Market barriers, feedstock availability & suitability for advanced biofuels

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Suitability of Lignocellulosic Feedstock and Intermediates for Advanced Biofuel Conversion Processes

Stavros Papadokonstantakis
Chalmers University of Technology
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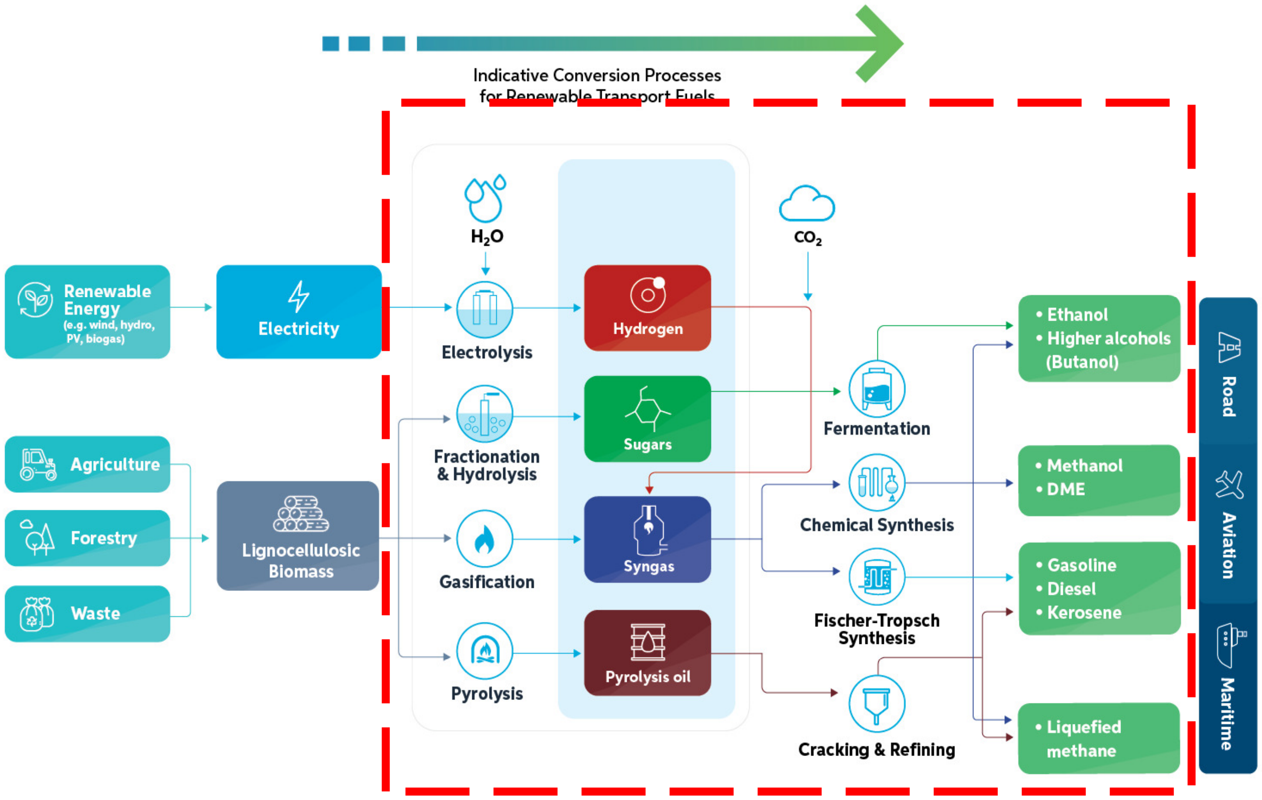
Scope of Conversion Technologies



Renewable resources
ADVANCEFUEL will focus on fuels produced from renewable resources, such as residues from agriculture and forestry, sustainable woody and grassy crops, waste and renewable energy, carbon dioxide and hydrogen.

Conversion processes
ADVANCEFUEL will look at different conversion processes that are already at a high development stage and have been validated in an industrial environment.

Renewable liquid fuels
Ultimately, ADVANCEFUEL aims to support uptake of both advanced biofuels and fuels produced from renewable hydrogen and CO2 in the road, aviation and maritime transport sectors.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N.° 764799.

