Interreg
Danube Transnational Programme
ENERGY BARGE

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 4.1.3

Analysis of logistics requirements of raw materials, intermediates and end products for the bioenergy industry

15 December, 2017

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.

Content

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 facilitate the market uptake of biomass, support better connected transport systems for green logistics and provide practical solutions and policy guidelines. FNR coordinates the project with its fourteen partners from Austria, Bulgaria, Croatia, Germany, Hungary, Slovakia and Romania.

Project coordinator

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

Project partners

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

II. About this document

This report corresponds to D 4.1.3 analysis of logistics requirements of raw materials, intermediates and end products for the bioenergy industry of ENERGY BARGE. It has been prepared by:

Due date of deliverable:	2017-12-31
Actual submission date:	2017-12-15
Start date of project:	2017-01-01
Duration:	30 months

Work package	WP4
Task	D 4.1.3
Lead contractor for this deliverable	Austrian Waterway Company (VIA)
Editor(s)	Thies Fellenberg (FNR), Martin Behrens (FNR), Ann-Kathrin Kaufmann (BCG), Simon Hartl (VIA), Benedikt Grath (VIA), Christa Dissauer (BE2020), Rastislav Veselko (SPaP)
Author	Simon Hartl (VIA), Benedikt Grath (VIA)
Quality reviewer	Birger Kerckow (FNR)

Version	**Date**	**Author(s)**	**Reason for modification**	**Status**
1.1	*2017-11-27*	*Benedikt Grath, Simon Hartl (VIA)*	*First draft of the D 4.1.3 report*	*finalised*
1.2	*2017-12-14*	*Thies Fellenberg, Martin Behrens (FNR), Ann-Kathrin Kaufmann (BCG), Christa Dissauer (BE2020), Rastislav Veselko (SPaP)*	*Feedback on first draft*	*finalised*
2.0	*2017-12-15*	*Simon Hartl, Benedikt Grath (VIA)*	*Final draft*	*finalised*

III. Executive Summary

To support the integration of inland waterway transport (IWT) into supply chains of the biomass and bioenergy sector, Work Package 4 collected and analysed the requirements of potential customers of Danube logistics services in this field. Desk research, evaluation of existing sources and studies, but more importantly carrying out in total 38 interviews with experts and practitioners from five Danube countries, provided the basis for this assessment report. The report also identified existing potentials and needed investments. The final results of the analysis were clustered according to the types of biomass and products defined in WP3 as well as to the logistics processes (1) transport, (2) transshipment and (3) storage.

As a result of this analysis the general logistics requirements of the bioenergy industry can be summarized as follows:

- Reliable waterway infrastructure
- Efficient infra- and superstructure in the Danube ports (in terms of quantity and quality)
- Time-efficient and flexible administrative processes
- Flexible logistics concepts integrating Danube logistics services

In addition to these requirements which are also relevant for customers of Danube logistics services from other economic sectors, cargo-specific requirements were collected and analysed for the following types of goods from the bioenergy value chain defined in Work Package 3 which could potentially be transported on the Danube:

Bio-based raw materials

- Wood-based raw materials
- Starch-based raw materials
- Sugar beets
- Oil seeds
- Straw
- Other primary and secondary residue material (agri, wood and further processing industry)

Bioenergy Products

- Bioethanol
- Biodiesel
- Vegetable oil
- Pellets, briquettes, wood chips, firewood

Based on these findings an overall assessment of existing potentials and needed investments was carried out focusing on inland vessels (transport) and inland ports (transshipment, storage). The results of this analysis will in further consequence provide guidelines for the elaboration of deliverables and outputs created in Activity 4.2 and 4.3.

1. Background

This deliverable "D 4.1.3 Analysis of logistics requirements of raw materials, intermediates and end products for the bioenergy industry" is mainly based on the task as described in the latest approved version of the Application Form of the project ENERGY BARGE (Project Code: DTP1-175-3.2).

- *Activity 4.1 Analyze the requirements of the bioenergy industry regarding Danube logistics services* (Lead: VIA)

To achieve its specific objective to support the development of a better connected, interoperable and environmentally-friendly transport system for biomass logistics, ENERGY BARGE needs to analyze the logistics requirements of the bioenergy industry. The WP4 partners (BCG, MAHART, PoVi, PoVu, SPaP, VIA) were therefore asked to carry out expert discussions with potential customers of Danube logistics services from the biomass and bioenergy sector in their respective countries (Germany with a focus on Bavaria as DTP region as well as state with navigable Danube stretch, Austria, Hungary, Slovakia, Croatia).

The results of the interview survey were merged with information and data derived from other available sources in a next step. The used sources were:

- The report on the exchange workshop with a good practice port in Western Europe (D 4.1.1) which enabled an international know-how transfer on logistics requirements from the Bavarian Main area to the Danube region
- A comprehensive market study carried out for the Danube corridor in the frame of the project PLATINA II (Platform for the Implementation of NAIADES II) which covered an in-depth analysis of potentials for Danube logistics in the renewable resources sector
- A dedicated working initiative organised by viadonau between 2012 and 2014 focusing on potentials for the inland waterway transport of biomass (including regular workshops enabling Austrian logistics experts to exchange information and knowledge as well as success stories)

The findings and conclusions drawn from all these sources were processed into the overall assessment of logistics requirements for the transport of raw materials, intermediates and end products within bioenergy supply chains described in the following chapters. Based on these results existing potentials and investment needs in the involved ports were defined. This deliverable will in further consequence also provide guidelines for the elaboration of deliverables and outputs created in Activities 4.2 and 4.3.

2. Methodology

The collection and analysis of logistics requirements of the bioenergy industry was carried out by interpreting information and data gained from desk research, evaluation of existing sources and studies but more importantly by direct contacts with stakeholders and experts from companies active in the biomass and bioenergy sector. These expert discussions carried out in the frame of interviews with potential customers from the bioenergy and biomass industry as well as during the exchange workshop in Germany (D 4.1.1.) were regarded as particularly fruitful.

2.1. Expert discussions

The aim of the carried out expert discussions is to gain knowledge about the logistics requirements of raw materials, intermediates and end products especially in the biomass and bioenergy sector so that ENERGY BARGE can identify the potentials for an increased use of Danube logistics services.

The responsible project partner for this task was VIA which guided the interviews of all other involved partners and carried out interviews in Austria. The other comprehensive inputs for this task were collected from the project partners PoVi, BCG, SPaP, MAHART and PoVu. The findings of the carried out interviews are summarized in this report in the following chapters.

VIA provided an interview template as a solid basis for the expert discussions (see template in Annex I). The template is subdivided into six different blocks consisting of a general part, of four different blocks for each specific target group (supplier, processor, trader, end user) and of a concluding block dealing with the needed logistics requirements. For each country, at least five expert discussions with potential customers of Danube logistics services (especially from the biomass and bioenergy sector) were conducted by the involved project partners. The interview template was sent out to all involved project partners on 14 March 2017. The last expert discussions were carried out in October and reports submitted to VIA in November.

In a first step the potential companies (= experts) with relevance for the biomass and bioenergy sector were identified by the project partners for their country. When identifying the potential companies for the expert discussions, several criteria were taken into account for classifying the companies and its experts as relevant potential users of Danube logistics services:

- Identified company has to be within a 100 km radius of the Danube waterway
- Interviewed expert has to be in charge of logistics in the company
- It was recommended to have face-to-face interviews and to use the opportunity to present the service portfolio of the PPs to the bioenergy company.

For data protection and privacy reasons the names of companies and interviewed stakeholders are kept confidential. This is particularly important because both the bioenergy and the Danube logistics sector are rather fragmented and respondents are reluctant to provide data which could allow competitors to draw conclusions on a company's market strategy. On a content basis, the anonymised data can however of course be processed to implement future activities in the frame of ENERGY BARGE project. The project consortium also keeps the companies informed and involves them in the implementation process.

The next section deals with the description of the identified target groups of potential stakeholders (companies) along the entire bioenergy supply chains which were consulted during the interviews.

Figure 1 shows schematically the bioenergy supply chain based on three product groups (raw material incl. residue material used as raw material, intermediate products and end products), which are relevant for the bioenergy and biomass sector. The stakeholders have been identified based on the bioenergy supply chain and have been categorized into four target groups:

- **Supplier**: e.g. large agricultural enterprises, cereal growers
- **Processor:** e.g. producers of pellets, biodiesel, etc.
- **Trader**: e.g. traders of raw materials and end products
- **End user**: e.g. power plant operators (=bioenergy producers)

