

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 3.1.2

Catalogue and visualization of biomass feedstock flows

31st August, 2017

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I. About the ENERGY BARGE project

The Danube region offers a great potential for green energy in the form of biomass. The main objective of ENERGY BARGE is to exploit this potential in a sustainable way, considering the Renewable Energy Directive 2009/28/EC, thereby increasing energy security and efficiency in the Danube countries. The project brings together key actors along the entire value chain, including 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 /

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FNR

Germany

Project partners

BioCampus Straubing GmbH

BCG

Germany

Deggendorf Institute of Technology

DIT

Germany

Austrian Waterway Company

VIA

Austria

Port of Vienna

PoVi

Austria

Bioenergy2020+ GmbH

BE2020

Austria

International Centre of Applied Research and Sustainable Technology

ICARST

Slovakia

Slovak Shipping and Ports JSC

SPaP

Slovakia

National Agricultural Research and Innovation Center

NARIC

Hungary

MAHART-Freeport Co. Ltd.

MAHART

Hungary

International Centre for Sustainable Development of Energy, Water and Environment Systems

SDEWES Centre

Croatia

Public Institution Port Authority Vukovar

PoVu

Croatia

Technology Center Sofia Ltd.

TCS

Bulgaria

Romanian Association of Biomass and Biogas

ARBIO

Romania

Federation of owners of forests and grasslands in Romania

Nostra Silva

Romania

II. About this document

This report corresponds to “D.3.1.2. Catalogue and visualization of biomass feedstock flows” of ENERGY BARGE. It has been prepared by:

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1. Background

This deliverable “D.3.1.2. Catalogue and visualization of biomass feedstock flows” 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).

- *Short description (Lead: BIOENERGY 2020+)*

The purpose of this report is to provide insight into the relevance of international biomass trade for the Danube region countries. To allow identifying locations with high biomass and bioenergy potential at a later stage, special attention will be given to existing cross-border feedstock flows, resulting in a qualitative overview on options and potentials for sustainable feedstock supply through a catalogue and a systematic graphic model. Hence, the project team will develop a catalogue and visualization of domestic and cross-border biomass feedstock flows considering qualitative criteria (types, location, usage, flow direction) and potential for bioenergy production.

Activity 3.1 analyses the bioenergy market and related value chains’ looking at the situation in project partner countries, as well as including a transnational perspective, also considering sustainability aspects. It aims at identifying regional strengths, weaknesses and potential for improved energy supply and security via increased bioenergy usage in the Danube region. It is focusing on the macro-economic dependencies within the partner countries and aims at drawing conclusions on transnational level for the biomass and bioenergy market in the Danube region. Moreover, it mainly serves as a theoretical basis for the other thematic work packages as well as for the Outputs developed in Work Package 3. A validation of these outputs, mainly Output 3.1, the biomass and bioenergy atlas, will take place during the workshops organized during the expert delegation program.

Deliverable 3.1.2 (together with D.3.1.1 “Compendium of national market study reports” and D.3.1.3 “National Sustainability Framework Conditions for Bioenergy Feedstock Production” forms the first part of theoretic and data-related input for Output 3.1, the biomass and bioenergy ICT Tool. This means that the results gained from D.3.1.2 will be used to fill the ICT tool with content. Hence, the visualization of the biomass flows are an important input for the Danube transnational biomass and bioenergy atlas (Output 3.1) to enable better, sustainable exploitation of the region’s bioenergy potential.

An overall visualization of the relation of Work Package 3 and its activities is presented in the figure below:

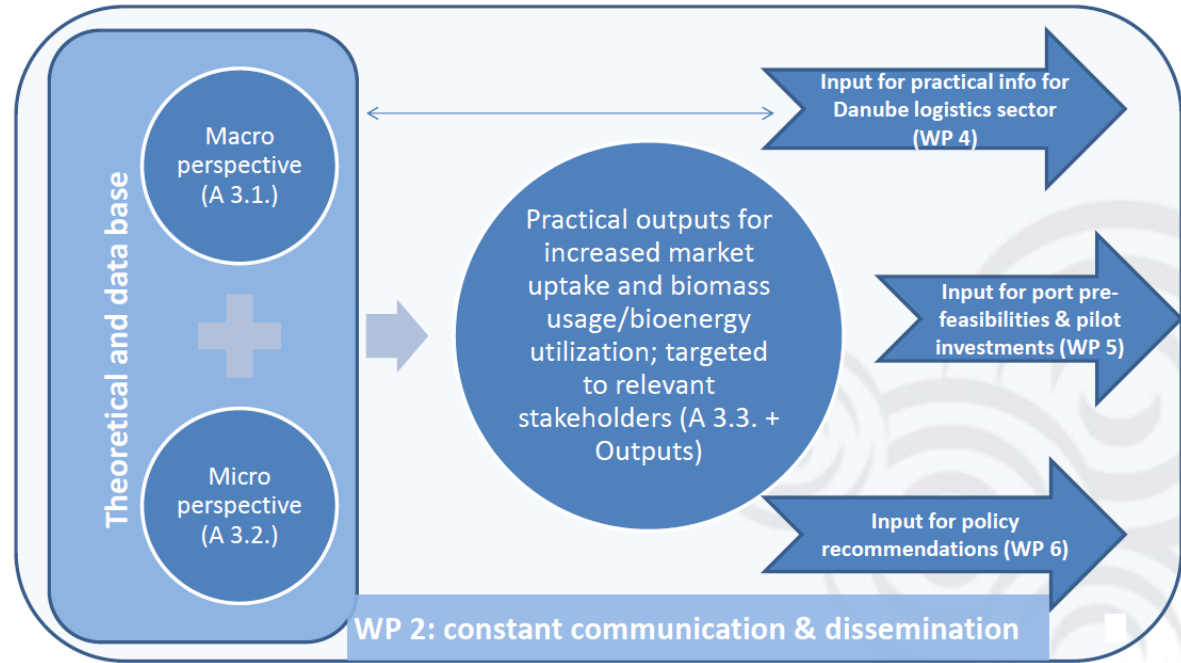


Figure 1: Role of WP 3 in the entire project
 (own visualization)



2. Introduction

In 2015, 38.3 million tons of goods were carried on the Danube waterway and its tributaries (Figure 2). As in previous years, the largest transport volume was achieved by Romania, amounting to just under 19.9 million tons, followed by Serbia with 12.6 million tons and Austria with around 8.9 million tons. Hungary was, after two years in second place to Romania, once again the largest exporter on the Danube. In 2015, Romania yet again boasted the largest volume of imports on the Danube. The second strongest import country on the Danube was again Austria, followed by Serbia (viadonau 2017). The majority (over 70 %) of freight transport along the Danube stays “within the Danube region”, meaning that both sending and receiving port are located along the river and in the region (Danube Commission, 2016).

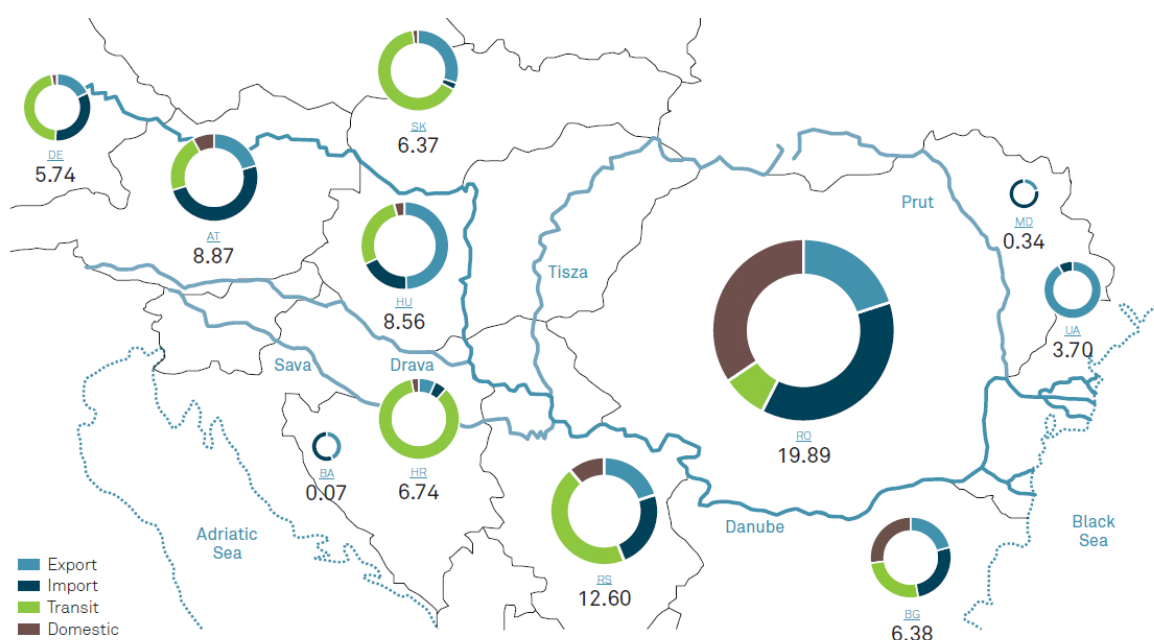


Figure 2: Freight transport on the entire Danube 2015.

Source: viadonau 2017, Data sources: Eurostat, National Traffic Statistics, viadonau

The transport goods category “agricultural and forestry goods”, under which, besides the classical agri- and food/feed industry products, also all kinds of bioenergy and biomass used for bioenergy can be subsumed, is already the second-biggest transport goods group in Danube freight (Danube Commission, 2016).

However, despite the extensive experience with freight transport on the Danube and the increasing biomass trade taking place via **inland waterway transport (IWT)**, biomass

businesses are confronted with several barriers regarding the biomass trade. Based on the viewpoints of biomass traders in many EU countries, the following barriers are currently limiting solid biomass trade (Alakangas et al. 2012, Junginger et al. 2010):

- Raw material scarcity is seen as a major bottleneck for the further increase in the production and trade of European biomass. At the same time, this shortage may actually increase the import of biomass from outside the EU e.g. from Canada, the USA and North-West Russia.
- Logistical issues, such as bad roads and lack of suitable infrastructures in harbours, are also a major barrier, hampering especially the low-density biomass types, e.g. residue materials.
- Differing sustainability criteria in different countries were seen as an (potential) obstacle by market actors, mainly because it is largely unclear if (and which) solid biomass streams will have to meet sustainability criteria.
- Clarity on biomass fuel¹ quality is generally required to increase consumer's confidence, especially for wood pellets delivered to households. General technical standards may be a solution. However, commodity-specific solutions to guarantee fuel quality may also be an option.

Hence, it is important to investigate the already existing transnational biomass feedstock flows in order to provide (potential) biomass businesses with a qualitative overview on options and potential feedstock supply chains in the Danube region. Moreover, when identifying the existing flows – independent of the currently used transport type(s) – it becomes additionally possible to inform IWT and Danube logistics actors about potentials for shifting biomass trade flows on the river.

Overall, the target groups of WP 3 are tailored towards the involvement of both actors from the national and EU wide bioenergy and bio-based industries sectors as well as from the Danube logistics side. Within this twofold realm, WP 3 aims to deliver input for an increased bioenergy uptake in the Danube region. It shall be usable for private business actors from the biomass, bioenergy and Danube logistics sectors, as well as for public regional and national authorities dealing with regional, energy and transport planning.

In the following chapters, the international biomass trade flows in the Danube region are therefore analyzed and visualized based on EUROSTAT trade statistics. For this deliverable, only the transport between/within the partner countries is considered – other relevant source and target countries and ports are considered in the Output 3.1. In addition, domestic feedstock flows are presented by the biomass Sankey diagrams of the JRC, also considering current utilization of these feedstock types.

¹ including solid, liquid and gaseous fuels derived from biomass

3. Biomass trade in the European Union

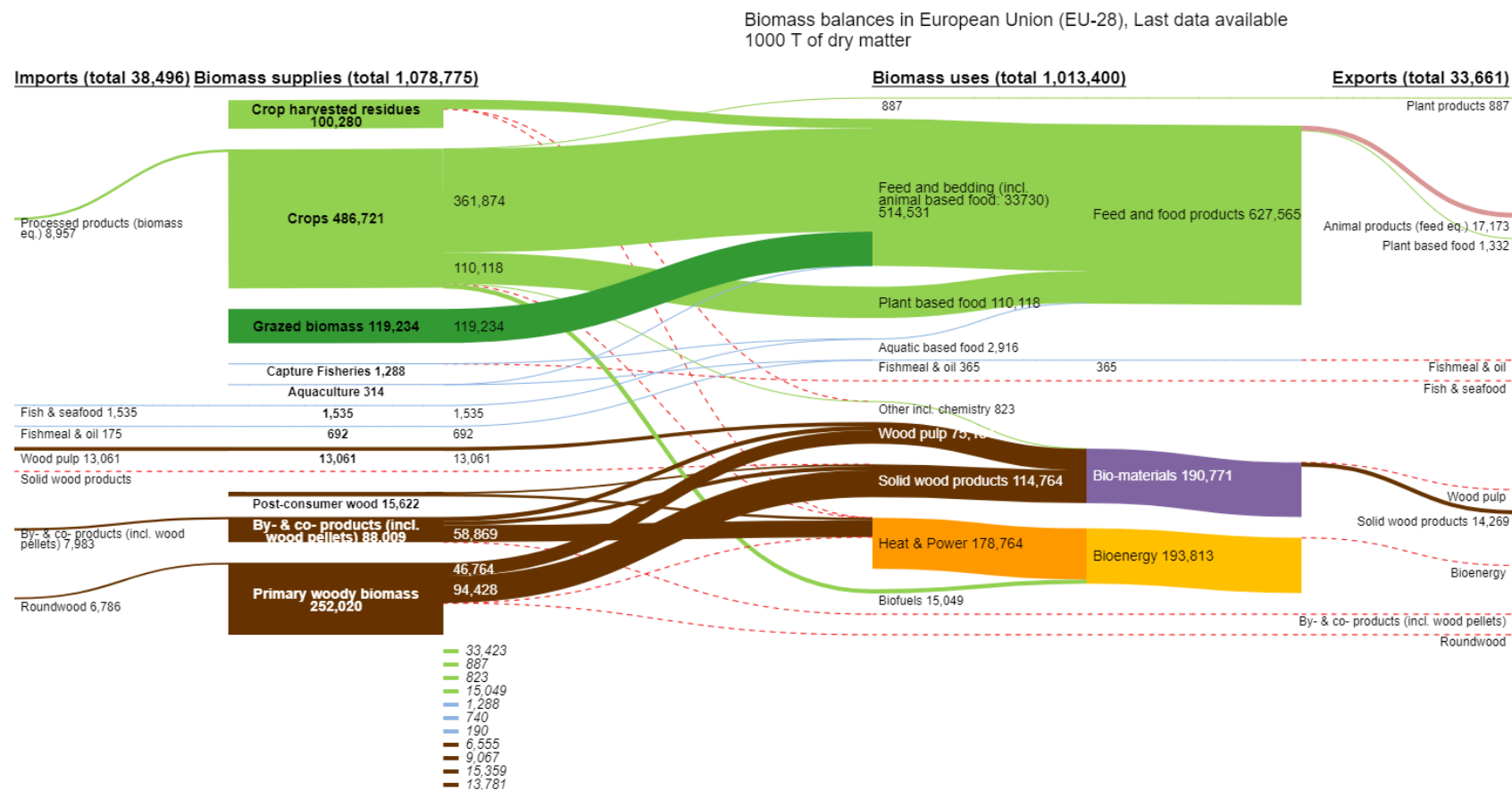
According to the EUBIONET III study (Alakangas et al. 2012) biomass trade in Europe has been growing strongly, especially for refined biomass fuels (such as wood pellets). While in many countries, local biomass potentials still remain to be exploited, on the longer term, it is likely that some European countries with a high demand for biomass but little supply may face a shortage of biomass. So far, only a small part of the total biomass utilised in the EU is traded internationally. This share is rapidly growing. Especially the trade of wood pellets has been growing strongly, and is likely to continue to grow in the years to come. Nevertheless, also other forms of solid biomass e.g. wood chips, waste wood, firewood and agricultural residues are traded, sometimes also in significant quantities.

In the JRC study “Biomass flows in the European Union: The Sankey Biomass diagram-towards a cross-set integration of biomass” (Gurría et al. 2017) biomass flows in the EU28 are presented.

Sankey diagrams are used to illustrate flows of a specific commodity. The amount of commodity in each portion of the diagram is represented by the width of the stream. Hence, Sankey diagrams visually emphasise the major transfers or flows within a system. The Sankey biomass diagram is a representation of harmonised data from the various Joint Research Centre (JRC) units contributing to the BIOMASS Assessment study of the JRC. It represents the flows of biomass for each sector of the bio-economy, from supply to uses including trade, which makes them suitable for the purposes of ENERGY BARGE as it becomes possible to identify utilization for energy generation. The diagrams represent the dry matter content of biomass.