Conversion Technologies Barriers

- **Multiple sources**
- Conversion efficiency
- Consumption of chemicals, water, energy
- Technical feasibility
- Biorefinery concepts and (sectoral) integration to infrastructure
- CAPEX, financing in R&D, piloting, etc.
- Long-term supportive policies

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Generic Parameters of Conversion Technologies

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- TRL and level of commercial application
- Detailed description of the operating principle
- **Detailed description of the input specifications**
- Material efficiencies and closed mass balance (e.g., less than 5% error)
- Energy efficiencies and requirements on when energy balances can be considered (e.g., less than 5% error in balance)
- Operating costs
- Lifetime of the equipment and investment costs
- Number of typical full load hours per year
- Labour requirements of typical installation (expressed in full-time equivalent (FTE))

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“Well characterized” feedstock for a conversion technology

- Maximum moisture content (% wet basis)
- Minimum bulk density (kg/m^3, wet basis)
- Maximum ash content (weight %, dry basis)
- Minimum ash melting point (= initial deformation temperature) (^oC)
- Maximum allowable content of nitrogen (weight %, dry basis)
- Maximum allowable content of chlorine (weight %, 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)

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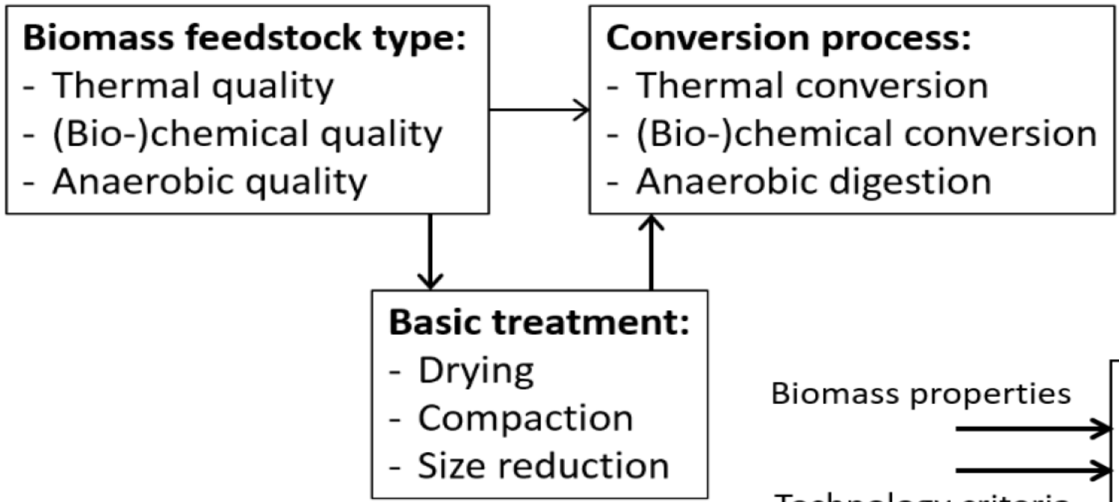
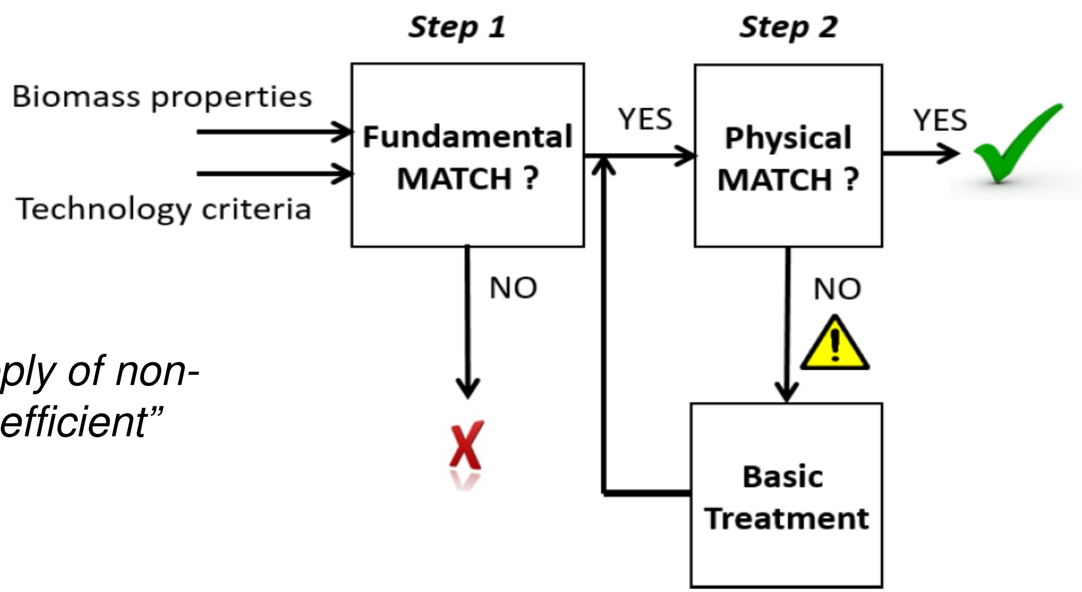
Matching Feedstock to Conversion Technology (Bio2Match Tool, S2Biom project*)





