generate electricity are fossil resources in Ukraine, among them: natural gas and coal, which together account for more than 60% of the domestic energy balance. In this document, the Ukrainian Government very positively evaluates the perspective of RED: “In recent years, as a result of changes in the price situation, technologies and world trends, the share of other types of energy in consumption is gradually increasing in Ukraine. In addition, today there are reasons to expect their further growth with a corresponding reduction in the share of fossil fuels in the country's energy balance. All these facts will contribute to the gradual strengthening of Ukraine's position in rational energy production and RED implementation.”[9]

2.2.3 Renewable energy capacity in Ukraine – biomass to energy

According to the National Action Plan for Renewable Energy Sources, approved by the government in October 2014, bioenergy should reach by 2020 the level to replace natural gas (7.2 billion m3 / year). The first steps have already been taken. For now in Ukraine there are already 5 power plants operating on solid biomass. Ivankovskaya TPP has an electric capacity of 18 MW, the CHP in Smila City generates 6 MW of electricity and 18 MW of heat. Both power plants operate on wood chips.

3 Thermal power station plants (TPS) operate on a sunflower husk at several oil extraction plants. In addition, in Ukraine there are 5 power plants operating on biogas of agricultural origin. The largest - 5 MW of electricity - on the poultry farm Orel’-Leader, the company “Mironovsky hleboproduct”, in the Dnipropetrovsk region. And about 5 power plants are working on biogas from landfills and landfills of solid household waste. Their average capacity is 1 MW of electricity, according to Georgy Geletukha, chairman of the board of the public association" Bioenergy Association of Ukraine."[10]

2.2.4 Renewable energy capacity – hydro

Large hydro power plants make up 80% of the total figure of the 0.9% of renewable energy, and only 20% comes from other renewable sources. By comparison, renewables typically account for more than 6% of TPES in OECD member countries and 13.5% worldwide. Only hydropower and biomass

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[8] I.Barnsley, A.Blank, A.Brown Enabling Renewable Energy and Energy Efficiency Technologies: Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean http://www.iea.org/publications/insights/insightpublications/EnablingRenewableEnergyandEnergyEfficiencyTechnologies.pdf

[9] "Energy Strategy of Ukraine for the period until 2035"

[10] Promising bioenergetics. UNIAN INFORMATIONAL AGENCY Information source: https://ecology.unian.net/1255704-perspektivnaya-bioenergetika.html

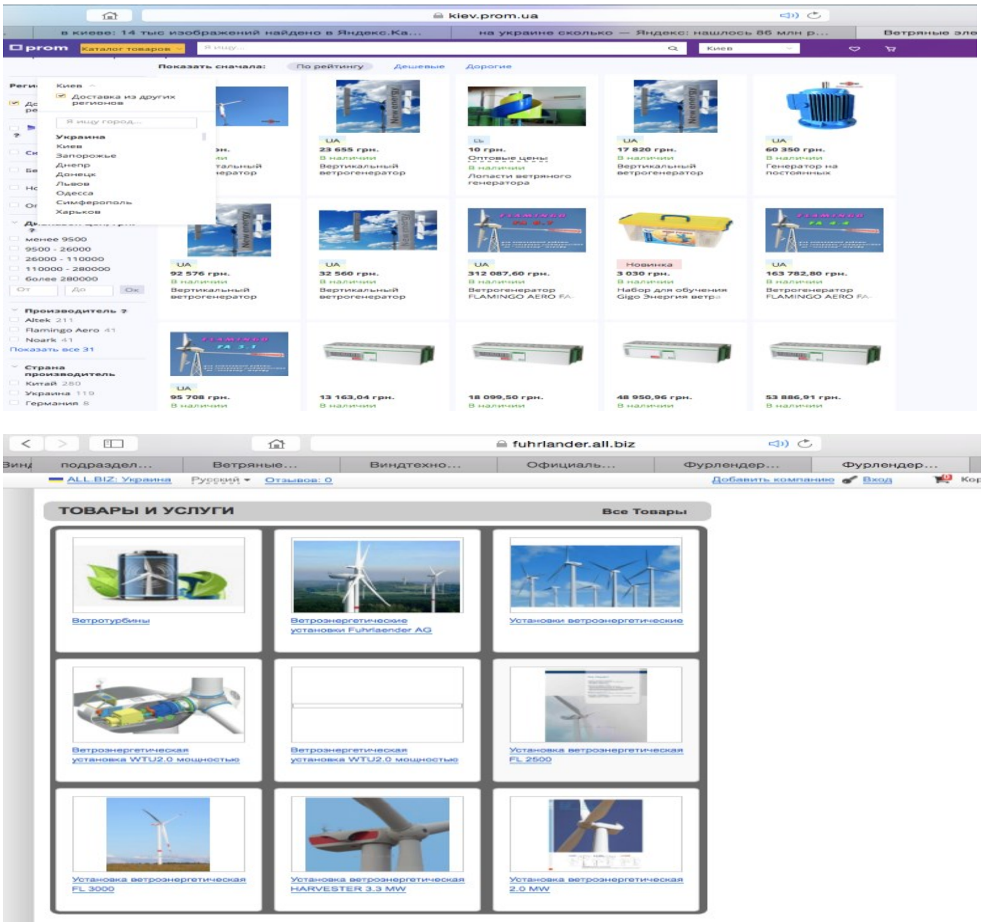
are used commercially in Ukraine; other renewable energy technologies are still at the stage of research and development or demonstration (RD&D), and their share in energy supply is still insignificant.

The state Energy Company of Ukraine, either directly or through its subsidiary Ukrhydroenergo, owns Ukraine's hydro and wind power facilities. It sells hydro and wind power on the wholesale market at tariffs regulated by the National Energy Regulation Commission (NERC). Owners of small, local renewable energy systems (e.g. farms, industrial companies and households) are both energy producers and consumers. The heat and electricity that such systems produce are not sold on the market. Collecting viable statistical data is therefore challenging.

2.2.5 Renewable energy capacity – wind

Ukraine has domestic production of wind turbines in Kramatorsk (Donetsk region). The company "Furlander Windtechnology"[11] (a division of UK "Wind farms of Ukraine"). At the same time there are many options for buying foreign produced new or second hand windmills[12].

Figure 2.3: Windmills sold via a web platform in Ukraine



[11] http://fwt.com.ua - official web-site of the company "Furlander Windtechnology"
[12] https://kiev.prom.ua/Sistemy-ispolzuyuschie-solnechnuyu-energiyu

If the new wind generator is too expensive, there are a large number of used renewed wind turbines on the market, which cost the half of a new one. But new wind generators on average pay back 2 times longer than renovated ones.

In terms of installed wind energy capacity: The biggest wind power station in Ukraine is the Botievskaya wind farm (Ukr. Botyivska VES), located near the village of Primorsky Posad in the Priazovskiy district of the Zaporozhye region. The installed capacity of the Botievskaya wind farm is 200 MW, construction was carried out in two stages: in 2012, 30 units were commissioned, and in 2014 another 35 units [4]. In 2016, the station generated 608.4 million kWh. The Botievskaya wind farm is managed by Wind Power, a subsidiary of DTEK's private energy holding company, which is part of the financial and industrial group “System Capital Management”. The construction of the Botievskaya wind farm was started in July 2011. The manufacturer of wind turbines for Botievskaya VES is Vestas Deutschland, a German subsidiary of the Danish company Vestas Wind Systems AS[13]. Next to the Botievskaya wind farm, there is also another company active on the market, with the name "Wind farms of Ukraine"[14]. It has built and exploits 8 wind parks[15], of which an overview can be seen in table 2.3.

Table 2.3: Overview of wind parks in Ukraine of the company “Wind farms”

Name of the wind park	**Total power, MW**	**Period of construction**	**Commissioning**
WP Novoazovsky	57,5	2010-2012	01.07.2011.
WP Ochakovsky	47,5	2011-2012 2011-2012 2014-2015	01.02.2012. (25 MW) 01.06.2012. (12.5 MW) 15.03.2015. (10,0 MW)
WP "Kerch"	25	2012-2013	01.12.2013.
WP "Vetroenergoprom"	5	2013	01.04.2013.
WP Krasnodonsky	25	2013	01.09.2013.
WP "Lutuginsky"	25	2014	01.04.2014
WP "Vetroenergoprom"	25,5	1998-2004	in concession until 2054.
WP "Prichernomorsky"	5	2016	01.11.2016.
Total	**215, 5 MW**		

According to the statistics for 2015, there are 74 windmills WTU2.5 with a capacity of 2.5 MW in Ukraine. According to the National Plan for the Development of Renewable Energy Sources, until 2020, Ukraine intends to increase the total capacity of wind farms to 2.28 gWh[16].

[13] http://www.scm.com.ua/ru/media-centre/news/view/1134/
[14] http://saee.gov.ua/sites/default/files/Sevastyznov.pdf
[15] http://saee.gov.ua/sites/default/files/Sevastyznov.pdf
[16] https://ecotechnica.com.ua/stati/619-vetryanye-elektrostantsii-v-ukraine-i-mire-chto-den-gryadushchij-nam-gotovit.html

Table 2.4: Ukraine: development of the total installed capacity of wind generators

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MW	77,3	86	89	90	94	87	151	302	371	498	509

Source: WWEA, 2017

2.2.6 Cost competitiveness

Large hydropower is the most mature and the technology is well-developed. Tariffs for hydropower are the lowest on the Ukrainian wholesale market for renewables. In areas with available biomass resources, biomass-fired boilers are often competitive with gasoline and diesel engine generators. Other renewable energy sources can be more cost-effective than conventional energy in some applications, including off-grid (distributed) electrification and heating, biomass-fired district heating and specific industrial uses.

Cost-competitiveness of most types of renewable energy depends on the availability of resources and other local conditions. Availability of technologies on the local market also plays a role.

Figure 2.4: Renewable Energy Technologies in Ukraine

Technology	Energy product	Status in Ukraine
Biomass combustion	Heat, electricity or combined heat and power	Used for cooking and space heating by residential and commercial sector, and for heat and steam production by industry and district heating. Electricity generation from combined heat and power is insignificant.
Biomass hydrolysis and fermentation	Ethanol	RD&D; some industrial production.
Biomass digestion/ extraction	Biodiesel or biogas	RD&D, several pilot projects. One operating large-scale combined heat and power plant on biogas.
Wind turbines	Electricity	70 MW installed power capacity.
Traditional wind mills and water pumps	Movement, power	Used in agriculture.
Hydropower stations	Electricity	Large-scale capacity: 4 600 MW. Small-scale capacity: less than 100 MW.
Geothermal energy direct use	Heat	13 MW installed thermal capacity.
Solar photovoltaic power systems	Electricity	Manufacturing PV panels and systems, mostly for export.
Solar heating	Heat	Manufacturing solar collectors for domestic use.

Source: Ukraine energy policy review[17]

The cost of renewable energy technologies decreases as their use increases. International experience shows that targeted governmental policies can significantly reduce costs and increase the economic attractiveness of renewables by creating a “virtuous circle”. Supportive policies lead to increased use of renewable energy, which further brings their costs down. In turn, lower prices open new market opportunities, which leads to further cost reductions via economies of scale. Therefore,

[17] Ukraine energy policy review 2006
http://www.iea.org/publications/freepublications/publication/ukraine2006.pdf

the situation in Ukraine might be still one of potential, and that growth in the sphere of renewable sources can be easily obtained given a stable set of policy measures and legal environment.

Financing is another challenge in expanding renewable energy. Potential users of renewable energy such as agricultural enterprises, rural settlements, residents of houses not connected to district heating and gas networks generally have low incomes and have no access to commercial financing. State budget financing is limited to wind energy only and is not enough to significantly boost the development of the sector. District heating companies, potential large users of biomass, have no money to invest in converting boilers to use biomass (most boilers were historically designed to use gas). At least two elements are needed to enhance investment in renewable energy technologies: facilitating end-users' access to financing and improving the financial situation of district heating and electricity companies. On top of these technical difficulties comes the Ukrainian general moratorium on land sale. It is difficult to clearly assess the consequences of such moratorium, but one thing is for sure, which relatively short term lease contracts to use to fields, major producers will most likely not invest too much in the long term soil fertility. It also means that investing in measures to increase yields, such as drainage and irrigation. Land owners can't get loans to invest in the land, as the land cannot be used as collateral for banks, since it can't be sold in any situation. It also severely limits the possibility to exchange small plots among each other in order to create larger more efficient ones.

2.3 Opportunities and barriers in the development of RED policies

The description of the current situation of the Ukrainian Renewable Energy Market of 2016 showed some results regarding the slow transition of Ukraine into renewable energy sources, as compared with other European countries. In this section, trends and developments are described related to the adoption of different renewable energy sources.

2.3.1 Development of solar energy

According to the "State Energy Efficiency Agency", last year, the number of households that installed solar panels increased by almost four times compared to 2015: from 244 to 1109 households. Of course, these are very small figures for a large country like Ukraine, but in terms of growth percentage it looks impressive and this solar energy market certainly deserves further monitoring of the developments in the coming years to see if the trend continues.[18]

"It is important that the capacity of solar panels increased almost sevenfold: from 2.2 MW in 2015 to 16.7 MW at the end of 2016. That means, households began to install more as well as more powerful panels"- according to the chairman of the State Energy Efficiency Sergei Savchuk. For all who installed solar PV panels in 2016, a sufficiently high green tariff of €0.19 per kWh will operate for each kW delivered back to the grid. Gradually, this tariff will decrease according to the same principle that works for industrial stations - down to €0.14 in 2030.

It is interesting to note that in many regions of Ukraine the situation related to solar RED projects are different. For example, "building a solar PV panels in the South of Ukraine, it will pay for itself in 8.5 years, in the North of Ukraine - 12-13 years", according to Igor Tynny, the founder of "Hydroenergoinvest". He noted that in Ukraine there is currently no project in the "green" energy

[18] When Ukraine become energy independent. Ukrainian informational agency. http://www.liga.net/projects/energoeffectivnost/#chapter3

sector, which payback time is less than 5-6 years.[19] Given the rather low risk of malfunctioning and low maintenance, solar energy seems to gain popularity.

In 2018 the first solar power plant in Ukraine is being commissioned in the town of Nikopol, with a planned capacity of 200 MW, which is a big step forward in the usage of solar energy in Ukraine[20].

2.3.2 Windenergy

There is a strong belief in Ukraine that wind energy is too expensive and cannot yet compete with traditional energy[21]. In some cases, this is not true. The payback period for wind energy projects depends on the average annual wind speed and equipment. To calculate the project economics, it is necessary to have wind monitoring data and perform an analysis of the external environment (how the wind generator will be connected, where it will be installed, who will be the consumer, etc.). The payback periods for wind power projects in Ukraine are ranging widely however, between 2 to 10 years. It depends largely on the price of the equipment. Today in the Ukrainian market there are micro and small wind turbines with a capacity of 50 watts (windmills) for about 3 thousand hryvnia. Wind turbines of 300 watts will cost 5-6 thousand hryvnia, a wind turbine for 500 watts - 8 thousand hryvnia. A wind generator of 1 kW (1000 watts) will cost 13-14 thousand hryvnia. Regarding the large turbines, there are many market proposals[22]. Financing large wind turbines is sometimes a problem in Ukraine, but there are many used and refurbished wind turbines on the market.

Even though wind energy may have a lot of potential, according the interview, which was done in Ukraine with a researcher of the renewable energy department of one of the universities, the main disadvantages of new wind generators are that the period of their "payback" on average is too long and therefore investors are not willing to invest. In addition, the new wind generators are upgraded from a technical point of view. In this situation, renovated (used) wind generators offer a lower price (2-3 times) compared to the new ones and therefore quicker payback periods. As a rule, for second-hand wind turbines there is the same warranty, as for new ones. They are usually in stock and are sold without a queue. The disadvantage is that the life of a renovated wind generator is on average only 15-20 years. In addition, there are unscrupulous suppliers on the market who are ready to sell very old models of wind turbines with limited capacity and life. During the interview with a lecturer in the Renewable energy department of one of the university – the respondent confirmed that the main disadvantage of new wind generators is the too long "payback" period and investors and are therefore generally not ready to invest this money. In addition, he mentioned specific disadvantages of new wind generators in the Ukrainian market: long production times and large minimum lot requirements, relatively high prices, large corruption as well as the strong lobby of interests of the old traditional energy sector working against the development of renewable energy in general and against wind energy in particular.

2.3.3 Biomass for energy

According to various estimates, biofuels used for district heating can replace from 10 to 18 billion cubic meters of natural gas. Especially in Ukraine, there is a high potential of bioenergy due to the

[19] https://ecology.unian.net/alternativeenergy/1699967-zelenaya-energetika-v-ukraine-jrebiy-broshen.html
[20] https://www.kyivpost.com/business/dtek-chinas-cmec-sign-contract-building-200-mw-solar-plant-nikopol.html
[21] https://ubr.ua/market/industrial/znakomimsia-s-vetrogeneratorom-chto-eto-takoe-skolko-stoit-i-komu-mojet-prigoditsia-179686
[22] https://kiev.prom.ua/Sistemy-ispolzuyuschie-solnechnuyu-energiyu

large surface, developed agricultural sector and favorable climate[23]. There seem to be some positive policy tendencies around biofuels in Ukraine: for example, on 29 November 2016, the President of Ukraine Petr Poroshenko signed a law that would abolish the need to maintain a state register of producers of liquid biofuels and biogas, which reduces bureaucratic obstacles to running this business.

One of the problems in the development of the biofuel industry is that the production of bioethanol in Ukraine is effectively blocked for now according to a study by AgroReview[24]. This study comments on the high amount of excise taxes for the production of any type of ethanol. To avoid the taxes, bioethanol should be exported, mixed with fossil fuels and then imported back again in Ukraine. However, exporting bioethanol is also challenging: Industries producing bioethanol can potentially be very attractive for private investors, but there is currently no harmonization of Ukraine and EU legislation in the import and export of alcohol products from the EU, according to the head of the bioethanol producer and state enterprise “Ukrspirt” Yuri Luchechko.

For example, the lack of harmonized legislation with the European Union in the export of excisable goods. In the Ukrainian Tax Code of today there is no explanation of what ethanol is. Even though the types of alcohol are quite distinguishable: food ethanol, technical ethanol, bioethanol for energy and alcohol-containing substances, the excise rate on them is unified. To name an example: On window washer liquid (for windshield wipers), is the same excise duty as on food ethanol (vodka). This leads to the fact that there is no domestic window washer production in Ukraine, all of it is imported. And there are even stories of people using vodka as widow cleaner, since the price can be lower than imported window washing liquid. “The production of bioethanol is blocked for today, it is not available due to lack of incentive for its production and sale on the domestic market" according to Luchechko at the conference of Ukraine Biofuels Association[25], naming the excise tax as the main reason.

Another complex of problems is related to the ecology and pollution of nature. It is mentioned in several sources that quite a lot of the production equipment is still from Soviet Union times and in some cases poorly maintained and seriously degraded. Residents of towns and cities do complain about pollution of bioethanol production. In Lutsk for example, 500 people held a protest demonstration with the demand to close the production of bioethanol at a sugar factory. These inhabitants of Lutsk require an independent examination of emissions and stench, because according to them, sulfuric acid is used in the production. According to local residents, as a result of the activity of the bioethanol production plant, carcinogenic substances are entering the environment near the Gnidava sugar plant LLC "Bio TEC" (ООО «БИО ТЭК»). People demand complete closure of bioethanol production[26].

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[23] The branch of alternative energy in Ukraine is extremely promising / ecotown "Green" energy in Ukraine: the die is cast. Informational agency UNIAN: https://ecology.unian.net/alternativeenergy/1699967-zelenaya-energetika-v-ukraine-jrebiy-broshen.html

[24] https://agroreview.com/news/bioetanol---druhe-dyhannya-dlya-spyrtovoyi-haluzi-ukrayiny

[25] Informational agency UNIAN: https://economics.unian.net/agro/2223336-bioetanol-yavlyaetsya-vtoryim-dyihaniem-dlya-spirtovoy-otrasli-ukrainyi-luchechko.html

[26]In Lutsk, 500 people held a protest action with a demand to close the production of bioethanol at a sugar factory http://утилизация.укр/novosti-ekologii/v-lutske-500-chelovek-proveli-aktsiyu-protesta-s-trebovaniem-zakryt-proizvodstvo-bioetanola-na-saharnom-zavode/

2.3.4 Key factors related to implementation of RED in Ukraine in the energy sector

As noted in the previous part of this chapter, Ukraine has always been an energy dependent country. One of the studies, which was held in 2007, shows Ukrainian energy sector as a strategic branch, prone to all kinds of risks, which are inherent to it ranging from fluctuating oil prices to development of different pipelines in Europe and development of renewable sources. Moreover, being state-governed, the energy sector is closely monitored like no other industry — that's why it is subject to all kinds of political risks. The main mechanisms of state regulations are directive tariffs and direct operational administering.

The major problem of the Ukrainian energy industry is under-budgeting. The state and government consider the sector not a sphere of business but rather a part of state infrastructure and a source of increasing the state budget. In fact, at the expense of direct withdrawal of profit from state energy manufacturing companies and forcefully imposed, relatively low tariffs, the government finances other sectors of economy and solves its budget problems with the help of the income from the energy sector.[27]

Upon accession to the Energy Community, Ukraine assumed the obligation in 2020 to receive 11% of electricity exclusively from renewable sources, which was enshrined in the National Action Plan for Renewable Energy. Now this figure is frozen at around 1%.[28] As a matter of fact, not only accession to the Energy Community and obligation in 2020 to receive 11% of electricity exclusively from renewable sources, obviously speaking has to stimulate RED in Ukraine: On 24 November 2017, TV-channel "112 Ukraine" ("112 Ukraine") announced (with reference to the press service of "Kyivenergo") that the total debt of inhabitants of Kiev for electricity is UAH 388.9 million (almost $14.5 million). The debt of the largest companies for electricity is UAH 379.9 million".[29]

At the same time, Ukraine does not import gas from Russia for more than 2 years already and as Prime Minister Vladimir Grossman, said "the main task is to make Ukraine an absolutely energetically independent country that produces gas and develops alternative energy". Of course, such goals cannot be achieved overnight and since importing Russian gas is considered undesirable for political reasons, another source of natural gas had to be found. That is why in 2016, Ukraine imported 11.1 billion cubic meters of gas from the EU, in particular:

- from Slovakia - 9.1 billion cubic meters,
- Hungary - 1 billion cubic meters
- and Poland - 1 billion cubic meters.

The situation in 2017 did not bring changes. Ukraine continues to import gas from the European Union. The government's ideal to become energy independent has led to plans to reduce imports and increase domestic production. The state company Ukrgazvydobuvannya[30] is currently

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[27]Ukraine's energy industry potential 2007. Investment research // http://common.regnum.ru/documents/Energy_of_Ukraine_06_08_07.pdf

[28] The branch of alternative energy in Ukraine is extremely promising / ecotown "Green" energy in Ukraine: the die is cast. Informational agency UNIAN: https://ecology.unian.net/alternativeenergy/1699967-zelenaya-energetika-v-ukraine-jrebiy-broshen.html

[29] "Kyivenergo" calculated the sum of debt of Kiev inhabitancies for electricity https://russian.rt.com/ussr/news/452584-dolg-kiev-elektroenergiya

[30] Ukrgazvydobuvannya Official web-site http://ugv.com.ua

implementing the 20/20 program, which envisages an increase in domestic gas production to 20 billion cubic meters by 2020.

However, while the Ukrainian government tries to develop RED policies, is behaves contradictory: There is virtually no existing high-tech industry to produce renewable energy sources, it must be built virtually from scratch. At the same time, innovations of new high-tech firms threaten by itself the status quo of the powerful traditional energy sector, making it especially in the context of the post-Soviet space to be almost a mission impossible. One of the examples of detrimental laws for developing new industries is the 2013 rule “of the local component”: first, 30% of the "green" tariff was to be received, and later 50% of the equipment used in the construction of renewable energy facilities should be of domestic (Ukrainian) origin. This requirement quickly closed the Ukrainian market for new foreign players, technology and investments. Because only few Ukrainian companies can produce necessary equipment or have access to renewable energy technology. The political instability also limits the attractiveness of foreign investors to invest in production capacity in Ukraine.

