Interreg
Danube Transnational Programme
ENERGY BARGE

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 5.1.3

MAHART Freeport Co. Ltd. – Pre-feasibility Pilot Study

June, 2018

Project co-funded by European Union funds (ERDF)

For the implementation of the project "ENERGY BARGE – Building a Green Energy and Logistics Belt" a subsidy is awarded from the European Regional Development Fund under the Danube Transnational Programme.

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 Deliverable 5.1.3 *Pre-feasibility pilot studies* of ENERGY BARGE. It has been prepared by:

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Background

Deliverable "D 5.1.3 Pre-feasibility pilot studies to prepare large-scale investments to transfer ports into biomass hubs" is based on the task as described in the latest approved version of the Application Form (AF) of the project ENERGY BARGE (Project Code: DTP1-175-3.2).

- Activity 5.1. *Pre-feasibility pilot studies to prepare large-scale investments to transfer ports into biomass hubs* (Lead: MAHART)

The port partners of the project elaborated pre-feasibility pilot studies (including investment plans) in order to define development plans and investment needs required to strengthen ports as logistics hubs for the bioenergy sector, where biomass is handled, stored and manipulated in the most appropriate way.

Individual pre-feasibility pilot studies were prepared following a common methodology (D 5.1.2) which helped the port partners to develop their pre-feasibility studies following a unified approach and it will also support the preparation of the synthesis report (D 5.3.2). Each individual pre-feasibility study defined development plans and investment needs - to prepare large scale investments beyond the project duration - of participating Danube ports in bioenergy logistics alongside the Danube River. Studies investigated existing value chains, industrial and logistics capacities and identified technological solutions and related investment projects with a budget, cost-benefit analysis and timeframe. Each of the five studies are interlinked in a way that the investment plans were coordinated to avoid competition and overlap.

Coordinator: MAHART (HU)

Involved Danube Ports: BCG (DE), PoVi (AT), SPAP (SK), MAHART (HU), PoVu (HR)

All involved Danube ports prepared their own pre-feasibility pilot study following the D 5.1.2 common methodology and were also responsible for the involvement of policy makers and at least five industry stakeholders to derive industry knowledge and experience.

The key focus of the pre-feasibility study structure was to provide a guideline for the elaboration of feasible and economically sound investments to strengthen ports as logistics hubs for the bioenergy sector alongside the Danube. The study structure was elaborated based on previous experience gained in the preparation of infrastructure development projects funded by the EU and also guides issued by various development organizations including the European Commission (*eg. Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion Policy 2014-2020 (European Commission 2014 - http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf).* Previous ENERGY BARGE activities and deliverables, including experiences gained during the preparation of D 5.1.1 surveys, impressions gathered during the port exchange workshop and results and deliverables of WP4, also contributed to the development of the structure and finally the pre-feasibility studies.

Local biomass markets are at a various development stages in each involved Danube port area. It is also reflected in the subject and results of the pre-feasibility studies:

- Port of Straubing (PP1 – BioCampus Straubing) is an operational logistics hub for biomass handling with a main focus on bioenergy utilization. The focus of its study is to put on a preliminary analysis of options to develop additional storage space for biobased feedstock and products serving the needs of current and future potential customers of services offered in the port by both the port management itself and private logistics companies operating based on the port's infra- and superstructure.
- Port of Vukovar (PP11 – Public Institution Port Authority Vukovar): several analysis on biomass market prices in the wider environment indicated the possibility of inclusion of the port in the production chain, and thus in the value chain via the establishment of a major biomass trade centre primarily for pellets and wood chips provided by the hinterland area of the Port of Vukovar.
- Port of Bratislava (PP7 – Slovak Shipping and Ports JSC): responding to the needs of a growing market and building upon the country's large forest areas on the supply side the subject of the study is to develop the transshipment and storage facility in the Port of Bratislava suitable for the handling of wood pellets and wood chips in bulk.
- Port of Budapest (PP9 – MAHART-Freeport Co. Ltd) is located at an ideal site for the implementation of a biomass-based energy production project. The necessary raw materials can be supplied through a waterway-based logistics network. With the planned Galvani bridge nearby the Freeport, a key district heating pipe network will be built very close to the planned place of implementation. For the feed in of green electricity transformers are available on the site as potential connection points. Preliminary calculations show that a profitable biomass-based power plant could be set up in the port.
- Port of Vienna (PP4 – Port of Vienna) is already the largest port and trimodal logistics centre on the Danube in Austria. The study investigates the potentials of log wood/roundwood and waste wood / wood residues in the Danube Region east of Austria up to the coast of the Black Sea in order to disclose relevant insights into price structures and trends to justify business cases and/or logistical value chains. As a conclusion a conveyor belt system is to be installed which will also serve the new generation of the wagon fleets carrying biomass to the port.

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AFBC

Atmospheric fluidized-bed combustion

BKSZTT

Budapest Central Wastewater Treatment Plant

CAPEX

Capital expenditure

CEF

Connecting Europe Facility

CHP

Combined Heat and Power

FBL

Freeport of Budapest Logistics Ltd. (Budapesti Szabadkikötő Logisztikai Zrt.)

FŐTÁV

Budapesti Távhőszolgáltató Zrt. – District Heating Company of Budapest

FŐKERT

Fővárosi Kertészeti Nonprofit Zrt. – Capital Gardener Company

HEA (MEKH)

Magyar Energetikai és Közmű-szabályozási Hivatal – Hungarian Energy and Public Utility Regulatory Authority

HEV

Suburban railway in Budapest

IWT

Inland Waterway Transport

LNG

Liquefied Natural Gas

MCC

MAHART Container Center

METÁR (KÁT)

Renewable Facilitator System – Megújuló Támogatási Rendszer (formerly called KÁT as Kötelező Átvételi Tarifa)

MNV

Hungarian National Asset Management Inc.

NFM

Ministry of National Development

RES

Renewable Energy Strategy

TEN-T

Trans-European Transport Networks

TEU

Twenty-Foot Equivalent Unit

WWII

World War II

1. Executive Summary

The objective of this preliminary feasibility study is to assess the possibility of initiating a biomass-based energy production unit at the Freeport of Budapest.

Based on the preliminary analyses of the present situation, planned future investments and available infrastructure, MAHART Freeport Co. Ltd. is located at an ideal site for the implementation of a biomass-based energy production project. Via the port, the necessary raw materials can be supplied through a waterway-based logistics network. With the planned Galvani bridge nearby the Freeport, a key district heating pipe network will be built very close to the planned place of implementation. For the feed in of green electricity, transformers are available on the site as potential connection points.

Preliminary calculations show that a profitable biomass-based power plant could be set up on the site. However, many aspects of the investment criteria will have to be further clarified in a detailed feasibility study and through high-level negotiations with key stakeholders and partners.

During the assessment of the project, idea key values of necessary investments, possible incomes and operational costs for four different versions were calculated. In each case, both electricity and heat production and sales were assumed. For the raw material supply, the use of the Danube waterway was preferred.

The figure below shows the general flow chart of biomass-based energy production:

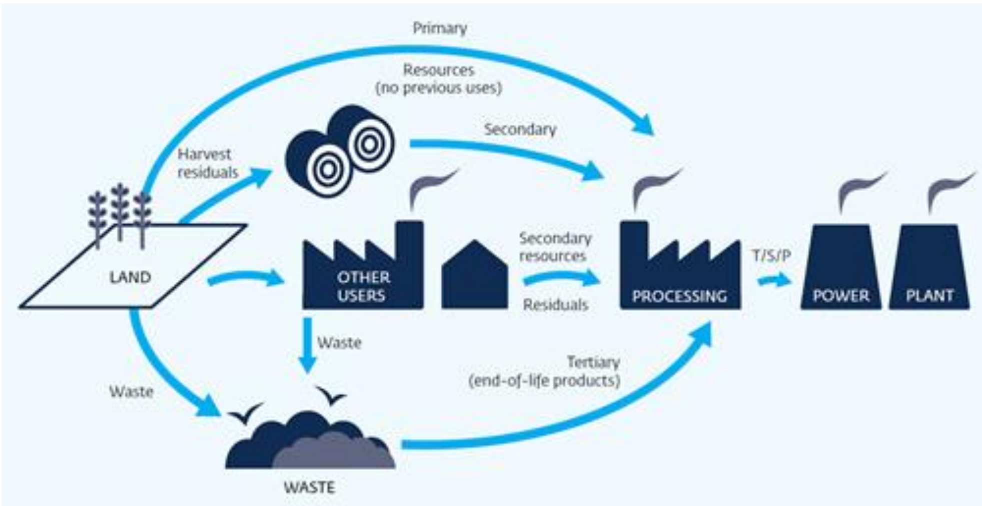

Figure 1. General flow chart of biomass-based energy production
Source: Own illustration

Based on the above calculations, a biomass-based power plant can be profitable and technically viable at the Port, however further analyses and negotiations are inevitable because there are risks in key factors of the project such as the following:

Availability and prices of energy biomass are key factors because of competing new investments based on solid biomass from forestry companies. The quantity and market of heat supply are key factors because of actual heat needs of present and future tenants of the Freeport, the planned new district heating pipe network of Galvani Bridge and the planned new power plant investment in the South-Pest (Budapest) area. A feed-in tariff for electricity is crucial because the prices are based on a competitive bed managed by the Hungarian Energy and Public Utility Regulatory Authority (HEA).

In order to continue the preparation of the project with more detailed information, the following steps are recommended:

Negotiations with potential heat purchasers (Metropolitan District Heating Company – FŐTÁV) are important based on heat output estimates to clarify long term market possibilities and prices. A detailed survey among tenants of the Freeport is also important to map their heat supply needs (quantities, temperatures, seasonality, technological heat etc.). Negotiations with HEA are recommended in order to calculate with possible load-in tariffs and terms based on electricity production estimates. Negotiation with Budapest Waterworks on the heat needs of the wastewater treatment unit, which is located north from the Freeport, can be useful to develop joint services, as functions of the Waterworks and the biomass power plant might possibly be connected. Negotiations with potential biomass suppliers (State forestry companies) are important to discover availability, prices and possible transport arrangements of woodchips. Negotiation with logistic companies is crucial to know biomass supply quantity data. Detailed feasibility analyses for different technically viable versions are useful too: technological (comparing different scales or potentially adapted technologies), cost analyses and financial target value calculations, and eventually transport costs based on quantity and loading prices, are to be estimated as well. Based on detailed feasibility study findings, negotiations on potential financing – subsidies, investors and financial institutions shall be completed too.

2. Introduction of the implementing organization

2.1. Organizational structure and activities

In this chapter, the ownership, management and operators of the Freeport of Budapest – the location of the planned project - are presented.

Port owner

The Public Port owner, i.e. the beneficiary of the project planned to be implemented in the Freeport of Budapest – is MAHART Freeport Co. Ltd. The Hungarian National Asset Management Inc. (MNV) had been holding the right of foundation of MAHART Freeport Co. Ltd. until 19 November 2014. The Minister of National Development changed decree 77/2012 (XII.22) about owner rights of managing companies by the state by decree 46/2014 (XI. 19). Hence, MAHART Freeport Co. Ltd. has no longer been owned by MNV, but now instead belongs to the portfolio of the Ministry of National Development (NFM).

MAHART Freeport Co. Ltd. has never had rights to run and maintain the Freeport of Budapest: neither before nor after its foundation by secession. Its founder established MAHART Freeport Co. Ltd. exclusively to have the owner rights. For running and maintaining the Freeport of Budapest, Freeport of Budapest Logistics Ltd. (FBL) is responsible. According to the privatization and operation contract, FBL committed itself not exclusively to the management of the port, but also to maintain the Public Port status properly.

MAHART Freeport Co. Ltd. had two employees in 2016 according to the company's official annual report (e-beszamolo.hu). As a state-owned company, there is one executive officer and an employee as general office manager and finance administrator.

Port management

The manager of the Public Port is a company or organization being the port owner or other organization that is responsible for maintenance, coordinated operation and development of the entire port by law according to legislation XLII year 2000 on water transportation. Management's tasks are:

- Maintenance:
    - organizing, operating, managing port logistics
    - organizing, coordinating, managing port services
    - operation, maintenance, renovation, reconstruction of such port equipment defined in contract
    - managing environment protection related issues of the port
    - organizing and operating port/logistics/ information system
- Managing utilization contract related issues
- Development management, especially designing future development principles
- Marketing

Being the beneficiary of an open public procurement in 2005, FBL is the manager of the Freeport of Budapest. The main profile of the company is to operate and develop buildings in the area of

the Freeport, renting treatment; logistic activities and services are provided by port operator companies.

Port operators

The operator according to 2000. XLII 87§40. is the owner of a floating facility or port, and has the right to operate the floating facility by legislation. In the case of the Freeport of Budapest, all the following actors participate in the operation of the Freeport:

- Owner: MAHART Freeport Co. Ltd.
- Management company: Freeport of Budapest Logistics Ltd. (FBL)
- Tenants, companies renting sites for their logistics services in the Freeport of Budapest. Main tenants providing logistics services and cargo handling are: ArcelorMittal Distribution Hungary Kft., Lagermax Car Transport Ltd., EKOL Logistics Kft., Ghibli Kft. and Mahart Container Center Ltd. (MCC)

Figure 2 shows the organization structure of port owner, port manager and port operators.

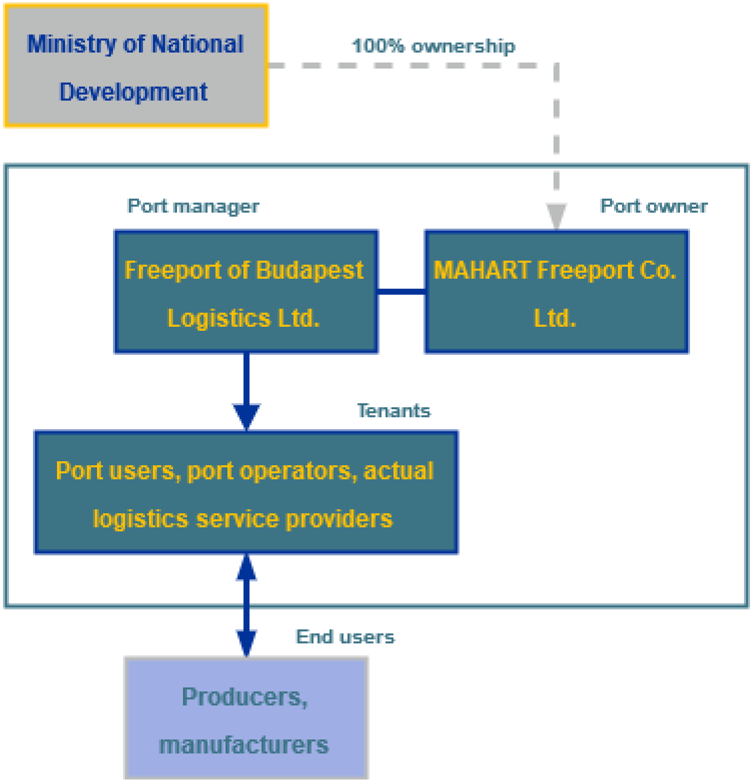

Figure 2. Organizational structure of the Freeport of Budapest
Source: Own illustration

Major port operators settled in the Freeport of Budapest

Operators of the port are private companies running their businesses at the port. FBL coordinates among them and supports them with hiring labour, meeting each other and improving their network, facilities and economic positions.

ArcelorMittal Distribution Hungary Ltd. is a subsidiary of a large steel company, employing 310,000 people in 60 countries. It is ranked among the world's top steel constructors, leading major global markets including automotive, construction, household appliances, packaging as well as R&D. The company holds operational rights and access for the properties of the Freeport according to a pact with the port management. Having been operating in the port area of nearly 0.4 ha with covered and open space storages since 2007, ArcelorMittal purchased a warehouse in 2013 by holding its pre-emptive right.

Ferroport Plc. was established in 1988 as a joint subsidiary of MAHART Freeport Co. Ltd. and a German private company M. Preymesser GmbH. Since then, Ferroport has been operating on its own 4.5 ha at the south-western corner of Commercial Basin I. The company has a 3,800 m^2 storage hall providing covered area and facilities for products arriving on road, rail or river. Ferroport has a 9,000 m^2 warehouse as well. Core activity of the company is handling metallurgic goods and agricultural products.

Lagermax Dunalogisztikai Kft. is a subsidiary of an Austrian company and has been operating in Hungary since 1990, having locations in Budaörs, Esztergom and since 1998 in the Freeport of Budapest as well. Employing 250 people, Lagermax works with a wide range of clients based on long term contracts e.g. Porsche Hungária, Ford, Toyota and partners from Ukraine, Romania and Serbia.

MAHART Container Centre Ltd. (MCC) operates a container terminal in the Freeport of Budapest and has intermodal services available (road and rail by the river). MCC has been operating in the port providing its own terminals independently for many clients since 1998. Having been growing since the 1990s, MCC has multiplied its container traffic. Therefore, the company requires ever improving infrastructure and equipment.

MAHART Gabonatárház Kft. (Grain Warehouse) is a subsidiary of FBL. The core activity of the company is grain storage and public warehousing. MAHART Gabonatárház undertakes full customs clearance for its partners. In its 3.3 ha hall, the company can store 30,000 tons of cereals, although it is not common to store more than 22,000-25,000 tons. Within the physical facilities of the warehouse, transit is made at customer's requests. The company handles several hundred thousand tons of transshipment per year. Since it was established in 1997, Agroterminatum is suitable for transhipping agricultural products intended mostly for export. It also ensures direct loading/unloading to and from river and road transport.

Ghibli was established in 1996 as a 100% Hungarian company, providing full-scale logistics services including transportation with Italian-interest and warehouse services since 1998. They have also been operating a VAT warehouse since 2004. On land, Ghibli manages distribution from warehouses to the whole country.

MASPED PORT Logistics Centre as a member of MASPED Group is a leading supra-regional distributor. The group provides high-end services to customers in Hungary and abroad in many branches. Since 2005, the company operates in the Freeport of Budapest, and provides services at two warehouses, taking the advantages of multimodal links to rail and river.

2.2. Description of technical, financial and legal capacity

Technical capacity

Northern connecting road has been constructed in order to relieve Weiss Manfréd road passing by the suburban railway lines on the Freeport side. This road is used by vehicles coming from the northern direction of the Csepel Island relieving Weiss Manfréd road. North-South connecting road also relieves Weiss Manfréd Road, as vehicles now can move into northern and southern directions within the port area.

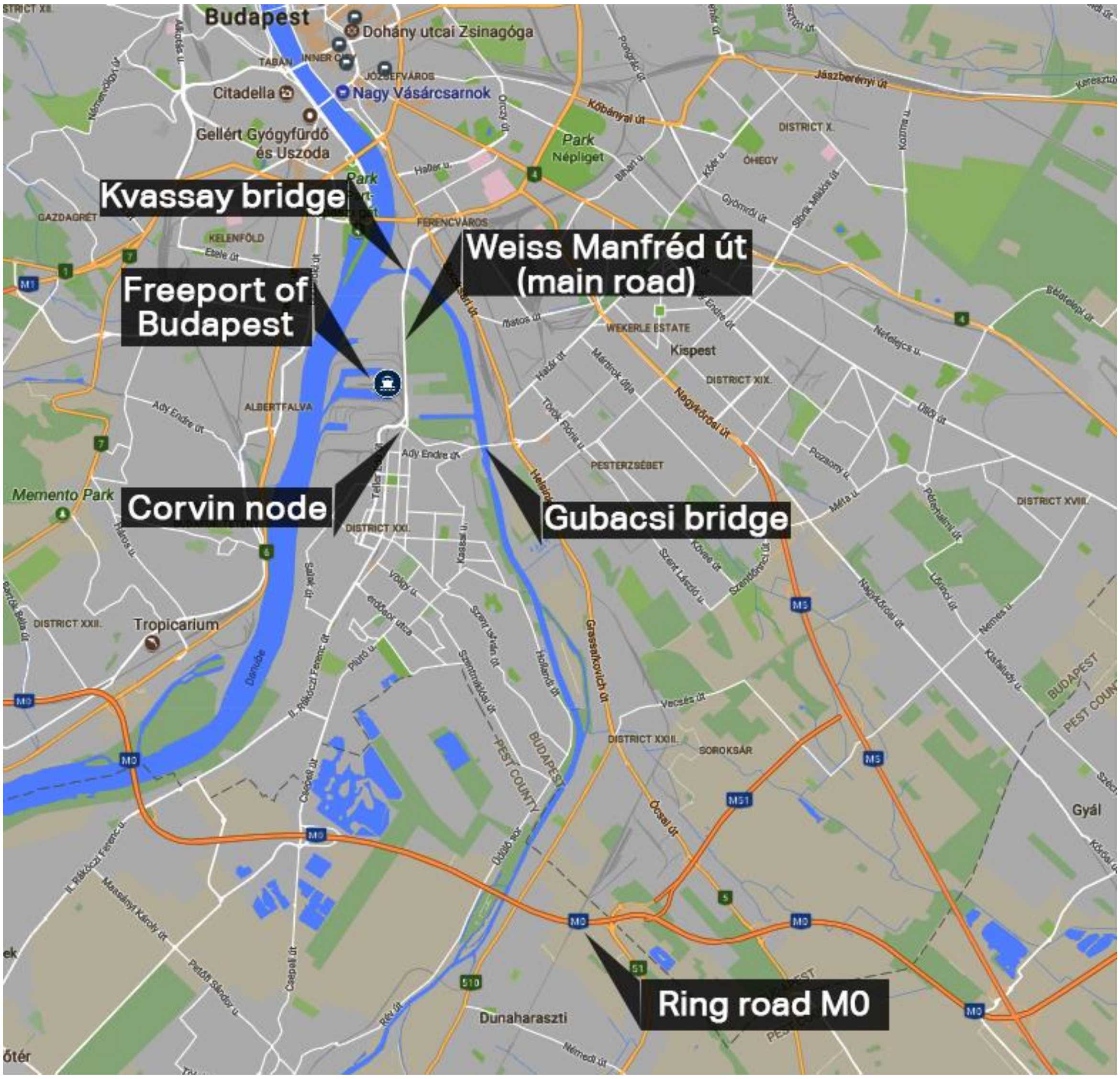

Figure 3. Infrastructural connections of the Freeport of Budapest
Source: Own editing based on Google Maps

There is a 13,200 m^2 parking place for lorries with good infrastructure and social facilities.

