TECH4 BIOWASTE

Functional design for technology database

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☐ **DEM** Demonstrator, pilot, prototype

☐ **DEC** Websites, patent fillings, videos, etc.

☐ **Other**

Dissemination Level

☒ **PU** Public

☐ **CO** Confidential, only for members of the consortium (including the Commission Services)

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Bio·based Industries Consortium

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List of abbreviations

Abbreviation	Description
HQ	Headquarters
IPR	Intellectual Property Rights
LCA	Life Cycle Assessment
T4B	Tech4Biowaste
TRL	Technology Readiness Level

Publishable executive summary

The purpose of the Tech4Biowaste database is to provide a complete overview of new and emerging technologies which are capable to valorise biowaste into useful products. Deliverable 2.3 elaborates the functional design of the Tech4Biowaste database, which is the blueprint of the final product, described in language that is understandable for database content users, suppliers, and (other) contributors. The earlier Tech4Biowaste Deliverable 2.2 concluded that the MediaWiki software satisfies nearly all requirements for the technology database without the need for heavily adapting the software or hardware infrastructure. In addition, the user-friendliness of the selected software ensures that the database can be supported by the community beyond the time frame of the project. Thus, the database will have a Wikipedia-like look and feel. During database design and set-up several aspects were considered including the overall structure, content, and functionalities of the database. Functional design objectives include the establishment of an overall structure and content scope to set the purpose and target group (e.g. potential stakeholders) of the database.

The feedstock- and technology -scope defines the later content of the database and follows the definition of the European Commission after which bio-waste is defined as biodegradable garden and park waste and food waste from kitchens households, restaurants, caterers and retail premises, as well was comparable waste from food processing plants. For the technology scope all emerging and established technologies along the value chain of bio-waste valorisation with Technology Readiness Level (TRL) ≥ 4 are considered including pre- and post-treatments as well as upgrading operations. No product scope is established in order to ensure that no biowaste valorisation technology will be excluded from the database.

The overall database structure is divided into three sections covering feedstocks, technologies, and products which will be crosslinked with each other to ensure that the user can perform search queries starting from the feedstock- or product- as well as from the technology side. Additionally, technology descriptions are harmonised to ensure that users with different background knowledge are able to quickly find requested information such as technology category, processable feedstocks and their pre-treatments, possible products and post-treatments, technology description and providers, patents, and references.

Essential functionalities of the database are established via a technology comparison tool and a matching tool allowing the user to find and compare technologies and to find further matching aspects about the company and technology.

The blueprint of the final product will be further refined incorporating (further) feedback and requests of the targeted users and contributors of the database which ensures a dynamic development of a functional design that is tailored to all potential stakeholders of the Tech4Biowaste database.

1 Introduction

The purpose of the Tech4Biowaste database is to provide a complete overview of new and emerging technologies which are capable to valorise biowaste into useful products.

The earlier Tech4Biowaste Deliverable 2.2 (Document describing technical requirements) concluded that the MediaWiki software satisfies nearly all requirements for the planned technology database without the need for heavily adapting the software or hardware infrastructure. These aspects ensure that the development of the technology database can be realistically implemented within the envisaged timeframe. In addition, the user-friendliness of the selected software ensures that the database can be supported by the community beyond the time frame of the project. Thus, the database will have a Wikipedia- or "wiki"-like look and feel which has not only technical advantages but also advantages for the user-experience. In order to build up the database with the MediaWiki software it was necessary to elaborate several functional design elements which will then lead to the blueprint of the final product.

The objectives of the current report (D2.3 Functional design for technology database) include the establishment of an overall content scope to set the purpose and target group (e.g. potential stakeholders) as well as to establish the overall structure (modules and pages that are included; functionality on all pages/modules; integration with other toolboxes or applications; overview of the content, etc.). As potential contributors the technology providers should have the opportunity to gain visibility by presenting their technology and company in a suitable format. On the other side the users or technology searchers should have the opportunity to find technologies for new valorisation options or alternative routes to high value products as well as to find innovative up- and downstream solutions including feedstock pre-treatments, post-treatments, and upgrading.

In Tech4Bowaste a bottom-up and iterative approach is adopted to develop the database. As general approach first the basic structure, content, and functionalities of the database were set-up. This will be followed by an iterative process in which the database set-up will be refined based on stakeholder feedback and user needs and requirements. In future the database will be therefore continuously developed and evolved.

2 Database structure

The overarching database structure (Figure 1) can be divided into 3 main branches which are feedstocks (types of biowaste), technologies (for biowaste valorisation), and products (bio-based products). The feedstock branch is subdivided into food waste and garden & park waste and will contain descriptions and statistics on biowaste as well as detailed descriptions about specific and relevant waste fractions that have the potential to be valorised. As a starting point, the technology categorisation of the partner project Pilots4U[1] was used and further refined. The technology branch follows the higher-level categorisation of the Pilots4U database[2] including primary processing and secondary processing,

[1] https://biopilots4u.eu/

[2] The Pilots4U project set up a database and a network of open access pilot and multipurpose demo-infrastructures for the European bio-economy. The database maps

additionally the hybrid processing category was introduced for the Tech4Biowaste database to cover technologies that can be utilised in primary or secondary processing. Primary processing results in intermediate chemicals and/or materials which will then go into the secondary processing after which the final product is obtained. In contrast to that the secondary processing covers either the direct or indirect (processing of intermediates from primary processing) valorisation of biowaste into a final product. Furthermore, hybrid processing covers processes that can be utilised in both primary processing and secondary processing. Separation technologies for instance would be hybrid processing technologies since they can either directly or indirectly lead to the final product or they can be used to obtain intermediates that will then go into the secondary processing. While the Pilots4U database includes "separation technology" as a main category (in addition to primary and secondary processing), hybrid processing was introduced for the Tech4Biowaste database and separation technologies were subordinated to this category. This serves the purpose of now being able to subordinate other "hybrid" technologies to such a category that are not separation technologies, such as densification or sizing. Each technology will be further subdivided based on their basic principles (e.g. chemical, physical, thermochemical and so forth). A preliminary subcategorisation is proposed for the feedstocks and technologies (see appendix, chapters 7.1 and 7.2) and will be finalised upon stakeholder feedback. The product branch is subdivided into chemicals, energy & fuels, food ingredients, and materials. The listed products will be supplied with descriptions and their application fields and may be further subcategorised as needed.

existing open access pilot and demo-infrastructures across Europe, with the aim of creating one, very visible and easily accessible network for the European bio-economy. The database includes 10 technological bioeconomy disciplines: algae cultivation and harvesting, anaerobic digestion, chemical processing, industrial biotechnology, material technologies, mechanical separations, physicochemical separations, pre-treatment, pulping, thermochemical conversion.

