Interreg
Danube Transnational Programme
ENERGY BARGE

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 3.2.3

Regional case studies

for biomass and bioenergy production –

Case Study Hungary 2:

Hungrana Ltd.

June 2018

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I. About the ENERGY BARGE project

The Danube region offers a great potential for green energy in the form of biomass. The main objective of ENERGY BARGE is to exploit this potential in a sustainable way, considering the Renewable Energy Directive 2009/28/EC, thereby increasing energy security and efficiency in the Danube countries. The project brings together key actors along the entire value chain, biomass companies and Danube ports as well as relevant public authorities and policy stakeholders. The project maps value chains and facilitates the market uptake of biomass, supports better connected transport systems for green logistics and provides practical solutions and policy guidelines. The Agency for Renewable Resources (FNR) coordinates the ENERGY BARGE project consortium with fourteen partners from Austria, Bulgaria, Croatia, Germany, Hungary, Slovakia and Romania.

Project coordinator

Agency for Renewable Resources / Fachagentur Nachwachsende Rohstoffe e.V.	FNR	Germany

Project partners

BioCampus Straubing GmbH	BCG	Germany
Deggendorf Institute of Technology	DIT	Germany
Austrian Waterway Company	VIA	Austria
Port of Vienna	PoVi	Austria
Bioenergy2020+ GmbH	BE2020	Austria
International Centre of Applied Research and Sustainable Technology	ICARST	Slovakia
Slovak Shipping and Ports JSC	SPaP	Slovakia
National Agricultural Research and Innovation Center	NARIC	Hungary
MAHART-Freeport Co. Ltd.	MAHART	Hungary
International Centre for Sustainable Development of Energy, Water and Environment Systems	SDEWES Centre	Croatia
Public Institution Port Authority Vukovar	PoVu	Croatia
Technology Center Sofia Ltd.	TCS	Bulgaria
Romanian Association of Biomass and Biogas	ARBIO	Romania
Federation of owners of forests and grasslands in Romania	Nostra Silva	Romania

II. About this document

This report corresponds to "D.3.2.3. Regional case studies for biomass and bioenergy production" of the ENERGY BARGE project. It has been prepared by:

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Background

ENERGY BARGE aims at exploiting the Danube macroregion's bioenergy potential to increase energy security and diversification of energy sources by establishing secure, efficient and sustainable bioenergy supply chains along the river. To this end, a holistic view on the bioenergy market and underlying value and supply chains is needed. Given national and regional disparities in theoretical, geographical and market potential for bioenergy, deployment, public support, and also cooperation between private and public actors, it is necessary to identify levers for tapping potentials and options for market actor cooperation, business development and market uptake.

A theoretical model designed to increase the market uptake of bio-based feedstock for both material and energetic (ideally cascading) use in the Danube region and thus to address the objectives also set out in the EU Strategy for the Danube Region (EUSDR) is a concept called "Green Energy and Chemistry Belt" (see Figure 1). It was developed by the BioCampus Straubing GmbH (Project Partner 1) and aims at using the Danube River as a natural biomass corridor and sustainable transport axis for biomass. The underlying principle follows the logic of "local harvesting – decentral processing into more transport-worthy states (e.g. oils, pellets, liquids) – central refinement or end use", so that added value creation can mainly remain in rural areas along the Danube. This concept forms the basic idea of the ENERGY BARGE project.

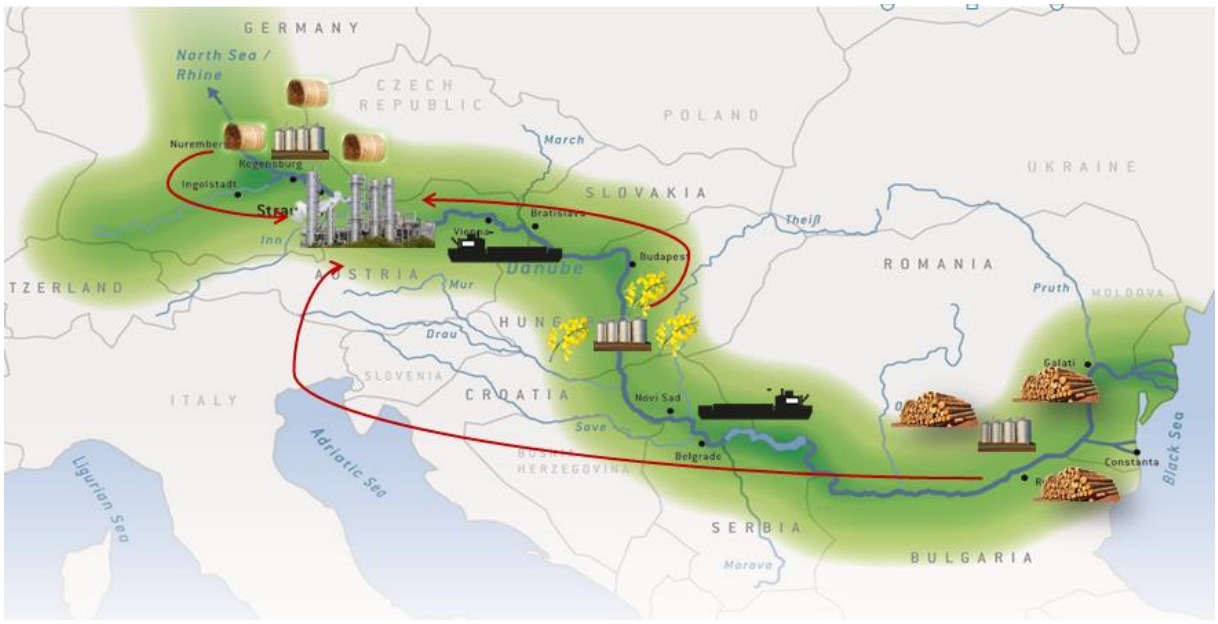

Figure 1: Green Energy and Chemistry Belt (Source: BioCampus Straubing GmbH, own visualisation).

In order to reach the targets as outlined above, Work Package 3 provides market-oriented mapping of the Danube region's value chains from biomass feedstock production and residues to energy generation from an integrated, transnational perspective, giving regional and transnational guidance for market development along the river (green bioenergy belt) and setting the stage for increased use of Danube logistics in the bioenergy sector. This will be achieved through a transnational market study compendium including biomass flows and sustainability aspects (macro-perspective, Activity 3.1), business landscape mapping, case studies and

identification of best practice locations for bioenergy value chain integration (micro-perspective, Activity 3.2).

Objective of the regional case studies

Deliverable "D 3.2.3 Regional case studies for biomass and bioenergy production" is based on the task as described in the latest approved version of the Application Form of the project ENERGY BARGE (Project Code: DTP1-175-3.2).

- *A3.2- Providing a systematic insight into the integrated bioenergy landscape along the Danube (lead: BCG)*

Activity 3.2 focusses on the biomass and bioenergy business sector, with the aim of mapping the state of the business landscape working along the bioenergy value and supply chain in the Danube region. This will mainly be achieved, in connection with a company inventory and a demand scenario analysis, via a set of regional case studies, focusing on exemplifying cases with already established (or currently being established) biomass and/or bioenergy markets/businesses, their future integration potential, and also covering their already existing as well as potential logistic connections with a focus on connections with nearby inland port terminals and inland waterway transport (IWT).

