Interreg
Danube Transnational Programme
ENERGY BARGE

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 3.2.3

Regional case studies

for biomass and bioenergy production –

Case Study Germany:

Straubing – Region of Renewable Raw Materials

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I. About the ENERGY BARGE project

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

Project coordinator

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

Project partners

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

II. About this document

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

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Background

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

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

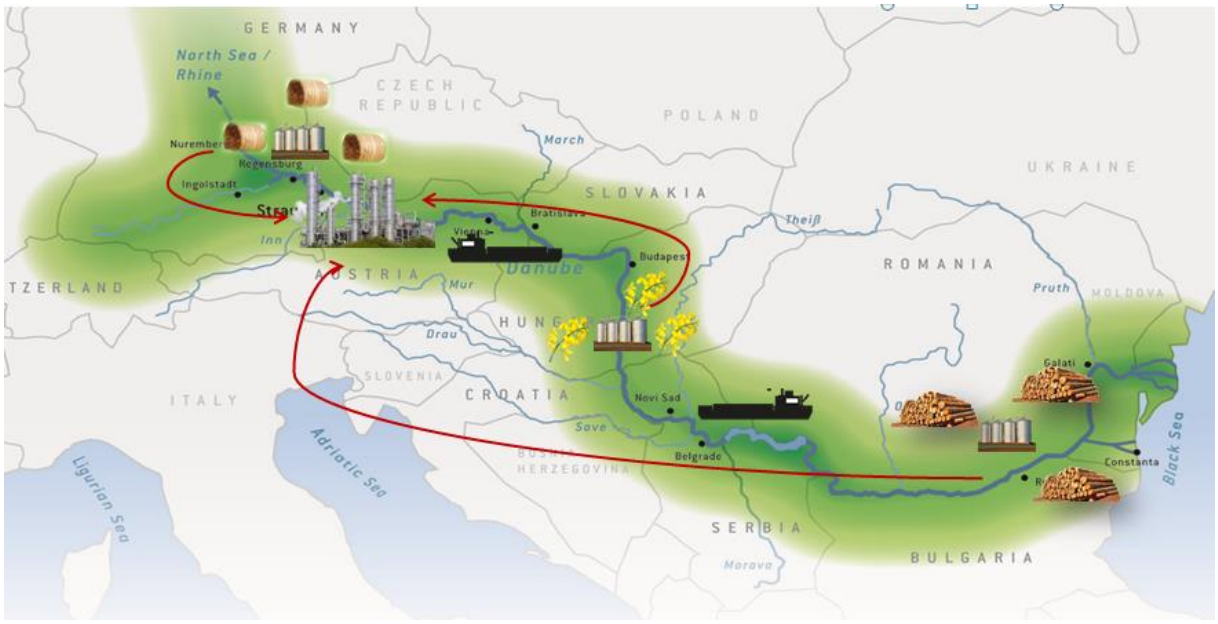

Figure 1: Green Energy and Chemistry Belt (Source: BioCampus Straubing GmbH, own visualisation).

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

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

Objective of the regional case studies

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

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

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

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

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

III. Executive summary

This case study covers the region of Straubing as model "Region of Renewable Raw Materials", using the two biofuel production sites of the companies Clariant (demoplant for lignocellulosic bioethanol) and ADM (rapeseed crushing mill for biodiesel production) as exemplifying cases for the production of bioenergy in the region.

The region of Straubing in Lower Bavaria, Germany, is a region shaped by the agricultural "Gäuboden" area and the wood-resource "Bavarian Forest" and has a direct inland waterway access via the Danube port in Straubing-Sand. The port is specialized in biomass handling and freight. The entire region is branding itself as "Region of Renewable Raw Materials". The main goal of this branding is to complete the entire value chain of renewable raw materials and bioeconomy in the region, including research and education institutes, industrial processing for energetic and material use of biomass, a strong bioenergy share in private households, industry and public entities as well as awareness and acceptance among the general public.

A broad set of public and private actors jointly works towards this goal. With the support of significant and continuous political support from the Bavarian and regional level in the form of political decisions and influx of funding sources, important actors such as the Competence Center for Renewable Raw Materials or the Campus Straubing for Biotechnology and Sustainability of the Technical University Munich were settled in Straubing. On regional level, the BioCampus Straubing GmbH is in charge of transforming the research and education results to the regional industry via means of regional business development, including site marketing for new biobased companies and start-ups in the port area of Straubing. The main structural instrument for this task is the regional branch cluster "Renewable Raw Materials". The BioCampus Straubing GmbH works towards establishing new value chains for the agricultural and forestry sectors by facilitating projects for novel and sustainable energetic and chemical-material utilisation paths of biomass feedstock. The integration of the port as a biomass logistics hub, the Danube as a potential environmentally friendly transport axis and the macro-region Danube as a region for the energetic and chemical-material use of biomass in the context of a bioeconomy for the Danube region including added value and job creation in rural areas are decisive elements of this strategy.

Due to the site attributes in the region, mainly the logistics connections and the political stability in support mainly on regional and Bavarian level, and the support activities present, the two globally active biobased companies ADM and Clariant chose the port of Straubing as location for their production, and demonstration processes, respectively. Both companies use biomass feedstock for the production of transport biofuels, contributing to the bioenergy market on different levels. Therefore, different levels of supply chain integration and utilisation of Danube logistics can be observed.

Overall, for the region of Straubing, the most relevant success factors for functioning as a model region in the field of biomass utilisation and bioeconomy are the broad and continuous political support and funding on regional level, a strong actor base from both research and industrial sphere, various sources of biomass feedstock supply including versatile logistics options enabling

the integration of biomass supply and bioenergy carrier production as well as a stringent development strategy. These are also factors that can be regarded as transferable to other cases. Regarding its role as a site for first- and second-generation biofuel production, the biggest risk factor is the volatile legislative situation on national and EU level in this sector. Lessons learnt include that a complex network of actors needs to be managed coherently, clusters can support the regional development of certain branches but need bottom-up commitment of actors, and relevance of regional feedstock supply and availability of biomass logistics depend on the scale and market of the respective processes.

1. Case study methodology

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

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

The Straubing case study was conducted on the basis of the joint methodology for all ENERGY BARGE case studies. This methodology comprises a common structure for all case studies as well as a set of selection criteria according to which each case was selected as can be seen in the Annex.

The aim of the case study is to provide an in-depth, systematic insight into the functioning of exemplifying cases of integrated biomass and bioenergy supply and value chains in the Danube-adjacent countries and their involvement of the Danube as a possible biomass logistics option.

The case of the region of Straubing as "Region of Renewable Raw Materials" including the corporate bioenergy examples of the two plants of Clariant and ADM was selected not only due to the fact that the authors of this study have expertise regarding the case, facilitating data collection, but also because it fulfilled the need to achieve "full" and "partial" matches in the case selection matrix indicating that the case is suitable for analysing important factors influencing the functioning of integrated biomass and bioenergy supply chains.

The content and data research for the study at hand was set up by the following elements:

- Desk research of publicly available data and material;
- Data available from previous reports of the ENERGY BARGE project;
- Data available from the Horizon 2020 project "BERST – building a regional bioeconomy strategy toolkit";
- Internal expert knowledge;
- Expert discussions with a set of representatives of the region as well as the two companies used as examples (see below).

