Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Current Status and Issues of Biomass Industrial Heat in Germany

Dr.-Ing. Volker Lenz





International Symposium on Biomass Industrial Heat, Tokyo
13th January 2023

DBFZ – Smart Bioenergy

- 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

Bilder: Stefan Rauchhaus / DBFZ, Michael Moser Images / Schulz und Schulz Architekten GmbH

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



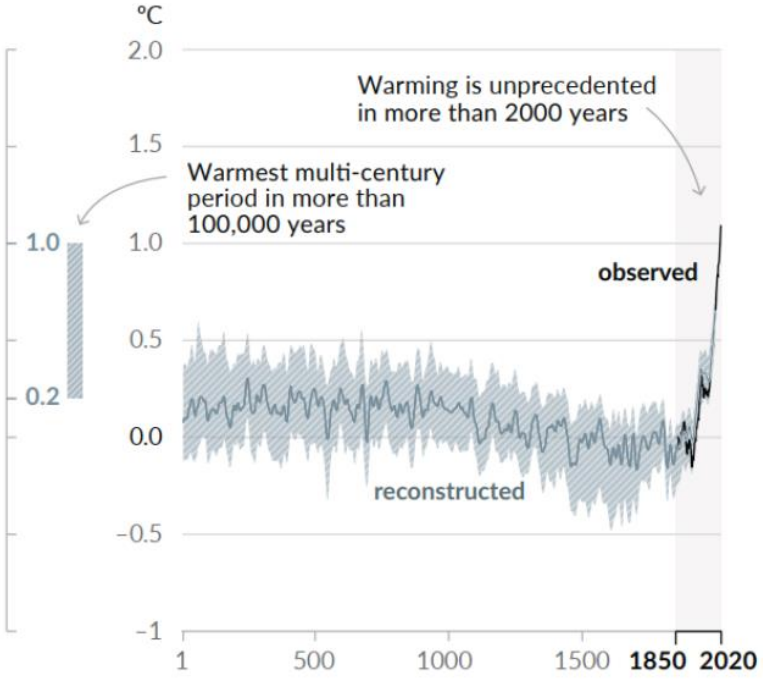


Research on all issues related to bioenergy.

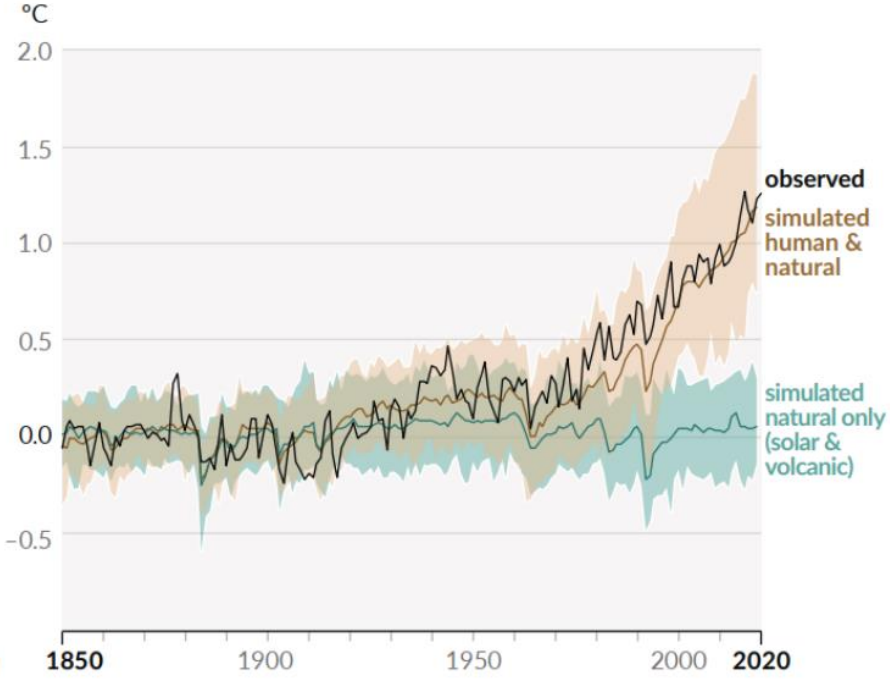
We heat the earth!

Changes in global surface temperature relative to 1850–1900

(a) Change in global surface temperature (decadal average) as reconstructed (1–2000) and **observed** (1850–2020)

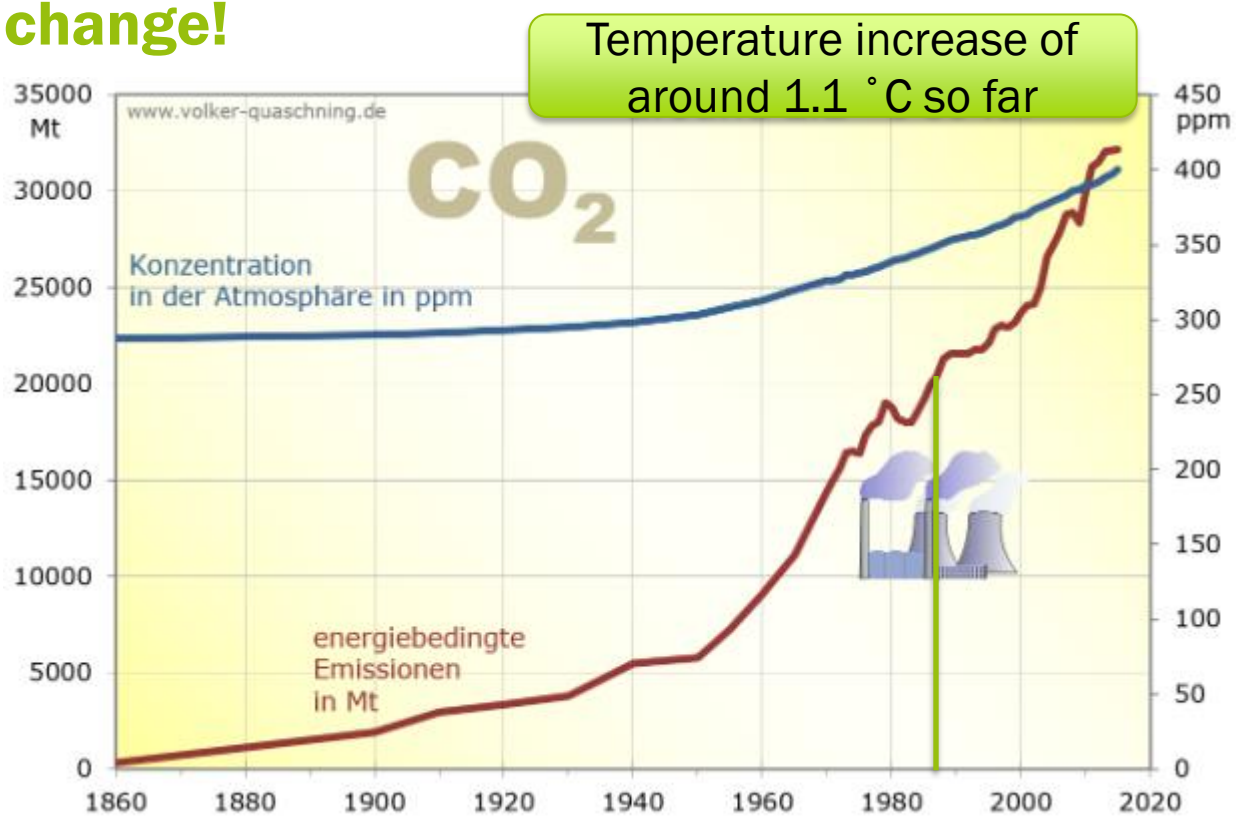


(b) Change in global surface temperature (annual average) as **observed** and simulated using human & natural and only natural factors (both 1850–2020)



Quelle: IPCC AG I zum 6. Sachstandsbericht: Klimawandel 2021. Naturwissenschaftliche Grundlagen. Zusammenfassung für die politische Entscheidungsfindung. 2021

Our generation is responsible for rapid climate change!

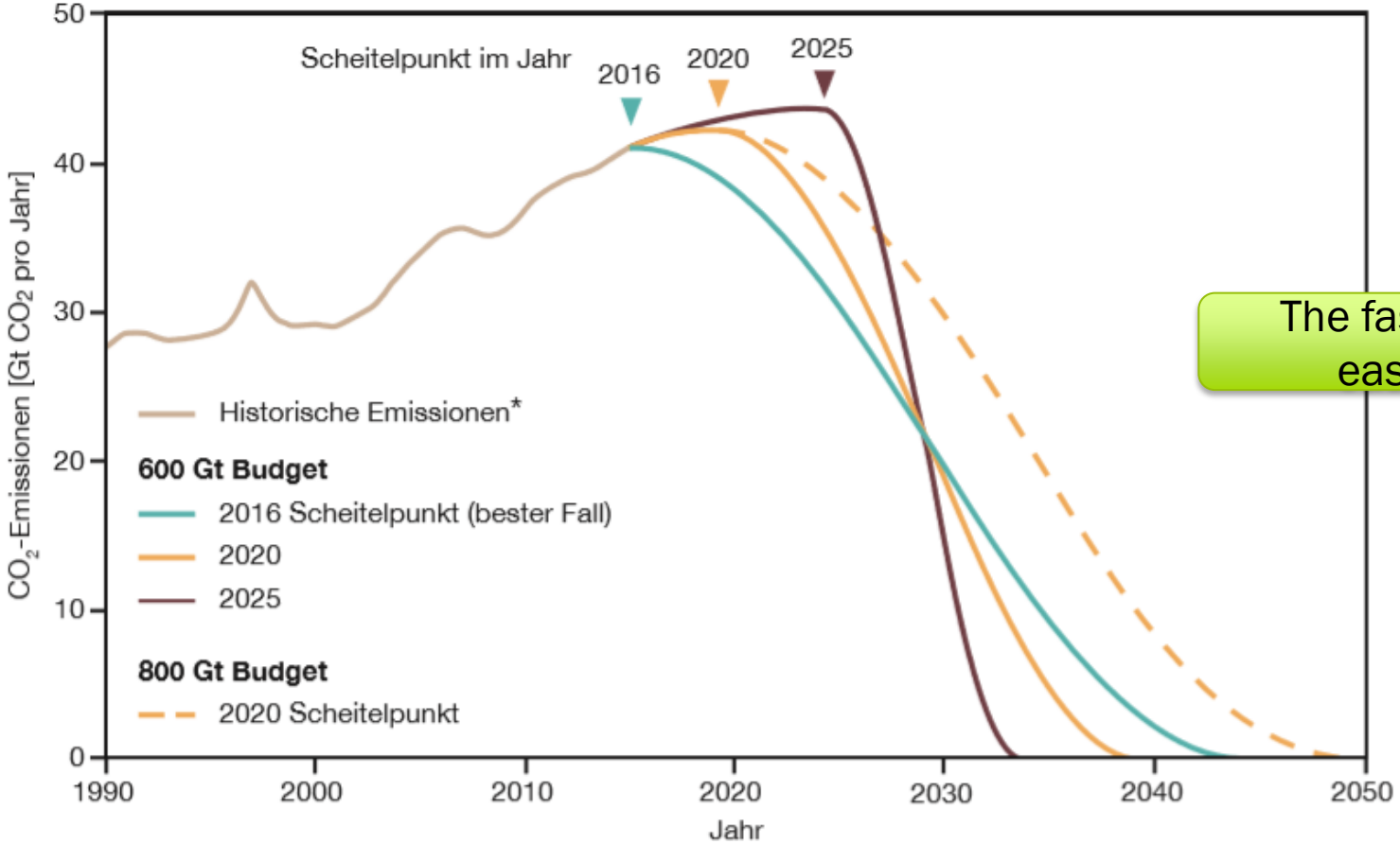


Our generation is responsible for rapid climate change!!

- SRU: Climate neutrality needs to be achieved by 2031 -2040.
- fully renewable heat supply by 2040 at the latest
- (Ukraine) war
- Climate change with flood disasters, droughts, heat deaths, hurricanes and forest fires

Quelle: https://www.volker-quaschning.de/datserv/CO2/index.php Zugriff: 10.01.2020

Pressure to act Climate protection worldwide



Achievement 1.5 - 2˚C target.

The faster we act, the easier it will be!

Quelle: WBGU 2018

Climate protection decision in Germany 2021

Federal Constitutional Court ruling of March 24, 2021
in conjunction with Climate Protection Act 2019.

- 1.5 - 2 °C target to be achieved by politicians on a binding basis -> residual GHG emissions budget of 6.7 Gt as of 2020
- Climate protection needs to be weighed up against other fundamental rights (especially civil liberties)

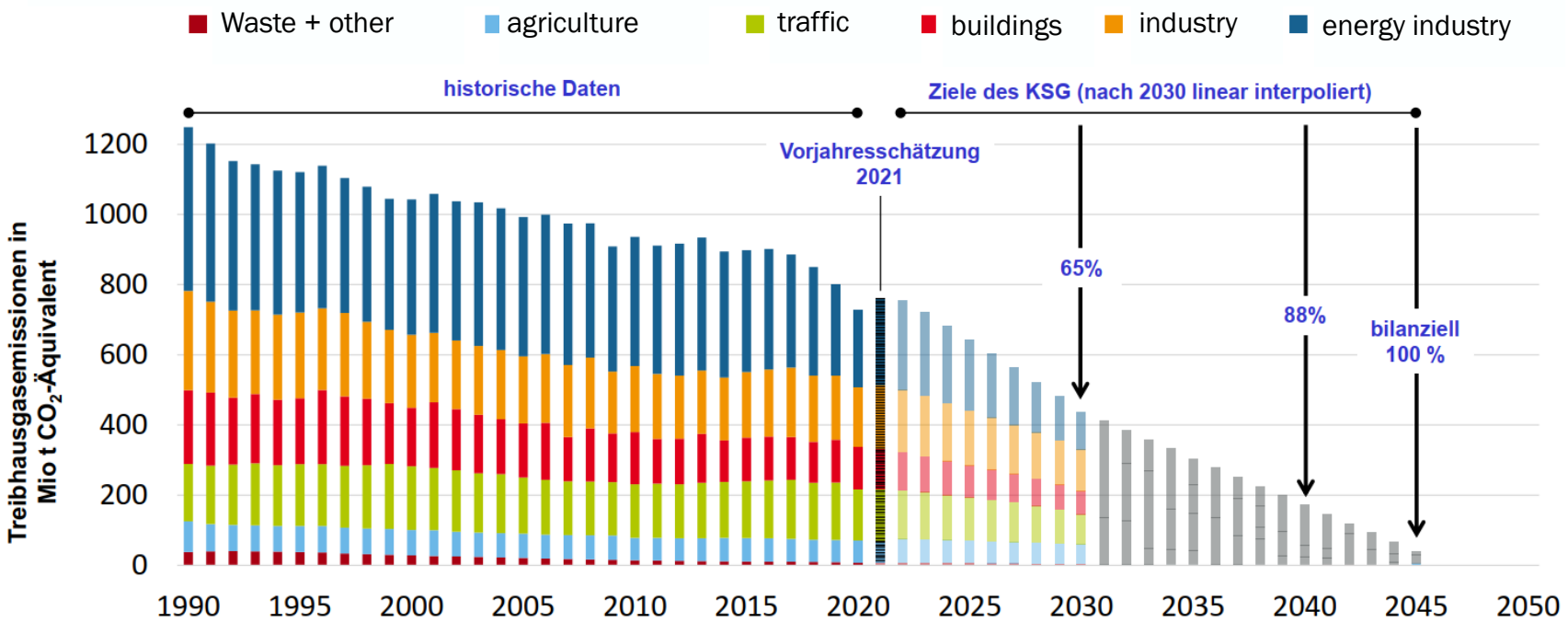
Massive promotion of the use of RE and successive bans on new fossil fuel-fired plants (e.g. BEG, BEW ...)