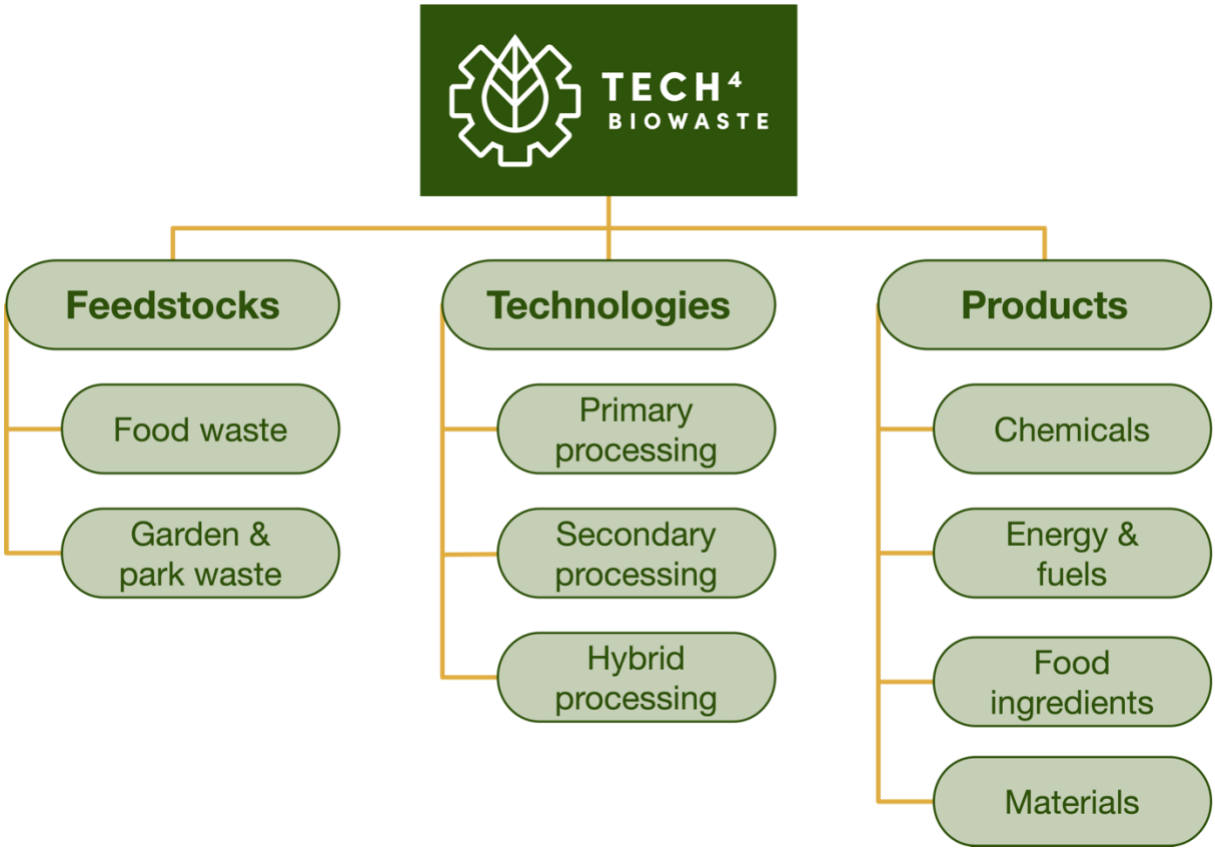


Figure 1: Visualisation of the overall database structure. Further subcategorisation will be applied as needed.

3 Database content

The database content was defined via specific feedstock- technology- and product- scopes as follows:

3.1 Feedstock scope and content

The feedstock scope follows the definition of the European Commission (European Commission 2021) where bio-waste is defined as biodegradable garden and park waste and food waste from kitchens households, restaurants, caterers and retail premises, as well was comparable waste from food processing plants. It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste such as natural textiles, paper or processed wood. It also excludes those by-products of food production that never become waste. In this context food waste is defined as any food that has become waste under the condition that (1) it has entered the food supply chain, (2) it has been removed or discarded from the food supply chain or at the final consumption stage, and (3) it is finally destined to be processed as waste (Eurostat 2021). The Tech4Biowaste consortium decided to include waste from food processing plants in the project scope since the overall impact of the database would be much higher, a view that was confirmed by the feedback received from early engagement and interviewing of different stakeholders in the framework of the "Pitch perfect and boost the European

Bioeconomy 2021" event[3] held in Brussels on 28 September 2021. Furthermore, garden and park waste are defined as any biogenic wastes that originate from gardens and parks such as green cuttings or bad harvests.

Within the database the feedstock is divided into food waste and garden & park waste, these are then further categorised in dependence on the waste fraction/stream. As a first step general data will be provided on food waste and garden & park waste (e.g. volumes, statistics). This data can be later further specified upon availability of more specified datasets (e.g. about composition, occurrence, supplier, volumes etc.) about different waste streams from the potential stakeholders. A preliminary subcategorisation is proposed (see appendix, chapter 7.1) and will be finalised upon stakeholder feedback.