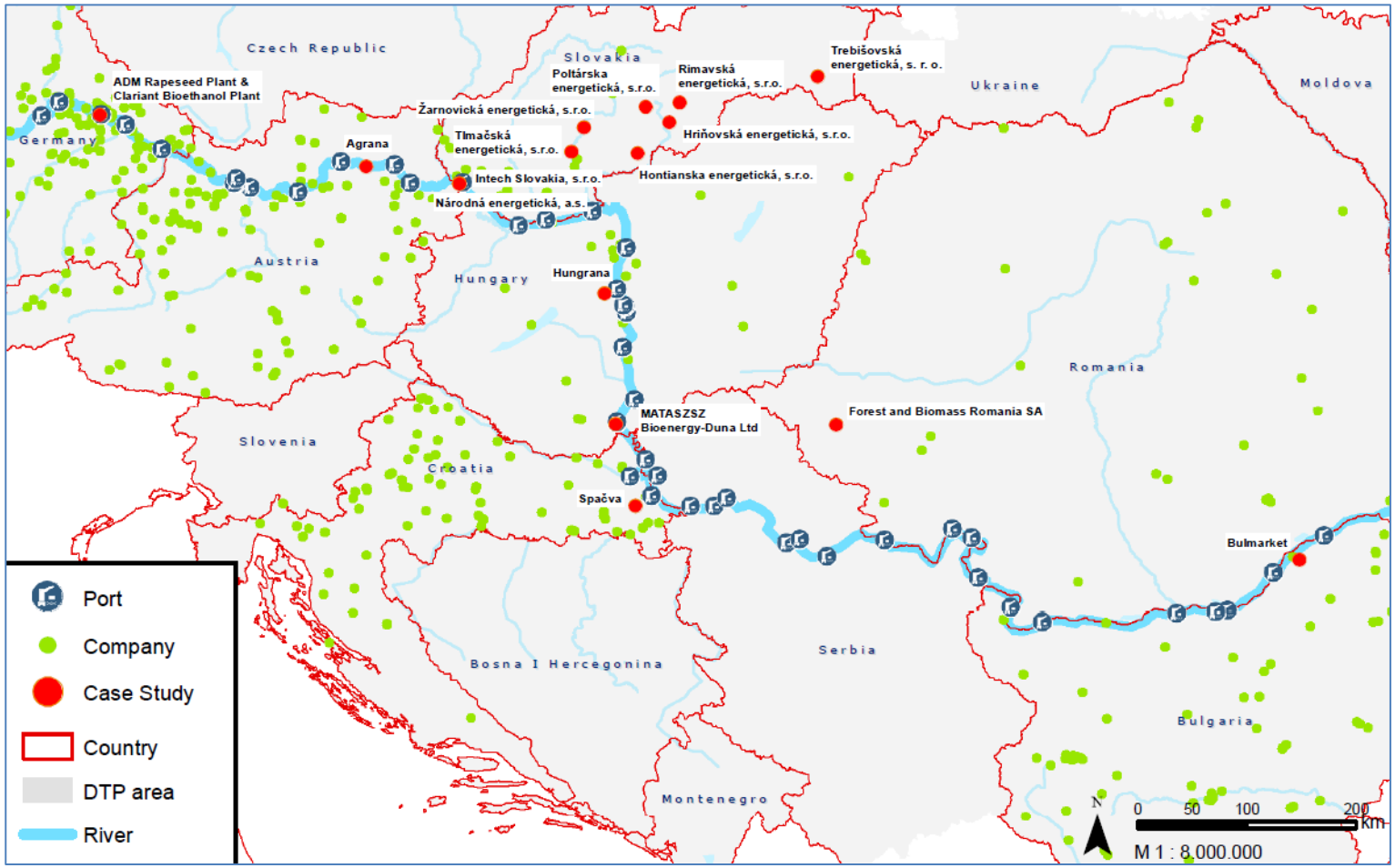

Figure 2: Overview of the location of the selected cases in the Danube region (DIT, 2018 source: open street map)

Information and data were collected from the following experts, using face-to-face and telephone discussions with the aim of gaining insights beyond the information already available at the BioCampus Straubing GmbH:

1. Andreas Löffert, CEO Port of Straubing-Sand & BioCampus Straubing GmbH;
2. Martin Bayer, port master port of Straubing-Sand;
3. Claudia Kirchmair, manager cluster communications BioCampus Straubing GmbH;
4. Markus Pannermayr, mayor City of Straubing;
5. Benjamin Nummert, office manager Bioeconomy Expert Council Bavaria;
6. Thomas Hoppe, plant manager Clariant sunliquid® lignocellulosic ethanol demonstration plant, Straubing;
7. René van der Poel, plant manager ADM Spyck GmbH, oil mill Straubing.

The following content is based on the information gathered from the sources mentioned above. All additional sources are indicated in the text body.

2. Case description

For the German case study, the case of the region of Straubing in Lower Bavaria, consisting of the two administrative entities City of Straubing (NUTS 3 code: DE223) and administrative district of Straubing-Bogen (NUTS 3 code: DE22B), were selected. In a joint endeavour of regional actors, this region is branded and managed as "Straubing – Region of Renewable Raw Materials". Here, the concrete case is the regional cluster "Renewable Raw Materials" as managed by the BioCampus Straubing GmbH (BCG). Corporate examples for supply and logistics chains are given by two bioenergy plants operated in the region, namely the demonstration plant of the Swiss speciality chemicals company Clariant producing lignocellulosic ethanol for transport purposes on the basis of agricultural residue material as well as the ADM Spyck GmbH's oil mill producing rape oil and soy oil, with the rape oil share going mainly into the biodiesel refinement in refineries in South-West Germany, mainly Mainz. Both these plants are located in the port of Straubing. Therefore, the port of Straubing is assumed as the geographical core of the region under study, which results in the following geographical coordinates:

Latitude: 48.89459

Longitude: 12.65816

In the following, the region under study is described in more detail. Separate sub-chapters are added for the two corporate examples, where suitable.

Straubing – Region of Renewable Raw Materials

With the case study of the region of Straubing, the main goal was to add a regional cluster case analysis to the mainly company-focussed case studies collected in the project. A cluster in this context is understood as a "geographic concentration of interconnected companies and institutions in a particular field" (Porter, 1998).

As described above, the region consists of the city of Straubing and the administrative district of Straubing-Bogen (equalling a county) which surrounds the city. In 2017, the city of Straubing had 47,833 inhabitants living on a surface of 67.58 km² (Stadt Straubing, 2018). The district Straubing-Bogen counts 97,494 inhabitants on a surface of almost 1,200 km² (Landkreis Straubing-Bogen, 2018). Dominating sectors and industries in the region stem from the production sectors, mainly supplier and manufacturing industries for automotive and engineering companies. Moreover, there is a strong presence of small and medium sized owner-run companies in the construction sector. The region is relatively rural with the proportion of people employed in agriculture and forestry significantly higher than the national average. This is mainly true for the administrative district: 12% of all inhabitants are employed in these sectors. The district counts more than 2,400 agricultural farms (Landkreis Straubing-Bogen, 2018).

The region of Straubing is defined in a geo-economic context by the two macro-landscapes surrounding it, namely the "Gäuboden" (agricultural area) and the "Bayerischer Wald/Bavarian Forest" (forestry area), see **Fehler! Verweisquelle konnte nicht gefunden werden.** 2). For centuries, these two macro areas have shaped the economy as well as the culture of this region. With the development of a Danube port during the 1980s and 90s and its inauguration in 1996, the region has gained another important characteristic. In the last five years, the port of Straubing has been constantly outperforming its earlier performances in terms of cargo handling, especially regarding the handling of biomass, making it the strongest Danube port in Lower Bavaria and the second-strongest in Bavaria as a whole. In 2017, the port of Straubing met an all-time record regarding waterside transhipment with 795,000 t, representing almost 20% of all cargo transhipment happening in the port. The port serves as a logistical hub for biomass goods and feedstock for energetic and chemical-material utilisation which are mainly imported from the Southern Danube-adjacent countries. Annually, the share of waterside handling of biomass (agricultural and forestry goods as well as food and beverages) amounts to over 80% (Hafen Straubing-Sand, 2018).

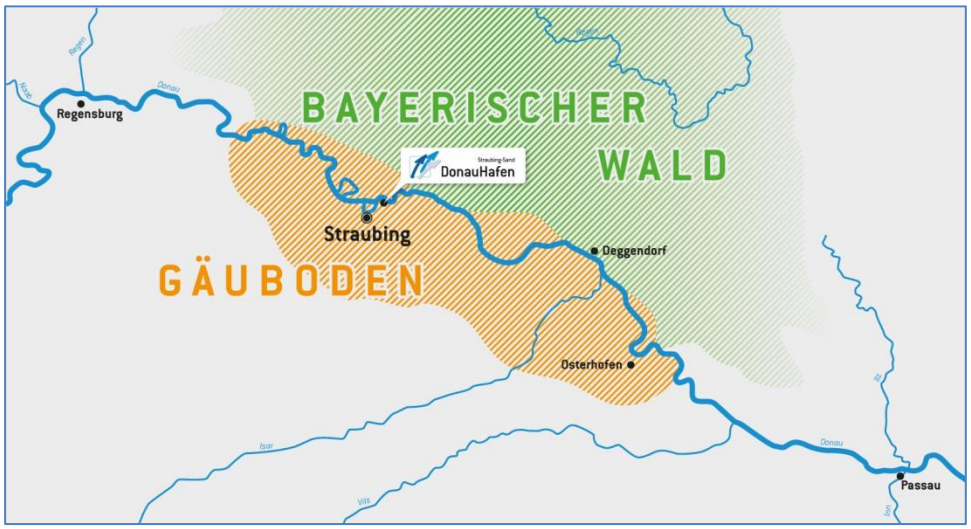

Figure 3: Straubing and its location at the Danube between Gäuboden and Bavarian Forest (own visualisation).