Wait and see means later operating bans for fossil-fired energy converters

- **The energy transition and especially the heat transition will have to accelerate, including a complete conversion of the industrial process heat supply!**
- **Bioenergy could quickly make additional contributions alongside and with air-to-water heat pumps.**
- **But: Sustainability of bioenergy no longer includes only quantity balance, but also biodiversity!**

GHG-emissions of industry and targets

GHG emissions of Germany - history and target values Federal Climate Protection Act



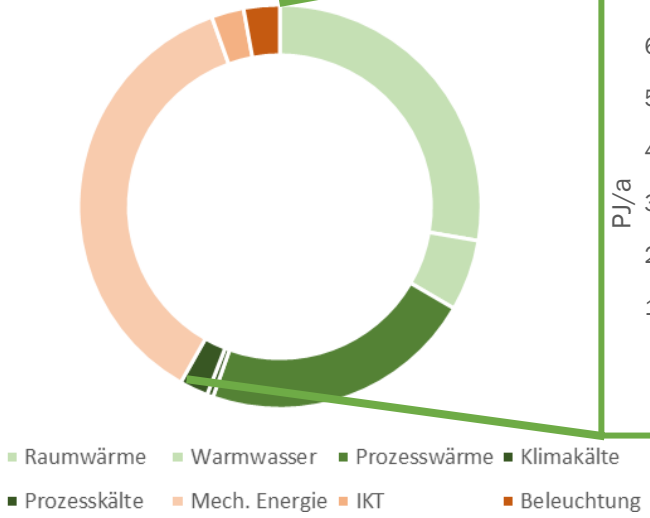
Historische Daten und VJS: Vorjahreschätzung (VJS) der deutschen Treibhausgas-Emissionen für das Jahr 2021. Umweltbundesamt, 15.3.2022

Quelle: FVEE-Jahrestagung 2022

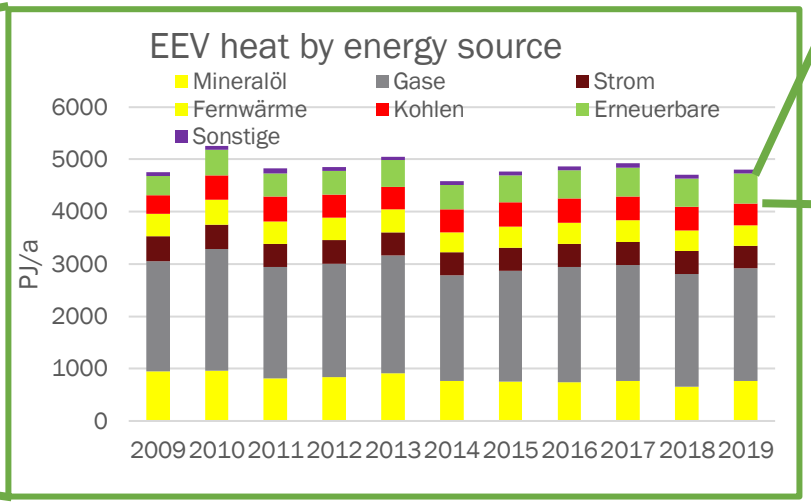
Status bioenergy in the heat sector

Heat approx. 50% of final energy consumption

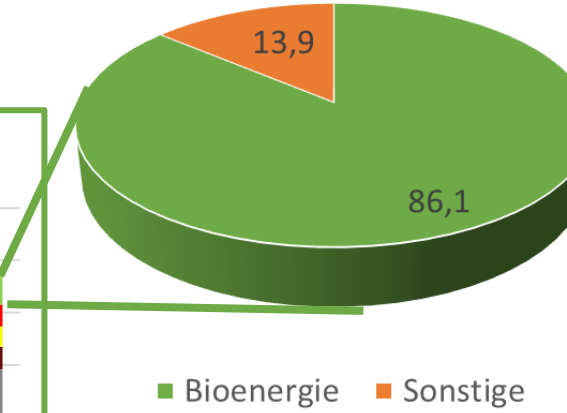
Endenergieverbrauch 2020 (%)



Renewables in heat (~16,5%)

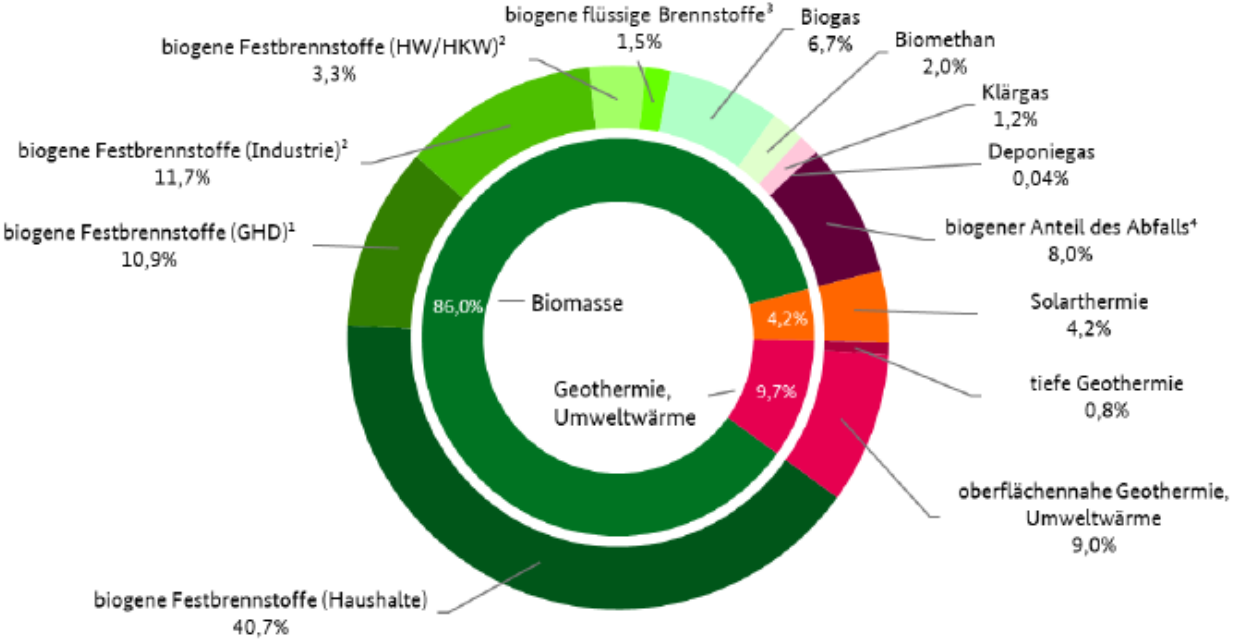


Biomass in Renewable (~86%)



Status of heat supply from biomass in Germany 2021

Final energy consumption of renewable energies for heating and cooling in Germany in 2021
Gesamt: 199,4 Mrd. Kilowattstunden



Industrial heat from wood: 11,7%

Tertiary sector (trade, commerce and services) by wood: 10,9%

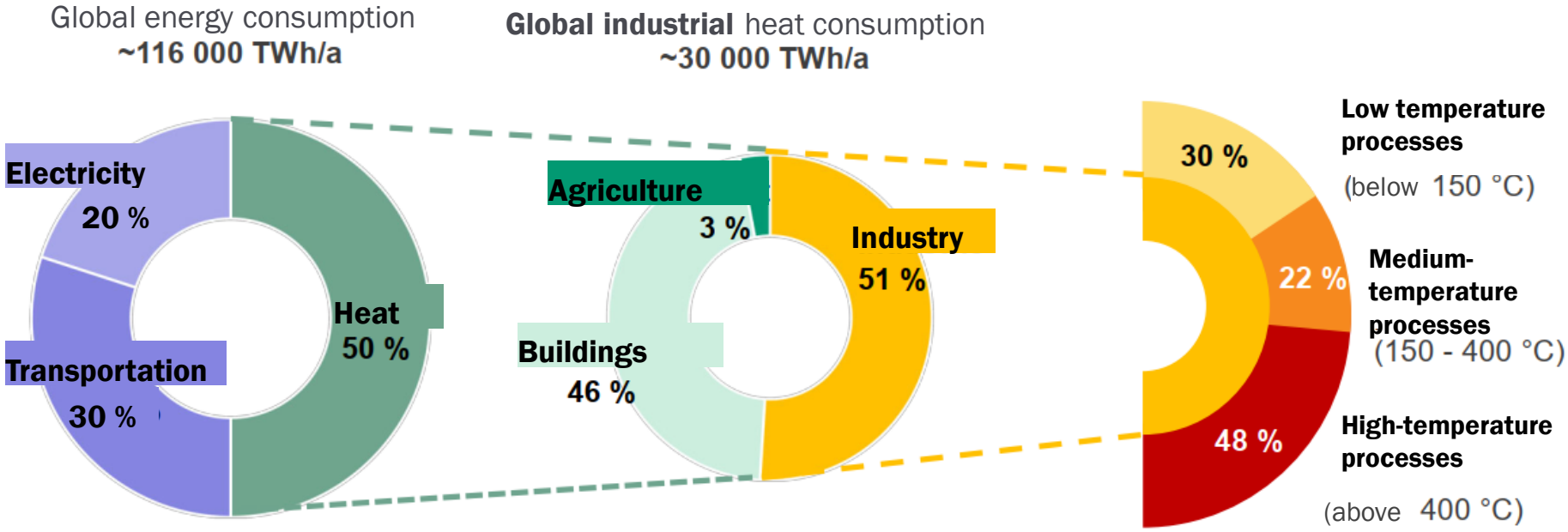
Usage of wood in households : 40,7%

[1] GHD = Gewerbe, Handel, Dienstleistungen; [2] inkl. Klärschlamm und Holzkohle; [3] inkl. Biokraftstoffverbrauch für Land- und Forstwirtschaft, Baugewerbe und Militär;
[4] biogener Anteil des Abfalls in Abfallverbrennungsanlagen mit 50 % angesetzt

BMWK auf Basis Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat); Stand: Februar 2022

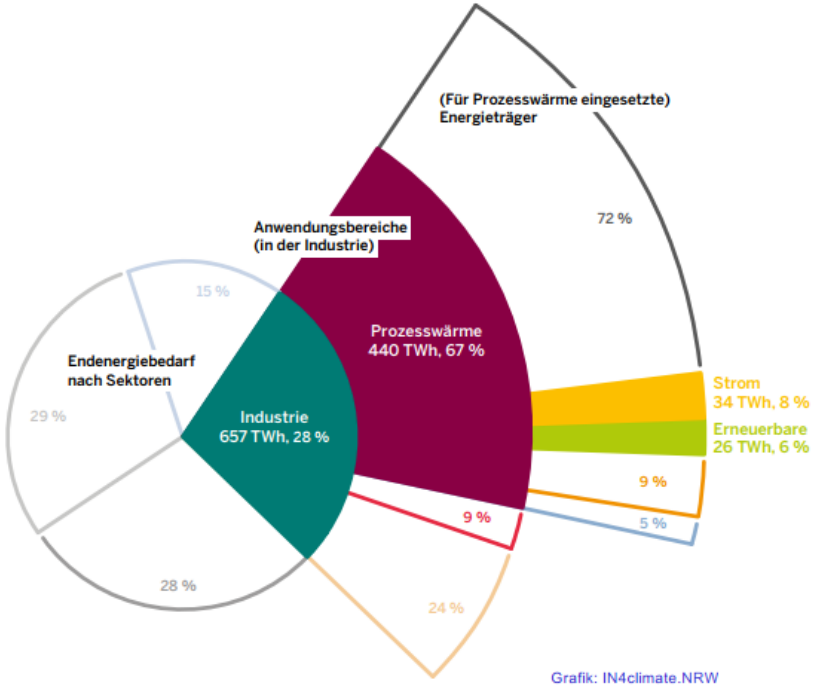
Global classification of industrial heat

Data based on IEA World Energy Balances Highlights 2021
"Heat" includes electricity used for heating.



Quelle: FVEE-Jahrestagung 2022

Industrial transformation in Germany is transformation of process heat



Grafik: IN4climate.NRW

Industrie 657 TWh
Verkehr 637 TWh
Haushalte 670 TWh
Gewerbe, Handel, Dienstleistungen (GHD) 354 TWh

Prozesswärme 440 TWh
Sonstige Wärme[a] 58 TWh
Elektrizität[b] 159 TWh

fossile Energieträger[c] 317 TWh
Strom[d] 34 TWh
Erneuerbare[e] 26 TWh
Fernwärme 42 TWh
Sonstige 21 TWh

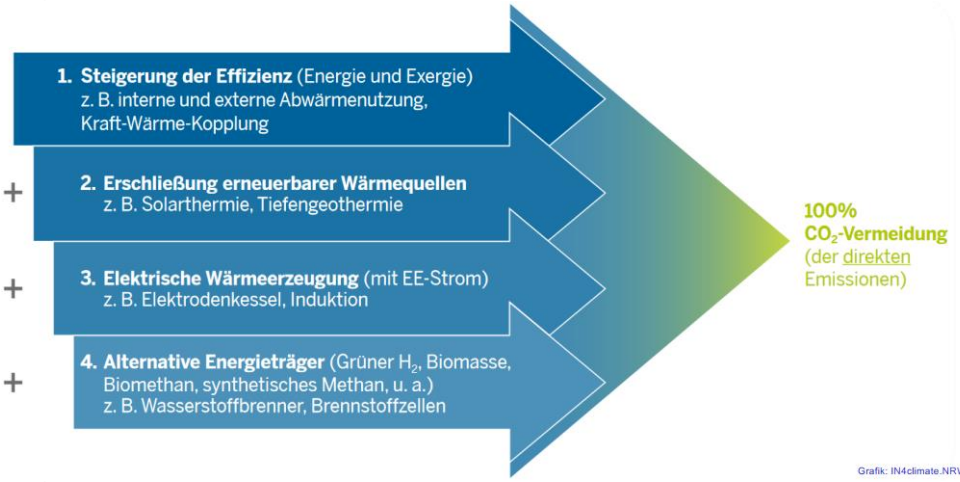
- 19 % of Germany's total final energy demand (2020) was used for industrial process heat
- of this, only a fraction has so far been provided from renewable energies or regenerative electricity

a) Hierunter fallen u. a. Raumwärme (z.B. Hallenbeheizung) und Warmwasser.
b) Hierunter fallen z. B. mechanische Energie (für Pumpen oder Antriebe), Beleuchtung, Informationstechnik und Kommunikation.
c) Mineralöl, Gas und Kohle
d) Strom verursacht in der Anwendung keine Emissionen. Da es sich hierbei um den Strommix aus dem Netz handelt, sind allerdings der aktuelle EE-Anteil und die resultierenden CO_2-Emissionen bei der Stromerzeugung zu berücksichtigen.
e) Unter Erneuerbare fallen z. B. Biomasse, Geothermie und Solarthermie

