Delivery of sustainable supply of non-food biomass to support a
"resource-efficient" Bioeconomy in Europe

S2Biom Project Grant Agreement n°608622

D2.3
Database of biomass conversion technologies

29 Feb 2016




About S2Biom project

The S2Biom project - Delivery of sustainable supply of non-food biomass to support a "resource-efficient" Bioeconomy in Europe - supports the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing strategies, and roadmaps that will be informed by a "computerized and easy to use" toolset (and respective databases) with updated harmonized datasets at local, regional, national and pan European level for EU28, Western Balkans, Moldova, Turkey and Ukraine. Further information about the project and the partners involved are available under www.s2biom.eu.

Project coordinator

Scientific coordinator

Project partners

About this document

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Executive Summary

This report describes the database that contains biomass conversion technologies, which was prepared for the S2Biom project. The database itself can be accessed online, at: http://s2biom.alterra.wur.nl.

The database contains about 50 entries, describing technologies in the following main categories:

- Direct combustion
- Gasification (and the syngas platform)
- Fast Pyrolysis
- Torrefaction
- Techniques from the pulp and paper industry
- Biochemical conversion technologies

In the process of creating the database a link was made with WP7, in order to take up the technologies relevant for producing the products described in the product market combinations that were defined in WP7. For heat, power and fuels, several technologies are available in the database, while for other bio-based products (especially through the sugar platform) some but fewer conversion technologies are available. This is a representation of the technology readiness levels and the current and expected market situation of these products.

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1. Introduction

The overall objectives of WP 2 are the following:

- To identify and extensively characterise existing and future non-food biomass conversion technologies for energy and bio-based products.
- To develop a standardized methodology according to which the different biomass categories identified and quantified in WP1 need to be characterised.
- To assess the optimal match of biomass categories of different quality with the existing and future non-food biomass conversion technologies.

This D2.3 report provides background information on the development of the database of biomass conversion technologies, which is now available online.[1] Biomass conversion technologies form the essential link between a variety of lignocellulosic biomass sources (WP1) of which a wide range of properties were gathered in the biomass characteristics database (D2.4), and a variety of final products (described in WP7).

Conversion technologies and end use applications (both bio-energy and bio-based products) are the essential elements of each pathway, and were characterised in detail in this task, and gathered in an online database. This includes existing conversion technologies (Subtask 2.1.1) as well as future conversion technologies up to 2030, including novel biorefinery concepts that are based on biochemical processes (Subtask 2.1.2) and thermochemical processes (Subtask 2.1.3).

This database and the biomass characteristics database together provide the relevant data for the selection method to optimally match biomass types with the most suitable conversion technologies (D2.2). This selection method will be further developed into a matching tool (part of WP4) for optimisation of biomass use from a technical perspective, with linkages to pretreatment and logistical parameters as developed in WP3. Figure 1 shows the linkages between WP1-4.

The following linkages with other WPs were established:

- WP1: the selected technologies cover the biomass sources assessed in WP1.
- WP3: the selection of technologies was done in close cooperation with WP3 logistics.
- WP4: the database structure was developed in close cooperation with WP4, especially taking into account the requirements for the biomass and technology matching tool.
- WP7: coordination was established on the information needed for the RESolve model as well as on the product-market combinations described in deliverable D7.2.
- All information has been available through the viewing tool in WP4, also for use in other WPs (theme 2 and 3).

[1] The actual database can be accessed at http://s2biom.alterra.wur.nl under the tab “biomass chain data”, by clicking “conversion technologies”.

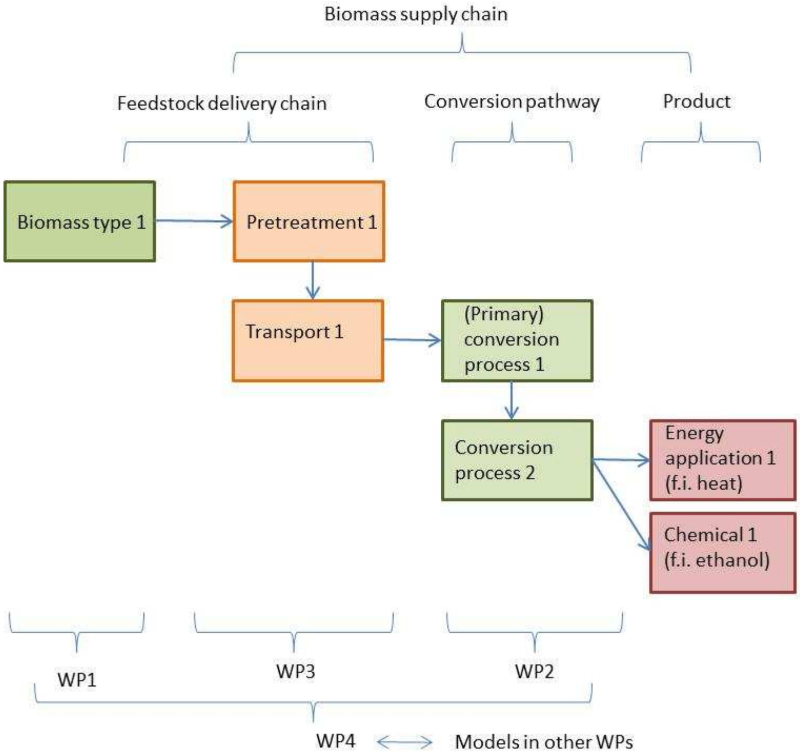


Figure 1. Structure of WP2 in WP1-4 of the S2Biom project

2. Contents of the database

This chapter describes the technologies that were taken up in the database, which bio-based products these technologies cover (including energy), the link with the product-market combinations that were defined in WP7, as well as the main characteristics of the technologies that can be found in the database.