In order to represent the biomass flows, the Sankey biomass diagram is split into biomass supply (shown on the left of the diagram) and biomass uses (right portion of the diagram) (Figure 3). Each of these areas shows different categories: agriculture, forestry and fishery (supply), as well as feed and food, biomaterials, bioenergy, and direct exports for each sector (uses) (Gurría et al. 2017).

Figure 3 shows the biomass Sankey diagram for the EU28. In the EU28, agriculture is the biggest **biomass supply** sector with a relative weight of approximately 65% (from 13% in Finland to 90% in Greece, Malta, Hungary and Cyprus), followed by forestry with 34% of the dry matter content (from 8% in Malta to 87% in Finland). The relative weight of the fishery sector is quite small (less than 1%). In agriculture, crops represent almost 62% of the biomass supply with collected crop residues (23%) and grazed biomass (15%) being closer in weight but representing much smaller portions. The dominant source of forestry biomass is primary woody biomass accounting for almost 70% of the total (Gurría et al. 2017).



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 3: Biomass Sankey diagram EU28.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

The European **agricultural biomass** total supply amounts to approximately 765 million tons of dry vegetal biomass equivalents, divided as follows (Gurría et al. 2017):

- The crop harvested production is estimated at 478 million tons of dry matter (t_{dm}) biomass in the EU-28 for the year 2013 (i.e. approximately 2 billion tons of fresh biomass).
- Collected crop residues provide additional 100 million t_{dm} of biomass.
- 19 million tons of biomass are derived from grazed pastures and meadows.
- Around 10 million additional tons of dry matter of crop residues could be collected without hampering the production of ecosystem services such as soil carbon conservation, fertility maintenance, water retention, etc..
- Around 67 million t_{dm} of vegetal biomass equivalents are imported, 53% in the form of crop products (non-manufactured), 25% in the form of food products and the rest in the form of biomaterial products (ca. 22%).

EU28 **woody sources** are estimated in total at almost 370 million t_{dm} . The total estimated removals from the forest of primary wood in EU28 add up to 252 million t_{dm} , while the net-import of roundwood is estimated to be about 6.8 million t_{dm} . Removals from forests were composed of 78.6% of industrial roundwood, and 21.4% of fuelwood. Fuelwood is estimated to be composed of 33% stemwood and 67% other wood components (branches, tree tops, sub-merchantable stems). In addition to the removals classified as fuelwood, the total amount of woody biomass used for energy in the wood resource balance also includes secondary residues from wood processing, black liquor, removals from outside forests, imported secondary residues and wood pellets, post-consumer wood and actually also part of pulpwood classified as industrial roundwood. Net-import of by- and co- products (incl. wood pellets) is about 8 million tons dry matter, while net-import of wood pulp is 13 million tons (Gurría et al. 2017).

Feed and food is the most important category in terms of **biomass use**, adding up to over 60% of the biomass. Bioenergy accounts for about 19% of the total biomass in the EU-28. However, it is important to note that biogas and bioelectricity have not been considered for the Sankey diagrams. Bio-materials² are the third biggest group (Gurría et al. 2017).

The biomass used for **feed and food** products is almost entirely of agricultural origin. 71% of the total agricultural biomass supply (expressed in dry matter) is used as food and feed: 69% is used as animal feed & bedding for the production of animal-based food while the rest is directly consumed as plant-based food (Gurría et al. 2017).

Most of the biomass used in **bioenergy** is sourced from forestry products. In 2013, 178.7 t_{dm} of wood were estimated to have been used for energy, either directly or indirectly gathered from forest. Only 2% of the EU agricultural supply is processed into sustainable biofuels for

² Bio-materials: Materials wholly or mainly derived from biomass (the biomass can have undergone physical, chemical or biological treatment) for material use

transportation. The rest is either used as biomaterial or waste. Biofuels use in the EU transport sector in 2013 totalled 12.0 ktoe in energy terms. Common arable crops had the main contribution to the total biomass supplied to the transport sector, at more than 90% in 2013. Based on the available data, the volume of domestic common arable crops supplied to the transport sector is estimated at 15 million t_{dm} in year 2013. Germany was the main supplier with 12 million t_{dm} followed by Slovakia (668 thousand t_{dm}) and Romania (475 thousand t_{dm}) (Gurría et al. 2017).

Almost all of the **bio-materials** also have an origin in forestry activities with the biggest component being solid wood products. In 2013, 189.9 million tons of dry matter of wood were used for bio-materials. EU-28 is also a net exporter (14.3 million t_{dm}) of solid wood products.

It becomes apparent from these data, that extensive volumes of biomass – both for conventional utilization in the agro- and food/feed industry as well as for purposes of bioenergy and biomaterials have to be transported within the EU28/between the member countries as well as in- and outside of the EU28 market (imports and exports), resulting in a high modal shift potential. A closer look at the situation in the Danube countries shall also provide insight into which kinds of feedstocks and bio-based products are traded and if countries with particular import or export profiles can be identified.

4. Catalogue of biomass flows in the Danube Region

In order to provide private business actors from the biomass, bioenergy and Danube logistics sectors, as well as public regional and national authorities with an overview of existing transnational biomass feedstock flows and to overcome barriers regarding biomass trade, data on biomass flows in and between the ENEGRY BARGE partner countries are presented in this chapter.

As shown in Table 1, all port partners are engaged in the transshipment of agricultural and forestry goods. The port of Straubing tranships the greatest volume of agricultural and forestry goods with a total amount of 390 tt, followed by the port of Mahart with a total biomass cargo of 307 thousand t. However, the port of Komarno has the highest share of agricultural and forestry goods: 88% of the total cargo transhipped (150 thousand t) is biomass. The ports of Vienna and Bratislava tranship the greatest total cargo volumes, however the shares of agricultural and forestry goods thereof are the lowest.

Table 1: Cargo of port partners in 2016

	Total cargo transhipped on waterside (in thousand t)	Share of biomass (agricultural and forestry goods) thereof in %	Total volume of agricultural and forestry goods (in thousand t)	Total volume thereof sent (in thousand t)	Total volume thereof received (in thousand t)	Share of transshipment to/from Danube region in %
Port of Straubing	621	62.9	390	313	77	66.4
Vukovar	332	23.7	79			
Mahart	1,039	29.5	307	300	7	n.a.
Vienna	1,068	14	153	93	60	50
SPaP - Bratislava	1,959	1	4			
SPaP-Komarno	150	88	131			

For the visualization of relevant biomass trade flows between the partner countries of the Danube region (listed in Table 2) on the project's online platform, trade statistics were extracted from the Eurostat database (<http://ec.europa.eu/eurostat/data/database>). The data declared of the respective reporting country is used for visualization. However, in the extracted EUROSTAT data, asymmetries could be found. Asymmetries occur when the declaration of the importer in country A is not consistent with the declaration of the exporter in country B. Asymmetries result either from errors in reporting or from differences in the concepts and definitions applied by the partner countries. For further information regarding data asymmetries please refer to: http://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_statistics_-_background#Asymmetries

Table 2: Reporting countries

Country	Reporter	Trade Partner
Austria*	✓	✓
Bosnia and Herzegovina		✓
Bulgaria*	✓	✓
Croatia*	✓	✓
Czech Republic	✓	✓
Germany*	✓	✓
Hungary*	✓	✓
Montenegro		✓
Republic of Moldova		✓
Romania*	✓	✓
Serbia		✓
Slovakia*	✓	✓
Slovenia	✓	✓
Ukraine		✓

*project partner country

Following the “Combined Nomenclature” trade flow data are available at different levels of aggregation. Based on the “CN8” nomenclature, the categories which are most relevant for bioenergy production have been identified. The selection was based on the results of D 3.1.1 “Compendium of national market study reports” which identified the biomass commodities which are already used and biomasses with the highest potential for bioenergy production in the Danube region. The ENERGY BARGE country reports have clearly shown that in all covered countries, wood biomass and bio-based residue material is the feedstock group most promising for energetic purposes in the Danube region. Furthermore, we included several agricultural biomass types, though their residues are not used for bioenergy production yet. However, there are already well developed Danube logistic chains for these categories which could serve as an example. Also, all types of biomass selected are potential feedstocks for a circular utilization in the sense of a bioeconomy (energetic and/or chemical-material use). However, the selection process was limited by the data availability, for instance, there is a lack of trade data for short rotation coppices. Moreover, the data available does not allow conclusions on the mode of transport used. The identified 21 categories/commodities are listed in Table 3.

Table 3: Selected commodities

Code CN8	Label
10011000	Durum wheat
10019900	Wheat and meslin (excl. durum wheat)
10020000	Rye
10030090	Barley
10040000	Oats
10059000	Maize
10070090	Grain sorghum
10086000	Triticale
12010090	Soya beans
12050090	Rape or colza seeds
12060090	Sunflower seeds
12129110	Fresh sugar beet
12129120	Sugar beet, dried, whether or not ground
12130000	Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets
15121110	Crude sunflower-seed or safflower oil, for technical or industrial uses (excl. for manufacture of foodstuffs)
38260090	Biodiesel and mixtures thereof, not containing or containing < 70 % by weight of petroleum oils or oils obtained from bituminous minerals
44011000	Fuel wood, in logs, billets, twigs, faggots or similar forms
44012100	Coniferous wood in chips or particles
44012200	Wood in chips or particles (excl. coniferous wood)
44013090	Wood waste and scrap, whether or not agglomerated
44013100	Wood pellets

Annual data from 2012-2016 is used and for the visualization on the platform the biomass commodities are assigned to the following biomass & bio-based product categories:

- Starch-based products
- Oilseeds
- Sugar beet
- Wood-based products
- Energy crops
- Residues
- Biofuels

The final visualization of the biomass trade flows will be available on the following platform: <http://energy-barge.eu/>. The platform will be the basis for the integrated visualized ICT Tool that maps transnational bioenergy value chains, feedstock flows and potentials for market uptake and cooperation. Figure 4 shows a screenshot of the platform which will be optimized regarding visualization and usability during the project lifetime.

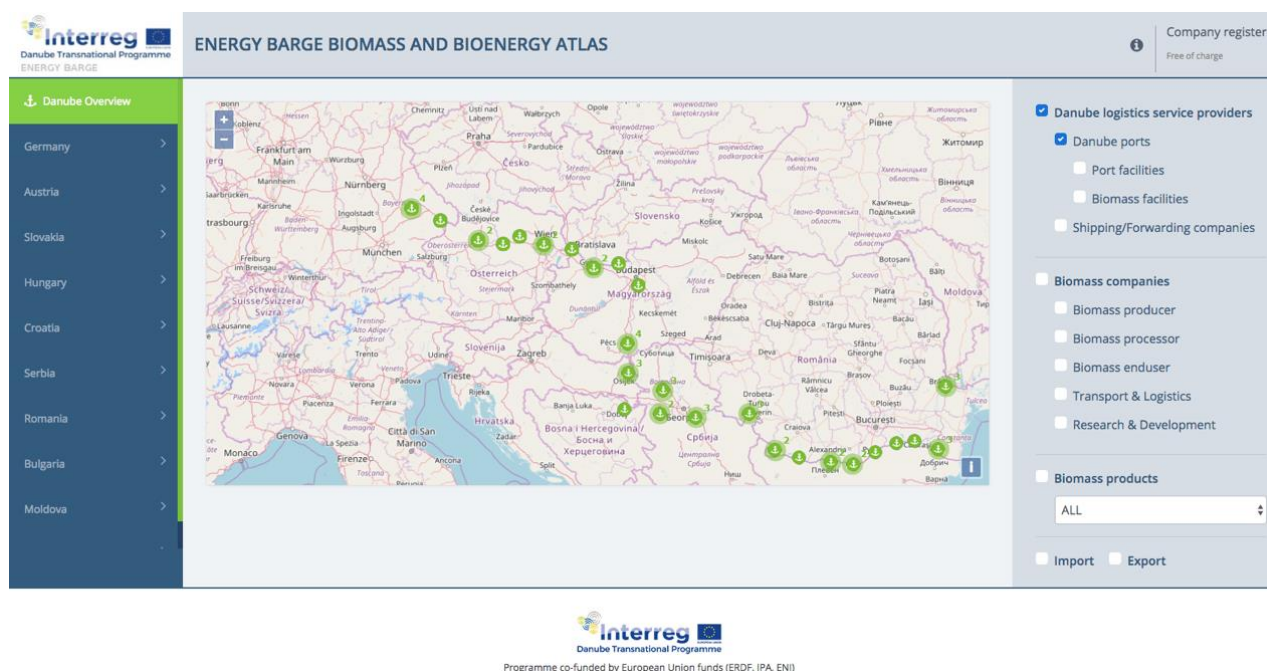


Figure 4: Screenshot ENERGY BARGE platform (ICT Tool)

The following chapters provide insight into biomass imports and exports and the domestic biomass flows according to the Sankey Diagrams and the EUROSTAT data for each project partner country in the Danube region. The catalogue at hand forms the methodological basis for the online platform that will be the project's output. For the visualization in this catalogue, data of export and import volumes between the project partner countries of 2012 and 2016 had been selected. The data is presented in bar diagrams.

The visualization at the final online platform will include all the selected data from Table 2 and Table 3. It will moreover include trade flows from and to relevant countries outside the project area reachable via IWT as well as multiple functions for displaying trade flow types, directions and volumes (see Figure 5 and Figure 6).

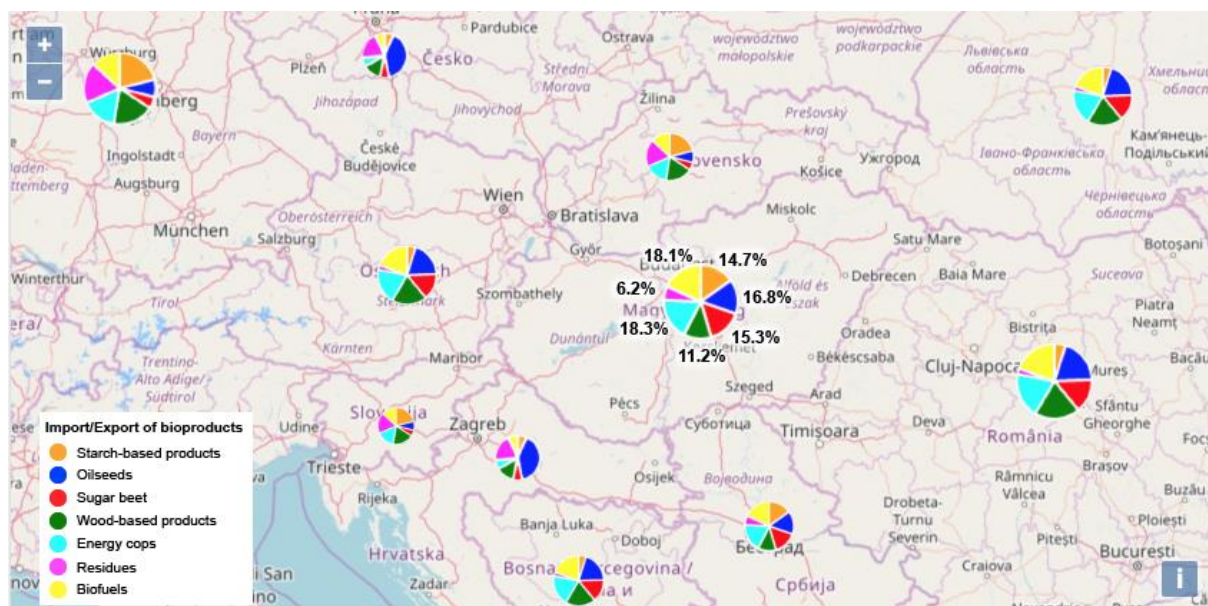


Figure 5: Example of pie chart visualization of trade of bio-based product types as available on the online platform.