2.4 Analysis of barriers in implementing RED related to biofuels in Ukraine

2.4.1 Research methodology

The previous section was a description of the current situation in Ukraine and consisted of an overview of the renewable energy sector in general. This part is specifically about biomass for heating and/or energy, related to RED policies in Ukraine. It gives a description of barriers, policy options and role of Ukrainian institutes related to the implementation of biofuel policies. From this overview some recommendations for overcoming the barriers can be formulated.

This part of the study is based on the following methods of data collection:

- Face-to-face interviews with experts, which were made during a visit to Ukraine, at the State National University of Ukraine and the State Technical University, as well as representatives of companies.
- On-line interviews with the persons active in the renewable energy sector, among them: Representatives of Bioenergy Association of Ukraine, Members of Parliament (Verkhovna Rada), Ex-chairman of the Kherson regional state administration, Leader of the party “Social Justice”, experts of the Bioenergy Association of Ukraine.
- Analysis Legislation of Ukraine, and legal documents influencing and supporting the implementation of RED in Ukraine;
- Analytical reports and the results of recent market research, which was made with foreign foundations and independent experts in the field of bioenergy;
- Some unpublished materials received from interviewees, which were not officially published or are still forthcoming.

Where possible, the statements done in the interviews are compared to what is written in different existing studies as well as available statistical material.

2.4.2 Developments in the Ukrainian energy transition towards renewable energy sources

As is mentioned in section 2.2, Ukraine has one of the lowest shares in Europe of renewable energy from total energy generation. The reason for this low percentage as well as the stagnation in the energy transition is commented on by the head of the Verkhovna Rada Committee on Fuel and Energy Complex, Nuclear Policy and Nuclear Safety, Alexander Dombrovsky. His statement is that the key challenge to date is the *implementation* of the laws and government decisions passed by the parliament: “Today we are systematically working on the introduction of a new electricity market and the Coordination Center is dealing with a whole range of issues related to this". At the same time, the degree of deterioration of the energy complex is almost 90%.[31] Even though for several years energy substitution policies have been pursued, including more attention for biomass (wood pallets) as source of energy generation, as was estimated at the Ukrainian Energy Forum-2018 in Kiev, at the end of 2017, less than 1.5% in electricity generation was generated by renewables.

The slow pace of transitioning to renewable energy has been picked up by the Cabinet of Ministers of Ukraine. On August 9, 2017 they created a coordinating centre for the introduction of a new electricity market. It was headed by Vice Prime Minister of Ukraine Vladimir Kistion. The Coordination Centre for ensuring the introduction of a new electricity market is a consultative body under the Cabinet of Ministers of Ukraine, which the Government had to create in accordance with the provisions stated in the "On the Electricity Market" law of Ukraine. The Law "On the electricity Market of Ukraine" came into force earlier in 2017. It implements the norms of the Third Energy Package of the EU, including in the matter of the division of oblenergo (*author translation:* "regional power supply company ") in the areas of distribution and supply of electricity. The new market should start working on July 1, 2019. Most of the secondary legislation should be adopted in 2018. Recently, in Ukraine Mass Media has published general comments and proposals to the Rules of the retail electricity market, the Code of the Transmission System, the Code of Distribution Systems, the Code of Commercial Accounting for Electric Energy, the Methodology for Forming Fees for Connection to the Transmission System and Distribution Systems, the Market Rules, the Rules for Limitations Management and the Procedure for Distribution of Transit the ability of interstate cross-sections, as well as to the "Day ahead" market rules and the intra-day market, which are all developed within the framework of the of the Law "On the Electricity Market of Ukraine".

2.4.3 Policy barriers in implementing the Renewable Energy Directive in Ukraine

This section contains the most significant problems/barriers which prevent a higher realization of the Renewable Energy Directive (RED) in Ukraine in general and using the biomass energy potential in particular.

Data collection in this chapter is based on several interviews with politicians and experts. In one of the interviews, Odarchenko Yuri Vitaliyovych - Member of the parliamentary faction of the political party "All-Ukrainian Association" Batkivshchyna "in the Verkhovna Rada of Ukraine. Ex-head of Kherson Regional State Administration mentioned the following:

> *In general, there is no overall legislative problem for the development of alternative energy sources in Ukraine. There is a fairly high feed-in tariff rate for renewables, there are state guarantees until 2030 and anchoring to the euro. Rather, the problems relate to the bureaucratic obstacle and the overall economic situation in the country. For example, the construction of an official Sustainable Energy Supplier requires a huge number of permits. In addition, there are problems in the process of connecting to the grid, especially in private households: it is necessary to cooperate with Oblenergos, each of which is a monopolist in their region. Accordingly, there are problems with connection permissions, and the existence of multi-million dollar projects depends on several signatures. Similar bureaucratic delays in domestic business are difficult to explain to foreign investors. And without foreign investment, this market would not exist at all. In addition, it is necessary to reduce the regulatory impact of National Commission for State Regulation of Energy and Public Utilities and to carry out the envisaged reform of the Ukrainian electricity market. A case*

[31] http://oilreview.kiev.ua/2018/02/28/dombrovskij-implementaciya-zakonodatelstva-glavnyj-vyzov-v-energeticheskoj-sfere/

that occurred last November, when the activities of this body, from which the rates were directly blocked by the mistakes of some human individuals, should not be repeated. The market needs liberalization, which will put it into the general architecture of European markets. Today's insufficient diversification of risks makes the market too sensitive to any force majeure.

Another problem that can be highlighted is the lack of state support for the development of the alternative energy market, according to Odarchenko:

The state really gives enough interesting conditions for investments, but it is necessary to understand that foreign investment organizations are often not ready to invest 100% of themoney first, they need co-financing. Therefore, most projects are looking for at least a smaller share of funds from inside the country. And here there are problems, especially at the regional level. The state needs to develop powerful regional development programs, possibly with state lending programs or provide preferential rates from state-owned banks. If such decisions are taken, we will see a real boom in green projects. And foreign investors, even more willingly, will start to enter the country, which itself invests in this industry.

Another politician / expert on the topic is Alla Shlapak - Leader of the party Social Justice. PhD in Economic Sciences and deputy in the Kiev city council makes the following comments:

Energy security is the foundation on which the future of the Ukrainian economy is built, and on which the quality and standard of living of Ukraine will depend. It's no secret that Ukraine is an energetically dependent country. We import everything: gas, oil, oil products, nuclear fuel and even coal. Over the past 6 years, energy imports have exceeded $ 100 billion. Ukraine is not only dependent on imported energy resources, but also on specific supplying countries. It is impossible to achieve energy independence, unless we have a detailed plan. It's like trying to build a house without a project.

Shlapak comments on the – in her eyes – weak strategy of implementation of the RED plans of the government:

And when the whole world is focused on increasing the amount of energy from alternative sources, the Ministry of Energy and Coal Industry of Ukraine adopts the Energy Strategy until 2035. I was surprised reading it: the document does not answer the question: "How does Ukraine maximize its energy potential, how to achieve full self-sufficiency in energy resources, guarantee energy security and independence? It means that the document has no practical significance and value.

Shlapak comments on the lack of practical applicability of the goals that have been set and explains the need for more serious assistance from experts to work on feasible steps to implement the goals:

One of the main goals of the Strategy is to reduce the energy intensity of the Ukrainian economy to 2035 by almost 2 times. Of course, this is critically important. However, this approach is one-sided. It is advisable not only to reduce energy intensity, but also to provide for domestic needs with own sources of energy, including by developing alternative energy. To develop own extraction and processing. After all, these are whole industries and segments in which jobs are created, incomes of the population, value added. And we officials, not for the first year, say that it is expensive and unprofitable. Therefore, for the development of alternative energy sources, we need, above all, experts and professionals in the government that they will prepare high-quality legislation in this area, and not populists.

Ukraine urgently needs more of a level playing field for both domestic and foreign investors, argues Shlapak. The currently existing market asymmetry in which “well-connected” people have strong advantages, is seriously hindering innovations in the field.

The first task is to introduce clear rules of the game, to guarantee ownership and simplify procedures for investors. (…) We also need construction of new refineries, nuclear fuel plants *and stimulation of development of alternative energy in the territory of Ukraine within the framework of public-private partnership.*

At the end of the interview, Shlapak stresses once again the importance of legislation and the rule of law in keeping up the chosen policies.

Investments in production and more innovative technologies will affect the salaries of employees, leads to increased production and income in related industries, which finally brings also additional budget revenues. By changing the legislation, simplifying the procedures and becoming transparent to investors, we need to give impetus to the development of the energy sector. In turn, this sector will become a powerful multiplier, capable in the shortest possible time to launch the economy of the country and accelerate its growth. But, first and foremost of all, this requires the political will to make legislative decisions, and keeping them as well as the presence of responsible experts in each of these sectors.

During interviews with Ukrainian experts on renewable energy development[32], several barriers came forward. The issues have been summarized to a list of main factors that may hinder implementation of RED policies in Ukraine.

1) Production of bioethanol as biofuel in Ukraine is for now blocked, mainly because of excise tax legislation, which treats it as spirit production (food ethanol).
2) Old and therefore less efficient equipment and production facilities, which are in need of serious reconstruction, and, of course, extra investment.
3) All sorts of environmental problems, mainly pollution, which can be a big trouble for investors and entrepreneurs, who will be obliged to pay for clean-up of sites. Additionally, there is the problem of non-compliance with environmental and state standards of many production locations, which currently can continue to keep running with the help of bribes.
4) The problem of regional power company monopolisation, owned by a small circle of Ukrainian businessmen, who aren't that interested in any move forward with RED, because they have a good profit from the current situation of the energy sector in Ukraine and any changes bring them extra costs and a decrease in profits.
5) All RED projects in Ukraine are projects designed for long-term investments and a long payback period. At the same time, the (political) situation in the country is not so stable and this high uncertainty, makes any long-term-oriented project too risky for entrepreneurs.
6) Several more technical barriers limit the implementation of effective energy transition to more renewable sources.

The experts express during the interviews that some of the problems are discussed now in the public sector and that the Verkhovna Rada together with the business sector (in the renewable energy sector) is trying to remove or is in the process of amending respective legislative acts (see chapter 2.3.2).

In addition to the expert interviews, the following studies should also be mentioned:

1) The publication "Ukrainian law and foreign investment attractiveness" concludes that there are two important conditions for the receiving (foreign) investments: profit and security of investments. One of the reasons for the unattractiveness of Ukraine for a foreign investor is the instability of the legislative framework for investment[33]**.** Both issues are suboptimal at the moment, although there is some development.

[32] The interviews are held anonymously, but the names of the respondents are known by the client.

[33] ЗАКОН УКРАЇНИПро режим іноземного інвестування http://search.ligazakon.ua/l_doc2.nsf/link1/Z960093.html

2) Ukraine has low rating in global rankings of world cooperation (e.g. the Ease of doing business list of the World Bank), where Ukraine belongs to countries with an increased level of political and economic risks. This is influenced by constant changes of leaders of all branches of power[34]. There are however different rankings on which none of these Ukraine scores very favourable, making the process of doing business in Ukraine challenging.

From these two sources, the following list of problems with the Ukrainian business climate can be distilled:

- External debt and budget deficit**.** This is a threat to the economic independence of Ukraine. This is due to the growth of external debt, as well as the decline in the Gross Domestic Product. The country's debt is almost reaching 100% of the GDP. Since most of the debt is external, there is a chance that Ukraine has to default on interest payments, which will severely hinder international trade and investments.
- Reforming the economy. In Ukraine, the issue of "ownership of land" is still uncertain. There is no solid cadastre for most places.
- Insufficient level of development of investment market infrastructure. Unsatisfactory condition of roads, transport, service enterprises, supply and sale, etc.
- High inflation. The inflation percentage is one of the significant indicators that adversely affect the formation of the investment climate of the state.
- The fall in the level of the population's solvency. Low income level of the population reduces its solvency, narrows the market for finished products and negatively affects the investment climate and the overall economic situation in the country.
- Extremely low rates of domestic investment, which indicates problems within the Ukrainian market itself.

[34] https://www.pravda.com.ua/cdn/graphics/ratings/eng.html#cor

Figure 2.5: Ukraine's position on several global rankings

Ranking list	Year of the ranking	Place of Ukraine /Total number	Dynamics
The Global Innovation Index	2017	50/127	↑ 6 pos
Global Slavery Index	2016	25/167	no data
Global Terrorism Index	2017	17/134	↓ -6 pos
Global Peace Index	2017	154/163	↑ 2 pos
Health and primary education (GCI - WEF)	2017	53/137	↑ 1 pos
Rule of law index	2017	77/113	↑ 1 pos
The Global Gender Gap Index	2017	61/144	↑ 8 pos
Index of Globalization	2016	45/207	↓ -3 pos
Democracy Index	2017	83/167	↑ 3 pos
The Global Wealth Report	2016	95/173	↓ -12 pos
Environmental Performace Index	2017	109/180	↓ no data
Index of Economy Freedom	2017	150/180	↑ 16 pos
English Proficiency Index	2017	47/80	↓ -6 pos
Bloomberg innovation index	2017	46/50	↓ -4 pos
The Global Competitiveness Index (WEF)	2017	81/137	↑ 4 pos
Higher Education (GCI - WEF)	2017	35/137	↓ -2 pos
Institutions (GCI-WEF)	2017	118/137	↑ 11 pos
Easy of Doing Business	2017	76/190	↑ 4 pos
The Human Capital Index	2017	24/130	↑ 2 pos
Human Development Index (UNDP)	2016	84/187	no change
Fragile States Index	2017	90/178	↓ -5 pos
Global Firepower Military Ranks	2017	30/133	no change
The legatum prosperity index	2017	112/149	↓ no change
Social Progress Index	2017	64/128	↓ -1 pos
Corruption perception index	2017	130/180	↑ 1 pos
World Happiness Report	2017	138/156	↓ -15 pos
Happy Planet Index	2016	70/140	no data
Paying taxes ranking	2017	43/189	↑ 41 pos
World Competitiveness Yearbook	2017	60/63	↓ -1 pos
World Press Freedom Index	2017	102/180	↑ 5 pos
Freedom in the World (Freedom House)	2016	107/195	↑ 1 pos
E&Y Fraud Surveys: Corruption perception	2016	1/41	↑ 1 pos

*The closer to the top - the worse

Source: Ukraine in Gobal Rankings (https://www.pravda.com.ua/cdn/graphics/ratings/eng.html#cor)

In the interviews was stated that under-budgeting of the government to support renewable energy development projects combined with the powerful position of monopolistic regional energy providers cause strong barriers. More issues are at stake however, as mentioned by the Minister of Energy and Coal production of Ukraine Volodimir Demchischin at the official press-conference with the heads of a private energy companies held with Informational Agency “Ukrinform” on 4 march 2015[35], it is better to wait until technology becomes cheaper:

> *Renewable Energy is quite expensive. Since the beginning of RED implementation, it brings profit only because of an extra high tariff and Ukraine at the current moment is not in the situation to develop RED projects. Better to wait until technology becomes much cheaper. (author’s translation of the report)*

Among the other opinions, which were discussed at that same press-conference, offering a similar explanation as Shlapak in the earlier mentioned interview:

> *There is a lack of specialists in that business, especially among those who are managing the energy sector in the country (Herman Inbinder - head of a Renewable Energy company)*

Some other speakers at this press-conference put the blame on Ukraine’s legislation for the stagnating energy transition:

> *The renewable energy sector is destroyed by the governors and ministry with the contradictory legislation* (*Igor Tinnii - owner of a Renewable Energy company)*

> *We have a chance to completely lose the renewable energy sector because of serious legal problems in Ukraine. (Andrey Sergienko – deputy director of a renewable Energy company)*

Regarding small businesses and home owners, the situation in Ukraine is viewed as very mixed. According to many comments from private individuals and small businesses on the platform energylogia.com (Energy-efficient solutions for home and business)[36], the green feed in tariffs are paid late or not at all, all due to under-budgeting of regional governments for these types of renewable energy. It is unclear in how far the issues mentioned on this platform are representative of the situation in the entire country, yet, there is a risk that such things – if they happen – threaten the credibility of the entire feed-in tariff program. More evidence for (structural?) problems with paying the feed-in tariffs was provided by several speakers at a conference in Kiev on renewable energy, called “Vision 2020: Capturing Innovations”[37]. Several major barriers for adopting sustainable energy were discussed (similar to the ones mentioned by the different sources of this study). One of the points made in the panel discussion of the forum about the stagnation in the renewable energy sector growth was that the only true barrier for implementing sustainable energy is the political-judicial system combined with the inability for most regions to pay the set green feed-in tariffs. Several panelists accused the government and president of cooperating with oligarchs in order to keep the status quo, because it brings a lot of profit for them and the uncertain future

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[35] Renewable Energy ignore in Ukraine
https://www.youtube.com/watch?time_continue=1&v=XrdvyGAGtfc

[36] How to sell electricity to the state with the green tariff and getting paid?
http://energylogia.com/home/avtonomnost/zelyonyj-tarif-v-ukraine.html

[37] See further: https://www.kyivpost.com/technology/economy-suffers-ukraine-fails-embrace-innovations.html

keeps them from investing in renewable energy. The panelists stated that new companies/projects are often blocked and if that doesn't work, they would try to acquire these companies on way or the other. On the other hand, the Ukrainian minister for coal and energy mentioned at the same conference that Ukraine has especially great potential for solar energy and stated: "The worst place in Ukraine is better for a solar plant then the best place in Germany", although without getting into too much details about how exactly he would facilitate tapping this potential.

If there is a problem with feed-in tariffs or not in some regions, cannot be concluded from the data that is at the disposal of the authors. From the sources does however emerge a picture of the Ukrainian renewable energy sector caught in a catch-22 dilemma of investments, costs, legislation and profitability. Only few and small clear steps forward have been set until now. This however does not mean that there are no opportunities, in principle, it is clear that slowly but surely there is more attention for renewables and this will reflect into the legislation and policies that will be formulated and adopted and eventually also implemented.

2.4.4 Technical barriers in implementation of the Renewable Energy Directive in Ukraine

This section consists of an overview of some of the most pressing technical barriers that need to be solved in order for Ukraine to successfully connect different sources of energy generation with each other and with the end-users of that energy, to build more integrated energy networks. The data for this chapter has been mostly taken from an unpublished report of the Bioenergy Association of Ukraine[38]. In this report the authors mention several barriers for the further development of the bioenergy sector, most of which are on a technical level.

1) Underdeveloped biofuel market in Ukraine
2) Problems of land allocation for renewable energy installations
3) Overstated cost for nonstandard connection of power installations to the power network
4) Independent heat producers have difficulties in connecting to the heat network
5) District heating networks are not interconnected
6) Problems of biomethane production and consumption
7) Subsidized natural gas price for households
8) Understated (less than fair) tariff for heat transportation.
9) Sugar factory producing bioethanol

When looking at these barriers in more detail, it can be observed that there is just like in the previous paragraph a will to improve policies, but in practice it turns out to be very hard to implement changes. It is therefore important to think about all the issues mentioned with a long-term perspective.

The first barrier from the list deals with the underdevelopment of the Ukrainian biofuel market. There are simply still too few companies that offer their services and products and there is no dedicated trade platform for selling and purchasing biomass/biofuels. At present, only separate elements of the biofuel market exist, for instance, Ukrainian biofuel portal[39] (pellets/briquettes trade); Commodity Exchange «Ukrainian Interregional Specialized»[40] (first attempts of pellets trade in 2017); electronic system for public procurement ProZorro[41] (trade in fuel wood, straw, pellets, briquettes). However, in all these cases it is a trade of relatively small amounts of biofuels, and there is no general system that can provide bioenergy plants with the required quantity of fuel at any

[38] www.uabio.org
[39] http://pelleta.com.ua/
[40] https://www.uisce.com.ua/
[41] https://prozorro.gov.ua/

time. The absence of a system approach makes the search of potential suppliers of biomass/biofuels much more difficult and puts obstacles in the way of realization of new bioenergy projects.

On top of the underdeveloped market, there are also problems associated with market access to forest biomass and agro-biomass. At present, most of the Ukrainian forests (73%) are state-owned and subordinated to the State Forestry Agency of Ukraine. According to the *Forest Code of Ukraine*[42], permanent users of forests (State Forest Enterprises, SFE) have the exclusive right to harvest wood. SFEs have the obligation to harvest firewood but do not have similar plans for the production of wood chips from felling residues, which in fact are not accounted now. Unprocessed wood harvested by SFEs, is sold by auctions (*except for firewood* according to valid "Regulations regarding arranging and holding auctions for the sale of unprocessed wood"[43]). Firewood is sold by direct contracts between forestry enterprises and consumers of the internal market (population and legal entities). At that, now there are no dedicated trade platforms such as exchange or auction for the wood fuel intended for bioenergy installations that makes it difficult to arrange stable procurement.

Problems connected with the access to agro-biomass and the possibility to collect it for energy purposes differ a lot from the case of forest biomass. The problems are associated not with legal issues but with such factors as seasonal nature of biomass generation, limited period available for the biomass collection (harvesting), low yield of biomass (usually 2-5 t/ha in Ukraine), and dependence on crop production operations. In addition, experience in searching suppliers of crop residues (straw, grain maize and sunflower production residues, etc.) shows that agricultural companies agree to collect these types of biomass on condition that reliable consumers are available. If the demand is available, the agricultural companies can change the harvesting technology and switch over from the scattering of comminuted crop residues to collection of the residues (for example, swathing of straw). Sometimes an owner is ready to sell his/her biomass, but a purchaser must collect (bale) and transport the biomass by his/her own machines and vehicles. Unfortunately, at present there are no dedicated trade platforms for selling and purchasing baled straw, maize stalks and other types of biomass of agricultural origin. Consumers must find biomass producers and negotiate with them on their own. The price of agro-biomass is a problem too. Due to a small number of suppliers and the absence of competitiveness, owners (producers) of biomass can fix the price and then raise it at their own discretion; at that, a purchaser will not be able to influence the situation.

The second barrier is about the allocation of land for renewable energy installations. At present, the rules for allocating land for the construction of energy installations are rather complicated (the area zone plan or detailed area plan is required; the change in the purpose of a plot of land is required). That creates an additional barrier to the implementation of new bioenergy projects. According to the law of Ukraine «*On regulation of urban development activity*»[44], construction activity on a plot of land must be in line with the legally determined *purpose* of the land. In addition, the transfer of state or communal plots of land to possession/use of natural persons/legal persons for construction activity is allowed only if the legally approved *area zone plan or detailed area plan is available*. It is prohibited to change the purpose of a plot of land which does not conform to its area zone plan and/or detailed area plan. In practice however, *area zone plans, or detailed area plans very often are*

[42] Law № 3852-XII of 21.01.1994 (with amendments) http://zakon3.rada.gov.ua/laws/show/3852-12
[43] Resolution of the State Forestry Committee № 42 of 19.02.2007 http://zakon3.rada.gov.ua/laws/show/z0164-07
[44] http://zakon5.rada.gov.ua/laws/show/3038-17

not available, and this makes the implementation of a planned bioenergy project practically impossible.

The third barrier is about the overstated cost for nonstandard connection of power installations to power network. On 31 January 2017, the National Energy and Utility Regulatory Commission (NRCEU) adopted Resolution «On setting specific cost of nonstandard connection of power installations to power network for 2017»[45] № 148. According to the Resolution, tariffs for the nonstandard connection of 160-5000 kW power installations to the power network will rise on average by *six times* (up to over 6000 UAH/kW that is about 200 EUR/kW) as compared with the current tariff[46]. The Resolution directly affects renewable energy power generation installations, making *most of renewable energy power generation projects unprofitable*, and investors may cease their implementation in Ukraine.