The port is designed for continuous maintenance and development of core infrastructure such as an internal railway network. The length of the internal railway network is 22 km: 17 km is for

public use and 5 km is closed to the public. As a result of already implemented investments, a 3.5 km long railway network has been reconstructed.

In the frame of modernizing Kültelki (exterior) and Mirelit railway lines, the core network in the territory of the Freeport has been reconstructed and developed for internal mobility.

Railway lines by the Grain Warehouse have been modernized as well, as new loading sites were built for a more efficient service provision. Open space loading sites and their railway lines have been reconstructed as well. Public utility, drainage and covered rail lines have also been created here.

10 years ago, in 2008, 200 m of vertical quay protection was developed with necessary portal facilities. At the open space loading site, modern, hydraulic loaders and more machines at different berths can operate all along the quay, even parallel with it.

Table 1. Core infrastructural information about the Freeport of Budapest
Source: MAHART Freeport Co. Ltd. Mobile Flood Dam Feasibility Study (2016) and *FBL (2015)

Port/berth basic information	
Area	1,533,000 m^2
Undeveloped area*	227,159 m^2
Storage capacity	Closed warehouse: 92,800 m^2
	Open space storage: 49,120 m^2
	Silo capacity: 5,000 m^2 Container terminal: 100,000 m^2
Handled modes of transportation	IWW
	Rail
	Road
	Multimodal
Number, type and lengths of quays	Vertical: 1,650 m
	Slope: 3,200 m
Max. size of vessel	Length: 150 m
Number of basins	Commercial basin I.
	Commercial basin II.
	Petrol basin (for oil products)
Number of berths	18
Length of industrial railway lines	17km
Number and length of main railway lines in the port	rail lines 2-5 by open space storing
	rail lines 20-26 for marshalling
	rail line 34 as transit lines to container centre
Handling closed freight rails	YES
Shunting station	YES
Extern shunting modes	Extern
Distance from highway	7 km
Distance from nearest river port	20 km
Number of parking places for cargo vans	64
Handling swaps	YES

Table 2. Core technical information about the Freeport of Budapest
Source: MAHART Freeport Co. Ltd. Mobile Flood Dam Feasibility Study (2016)

Handling facilities				
Total loading capacity	193,010 TEU capacity/year			
	1,011,301 t capacity/year			
Total container storage capacity	5.000 TEU			
Number and capacity of gantry cranes	Max. bearing capacity (ton)	Length above the water (m)	Loading capacity	
			Bulk cargo (ton/hour)	TEU (TEU/hour)
	2x12	5-15 m (depending on water level)	80	
	16/27.5	5-15 m (depending on water level)	60	
	5	5-15 m (depending on water level)	20	
	12.5	5-15 m (depending on water level)	30	
	16	5-15 m (depending on water level)	30	
	32	10 m		100
Number and capacity of other cranes	Max. bearing capacity (ton)	Type of cranes	Loading capacity	
			Bulk cargo (ton/hour)	
	3x6 t 5x10 t	Gantry cranes in warehouse	50	
Loaders	-			
Forklift	Capacity		Quantity	
	< 3 ton		3	
Conveyor belt	-			
Pneumatic equipment	-			
Ro-Ro ramp	Cars	Vans	Rail wagons	
	capacity (vehicle/hour): 100	capacity (vehicle/hour): 25	-	
Port management information system	Managing vehicles			
	Traffic management			
	Protection of port equipment and buildings			
Other loading and container moving facility	Gantry crane			
	Container moving ‘Kalmar’			

Terminal for crude oil carrying	-

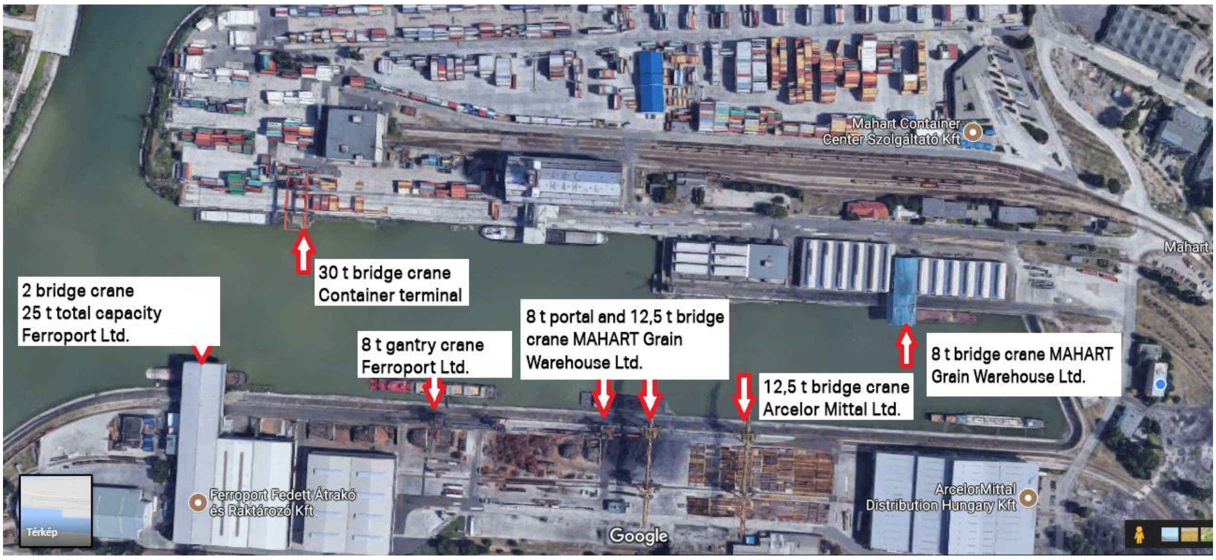

Figure 4. Location of equipment and capacities in the Freeport of Budapest
Source: BSZL – Budapest Dock Budapesti Szabadkikötő Logisztikai Zrt. (Freeport of Budapest Logistics Ltd.)

One of the most relevant actors in biomass handling in the Freeport is MAHART Gabonatárház Kft. (Grain Warehouse Ltd.). It operates the covered loading area of Agroterminal for loading to/from road and ships. Multipurpose equipment - a 10.5 ton bridge hydraulic gripper spatula and slide, extending over 14 meters above the water - provides fast, reliable and professional transshipment, thus accelerating service for waiting and outgoing ships. Jointly with Agroterminal, Gabonatárház usually deals with grain handling, and has experiences on loading coke, break bulk goods and fertilizer.

Financial and legal capacity

Within the territory where development will be implemented, Freeport of Budapest Logistics Ltd. (FBL) has the right to operate the Freeport of Budapest for 75 years due to the privatization and operation contract between them. This contract includes the possession, utilization and use of property owned by MAHART Freeport Co. Ltd. The infrastructure planned to be developed in the frame of the current project will be used at the Freeport. New facilities based on project ENERGY BARGE will also be owned by MAHART Freeport Co. Ltd. but operated by FBL. Therefore, core information on their financial situation is presented in table 5.

Table 3. Financial data of the port owner MAHART Freeport Co. Ltd. and port management FBL
Source: opten.hu and e-beszamolo.hu

	MAHART Freeport Co. Ltd.		FBL	
	2015 (EUR**)	2016 (EUR**)	2015 (EUR**)	2016 (EUR**)
Net sales revenues	366,394	363,659	7,072,785	6,920,577
Profit before tax	2,038	104,315	-87,312	1,890,830
Shareholders' equity	2,845,662	2,940,445	1,785,789	3,332,375
Total assets	23,124,524	23,814,590	23,527,962	24,818,593
Operating result	-2,281	101,568	2,573,675	2,132,659
Headcount	2 persons	2 persons*	13 persons	12 persons

Notes:

*current headcount: 5 persons.

**These calculations were accounted in Hungarian Forint, base of estimations is HUF 317=EUR 1.

Table 3. shows that the port owner – and project partner – MAHART Freeport Co Ltd. has a low-level of income and therefore does not have the financial capacities to make larger investments from its own resources. The FBL as a private actor in the market might potentially be capable of managing the investigation and later maintain the establishment. Further options are described in Chapter 6.

2.3. Previous investments

Completed projects in recent years

'Intermodal and capacity building development of the Freeport of Budapest – Phase 1' (KÖZOP-4.5.0-09-11-2012-0003

The Project was co-founded by the EU and was implemented in 2013-2015. The Freeport of Budapest has a 7.1 km long road network. In recent years, project 'Intermodal and capacity building development of the Freeport of Budapest – Phase 1' has been implemented: 70,000 m^2 of road has been (re)constructed and public utilities have been modernized. The project was financed in the framework of the following call: 4.5.0 of Transport Operational Program in 2015 (SZÉCHENYI2020, 2018). In the framework of the project, the following developments were completed:

- modernization of Kültelki (exterior) and Mirelite rails
- construction of small open space loading site and Commercial basin II
- lighting the 5th rail line
- construction of the northern section of the Northern connecting road
- construction of roundabout and the southern section of the Northern connecting road
- construction of north-south connecting road
- construction of parking place IV
- reconstruction of railway lines and pavement at the Grain Warehouse
- reconstruction of railway lines and pavement at the open space loading site

'Development of basic infrastructure of MAHART Hungarian Shipping Co. Ltd. in the Freeport of Budapest' (KÖZOP-4.7.0-15-2015-0045)

The objective of the project cofounded by the EU via the Transport Operational Program in 2015 was to improve the accessibility of services provided in the Freeport of Budapest. MAHART planned to create enter and exit points at the meeting of public and private areas in the port. The purpose of these points is to register, control and load cargo vehicles. During development, 2,950 m^2 received new pavement. Parking and related services improved, resulting in better access to port services. Managing internal traffic could become safer and more controlled by establishing new facilities.

Ongoing projects

'MAHART Mobile Flood Dam' (IKOP-2.1.0-15-2016-00025)

The objective of the project – implemented in the framework of Integrated Transport Development Operational Program – is to reduce risks of floods in the Freeport of Budapest and to reduce the number of occasions when the port has to pause operations. Floods significantly affect waterside operations, but compromise road and rail transshipments, too. By constructing a mobile dam in the Freeport, waterside operation will not change much compared to the situation without the dam, but at least it will ensure that road and rail transactions are no longer at risk. The Freeport will become a more countable and expectable place of business for tenants, and trade in goods will not need to be reduced.

'PAN-LNG-4-DANUBE (Connecting Europe Facility 2015-HU-TM-0349-M)

PAN-LNG-4-DANUBE is a dedicated project being implemented with the coordination of the Ministry of National Development and granted by the Connecting Europe Facility (CEF) via its Transport priority. The project contributes to the increase of inland waterway liquefied natural gas (LNG) use by constructing infrastructure and establishing the first fixed and mobile LNG stations. Objectives of the project are:

- Creating the infrastructural background for both profitable and eco-friendly operation of LNG fuelled inland waterway transport (IWT)
- Establishing a regional knowledge and service centre
- Transforming a vessel to be capable of LNG consumption as a regular full-service boat
- Providing information, data and experience regarding LNG terminal.

During the project, there will be an LNG fuel terminal installed for ships at the Freeport of Budapest and a floating supplying vessel constructed.

Master Plan and feasibility study for the development of the TEN-T ports, including Komárom Port (Connecting Europe Facility 2015-HU-TM-0152-S)

The master plan for strengthening Danube freight transport by improving TEN-T (Trans-European Transport Networks) port infrastructure, especially in the Port of Komárom, is a dedicated project being implemented with the coordination of the Ministry of National

Development and granted by the Connecting Europe Facility (CEF) via its Transport priority. Project objectives are:

- Ensure the competitiveness of Hungarian TEN-T port capacities
- Increase the volume of IWT and transshipment
- Increase the share of sustainable IWT
- Reduce environment pollution

As a result of the project a 'main plan' on the development of Hungarian TEN-T ports will be elaborated on, analysing IWT while looking at international aspects.

3. Analysis of the current situation

As declared in the National Renewable Energy Action Plan, Hungary has great agro-ecological conditions for long-term biomass production. Regarding volumes, solid biomass for energy purposes will show the largest growth by 2020. The sector is committed to the utilization of energy biomass for local heat generation purposes and electricity generation if possible by the construction of low to medium capacity local biomass-based power plants.

In this chapter, the hinterland of the port (defined as a 100-km radius) mostly includes Central-Hungary. Unfortunately, national data is provided as there is no available information specifically on this 'hinterland-level' on bioenergy raw material supply.

3.1. Supply of bioenergy raw materials

The focus of this chapter is biomass raw materials available in the hinterland of the Freeport of Budapest. Raw materials for biofuel and biogas production are less relevant in terms of the planned new establishment in the port. After presenting areas with different purposes (forestry and lands), annually harvested volumes will be named. Based on data provided by partners (forestry, district heating companies) those quantities of biomass extracted and transhipped to the port are defined by the power plant they could be operated by. All in all, the most suitable power plant based on the maximum available raw materials can be defined.

3.1.1. Hinterland of the Freeport of Budapest

Biomass raw materials are available from forest and agriculture. As declared in deliverable 3.1.1 of the ENERGY BARGE project, the most potential has wood biomass from forests among different feedstocks e.g. wooded lands, agriculture. Great plains with large fields are out of the hinterland (defined by ENERGY BARGE as a 100-km radius) to the south from the capital, however, the hinterland which more or less covers the Central-Hungary region, has still quite promising

feedstocks as described below. As statistics and information were not always available on the hinterland level, in some cases national statistics were used.

In Central-Hungary, arable land amounts to 300,000 ha, and uncultivated land to 190,000 ha. Grassland, orchards, reed and vineyards are also noticeable with more than 80,000 ha overall.

In the territory of the capital, there are plenty of public parks covering approximately 2,370 ha.

The region's woods, forests and the capital's public parks are maintained by several organizations. Pilisi Parkerdő Zrt operating in Komárom-Esztergom, Pest and Bács-Kiskun counties are the largest forestry covering 65,000 ha. Ipoly Erdő Zrt, operates in Nógrád and the northern parts of Pest county on 64,000 ha overall. HM Budapesti Erdőgazdaság Zrt covering 37,000 ha belongs to the Ministry of National Defence.

The following map shows land use in the hinterland of the Freeport i.e. Central-Hungary and beyond.

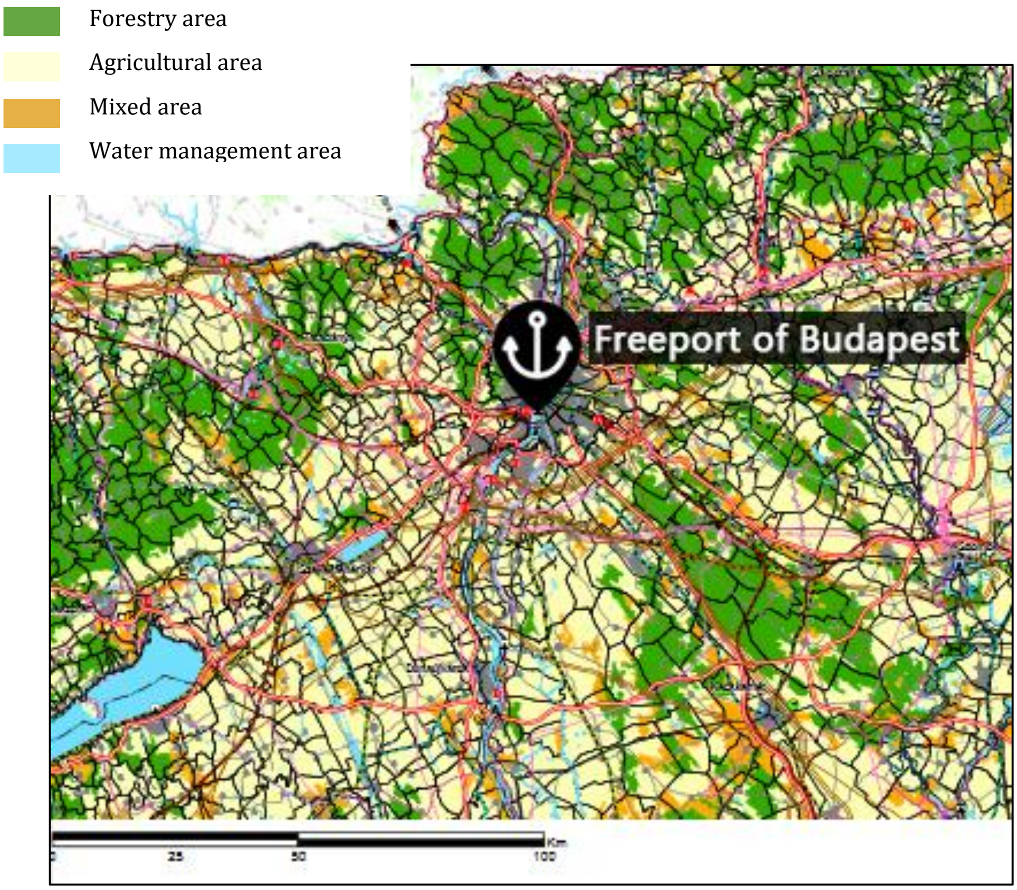

Figure 5. National land use categories (Central-Hungary)
Source: National Spatial Planning Plan of Hungary (2014)

3.1.2. Potential amount of raw materials from the hinterland

In Central-Hungary, 250,000-300,000 tons of waste from both wood extraction and processing are available, but green waste generated in parks and forests can hardly be used as raw materials. A competitor activity of the planned project is composting, a common practice in the capital and the suburban area in regard to park and forest maintenance. FŐKERT Zrt. (Capital Gardener Company) collects and processes biomass from public parks for composting purposes in Budapest and the agglomeration. (FŐKERT Zrt. 2018)

Regarding the average yield, sugar beet has potential in Central-Hungary (71,740 kg/ha). The average yield per ha is quite high in Central-Hungary in comparison to other regions, but the area for sugar beet production is very limited: 445 ha in 2017, which is only a small fraction of other regions' land.

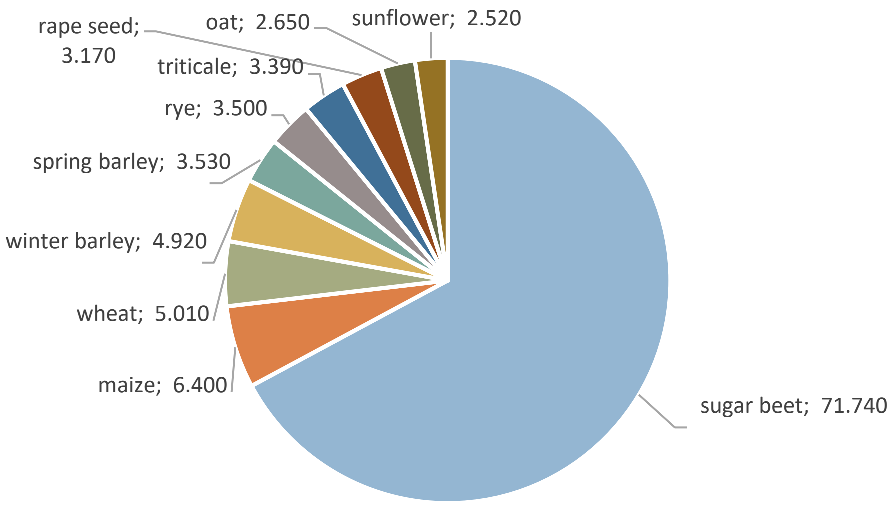

Figure 6. Average yield of all crops in Central-Hungary in 2017 (kg/ha)
Source: Own editing based on KSH data (Central Statistical Office, 2016 and 2017)

As examined in Deliverable 3.1.1 of the ENERGY BARGE project (Compendium of national market study reports), experts expect major biomass raw material use will change. The share of crops specifically grown for energy purposes will decrease while use of by-products and waste-products will increase. According to Deliverable 3.1.1, the ratio of waste among other biomass raw materials will reach 50% by 2020.

3.1.3. Actual amount of available raw materials to be utilized

In the framework of Deliverable 3.1.1 one of the ENERGY BARGE project partners, NARIC, gathered information on the national level on quantities of biomass that can potentially be used for energy generation on a medium term basis (i.e. 7-15 years) in Hungary, as well as the amount

of energy that could be generated. Due to the lack of available data specifically from the hinterland national-level, statistics are used. Here below is the referred table.

Table 4. Quantities of biomass to be secured for energy generation on medium term in Hungary
Source: ENERGY BARGE D3.1.1

Source of biomass	Realistically produced/collected (million t/year)	Energy content (PJ/year)	Electricity (GWh/year)
From forestry	3.25	45.5	2,275
Produced for this purpose	5.6	74.16	6,180
Agricultural by product and waste	5.4	62	5,100
Other by-products and waste	0.55	6.6	550
Total	**14.8**	**188.26**	**14,105**

In 2016, the nationally planned forest area decreased by 0.1% (FATÁJ 2018). This is due to different forms of utilization of forests and a high volume of extraction with other purposes. Meanwhile, plantation of forest decreased as well.

However living wood stock increased by 3,300,000 m^3. In 2016, 56.4% of the timber growth was harvested, i.e. 0.2% less than in the year before. Further increase in the proportion of forests for protection purposes serves to increase their biological richness.