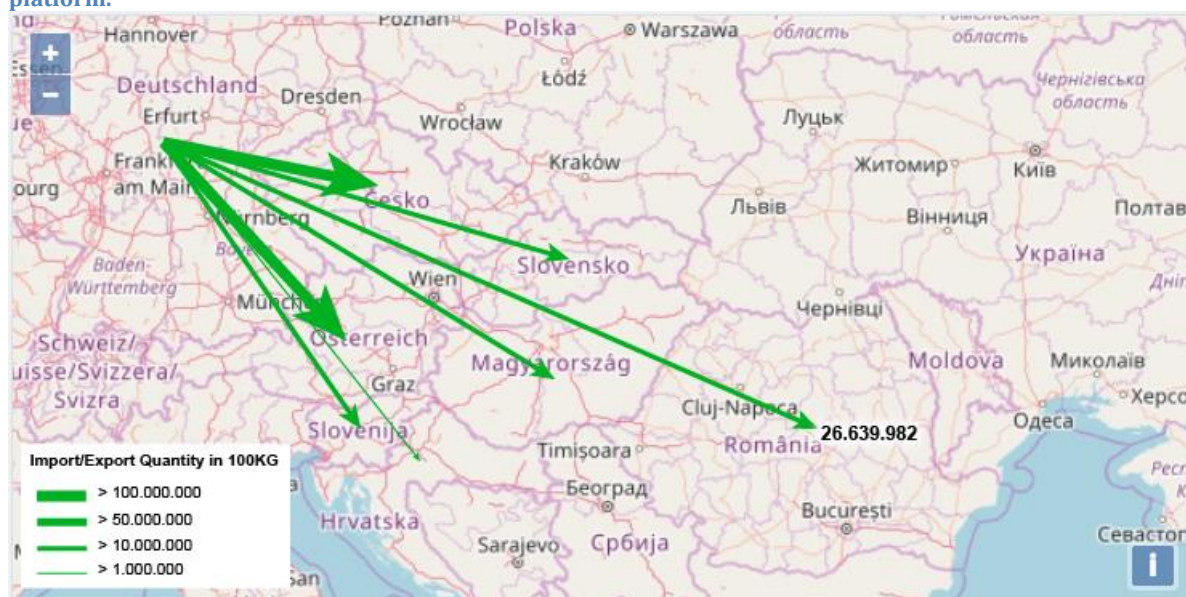


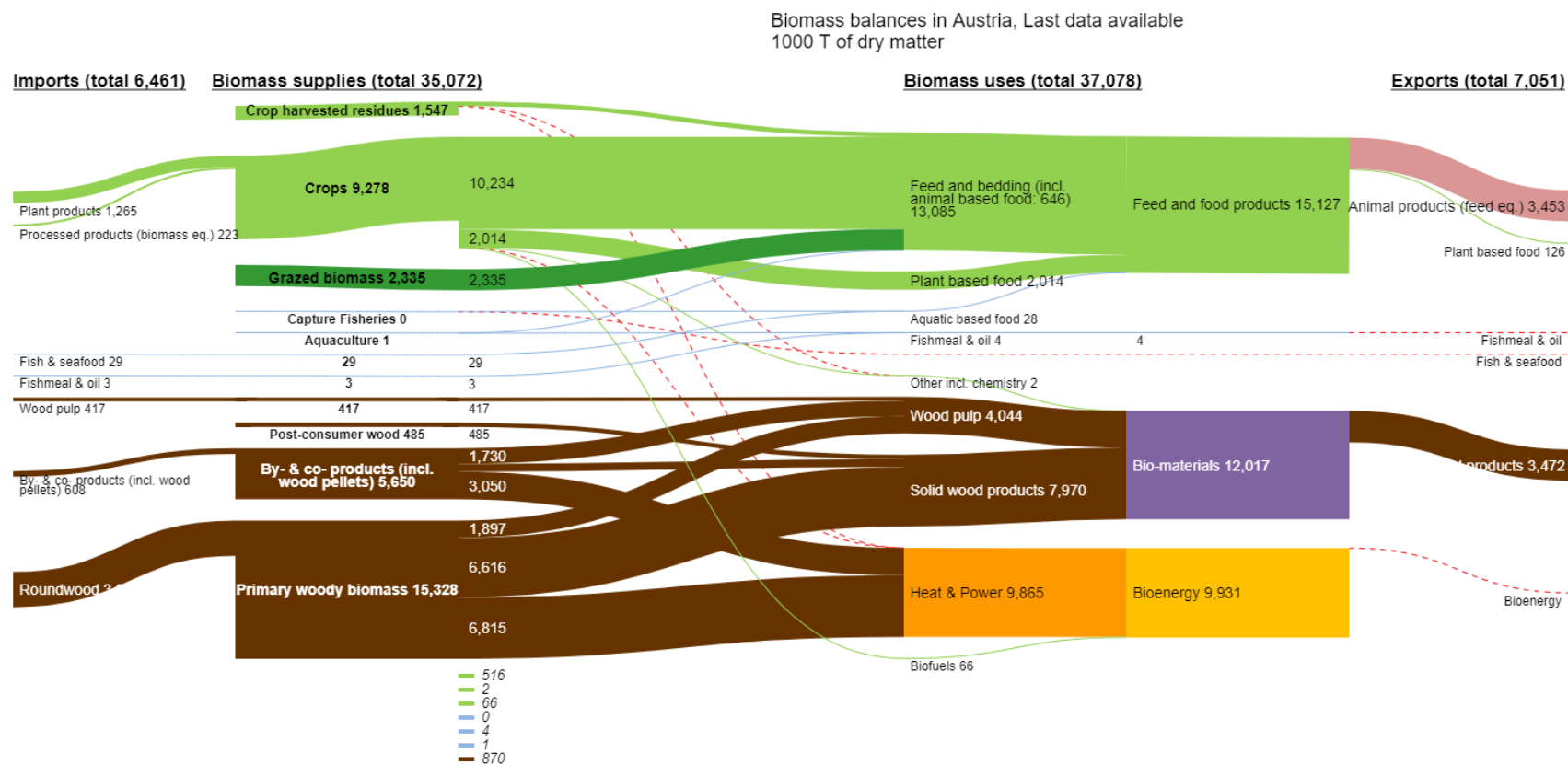
Figure 6: Example of flow direction and volume visualization of trade of bio-based product types as available on the online platform

4.1 Austria

According to the biomass Sankey diagram (Figure 7) the total biomass supply in Austria amounts to 35 million t_{dm} , most of which originate from primary woody biomass (15.3 million t_{dm}). Total imports amount to almost 6.5 million t_{dm} , exports to 7.1 million t_{dm} . The Sankey diagram shows also the domestic biomass flows: The main biomass uses are in the category of “feed and food products” (15.1 million t_{dm}), followed by bio-materials (12.0 million t_{dm}). 9.931 million t_{dm} biomass are used as bioenergy, mainly for heat and power production.

Figure 8 shows that Austria imports large amounts of wood chips (mainly non-coniferous wood chips) from Germany, Romania and Slovakia. The import volume of wood chips from Germany and Slovakia increased 2016 compared to 2012, whereas the import volume of wood chips from Romania decreased. However, the wood pellet imports from Romania increased significantly, from 103,724 tons in 2012 to 190,011 tons in 2016. Austria imports fuel wood from all partner countries, mainly from Hungary. Large amounts of wheat and meslin as well as maize are imported from Hungary and also from Slovakia. The total import volumes from Bulgaria and Croatia to Austria were less than 50,000 tons in 2016. Furthermore, Austria imported 14,300 tons and 12,500 tons biodiesel from Germany in 2012 and 2016, respectively. In total, the import volumes of the selected biomass commodities increased 2016 compared to 2012.

Figure 9 shows the export volumes of the selected biomass commodities from Austria to the partner countries Bulgaria, Croatia, Germany, Hungary, Romania and Slovakia in 2012 and 2016. Mainly agricultural commodities are exported. The main trade partner is Germany: Austria exports large amounts wheat and meslin, maize and wood pellets to Germany. However, the maize and wood pellet exports to Germany as well as the total export volumes to the partner countries decreased 2016 compared to 2012. In 2016, Austria exported 6,000 tons biodiesel to Croatia.



Source: data from the BIOMASS project, European Commission – Joint Research Center

Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.

Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 7: Biomass Sankey diagram for Austria.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

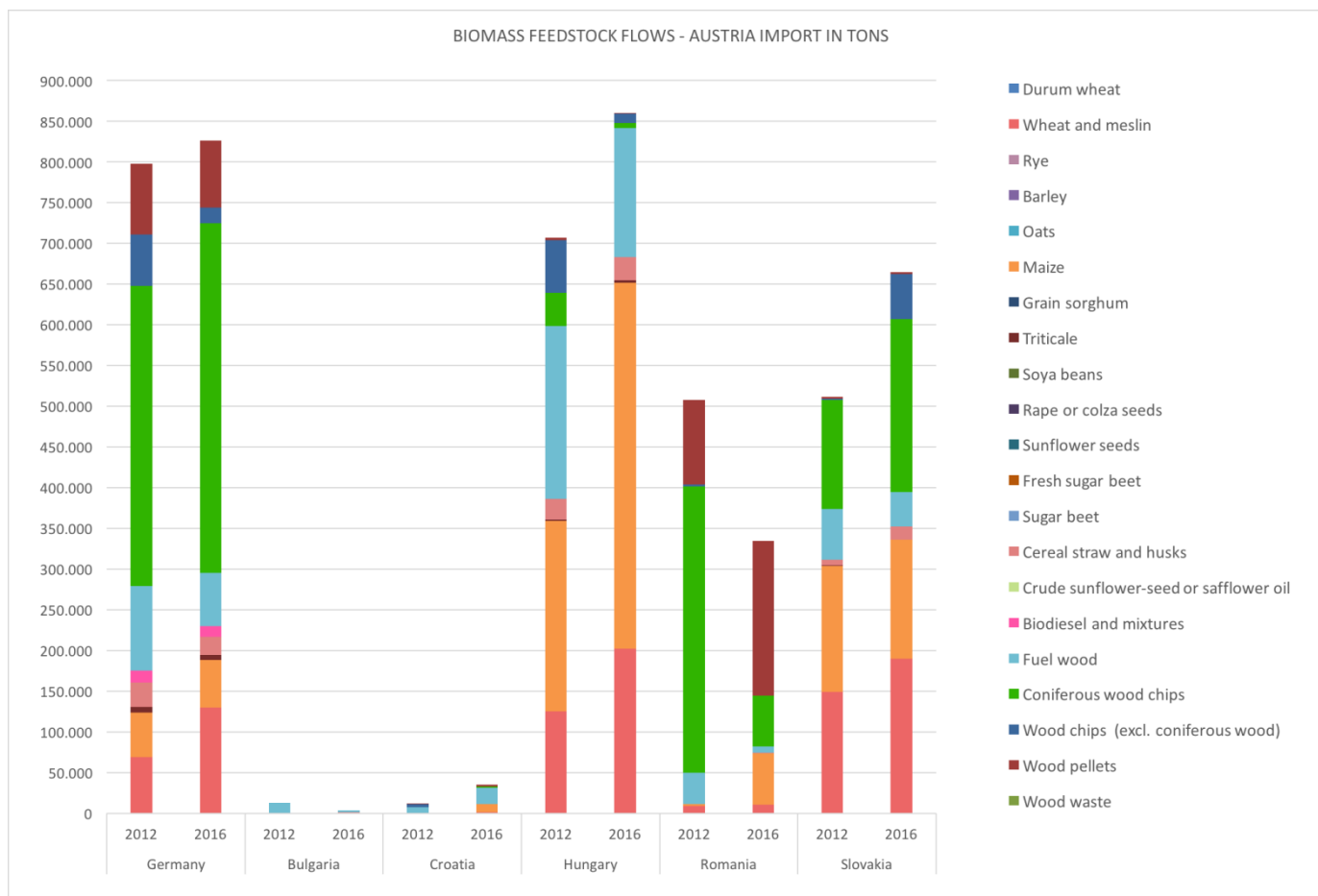


Figure 8: Austria - selected biomass import flows.
 Data Source: EUROSTAT

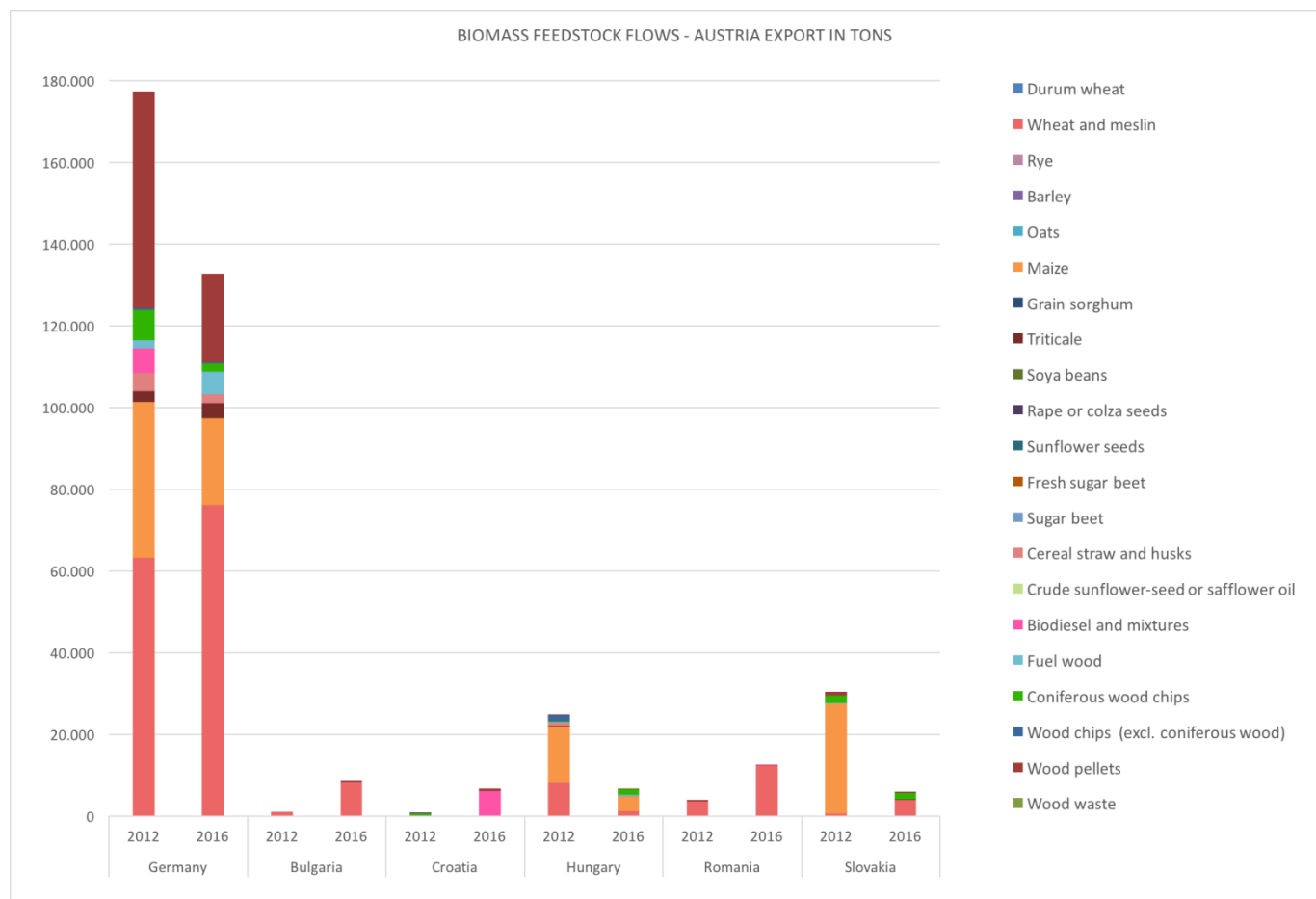
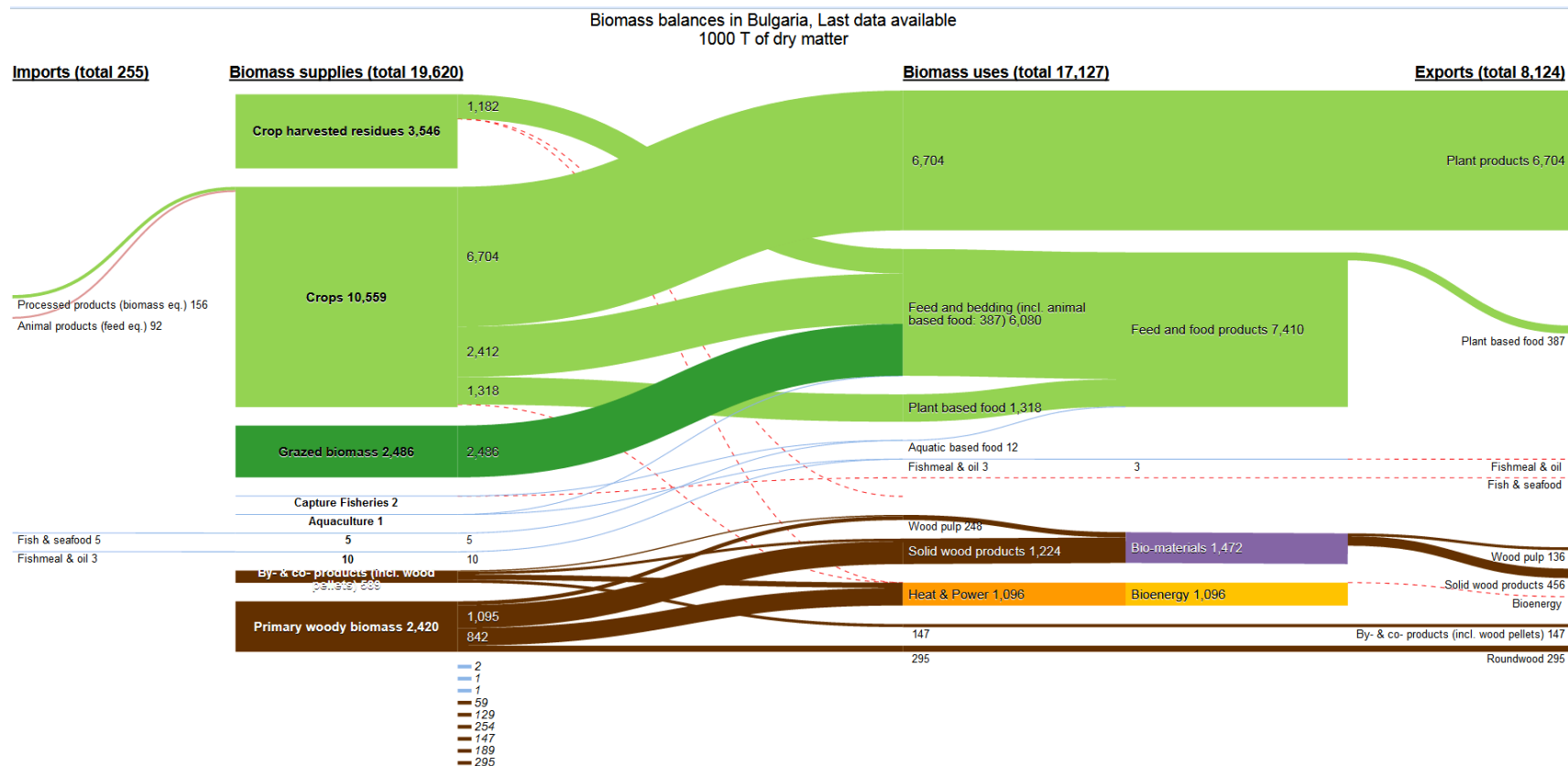