With D 3.2.3, the aim is to identify cases, i.e. specific real-life situations (businessdictionary, 2018), in each of the partner countries in which biomass production and/or utilisation in the bioenergy sector (as well as other utilisation sectors, e.g. chemical-material use) plays a dominant role in comparison to other cases. After identification via a standardized matrix, the objective is to coherently analyse these cases in case study reports. The focus here shall be on describing the status quo of these cases with respect to a set of characteristics and on subsequently analyzing the success factors (enablers & inhibitors) influencing this status quo. In addition to this qualitative analysis, each case shall be accompanied by a GIS-based (geographical information system) map depicting land use, as well as options for regional supply and logistics chains (roads, ports, business partners). Through the direct contact to responsible managers and other important people in charge at the cases, the project can be further disseminated. Moreover, discussions and considerations about challenges and chances of the bioenergy sector in the Danube region are spurred, contacts made and options for future integration of inland waterways and ports can be presented and discussed.

In the following project steps, the aim is to use these case studies for Output 3.2 as a basis to identify good practice examples on how and in what ways biomass and bioenergy production and utilisation can be regionally and locally integrated, how supply chains can be improved or established and – ideally – how inland ports can contribute to this integration via their logistics services as biomass and bioenergy hubs.

Executive summary

The case study analyses the present production activities and future opportunities of the Hungrana Starch and Isosugar Manufacturing and Trading Co. Ltd, which is the most significant corn processing company in Europe.

The introduction and operation of the plant have been presented by the company's experts. Information was gathered from the fodder, sugar and alcohol production, solid biomass combustion as well as the logistic department. Among others, quality and amount characteristics of the raw materials, production features, especially bioenergy production as well as logistic and commercial parameters have been assessed.

In case of the Hungrana plant in the town of Szabadegyháza, the supply chain is quite complex. Feed corn is transported on road or on rail directly after harvesting (during the harvest period between September and November) or in dried form after storage. Port capacities are a part of the logistics chain regarding the company's export activity. The transport of various by-products (corn germ, corn gluten, pellets etc.) is carried out by waterways. The produced bioethanol is transported on rail or road to refineries or to export.

Based on the findings of the case study, Hungrana is able to capitalize on the utilization of renewable energy sources due to the environmentally friendly and efficient production method. In addition to bioethanol production, Hungrana burns approximately 70,000 t of residue biomass such as sunflower husks annually in its existing biomass power plant, generating steam and thermal energy covering two-thirds of its needs.

Hungarian ethanol producers have invested approximately 430-450 Mio. Euro over the past ten years, which has only partially recovered up until today. The domestic ethanol production has only a short-term future vision until 2020. It is not clear yet which EU quota will be determined after 2030 in terms of the compulsory mixing rate for gasoline. On the other hand, it is important to emphasize that together with bioethanol, valuable feed materials are also produced during the process.

1. Case study methodology

Overall, six partner countries present case studies: Austria, Germany, Hungary (2 studies), Croatia, Slovakia, and Romania. Each country's case study report is designed as additional information to the interactive ENERGY BARGE platform. A summarizing case study report is made available in order to get an overview to the whole case study area and the sites chosen.

In Figure 2, an overview of the Danube region and all cases covered (red dots) is presented. The map is an extract from the ENERGY BARGE modal shift platform (www.energy-barge.eu) and also depicts an abstracted level of bioenergy company locations in the macro region (green dots).

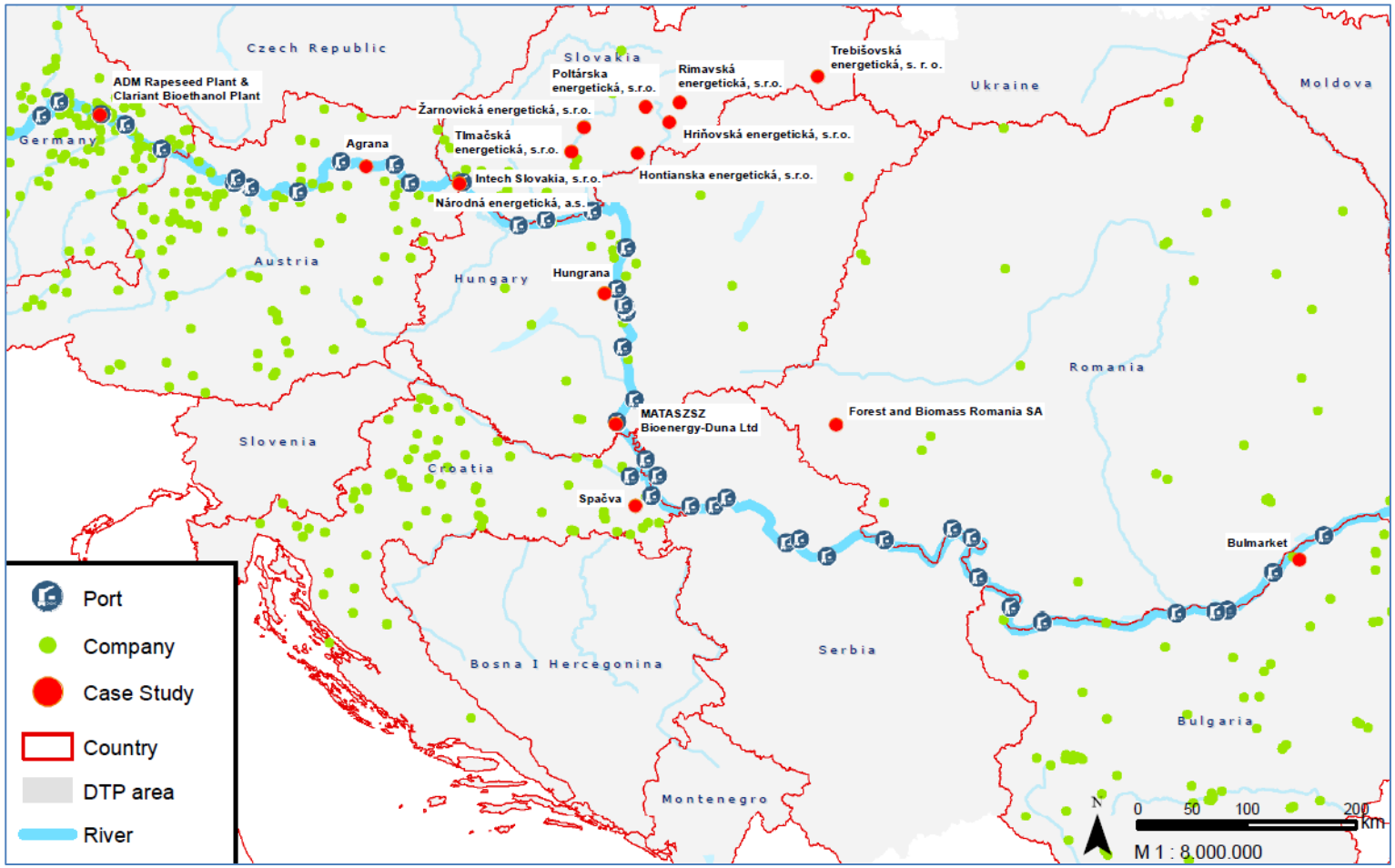

Figure 2: Overview of the location of the selected cases in the Danube region (DIT, 2018 source: open street map)

The case study is based on publicly available professional data and expert interviews. As a concrete example, the study examines the case of Hungrana Starch and Isosugar Manufacturing and Trading Co. Ltd, which is the most significant corn processing company in Europe**.** The company makes natural products exclusively, using a broad range of the most modern technologies and renewable energies, without waste.

