Biomass in Industry - How, When and Why?

Thore Berntsson
Chair of IEA, Industrial Energy-Related Technologies and Systems
Chalmers University of Technology, Gothenburg, Sweden
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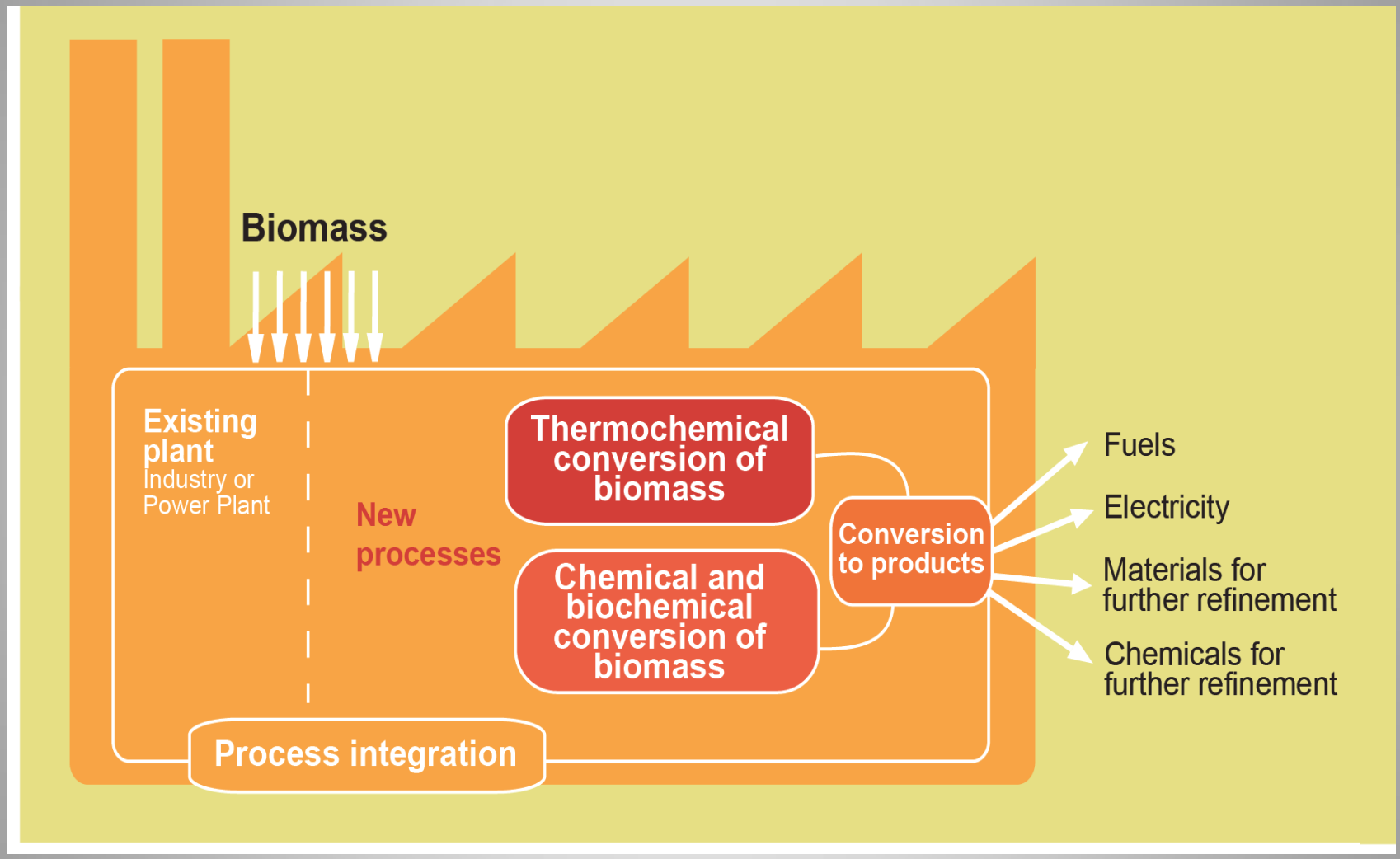
Biomass in Industry

Traditional Use:

- Replacing fossil fuels for industrial heating
- Biomass-based industrial combined heat and Power (CHP)

Biorefinery concepts:

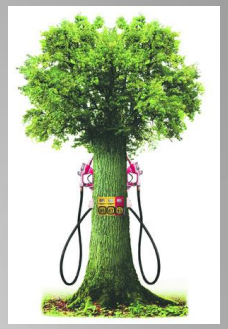
- Advanced biomass-based CHP
- Products from biomass (biofuels, materials, chemicals)

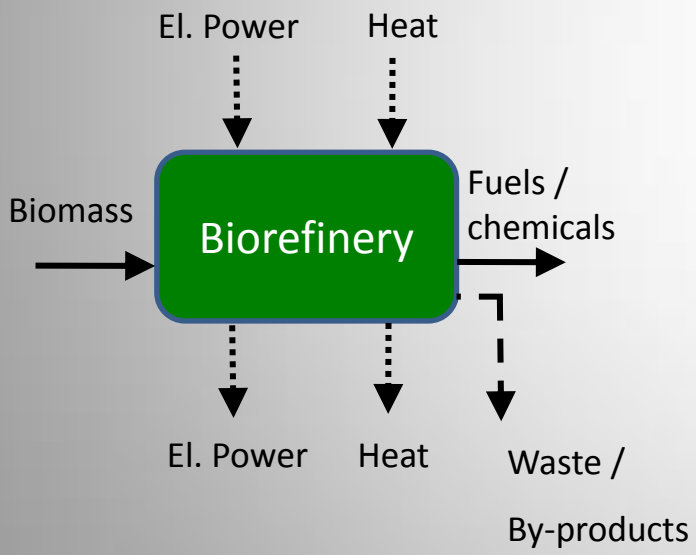

Biomass
Existing plant
Industry or Power Plant
New processes
Thermochemical conversion of biomass
Chemical and biochemical conversion of biomass
Conversion to products
Fuels
Electricity
Materials for further refinement
Chemicals for further refinement
Process integration