Achievable temperatures and potential areas of application for renewable heat

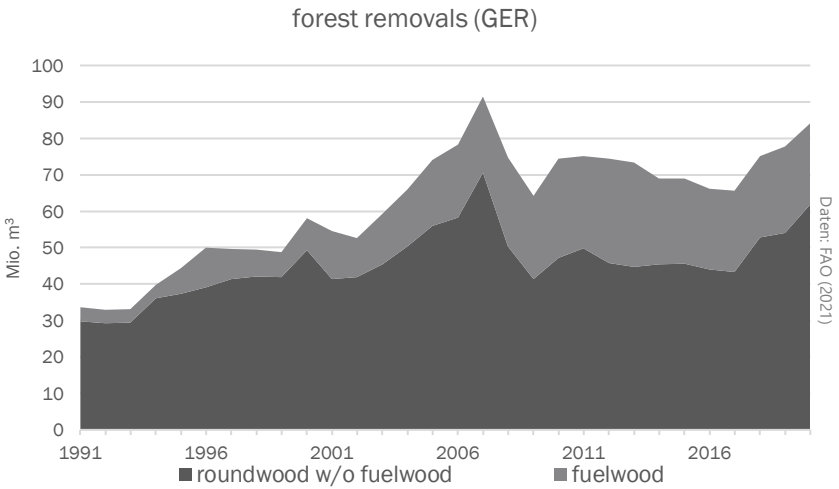
Grafik: IN4climate.NRW, eigene Ergänzungen

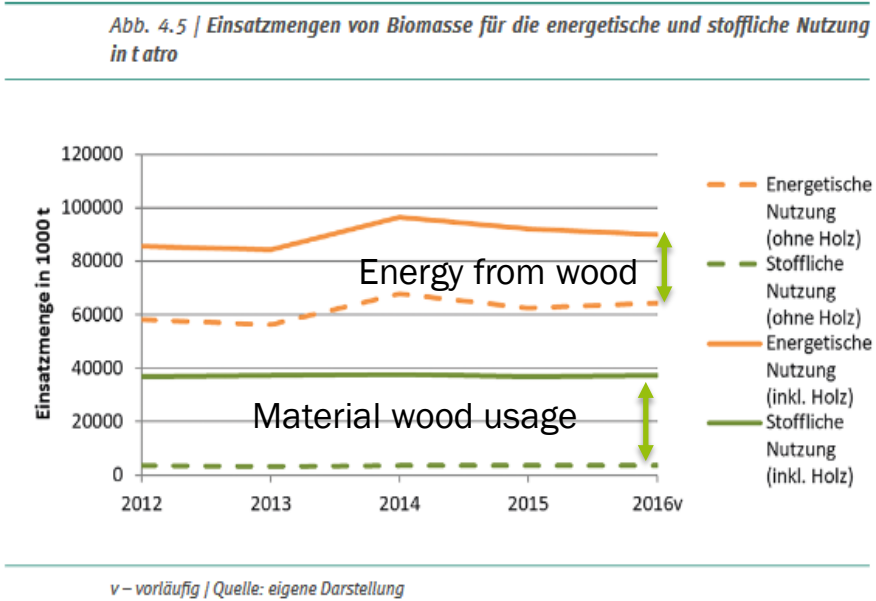
4-step model for decarbonization



Grafik: IN4climate.NRW

Wood utilization in Germany

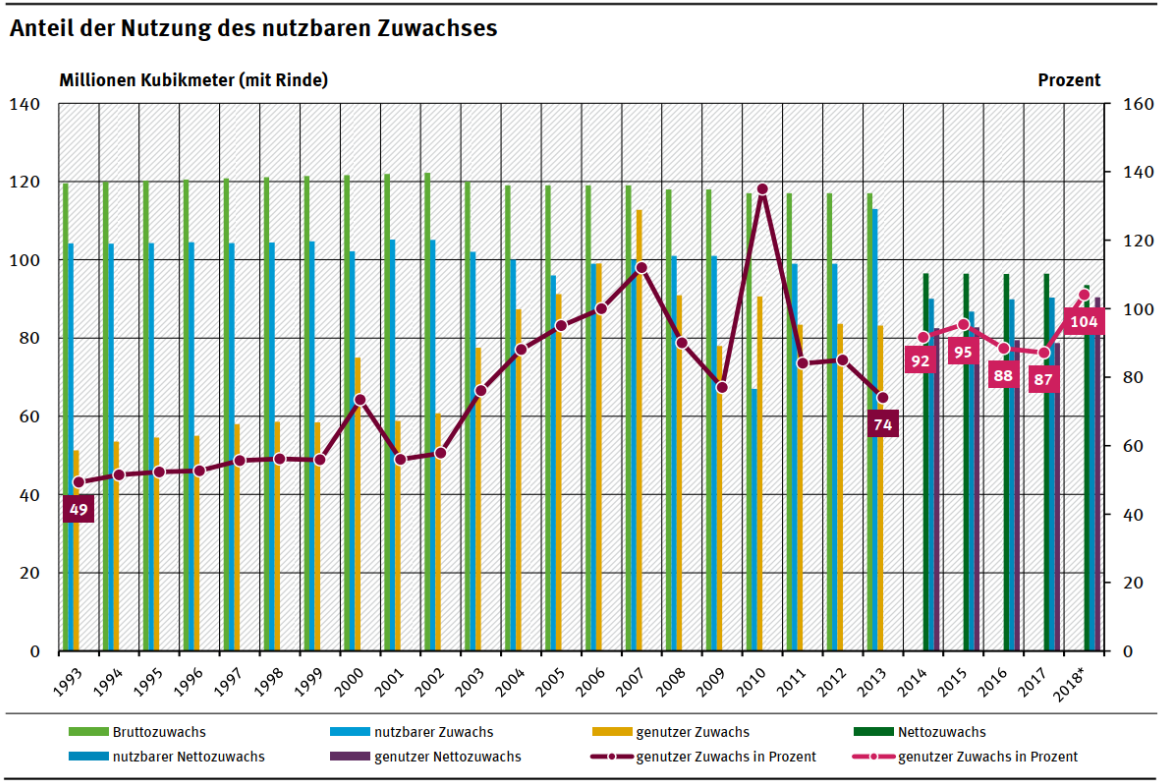




Quelle: Pilotbericht Biookonomiemonitoring

Material and energy use roughly equal

Wood potential in Germany



Die Daten, die in der Abbildung dargestellt sind, wurden für die Jahre 2003 bis 2013 auf Basis der Revision der Tabelle 13.2 der UGR überarbeitet.
* vorläufige Angaben

Quelle: Statistisches Bundesamt, Umwelt und Wirtschaft, Kapitel 6.4, Tabelle 13.2 (Zeitreihe 1993-2013); Statistisches Bundesamt (2019), Umweltökonomische Gesamtrechnung - Waldgesamtrechnung, Berichtszeitraum 2014-2017, Tabelle 2 "Physische Holzvorratsbilanz" (Zeitreihe 2014-2017)

Derb wood felling in Germany:

Comparison of growth (theoretical biomass potential) and utilization.

- 1993: 49% of the growth used
- 2007: 112% of the growth utilized
- After 2009: approx. 80% of increment utilized
- 2018-2020: utilization > increment (unplanned utilization)

Biokraft-Project (in progress)

Bundesministerium für Digitales und Verkehr

THÜNEN

DBFZ

Eberswalde University for Sustainable Development

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Expansion of wood energy only possible regionally and only to a limited extent!

Future wood energy potentials in Germany

2020 **Timber harvesting** is at the level of growth in Germany

approx. 50% goes into direct energetic use

especially for low-temperature applications at end customers or in wood (heating) power plants

Upcoming changes:

Biodiversity goals have been neglected for years -> forest must be converted to climate-resilient mixed forest + more untouched areas (up to 30%) are planned and more deadwood should remain in the forest!

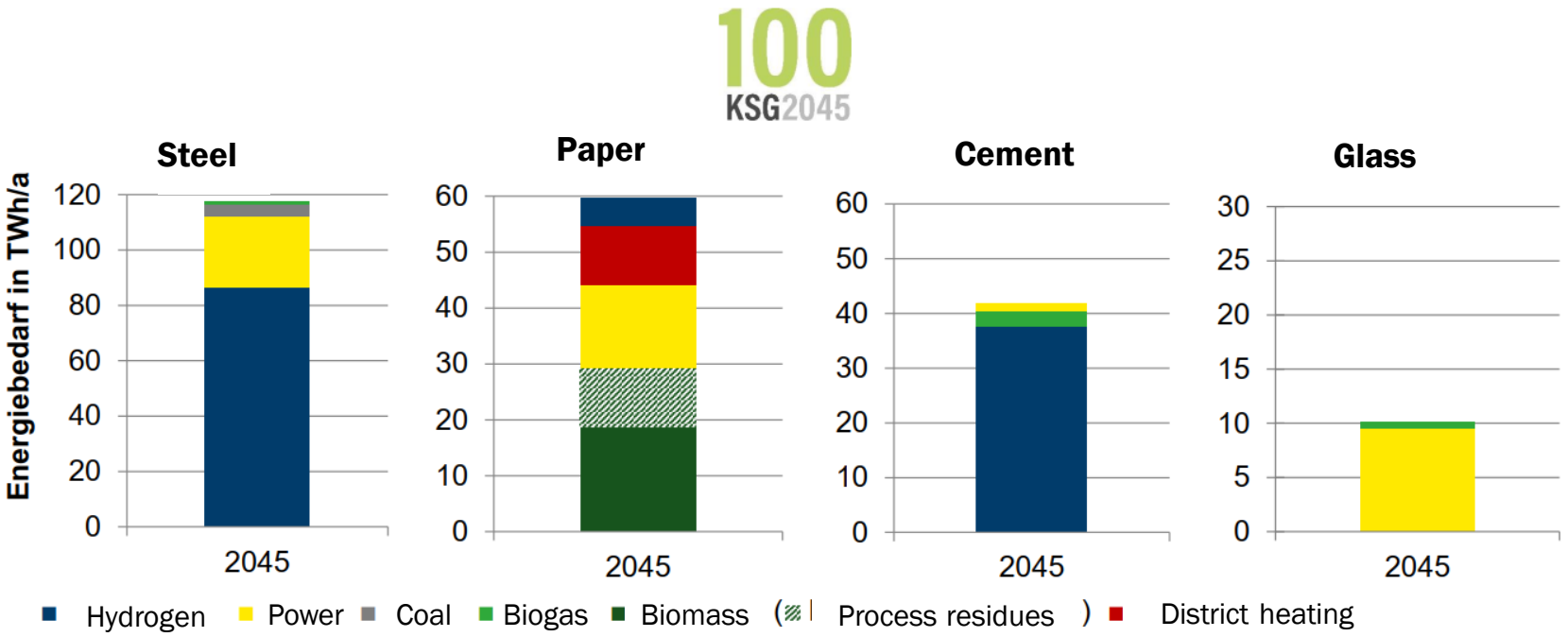
Climate neutrality 2045 requires **negative emissions** from agriculture and forestry: Germany foresees 20 million t for 2030; EU expects 34 million t from Germany => approx. 20-30% of the new growth must remain in the forest or the forest area must be expanded accordingly (+ 2-3 million ha)

Timber construction strategy and **bioeconomy strategy** require expansion of felling for material use

In Germany, the energetically usable potential of primary wood without imports will drastically decrease (from currently approx. 90 TWh/a to estimated 20 TWh/a).

Process heat scenarios Germany KSG45

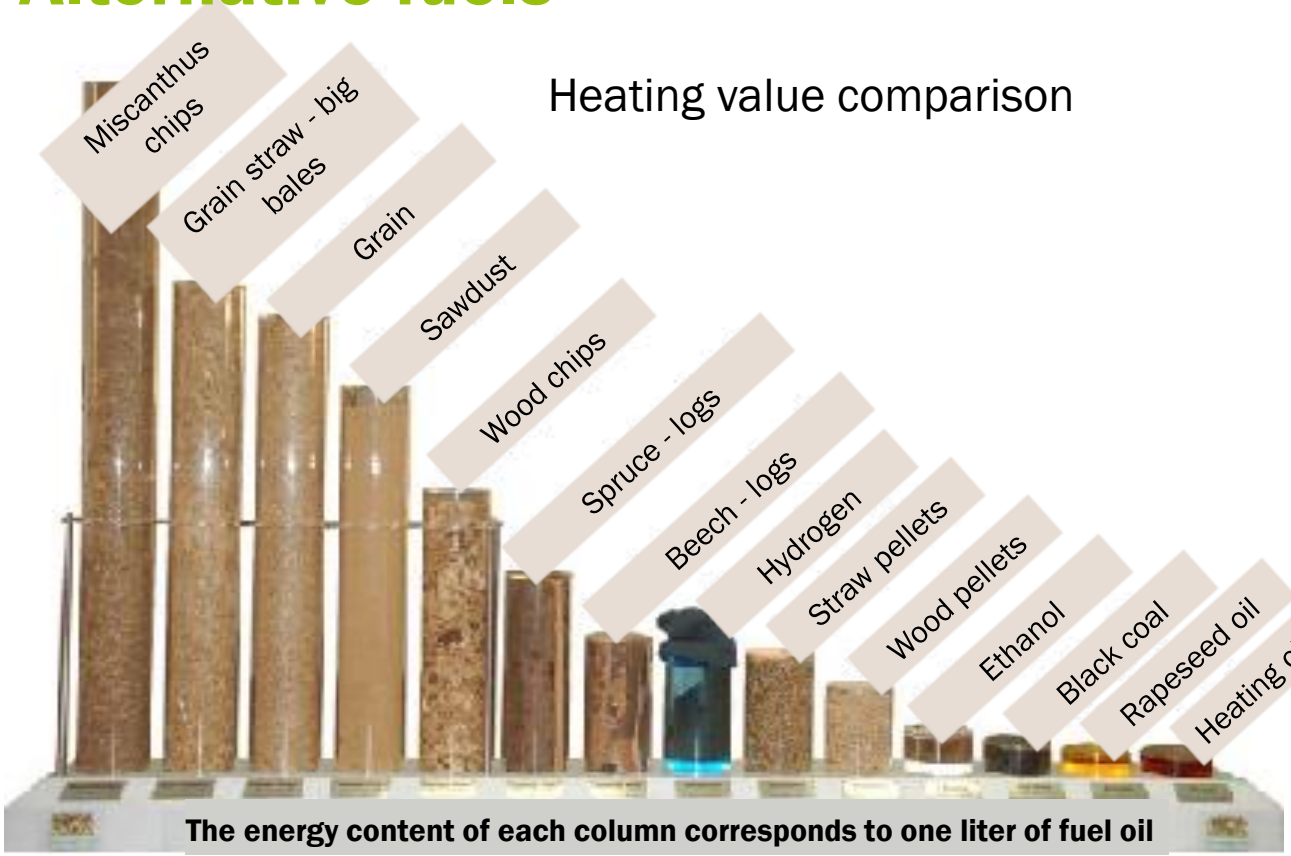
Industrial development in a greenhouse gas neutral energy system in Germany