As the ENERGY BARGE project focuses on the transportation of biomass on inland waterways, this issue is presented as a practical example in the case study.

Detailed information was collected about the fodder production, solid biomass utilization, alcohol production as well as the characteristics of the logistics industry within the company.

During the elaboration of the case study, the following experts were interviewed:

Table 1: Steps of company contact

Name	Organisation	Date
Dr. Sándor Nagy	Verbál Studió Kft (Mechanical engineer, Technical expert)	08.03.2018
Dr. László Fenyvesi	Szent István University, Faculty of Mechanical Engineering	14.03.2018
Dr. Szabolcs Magyar	Hungrana Ltd	April 2018 (prior consultation)
Norbert Anfort	Hungrana Ltd	17.05.2018
Dr. András Román	Hungrana Ltd	17.05.2018
Dániel Kustán	Hungrana Ltd	23.05.2018
László Csordás	Hungrana Ltd	23.05.2018

2. Case description

As the most significant corn processing company in Europe, Hungrana Ltd. has been a significant player in the Hungarian food industry for more than 100 years**.** In respect of its range of products and its size, the company is at the cutting edge of European manufacturers, and the European Union market leader in isosugar production. The number of employees amounts to 340 people, but the number of indirect jobs is ten times bigger. The facility is located at the heart of Hungary's principal corn-growing region and is conveniently situated. The Austrian Agrana Group and the American ADM company own 50% each of the company.[1]

[1] http://www.hungrana.hu/

Figure 3 View towards the Hungrana Company (Hungrana, 2017)

Hungrana processes exclusively Hungarian GMO (genetically modified organism)-free corn, more than 1,000,000 t on a yearly basis and provides 5.5-6% of the Hungarian food exports. It represents about 10-15% of the Hungarian corn production annually. The plant has undergone constant development and expansion which continues to the present day. In 1990, Hungrana had the capacity to process 400 t of maize per day. Today, the capacity increased to 3,500 t per day.

The plant uses the so-called wet milling technology. This takes the form of wet corn, which is supplied after being freshly harvested four months a year, while dry corn is used for the rest of the year. The Corn wet-milling process is designed to extract the highest use and value from each component of the corn kernel. While the wet milling process is capital intensive with higher operating costs, the ability to produce a variety of products can be valuable in dealing with volatile markets. The wet milling process results in slightly lower ethanol yields than a traditional dry milling process since some of the fermentable starch exits the process attached to the saleable co-products.

A significant part of the processed corn comes out of the factory as feed materials, and stays in Hungary, thus greatly relieve the Hungarian protein deficit, primarily by replacing imported GMO soya. Approximately, 1,000 to 1,100 t of feed comes out of the plant, which is 30% of the incoming maize. In 2016, 15-18% of Hungarian corn yields were processed by the plant. All this means that the plant uses 3,300 t of maize per day, which corresponds to 140 trucks. The number of suppliers is nearly 700 nowadays, mainly farmers, but also traders/warehouses.

Four major product groups are produced at the factory:

1. Starches
   Hungrana produces starch powder 32,500 t/a and liquid starch (slurry) 28,000 t/a.

2. Alcohols
   Bioethanol, medical, chemical, cosmetic, or rectified spirit.

3. Fodder products
   CGF (Corn gluten feed): Hungrana produces: dry CGF: 170,000 t/a (meal & pellet) and wet CGF: 100,000 t/a
   During starch production by the moist processing of corn, after separation of the larger proportion of the starch, the corn germs and the corn gluten, CGF is the remaining source of protein, energy, vitamins and mineral substances which can be economically utilised for feedstuff purposes. The CGF is marketed as moist or dry powder and in pellet form
   Gluten: The gluten feed production amounts to 600,000 t/a. Gluten is one of the main components of corn. It is obtained from the corn during moist processing. Corn gluten is a premium quality basic commodity containing concentrated protein, used for the feeding of livestock, fish and animals kept as pets (dogs, cats), with protein over 60%.

   Corn germ: Hungrana produces 67,000 t/a. The corn germ is separated from the corn grains by physical means during the first phase of starch production by moist processing.

4. Sugars
   Hungrana has a production quota of approx. 300,000 t/a, which is one of the biggest in the EU (including out of quota sales to non-EU countries).

Starches	Alcohols	Fodder products	Sugars
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The bioethanol unit was commissioned in 2008, then the 100 year anniversary was also encompassed with recent developments, the most significant was the construction of a biomass power plant providing 25% of the plant's energy input. Environmental responsibility is of high priority for Hungrana, whereby the production of bioethanol fuel made from renewable energy resources and marketed under the name GreenPower E85 constitutes a good example. The bioethanol produced in Szabadegyháza is used in line with the EU directive of renewable energies. Bioethanol is either used as a pure fuel or as an admixture to normal petrol. Double usage is in place as the starch-rich components of the plants are used to make ethanol while the protein-rich components are used to make valuable animal feed.

In 2013, the new Pharma2 plant with a capacity of 900 hl/d was put into operation, which produces ultra-high purity organic ethanol for pharmaceuticals, cosmetics and other fine

chemicals. The production quota of 220,000 t of isosugar grew to 250,000 t this year, which is the largest in the European Union (Hungrana Ltd, 2018)

Two years ago, as a result of the investment of 2.7 billion Hungarian Forint (HUF), a new pelletizing unit was installed where the pelletized CGF is produced from corn fiber and other protein-rich ingredients. The product is a high-quality dust free, non-GMO fodder material.

Central actors and their roles

The most important groups of stakeholders in this case are the following:

1) Feed corn suppliers,
2) Raw material (biomass) suppliers,
3) Public actors, authorities, government organisations relevant in the field,
4) Relevant logistical actors,
5) Research and development (R&D) organizations,
6) Customers (feed manufacturers, farmers, bioethanol producers etc.),
7) Certification organisations.

1. Feed corn suppliers

Approximately 700 agricultural feed corn suppliers have a contract with the Hungrana company covering the whole country. Corn procurement can take place directly from farmers, traders, integrators or from the spot markets. From logistical point of view, acquisition can be done on site, delivered from a site or from warehouses. These suppliers are providing the feed corn for the company's processes.

2. Raw material (biomass) suppliers

The biomass suppliers in the region are providing the biomass materials (wheat and barley straw, sunflower husk pellet) for the company's power plant.

3. Public actors, authorities, government organisations relevant in the field

<u>Ministry of National Development</u>

The Ministry is responsible for drafting laws and regulations related to climate policy, the promotion of biofuels and other renewable energies for transport, the use of renewable sources for generating electricity and heat and increasing energy efficiency and energy saving.

<u>Ministry for National Economy</u>

The Ministry for National Economy is responsible for the general planning of Hungarian economic policy and the implementation of any strategy for the national economy. They prepare climate and

energy policy plans with a view to sustainable development, and it supervises and directs Hungary's international economic relations on the basis of a strategy for foreign economic affairs.