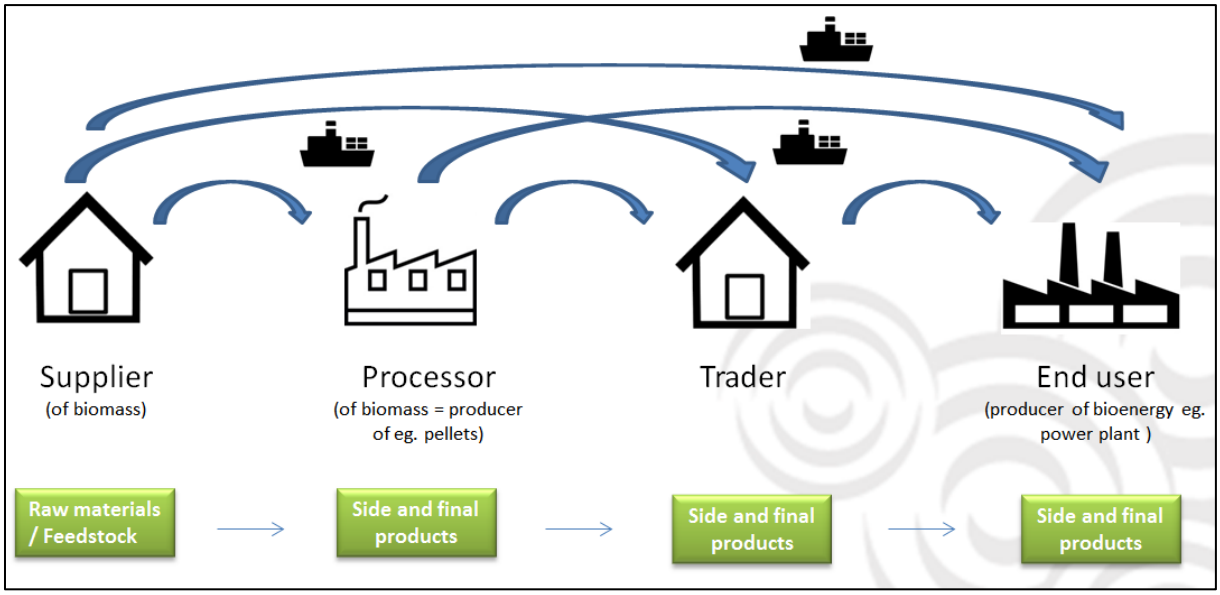


Figure 1: Bioenergy supply chain, © viadonau

The definition of key elements along the biomass supply chains further supports the identification of logistics requirements along the entire logistics chain of a biomass product. The logistics chain mainly involves the three logistics processes (1) transport, (2) transshipment and (3) storage. The corresponding requirements for successful inland waterway transports are particularly discussed in chapter 4 (*Logistics requirements of the bioenergy industry*).

2.2. Other sources used for the analysis of logistics requirements

Once the expert discussions were carried out, VIA collected and edited the gained information and completed it with data derived from other available sources such as publications and findings from previous projects and initiatives.

In coordination with the other partners VIA used the following sources:

- Report on the exchange workshop with a good practice port in Western Europe (D 4.1.1) which enabled an international know-how transfer on logistics requirements from the Bavarian Main area to the Danube region.
- A comprehensive market study carried out for the Danube corridor in the frame of the project PLATINA II (Platform for the Implementation of NAIADES II) which covered an in-depth analysis of potentials for Danube logistics in the renewable resources sector.
- A dedicated working initiative organized by viadonau between 2012 and 2014 focusing on potentials for the inland waterway transport of biomass (including regular workshops enabling Austrian logistics experts to exchange information and knowledge as well as success stories).
- viadonau's Manual on Danube Navigation (third edition, November 2013), which is considered one of the major standard publications for European inland waterway transport.

2.3. Clustering of logistics requirements according to defined types of biomass and products

After the collection and analysis of information from aforementioned sources the logistics requirements of the bioenergy industry were clustered to the types of biomass and products defined in Work Package 3. The logistics partners involved in Work Package 4 also introduced a distinction between requirements related to the (1) transport, (2) transshipment and (3) storage of the cargo. Even though the authors of this report are aware that the price for the described logistics services is probably the most decisive factor for the logistics planning of a company, ENERGY BARGE does not want to intervene directly in market mechanisms and therefore does not consider this criterion. The following illustration (Table 1) shows a schematic overview of the covered products as well as the surveyed requirements analysed for the mentioned logistics processes.

Table 1: Schematic overview - clustering of logistics requirements

Products	Transport	Transshipment	Storage
Bio-based raw materials	**Surveyed requirements** - Type of cargo (dry bulk, liquid bulk, break bulk/ general cargo) - Transport volumes and relations - Transit times - Deployed vessels (special vessels for dry bulk or liquid bulk etc.) - Moisture sensitivity (covered/uncovered transport) - Equipment aboard (due to additional requirements regarding safety or quality) - Specific weight of the transported cargo - Other transport requirements	**Surveyed requirements** - Type of cargo (dry bulk, liquid bulk, break bulk/ general cargo) - Transshipment volumes - Lifting capacity and performance of equipment (t/h or t/d) - Deployed handling equipment (grabbers, timber gripper, hook, fillers for liquid cargo etc.) - Moisture sensitivity (covered/uncovered transshipment) - Other transshipment requirements	**Surveyed requirements** - Type of cargo (dry bulk, liquid bulk, break bulk/ general cargo) - Inventory (required storage capacity) - Duration of storage and seasonal patterns - Deployed storage facilities (silos, liquid cargo tanks, special warehouses etc.) - Moisture sensitivity (covered/uncovered storage) - Other storage requirements
Wood-based raw materials			
Starch-based raw materials			
Sugar beets			
Oil seeds			
Special energy crops*			
Straw*			
Other primary and secondary residue material (agri, wood and further processing industry)			
Other (household waste)*			
Bioenergy Products			
Bioethanol			
Biodiesel			
Vegetable oil			
Pellets, briquettes, wood chips			
Firewood			

*no data available from expert discussions and other sources

3. Summary of results from expert discussions with potential customers of Danube logistics services from the bioenergy sector

As stated before, the aim of Activity 4.1 is to define the logistics requirements of the bioenergy sector regarding Danube logistics services and to point out potentials based on this definition. In chapter 3, the results and key statements of the carried out experts discussions are summarized and analysed. These results constitute the basis for further actions within the ENERGY BARGE project. This survey is an essential supplement to the expert knowledge exchange carried out during the visit of the port locations of the bayernhafen group in Bamberg and Aschaffenburg in the frame of deliverable D 4.1.1.

In total, 38 expert discussions were carried out and submitted to VIA as the responsible partner of Activity 4.1. The majority of the expert discussions were carried out in the months May and June; the last expert discussion was conducted at the end of October 2017. Table 2 shows the number of interviewed companies for each country. All countries were covered with at least five expert discussions which led to a good geographical coverage of the survey.

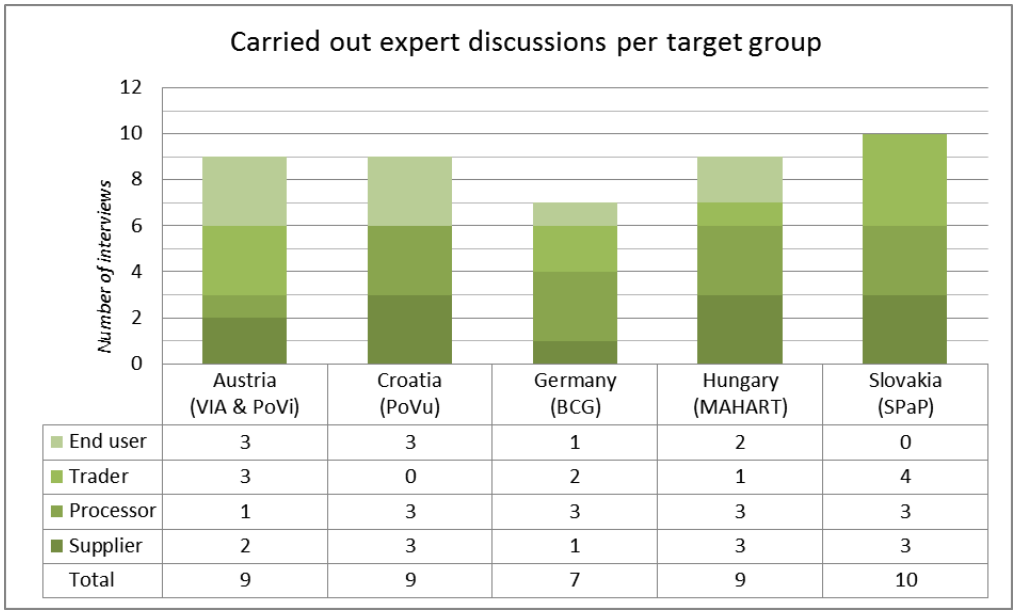
In some cases, the interviewed companies represented multiple target groups, like in the case of Slovakia where one interview partner represented a supplier, processor and trader of biomass. The same applies for further interviewed companies in Slovakia and Hungary. Thus the discrepancy between the numbers of interviewed representatives of the defined target groups (44) and the number of interviewed companies (38) can be explained (Table 2). The high number of carried out expert discussions constitute a useful and comprehensive basis for further planned actions within the ENERGY BARGE project.

Table 2: Number of expert discussions and interviewed companies

Country (Project Partner)	Interviewed representatives of target groups	Interviewed companies
Austria (VIA & PoVi)	9	9
Croatia (PoVu)	9	9
Germany (BCG)	7	7
Hungary (MAHART)	9	8
Slovakia (SPaP)	10	5
TOTAL	**44**	**38**

The share of the four specified target groups is very balanced since all interviewed target groups show an almost equal number between nine and thirteen expert discussions (see Figure 2). Most of the interviewed companies represent the target group *processor* (13 interviews) which comprises stakeholders such as producers of pellets. The second largest interview group are *suppliers* (12 interviews) that provide the bioenergy supply chain with raw materials and feedstocks. The target groups *trader* and *end user* are represented by 10, respectively 9 interviews. The first group deals with trading of biomass and bioenergy products and latter involves bioenergy producers such as power plant operators. Only two interview categories

from two countries, namely the *trader* group in Croatia and the *end user* group in Slovakia, could not be reached due to different reasons (companies were not cooperative, etc.).



