Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Applied research to biomass production logistics and applied research for feedstock diversification for advanced biofuels




Daniela Thrän, São Paulo workshop

Introduction to DBFZ

National research organisation

Shareholder: ministry for food and agriculture

Funded in 2008

About 200 employees

About 50% third party funding

DBFZ vision:
Smart bioenergy for a sustainable future

Secure, clean, integrated and smart use of bioenergy for a sustainable economic system

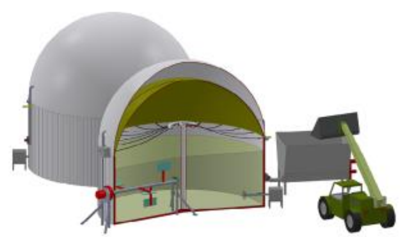
- Integrated, free competition and demand-oriented energy supply
- Combined production of bio-based fuels
- Development of high efficient and clean technologies
- Fully comprehensive sustainability monitoring
- Optimal value chain from biomass

OBJECTIVE: A carbon-neutral bio-economy based on renewable resources

Smart Bioenergy

sustainable resource basis

tradtional bioenergy provision



modern bioenergy provision

integrated bioenergy provision

BioEconomy

Applied research at the DBFZ

Biogas pilot plant

Combustion lab

Fuel conditioning lab

HTC test bed

Engine test bed

Fuel technical centre

Pictures: Jan Gutzeit / DBFZ

Applied research at the DBFZ

DBFZ

Fuel technical centre

Analytical lab

Biogas lab

Laboratory work

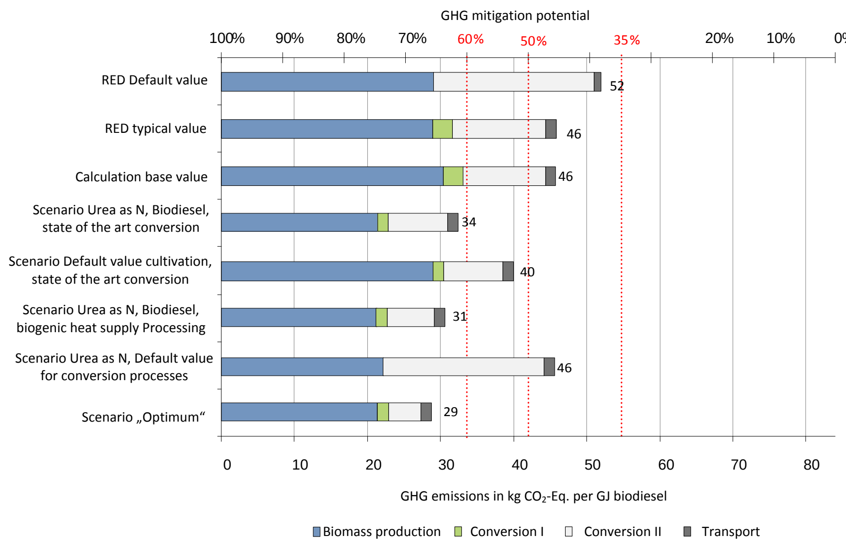
Fuel conditioning lab

HTC lab

Pictures: Jan Gutzeit / DBFZ / Jürgen Lösel

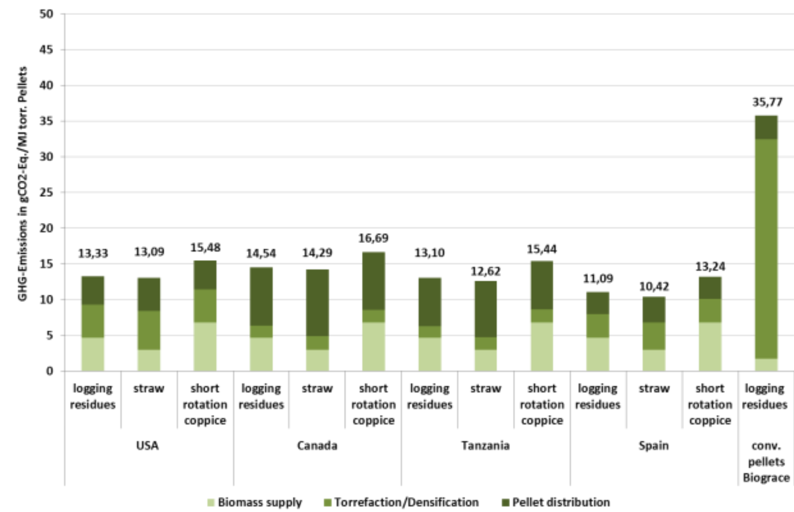
Applied research at the DBFZ

Scenarios & strategies for GHG reduction

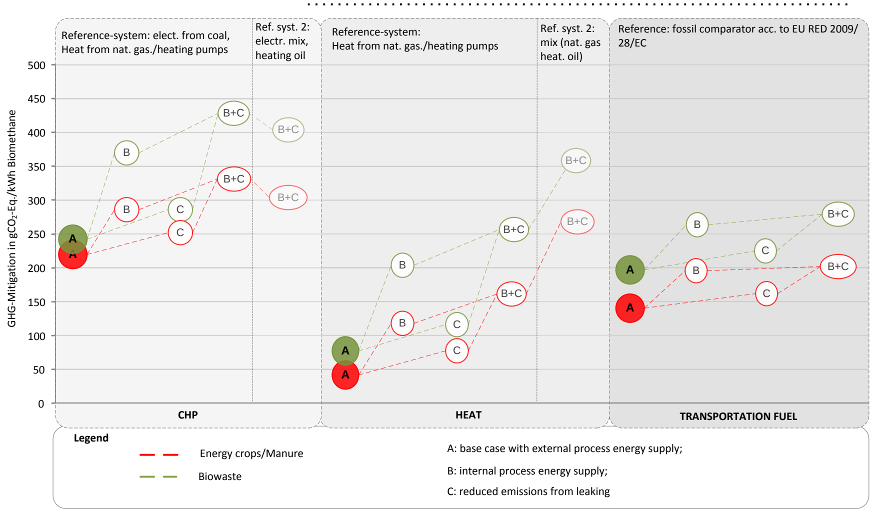


Source: Majer et. al. 2010

Technology assessment

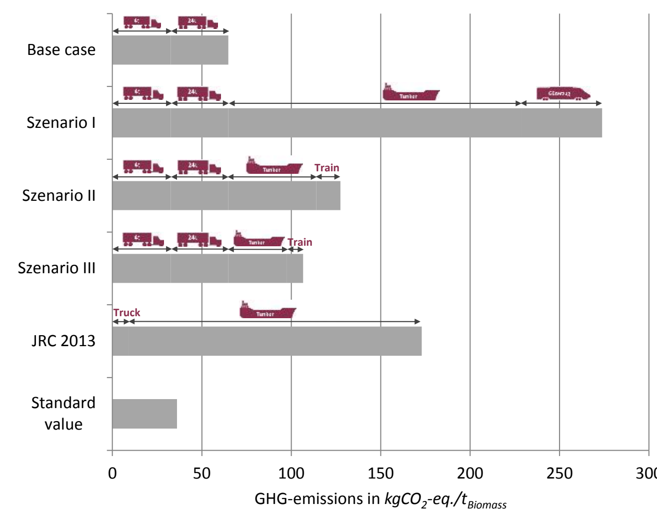


Source: Majer et. al. 2015; Sector project



Source: Thrän et. al. 2012

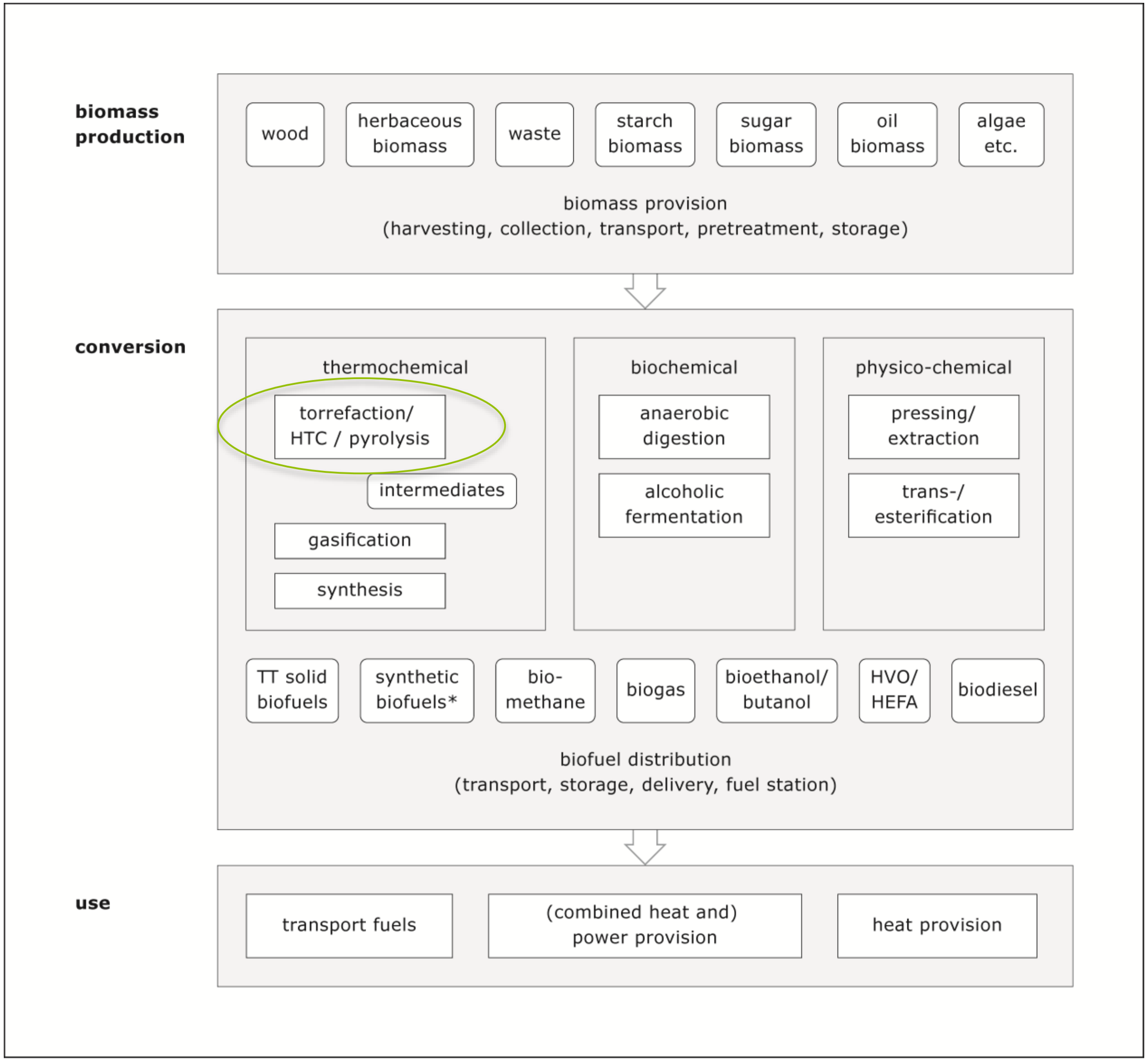
Assessment of different application



Source: Oehmichen et. al. 2014

GHG-effects of biofuel distribution

Biomass production logistics



Advances biofuels are based on i.e. lignocellulosic mate-rials, different waste streams and algae