Table 5. Areas directly or indirectly serving forestry in Hungary
Source: Ministry of Agriculture (2017)

Planned forest area	1 Jan 2016	1 Jan 2017	Change
	ha		
Forest area	1,940,720	1,939,342	-1,378
Other	120,099	119,386	-713
Total planned forest area	2,060,819	2,058,728	-2,091

From 2015 to 2016, arable lands decreased by 11,000 ha (Ministry of Agriculture, 2017). On 1 January 2017, according to the National Forest Database, forests were 1,939,342 ha (20.8%).

Table 6. Ownership structure of forests in Hungary, 1 January 2017
Source: Ministry of Agriculture (2017)

Forest area ownership structure	%
Public (state-owned)	56.15
Community-owned	1.04
Private-owned	42.81
Total	100.00

In Hungary, since 2009, the share of protected forests has been increasing, while the share of forests with economic purposes has been decreasing. This trend is due to soil, water, municipal and natural environmental protection.

Table 7. Primary purposes of forests in Hungary, 1 January 2017
Source: Ministry of Agriculture (2017)

Planned forest area	%
Protection purposes	37.4
Economic purposes	61.4
Common wealth (health care, parks, experimental forest, etc.)	1.1
Forest plantations	0.1
Total	100.00

Living wood stock in the country has been increasing since 2004, because annual increment exceeds factors causing decrease (e.g. extraction, mortality, damages).

Hungary's living wood stock is 381.9 million gross m^3 (bark and twigs included). The average living wood stock is 204 m^3/ha.

Table 8. Forest stock management in Hungary
Source: Ministry of Agriculture (2017)

Definition	2015	2016
Extracted wood stock (thousand m^3)	7,354	7,338
Thinning (thousand m^3)	5,015	4,909
Cleansing (thousand m^3)	1,492	1,647
Other use (thousand m^3)	617	538
Reforestation (ha)	20,083	20,137
Empty areas and replacement (ha)	73,883	70,153
Successful first-time forestation (ha)	19,989	17,831
Completed reforestation (ha)	18,853	19,065
First-time implementation of forestation (ha)	318	158
Completed forestation (ha)	5,799	5,662

The afforestation program is co-financed by the European Union. Due to the cyclical characteristics of EU sources, the previous drastic decline in afforestation continued. The first extraction area was 158 ha in 2015/2016, which is half of the area as in the previous year. The first production of oak decreased by almost 18% compared to the previous year and oak is 40% in total, acacia is 16.6% and domestic aspen and other softwood 22.8%. 48% of the first production of afforestation had economic purposes, while 52% were for protection purposes, 38% were private, 13% belonged to communities and 49% were owned by the public sector.

3.2. Demand for raw materials

In Hungary, energy biomass is primarily used by households as firewood or utilized by former coal power plants in larger quantities (approx. 13 PJ in 2013) (MEKH-MAVIR, 2014). These power plants are mostly characterized with low efficiency and high greenhouse gas emissions. Their fossil fuels are partially or entirely switched to biomass-based production as biomass or waste incineration is CO_2-neutral according to EU policies. They completed the change with or without any technological transformation (e.g. plants in Pécs and Oroszlány) to meet stricter regulations. Using high quality logs is unsustainable due to the lack of available raw materials. In case of future energy systems, biomass potentials should be favoured by agricultural and forestry by-products and wastes that are not essential for soil replenishment. Furthermore, compromise on the use of energy crops is necessary, limiting their possible use in time and space.

Based on interviews with forestry experts, solid biomass raw material stocks for energy production are more and more limited especially in regions where larger biomass power plants are in operation. Annual firewood production is between 3 – 4 million m^3 in Hungary, showing a trend towards reduction since 2010. More than 50% of production is from state forestry companies who are also responsible for the social household firewood supply, which requires safety reserve stocks and limits available quantities on the market.

Beside biomass power plant use, households have increasing supply need as well. Because of increasing demand, prices have increased in recent years.

In many cases, suppliers prefer shorter contract periods in order to adjust theirs prices to the actual market situation.

Most of the wood used for energy production purposes is harvested for firewood, but cutting waste and industrial waste are used in smaller quantities. The increase of energy purpose plantations is limited, although increasing demand may bring new investments to this sector as well.

When initiating a biomass project, the amount, quality, and availability of the biomass is essential for the success of the project. The characterization of the different types of biomass consists of their calorific value (energy content of the fuel), biogas potential, chemical composition, ash content, and moisture content. It is also important to explain the elements needed to secure biomass availability, including supplier agreements, realistic transport distances and acceptable costs of collection, transport and storage all need to be taken into consideration when evaluating the right fuel for the power plant.

Table 9. Main characteristics of the most common biomasses available in Central-Hungary
Source: IFC (2017)

Biomass	Form of trading	Energy conversion technology	Net calorific value MJ/kg	Bulk density, kg/m³	Ash content, %	Moisture content, %
Wheat straw	bales	combustion / fermentation	16.6-20.1	20-40	n.a.	n.a.
Woody biomass	chips / chopped (20-80)	combustion	18.6-19.8	200-330	0.4-2	15-55
Switch grass	20-80 (chopped)	fermentation / combustion	15.7	49-266	4.3	8-15

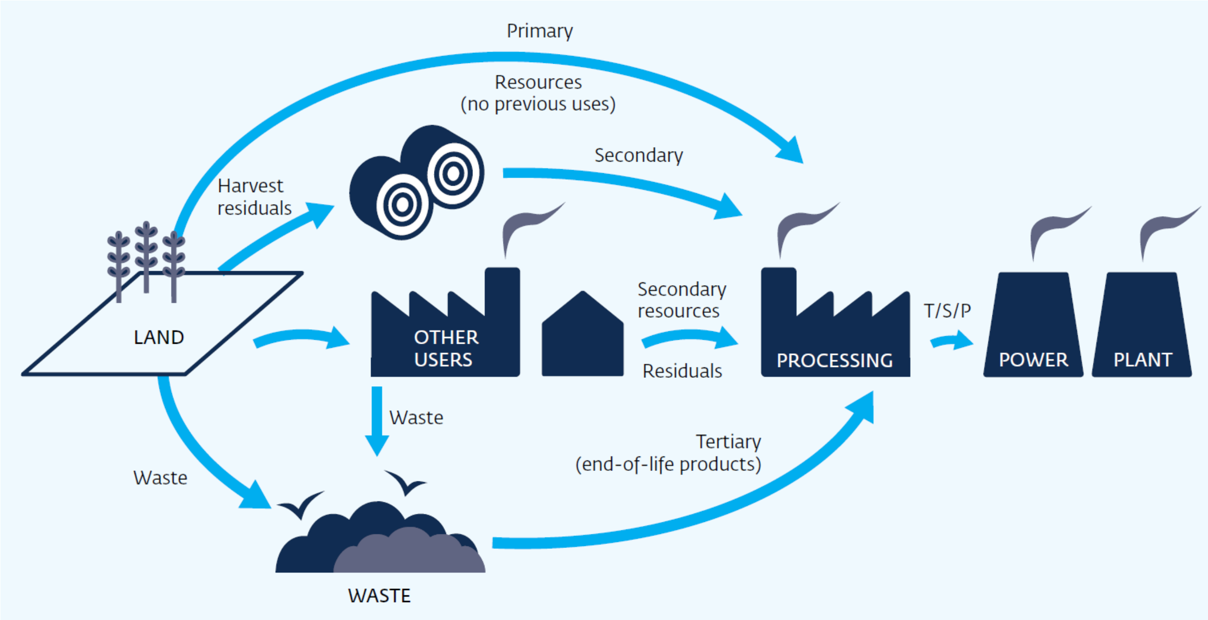

Figure 7. Categorization of potential biomass sources
Source: IFC (2017)

3.3. Existing value chains, industrial and logistics capacities for energy biomass

In Hungary, demand for renewable energy is increasing, and therefore 8,000,000 tons of biomass will be required by 2020 annually. Almost half of this is available in public and private forests throughout the country.

Power plants have intensive raw material demand taking up the majority of sustainably logged timber capacities of forests in the country. Besides forest management, agricultural by-products and energy crops, the greatest potential is in the pellet market.

Characteristics of solid biomass determine its transportability and possible transportation distances; technological and logistics improvements are required. Systems of decentralized heating plants mean a possible solution for utilization of biomass with energy purposes. Because of functioning support mechanisms, biomass in Hungary is mostly utilized in co-firing with coal in larger scale power stations in a centralized energy system, driving national problems regarding unsustainability in energy biomass utilization and transportation. Thus, biomass is mostly efficient when used locally in small scale plants in the frame of a decentralized regime – however, this first requires a well-designed afforestation policy and strategy, as currently Hungary lacks wood.

Boilers and boiler manufacturing are well-developed in Hungary, and special types of boilers are designed to be suitable for burning green by-products. 7% of Hungary's decentralized heat demand could be supplied with pellets, providing heat and thermal water for 234,000 households.

Unfortunately, there are hardly any existing value chains among industrial and biomass logistics market players around the Freeport of Budapest, or even throughout the country. In case of

implementation, customers are partly given: a target group of port operators with offices, warehouses and companies settled in the port.

3.4. Currently available infrastructure at the port, technical conditions

The owner of the infrastructure is MAHART Freeport Co. Ltd., representing the Hungarian State in the public port. Freeport of Budapest Logistics Ltd. is responsible for maintenance of the road and rail network, water side and public utility related infrastructure.

The Freeport of Budapest was created by constructing basins on the western side of the Csepel Island in the 1920s. Public utility of the Freeport was designed for dependent self-service. Electricity connections were developed before WWII, and were linked to the plant of Weiss Manfréd Steel and Metal Works. After WWII, connections to public water were developed, then to traditional gas in the 70s. Through this development and connection, partial supply of the Freeport had been solved, and operation has continued in the same manner to this day.

In 2012, sewage water channels were developed in the port. Buildings had been linked to this network by the end of 2017. At the outflow points of the rainwater network, oil and sediment isolating structures have been installed.

In the framework of partial public utilities supply, drinking and fire water supply, rainwater drainage, natural gas supply, electricity supply and electronic communications network system, sewerage is a unique and local solution.

In the Port, basic infrastructure elements are available for energy production. However, further developments are necessary as well. For the distribution of thermal energy, the old district heating system is out of use, and most buildings are now supplied by their own natural gas boilers. A previous study analysed the infrastructural development needs of new development areas and made estimations for public utility capacities. That time, the concept for central local heat production was not analysed.

Beside the local heat supply for tenants of the Freeport, new investment may open new possibilities for selling the heat produced in a new biomass based power plant. There are preliminary plans for a new bridge (Galvani Bridge) which connects the two sides of the Danube using territories of the Port as well. The new bridge will serve as a network element of the district heating system connecting the FŐTÁV system.

For electricity, many transformers are available in the area that can serve as connection points for the feed-in of electric energy. At both potential locations for the biomass based powerplant, electric network connections are available within optimal distance.

Thermal energy

Heat produced in the planned power plant can be utilized in two ways – supplying the present and future tenants of the Port, and through the FŐTÁV district heating system.

Regarding local utilization, previous studies made estimations on heat needs of existing buildings (short term) and development areas (long term).

Requirements differ the most in terms of thermal energy in short and long-term concepts. This is due to the low rate of office functions in tenant buildings of the Port, as most of them are warehouses or smaller production units. Numbers in the left most columns in Table 13 refer to Figure 8 facilities shown.

Table 10. Thermal requirements in short and long-terms

Source: FBL (2017)

Nr.	**SHORT TERM Thermal requirements**				**LONG-TERM Thermal requirements**				**Difference**
	office	hall	refrigerated hall	total	office		hall	total	total
	kW	kW	kW	kW	m³/day	m³/ day	m³/day	m³/day	m³/day
1	34	11	17	61.9	1,753.9	0	0	1,753.9	1,692
2	39	15	23	77.3	2,639	0	0	2639	2,561.7
3a	34	13	20	67.7	1,294.3	0	0	1,294.3	1,226.6
3b	17	6	9	30.9	627.2	0	0	627.2	596.3
4a	53	16	25	93.9	188.7	16.2	25.2	230.1	136.2
4b	53	15	24	91.2	192.6	15.1	23.6	231.3	140.1
5a	56	38	60	154	342.1	37.5	58.6	438.2	283.8
5b	56	38	60	154	348.8	38.2	59.7	446.7	292.3
5c	32	9	14	54.8	90.9	14.9	23.3	129.1	74.3
5d	39	21	33	92.1	129.5	21.3	33.2	184	92
6	0	0	0	0	0	0	0	0	0
7a	0	0	0	0	528.9	0	0	528.9	528.9
7sz	0	0	0	0	392	0	0	392	392
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10a	101	21	33	155	125.6	20.6	32.2	178.5	23.5
10b	118	25	39	181	92.8	15.2	23.8	131.9	-48.8
10c	35	19	30	83.7	91.8	15.1	23.6	130.6	46.9
10d	28	9	14	51.6	1,011.8	0	0	1,011.8	960.2
11	0	0	0	0	0	0	0	0	0
Total	**692**	**256**	**401**	**1,350**	**9,849.9**	**194**	**303**	**10,347**	**8,997.9**

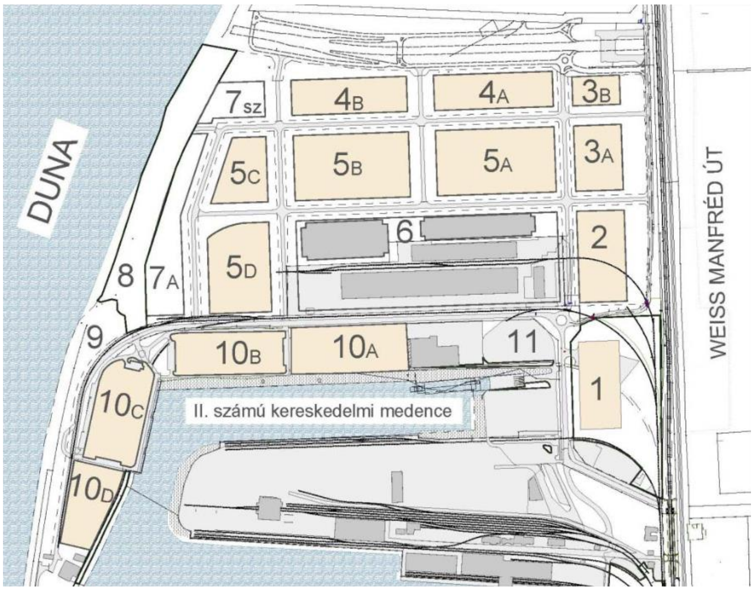

Figure 8. Facilities of the development area
Source: FBL (2017)

Thermal energy supply can be ensured by sources such as

- traditional gas supply
- district heating supply
- a heat pump installed on 2x600 sewage channel
- a heat pump installed on the Danube water abstraction
- ground probe installation
- construction of a biomass power plant and reconstruction of the current supply network

Electricity

Electricity distribution in Budapest is provided, and the network is operated by ELMŰ Hálózati Kft. (ELMÜ Network Ltd). Electricity is supplied through this network, but it is established under a competitive market contract. ELMŰ operates a 132 kV network that used to be a transmission network. This network supplies 132/10 kV substations as well. Medium voltage ground cable circuits starting from substations support 10/0.4 kV transformers satisfying direct customer needs. Consumers receive electricity through a low voltage network.

When determining energy fees and system usage fees, the supplier takes into consideration whether the distributor (ELMŰ) or consumers are responsible for completing the distribution tasks listed above. In exchange for taking over the operator's tasks, smaller system usage fees and energy charges have to be paid. The customer undertakes the operation of certain sections of the network.

The average consumer takes a low voltage, and in this case the distributor is responsible for investing in the low voltage network as well.

In the case of higher energy demands, if the consumer is willing to undertake the difficulties of establishing and operating the low voltage network, low and middle voltages are possible. The cost of setting up the transformer is on the distributor. In this case, power supply is measured at the low voltage side of the transformer, and operation is the consumer's responsibility from this moment. Operating the low-voltage network is not a particularly complicated activity; hence, a simple electrician is able to deal with it. The port is currently being supplied according to this procedure.

In the case of medium-voltage supply, the consumer assumes the operation of the transformer or even a part of the low voltage network. In exchange, energy charges and fees are more favourable. Furthermore, energy distribution between transformers is becoming possible.

In the case of low or medium voltage, the consumer reserves a certain volume of power of a certain transformer. In an advantageous situation, even two or three storage halls can be supplied from one transformer, but not more because otherwise too many underground cables would be laid down and huge investments would be needed. Peak demands can only be balanced if consumers are supplied by one transformer, i.e. low voltage balance can be ensured.

In the case of medium voltage, the operating costs of the transformer and medium voltage network are taken over. However, the required energy demand can be expanded more accurately, thus saving a lot of energy. The energy consumption is balanced within the medium voltage supply.

The more extensive the network, the less likely parallel peak loads appear. Thus, the amount of energy taken is reduced in proportions. It is worth considering dealing with transformers operating on parcel 210028/3 in the long-term. Currently, there is a problem with low voltage balancing the demands on the parcel by using locally spread transformers. Availability of the container- and v-crane capacities also causes issues.

Parcel 210028/3 can be supplied by reconstructing the medium voltage grid for the Northern Development Area. Establishment fees for connection and public networks are set out in the MEKH Decree 7/2014 (IX.12.). The system usage fees valid from 1 January 2017 are contained in the MEKH Decree 10/2016 (XI.14.).

There is an additional possible synergy in the development area: the port's transportation and storage possibilities make the area perfect for logistical purposes for biomasses, e.g. the biomass shipped in could be distributed by train or by using public roads.

Possible location of loading/unloading and buffer storages

The overview of the site is shown on the figures below, as are the potential development sites of the biomass power plant.

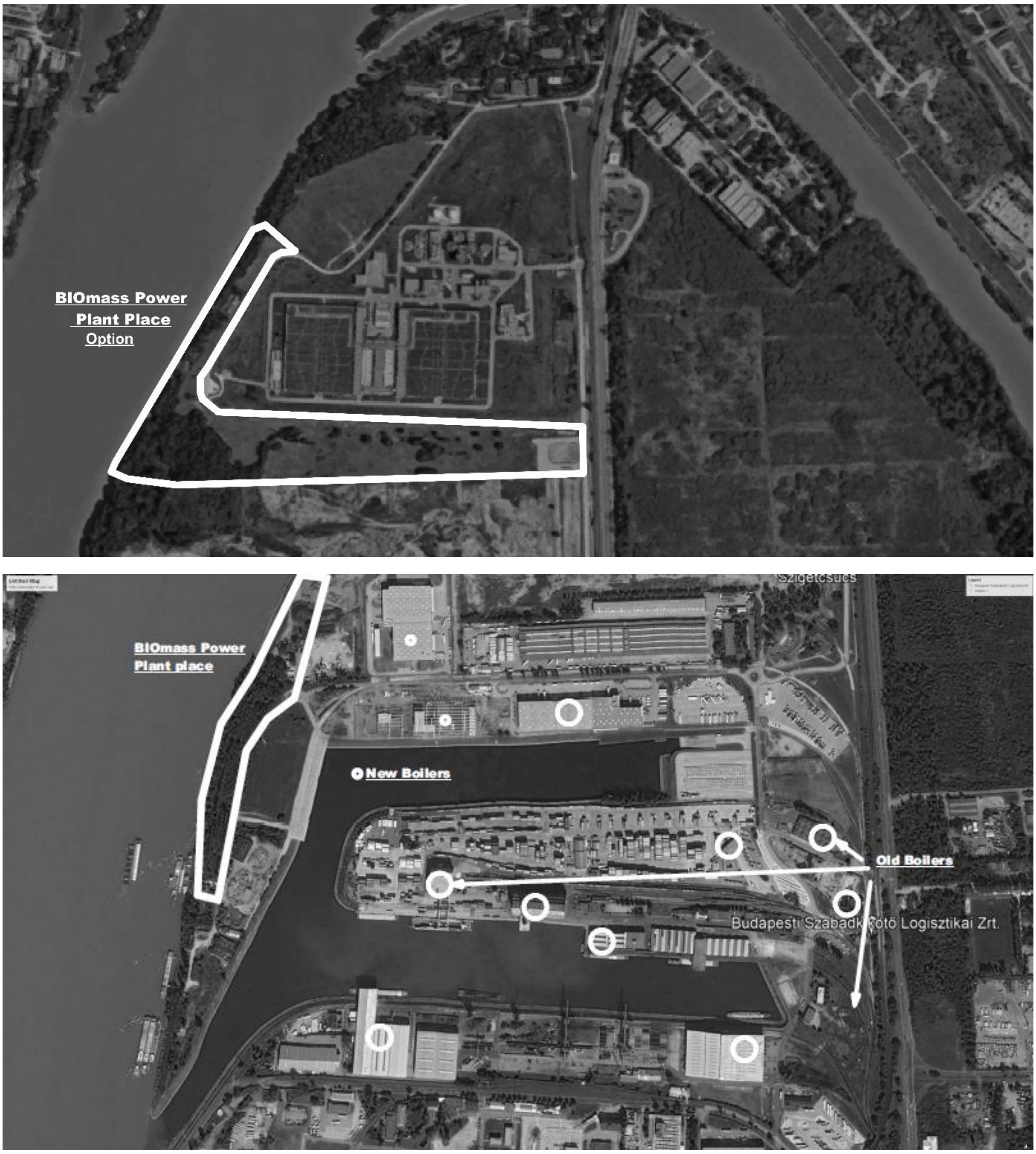

Figure 9. The potential development sites
Source: own editing based on FBL webpage

4. Development issues

4.1. Analysis of future requirements and demand

Future heat and electricity demands may come from two main directions, partly from the heat and electricity demands of the new real estate developments within the port. Partly from neighbouring investments, or network connections which make energy transfer possible.

From a network connection point of view, the planned Galvani bridge project, which connects the two sides of the Danube at the port, may give ample opportunity for a new energy production unit.