**S2Biom: Delivery of sustainable supply of non-food biomass to support a "resource-efficient" Bioeconomy in Europe*

http://s2biom.alterra.wur.nl/bio2match

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Indicators for Fundamental Match

Property	Unit	1	2	3	4
Chlorine content	wt-% d.m.	<0.02	0.02-0.1	0.1-0.4	>0.4
Ash deformation temperature	^oC	>1200	1000-1200	800-1000	<800
Ash content	wt-% d.m.	<1	2 to 4	3 to 10	>10
Nitrogen content	wt-% d.m.	<0.3	0.3-1	1-2.5	>2.5
Carbohydrates	wt-% d.m.	>65	50-65	30-50	<30
Lignin content	wt-% d.m.	<10	10 to 25	25 to 35	>35
Biogas yield	m3/ton	>300	150-300	50-150	<50
Digestate has an application		Yes	n.a.	n.a.	No

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Example for Pimary Forest Residues

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		Logging residues from final fellings (tops and branches mainly)		Logging residues from thinnings (tops and branches mainly)		Stumps from final fellings	
		Logging residues from final fellings originating from broadleaf trees	Logging residues from final fellings originating from conifer trees	Logging residues from thinnings originating from broadleaf trees	Logging residues from thinnings originating from conifer trees	Stumps from final fellings originating from broadleaf trees	Stumps from final fellings originating from conifer trees
Chlorine content	wt-% d.m.	0.01	0.01	0.01	0.01	0.01	0.01
Ash deformation temperature	°C	1175	1175	1175	1175	1175	1175
Ash content	wt-% d.m.	4.00	4.00	4.00	4.00	6.00	6.00
Nitrogen content	wt-% d.m.	0.4	0.4	0.4	0.4	0.3	0.1
Carbohydrates	wt-% d.m.	72.8	67.9	72.8	67.9	72.8	67.9
Lignin content	wt-% d.m.	23.4	28.6	23.4	28.6	23.4	28.6
Thermal conversion classification							
Ash content		3	3	3	3	3	3
Ash melting temperature		2	2	2	2	2	2
Nitrogen content		2	2	2	2	2	1
Chlorine content		1	1	1	1	1	1
Biochemical conversion classification							
Lignin content		2	3	2	3	2	3
Ash content		3	3	3	3	3	3
Carbohydrate content		1	1	1	1	1	1

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Technology Parameters: Example Gasification

Input Parameters	Definition
Biomass Feedstock	A well characterized feedstock; of special interest is the moisture content), ash content, ash melting point, chlorine content, lower heating value and bulk density
Pre-treatment	Grinding and thermal pre-treatment methods including drying, torrefaction, flash pyrolysis and treatment with organic liquids are some typical examples
Process Parameters	**Definition**
Gasification agent	Steam (Indirect gasification), Oxygen (Direct gasification)
Operating Temperature	800-1500 °C
Operating Pressure	1-30 bar
Main Equipment	Entrained flow, fluidized beds (circulating or bubbling in a dual-bed setup)
Auxiliary Equipment	Heat exchangers, Gas cleaning filters, Scrubber/Absorption columns
Gasification agent to fuel ratio	Important for controlling the catalytic activity in DFB systems and the λ ratio
Solid circulation	Primary circulation of bed material and secondary circulation of ash fractions
Supplementation of inorganics	Inorganic compounds containing potassium, Sulphur and calcium for improving the activity of the catalytic bed
Catalytic Bed	The type of catalyst used in the fluidized bed (e.g., nickel based catalyst)
Output Parameters	**Definition**
Type of main product	Syngas (Mixture of primarily CO and H_2, that can also contain amounts or traces of CO_2, H_2O, CH_4, alkenes, alkynes, inert gases; the composition can vary depending on raw gas treatment)
Type of additional products	Mainly aromatics (e.g., benzene) but also heavier tar components, either single (e.g., naphthalene) or in the form of mixtures, can be recovered and used in various market applications