Figure 9: Austria – selected biomass export flows.
 Data Source: EUROSTAT

4.2 Bulgaria

In Bulgaria, the total biomass supplies amount to 19.620 Million t_{dm} , most of which originate from agricultural crops (Figure 10). The main domestic use for biomass is the feed and food production with 7.410 million t_{dm} . However, almost the half of the total biomass supply is exported (8.124 million t_{dm}). In contrast, the biomass imports only amount to 0.255 million t_{dm} . Only 1.096 million t_{dm} , mainly woody biomass, are used for bioenergy production.

Regarding the selected biomass commodities, the main trade partner of Bulgaria in the Danube region is Romania (Figure 11 and Figure 12). The total imports from Romania to Bulgaria amount to over 30,000 tons in 2012 and to around 63,000 tons in 2016. The main share is wood pellets with 15,058 tons in 2012 and 46,697 tons in 2016. The total exports from Bulgaria to Romania increased from around 480,000 tons in 2012 to over 750,000 tons in 2016. The main shares are the commodities “wheat and meslin” as well as “maize”. In 2012, Bulgaria imported 47,500 tons of maize from Hungary. However, the total import volumes from Hungary decreased to only 10,500 tons – mainly wheat and meslin- in 2016.



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 10: Biomass Sankey diagram for Bulgaria.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

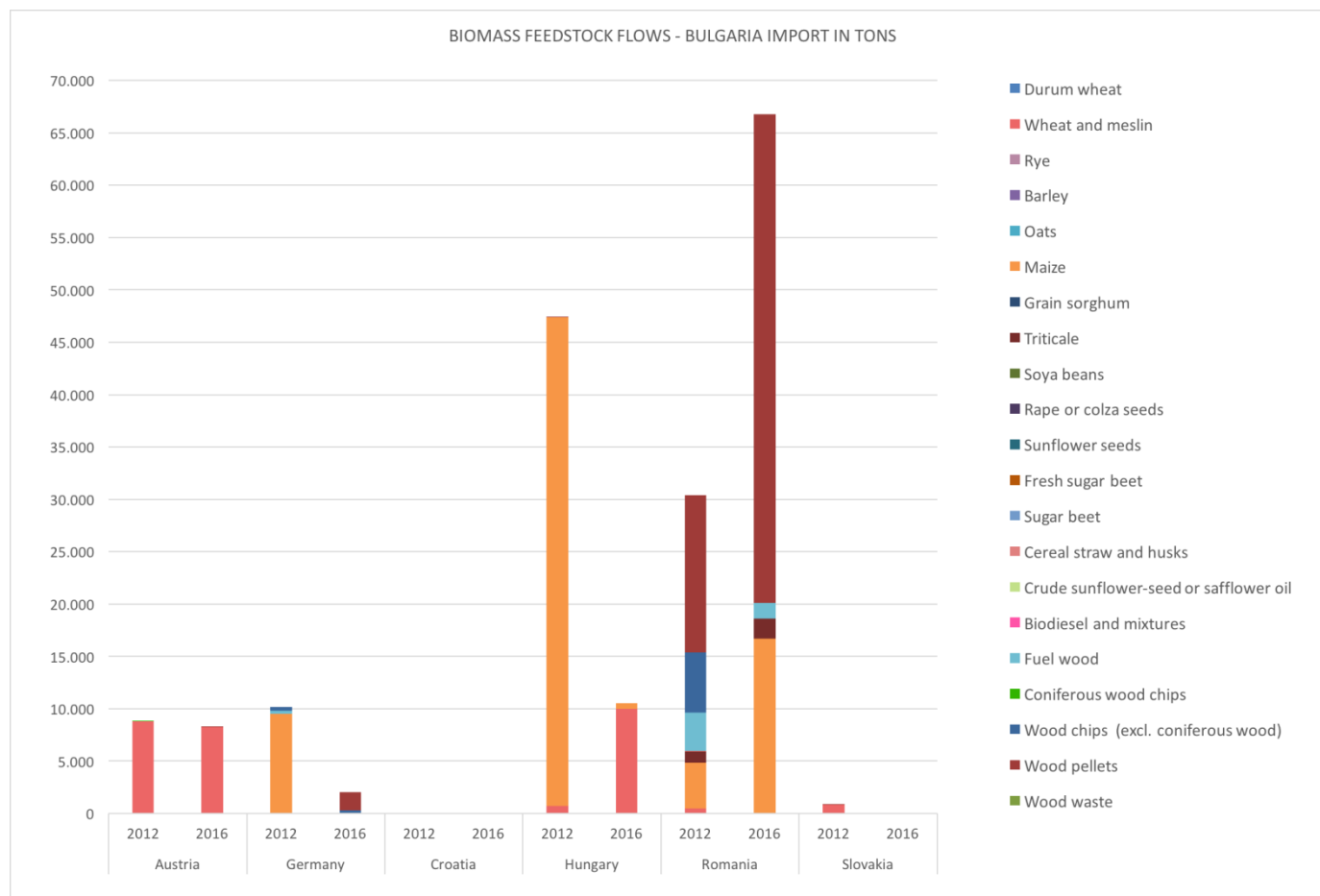


Figure 11: Bulgaria – selected biomass import flows.
 Data source: EUROSTAT

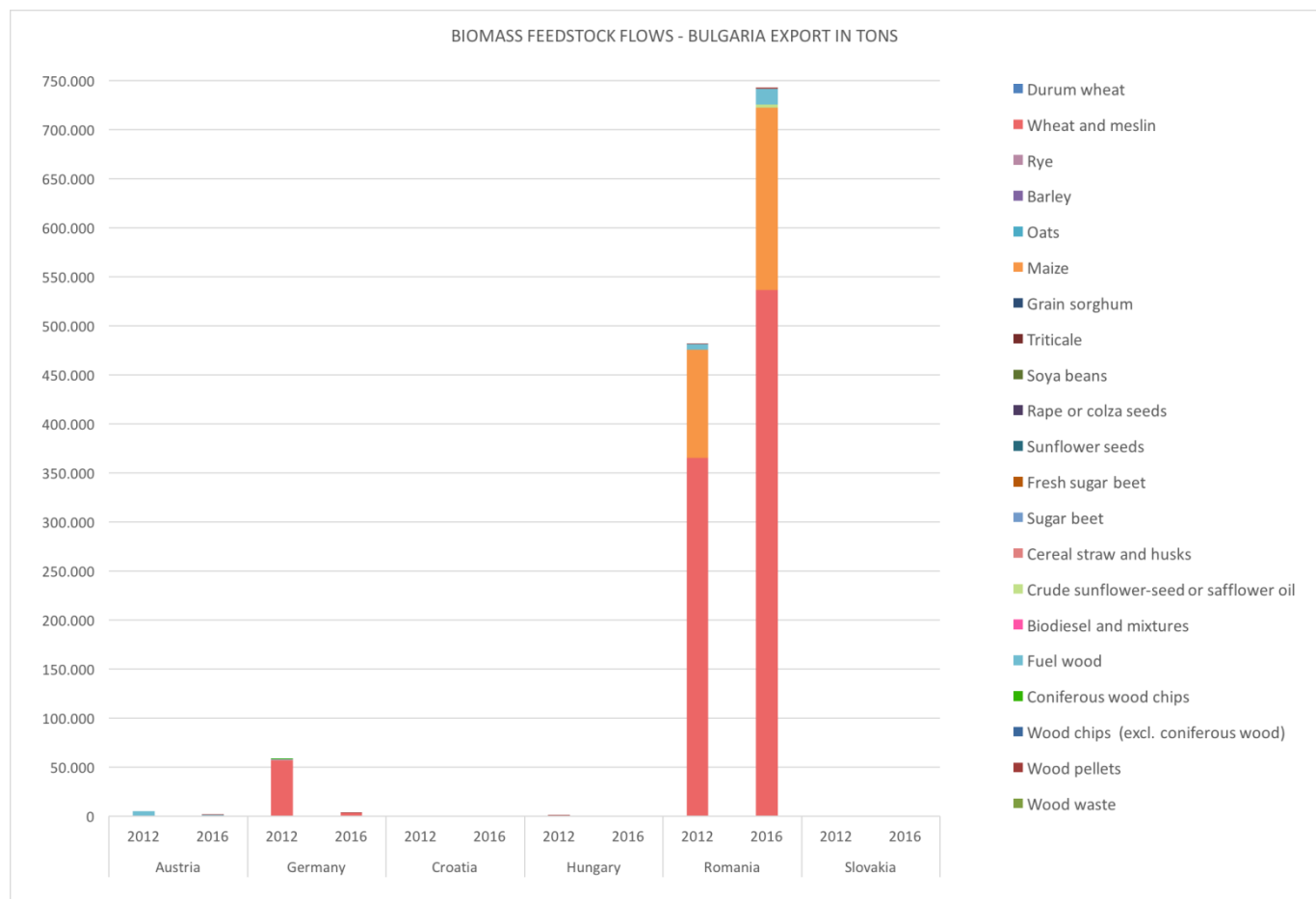
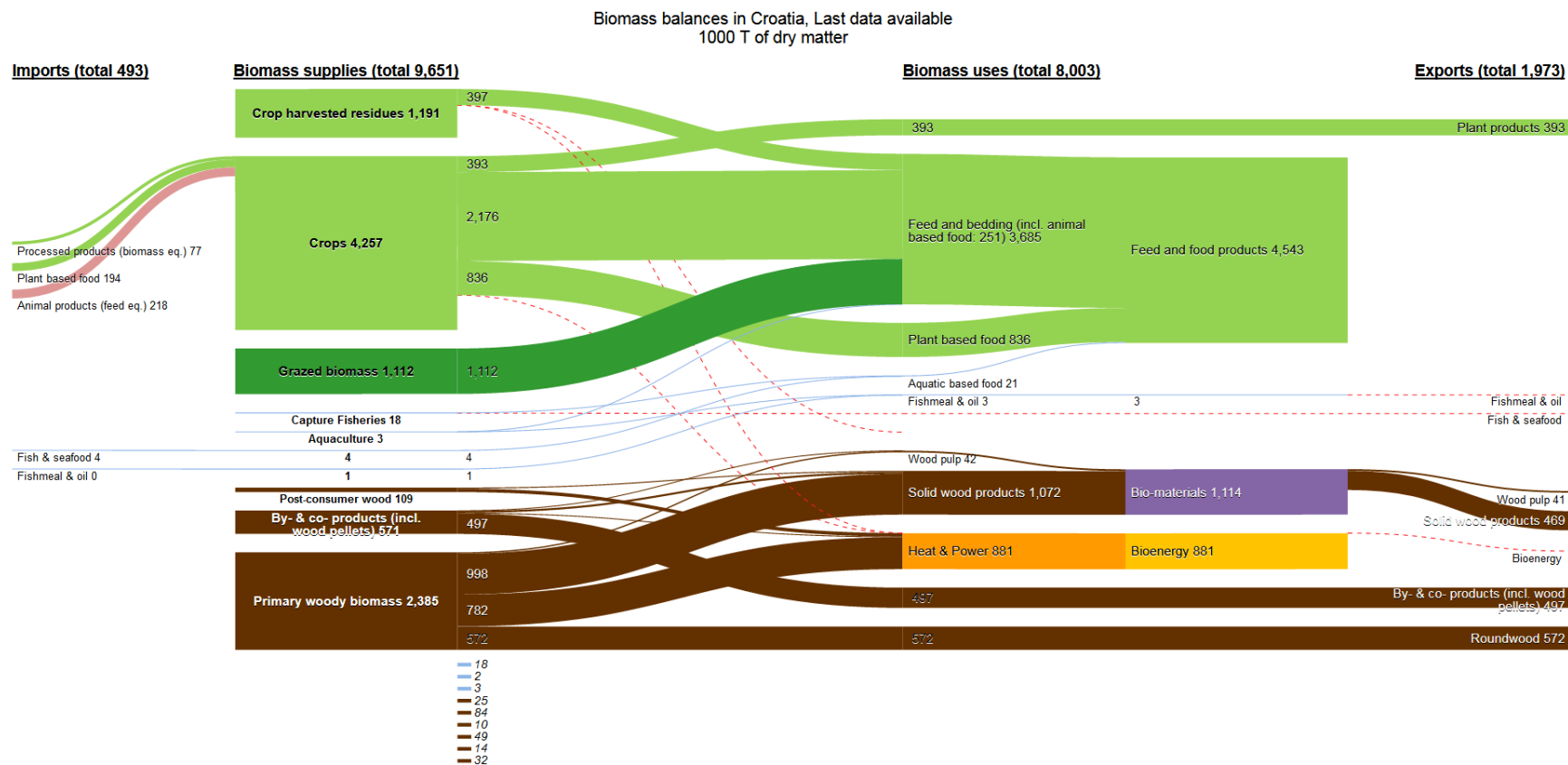


Figure 12: Bulgaria – selected biomass export flows.
 Data Source: EUROSTAT

4.3 Croatia

Figure 13 shows the domestic biomass flows in Croatia. The total biomass supply amounts to 9.651 million t_{dm} . Crops and primary woody biomass have the largest share of the total biomass supply with 4.257 million t_{dm} and 2.385 million t_{dm} , respectively. The main biomass uses are in the category of “feed and food products” (4.543 million t_{dm}), followed by bio-materials (1.114 million t_{dm}). 0.881 million t_{dm} biomass are used as bioenergy, mainly for heat and power production. Croatia exports in total 1.973 million t_{dm} (mainly woody biomass) and only import 0.493 million t_{dm} of biomass.

Regarding the selected biomass flows between the project partner countries, Figure 14 show that the main trade partner of Croatia is Hungary. In 2016, Croatia imported over 55,000 tons wheat and meslin from Hungary. However, total import volumes, mainly maize, from Hungary amounted only to 8,000 tons in 2012. In 2016, Croatia imported 6,000 tons biodiesel from Austria. The export flows are presented in Figure 15. Besides agricultural commodities, Croatia exports large volumes of non-coniferous wood chips, fuel wood and coniferous wood chips to Austria and Hungary as well as to a small extent to Germany. Overall, Croatia is rather a biomass exporter than an importer.