Both municipal entities mentioned above have joined forces in the form of an administration union called "Zweckverband Hafen Straubing-Sand" (ZVH) in the 1970s with the objective of developing an inland port, an industrial park around the port as well as – as of the early 2000s - a model region for the energetic and material use of biobased raw materials (biomass) under the branding of "Straubing – Region of Renewable Raw Materials". In charge of the latter activities is the public regional business development agency BioCampus Straubing GmbH (BCG), which is a subsidiary of the ZVH and fulfils the task of the regional branding and development by means of the regional branch cluster "Renewable Raw Materials", working together with more than 100 cluster partners from industry, research and supporting institutions (BioCampus Straubing GmbH, 2018).

The reason behind this strategic decision to engage in regional business development in the field of renewable raw materials on regional level was a development that started in 2001, when the Bavarian government and its responsible ministries, i.e. agriculture & forestry, research & education, economic affairs, decided to settle the state-run institutions active in the fields of research and development, technology transfer, state support and education regarding renewable raw materials, biomass and bioeconomy in Straubing. These institutions are:

- Central Agricultural Resource Marketing and Energy Network (C.A.R.M.E.N. e.V.);
- Technology and Support Centre for Renewable Raw Materials (TFZ);
- Straubing Centre of Science, since October 2017 "Straubing Campus for Biotechnology and Sustainability of the Technical University Munich";
- Fraunhofer BioCat, part of Fraunhofer IGB ;
- Office of the Bioeconomy Expert Council Bavaria (part of C.A.R.M.E.N. e.V., run by Bavarian Ministry for Agriculture and Forestry).

The first three entities functioned as pillars of the overall roof organisation "KoNaRo Kompetenzentrum für Nachwachsende Rohstoffe" (Centre of Excellence for Renewable Raw Materials" until late 2017, when the Centre of Science became a full campus of the Technical University Munich (TUM CS) and left the common organisational roof. The accumulation of these institutions in Straubing, according to the expert discussions, was politically driven on Bavarian / free-state level, and aimed for profile development and fulfilment of regional political objectives. The generally strong agricultural and forestry profile of Straubing and its surroundings greatly contributed to this decision.

The goal of regional political actors and a set of committed individuals working in Straubing's regional business development section who decided to found the BCG were to establish a business and technology transfer-oriented regional counterpart to the mentioned institutions. The main tasks of the BCG are transferring and communicating the work of the Bavarian institutions listed to the regional industry actors, facilitating joint research and innovation projects, familiarizing regional businesses as well as the broader public with the topic of utilisation of renewable raw materials, attracting new companies to the region via a set of dedicated business development tools as for example the setting-up of a regional cluster. The BCG as well as its mother entity, the ZVH and the port of Straubing are currently also running a business centre for renewable raw materials, the so-called BioCubator (financed with Bavarian funds) as well as a start-up

competition for business ideas from the biomass value chains called "PlanB – Biomass.Business.Bavaria.". Moreover, a marketing branding for the port of Straubing as "Green Chemistry and Energy Port" has been developed, as well as an economic sustainable development concept for the Danube region called "Green Chemistry and Energy Belt". This concept rests on the idealised value chain of decentral harvesting, regional conversion and central refinement of biomass feedstock for energetic and chemical-material purposes and the utilisation of the Danube as transport and connection axis, adding to rural job and added value creation. The BCG war awarded with the innovation award "Germany – country of ideas" for this concept in 2013 (BioCampus Straubing GmbH, 2018).

The strategic goal of the port management and the BCG is to further develop port as a hotspot for the transport and utilisation of biomass for energetic and industrial purposes in the framework of the "region of renewable raw materials". The BCG moreover closely cooperates with the three entities of the KoNaRo and the city and administrative district of Straubing, the regional waste disposal authority in the so-called "Netzwerk Region der Nachwachsenden Rohstoffe" (Network Region of Renewable Raw Materials).

Important actors in the region

As described above, Straubing as Region of Renewable Raw Materials functions as a regional profiling project with a set of multiple actors contributing to it on regional level both from the public as well as from the private sector. Regarding the private sector, the actors can be subdivided into suppliers, traders, processors and end users of biomass as well as companies providing logistics and transport services for biomass products. All of these actor groups are represented in the region, adding to its overall functioning and success. Additionally, especially Bavarian state politics play a decisive role, mainly by role of the relevant ministries and to the capacity of providing public funds for the constant development of the region's several public entities (as well as – partially – for private companies, as will be described below.

The most relevant public and political actors are:

- City of Straubing, city administration incl. business development agency;
- District of Straubing-Bogen, district administration including business development agency and until 2015: "Bioenergy Region Management Unit" as part of the German "Bioenergie-Region" initiative, a funding scheme supporting regions to develop the utilisation of bioenergy locally;
- Zweckverband Hafen Straubing-Sand;
- BioCampus Straubing GmbH;
- Office of the Bioeconomy Expert Council Bavaria;
- Bavarian Ministry for Economic Affairs, Technology and Energy;
- Bavarian Ministry for Food, Agriculture and Forestry;
- Bavarian Ministry for Education and Research.

The most relevant research, education & development actors are:

- TFZ;

- C.A.R.M.E.N. e.V.;
- TUM Campus Straubing;
- Fraunhofer BioCat for biocatalysis;
- School for biological technology assistants.

The most relevant corporate/private sector actors in the port of Straubing and along the Lower Bavarian Danube and their sector are:

- Clariant demoplant sunliquid® for lignocellulosic ethanol (processor);
- ADM Spyck GmbH vegetable oil mill for rape and soy oil (trader, processor);
- DoFu Donaufutter GmbH feed plant (processor, trader);
- Raiffeisen Straubing trading center (supplier, trader);
- BaWa Straubing trading center (supplier, trader);
- Bayernhof GmbH trading center (supplier, trader);
- Reinsch / SR LOG (biomass logistics, waterside handling and storage);
- Hafenlogistik Straubing GmbH (biomass logistics, waterside handling and storage);
- Südzucker sugar plant, Plattling, 25 km from Straubing (supplier, processor);
- Südstärke starch plant, Sünching, 20 km from Straubing (supplier, processor);
- Kelheim Fibres cellulose fibre plant, 40 km from Straubing (processor, end user);
- UPM pulp and paper plant, Plattling, 25 km from Straubing (processor, trader, end user).

Moreover, there is a significant amount of small to medium sized and start-up companies along the biomass value chain (energetic and material use) settled in the BioCubator (10 companies, 50 employees), the entrepreneur center for the biobased economy in the port of Straubing, which are partners in the regional cluster and profit from cluster services.

The current state of industrial companies in the port of Straubing regarding the biomass sector is depicted in Figure 3. The Lower Bavarian region along the Danube and its main industrial and research players in the field including the annual amounts of biobased products produced are depicted in Figure 4.

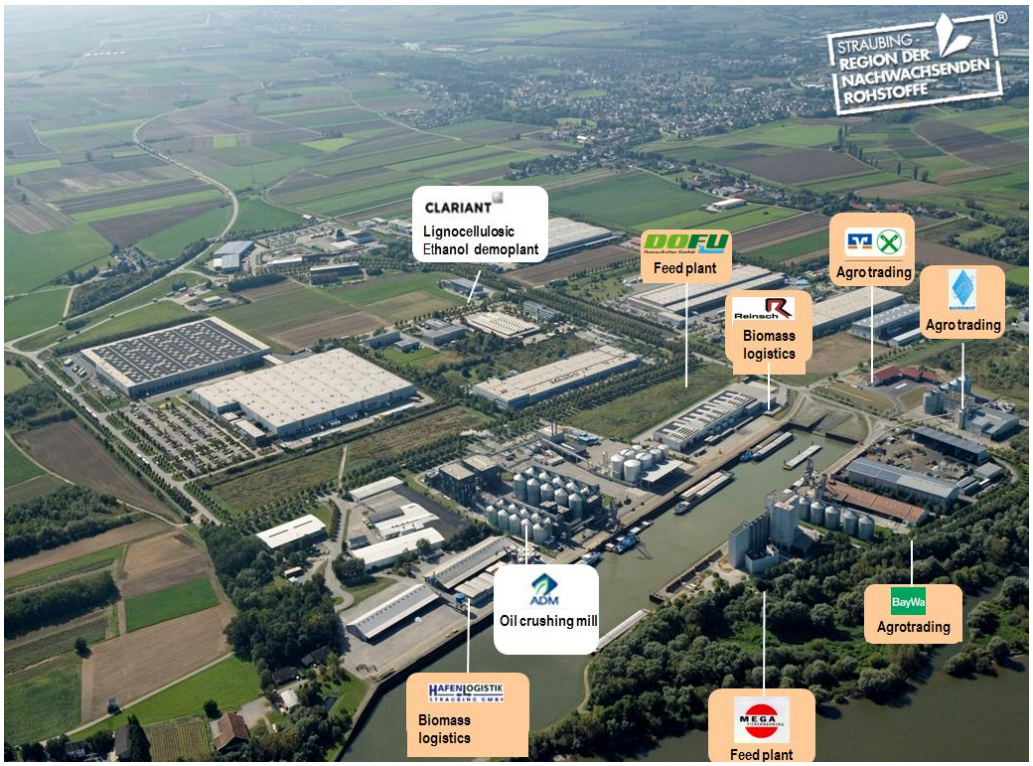

Figure 4: The two plants processing biomass for energetic purposes in the port of Straubing (white) including the logistics companies providing services for biomass logistics (orange) (own visualisation).