Hydrogen and biomass are key energy carriers for the defossilization of German industry

Quelle: Forschungszentrum Jülich, Vortrag FVEE 2022

Alternative fuels

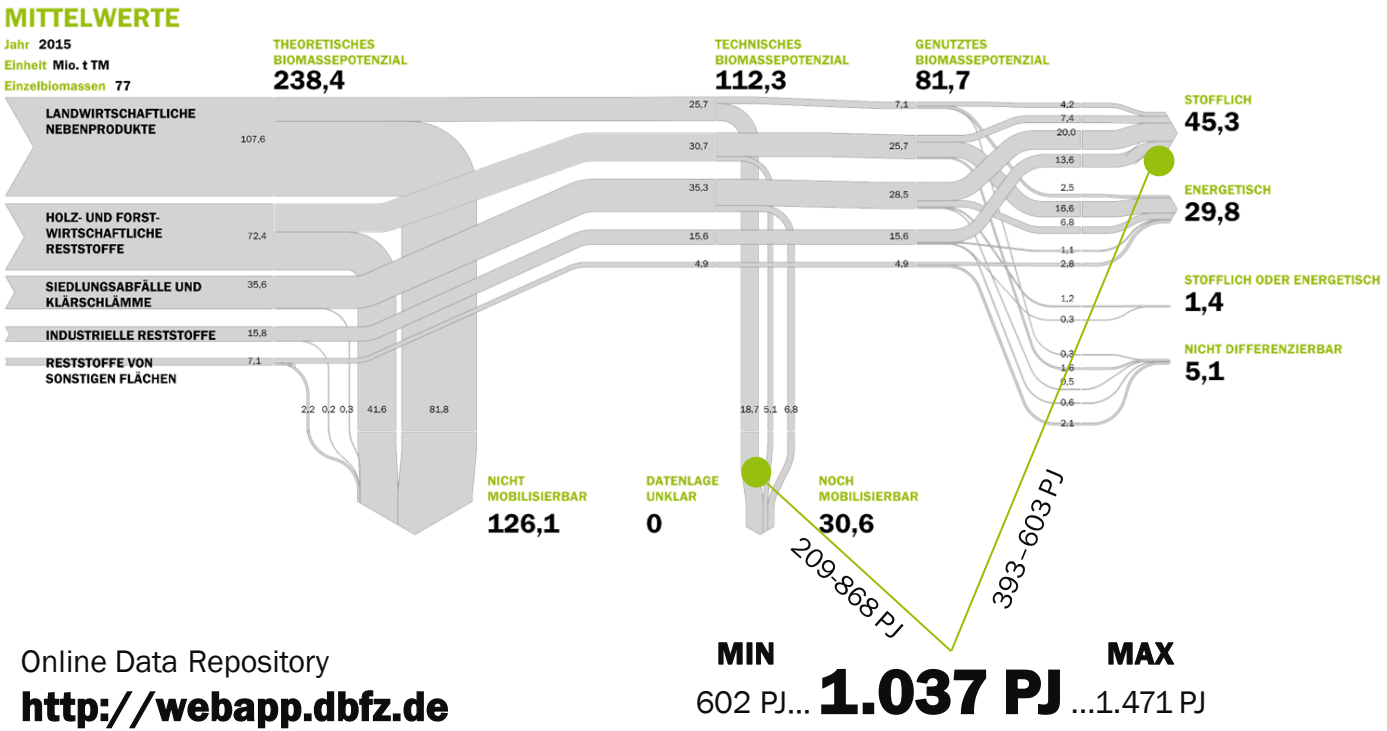


Compared to wood, alternative biomass fuels have:

- lower specific energy density
- higher ash content
- slag more easily
- higher risk of corrosion (C-content)
- higher NOx emissions
- higher PM emissions
- more inhomogeneous properties
- often higher price

Source: TFZ

Biomass potential & utilization in Germany



77
Biomasses

5
Sectors

1.113
Calculation elements

Min/Max
Values available

Online Data Repository
http://webapp.dbfz.de

MIN 602 PJ... **1.037 PJ** ...1.471 PJ **MAX**

Quelle: Brosowski et al. (2016), DOI 10.1016/j.biombioe.2016.10.017; Brosowski et al. (2019), DOI 10.1016/j.biombioe.2019.105275; Brosowski et al. (2019), https://www.fnr-server.de/ftp/pdf/berichte/22019215.pdf

Innovative fuel options

Initial situation :	Use of primary forest biomass for energy should not increase further (no funding incentives) - Federal Environment Ministry, environmental associations …
Possible Solutions:	Waste wood processing into premium fuels Landscape maintenance materials incl. paludiculture

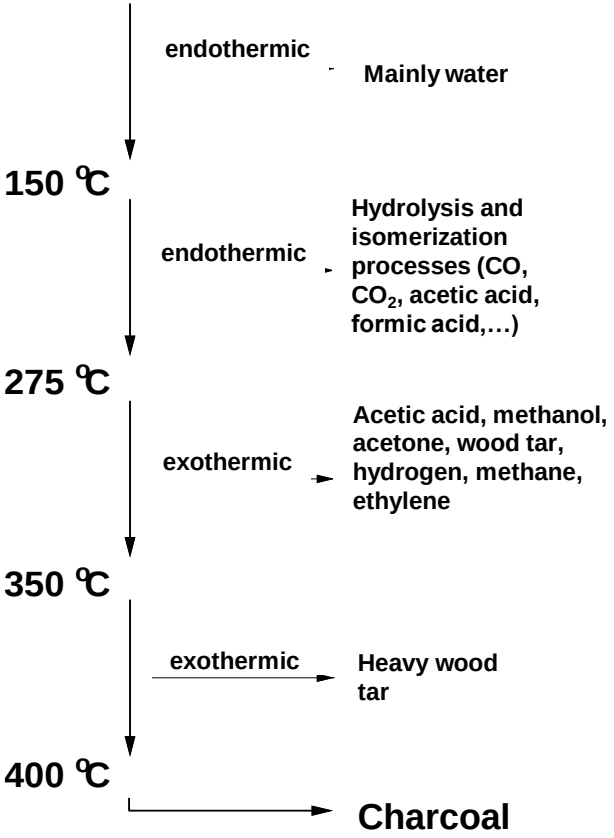
Florafuel AG plant

Washing,
mixing,
conditioning,
compacting

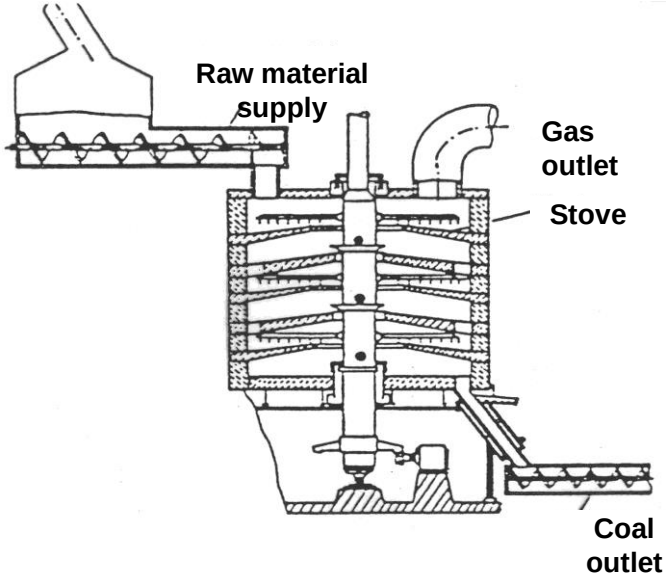
Torrefaction

Source: https://www.holzkurier.com/uebrige_wirtschaft/2012/08/andritz_mit_geschaeftsentwicklungzufrieden.html

Charcoal production



Source: Kaltschmitt

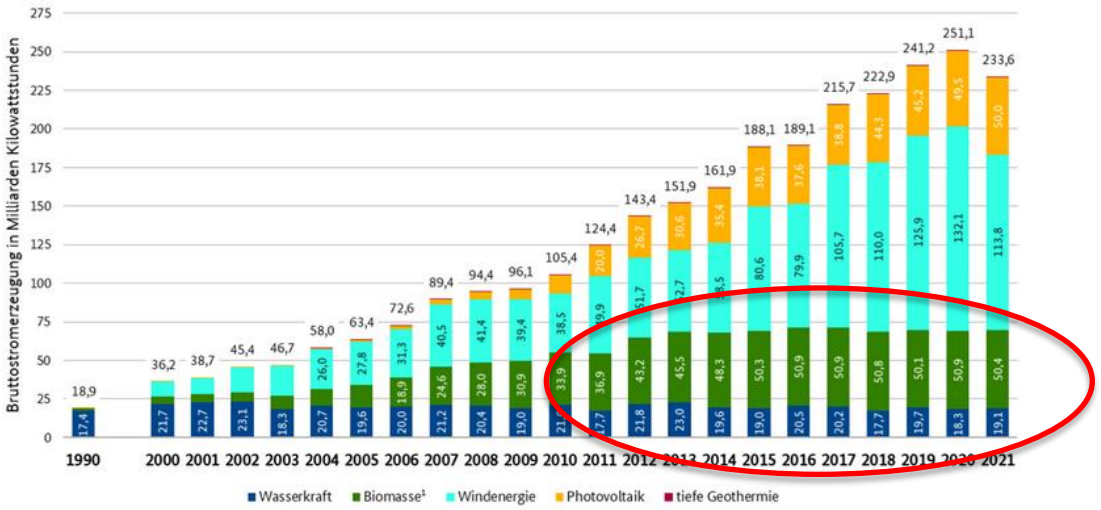


Source: www.bestongroup.com

Excursion: Development renewable power production in Germany

Bundesministerium
für Wirtschaft
und Klimaschutz

Entwicklung der Bruttostromerzeugung aus erneuerbaren Energien in Deutschland

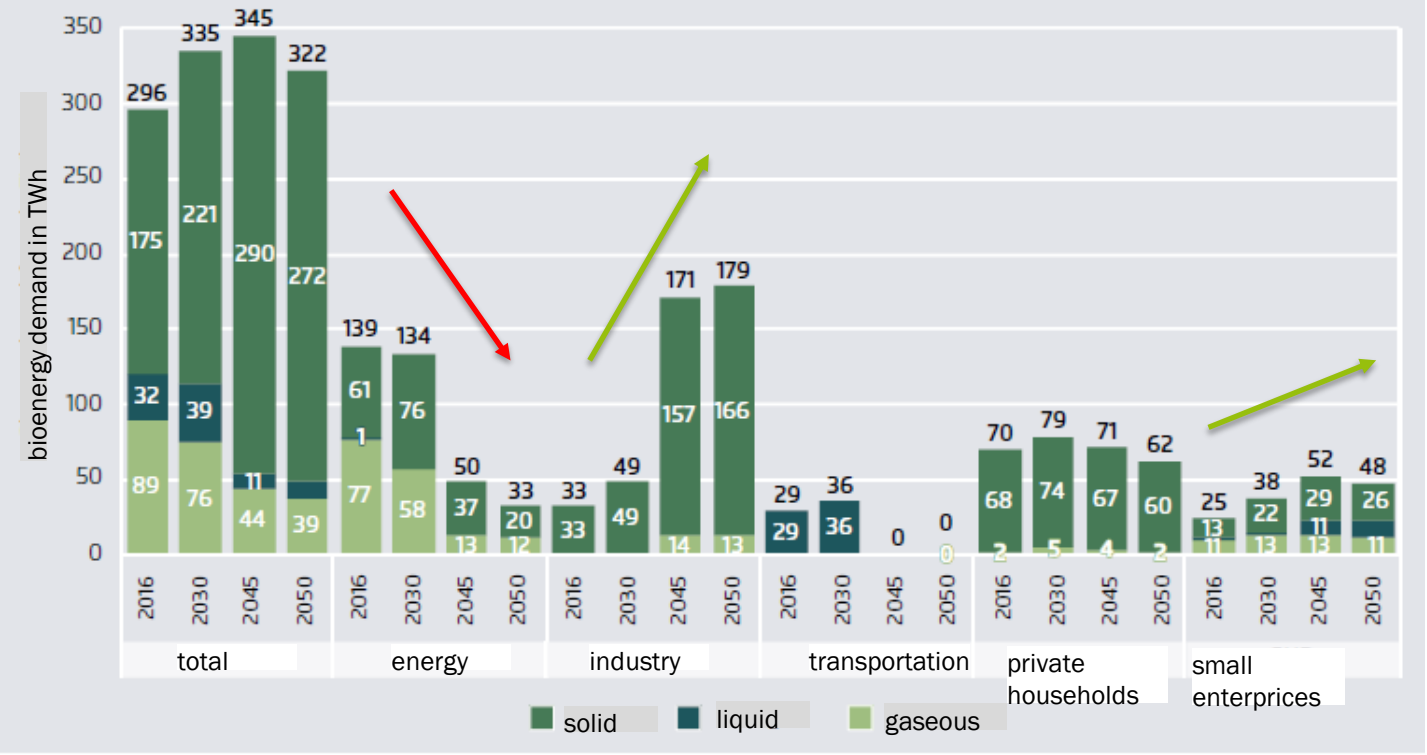


¹ inkl. feste, flüssige und gasförmige Biomasse, Klärschlamm
sowie dem biogenen Anteil des Abfalls (in Abfallverbrennungsanlagen mit 50 % angesetzt, ab 2008 nur Siedlungsabfälle)

BMWK auf Basis Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat); Stand: Februar 2022

- Since 2013 no significant increase in power from biomass due to much decreased funding
- First wood to power plants went out of operation.
- Clear political change in position away from wood to power – not only on German, but also on European level.