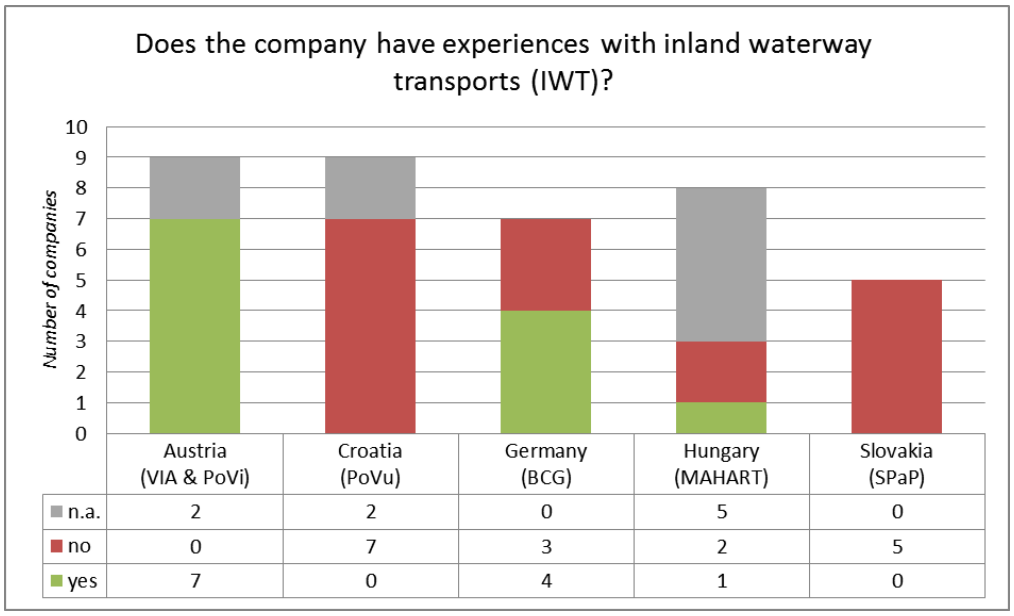
	Austria (VIA & PoVi)	Croatia (PoVu)	Germany (BCG)	Hungary (MAHART)	Slovakia (SPaP)
End user	3	3	1	2	0
Trader	3	0	2	1	4
Processor	1	3	3	3	3
Supplier	2	3	1	3	3
Total	9	9	7	9	10

Figure 2: Number of carried out expert discussions per target group

The produced, traded and processed goods of the interviewed companies were identified during the expert discussions, as the ENERGY BARGE project aims to assess the needs and logistics requirements individually for each product group. The most frequently mentioned product types during the expert discussions for each target group were as follow (in order of significance):

- **Supplier (raw materials):** Wood-based raw materials such as wood chips, pellets, briquettes; firewood; straw-based raw materials.
  To a small extent: sawdust, residues (wooden, agricultural), bulk timber residues, wheat, sugar, beat, soya, sunflower, corn.
- **Processor (raw materials):** Wood-based raw materials, residues (wooden, agricultural), agricultural starch-based residues (wheat, maize), rapeseed, soybeans and other oil seeds, corn, sunflower.
  To a small extent: agricultural residues (sun flower, rape, etc.), oilseeds, materials based on straw, other: miscanthus x giganteus.
- **Processor (produced goods):** Pellets, briquettes, firewood, wood chips; bioethanol, biodiesel, vegetable oils, DDGS (dried distillers grains with solubles).
- **Trader (intermediate products):** Pellets, briquettes, firewood, wood chips; residues (wooden, agricultural).
  To a small extent: firewood, saw wood, bioethanol, plant oil, biodiesel, DDGS, rape scrap, glycerine, lecithin, sludge.
- **End user (final products):** Wood chips, pellets, briquettes, firewood, wood-based raw materials.
  To a small extent: wood residues from timber industry.

Figure 3 highlights the previous experiences of the consulted experts with inland waterway transport (IWT) and shows a clear tendency of the interviewed countries. In Austria and Germany, seven respectively four companies already have experiences with IWT. Almost all 22 interviewed companies in Croatia, Hungary and Slovakia stated that they have no experience with IWT or else did not answer the question, except one company from Hungary confirmed its experience with IWT.



	Austria (VIA & PoVi)	Croatia (PoVu)	Germany (BCG)	Hungary (MAHART)	Slovakia (SPaP)
n.a.	2	2	0	5	0
no	0	7	3	2	5
yes	7	0	4	1	0

Figure 3: Number of companies with experiences in IWT

For the following activities of ENERGY BARGE, both cases can be interesting. Current users of Danube logistics services can be supported in extending the transport volumes on the Danube waterway whereas potential/new users can be convinced to shift cargo transports for the first time towards the Danube. Thus a good mix of these two groups seems most promising for a mutual exchange of know-how among the involved companies and the project consortium leading to a successful project implementation.

4. Logistics requirements of the bioenergy industry

The main objective of ENERGY BARGE is to provide added value to the bioenergy industry and the Danube logistics sector by analysing the mutual expectations and by building a common decision-making basis for facilitating the politically and economically reasonable modal shift towards the Danube waterway. In Work Package 4 the ENERGY BARGE project team collects and analyses the logistical requirements of the bioenergy industry in order to define the scope of application for inland waterway transports. To this end, the following chapters of this deliverable summarize general requirements of the bioenergy sector towards Danube logistics services (chapter 4.1) as well as cargo-specific requirements relevant for the individual bioenergy companies and the specific products in their business area (chapter 4.2).

4.1. General requirements regarding the use of Danube logistics services

One of the most important tasks of the ENERGY BARGE project is to define under which circumstances inland navigation can be used to transport raw materials, intermediates and end products for the bioenergy industry. On this basis Danube logistics companies such as shipping companies, ship brokers, port and terminal operators as well as specialised forwarding companies can adapt their service portfolio to the needs of this specific sector.

There are however also requirements towards Danube logistics services that the bioenergy industry shares with other economic sectors (e.g. steel industry, chemical industry or building sector). Many of these preconditions for competitive inland waterway transports in comparison to road and rail transport can only be solved with the support from the public sector. The following requirements therefore also can be seen as a to-do-list for public administrations which needs to be worked through in order to set a favourable framework for economically viable transports on the Danube which is also in line with general EU objectives, as e.g. formulated in the European Strategy for the Danube Region.

Reliable waterway infrastructure
Larger cargo volumes per vessel or convoy improve the relation between freight revenues and costs and thus the overall competitiveness of inland waterway transport. This implies that there is a direct relationship between fairway conditions, the load factor of vessels and ultimately the competitiveness of this mode of transport. In order to enable Danube navigation to make use of its key strengths, waterway maintenance and ensuring reliable fairway depths remains an indispensable task of all Danube countries.

The recommended minimum fairway parameters for European waterways – including the Danube – are listed in the European Agreement on Main Inland Waterways of International Importance (AGN) of the United Nations Economic Commission for Europe. With regard to the fairway depths to be provided by waterway administrations, the AGN makes the following provisions: On waterways with fluctuating water levels the value of 2.5 meters minimum draught loaded of vessels should be reached or exceeded on an average of 240 days per year. However, for upstream sections of natural rivers characterized by frequently fluctuating water levels due to weather conditions (e.g. on the Upper Danube), it is recommended to refer to a period of at least 300 days on average per year.

Based on the Convention Regarding the Regime of Navigation on the Danube, which was signed in Belgrade on 18 August 1948, the Danube Commission recommended a minimum water depth of 2.5 metres at LNWL (low navigable water level) in free-flowing sections of the Danube. LNWL designates the water level that corresponds to a long-term water discharge reached or exceeded on 94% of the days per year (excluding periods of ice). The current observation period used for the calculation of this statistical value is 30 years.

In principal, the infrastructural standards required form the Danube riparian states by the United Nations Economic Commission for Europe and the Danube Commission can be regarded as equivalent with respect to the service level achieved for the inland waterway transport sector.

On some sections of the Danube the minimum fairway conditions can currently not be guaranteed resulting partly from poor planning, partly from the lack of adequate maintenance equipment and finally from a lack of financial resources in the respective Danube countries.

This deliverable takes into account that some cargo types are rather "critical on volume" whereas others are "critical on weight" which implies that the draught of loaded ships is higher for the latter ones. Many types of biomass used for bioenergy production (e.g. sugar beet or sunflower seeds) are for instance more flexible regarding the available fairway depths than heavier goods such as some end products (e.g. biodiesel or bioethanol). These considerations are reflected by the collection and the analysis of the specific weight of the transported goods. This does of course not imply that cargo with a higher specific weight cannot be transported on the Danube; it rather means that the logistics planning should be adapted for these types of goods (e.g. additional storage capacities in ports).

Efficient infra- and superstructure in the Danube ports

From the point of view of the shipping industry, Danube ports and transshipment sites shall be equipped with efficient infra- and superstructure. A ports' infrastructure is formed by quay walls, rail tracks and roads as well as other paved surfaces while the superstructure is built on the infrastructure and includes e.g. cranes, warehouses and office buildings.

The performance of port transshipment equipment is in general defined by the maximum lifting capacity as well as the hourly and/or daily output of each individual crane. With Lift-on-Lift-off transshipment (Lo-Lo) by cranes, the hourly output is estimated according to the number of crane cycles per hour, the capacity of the grabbers used and the specific weight of the goods handled. The daily output of a port determines the time which an inland vessel spends in a port, thereby influencing the total costs of inland waterway transport.

In addition, different cargo groups require different handling and storage facilities. In general, it is distinguished between general cargo/break bulk on the one hand and bulk cargo (dry and liquid) on the other hand. The availability of adequate, cargo-specific handling and storage equipment at a certain location is therefore – in combination with the overall service quality provided in ports (opening hours, flexibility, etc.) - a decisive factor concerning the question whether a modal shift towards inland waterway transport can be achieved or not.

One important finding of the exchange workshop organised in the frame of Deliverable 4.1.1 and Output 4.3 was that inland ports also need to ensure adequate fairway depths at the port entrances and throughout the entire port basin. This ensures that ports will not become infrastructural bottlenecks in case that the waterway itself is well maintained.