Indicative operating threshold
for moisture: 35% for fluidized bed combustors, 20-30% for gasification reactors
for ash content: more than 5% is unacceptable and alkali index above 0.34 kg/GJ will cause fouling

(Tanger et al., 2013)

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Technology Parameters: Example Pyrolysis

Input Parameters	Definition
Biomass Feedstock	A well characterized feedstock; of special interest is the particle size (e.g., less than 2 mm for fast pyrolysis and 200 µm for flash pyrolysis), moisture content, lignin content, extractives content, mineral matter content and composition
Pre-treatment	Combination of methods mentioned in the pre-treatment section (3.1); bigger particles, higher moisture and (acid) washing leads to lower bio-oil yields
Process Parameters	**Definition**
Heating rate	The gradient of temperature increase (e.g., 10-200 °C/s for fast pyrolysis)
Residence time	0.5 to 10 seconds; shorter residence times favor bio-oil production; interaction between residence time and temperature on product quality
Operating Temperature	450-650 °C (fast pyrolysis), 800-1000 °C (flash pyrolysis)
Pyrolysis atmosphere	Typically inert gases; steam for partial gasification; CH_4 for increasing the bio-oil yields and H_2 for increasing the HHV
Type of equipment	Bubbling and circulating fluidised beds, heated kilns, rotating cone, auger/screw feed, vacuum
Output Parameters	**Definition**
Type of main product	Bio-oil typically comprises of water (15-35 wt%) and hundreds of organic compounds, such as acids, alcohols, ketones, aldehydes, phenols, ethers, esters, sugars, furans, alkenes, nitrogen compounds and miscellaneous oxygenates, as well as solid particles Oxygen content: 35-40 wt% (dry basis), HHV: 15-20 MJ/kg, pH: 2-3.7, specific gravity: 1.2, pour point: -33 °C
Type of additional products	Bio-char typically containing unconverted organic solids, carbonaceous residues, and a mineral fraction. Carbon content: 53 to 96 wt%, HHV: 20-36 MJ/kg Pyrolytic gas typically contains CO_2, CO, H_2, hydrocarbons such as CH_4, C_2H_6, C_2H_4, C_3H_8, and small amounts of other gases such as NH_3, NO_x, SO_x, and alcohols of low carbon numbers

Indicative operating threshold for moisture 10% (Tanger et al., 2013)

Similar Tables for:

- Pretreatment Technologies (physical, chemical, biological)
- Biochemical Technologies (SHF, SSF, dSSF, CBP)

+ Information on Downstream chemical synthesis and refining

See Deliverable 3.1 for more Information

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Example: Pretreatment Matching (Level-1)

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Pre-treatment Technology	Thermochemical Conversion	Biochemical Conversion
Chipping, grinding, milling	√	√
Pelletisation	√	
Torrefaction	√	
Acid hydrolysis		√
Organosolv		√
Alkaline		√
Steam explosion	√	√
Liquid hot water		√
AFEX		√
Biological		√