Heat supply of buildings within the Port and neighbouring developments

In this chapter, information and descriptions presented regarding inner energy supply of the Freeport of Budapest are based on the Concept Plan for Public Utility Supply of the Northern Development Area (KÉSZ Tervező Kft, 2017 – Északi Fejlesztési Terület Közműellásátási Koncepcióterv) completed for Freeport of Budapest Logistics Ltd. (FBL) and also future connection possibilities which other energy demands.

The regulatory plan approved for the area provided allows significant construction going far beyond mid and long-term needs of the port, so it is not a baseline for public utility network development.

During the preparation of the concept plan, estimated utility requirements were reduced by clarifying investors' and operators' ideas. Based on data on requirements of FBL and port operators, two major concepts were taken into account. The long-term image is to become a city-logistic hub with such warehouses, meanwhile in case of the short-term concept, less offices and more warehouses and halls will be constructed. As a result of the short-term concept, demand of public utility is significantly lower, but this is only in case of initial investments in certain branches.

Public utility of the development area is carried out along the roads regulated in the current regulatory plan. Relatively wide exploration paths will be created so that the maintenance of public utilities can be ensured by one-sided drilling, which is necessary due to frequent freight traffic. The area of some large objects (sewage lifting, concrete house of transformer) goes beyond the width approved in regulations, so that they can be located within the land boundaries. As a result of the green area placement, surface of manholes and objects do not have to be covered in the casing. Where public utilities cross roads, they will be designed in a way that the can be exchanged and repaired without reconstructing the surface of roads.

Depending on the utilization of the development area, utility requirements can differ. Smaller capacities are needed in simple halls, while the greatest energy and water demand is expected to occur in advanced office functions. Special producer, processor and manufacturer needs are not yet known, but their service is expected to require specific public utility development.
When estimating needs, expected number of stuff, constructions and installations were taken into account, which established estimated requirements on public utilities by branch. Estimates were made for both short and long-term concepts, as the vast majority of public utilities were made to last longer than installations designed for the short-term concept. Furthermore the area's

regulation plan (the build-up area of individual plot cannot exceed 70%) and the future plans of the investors (significant demands for storage hall vs. office) also were taken consideration resulting an estimation of nearly 3000 new employees and additional electricity consumption of 15 MW. investor's vision had significant demands on storage hall vs. office distribution (e.g. electricity 15 MW) and nearly 3,000 new employees. Image design being completed in parallel with the public utility development concept makes estimating land use more accurate, and incorporating estimations on public utility requirements did not reduce the demand substantially.

In Table 11, the numbers of the left-most column refer to facilities shown in Figure 8 (Facilities of the development area). The table shows the size of establishments that need to be supplied and staff working in those facilities to help understand and estimate public utility supply in the future.

Table 11. Estimated data on public utility based on long-term image design plan

Source: FBL (2017)

Nr.	**Area**	**Share of use**		**Nr of floors**	**Floor area**		**Installation**		**Size**		**Staff**	
		office	**industrial hall**	**office**	**office**	**industrial hall**	**office**	**industrial hall**	**office**	**industrial hall**	**office**	**industrial hall**
	m²	%	%	pc	m²	m²	m²	m²	m³	m³	no.	no.
1	5,011	100	0	5	5,011	0	25,055	0	87,693	0	501	0
2	7,540	100	0	5	7,540	0	37,700	0	131,950	0	754	0
3a	3,698	100	0	5	3,698	0	18,490	0	64,715	0	369	0
3b	1,792	100	0	5	1,792	0	8,960	0	31,360	0	179	0
4a	-	-	-	4	674	8,075	2,696	8,075	9,436	96,900	53	16
4b	-	-	-	4	688	7,550	2,752	7,550	9,632	90,600	55	15
5a	20,372	8	92	3	1,629	18,742	4,887	18,742	17,105	224,904	97	37
5b	20,764	8	92	3	1,661	19,102	4,983	19,102	17,441	229,224	99	38
5c	8,115	8	92	2	649	7,465	1,298	7,465	4,543	89,580	25	14
5d	11,564	8	92	2	925	10,638	1,850	10,638	6,475	127,656	37	21
6	-	-	-	0	0	0	0	0	0	0	0	0
7a	3,778	100	0	2	3,778	0	7,556	0	26,446	0	151	0
7sz	2,800	100	0	2	2,800	0	5,600	0	19,600	0	112	0
8	-	-	-	0	0	0	0	0	0	0	0	0
9	-	-	-	0	0	0	0	0	0	0	0	0
10a	11,216	8	92	2	897	10,318	1,794	10,318	6,279	123,816	35	20
10b	8,288	8	92	2	663	7,624	1,326	7,624	4,641	91,488	26	15
10c	8,211	8	92	2	656	7,554	1,312	7,554	4,592	90,648	26	15
10d	4,818	100	0	3	4,818	0	14,454	0	50,589	0	289	0
11	-	-	-	2	0	0	0	0	0	0	0	0
Sum - Based on Image design plan							140,713	97,068	492,497	1,164,816	2,808	191

Public utility in the Freeport of Budapest and in the related logistics park was constructed with various supply networks in the last 100 years. An area of the Freeport that can be handled separately as an individual unit of the public utility network is located between Petróleum út and the southern embankment of the Budapest Central Wastewater Treatment Plant (BKSZTT); embankment of the suburban railway (HÉV) from the east and the Danube from the west. Since the beginnings of the history of the port, two bigger exploratory roads reached this area: Petróleum út and Szikratávíró út. However, these roads are private, public networks are connected to them. A similar exception would be the power supply if medium voltage underground cables and transformers are operated by ELMŰ in the operation territory of FBL. 2x600 channels as public network operated by the Budapest Sewage Works Pte Ltd. also reach this area.

The buildings' needs for thermal energy and electricity are supplied with renewable solutions, as well as a pipeline. TNM decree 7/2006 (V.27.) declares that 25% of the energy needs of buildings must be met by renewables after 31 December 2020.

If certain buildings are sold, it should be stressed that regardless of their real energy efficiency, they cannot be better rated than CC. An energy certificate or other classification e.g. LEED, BREEM, etc. may also arise as a request from tenants.

Supply of heat for the FŐTÁV district heating network

Aside from tenants' need for a supply of local energy in the Freeport area, there are further possibilities for using the thermal energy produced in the planned power plant. These possibilities are based on the following planned developments.

By the plans of the government, a new bridge will be built on the Danube between Illatos and Galvani streets in Budapest, crossing the area of the Port. This new bridge will serve also as an infrastructural network element, and will contain heat transfer network elements as well. The availability of the heat pipe system for the planned new power plant at the Freeport gives the opportunity to meet the heat needs of the district heating system as well.

Very close to the planned location of the power plant operates the Csepel Sewage Treatment plant, where a considerable amount of sewage sludge is generated. There are future plans for the utilization of the sewage sludge as a co-incineration raw material in the future waste incineration unit of Budapest. For the preparation of the sewage waste for further utilization, drying of the material, for which waste heat of the new plant can be utilized, will be required.

Electricity supply of development areas inside the Freeport

For supplying the Northern Development Area, a new 10 kV cable loop – operated by FBL – shall be constructed. For power supply, a 10 kV switching station is required in which measuring and setting consumption take place by the distribution network and the power supply provider. Next, a 10 kV cable loop can be used to reinforce the FBL operated transformers in concrete buildings. The assembly of the transformer should be designed to accommodate 630 kVA machines –

although, using 250-400 kVA machines are justified. In this case, a transformer could be located rationally close to the power supply of storage halls; minimalizing costs of investment into low voltage cables. For comparison, a 3,800 kVA energy requirement of the short-term concept could be used. According to prior consultation, for a high safety level with these energy needs, approx. 2,500 kVA is required for medium voltages, and the expected annual consumption would be 2,000,000 kWh regardless of the receiving voltage level. It would also be required to design a low voltage measuring station for recording at medium voltage reception. For security reasons, the costs of running longer low-voltage underground cables will be neglected. The merchant fees for supplying power are typically sensitive to the amount consumed and not to the voltage level. Therefore, this will also be neglected when calculating.

4.2. New technological solutions foreseen

Biomass is typically utilized in 2 major ways:

- fermentation and biogas production (and the combustion in biogas in gas engines/gas turbines or in boilers) if the moisture content is above 65%, and the biogas potential is high
- combustion in boilers if the moisture content is below 65%

The combustion technology can be categorized by the type of boiler:

- Grate firing boiler: low and volatile quality biomass
- Atmospheric Fluidized Bed Combustion: typically, this is a Bubbling Fluidized Bed Boiler in atmospheric pressure
- Bubbling Fluidized Bed Boiler: atmospheric or higher pressure, the pressure defines the overall efficiency.

The Circulating Fluidized Bed Boiler is an application for higher capacity applications, with higher efficiency and stable quality of biomass needed.

The right type of boiler application will definitely be a commercially available boiler technology.

The adapted technology will be highly dependent on the available quantity of raw materials and the ratio of thermal and electricity demand.

4.3. SWOT analyses on biomass logistics

Table 12. SWOT analysis
Source: own editing

STRENGTHS	WEAKNESSES
• Freeport's great location: the closest logistics hub to the city centre in comparison to others in the agglomeration • port management FBL's experience in maintenance of public utilities and necessary infrastructure for heat and energy supply in the port • public utility infrastructure and connections and linkages are well developed • distance between possible raw material suppliers and the port is favourable	• lack of experience by owner, manager and operator companies of the Freeport of Budapest • traditional gas utility infrastructure needs to be changed entirely
OPPORTUNITIES	**THREATS**
• Galvani bridge links possible end-users on Buda and Pest sides with the power plant on the island • FŐTÁV contribution to supply chain development • possible cooperation with Budapest Sewage Water Pte Ltd. • changes of traditional gas' prices contributes to a wider range utilization of green energy sources	• lack of free space for construction of the public utility infrastructure • project's return is dependent on overtaking prices of green electricity to the grid and changes in related regulations • limitations in quantity of biomass raw materials

5. Project description

5.1. Aims of the development

The general objective of the project in the short term is to establish the background of new market opportunities by widening the profile of the Freeport of Budapest and expand logistics services provided in the port via entering the biomass industry.

Specific objectives in the short, middle and longer terms are

- to complete a shift in terms of inner energy supply by switching from traditional gas supply system to a renewable energy based one
- supply of heat and electric energy for the relevant networks and grids
- to become a knowledge hub of the region concerning biomass utilization
- to become a logistics hub of the region concerning biomass utilization and value chains
- to increase employment by shifting to a socially and environmentally sustainable industrial regime in the port

5.2. Definition of development needs

The total electricity consumption in the area in 2017 has been 3,000,000 kWh (total yearly – per 8,760 hours – average: 342.5 kWe), while natural gas consumption has been 206,000 m^3 (34,330 m^3/month from October-March period). Unfortunately, the average value cannot be used as a design value, but only for indication.

The following factors determine the optimal plant size:

- **Demand for electricity and heat**
- Amount of biomass residue available
- Site conditions (for technology and storage spaces)
- Grid connection options, voltage level,
- Regulatory restrictions
- Economics including investment requirements, O&M costs, and price of energy sold.

In a preliminary phase like this, it is better start from the boundaries: if the maximum need can be supplied from a single plant, and the feasibility and other listed factors can be fulfilled, then the maximum local plant size shall be built.

The total electricity consumption in the area in 2017 was 3,000,000 kWh (total yearly average: 34.5 kWe), while natural gas consumption was 206,000 m3 (34,330 m^3/month from October-March period). Unfortunately, the average value cannot be used as a design value, but only for indication; it is better to design for the peak value.

The area has the following peak needs (with a utilization factor of 70%) in the near future:

- electricity: 15 MWe
- heat: 1.35 MWth (the total peak value of the area)

If these peak demands can be fulfilled from a single plant, then the capacity of the plant can be modified (decreased) by taking into consideration the other factors, like efficiency and ideal heat/power ratio.

Furthermore the heat and electricity produced by a future plant can be fed into the National Grid (electricity) and the municipality's network of distant heating.

If the new Galvani Bridge will be built, an essential network potential will be available for the plant. Through the heat pipe crossing the bridge, a considerable amount of heat could be sold to the district heating network, where the only limit is the so-called reference price system which limits feed in heat process related to average prices.

5.3. Definition of planned products/services

The biomass power plant has the following products:

- supplied electricity: basically the local need, but through connecting to the National Grid, and participating in the operation of the grid, different electrical products can be supplied: participation in primary, secondary and/or tertiary power regulation,

- supplied heat: direct connection with the local consumers though a heating centre, the other capacity could be sold to the District Heating Company of Budapest (FŐTÁV),

- by-products: ash and other residues from the firing can be sold as fertilizer after certification that they do not contain hazardous elements,

- local biomass trade and distribution: the shipped, storage biomass could be sold to local consumers,

Based on the site data, available biomass and demand data the following plant sizes have been identified:

Table 13. Possible plant sizes
Source: own calculation

Plant nominal power generation, MWe	15	12	6
Peak supplied heat, MWth	1.35	1.35	1.35
Self-consumption, MWe	1.275	1.02	0.51
Electric output, MWe	13.725	10.98	5.49
Electric efficiency, %	34	32	30
Biomass input, MWth	50	40	20

The biomass consumption calculation can be seen in the following table:

Table 14. Biomass consumption calculations
Source: own calculation

Biomass input	***50***	***40***	***20***	***MWth***
Wood (general: fresh wood from the forest)	10	10	10	MJ/kg
	5	4	2	kg/s
	18	14.4	7.2	t/h
	432	345.6	172.8	t/day
Wheat straw	16.6	16.6	16.6	MJ/kg
	3,0	2.4	1,2	kg/s
	10.8	8.7	4,3	t/h
	260.2	208.2	104.1	t/day
Used Wood (industrial waste wood)	19	19	19	MJ/kg
	2.6	2.1	1,1	kg/s
	9.5	7.6	3.8	t/h
	227.4	181.9	90.9	t/day

5.4. Target group/stakeholders

There are two main options for the utilization of the produced heat: supply of local needs (present and future tenants of the Freeport and the neighbouring new investments) and direct connection with the FŐTÁV district heating network.

For local supply, there are hardly any difficulties regarding distances between the location of the power plant and supplied target group, since supplied temperature is cooling down in the district heating pipes 1 Celsius per kilometre, and this loss is not significant.

Thus, the target group to be supplied with biomass energy and heat covers tenants and settled companies in the port, and beyond its official territory in the industrial logistics zone:

- MAHART Container Center Kft. (MCC)
- MAHART Gabonatárház Kft. (Grain Warehouse)
- Arcelormittal Kft.
- Lagermax Dunalogisztika Szállítmányozási Kft.
- Ferroport Fedett Átrakó és Raktározó Kft.
- EKOL Logistics Kft.
- MASPED Port Logistics Centre

Companies technically located outside the Freeport of Budapest, but close enough to receive biomass energy and heat provided from the port area:

- Ghibli Raktárlogisztika Kft.

- MOL Nyrt. (located by petrol basin)
- OWM Hungária Kft. (located by petrol basin)
- Dunai Kikötő Kft.
- Dunai Nehézrakodó Kft.

Other stakeholders are the investor and site owner MAHART Freeport Co. Ltd. and possible future maintainer of the supply infrastructure and the entire establishment, port management company Freeport of Budapest Logistics Ltd. (FBL).

District Heating Company of Budapest (FŐTÁV) can be a key stakeholder of the project also involved as a service provider and operator of the new plant and buyer of considerable amount of heat through the new crossing network on the Galvani Bridge.

Regarding the produced electricity, Mavir (Hungarian Transmission System Operator Company) is the key partner who regulates the national system and sets the requirements of running the plant. Regarding feed-in tariffs MEKH (Hungarian Energy and Public Utility Regulatory Authority) is the regulating authority.

5.5. Location, site

Two of the possible locations of the planned biomass power plant and its related facilities and storages have multimodal connections as designed to be installed on the riverside.

According to the analysis and currently free sites, the biomass power plant could be settled either next to the planned LNG terminal and be closely connected to most possible users within the port area (*Spot 1* on the following picture) or at the north-western corner of the Freeport (*Spot 2* on the following picture), at the future Galvani Bridge linking Buda and Pest sides with Csepel Island serving thousands of possible users in offices and households.

Spot 1 is a possible site for settling both the power plant itself and its related storage facilities. This area is one of the very last, under-utilized, unoccupied and very expensive sites in the Freeport of Budapest due to its trimodal connections. Vessels from the river would arrive at the trimodal fueling station LNG and would be unloaded either to a regular storage above the ground or to a tanker barge floating on the Danube. A biomass power plant could also serve the future LNG terminal's cooling demand for 365 days annually.

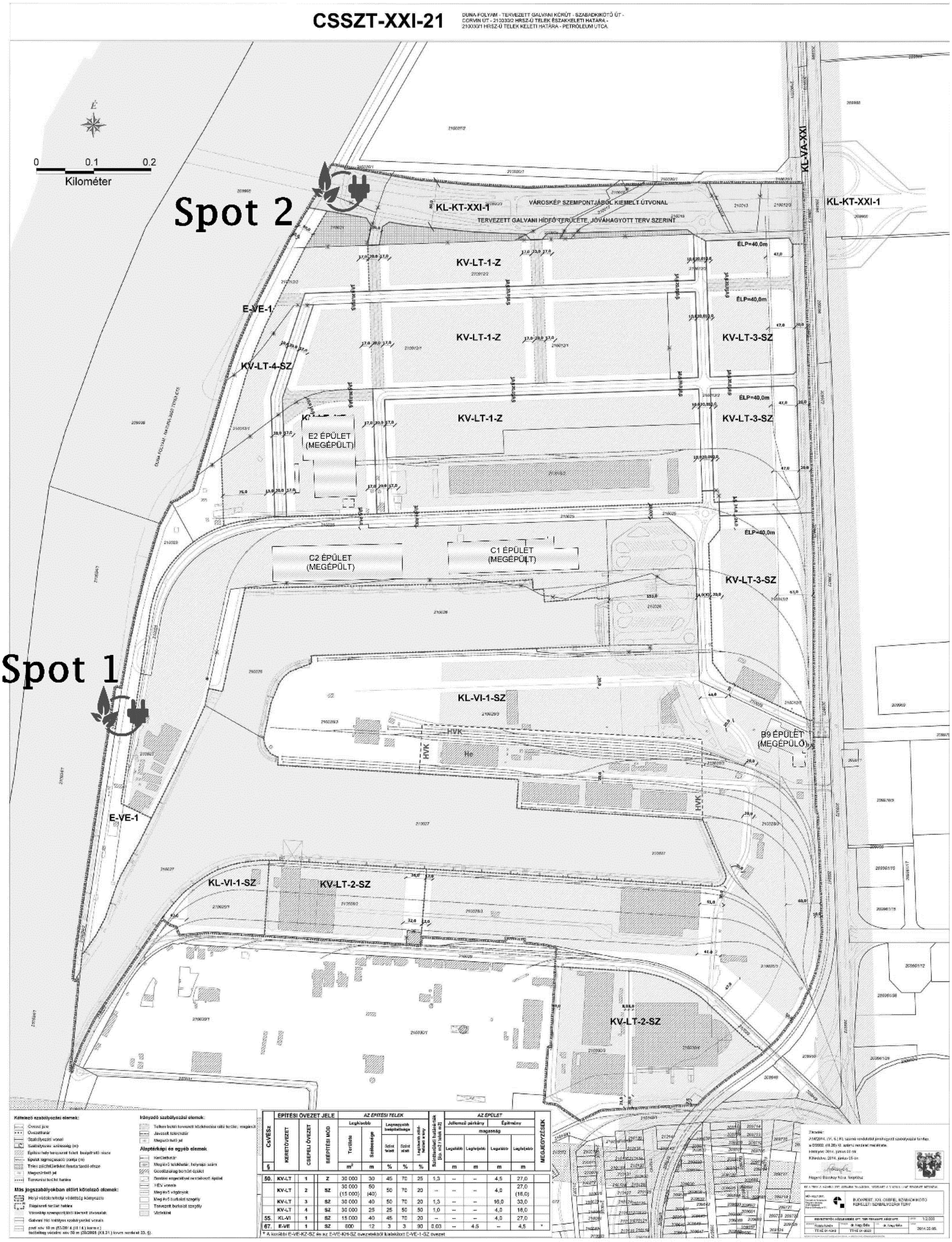

Figure 10. Possible locations of the planned biomass power plant

Source: FBL (2017)

An issue to be solved is the design and regulation of the area regarding activities. Spot 2 on the map above is another possible location of the planned biomass power plant. In the north-west corner of the territory of the Freeport, owner MAHART Freeport Co. Ltd. has a 1-ha area which is not part of a protected forest, despite a long section of the riverside on parcel E-VE-1.

However, there are several factors that the success of this site depends on if it is indeed going to be the location of the planned biomass power plant and related buffer storage facilities.

- Regulations from the District-level Local Government regarding constructions and establishments
  - What is the maximum size of the area that can be built on
- When and how exactly the new Galvani bridge will be constructed
  - How it will curve
- How many consumers will appear on the other sides of the bridge
  - New living and working zones, offices and gated communities on Buda and Pest sides

Figure 11. Location of the planned Galvani bridge
Source: Magyar Építők (2017)

5.6. Technical parameters/capacities

Depending on the type of biomass being used, different type of boilers and different firing parameters are needed.