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 13: Biomass Sankey diagram for Croatia.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

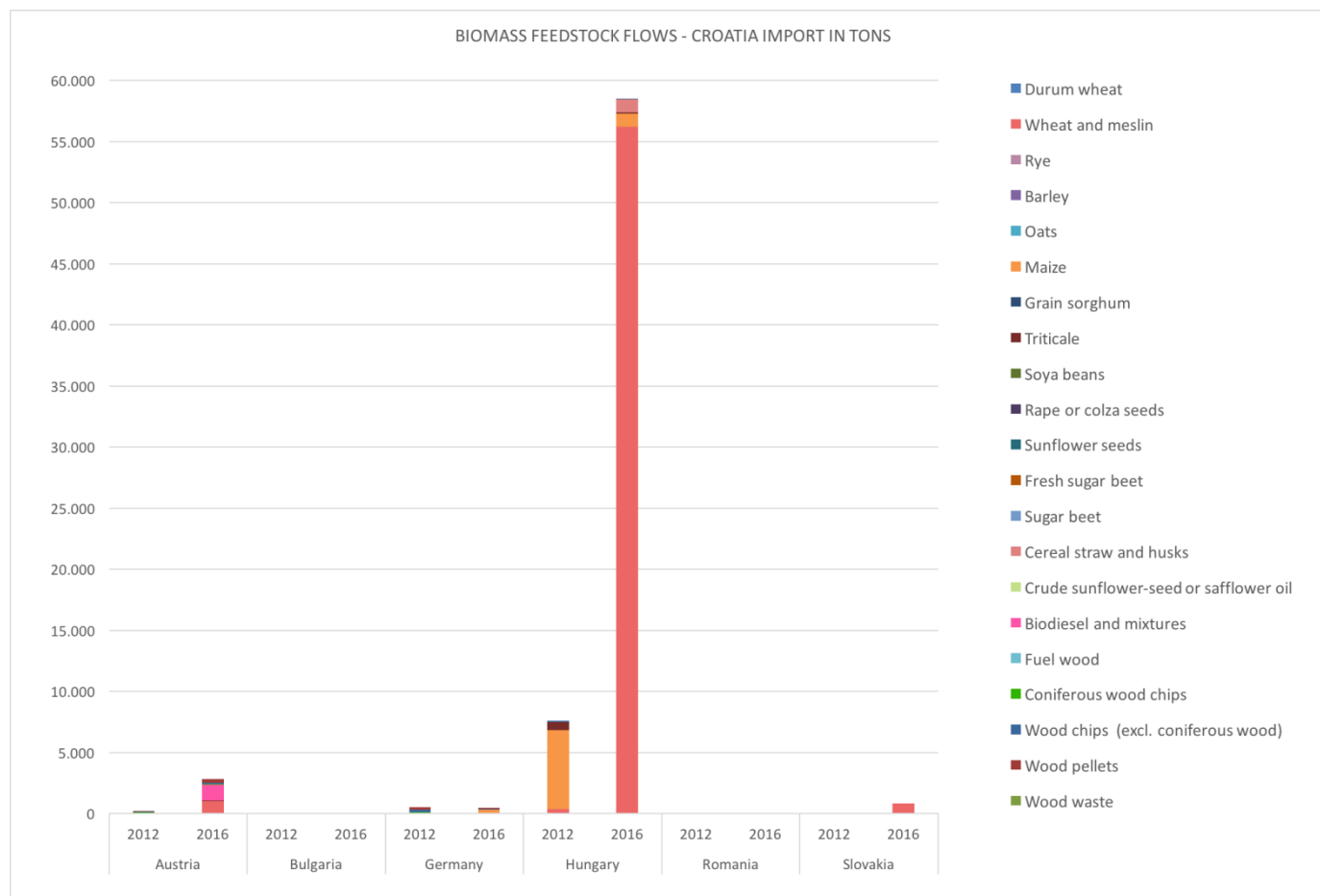


Figure 14: Croatia – selected biomass import flows.
 Data Source: EUROSTAT

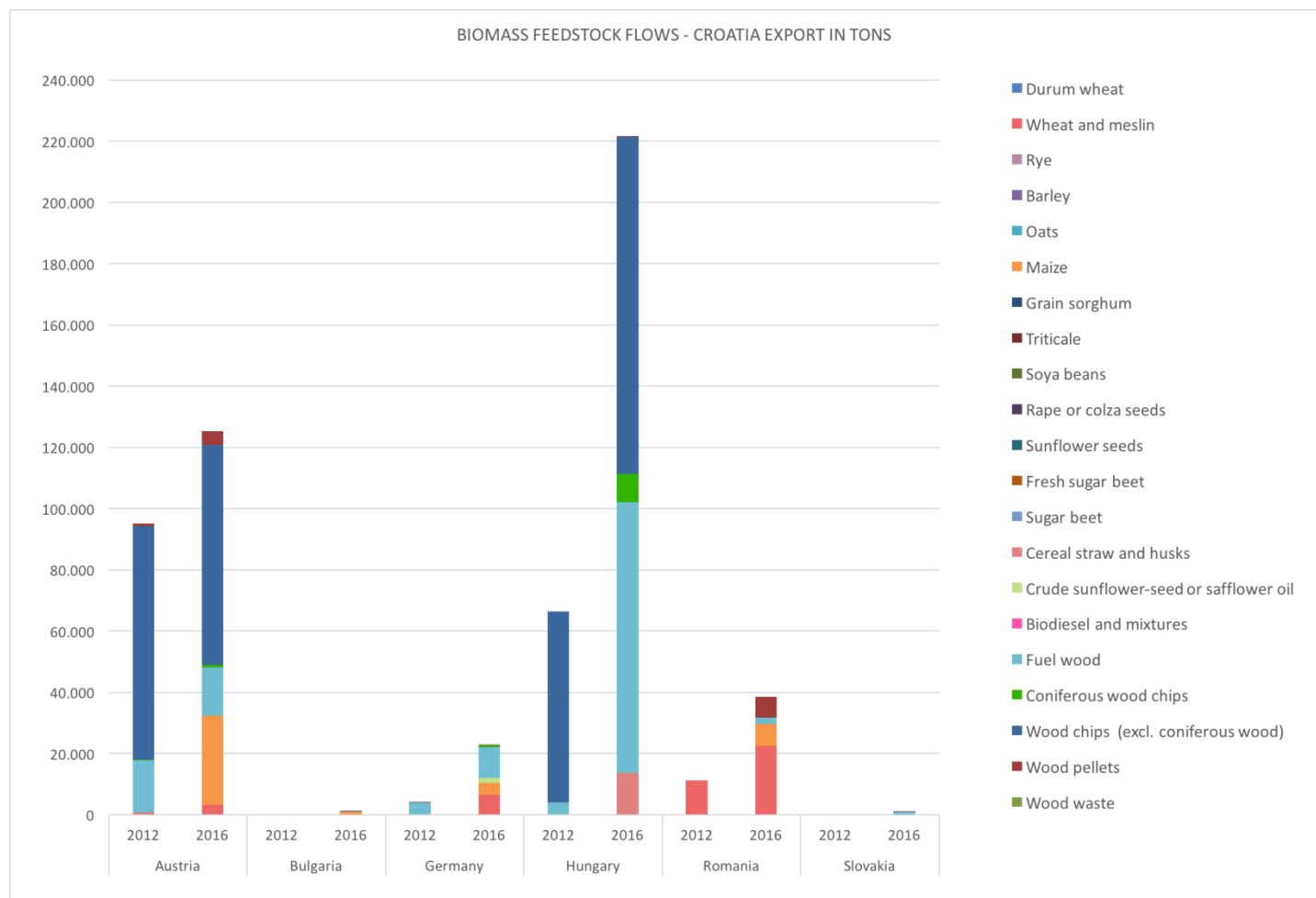


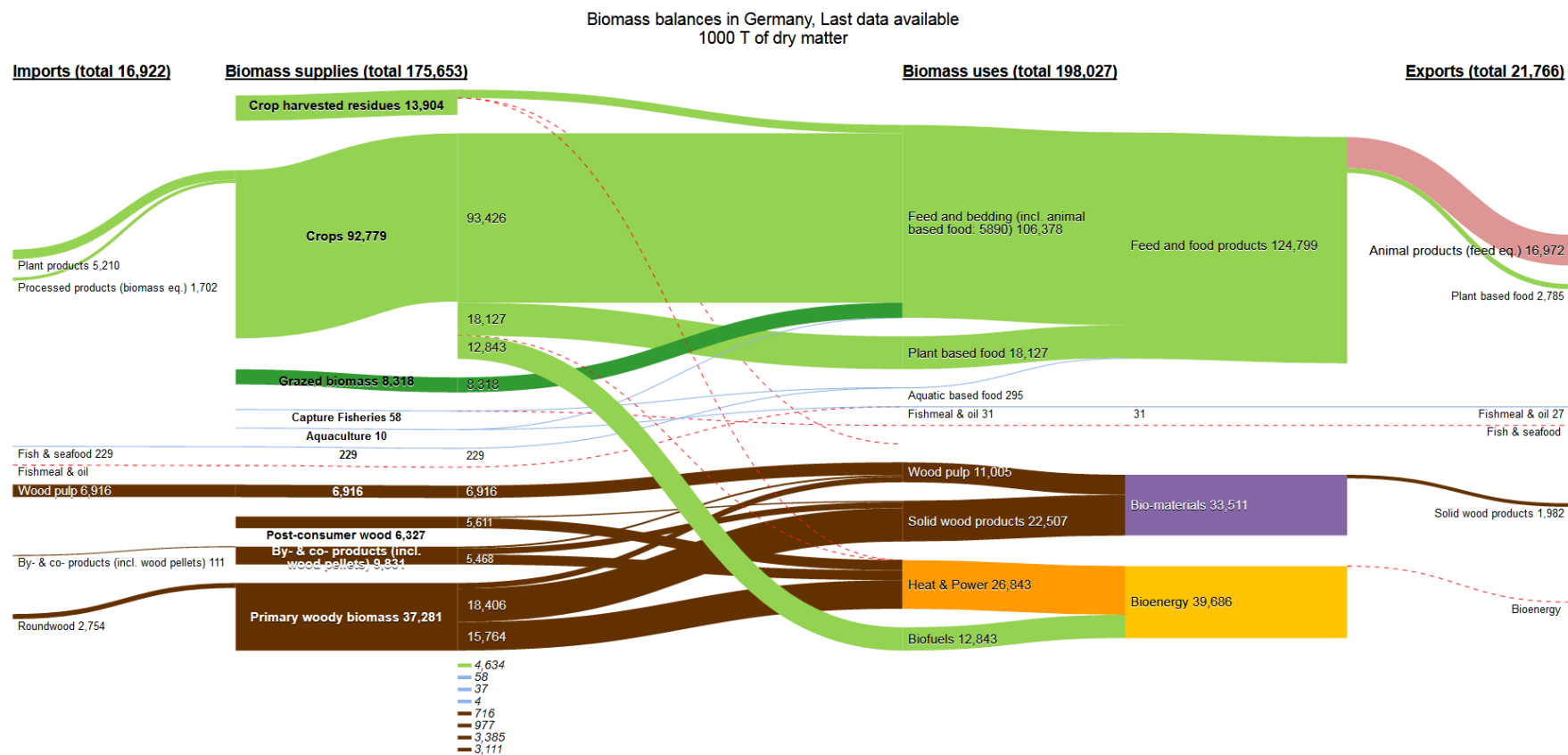
Figure 15: Croatia – selected biomass export flows.
 Data Source: EUROSTAT

4.4 Germany

In Germany, the total biomass supply amounts to 175.653 million t_{dm} according to the Sankey biomass diagram (Figure 16). Crops have the largest share of the biomass supply with 92.119 million t_{dm} . The main biomass uses are in the category of “feed and food products” (124.799 million t_{dm}), followed by bioenergy (39.686 million t_{dm}) and bio-materials (33.511 million t_{dm}). Regarding bioenergy, there is a high share of biofuels (12.843 million t_{dm}). Germany imports mainly plant products and wood pulp. The total biomass imports amount to 16.922 million t_{dm} . The exports (21.766 million t_{dm}) mainly consist of products for animals (feed etc.).

Figure 17 presents the selected biomass import flows from the project partner countries to Germany. In 2012 and 2016, Germany imported mainly agricultural biomass such as wheat and meslin as well as maize from Hungary, Slovakia, Romania, Austria and Bulgaria. In addition, about 50,000 tons of wood chips, wood pellets and fuel wood were imported from Austria. In 2016, Germany also imported 9,300 tons biodiesel from Austria and 7,400 tons biodiesel from Slovakia. However, the total import volumes decreased from 2012 to 2016.

Regarding the selected biomass export flows, the main trade partner of Germany is Austria (Figure 18). Particularly large was the export volume of coniferous wood chips from Germany to Austria (567,400 tons in 2012 and 437,600 tons in 2016). In addition, non-coniferous wood chips and wood pellets were exported to Austria. However, the total biomass export volumes decreased from 2012 to 2016.



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 16: Biomass Sankey diagram for Germany.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