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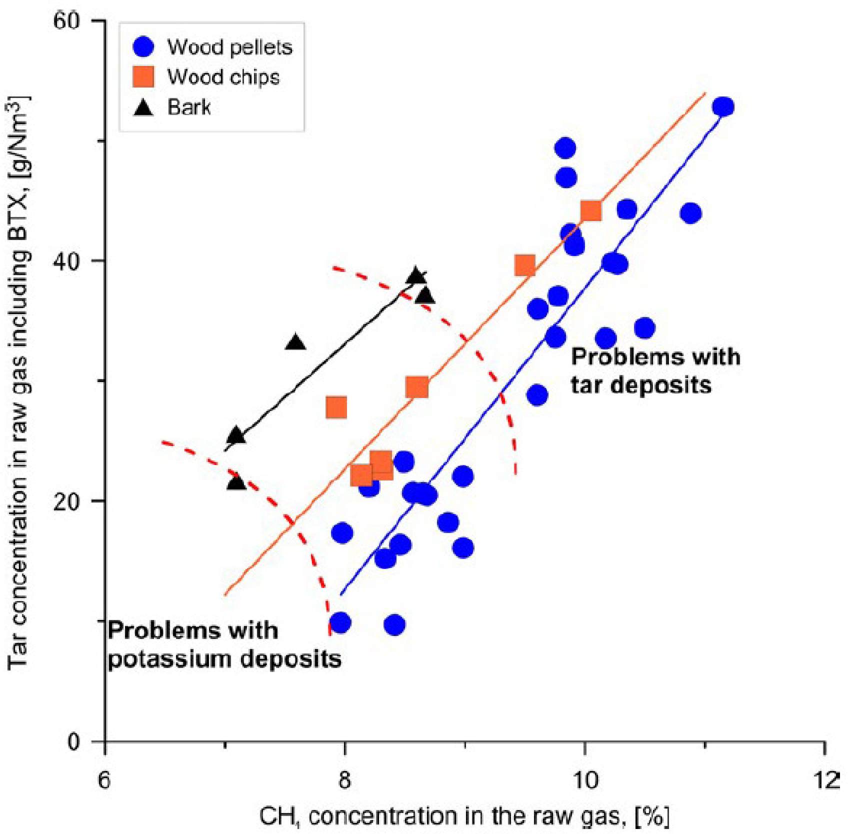
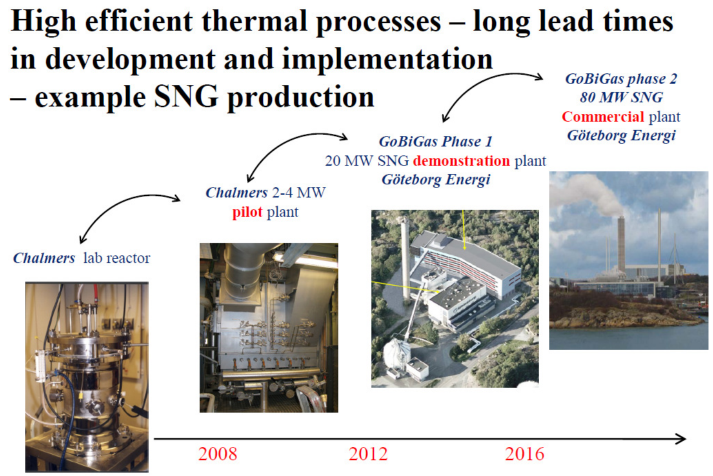
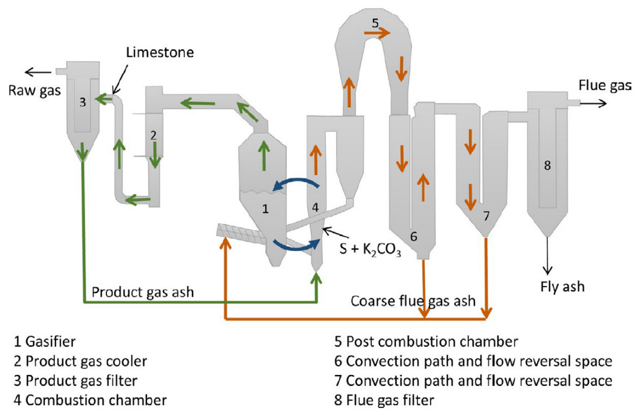
Beyond Simple Matching: Example of Feedstock Impact on Indirect Gasification



(Thunman et al., 2018)





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Conversion Technologies KPIs

- Well-to-wheel system efficiency increase (2020, 2030, 2040)

- CAPEX requirements for TRL increase

- CAPEX and OPEX reduction by integrating into infrastructures

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Thank you for your attention

Stavros Papadokonstantakis
Chalmers University of Technology
stapap@chalmers.se