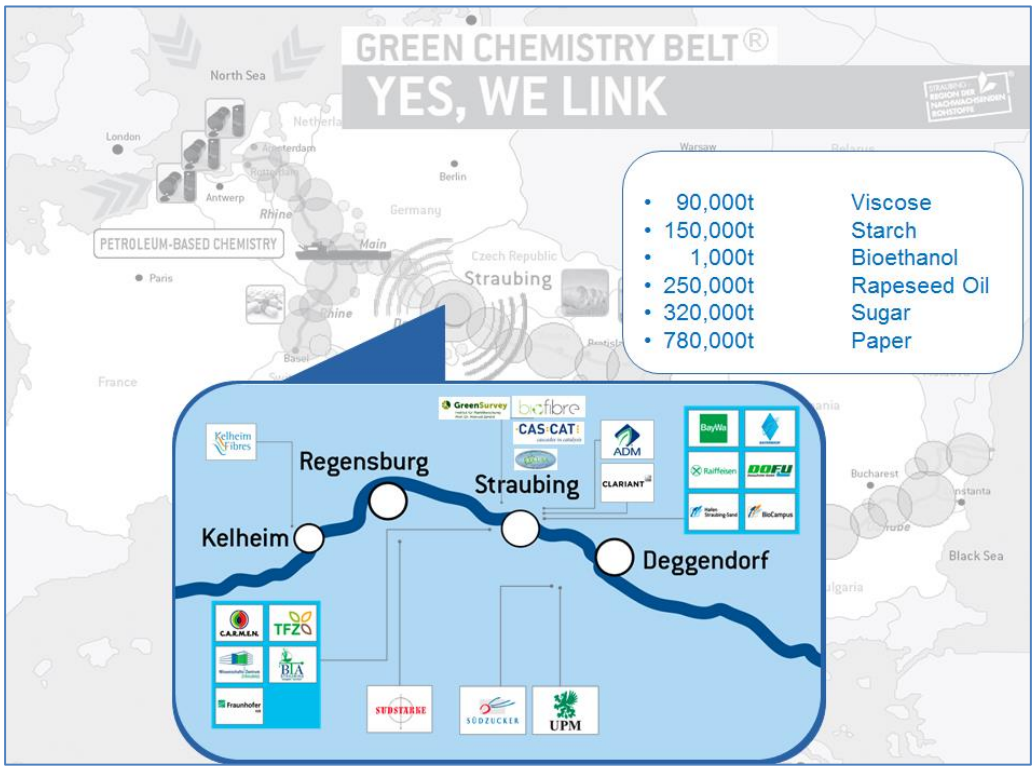

Figure 5: The Lower Bavarian biomass cluster's major actors surrounding Straubing and tons of biomass products produced per year.

In the following section, the two corporate examples from the bioenergy sector in the region are introduced in more detail.

Clariant demonstration plant for lignocellulosic ethanol

Clariant is a Swiss speciality chemicals company, its German headquarters are located in Frankfurt-Höchst. In Bavaria, it has locations in Gendorf, Gersthofen, Gammelsdorf, Heufeld, Moosburg, Sulzbach, Straubing and Munich, with its biotechnological research center "Biotech and renewals center" and management being located in Munich. The field of this center is the industrial biotechnology with the focal points of developing biocatalysis and biorefinery-concepts for energy- and resource efficient production of biobased chemicals and transport fuels from renewable raw materials (Clariant, 2018).

The plant in Straubing, which has been chosen for the ENERGY BARGE case study, functions as the second Bavarian location of the company's biotech center and is a classic demonstration plant with the focus of scaling-up lab processes to pre-industrial and industrial scale as well as testing of different feedstock materials. The main purpose of the plant is the upscaling of Clariant's so-called "sunliquid®" process, which converts agricultural lignocellulosic residue material into ethanol, which can be used as a blend or pure transport fuel. This fuel is a so-called "2nd Generation" fuel with a considerably better greenhouse case emission balance sheet than conventional biofuels as well as the advantage of not being in direct competition with food and feed applications. The plant in Straubing (see **Fehler! Verweisquelle konnte nicht gefunden werden.** 5) is the largest demonstration plant of its kind in Germany and was inaugurated in 2012 (Clariant, 2018). Therefore, the Clariant depicts an example for second-generation biofuels.

The plant site amounts to approx. 1 ha and is located in the port of Straubing's so-called physical BioCampus, an approx. 8 ha large area which has been dedicated and reserved for facilities like the sunliquid® plant, working along the biomass-conversion value chain. The plot is around 400 m away from the port basin (see **Fehler! Verweisquelle konnte nicht gefunden werden.** 3). Clariant announced in late 2017 that a first license of the sunliquid® process has been sold to ENVIRAL, a Slovak bioethanol company. Additionally, Clariant announced that it will build a first industrial-scale sunliquid® plant in Southwest Romania (Clariant sunliquid® , 2018). These two announcements clearly indicate that commercial actors have identified the Danube region's biomass potential.

Figure 6: The Clariant demoplant in the port of Straubing (picture: Clariant, 2015).

ADM Spyck GmbH – vegetable oil mill

The ADM Spyck GmbH, a subsidiary of ADM Germany, operates an oilseed crushing mill in the port of Straubing since 2008. ADM stands for Archer Daniels Midland. The ADM is a globally leading processor of agricultural goods for food, feed and energy purposes and over 33,000 employees worldwide (Straubing-Sand, 2018). The Straubing-plant is directly located at the quay, as can be seen in **Fehler! Verweisquelle konnte nicht gefunden werden.** 3. Other German locations of ADM's oilseed crushing business are in Hamburg, Mainz and Spyck – all of these locations have water-side access and port facilities, indicating the importance of this logistics option for large-scale bulk commodity production facilities.

The main focus of the Straubing-plant lies on rapeseed and soybeans as feedstock, mainly imported from the Danube region. The end product produced in Straubing is vegetable oil as an intermediary good, which is then further processed into biodiesel in the refinery location in Mainz. Therefore, the ADM plant in Straubing depicts a first-generation biofuel example. The protein-rich residue materials from the crushing process, namely the rape and soy meal, are sold to the animal feed market amongst others. The soy crushing capacities of the plant have been added and expanded just recently.

ADM took over the 55,000 m^2 large plant site at the port of Straubing from the Campa company, which invested 60 Mio. € in the construction of the plant. It was inaugurated 2007 and, back then, also had a biodiesel refining unit (Straubing-Sand, 2007).

Figure 7: The ADM oil mill in the port of Straubing (Picture: port of Straubing, 2016).

3. Socio-economic indicators

The socio-economic conditions in which a case operates can have decisive influence on the case's performance. Therefore, the main socio-economic indicators of the region of Straubing are presented below.

The table below presents the main socio-economic indicators for the region as a conglomerate of the city and administrative district according to the most recent statistical data available from 2010 to 2017) (Bayerisches Landesamt für Statistik, 2017).

Table 1: Main socio-economic and statistical indicators of the region (Bayerisches Landesamt für Statistik, 2017; IHK Niederbayern, 2017).

	City of Straubing	District Straubing-Bogen
Population	47,142	99,221
Population growth rate projected for 2034	6.6%	4.9%
Population Density (Inhabitants per km^2)	654	80
Average age in years	44.6	43.5
Private households	21,825	37,707
Gross value added	1,960 Mio. €	2,054 Mio. €
Thereof agriculture and forestry	6 Mio. €	69 Mio. €
Secondary and teritary education (share of total population)	86.7%	83%
Unemployment rate	5.7%	2.4%
Surface/Area total	6,795 ha	120,162 ha
Share of land used for agriculture	57.8%	58.6%
Share of forest	0.5%	26.2%
Farms	100	2,359
Manufacturing and producing industry with > 20 employees– number of companies	38	67

Looking at the indicators above, it becomes visible that the Straubing region is economically vital. Moreover, the chamber of commerce predicts overall population growth for both the city and the district. As has already been pointed out above, agriculture and forestry still play a comparatively important role, both in terms of employment as well as in terms of gross value added as compared to German federal levels (share of employment on federal level: 1.6%; share gross value added: 0.6%) (Bundeszentrale für politische Bildung, 2013; Destatis, 2017).