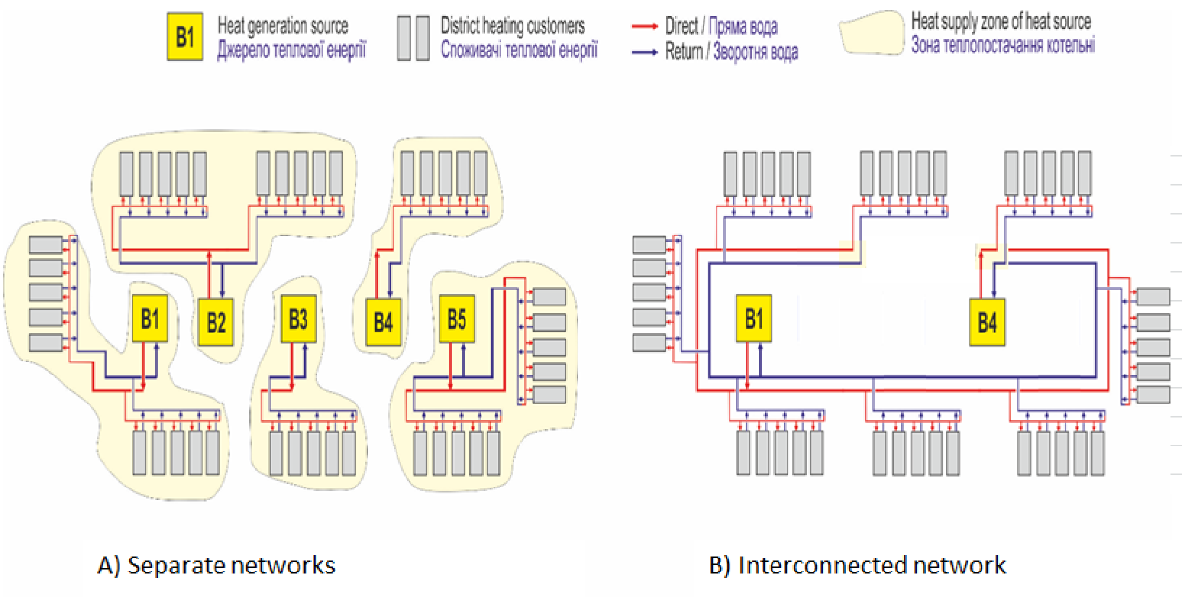
Barrier number 4 is about the difficulty that independent heat producers have in connecting to heat networks. Currently, almost all heat producers and heat suppliers in the district heating sector of Ukraine are municipal or state owned. Moreover, these organizations often combine activities on heat production, transportation and supply and have been monopolists in district heating for some decades. Most of them use natural gas as fuel, although some of them do implement biomass boiler plants, the share of which, according to estimations, is about 2-3% in the total heat production. The possibilities of communal heat supplying entities to implement biomass boiler-houses are limited by the amount of funds provided in their investment programs. Some large projects for biomass energy use in district heating are carried out under the support of international financial institutions. At the same time, in case of favorable conditions for doing business in this area, independent heat producers could attract additional investments for implementation of biomass boiler houses and significantly increase the share of biomass in district heating. However, currently they implement biomass boilers mainly for the heat supply to individual facilities, without joining the district heating network. For example, replacement of separate gas boiler houses on budgetary objects (schools, hospitals) by boiler houses on other types of fuel is quite a common practice. It means that for private business it is easier to enter this area without interfering in district heating supply. One of the reasons for this is *the difficulty of connection of new heat producers to existing district heating networks of utilities*. The possibility of competition in heat supply is provided by existing Ukrainian legislation. Thus, the Law of Ukraine *"On Heat Supply"*[Error! Bookmark not defined.] explicitly states that one of t he principles of state policy in heat supply sector is "promoting the development of competitive relations in the heat energy market", and one of the tasks of state regulation activity in this area is "prevention of monopolization and creation of conditions for the development of competition in heat supply". If two or more heat-generating organizations are connected to the main or local heat supply network of heat supply organization, the prioritization of contracts for heat purchase is carried out on a competitive basis. The tender should be organized by executive body of the city or settlement council in accordance with the procedure established by law. If the heat supply organization has its own heat generating capacity, its participation in the tender for heat purchase is obligatory. However, the procedure of organizing such competitions has not been developed yet. Typically, installed heat generating capacity of existing utilities exceeds the associated heat load of consumers. Therefore, they formally have no reason to connect other heat producers who would take over the heat load of their consumers, leading to further increasing the imbalance between generating capacities and existing heat load. Utilities and local governments have the means to

[45] http://www.nerc.gov.ua/index.php?id=23624
[46] UABio's letter of 07.02.2017 http://uabio.org/img/files/docs/uabio-letter-298-to-poroshenko-on-grid-connection.pdf

prevent potential independent heat producers to use their right to access heat networks: refuse to provide a land plot for the construction of a boiler-house or not to provide technical conditions for joining the heating system, referring to the absence of an approved heat supply scheme of the settlement, or referring to absence of heat consumption increase in the heating system and excess of own heat-generating capacities. The provided technical conditions for the connection may be inappropriate for a potential independent heat producer from a technical or economic point of view. In the absence of practical possibility to appeal, in many cases these conditions make connection to the network impossible.

The fifth barrier is about the non-interconnectedness of district heating networks. The vast majority of District Heating systems in Ukraine are based on the principle of "one heat generation source for one separate heating network" (See figure 2.6). The reason is that the traditional Ukrainian concept for district heating system is the fixed flow regime that implies operation of one heat generation source/plant per distribution network. Interconnections between the separate heating networks exist in several large cities, but only used as backup or reserve in case of accidents or switching to a more efficient heat source in the summer.

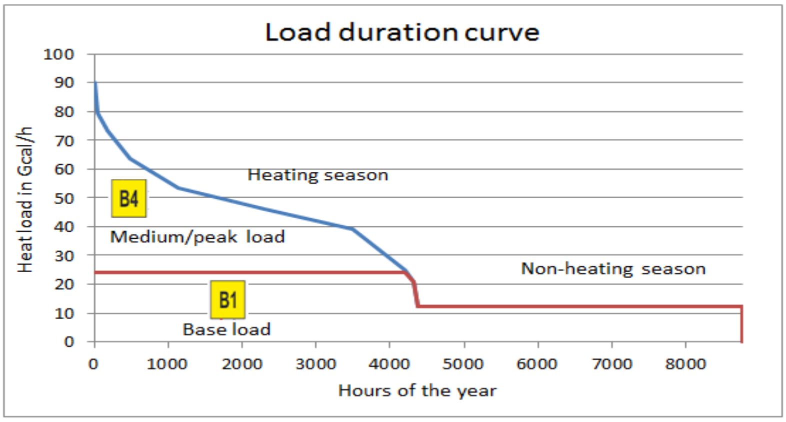
Figure 2.6 Types of district heat supply networks



Source: Bioenergy Association of Ukraine (www.uabio.org)

When a district heating system is modernized, a main target is to switch to variable flow regime and thereby making the system capable to manage several heat sources at the same time in one district heating system. Figure 2.6 B illustrates that modernization of Ukrainian district heating systems involves the installation of interconnections between boiler houses to create an effective heat load dispatch. The benefits are sketched in figure 2.7, which illustrates a form of wholesale competition between two heat production plants. Because plant B1 has the cheapest heat production price, the plant is operating as base load with a high utilization of the installed capacity, while Plant B4 has a more expensive heat price and is only used for medium/peak load (and as reserve for Plant B1). Load dispatch creates a competitive wholesales market where biomass combined heat and power, biomass boilers and gas boilers are ‘competing’ on the heat price - independently of the ownership. The purpose of 3rd party access to district heating in Ukraine is to attract additional investors. They can only make business if they can sell heat cheaper to the district heating system than the local district heating company can.

Figure 2.7: Load duration curve with load dispatch for two heat production plants



Source: Bioenergy Association of Ukraine (www.uabio.org)

However, in Ukraine, there are no current examples of variable flow with load dispatch of several heat sources (including sources of various forms of ownership) for the same district heating network. In addition to the possibility of diversifying heat supply sources using different types of fuels, interconnected district heating networks make it possible to improve the reserve of generating capacities in case of emergency, as the need to maintain the necessary reserve in each individual boiler house is reduced. In district heating systems functioned on competitive basis, such schemes for connection of heat sources enable to maximize the market benefits of competition, since they provide a better opportunity for the accession of new independent producers to the overall district heating system. Due to lack of experience such projects are currently not considered to be a priority for district heating in Ukraine, as it can be concluded from recently approved *"Concept of Implementation of State Policy in Heat Supply Sector"*[47].

Barrier 6 is about problems of biomethane production and consumption. For using heat produced from biogas in a district heating system, a large biogas plant can be located appropriately close to heat network (the minimal distance to heat network and other objects is determined by environmental and other relevant regulations). The produced biogas can be burned in a gas engine (with power generator), which is connected to the district heating system with a pipe to transfer heat. This option does not have legal barriers; the only condition is that it should be feasible. Another option for natural gas substitution by biogas for heating purpose is production of biomethane (CH_4). Ukraine has a large potential of biomethane production from agribusiness by-products and residuals and from using abandon or even available arable fertile land for energy crops cultivation. Biomethane can be sent into the natural gas network. Moreover, district heating companies in principle can buy the upgraded biogas by buying the equivalent energy amount of natural gas from the gas network. However, that requires a special scheme and state support. Despite so far limited number of implemented Ukrainian biogas projects, the technical scope covers a wide range of industries and different types of raw material for biogas production including pig and cattle manure, chicken litter, maize and sugar sorgo silage, sugar beet pulp, food treatment waste, municipal solid waste and waste water. The main barrier associated with biomethane is that biomethane consumption in the domestic market may be limited due to high cost of its production in comparison with the current market prices of natural gas. Another barrier in this respect is the

[47] http://zakon2.rada.gov.ua/laws/show/569-2017-%D1%80

additional cost and practical difficulty of connection to the national gas grid for a biomethane producer. The Law of Ukraine "On the natural gas market" № 329-VIII of 09.04.2015[48] contains a statement that producers of biogas shall have the right to obtain access to gas transmission and distribution systems in case of physical and technical characteristics of biogas conform to standards applicable to natural gas. NRCEU Decree #2493 "On approval of the Code of gas transportation system"[49] (registered by Ministry of Justice under № 1378/27823 of 06.11.2015) defines the legal, technical, organizational, and economic principles of operation of the gas transportation system of Ukraine. Access to the transmission system is provided based on equal rights of access and connection for all subjects of gas market including biogas producers. In particular, the Code describes the physical and technical characteristics standards for the gas. Obviously, the degree of biogas upgrading and purification by present commercial technologies (CH_4 content in biomethane at 95-98%) is sufficient to meet the requirements of the above standards, so there is no technological barrier for biomethane production in Ukraine. However, a biogas supplier should pay the total cost of grid connection. It is also responsibility of the supplier to install all monitoring equipment and cover all the cost associated with measurement procedure.

Barrier number seven is about the subsidized natural gas price for households and the housing-communal sector. Today, the price of natural gas for communal heat supply companies that produce heat for the needs of the population remains subsidized. The government imposed a *special obligation* on NSC "Naftogaz of Ukraine", to sell/supply natural gas to household consumers and communal heat supply companies at a *price, which is below the market value*. This creates barriers for biomass boiler plants entering into district heat systems, since the heat tariff for such boiler plants is tied to the tariff for heat produced from natural gas for the respective category of consumers. To implement provisions of the Memorandum between Ukraine and IMF[50] (dated 02.03.2017), a new *"Regulation on imposing special duties on the natural gas market entities to ensure the public interests in the process of the natural gas market functioning"*[51] (hereinafter referred to as the PSO Regulation) was adopted. An important feature of this PSO Regulation is that from October 1, 2017, the price of natural gas for household consumers and communal heat supply companies is tied to the estimated gas price at the level of import parity. The idea is to further limit the height of subsidies and finally abolish them. This means that slowly but surely this barrier will be removed, although it currently still plays a role.

The eighth barrier is about the understated (less than fair) tariffs for heat transportation. In Ukraine, there is a problem of tariff formation in the production and transportation of heat energy. This problem arises when calculating tariffs for the production and transportation of heat energy for those heat supply companies that carry out both activities - the production and transportation of heat energy. The problem lies in *partial referring the costs associated with heat energy losses in heat networks to the production of heat energy, and not to its transportation.* Under existing practice, the tariff for transportation includes only normative heat losses in the networks (on average 12%), and the excessive losses (which can reach 20-25%) are included in the tariff for the production of thermal energy. In fact, there is a cross-subsidization, while in reality part of the costs taken into account in the tariff for the production of heat energy should be attributed to its transportation. When

[48] http://zakon3.rada.gov.ua/laws/show/329-19
[49] http://zakon4.rada.gov.ua/laws/show/z1378-15
[50] https://www.minfin.gov.ua/uploads/redactor/files/%D0%9C%D0%B5%D0%BC%D0%BE%D1%80%D0%B0%D0%BD%D0%B4%D1%83%D0%BC%20%D0%9C%D0%92%D0%A4_%D0%9A%D0%B8%D1%97%D0%B2,%202%20%D0%B1%D0%B5%D1%80%D0%B5%D0%B7%D0%BD%D1%8F%202017.pdf
[51] CMU Resolution № 187 of 22.03.2017. The Resolution will be terminated on 01.04.2018 http://zakon5.rada.gov.ua/laws/show/187-2017-%D0%BF

production, transportation and supply of heat is carried out by the same enterprise, there seems to be no apparent contradictions. However, with implementing the allocation of expenditures to respective type of activity (production, transportation and supply of heat) as well as with connection of independent heat energy producers, there arises a conflict of interest for a heat transportation company, as transportation of "someone else's" heat will be unprofitable for it. If, for example, a heat transportation company decides to be engaged only in the transportation of heat energy, it can be stated in advance that such activity will not be profitable under the current principles of the formation of tariffs for the transportation of thermal energy. The current situation contradicts the requirement of prevention of cross-subsidization stipulated by the Licensing Conditions for economic activity in the area of heat supply[52]: "to prevent cross-subsidization of other activities at the expense of economic activity on the production of thermal energy". In addition, it creates a false picture of tariffs for heat supply: the tariff for heat energy transportation is artificially understated, and the production tariff, on the contrary, is overstated. This approach "disguises" the problem of high heat losses in heat networks and does not create incentives for their reduction.

The last barrier identified by the report of the Bioenergy Association of Ukraine is the production of bioethanol at sugar factories and the imperfections of legislation on this topic. «In Ukraine about 11% of biomass is used for bioenergy production. As for the sugar beet pulp, it is only 4% of the potential», — commented Oleksandr Nikolayenko, the head of the department for investments attraction in sustainable development, EBRD. He noticed that European Bank for Reconstruction and Development not only permits producers to attract grants for the introduction of bioenergy production technologies, but also provides support to the government for the legislative framework improving[53]. This is all the more interesting because of the stagnating growth in the usage of white sugar in Europe, due to health issues (for example diabetes). Even though technology is readily available (if necessary with help of foreign investors/technology, see further chapter 3 for the calculation of a business case), today in Ukraine there is a situation when any sugar factory, which has invested in the processing capacity of molasses for bioethanol, is not able to sell products without a license from the state company Ukrspirt. That is because legislatively, bioethanol is equated to spirit and both products have the same code. Thus, the plant can not realize bioethanol, since for the sale of alcohol a wholesale license worth UAH 500 000 per year is needed, which the Cabinet of Ministers issues only for "Ukrspirt". In Ukraine there are currently 2 complexes for the production of bioethanol from molasses, "BIOPEK" (Gnidava sugar plant) and the bioethanol complex on the premises of the Uzinsky sugar plant[54]. More on this issue can be found in chapter 3.

2.5 Conclusion and recommendations

2.5.1 Conclusion

The aim of this chapter is to understand why the implementation of the RED is lagging behind the set schedule. Ukraine has in 2017 at its very best 1.5% of its total primary energy supply and less than 1% of its electricity generation from renewable sources.

These low numbers of Ukraine, also in comparison with most of its neighbouring countries, are also growing just slowly, except for solar energy (which shows a high growth rate, but still a very low installed capacity, making it at this moment not a very significant factor). Some development can be seen in the biomass sector, where biomass fired boilers both for heating and electricity generation

[52] http://zakon2.rada.gov.ua/laws/show/v0308874-17
[53] http://www.ukrsugar.com/en/post/biogas-and-bioethanol-alternative-earnings-for-sugar-industry
[54] https://latifundist.com/novosti/39019-bioetanolnoe-podrazdelenie-na-sahzavode-pozvolit-povysit-ego-rentabelnost--dolinskij

are slowly becoming more popular. Given the huge surface of Ukraine and the large amount of land used for agricultural purposes, there is a huge potential for further growth in biomass for energy production. With the help of expert interviews, several barriers were identified in the policy and legislation area and with the help of the Bioenergy Association of Ukraine several more technical barriers were identified that hinder the development of the transition to renewable energy for electricity generation and heating in Ukraine.

From the description and analysis of the consequences of these barriers the classical picture of a Catch-22 situation emerges. Even though there is a large potential in Ukraine for using renewable sources, the growth of the energy market for renewables is constrained by legislation and bureaucracy which makes it unprofitable to invest in renewable energy, and the resulting high price of energy of existing renewable energy projects gives the sector an image of non-profitable and reduces the demand among end-users for this type of energy. To break this circle of stagnation, the Ukrainian government has made some steps with introducing feed-in tariffs, but even that did not significantly raise the amount of renewable energy projects, as among others investors are reluctant to invest because of (perceived) political instability within the country and maybe in some cases, as one source reports, because of under-budgeting the inability to always pay the promised feed-in tariff.

This means that some more steps need to be taken in order to break this circle of stagnation and one of the ways of doing this is maybe with help of foreign advisors and specialists, to assist with more simple legislation which is profiting the necessary energy transition towards more sustainable energy. This maybe a role of some international institutions like the World Bank or the EBRD, or maybe in more intensive Government to Government cooperation with Western European countries.

2.5.2 Discussion

When looking at the result of this study into institutional and technical barriers, some other related issues could pop up that follow from the analysis and conclusion of this study but fall outside the scope of this study. In this section, a few of such pressing matters are briefly discussed and may provide good opportunities for further study.

In Ukraine, there are a number of specific issues for the usage and market development of the renewable energy market, which still have to be solved, for example the issues related to:

- What will be the system of certification of renewable energy products in Ukraine? Will it have the same certification as the products in the European Union?
- In terms of the production of biofuels, it is not yet clear how the product will enter the market - already mixed bioethanol with fossil fuel inside Ukraine or mixed outside of Ukraine? Does Ukraine has the refinery capacity to process and mix these fuels?
- In the case of biofuels, how can the domestic market be further developed and how will the domestic market be regulated?

2.5.3 Recommendations for foreign investors in the renewable and bio-energy markets

As written in previous parts of this chapter, doing business in Ukraine can be challenging, and the energy sector is no exception. It does offer a lot of potential, given the large amount of biomass that is available as well as the climate and the amount of land available for wind and/or solar energy.

Because of economic problems (among others the war in Eastern Ukraine), the currency has lost much of its value and it means that Ukrainian based production and/or local assets are available for low prices for foreign investors. This means that in spite of the economic crisis, there are good opportunities to invest, probably mainly export based production at first, but after recovery of the economy certainly also for the domestic market, which with 45 million inhabitants can be certainly interesting. Taking care about risks while investing in Ukraine is however necessary. In this section some advice for being successful in Ukraine, all recommendations can be divided into 5 major groups:

1) Thorough business planning: make a proper risk evaluation when planning business in Ukraine
2) Invest in personal relations: Business has to be done only with a trustworthy Ukrainian partner
3) Understanding of cross-cultural differences and the language barrier – there are many differences with other European countries (especially with Western Europe).
4) Weakness of hryvnia is generally positive for foreign investors bringing in Euros or Dollars, although there is a risk of "import-inflation".
5) Changes in legislation in Ukraine and the specifics of the business environment, has to be known before starting to invest in the Ukrainian market.

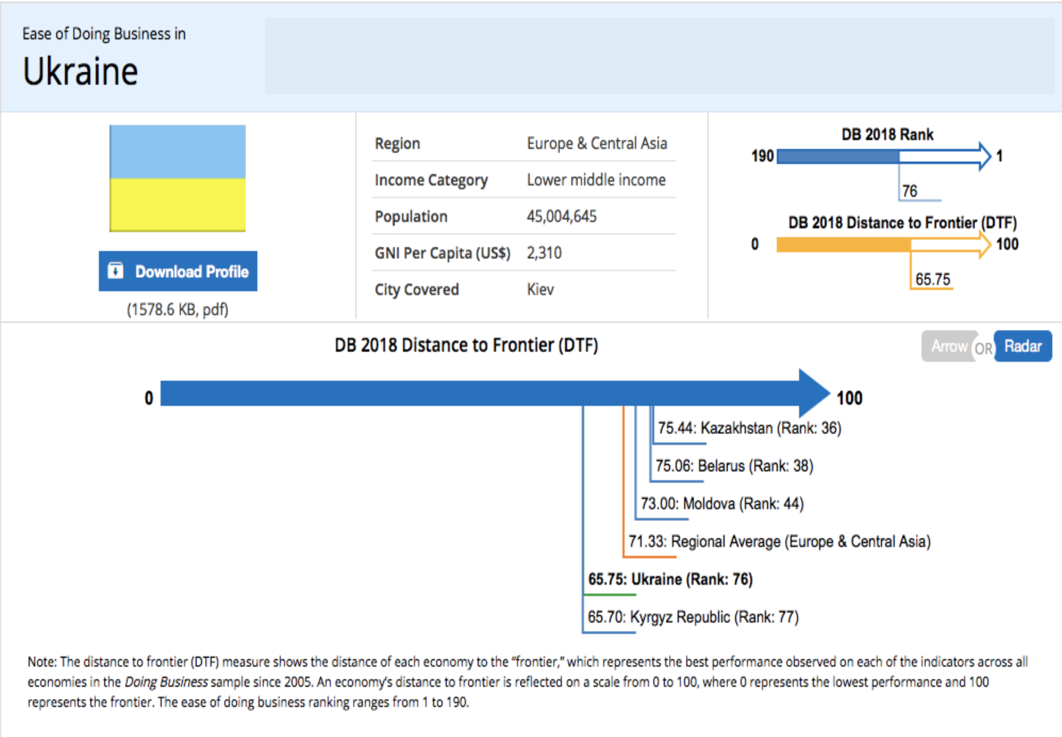
In the following part, the groups of recommendations are described in more detail, in order to provide a real picture of the Ukrainian market and the opportunities and threats that one can expect there.

Recommendations about business planning

It is necessary to make a proper risk evaluation when planning to do business in Ukraine. It is well-known that a large part of production in the country is controlled by a narrow circle of politically influential businessmen. In recent years, there was no any significant initiative to create a competitive business environment, but changes are slow to occur. It is therefore not advisable as foreign newcomer to the market to directly compete with existing large companies controlled by these elites. When analysing the country's rating on the "Ease of doing Business" [55] list of the World Bank, it shows that especially property safety and security is still weakly developed, however there are some positive trends visible in the last couple of years (see figure 2.8 and 2.9).

[55] http://www.doingbusiness.org/data/exploreeconomies/ukraine

Figure 2.8: Doing business rating in Ukraine



Source: World Bank, 2018

Figure 2.9: Ease of doing business in Ukraine, developments

Topics	DB 2018 Rank	DB 2018 DTF	DB 2017 DTF	Change in DTF (% points)
Overall	76	65.75	63.85	↑1.90
Starting a Business	52	91.05	91.03	↑0.02
Dealing with Construction Permits✔	35	75.81	65.77	↑10.04
Getting Electricity	128	58.80	58.45	↑0.35
Registering Property	64	69.61	69.50	↑0.11
Getting Credit	29	75.00	75.00	..
Protecting Minority Investors✔	81	55.00	53.33	↑1.67
Paying Taxes✔	43	80.77	74.27	↑6.50
Trading across Borders	119	64.26	64.26	..
Enforcing Contracts	82	58.96	58.96	..
Resolving Insolvency	149	28.24	27.95	↑0.29

✔= Doing Business reform making it easier to do business. ✗= Change making it more difficult to do business.
Click here to see all reforms made by Ukraine.