Ministry of Agriculture

The Ministry of Agriculture formulates government measures that relate to agricultural development, and supervises food retail chains, environmental protection, and agricultural economy.

Hungarian Energy and Public Utility Regulatory Authority (HEA)

The Hungarian Energy and Public Utility Regulatory Authority (HEA) is the regulatory body of the energy and public utility market, supervising the national economy's sectors of strategic importance. The Authority's responsibility covers licensing, supervision, price regulation, tariff- and fee preparatory tasks in the fields of electricity, natural gas, district heating as well as in water utility supply, besides pricing of public waste management services.

National Transport Authority (now part of Ministry of National Development)

The National Transport Authority (NTA) was the budgetary institution responsible for transport. The first instance shipping authorities of Hungary acts with national competence for water transport administrative affairs. The task of the shipping authorities in general is to ensure with administrative means the safety, the lawful and professional participation in water transport of persons, assets, facilities, organisation and companies acting there as well as water areas serving for water transport (tracks), briefly the establishment and maintaining the safety guarantees of shipping. From 1 January 2017, the Government Office of the Capital City Budapest is responsible as shipping authority in waterway freight transportation affairs. ADR (The European Agreement concerning the International Carriage of Dangerous Goods by Road), RID (Regulations concerning the International Carriage of Dangerous Goods by Rail) and ADN (The European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways) are also covered by this authority.

Hungarian Trade Licensing Office

The Hungarian Trade Licensing Office implements national tasks related to the Common Commercial Policy of the EU.

National Directorate General for Disaster Management, Ministry of the Interior (NDGDM)

The basic function of the National Directorate General for Disaster Management, Ministry of the Interior (NDGDM), is protecting the lives and the property of the population living in Hungary and insuring the safe operation of the national economy and protecting the elements of the critical infrastructure. It is a highly important public safety task; therefore NDGDM is a law enforcement body with a national competence.

4. Relevant logistical actors

The logistic side contains road, rail and waterway transportation companies and other logistic actors that provide complex logistic services. Since Hungrana runs complex supply chains covering feedstock, products and co-/side-products, actors from all these logistics modes are involved in Hungrana's processes.

5. Research and development (R&D) organisations

The Hungrana company has good relationships with many national research institutes and universities. From these, the Szent Istvan University and the University of Pannonia can be highlighted. Both of them have a relationship with the company in terms of a dual training.

The National Protein Feed Programme was announced at the end of 2017. The three-year research & development programme was launched to fully replace imports of genetically manipulated soy in Hungarian animal feeds with domestic protein-based plants. For the implementation of the programme, not only soybean but also the by-products arising from industrial processing of maize and sunflower, as well as the protein-by-product of bioethanol production in animal husbandry are taken into account. Within this programme, Hungrana's plans include cooperation with the National Agricultural Research and Innovation Center (NARIC) and other companies involved in the programme. NARIC coordinates and arranges the new National Protein Programme (Agrarszektor.hu, 2017). NARIC was founded on 1 January 2014. An integrated, single legal entity was established from the fragmented and ill-proportioned sectoral governmental RDI capacities (12 research institutes and 4 business entities in the field of agriculture and food science). The organisation, by employing nearly 1,200 people (approximately 800 people employed by researchers or technicians), is of significant size even at international level. It is able to join the world's scientific circulation and increase the recognition of Hungarian agricultural research. NARIC is ENERGY BARGE project partner.

6. Customers

Customers of the company include feed manufacturers, farmers, resellers, oil refineries, etc. They are forming the market for the company's products. In terms of bioethanol, 70% of the bioethanol produced stays within Hungary, 30% are exported.

7. Certification organisations

The company has several certificates related to its operation: EFISC - European Feed Ingredients Safety Certification;, BRC - Global Standard for Food Safety; Kosher; Halal - Contol Office of Hala Slaughtering, Halal Quality Control;, ISCC EU (International Sustainability & Carbon Certification).

3. Socio-economic indicators

The subject of the present case study is Hungrana Ltd., which is located in Szabadegyháza. Szabadegyháza is a village in Fejér County in the Central Transdanubia Statistical Region. The county had a population of 417,651 and the population density was 96/km^2 in 2015. The village is located about 10 km from Székesfehérvár (county seat). Due to its location it is an important transport hub. It can be reached via road 62 between Székesfehérvár and Dunaújváros cities and on a side-road. the city is connected by the Budapest-Pécs railway line (Hungarian Central Statistical office, 2018)

Fejér is an administrative county in Central Hungary. It lies on the west bank of the river Danube and nearly touches the eastern shore of Lake Balaton. Székesfehérvár, the county seat, is one of the most significant cities in the history of Hungary. Geographically, Fejér County is very diverse. Its southern part is similar (and adjacent) to the Great Hungarian Plain, and other parts are hilly. The county is featured by duality, as industrialized cities are mainly located in the north-western part of the county, while the majority of the county is dominated by the Mezőföld region, a transitional area between the Great Hungarian Plain and the Transdanubian mountains, suitable for agricultural activities in the first place. The possibility of development of economic, geographic region is greatly influenced by the proximity to the international routes, which inter alia means the existence of adequate transport facilities.

Its economic center is one of the most important towns in the country, Székesfehérvár, but the other big city, Dunaújváros, is also a significant center. In the case of Fejér County enterprises, net sales exceeded 2,884 billion HUF in 2014. The most significant companies in the county include: food trader companies, light metal industry, tire manufacturers, electronics manufacturers as well as a metallurgical engineering complex.

Approximately 6% of the country's territory is occupied by the county, however, more than 11% of Hungary's GDP is produced here (mainly due to a large number of production and service companies settled in Székesfehérvár). The structure of the economy is stable, farms with less than 100 hectares have an important role as they cultivate approximately 30% of the county's arable land.

Key feature of the economic structure of Fejér County is that in terms of industrial production it is in one of the leading positions in Hungary. Multinational companies have settled in the region, the number of small and medium enterprises continues to grow, the investment environment is improving, not least because of relatively low-cost, skilled, workforce well adaptable to changes. Based on 2013 data, 76% of industrial products are sold on export markets, while 24% are sold domestically. Almost every segment of the economy - automotive and construction, electronics industries, medicine - are increasingly relying on the plastics industry.

4. Biomass availability and utilization

Crop production in Hungary is carried out on a total of 4.5 Mio. ha. (from which 600-800 ha are marginal lands) and alternatives are required there such as the cultivation of crops that are produced expressly for energy purposes.

Corn was overall harvested from an area of 988,000 ha in 2017 at national level. Total production was 6,811,000 t while average yield was 6.89 t/ha. One quarter of all Hungarian farmland is devoted to the cultivation of maize, while half of the total maize yield is exported (to Italy, Germany and Austria) without being processed (AKI, NAK, FM; 2016; Hungarian Central Statistical Office; 2016).