A major socio-economic goal of the region is to increase the number of highly qualified jobs and workforce. To this end, the regional politics have put enormous efforts into the establishment of the campus of the Technical University of Munich in Straubing. This step was also highly welcomed by the companies involved in conversion processes of biomass in the region.

4. Biomass availability and utilisation

As aforementioned, Straubing is located between the Bavarian Forest and the agricultural region of the Gäuboden with the Danube as a natural border. It is this unique geographical situation that was the origin of branding Straubing as "Region of Renewable Raw Materials".

The cluster "Renewable Raw Materials" bases its marketing strategy mainly on the site advantages for biomass feedstock supply resulting from this location. Three levels of feedstock supply are mentioned:

- Small-scale supply for lab tests: option to use the currently free plots in the port area for test fields and plantations; realized examples: miscanthus and short rotation coppice plantations for energetic use, biogas crops, Caucasian dandelion for material use/latex;
- Medium-scale supply for pilot and demonstration plants: supply of residue and primary biomass feedstock from regional sources of Gäuboden (main crops: sugar beets, potatoes, maize and wheat) and Bavarian Forest (coniferous wood); realized examples: wheat straw for the Clariant sunliquid® plant);
- Large-scale supply for industrial production: supply of large-scale volumes of biomass feedstock material via the waterway; realized example: ADM rapeseed and soy crushing mill.

In terms of industrial biomass utilisation for bioenergy purposes, a closer look shall be laid on the two exemplifying corporate cases.

The main hard facts on the biomass types and utilisation for both the ADM and the Clariant plant are summarised below in **Fehler! Verweisquelle konnte nicht gefunden werden.**2.

Table 2: Overview of biomass utilisation of exemplifying cases.

	Clariant demo plant	**ADM oilseed crushing mill**
Feedstock Type	Lignocellulosic agricultural residue material, mainly wheat straw but also bagasse,	Oil seeds (rape seed and soy beans)

	rice straw and other feedstock for test purposes for clients	
Challenges in feedstock supply and procurement	Procurement of feedstock (residue material, straw) in sufficient quantities and constant quality as well as to competitive prices; challenge of different cultures and languages (chemical industry vs. farmers/agricultural players)	Procurement of sufficient quantities in times of low water levels or other infrastructural barriers
Primary product	Lignocellulosic ethanol	Vegetable oil
Secondary / residue products	Lignin, vinasse	Rape and soy meal
Utilisation/valorisation path of residue products	Potentially in large-scale applications: lignin as energy source for process energy, vinasse as fertiliser and/or substrate for biogas plants	Food and feed industry (protein source)
Feedstock input annually	Approx. 5,000 t	n/a
Product output annually	Approx. 1,500 t	n/a
Origin of feedstock	Mainly regional, also trial runs for international clients	imported from Danube region and regional

It is obvious that the study cases utilise biomass feedstock to a different extent in terms of quantities as well as in terms of type of feedstock. For Clariant and its residue material-based process, different supply chains have to be used compared to the ADM's case, where agricultural commodities that are traded regularly on the agricultural market are the feedstock material. Therefore, different procurement systems and markets as well as logistics strategies are of relevance for the two cases. These points are discussed in more detail in chapter 6.

In both cases, as it is typical for biobased production processes, the processes are not only providing a single product. Secondary or residue products in relatively large quantities / shares are produced which function as biomass supply for further added value creation processes. In the case of the ADM, this is already realised. The protein-rich residue meals are sold to the food and feed market. Clariant is currently putting considerable efforts into closing the loops and utilising the residue streams, mainly for energy supply to fuel the production process itself, making it energy autonomous. The theoretical groundwork and calculations for this are done at the demo plant in Straubing. However, the plant is too small to utilise the residue streams in an economic manner, so that they are currently disposed of or used for research purposes. However, for Clariant's industrial plant in Romania, the integration of lignin and vinasse in the value chain, mainly as bioenergy carriers are foreseen.

5. Bioenergy production and utilisation

Regarding the production and utilisation of bioenergy for electricity, heating/cooling and transport in the case region, two levels can be identified:

- Technical, informational and funding support for private, public and industrial bioenergy applications and share of bioenergy applications in the region;
- Industrial production of biofuel products.

In the following, these levels and how they translate into results in the Straubing region are presented.

The administrative district of Straubing-Bogen was named "Bioenergy Region" in two consecutive funding periods by the Agency for Renewable Resources (FNR) between 2009- 2012 and 2012-2015 (Bioenergieregion Straubing-Bogen, 2015). In order to implement the programme that was drafted to support the generation of bioenergy in the region, a network management office was established at the administration of the district.

Since the project life time's end in mid-2015, the activities of the administrative district with respect to bioenergy utilisation lie in the responsibility of the successor institution, namely the Regional Development Union (Regionalentwicklungsverein), which also covers a broad set of other topics (Landkreis Straubing-Bogen, 2018). Moreover, the institutions of TFZ and C.A.R.M.E.N. e.V. offer a wide array of service and information packages for private, public and industrial use of bioenergy – however with a Bavaria-wide scope. These include:

- Research and technology transfer for different utilisation fields of solid and liquid bioenergy carriers;
- Consultancy services for development of private, public and industrial bioenergy projects in the context of the "Energiewende";
- Promotion and processing of Bavarian funding programmes for the utilisation of bioenergy;
- Expert studies and assessments of bioenergy projects for the Bavarian government, ministries and administrative bodies.

The following map (Figure 7) visualises all bioenergy applications beyond private household applications as assessed in 2014 (Bioenergieregion Straubing-Bogen, 2014).

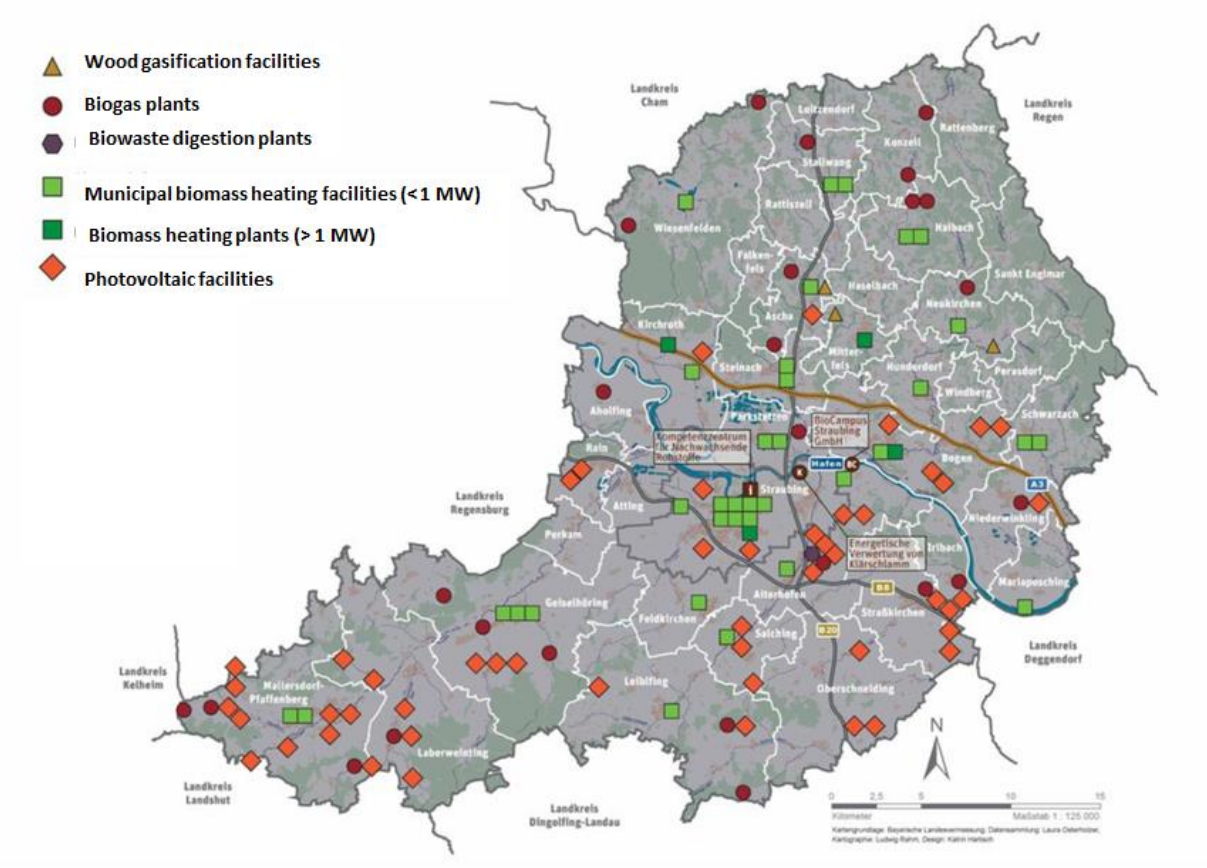

Figure 8: Administrative district of Straubing Bogen and city of Straubing: renewables facilities (Bioenergieregion Straubing-Bogen, 2014).