Source: World Bank, 2018

Despite the low ranking on most indicators, Ukraine shows progress in point rankings that assess the state of the economy in one or more areas. Given that other countries do not stand still either, the progress of Ukraine in these rankings is positive in terms of net development among other countries. This is represented in different other publications as well. For example, according to a recent European Business Association survey, businesses believe the investment climate and business environment in the country improved considerably - the index has reached its highest level since 2011.

Although there is certainly improvement, the situation in Ukraine still remains challenging for businesses. Rankings such as the Global Competitiveness Index, Index of Economic Freedoms or the Prosperity Index are systemic and cover many areas and components that are not always directly related to the economy or incapable of quick changes (e.g. infrastructure). They also take into account factors that are independent of the country's leadership (armed conflicts, natural resources) and are based on a rather long list of historical data (3-5 years), on most of these indices Ukraine still doesn't make significant progress.

The country receives the lowest rankings in the areas related to governance. This includes protection of property rights, the level of corruption, and the effectiveness of the judicial system. In this case, external factors do not play a large role, because everything depends on the political will power of the authorities. This is maybe the most likely potential risk of instability, because in 2019 will be the elections for the President of Ukraine, and this will likely lead to renewed political fights within the earlier described narrow circle of businessmen, trying to attract new resources and potential reforms may lead to uncertain situations. Staying out of the direct circle of business interests of the largest business owners can certainly help.

Investing in personal relations

Ukrainian business is very personal oriented, and it is therefore of the utmost importance to build strong relationships with Ukrainian business partners before moving into doing actual business. It is important to have long-term goals and a long-term commitment in order to become active in Ukraine. Important is to work with a reliable local partner, as entering the Ukrainian market alone is very difficult. A reliable local partner is needed for the audit of general documents, collection of initial data for design, development of feasibility studies of power delivery schemes, selection and delivery of basic equipment, obtaining a license for the production of electricity and arranging all the necessary contracts for the sale of electricity just to name a couple of activities.

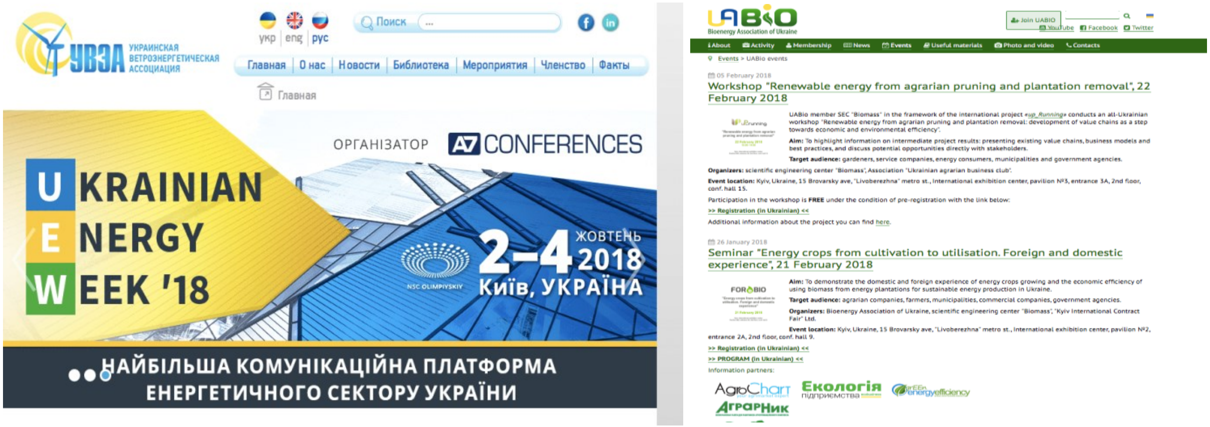
Finding a trustworthy partner is challenging and of course personal. In terms of renewable energy in Ukraine, it might be worthwhile to look for business partners among the members of the:

- Bioenergy Association of Ukraine http://uabio.org/en/events/events
- Biomass Sec http://biomass.kiev.ua/en/
- Association of Alternative Fuel and Energy Market of Ukraine www.apeu.info
- Ukrainian Agrarian Confederation http://agroconf.org
- Ukrainian Agribusiness Club http://ucab.ua/ua
- Ukrainian Committee of the International Chamber of Commerce (ICC Ukraine) http://iccua.org
- Kyiv International Energy Club Q-club www.qclub.org.ua
- Energy Association of Ukraine www.eau.org.ua
- Ukrainian Wind Energy Association www.uwea.com.ua
- Association of Energy Efficient Cities of Ukraine http://www.enefcities.org.ua/uk
- European-Ukrainian Energy Agency http://euea-energyagency.org

- National Ecological Centre of Ukraine http://en.necu.org.ua
- Ukrainian Network of Environmental Innovation Greencubator http://greencubator.info

These professional unions were founded to improve Ukraine's energy independence via facilitation of renewable development and creating a common platform for cooperation on the renewable energy market of Ukraine in order to ensure the most favourable business environment, fast and sustainable development of renewable energy as a business sector. All of them have organized several professional events and conferences. Some of them offer services related to project management of international projects.

Figure 2.10: Examples of websites of renewable energy business networks



Of course, this kind of organisations will not give 100% guaranty, but will bring market entrants in contact with experts and professionals who know of market specifics and how to deal with an unstable political environment.

Figure 2.11: Large general business networks also start to pay attention to renewable energy

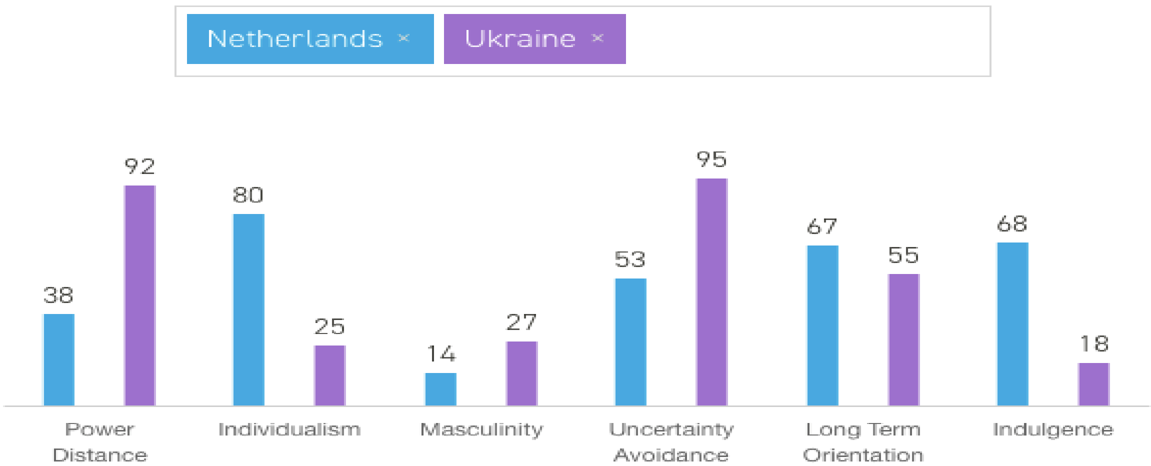
Understanding cultural differences and the importance of language

Ukraine is a country with rich historical traditions and customs that are in some cases rather different from those in Western Europe. One of the way to describe and analyse the existing cultural differences is with the help of the cultural dimensions model of Geert Hofstede[56]. In this model, cultures are compared based on six dimensions and it can help to understand how people communicate with each other, their expectations about several aspects of life and the way they prefer to negotiate for example.

Figure 2.12 is an overview of the cultural differences between Ukraine and The Netherlands. It shows the differences in scores for the six indicators as formulated by Hofstede. When looking at the scores in more detail, some striking cultural differences can be observed. On the first indicator, that of "Power distance", Ukraine scores 92, which indicates that most people perceive it as normal that not everyone is equally powerful in society, but instead that a strong hierarchy in society (and also within business) is acceptable. This score is not surprising given the history of Ukraine, being a part of a rather strongly centralized Russian empire and Soviet Union. Even today, after the 1991 independence, Ukraine also developed a highly centralized country and government. One of the consequences of the high power distance is the great importance of status symbols. Behaviour must reflect and represent the status roles in all areas of business interactions: be it visits, negotiations or cooperation; the approach should be top-down and provide clear mandates for any task.

The second cultural dimension is about the difference between individualism and collectivism. The fundamental issue addressed by the individualism score is the degree of interdependence a society maintains among its members. The lower the score on individualism, the stronger the interdependence relations. Ukraine has a low score on individualism, that is why, for example, you would definitely see a lot of "family members" or "close friends" at the company. And in many cases trustful business relations build on the principal of being a "member of the family".

Figure 2.12: Comparison between The Netherlands and Ukraine on Hofstede's cultural dimensions



The third cultural dimension of masculinity vs. femininity is about the importance of certain values in life. In strongly masculine cultures, results, promotions, and getting material welfare are seen as important, generally, a will to win. A low score on this dimension means that the dominant values in society are caring for others and quality of life. Ukrainians at workplace as well as when meeting a stranger rather understate their personal achievements, contributions or capacities. Dominant

[56] https://www.hofstede-insights.com/country-comparison/the-netherlands,ukraine/

behaviour might be accepted when it comes from the boss, but is not appreciated among peers. On this dimension, the Dutch and Ukrainians don't differ too much from each other.

The fourth dimension Uncertainty Avoidance stands for the extent to which the members of a culture feel threatened by ambiguous or unknown situations. A high score means a low tolerance for ambiguity and a low score means that members of society accept open and more fuzzy situations. Ukraine scores 95 on this index, which may indicate that Ukrainians generally feel threatened by ambiguous situations. Presentations are either not prepared, e.g. when negotiations are being started and the focus is on the relationship building, or extremely detailed and well prepared. Also detailed planning and briefing is very common, even though this seems for Dutch people sometimes to go too far, as it is not possible to plan so detailed everything in advance. Ukrainians prefer to have context and background information. As long as Ukrainians interact with people considered to be strangers they appear very formal and distant. At the same time formality is used as a sign of respect.

The fifth dimension long term orientation is about the outlook that people have, a long term view or a short term view. A high score on long term orientation also often means that rules and regulations can be more flexible (or dealt with in a more flexible way), since the outlook is long and far away, there is generally tolerance for different ways of getting there. When the score on this dimension is low, there is more attention for immediate success, more need for strong procedures and generally a single way of moving forward that is seen as best. With a moderately score of 55 on long term orientation, Ukrainian culture does not express a clear preference on this dimension. But, given the current political and economic situation, it can be expected, that there is not a lot of trust in "long-term oriented business investments" among the local businesses. This is of course connected with the high risks of their loss, but is not something very natural to the Ukrainian culture.

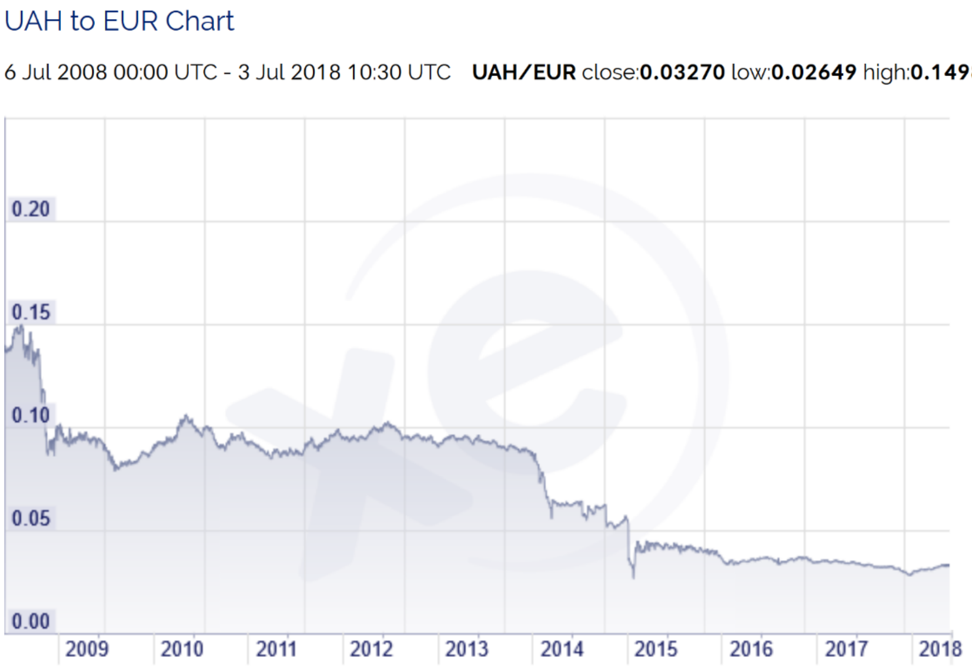
And finally, sixth dimension on indulgence vs. restrained measures something about the level of happiness or maybe better said hedonism in the culture. The higher the score on this dimension, the more hedonistic people usually are. the Restrained nature of Ukrainian culture is easily visible through its very low score of 18 on the Indulgence dimension. Societies with a low score in this dimension tend to display cynicism and pessimism. Also, in contrast to indulgent societies, restrained societies do not put much emphasis on leisure time and control the gratification of their desires. People with this orientation have the perception that their actions are restrained by social norms and feel that indulging themselves is somewhat wrong, although the situation may be very different if they feel that these societal norms and values are absent.

When comparing Dutch and Ukrainian cultures, there are certainly some differences and it is therefore advisable to prepare oneself well before starting to operate with a business in Ukraine. An even more pressing issue than culture might be the problem of the differences in language. There is a lack of English speaking specialists and professionals in Ukraine. There is a low percentage of English speakers among the general population, which means extra efforts with the organisation of negotiations and business meetings (among others interpretation and translation). It can take a while before effective cooperation will start and the language barrier will be overcome.

Weakness of the Hryvnia and & insurance guarantees for foreign investors

The weak exchange rate of the Hryvnia (UAH) against for example the Euro, made Ukraine nowadays the place where it is possible to earn relatively quickly and easily when producing for export. But in general, investing in the Ukrainian economy is at the same time challenging because of rather strong fluctuations of the exchange rates. Even with high political risks and uncertainty, a country with a weak exchange rate of the national currency is a good place for outsourcing. The low cost of labor and capacity makes almost any production for export in Ukraine extremely profitable.

Figure 2.13: Development of the exchange rate between Euro and Hryvnia (2008 – 2018)



Source: www.xe.com

Meanwhile, it makes sense to sign the contracts only in the case of an independent insurance (or insurance deposits through the property or the capital of the partner also called letter of credit). This measure is designed to prevent the avoiding of the responsibility of the Ukrainian partner.

Keep a close watch on legislation changes

To summarize the recommendations for potential investors, special attention should be paid to the situation of changes in legislation in Ukraine. Most reforms are meant to improve administrative, economical, social environment in business, but can be sometimes hard to understand and/or hard to comply with. Therefore, it is strongly advisable to keep a close watch on the changes in legislation and the potential consequences for business processes. Fortunately, there are several on-line resources available that help with getting a picture on the most important issues in legislation at hand:

- The Ministry of Economic Development and Trade of Ukraine created an on-line service which provides different kind of services for example in registration of business as well as many other services for individuals, and non-profit organizations (https://poslugy.gov.ua);
- There is also an electronic on-line system of procurement and tenders (www.prozorro.gov.ua);
- Electronic administrative services from State Architectural and Construction Inspection of Ukraine (including progress of the preparatory work, progress of construction and declaration of readiness for use, etc.) (https://e-dabi.gov.ua);

All these on-line services are only available in the Ukrainian language. In principle these electronic systems work effectively against corruption, but given the language issues, it is still recommended to hire a trustworthy Ukrainian speaker.

The main changes in legislation in 2018 concern the Law of Ukraine "On Amendments to Certain Legislative Acts of Ukraine on the Facilitation of Business[57] and Investment Attraction by Securities Issuers" of 11/16/17, No. 2210-VIII. This law provides for a series of changes. In particular, the new law:

- improves order of securities issue, information disclosure system on the stock market, corporate governance in joint-stock companies;
- organizes the activity of providing information services in the stock market;
- provides for by an exclusive list of cases of non-distribution of requirements;
- has improved and clearly written articles related to the issuance, approval, disclosure of the prospectus and the validity period of such a prospectus;
- cancels the disclosure of the securities prospectus in paper form;
- improves the rules on regular information about the issuer, in particular:
- the requirements for public and private joint-stock companies are differentiated;
- the period of disclosure of information on holders of voting shares of private joint stock companies is reduced from 10% to 5%;
- additional disclosure requirements by separate categories of issuers were excluded;
- requirements for independent directors were improved;
- specifies separate requirements for independent directors of banking institutions;
- the mechanism of payment of dividends is improved;
- restrictions when determining the quorum of the general meeting and the right to vote in the general meeting are specified;
- the issue of the election of the auditor is the representative of the audit committee of the general meeting;
- provides access to documents of the joint-stock company containing information about the financial and economic activities of a joint-stock company, each shareholder owning a large block of shares, namely - 10% or more;
- features of corporate governance in joint-stock companies - banks are taken into account;
- provides a transition period for joint stock companies to ensure the composition of the supervisory boards and their committees in accordance with the law.

The aforementioned legislative initiatives will undoubtedly bring positive changes in the investment climate of Ukraine and a certainly welcomed by most foreign investors, making the business situation more transparent.

[57] http://www.president.gov.ua/ru/news/prezident-pidpisav-zakon-spryamovanij-na-sproshennya-vedenny-45346

Further reading

1 Victor Logatskiy and others. - Natural Gas Recovery in Ukraine: Tax Incentives and Initiatives for Discussion. Razumkov Centre edition, 2015. – Kyiv, 44 pp.

2 Kateryna Markevych and others. - Energy Sector of Ukraine: Summary for 2015. Razumkov Centre edition, 2016. – Kyiv, 72 pp.

3 Olexandr Alymov and others. - Economic Development of Ukraine: Institutional and Resources Provision. United Institute of Economy National Academy of Sciences of Ukraine, 2005. – Kyiv, 540 pp.

4 Black Gold of Ukraine: Infographics. Ukrinform Information Agency. http://www.ukrinform.ua/rubric-other_news/1536886-vidobutok_vugillya_v_ukraiini_nini_vedetsya_v_160_shahtah_infografika_1857135.

5 Georgiy Geletukha and others. – Energetic Potential of Biomass in Ukraine. http://elibrary.nubip.edu.ua/8102/1/10ggg.pdf.

6 United Energy System of Ukraine: Capacity at the end of 2014. http://2014.ukrenergo.energy.gov.ua/ukrenergo/control/uk/publish/article?art_id=182509&cat_id=171201

7 Data of PJSC Ukrtransgas. http://utg.ua/en/utg/gas-transportation-system/characteristic.html

8 Data of NJSC Naftogaz of Ukraine.

9 Data of PJSC Ukrtransnafta. http://www.ukrtransnafta.com/en/about_company/shema/.

10 Interfax-Ukraine Information Agency. http://ua.interfax.com.ua/news/general/323378.html.

11 Refinery Industry of Ukraine: Condition, Problems and Development Ways. National Security and Defence Journal, No 3. Razumkov Centre edition, 2006. - Kyiv, 48pp.

12 News report: http://oilnews.com.ua/a/columns/Patsient_skoree_mertv_u_ukrainskih_NPZ_perspektiv_net/221279

13 New Energy Strategy of Ukraine Until 2020: Security, Energy Efficiency, Competition. National Security and Defence Journal, No 1. Razumkov Centre edition, 2015. - Kyiv, 56 pp.

Chapter 3.

Alternative processing technologies for sugar beets

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3.1 Introduction

One of the crops most suited for development in terms of producing biofuels are sugar beets, due to its large percentage of sugar which can be transformed into bioethanol. One of the methods to do this is the so called "Direct Processing with Betaprocess" (indicated further on as DP+Beta), a patented technique that increases the substrate's digestibility and strongly reduces the time-consuming hydrolysis phase of fermentation processes. Subsequently, the total fermentation proceeds much faster and more efficiently, generating considerably higher yields and an improved process efficiency. Betaprocess is not a fermenter itself, but a pre-treatment unit that can be easily integrated into an existing production process or development plans (http://betaprocess.eu/betaprocess-your-bio-booster.php).

This report is the result of a research project for the company Dutch Sustainable Development BV (DSD) and commissioned by the Dutch Enterprise Agency of the Dutch Ministry of Economic Affairs. In this research project, the feasibility of developing the Ukrainian market for direct processing methods of sugar beets is examined, in collaboration with Astarta, Ukraine's largest sugar beet processing company. The report consists of the different components of the production process and their related costs.

As central research question, this study has the following question: Is there an economically viable business case for DP+Beta in the context of Ukraine?

3.2 Alternative technologies for processing sugar beets

The sugar beet as crop gives in terms of performance the largest potential in greening the chemistry, is the conclusion a report by Deloitte (2014), titled "Opportunities for the fermentation based industry", a study in which the most attractive crops are compared for developing the green chemistry within the Bio Based Economy (BBE) sector. The report further concludes that sugar beet has a very positive effect on the fertility of the soil, together with other crops in the crop rotation, when looking at diseases, pathogen resistance, insects, etc. Furthermore, using sugar beets in the crop rotation schemes adds value to the soil, the farmer's income and reduces Green House Gas (GHG) emissions (Deloitte, 2014; Klenk, Landquist, & Ruiz de Imaña, 2012).

Traditionally, sugar beet is seen as a crop for white sugar production, but since the green revolution there has been more and more attention for this crop as one of the most attractive bio-based sources of plant origin. Among the wider public, discussions about obesity have brought the sugar beet and especially white sugar for consumers in a bad light. There is however another side to the story of the sugar beet. For a very long time, the sugar beet has an important place in crop rotation schemes (Klenk et al., 2012), and with good reason. The study by Klenk et al. as well as the before mentioned Deloitte report both conclude that the sugar beet as a crop is one of the few deep rooting crops and has a different effect on the soil when compared to sunflower, corn and wheat, effectively increasing fertility of the soil and the yields of other crops the next years. A joint study done by the Sugar Sustainability Partnership and the Center for Farming Sustainability, shows an effective increase of no less than 10-20% of long term yields of the fields when sugar beets are part of the crop rotation scheme (CIBE-CEFS, 2010).

Nonetheless, the obesity discussion in society will probably lead to less production of white sugar for human consumption on the long term, so alternative ways for processing sugar beets as well as different products are welcome. A good first step could be the production of bioethanol/biofuels from sugar beets, followed by other more value adding green products. These products are a welcome addition for economically struggling rural areas and can help local farming communities.

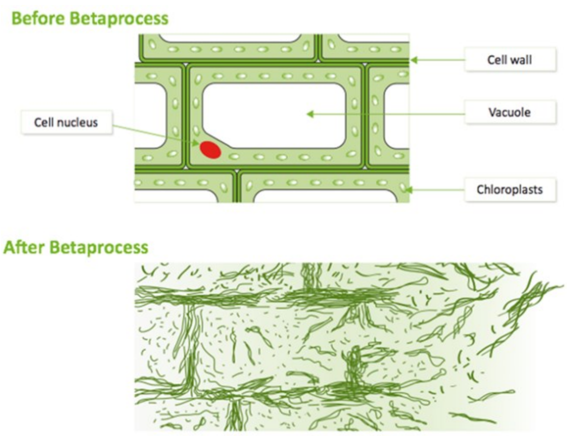
The problem of traditional production methods of bio ethanol is that it is very difficult to make these profitable in the European business context. Therefore, new production methods have to be found, which can significantly cut the production costs. One of such methods is Direct Processing of sugar beets into ethanol with the help of the so called Betaprocess (from here in this chapter abbreviated as DP+Beta). In this chapter, the parameters and calculations of the business model are explained step by step, in order to find out whether DP+Beta can be introduced in Ukraine, while maintaining sufficient enough added value, to make a profitable business case.