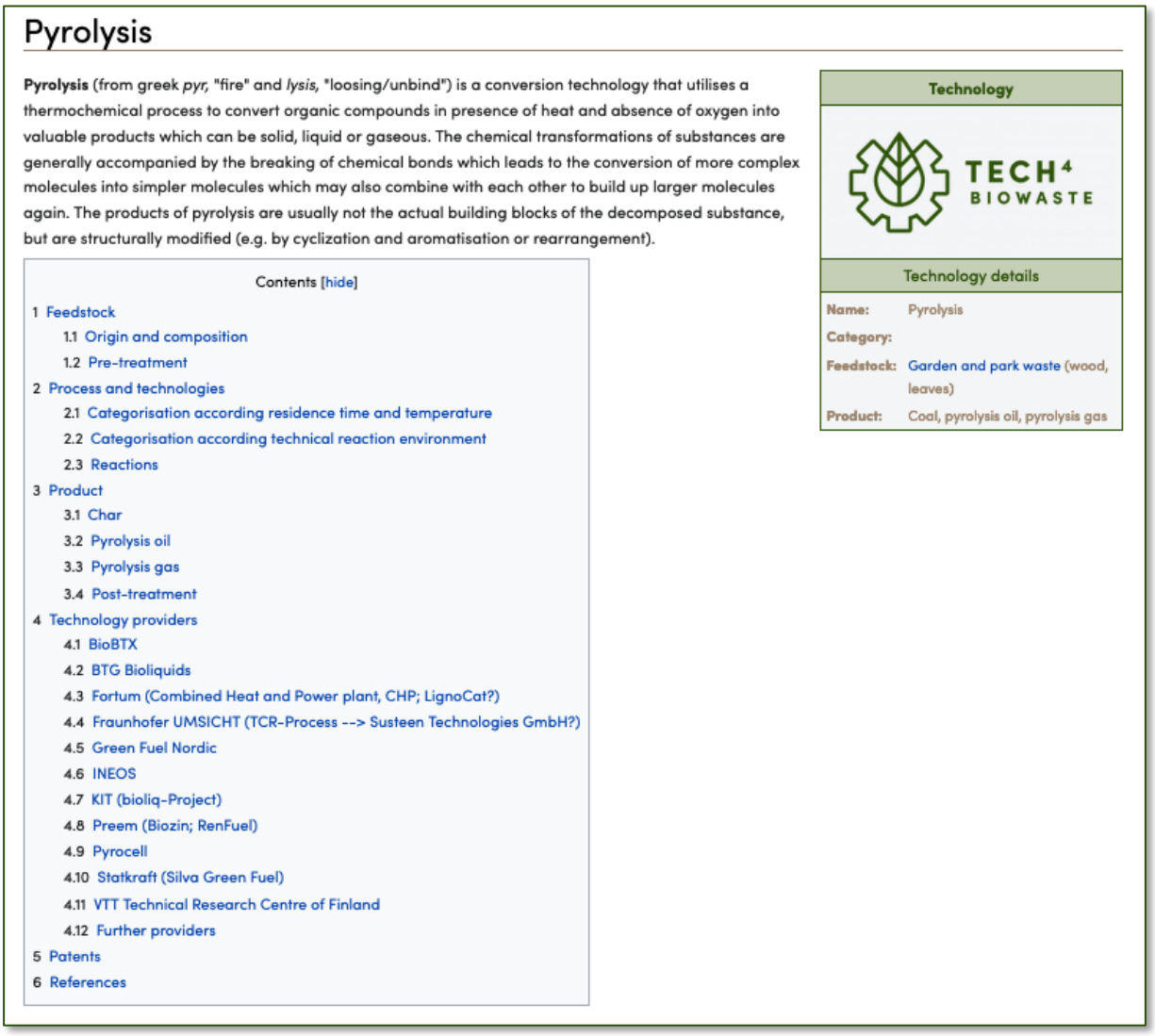
3.2 Technology scope and content

The technology scope considers all emerging and established technologies along the value chain of bio-waste valorisation with Technology Readiness Level (TRL) ≥ 4. Therefore, also applicable pre- and post- treatment technologies are relevant for the database. In order to ensure that users with different background and knowledge are able to quickly find requested information the database includes a harmonised description for each technology. Each general technology will be represented as a separate page with the following structure:

3.2.1 Technology description/introduction

Technology description/introduction of its basic process principles, capabilities, feedstock, product, application fields etc. (Figure 2). The description/style is similar to that of an encyclopaedia article. A technology infobox (Figure 2, top right) as dedicated template within the wiki system delivers first quick and general information about the technology name, category (e.g. primary processing, secondary processing, or hybrid processing), feedstock (e.g. food waste, garden & park waste as well as more specified examples, and product (e.g. chemicals, energy & fuels, food ingredients, or materials). Below the introduction a table of content is implemented (Figure 2, bottom) which will be updated automatically based on the section titles.

[3] https://biopilots4u.eu/events/pitch-perfect-and-boost-european-bioeconomy-2021



Pyrolysis

Pyrolysis (from greek *pyr,* "fire" and *lysis,* "loosing/unbind") is a conversion technology that utilises a thermochemical process to convert organic compounds in presence of heat and absence of oxygen into valuable products which can be solid, liquid or gaseous. The chemical transformations of substances are generally accompanied by the breaking of chemical bonds which leads to the conversion of more complex molecules into simpler molecules which may also combine with each other to build up larger molecules again. The products of pyrolysis are usually not the actual building blocks of the decomposed substance, but are structurally modified (e.g. by cyclization and aromatisation or rearrangement).

Contents [hide]

1 Feedstock
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- 1.2 Pre-treatment

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- 4.2 BTG Bioliquids
- 4.3 Fortum (Combined Heat and Power plant, CHP; LignoCat?)
- 4.4 Fraunhofer UMSICHT (TCR-Process --> Susteen Technologies GmbH?)
- 4.5 Green Fuel Nordic
- 4.6 INEOS
- 4.7 KIT (bioliq-Project)
- 4.8 Preem (Biozin; RenFuel)
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- 4.10 Statkraft (Silva Green Fuel)
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- 4.12 Further providers

5 Patents

6 References

Technology
TECH4 BIOWASTE
Technology details
Name: Pyrolysis
Category:
Feedstock: Garden and park waste (wood, leaves)
Product: Coal, pyrolysis oil, pyrolysis gas

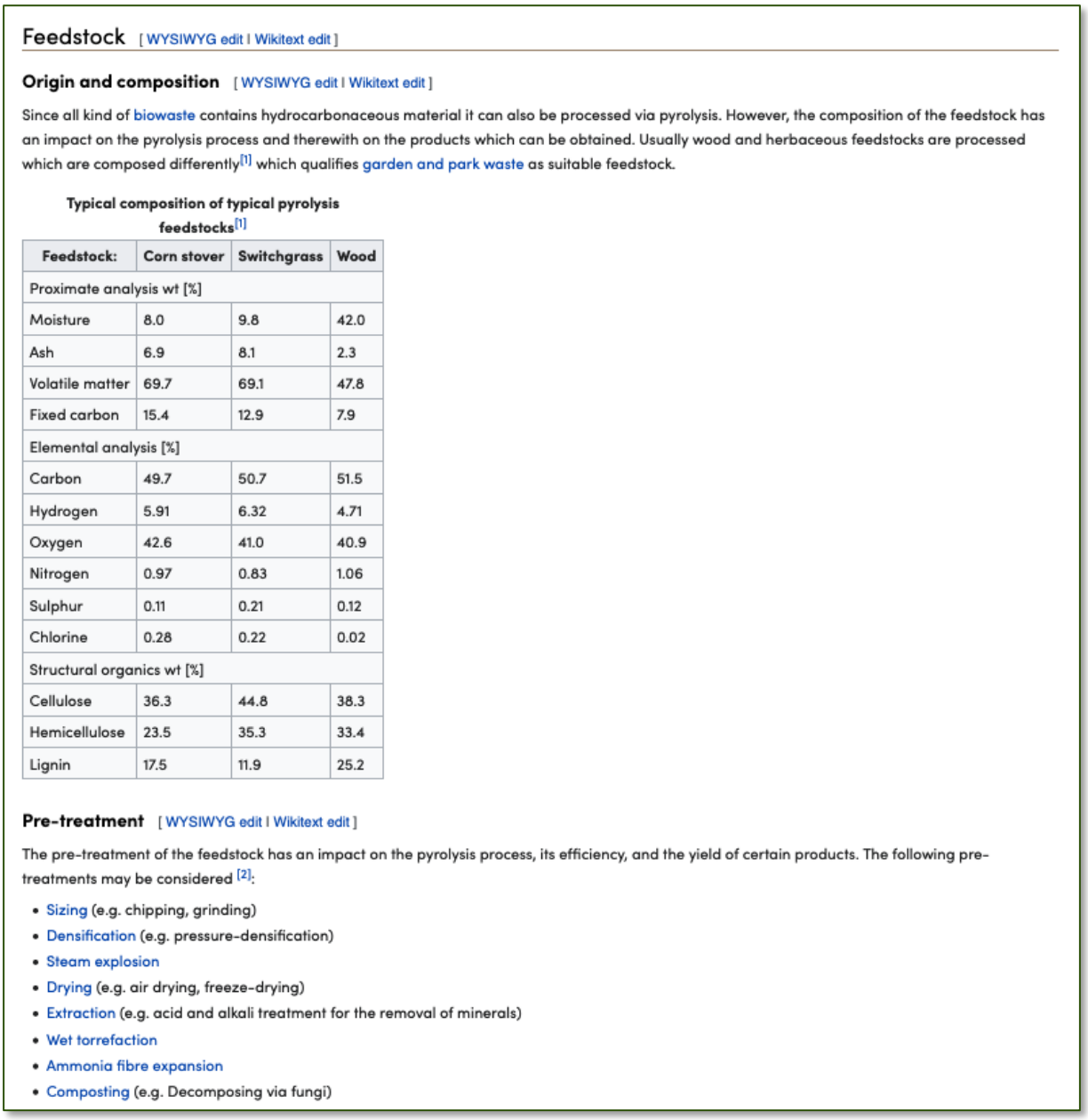
Figure 2: Screenshot of the description/introduction section shown by the example of pyrolysis technology. The technology infobox can be found at the top right, the table of content providing clickable access to the other sections are located at the bottom left.