In Hungary, the following boiler applications are the most commonly available:

- Bubbling fluidized bed boiler: for co-firing the biomass with brown coal,
- Travelling grate boiler: for biomass firing, with volatile biomass quality,

In the Hungarian market the following biomasses are available:

- Wood (primary from the forest industry, secondary and/or tertiary)
- Energy crops
- Straw

Table 15. Availability and self-consumption factors of different types of power plants
Source: REKK, MAVÍR and HEA (2018)

	Availability, %	Self-consumption, %
Gas and oil fired PP	90	5
Coal fired PP	85	13
Nuclear PP	95	6
CCGT	90	5
Wind PP	20	0
Biomass, biogas PP	**85**	**8.5 (biomass)** **13 (biogas)**

5.7. Technology and equipment

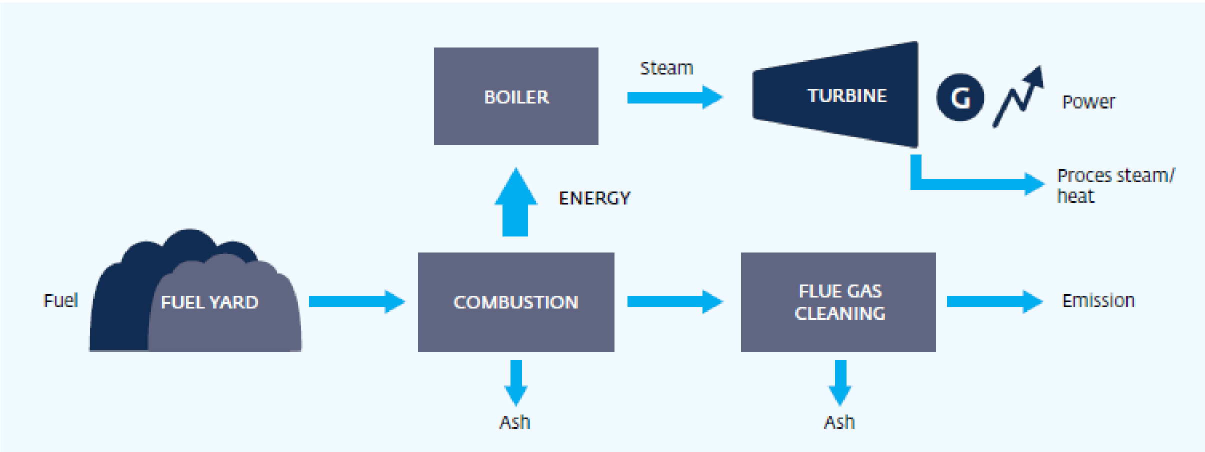

Figure 12. The main elements of a biomass fired power plant
Source: COWI

The purpose of the boiler is to generate steam at a desired rate, temperature and pressure by transferring heat from the combustion of fuel into water, which is then evaporated into steam. The steam can be used for different applications, such as power generation, district heating, industrial processes, or combinations thereof, depending on the steam pressure/temperature.

A boiler can be either a fire-tube boiler, where hot flue gases flow through tubes surrounded by water in a shell, or a water-tube boiler, where the water flows through tubes and the hot flue gases flow over the tubes. In high-pressure applications, such as power generation, it is an advantage (in terms of metal stress) to have the high-pressure water/ steam inside relatively small-diameter tubes. Hence, the water tube configuration is preferred. For small hot water or process steam boilers, the fire tube boiler is often used. Boilers that use a drum and recirculate water for changing into steam are called drum boilers.

The emissions can be reduced by either primary measures (combustion process integrated measures) or secondary measures (post-combustion cleaning).

Based on the areas' direct connection with the Danube, direct cooling system is advised to be used for closing the steam cycle, which can be integrated into the new port for the biomass river transport.

5.8. Design and permissions

In order to define the exact need, usually a detailed feasibility study is prepared, which defines the opportunities and evaluates the exact site potentials of a biomass power-plant development area.

The main steps of the preparation of a Feasibility Study can be found in the following scheme, which includes the data needs and output material of the preparation of the study.

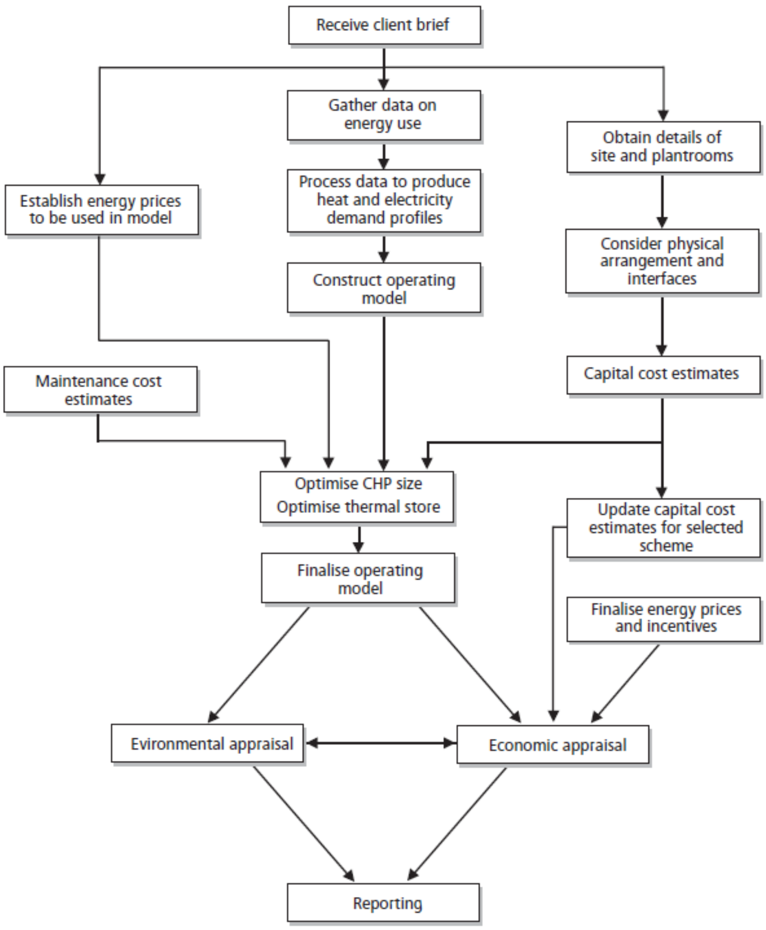

Figure 13. Process of a detailed feasibility study

Source: own editing

Different approvals/licenses at the general level include:

- General documentation related to business operation
- Investment license, if applicable
- License to import equipment, if applicable
- Approvals from local authorities for the right to conduct business
- Land-use right
- Permits from cultural heritage authority
- Procedures specific to renewable energy production
- Permits for the construction phase.

The entire authority approval process includes several steps, which vary among countries due to different national standards, conditions, and requirements. Variations may occur due to the location and size of the project, but they also may relate to how the project fits into the national legal framework. Obtaining the necessary permits and licenses may be a time-consuming exercise, but it can also be a valuable process. As part of the work in obtaining, for example, an environmental permit, environmental risks and impacts are identified.

The basic permitting procedure in Hungary can be seen in Figure 14.

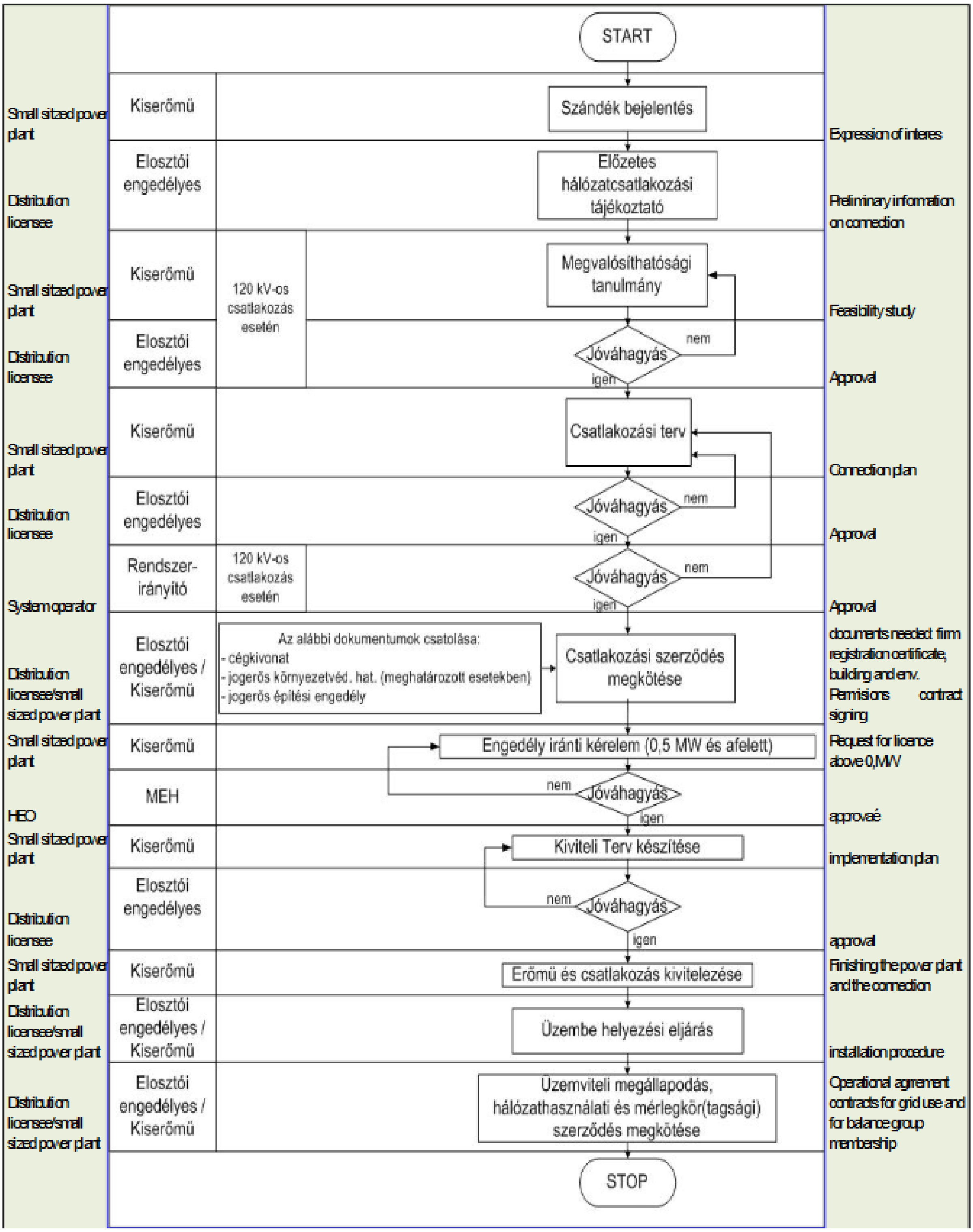

Figure 14. Licensing procedure

Source: Hungarian Renewable Energy Utilization Strategy 2010-2020

5.9. Partners to be involved

Here are listed the list of all partners to be involved during the preparation phase when managing investments related to the biomass power plant and storage capacities in the Freeport.

- Engineers and a designer team
- Port management company, Freeport of Budapest Logistics Ltd. (http://www.bszl.hu/en/budapest-dock)
- Consultants and experts in finance
- Consultants and experts in project preparation
- Authorities and ministries e.g.
    - Ministry of National Development (NFM) (http://www.kormany.hu/en/ministry-of-national-development)
    - Ministry for National Economy (NGM) (http://www.kormany.hu/en/ministry-for-national-economy)
    - Municipality of Csepel (capital district 21 of Budapest) (https://www.csepel.hu/)
- Budapest district heating company, FŐTÁV Zrt. (http://www.fotav.hu/) – as potential buyer of heat
- Budapest Sewage Water Pte Ltd. (Fővárosi Csatornázási Művek) (http://www.fcsm.hu/en)
- Hungarian Energy and Public Utility Regulatory Authority (MEKH) (http://mekh.hu/home)
- Suppliers of biomass (e.g. forestry companies)
- Construction company and technology providers
- Technical operator of the plant (new personnel at MAHART Freeport Co. Ltd., investor/operator partner)

5.10. Recommended implementation schedule

Once the technology has been chosen and the quality of sufficient amounts of biomass is confirmed, procurement and contracting of the biomass plant becomes relevant.

During the construction phase, special attention must be given to the time schedule and follow-up on progress, the handling of claims for extra work, and the handling of risks related to the project and environmental, health and safety (EHS) aspects.

When the construction of the plant is completed, it will be time for the commissioning phase, which includes training, cold testing, hot testing, functional testing, and trial operation.

The most visible activity in the construction phase is the actual construction of the biomass plant where all the mechanical, electrical, and control and instrumentation (C&I) components are erected and installed. This is normally the job of a turnkey EPC contractor, or alternatively with a multiple contract approach two to four main contractors are employed depending on the chosen contract strategy.

A typical implementation schedule can be seen in the following picture:

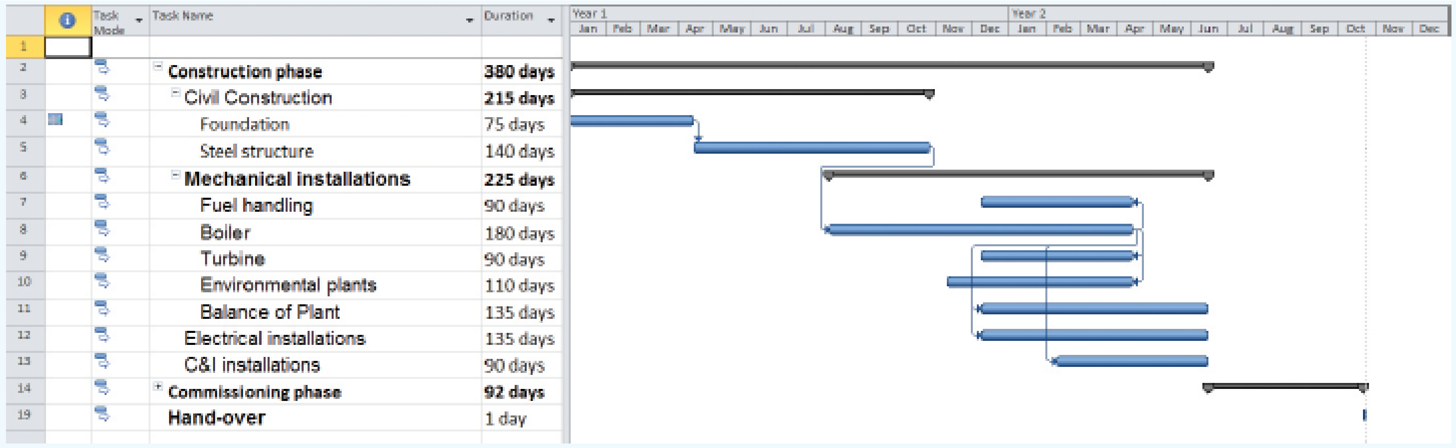

Figure 15. Typical overall construction schedule of a biomass power plant

Source: own editing

5.11. Investment costs, financing

The total nominal investment cost has been taken from the TOP-6.5.2-15 (Renewable energy developments for county municipalities in 2016) calculation, which gives a nominal investment cost of 600,000 Ft/kWe. Based on this nominal value, and the nominal capacities, the following investment will be necessary for the different sizes of biomass power plants.

Table 16. Investments for different biomass power plant sizes

Source: own calculation

Plant nominal power generation, MWe	15	12	6
Peak supplied heat, MWth	1.35	1.35	1.35
Electric output, MWe	13.72	10.98	5.49
CAPEX			
Nominal investment cost, Ft/kWe	600,000		
Investment cost (CAPEX), MFt	9,000	7,200	3,600
Investment cost (CAPEX), MEUR	29.0	23.2	11.6
OPEX			
Fixed OPEX, MEUR/y	2.90	2.32	1.16
Variable OPEX (consumables), MEUR/y	4.90	3.94	2.02
Total OPEX, MEUR/y	7.81	6.27	3.18

The table also provides an assumption for the OPEX, which is based on the CAPEX (10% of the CAPEX is the fixed ratio: wages, bank loan, etc., and the variable part of the OPEX is basically the fuel cost).

The table does not include financing costs. The investment can be financed via grants (EU Structural Funds), bank loans and with the involvement of financial investors.

To optimize size variants, different factors have to be taken into consideration, such as: size of the heat market; availability of biomass and optimal operational cost and incomes.

Table 17. Annual production parameters
Source: own calculation

Plant nominal power generation, MWe	*15*	*12*	*6*
Peak supplied heat, MWth	1.35	1.35	1.35
Electric output, MWe	13.725	10.98	5.49
Production			
Operating hours, h/y	8,000	8,000	8,000
Heat supply period, h/y	4,000	4,000	4,000
Average heat supply, MWth	0.81	0.81	0.81
Produced electricity, MWh/y	109,800	87,840	43,920
Supplied heat, GJ/y	11,664	11,664	11,664
Biomass consumption, t/y			
Wood (fresh from the forest)	127,059	108,000	57,600
Wheat straw	76,541	65,060	34,699
Used wood	66,873	56,842	30,316
Income			
Electricity, MFt/y	3,513.60	2,810.88	1,405.44
Electricity, MEUR/y	11.33	9.07	4.53
Heat, MFt/y	31.49	31.49	31.49
Heat, MEUR/y	0.10	0.10	0.10
Total, MEUR/y	11.44	9.17	4.64
Plant nominal power generation, MWe	15	12	6
Peak supplied heat, MWth	1.35	1.35	1.35
Electric output, MWe	13.725	10.98	5.49

Table 18. Biomass prices allowed for different plant sizes
Source: own calculation

Expected biomass procurement price, EUR/t			
Wood (fresh from the forest)	38.6	36.5	35.1
Wheat straw	64.1	60.6	58.3
Used wood	73.3	69.4	66.7

Expected biomass procurement price, Ft/t			
Wood (fresh from the forest)	11,963.69	11,318.65	10,884.68
Wheat straw	19,859.72	18,788.96	18,068.56
Used wood	22,731.00	21,505.44	20,680.88

The following picture shows the typical cost distribution of the main CAPEX (capital expenditures) elements for a biomass plant.

Table 19. Cost item percentages of a biomass plant
Source: COWI (2015)

Main item	Sub-item	Steam Cycle (% of CAPEX)	ORC (% of CAPEX)	Biogas (% of CAPEX)
Project development	Design and engineering	10	10	10
	Supervision			
	Environmental assessment			
	Administration			
Storage and handling fuel and residual products	Fuel handling equipment	7	10	20
	Pretreatment of fuel			
	Storage for fuel and ash	3		
Main process equipment	Boiler	15	20	
	Biogas process plant			30
	Fuel gas cleaning	5		
	Turbine/generator	15		
	ORC modulate		20	
	Engine/generator			15
	Electrical systems	7		
	Controls and instrumentation	3		
	Balance of plant (BOP)	15	20	10
Civil works	Buildings	20	20	15
	Roads on site			

The following table provides international benchmark for biomass plants in the same size-range.

Table 20. International nominal CAPEX benchmark
Sources: Turboden (2016); Danish Energy Agency and Energinet.dk (2015); Ea Energianalyse (2014); IRENA (2015); COWI (2015)

Plant size (MWe)	Steam Cycle (CAPEX (s/kW)	ORC CAPEX (s/kW)	Biogas CAPEX (s/kW)
1-5	5,000-10,000	3,000-8,000	3,500-6,500
5-10	4,000-8,000	2,000-5,000	n.a.
10-40	3,000-6,000	n.a.	n.a.

6. Operation

6.1. Project Management Organization, human resources

In the following, various models are presented including the same organizations but in different business relations depending on responsibilities regarding maintenance and operations in the energy biomass power plant.

Table 21. Alternative structures of project management organizations
Source: own editing

	Owner	Investor	Maintenance and operations	Logistics, supply chain management
1	MAHART leases out the site. Project company is a 'regular' tenant, not owner of the area.	External company invests and constructs the power plant as an establishment.	FBL is the maintainer and operator of the establishment and service provider, energy and heat supplier	FBL; port operator companies
2			External company is the maintainer and operator of the establishment and service provider, energy and heat supplier	FBL; port operator companies; external company
3	MAHART sells the site. Project company becomes the owner of the area.	External company purchases the territory, invests and constructs the power plant as an establishment.		
4	MAHART does not sell nor lease the site.	MAHART's specified project company completes the investment, construction works of the power plant as an establishment.	MAHART's specified project company is the energy and heat supplier of the port.	MAHART's specified project company; FBL; port operator companies

Possible management model 1 – Project implementation is outsourced to an expert external company

Owner of Freeport of Budapest, MAHART Freeport Co. Ltd. provides the territory for the site of the power plant for an annual fixed fee.

External company invests in prior development, design and construction of the biomass power plant.

Port authority and Management Company of the port, Freeport of Budapest Logistics Ltd. (FBL) maintains the power plant and the related infrastructure: public utility, administration processes related to fees and operations for energy and heat supply. FBL has a contract with the external company in a form ensuring fluent repayment and profitability for both partners.

Logistics services, coordinating supply chain and contact with raw material producers and forwarding companies are managed by

a) FBL
b) port operators, logistics companies settled in the Freeport

Possible management model 2 – Project implementation and future service provision are outsourced to an expert external company

Owner of the Freeport of Budapest, MAHART Freeport Co. Ltd. provides the territory for the site of the power plant.

An external company invests in prior development, design and construction and also, the operation of the biomass power plant.

FBL is not involved significantly in this case.

Logistics services, coordinating supply chain and contact with raw material producers and forwarding companies are managed by

a) the external company
b) FBL
c) port operators, logistics companies settled in the Freeport

Possible management model 3 – Project implementation and future service provision are outsourced to investor company

Owner of the Freeport of Budapest, MAHART Freeport Co. Ltd. sells the territory for the site of the power plant to the investor company implementing the project and supplying heat and energy for port companies.

External expert company invests in the project by purchasing the territory of the location of the power plant. Once the power plant and related storage facilities are constructed, this company provides energy and heat supplying services to port operators and companies settled in the logistics centre of the dock.

Logistics services, coordinating supply chain and contact with raw material producers and forwarding companies are managed by

a) the external company
b) FBL
c) port operators, logistics companies settled in the Freeport

Possible management model 4 – Project implementation and future service provision are completed and ensured in-house entirely; specified, well-experienced human capacities are required

MAHART Group establishes a project company for completing both planning and construction works.