They demand diffe-rent pretretment concepts

Biomass production and logistics

Biomass potentials

Thermochemical pretreatment of dry biomass: Torrefaction

Thermochemical pretreatment of wet biomass: Hydrothermal Carbonisation

Excursus: Additional energy via biogas from vinasse and filter cake

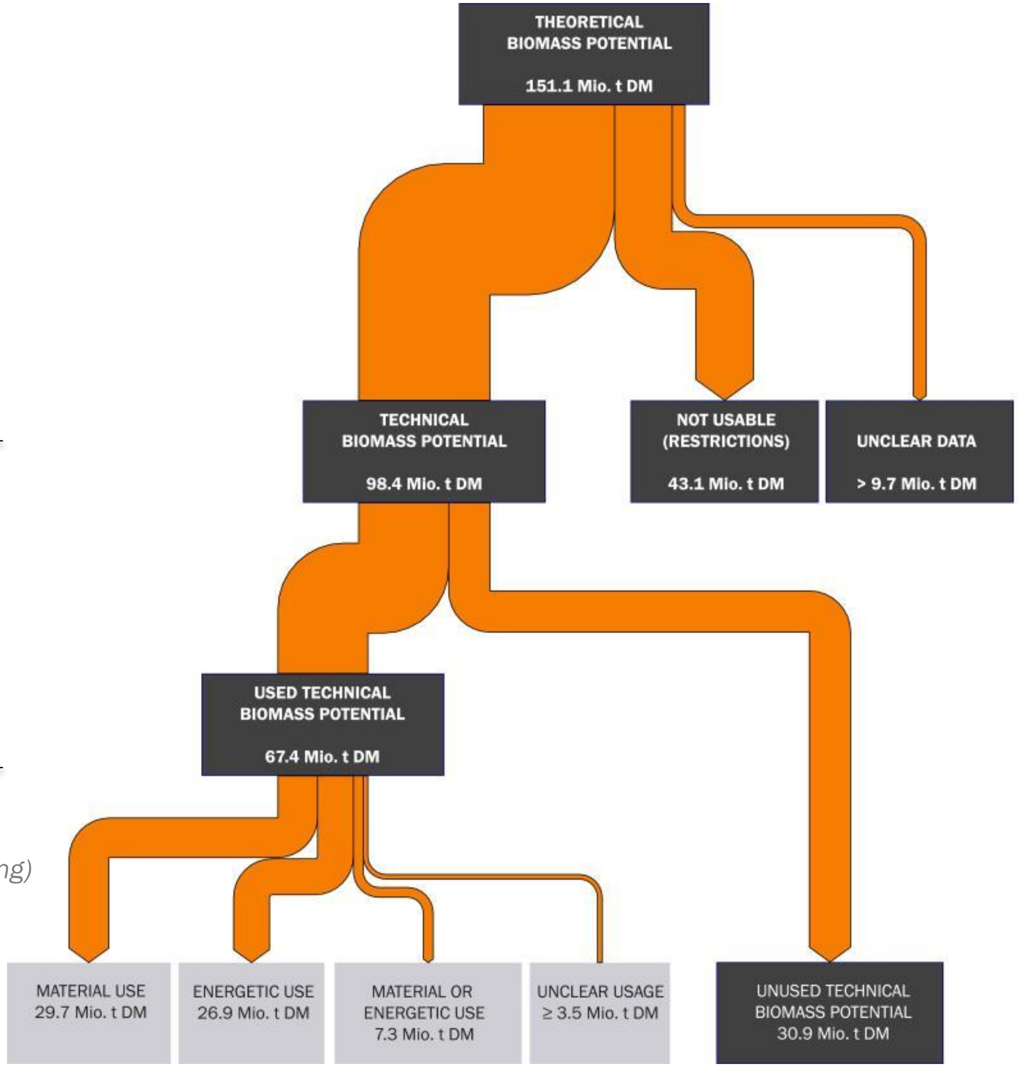
Conclusion

How much biomass is available?
Example: waste and residues in Germany

Biomass potentials from Waste and residues
And their actual use – Status quo in Germany
77 Single biomasses have not been considered
Time references are not uniform

	151.1 Mio. t DM	Theoretical potential
-	43.1 Mio. t DM	Not usable (Restriction)
-	9.7 Mio. t DM	Unclear data
=	98.4 Mio. t DM	Technical potential
-	29.7 Mio. t DM	Material use
-	26.9 Mio. t DM	Energetic use
-	7.3 Mio. t DM	Material or energetic use
-	3.5 Mio. t DM	Unclear usage
=	30.9 Mio. t TS	Unused potential