2.1 Overview of conversion technologies in the database

The rationale behind the selection of the conversion technologies was described in deliverable D2.1, “A method for standardized biomass characterization and minimal biomass quality requirements for each biomass conversion technology”, as well as which technologies were selected.
Table 1 summarizes the conversion technologies that were taken up in the database.

In order to be able to match the technology requirements with biomass characteristics, the different technologies were categorized into three main categories, all with a different set of specifications, as described in deliverable D2.2, “A selection method to match biomass types with the best conversion technologies”. The first category contains thermal conversion technologies, with requirements for corrosion, ash agglomeration (fouling), ash content, and NO_x emissions. The second category contains both chemical and biochemical processes that have requirements on the lignin, (hemi-) cellulose and ash content. The third category specifically contains anaerobic digestion, and has requirements for digestibility and biogas yield.

Each category is further split down into three levels, in order to provide sufficient level of detail to distinguish each technology. An example of this is for thermal conversion processes: one category (level 1) is ‘direct combustion of solid biomass’, with subcategory (level 2) ‘fluidized bed combustion’, and process name (level 3) Circulating Fluidized Bed direct combustion’.

Table 1. Conversion technologies described in the database.

Category	Subcategory	Process name
Thermal conversion technologies		
Direct combustion of solid biomass	Fluidised bed combustion for CHP (steam cycle)	BFB direct combustion
		CFB direct combustion
	Fixed bed combustion for heat	Grate boiler for heat
	Fixed bed combustion for CHP (steam cycle)	Grate boiler with wood chips for CHP
		Grate boiler with agrobiomass for CHP
	Direct co-combustion in coal fired power plants	Co-firing in PC
	Waste incinerators with energy recovery	Grate fired waste incinerator
	Domestic pellet burners for heat	Pellet boiler for heat
	Domestic residential batch fired stoves for heat	Batch stove for heat

Gasification technologies	Circulating Fluidized bed for CHP (gas engine)	CFB for CHP
	Circulating Fluidized bed for IGCC	CFB for IGCC
	Bubbling fluidized bed for CHP (gas engine)	BFB for CHP
	Circulating Fluidized bed for syngas production	CFB for syngas
	Dual Fluidized bed for CHP (gas engine)	DFB for CHP
	Dual Fluidized bed for syngas production	DFB for syngas
	Entrained flow for syngas production	Entrained flow for syngas
	Fixed bed (downdraft) for CHP (gas engine)	Fixed bed for CHP
	Fixed bed (updraft), direct combustion	Fixed bed, direct combustion
	Bubbling fluidized bed for IGCC	BFB for IGCC
	Bubbling fluidized bed for syngas production	BFB for syngas
Syngas platform	Fluidised bed gasification for methanol production	Syngas to methanol
	Indirect gasification for SNG production	Producer gas to biomethane
	Fluidised bed gasification for FT-fuels production	Syngas to FT-diesel
Fast pyrolysis	Pyrolysis plus boiler for heat and steam	Fresh wood chips to pyrolysis oil
		Agricultural residues to pyrolysis oil
		Pyrolysis oil to heat
		Pyrolysis oil to steam
	Pyrolysis and hydrogenation for diesel fuel	Pyrolysis oil diesel
	Pyrolysis oil and diesel engine for electricity	Pyrolysis combustion engine (compression-ignition)
		CHP Gas Turbine
	Pyrolysis plus boiler for heat and steam	Pyrolysis plus boiler for heat, integrated
	Pyrolysis plus boiler for heat and steam	Pyrolysis plus boiler for steam, integrated
	Pyrolysis oil and diesel engine for electricity	Pyrolysis plus combustion engine, integrated
	Pyrolysis oil and diesel engine for electricity	Pyrolysis plus CHP, integrated
Torrefaction	Moving bed reactor	torrefaction and pelletisation (TOP)
(Bio-)chemical conversion technologies		
Techniques from pulp and paper industry	Kraft process with LignoBoost process	Kraft process with Lignoboost
	Prehydrolysis Kraft process in water phase	Prehydrolysis kraft
Chemical pretreatment	Alkaline hydrolysis	Alkaline hydrolysis
	Dilute acid hydrolysis	Dilute acid hydrolysis
Biochemical hydrolysis and fermentation	Enzymatic hydrolysis	Enzymatic hydrolysis alkaline pretreated
		Enzymatic hydrolysis acid pretreated
	Fermentation	Fermentation alkaline pretreated
		Fermentation acid pretreated
Biochemical ethanol and biobased products	Simultaneous saccharification and fermentation	Ethanol from lignocellulose (dilute acid pretreatment), value chain example
Treatment in subcritical water	Aqueous Phase Reforming	Aqueous Phase Reforming

Anaerobic digestion technologies		
Anaerobic digestion	Complete mix digester	Complete mix digester state of the art 2014
Anaerobic digestion	Plug flow digester	Dry Batch Digestion (MSW)

Abbreviations:
BFB: bubbling fluidized bed
CFB: circulating fluidized bed
CHP: combined heat and power
DFB: dual fluidized bed
FT: Fischer-Tropsch
IGCC: integrated gasification combined cycle
MSW: municipal solid waste
PC: pulverized coal-fired boiler
SNG: synthetic natural gas

2.2 Bio-based products covered by the database

WP7 defined ten product market combinations (PMCs) for bio-based products (D7.2). These are shown in Table 2.