Scenario comparison of future use of biomass in Germany



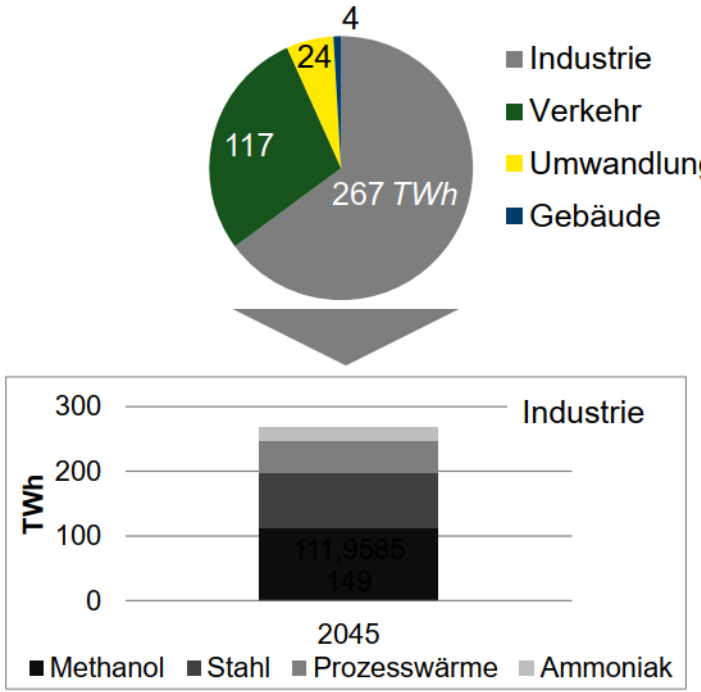
Prognos, Öko-Institut, Wuppertal Institut (2021)

German perspectives are:

- reduced use of wood for power
- much increased use for industrial heat
- slight increase in heat for SME

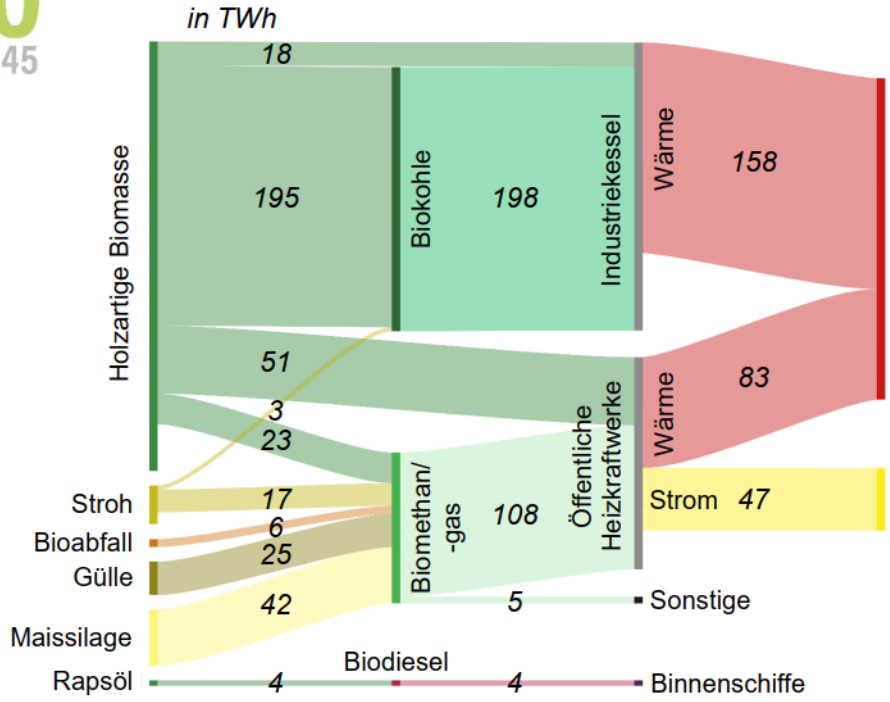
Process heat scenarios Germany KSG45

Industrieller Wasserstoffbedarf in 2045 in DE



100 KSG2045

Biomasseverwendung

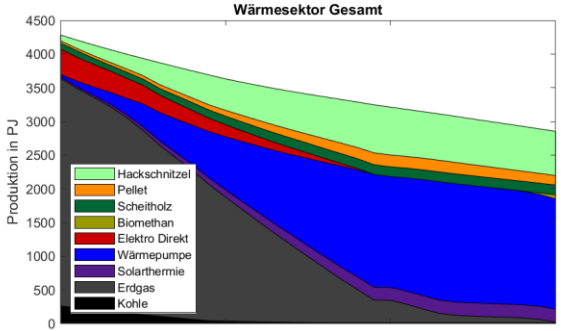


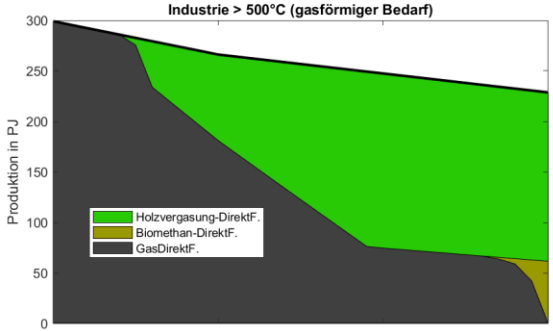
D. Stolten et al. (2022) Neue Ziele auf alten Wegen? Strategien für eine treibhausgasneutrale Energieversorgung bis zum Jahr 2045, Schriften des Forschungszentrums Jülich Reihe Energie & Umwelt, Volume 577, VI, 81 pp ISBN: 978-3-95806-627-4

Quelle: Forschungszentrum Jülich, Vortrag FVEE 2022

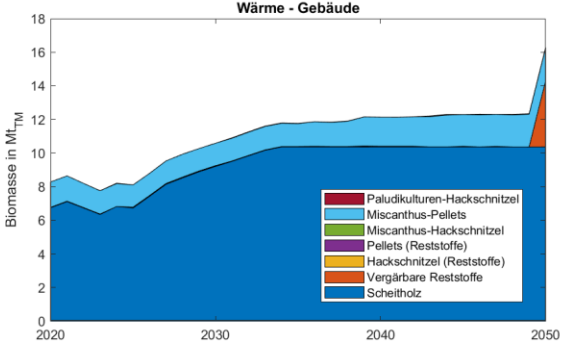
Scenarios of future biomass use in Germany

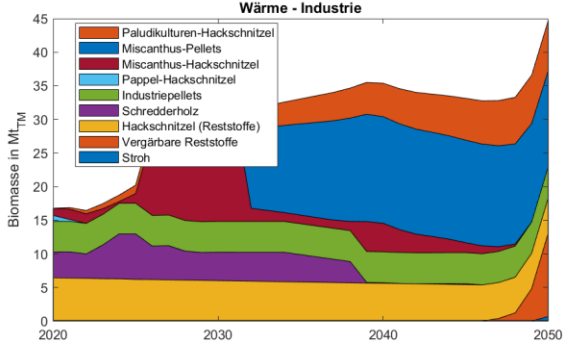
Robust insights into the long-term, cost-optimal use of biomass across a variety of scenarios through 2050*.





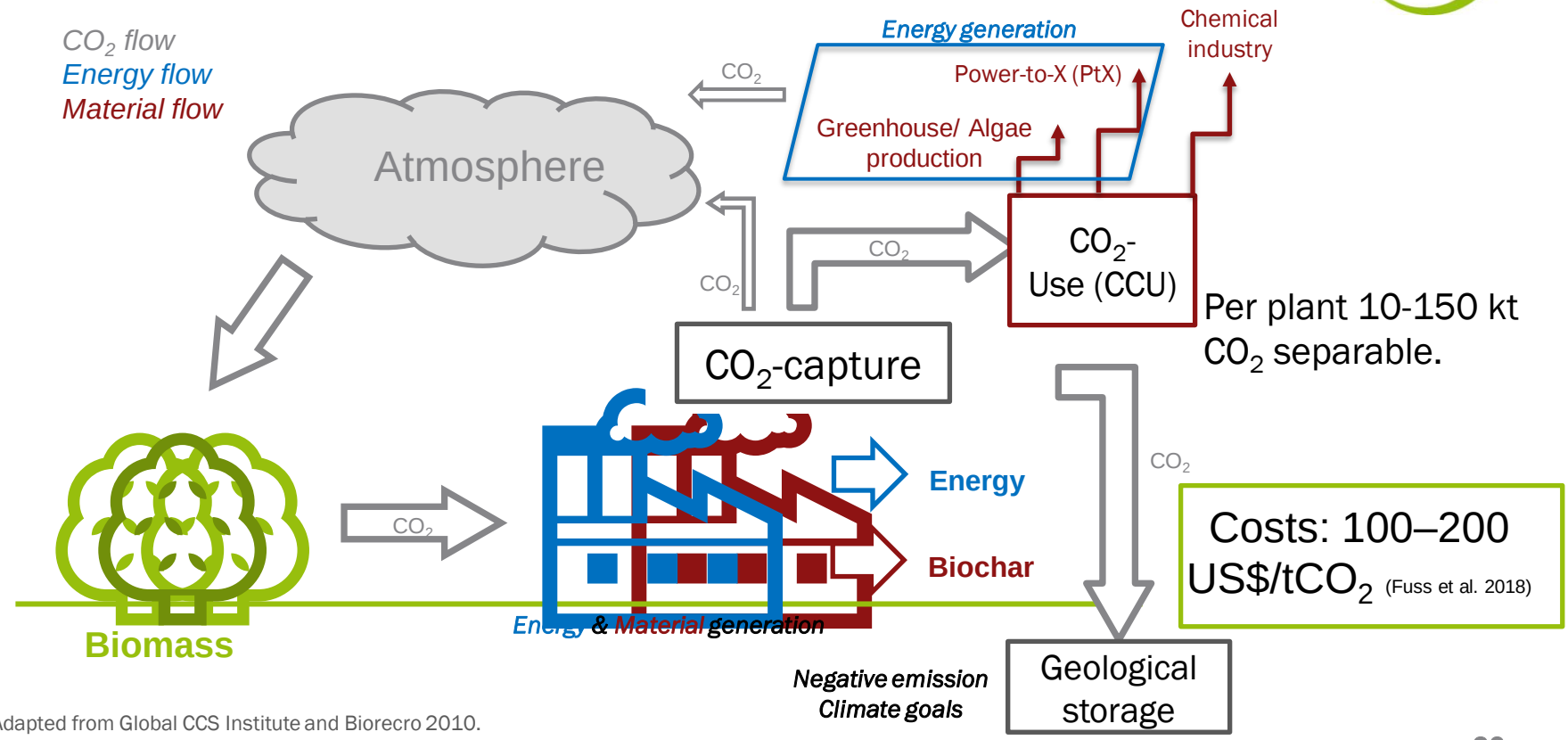
*DBFZ/ UFZ project SoBio: Strategy for the optimal energetic use of biomass in the future German energy system: An energy system modeling with the model BenOpt
Assumption: 47 Mt_{DM} Residuals + 2,3 Mio ha cultivation area





- Woody residues in high-temperature heat applications in industry
- Fermentable residues in the long term as flexible biomethane in various sectors that are difficult to decarbonize, e.g. high-temperature industry, district heating, buildings
- Cultivated biomass for flexibility in the power sector, as well as in high-temperature heat applications.

Industrial application with BeCCS



Source: Adapted from Global CCS Institute and Biorecro 2010. https://www.globalccsinstitute.com/publications/global-status-beccs-projects-2010 by UFZ/DBFZ

Negative emissions from biomass energy use

- **Industrial high-temperature processes with possibly inherent GHG emissions are suitable for CO_2 capture incl. biomass use: e.g. cement production**

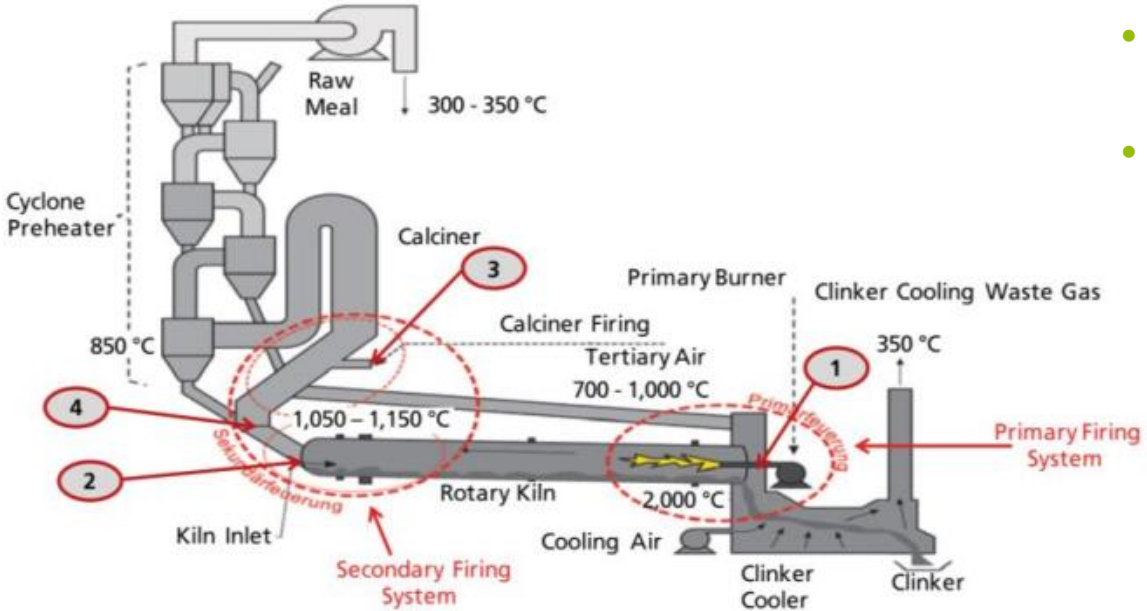
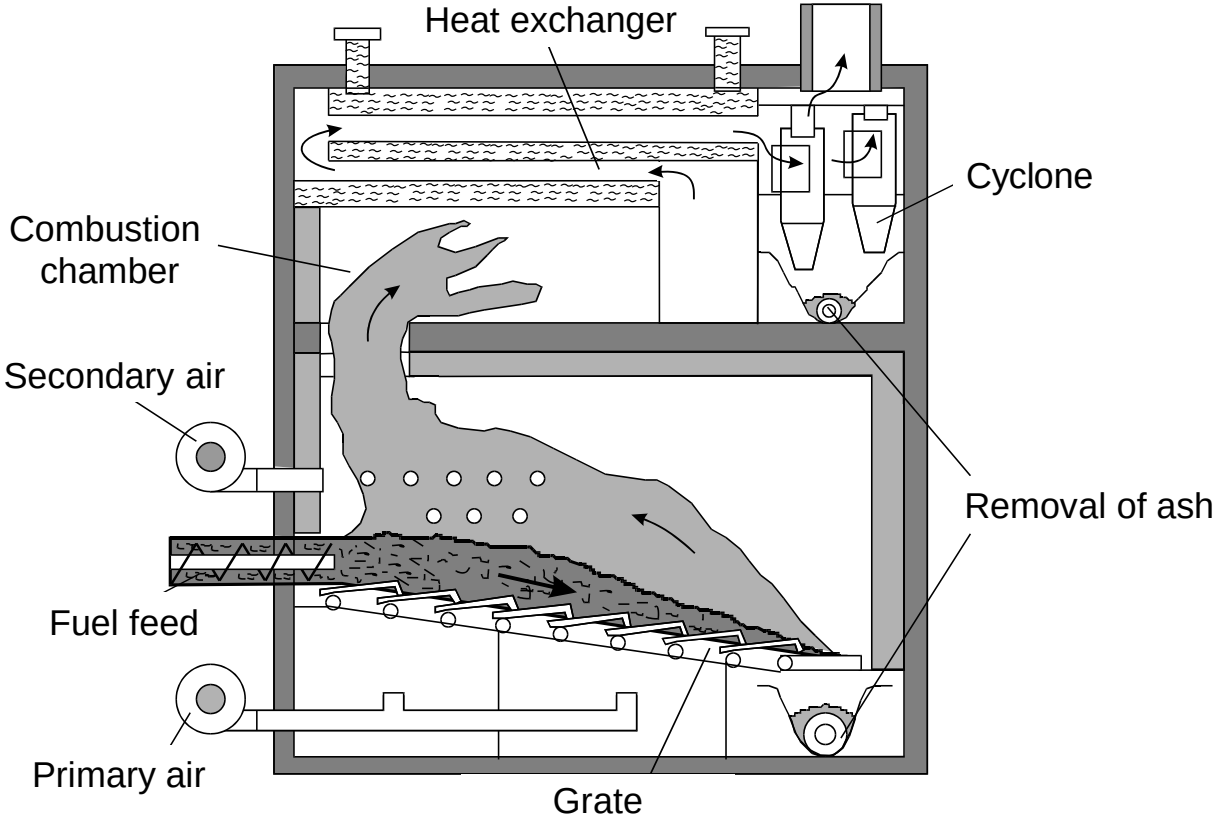