In recent years, the most important culture was corn in Fejér County. Nearly two-thirds of the area of Fejér County is under agricultural cultivation. Most of it is dominated by the contiguous arable land of Mezőföld, which is an outstanding grain-growing region. Two-thirds of the arable land produces wheat and maize, one fifth of industrial plants, mainly sunflower, rape and sugar beet are also grown (Puskás, 2014)

Table 2: Production of the main arable crops in Fejér County (2015)[2]

Feedstock	Yield (annual)		Average (annual)	
	t/a	national-wide = 100%	kg/ha	national-wide = 100%
Corn	560,033	8.6	6,150	108.1
Sunflower seeds	97,936	6.4	2,630	104.8
Barley	30,907	5.3	2,600	98.9
Wheat	408,187	7.7	5,850	113.8

Fejér County has the lowest forest coverage in Transdanubium, which owes partly to good quality of agricultural lands and partly to extremely inferior soil. Hence, the forest land area being managed by the VADEX Mezőföldi Co. covering an area of 16,500 ha plays a significant role. In

[2] The Hungarian Agriculture and Food Industry in Figures 2016.

addition, the Lovasberény Forestry Directorate (part of Budapest Forestry Company) cultivates 4,074 ha of land.

Hungrana Ltd. provides the procurement of feed corn and other biomass raw materials from external sources which are used in the production process.

Quality requirements as communicated by Hungrana officials:

- For the manufacture of the products, the company purchases corn grown in Hungary for which seed corn officially marketed and certified in Hungary has been used, which may be tracked and documented and which complies with the contents of article 18 of EC regulation 178/2002 (Hungrana Ltd, 2018).
- At the request of the customer, the supplier is obliged to certify the origin of the seed corn in a credible manner in writing; during the growing season chemical ripening accelerators or desiccating agents may not be used.
- The commodity must comply with the contents of MSZ standard no. 12540-98, with the enhancement that it may not include mouldy grains (Hungrana Ltd, 2018).
- The commodity must comply with the health and plant protection regulations currently in force, the regulations included in law XLVI of year 2008 on the food chain and its official supervision, as well as the regulations of MRD order 65/2012. (VII. 4.) on the enforcement of law CXIX of year 2001 on the production, marketing and utilisation of feedstuffs including detailed specifications, and the relevant regulations of MARD order 44/2003 (IV.26.) on the compulsory regulations of the Hungarian Feed Code..

<u>Biomass acquisition</u>

Hungrana Ltd. covers a significant proportion of its energy requirements by burning biomass, thus decreasing greenhouse gas emissions and fossil energy consumption.

In general, the following biomass raw materials are purchased by the company and solely include residue materials.

Primary basic material types purchased for heating purposes:

- Wheat straw
- Triticale straw
- Barley straw
- Rye straw
- Oat straw

Secondary basic material types purchased for heating purposes:

- Rape stems
- Lake reeds

- Energy reeds
- Sedge
- Alfalfa stems

Dimensions of accepted bales:

- Height: 0.9 m
- Length: min. 2.25 m - max. 2.55 m
- Width: 1.2 m
- Mass: min. 400 kg - max. 600 kg

In addition, the company also buys bulk biomass raw materials

- Woody biomass
- Other bulk biomass

Currently, wheat and small quantities of barley straw plus sunflower husk pellets with 10% moisture content are delivered to the plant for energy purposes. The transport mode is by road. Approximately a total of 10 t of fuel per hour is used. On a monthly level, this number represents 6,000 t of fuel on average (yearly average of 70-80,000 t) (Hungrana Ltd, 2018).

5. Bioenergy production and utilization

Prior to the emergence of bioethanol production, the 4-5 million t of maize surpluses were sold as crops in unprocessed form by Hungarian producers, which in many cases led to a significant fall in prices and caused a serious loss for farmers year after year. Nowadays, the demand of the ethanol industry is nearly 2 million t of maize per year, and the processing could reach a level soon, that requires 3 million t of maize yearly.

According to Agronaplo (2007), the production of liquid biofuels has started in Hungary about a decade ago , and made significant progress compared to other countries of the region. However, it is predominantly focusing on first generation biofuels. Investigations are being made in second generation biofuels, mostly driven by the search for enhanced efficiency in conventional plants. The bioethanol market directly and indirectly employs more than 4,000 people and plays an important stabilizing role in the Hungarian agriculture. Conventional ethanol facilities are fed mainly with domestic corn (2 million t per year) and are operated by Hungrana and Pannonia Ethanol companies. The end products are nearly 900 million liters of ethanol and more than 0.5 million t of DDGS (dried distillers grain), CGF and gluten feed products. Domestic ethanol production has a short-term future vision only until 2020. According to the EU regulation, by 2020, 10% of renewable energy should be allocated to transport energy. This is currently 4.9% (until the end of 2018) in Hungary and the EU average is 5-6%.

Hungrana is not only Europe's largest maize processor but one of the most important players in bioethanol production. Bioethanol is a fuel made from the fermentation of carbohydrate-rich biomass such as sugar and starch, and has an alcohol content of at least 99% by volume, making it practically water-free. Bioethanol can essentially be produced from any raw material that contains either sugar or starch. In Europe, the most important raw materials used to produce bioethanol include all crops containing starch, as well as concentrated sugar beet juice.

Hungrana's bioethanol reaches more than 73% GHG savings, based on information provided by the company (Zoltán Reng, 2016). The bioethanol production process is visualized in Figure 4.

Hungrana produces bioethanol on an annual basis (Zoltán Reng, 2016):

Type	Amount [m³]
96% potable	12,000
96% chemical	5,000
99% pharma	30,000
99% fuel grade	132,000
TOTAL	179,000