Time-efficient and flexible administrative processes

Long-winded and inflexible administrative processes and paperwork can be a significant competitive disadvantage for inland waterway transport on the Danube. The administrative processes that from the vessel operators' perspective cause the biggest time losses and highest operational costs are border controls and customs clearance at the EU's external borders (e.g. Serbia, Ukraine), bureaucratic processes in the Danube ports and administrative procedures related to navigation surveillance.

In order to solve some of the most pressing administrative barriers for Danube navigation and to support modal shift more effectively, public authorities and the Danube logistics sector should enter a more intensive dialogue how administrative procedures can be implemented in a flexible and at the same time effective way. A harmonization of administrative procedures in all Danube countries should also be a mid-term objective in order to ensure seamless transport chains and a higher competiveness compared to road and rail transport.

A dedicated working group on "administrative processes" has been established in the frame of Priority Area 1a "inland waterways" of the EUSDR[1]. Many bio-based raw materials from the agri and forest sector within the scope of ENERGY BARGE require phytosanitary controls which often cause additional bureaucratic burden during the controls at the EU's external borders. This is why it is important that ENERGY BARGE will support the activities of the working group by feeding in technical inputs from the bioenergy and biomass industry.

Flexible logistics concepts integrating Danube logistics services
Cargo owners from the bioenergy industry are often bound to harvesting seasons and seasonal fluctuations of cargo volumes. This can lead to a situation where the availability of vessels is scarce during peak seasons. Therefore this report also analyses seasonal fluctuations and cargo-specific transport patterns (e.g. transport demand in certain months of the year) in chapter 4.2 which can additionally support the optimal use of inland waterway transport on the Danube.

In the case of blockages of the Danube (e.g. due to ice or flooding) as well as during low water periods cargo owners expect logistics providers to have adequate back-up systems via road or railway networks in place to ensure a continuous supply. The analysis of good practice examples at the Port of Bamberg and Port of Aschaffenburg (D 4.1.1) however also shows that sufficient storage space at the transshipment hubs can help to ensure more resilient transport chains via inland waterways and to avoid shortages in the supply chains.

ENERGY BARGE will provide B2B platforms to facilitate discussions between supply and demand side in order to develop more flexible logistics concepts along the Danube.

4.2. Cargo-specific logistics requirements

The collected logistics requirement data from the logistics partners were complemented and verified with data derived from other available sources such as publications and findings from previous projects and initiatives (see chapter 2.2. *Other sources used for the analysis of logistics requirements*). The allocation of the product groups was made during the activities carried out in work package 3 and was adopted similarly in this report for reasons of clarity (see also Table 1), meaning that the product groups are subdivided into the two general sections *bio-based raw materials* and *bioenergy products*.

Further, the aforementioned logistics processes (1) transport, (2) transshipment and (3) storage were reduced to two components (due to practical reasons) since the requirements for

[1] https://www.danube-navigation.eu/

transport and storage are derived from the same characteristics of goods in most cases. Although the efforts to collect data material were significant, there are still data gaps for some product groups. The detailed requirements in terms of transport, transshipment and storage will be clarified and analysed during B2B meetings organised in Activity 4.3.

4.2.1 Bio-based raw materials

Raw biomass often lacks the qualities that enable it to be traded outside of its local production area, such as uniformity in format and chemical content, high bulk density, flowability within high-volume handling infrastructures, and storability. Because biomass is dispersed, it is often processed to facilitate handling prior to transport from the field. This introduces further variability in the biomass by creating a variety of formats, including round bales, square bales, chips, etc. This variability in chemical composition and physical characteristics (such as bale type, particle size and range, etc., generally termed "format") creates challenges to bioenergy traders and producers. In addition, the aerobically unstable biomass can rot during storage, resulting in dry matter losses and further degradation of quality (Searcy et al. 2014).

Transportation and handling of low-density, cohesive, and degradable biomass materials are substantial barriers to a long-distance biomass feedstock supply system. These challenges can be addressed by either (1) designing transport, handling, and storage systems that accommodate the variety of types and formats of raw biomass or (2) formatting the biomass to be compatible with existing infrastructure (Searcy et al. 2014).

4.2.1.1 Wood-based raw materials

Round wood

In dependence of the weight and length round wood is transported either individually or bundled in logs. One single piece of round wood can weigh 15 tons and more.

Transport and storage
The optimal transport temperature is lower than 10°C, otherwise higher temperatures might activate insects and fungal infestations. Temperatures lower than 0°C might cause crack formation through frost. Furthermore, (round) wood should be protected from humidity in order to prevent quality loss and tonnage variations. Moreover, regarding storage, bigger quantities of round wood due to their physical characteristics require comparatively much storage space and compacted ground as a minimum requirement.

Measures for maintaining quality of (round) wood can be summarised as follows:

- Mechanical means: Sheet steel protectors are applied around the cross-section of the trunk in order to prevent splitting due to drying-out of the lumber. In the case of woods with high tannin content, however, this may result in oxidative discoloration.
- Chemical lumber preservatives: In order to inhibit splitting, oxidative discoloration and fungal attack, the cross-sections or bark-free surfaces of the logs are preserved immediately after felling with wax, paraffin, latex or lime.
- Sprinkler systems: Sprinkler systems may be set up to prevent deck cargoes of lumber from drying out. When setting up a sprinkler system, it must be borne in mind that the veil of water can be blown away by the wind.

Transshipment
During transshipment one has to bear in mind that single timber parts which fall into the water may sink due to their high density. For transshipment of round wood timber grippers are suitable.

Specific weight: very light species: < 0.40 t/m^3, very heavy species: > 0.80 t/m^3

Figure 4: Transshipment of round wood, © Rhenus Donauhafen Krems

4.2.1.2 Starch-based raw materials (wheat, maize)

Wheat

Wheat, which is dry for shipment, is more than 12 months durable. The water content of wheat should not exceed 15% due to danger of mold, fermentation and germination. Optimal condition for wheat transport and storage are 70% humidity and 20°C. Sufficient ventilation if case of higher water content should be ensured in order to prevent self-heating.

Transport and storage
Wheat transport as bulk material is more common than transport in bags. But seed corns are usually packed into sealed bags. The predetermined limits of the water content of the goods have to be observed. Bugs and rats lead to quality reduction of the transported good. In case of foodstuff particular caution is recommend in decreasing the risk of possible diseases. To ensure a high quality of the cargo, the following certificates can be applied: GMP (Good Manufacturing Practice)-certificate for the vessel, phytosanitary controls and sustainability guidelines.

Transshipment
In humid weather (rain, snow) the cargo must be protected from moisture, since wetting and extremely high relative humidity may lead to mold growth, spoilage and self-heating due to increased respiratory activity. Suction and blowing devices may cause not inconsiderable damage to the grains (damages through mechanical devices).

Specific weight: 0.74 - 0.85 t/m^3 (bulk cargo); 0.67 – 0.75 t/m^3 (bags)

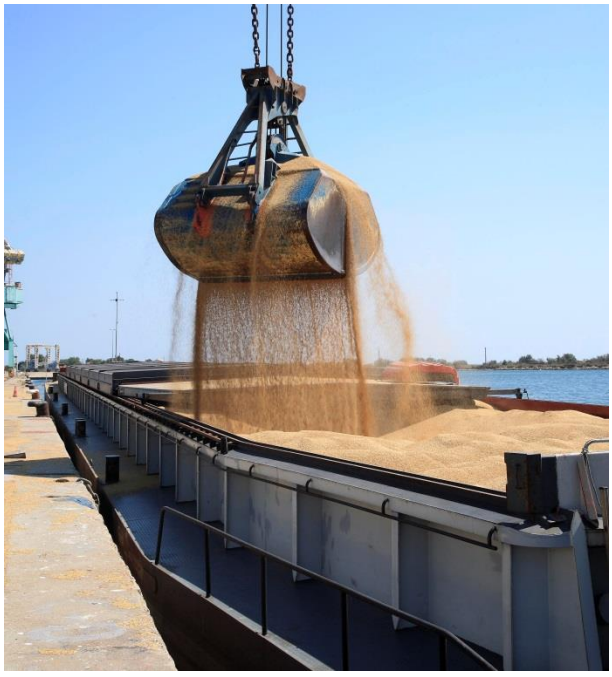


Figure 5: Transshipment of wheat, © Voies navigables de France

Maize

Maize, which is dry for shipment, is more than 12 months durable. The water content of maize should not exceed 15.5% since humidity can lead to mold and loss of quality, especially in winter. The humidity protection should also be respected during transshipment and storage with a maximum of 75% as well as temperature with an optimum of 20°C. Higher temperatures cause mold growth and reinforce self-heating. Bugs and rats lead to quality reduction of the transported good. In case of foodstuff, particular caution is recommended in decreasing the risk of possibly diseases. To ensure a high quality of the cargo, following certificates are respectively can be applied: GMP-certificate for the vessel, phytosanitary controls and sustainability guidelines.

Transport and storage
Maize transport as bulk material is more common than transport in bags. Predetermined limits of the water content of the goods have to be observed. A risk factor is the change of the specific weight of this cargo due to drying processes which may lead to a reduced price and which might reduce the willingness of cargo owners to use IWT.

Transshipment
In humid weather (rain, snow) the cargo must be protected from moisture, since wetting and extremely high relative humidity may lead to mold growth, spoilage and self-heating due to increased respiratory activity. Suction and blowing devices may cause considerable damage to the grains.

Specific weight: 0.72 – 0.74 t/m^3 (bulk cargo)

Figure 6: Transshipment of maize, © viadonau

4.2.1.3 Sugar beets

Transport and storage
Sugar beet is usually transported via rail and truck. If sugar beet is carried as bulk cargo, the specific weight is crucial for the determination of the tonnage needed. The cargo must be protected from moisture (water content), diseases as well as animals such as mice which pose risk factors to the product quality. Besides the transport of sugar beet as a whole, sugar beet pulp is also transported as bulk cargo on the Danube on regular basis (feedstuff). As moisture sensitive cargo, sugar beet must be protected from moisture throughout the whole transport chain.