MAHART Freeport Biomass Power Plant Co. Ltd. is member of the MAHART Group and is responsible for maintenance and operation of the power plant, energy and heat supply for port companies, maintenance of the public utility infrastructure.

Logistics services, coordinating supply chain and contact with raw material producers and forwarding companies are managed by

a) MAHART Freeport Biomass Power Plant Co. Ltd.
b) FBL
c) port operators, logistics companies settled in the Freeport

6.2. Operation and maintenance costs

Plant operation includes a number of tasks and responsibilities, such as:

- Scheduling of power and heat production and fuel supply
- Operating and monitoring all functions of the energy producing plant and equipment
- Operation of fuel reception and handling, including weight measuring and quality control (moisture content and presence of stones, metal pieces, and oversize particles or elements)
- Operation and handling of systems for bottom ash, fly ash, and other by-products
- Supervising plant operation, including scheduled “walk through” on each shift
- Planning and ordering of necessary maintenance work and securing the plant before the start of work.

The typical operation and maintenance staff at a plant may vary in size from 3 to 5 people for a 1 to 5 MWe plant to up to 20 to 40 people for a 20 to 40 MWe plant. The size of the on-site operation and maintenance staff and organization will depend largely on:

- Plant size
- Fuel type
- Plant design
- Degree of plant automation
- The need for a 24/7 presence of a dedicated shift staff versus possible cooperation or integration with other industrial operations
- The operation and maintenance strategy; on the one extreme, the owner does everything; on the other extreme, substantial work (both for scheduled and unscheduled outages) is outsourced.

The staff should have the necessary skills and education. It will be beneficial if the future plant staff can participate in plant construction, commissioning, and testing. This will generate a good knowledge and understanding of the plant before the start of commercial operation.

There are several ways of transferring the responsibility from the owner of the plant to the contractor(s), listed below in order of increasing responsibility for the contractor:

- Traditional contracts with division of the plant into a number of partial contracts with separate detailed designs
- DB (Design–Build) / EPC (Engineering, Procurement, Construction) / Turnkey contract with one contractor being responsible for the design and construction of the entire plant
- DBO (Design–Build–Operate) / BOT (Build–Operate– Transfer) type contracts where the contractor also operates and maintains the plant
- DBFO (Design–Build–Finance–Operate) where the contractor takes full responsibility for the provision of a biomass-based power plant and is remunerated through the sale of heat and power.

The decision of the type of contract will depend on the degree to which the biomass plant is integrated with the owner's existing facilities and the owner's ability and willingness to transfer design decisions, operational control, and project risks to the contractor.

The following table presents the typical O&M costs of a biomass plant, based on international benchmarks.

Table 22. Typical O&M costs of a biomass plant on CAPEX basis

Sources: Turboden (2016); Danish Energy Agency and Energinet.dk (2015); Ea Energianalyse (2014); IRENA (2015); COWI (2015)

	Fixed O&M per Year (% of CAPEX)	Variable O&M (2014 s/MWh)
Stoker/BFB/CFB boilers	3-2	4-5
Biogas	2.1-3.2 2.3-7	4-4

Beside the boiler, the technology itself has the following O&M costs in the international benchmark.

Table 23. Fixed and variable costs of the different size and type of biomass power plants

Sources: Turboden (2016); Danish Energy Agency and Energinet.dk (2015); Ea Energianalyse (2014); IRENA (2015); COWI (2015)

Plant Technology	Plant Size (MWe)	OPEX Fixed Costs per Year (% of CAPEX)	OPEX Variable Costs (s/MWh)
Steam boiler and turbine	1-5 5-10 10-40	3-6% 3-6% 3-6%	3-7 3-7 3-7
ORC	1-5 5-10	2-3% 15-2%	5-10 5-10
Biogas	1-5 5-10	Included in variable costs	20-40

As it can be seen, we have over-estimated the fixed O&M costs in our estimation, but our estimation still provides reasonable results.

The fuel costs can vary in a wide range, and are highly dependent on the cost of transportation. The variation can be seen in the following table (based on the same procurement fuel-price).

Table 24. Cost ratio of transportation in the fuel price
Source: own editing

Distance, km	Cost of transportation, %
up to 15	8
up to 35	13
up to 50	18
above 50	20

6.3. Pricing

Investment data also may be unclear regarding the technology, actual cost elements included, and country or geographical situation of the projects presented.

In mid-June 2016, the Parliament of Hungary enacted the Renewable Energy Support System (in Hungarian: *"Megújuló energia támogatási rendszer"*) ("**METÁR**"), the new regulatory and support scheme for electricity generation from renewable energy sources ("**RES**"). Via METÁR, Hungary aims to meet its undertakings in the field of RES generated electricity by 2020.

METÁR consists of a mandatory off-take regime and a "premium support" regime, both of which will be differentiated on the basis of the energy resources applied, production methods, nominal capacity of the power plant, and efficiency of energy transformation and the date of development of the relevant power plant.

RES electricity producers with less than 0.5 MW capacities will continue enjoying the mandatory off-take regime. RES electricity producers with capacity between 0.5 MW and 1 MW will be subject to the specific support system operated under METÁR. RES electricity producers with capacity over 1 MW must sell the electricity produced by them on the free market and can only be entitled to support in the form of a "premium" allocated to RES power plants via tenders. Premiums will be paid only over the average market price.

In order to prevent illegal logging and to protect forests, METÁR contains strong guarantees regarding the usage of wood as fuel in the course of RES electricity generation.

The producers of electric energy are classified into three different categories depending on the performance and the type of generation power plants.

Producers with a performance under 0.5 MW and with demonstration projects are exempt from the METÁR premium system, they remain under the scope of KÁT. The newly established terminology "demonstration projects" stands for such projects using innovative technology which

is not fully fledged, where the investment and operational experiences and references helping to calculate the aid are lacking.

The most fundamental innovation compared to KÁT is that bigger energy producer, with over 1 MW capacity, may only be entitled to state aid - the so-called premium support - if they participate and win a tender, announced and coordinated by HEA (Hungarian Energy and Public Utility Regulatory Authority). The yearly quantities to be supported will be announced regularly and it is likely that the quantities will be distributed by technologies (e.g. wind, photovoltaic). This new system is in compliance with the internal market, but it is worth noting that if the targets are to be achieved by 2020, there is not much time to announce and close tender procedures. Furthermore, it would be more than desirable if the upcoming enforcement laws would ensure that the winners of the tenders actually build and operate the power plants.

Producers with between 0.5 – 1 MW performance are not obliged to participate in tender procedures, and are entitled to receive the so-called administrative premium over the market price.

Apart from the above green premium system, METÁR also introduces the so-called "brown premium" to promote the generation of electricity from biomass or biogas sources. In this special procedure carried out by HEA the producer should request the brown premium after the procedure, and if HEA accepts the request, eligibility is granted for 5 years.

To summarize the above information and market conditions, it should be noted that an investor would calculate 10-15 years of return in advance in the sector and that the KÁT system was always criticized for not ensuring planning. The METÁR system ensures that renewable energy will be placed in the market, so an investment will result in a better return. In light of the above, it is obvious that the declared goals of the new support scheme are cost-effectiveness, and the development of new generation capacities apart from ensuring competitiveness.

The current prices are stated in the 389/2007. (XII. 23.) gov. decree, which provides the following unit prices for the electricity generated from biomass, fired power plants:

Table 25. Feed-in tariff periods for electricity produced from biomass

Source: own editing

	Winter	Summer
Peak period	06:00-22:00	07:00-23:00
Off-peak period 1	22:00-01:30 and 05:00-06:00	23:00-02:30 and 06:00-07:00
Off-peak period 2	01:30-05:00	02:30-06:00

Table 26. Actual feed-in prices for the different periods
Source: own editing

Feed-in tariff prices for biomass and biogas fueled power plants	Ft/kWh
Peak period	35.5
Off-peak period 1	31.77
Off-peak period 2	12.96

The weighted average of the feed-in tariff price is around 32 Ft/kWh, so in order to simplify, we are taking this value into consideration.

For the heat prices, we took the rounded current value from tariff of Budapest Heating Company (FŐTÁV) 2,700 Ft/GJ.

The guaranteed feed-in tariff period for biomass fired power plants are 25 years from commissioning.

In order to evaluate and compare the biomass project with other projects, the Levelised Cost of Electricity as an indicator will be used. The following picture shows, the position of the biomass power-plants compared to other PP options.

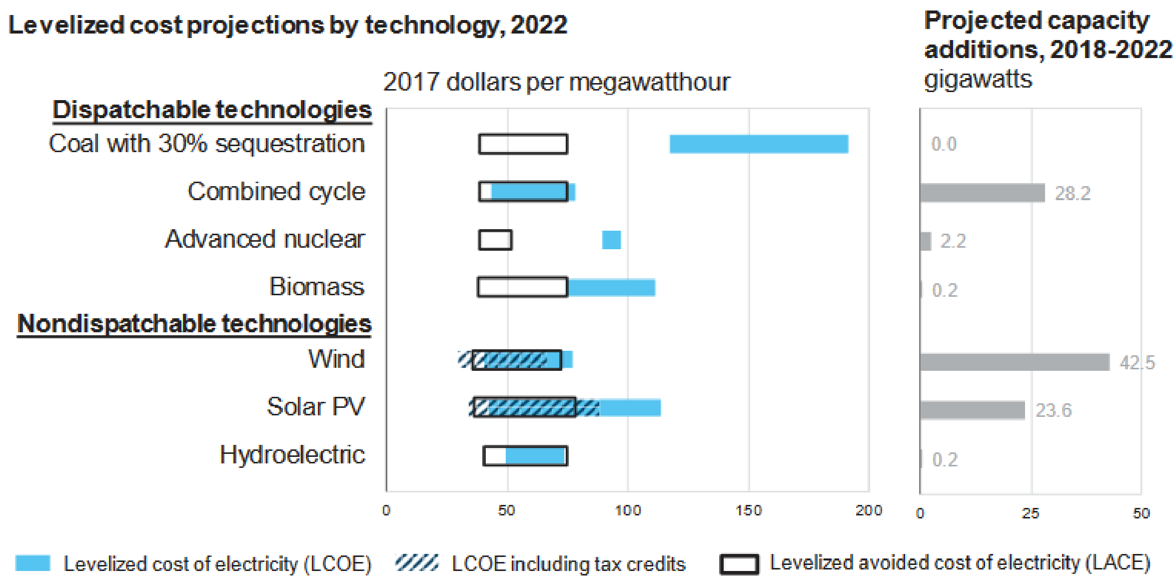

Figure 16. Levelized Cost of Electricity by power plant types
Source: Annual Energy Outlook (2018)

Table 27. Typical regulatory risks related to biomass projects
Source: COWI (2015)

Regulatory Risk	Strategy for Mitigation
Availability of policy support measures necessary for project viability	Seek early engagement with relevant authorities in relation to eligibility process, and terms for policy support measures. Key points to consider are: is the country/region generally supportive of renewable energy? are there support mechanisms in place (most importantly feed-in tariffs, but also renewable energy certificates, taxes on carbon dioxide, renewable energy tenders, renewable energy mandates/obligations, investment grants, or tax incentives)? are policies limited in time, and what are the procedures for benefiting?
Changes in political priorities that may reduce attractiveness of regulatory regime	The best insurance against adverse changes in the regulatory regime (such as a reduction in or abolition of feed-in tariffs) is to seek contractual security on regulatory regime aspects that are essential to project viability at the time of the investment decision.
Planning permits are not obtained in a timely and transparent manner	Seek early engagement with relevant authorities on process and documentation need. National support for projects and engagement with international donors also may help ensure transparency of permitting procedures.
Environmental impact assessment process is smooth and predictable	Seek early engagement with relevant authorities and key stakeholders (including nongovernmental organizations and local communities) on the project's environmental and social aspects and on how to mitigate any adverse effects.

6.4. Preliminary cash flow estimates

The cash flow estimates of the planned project are calculated for all four possible versions. The final decision on the size of the investment will have to be done based on a detailed feasibility study and negotiations with key stakeholders and partners like tenants of the Freeport, raw material suppliers (forestry companies); representatives of the Hungarian Energy and Public Utility Regulatory Authority (MEKH) and the FŐTÁV (Metropolitan District Heating Service Company).

Income and cost plans are based on actual estimated values. The most critical values of the below cash flow estimates are the heat and electricity sales process and the supply price of the energy biomass raw material.

For the heat price presently, we calculated with the natural gas-based energy production cost, however in case of an agreement with FŐTÁV, price will be set based on the reference prices of the heat circle. When incomes were calculated we estimated only 6 months per year of heat markets. However, further year-round industrial buyers may be connected to the system as well.

In case of a biomass-based electricity production over the size of 1 MW, the regulation provides the feed in tariff based on a competitive bidding where the producer has to offer a price for which he is able to produce the electricity. According to industry opinions, the profitable feed in tariff for electricity is somewhere between 30 – 38 HUF/kWh which is calculated only with sale of electricity.

Table 28. Summary of annual production, incomes and costs
Source: own calculation

Plant nominal power generation, MWe	15	12	6	6
Peak supplied heat, MWth	1.35	1.35	1.35	1.35
Electric output	13.725	10.98	5.49	5.49
CAPEX				
Nominal investment cost, HUF/kWe	600,000	720,000	864,000	864,000
Investment cost (CAPEX), MHUF	9,000	8,640	5.184	5,184
Investment cost (CAPEX), MEUR	29.0	27.9	16.7	16.7
OPEX				
Fixed OPEX, MEUR/y	2.90	2.79	1.67	1.67
Variable OPEX (consumables), MEUR/y	5.16	4.39	2.34	2.42
Total OPEX, MEUR/y	8.07	7.18	4.01	4.09
Net income (Total income-Total OPEX), MEUR/y	**3.37**	**1.99**	**0.62**	**0.48**

6.5. Cost benefit analysis

In the present cost-benefit analyses we calculated the relevant data for four different versions to see the optimal size of the planned biomass power plant size from profitability point of view. The planned power plants are optimized for electricity production, as in the case of feed in agreement, this income is year-round while the heat market is only 6 months per year. Calculations of investment cost are based on the presently defined specific unit costs of the state subsidy system for biomass-based energy production investments.

Table 29. Version analysis
Source: own calculation

Plant nominal power generation, MWe	15	12	6	6
Peak supplied heat, MWth	1.35	1.35	1.35	0.5
Electric output, MWe	13.725	10.98	5.49	5.49
Production				
Operating hours, h/y	8,000	8,000	8,000	8,000
Heat supply period, h/y	4,000	4,000	4,000	4,000
Average heat supply, MWth	0.81	0.81	0.81	0.30
Produced electricity, MWh/y	109,800	87,840	43,920	43,920
Supplied heat, GJ/y	11,664	11,664	11,664	4,320
Biomass consumption, t/y				
Wood (from the forest)	127,059	108,000	57,600	59,586
Wheat straw	76,541	65,060	34,699	35,895
Used wood	66,873	56,842	30,316	31,361

In case of raw materials, we collected information on the characteristics and prices of different agricultural and forestry biomass types. In practice, for the calculation we used the average biomass supply cost of district heating companies who are major consumers of energy biomass in the form of wood chips.

Table 30. Version analysis

Source: own calculation

Wood (general wood from the forest)	10	10	10	MJ/kg
	4.4	3.75	2	kg/s
	15.9	13.5	7.2	t/h
	381.2	324	172.8	t/day
Wheat straw	16.6	16.6	16.6	MJ/kg
	2.7	2.3	1.2	kg/s
	9.6	8.1	4.3	t/h
	229.6	195.2	104.1	t/day
Used wood (incl. waste wood)	19	19	19	MJ/kg
	2.3	2.0	1.1	kg/s
	8.4	7.1	3.8	t/h
	200.6	170.5	90.9	t/day

Basic data available on optimal investment size shows that the larger the investment (power plant size) the larger the profitability of the power plant. The final size of the power plant will in fact be determined mainly by market conditions. One of the potential bottlenecks of the nominal power generation capacity is the size of the heat market which determines the profitability of the investment. The other key element which has to be considered before the investment is the availability and price of the biomass.

Table 31. Economical optimum target value
Source: own calculation

Plant nominal power generation, MWe	15	12	6	6
Peak supplied heat, MWth	1.35	1.35	1.35	1.35
Electric output	13.725	10.98	5.49	5.49
Income				
Electricity, MHUF/y	3,513.60	2.810.88	1,405.44	1,405.44
Electricity, MEUR/y	11.33	9.07	4.53	4.53
Heat, MHUF/y	31.49	31.49	31.49	11.66
Heat, MEUR/y	0.10	0.10	0.10	0.04
Total, MEUR/y	11.44	9.17	4.64	4.57
Plant nominal power generation, MWe	15	12	6	6
Peak supplied heat, MWth	1.35	1.35	1.35	1.35
Electric output, MWe	13.725	10.98	5.49	5.49
CAPEX				
Nominal investment cost, HUF/kWe	600,000	720,000	864,000	864,000
Investment cost (CAPEX), MHUF	9,000	8,640	5.184	5,184
Investment cost (CAPEX), MEUR	29.0	27.9	16.7	16.7
OPEX				
Fixed OPEX, MEUR/y	2.90	2.79	1.67	1.67
Variable OPEX (consumables), MEUR/y	5.16	4.39	2.34	2.42
Total OPEX, MEUR/y	8.07	7.18	4.01	4.09
Estimated net income (without financing), MEUR/y	**3.37**	**1.99**	**0.62**	**0.48**

From the profitability of the planned power plant point of view the following key sensitive parameters have to be taken into consideration.

- Availability and supply cost of raw materials (risk of price stability)
- Raw material quality [moisture content, homogeneity, etc.]
- Costs logistics (possibilities for waterway shipment, loading possibilities)
- Higher CAPEX cost because of increasing number of biomass plants in Hungary and the EU
- Planned new biomass-based investments in the South-Pest region (FŐTÁV, the new waste incinerator)

For detailed analyses of scenarios see in Annex 1.

6.6. Market analysis and marketing concept

The new biomass-based power plant's key products are heat and electricity. The proportion of the two outputs is variable within give technological limits. Besides the direct sales of energy, the new plant can supply woodchips for other biomass-based energy producers of the neighbourhood and as a by-product wood ash will be an output as well.

For the electricity, a feed in tariff is defined by the Renewable Energy Support System ("METÁR"), the new regulatory and support scheme for electricity generation from renewable energy sources ("RES"). The planned project size falls under the regulations of the "premium support" regime, on the basis of the energy resources applied, production methods, and the nominal capacity of the power plant. In this category the prices are set based on a competitive bidding managed by the Hungarian Energy and Public Utility Regulatory Authority. The yearly quantities to be supported will be announced regularly, and the quantities will be distributed by technologies (e.g. wind, photovoltaic, biomass etc.). The system is relatively new, but based on industry estimates, feed-in tariffs in the case of biomass-based electricity production will have to be between 30 – 38 HUF/kWh to maintain profitable operations. For the calculations of this study we used the feed-in tariff price of the present subsidized process (32 Ft/kWh).

The produced heat, which can be available all year around parallel with the electricity production, will mainly be sold during the heating season.

The most convenient potential users of the produced heat are the tenants of the Free Port, taking into consideration both the present and the future potentials. In case of these consumer groups, the key factor - the price of heat - will be the cost of heat produced with natural gas. Based on previous experiences, the heat price has be at least 20 % cheaper than the present heat cost with natural gas to satisfy consumer satisfaction.

Another opportunity on the heat market relates to the new infrastructure development with the planned Galvani Bridge, which will provide heat pipe connection from the planned project site to the district heating system of the FŐTÁV. This case's prices have to be set to the reference heat price of the given system (presently 2,600 – 2,900 Ft/GJ) but the network is able to take relatively large quantities when the new connection pipe system is completed.

In regard to the heat market, other competing investments have to be taken into consideration. In Dél-Pest, the FŐTÁV plans to initiate a 20 MW biomass-based heat power plant. If this project is concluded, it may compete on the heat market close to the Freeport area. Another major heat source can be the planned waste incinerator, which may join the same heat system if and when completed.

Further possibilities for the utilization of heat can be future tenants of the Freeport area (presently only a wood drier plant is there which requires heat all year round) or the neighbouring sewage refinery unit that may require heat for the drying of the sewage sludge before incineration.

As for energy biomass raw material, the logistic chain, which supplies the planned new power plant, can be used for the supply of other biomass-based energy producers of the neighbouring area. Municipalities, institutions or smaller local district heating networks can be suppliers of market quality woodchips for the port.

Wood ash is a by-product of energy production. Good quality (free from residues) ash can be well utilized by partners with agricultural or horticultural activities.

Key elements of marketing activities:

- detailed survey on tenants' energy needs – a quotation for heat supply taking into consideration natural gas-based energy productions costs,

- negotiations with Budapest Waterworks on utilization of waste heat for the drying of waste water sludge,
- negotiations with FŐTÁV on optimal heat supply and connection cost.

6.7. Partners to be involved

Here we list all the partners to be involved during the implementation phase when maintaining the infrastructure of the biomass power plant and storage capacities in the Freeport.

- Engineers for operations
- Port management company, Freeport of Budapest Logistics Ltd. (http://www.bszl.hu/en/budapest-dock)
- Consultants and experts in project management
- Budapest district heating company, FŐTÁV Zrt. (http://www.fotav.hu/)
- Budapest Sewage Water Pte Ltd. (Fővárosi Csatornázási Művek) (http://www.fcsm.hu/en)
- Hungarian Energy and Public Utility Regulatory Authority (MEKH) (http://mekh.hu/home)
- Forestries e.g.
    - Ipoly-Erdő Zrt. (http://www.ipolyerdo.hu/)
    - Pilisi Parkerdő Zrt. (http://parkerdo.hu/erdogazdalkodas/)
- Shipping companies e.g.
    - Plimsoll Ltd.