3.2.2 Feedstock

The feedstock section includes information about the origin and composition of the potential feedstocks as well as suitable pre-treatments (Figure 3).

- **Origin and composition:** Description about which kind of relevant feedstock (biowaste) is usually processed (relevant feedstocks can be found under food waste and garden & park waste). More information about origin and composition (chemical and physical) and how that is related to the process and product outcome (quality, advantages, disadvantages, needs for technology-/process-adaptations with respect to the feedstock composition etc.). Tables will be included to give a better overview.

- **Pre-treatment:** Description or list about pre-treatments that are necessary before the feedstock can be processed via the technology. Primary processing or hybrid processing will be linked where applicable.



Feedstock [WYSIWYG edit | Wikitext edit]

Origin and composition [WYSIWYG edit | Wikitext edit]

Since all kind of biowaste contains hydrocarbonaceous material it can also be processed via pyrolysis. However, the composition of the feedstock has an impact on the pyrolysis process and therewith on the products which can be obtained. Usually wood and herbaceous feedstocks are processed which are composed differently[1] which qualifies garden and park waste as suitable feedstock.

Typical composition of typical pyrolysis feedstocks[1]

Feedstock:	Corn stover	Switchgrass	Wood
Proximate analysis wt [%]			
Moisture	8.0	9.8	42.0
Ash	6.9	8.1	2.3
Volatile matter	69.7	69.1	47.8
Fixed carbon	15.4	12.9	7.9
Elemental analysis [%]			
Carbon	49.7	50.7	51.5
Hydrogen	5.91	6.32	4.71
Oxygen	42.6	41.0	40.9
Nitrogen	0.97	0.83	1.06
Sulphur	0.11	0.21	0.12
Chlorine	0.28	0.22	0.02
Structural organics wt [%]			
Cellulose	36.3	44.8	38.3
Hemicellulose	23.5	35.3	33.4
Lignin	17.5	11.9	25.2

Pre-treatment [WYSIWYG edit | Wikitext edit]

The pre-treatment of the feedstock has an impact on the pyrolysis process, its efficiency, and the yield of certain products. The following pre-treatments may be considered [2]:

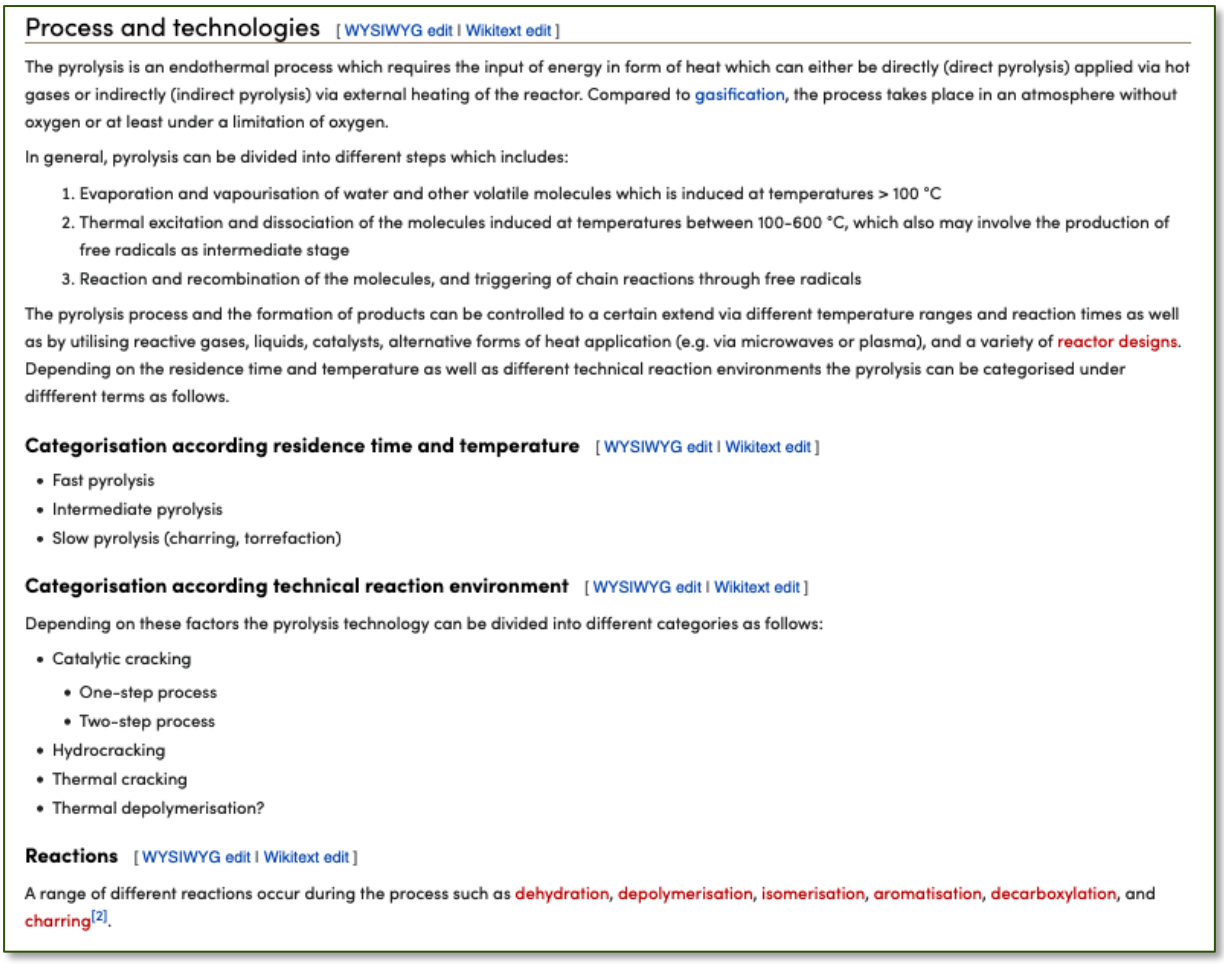
- Sizing (e.g. chipping, grinding)
- Densification (e.g. pressure-densification)
- Steam explosion
- Drying (e.g. air drying, freeze-drying)
- Extraction (e.g. acid and alkali treatment for the removal of minerals)
- Wet torrefaction
- Ammonia fibre expansion
- Composting (e.g. Decomposing via fungi)

Figure 3: Screenshot of the feedstock section shown by the example of pyrolysis technology.

3.2.3 Process and technologies

Main description about the process and technologies including process conditions etc. (Figure 4). The technologies might have further sub-categorisations (for instance pyrolysis can be divided into fast-, intermediate-, and slow pyrolysis). These sub-categories are then used for the technology comparison tool and technology provider infobox (see chapter 4)

under the section technology providers. The sub-categories can be introduced and described in subsections. Reactions or physical principles will be explained in more detail where needed. They can be explained in separate articles/pages which is useful to prevent repetitions when several technologies are based on same principles. Separate articles/pages can be linked accordingly in this section.