Transshipment
Sugar beet is a quite sensitive plant which can easily be damaged during transshipment which has a decrease in quality as a consequence.

Specific weight: 0.60 – 0.76 t/m^3

4.2.1.4 Oil seeds (rape, soy beans, sun flower)

Rape

Transport and storage
Rape seeds are mainly transported as bulk material and in exceptional cases (especially small quantities) the transport is carried out as bagged cargo. The cargo must be protected from moisture (water content), diseases as well as animals such as mice which pose risk factors to the product quality.

According to the ENERGY BARGE partner SPaP it can in some cases however also be advisable to open the cargo hold during transport, in order to allow the agricultural products to "breathe". Opening cargo holds to ventilate products is of course only recommended in coordination with the cargo owner and if the weather conditions allow so.

Transshipment
Heavily heated goods should be only loaded and unloaded with cable-operated grippers since grippers operated via hydraulic lines are not able to cope with the prevailing temperatures of the goods. Suction and blowing devices may cause considerable damage to the grains (damages through mechanical devices).

Specific weight: around 0.67 t/m^3

Soybeans

Soybean plants are annual plants, which prefer warm and humid growing areas. Soybeans have high contents in protein (39%) and oil (17%). Consequently, soybeans are mainly used for oil

production while production residues as soybean meal or soybean cake are processed to feedstuff or meat substitutes in the food industry.

Transport and storage
Soybeans are mainly transported as dry bulk material and in exceptional cases (especially small quantities) the transport is carried out as bagged cargo. The cargo must be protected from moisture (water content), diseases as well as animals such as mice which pose risk factors to the product quality.

Transshipment
Heavily heated goods should be only loaded and unloaded with cable-operated grippers since grippers operated via hydraulic lines are not able to cope with the prevailing temperatures of the goods. Suction and blowing devices may cause not inconsiderable damage to the grains (damages through mechanical devices).

Specific weight: 0.62 – 0.75 t/m^3 (bulk)

Sun flower seeds

Transport and storage
Sun flower seeds are transported as bulk or bulk cargo in sacks of woven natural materials (e.g. jute) or plastic fabric sacks. The seeds can be transported in a ventilated container if the minimum levels of the water content of goods, packaging and container floor as well as the oil content of the goods are kept. The cargo must be protected from moisture (water content), diseases as well as animals such as mice which pose risk factors to the product quality.

In cases the products do not need to be ventilated, or it is obvious that the weather conditions will not allow to open the cargo hold during transport, shipping companies often use seals (in agreement with the customer). The cargo hold is sealed right after loading and exact weights are documented in the relevant documents. The seal is supposed to be removed only after reaching the destination or port of discharging.

Transshipment
In moist weather (rain, snow) the cargo must be protected from moisture since this can lead to mold growth, spoilage and self-heating due to increased breathability. Plate or bag hooks are well suited for the handling of sacks.

Specific weight: around 0.45 t/m^3

Figure 7: Sun flower seeds, © Rhenus Donauhafen Krems

4.2.1.5 Straw

Straw as a byproduct of the harvest of cereal crops is suitable for many agricultural and industrial applications. Mostly it is saved as fodder or bedding in animal production or for energy utilization.

Both quality assurance and the minimization of supply costs require an optimization of the entire logistic chain from the field to the storage. Due to the bulkiness of straw, an appropriate level of compaction is particularly important to reduce the storage space requirements. With normal compaction systems, the density spectrum ranges from 80 to 160 kg/m^3.

The supply of raw material such as straw may be time-critical for processors in case of limited storage capacities. The straw cargo is usually transported as dry bulk, break bulk or as standard bales (0.5 tons per standard bale) but usually straw cargo is not yet transported via inland waterway transports due to its extremely low specific weight.

The risk factor of straw as raw material is moisture, since it highly degrades the quality of straw as feedstock and can increase the risk of fungal infestations. During transport and storage the humidity has to be observed and appropriate ventilation must be ensured in order to avoid self-heating hazards. The quality of straw must be uncompromised as the work technology requires high straw quality.

Specific weight: around 0.15 to 0.20 t/m^3

4.2.1.6 Other primary and secondary residue material (agri, wood industry)

Transports of residues, e.g. husks, oil press cake or rape seed shells are varying from very time-critical to not time-critical. They are carried out as bulk cargo and have to be protected

especially from moisture and contamination risks. During transshipment, the moisture of the cargo should be on a constant level. Another essential risk factor is the contamination of the cargo such as fungal infestation. The recommended certificate for handling with residues is the GMP (Good Manufacturing Practice) certificate.

4.2.2 Bioenergy products

4.2.2.1 Bioethanol

Bioethanol as well as gasoline with blended bioethanol as liquid cargo are subject to the ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road) regulation and have to be transported exclusively in tank containers such as tank ships, rail tanks or tank trucks. Bioethanol is an explosive and highly flammable product. Moreover, bioethanol is a product regulated under customs law due to its potential usage in the spirits industry. In Slovakia, the ISCC (International Sustainability & Carbon Certification) certificate is applied for the transport of bioethanol. Recent investments in the Danube region as well as corresponding interviews seem to indicate that bioethanol might become a more interesting IWT cargo in the near to medium-term future.

4.2.2.2 Biodiesel

Biodiesel is a liquid cargo and not classified as a dangerous good since it is easily biodegradable and does not endanger the soil in case of accidents. Biodiesel has, in contrast to bioethanol, a high flashpoint.

Transport and storage

When biodiesel is transported, the transportation container has to be cleaned (unless it previously carried petro-diesel or biodiesel) and there should be no water in the tank. The tank may need insulation or heating if the biodiesel is being transported in cold weather. Alternatively, the biodiesel can be allowed to freeze in the tank and then be heated at the destination.

Pure biodiesel is not considered flammable, has a flashpoint higher than 93°C, and can be transported without any warning signs. Biodiesel blends require warning signs if the flashpoint of the blended fuel is lower than 93°C.

Biodiesel that leaves the production plant in good condition can become unacceptable during distribution without proper care and attention. Biodiesel can degrade due to oxidation, contact with water, and/or microbial activity. In general, biodiesel will degrade more quickly than petro-diesel. Hence, a biodiesel spill will biodegrade quickly and not cause as many environmental problems as a petro-diesel spill. Nevertheless, both fuels will eventually degrade, and the same

good housekeeping practices that apply to petro-diesel will also keep biodiesel in good condition.

Another problem is that biodiesel has a tendency to gel (freeze) at higher temperatures than petro-diesel. Therefore, storage and transportation tanks must be designed to deal with this tendency. In addition, because biodiesel may not be compatible with some elastomers in common use with petro-diesel, it can cause the degradation of some materials used in hoses, seals, and gaskets.

4.2.2.3 Vegetable oil

Vegetable oils and fats as intermediary products for the biodiesel production or as final products for the bioenergy and agroindustry are transported in bulk as dry or liquid cargo. Relevant certificates for the transport of vegetable oils and fats are the GMP+ (Good Manufacturing Practice guidelines for e.g. foodstuff and feedstuff) certificate. In the case of DDGS products (Dried Distillers Grains with Solubles) the risk factors are among others humidity, which may lead to a reduced quality. The logistics requirements of oil seeds are similar to the ones for soybeans, rape or maize.

4.2.2.4 Pellets, briquettes, wood chips and firewood

Transport and storage

Pellets, briquettes, wood chips or firewood are either transported as bulk cargo, in bags or on palettes. Pellet sacks need only be protected and stored dry since the specific weight of this cargo may change due to drying processes which leads to a reduced price. An essential risk factor is the contamination of the cargo such as fungal infestation or breakages of pellets (due to heavy weighting). To ensure a high quality, sustainability and reliability in pellets trading, the PEFC (Programme for the Endorsement of Forest Certification Schemes) certificate system is applied by some pellets traders.

Fresh pellets may lead to an unpleasant odour in the storage. This smell usually disappears within a few weeks. The odour comes from the so called off-gassing of wood materials. Off-gassing includes emissions from wood extractives as well as emissions from the slow natural decomposition of the wood. Furthermore, compared to other wood products, wood pellets have a larger surface and the cellular structure has been under heavy stress during production. This may result in faster dissipation of the volatile compounds – especially in fresh pellets and at high ambient temperatures. The emissions generally abate within a few weeks and the smell disappears completely.

Emissions from wood pellets consist of volatile organic compounds (VOCs), carbon monoxide (CO) and carbon dioxide (CO_2). The volatile compounds include so called terpenes that are responsible for an occasional “chemical” smell reminding of turpentine. Other ingredients such as aldehydes and carbon monoxide can be harmful to health and should not end up in the living area. Hence, wood storages have to be sealed against the living area. However, ventilation of the

storage to the outside is beneficial to a faster decrease of the emissions and shortens the time until the odorous components have dissipated.

Pellets are hygroscopic, meaning they absorb water rapidly, while increasing their volume at the same time. If large volumes of water enter a pellet storage (e.g. during a flood) the silo fabric or separation walls can be damaged. Pellets will also lose shape and clump together. In this case pellets cannot be used as a fuel anymore and have to be removed quickly before they dry and harden. In contrast to heating oil tanks, flooded pellet storage rooms do not cause any danger to the environment. It is nevertheless recommended to empty pellet storage rooms if floods are expected (Source: http://www.safepellets.eu/).