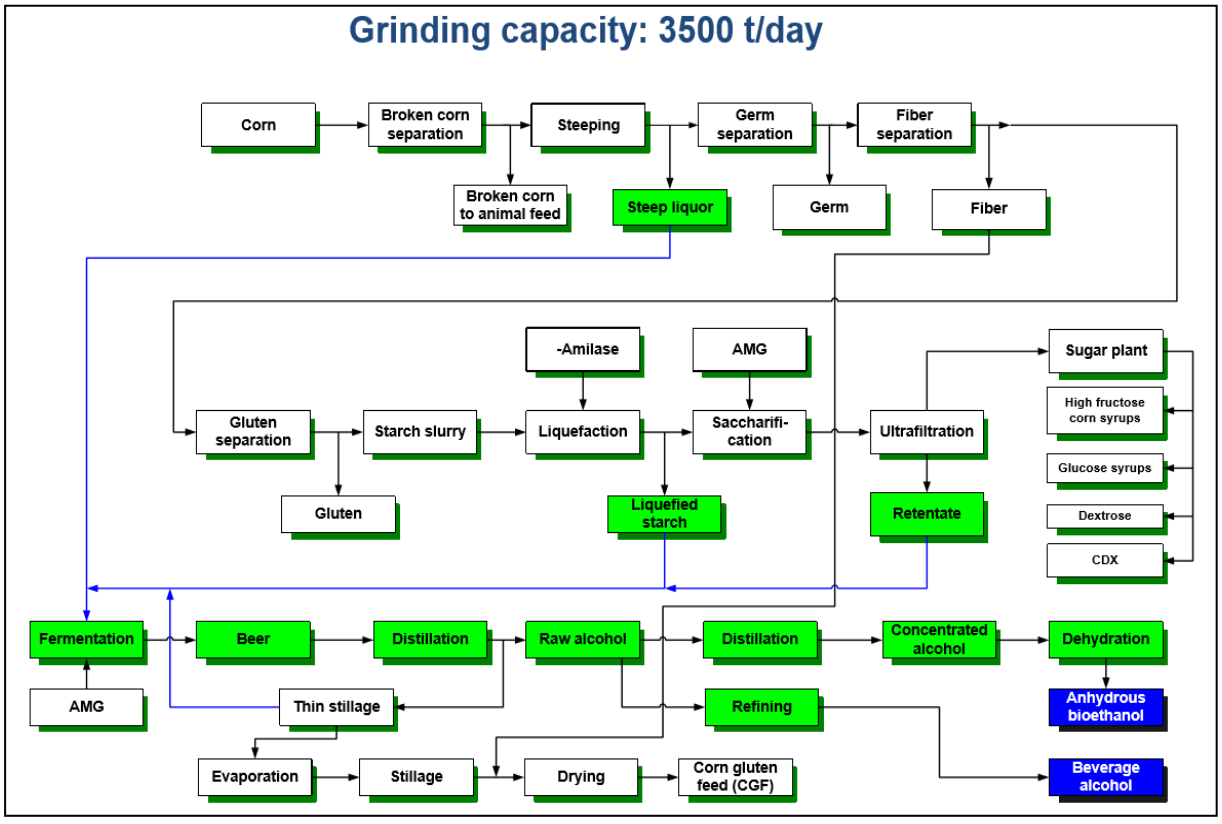

Figure 4: Ethanol production process (Hungrana) (Zoltán Reng, 2016)

In addition to bioethanol production, Hungrana burns 60,000 t of straw and 12-15,000 t of sunflower husk pellets annually in its existing biomass power plant, generating steam and thermal energy covering two-thirds of its needs. The first biomass boiler was inaugurated in 2012. Hungrana invests most recently 48 Mio. € in a new biomass power plant. The new development will cover the company's 100% demand for steam and thermal energy fields.

Currently, there are three boilers in operation with a power of 11-12 MW per boiler. 50 t of steam is produced every hour. The main utilisation areas of the steam are the heating of the alcohol and sugar plant distillation columns. In winter time it can cover roughly 50-60% of the factory gas consumption. Furthermore, the produced steam is also used for the heating of the evaporator in the sugar factory, which is intended to facilitate the disintegration of the starch molecule. This investment significantly increases the plant's independency on energy and adds to the CO_2 balance sheet and contributes to mitigating GHG emissions .

6. Infrastructure, logistics & integration of supply chain and logistics

The geographic location of Fejér County is favourable not only regarding biomass availability, but also in terms of logistics. Its area is one of new development zones in Central Europe. As a result, European development zones and trends can influence the development of the county. In this regard, two major lines of power shall be mentioned: Vienna-Bratislava-Gyor-Budapest development axis connected to the southern Bavarian Innovation Area, and Trieste-Zagreb-Nagykanizsa line connected with the Mediterranean area, which also has a connection to Budapest through the Kiev-Trieste corridor. Budapest, as a pole of international growth, connects to these two Central European development zones through the area of the region, where due to its location and economic potential Fejér county is as well of outstanding importance.

Fejér County is crossed by important railways (450 km), roads and highways (1,509 km), and navigable river segments define the area. Currently, road freight forwarding and transport are the most dominant in Europe, therefore the existence of motorways, the proximity of and access to these motorways are highly important. Administrative areas of Fejér County are located close to several motorways and motorway hubs, and this can be interpreted as a competitive advantage.

Feed corn procurement covers the entire country as Hungrana Ltd is situated in the middle of the country. Procurement is done within a range of 400-500 km. Considering the supply of raw materials, the typical mode of transport can be described as follows: one-third by rail and two-thirds by road. It can be stated that one third of the products of Hungrana are sold in Hungary, two-thirds are exported.

The transport of feed corn and other biomass to Hungrana are financed by the suppliers, who are focussed mainly on cost-effectiveness and are less interested in environmental effects.

Domestic sales

At least 70% of ethanol is transported by rail to Hungarian partners. The remaining amount is transported by road within the country. By-products are transported 100% by road (bulk by-product, some products are also packaged). Beyond bulk products, packaged products are also included in the product range such as corn gluten and other feed by-products. These products are packed in 25 kg sacks (pallet) or in 1 t big-bags.

Export

Currently, rail transport (minimum 85%) has the greatest role in ethanol transport, the rest of 15% is transported by road.

In case of other company's products (by-products) such as corn germs, corn gluten, pellet etc., the rail and water transportation are the commonly accepted transport solution. Where the volume of the contract is more than 1,000 t and can be delivered efficiently, water transport is used. Smaller amounts are transported by road. The distance of transportation is also an important factor, when the method of delivery is selected.

Presently one third the transport is carried out respectively by road, rail and water transport respectively. The share of rail transport shows a growing tendency. The main reasons for this circumstance comprise a limited number of available water transportation partners, the rail solution has a more predictable and faster timetable (predictability is more important than the specific costs) and fluctuating Danube water levels can cause additional costs for the shipping companies.

Technical characteristics of the transport

The company's standard tanker volume is 30 m^3; 90-95% can be filled. In case of normal road alcohol transport, the truck can be filled with 27-28 m^3. The filling capacity varies between 10 and 30 m^3 depending on the customer's request.

Figure 5 Hungrana company truck (Hungrana, 2018)

Railway wagons have 85-90 m^3 maximum capacity, which can be filled up to 80-85%. This means net 70-75% m^3 of alcohol. The type of wagon is the dominant feature, wide range is available on the market from 70 to 95 m^3. The available routes are specified. In Hungary, the axe load is limited by the state of the railroad.

Water transport can be realistic for larger quantities, 500 or 1,000 t of goods, or even more. The question of size efficiency is a very important feature in this delivery mode. The nearest harbor is the port of Adony, which is 17 km away from the facility. This port can be reached by road.

Figure 6: The view of Port of Adony (Port of Adony, 2018).

Port of Adony operated by Adony Logisztikai Központ Ltd. is located in Adony, Central Hungary, 55 km to the South from Budapest and 45 km from. the next motorways. The logistics hub consists of 5 railway tracks, 5 loading berths, 162,000 m^2 covered storage area and grain drying facility. One of the largest warehousing facilities is CEE with a 550,000 t bulk storage capacity (Port of Adony, 2018). It has a strategic location at the intersection of the European transport corridors Nr. V and VII.[3]

Strategically, it is located on the Danube River between the Black Sea and the North Sea benefiting from underutilized inland waterways in Central Europe. The port and its facilities provide direct access to water transportation on the Danube with 960 m river frontage. The port enables the simultaneous docking of 6 barges or vessels and loading and unloading of 4 barges, and is equipped with conveyor belt loading system with a nominal capacity of 300 t per hour per loading berth. The port is also suitable for general cargo loading/unloading. The transhipments are supported by 6 road weighbridges of 60 t capacity each and 2 rail weighbridges of 50 t capacity each. The terminal railway lines are connected to the national and international network. The road

[3] http://portofadony.hu

transport capacity is approximately 7,500 t per day. Transhipments are provided between different transportation modes including road, water, and rail. Hungrana also uses storage services in the port area.
The other nearby harbour is the port of Dunaújváros, which is approximately 22 km away from Hungrana and can also be reached by road. Both mentioned ports are able to receive bulk products. Dunaújváros Port activities are loading/discharging, storing/warehousing goods carried by river, maintenance and repair of port equipment/machinery/vessels and barges, providing port services. In the past few years there has been a steady increase in the demand for port services and the port continuously expanded the range of services. In 2008, Dunaújváros Port realized a turnover of more than 1,280,000 t and today it is a river port with one of the biggest turnovers on the Hungarian Danube section. Its location is between km 1580 and 1579, in a bay constructed parallel to the right bank of the Danube.