3.2.1 Description of the Betaprocess

The Betaprocess is a pre-treatment unit that can be implemented into existing bio-gas or bio-ethanol production processes (when they are of the fermentation type). Betaprocess degrades the biomass's macrostructures in a fraction of a second only. Hereby this part of the hydrolysis phase, which normally takes about 10-15 days, is basically reduced to nil. Subsequently, the total fermentation proceeds much faster and more efficient, generating considerably higher yields and a strong improvement of the production plants efficiency.

The process starts with the crop being washed, cut and cleaned. Then the crushed biomass will go through the Betaprocess. During the Betaprocess the crushed biomass is pumped through a heat exchanger where it is heated up to 65 °C. Then the biomass is pressed through a vacuum lock into a vacuum vessel where a reaction takes place. The cells of the biomass explode, meaning the fibres, cell walls and cell membranes are ripped apart.

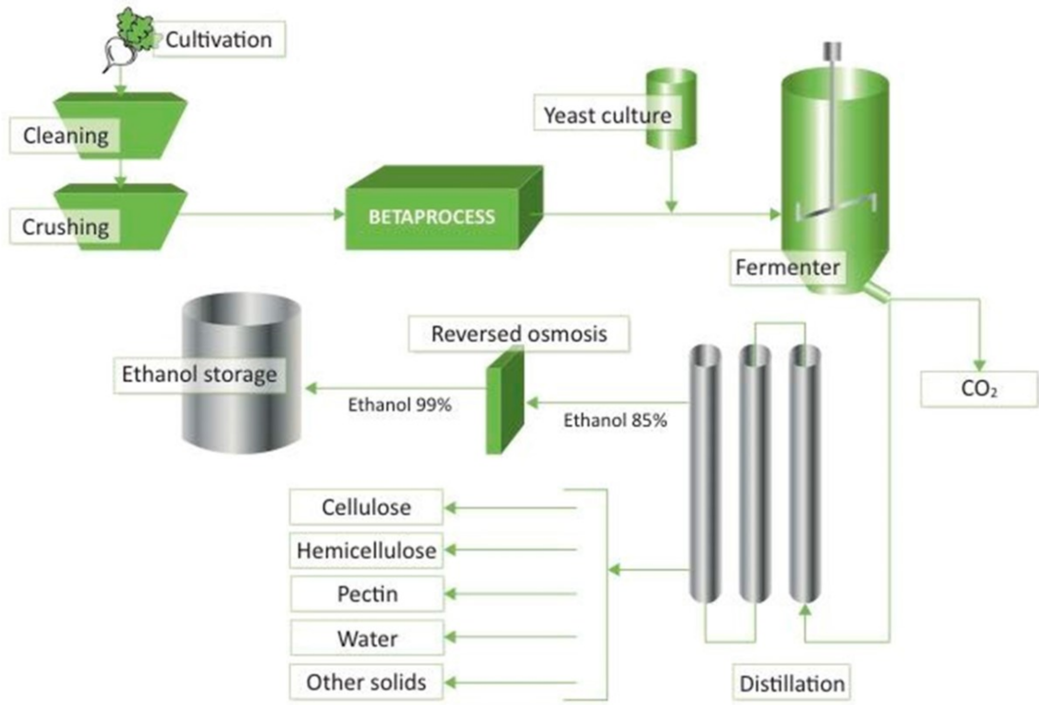
Figure 3.1: Description of the vacuum shock



Source: DSD (www.betaprocess.eu)

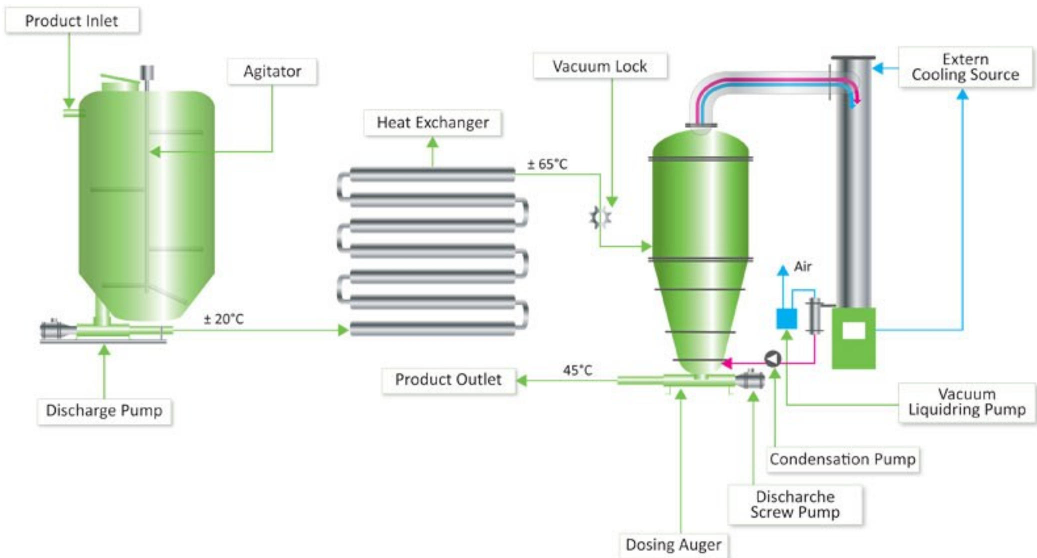
This explosion causes a change in the molecular structure of different substances and their release. This effect facilitates and accelerates massively bacterial activity, fermentation, and thereby the formation of gas and ethanol. This results in a much more efficient production process generating higher gas yields, gas with higher methane content, higher ethanol yields, while leaving less digestate residues. The additional ethanol yield of DP+Beta in comparison to the traditional methods of ethanol production is about 10 to 13%. The additional advantage is that no enzymes are needed, because via the Betaprocess vacuum explosion already brought the most advantageous materials right to the surface. Combining these two factors means that a total investment reduction of 10 to 20% can be reached for producing bio-ethanol. In figure 3.2 and 3.3, the potential applications of DP+Beta and the process flow itself are graphically displayed.

Figure 3.2: Direct Processing with Betaprocess



Source: DSD

Figure 3.3: Schematic depiction of the Betaprocess unit itself



Source: DSD

3.2.2 Ethanol yield per hectare with Betaprocess

In section 3.2.1, the focus of the text was on the sugar beet, although different crops can be used to produce bioethanol. So far sugar beets offer by far the largest amount of bioethanol per hectare, of all known alternatives. Besides that, sugar beets play an important role in the crop rotation process of farms, thereby giving an additional yield per hectare of the other crops in the years after producing sugar beets during the crop rotation cycle. When comparing sugar beets with other crops in CO2 collecting (1 HA = at least 40 ton CO2), production of oxygen and using water, sugar beet as crop show good results compared to other crops. The Water Footprint (WF) from sugar beet (Report FAO), during ethanol production is 1400 liter for sugar beets. Producing ethanol from cane sugar for example, has a WF of 2800 liter, and the WF of corn is 1900.

The problem of sugar beets is that they are not available the entire year. In order to have not too much downtime of the machinery, other crops can and probably have to be used to replace sugar beets during the time of the year that no sugar beets are available. According to a study by Wageningen University & Research the crop that is second in attractiveness, corn kernels, doesn't have the problem of limited availability during the year. A challenge when using corn kernels is that enzymes need to be added, in order to change starch into sugars, before the fermentation process will start. This leads to about 15 - 25% higher costs per litre ethanol produced, as compared to sugar beets. In table 3.3, potential yield figures of ethanol per hectare can be found, as calculated for the situation in the EU as average, Ukraine and the Netherlands.

3.2.3 Description of the business context of Ukraine

Ukraine is one of the largest countries in Europe in terms of surface and consists of a relatively flat landscape, and a temperate climate, which makes it a country very well suited for agriculture. It is not surprising that Ukraine has extensive agricultural areas and has a potential to be one of the world's largest agricultural producers. So far, for several reasons the agricultural productivity of Ukraine is relatively low. Logistical problems, obsolete / suboptimal farming technology and the moratorium on land sale are often mentioned as major problems for farmers and agricultural companies to increase productivity.

Size of agricultural firms

The structure of the Ukrainian farm sizes is quite different from the one in The Netherlands. Whereas in the Netherlands there are mostly owner-occupied farms, seldomly larger than 100 hectares each, in Ukraine there are several very large agricultural firms with over 10 000 hectares of land, next to smaller farms which have smaller sizes but are on average still much larger than their Dutch counterparts. Table 3.1 shows a classification of the sizes of Ukrainian farms.

Table 3.1: Development of Ukrainian farm size classes and area.

	2010		2011		2012		2013	
	Area (ha)	Number of agricultural holdings	Area (ha)	Number of agricultural holdings	Area (ha)	Number of agricultural holdings	Area (ha)	Number of agricultural holdings
TOTAL	21,585,900	56,493	21,570,600	56,133	21,914,200	55,866	21,800,100	55858
0	-	7,669	-	7,877	-	8,214	-	8416
< 5.0	18,300	5,784	17,800	5,639	16,800	5,332	16,000	5026
5.1–10.0	31,900	4,038	31,400	3,983	30,000	3,809	29,600	3755
10.1–20.0	76,300	4,925	75,600	4,897	74,200	4,795	74,100	4784
20.1–50.0	519,800	13,707	512,200	13,535	504,300	13,334	504,000	13294
50.1–100.0	345,200	4,831	350,000	4,895	360,900	5,016	383,000	5275
100.1–500.0	1,743,100	7,181	1,757,400	7,195	1,777,400	7,261	1,770,900	7233
500.1–1000.0	1,919,400	2,667	1,870,400	2,595	1,883,900	2,624	1,908,400	2666
1000.1–2000.0	3,822,800	2,661	3,664,800	2,549	3,683,600	2,565	3,636,000	2531
2000.1–3000.0	3,295,500	1,347	3,188,800	1,304	3,102,500	1,270	3,038,400	1251
3000.1–4000.0	2,293,000	666	2,206,300	640	2,178,900	632	2,141,600	619
4000.1–5000.0	1,670,500	376	1,577,900	355	1,481,800	334	1,434,000	323
5000.1–7000.0	1,919,600	332	1,975,200	342	1,959,100	337	2,016,200	345
7000.1–10000.0	1,479,600	178	1,456,000	175	1,504,300	179	1,379,000	165
> 10000.0	2,450,900	131	2,886,800	152	3,356,500	164	3,468,900	175

Source: (Nivievskyi, Stepanuik, Movchan, Ryzhenkov, & Ogarenko, 2015)

It can be expected that most of the small farms have limited technology available and will reach a lower output per hectare as most of the large agricultural companies. According to other recent market studies, there can even be spoken of a dualistic nature of the Ukrainian agricultural market, on the one hand the small classical family farms and on the other hand the large agro-industrial conglomerates with access to modern technology and capital, of which the agricultural activities are just a part of the larger industrial activities of the firm (Balmann et al., 2013). The same study also argues that this situation in the Ukrainian market exists because of an underdeveloped agricultural market within the country, and that it is therefore a strategy of these large enterprises to incorporate agricultural activities within their business, so that there are no problems with insufficient supply of factories as well as to dampen major price fluctuations.

Moratorium on land sales

Since the privatisation and restitution of agricultural land in 1992 to local farmers, the Ukrainian government has issued a ban or moratorium on the sale of agricultural land, until there would be a favourable legislative framework in place. The moratorium on land sale expired on 31 December 2017, but was extended with one year until December 2018. What will happen after that remains unclear. Several arguments have been brought to the table both in favour of lifting the moratorium and on keeping it (see for an overview of arguments: Bonenberger, 2017). Discussing the exact consequences of lifting or keeping the land moratorium falls outside the scope of this study, although it is good to note that many of the moratorium “abolitionists” (among which institutes like the WorldBank and IMF) expect that lifting the ban will lead to a strong land consolidation and increased investment in the long term quality of the land, thus ensuring higher agricultural productivity (Segura & Ustenko, 2016). The expectation is that the moratorium on land sale will remain in place for the foreseeable future, as many populist and nationalist politicians have made it one of the crucial issues of their policy proposals (Bonenberger, 2017).

Ease of doing business

Each year the World Bank publishes a list of “Ease of doing business”, with a ranking of all countries in the world on several indicators that they consider to be crucial for having success as a business. When comparing Ukraine with other post-soviet countries, the picture of table 3.2 appears.

Table 3.2: Ease of doing business in Ukraine as compared to other post-Soviet economies

Country	**Worldwide Rank**	**Rank in group “Post-Soviet economies”**
Georgia	9	1
Estonia	12	2
Lithuania	16	3
Latvia	19	4
Russian Federation	35	5
Kazakhstan	36	6
Belarus	38	7
Moldova	44	8
Armenia	47	9
Azerbaijan	57	10
Uzbekistan	74	11
Ukraine	**76**	**12**
Kyrgyz Republic	77	13
Tajikistan	123	14
Turkmenistan	No data	15

Source: (World Bank Group, 2018)

Table 3.2 shows that Ukraine has a rather unfavourable business climate for international businesses when compared to countries with similar characteristics and history. This observation is shared by different studies about the quality of Ukrainian democracy, its institutions and protection of foreign investor rights for the development of (foreign) businesses (Frye, 2002; Smallbone & Welter, 2001; Smallbone, Welter, Voytovich, & Egorov, 2010; USAID, 2016). The different studies mentioned here lead to the conclusion that doing business in Ukraine is difficult but offers potential.

3.3 Business Cases

3.3.1 Introduction

In order to formulate a solid and meaningful advice about the attractiveness of introducing DP+Beta in Ukraine, it is necessary to look at different aspects of the business case. In this paragraph the data on sugar beets and corn kernels (2nd most favourable crop) obtained during this study will be presented and formulated into a business model with a number of corresponding scenario's. In this study, only the production of bioethanol has been taken into account, whereas the cost price calculation for biogas is left out as well as the production costs and revenues of any rest streams. The actual model can be found in Annex 1, and the different assumptions and calculations used are explained in the following sections. The potential costs and revenues of biogas and rest streams are being described in the text of this chapter although not calculated in the main model.

3.3.2 Assumptions behind the model

The assumptions in the model presented in this study are a sugar beet campaign of around 200 days, and 150 days production of bioethanol from corn kernels for the time that no sugar beets are available. The remaining 15 days in the year are reserved for planned and unplanned downtime of operations. The total daily capacity for the production of sugar beets has been set to 3 000 tonnes of sugar beets per day, resulting in a production of 600 000 tons of sugar beets per year. For the period that the factory runs on corn kernels, the remaining days of the year, 850 tonnes of corn kernels per day have to be used in order to achieve an equal daily output of bio-ethanol.

Regarding to prices, for the raw materials, the costs of sugar beets average around €28 per tonne in Ukraine (see table 3.5), but in the different scenario's both a higher and lower prices per tonne are used as a basis for the cost price calculation. In all three scenario's a selling price of €0.50 cents per litre is used for bioethanol. This is the average price of ethanol in the EU for the last three years according to IMF data and since their expectation is that prices of bioethanol in the EU will rise due to increased demand (see table 3.13), € 0.50 seems to be a safe estimation of the future price. Besides export to the European Union, there is an expected increase on the domestic market for bioethanol in Ukraine because of the Renewable Energy Directive of the Ukrainian government (see further chapter 2 for more detailed information), which foresees in the blending of bioethanol in ordinary fuels for road transport. And not in the last place, bioethanol from sugar beets, can easily be the basis of more added value ethanol applications, which fetch even higher prices on the world and domestic markets.

3.3.3 Costs & types of raw materials

Bioethanol can be obtained from several crops, of which sugar beets is just one of the options. In this section different options for crops to produce bioethanol from are being evaluated. The numbers provided in this section are data provided by Astarta-Kyiv, one of Ukraine's large agricultural companies, as well as statistics and data from literature. It is important to look at the different variables related to yields per hectare, cost price of producing sugar beets and sugar beet prices, in order to understand whether growing (extra) sugar beets (or alternative crops) provides enough revenue for farmers as well as a stable enough supply of sugar beets with a low enough price for processing the beets.

Yields per hectare

In the first place, the different potential crops for bioethanol production are ranked in terms of yields of crops per hectare, which gives some insight in the amount of land that is needed for the production of a certain crop. Ukraine is a large country, with different climate zones, and therefore it is necessary to understand the yields of crops in different parts of the country. In this study, there is a difference made between Western and Eastern Ukraine. Western Ukraine has favourable conditions for arable farming compared to Eastern Ukraine, because of the greater availability of water and less eroded soils. The data on crop yields is summarized in table 3.1. The data is obtained from Astarta and in the case of soybeans from the study of Langemeier (2015), which explores the attractiveness of soybean production in Ukraine, but does not differentiate between Western and Eastern Ukraine. Astarta grows only a small amount of soybeans and could not provide reliable data on this issue.

Table 3.1: Yield of potential bioethanol crops per hectare in Ukraine

	Tonnes per hectare			Ranking
	average-UA	west-UA	east-UA	
Sugar Beets	45	55	40	1
Wheat	5	6.3	4.2	3
Sunflowers	2.3	2.9	2.1	5
Corn	6	10.5	4.5	2
Soybeans	3.4	*	*	4

* information not available

Source: Astarta-Kyiv, 2018; Langemeier, 2015

In terms of per hectare yield of bioethanol crops, sugar beets provide the highest tonnage per hectare, followed by corn. However, it needs to be mentioned that sugar beets are only available for a limited time throughout the year, which makes it necessary to look for alternative crops as well to be processed during the rest of the year.

Amount of seeds and price per hectare

In order to produce the required amount of raw materials, seeds have to be planted and this has to be taken into consideration as well in the cost price calculation. Prices for water, fertilizer and pesticides have been left out of the calculation. All data is obtained from Astarta-Kyiv, one of the large agricultural corporations in Ukraine.

Table 3.2: Seeds and prices of seeds per hectare in Ukraine (Astarta-Kyiv data)

	Seeds per hectare		**Price**	**Ranking**
	Number of seeds	Weight in Kg	per hectare (€)	
Sugar Beets	100 000	140	89	2
Wheat	*	270	152	4
Sunflowers	150 000	62	56	1
Corn	80 000	76	90	3
Soybeans	*	140	473	5

* information not available

Source: Astarta-Kyiv, 2018

When ranking crops on seed prices, sunflowers come out cheapest, followed by sugar beets and corn. However, given the much higher per hectare yield of sugar beets, cultivating sunflowers for bioethanol production does not seem to be a very attractive option.

Ethanol production in liters per hectare

Astarta reported that the sugar beets that they process have an average effective sugar content of 16%. This means that the average ethanol yields per hectare will be rather different from the European average. For the Ukrainian situation realistic ethanol yields per hectare would be closer to the figures mentioned in table 3.3. Even though significantly lower yields can be expected than in other EU countries, the yield is still high enough to offer a serious consideration for growing sugar beets and/or some other crops to process into bioethanol. The details of the calculation of the per hectare yield of ethanol can be found in annex 2.

Table 3.3: Average per hectare yield of bioethanol for the DP+Beta process

Crop	EU Average	The Netherlands	Ukraine
Sugar beet	6 000 litre	8 500 litre	4 300 litre
Corn	4 000 litre	5 800 litre	3 000 litre
Miscanthus	3 800 litre	5 510 litre	2 750 litre
Poplar	2 600 litre	3 750 litre	1 900 litre
Corn stover	1 600 – 2 400 litre	2 300 – 3 500 litre	1 150 – 1 750 litre

Source: Wageningen University & Research, Astarta-Kyiv, DSD BV

Optimal growth temperatures

Sugar beets are cultivated in large parts of Europe, which offer mild but not too hot climatic circumstances. In order to understand the potential yield for sugar beets and alternative crops, it is necessary to look at growth conditions in Ukraine for both sugar beets and alternative crops. Table 3.4 offers an overview of growth conditions of several crops and table 3.5 gives an overview of the climatic conditions of Ukraine in combination with the optimal temperature range for the different crops involved.

Table 3.4: Optimal growth temperatures for different crops

	Optimum growth temperatures		**Growth season** (days)
	Minimum	Maximum	
Sugar Beets	15	25	100
Barley	12	25	160
Sunflowers	21	26	60-100
Corn	12	19	160
Soybeans	20	30	140
Carrot	16	21	70-80

* information not available

Source: *Saxion, 2018*

Table 3.5a: Temperature data for Kiev and Odessa

Kiev	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min (°C)	-6	-6	-1	5	11	14	16	15	10	5	0	-5
Max (°C)	-1	0	6	14	21	24	26	25	19	12	5	0

Odessa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min (°C)	-3	-3	1	7	12	16	18	18	14	9	3	-1
Max (°C)	2	3	7	13	20	24	27	26	21	15	8	4

Source: *Climatestotravel.com*

Table 3.5b: Overview climate conditions in Ukraine & optimum growth conditions in Kiev and Odessa

KIEV	months											
	Jan	Feb	Mrt	Apr	Mei	Jun	Jul	Aug	Sep	Okt	Nov	Dec
Sugar Beets	Orange	Orange	Orange	Green	Green	Green	Orange	Green	Green	Orange	Orange	Orange
Barley	Orange	Orange	Orange	Green	Green	Green	Orange	Green	Green	Green	Orange	Orange
Sunflowers	Orange	Orange	Orange	Orange	Green	Green	Green	Green	Orange	Orange	Orange	Orange
Corn	Orange	Orange	Orange	Green	Orange	Orange	Orange	Orange	Green	Green	Orange	Orange
Soybeans	Orange	Orange	Orange	Orange	Green	Green	Green	Green	Orange	Orange	Orange	Orange
Carrot	Orange	Orange	Orange	Orange	Green	Orange	Orange	Orange	Green	Orange	Orange	Orange

Odessa	months											
	Jan	Feb	Mrt	Apr	Mei	Jun	Jul	Aug	Sep	Okt	Nov	Dec
Sugar Beets	Orange	Orange	Orange	Green	Green	Green	Orange	Orange	Green	Green	Orange	Orange
Barley	Orange	Orange	Orange	Green	Green	Green	Orange	Orange	Green	Green	Orange	Orange
Sunflowers	Orange	Orange	Orange	Orange	Orange	Green	Orange	Green	Green	Orange	Orange	Orange
Corn	Orange	Orange	Orange	Green	Orange	Orange	Orange	Orange	Orange	Green	Orange	Orange
Soybeans	Orange	Orange	Orange	Orange	Green	Green	Green	Green	Green	Orange	Orange	Orange
Carrot	Orange	Orange	Orange	Orange	Green	Orange	Orange	Orange	Green	Orange	Orange	Orange

Orange = not optimum temperature
Green = Optimum temperature

Tables 3.4 and 3.5 show that there are enough days in the growth season to receive optimal results, the same is true for crops like barley and sunflowers. The climate in Ukraine seems to be a bit too hot for corn to achieve optimal growth results.

Looking at the climatic conditions, average yields per hectare, seed costs and ethanol yield per hectare, sugar beets offer, from all crops analyzed in this section, the best conditions for bioethanol production. Corn is the next best fit, followed by soybeans, although the seed costs for soybeans seem to be quite high. Another thing is that Ukrainian farmers have not a lot of experience with growing soybeans, but still may be an option. Other crops seem to have a low ethanol yield per hectare and it might very well be not economically feasible to produce these crops for bioethanol production.

Influence of fluctuations in sugar beet prices

Prices of sugar beets are fluctuating throughout the years. Astarta-Kyiv reported that the last years, the average prices of sugar beets in Ukraine has been the equivalent of € 28 per tonne. In the calculation of different scenarios, this price will be used as the middle variant, whereas the low variant of the sugar beet price is set at € 24 per tonne and the high variant at € 32 per tonne. The resulting changes in ethanol production cost prices per litre as indicated by the model used, are displayed in table 3.6.