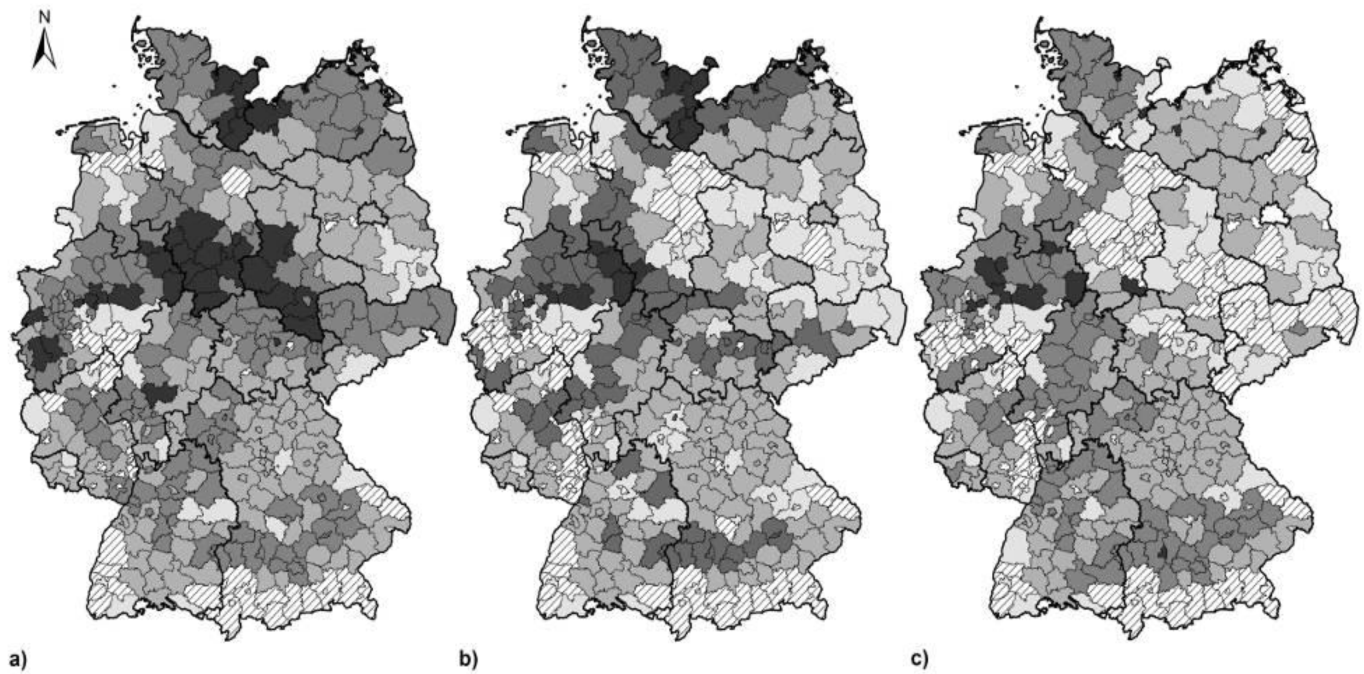
(Discrepancies due to rounding)



Source: Brosowski et al. 2015

How much biomass is available?
Example: Where is the straw potential located?

Sustainable straw potential in Germany 2013
(higher potentials in regions with darker shadows) considering current use and the humus balance calculated with three different approaches



Christian Weiser, Vanessa Zeller, Frank Reinicke, Bernhard Wagner, Stefan Majer, Armin Vetter, Daniela Thrän (2013): Integrated assessment of sustainable cereal straw potential and different straw-based energy applications in Germany. Applied Energy, Volume 114, February 2014, Pages 749-762

What is Torrefaction?

... destruction of hemicellulose, depolymerisation of cellulose and lignin (but it should keep its binding capacity (for pelletisation))

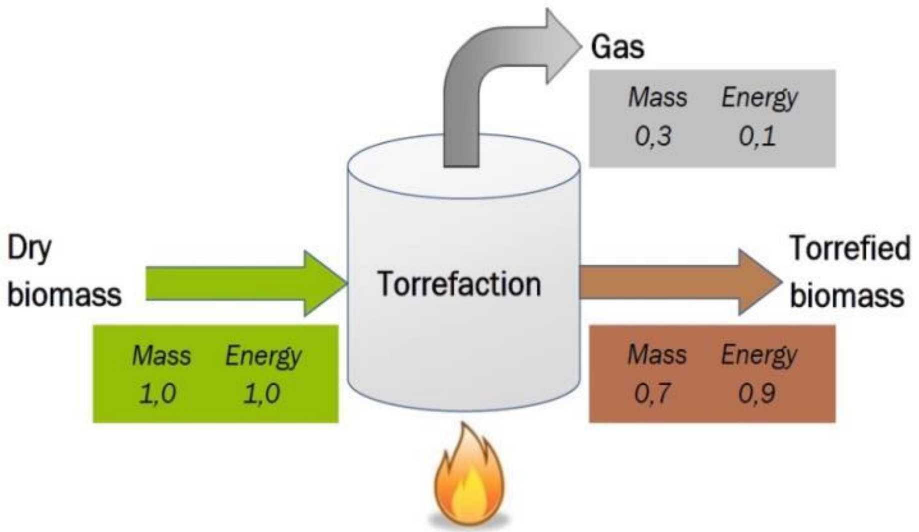
... a mild form of pyrolysis at temperatures typically ranging between 200-320° C

... thermal upgrading process of solid biofuels

...a dry, fat-free heating of plants (foodstuff) up to 300° C - extension for biofuels: in the absence of oxygen

... controlled carbonisation of biomass

Simplified mass and energy streams of the torrefaction process



Input and Output of Torrefaction Processes

Input

- Woody biomass: commercially available
  - E.g. stem wood (e.g. spruce, pine), forest residues, by-products and residues from wood processing industry, used wood
- Non-woody: under development
  - E.g. cereal straw, rice husks, olive pruning, bagasse, other agricultural residues
- Additional possible energy crops
  - E.g. Miscanthus, Reed canary grass, poplar, other short rotation coppice

Output

- Torrefied pellets
- Torrefied briquettes
- Suitable for
  - Small scale boilers (with adoptions)
  - Medium to large scale (co-)firing
  - (co-)gasification
  - Bioeconomy via gasification routes
- Torrgas
  - Burned for heating the process
  - Condensables may be used for pesticides, wood protection and binder (pellets, plywood)