The port of Dunaújváros has the following features according to their website (Port of Dunaujvaros, 2018):

- Water surface used by the Port: 381,709 m^2;
- Number of basins: 1;
- Length of quay: 563 m;
- Loading and discharging general cargo, bulk cargo, liquid cargo;
- Bulk and general cargo can be transshipped from vessels/barges into open railway wagons and/or on road vehicles. Commodities can be transshipped from road vehicles or open/covered (opening) wagons into vessels/barges;
- Rail siding connection: length of rail siding 1,100 m, the private siding is operated round the clock on workdays;
- Road connection: distance to Motorway M6: 3 km;
- Parking lot for trucks: 30 trucks (ISD Portolan Ltd, (2018)

In summary, Hungrana has business connection with 35 countries, with nearly 1,000 customers taking into account all transport modes.

7. GIS-map

For the case study, a map visualizing geographical conditions and context based on a geo-information system (GIS) was designed. It includes a set of aspects defining the case and its surrounding area with a particular focus on the proximity to the Danube and relevant ports. For the case, a catchment area with a radius of 50 km has been defined in order to allow for theoretically economically viable pre- and post-haulage logistics. Within this area, also the companies along the biomass and bioenergy value chain as well as the port locations as identified in the course of the ENERGY BARGE project are depicted via icons.

The following information is provided on the map:

- Location of the case;
- Land cover categories on NUTS 3 level (CORINE land cover data, Eurostat, 2012);
- Land use data on NUTS 2 level for selected biomass feedstock (Eurostat, 2017);
- Market actors in the biomass and bioenergy sector in the region (ENERGY BARGE project, company landscape, 2017);
- Danube port locations with equipment for biomass handling (ENERGY BARGE project, inventory of logistics service providers, 2018).

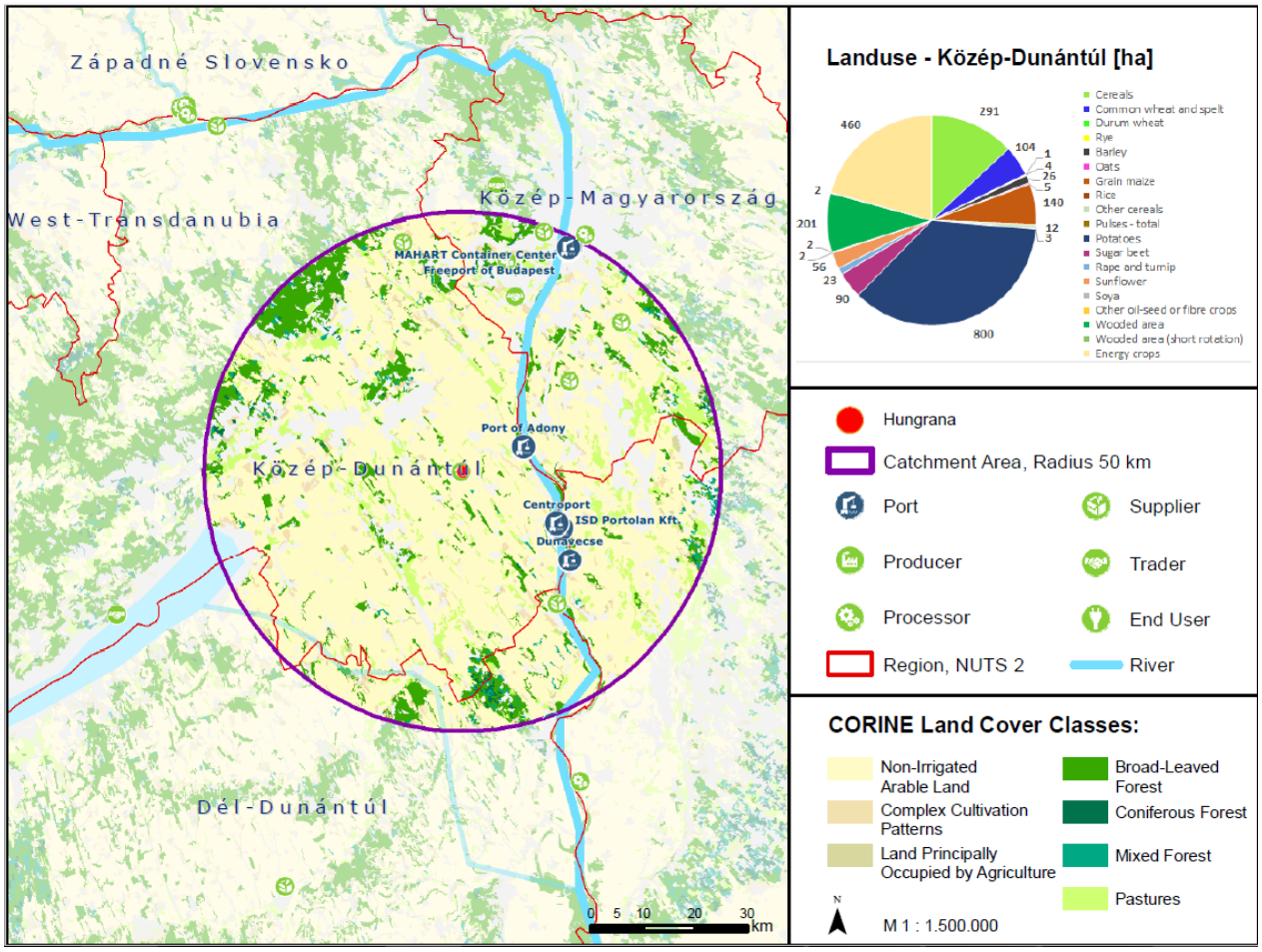

Figure 7: GIS analysis of the case location (visualization: DIT for ENERGY BARGE project; sources: ENERGY BARGE, 2017/2018; EUROSTAT land use data, 2017; CORINE landcover data, EUROSTAT, 2012).

8. Analysis of success factors & lessons to be learnt: enablers and barriers

In the following Table 3, the success and enabling factors of the case are presented. Among others biomass and bioenergy production characteristics, logistics factors and legal features are also be analyzed.

Table 3: Success and enabling factors of the case.

	Enablers	**Barriers**	**Learning and degree of transferability**
Biomass availability	The demand of the ethanol industry is nearly 2,000,000 t of maize per year, and the processing could reach the level soon, that requires 3,000,000 t of maize yearly. This level can be assured now by the domestic plant production. This can even be promoted by the National Protein Program (Agrarszektor.hu, 2017).	The Common Agricultural Policy will soon be renewed, it is important to consider which crops will be cultivated. The regional features of the biomass raw material production are limited.	Long term plans and strategic cooperation via contracts are necessary with feed corn and biomass suppliers. This can be transferred to both large-scale biomass processing as well as to small-scale plants. The integration of production may also be required within which volume increase can only be achieved by rising production.
Biomass utilization/valorization	Efficient technologies and operational experiences are available for biomass utilisation at Hungrana, including the biomass power plant. The efficiency will increase with the commissioning of a new boiler.	In many cases, it may be difficult to integrate e.g. the purchase of straw for farmers' insistence on agricultural utilization. The type and amount of available raw material determine the amount of energy that can be produced.	A predictable economic environment should be provided to farmers. In flexible integration, the system has an acceptable fee and value ratio.