Table 2. Product Market Combinations of bio-based (lignocellulosic) products, with their expected contribution to the EU28 demand in 2020 and 2030, as described in D7.2.

	Product	Market	PJ in 2020	PJ in 2030
1.	Heat	District heating	3242	4740
2.	Electricity	Power market	743	1040
3.	Advanced biofuels	Transport fuel	112	629
4.	C6 sugars	Polymers & plastics, solvents, surfactants	8	23
5.	C5 sugars			
6.	Biomethane	Grid, transport	64	188
7.	Aromatics (BTX)	Petrochemical industry	9	26
8.	Methanol	Transport, chemical industry	3	13
9.	Hydrogen	Transport, (petro)chemical industry	2	19
10.	Ethylene	(petro)chemical industry	0	23

The technology database covers the production of heat and electricity extensively, because these technologies are currently the furthest developed and widely available. The production of advanced biofuels is covered by a number of technologies, such as through biochemical production of cellulosic ethanol as well as through the production of drop-in fuels with pyrolysis or gasification. Biomethane was covered by incorporating production technologies through anaerobic digestion and gasification. For methanol the production route through gasification was incorporated, as described in D7.2c. For the PMCs 7, 9 and 10 (BTX, hydrogen, ethylene), no data could be obtained of a sufficient quality to take up the technologies in the database.

With regards to the production of bio-based products through the sugar platform, it was decided only to take up the product ethanol in the database, through the combination of the separate entries for pretreatment and enzymatic hydrolysis (producing C5/C6 sugars) with fermentation (converting the sugars into ethanol). The rationale for creating such value chains in the database and for only taking up ethanol as a product and no other sugar-based products (e.g. bioplastics) is explained in the following paragraph.

2.2.1 Products of the sugar platform

Author of this paragraph: P. Harmsen (DLO)

Sugars or carbohydrates are an important raw material for food and feed. In addition, carbohydrates play an important role in the Biobased Economy, especially for applications in the biofuel sector and the chemical industry, as many of the chemicals and materials from fossil resources can also be produced from carbohydrates. Many developments are taking place to change from petrochemical to renewable raw materials, and carbohydrates play an important role. In a Biobased Economy the demand for renewable raw materials is large and resource efficiency is an important topic. This

requires a tailor-made approach, in which (a) desired product(s) or chemical building block is coupled to the most suitable biomass and vice versa.
'Carbohydrate' is a collective name for a number of different sugar commodities. A major source of sugar is sugar beet and sugar cane from which table sugar or granulated sugar is made (sucrose, a disaccharide). Also starch crops like cereals (maize, wheat) and potatoes are a rich source of carbohydrates (starch, a glucose polymer). These biomass sources are so called 1G-materials, they are used for food and feed. In addition, wood and other lignocellulose material contain the carbohydrate polymers cellulose and hemicellulose (and also lignin). These sources are called 2G-materials as they cannot be used for food (humans cannot digest cellulose).
The relationship between raw biomass, type of carbohydrates, fermentable sugars as key intermediate product and chemical building blocks is shown in Figure 2.