Regarding this case study's two corporate examples, the different aspects of bioenergy production become apparent. While bioelectricity and bioheat utilisation are closely linked to the location of their production, biofuels for transport can be produced wherever site conditions are favourable and transported then via suitable transport containers and different modes of transport to places and networks of distribution, mostly gas station. This is visible in practice in the case of the ADM plant that produces oil as basis for biodiesel in Straubing transports oil to refinery locations, e.g. Mainz. Biodiesel is sold from there to oil and gas companies blending or directly selling the final biofuel. On a small demonstration scale, the same procedure has been tested by Clariant for their lignocellulosic ethanol, although the product or a blend of it cannot be bought and used yet.

For their own energy supply in their production processes, neither the Clariant nor the ADM use biobased energy resources. Both processes are fuelled/heated based on fossil gas and electricity from the grid. However, both companies are interested in a central heating concept based on biomass which is currently under scrutiny in the port of Straubing.

Overall, this section shows that the region of Straubing-Bogen can be seen as a model region for the production and utilization of biobased energy both on private household, public, and

commercial level. Therefore, it can be seen as exemplary in the ENERGY BARGE context and can function as a source for transfer lessons to other regions along the Danube.

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

The previous chapters have provided an insight into the overall set-up of the region of Straubing and its efforts to develop towards a model region for the energetic and chemical-material utilisation of biomass. By doing so, it was emphasized that the Danube port plays an important role in this effort, both regarding the provision of logistics services for biofuels production and other utilisation paths of biomass, and regarding the development of the region since the port area functions as dedicated settling location for biobased companies. It aims to provide an attractive site advantage for companies in need of large-scale feedstock and product logistics.

The following section briefly investigates the role of the available transport infrastructure and logistics with a focus on inland waterway navigation (IWT) in the region in general as well as the current and potential utilisation for the transport of biomass feedstock and bioenergy products in the two exemplifying cases. Exemplifying supply chains are provided.

Port of Straubing-Sand: Biomass logistics

The Danube port of Straubing-Sand is a trimodal Danube port, meaning it facilitates all three classic modes of freight cargo transport: road, rail and water. In 2017, 3.6 Mio. t of cargo were handled in the port, 20% of this (795,000 t) on waterside. The main share still accounts to road freight (Hafen Straubing Sand GmbH, 2018).

The port specializes in biomass handling. On waterside, in 2017, 85% of the 795,000 t handled, were agricultural and forestry goods. Almost three quarters of this total amount is attributable to the production plant of ADM, namely feedstock supply and logistics of residue material. Regarding the transport on rail, the share is even higher: over 90% of all cargo leaving or entering the port was biobased. Here, as well, ADM is the port's key account, facilitating its oil logistics via rail. The following graphs (Figure 8 & 9) visualise the shares.

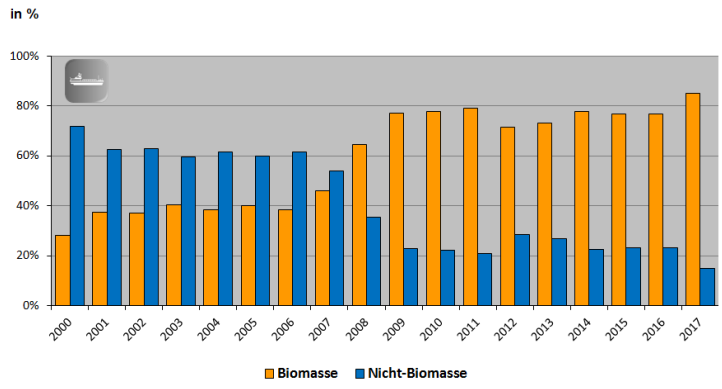

Figure 9: Share of biomass (orange) in total waterside transhipment (own visualisation).

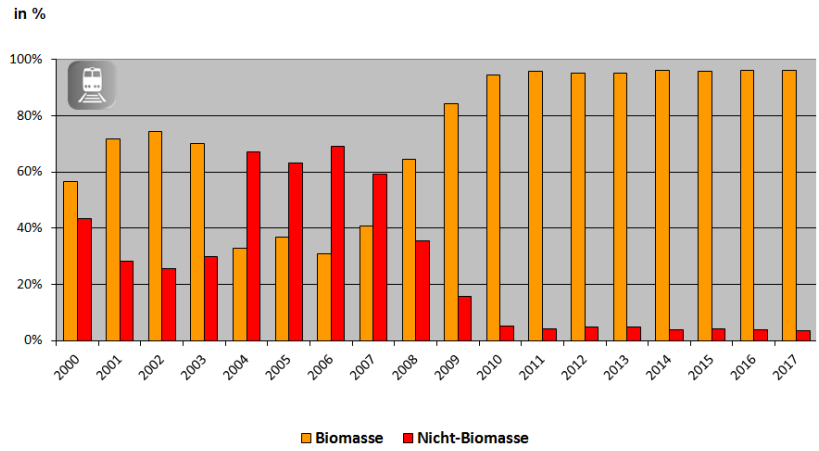

Figure 10: Share of biomass (orange) in total rail transhipment (own visualisation).

For the handling of biomass materials, including dry bulk (rape seed, soy, grains, maize, etc.), break bulk (big packs, e.g. for pellets) and log wood, the port management disposes of all standard handling equipment: portal and gantry cranes as well as multiple grippers. Currently, it is not possible to handle liquid cargo including liquid biobased goods in the port of Straubing. Almost all logistics and companies that are trading agricultural goods settled at the port basin, offer a wide set of services for biomass logistics including storage services.

The port's main transport infrastructure and handling equipment as well as the logistics service providers (private transhipment companies) are depicted in **Fehler! Verweisquelle konnte nicht gefunden werden.** 10.

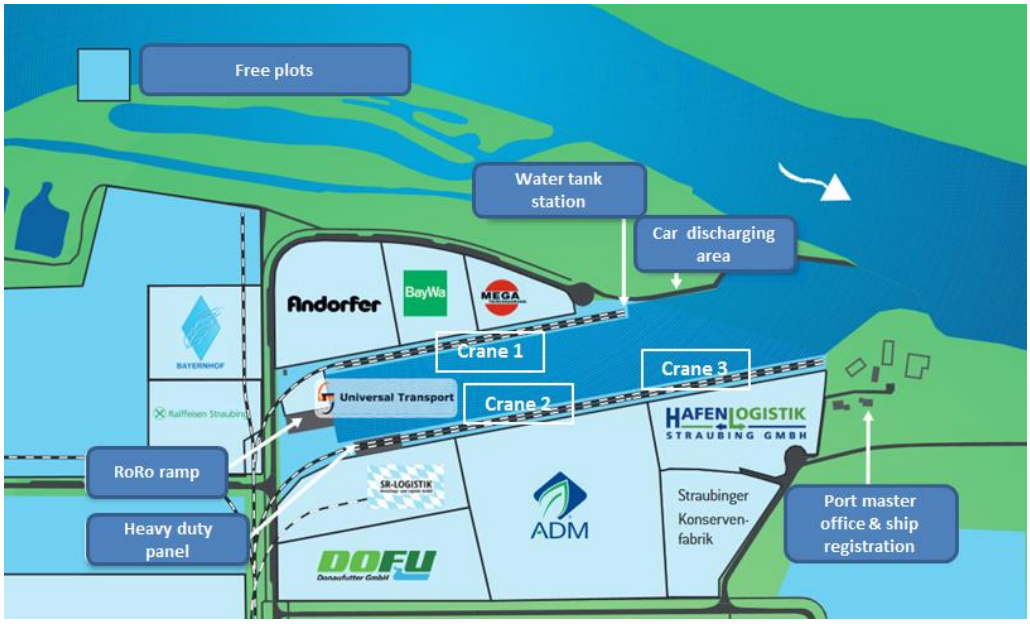

Figure 11: Overview on the infrastructure in the port of Straubing (own visualization).