Bioenergy production/ Utilization	The produced bioethanol amount can help to meet the country's renewable energy goals.	Change in the compulsory mixing ratio of bioethanol at EU level for petrol. Changing legislation and market environment may affect the further investment plans of the companies affected.	An often misperceived situation is that only biofuel is considered to be the product of the ethanol industry. Besides alcohol, valuable protein concentrate, protein feed, is also produced. Hungary, just as the European Union is a net importer of protein and with increased biofuel production, the protein deficit could be decreased. This learning is transferable to the entire biofuels (first generation) industry in the EU.
Existence of a strategy or concept	The company would like to carry on production of bioethanol and solid biomass combustion. The new biomass boiler is currently under construction to reduce natural gas dependence of the facility. The National Protein Strategy can also be seen as a chance for the company.	Biofuel production does not have a long-term production concept. Lack of supports, funds and sources.	The elaboration of a national level biomass supply strategy is necessary to stabilize raw material supply for the long run. Also, companies engaging in becoming more energy-independent should be supported from state-side.

Role of legislative framework	Bio-quota obligations are secured until 2020. 01.09.2017 until 31.12.2018: 4.9% 01.01.2018 until 31.12.2020: 6.4% (Flora Borek, 2017).	National ethanol production has only a short-term vision for 2020. Afterwards, the renewed RED directive puts a not negligible threat on the Hungrana bioethanol production.	Renewable energy production targets have to be harmonised in order to increase biomass-based heat and bioethanol production. The legislative situation on EU level as well as market demand are currently not in favor of biofuel markets to expand.
Role of stakeholders	The company's business creates a market for feed corn and biomass supply. End products of Hungrana appear in many markets (fuel, fodder, sugar etc.). Numerous stakeholders play a role in the supply chain as well as on the legislative stage, but as a big company, Hungrana is able to strategically manage this situation.	Transport of feed corn and other biomass to Hungrana is financed by the suppliers, who focus mainly on cost-effectiveness and are less interested in environmental effects. Investment capacities are limited for new developments; most new projects are co-financed with EU subsidies.	Suppliers have to be motivated to select more environmentally-friendly transport modes. Regulatory and funding/ investment environment must be stable. The complex supply chain needs active stakeholder management.

Role of socio-economic factors	The company employs approx. 340 people, but the number of indirect jobs is ten times higher. Due to the bioethanol production, the country can contribute to renewable energy targets as well as to decreasing the protein-deficit and the feed industry. Also, the major part of input as well as output comes from/stays in Hungary.	Staff numbers and quality are currently assured. Taking into account European trends, the availability of skilled workforce is questionable, but the company makes efforts towards this problem (e.g. dual training).	Complex process routes such as the one underlying the Hungrana plant creates jobs in several branches and especially strengthens the agricultural sector.
Integration of supply chains	The company has business connections with 35 countries, nearly 1,000 customers and 700 suppliers. The supply chain is complex but as Hungrana is a big company, it runs efficient supply chain management, integrating all modes of transport available. The inbound radius for feedstock is approx. 500 km and thus comparatively large.	There is no system to optimize transportation, taking into consideration environment friendly solutions.	Coordinated supply and transport chains are a future option to increase security of supply and optimize purchases.

Role of logistics infrastructure	The company uses water, road and rail transport solutions. It is located ideally and connected to all important transport corridors. Two major, well equipped Danube ports are less than 25 km away from the site. However, the majority of transport is focusing on road. The supplier and processor parts as well as the delivery and distribution are well-coordinated.	Change of energy prices (e.g. freightage) could be a periodic influencing factor. Danube logistics is only an option for large transport volumes and reliability factors can minimize the cases in which inland waterways become a suitable logistics option. Another barrier is the distribution of the fragmented areas for raw material production and final products use.	Ports located close to the facility and the water transport mode can still be improved. The mode of transport always depends on the type of product, quantity, location of transport and, above all, customers demand. Reliability is of high importance. These findings can be transferred to all large-scale/large-volume producing facilities.

9. Recommendations & suggestions for future development

1) The future successful development of the case, especially in further utilizing the case's biomass and bioenergy potential.

a. The installation of a new biomass combustion unit would cover the company's demand for steam and thermal energy by 100%. Thanks to the new investment, Hungrana cannot only produce more economically, but can dramatically reduce greenhouse gas emissions and fossil energy use. Therefore, the stringent strategy for own sustainable energy supply and efficiency investments has to be kept up.

b. At this point, Hungary is progressing at the right pace, increasing the proportion of ethanol to gasoline year by year. This is currently 4.9% in the country and the EU average is 5-6%. By 2019, Hungary has to reach a value above 6% and after the target would be 10%. However, the REDII will negatively affect this situation. Therefore, companies like Hungrana have to engage in political lobbying on national and EU level and in parallel, look into options to keep up their running business model in case political framework conditions do not allow price-competitive selling of bioethanol anymore.

c. Bioethanol production also has a great importance for the fodder industry, because in the case of corn grains, alcohol is only prepared from starch, all other parts (protein, fibre, other

minerals, fats) can be used as feed. The National Protein Programme can promote the development of the sector and thus should be followed up on.

2) The future options / potential to integrate Danube ports into the success of the case.
The company is already using the waterway mode, but has many limitations and barriers.

2.1 Limited number of partners requiring and using water transport. In many cases, the existence of an adequate port infrastructure is also a problem.

2.2 Rail transport compared to water transport has a more predictable timetable and it is faster. In this industry, predictability is more important than the specific costs.

2.3 The shipping companies can incur additional costs to the company, due to of the change of the Danube water level. This does not increase the acceptance of the water transport mode.

Overall, if the Danube waterway shall be utilized in an increased manner for the logistics of Hungrana, the three aspects listed above have to be recognized, analysed as well as to be tackled by the Danube logistics companies in order to gain new or stronger relations with high volume clients such as Hungrana (as well as their shareholders Agrana and ADM).

3) The three most valuable "lessons learnt" from the case that could give guidance to other regions.
3.1 Major investments in solid biomass-based energy production can change raw material market conditions considerably which could make operational cost and profitability forecasts difficult. However, these investments offer new options for creation of added value domestically and usage of biomass feedstock in the country of harvest. Long term strategy and identification of possible alternative solutions of raw material supply are inevitable in the preparatory phase.

3.2. Renewable energy generating plants cannot only benefit from energy production, but other by-products produced during the process. A bioethanol plant can be a good example, because besides the renewable energy source, feed material is also produced. Therefore, the utilization of biomass should ideally be based on an integrated process, not just a single-stream process in order to make the best use of the feedstock's potential.

3.3 The European Union has modified the bioethanol segment and regulations for the third time in the last ten years. This does not create a sense of security for investors. If the market is stable and the technology is available, Hungary can be an extremely suitable place to produce bioethanol. Without the current manufacturers the country would export this valuable biomass material (maize) in unprocessed form and lose added value.

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