Figure: Sarc R, Pomberger R, Lorber KE. Innovative Technical Solutions for Reduction of Waste Fuel Specific Emissions in Cement Plants. In: Thomé-Kozmiensky KJ, Thiel S, Thomé-Kozmiensky E, Winter F, Juchelková D, editors. Waste Management. Neuruppin, Germany: TK Verlag Karl Thomé-Kozmiensky; 2017, 475–497

- in many other industries hydrogen seems to be promising
- in the field of small combustion plants, the increase in the amount of residual coke (C-rich ash) and its incorporation into the soil could lead to negative emissions (+ soil improvement)

Ash recovery versus coal recovery



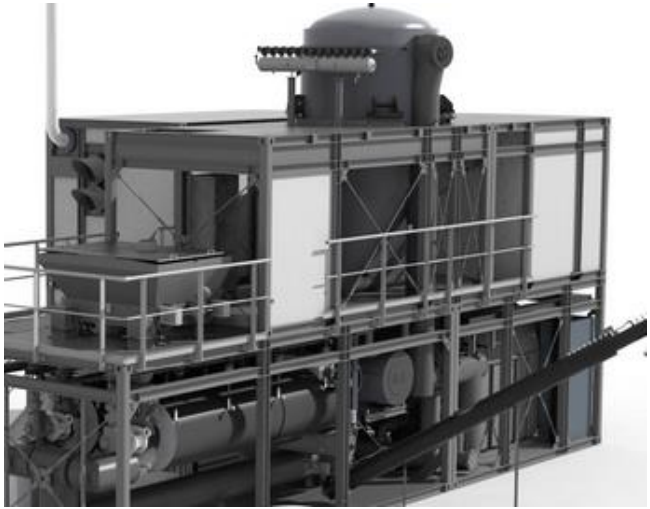
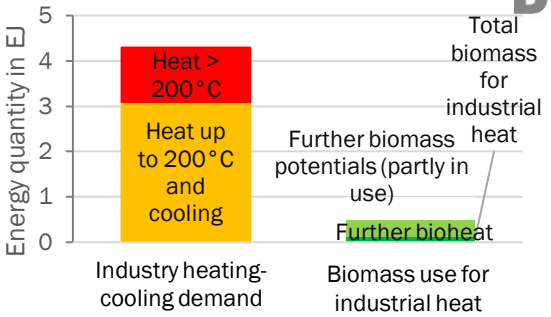


Bild: Pyreg https://pyreg.com/de/unsere-technologie/

Quelle: Kaltschmitt

Conclusion: Role of bioenergy in the industry

+ Building heating

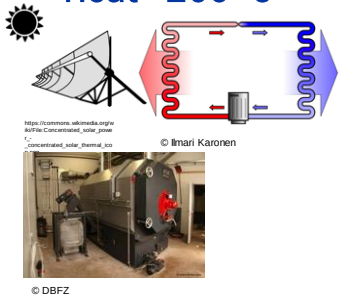


Interim conclusion: Biomass is storable, flexibly applicable and available!

However, quantities are limited and associated with costs!

Consequence: Use only for selected applications with additional benefits

Heat <200 °C



Hybrid technology

Process effects

Biocoke for steel incl.H_2

Ash for cement

+ biogenic silica

CCS + BeCCS

$CaCO_3$ + Bio heat

CO_2

@ José David Mendoza Terrazas

Bioeconomy

HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

DBFZ

Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Smart Bioenergy – Innovationen für eine nachhaltige Zukunft

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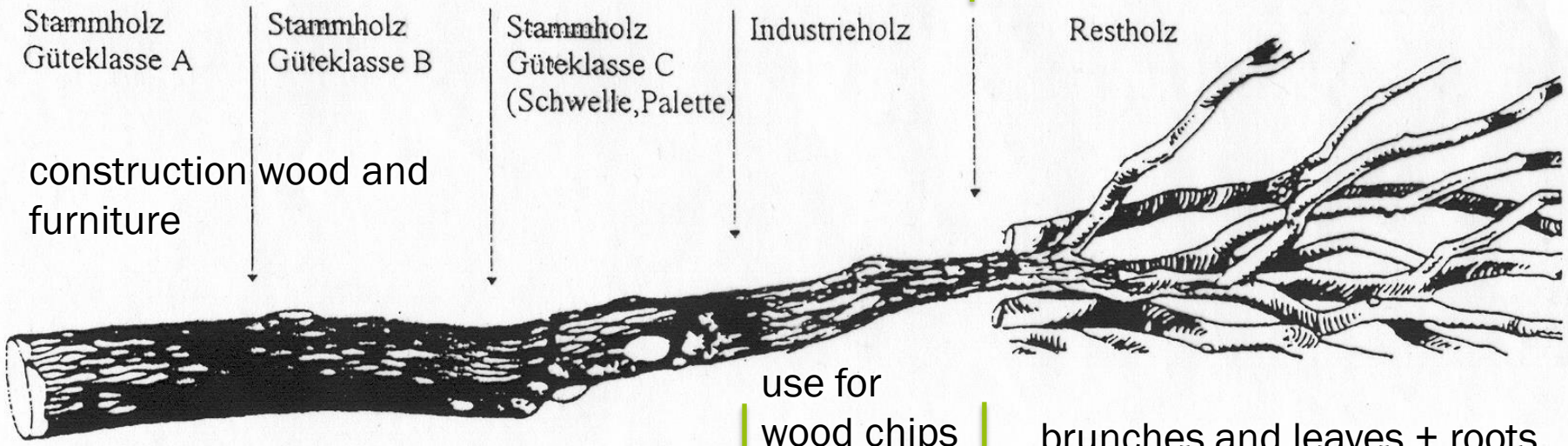
Wood qualities

debarkable



construction wood and furniture

use in wood industry for products or wood export

use for wood chips for pulp and paper or chipboard or energy

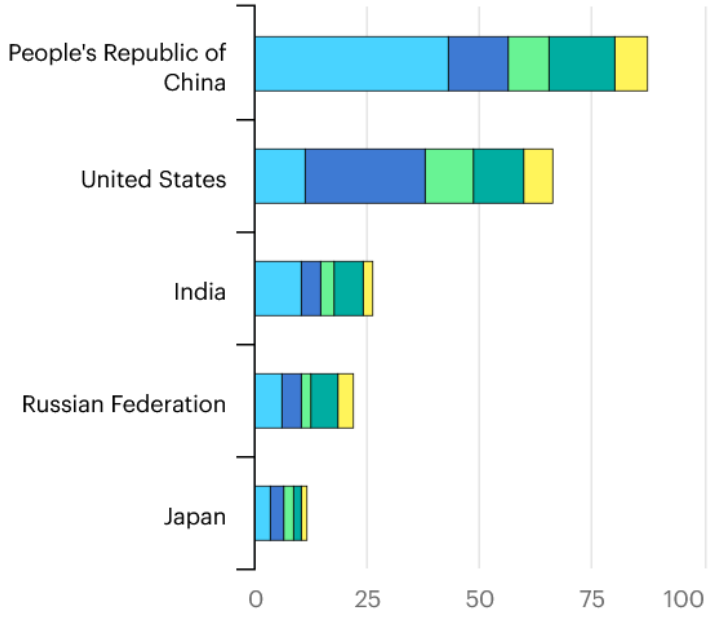
brunches and leaves + roots

sorting for compost (Biomeiler) and energy chips

Quelle: Küthe, 2001, adopted

Top five countries by total final consumption by sector, 2019

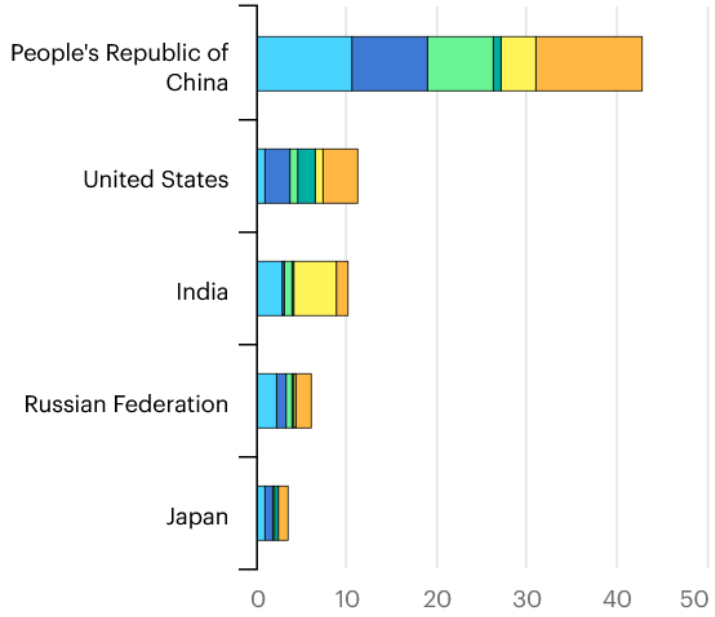
Open



Industry · Transport · Other · Residential · Non-energy use

Industry consumption by sub-sector of top five countries by total final consumption, 2019

Open



Iron and steel · Chemical and petrochemical · Non-metallic minerals · Paper, pulp and print · Industry not elsewhere specified · Other

Energy carrier-specific properties

		Woody biomass		Herbaceous biomass			
Para-meter	Unit	Wood pellets[1]	Spruce wood with bark[2]	Miscan-thus[3]	Wheat straw[3]	Reed[4]	Reed Glossy Grass[4]
Water content	[Gew.-% (roh)]	≤ 10	13	8,3	11	9,5	13
Calorific value,Hu	MJ/kg (wf)]	≥ 18,0	18,8	17,7	17,0	17,2	16,2
Ash content	[Gew.-% (wf)]	≤ 0,50	0,6	3,2	6,4	4,0	8,5

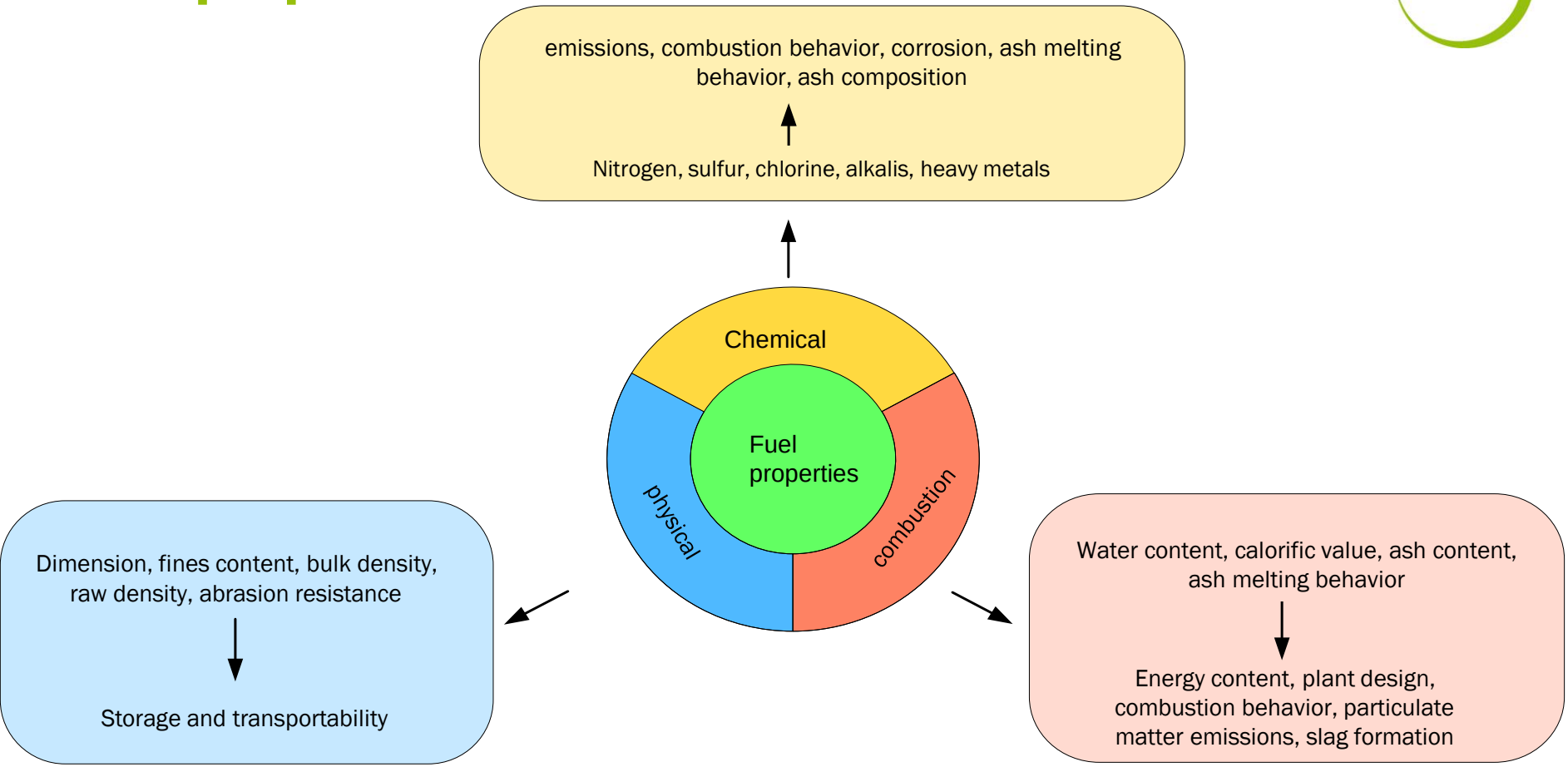
Quelle: Leitfaden Bioenergie[1]; DINplus[2]; interne Analysen DBFZ[3]; Endbericht der FH Strahlsund zum Teilprojekt „Charakterisierung und Analyse der Biobrennstoffe „Schilfrohr“ und „Rohrglanzgras“ und Verbrennungstests, Stand: 30.06.2008[4]