Process and technologies [WYSIWYG edit | Wikitext edit]

The pyrolysis is an endothermal process which requires the input of energy in form of heat which can either be directly (direct pyrolysis) applied via hot gases or indirectly (indirect pyrolysis) via external heating of the reactor. Compared to gasification, the process takes place in an atmosphere without oxygen or at least under a limitation of oxygen.

In general, pyrolysis can be divided into different steps which includes:

1. Evaporation and vapourisation of water and other volatile molecules which is induced at temperatures > 100 °C
2. Thermal excitation and dissociation of the molecules induced at temperatures between 100-600 °C, which also may involve the production of free radicals as intermediate stage
3. Reaction and recombination of the molecules, and triggering of chain reactions through free radicals

The pyrolysis process and the formation of products can be controlled to a certain extend via different temperature ranges and reaction times as well as by utilising reactive gases, liquids, catalysts, alternative forms of heat application (e.g. via microwaves or plasma), and a variety of reactor designs. Depending on the residence time and temperature as well as different technical reaction environments the pyrolysis can be categorised under diffferent terms as follows.

Categorisation according residence time and temperature [WYSIWYG edit | Wikitext edit]

- Fast pyrolysis
- Intermediate pyrolysis
- Slow pyrolysis (charring, torrefaction)

Categorisation according technical reaction environment [WYSIWYG edit | Wikitext edit]

Depending on these factors the pyrolysis technology can be divided into different categories as follows:

- Catalytic cracking
  - One-step process
  - Two-step process
- Hydrocracking
- Thermal cracking
- Thermal depolymerisation?

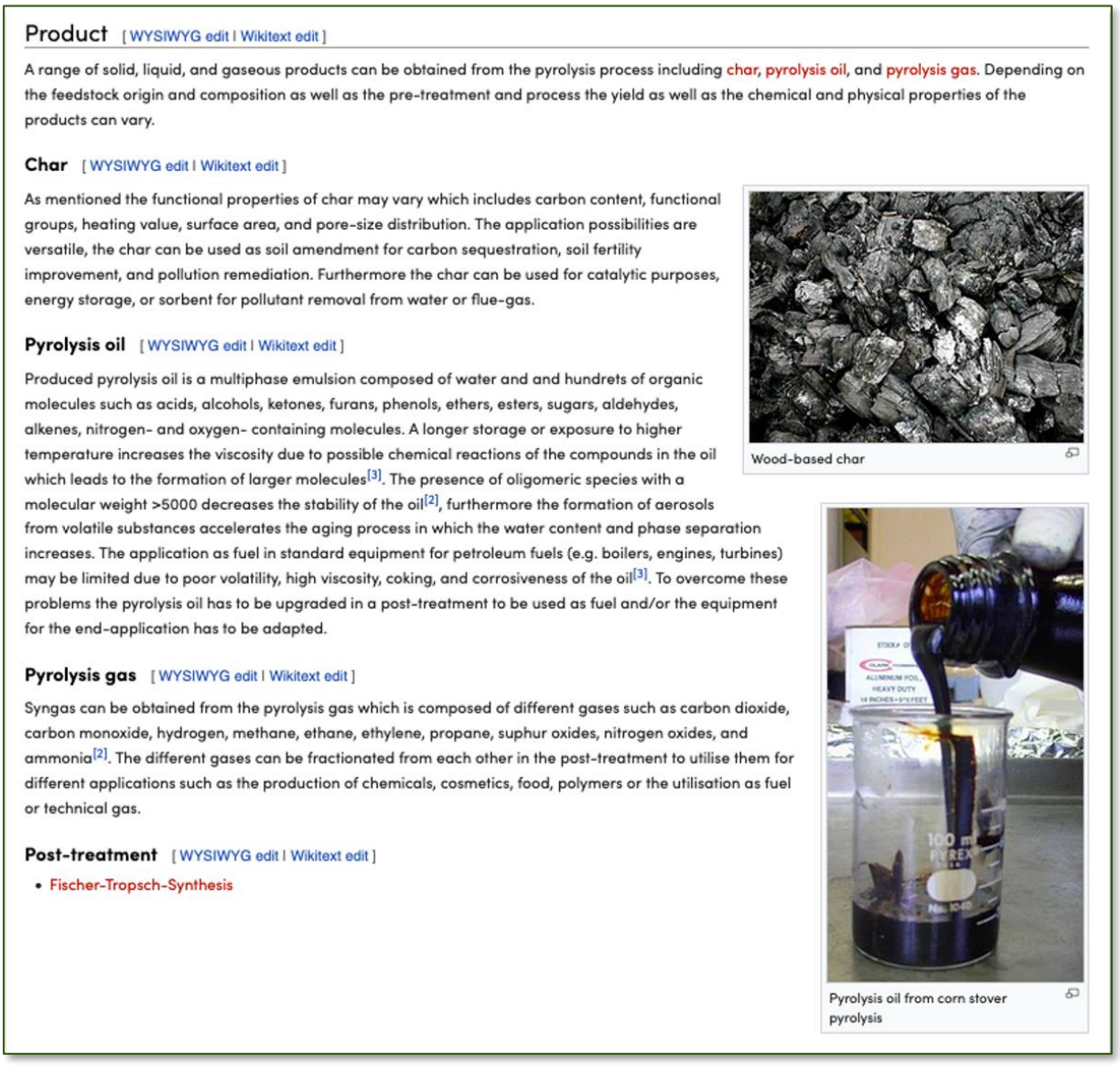
Reactions [WYSIWYG edit | Wikitext edit]

A range of different reactions occur during the process such as dehydration, depolymerisation, isomerisation, aromatisation, decarboxylation, and charring[2].

Figure 4: Screenshot of the process and technologies section shown by the example of pyrolysis technology.

3.2.4 Product

Main description about the products that are obtained including application fields, as well as potential impacts on quality, yield etc. (Figure 5). Subsections are recommended if several products are obtained. For instance, in case of pyrolysis a range of different products can be obtained such as char, pyrolysis oil, and pyrolysis gas. In this case each product will have its separate subsection to ensure clarity.



Product [WYSIWYG edit | Wikitext edit]

A range of solid, liquid, and gaseous products can be obtained from the pyrolysis process including char, pyrolysis oil, and pyrolysis gas. Depending on the feedstock origin and composition as well as the pre-treatment and process the yield as well as the chemical and physical properties of the products can vary.

Char [WYSIWYG edit | Wikitext edit]

As mentioned the functional properties of char may vary which includes carbon content, functional groups, heating value, surface area, and pore-size distribution. The application possibilities are versatile, the char can be used as soil amendment for carbon sequestration, soil fertility improvement, and pollution remediation. Furthermore the char can be used for catalytic purposes, energy storage, or sorbent for pollutant removal from water or flue-gas.

Wood-based char

Pyrolysis oil [WYSIWYG edit | Wikitext edit]

Produced pyrolysis oil is a multiphase emulsion composed of water and and hundrets of organic molecules such as acids, alcohols, ketones, furans, phenols, ethers, esters, sugars, aldehydes, alkenes, nitrogen- and oxygen- containing molecules. A longer storage or exposure to higher temperature increases the viscosity due to possible chemical reactions of the compounds in the oil which leads to the formation of larger molecules[3]. The presence of oligomeric species with a molecular weight >5000 decreases the stability of the oil[2], furthermore the formation of aerosols from volatile substances accelerates the aging process in which the water content and phase separation increases. The application as fuel in standard equipment for petroleum fuels (e.g. boilers, engines, turbines) may be limited due to poor volatility, high viscosity, coking, and corrosiveness of the oil[3]. To overcome these problems the pyrolysis oil has to be upgraded in a post-treatment to be used as fuel and/or the equipment for the end-application has to be adapted.