Properties in Comparison

	Wood chips	Wood pellets	Torrefied wood pellets	Charcoal	Coal
Moisture content (wt%)	30 – 55	7 – 10	**1 – 5**	1 – 5	10 – 15
Calorific value (LHV, MJ/kg)	7 – 12	15 – 17	**18 – 22**	30 – 32	23 – 28
Volatile matter (wt% db)	75 – 84	75 – 84	**55 – 80**	10 – 12	15 – 30
Fixed carbon (wt% db)	16 – 25	16 – 25	**22 – 35**	85 – 87	50 – 55
Bulk density (kg/l)	0.20 – 0.30	0.55 – 0.65	**0.65 – 0.80**	0.18 – 0.24	0.80 – 0.85
Vol. energy density (GJ/m^3)	1.4 – 3.6	8 – 11	**12 – 19**	5.4 – 7.7	18 – 24
Hygroscopic properties	Hydrophilic	Hydrophilic	**(Moderately) Hydrophobic**	Hydrophobic	Hydrophobic
Biological degradation	Fast	Moderate	**Slow**	None	None
Milling requirements	Special	Special	**Standard**	Standard	Standard
Product consistency	Limited	High	**High**	High	High
Transport cost	High	Medium	**Low**	Medium	Low





<u>Abbreviations:</u>
db = dry basis
LVH =Lower Heating Value

sources: ECN (table, fig.1, 3), Pixelio (fig. 2, 5), OFI (fig. 4)

Torrefaction Technologies

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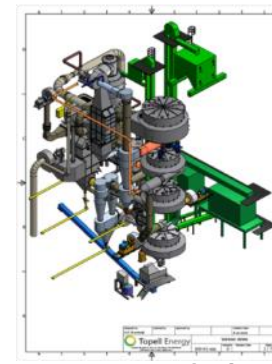
Different technologies

Moving bed*
(ECN)
pilot

Rotary drum / Auger
(Umeå University)
pilot

Rotary drum
(CENER)
pilot



Toroidal
(Topell Energy)
demo

Production with available **pilot scale facilities**
Typical test runs 50-100 hours
Typical production per test few tonnes
3-6 different feedstocks

Production with available **demo plant**
Continuous operation
Production of 100-200 tonnes
Specific feedstock

** And the resulting Andritz/ECN technology, successfully demonstrated in Denmark at a scale of 1 ton/h*

Torrefaction at EU: The SECTOR project

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Collaborative project:	**SECTOR**
Project start:	**01.01.2012**
Duration:	**48 months**
Total budget:	**10 Mio. Euro**
Participants:	**21 from 9 EU-countries**
Coordinator:	**DBFZ**

University of Stuttgart Germany
ECN
DANISH TECHNOLOGICAL INSTITUTE
Deutsches Biomasseforschungszentrum gemeinnützige GmbH DBFZ
e·on
SLU Swedish University of Agricultural Sciences
RWE The energy to lead
VATTENFALL
ofi
VTT
JEN
Topell Energy
UMEÅ UNIVERSITET
cener centro nacional de energías renovables FUNDACIÓN CENER CIEMAT
PROCEDE BIOMASS B.V.
DOOSAN Doosan Power Systems
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ
Technologie- und Förderzentrum im Kompetenzzentrum für Nachwachsende Rohstoffe
TU WIEN
bioenergy2020+
BIOS BIOENERGIESYSTEME GmbH

What is Hydrothermal carbonisation (HTC)?

	Hydrothermal carbonisation (HTC)	Hydrothermal liquefaction (HTL)	Hydrothermal gasification (HTG, SCWG)
Condition	Water (liquid)	Water (liquid)	Water (supercritical)
Temperature range	180 – 250°C	250 – 350°C	600 – 700°C
Pressure range	10 – 40 bar	50 – 200 bar	250 – 300 bar
Dwell time range	2 – 16 h	10 – 15 min	1 – 5 min
Main product	Carbon suspension, Carbon granulate	Phenol rich, Oily, hydrophob liquid	Hydrogen, Carbondioxid, Methane
Current state of development / TRL	Several demo plants available in Germany TRL 6-7	Today only pilot plants are running TRL 4-6	For energetic purpose labscale up to pilot plants are running TRL 4-5