Charcoal properties

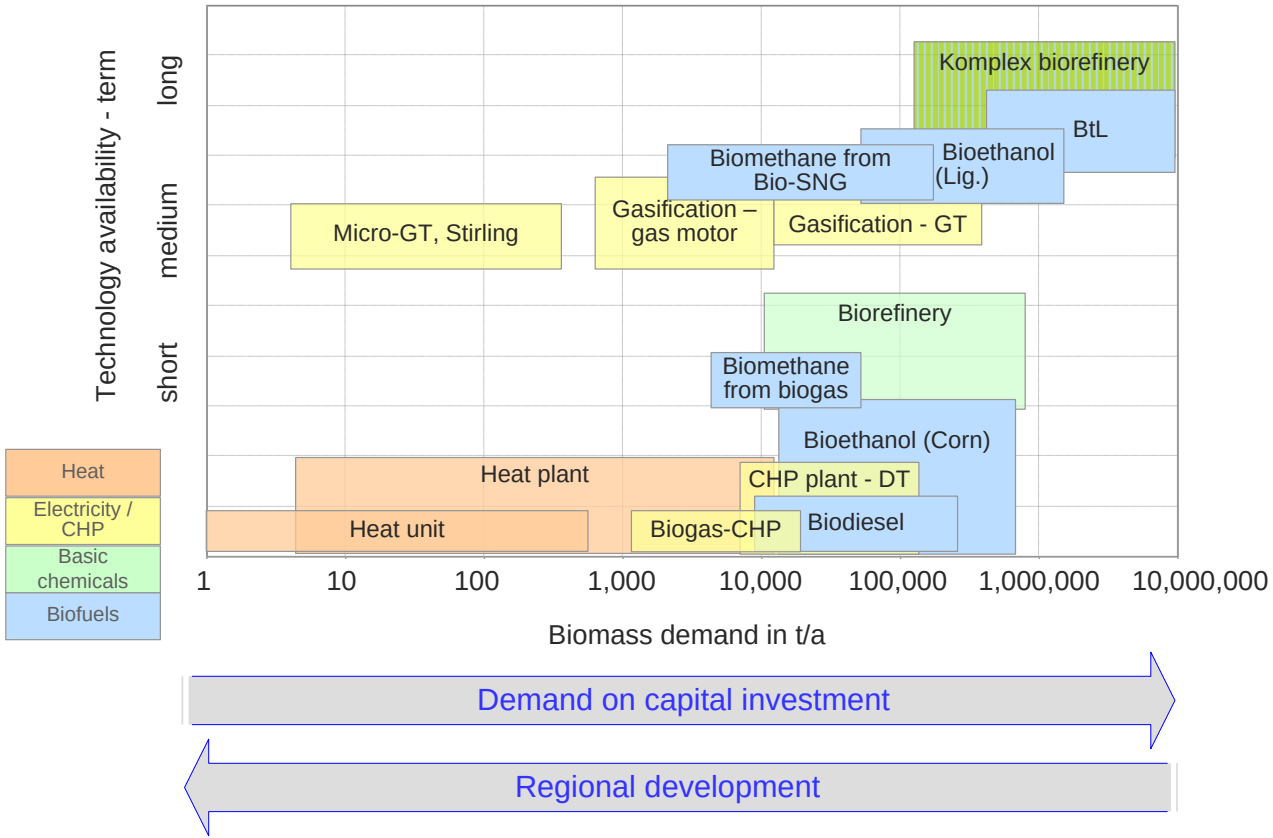
Temperature in ° C	Composition C in %	H in %	O in %	Yield in % of wood dry matter
200	52,3	6,3	41,4	91,8
250	70,6	5,2	24,2	65,2
300	73,2	4,9	21,9	51,4
400	77,6	4,4	18,0	40,6
500	89,2	3,1	7,7	31,0
600	92,2	2,6	5,2	29,1
800	95,4	1,1	3,5	26,7
1 000	96,6	0,5	2,9	26,5

Quelle: Kaltschmitt

Fuel properties - overview and influence



Technology Overview

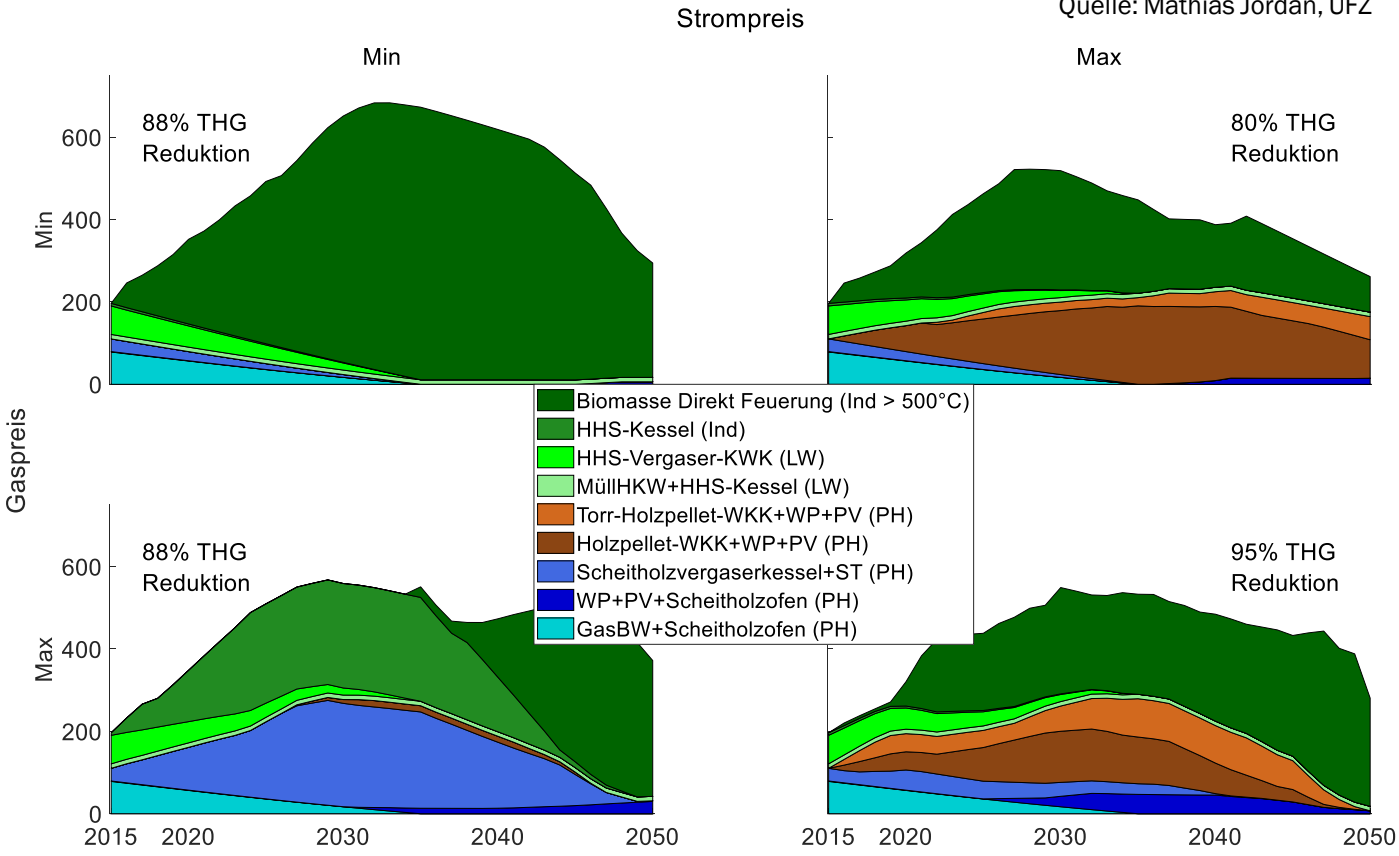


Simulation of biomass use in the heating market (BioPlanW)

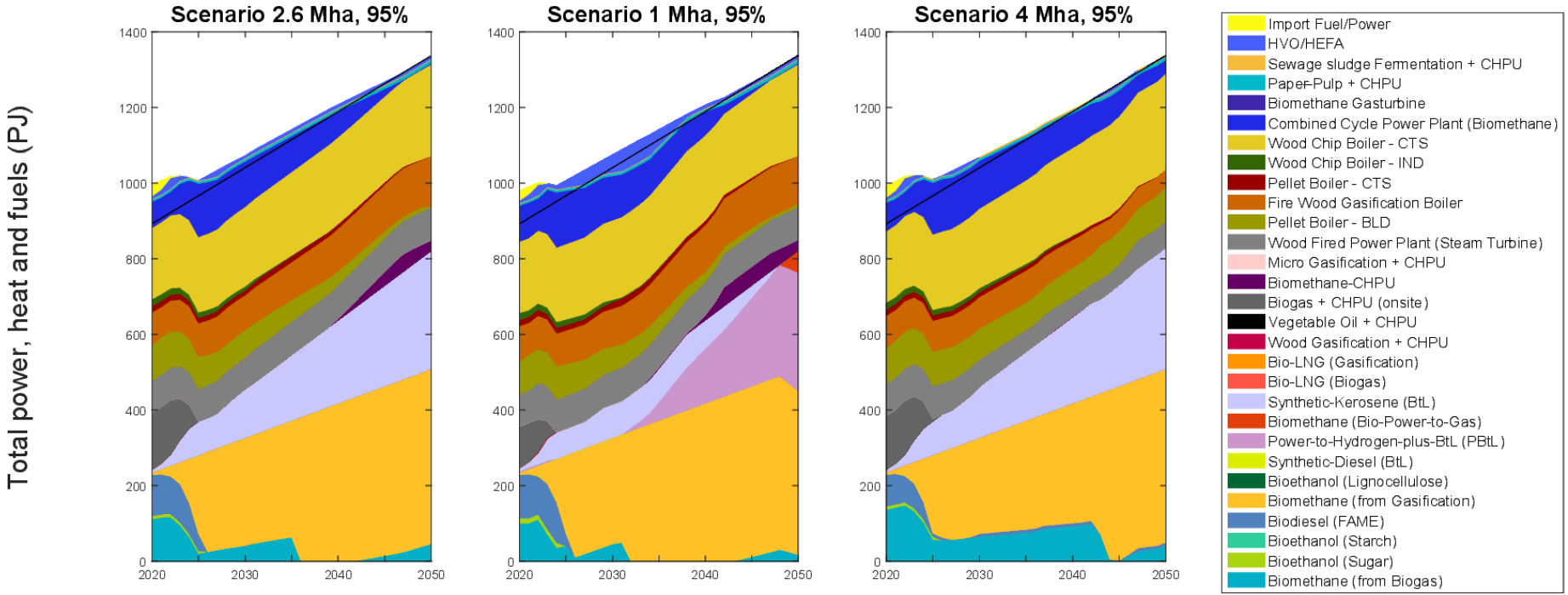
Quelle: Mathias Jordan, UFZ

52 Supply scenarios for heat supply from biomass and other renewable energies

Solution space for bioenergy technologies under uncertain developments

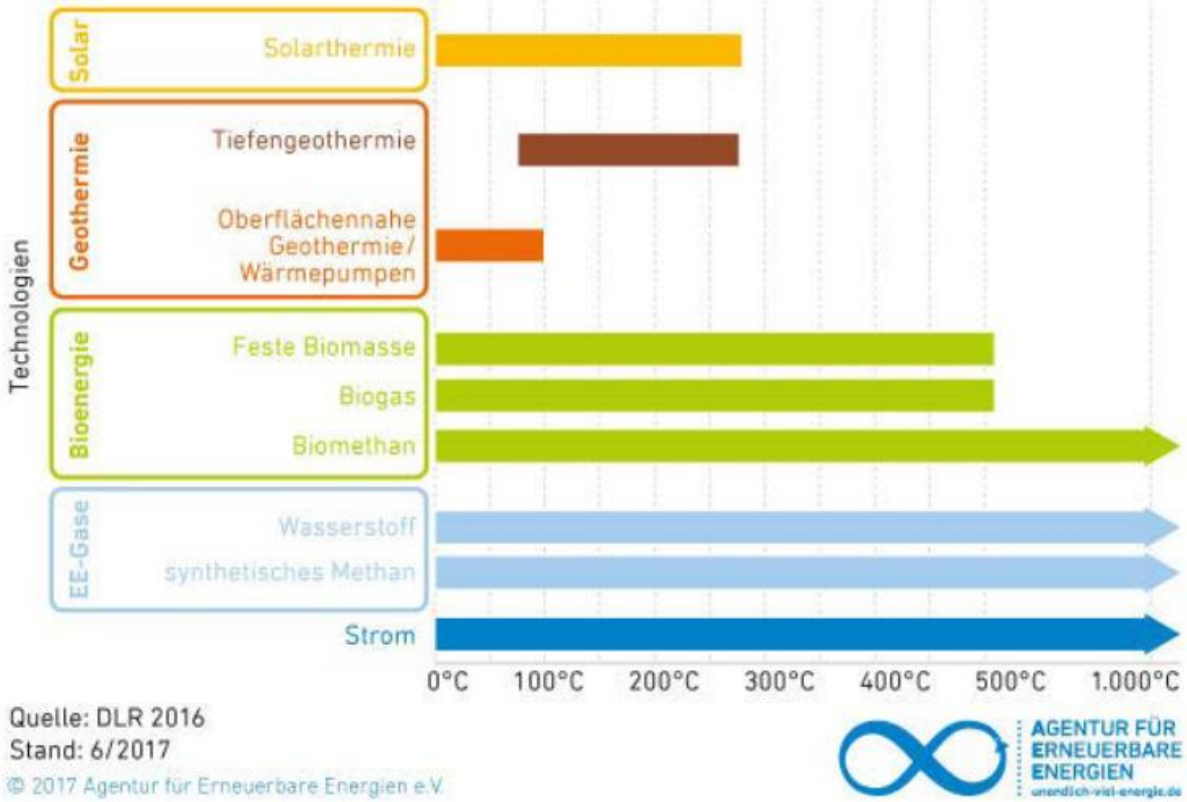


95% EE-Szenario - Bioenergy Perspectives



Quelle: TatBio Report (auf der BMWi oder DBFZ Webseite zu finden)