Transshipment

Transshipment of pellets (Figure 8), briquettes, wood chips or firewood requires caution in order to prevent damages. Good quality pellets can be transshipped more often without any quality loss. The cargo can be handled with pneumatic pumps which is recommendable for pellets and wood chips or with cranes and grabbers (especially recommended for briquettes and firewood). Pumps have the advantage of optimal cargo transportation speed, elimination of dust formation and the general transportation speed with 500 tons per hour. During transshipment, the moisture of the cargo should be on a constant level. However, wood pellets are safe in bags when shipped in bulk in large volumes. Pellets are classified as hazardous material due to off-gassing of high levels of CO, CO_2 and CH_4 , as well as spontaneous combustion potential.

Specific weight: 0.40 – 0.90 t/m^3

Figure 8: Transshipment of pellets in the Port of Krems, © Rhenus Donauhafen Krems

5. Assessment of existing potentials and needed investments in the Danube logistics sector

Another important task of the ENERGY BARGE project is the assessment of needed investments in the Danube logistics sector to exploit existing potentials for cooperation with the bioenergy industry. This particularly refers to investments in the deployed inland vessels, port super- and infrastructure including handling equipment as well as in storage facilities for biomass. On this basis, Danube logistics companies such as shipping companies, ship brokers, port and terminal operators as well as specialised forwarding companies can adapt their service portfolio to the needs of this specific sector. Many of these needed investments can only be accomplished with the support from the public sector and can be additionally triggered by using national as well as international funding programmes.

The following chapter 5 summarizes the logistics requirements with regard to inland vessels (transport) and inland ports (transshipment, storage) and evaluates the derived investment needs along the Danube corridor.

5.1 Inland vessels

Basically, inland cargo vessels operating on the river Danube and its navigable tributaries can be divided into three types according to the combination of their propulsion systems and cargo holds, namely motor cargo vessels, pushed convoys and tugs.

Tugs are used to tow non-motorised vessel units, so-called barges (vessels for carriage of goods with a helm for steering). Given the fact that towed convoys are rarely used on the Danube anymore because they are less cost-effective we will focus in this chapter on motor cargo vessels and pushed convoys.

Motor cargo vessels
Motor cargo vessels (or "self-propelled vessels", Figure 11) are equipped with an engine and a cargo hold. Motor cargo vessels can be subdivided into dry cargo vessels, tankers, container vessels and Ro-Ro vessels (Figure 9):

- **Dry cargo vessels** are used for transporting a wide variety of goods including logwood, grain, steel coils and ore. These vessels can be used for almost anything and therefore reduce the number of empty runs (journeys with no return cargo). This class of vessel can generally carry between 1,000 and 2,000 tons of goods.
- **Tankers** transport various types of liquid goods, such as mineral oil and derivates (petrol, biodiesel, heating oil), chemical products or liquid gas. The majority of the liquid goods mentioned above are hazardous goods which are transported using special tanker vessel units equipped with the appropriate safety devices. European regulations and recommendations, such as the ADN (European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways), as well as national legislation governing the transport of hazardous goods have particular relevance in this context.

Modern tankers have a double hull which prevents the cargo from leaking in the event that the outer hull is damaged. Most tankers have pumps on board which can load and unload the goods directly into the tanks in ports not equipped with such special loading systems.

- **Container vessels** are ships constructed specifically for the transport of containers and are currently used primarily in the Rhine region. In the Danube region container convoys with four pushed lighters are regarded as the best way to increase capacity.
- **Roll-on-Roll-off** means that the goods being transported can be loaded and unloaded using their own motive power via port or vessel ramps. The most important types of goods transported in this way include passenger cars, construction and agricultural machinery, articulated vehicles and semi-trailers ("floating road") as well as heavy cargo and oversized goods. For the bioenergy industry Ro-Ro vessels could be relevant in case high and heavy cargo such as turbines, generators or other machinery is transported on inland waterways.

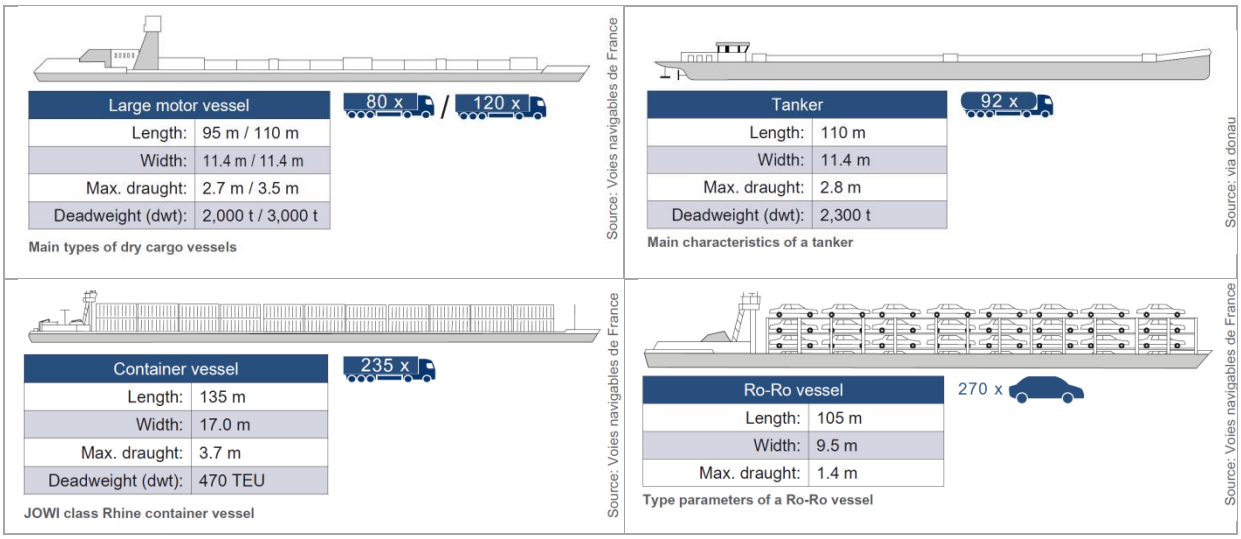


Figure 9: Main types of: dry cargo vessels, tankers, container vessels, Ro-Ro vessels, sources: © Voies navigables de France & © viadonau

Pushed convoys

Pushed convoys consist of a pusher (motorised vessel used for pushing) and one or more non-motorised pushed lighters that are firmly attached to the pushing unit (Figure 10). If a motor cargo vessel is used for propelling the formation or convoy instead of a pusher, then this is known as a coupled formation or pushed-coupled convoy.

Cargo shipping on the Danube is predominantly carried out by means of convoys (pushed convoys, coupled formations as well as pushed-coupled convoys), and only a small share by individual motor cargo vessels. On the Rhine, the ratio of convoys to motor cargo vessels is approximately the reverse.

The basic rule for the formation of convoys is: vessel units in pushed convoys are grouped so as to reduce water resistance when in motion as much as possible or so that sufficient stop and manoeuvre characteristics can be ensured (e.g. when navigating downstream). In order to lessen the resistance, the lighters are placed in a staggered arrangement towards the rear.

If the appropriate technical features of the units used in a convoy allow it, vessel units are not attached to one another rigidly, but rather coupled with flexible connectors to enable the convoy to negotiate curves in areas with particularly narrow curve radii. For upstream travel, the convoy should have as small a cross-sectional area as possible and thus the lowest possible resistance, which is why the lighters are arranged next to each other when travelling downstream, to facilitate the manoeuvrability of the convoy and most especially its ability to stop in the direction of the current.

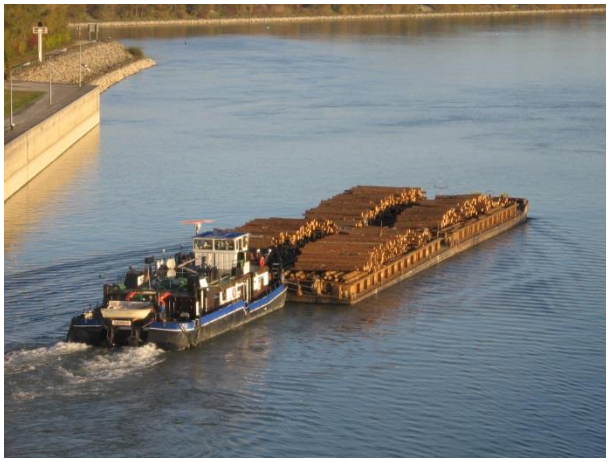


Figure 10: Convoy with two pushed lighters (round wood as cargo), source: © viadonau

Figure 11: Motor cargo vessel, source: © viadonau

The vessels currently deployed along the Danube are suitable and capable for the transport of large volumes of biomass (dry and liquid bulk). Due to their large cargo hold and the ability to form convoys according to the customers' needs (major potential in terms of capacity), transports on the Danube can be operated in an efficient and cost-effective way. Flexible hatch covers facilitate covered transport (e.g. moisture-sensitive cargo) and uncovered transport (e.g. oversized cargo or bigger lots of bulk goods). The ENERGY BARGE team does not expect larger investments to adapt the Danube fleet to the logistics requirements of the bioenergy industry. Given the fact that a large number of the vessels currently operating along the Danube is outdated, the revenues from additional customers in this sector can however foster a general modernisation of the fleet and trigger investments in new vessels.

5.2 Inland ports

Figure 12 illustrates around 50 transshipment locations, either ports or transshipment sites, along the Danube from Kelheim to the Black Sea, which are in principle suitable for handling of biomass in the entire Danube region. The high number of possible transshipment locations shows a great potential of fostering new inland waterway transports of biomass cargo along the entire Danube. However, to increase the ports' competitiveness and to offer a high level of logistics services on port sites, investments in handling equipment and storage facilities are strongly needed.