Pyrolysis oil from corn stover pyrolysis

Pyrolysis gas [WYSIWYG edit | Wikitext edit]

Syngas can be obtained from the pyrolysis gas which is composed of different gases such as carbon dioxide, carbon monoxide, hydrogen, methane, ethane, ethylene, propane, suphur oxides, nitrogen oxides, and ammonia[2]. The different gases can be fractionated from each other in the post-treatment to utilise them for different applications such as the production of chemicals, cosmetics, food, polymers or the utilisation as fuel or technical gas.

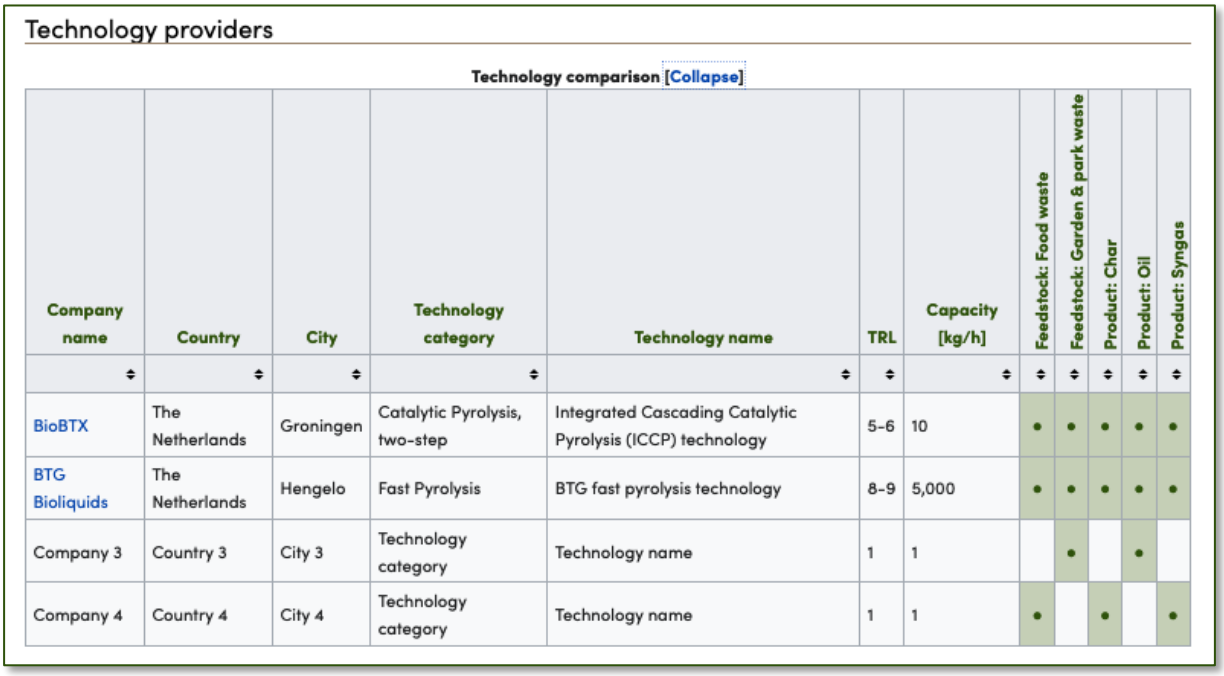
Post-treatment [WYSIWYG edit | Wikitext edit]

- Fischer-Tropsch-Synthesis

Figure 5: Screenshot of the product section shown by the example of pyrolysis technology.

3.2.5 Technology providers

This section begins with the technology comparison tool (Figure 6) that includes a customised selection of the obligatory data fields. Below the technology comparison tool, the companies/technology providers are listed and described in alphabetical order. Each company description starts with a technology provider infobox followed by a coherent text about the technology/provider (Figure 7). The exact data coverage in a technology provider infobox is customised for each technology (since especially the technology and process details as well as the feedstock and product details need relevant/suitable fields). Access to (further details and/or) further providers is available through a link to the Pilots4U Database (Figure 7). The technology comparison tool and technology provider infobox are further described in chapter 4.



Technology providers

Technology comparison [Collapse]

Company name	Country	City	Technology category	Technology name	TRL	Capacity [kg/h]	Feedstock: Food waste	Feedstock: Garden & park waste	Product: Char	Product: Oil	Product: Syngas
BioBTX	The Netherlands	Groningen	Catalytic Pyrolysis, two-step	Integrated Cascading Catalytic Pyrolysis (ICCP) technology	5-6	10	•	•	•	•	•
BTG Bioliquids	The Netherlands	Hengelo	Fast Pyrolysis	BTG fast pyrolysis technology	8-9	5,000	•	•	•	•	•
Company 3	Country 3	City 3	Technology category	Technology name	1	1		•		•	
Company 4	Country 4	City 4	Technology category	Technology name	1	1	•		•		•

Figure 6: Screenshot of the technology comparison tool shown by the example of pyrolysis technology.

BioBTX

[Technology name] provider

General information			
Company:	Bio-BTX B.V.	Webpage:	https://biobtx.com/
Country:	The Netherlands	Contact:	
Technology name:	Integrated Cascading Catalytic Pyrolysis (ICCP) technology	Technology category:	Catalytic Pyrolysis, two-step
TRL:	5-6	Capacity:	10 $kg \cdot h^{-1}$
Technology and process details			
Reactor:	Fluidised sand bed, fixed bed	Heating:	Fluidised sand bed
Atmosphere:	Inert	Pressure:	1-4 bar
Capacity:	10 $kg \cdot h^{-1}$	Temperature:	450-650 °C
Catalyst:	Zeolite	Other:	Unknown
Feedstock and product details			
Feedstock:	Biomass (liquid, solid), wood pulp lignin residues, used cooking oil	Product:	Benzene, toluene, xylene, aromatics, light gases

BioBTX was founded in 2012 by KNN and Syncom, in collaboration with the university of Groningen, Netherlands. The company is a technology provider developing chemical recycling technologies for different feedstocks including non-food bio- and plastics waste. In 2018 a pilot plant with the capability to process biomass and plastic waste was set up at the Zernike Advanced Processing (ZAP) Facility. The company is now focused on setting up their first commercial plant with a capacity of 20,000 to 30,000 tonnes. The investing phase B was recently completed, with the last investment phase in 2019 the financial requirements are fulfilled to complete the commercialisation activities to build the plant which is expected for 2023.

The technology is based on an Integrated Cascading Catalytic Pyrolysis (ICCP) process, being able to produce aromatics including benzene, toluene, and xylene (BTX) as well as light olefins from low grade biomass and plastics waste. This technology utilises catalytic cracking in a two-step process at temperatures between 450- 850 °C. In the first step the feedstock material is vaporised via thermal cracking. The pyrolysis vapours are then directly passed into a second reactor in which they are converted into aromatics by utilising a zeolite catalyst which can be continuously regenerated. Finally, the products are separated from the gas via condensation. An ex situ approach of catalytic conversion has several advantages such as the protection of the catalyst from deactivation/degradation expanding its lifetime, a greater variety of feedstock, and a precise adjustment of process conditions (e.g. temperature, catalyst design, and Weight Hourly Space Velocity (WHSV) in each step for improved yields. In current pilot plant with 10 kg h-1 feed capacity for either waste plastics or biomass, final design details are established, which will be include in the running engineering activities for the commercial plant.