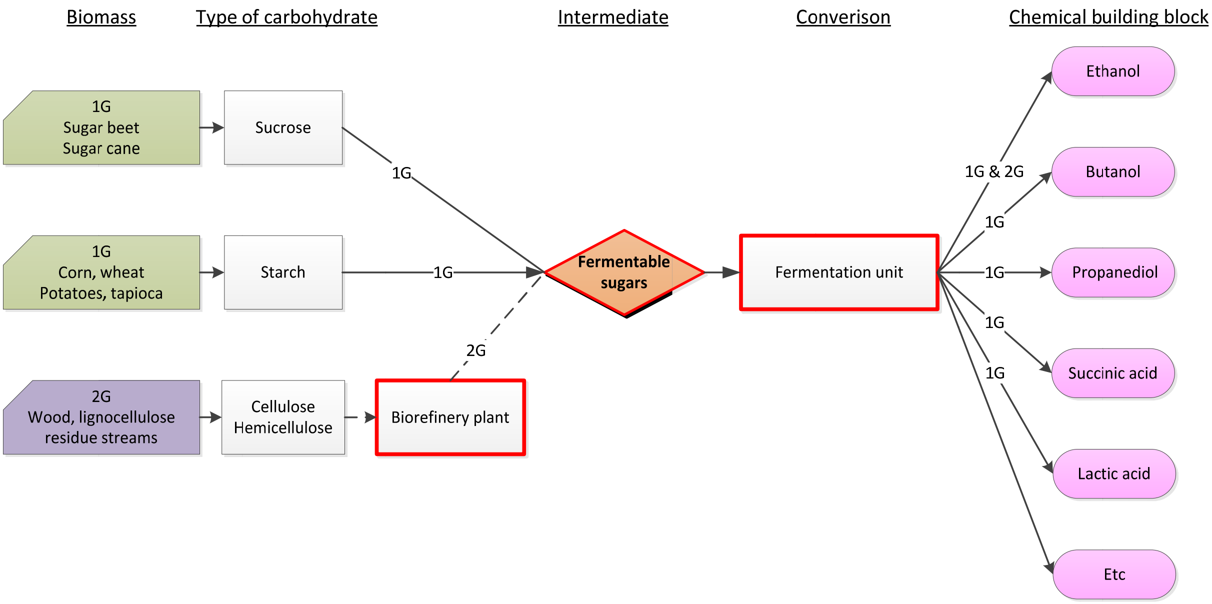


Figure 2. Relationship between raw biomass materials, carbohydrates, intermediate product and chemical building blocks.

The following remarks can be made in connection to Figure 2:

- 1G biomass is easily converted to high-purity sugars with conventional technology. On average, 1G biomass (sugar or starch rich raw materials) contains 72 wt% dry matter carbohydrates. Isolation efficiency of these carbohydrates is 95%.
- 2G biomass also contains carbohydrates but these are more difficult to isolate as the polymers are imbedded in a lignocellulosic matrix with lignin, a strong polymer of aromatics. On average, 60 wt% of the dry biomass are carbohydrates, and these carbohydrates can be isolated with an efficiency of 80%. These sugar streams are less pure than sugars from 1G biomass due to the isolation and extraction processes. Further purification is a costly process.
- Sucrose can be fed to the fermentation unit directly, and starch can be enzymatic hydrolysed by amylases to glucose prior to fermentation. The latter is also used to produce High fructose corn syrup (HFCS), which can be used in the production of drinks and food.

- For the conversion of cellulose and hemicellulose (from lignocellulosic biomass) to sugars a biorefinery plant is required. This biorefinery plant can be compared to a pulp mill for the production of paper, with the difference that the carbohydrate polymers cellulose and hemicellulose are now further degraded to monomers for fermentation. A schematic representation of the biorefinery plant is shown below, including the two main processing steps:

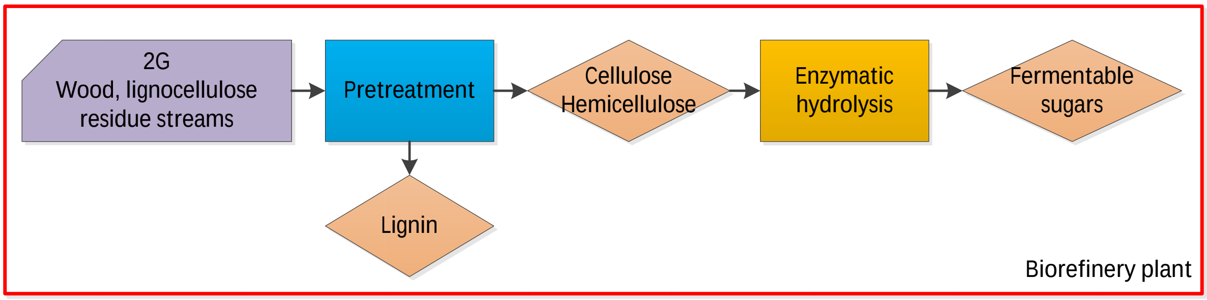


Figure 3. Biorefinery plant.

Pretreatment is the first and also crucial step in the conversion of lignocellulose to sugars. It is required to alter the structure of the biomass to make the cellulose more accessible to the enzymes that convert the carbohydrate polymers to fermentable sugars. Pretreatment has been recognised as one of the most expensive processing steps in lignocellulose conversion. A wide range of different pretreatment techniques are available, and the choice depends on the desired products and the type of lignocellulose biomass. In general, pretreatment techniques can be divided in acid-related processes (aiming for hemicellulose degradation) and alkaline-related processes (aiming for lignin removal). Only few pretreatment methods have been reported as being potentially cost effective for the production of fermentable sugars, like acid-catalysed steam explosion or liquid hot water. Pulp mills often apply alkaline processes (*e.g.* Kraft) as they want paper pulp with a limited amount of lignin.

In the second step the cellulose and hemicellulose polymers are being converted to fermentable sugars by enzymatic hydrolysis. This step is costly due to the use of expensive enzymes. Major challenge is the full conversion of the carbohydates to monomers and to reduce the amount of enzymes used.

The fermentation unit converts the sugars to various chemical building blocks like ethanol, butanol, lactic acid etc. Chemically speaking there is no difference between glucose from starch (1G) and glucose from lignocellulose (2G). However, in order to isolate sugars from lignocellulose, elevated temperature and pressure is required to remove lignin and disrupt the crystalline structure of cellulose. Hereby sugar and lignin degradation products are formed that inhibit enzymatic hydrolysis and fermentation as well. A cost effective process with the limited formation of inhibitors is still one of the most important challenges in current lignocellulose conversion technologies.