Achievable temperatures from renewable heat sources



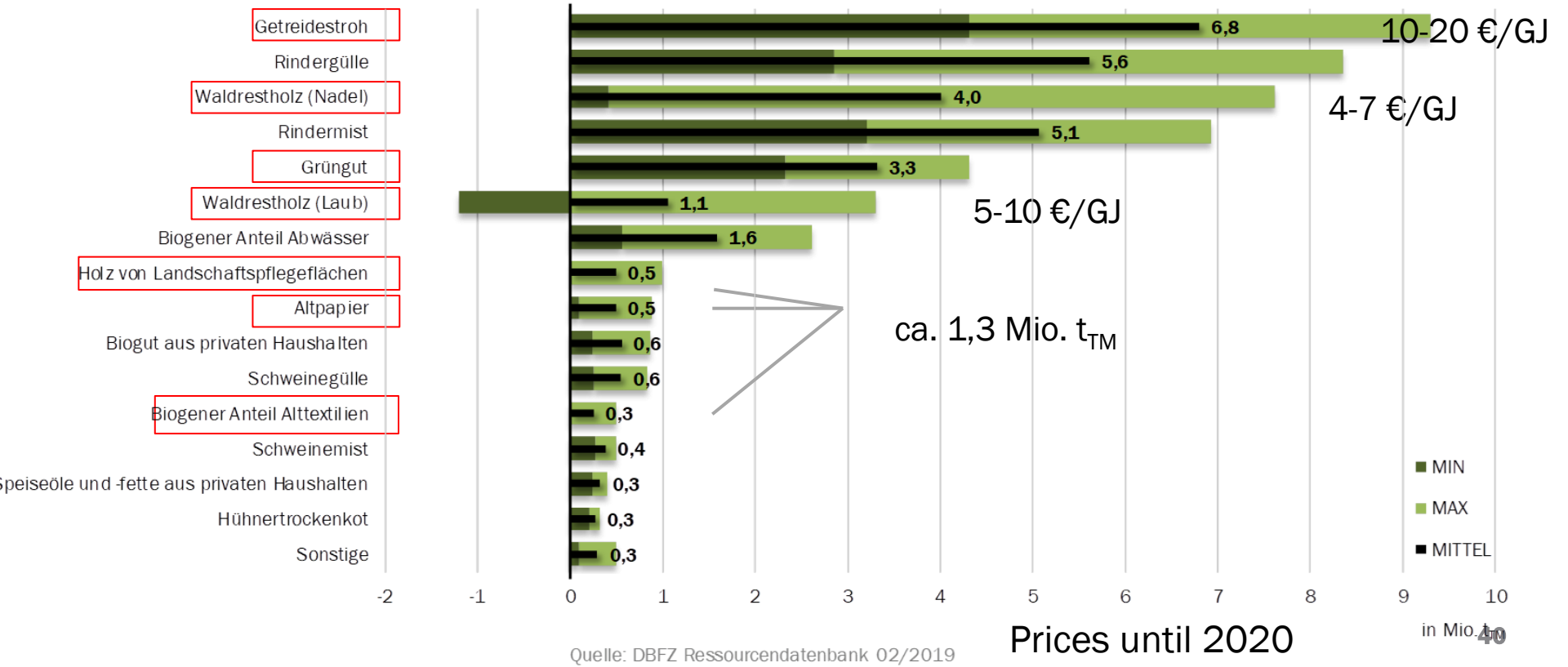
Quelle: FVEE-Jahrestagung 2022

Top 15

MOBILISIERBARES TECHNISCHES BIOMASSEPOTENZIAL

Reststoffe/Nebenprodukte/Abfälle [Mio. t_{TM}]

Deutschland - Bezugsjahr 2015



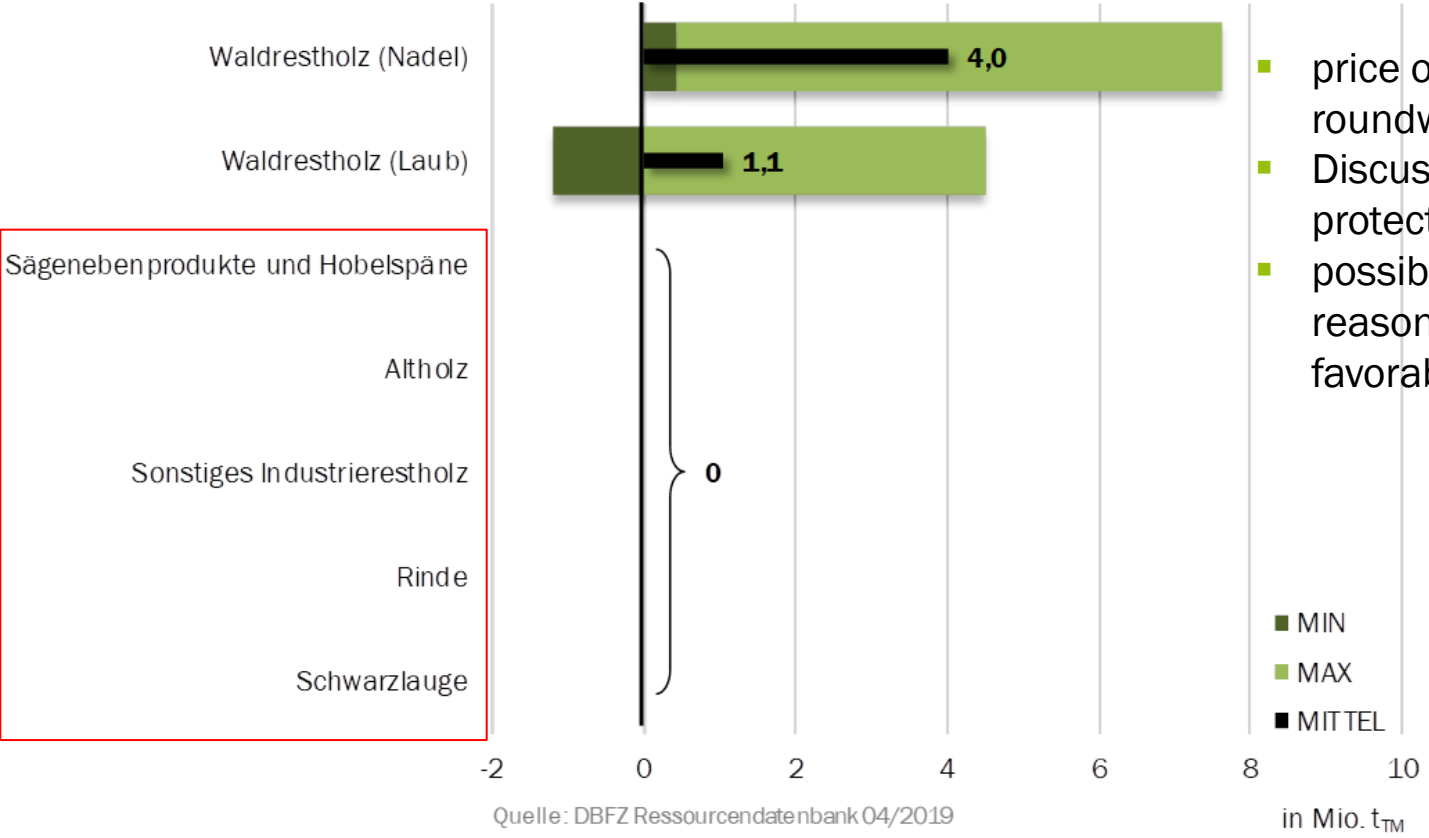
Prices until 2020

Quelle: DBFZ Ressourcendatenbank 02/2019

MOBILISIERBARES BIOMASSEPOTENZIAL

Holz- und forstwirtschaftliche Reststoffe [Mio. t_{TM}]

Deutschland - Bezugsjahr 2015



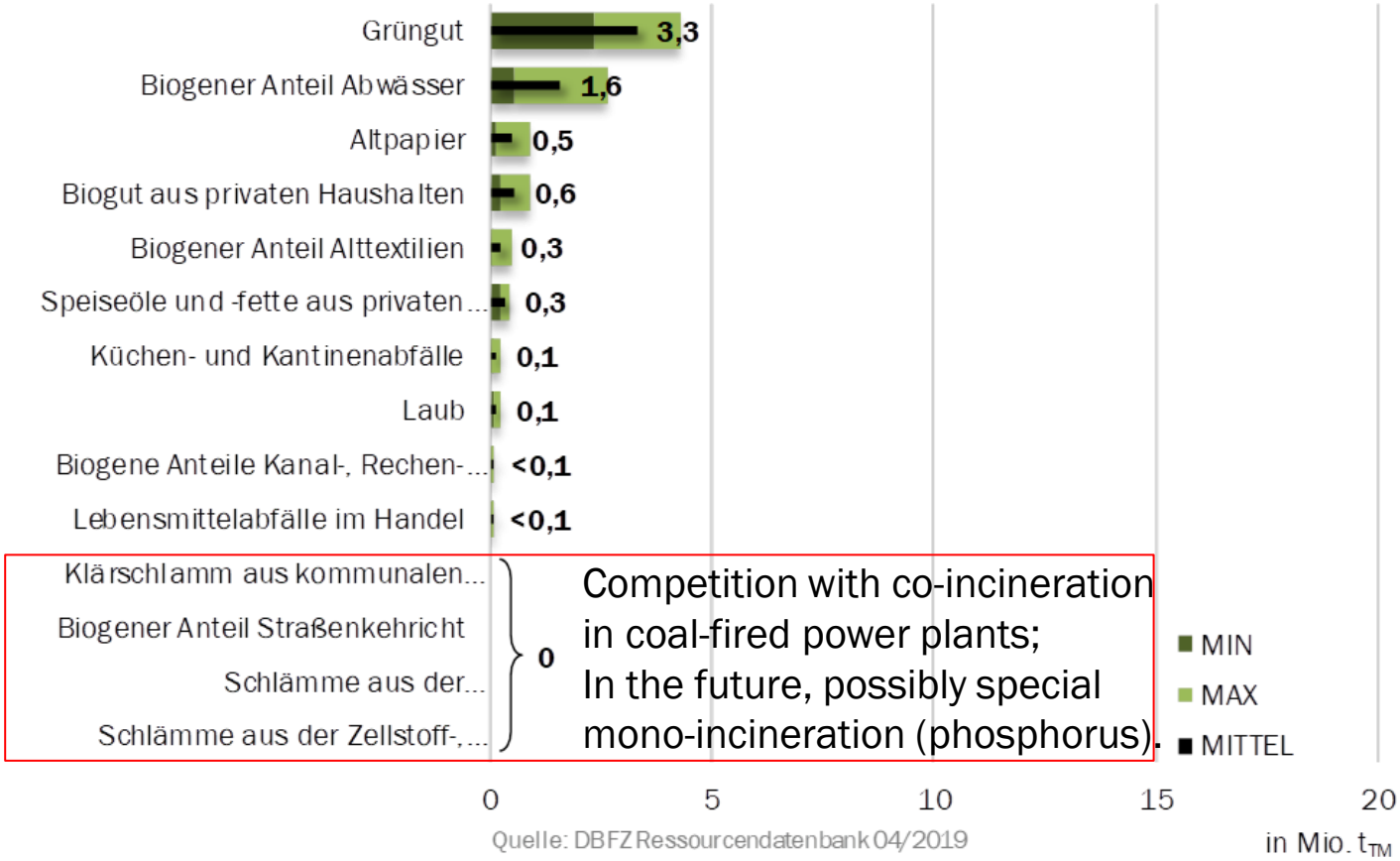
- price only slightly cheaper than roundwood;
- Discussion about forest protection
- possibly for fire protection reasons and calamities favorable offers

Quelle: DBFZ Ressourcendatenbank 04/2019

MOBILISIERBARES BIOMASSEPOTENZIAL

Siedlungsabfälle und Klärschlamm [Mio. t_{TM}]

Deutschland - Bezugsjahr 2015



Competition with co-incineration in coal-fired power plants;
In the future, possibly special mono-incineration (phosphorus).

Quelle: DBFZ Ressourcendatenbank 04/2019

Biomass energy use in Germany 2020

Wärme	Erzeugung in PJ (Stand 2020)	Erzeugung in PJ (Ausblick 2023)	Primärenergie-äquivalent in PJ (Stand 2020)	Primärenergie-äquivalent in PJ (Ausblick 2023)
Biogene Festbrennstoffe[a]:				
- nur Wärme	365	394 bis 397	464 [I]	501 bis 505 [I]
- KWK-Wärme	108	103 bis 114	59	56 bis 63
Biogas (vorrangig KWK Wärme)	69	66 bis 69	4,4 [b,III,VII,VIII]	4,8 bis 5,4 [b,III,VII,VIII]
Flüssige Bioenergieträger	10,8 [b]	12,6 bis 14,4 [b]	11,7 [b, II]	14 bis 16 [b, II]
Summe	553	576 bis 594	539	576 bis 589
Strom	Erzeugung in PJ (Stand 2020)	Erzeugung in PJ (Ausblick 2023)	Primärenergie-äquivalent in PJ (Stand 2020)	Primärenergie-äquivalent in PJ (Ausblick 2023)
Biogene Festbrennstoffe:				
- Biomasse	41	37 bis 43	165 [IV]	151 bis 175 [IV]
- Abfälle	21	20 bis 22	37 [V]	36 bis 38 [V]
Biogas				
- KWK-Prozess	110	104 bis 108	445 [VI;VII]	421 bis 436 [VI;VII]
- Biomethan	9	9 bis 10	40 [VII;VIII;IX]	38 bis 41 [VII;VIII;IX]
Flüssige Bioenergieträger	1,1	1,1 bis 1,4	3 [VI, X]	3 bis 4 [VI,X]
Summe	182	171 bis 184	690	649 bis 694

[a] inklusive biogener Anteil des Abfalls [b] das Biomasse-Primärenergieäquivalent bei den Biogas- und Pflanzenöl-BHKW ist bei der Stromerzeugung berücksichtigt, [c] einschließlich der KWK- Wärme; [I] Nutzungsgrad der Umwandlung fester Biomasse in Feuerungsanlagen in Wärme ein Einzelraumfeuerungen 75 und Kesseln 80 %; [II] Nutzungsgrad Umwandlung flüssige Bioenergieträger in Feuerungsanlagen in Wärme etwa 80%; [III] Nutzungsgrad der Umwandlung von Biomethan in Wärme 90%; [IV] Stromwirkungsgrad zur Verstromung fester Biomasse ohne Wärme 31 %, mit teilweiser KWK 25 % bei Holzvergaser-BHKW in KWK 35%; [V] Stromwirkungsgrad zur Verstromung fester organischer Abfälle mit teilweiser KWK 20 %, Wärmegutschrift i.V. zu Biomassekessel 80%; [VI] elektrischer Nutzungsgrad der Verstromung von Biogas in BHKW mit KWK 38 % und Pflanzenöl-BHKW 40%; [VII] Abbaugrad der Biomasse im Fermenter 65 % (nur der Biomasseinhalt im Biogassubstrat wird berücksichtigt); [VIII] Konversionseffizienz Biomethanaufbereitung 90% ; [IX] Wirkungsgrad der Umwandlung von Biomethan im BHKW zu Strom 40% ; [X] da die Rückstände der Biotreibstoffherstellung als Futtermittel oder energetisch genutzt werden, wird nur der Energiegehalt des Produkts als erneuerbarer Primärenergieaufwand angesetzt.

Heating and cooling demand compared to biomass use (2015-2018 data)

	World	EU	Germany
Total demand for heating and cooling [a)]	200 EJ	22.0 EJ	4.3 EJ
Industrial process heat demand (>200 °C) [a)]	~50 EJ	4.1 EJ	1.2 EJ
Biomass potential	56-160 EJ	33 EJ [a)]	1 EJ
Biomass used for heating purposes	41.7 EJ	3.7 EJ	0.5 EJ
Biomass used for industrial process heat (all)	~3.5 EJ	~1 EJ	0.1 EJ

Quelle: Volker Lenz, Nora Szarka, Matthias Jordan, Daniela Thrän: Status and Perspectives of Biomass Use for Industrial Process Heat for Industrialized Countries, 2020, DOI: 10.1002/ceat.202000077

[a)] including Eurasia