Further providers

Pilots4U Database

Figure 7: Screenshot of the technology provider section showed by the example of pyrolysis technology.

3.2.6 Patents and references

Relevant patents und used references (Figure 8) can be listed and discussed in these sections. The references will be automatically added/updated/sorted once they were inserted via the citation function of the Tech4Biowaste database.

Patents

References

1. ↑ [a] [b] Carpenter, D., Westover, T. L., Czernik, S. and Jablonski, W., 2014: Biomass feedstocks for renewable fuel production: a review of the impacts of feedstock and pretreatment on the yield and product distribution of fast pyrolysis bio-oils and vapors. Green Chemistry, Vol. 16, (2), 384-406. doi: https://doi.org/10.1039/C3GC41631C
2. ↑ [a] [b] [c] [d] Hu, X. and Gholizadeh, M., 2019: Biomass pyrolysis: A review of the process development and challenges from initial researches up to the commercialisation stage. Journal of Energy Chemistry, Vol. 39, 109-143. doi: https://doi.org/doi:https://doi.org/10.1016/j.jechem.2019.01.024
3. ↑ [a] [b] Czernik, S. and Bridgwater, 2004: Overview of Applications of Biomass Fast Pyrolysis Oil. Energy & Fuels, Vol. 18, (2), 590-598. doi: https://doi.org/10.1021/ef034067u

Figure 8: Screenshot of the Patents and references section showed by the example of pyrolysis technology.

The exact content (data fields) of technology provider infoboxes is fine-tuned to reflect the character of the specific technology. Supplier details, general information and supplementary information will be the same for each and every technology. However, a select number of certain details (e.g. about the process, feedstock or product) may vary depending on the technology. Each company and their technology need to be represented in the comparison tool, a technology provider infobox, and in a coherent text which requires different information with different priorities (Table 1). This will ensure the core functionalities of the technology comparison- as well as the matchmaking-tool.

	Information	Obligatory	Preferred	Optional	Comparison	Technology provider infobox	Text
Supplier details	City (HQ and/or facility)	X					X
	Contact	X				X	
	Company name	X			X	X	
	Country (HQ)	X			X	X	
	Webpage (URL)	X				X	
General information	"Brand name"	X			X	X	
	Capacity	X			X	X	
	Category (T4B category)	X			X	X	
	Maturity (TRL)	X			X	X	
	Feedstock/Input, basic info (T4B category)	X			X		
	Product/Output, basic info (T4B category)	X			X		
Detailed information	Company profile and strategy		X				X
	Feedstock/Input more specified (T4B category)	X				X	X
	Feedstock/input requirements/composition	(X)	(X)		(X)		X
	Needed/Optional pre-/post-treatments		X				X
	Other			X		X	X
	Product/Output more specified	X				X	X
	Product/Output quality/composition	(X)	(X)		(X)		X
	Technology/Process details (T4B category)	X			X	X	
	Technology/Process detailed description		X				X
Supplementary information	Business model			X			X
	Combined use with other technologies			X			X
	Economic data			X			X
	Engineering studies			X			X
	Environmental data (LCA, etc.)			X			X
	Patent & IPR situation			X			X

Table 1: Data fields including different priorities of information for the comparison tool, technology provider infobox, and text. Checkmarks in brackets (X) indicate that this only partially applies depending on the technology.

3.3 Product scope and content

Four major product groups were defined to cover all relevant products as follows:

- Chemicals (such as bulk and fine chemicals)
- Energy & fuels (such as electricity and heat or syngas)
- Food ingredients (such as binding agents or nutritional components such as proteins, sugar, and other supplements)
- Materials (such as polymers)

The product scope remains to be defined in more detail.

4 Database functionalities

Essential functionalities of the database will be delivered via a technology comparison tool (Figure 9) and a matching tool in form of a technology provider infobox (Figure 10) as well as a coherent text about the technology/provider. The comparison tool is based on a sortable table which allows the user to sort the technology providers according to different criteria such as company name, country, capacity, category, maturity, feedstock, product, or process details. Depending on the technology different suitable criteria may be defined for each technology page. Once the user has found a suitable technology provider via the comparison tool the user can be directed to the matching tool via a direct link. From there the user will find summarised information about the company and technology in form of a technology provider infobox as well as further and more detailed information in form of a coherent text. Depending on the technology different technology provider infoboxes are defined for each technology page in form of dedicated templates within the wiki system. Different priorities need to be defined for the provided information since there might be a risk for an impaired user-experience if contributors do not provide information on critical data fields. This will ensure the core functionalities of the technology comparison- as well as the matchmaking-tool. Obligatory information will ensure core functionalities, such information is requested for instance for all data fields of the technology comparison tool to ensure that all technology providers can be sorted according certain criteria. The purpose of the technology comparison tool would no longer be given if several data fields would be left empty. Preferred information refers mainly to information that improves the quality of the matching tool. With this information, the user or technology searcher can easily identify suitable technology providers e.g. based on the company's strategy or technology details. Optional information will further improve the overall quality of information but is not essentially necessary for the identification of suitable technology providers. Furthermore, optional information may also include data that some companies cannot or do not want to disclose. Information with different priorities for the text are summarised as follows:

Obligatory information on:

- City of Headquarter and/or facility/plant -location
- Feedstock/Input more specified (analogous to technology infobox, if possible: link to feedstocks from biowaste, garden and park waste, and food waste)
- Product/Output more specified (analogous to technology infobox)

Preferred information on:

- Company profile and strategy
- Feedstock/input requirements/composition
- Needed/Optional pre-/post-treatments. They will be linked with suitable candidates from primary processing or hybrid processing.
- Product/Output quality/composition
- Technology/Process details (explaining the technology and process details from the comparison tool/technology provider infobox in a coherent text)

Optional information on:

- Business model
- Combined use with other technologies
- Economic data
- Engineering studies
- Environmental data (LCA, etc.)
- Patent & IPR situation

Technology comparison [Collapse]

Company name	Country	Technology category	Technology name	TRL	Capacity [kg/h]	Detailed information 1 [unit]	Detailed information 2 [unit]	Feedstock: Food waste	Feedstock: Garden & park waste	Product: Product 1	Product: Product 2	Product: Product 3
Company 1	[Country HQ location]	[Technology category (if different sub-categories are defined this has to be specified here, the available categories can be found on each technology page under the chapter Process and technologies)]	[Technology name (the "branded name" or the usual naming from company side)]	[4-9]	[numeric value]				•	•		
Company 2	[Country HQ location]	[(if different sub-categories are defined this has to be specified here, the available categories can be found on each technology page under the chapter Process and technologies)]	[Technology name (the "branded name" or the usual naming from company side)]	[4-9]	[numeric value]			•				•

Figure 9: General layout of the technology comparison tool realised via a sortable table. The comparison tool will be adapted for each technology.