Nowadays the number of chemical building blocks produced from renewable resources is still limited. Most examples of industrial production of biobased chemicals are based on first generation (1G) materials, with ethanol as the only exception. Ethanol is being produced commercially on large scale from maize or sugar cane and on a much smaller scale from lignocellulose biomass, mainly for applications in biofuel. Production of bioethanol is strongly related to the oil prices. At the moment oil is very cheap, making it difficult for companies to produce bioethanol in a cost effective way. Especially chemical building blocks of which production from sugar is cheaper than from oil will continue to grow, examples are lactic acid and propanediol.

Transition from petrochemical to renewable raw material is a step-by-step process. Companies initially work with materials that are as pure as possible, *i.e.* 1G-sugars. If this is successful they can take the next step, like sugar production from lignocellulose biomass. These sugars are often less pure which makes the production of chemical building blocks far more challenging. Additionally, using lignocellulosic biomass as source of sugars results in formation of lignin residues for which a useful application, to ensure an economically feasible process, has yet to be found.

Biochemical conversion technologies in the database

The production of biobased products through the sugar platform is complex as many options are possible and only those examples can be used where data of sufficient quality is available. The main question is which part of the biomass value chain needs to be covered. Looking at the relationship between raw materials and chemical building blocks in Figure 2 it is clear that the intermediate product fermentable sugar is most important, and that the production of cheap sugars of sufficient quality is the key issue here.

For this reason it was decided to focus on processes (conversion technologies) that convert lignocellulose biomass to fermentable sugars, rather than including various fermentation processes that currently make use of 1G carbohydrates. Given the large number of pretreatment processes a choice was made to differentiate between acid-related processes and alkaline-related processes. As these processes generate different intermediate products as shown in Figure 4, it was also necessary to differentiate in the database between acid and alkaline routes.

Ethanol is the only chemical building block today that is produced on a large scale from lignocellulose, others are still at R&D-level. For that reason ethanol was chosen as end-product as reports are available describing the production of bioethanol from lignocellulose.

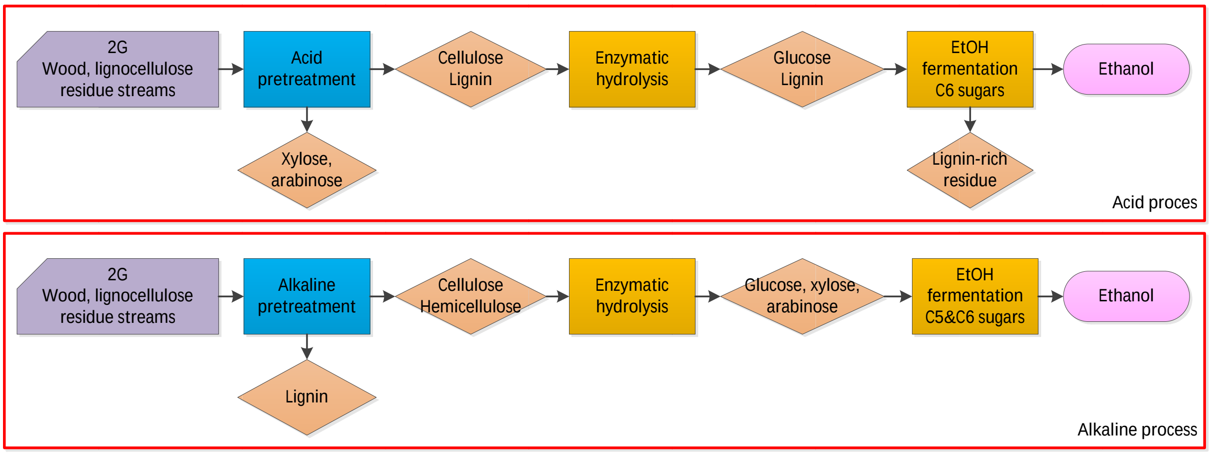


Figure 4. Bio-based routes in the database

In the search for data of sufficient quality to be used in the database a problem was encountered: in reports and articles about the conversion of lignocellulose to ethanol, only the overall process parameters were described, not the separate processes of pretreatment, enzymatic hydrolysis, fermentation and downstream processes. For that reason only less reliable experimental data from previous projects could be used to describe the various separate processes. Unfortunately, it was not possible to elucidate sufficient data to describe the key issue here, *i.e.* the production of fermentable sugars from lignocellulose.

In order to be able to use the data in the database for the matching tool, in matching biomass to a final product, the description of a full value chain from biomass to ethanol was required. This value chain consists of multiple processes, which makes it a complex entry in the database. Moreover, different companies use different technologies, which could not all be described due to lack of accessible or reliable data. Therefore it was chosen to add one specific example of a value chain, based on a study that was reported by NREL. It needs to be emphasized that this is just one single example of a biomass to ethanol value chain, and many other technology choices are possible.

2.2.2 Products of the pyrolysis platform

A similar argument can be made for the pyrolysis platform. The general concept of fast pyrolysis is to produce pyrolysis oil close to the location of the biomass. The pyrolysis oil can be transported much more efficiently than the raw biomass, and will often be further processed at another location. Further processing then means the production of pyrolysis oil diesel (a drop-in biofuel), for example, but could also mean the direct combustion of pyrolysis oil in a district heating or power plant. So a range of bio-based products can be made from pyrolysis oil, and choices had to be made.