The port itself does currently not utilise bioenergy for the energy supply of its own infra- and superstructure. As aforementioned, a concept for a central biomass-fueled heat and steam supply facility to be located in the port as a supplier for the port settlers is being surveyed and studied by the port management.

Clariant sunliquid® demo plant: Biomass and bioenergy logistics

The logistics and supply chain in the case of the Clariant demo plant functions under special circumstances due to its demonstration character. Feedstock supply is organised primarily on regional level with the exception of international clients providing their biobased feedstock of choice for process testing (e.g. sugar cane bagasse). The residue materials are also mainly utilised in proximity to the plant. The product (bioethanol) is transported to commercialization partners for product development and testing depending on their location throughout Germany as well as to potential clients.

The feedstock used comes in the form of break bulk, mainly straw bales with dimensions of 2.5 m x 1.7 m x 1 m. The specific weight varies according to the type of straw used. The residue material vinasse is liquid bulk cargo and has to be transported in tank containers. The lignin is solid and broke into small pieces. It is collected in containers. The ethanol is a liquid bulk under special toll conditions which needs to be transported in sealed containers. The entire logistics at the moment is facilitated via road transport, based on trucks and tractors.

The main actors involved in the supply chain in Straubing are:

- Farmers supplying agricultural residue material;
- Agricultural warehouses supplying agricultural residue material;
- Clariant demonstration plant (management and engineering);
- Customers of Clariant providing test feedstock material;
- Development and commercialization partners of Clariant utilising the lignocellulosic ethanol for product development and specification studies;
- Facilities utilising the residue streams for energy production.

A similar set of actors will be part of the commercial-scale sunliquid® process supply chain as the aim is to establish a broad farmer-based supplier network:

- Farmers supplying agricultural residue material;
- Agricultural warehouses supplying agricultural residue material;
- Clariant sunliquid® plant (management and engineering);
- Customers buying the ethanol;
- Customers buying the vinasse or residue material;
- Logistics service providers.

As described above, Clariant does currently not make use of Danube logistics for their sunliquid® process. A set of reasons accounts for this.

- Demonstration-scale of the plant: no large-scale feedstock supply needed;
- Goal of the process's concept to develop a regional feedstock supply network independent of imports;
- Lack of suitable permissions and equipment at the port to handle liquid bulk goods / dangerous goods such as bioethanol or vinasse.

However, for their industrial-scale plant in Craiova, Romania, although not directly located at a port location (70 km distance to next port), the company expressed general interest in looking into options of waterway transport for their logistics.

ADM rapeseed and soy crushing mill: Biomass and bioenergy logistics

In case of the ADM, the feedstock input exceeds the availability of rape seed in the Gäuboden and even in Bavaria in total, making it highly dependent on feedstock imports. A regional supply is not possible. In this respect, the logistics connection to the Danube plays a decisive role for the company, making it the key account with regards to biomass handling for the port of Straubing.

The feedstock supplyis facilitated via water and road, the import quota is approx. 80%. The share of water and road can vary depending on the season and production. The port of Straubing and two private logistics companies facilitate the unloading from vessels to the production plant. For this logistics step, dry conditions are of highest priority. In case of rain, no unloading can take place. The product, namely the vegetable oil (liquid bulk), is loaded into tank wagons and transported to refinery locations via rail. The ADM facilitates this transhipment itself. The residue materials, mainly the meal (dry bulk cargo good), are transported predominantly on waterside.

The main actors involved in the supply chain in Straubing are:

- Logistics service providers (transport, handling, storage) on road, water & rail;
- Agricultural warehouses supplying feedstock;
- agricultural trading facilities;
- ADM-owned and other customer refinery sites processing the vegetable oil;
- Customers buying the residue materials for food and feed purposes.

The main share of imported rape seed and soy in the port of Straubing originates from Hungary, Serbia, Croatia, Romania and Slovakia (Hafen Straubing-Sand, 2017).

The ADM poses the following infrastructural and service-related requests in terms of port transport to the port operator:

- Availability of transhipment and handling services according to 24h-shifts;
- Flexibility of handling services and intermediate storage options according to weather conditions;
- Avoidance of risk factors for pest contamination;
- Good manufacturing practices-certification of logistics service providers.

Overall, it can be seen that one of the exemplifying cases highly depends on port infrastructure and inland waterway transport and has optimised the integration of inland waterway transports to the highest degree possible in the context of the specific conditions its business model and process have. The second case is not utilising inland waterway logistics yet but signalised its general interest in looking deeper into the options with regard to its new plant in Romania.

In general, the following barriers and challenges with regard to utilising inland waterway transport for biomass logistics were identified:

- Potential contamination with possible entry during open-air handling (vessel loading / unloading);
- Lacking economic viability of long-distance transport of comparatively light-weight feedstock such as straw;
- Lacking permission and infrastructure for waterside handling of liquid bulk cargo including hazardous goods in most ports;
- Fluctuations in reliability due to weather and water level conditions.

7. GIS-map

For the case study, a map visualising geographical conditions and context based on a geo-information system (GIS) was designed (Figure 11). It is a set of aspects defining the case and its surrounding area with a particular focus on the proximity to the Danube and relevant ports. For the case, a catchment area with a radius of 50 km has been defined in order to allow for theoretically economically viable pre- and post-haulage logistics. Within this area, also the companies along the biomass and bioenergy value chain as well as the port locations as identified in the course of the ENERGY BARGE project are depicted via icons.

The following information is provided in the map:

- Location of the case
- Land cover categories on NUTS 3 level (CORINE land cover data, Eurostat, 2012)
- Land use data on NUTS 2 level for selected biomass feedstock (Eurostat, 2017)
- Market actors in the biomass and bioenergy sector in the region (ENERGY BARGE D3.2.1 Transnational inventory of biomass and bioenergy companies in the Danube corridor)
- Danube port locations with equipment for biomass handling (ENERGY BARGE D4.1.3 Analysis of logistics requirements for the bioenergy industry)