Table 3.6: Three scenarios with cost price calculation of one litre of bioethanol

	Low variant	Middle variant	High variant
Sugar beet price per tonne	€ 24	€ 28	€ 32
Cost price of bioethanol per litre	€ 0.406	€ 0.431	€ 0.457

3.3.4 Production costs

The production process of bioethanol with DP+Beta consists of a number of steps and a number of factors that have to be taken into consideration when evaluating the DP+Beta business case.

First of all, sugar beets have to be washed thoroughly, as the process requires a maximum of 2.5% of tare on the beets. Then, the sugar beets have to be mechanically crushed, so that a thick beet bray is formed. This bray is heated in a heat exchanger, from an input temperature of 20 degrees to 65 degrees. Then the bray is pushed to the vacuum lock, where the temperature is about 37 degrees in nearly vacuum conditions and the cells are exploding. The bray coming out of the vacuum lock has a temperature of 35 to 40 degrees and is pumped into the fermenter, in order to convert the available sugars into bioethanol. In order to let this fermentation process run in a stable way, several chemicals are needed. The cost and amount of these chemicals can be found in the DP+Beta cost price calculation model in Annex 1. Since the chemicals used come from the same suppliers in both The Netherlands and Ukraine, similar quantities and costs can be assumed. Therefore in the model similar numbers are used for Ukraine as are used in The Netherlands.

Besides process stabilizing chemicals, energy is also needed to produce bioethanol, as the ideal temperature for the vacuum shock and subsequent fermentation is around 28 – 34 degrees centigrade, and this fermentation process takes 30 hours. After that the bray is pumped into a storage tank for later distillation. The necessary energy for the entire process is provided by either an own biogas plant, or via burning wood chips or methane/natural gas from the public net. In the model presented in this document, methane from the public net is used for calculations, as this is easily available for sugar factories in Ukraine with no need for investments in infrastructure. The amount of natural gas needed for the production of 1000 litres of ethanol is around 175 cubic meters. Natural gas reference price in Ukraine is 8186.50 UAH/1000 cubic meter[58], which comes with the current exchange rate UAH to Euro (April 2018) to a price 0.275 Euro per cubic meter of natural gas. It is important to note that because of the lower required temperature and low pressure, there is a significantly lower energy need for the DP+Beta process as compared to traditional ways to obtain bioethanol as there is a lower temperature, pressure and fermentation time as compared to a conventional production process. A comparison of the energy usage of the DP+Beta process and conventional production can be found in table 3.7. Some of the conventional bioethanol production processes have a higher conversion rate from sugar beet to ethanol, but in all cases the energy usage as well as CO2 output is significantly higher. An overview of some conventional production methods compared to DP+Beta can be found in table 3.8.

[58] http://utg.ua/en/utg/business-info/tariffs.html

Table 3.7: Example energy usage of conventional and DP+Beta bioethanol production (based on 2000 tonnes of sugar beets as raw material)

	Conventional	DP+Beta
Steam (GJ)	574 743	293 525
Electricity (kWh)	3 369 746	3 755 654
Electricity (GJ)	12 131	13 520
Total energy (GJ)	586 874	307 045
Energy per m3 ethanol (GJ/m3)	11	5.8

Source: KH Engineering

Table 3.8: Comparison of energy usage and beet to ethanol conversion of different types of conventional bioethanol production systems (numbers are based on EU averages)

	Unit	KH conv	DP+Beta	ACRRES conv	USA conv
Beet capacity	KT/y	600	600	600	600
EtOH/Beet	Kg/kg	0.073	0.075	0.073	0.081
PJ/EtOH	PJ/y	1.11	0.53	0.89	1.69
CO2/EtOH	Kg/Kg	2.9	2.2	2.4	3.1
CAPEX/EtOH	m€/Kt	1.84	1.00	1.16	0.91

Source: Reports KH Engineering & Wageningen University & Research

Electricity is the second major energy source which is needed for the production of bioethanol, in order to run the machinery. Experiments have pointed out that the amount of electricity needed to produce 1000 litres of ethanol is around 269 KWh[59]. The price for electricity at the Ukrainian wholesale market is 1353 UAH per MWh in 2017[60]. This translates in a per KWh price of around 0.05 Eurocents, when calculated with the current exchange rate of UAH to Euro (April 2018).

Some other, relatively minor production costs are taken into account in the model as well. These consist of the following:

- Boiler water treatment, a yearly fixed cost of almost € 90 000 for both The Netherlands as well as Ukraine
- Potable water, which is also assumed to have similar costs in both The Netherlands and Ukraine and is calculated at € 53 757 yearly
- Cooling tower treatment, again assumed similar costs in The Netherlands and Ukraine and expected to be around € 86 000 yearly.

3.3.5 Labour & staff costs

Producing bio-ethanol implies not just costs of raw materials and production costs of the process itself, but also labour costs. To calculate labour costs for production, two aspects have to be taken into consideration. The first is how many employees are needed and the second one is the costs per employee. The number of employees needed for a production unit of 3000 tonnes daily can be estimated by the amount of people needed for current operations, as DP+Beta will require a more or less similar amount of labour input as a traditional sugar production unit. When using current employment figures, it turns out that a workforce of 50 full time equivalents is needed. The total average labour costs for both production staff and supporting office staff together are calculated by

[59] Study by ACCRES (Wageningen University & Research)
[60] https://en.interfax.com.ua/news/economic/482473.html

Astarta-Kyiv to be UAH 19 per tonne of processed sugar beets. Calculations of total labour costs can be found in table 3.9, which leads to an annual gross labour cost of € 9 500 per production worker.

Table 3.9: Labour costs for a sugar factory (based on figures from Astarta-Kyiv)

Type of labour	Currency
Labour costs per tonne of sugar beets produced	UAH 19
Daily labour costs based on a daily production capacity 3000 tonnes of sugar beets	UAH 57 000
Yearly labour costs based on a daily production capacity of 3000 tonnes of sugar beets	UAH 20 805 000 (€ 595 000)
- Of which 20% overhead / office costs	€ 120 000
- Of which production labour costs	€ 475 000

Source: Astarta-Kyiv

3.3.6 Other costs

In the business model, several other costs are calculated, which are necessary to let the production process run smoothly. For laboratory costs, a similar yearly sum of money is reserved for both The Netherlands and Ukraine, namely € 56 000 for costs of laboratory equipment. Since the technology and machines used in both the Netherlands and Ukraine are similar and from the same suppliers, it is very likely that the cost price in both countries will be identical. Maintenance costs are also calculated at the same amount as in The Netherlands, namely € 180 000, since the machinery and other equipment comes from the same suppliers and will have more or less the same cost and maintenance price. Actual maintenance costs in Ukraine may be a little bit lower, given the lower wages, but costs for importing machinery and equipment may actually be a bit higher than in the Netherlands, so that this would compensate for the lower wage costs. General expenses, the third parameter in this part of the model has also been kept at a similar level between the Netherlands and Ukraine. Actual general expenses may very well be lower in Ukraine, than the figures used in the model, which may in practice lead to a small financial buffer.

3.4 (By) product streams

3.4.1 Types of product streams

Next to bioethanol, other products could be gained from directly processing sugar beets DP+Beta. With a slightly different production process alternative products for bioethanol can be obtained from the direct processing of sugar beets. Table 3.10 shows the different alternative end-products of the DP+Beta process. It is also relevant to mention here figure 3.4, that shows the so-called value pyramid, with options for further processing of sugar beets, into products with a higher added value. The potential extra income of these high value products has not been taken into consideration in the model that is used in this study, but certainly offers nice additional business cases in the future, in order to further increase return on investment of DP+Beta.

Sugar beet is an important crop for the Biobased Economy, it can act as intermediate, it is a significant ingredient in food, feed, pharma and cosmetics. With sugar beet the sugars are much easier and quicker available compared with starch crops were enzymes are needed to free the sugars. That means one step less in the process, resulting in a cheaper cost price. Sugar beet or the product derived from this can be used in:

a. Bulk chemicals → commodity chemicals, low added value;
b. Fine chemicals → small quantities, relatively high prices and "what it is" specification:
    i. building blocks;
    ii. advanced intermediates;

iii. active ingredients;

c. Specialty chemicals → specialties, effect chemicals, high value added to functional value, agrichemicals, essential oils, food supplements, ingredients for cosmetics and pharmacy.

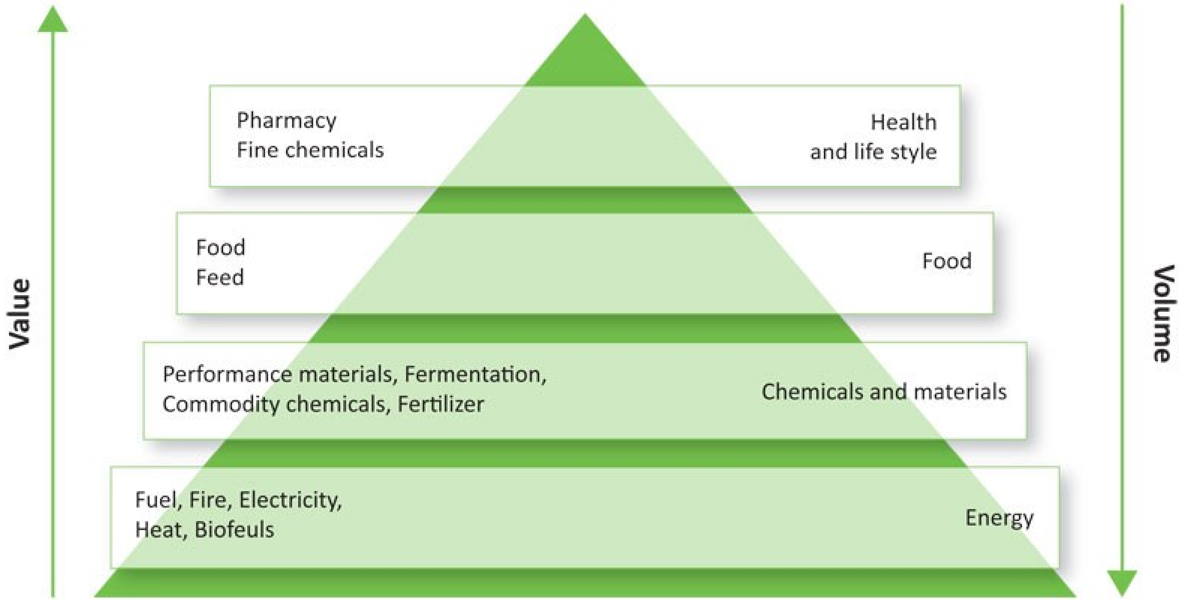
Sugar beet as crop for greening the chemistry and cultivation of this crop leads to a sustainable model. Also the LCA as well as GHG emissions (2018: conclusion UWM, partner Eranet Chembeet project) are reduced, which is a perfect fit for the future. Several institutions, like NOVA Institute, WUR, FAO have shown in their publications sugar beets as sustainable cultivations.

Table 3.10: Products that can be obtained using the DP+Beta technique.

Product	Kg product per kg sugar beet	Revenue / Cost ratio
n-Butanol	0.05	2.73
Succinic Acid	0.13	11.4
Lactic Acid	0.15	6.32
Bioethanol	0.10	1.60 (fuel) / 2.56 (food)

Source: DSD

Figure 3.4: Value pyramid for sugar beet applications



3.4.2 Rest streams of the DP+Beta process

There are a couple of by product streams when using the DP+Beta technique. These are different from conventional white sugar production. In traditional white sugar production, typical by products are so-called molasses. With DP+Beta, the by product is a watery bray with no sugar content. This bray can be used for different purposes. It is possible to sell the bray as animal fodder, but with some additional production steps it is also possible to extract the by products as mentioned in table 3.11.

Table 3.11: Rest streams from the DP+Beta technique

Product	Kg product per kg sugar beet	Price per kg in the EU (€)
Rest stream bray: solids	0.07	0.10 (when used as animal fodder)
- of which Cellulose	0.014	0.70
- of which Hemicellulose	0.014	1.00
- of which Pectins	0.032	1.50
- other solid products	0.01	-

Source: DSD

In the model in Annex 1, none of the potential revenues of the by-products is put into the calculations of the model, as it requires additional investments in the production process or another production partner using this bray as raw material. It falls beyond the scope of this study to calculate the investments, production costs and revenues of these rest streams.

In principle, the processing of sugar beets will result in three kinds of rest streams; gaseous, liquid and solid ones. The solid by products of DP+Beta can be used for animal fodder or be further processed to extract pectines, hemicellulose and cellulose (Table 3.11). Each tonne of sugar beets processed with DP+Beta produces 95 kilograms of CO_2. This CO_2 gas can be captured and sold to greenhouse farmers as a nutrient for faster plant growth. This requires small additional investments in the production process and is therefore left out of the business case in this study, but it is good to note that it optionally could yield additional revenues. If chosen, then a location close to greenhouses for simple distribution of CO_2 is highly advisable.

The liquid rest streams consists of the water used for cleaning the sugar beets, which needs to be filtered several times before it can be used again for cleaning other sugar beets or discharged into the environment. In total, 952 litres of water is leftover after processing one tonne of sugar beets. The resulting mud from the cleaning process is sent back to farm fields as fertilizer. In the model, the cost of selling off the mud is set at €0.05 per kilogram. Eventual yields of selling of the muds have not been taken into account, but these are expected to be low. After thorough cleaning, the sugar beets can be processed by DP+Beta.

To summarize the rest stream flows and potential usage of these rest streams, the mass balance is displayed in table 3.12, although it needs to be noted that these figures are for the EU as average and figures for Ukraine could be slightly different, as the sugar content of sugar beets can be different, although no large differences are to be expected.

Table 3.12: Mass balance of the DP+Beta process, based on 1000 kg sugar beets

Raw materials		**Production process**		**Output**	
Sugar beets	1000.0 kg	Sugar beets	1000.0 kg	Ethanol	100.0 kg
- of which sugar	175.0 kg	Tare (mud)	25.0 kg	**Rest streams**	
- of which others	70.0 kg	Process water	174.3 kg	CO_2	95.0 kg
- of which water	755.0 kg	Yeast & stabilizers (for the fermentation process)	18.0 kg	Water (dirty)	952.2 kg
				Restproducts	70.0 kg
				- of which Cellulose	14.0 kg
				- of which Hemicellulose	14.0 kg
				- of which Pectines	32.0 kg
				- of which Other products	10.0 kg

Source: DSD

3.4.3 Costs of producing Animal fodder and biogas

One of the by-products that can be made from beet bray after distillation or beet pulp (a rest stream of the classical sugar process) is biogas. When looking at the conditions in Ukraine, the company Astarta has a specific plant to proceed the beet pulp into biogas at Globyno sugar factory, which means there will be no need to buy some new technology and machines to produce biogas. The ratio between beet pulp and biogas produced is variable and based on the input. The input for biogas is not just granulated beet pulp, but can also be sugar beet leafs. In the case of Astarta, the capacity of the existing installation to process biogas is 400 tons per day. In total, the technology could produce 76 353 m3 of biogas per day. Despite of the huge potential for biogas-to-energy production in Ukraine, the market is not yet developed. All biogas that Astarta produces is used for generating electricity on-site. This helps to reduce costs for electricity to keep the plant running non-stop. The absence of a market for biogas in Ukraine could potentially be problematic business wise (in terms of making a thorough business case); and it is not expected that this situation will change in the near future, as there are only a small number of bioenergy plants in the country. Currently there are about 10 larger electricity producing biogas plants in Ukraine, with a total installed capacity of 35 MW, based on data from end of 2016. The State Agency on Energy Efficiency and Energy Saving of Ukraine assumes that the potential amount of biogas from the agricultural sector alone could cover 5,7% of the energy consumption in Ukraine. This figure is excluding biogas production related to landfills, sewage water treatment and the food industry[61].

As indicated in one of the previous paragraphs, after the production of bioethanol with DP+Beta, a watery bray is left, which besides as input for biogas can also be used as animal fodder. The farming and livestock market in Ukraine is big and growing over the last decades and consists of various animals ranging from rabbits, sheep, pigs and cows, to horses. A steadily growing demand for animal fodder can be expected. As reported by Astarta-Kyiv, each ton of sugar beets processed with conventional white sugar production techniques can – on average – result in the following amounts of animal fodder:

1. Processing stem and beet leaves can produce in 0,082 tons of animal fodder,
2. Processing molasses can produce 0,016 tons of animal fodder,
3. Processing pulp can produce 0,064 tons of animal fodder.

Using the DP+Beta process, input for fodder is just the stem and beet leaves, as well as the beet bray, which brings a slightly lower amount of fodder than the pulp mentioned under number 3, since with DP+Beta almost no sugar content is left over.

Currently Astarta company is already producing biogas and animal fodder from the side streams of this conventional white sugar production process. Table 3.13 shows the production figures for the Astarta sugar plant in 2016. Yearly Astarta could produce 116 150 tonnes of wet pulp that needs to be processed again in order to become biogas and animal fodder. In the following section are calculations for the current rest streams of the Astarta white sugar production process. It is important to realize that with DP+Beta, the amount of animal fodder and/or biogas will be lower, since there are less rest product stream volumes from the main ethanol production process. There are however other potential applications with a much higher added value (See table 3.11).

Table 3.13: Sugar Beets -> By-Products (pulp) in Astarta Globyno Sugar plant

	Tons of sugar beets processed (ton)	**Ratio** (Sugar Beets: By-Product)	**Total pulp produced**
Daily	4208.33	1 : 0.23	967.92
Yearly	505 000	1 : 0.23	116 150

Note(s): The process runs 120 days per year

Source: Astarta

In order for Astarta to further process the wet beet pulp into biogas and animal fodder, several steps have to be taken, for which also costs are involved. The first side-product, taken into consideration is

[61] See for more information: http://saee.gov.ua

beet pulp, dried processed pulp from sugar beets that contains only a small percentage of sugar and is intended to be sold as livestock fodder. In table 3.14 the maximum daily and yearly production of animal fodder based on the production numbers of the Astarta Globyno sugar plant are taken into consideration. This table shows how much animal fodder can be produced per day and per year in tons. Astarta reported a ratio of 1:0.04 for every tonne of sugar beets processed. This would result in 40 kg of granulated pulp that equals with 25 kg of dry matter (see Annex 2 about the composition of sugar beets). It means that Astarta could produce 168.3 tons of animal fodder per day. In table 3.14, the cost price for producing this amount of animal fodder is calculated. At the Astarta Globyno sugar plant, production costs of animal fodder per tonne are calculated at UAH 1905, and for biogas at UAH 59 600 per day, with a maximum production capacity of 774 333 m3 of biogas per day.

Table 3.14: Production of animal fodder in the Astarta Globyno sugar plant

	Tons of sugar beets processed (tonnes)	**Ratio** (One ton of sugar beets : Animal fodder)	**Total Animal Fodder Produced** (tonnes)
Daily	4 208.33	1: 0.04	168.33
Yearly	505 000	1: 0.04	20 200

Source: Astarta

The biogas itself is made from processing sugar beets, pressed pulp, and beet leaves. The amount and quality of biogas produced depends on what is the input to this process. Generally speaking, according to data from Astarta, one tonne of sugar beets yields between 70 and 130m3 of biogas. One ton pressed pulp, one of the by-products of the sugar production process yields between 30 and 60m3 of biogas and from one ton of beet-leaves, 200-300m3 biogas could be produced.

Table 3.15: Production of biogas from side-product streams in the Globyno sugar plant

	Total side-products produced (tonnes)	**Ratio** (By-product: Bio-gas)	**Total Bio-gas Produced** (m3)
Daily	967	800	774 333
Yearly	116 150	800	92 920 000

Source: Astarta-Kyiv

Table 3.16a and b provides a short overview of the current production costs and figures in a short overview. Table 3.16a is about the production costs and capacity of animal fodder, whereas table 3.16b is about the production of biogas.

Table 3.16a: Production costs and capacity of animal fodder at the Astarta Globyno sugar plant

	Total Animal Feed Produced (tonnes)	**Cost for processing animal feed** (per ton)	**Total Cost for processing animal feed**
Daily	168.33	UAH 1 905	UAH 320 675
Yearly	20 200	UAH 1 905	UAH 38 481 000

Table 3.16b: Production costs and capacity of biogas at the Astarta Globyno sugar plant

	Total Bio-gas Produced	Cost for processing Bio-gas	Total Cost for processing Bio-gas
Daily	774 333	UAH 59 600	UAH 59 600
Yearly	92 920 000	UAH 59 600	UAH 7 152 000

Source: Astarta-Kyiv

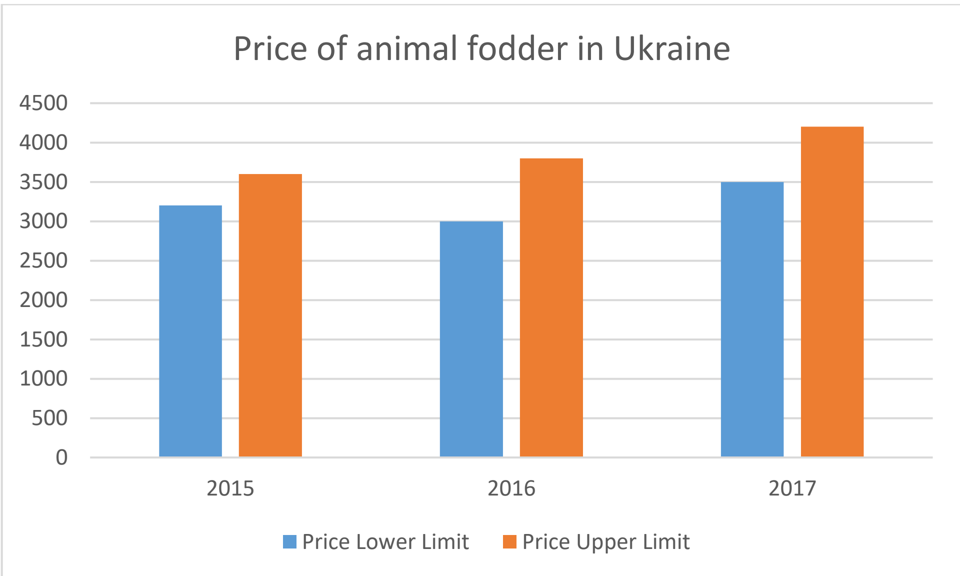
The cost calculations presented in the tables 3.16a and 3.16b are without using DP+Beta. According to the data provided by Astarta in table 3.13, the Globyno sugar plant produces almost 1000 tonnes of pulp daily.

3.4.4 Revenue of animal fodder and biogas

When looking at potential revenue and profit of both biogas and animal fodder, it is important to look at the longer term market trends. The market for biogas proves problematic in this case: in Ukraine it is still very small or even almost non-existent (See also chapter 2). Astarta therefore uses the biogas from its Globyno plant for generating electicity on-site, to run the plant. From each m3 of biogas, 2.87 kWh of electricity could be obtained. Therefore, the total amount of potential electricity generation is 266 680 400 kWh per year and when the Betaprocess technology for biogas production is used, it will raise the produced amount by approximately 10%. Table 3.15 shows of how much (in m3) biogas could be produced daily and yearly from the side-product streams of sugar beets. Since there is no established market price, it is not possible to calculate the monitary value of the biogas.

The prices for animal fodder have a rising trend, from the data in figure 3.5 can be seen that in 2017, the price for animal fodder varied from 3500-4200 UAH per ton. For the calculation, to be on the safe side, the lower limit of the price (in 2016) will be used which is UAH 3000.