In the database a couple of separate entries were combined into new ones, in order to provide examples of value chains from biomass to a final product via fast pyrolysis. These examples were not meant to cover all the possibilities regarding the production of bio-based products from biomass through the fast pyrolysis process.

2.3 Overview of technology criteria and characteristics in the database

The aspects of the conversion technologies that were to be captured in the database were described in deliverable D2.1, annex III. A short overview of the most important ones is given below. This list is not exhaustive, but is meant to give a brief overview of what can be found in the database.

General information

- Name and subcategories (seeTable 1)
- Description of main operating principle of technology
- Level of commercial application
- Current Technology Readiness level in 2014
- References

Technology parameters

- Type and capacity of outputs (typical values)
- Conversion efficiencies
- Number of typical full load hours per year
- Typical lifetime of equipment
- Investment costs
- Labour requirements for typical installation (FTE for typical installation)

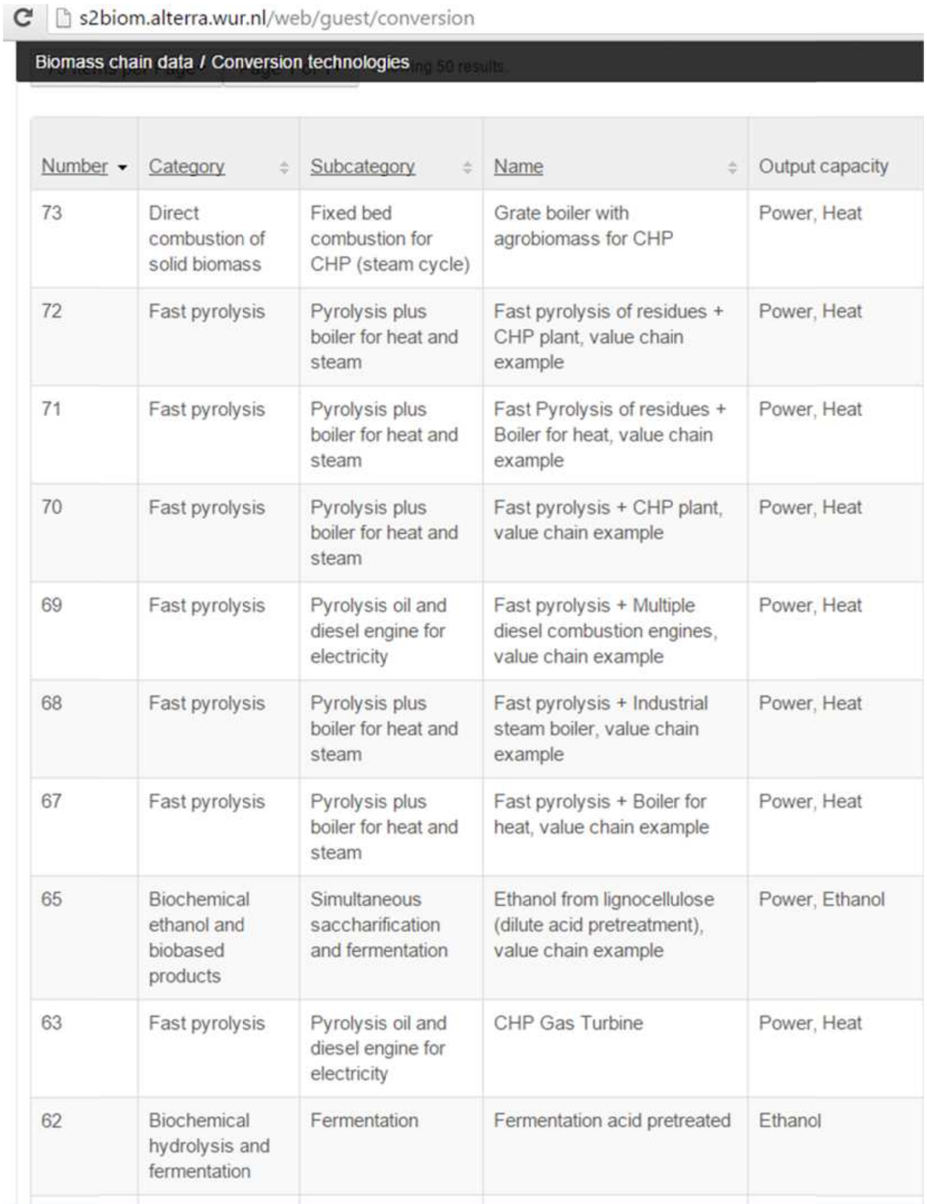
Biomass input specifications

- Biomass input common for the technology used
- Traded form of biomass
- Dimensions of biomass
- Maximum moisture content (% wet basis)
- Minimum bulk density (kg/m3, wet basis)
- Maximum ash content (weight %, dry basis)
- Minimal ash melting point (= initial deformation temperature) (°C)
- Maximum allowable content of nitrogen (wt%, dry basis)
- Maximum allowable content of chlorine (wt%, dry basis)
- Maximum allowable content of lignin (g/kg dry matter)
- Minimum allowable content of cellulose (g/kg dry matter)
- Minimum allowable content of hemicellulose (g/kg dry matter)
- Minimum biogas yield (m^3 gas/ton dry biomass)

3. Description of the database

The database was integrated in the general user interface as supplied by WP4, and can be accessed at http://s2biom.alterra.wur.nl, under the tab "biomass chain data", by clicking on "conversion technologies".