Input and Output of HTC Processes

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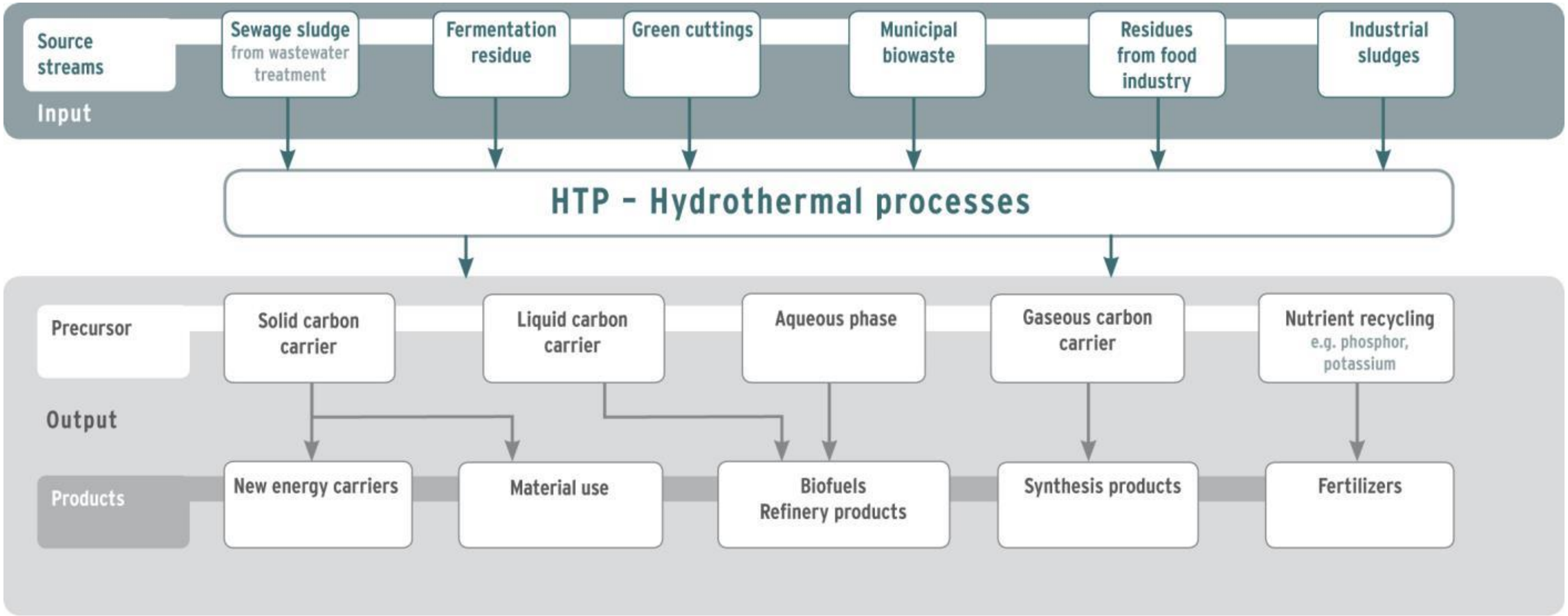
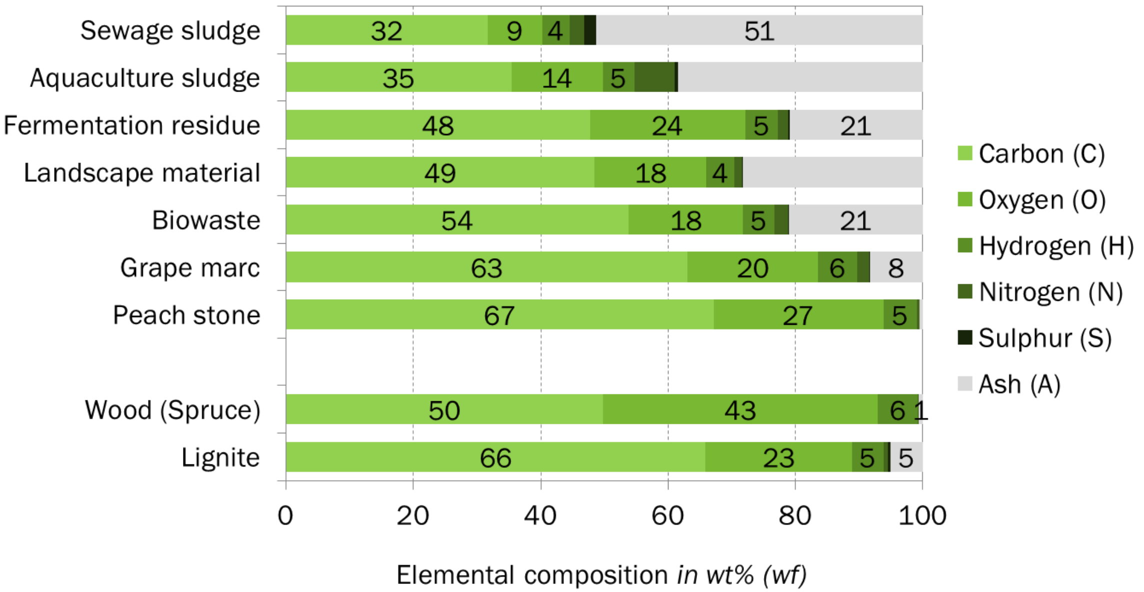


Work at HTC in DBFZ: Demo plant operation

- Reaction steps are hydrolysis, dehydration, repolymerisation and maturing >> brown coal like HTC-coal that can be used in different energetic and material applications.
- Experimental investigations mainly conducted in stirred batch-reactors because of long residence times of 2 – 6 h at temperatures from 180 to 220 ° C
- A demonstration plant for 2500 t/a input is realised in Halle/Saale.
- Processes for chemicals isolation from the process water currently developed.