Figure 3.5: Development of animal fodder prices in Ukraine, 2015 - 2017



Source: Astarta-Kyiv

Table 3.17 shows the calculation details with the sales price of animal fodder and the potential total revenue for animal fodder of Astarta. The cost price of producing animal fodder have been reported by Astarta to be 1905 UAH per tonne. Therefore, in table 3.18 the total potential profit for producing animal fodder can be found. The profit that can be obtained from selling animal fodder with price of at least UAH 3000 is UAH 22 119 000 per year. It should be noted that the number shown is not the total profit: Only the variable costs per tonne have been calculated. Fixed costs are left out from the calculation as there was not enough information provided to take this into the calculation.

Table 3.17: Total revenue of Astarta's animal fodder production in the Globyno sugar plant

	Total amount of animal fodder Produced	**Price of animal fodder** (per tonne)	**Total revenue from animal fodder**
Daily	168.33	UAH 3 000	UAH 504 990
Yearly	20 200	UAH 3 000	UAH 60 600 000

Source: Astarta-Kyiv

Table 3.18: Profits of Astarta's animal fodder production in the Globyno sugar plant

	Variable costs for processing Animal Fodder	**Total Money Earned from Animal Fodder**	**Profit Gained from Animal Fodder**
Daily	UAH 320 675	UAH 504 990	UAH 184 315
Yearly	UAH 38 481 000	UAH 60 600 000	UAH 22 119 000

Source: Astarta-Kyiv

3.5 Alternative options for beet / molasse processing in existing factories

In section 3.2 is mentioned already that there is a strong debate in society related to the use of white sugar as food additive, in relation to increasing levels of obesity and other health issues. Therefore, it can be expected that the market for white sugar in both Europe and the USA will be under pressure in the future. Already the last decade, a falling trend in the trading prices of white sugar can be observed (see figure 3.6), and the prognosis is that, due to both falling demand from consumers and the worldwide overproduction of white sugar, this falling trend will continue. These falling prices may very well be a good motivation to think about different uses for the sugar beet, of which bio ethanol could be one, since prognoses show an increasing trend in demand and price in the future (see section 3.6 for more details). Given the positive effects of the sugar beet in crop rotation schemes for the other crops in the years afterwards, and the other potential products coming from the sugar beet, abandoning the sugar beet as a crop may not be the best option for the long term.

Figure 3.6: Sugar world market prices in US dollar cents per lb.

Source: Tradingeconomics.com

One of the options for dealing with the already changed and changing market circumstances in the future is the development of a more hybrid production system, which offers the possibility to easily switch between producing white sugar and bio ethanol. Figure 3.7 shows how such production scheme may look like.

Figure 3.7 shows two variants, that may be feasible to adopt separately or together. The first version is to create a flexible bypass to divert some or all the sugar beets – as considered necessary – into a production line for bioethanol (similar to what cane sugar factories in Brazil do). The second variant is the option to process the molasses as rest stream of white sugar production into bio ethanol.

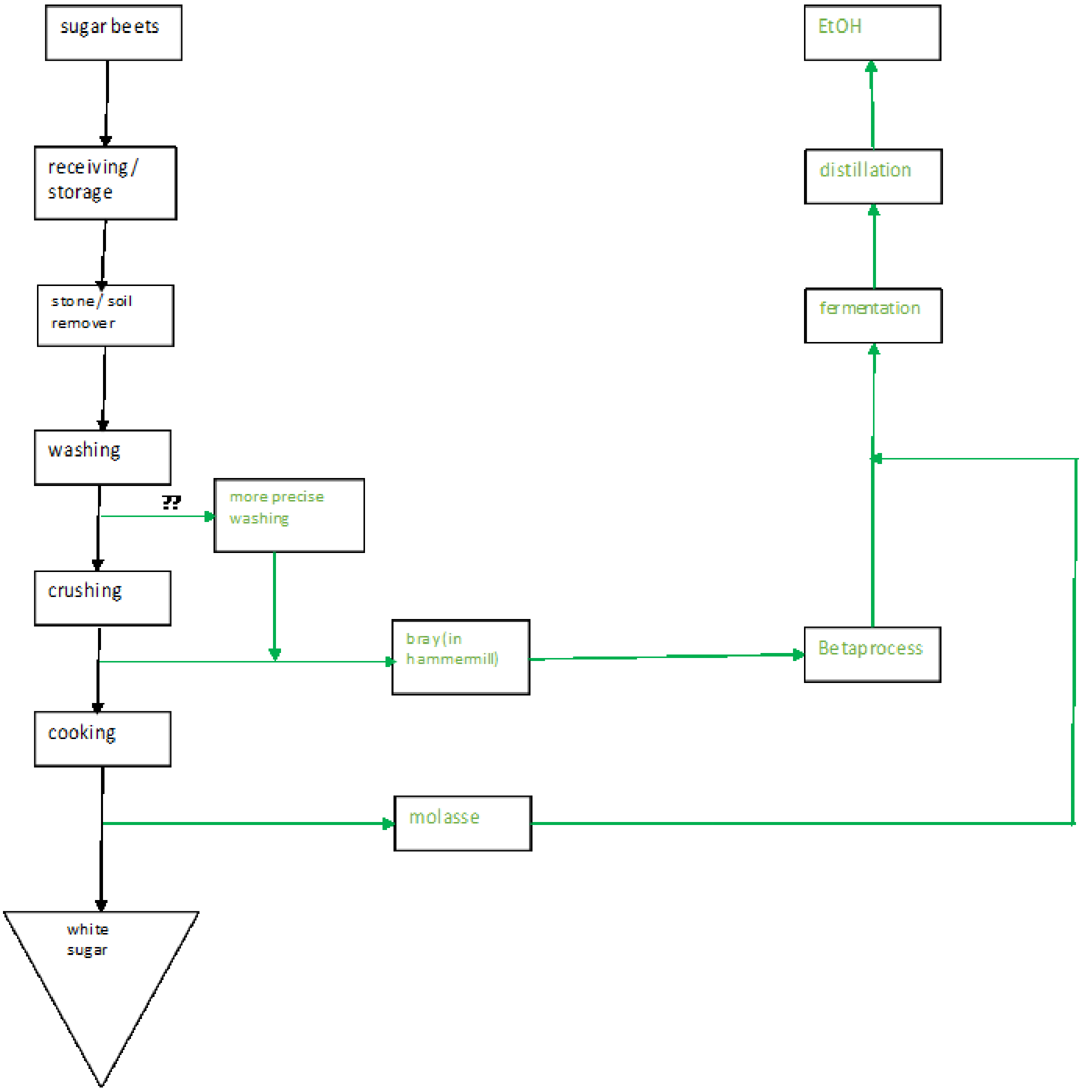
The first variant of making a hybrid production line, by adding a second production line next to the already existing line, in which the additional one can be used to produce bio ethanol. Some steps are necessary to add to the current production line, but since a number of process steps can be shared with traditional white sugar production, the investment costs for such a second production line may very well be smaller in total as for a building a new factory. What needs to be added in the production line is a more precise washing system, as the DP+Beta system tolerates less mud or other tare on the sugar beets (a maximum of 2.5%). Just as with the ordinary white sugar production, sugar beets have to be crushed. Another addition to the production line is the Betaprocess unit, which administers the vacuum shock in order to destroy the cell walls and free the fibres and other cell content, in order to facilitate and accelerate the fermentation process. The next addition is the fermenter, in which the fermentation takes place and finally the distillation unit, to extract the ethanol from the bray.

The second variant is the variant in which the molasse rest streams (stored during the campaign and processed afterwards) from the white sugar production process are used to produce ethanol. The molasses should be led to a fermenter which has to be added to the production process, to let the available sugars in the molasse ferment into ethanol. After this, a distillation unit, which also needs to be added to the production process, is used to extract the ethanol.

For the first variant, in terms of operational costs, more or less the same financial model can be used as discussed in the previous parts of this chapter (See also Annex 1). The second variant, that of using the molasses will need some further study, as it falls largely outside of the scope of this study.

A few things can be said about this variant however. It is known from literature that the ethanol yield from molasses is between 27% and 32%. This requires however molasses which are thickened. Further research is necessary to establish more details, in order to calculate the business case for molasse processing, but given the known parameters it may very well be an economically interesting technology as well.

Figure 3.7: Model for implementing DP+Beta within existing sugar factories



Source: DSD

3.6 Development of the bio-ethanol price

The profitability of the bioethanol in the Ukraine does not only depend on the lower cost price of the DP+Beta process itself, but also on the biofuel market in the Ukraine. If bioethanol prices in Ukraine are too low, then DP+Beta will become unprofitable, since the majority of the bioethanol produced will – at least in the current market circumstances – be used as fuel, to be mixed with ordinary fossil fuels. The market demand for biofuels is expected to increase, as the Ukrainian government is bound to adopt the so-called Renewable Energy Directive (RED). This RED will consist of the requirement to blend bioethanol with regular fuels and foresees in using 7% bioethanol per litre of fuel. Figure 3.19 shows the development of (fossil) fuel energy usage in Ukraine. Even though over the last 25 years a yearly energy usage reduction of 2.5% per year has occurred, a significant domestic Ukrainian market still exists for blending with biofuels. In any case, it is useful for any investment in bioethanol production capacity to look at a forecast of bioethanol prices. Figure 3.20 shows a forecast of bioethanol prices developed by the OECD. A worldwide-expected rise in prices of bioethanol can be observed.

Table 3.19: Development of the fuel market in Ukraine

Year	**Total energy use** (mln metric tonnes of oil equivalent)	**Fossil fuels** (% of total fuel consumption)	**Total fossil fuels usage** (mln metric tonnes of oil equivalents)	**Average yearly energy use growth** (%)
1990	252.0	91.8	231 336	-2.5%
2014	105.7	75.3	179 592	

Source: World Bank

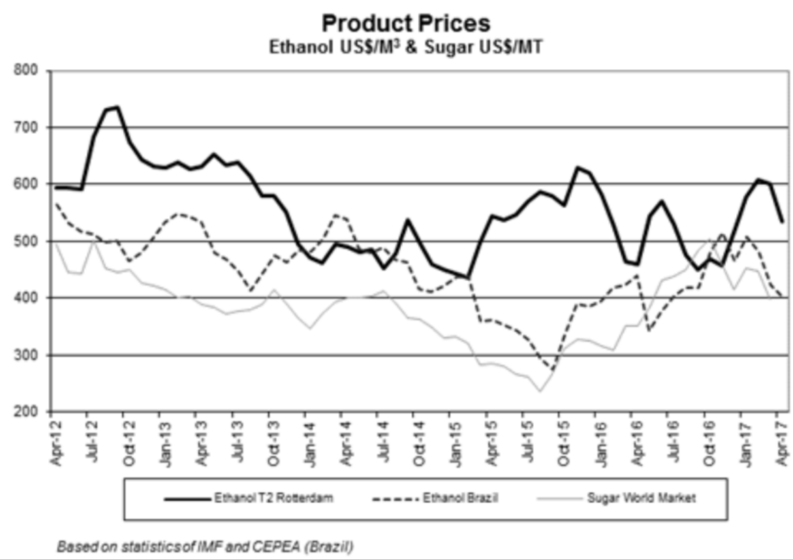
Table 3.20: Forecast of the world market bioethanol price per hectolitre in US Dollar.

Product	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Bioethanol	51.0	44.5	46.0	47.3	48.4	49.7	50.9	51.9	53.2	54.5
Biodiesel	86.9	86.1	88.0	89.4	90.4	90.9	91.3	92.1	92.7	93.2

Source: OECD, FAO Agricultural outlook (https://www.oecd-ilibrary.org/docserver/agr_outlook-2017-en.pdf)

In Ukraine there is currently almost no bioethanol production, due to excise taxes, which make any bioethanol production for the local market unprofitable (see chapter 2 for more details on this issue). There may happen some amendments to this law in the near future, but in principle this does constitute a risk when producing for the local market. There is currently a monopoly of the company Ukrspirit in the ethanol market. Therefore, in order to produce ethanol for other companies than Ukrspirit, it is advisable to produce directly for export and organize the required blending of bioethanol with other fuels outside of the country. Therefore it is useful to look at the development of the EU prices for bioethanol over the last couple of years (Figure 3.8). The average EU price of bioethanol over the last five years has approximately been € 0.50 per liter on average. Therefore, in the business case this figure is taken as the average calculated bioethanol price for now.

Figure 3.8: EU Bioethanol prices per 1000 liters in US Dollars



Source:https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_6-19-2017.pdf

3.7 Conclusion

Based on the results of this study it can be concluded that there are other economically viable options for sugar beets besides the traditional use of beets for producing white sugar. This is all the more important because of the falling trend of white sugar prices, among others because of the expected long term decrease in demand for white sugar (among others because of the obesity discussion in society).

The sugar beet plays an important role in the crop rotation schedule, improving the general soil quality, biodiversity and yields of crops in the following years after growing sugar beets. Even though this will not directly lead to new business models, as there needs to be support from all players in the value chain and maybe most important a well-structured governmental legislation, support and promotion program, it is certainly interesting to look for different uses of sugar beets beside white sugar production. Direct Processing with the Betaprocess (DP+Beta) for example, makes sugar molucules directly available from the sugar beet. This is one production step less than with starch crops such as cereals or corn.

In this study, the focus was on using sugar beets for producing bioethanol with DP+Beta, however this is just one of the possible options. A business model was formulated in order to assess the feasibility of DP+Beta. When looking at all parameters of the model (see annex 1), the conclusion can be drawn that in Ukraine, DP+Beta is in principle economically feasible. Taking all production costs into account, the cost price of one litre bioethanol is on average € 0.431, when using the middle variant of the sugar beet prices per tonne (see table 3.6), well below the average selling price of € 0.50 per litre of bioethanol. Even when the project is financed with external capital and interest payments are taken into consideration in the model, the average production costs per litre of bioethanol is still below the average selling price of a litre of bioethanol. Given the limited ability of sugar beets throughout the year, alternative products have to be used during the rest of the year. Calculations show that corn kernels is the most suitable alternative crop. For the business model, this means that during the time of the year that sugar beets can be used, the average production costs are a bit lower and when corn kernels have to be used, a bit higher, but still within the limits of building a profitable business case.

Risks for bioethanol production in Ukraine are especially apparent in the field of government policy. The excise tax on biofuels has brought bioethanol production in Ukraine to a standstill, although there seems to be at least some movement to support the production and mixing of biofuels within the Ukrainian RED, it remains uncertain when this will be implemented. The business environment is therefore challenging, but with a lot of potential at the same time.

References

Balmann, A., Curtiss, J., Gagalyuk, T., Lapa, V., Bondarenko, A., Kataria, K., & Schaft, F. (2013). *Productivity and Efficiency of Ukrainian Agricultural Enterprises*. Retrieved from Kiev: https://apd-ukraine.de/images/APD_APR_06-2013_Efficiency_eng.pdf

Bonenberger, A. (2017). Not for sale: Private farmland in Post-Soviet Ukraine. *The Wrath-bearing Tree*.

CIBE-CEFS. (2010). *The EU Beet and Sugar sector: a model of environmental sustainability* Retrieved from http://cibebeta.cibe-europe.eu/img/user/file/Brochure%20CIBE-CEFS%20Final_05_05_2010.pdf

Deloitte. (2014). *Opportunities for the fermentation-based chemical industry. An analysis of the market potential and competitiveness of North-West Europe* Retrieved from https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/manufacturing/deloitte-nl-manufacturing-opportunities-for-the-fermentation-based-chemical-industry-2014.pdf

Frye, T. (2002). The Perils of Polarization: Economic Performance in the Postcommunist World. *World Politics, 54*(3), 308-337.

Klenk, I., Landquist, B., & Ruiz de Imaña, O. (2012). The product carbon footprint of EU beet sugar. *Sugar Industry Journal, 62*(137).

Nivievskyi, O., Stepanuik, O., Movchan, V., Ryzhenkov, M., & Ogarenko, Y. (2015). *Country Report: Ukraine*. Retrieved from Kiev: http://www.agricistrade.eu/wp-content/uploads/2015/06/Agricistrade_Ukraine.pdf

Segura, E., & Ustenko, O. (2016). *Assessment of the Consequences of Lifting the Land Moratorium in Ukraine*. Retrieved from Kiev:

Smallbone, D., & Welter, F. (2001). The role of government in SME development in transition economies. *International Small Business Journal, 19*(4), 63-77.

Smallbone, D., Welter, F., Voytovich, A., & Egorov, I. (2010). Government and entrepreneurship in transition economies: the case of small firms in business services in Ukraine. *Service Industries Journal, 30*(5), 655-670. doi:10.1080/02642060802253876

USAID. (2016). *Annual Business Climate Assessment*. Retrieved from Washington: http://www.lev.org.ua/en/abca.html

World Bank Group. (2018). *Doing business 2018: Reforming to Create Jobs. Comparing business regulation for domestic firms in 190 economies*. Retrieved from Washington: http://espanol.doingbusiness.org/~/media/WBG/DoingBusiness/Documents/Annual-Reports/English/DB2018-Full-Report.pdf

Chapter 4

Soil effects due to crop residue removal and possible measures to reduce impacts

On the effects on soil carbon for scenarios of crop residue management

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4.1 Introduction

4.1.1 Background

In Ukraine crop residues are more and more being used as biomass for heat production to decrease the use of imported natural gas. This is leading to concerns about the effect of removing crop residues on soil quality. The famous Chernozem soils of Ukraine have been formed over thousands of years under a grassland vegetation with relatively low rainfall. Since the fall of the Soviet Union the use of fertilizers, both chemical and manure, has decreased, contributing to a lowering of soil carbon and nutrient contents of the soil and therefore the productivity of the soil.

At the same time Ukraine has suffered severely from increasing natural gas prices which cost billions of Euros in foreign exchange. This has led to the conversion of natural gas fired boilers for local heating, into biomass boilers. The feedstock consists of locally sourced biomass such as processing residues (for example sunflower husks). Increasingly also field residues are being collected and used, as illustrated by the pictures of a straw burning facility in central Ukraine.

The cost for these bails was quoted to be below €20 per ton delivered to the local bale storage. This cost seems quite low considering that the value of nutrients in the straw would be expected to be between €5 and €10 per ton of straw and the cost of collection, baling and local transport should be close to €15 per ton of straw. The farmer apparently did not appreciate the value of the nutrients to the soil, and also did not value the organic matter of the straw to the soil. The fact that farmers are not happy to leave straw on the field was illustrated by the pictures taken on the same day near the straw boiler location, showing straw being burned in the field. A practice which is not allowed but does happen frequently in Ukraine and in many countries in the world.

Figure 4.1: Biomass in Ukraine

The apparent lack of interest in using straw to maintain soil organic matter can be explained however. Straw in the field is a nuisance during ploughing and seeding of a following crop and may increase disease pressure. In addition straw can immobilize nutrients when ploughed under, which can potentially lower the yield of the following crop. The benefit of maintaining soil organic matter and soil nutrients is mainly relevant in the long term, and of little value to a farmer leasing land for short periods of a few years. Removal of straw would be less of a problem if fertilisation rates would be adequate and yields would be much higher than they are now and if manure or other organic fertilizer would be applied. Actually, the yield gaps for wheat and corn are close to 60% in Ukraine, meaning that current yield are 40% of potential rainfed yields. Applying optimal agronomic practices could double the yield for these crops (www.yieldgap.org) and thereby increase the amount of harvestable straw. Many explanations can be provided why farmers in Ukraine do not apply optimal agronomic practises. Ukraine produces crops for the world market where prices are low and can fluctuate unpredictably. Also, droughts can occur (as was the case in 2017), reducing the effectiveness and return on investment of fertilisation. This means that investments in fertilizers, high quality seeds, pesticides irrigation systems and precision agriculture may be uneconomical, the investment is lost.

In Ukraine, harvesting crop residues comes at a cost to soil quality but it can also reduce the cost of natural gas imports, increase energy security and save a lot of money and reduce GHG emissions. It may however be possible to use the money saved by using crop residues instead of natural gas to take measures that maintain soil quality. Would this still make using crop residues attractive?

4.1.2 Objectives

This short project aims to generate information to be presented at workshops for policymakers and financing institutions in Ukraine and Europe. In the workshops the soil quality problem is explained and measures to harvest residues while reducing soil quality problems are put forward. The purpose is to elicit an interest in setting up projects to implement research on this subject and to provide input for policy makers in Ukrainian and EU and for funding agencies and companies investing in bioenergy. This study was partially funded by the Netherlands Enterprise Agency as part of the partners for international business project Biomass Ukraine (http://www.biobased-ukraine.nl/).

4.1.3 Outline of this chapter

This study describes the results of the preliminary analyses and model runs for different scenarios of crop residue removal. In Chapter 4.2 the methodology, the model and the input data are described. The results of the model analysis are presented and discussed in Chapter 4.3.

The first results have been presented at a workshop “New opportunities for rural areas” at the Saxion Hogeschool in Enschede at 20 March 2018. Another workshop is planned for September, where results will be presented in in Kiev at a workshop on this issue.

4.2 Methodology

4.2.1 Overall approach

In this study we evaluated the effect of crop residue removal on the soil and the effect of methods to alleviate negative effects on soil quality. The focus was on wheat straw and corn stover removal for heat production. A soil model (RothC) (Coleman and Jenkinson, 1999) was used to evaluate the soil effects of the measures proposed and results will be compared to residue removal and field burning of residues.

Wageningen Research has done previous analyses based on calculations with the RothC model, a soil carbon model, linked to the environmental assessment model MITERRA-Europe, to assess potential residue removal at regional scale for the Ukraine. In this project the RothC model will be used for a more detailed analysis for one Ukrainian site at field level. The Ukrainian institute of bioenergy crops and sugar beet provided soil and crop data for this analysis. Ideally data should be from long term field experiments should be used to validate these model calculations, but such data were unfortunately not available.

Mitigation effects of residue removal was modelled with the model and Ukrainian case data. The following options have been proposed to mitigate the negative effects of crop residue removal for soil carbon/quality:

- No-till planting – no ploughing
- Harvesting straw only once every 2 or 3 years

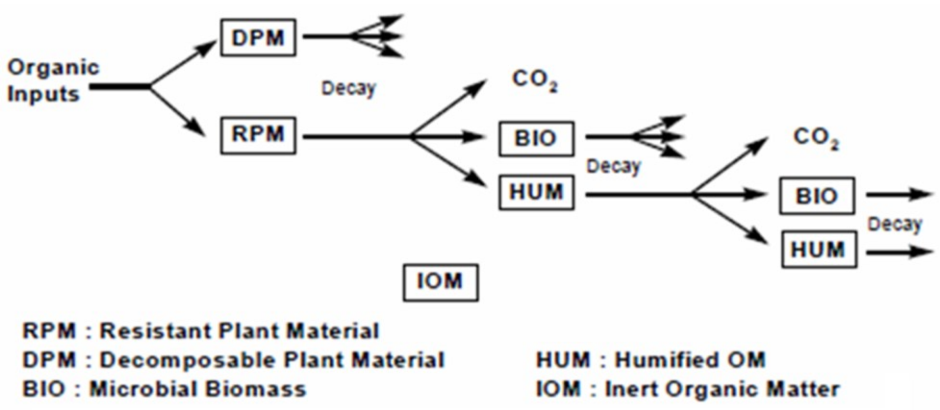
- Planting a green manure crop after harvest
- Use stems, leaves for the soil. 2/3 nutrients left in the field + 1/3 of organic matter
- Returning ash from straw burning to the field
- Requiring balanced fertilisation from farmers
- Apply other organic fertilizers: biogas digestate, manure, ..
- Better use maize straw not wheat straw

4.2.2 RothC soil carbon model

The RothC model (Coleman and Jenkinson, 1999) was used to calculate the SOC balance. RothC (version 26.3) is a model of the turnover of organic carbon in non-waterlogged soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (ton C ha^{-1}), microbial biomass carbon (ton C ha^{-1}) and Δ14C (from which the radiocarbon age of the soil can be calculated) on a year to centuries timescale (Coleman and Jenkinson, 1999).