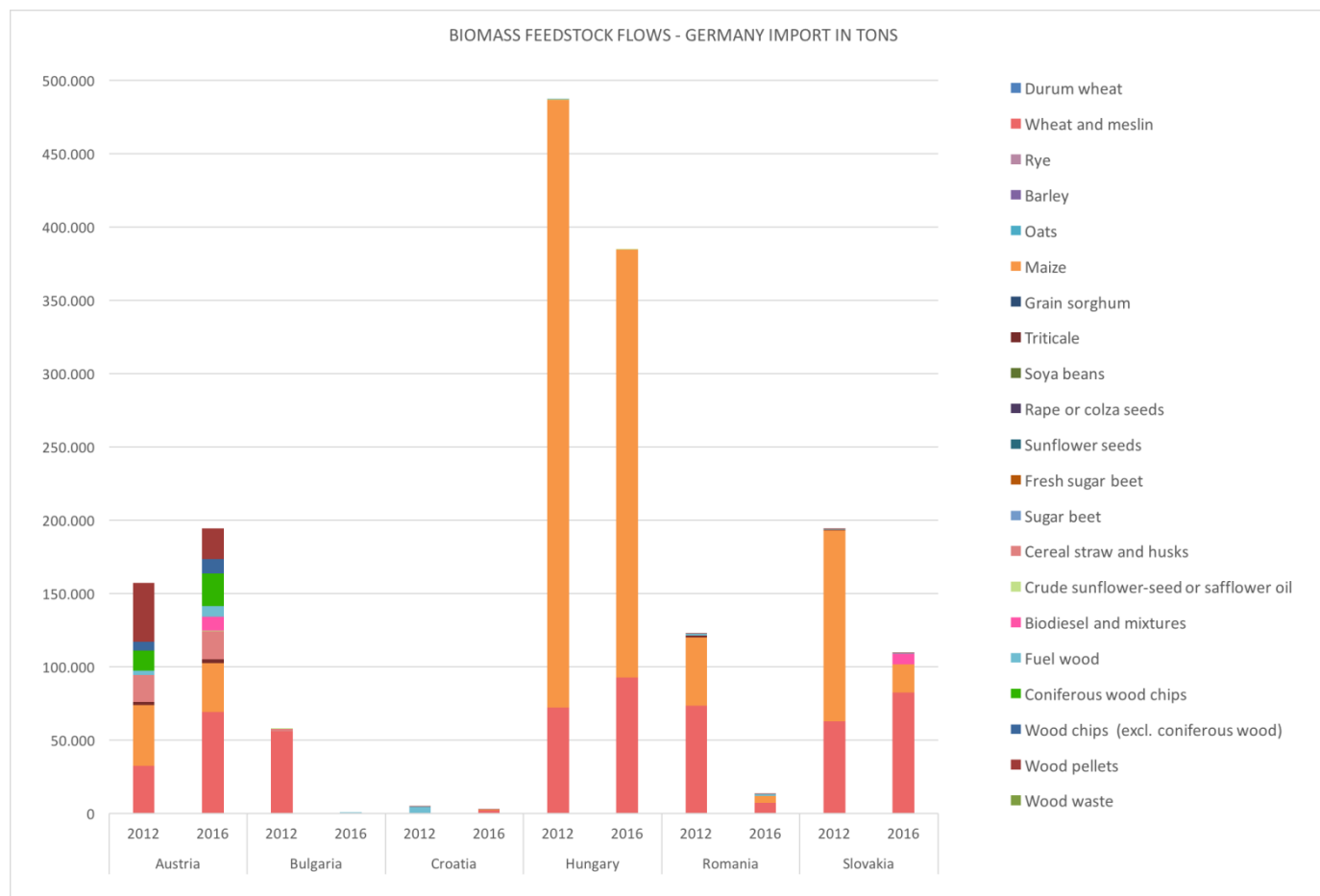


Figure 17: Germany – selected biomass import flows.
 Data Source: EUROSTAT

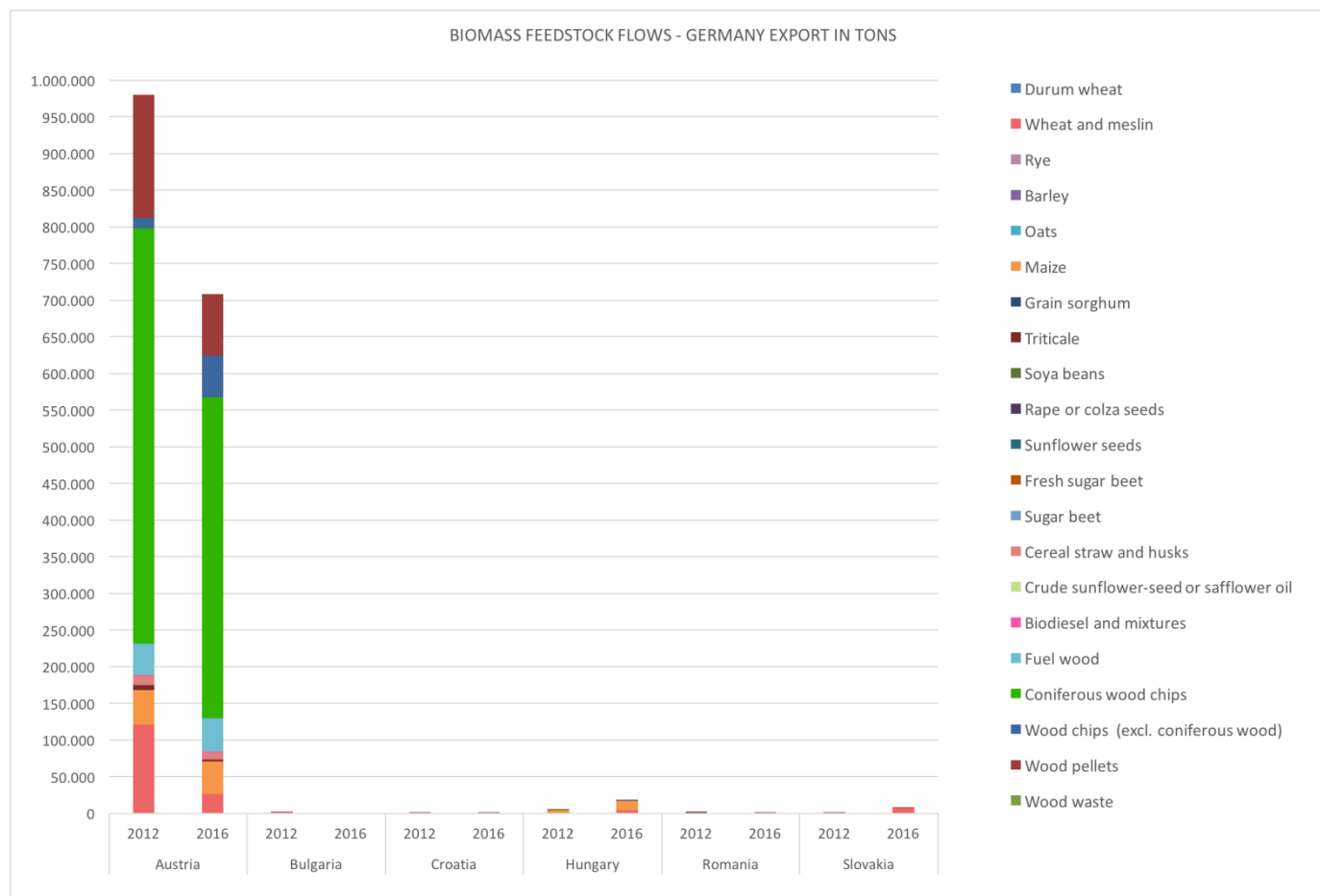


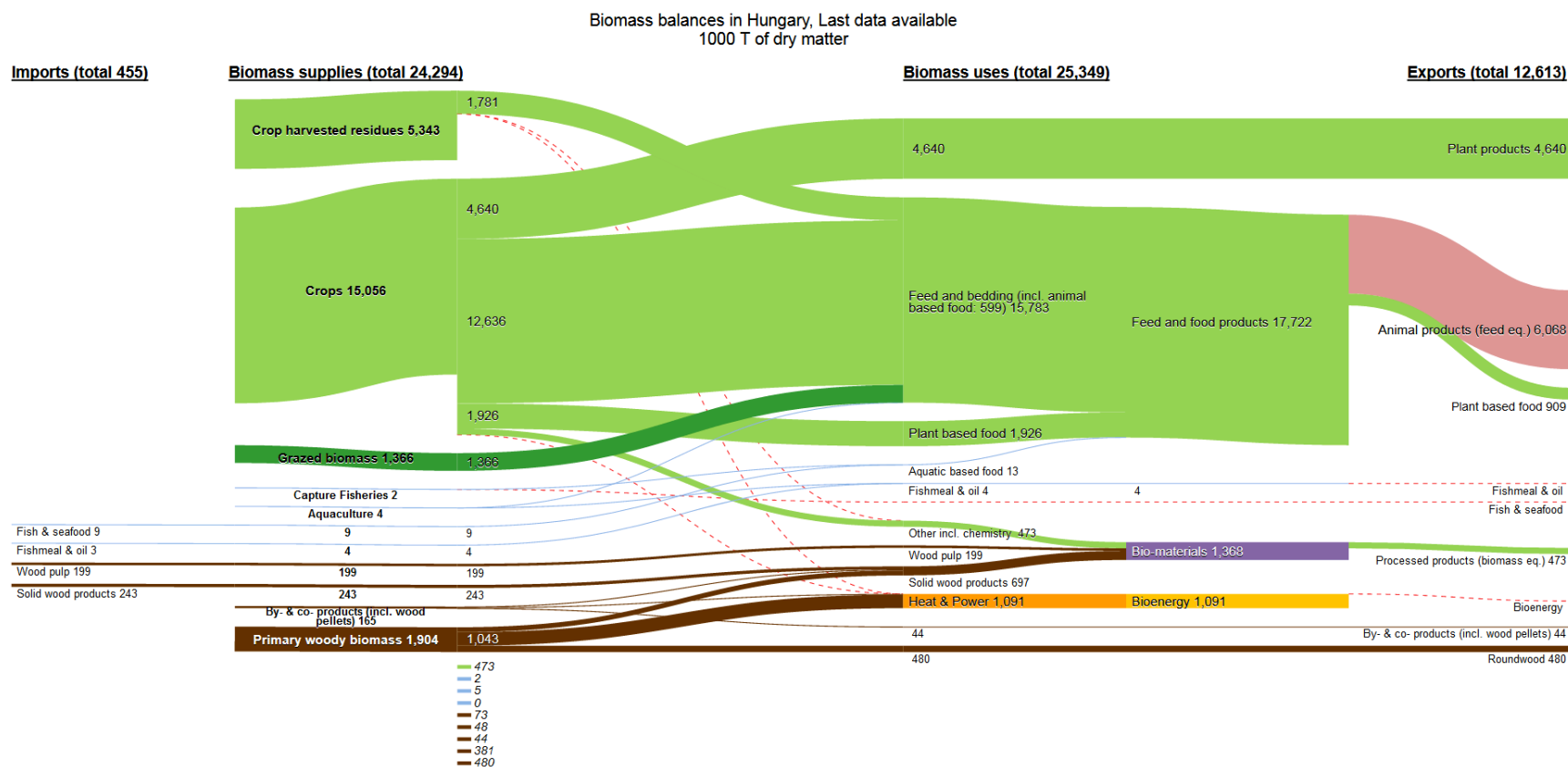
Figure 18: Germany – selected biomass export flows.
 Data Source: EUROSTAT

4.5 Hungary

Figure 19 shows the biomass supply and uses in Hungary. The total biomass supply amounts to 24.294 million t_{dm} most of which originates from crops and crop harvested residues. 17.722 million t_{dm} biomass are used for feed and food production. Over 39% of this category is exported. The main raw material for bioenergy production (heat and power) is woody biomass. Total biomass exports amount to 12.613 million t_{dm} and imports amount only to 0.455 million t_{dm} .

The import and export flows of the selected biomass commodities are presented in Figure 20 and Figure 21. Hungary imported large amounts of agricultural biomass from Slovakia. 62,400 tons of non-coniferous wood chips were imported from Croatia in 2012 and 108,000 tons in 2016. In addition, coniferous wood chips were imported from Austria and Slovakia in 2016. The total import volumes of the selected commodities almost doubled in 2016 compared to 2012.

Hungary mainly exported agricultural biomass, for the most part maize, wheat and meslin, in 2012 and 2016, respectively. Furthermore, Hungary exported wood chips and fuel wood to Austria and Slovakia.



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 19: Biomass Sankey diagram for Hungary.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

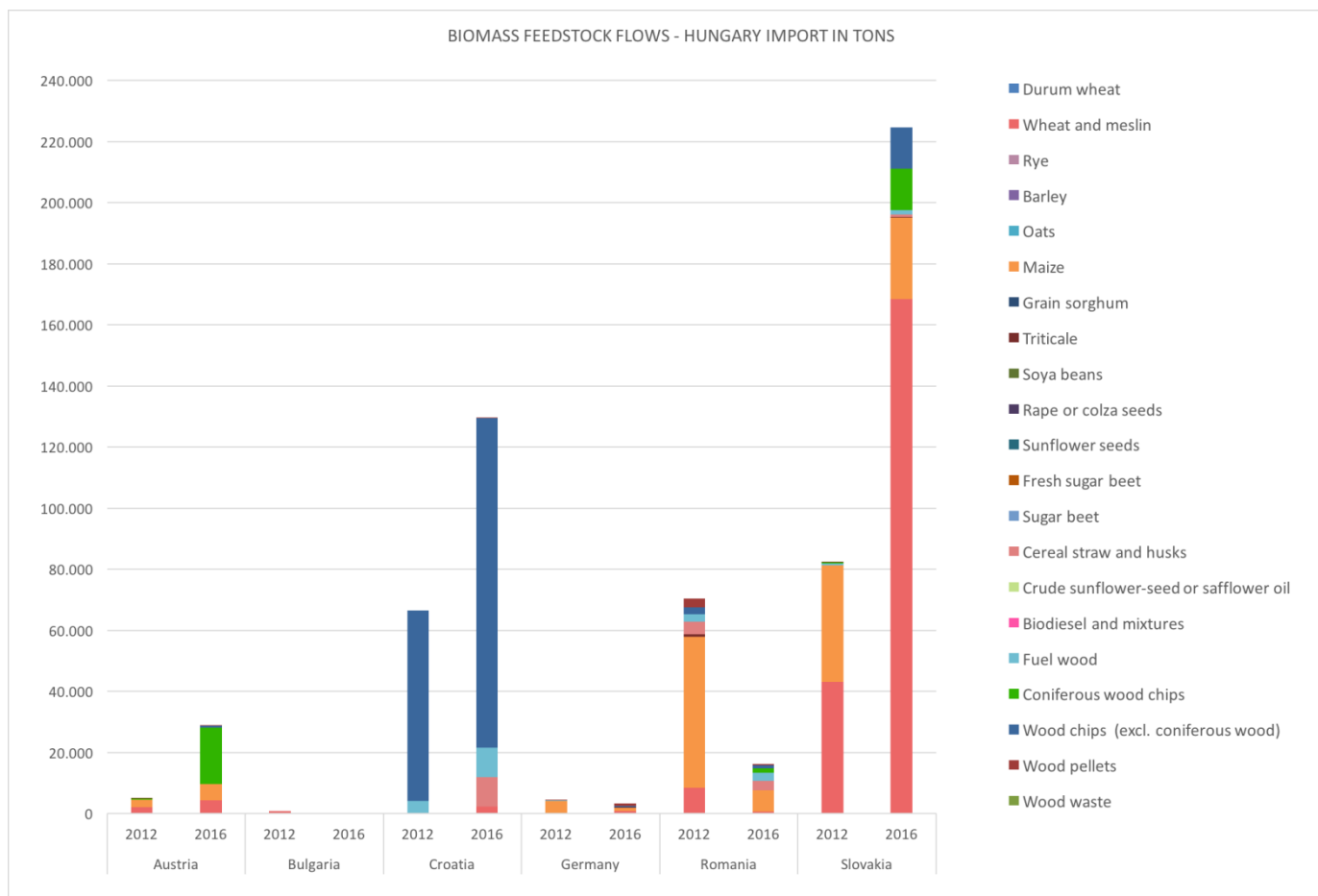


Figure 20: Hungary - selected biomass import flows.
 Data Source: EUROSTAT

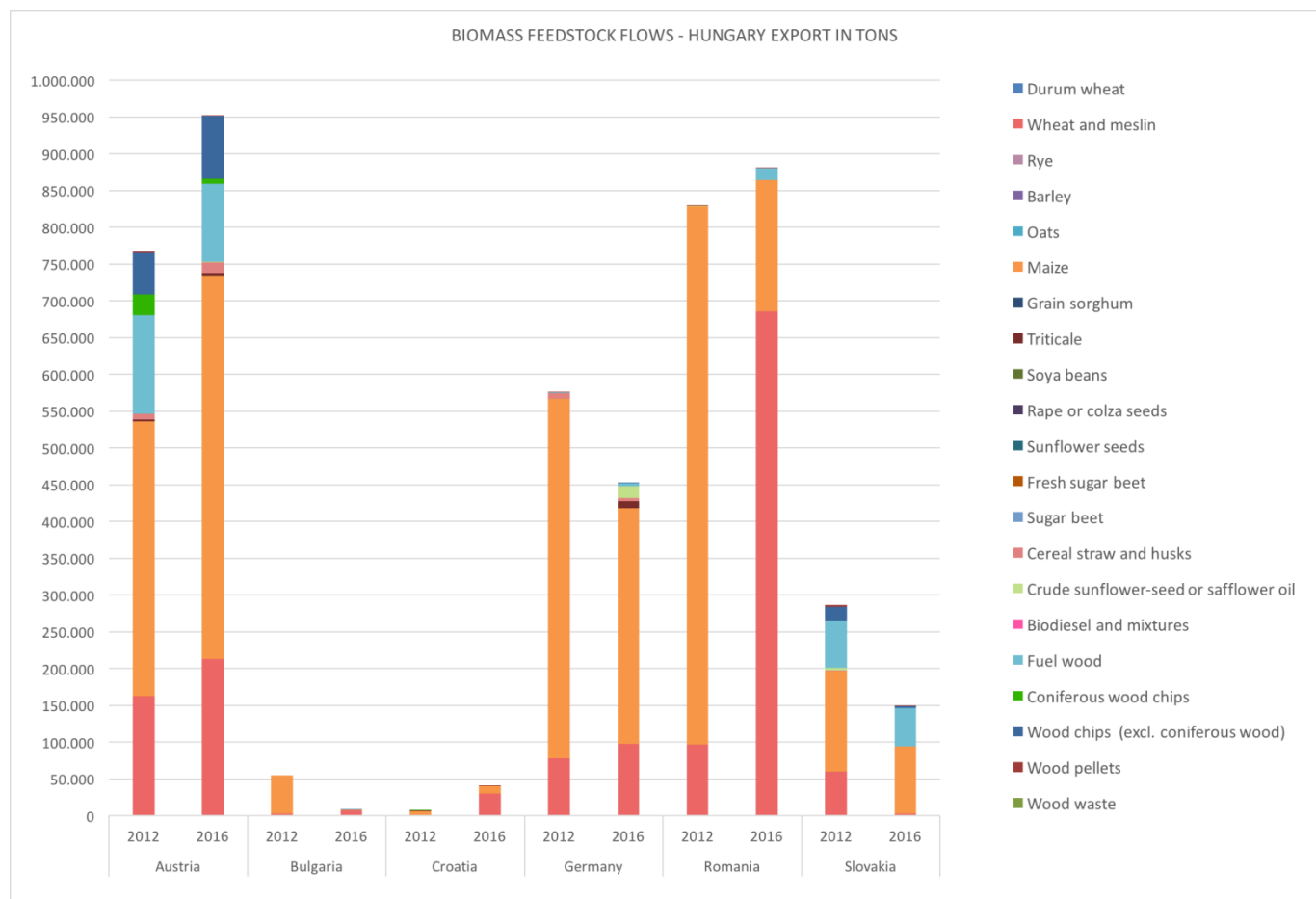
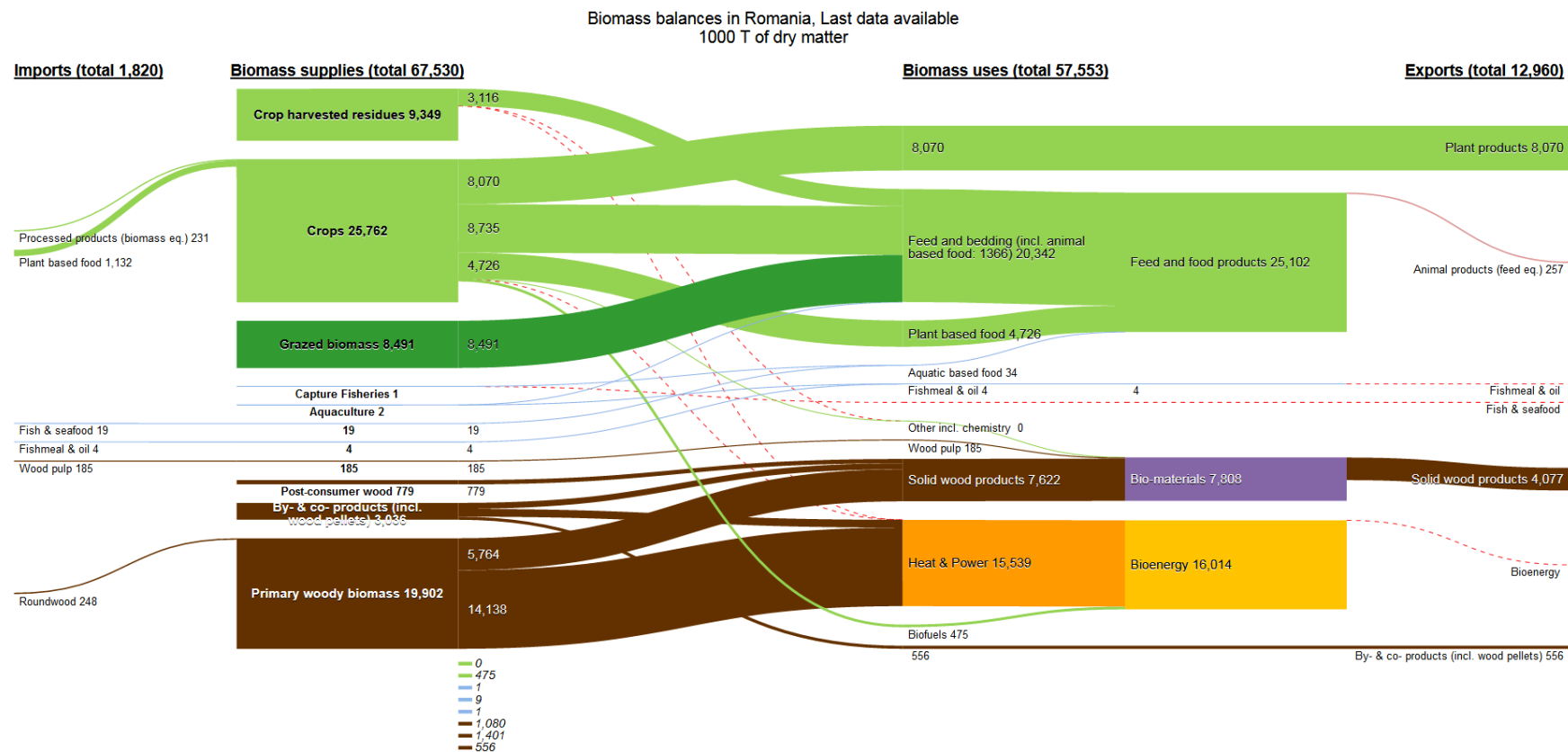