Demo plant in Halle/Lochau ©DBFZ 2013

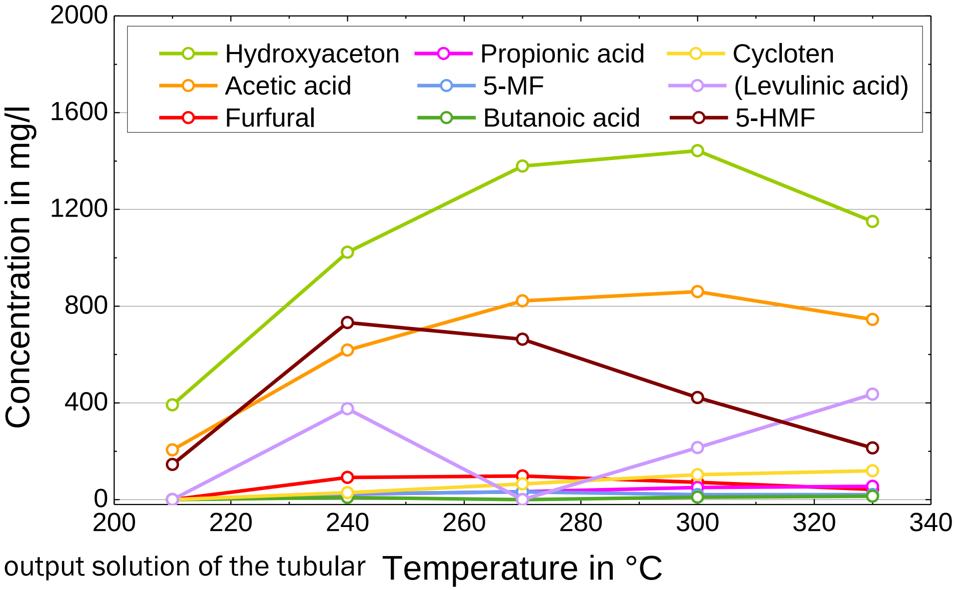


Sources for wood, lignite from Kaltschmitt et al. 2009

Work in HTL at DBFZ: Two step processes

- Transport HTL fuel, different bulk chemicals, such as furan derivatives, organic acids and phenols as products
- A continuous tubular reactor >> typical operational parameter: up to 350 ° C, up to 100 bar, flow rates up to 5 l/h and residence times from 1.5 up to 16 min
- Feedstocks: solution and suspension with a particle size smaller than 0.25 µm
- One step HTL processes for the production of low quality oil are state of the art >> two step process to pre-products for liquid-fuel was developed by DBFZ and partners, technical plant is under construction.

Lab tubular reactor at DBFZ ©DBFZ 2013



Concentration of main substances in the output solution of the tubular reactor: model substance, suspension with 3 % (m/m) dry matter, residence time 3.8 min

Excursus: Anaerobic digestion of residues from ethanol production (work at DBFZ)

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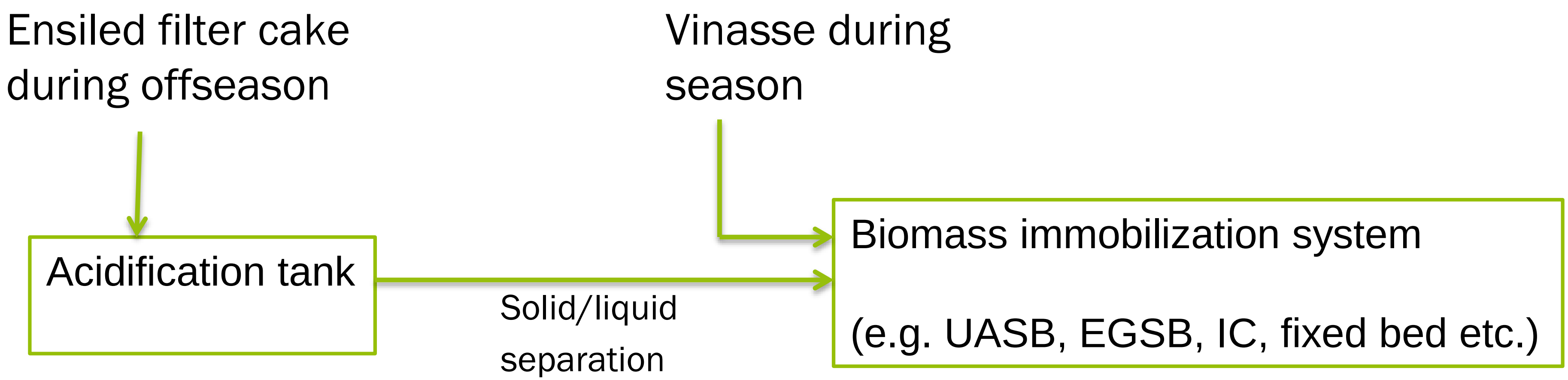
Background: Sugarcane plant: 4 million TC per year:

Potential CH_4 production of vinasse during season: 63,383 Nm^3/day

Potential CH_4 production of filter cake during offseason: 65,193 Nm^3/day

Concept idea



Note: 1 season period: 236 days/year 2 offseason period: 129 days/year

Source: Janke et al 2015

Conclusion

For advanced biofuels pretreatment of the biomass can improve the value chains

Different approaches on thermochemical treatment (torrefaction, HTC) are under research, develoment and implementation.

TRL depends not only on the pretreatment technology but also on the biomass resource quality and on the expectation of the product spectrum

Pretreated materials can reduce logistic effort for biomass (i.e via higher energy density, better storage properties etc.). Dedicated concepts have to be developed specifically.

Cost analysis and LCA are necessary for development and optimisation of the pretreatment processes and logistics as well.

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Researching the energy of the future – come and join us!