First a list of all the different technologies is presented, an excerpt of which is shown in Figure 5.


s2biom.alterra.wur.nl/web/guest/conversion

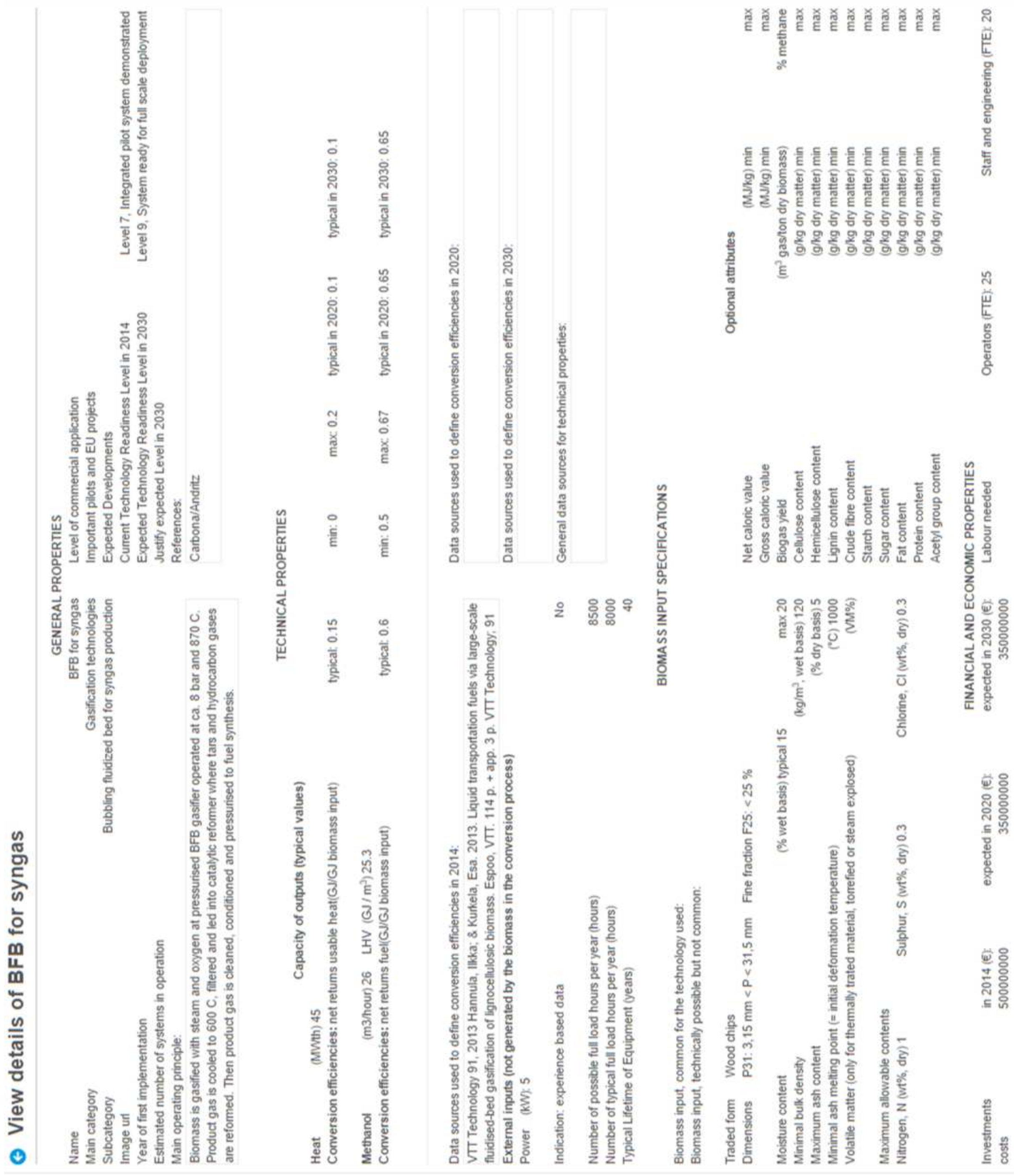
Biomass chain data / Conversion technologies

Number	Category	Subcategory	Name	Output capacity
73	Direct combustion of solid biomass	Fixed bed combustion for CHP (steam cycle)	Grate boiler with agrobiomass for CHP	Power, Heat
72	Fast pyrolysis	Pyrolysis plus boiler for heat and steam	Fast pyrolysis of residues + CHP plant, value chain example	Power, Heat
71	Fast pyrolysis	Pyrolysis plus boiler for heat and steam	Fast Pyrolysis of residues + Boiler for heat, value chain example	Power, Heat
70	Fast pyrolysis	Pyrolysis plus boiler for heat and steam	Fast pyrolysis + CHP plant, value chain example	Power, Heat
69	Fast pyrolysis	Pyrolysis oil and diesel engine for electricity	Fast pyrolysis + Multiple diesel combustion engines, value chain example	Power, Heat
68	Fast pyrolysis	Pyrolysis plus boiler for heat and steam	Fast pyrolysis + Industrial steam boiler, value chain example	Power, Heat
67	Fast pyrolysis	Pyrolysis plus boiler for heat and steam	Fast pyrolysis + Boiler for heat, value chain example	Power, Heat
65	Biochemical ethanol and biobased products	Simultaneous saccharification and fermentation	Ethanol from lignocellulose (dilute acid pretreatment), value chain example	Power, Ethanol
63	Fast pyrolysis	Pyrolysis oil and diesel engine for electricity	CHP Gas Turbine	Power, Heat
62	Biochemical hydrolysis and fermentation	Fermentation	Fermentation acid pretreated	Ethanol

Figure 5. Print-screen of a part of the overview page of the conversion technologies database.