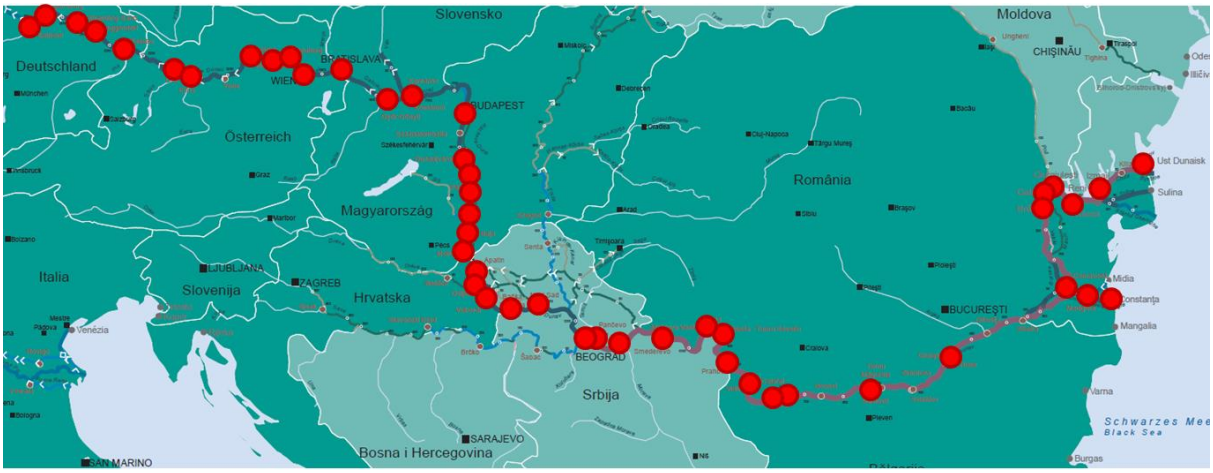


Figure 12: Potential transshipment locations in the entire Danube region for agricultural and forestry products, © viadonau

5.2.1 Handling equipment

The performance of handling equipment is defined by the maximum lifting capacity as well as the hourly and/or daily output of each individual crane. Modern gantry cranes or mobile cranes can accommodate 30 tons with 20 metre outreach and thereby efficiently transship full containers or heavy steel coils from vessel to dock or from truck to railway wagon.
With Lift-on-Lift-off transshipment (Lo-Lo) by cranes, the hourly output is estimated according to the number of crane cycles per hour, the capacity of the grabbers used (in inland ports usually between 2 and 15 m^3) and the specific weight of the goods handled. The daily output of a port determines the time which an inland vessel spends in the port, thereby influencing the total costs of inland waterway transport (see Figure 13).

	Luffing and slewing crane up to 15 tons	Luffing and slewing crane up to 30 tons	Gantry crane (bridge) up to 40 tons
Grab operation	120 tons/h	160 tons/h	200 tons/h
Hook operation	80 tons/h	100 tons/h	120 tons/h
Spreader		15 container/h	25 container/h

Source: via donau

Figure 13: Performance of handling equipment

In general, a distinction of different cargo types is made between break bulk/general cargo on the one hand and dry or liquid bulk on the other hand. Biomass and bioenergy products are mainly transported as dry or liquid bulk. To cover all transports relevant for the bioenergy industry however we also included handling equipment (cranes, ramps, etc.) for general cargo which can be used for the transshipment of generators, turbines and transformers.

Cranes and ramps

Cranes are classified as gantry cranes (Figure 14), luffing and slewing cranes, mobile cranes or floating cranes. They can be distinguished by their features and hence with regard to their procurement and operating costs. The installation and acquisition of the cranes for specific terminals mainly depends on the types of goods being handled.

Figure 14: Gantry crane at the Port of Linz, Source: © Hafen Linz AG

Gantry or portal cranes are primarily used for transshipping containers and can also be used for other cargo relevant for the bioenergy industry. The capacity is, on average, around 25 containers per hour. Full utilisation of transshipping containers is achieved by using spreaders as specific lifting equipment.

A luffing and slewing crane is a multipurpose transshipment crane and is suited for transshipment of goods using e.g. grabbers for biomass. Procurement costs are significantly less than those of a bridge crane.

Mobile cranes can be used as primary equipment at a port and can also provide support for existing crane equipment.

Figure 15: Luffing and slewing crane at the Port of Vienna; Source: © Port of Vienna

Figure 16: Mobile crane with caterpillar track system, © viadonau

Loading hoppers

Loading hoppers are used for the transshipment of bulk goods such as wheat, maize or rape from an inland vessel to a railway wagon or to a truck (Figure 17). Due to the fact that an inland navigation vessel can carry far larger amounts than a truck trailer or a rail wagon, loading hoppers are needed in order to decouple the transshipment process in a short period of time. A crane loads the bulk goods from the inland vessel from above into the hopper, while trucks or railway wagons located under the hopper are being filled at the same time. Loading hoppers can also be used as a temporary storage facility.

Suction and pumping equipment

Special suction and pumping equipment is used for transshipping liquid goods (Figure 18). This equipment, so-called fillers, are connected to the tanker vessel using a swinging arm and the cargo is pumped directly into storage tanks or waiting railway wagons or trucks. Vice versa, tankers are filled from the warehouse. Since the majority of liquid goods are classified as dangerous goods, these transshipment facilities are subject to stringent safety standards. This is particularly relevant for the transport and transshipment of bioenergy products which are covered by the existing dangerous goods regulations (e.g. bioethanol).

Floor-borne vehicles

Floor-borne vehicles are used for the horizontal transport of goods; they are mostly used in-company at ground level. Reach stackers are wheeled vehicles which can transship containers using spreaders. Such vehicles are predominantly used as a supplement to cranes or gantry cranes. Whereas a forklift can only hoist containers upwards in vertical direction, a reach stacker can also move containers forward by using an extendable lifting arm. This allows for the vertical storage of containers in piles, which can reach a height of 4 to 6 containers.

In addition to reach stackers, full and empty container forklifts can be used for the horizontal manipulation of containers. But Forklifts are also used for the efficient and safe transshipment of numerous goods such as round timber and require special equipment, such as clamps, claws or timber grippers.

Figure 17: Loading hoppers in the port of Krems, Source © Rhenus Donauhafen Krems

Figure 18: Transshipment facility for liquid cargo in the Port of Vienna-Lobau, Source © viadonau

Covered transshipment

Transshipment of goods in a building that is cantilevered over the water and protected along the sides from the rain allows moisture-sensitive goods, such as grain, to be manoeuvred regardless of weather conditions. The construction of the roof above the inland vessels protects the cargo from direct rain and – depending on the construction – also against driving rain from the side. Ideally, the vessel can completely enter the building, which is similar to a garage (Figure 19). The transshipment in such halls is carried out by overhead gantries, which span both the storage area and the transport vessel.

Figure 19: Covered transshipment at the facility of Industrie-Logistik-Linz, Source © Industrie-Logistik-Linz GmbH

Transshipment of bulk goods without grabbers

Bulk goods such as soya meal and grain are most frequently transshipped without cranes or grabbers, but by means of pneumatic or mechanical equipment. When using pneumatic systems such as suction or pumping devices, the bulk goods are transported via fixed pipes or flexible hose connections with high pressure or suction. Mechanical systems such as conveyor belts,

elevators and screw conveyors are also used in a similar way. In the case that only the loading of inland vessels is necessary, simple methods of transshipment such as tubes are also often used.

5.2.2 Storage facilities

The basic function of a warehouse is to serve as a buffer, which means the collection and distribution of flows of goods. This is especially important when using different transport modes, since the capacity differs according to the means of transport being chosen.

Based on the different characteristics of the transported goods, a port must offer various or event tailor-made types of storage facilities in order to prevent damage to cargo. Depending on the intended purpose, there are three different kinds of warehouses: storage warehouses, transshipment warehouses and distribution warehouses. With regards to the type of construction, there are open storage facilities, covered storage facilities and special-purpose storage facilities.

Open storage
This is the place where non-sensitive goods are stored, e.g. round wood (Figure 20). These goods have a comparatively low value and are not or less affected by rain or fluctuation of air temperature.

Covered storage
In a covered storage facility, goods are partly protected from adverse weather conditions and high value goods can be stored safely. In general, a covered storage facility is a storage area covered with a roof and located in a hall respectively (Figure 21).


Figure 20: Open storage, source © viadonau


Figure 21: Covered storage, source © Hafen Wien

Special storage
Special depots can be silos, tanks or bulk goods storage facilities. Agricultural bulk goods such as grain, soya and corn are stored in silo installations (Figure 22). Such facilities allow the storage of seasonal goods over longer periods of time, while guaranteeing storage and treatment such as dehumidification without loss of quality to the product. Goods in silos can be used continuously

or transshipped onwards to other modes of transport. Storage tanks are used for the storage of liquid goods and basically function in the same way as silo installations.

Some ports on the Danube have modern storage facilities and boxes for bulk goods at their disposal. These boxes have a special roof construction with a wide opening, enabling the cargo to be unloaded directly from the vessel to the storage facility by crane (Figure 23). The goods are delivered as an entire vessel's load and transshipped directly into the boxes using gantry cranes with grabbers. Each box contains one type of raw material, ensuring that many different kinds of cargo can be stored, thus expanding the services provided by the ports.

Figure 22: Silo as special storage depot, source © viadonau

Figure 23: Bulk goods storage, source © Hafen Wien

Regarding handling equipment and storage facilities in ports, the ENERGY BARGE team concludes that every individual type of cargo (raw material, intermediate or end product) has its own requirements regarding transshipment and storage. Particularly along the Upper Danube a lot of Danube Ports are well equipped for the handling and storage of various types of biomass. In the case that new equipment is needed at a particular location, the port or terminal operator can build its investment decision on good practice examples existing elsewhere.