6.8. Co-operation possibilities with other ports

The main purpose of cooperating with other ports on the Danube is to transport biomass raw materials stored in different warehouses, silos and terminals to the Freeport of Budapest to supply the new power plant. Additionally, other jointly developed services could be launched together with Hungarian Danube ports building on common knowledge and goals in the frame of eco-friendly biomass logistics and green IWT. Jointly completed research work and knowledge transfer could serve this cooperation.

Technical, operational conditions

Every forestry located by the River Danube shall have its own well-equipped port with necessary machinery, facilities and capacities for loading wood-based biomass. Minimal required storage facilities can be established for their ports. However, the aim of the cooperation with forestry is to transport wood to the Freeport of Budapest on a weekly basis.

Danube ports specified for grain and agricultural product handling, storing and loading (e.g. Komárom, Adony, Dunavecse) will be involved as well. These ports' equipment are already available and have been developed for high-end service provision in the field of cereal handling.

For instance, 20% of carried/stored products in case of the Port of Adony are raw material for biofuel producer companies. Agricultural by-products, remaining straws and grains could be transported to the Freeport of Budapest on the Danube.

IT conditions

Cooperation with these actors, riverside forestry on one hand and grain handler ports on the other, could be respectfully supported with a well-developed IT system. An up to date information system as an administration background could help following and registering available biomass raw material stocks by the Danube. The service could also facilitate a quality control system of wood and bulk product-based biomasses helping buyers and sellers to find what they might be looking for.

7. Risks and barriers

7.1. Risks and barriers during the implementation

To implement the project, managing risk events is crucial; therefore, an action plan will be developed to address them.

Table 32. Risk matrix
Source: own editing

Name of risky event	Impact of risk if happens	Chance of occurrence	Impact volume of occurrence	Level of risk	Mitigation and prevention measures	Remaining level of risk
Group of risks 1 – Economic risks						
Shifting of implementation in time	If completing other investment in the area (e.g. Galvani bridge), this investment can be late too	Insignificant impact	Little impact	Low	Prevention	Low
Bad conditions for Danube navigation	Unnavigable periods have negative impact on the volume of IWT	Little chance	Little impact	Low	Prevention	Low
Lack of available grants and external sources, NO INTERESTS FROM INVESTORS	External financial resources (e.g. EU funds) completing the development is in question	Little chance	Moderate impact	Moderate	Mitigation or prevention	Moderate
Group of risks 2 – Institutional risks						
Public procurement	Prolongation of the procurement procedure for the execution	Insignificant chance	Moderate impact	Low	Mitigation	Low
Exceeding budget of investment, under estimate project budget	Real cost of the project exceeds the planned costs; need for additional own contribution	Moderate chance	Low impact	Moderate	Mitigation or prevention	Moderate
Costs raising	Increase of general costs	Moderate chance	Moderate impact	Moderate	Mitigation or prevention	Low
Liquidity issues	Suppliers are not paid in time; project implementation is late	Moderate chance	Low impact	Moderate	Mitigation or prevention	Low
Subcontracting company becomes insolvent	Significant prolonging; additional expenses occur	Little chance	Moderate impact	Moderate	Mitigation or prevention	Low
Legal issues	Legal disputes with suppliers and authorities may cause significant delays in project implementation	Little chance	Moderate impact	Moderate	Mitigation or prevention	Low
Deadlines	Deadlines in contracts cannot be handled	Moderate chance	Moderate impact	Moderate	Prevention	Low

Name of risky event	Impact of risk if happens	Chance of occurrence	Impact volume of occurrence	Level of risk	Mitigation and prevention measures	Remaining level of risk
Conflicts among stakeholders NO PREVIOUS EXPERIENCE REGARDING SIMILAR INVESTMENTS	Conflicts among FBL, MAHART, suppliers, management; without clear decision-making, project is late	Little chance	Moderate impact	Moderate	Mitigation or prevention	Moderate
Group of risks 3 – Technical risks						
Prolonging design	Completing implementation of plans is late	Little chance	Moderate impact	Moderate	Mitigation or prevention	Low
Prolonging implementation	Timing of implementation is late	Little chance	Moderate impact	Moderate	Prevention	Moderate
Implementation issues	Unexpected issues during the reconstruction works	Little chance	Moderate impact	Moderate	Prevention	Low
Technical issues	After implementation, technical issues occur	Little chance	Little impact	Low	Mitigation or prevention	Low
Bad weather conditions	Completing project can be late due to extremely high water level	Little chance	Moderate impact	Moderate	Prevention	Low
Issues of implementation	Final delivery is postponed, resulting in later deadline of project, resulting additional costs	Little chance	Little impact	Low	Prevention	Low

Evaluation of risky events by their impact and chance of occurrence are presented below.

Table 33. Categories of possible impacts of risks
Source: own editing

Impact in case of occurrence	Definition of impact volume
I – insignificant impact	Even without any other measures, it does not have any significant impact.
II – little impact	Small scale socio-economic damage that minimizes the long-term impact of the project. Corrective measures are required.
III – moderate impact	Moderate socio-economic damage; mainly financial problems, whether on medium or long term. Corrective measures can correct the problem.
IV – critical impact	Major socio-economic damage; emergence of the risk causes damage to the main function of the project. Even serious repairs may not be enough to avoid damage.
V – catastrophic impact	Project failure, which can seriously or even completely damage the functioning of the project. Main impacts of the project in the middle and long term do not appear.

Table 34. Applying risk mitigating and preventing strategies according to the level of risks
Source: own editing

Impact / chance	I Insignificant impact	II Little impact	III Moderate impact	IV Critical impact	V Catastrophic impact
A Insignificant chance (0-10%)	**none**	**mitigation**	**mitigation**	**mitigation**	**mitigation and prevention**
B Little chance (10-33%)	**prevention**	**mitigation or prevention**	**mitigation or prevention**	**mitigation and prevention**	**mitigation and prevention**
C Moderate chance (33-66%)	**prevention**	**mitigation or prevention**	**mitigation or prevention**	**mitigation and prevention**	**mitigation and prevention**
D Big chance (66-90%)	**prevention**	**mitigation and prevention**	**mitigation and prevention**	**mitigation and prevention**	**mitigation and prevention**
E To be sure (90-100%)	**mitigation and prevention**	**mitigation and prevention**	**mitigation and prevention**	**mitigation and prevention**	**mitigation and prevention**

Risk management strategy

In relation to the risks identified above in the risk matrix, risk management strategies could be applied based on the following table. Impact volume of factors and chance for occurrence are taken into account.

Table 35. Risk management strategy during implementation
Source: own editing

Risk	Impact volume	Chance for occurrence	Risk management strategy
Lack of available grants (external risk) External financial resources (e.g. EU funds) completing the development is in question	Moderate impact	Little chance	Cooperation with homeland EU institutions
Public procurement Prolonging of public procurement	Moderate impact	Insignificant chance	Appropriate preparation of public procurement processes, administration and documentation (detailed specification and availability of background services, plans, list of equipment)
Exceeding budget of investment, under estimate project budget Real cost of the project exceeds the planned costs; need for additional own contribution	Moderate impact	Moderate chance	As precise estimations as possible taking into account reserves
Increase of general costs	Low impact	Moderate chance	Mapping market prices
Prolonging of receiving grants	Moderate impact	Moderate chance	Completing payment requests and reports every 2-3 months
Miscalculating timing of project	Low impact	Moderate chance	Timing and deadlines of the project ought to be estimated correctly
Liquidity issues Suppliers are not paid in time; project implementation is late	Moderate impact	Little chance	Risks can be reduced by financing suppliers
Subcontracting company becomes insolvent Significant prolonging; additional expenses occur	Moderate impact	Little chance	Strict financial eligibility criteria to be defined and applied for procurement
Deadlines Deadlines in contracts cannot be handled	Low impact	Moderate chance	Contracts to be strict to deadlines

Risk	Impact volume	Chance for occurrence	Risk management strategy
Conflicts among stakeholders Conflicts among FBL, MAHART, suppliers, management; without clear decision-making, project is late	Moderate impact	Moderate chance	Clear communication among partners, completing project launching documentation to clarify responsibilities, decision making processes, communication channels. Experienced project management is required.
Legal issues Legal disputes with suppliers and authorities may cause significant delays in project implementation	Moderate impact	Moderate chance	Experienced legal professionals, well-prepared contracts, agreements.
Prolonging design Completing implementation plans is late	Moderate impact	Moderate chance	Preparation of contract with tight deadlines
Prolonging implementation Timing of implementation is late	Moderate impact	Moderate chance	Conclude and comply with a contract with tight deadlines
Implementation issues Unexpected issues during the reconstruction works	Moderate impact	Little chance	Availability of accurate documentation related to all disciplines
Technical issues After implementation, technical issues occur	Low impact	Little chance	Contract guaranteeing the suitability of construction works for minimum 5 years.
Bad weather conditions Completing project can be late due to flood	Moderate impact	Little chance	Incorporating reserve time, using waterproof and weather-independent technologies. During the implementation period, contractor must report on the occurrence of flooding problems and related tasks in the work area.
Issues of implementation Final delivery is postponed, resulting in a later deadline of the project, resulting in additional costs	Low impact	Little chance	Reserve time when scheduling. Defining deadlines carefully, technical inspection

7.2. Risks and barriers during operation

In the following, risks and limitations are presented during the operation once the project is completed, namely the power plant is installed, and it starts running. Factors are grouped into economic, institutional and technological barriers.

As noticeable under the right column, where ‘Risk management strategies’ are presented, lobbying and external communication with governmental stakeholders is necessary, because many of the occurring risks are external, and the Freeport has hardly any influence on them.

Table 36. Risk management strategy during operation
Source: own editing

Risk	Impact volume	Chance for occurrence	Risk management strategy
Economic risks and barriers			
potentials are lying fallow; the capacities of biomass power plants are underutilized due to low volume of internal and external heat demand: neither the companies located in the port area, nor the public citizens of Budapest in households and offices are in need of biomass-based district heating services and energy supply	high impact	moderate chance	pressure on policy makers to facilitate switching from traditional gas supply to renewable heat supply regarding public consumption
quantity of solid biomass raw materials (wood and chips) are less and less, causing significant price increase, thus threatening technological and financial sustainability of the construction	high impact	moderate chance	pressure on policy makers to modernize regulations on afforestation
price of the produced heat is not competitive enough with current traditional gas prices	high impact	low chance	policy makers need to be forced to ensure stability of METÁR (renewable supporting system)
changes of overtaking prices of electricity is unfavourable	moderate impact	low chance	policy makers need to be forced to ensure stability of METÁR (renewable supporting system)
Institutional risks and barriers			
MAHART has no experiences in the field of operating such an establishment, neither does FBL	low impact	high chance	outsourcing of services with the involvement of engineers, constructers and external project manager companies is necessary; a possible solution is establishing a project company within MAHART group

Risk	Impact volume	Chance for occurrence	Risk management strategy
The operational department is unsatisfying: such an establishment requires a specified labour force, skills and competencies for operating the related infrastructure, organizing related logistics and fuelling, and maintaining the power plant on its higher and lower capacities depending on seasonal peaks and valleys			outsourcing of services; establishing a project company within MAHART group; employing a well-educated and experienced engineer team and dedicated logistics department for the maintenance and operation of the power plant
potential users, clients cancel contracts	high impact	low chance	trust-based cooperation among actors is necessary
Technological risks and barriers			
establishment is not performing as expected based on previous calculations on efficiency	high impact	low chance	redesign and recalculation of maintenance costs and expected performance; reinvesting in the/new technology
considering raw material supply, limitations in logistics can occur due to extreme weather conditions (e.g. vessels cannot navigate on the Danube because of low water level or ice)	moderate impact	low chance	buffer storage capacities need to be settled and multiple supply channels are required to be developed

8. Recommendations

Based on the preliminary analyses of the planned project, MAHART Freeport Co. Ltd. is located at an ideal site for the implementation of a biomass-based energy production project. Via the Port, the necessary raw materials can be supplied through a waterway-based logistics network. With the planned Galvani Bridge, the key district heating pipe network will be built very close to the planned place of implementation for the project. For the feed in of green electricity, more transformers are available on the site as potential connection points.

For the preparation of the project, the following suggested key further steps are recommended:

- Negotiations with potential heat purchasers (Metropolitan District Heating Company – FŐTÁV) based on heat output estimates to clarify long term market possibilities and prices,
- Detailed surveying among tenants of the Freeport on their heat supply requirements (quantities, temperatures, seasonality, technological heat etc.),
- Negotiations with Hungarian Energy and Public Utility Regulatory Authority (MEKH) on possible load-in tariffs and terms based on electricity production estimates,
- Negotiation with Budapest Waterworks on the heat needs of the wastewater treatment unit,
- Negotiations with potential biomass suppliers (state forestry companies) on availability, prices and possible transport arrangements of woodchips and a more specific analysis of the hinterland area in terms of e.g. available biomass or companies along the value chains,
- Negotiation with logistic companies based on biomass supply quantity data,
- Detailed feasibility analyses for different technically viable versions:
    - Technological version analyses [for other technically equivalent solutions]
    - Optimal cost analyses and financial target value calculation
    - Estimation of transport cost based on quantity and loading point information,
- Based on detailed feasibility study findings negotiations on potential financing – subsidies, investors, financial institutions.

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ANNEX 1 - Cost-benefit analyses

The objective of these analyses is to assess the possibility of initiating a biomass-based energy production unit at the Port of Budapest. The aim of the planned investment is to construct a combined heat and power generation unit which utilizes the biomass transported to the Port from neighbouring forestry companies using the waterway and the technical equipment available in the Port.

The investment costs, possible incomes and operational cost are analysed for a 15 MWe CHP power plant as it became clear from preliminary calculation that smaller plant sizes were less profitable because of economy-of-scale reasons.

During the operation of the power plant, key influential factors of profitability would be the cost of raw material, the feed-in tariff for renewable electricity and the sales price of heat. In these analyses we assess the effect of changes of the above cost and revenue factors (costs of raw material supply, feed-in tariff and heat price) versus profitability of the investment.

Cost of raw material supply

In the initial calculations we used the 2017 average raw material supply cost of a district heating company running a similar size biomass fuelled heat power plant. The cost 1.62 HUF/MJ is calculated for standard quality wood chips transported to plant.

Based on collected market information, the supply cost of energy biomass may rise partly because of limited availability on the production side (forestry companies) and partly because of the construction of new biomass-based power plants in the Budapest region. In our calculations, we assumed 15% raw material cost increase in the 4th year of the operation and a further 15% increase during the 6th year of operation.

Feed-in tariff

For the sale of electricity, a feed in tariff is defined by Renewable Energy Support System ("METÁR"), the new regulatory and support scheme for electricity generation from renewable energy sources ("RES"). The planned project size falls under the regulations of the "premium support" regime, on the basis of the energy resources applied, production methods, and the nominal capacity of the power plant. In this category the prices are set based on a competitive bidding managed by the Hungarian Energy and Public Utility Regulatory Authority.

For the initial calculations, we used the presently calculated weighted average of the feed-in tariff price which is 32 Ft/kWh. In these analyses we examine two scenarios: one where feed-in tariffs are changing only with the rate of inflation, and another scenario where feed-in tariffs are increasing by 10% each year over a 5 year period due to the fact that renewable energy prices in Hungary are lower than in neighbouring countries.

Heat price

For the selling of generated heat in the planned power plant, there are two basic options. One to sell the heat through the district heating system to be developed close to the planned site of the power plant, and one to sell heat for the tenants of the Free Port logistic and industrial park. In our calculations we used the heat prices of the local district heating company (FŐTÁV) 2700 HUF/GJ. In the analyses two options are examined: First, the decrease of heat prices due to new planned investments which may provide considerable quantities of heat for the district heating network (new waste incineration plant in South-Pest, and a new biomass based thermal power plant at Kőbánya), which may result in a 30% price fall in the 5th year of operation. As a second option we analyse the effect of a natural gas price increase which could reduce the effect of the planned new power plants, leading to a price fall of only 10%.

Assumptions for the financial analysis

By the definition of the assumptions for the financial and economic calculation the GUIDE TO COST-BENEFIT ANALYSIS OF INVESTMENT PROJECTS, Economic appraisal tool for Cohesion Policy 2014-2020, was used (referred as CBA guide in the following).

In accordance with the document, the following assumptions were applied:

- The financial analysis methodology used in the analysis is the Discounted Cash Flow (DCF) method, in compliance with section III (Method for calculating the discounted net revenue of operations generating net revenue) of Commission Delegated Regulation (EU) No 480/2014. Only cash inflows and outflows are considered in the analysis, i.e. depreciation, reserves, price and technical contingencies and other accounting items which do not correspond to actual flows are disregarded.

- A financial discount rate of 4% was used according to Article 19 (Discounting of cash flows) of Commission Delegated Regulation (EU) No 480/2014, for the programming period 2014-2020.

- The project time horizon is 20 years according to the CBA guide and lifetime of the assets implemented during the project.

- As the project time horizon matches the lifetime of the assets we did not calculate with residual value of the assets.

- We did not calculate with replacement costs in the time horizon of the project. Renovation and maintenance costs are included in the financial operating costs.

- The analysis was carried out in real prices. Regarding to the operational costs and the financial revenues we calculated with 1% price increase per year, except for Electricity income where the price increase is 3% per year.

- VAT is not considered in the analysis since direct revenues are generated and therefore VAT is recoverable.

Table 37. General input data

General input data	
Plant nominal power generation, MWe	15
Produced electricity, MWh/y	109 800
Supplied heat, GJ/y	11 664

Table 38. Starting case

	Starting case									
	Return indicators (thousands of EUR)									
No.		FPV	Year1	Year2	Year3	Year16	Year17	Year18	Year19	Year20
1	Financial investment cost	27 915	29 032	0	0	0	0	0	0	0
2	Fixed cost	39 691	0	2 903	2 932	3 337	3 370	3 404	3 438	3 472
3	Raw material cost	89 664	0	6 558	6 624	7 538	7 614	7 690	7 767	7 844
4	Other variable costs	0	0	0	0	0	0	0	0	0
5	Variable cost (3+4)	89 664	0	6 558	6 624	7 538	7 614	7 690	7 767	7 844
6	Financial operating cost (2+5)	129 355	0	9 461	9 556	10 875	10 984	11 094	11 205	11 317
7	Cash outflow (1+6)	157 270	29 032	9 461	9 556	10 875	10 984	11 094	11 205	11 317
8	Electricity income	182 773	0	11 334	11 674	17 144	17 658	18 188	18 733	19 295
9	Heat income	1 395	0	102	103	117	118	120	121	122
10	Financial revenue (8+9)	184 168	0	11 436	11 777	17 261	17 776	18 307	18 854	19 417
11	Cash inflow (10)	184 168	0	11 436	11 777	17 261	17 776	18 307	18 854	19 417
12	Financial residual value	0	0	0	0	0	0	0	0	0
13	Total net financial cash flow (11+12-7)	26 898	-29 032	1 975	2 221	6 386	6 792	7 214	7 649	8 101
14	**Financial net present value (FNPV/C)**	26 898								
15	**Financial internal rate of return FRR/C**	11,17%								

Table 39. Case 1: Raw material cost increase

	Case 1: raw material cost increase									
	Return indicators (thousands of EUR)									
No.		FPV	Year1	Year2	Year3	Year16	Year17	Year18	Year19	Year20
1	Financial investment cost	27 915	29 032	0	0	0	0	0	0	0
2	Fixed cost	39 691	0	2 903	2 932	3 337	3 370	3 404	3 438	3 472
3	Raw material cost	109 278	0	6 558	6 624	9 773	9 871	9 969	10 069	10 170
4	Other variable costs	0	0	0	0	0	0	0	0	0
5	Variable cost (3+4)	109 278	0	6 558	6 624	9 773	9 871	9 969	10 069	10 170
6	Financial operating cost (2+5)	148 969	0	9 461	9 556	13 110	13 241	13 373	13 507	13 642
7	Cash outflow (1+6)	176 885	29 032	9 461	9 556	13 110	13 241	13 373	13 507	13 642
8	Electricity income	182 773	0	11 334	11 674	17 144	17 658	18 188	18 733	19 295
9	Heat income	1 395	0	102	103	117	118	120	121	122
10	Financial revenue (8+9)	184 168	0	11 436	11 777	17 261	17 776	18 307	18 854	19 417
11	Cash inflow (10)	184 168	0	11 436	11 777	17 261	17 776	18 307	18 854	19 417
12	Financial residual value	0	0	0	0	0	0	0	0	0
13	Total net financial cash flow (11+12-7)	7 283	-29 032	1 975	2 221	4 151	4 535	4 934	5 347	5 775
14	**Financial net present value (FNPV/C)**	7 283								
15	**Financial internal rate of return FRR/C**	6,32%								

Table 40. Case 2: Feed in tariff increase

No.	Case 2: feed-in tariff increase 50%/5 years Return indicators (thousands of EUR)	FPV	Year1	Year2	Year3	Year16	Year17	Year18	Year19	Year20
1	Financial investment cost	27 915	29 032	0	0	0	0	0	0	0
2	Fixed cost	39 691	0	2 903	2 932	3 337	3 370	3 404	3 438	3 472
3	Raw material cost	89 664	0	6 558	6 624	7 538	7 614	7 690	7 767	7 844
4	Other variable costs	0	0	0	0	0	0	0	0	0
5	Variable cost (3+4)	89 664	0	6 558	6 624	7 538	7 614	7 690	7 767	7 844
6	Financial operating cost (2+5)	129 355	0	9 461	9 556	10 875	10 984	11 094	11 205	11 317
7	Cash outflow (1+6)	157 270	29 032	9 461	9 556	10 875	10 984	11 094	11 205	11 317
8	Electricity income	237 355	0	11 334	11 674	23 817	24 531	25 267	26 025	26 806
9	Heat income	1 395	0	102	103	117	118	120	121	122
10	Financial revenue (8+9)	238 750	0	11 436	11 777	23 934	24 650	25 387	26 146	26 928
11	Cash inflow (10)	238 750	0	11 436	11 777	23 934	24 650	25 387	26 146	26 928
12	Financial residual value	0	0	0	0	0	0	0	0	0
13	Total net financial cash flow (11+12-7)	81 480	-29 032	1 975	2 221	13 059	13 666	14 293	14 941	15 611
14	**Financial net present value (FNPV/C)**	81 480								
15	**Financial internal rate of return FRR/C**	19,63%								