One can then click on one of the technologies to move to a page with a detailed description of the technology, as shown in Figure 6. This figure shows an excerpt of the entry in order to show what the database looks like.

The database contains many different fields for which data can be supplied, in order to standardize it for the various different types and categories of conversion technologies. Therefore not all the attributes were filled in. However, all the important attributes for matching the various technologies to the different types of biomass were filled in for all the technologies, as well as for example conversion efficiency, investment costs and required labour, which are important parameters for a stakeholder to be able to compare different technologies.



View details of BFB for syngas

GENERAL PROPERTIES

Name: BFB for syngas
Main category: Gasification technologies
Subcategory: Bubbling fluidized bed for syngas production
Image url
Year of first implementation
Estimated number of systems in operation
Main operating principle:
Biomass is gasified with steam and oxygen at pressurised BFB gasifier operated at ca. 8 bar and 870 C. Product gas is cooled to 600 C, filtered and led into catalytic reformer where tars and hydrocarbon gases are reformed. Then product gas is cleaned, conditioned and pressurised to fuel synthesis.

Level of commercial application
Important pilots and EU projects
Expected Developments
Current Technology Readiness Level in 2014: Level 7, Integrated pilot system demonstrated
Expected Technology Readiness Level in 2030: Level 9, System ready for full scale deployment
Justify expected Level in 2030
References:
Carbona/Andritz

TECHNICAL PROPERTIES

Capacity of outputs (typical values)

Heat	(MWth) 45					
Conversion efficiencies: net returns usable heat(GJ/GJ biomass input)		typical: 0.15	min: 0	max: 0.2	typical in 2020: 0.1	typical in 2030: 0.1
Methanol	(m3/hour) 26 LHV (GJ / m^3) 25.3					
Conversion efficiencies: net returns fuel(GJ/GJ biomass input)		typical: 0.6	min: 0.5	max: 0.67	typical in 2020: 0.65	typical in 2030: 0.65

Data sources used to define conversion efficiencies in 2014:
VTT Technology 91, 2013 Hannula, Ilkka; & Kurkela, Esa. 2013. Liquid transportation fuels via large-scale fluidised-bed gasification of lignocellulosic biomass. Espoo, VTT. 114 p. + app. 3 p. VTT Technology; 91
External inputs (not generated by the biomass in the conversion process)
Power (kW): 5

Indication: experience based data: No

Number of possible full load hours per year (hours): 8500
Number of typical full load hours per year (hours): 8000
Typical Lifetime of Equipment (years): 40

Data sources used to define conversion efficiencies in 2020:
Data sources used to define conversion efficiencies in 2030:
General data sources for technical properties:

BIOMASS INPUT SPECIFICATIONS

Biomass input, common for the technology used:
Biomass input, technically possible but not common:

Traded form: Wood chips
Dimensions: P31: 3,15 mm < P < 31,5 mm Fine fraction F25: < 25 %

Moisture content (% wet basis) typical 15 max 20
Minimal bulk density (kg/m^3, wet basis) 120
Maximum ash content (% dry basis) 5
Minimal ash melting point (= initial deformation temperature) (°C) 1000
Volatile matter (only for thermally trated material, torrefied or steam exploded) (VM%)

Maximum allowable contents
Nitrogen, N (wt%, dry) 1 Sulphur, S (wt%, dry) 0.3 Chlorine, Cl (wt%, dry) 0.3

Optional attributes

Net caloric value	(MJ/kg) min	max
Gross caloric value	(MJ/kg) min	max
Biogas yield	(m^3 gas/ton dry biomass)	% methane
Cellulose content	(g/kg dry matter) min	max
Hemicellulose content	(g/kg dry matter) min	max
Lignin content	(g/kg dry matter) min	max
Crude fibre content	(g/kg dry matter) min	max
Starch content	(g/kg dry matter) min	max
Sugar content	(g/kg dry matter) min	max
Fat content	(g/kg dry matter) min	max
Protein content	(g/kg dry matter) min	max
Acetyl group content	(g/kg dry matter) min	max

FINANCIAL AND ECONOMIC PROPERTIES

Investments costs	in 2014 (€): 500000000	expected in 2020 (€): 350000000	expected in 2030 (€): 350000000
Labour needed	Operators (FTE): 25	Staff and engineering (FTE): 20	

Figure 6. Excerpt of the datasheet of one technology entry in the database.

This database is open as such to be accessed by the public to obtain data for a certain technology, but more importantly it serves to supply data to the biomass and technology matching tool that is being developed in WP4, which will have a much more user-friendly and interactive user interface.