Figure 21: Hungary- selected biomass export flows.
 Data Source: EUROSTAT

4.6 Romania

In Romania, the main biomass supply originates from crops (25.762 million t_{dm}) followed by primary woody biomass (19.902 million t_{dm}). The main biomass uses are feed and food production with 25.102 million t_{dm} , followed by bioenergy with 16.014 million t_{dm} . After food and feed products, bioenergy is the main use of biomass with 16.014 million t_{dm} : besides heat and power generation, 475 million t_{dm} are used for biofuels. Romania imports 1.820 million t_{dm} biomass per year and total exports amount to 12.960 million t_{dm} .

The most important import countries for Romania are Hungary and Bulgaria, as well as Slovakia in 2016. Romania imported mainly agricultural biomass such as maize, wheat and meslin in 2012 and 2016. Large amounts of agricultural biomass were also exported to Hungary and Germany. In addition, the wood pellet export to Bulgaria and Austria increased significantly, from 17,400 and 103,724 tons in 2012 to 37,800 and 190,011 tons in 2016. Furthermore, Romania exported fuel wood to Hungary and Germany.



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 22: Biomass Sankey diagram for Romania.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

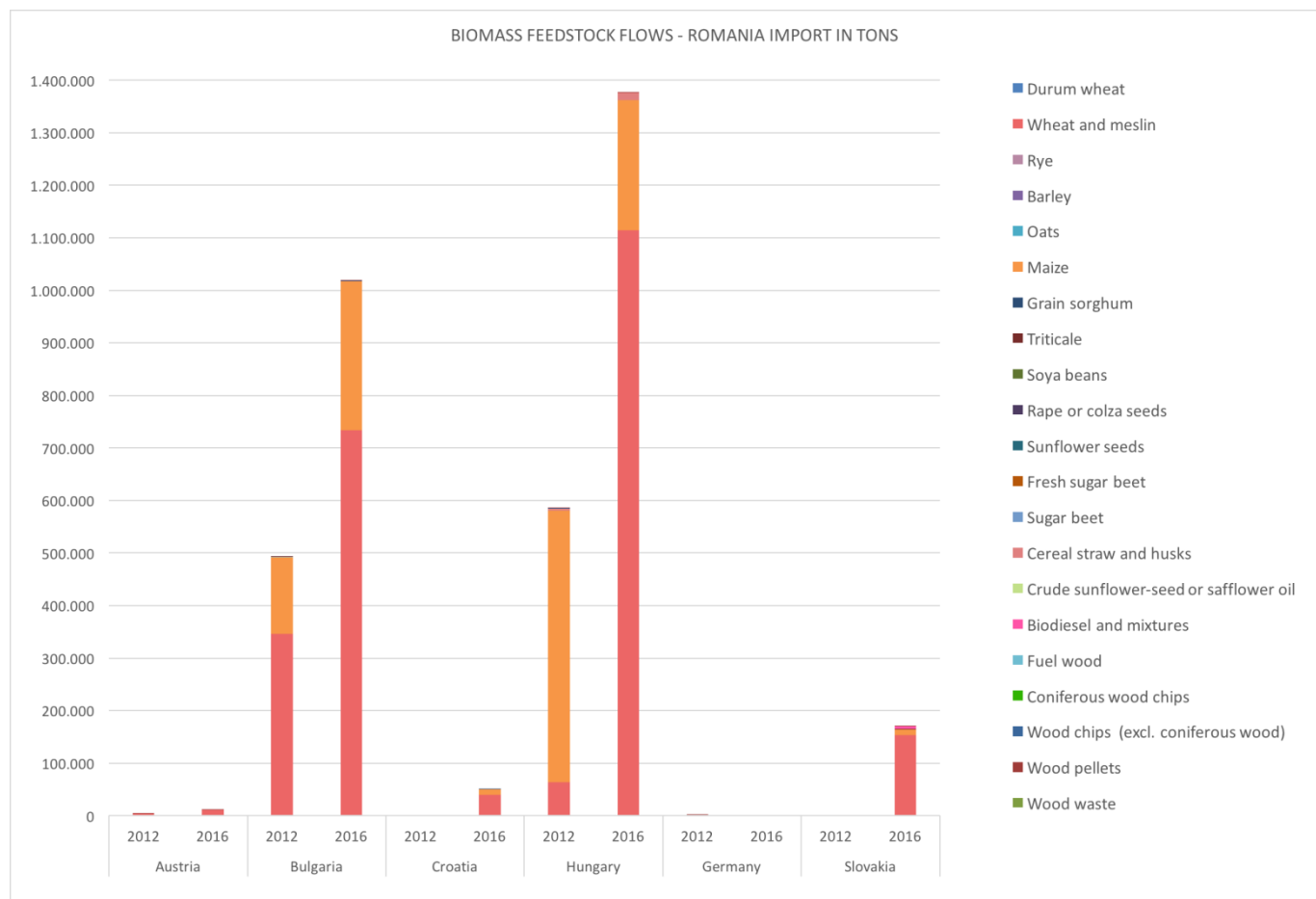


Figure 23: Romania- selected biomass import flows.
 Data Source: EUROSTAT

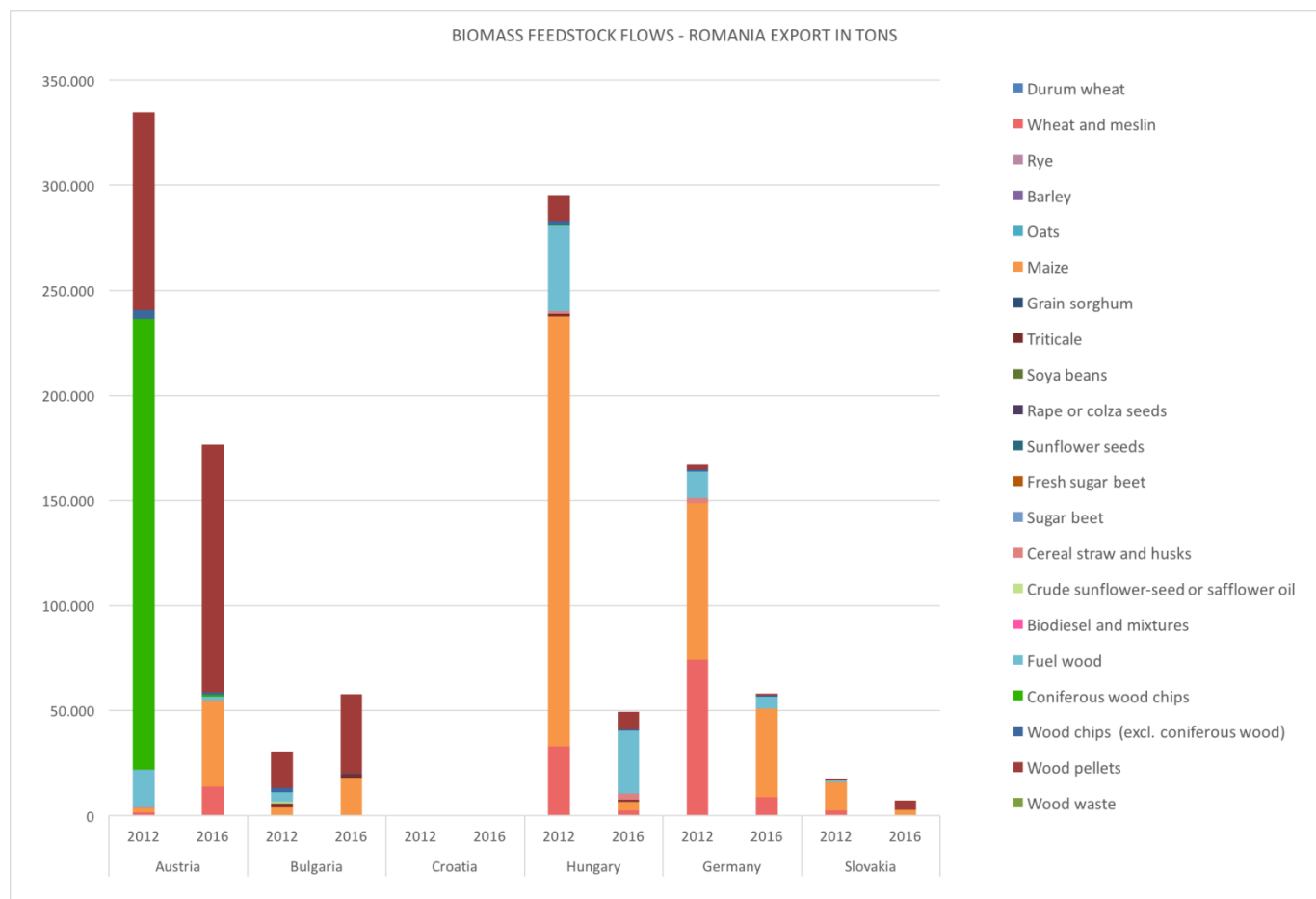
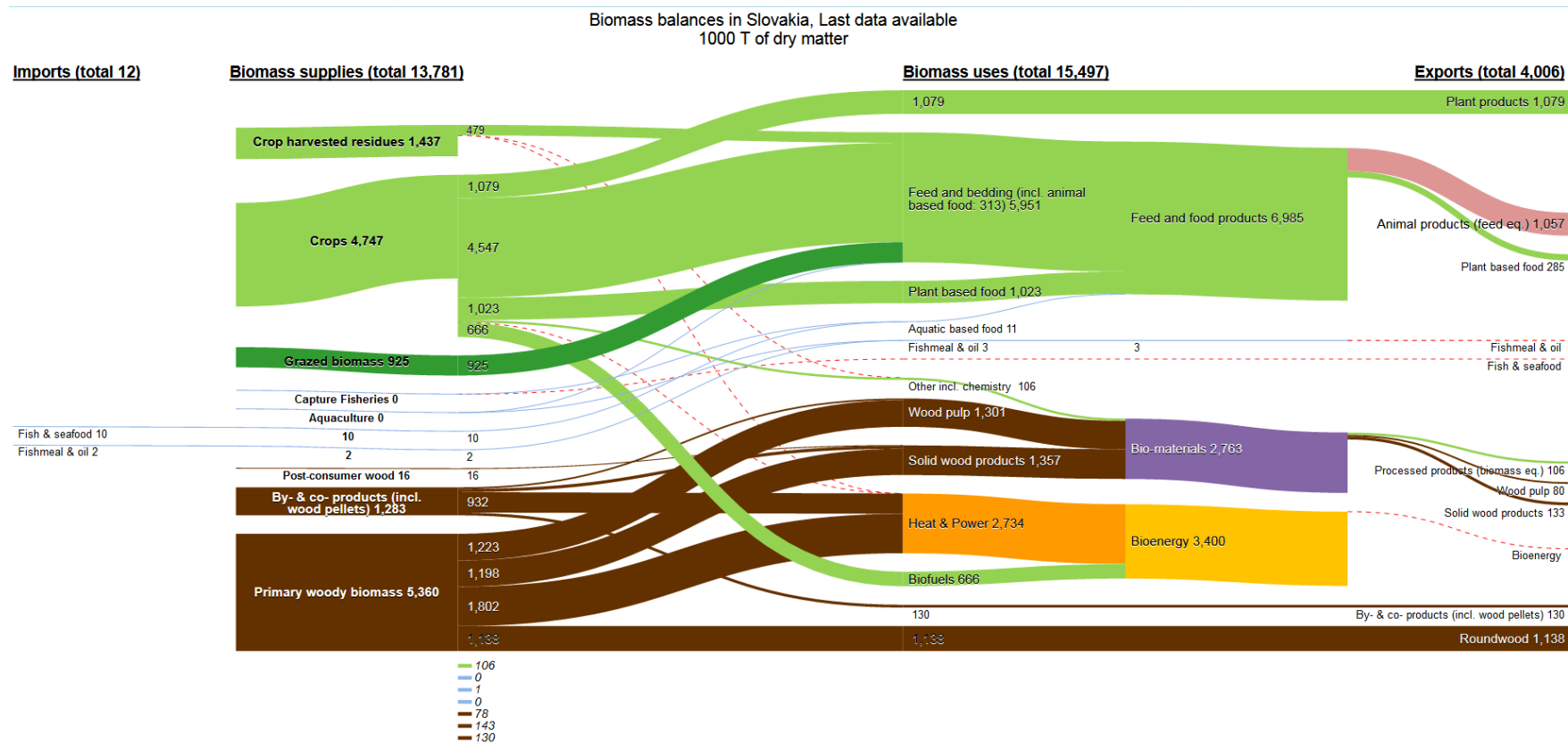


Figure 24: Romania – selected biomass export flows.
 Data Source: EUROSTAT

4.7 Slovakia

Figure 25 shows the biomass supplies and uses in Slovakia. The main biomass resource is primary woody biomass (5.360 million t_{dm}). Furthermore, 1.283 million t_{dm} of wood based by- & co-products are supplied. Crops and their residues amount to 6.184 million t_{dm} . The main biomass uses are feed and food products (6.985 million t_{dm}) and bioenergy production (3.400 million t_{dm}). Regarding bioenergy, woody biomass is used mainly for heat and power production (2.734 million t_{dm}), whereas crops are used for biofuel production (0.666 million t_{dm}). Slovakia exports a high amount of roundwood (1.138 million t_{dm}). The total exports amount to 4.006 million t_{dm} , total imports only amount to 0.012 million t_{dm} .