In addition to basic services such as transshipment and storage, inland ports are cargo handling centres which offer a wide range of value-added services such as the packing and quality control, stuffing and stripping of containers, commissioning, distribution and project logistics. The good practice examples visited during the exchange workshop in Bamberg and Aschaffenburg and the implemented cluster strategies (D 4.1.1) showed how bioenergy and biomass companies can benefit from these added-value logistics services. A mutual specialization of both sides, bioenergy companies/plants and inland ports, in the field of logistics services will support the exploitation of potentials along the Danube and trigger additional investments, which will further accelerate this synergetic development in the future.

6. Conclusions

As a result of this assessment report, the general logistics requirements of the bioenergy industry can be summarized as follows:

- Reliable waterway infrastructure
- Efficient infra- and superstructure in the Danube ports
- Time-efficient and flexible administrative processes
- Flexible logistics concepts integrating Danube logistics services

In addition to these requirements, which are also relevant for customers of Danube logistics services from other economic sectors, cargo-specific requirements were collected and analysed for specific types of goods defined in Work Package 3.

The assessment carried out by the Work Package 4 team shows that bio-based raw materials and bioenergy products are highly suitable for being transported on the Danube waterway due to the high level of consistence between logistics requirements of the bioenergy industry and the service portfolio of the Danube logistics sector. The conducted expert discussions showed however that sufficiently large transport volumes and company locations in the vicinity of the Danube (at least one node of the transport route) are a prerequisite to facilitate a modal shift towards inland waterway transport.

Even though investments in the Danube fleet are necessary on a general level, this need for modernisation does not result from additional requirements coming from the bioenergy industry. The vessels currently deployed along the Danube are more than suitable to facilitate the transport of raw materials, intermediates and end products.

Many Danube ports (especially along the Upper Danube) currently already dispose of suitable handling equipment and storage facilities to serve the needs of the biomass and bioenergy industry. In the case that new equipment is needed at a particular location, the port or terminal operator can build its investment decision on good practice examples existing elsewhere. To this end ENERGY BARGE can build a platform for this know-how exchange and also integrate findings derived from the exchange workshop with the bayernhafen group in the frame of Output 4.3 and Deliverable 4.1.1.

The results derived from this report will provide inputs and guidelines for the elaboration of the modal shift platform for green bioenergy logistics (Output 4.1), which will facilitate the transfer of expertise on the transport, handling and storage of biomass to bioenergy actors. This expertise will be tailored towards the logistics requirements expressed in the expert discussions carried out to elaborate this deliverable. Moreover, the results of the conducted expert interviews can be further used for the development of the following activities and tasks of the project. In Activity 4.2 and 4.3 the previously involved potential customers of Danube logistics services and the ENERGY BARGE team will have the opportunity to discuss these requirements directly with logistics providers, especially in the frame of the regional B2B meetings (Output 4.2).

7. References

- Cargohandbook (2017) available at http://www.cargohandbook.com/index.php/ [Accessed 24 Nov 2017].
- Convention Regarding the Regime of Navigation on the Danube (1948), Belgrade, August 1948, available at http://www.danubecommission.org/uploads/doc/convention-en.pdf [Accessed 15 Dec 2017]
- European Agreement on Main Inland Waterways of International Importance (AGN) (1996), Geneva, January 1996, available at https://www.unece.org/fileadmin/DAM/-trans/conventn/agn.pdf [Accessed 15 Dec 2017]
- Report on market transfer conditions - Market Analysis Danube Corridor, PLATINA II (2016) available at http://www.viadonau.org/fileadmin/content/viadonau/05Wirtschaft/Dokumente/2016-04-06_D1.7_Platina_II_WP_1__Feedback_EC.pdf [Accessed 15 Nov 2017].
- Report on the exchange workshop with a good practice port in Western Europe (ENERGY BARGE D4.1.1).
- SafePellets, section Pellet transport & storage (2017) available at http://www.safepellets.eu/pellets-transport-storage/ [Accessed 6 Dec 2017].
- Searcy E., Hess J.R., Tumuluru J., Ovard L., Muth D.J., Trømborg E., Wild M., Deutmeyer M., Nikolaisen L., Ranta T., Hoefnagels R.,(2014): Optimization of Biomass Transport and Logistics. In: Junginger M., ShengGoh C., Faaij A. (Ed.): International Bioenergy Trade.Springer Science+Business Media Dordrecht 2014.
- TIS-Transport Information Service (wheat, maize, soybean, round wood) (2017) available at http://www.tis-gdv.de/ [Accessed 24 Nov 2017].
- viadonau (2013), Manual on Danube Navigation, third edition, Vienna, November 2013.
- viadonau (2014), factsheets of the working initiative renewable resources (for bioethanol, round wood, maize, rape, soy beans, sun flowers, wheat, sugar beet, pellets) (not published), Vienna.

Annex I: Template for implemented expert discussions

ENERGY BARGE
Survey guidelines for the evaluation of logistics requirements of bioenergy industry

Interreg
Danube Transnational Programme
ENERGY BARGE

Columns to be filled in by Project Partners:

General Information	Name of Project Partner:	
	Name of company:	
	Name of interview partner:	
	Business segment of the company:	
	Category: Supplier / Processor / Trader / End user:	
	Date and time of expert discussion:	

Columns to be filled in by Project Partners:

Theme: **Biomass**	**Cargo**	
	Questions for supplier	
	Questions for supplier: Which raw materials are produced?	*Please select and specify* *- Wood-based raw materials* *- Straw-based raw materials* *- Starch-based raw materials* *- Energy crops* *- Oilseeds* *- Sugar beet* *- Residues (wooden, agricultural)* *- Other:*
	What is the average annual traded volume?	
	Countries / Regions of origin of the raw material(s):	
	What is the specific weight of the product?	*in t/m3*
	What is the moisture content of the product?	*[% wet basis]*
	Target markets (Countries / Regions) of the raw materials:	
	Which countries in the Danube Region/Western Europe/rest of the world are important customers?	
	Questions for processor	
	Questions for processor: Which raw materials are processed (if applicable):	*Please select and specify* *- Wood-based raw materials* *- Straw-based raw materials* *- Starch-based raw materials* *- Energy crops* *- Oilseeds* *- Sugar beet* *- Residues (wooden, agricultural)* *- Other:*
	What is being produced? Please specify main and by-products (if applicable)	*Please select and specify* *- Bioethanol* *- Vegetable oil* *- Biodiesel* *- Pellets, Briquettes, Firewood, Wood chips* *- Biogas* *- Residues (wooden, agricultural)* *- Other*
	What is the average annual demand for the raw material(s)?	
	What is the average production quantity of (semi) final products?	
	Are there annual patterns and peaks in production?	
	What is the specific weight of the raw material?	
	What is the moisture content of the product?	*[%]*
	Countries / Regions of origin of the raw material(s):	
	What is the specific weight of the final product?	
	Target markets (Countries / Regions) of the (semi) final product:	
	Which countries in the Danube Region/Western Europe/rest of the world are important suppliers/customers?	

	Questions for trader	
	Questions for trader Which (semi) final products are traded?	*Please select and specify* *- Bioethanol* *- Vegetable oil* *- Biodiesel* *- **Pellets, Briquettes, Firewood, Wood chips*** *- Biogas* *- Residues (wooden, agricultural)* *- Other*
	What is the average annual traded volume?	
	Countries / Regions of origin of the products?	
	What is the specific weight of the product?	*in t/m3*
	What is the moisture content of the product?	*6-8% [% wet basis]*
	Target markets (Countries / Regions) of the products:	*AT,*
	Which countries in the Danube Region/Western Europe/rest of the world are important suppliers/customers?	
	Questions for end user	
	Questions for end user: Which products are turned into energy?	*Please select and specify* *- Bioethanol* *- Vegetable oil* *- Biodiesel* *- Pellets, Briquettes, Firewood, Wood chips* *- Biogas* *- Residues (wooden, agricultural)* *- Other*
	What is the average annual demand for biomass?	
	Which share does biomass have in the total energy production?	*in %*
	Total energy production per year	*in MWh_{el} (electric megawatt) and MWh_{th} (thermal megawatt)*
	What is necessary to increase share in biomass in energy production?	
	Who are the end consumers of the produced power/heat?	
	Which countries in the Danube Region/Western Europe/rest of the world are important suppliers/customers?	
Theme: **Transport**	**Logistics**	
	Which means of transport is used for the transport of raw materials/(semi) final products (road/rail/waterway/pipeline)	
	Reasons for the indicated means of transport?	
	How time-critical are transports/products?	
	Are the raw materials/(semi) final products transported as dry bulk, liquid bulk, break bulk, other?	
	Which certificates are relevant for the transport/storage/handling?	
	Are there any risk factors which have to be observed while transport/handling/transshipment?	*e.g. humidity, moisture, ventilation, self-heating, diseases, shrinkage, damage through mechanical devices, ..*
	Does any of the risk factors lead to reduction of quality?	*e.g. does mechanical damage of pellets lead to lower quality?*
	Is the product/raw material classified as dangerous good?	
	Does the company have experience with inland waterway transports ?	
	Which transport route is/was relevant for waterway transports:	*if applicable*
	Which inland ports served for loading and unloading:	*if applicable*
	Are you interested to receive more information on IWT? Which information?	

Comments:
1. Interviewed company has to be within a 100km radius to the Danube waterway
2. Interview partner has to be in charge of logistics in the company

Interreg
Danube Transnational Programme
ENERGY BARGE

Contact

Austrian Waterway Company (VIA)

Simon Hartl

Donau-City-Straße 1

1220 Wien

E-mail: simon.hartl@viadonau.org

http://www.interreg-danube.eu/energy-barge

Project co-funded by European Union funds (ERDF)