In RothC model, SOC is split into four active compartments and a small amount of inert organic matter (IOM). The four active compartments are Decomposable Plant Material (DPM), Resistant Plant Material (RPM), Microbial Biomass (BIO) and Humified Organic Matter (HUM), see Figure 4.2. Each compartment decomposes by a first-order process with its own characteristic rate. The IOM compartment is resistant to decomposition.

Figure 4.2: Structure of the Rothamsted Carbon Model



RothC requires the following input data on a monthly basis: rainfall (mm), open pan evaporation (mm), average air temperature (°C), clay content of the soil (as a percentage), input of plant residues (ton C ha^{-1}), input of manure (ton C ha^{-1}), estimate of the decomposability of the incoming plant material (DPM/RPM ratio), soil cover (if the soil is bare or vegetated in a particular month) and soil depth (cm). Initial carbon content can be provided as an input or calculated according to long term equilibrium (steady state).

4.2.3 Input data

For the analysis we used soil, climate and crop data, which are representative for the Vinnytsia oblast. The Vinnytsia oblast is located in the central western part of Ukraine and is a region where mainly cereals and sugar beet are grown.

Climate data

The average annual temperature is 7.6 °C and annual rainfall about 624 mm (Table 4.1), which makes this region on average more productive compared to other drier regions of Ukraine.

Table 4.1: Average climate data for Vinnytsia oblast used for soil carbon modelling

Month	**Temperature** (°C)	**Precipitation** (mm)	**Evapotranspiration** (mm)
January	-5.3	38	11
February	-3.9	36	12
March	0.6	32	31
April	8.5	48	67
May	14.4	63	112
June	17.7	88	123
July	19.0	92	134
August	18.4	62	122
September	14.1	49	77
October	8.2	33	43
November	2.3	40	18
December	-2.2	42	11

Crop data

The two main cereal crops, wheat and grain maize, have been assessed for the modelling, the properties of these crops are stated in Table 4.2. Crop yield is based on statistical data and the carbon input for the different residue components are calculated based on different formulas. The total amount of aboveground residues is based on new formulas from JRC (Camia et al., 2018), see also Figure 4.3. The ratio between straw and stubble is based on Panoutsou and Labalette (2007), who proposed a straw:stubble ratio of about 55%, however, if a farmer aims to harvest most of the straw a higher ratio can be obtained, therefore we used for the modelling an average straw:stubble ratio of 60%. The belowground C input is set at 25% of the total assimilated carbon, based on Taghizadeh-Toosi et al. (2014). The carbon content of residues is set of 45% of the dry matter fraction.

Figure 4.3: Relation between economic yield and crop residue yield (Camia et al., 2018)

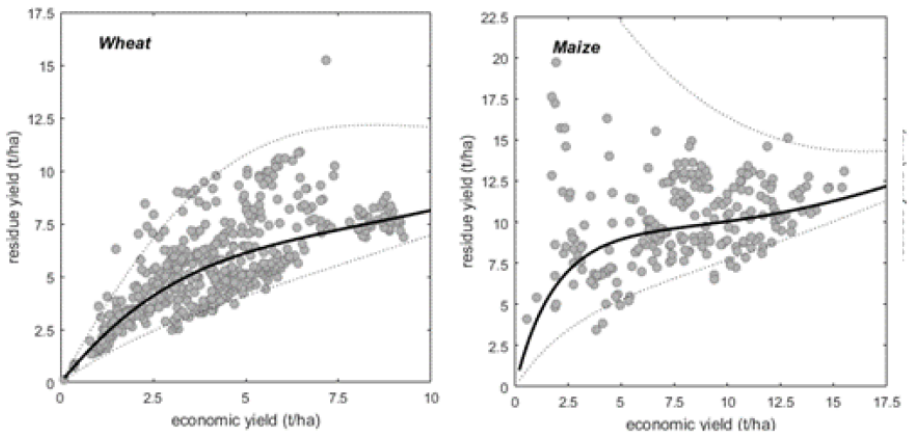


Table 4.2: Crop data used for baseline soil carbon modelling

Parameter	Unit	Wheat	Maize
Yield	kg FM/ha	5250	6790
DM content product	Fraction	0.85	0.85
Aboveground residues	kg/ha	6315	9321
DM content residue	Fraction	0.85	0.70
Stubble	kg FM/ha	2526	3728
Straw / stover	kg FM/ha	3789	5593
Belowground C	kg C/ha	1474	1844
Stubble C	kg C/ha	966	1174
Straw / Stover C	kg C/ha	1449	1762
Total C input	kg C/ha	3890	4781

Soil data

For the soil data we used two representative soil types from the ISRIC WISE database. One profile is a Haplic Chernozem with high C content and the other profile a Luvic Phaeozem with lower C content. The characteristics of both soil types are provided in Table 4.3. For the modelling a soil depth of 25 cm is assumed.

Table 4.3: Soil data used for soil carbon modelling

	Org C content	Bulk density	Depth	C Stock	Clay content
	%	kg/dm^3	cm	ton/ha	%
Chernozem	3.3	1.18	25	97.4	34
Phaeozem	2.2	1.31	25	72.1	20

4.2.4 Parameterisation of options

Not all options stated in Chapter 4.1 were assessed with the RothC model, as this is a preliminary and exploratory study, which does not have the budget for a full scale analysis of all options. Furthermore, some of the options only have an effect on the nutrient balance, and not on the soil carbon stocks (e.g. balanced fertilization and returning ash from straw burning to the field.

The following options have been assessed:

- Full straw removal (baseline)
- Incorporation of straw (baseline)
- Straw removal in combination with no-till planting (no ploughing)
- Increased crop yield (requires improved fertilization)
- Harvesting straw every second year

Based on preliminary model runs, the carbon pools were initiated, which depend on the soil type and the carbon input (Table 4). The resistant plant material (RPM) and humified organic material (HUM) pools are the main carbon pools, whereas the decomposable plant material (DPM) and microbial biomass (BIO) pools are only small, as these have a quick turnover.

Table 4.4: Initial distribution over soil carbon pools (ton C/ha) for soil crop combinations

	DPM	**RPM**	**BIO**	**HUM**	**IOM**	**Total**
Chernozem - wheat	0.8	18.4	2.0	67.2	8.9	97.4
Phaeozem - wheat	0.6	15.0	1.5	48.5	6.4	72.1
Chernozem - maize	1.3	29.9	1.7	55.6	8.9	97.4
Phaeozem - maize	0.9	21.3	1.3	42.1	6.4	72.1

The RothC model does not have a clear parameter for simulation a scenario with no tillage, as the model does not have a plough factor and only simulates for one soil layer. However, we assumed that zero tillage results in a soil that will not become bare, but remain covered with crop residues. Therefore we assumed this could be simulated through the ground cover factor, which we kept as covered for the whole year. As we did not have data to verify this assumption, this remains an uncertain outcome.

For the option with increased yield, we looked at the potential yield from the Yield Gap Atlas (http://www.yieldgap.org/). In this project yield gaps are estimated for the main crops in a range of countries, including Ukraine. For wheat the potential water limited yield could be 8.2 ton/ha, compared to the average current crop yield of only 4.1 ton/ha. We assumed that 80% of the water limited potential crop yield should be feasible with good fertilization and crop management. This means that wheat yield could increase by 60%. In that case also more crop residues from roots and stubble become available.

4.3 Results

4.3.1 Results for baseline scenarios

In Figure 4.4 the baseline scenario results are shown for removal of straw every year, or incorporation in the soil, for both wheat and maize for a Chernozem soil. The scenarios with straw removal have a stronger decline compared to straw incorporation, for maize the soil organic matter declines to 5.3% when straw is harvested, whereas for straw incorporation the organic matter content remains at 6.1% after 30 years. For wheat the difference is a bit smaller with 4.9% in case of straw removal and 5.5% without removal. The soil organic matter trends show a clear annual pattern with higher content after the crop harvest when carbon input from plant residues become available. For all scenarios there is a decline during the first 5 years, which might be an effect of the initialisation.

Figure 4.4: Results of baseline simulation with and without straw removal for wheat and maize for a Chernozem (high carbon) soil

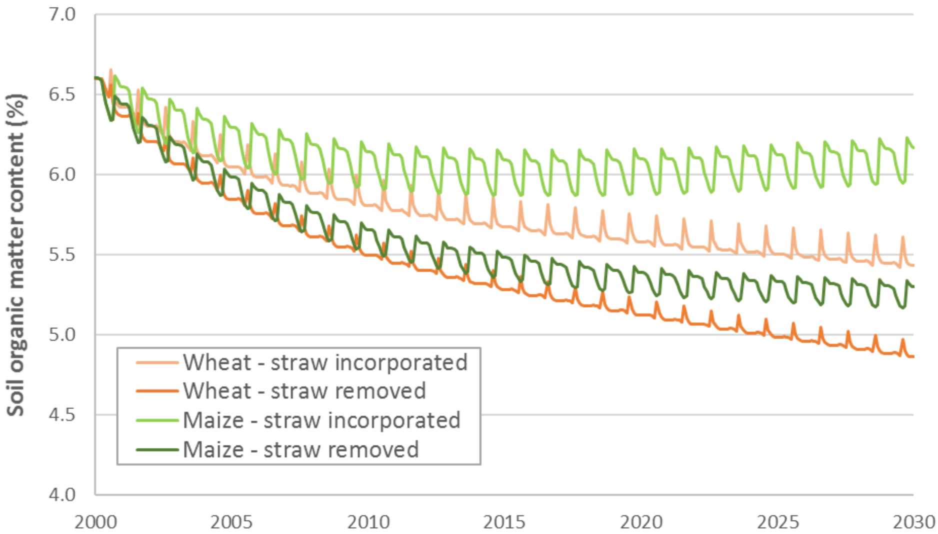
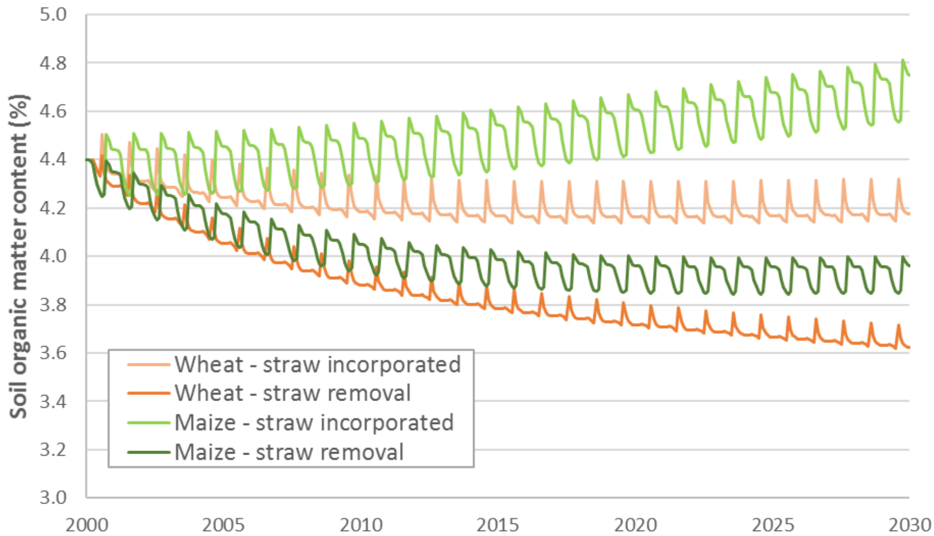


Figure 1.5: Results of baseline simulation with and without straw removal for wheat and maize for a Phaeozem (lower carbon) soil



In Figure 4.5 the baseline scenario results are shown for a Phaeozem soil, which has a lower soil organic matter content. Also, here the scenarios with straw removal have a lower soil organic matter content, however, for this soil the incorporation of maize straw can increase the soil organic matter content and for wheat straw it remains stable.

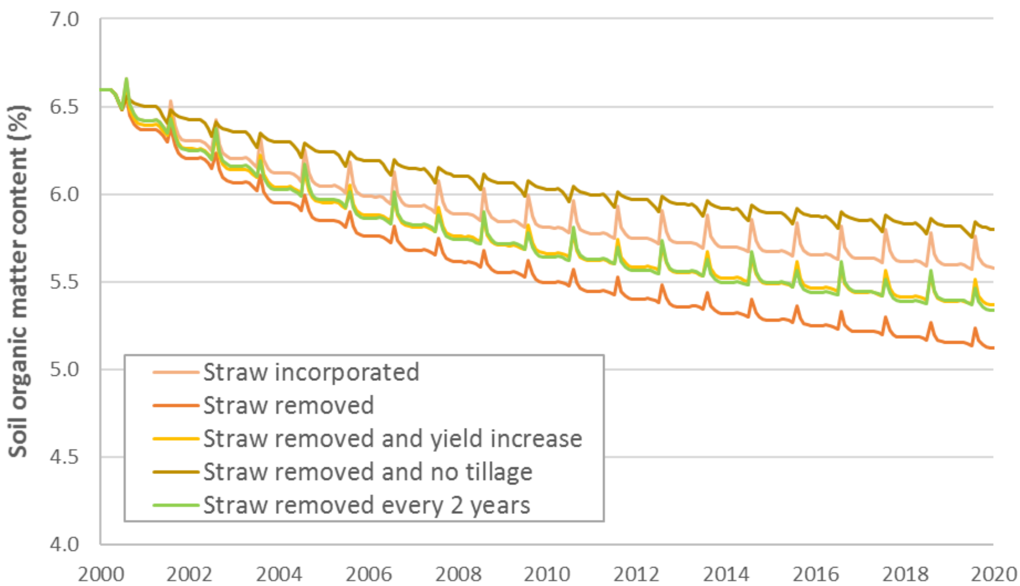
4.3.2 Effect of improvement options

For this study we simulated the effect of three alternative options to use the straw for bioenergy purposes and reduce the negative effects on the soil organic matter content. The three options assessed were:

- Yield increase
- Use of no tillage
- Remove straw every second year

The results for wheat on a Chernozem soil are shown in Figure 4.6. All three options increase the soil organic matter content compared to the baseline where straw is removed. The zero tillage option has even a higher organic matter content compared to the scenario where straw is incorporated. This effect might be large as these soils are losing carbon even in the scenario where straw is left on the field, in that case it can be effective to prevent further soil disturbance by ploughing. In case of the yield increase option, also the straw yield increases from 3.8 to 4.6 ton/ha.

Figure 4.6: Results of simulation of improvement options for wheat on a Chernozem soil



4.4 Discussion and conclusion

The results show that for soils with a high soil carbon content, such as Chernozems, the baseline trend is a decrease in soil carbon, even if all straw is not removed but incorporated in the soil. These Chernozem soils have been formed over thousands of years with a steppe vegetation, which resulted in accumulation of soil carbon. Since these soils have been converted to arable land, the disturbance due to ploughing and the lower input of organic material, make that these soils are losing carbon. Since the soil horizon with high carbon content is rather thick for a Chernozem, the loss of carbon does not have a direct negative effect on the agricultural production, but on the long-term the productivity will decline. To compensate these losses, these soils should be converted either to grassland vegetation, which has much higher carbon inputs, or high inputs of external organic material such as manure or compost.

The three simulated improvement options all increased the soil organic matter content compared to the baseline where straw is removed. Zero tillage seems a very good option to increase the soil organic matter content of the soil. However, this is not a common practice in Ukraine and should be tested whether this can be effective, and if weed problems can be suppressed without large amounts of herbicides.

These model simulations of trends in soil organic matter should also be tested in practice, as models are always a simplified representation of the reality. For example, the effects of crop rotations have not been taken into account and the model has not been validated for Ukraine, as we don't have the data from long-term experiments. However, models are very useful for assessing the long term effects of improvement practices, and can give good insights into the relative differences in how these strategies perform.

Crop residue removal can further decrease soil quality and the amount of organic matter in the soil. Different strategies may be available to avoid this problem and the model results demonstrate that these can be effective. Still we do need to understand better how these strategies can be applied, in order to use crop residues for energy and other added value applications, without having negative effects on the soil. Knowledge on the economic and environmental effects of these strategies and their application in practice needs to be further developed and tested in the field. Ultimately, this kind of knowledge needs to be incorporated in policies that aim to use crop residues for energy production. Also financiers and donors can include these recommendations as prerequisite for loans or subsidies for sustainable use of crop residues.

References

Camia A., Robert N., Jonsson R., Pilli R., García-Condado S., López-Lozano R., van der Velde M., Ronzon T., Gurría P., M'Barek R., Tamosiunas S., Fiore G., Araujo R., Hoepffner N., Marelli L., Giuntoli J., Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment, EUR 28993 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN978-92-79-77237-5, doi:10.2760/539520, JRC109869

Scarlat, N., Martinov, M., Dallemand, J.-F. 2010. Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use. Waste Management, 30: 1889–1897.

Taghizadeh-Toosi, A., Christensen, B.T., Hutchings, N.J., Vejlin, J., Kätterer, T., Glendining, M., Olesen, J.E., 2014. C-TOOL: A simple model for simulating whole-profile carbon storage in temperate agricultural soils. Ecological Modelling 292, 11-25.

Annexes

Annex 1: Business Model for bioethanol from sugar beets

ALCOHOL PRODUCTION COST BY "BETAPROCESS"

to run the program only fill the yellow cells

PLANT CAPACITY	Raw materials tons/day	SEASON days/year	ALCOHOL liters/day	ALCOHOL liters/year	fermentable sugars	process effiency	sugar%
Sugar beets	3.000	200	270.000	54.000.000	18%	90%	
Corn kernels	850	150	267.750	40.162.500	20%	90%	70%
Downtime		15					
Total	3.850	365	537.750	94.162.500			

FINANCING	Costs Euro	Cash payment Euro	Financed amount Euro	depreciation years N°	Financing years N°	rate /year %	Number of instalments/year
Plant	€ 56.920.000,00	€ 0,00	€ 67.186.000,00	10	10	4	12
Land and buildings	€ 10.266.000,00			30			
				AVERAGE PRODUCTION COST PER LITER OF ALCOHOL		Euro	€ 0,431

ALCOHOL PRODUCTION COST

(prices in Euro)

Raw Material		consumption for 1 cm	prices Euro/ton	costs Euro	TOTAL Euro/m3 BEETS	TOTAL Euro/m3 CORN KERNELS
BEETS	per Ton	11,11	€ 28,0		€ 311,11	
BEETS TRANSPORT COST	per Ton		€ 4,0		€ 44,44	
Corn kernels	per Ton	3,17	€ 112,0			€ 355,56
Corn kernels transport cost	per Ton		€ 4,0			€ 12,70
Chemicals / Enzymes	quantity	10%				€ 35,56
sulphuric acid @ 98%	kg	2,29	€ 0,12	€ 0,27		
sodium hydroxid 25%	kg	3,74	€ 0,10	€ 0,37		
calcium cloride	kg	0,00	€ 0,20	€ -		
urea	kg	0,00	€ 0,20	€ -		
ammonia water	kg	0,00	€ 0,10	€ -		
(NH4)2HPO4 @ 53%P2O5	kg	0,10	€ 0,80	€ 0,08		
K2SO4	kg	0,00	€ 0,20	€ -		
yeast	kg	0,125	€ 7,50	€ 0,94		
rhizozyme	kg	0,000	€ 6,00	€ -		
alfa amilase	kg	0,00	€ 5,00	€ -		
amilo glucosidase	kg	0,00	€ 4,00	€ -		
nitric acid 50 %	kg	0,40	€ 0,20	€ 0,08		
antifoam	kg	0,24	€ 1,00	€ 0,24		
HCl 33 %	kg	0,00	€ 0,15	€ -		
polielectrolyte	kg	0,01	€ 5,00	€ 0,05		
diammonium phosphate	kg	0,24	€ 0,50	€ 0,12		
Chemicals total					€ 2,16	€ 2,16
methane for steam production	Ncm	175	0,2570	(per 1000 liter EtOH)	€ 44,98	€ 44,98
wood chops for steam production	kg	0	0,0544		€ -	
Boiler water treatment				€ 89.625,00	€ 1,66	€ 2,23
Ashes waste disposal	kg	0,00	0,0500		€ -	
Electric energy	KWh	269	€ 0,05	(per 1000 liter EtOH)	€ 13,45	€ 13,45
Potable water	Euro			€ 53.775,00	€ 1,00	€ 1,34
purification plant muds sell off	kg	44,4	€ 0,05		€ 2,22	
cooling tower water treatment	Euro			€ 86.040,00	€ 1,59	€ 2,14
workforce	workers	50	€ 9.500,00	€ 475.000,00	€ 8,80	€ 11,83
	administratives and commercial personnel			€ 120.000,00	€ 2,22	€ 2,99
maintenance costs	Euro			€ 180.000,00	€ 3,33	€ 4,48
laboratory cost	Euro			€ 56.000,00	€ 1,04	€ 1,39
general expenses	Euro			€ 125.000,00	€ 2,31	€ 3,11
					€ 440,31	€ 493,91
interests	Euro	Interests incidence		€ 1.444.107,02	€ 26,74	€ 35,96
TOTAL COST per 1.000 LITERS OF ALCOHOL					€ 467,05	€ 529,86
TOTAL COST					€ 25.220.937,22	€ 21.280.643,48

AVERAGE COST per 1.000 LITERS OF ALCOHOL **493,84**

REVENUES		
	Alcohol selling price per liter	€ 0,500
	annual turn over	€ 47.081.250
	profit	€ 579.669

PRODUCTION COSTS per YEAR DURING the PAYBACK TIME

		BEETS		CORN KERNELS	total
RAW MATERIALS	69%	€ 16.800.000	75%	€ 14.280.000	€ 31.080.000
TRANSPORT	10%	€ 2.400.000	3%	€ 510.000	€ 2.910.000
CHEMICALS	0%	€ 116.440	0%	€ 86.602	€ 203.043
UTILITIES	14%	€ 3.504.390	13%	€ 2.575.934	€ 6.080.324
PERSONNEL	2%	€ 595.000	3%	€ 595.000	€ 1.190.000
MAINTENANCE	1%	€ 180.000	1%	€ 180.000	€ 360.000
LABORATORY	0%	€ 56.000	0%	€ 56.000	€ 112.000
INTERESTS	3%	€ 722.054	4%	€ 722.054	€ 1.444.107
GENERAL	1%	€ 125.000	1%	€ 125.000	€ 250.000
	100%	€ 24.498.884	100%	€ 19.130.590	€ 43.629.474

SALES REVENUES per YEAR DURING the PAYBACK TIME

ANHYDROUS ALCOHOL	100%	€ 47.081.250
	100%	€ 47.081.250

GROSS PROFIT

€ 3.451.776	3.451.776,32

Annex 2: Ethanol yield per hectare calculation for Ukraine

DP+Betaprocess (pilot)

1000	kgs	sugar beets	
189	kgs	sugar content	18.90%
		conversion rate	0.53
100.17	kgs	EtOH max	
		efficiency rate	80%
80.136	kgs	EtOH real	
0.789		density	
101.6	liter	EtOH	

85 ton per HA (average sugar beet yield)
8633 liter EtOH per HA

Ukraine

1000	kgs	sugar beets	
160	kgs	sugar content	16.00%
		conversion rate	0.53
84.8	kgs	EtOH max	
		efficiency rate	80%
67.84	kgs	EtOH real	
0.789		density	
86.0	liter	EtOH	

50 ton per HA (average sugar beet yield)
4299 liter EtOH per HA

the Netherlands

1000	kgs	sugar beets	
180	kgs	sugar content	18.00%
		conversion rate	0.54
97.2	kgs	EtOH max	
		efficiency rate	90%
87.48	kgs	EtOH real	
0.789		density	
110.9	liter	EtOH	

85 ton per HA (average sugar beet yield)
9424 liter EtOH per HA

EU

1000	kgs	sugar beets	
170	kgs	sugar content	17.00%
		conversion rate	0.54
91.8	kgs	EtOH max	
		efficiency rate	85%
78.03	kgs	EtOH real	
0.789		density	
98.9	liter	EtOH	

60 ton per HA (average sugar beet yield)
5934 liter EtOH per HA