Figure 26 and Figure 27 show the import and export flows of the selected biomass commodities between the project partner countries. In 2016, Slovakia imported large amounts of maize mainly from Hungary and to a small part from Austria. The total import flows decreased from 2012 to 2016. In contrast, the export volumes increased from 2012 to 2016. Wheat and meslin, maize, fuel wood and wood chips are mainly exported to Austria. Smaller amounts are exported to Hungary, Romania and Germany.



Source: data from the BIOMASS project, European Commission – Joint Research Center
 Please note: Supply and use figures might not match due to estimation errors, stock changes, waste and/or loss of biomass or differences in the data sources used.
 Known data gaps are shown as dotted red lines. Gaps derive from missing or incorrectly reported data, data not assigned to a specific category or data that cannot be estimated.

Figure 25: Biomass Sankey diagram for Slovakia.
 Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

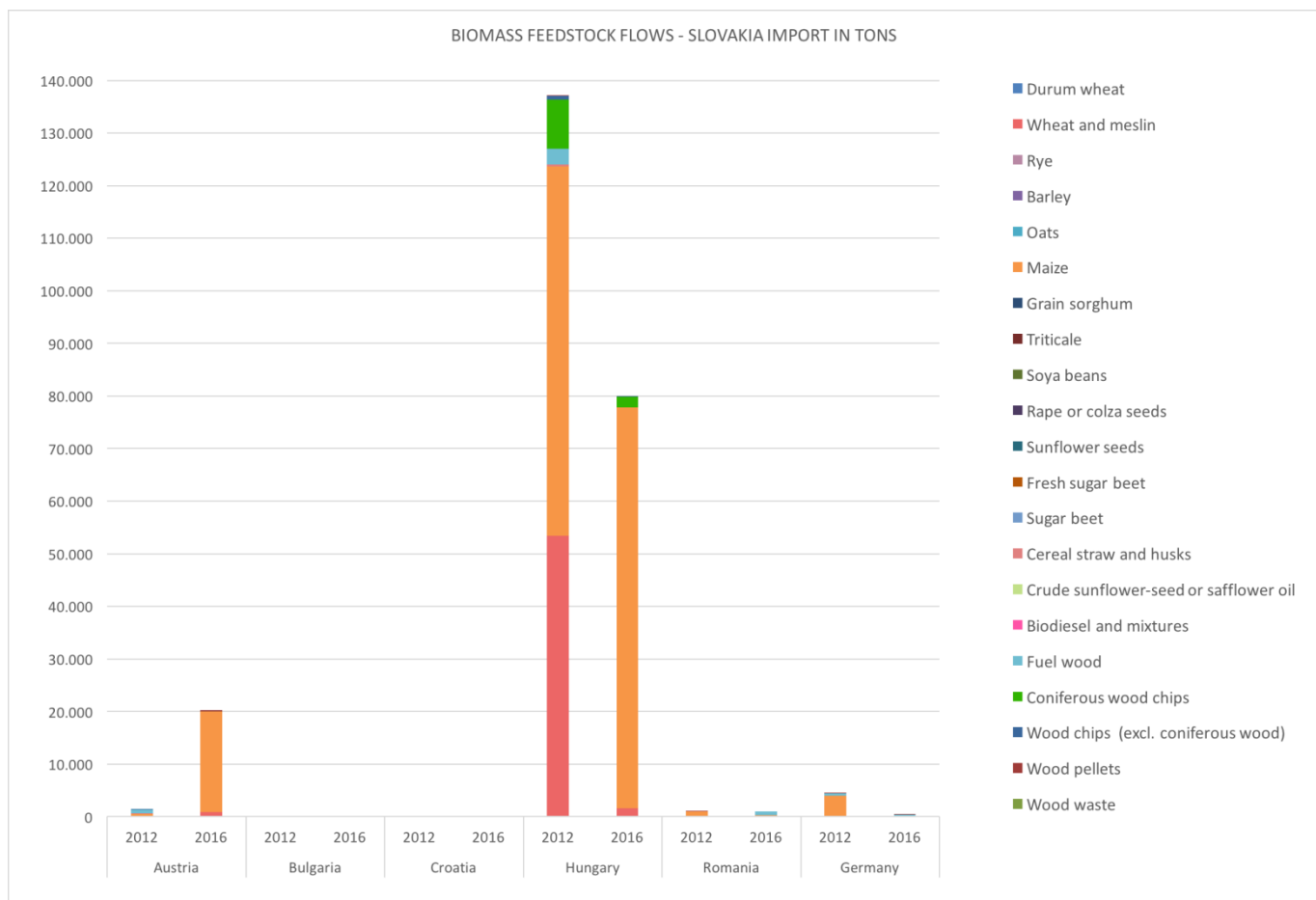


Figure 26: Slovakia – selected biomass import flows.
 Data Source: EUROSTAT

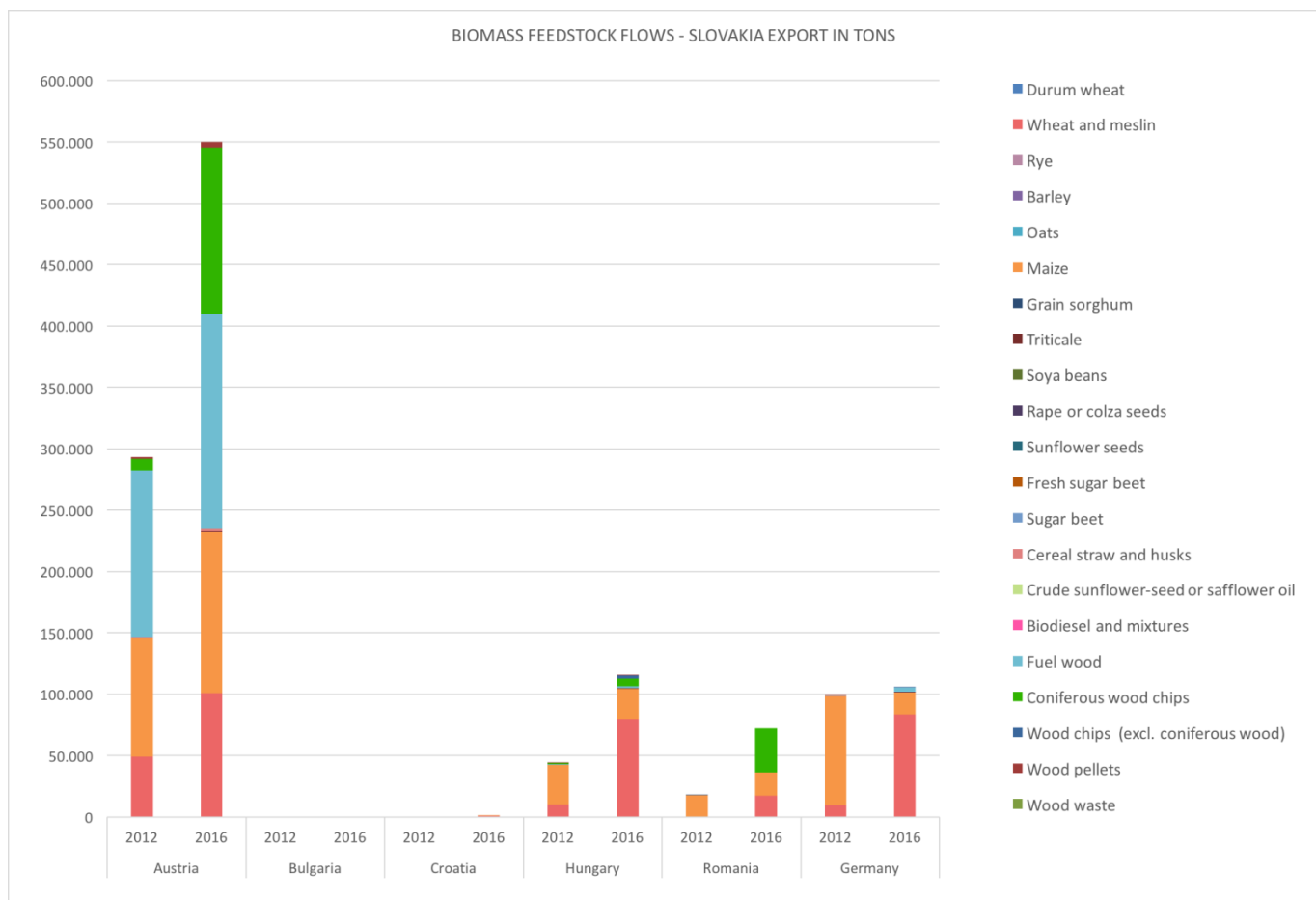


Figure 27: Slovakia – selected biomass export flows.
 Data Source: EUROSTAT



5. Conclusions

Internationally traded solid biomass volumes are growing rapidly. However, the refined solid and liquid biofuel markets still have a long way to go before they reach the level of agricultural biomass used for feed and food as well as fossil fuels. Unfortunately, there are still discrepancies in official statistics regarding the trade of biomass commodities. For instance, asymmetries of import and export data of the selected biomass commodities could be detected. Hence, further harmonisation in national practices of data collection and reporting is important in order to get rid of the asymmetries of a methodological nature.

The lack of market information is an important barrier to further development of trade in biomass for energy. If there is no readily accessible information on available quantities, trade flows and price levels, this presents a major obstacle to market actors aiming to trade the commodity. Hence, ENERGY BARGE investigated the already existing transnational and domestic biomass feedstock flows in order to provide (potential) biomass businesses with a qualitative overview on options and potential feedstock supply chains in the Danube region. The results shall be usable for private business actors from the biomass, bioenergy and Danube logistics sectors, as well as for public regional and national authorities dealing with regional, energy and transport planning.

In Bulgaria, Croatia, Germany, Hungary and Romania mainly agricultural biomass commodities such as crops (wheat, meslin, maize) are traded. In contrast, woody biomass is the main share of traded biomass in Austria and Slovakia. In the respective countries, most of the total agricultural biomass supply is used for feed and food production, only a very small part is used for bioenergy production. About the half of the total woody biomass supply is used for the production of bio-materials, the other half is used for bioenergy production. Austria, Germany and Croatia also import as well as export relevant amounts of biodiesel and mixtures thereof.

Table 4 summarizes relevant biomass trade flows based on the most recently available data in and between the ENERGY BARGE partner countries.

In the overview table, the two countries with the highest value for each category have been marked in green. While Austria and Germany are the two countries most relying on import in comparison with all seven partner countries, Bulgaria and Slovakia are classic exporting countries. Interestingly, although the export numbers include all types of biomass, these two countries are also the ones with the lowest application rate in per cent of biomass for bioenergy.

The types of most important biomass feedstock types and products for import and export with a direct affiliation to the production of bioenergy are marked yellow. It becomes visible that all countries except for Hungary either mostly import or mostly export a biomass product that is utilized for energy production purposes.

The most important import partner for project partner countries is clearly Hungary (5 out of 6). While the most important export partner is clearly Austria (4 out of 6).

From these insights, a number of conclusions and recommendations for the two main project target groups, the biomass and bioenergy sector, and the IWT sector, can be drawn.

Furthermore, the results on current biomass trade flows collected and visualized in this catalogue have implications for the next steps of the ENERGY BARGE project. All these are listed below.

Table 4: Overview domestic and transnational biomass flows 2016.
Data source: EUROSTAT (<http://ec.europa.eu/eurostat/data/database>),
https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

	Austria	Bulgaria	Croatia	Germany	Hungary	Romania	Slovakia
Total biomass use in million t _{dm}	37	17	8	198	25	58	16
Share of imports thereof in %	17	1.4	6.2	8,5	1.8	3.2	>1
Share of exports thereof in %	19	47	25	11	50	23	26
Share of bioenergy thereof in % ¹	27	6.4	11	20	4.3	28	22
Country's most important trade partner for biomass imports ²	Hungary	Romania	Hungary	Hungary	Slovakia	Hungary	Hungary
Country's most important trade partner for biomass exports ²	Germany	Romania	Hungary	Austria	Austria	Austria	Austria
Most imported biomass ³	Coniferous wood chips	Wood pellets	Wheat & meslin	Maize	Wheat & meslin	Wheat & meslin	Maize
Most exported biomass ³	Wheat & meslin	Wheat & meslin	Non-coniferous wood chips	Coniferous wood chips	Maize	Wood pellets	Fuel wood

¹ The Sankey diagrams do not consider the share of bioenergy sourced from biogas

² only ENERGY BARGE project partner countries are considered

³ only the selected biomass commodities are considered

Green: highest value for each category

Yellow: direct affiliation to the production of bioenergy



5.1 Conclusions regarding the IWT sector and new business in the biomass market

- The catalogue suggests that both in domestic and transnational terms, biomass feedstock and products both for conventional and bioeconomy-related utilization are moved in large, IWT-suitable quantities in and between the partner countries. These goods are generally suited for IWT transport regarding their physical properties. Moreover, an overall dynamic development in the trade flows in the last four years can be noticed – not only between neighboring countries. Hence, the Danube region biomass market depicts a considerable market potential for the product classes of different biomass types.
- The data underlying this catalogue does not allow conclusions on which modes of transport are used for the import/export transport; the same accounts for inland/domestic transport. In order to further utilize these data to inform actors from the Danube logistics sector about new market potential in the biomass transport sector, a primary data collection of current types of transport modes is needed.
- Especially the four countries with the highest import and export rates, respectively, Germany, Austria, Hungary and Bulgaria suggest themselves as interesting cases for increased business development for utilization of IWT. It would be advisable to use these countries for a more detailed analysis of currently used and optional/economically viable routes of transport and to actively engage in bringing together the actors from both sectors.
- With Hungary and Bulgaria together exporting almost 21 million Tdm (especially traditional agricultural goods), these countries are particularly interesting cases for IWT.

5.2 Conclusions regarding national and trans-national Danube region-wide biomass and bioenergy markets

- When comparing the current export and import data as derived from the Sankey diagrams with the country reports on national biomass markets and their identified most promising feedstock and bioenergy products (ENERGY BARGE, D.3.1.1.), it becomes apparent that almost all countries currently export the biomass feedstock and/or products (e.g. pellets) that promise the highest bioenergy market potential instead of using it domestically. Only Germany and Austria have a bioenergy product as top biomass import good, and a conventional agro-industry product as top export good. In order to strengthen the national bioenergy markets for exporting countries, a comparative assessment of utilizing the biomass domestically versus exporting raw materials or intermediary/finalized goods could be advised.
- When cross-checking the results from D.3.1.1., most promising feedstock types and products, a high agro- and forestry residue material potential becomes apparent; while trade flows barely include residue material, potentially mainly due to a limited transport worthiness in terms of physical and economic characteristics. Hence, especially the first process step from residue material to a bioenergy carrier product, e.g. pellet, or from straw into bioethanol should be taking place decentral, only the intermediary or final products are suitable for export, which also increases value creation in rural areas.
- In order to develop a business case for using IWT as logistics route for different types of biomass and bioenergy products, a closer look on the share of transport costs in the

entire value added of the different products must be made. Including a transport and logistics cost calculator in tools developed in ENERGY BARGE could thus be of advantage.

5.3 Implications for the next steps of the ENERGY BARGE project

- A more detailed version of the trade flow visualizations will be included in the ENERGY BARGE online platform.
- The insights gained into the biomass trade flows shall be considered in the compilation of further project tasks, mainly D3.2.2. (biomass demand scenario) and D.3.2.3. (regional case studies), especially in further identifying suitable trading partner countries and their options to both improve their sustainable bioenergy supply and to generate added value from trade, facilitated via IWT. The findings will also be taken up in WP4, especially in the analyses carried out in the frame of D 4.1.2 (inventory of potential users of Danube logistics services) and in the transnational coordination of an invitation list for the meetings carried out in Output 4.2 (regional B2B meetings on green bioenergy logistics). Ideally, recommendations for developing Danube ports into biomass and bioenergy hubs can be drawn.
- Data research on types of transport modes used to facilitate current trade flows is advisable.
- Currently, most IWT on the Danube stays within the Danube region; while the catalogue at hand only looked into the biomass trade flows between the project partner countries, also other source and target markets accessible via IWT could bear trade potential for biomass goods. Therefore, the consideration of other relevant markets outside the Danube region, particularly the big ports of Amsterdam, Rotterdam and Antwerp and biomass trade with the Netherlands and Belgium from/to the Danube countries need to be included in the development of the ENERGY BARGE online platform.

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