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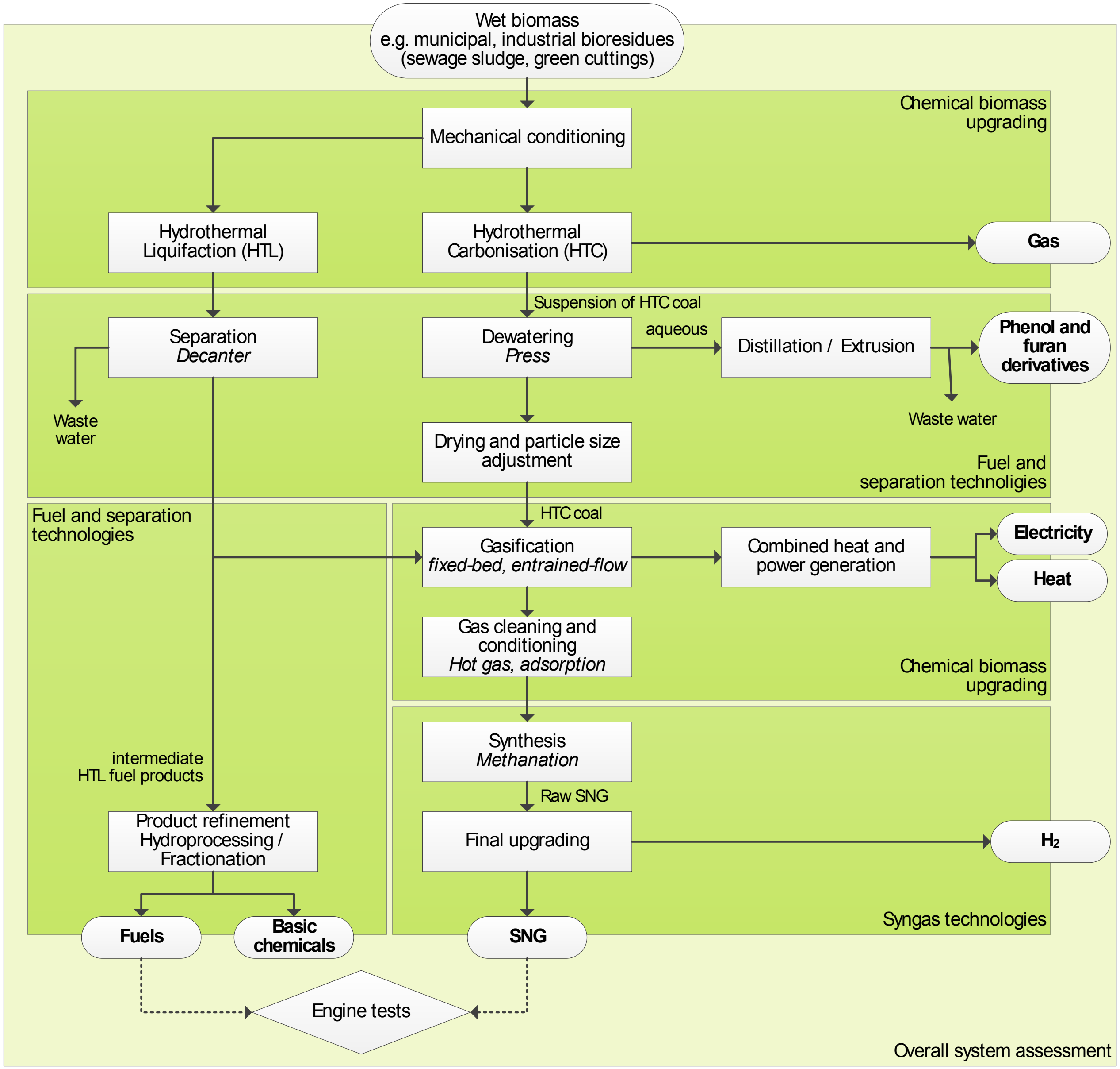
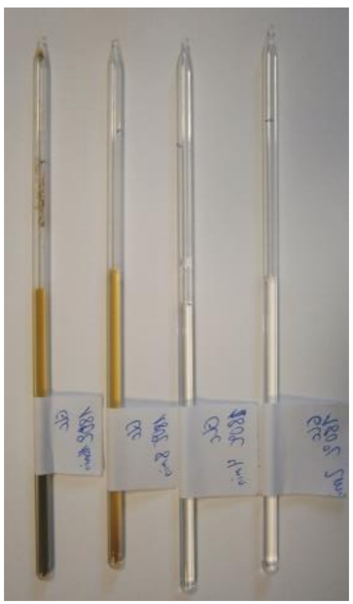
Options of integrating HTC into biorefinery concepts



Work in HTC at DBFZ: Basic properties

- Quartz capillaries (QC) used as reactors in sub-milliliter scale >> fast heating rates (>200 K/min) and also fast cooling rates (i.e. quenching) are possible.
- Experiments are conducted at temperatures from 150 to 300 ° C and residence times from 1.5 to 16 min.
- Model-compounds e. g. glucose (Glu), fructose (Fru) , xylan and vanillin >> products are analyzed visually and via GC-MS.



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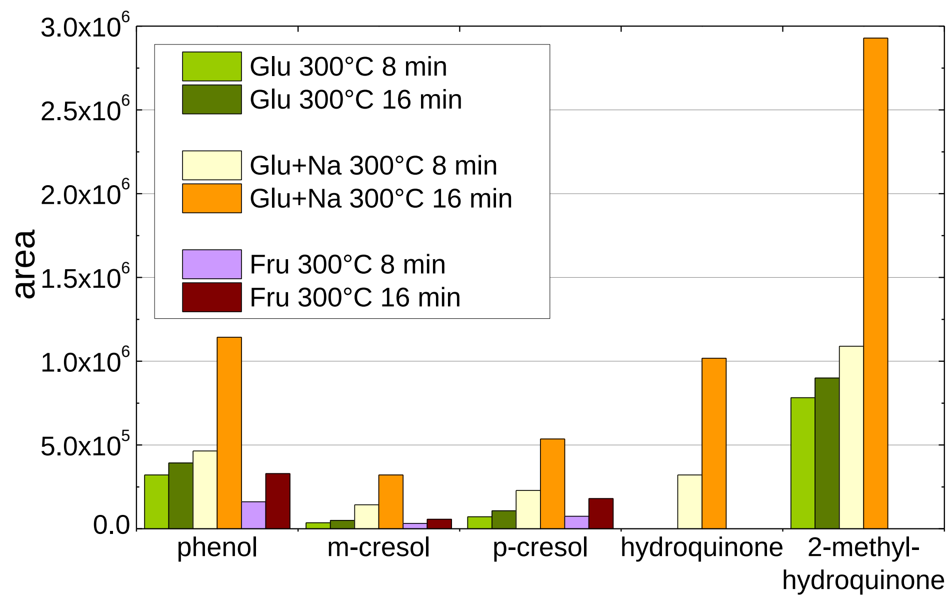

Exemplary results of phenol formation in the hydrothermal conversion of glucose (with and without Na_2CO_3 as catalyst) and fructose ©DBFZ 2013