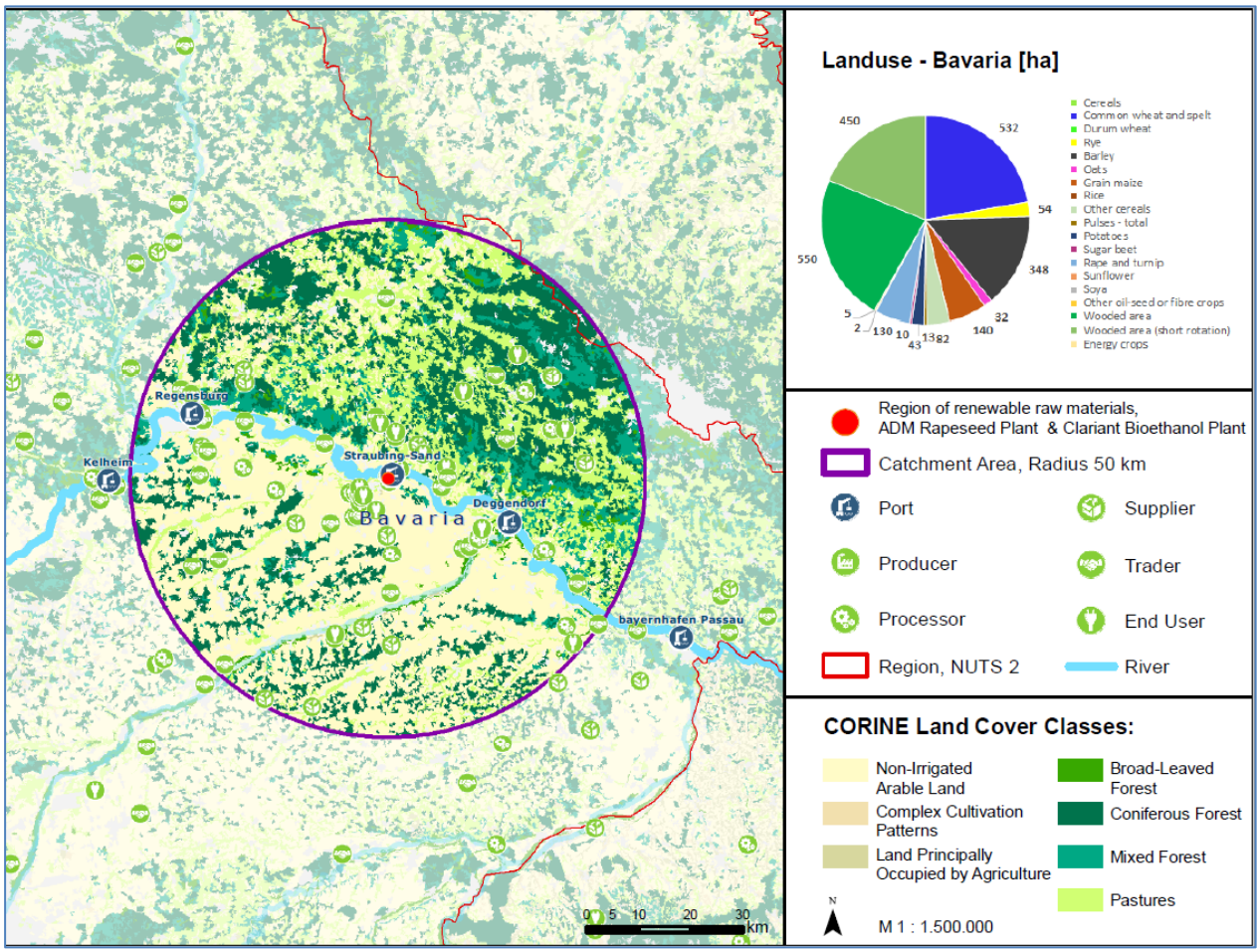

Figure 12: GIS map of the case location (visualisation: DIT for ENERGY BARGE project; sources: ENERGY BARGE, 2017/2018; EUROSTAT land use data, 2017; CORINE landcover data, EUROSTAT, 2012).

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

In this case study a qualitative in-depth analysis of Straubing as region of renewable raw materials including the two biofuel-producing facilities of ADM and Clariant has been provided. Based on the structure of the study, the following table gives a summarising overview over the different success factors – namely enabler and barriers – that characterise this regional case. From this, lessons to be learnt for other regions and cases are deduced and an indication of the potential to transfer the respective lesson learnt to other regions is given.

Table 3: Success factors characterising the case region.

	Enablers	Barriers	Lessons learnt

Biomass availability	Theoretically large-scale biomass availability in Gäuboden and Bavarian Forest (coniferous wood, starch- and sugar-based primary biomass); possibility to provide inland waterway transport of biomass feedstock and products	No comprehensive information on availability and utilisation potential of biobased residue materials and streams for bioenergy production	Domestic biomass availability is especially relevant for small- to medium-scale and decentral bioenergy production such as biogas plants; large-scale production facilities for biofuel production rely mainly on import; hard to transfer factors of biomass availability since domestic biomass availability is mainly a region-specific factor
Biomass utilisation/ processing	Existence of expert knowledge and infrastructure for several biomass conversion processes to biofuels and other bioenergy carriers; Existence of conversion technologies based on non-food feedstock with potential to utilise residue streams for process energy supply	No utilisation of bioenergy in large-scale production plant for biodiesel; biodiesel processes currently relying on first-generation feedstock input	Advantage of innovative processes utilising non-food feedstock for the production of bioenergy and other biobased products with respect to market viability; Closed loop concepts for residue stream integration in production processes should be aimed for; technological flexibility in biomass feedstock can provide comparative advantage and higher resilience to legislative and market fluctuations

Bioenergy production /utilisation	Existence of broad private, public and industrial bioenergy application network on regional level; existence of expert institutions supporting bioenergy production; Support scheme with significant impulse for bioenergy utilisation between 2009 and 2015	No utilisation of bioenergy in large-scale production plant for biodiesel	Existence of regional support and consultancy schemes for private, public and industrial application of bioenergy can be beneficial for development of bioenergy – monetary incentives for this are crucial; large-scale production plants of biofuels do not necessarily produce on the basis of biobased process energy
Existence of a strategy or concept	Regional multi-actor strategy for model region "Straubing – region of renewable raw materials" covering all elements of the value chain including marketing; site-specific business development concept "Green chemistry and Energy Port" and regional cluster "Renewable Raw Materials"; macro-regional development concept "Green Chemistry and Energy Belt" for the Danube region	Complex set of communicative arguments and aspects with potential for customer and stakeholder confusion; Lack of further large-scale investments in flagship examples like Clariant plant	Development of regional sector- and topic-specific strategies requires actor commitment as well as suitable availability of funds; potential for development of site advantages in comparison to sites with similar profile considerable; specialization based on specific factors such as a unique set of experts or logistics infrastructure is advisable; the sharper the profile, the more target-oriented and effective the measures

Stakeholders	Existence of committed individuals working towards establishment of regional profile on several levels; Coverage of all relevant actor and stakeholder types in the region (R&D institutions, corporate and industrial actors processing biomass/producing bioenergy carriers, agricultural and forestry actors, support institutions); Existence of cluster organisation gathering and managing cluster partners' interests	Numerous stakeholders and actors pose risk of asymmetrical communication and conflicts; Top-down structure of regional cluster causing limited motivation and identification at the level of cluster partners	Complex network of actors needs to be managed coherently, ideally at one central position; Innovative clusters should be ideally organised in a bottom-up or triple-helix manner, Especially big companies do not rely on cluster services
Socio-economic factors	Comparatively high share of agricultural and forestry sector in overall economic performance; potential for increase in skilled workforce and highly qualified jobs for the region given through newly established university	Currently complicated situation for technology-oriented companies such as Clariant or ADM to acquire skilled workforce willing to live in the countryside	Agriculturally shaped regions have a generally suitable profile for the development of biobased industries and the utilisation of bioenergy; bioenergy industry requires skilled and highly qualified workforce
Integration of supply chain	Corporate representatives of numerous biobased value and supply chains for biobased materials and energy present in the region; Clariant plant theoretically working on integration of residue streams into local and regional value creation on research level; ADM plant integrates its residue streams into countrywide and transnational food and feed supply chains	N/A	Biofuel production sites are not depending on regional outbound markets (no direct utilisation on site) and if large-scale, only limited regional supply

Role of logistics infrastructure	Strong current performance and image of port of Straubing regarding biomass handling; Multimodal transport infrastructure; Availability of infra- and suprastructure for companies along the biomass value chain including laboratories and offices in the BioCubator; Existence of portfolio of logistics services for numerous biobased feedstock types and products offered by private transhipment companies	Lack of equipment for transhipment of liquid cargo on waterside; role of inland waterway transport (IWT) for biomass logistics beyond the current utilisation scope restricted by economic and technical factors; role of road transport will remain	Relevance of multimodal logistics always given for large-scale industrial biomass conversion processes sector, however, IWT relevance depends on type of cargo & economic viability (economies of scale decisive) as well as production volumes and suitability of port infrastructure / services provided; availability of multimodal logistics infrastructure has significant influence on site and investment decisions

9. Recommendations & suggestions for future development

Based on the analysis of success factors and the previous case study, a set of recommendations and suggestions for the future success of the region of Straubing as a model region for the energetic and chemical-material utilisation of biomass can be derived.

The recommendations on organisational, administrative and application-related level pertaining to the overall future success and performance of the region are:

1) Further establishment and strengthening of the cluster management body via organisational innovation and consultancy processes to better tailor the cluster services to the corporate partners' needs.
2) Improvement of the governance situation of the cluster and attempt to include a more bottom-up culture, e.g. via establishing a supervisory board or an expert panel which includes actors from all important spheres.
3) Improvement of the region-internal communication between the relevant thematic partners via the establishment of a central coordination body with an own budget.
4) Continuing communication and information to private households and companies as well as municipalities on the advantages of biobased energy.
5) Increased marketing of Straubing as a bioeconomy site to companies who are not yet established in the region.

6) Widening of the portfolio of industrial biomass conversion processes and applications on site away from biofuels by means of increased site marketing and development of incentives for investment decisions in favour of the region.
7) Improved involvement of agricultural and forestry actors as well as agricultural trading and biomass logistics companies in order to provide a reliable data and information basis on different aspects of feedstock supply for companies interested in settling.

Regarding future options to further integrate the port as well as the Danube region into the case's performance and supply chains, the following recommendations are formulated:

1) Increased proactive marketing of the potentials and advantages of inland waterway transport for biomass feedstock and certain types of bioenergy products to the biomass and bioenergy sector by means of easily understandable information material.
2) Integration of inland waterway logistics for the biomass sector and procurement and supply chain management for biobased industry and bioenergy industry into the study programmes and syllabus of the TUM CS Campus University in Straubing
3) Assessment of unmet demand with regards to logistics services along the biomass supply chain offered in the port among current and potential port customers (forwarding companies).
4) Creation of supplier and logistics networks and strategic feedstock alliances along the Danube in order to secure sustainable feedstock supply chains and technology and knowledge transfer for potential future industrial-scale applications along the Danube countries.

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