[Technology name] provider

General information			
Company:	[Company name]	Webpage:	[URL]
Country:	[Country HQ location]	Contact:	[e-mail address]
Technology name:	["Brand name"]	Technology category:	[Secified technology sub-category from chapter process and technologies]
TRL:	[4-9]	Capacity:	[numeric value] $kg \cdot h^{-1}$
Technology and process details			
Obligatory detail 1:	[Detail 1] [unit]	Obligatory detail 2:	[Detail 2] [unit]
Obligatory detail 3:	[Detail 3] [unit]	Other:	[Other information, free to choose]
Feedstock and product details			
Feedstock:	[more specified feedstocks, (if possible: link to feedstocks from biowaste, garden and park waste, and food waste)]	Product:	[more specified products, (if possible: link to products)]

Figure 10: General layout of the technology provider infobox which can be inserted as template and will be adapted for each technology.

5 Conclusion and discussion

The established blueprint ensures to provide a complete overview of new and emerging technologies with TRL ≥ 4 that are capable to valorise biowaste streams into useful products.

In order to ensure a clear overview about the main aspects of biowaste utilisation the established database structure (see chapter 2) has three main categories including feedstocks, technologies, and products. The contents and sub-categories can be crosslinked with each other within the wiki-system to ensure that the user of the database can perform search queries starting from the feedstock- or product- as well as from the technology side.

With the defined scope the database (see chapter 3) has a clearly defined target group of protentional stakeholders including technology providers (core technologies, technologies for pre- and post-treatments, upgrading) and technology searchers (e.g. waste producers including food waste and garden & park waste). In order to ensure that users with different background knowledge are able to quickly find requested information the database includes a standardised description for each technology. General technology descriptions (including category, processable feedstocks and their pre-treatments, possible products and post-treatments, technology description and providers, patents, and references) will enable even non-experts to understand the basic aspects of the technology and its overall context within the framework of biowaste valorisation.

Essential functionalities of the database are established via a technology comparison tool and a matching tool (see chapter 4). Once the user has found a suitable technology

provider via the comparison tool, he will be directed to the matching tool. From there the user will find further and more detailed information about the company and technology. However, there might be a risk for an impaired user-experience if contributors do not provide information on critical data fields. Therefore, the definition of different priorities (see chapter 3 and 4) of the implemented data fields will ensure the core functionalities of the technology comparison- as well as the matchmaking-tool.

From a long-term perspective the established blueprint will and needs to be further refined upon feedback and requests of the users and contributors of the database to ensure a dynamic development of a functional design that is tailored to all potential stakeholders of the Tech4Biowaste database. This will include the development of the front-end (the presentation layer, or end-user facing views), the back-end (the data access layer, or administrative views). Data sheets, templates, tables, tools and classifications that facilitate the drafting of technology descriptions will also be further developed. More details about refinements as well as the technical set-up and aspects of programming the technology database will be summarised in Deliverable D3.1 - Description of the technical set-up and programming of the technology database which will be due in January 2022.

6 References

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7 Appendix

7.1 Feedstock subcategorisation

The following subcategorisation for feedstocks is proposed and will be further refined upon stakeholder feedback.

7.1.1 Food waste

- Kitchen waste
  - Cheese rinds without plastic
  - Coffee grounds, coffee filter, coffee pads
  - Egg shells
  - Flowers and (house) plants
  - Food waste (boiled, fried, raw)
  - Fruit and vegetable peelings
  - Gravy
  - Kitchen paper, soiled with food
  - Nuts and nuts shells
  - Plant pots made of organic material
  - Tea leaves and bags
  - Used cooking oil & grease

- Food industry waste
  - Beverages
  - Bread
  - Bulk organic waste
  - Dairy products
  - Decommissioning of the agri-food industry
  - Fruit and vegetable waste
  - Packaged food waste (various packaging except glass and ceramic) including raw and processed meat, poultry and fish waste
  - Packaged organic waste (e.g. tetra)
  - Raw materials from the food industry
  - Rejects from food industry
  - Prepared dishes, sauces
  - Meat, eggs, fish, ...
  - Sweets, food supplements

7.1.2 Garden & Park waste

- Bad harvests
- Grass, turf, roadside clippings
- Leaves, trunks and branches
- Pruning waste
- Soil, potting compost
- Tree roots, stumps

7.2 Technology subcategorisation

The following subcategorisation for technologies is proposed and will be further refined upon stakeholder feedback.

7.2.1 Primary processing

- Biochemical processes and technologies
  - Aeration
  - Anaerobic digestion
  - Composting
  - Insect farming
  - Enzymatic processes
  - Chemical processes and technologies (these might be hybrid processing, see chapter 7.2.3)

- Chemical processes and technologies (these might be hybrid processing, see chapter 7.2.3)
  - Hydrolysis
    - Acid
    - Alkali
    - Salt
      - Metal salts
      - Sulphite salt
    - Solvent
      - Organosolv
  - Ionic liquids
  - Oxidation

- Hybrid processes and technologies
  - Pulping
    - Chemical pulping
      - Organosolv
      - Soda
      - Sulphate
      - Sulphite
    - Hybrid pulping
      - Chemithermomechanical pulping (CTMP)
      - Neutral Sulfite Semi Chemical pulping (NSSC)
    - Mechanical pulping
      - Refiner
        - Refiner mechanical pulping (RMP)
        - Thermomechanical pulping (TMP)
      - Groundwood
        - Pressure groundwood (PGW)
        - Stone groundwood (SGW)
        - Thermal groundwood (TGW)

- Physical processes and technologies (these might be hybrid processing, see chapter 7.2.3)
  - Densification
  - Sizing
    - Chipping
    - Grinding

    - Microwave treatment
    - Steam explosion
    - Thermal expansion
    - Ultrasonication

- Thermochemical processes and technologies
    - Ammonia fibre expansion
    - Gasification
    - Hydrothermal processing
    - Pyrolysis
    - Torrefaction

7.2.2 Secondary processing

- Biochemical processes and technologies
    - Gas fermentation
    - Industrial fermentation
    - Solid state fermentation
    - Other biocatalytic conversions
        - In vitro processes
        - In vivo processes

- Chemical processes and technologies
    - Heterogeneous catalysis
    - Polymerisation

- Material processes and technologies
    - Biocomposite processing
    - Coating and lamination
    - Fibre web production
    - Nano/micro fibre production
    - Textile fibre spinning

- Thermochemical processes and technologies
    - Gasification
    - Pyrolysis

7.2.3 Hybrid processing

- Separation technologies
    - Mechanical separations
        - Centrifugation
        - Membrane filtration
        - Particle classification, sieving
        - Particle filtering
    - Physicochemical separations
        - Chromatography
        - Crystallisation and precipitation
        - Distillation
        - Drying
            - Air drying
            - Nitrogen drying
            - Freeze drying
            - Thermal drying
            - Vacuum drying
        - Extraction

        - Field-Flow fractionation (FFF)
            - Asymmetric flow FFF (AF4)
            - Centrifugal FFF
            - Electrical FFF
            - Split flow thin-cell fractionation (SPLITT)
            - Thermal FFF
        - Flocculation

    - Other
        - Integrated hydroxyl radicals and hot water pre-treatment (IHRWT)

7.3 Product subcategorisation

The following categorisation for products is proposed and will be further refined upon stakeholder feedback, further subcategorisation remains to be developed:

- Chemicals
- Energy & fuels
- Food ingredients
- Materials