Table 41. Case 3: Heat price decrease

No.	Case 3: heat price decrease 30% Return indicators (thousands of EUR)	FPV	Year1	Year2	Year3	Year16	Year17	Year18	Year19	Year20
1	Financial investment cost	27 915	29 032	0	0	0	0	0	0	0
2	Fixed cost	39 691	0	2 903	2 932	3 337	3 370	3 404	3 438	3 472
3	Raw material cost	89 664	0	6 558	6 624	7 538	7 614	7 690	7 767	7 844
4	Other variable costs	0	0	0	0	0	0	0	0	0
5	Variable cost (3+4)	89 664	0	6 558	6 624	7 538	7 614	7 690	7 767	7 844
6	Financial operating cost (2+5)	129 355	0	9 461	9 556	10 875	10 984	11 094	11 205	11 317
7	Cash outflow (1+6)	157 270	29 032	9 461	9 556	10 875	10 984	11 094	11 205	11 317
8	Electricity income	182 773	0	11 334	11 674	17 144	17 658	18 188	18 733	19 295
9	Heat income	1 077	0	102	103	81	82	83	84	85
10	Financial revenue (8+9)	183 851	0	11 436	11 777	17 225	17 740	18 271	18 817	19 380
11	Cash inflow (10)	183 851	0	11 436	11 777	17 225	17 740	18 271	18 817	19 380
12	Financial residual value	0	0	0	0	0	0	0	0	0
13	Total net financial cash flow (11+12-7)	26 580	-29 032	1 975	2 221	6 350	6 756	7 177	7 612	8 063
14	**Financial net present value (FNPV/C)**	26 580								
15	**Financial internal rate of return FRR/C**	11,11%								

Table 42. Case 4: Combination of Case 1 and Case 2

No.	Case 4: combination of Case 1 and Case 2 Return indicators (thousands of EUR)	FPV	Year1	Year2	Year3	Year16	Year17	Year18	Year19	Year20
1	Financial investment cost	27 915	29 032	0	0	0	0	0	0	0
2	Fixed cost	39 691	0	2 903	2 932	3 337	3 370	3 404	3 438	3 472
3	Raw material cost	109 278	0	6 558	6 624	9 773	9 871	9 969	10 069	10 170
4	Other variable costs	0	0	0	0	0	0	0	0	0
5	Variable cost (3+4)	109 278	0	6 558	6 624	9 773	9 871	9 969	10 069	10 170
6	Financial operating cost (2+5)	148 969	0	9 461	9 556	13 110	13 241	13 373	13 507	13 642
7	Cash outflow (1+6)	176 885	29 032	9 461	9 556	13 110	13 241	13 373	13 507	13 642
8	Electricity income	237 355	0	11 334	11 674	23 817	24 531	25 267	26 025	26 806
9	Heat income	1 395	0	102	103	117	118	120	121	122
10	Financial revenue (8+9)	238 750	0	11 436	11 777	23 934	24 650	25 387	26 146	26 928
11	Cash inflow (10)	238 750	0	11 436	11 777	23 934	24 650	25 387	26 146	26 928
12	Financial residual value	0	0	0	0	0	0	0	0	0
13	Total net financial cash flow (11+12-7)	61 865	-29 032	1 975	2 221	10 824	11 409	12 013	12 639	13 286
14	**Financial net present value (FNPV/C)**	61 865								
15	**Financial internal rate of return FRR/C**	16,97%								

Table 43. Financial Internal Rate of Return for Cases 0-4

Financial Internal Rate of Return for Cases 0-4

Case	Plant 1	Oszlop1	Oszlop2	Oszlop3
Starting case	11,17%			
Case 1	6,32%			
Case 2	19,63%			
Case 3	11,11%			
Case 4	16,97%			

ANNEX 2 – Additional tables

Table 44. Comparison of biomasses and coal characteristics
Source: Rao (2015)

	Woody biomass		Switchgrass		Bituminous coal	
Basis	**Dry**	**As received**	**Dry**	**As received**	**Dry**	**As received**
Ultimate analysis (%)						
Carbon	52.36	26.18	42.60	36.21	71.72	63.75
Hydrogen	5.60	2.80	6.55	5.57	5.06	4.5
Nitrogen	0.37	0.19	1.31	1.11	1.41	1.25
Sulfur	0.03	0.02	0.01	0.01	2.82	2.51
Chlorine	0.10	0.05	0.04	0.03	0.33	0.29
Ash	1.38	0.69	7.41	6.30	10.91	9.7
Moisture	0.00	50.00	0.00	15.00	0	11.12
Oxygen	40.16	50.08	42.08	35.77	7.75	6.88
Total	100.00	100.00	100.00	100.00	100.00	100.00
Heating value						
HHV (kJ/kg)	19,627	9,813	18,113	15,396	30,531	27,135
HHV (Btu/lb)	8,438	4,219	7,787	6,619	13,126	11,666
LHV (kJ/kg)	18,464	9,232	16,659	14,161	29,568	26,172
LHV (Btu/lb)	7,938	3,969	7,162	6,088	12,712	11,252

Table 45. Typical amount of biomass need for different size of power plants
Source: IFC (2017)

	1-5 MWe	5-10 MWe	10-40 MWe
Technology/Range	**Minimum input (GJ/day)**		
Combustion plants using a water/steam boiler	20-100 tons per day	100-200 tons per day	200-900 tons per day
Combustion plants using ORC technology	50-200 tons per day	200-500 tons per day	n.a.
Biogas production with gas engine	40-200 tons per day	n.a.	n.a.

The possible ways to convert the energy from biomass are the following:

1) Combustion technology with water/steam cycle: this is the most conventional – and easiest - way of the utilization, which gives the highest cost/effectiveness factor.

2) Combustion technology using ORC (Organic Rankine Cycle) technology: combustion technology with a different type of heat-cycle. Not so well-developed, like the steam-cycle, but the application range – due to the lower temperatures – is wider than the steam-cycle. A more complex technology, with more equipment.

3) Biogas production: this procedure produces gas phase from solid biomass (that is why the biogas production rate is important), which can be used as fuel in a boiler or even in gas engines. The remaining solid phase can still be utilized in the combustion technology.

In order to determine the applicable technologies and project development needed, the potential and features of the available biomasses in the region shall be examined as well.

Based on the source from which the biomass is derived, we define three separate types of biomasses.

Table 46. Categorization of biomasses
Source: IFC (2017)

	Woody Biomass	Herbaceous Biomass	Biomass from Fruits and Seeds	Other (including Mixtures)
	Wood fuels	**Agro-fuels**		
Primary (Energy crops)	Energy forest trees Energy plantation trees	Energy grass Energy whole cereal	Energy grain	
Secondary (By-products)	Thinning by-products Logging by-products	**Crop production by-products**		Animal by-products Horticultural by products Landscape management by products
		Straw	Stones, shells, husks	
	Wood processing industry by products Black liquor	Fibre crop processing by products	Food processing industry by products	Bio-sludge Slaughter by products
Tertiary (End-use materials)	Used wood	Used fibre products	Used products of fruits and seeds	

New technological solutions

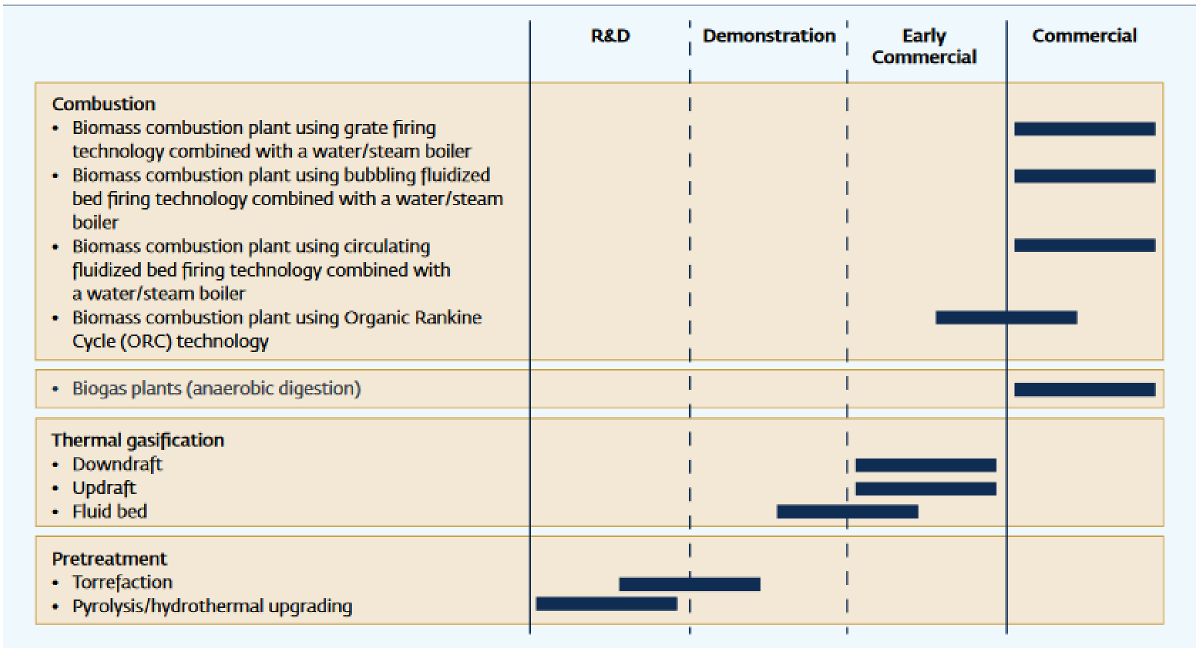

Figure 17. Maturity of the different biomass utilization technologies
Source: IFC (2017)

Overview of Biomass Conversion Technologies and Their Current Development Status based on Converting Biomass to Energy by IFC, 2017.

The basic operation and applications of an ORC cycle can be seen in the following picture.

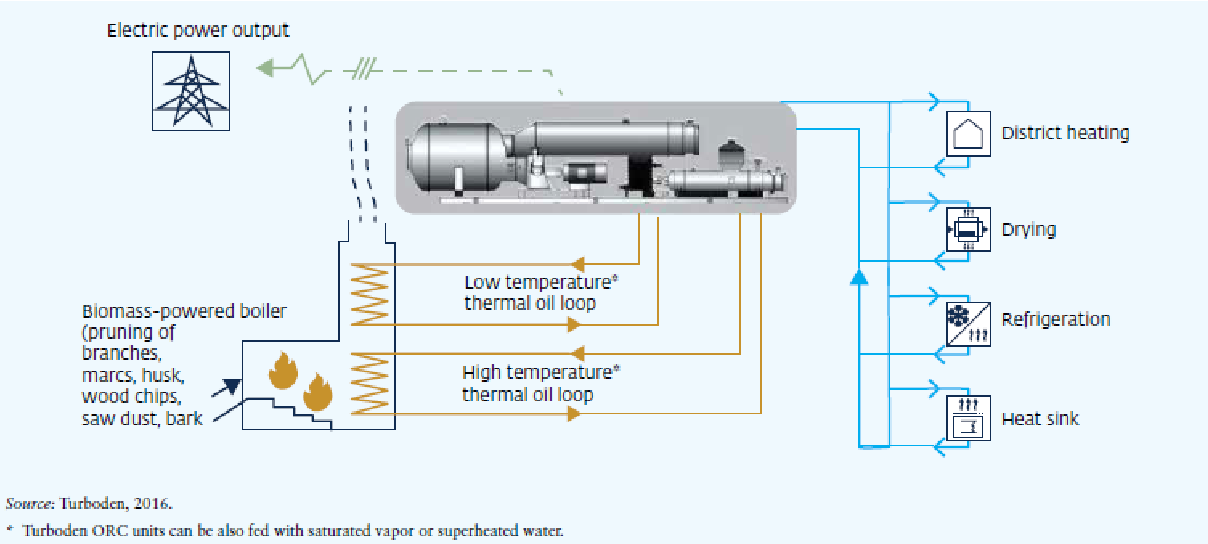

Figure 18. Typical configuration and products of an ORC cycle
Source: IFC (2017)

The ORC is currently somewhere in the early commercial and commercial phase, which usually means that some developmental issues (parameters and manufacturing) and operational experience need to be gained before the real commercial availability can be reached.

The most common, technologically mature cycle for the biomass application is the water/steam cycle, so this document does not deal with ORC cycles, biogas plant and pyrolysis technology. These technologies are more complex, consisting of not so mature equipment, which means that the total cost of ownership (including the total CAPEX and total OPEX during the lifecycle) is higher than the conventional water/steam cycle. The higher CAPEX and OPEX result in a lower return on investment if we consider the same electricity and heat prices.

Based on the experience gained on biomass firing, the following heat and power production technologies are suggested to be further examined:

Fluidized bed combustion boilers – CFB and BFB boilers

Circulating fluidized-bed combustion CFB boiler technology offers high reliability and availability coupled with low maintenance costs, and complies with stringent emission regulations. The CFB technology utilized employs a unique, simple U-beam particle separator design.

Fluidized-bed boilers are the most common type of boiler recommended for biomass fuel, which is burned within a hot bed of inert particles, typically sand. The fuel-particle mix is suspended by an upward flow of combustion air within the bed. As velocities increase the gas/solid mix exhibits fluid-like properties. The scrubbing action of the bed material on the fuel also enhances the combustion process by stripping away the CO2 and solids residue (char) that normally forms around the fuel particles, allowing oxygen to reach the combustible material more readily and increase the rate and efficiency of the combustion process.

This process also increases heat transfer and allows for lower operating temperatures: bed temperatures range about 760° C to 870° C, far less than the 1200° C for a spreader stoker boiler. Lower boiler temperatures also produce less nitrogen oxide, an environmental and regulatory benefit when burning high nitrogen-content wood and biomass fuels. Sulphur dioxide emissions from wood waste and biomass are generally insignificant; however, if sulphur is a contaminant it can be neutralized by adding limestone to the fluid bed.

Boiler engineers can choose between two main types of fluidized-bed boilers—bubbling fluidized bed (BFB) and circulating fluidized bed (CFB). In BFB boilers the velocity of the combustion air is low enough that the fluidized particles remain in the lower furnace; in a CFB unit the velocity is greater and hot particles are circulated through the entire range of the boiler combustion zone. The fuel is in contact with the particles and effective mixing and combustion allows good efficiency and low emissions. Typically 97% to 99% of all burnable carbon in the fuel stream is combusted, even hard-to-burn materials. Boiler thermal efficiencies can be as high as 87% or more. Although both BFB and CFB systems are effective with biofuels, CFB is especially suitable for large boiler load ranges, while BFB is commonly used for smaller applications with varying LHV biomasses (Crawford, 2012).

Fluidized Bed Combustion - Atmospheric fluidized bed combustion boilers - AFBC boilers

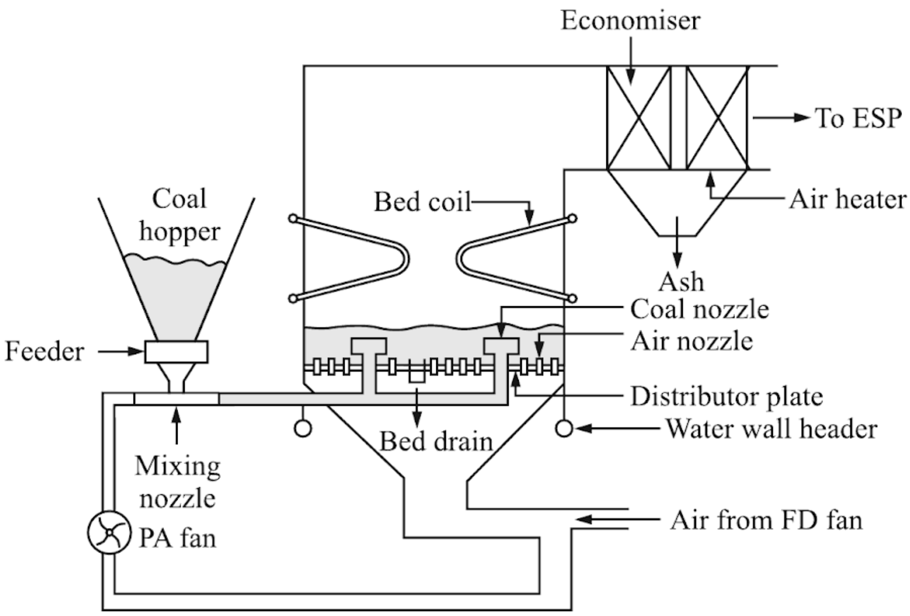

Figure 19. Main parts of a fluidized bed boiler
Source: Mallick (2015)

Main parts of the technology:

- Air distribution
- Fluidized bed
- Fuel feeding system
- In bed heat transfer surface
- Ash handling system

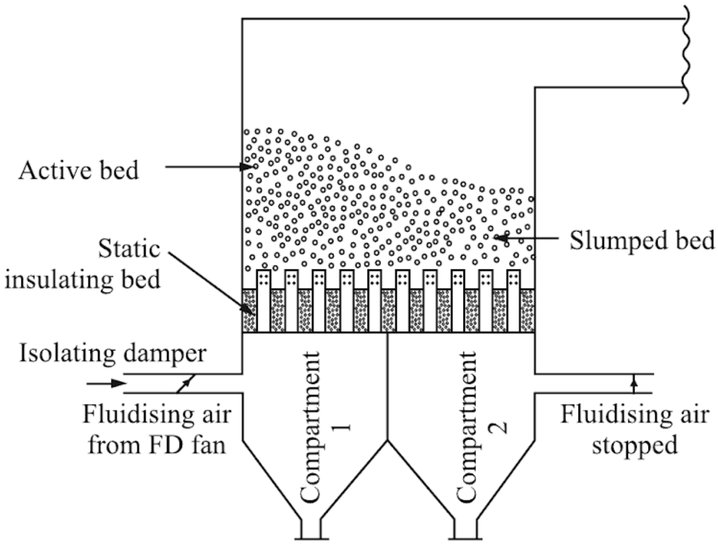

Figure 20. Bubbling fluidized bed boiler's internal structure
Source: Mallick (2015)

Atmospheric fluidized-bed combustion (AFBC) boilers offer efficient, cost effective and reliable steam generation. AFBC technology promises to provide a viable alternative to conventional coal-fired boilers and other solid fuel-fired boilers. ZG utilizes the technology to offer hopper bottom design AFBC boilers with a capacity of up to 300 t/h of steam generation. These AFBC boilers are designed with no moving parts in the combustor, which ensures reduced maintenance costs. Uniform temperature distribution in the bed along with the agitating characteristic of the fluid bed provide optimum combustion, resulting in a minimum of unburnt fuel, reduced carbon monoxide emissions and improved efficiency.

Travelling Grate Boiler

Travelling Grate Boilers are operated through burning of mustered husk and paddy straw and provides for superior combustion efficiency. Providing for high operation reliability, these also ensure low down time as well as comparatively less fouling and sagging possibilities (Ashoka Machine Tools Corporation, 2018).

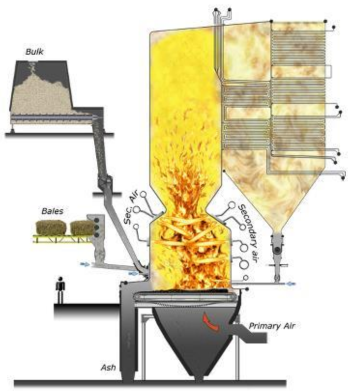

Figure 21. Travelling grate boiler
Source: AET (2018)

The main advantage of the technology is that it is robust, which means that the stability does not depend on the quality of the fuel.

In a traveling grate-fired boiler unit, the fuel bed is moved continuously from fuel inlet to ash outlet on a belt with “hinged” cast iron grate bars, attached to chains, and moved by a drive system. Fuel is supplied to the grate by screw conveyors (stokers) to give an evenly distributed fuel layer on the grate.

At the back end of the grate, the bars are cleaned for ash and slag. On the way back, the “loose” bars are cooled by the primary air to the grate. The combustion process on the grate is controlled by the height of the bed layer, the grate velocity, and the combustion air (primary air) to ensure a complete burnout of the char without slagging or overheating the grate.

A too-high content of fine fuel particles will increase the amount of fly ash with uncontrolled burnout. Blends of different biomass fuels should be evenly distributed across the grate, not leaving openings in the fuel bed layer that will allow primary air to “leak” directly into the furnace.

The maintenance cost for this type of grate is normally higher, as the traveling grate chain requires regular maintenance.

The traveling grate principle is well suited for:

- Wet biomass fuels
- High ash fuels
- Fuels with different sizes

The planned biomass-based power plant will be based on combustion technology, the type of boiler will have to be selected based on power plants size, required quantities of heat, and the type and quality of biomass utilized. Based on preliminary financial calculation larger units bring better returns. Present investment costs of ORC technology-based plants are do not provide ideal profitability results for similar set up.

Technology and equipment

A biomass plant is a complex construction, and for a typical steam-based power plant, the following systems should be considered:

- Fuel reception station
- Fuel yard
- Fuel shredding
- Fuel storage
- Fuel transport
- Boiler feeding
- Combustion
- Boiler
- Fuel gas cleaning

- Emission monitoring
- Chimney
- Bottom ash transport and storage
- Fly ash transport and storage
- Turbine/generator
- Condensate
- Makeup water
- Chemical dosing
- Compressed air
- Soot-blower system
- Control and instrumentation
- Electricity and power distribution
- Grid connection
- Connection to steam or district heating
- Workshop
- Cooling (in this case, direct cooling system from the Danube)

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