Biorefinery - definition

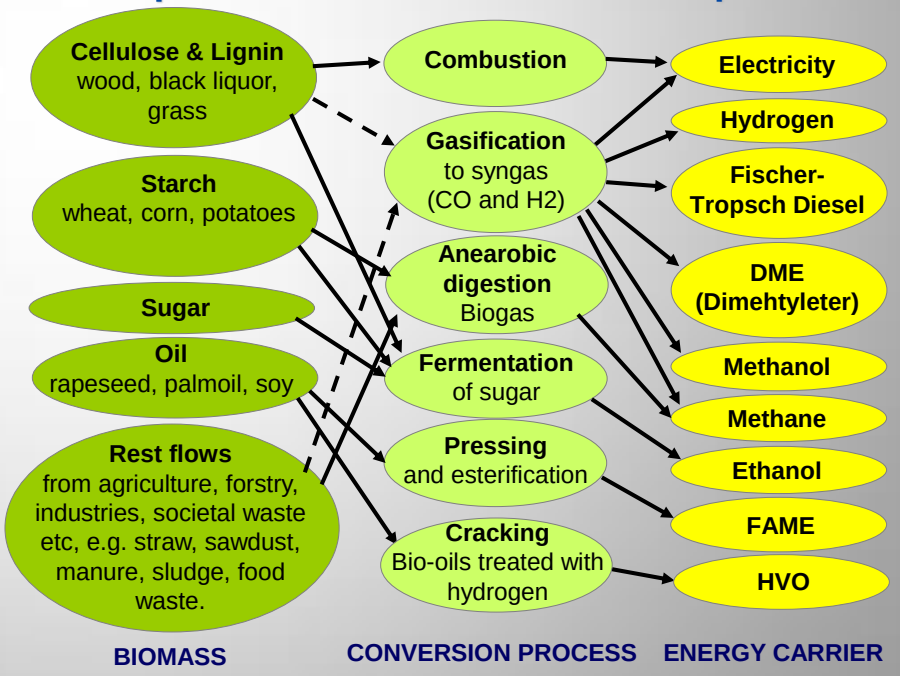
”A wide range of technologies able to separate biomass resources (wood, grasses, corn, etc.) into their building blocks (carbohydrates, proteins, fats, etc.) which can be converted into value-added products such as biofuels and bio-chemicals”.

F Cherubini and A Strømman, ”Principles of Biorefining”, Elsevier 2011.





Example of biofuels and conversion processes



Two Types, in Principle, of Biorefineries

Non-Bulk Products

Normally small-or medium-scale size

High-value products

Reduction of CO2 emissions? Our knowledge for different products limited

Typically limited market

Bulk Products

Economy possible due to large-scale processes (economy of scale)

Biobased transport fuels, materials, chemicals, green power, heat

Important advantages through integration with e. g. process industries

Reduction of CO2 emissions vary, but is in many cases considerable

Generally speaking, carbon footprints directly dependent on what is replaced, i. e. coal, oil or natural gas

The pulp mill biorefinery – Studied products

Energy

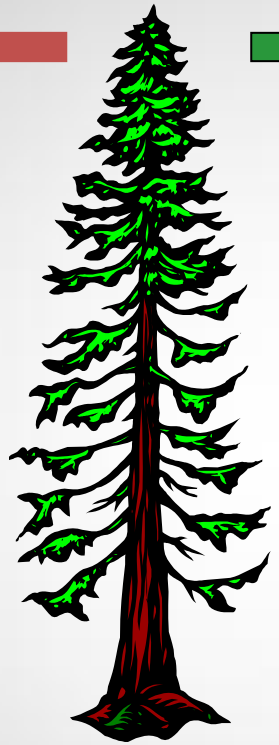
- *DME*
- *Ethanol*
- *FT-diesel*
- *Biooil*
- *Heat*
- *Electricity*
- *Pellets*
- *Lignin*

Lignin

Cellulose

Bark

Forestry residues



Chemicals/Materials

Lignin

- *Phenols*
- *Carbon fiber*
- *Binders*
- *Dispersants*
- *Activated carbon*

Hemi-cellulose

- *Fiber additives*
- *Barriers*
- *Hydrogels*

Cellulose

- *Fibers*
- *Derivatives*
- *Nanocellulose*

Extractives

- *Functional polymers*
- *Bioactive compounds*

Some Major Processes

- Biomass gasification
- Black liqour gasification (in chemical pulp and paper industry)
- Fermentation (to ethanol and more advanced end products)
- Torrefaction and pyrolysis
- Fractionation

Examples of Bulk Type Biorefineries in Process Industries

Pulp and Paper Industry

- Black Liquor Gasification	Green Power, DME
- Biomass Gasification	Green Power, Methanol, FT-diesel, SNG
- Fermentation	Ethanol
- Dissolving Pulp	E g ethanol from hemicellulose
- Lignin Precipitation	Carbon fibre, etc

Iron and Steel Industry

- Biomass for replacement of coal/char

Chemical and Petrochemical Industry

- Biomass Gasification replacing cracker gas	Methanol, polyethylene, etc
- Fermentation	Polyethylene

Oil Refineries

- Biomass Gasification	Hydrogen
	FT-diesel
	SNG

Time and System Perspectives

Only a few biorefinery concepts are available in a short time perspective

For many concepts pilot and demo plants are needed

Demo plants for bulk products normally expensive (10-50 million Euros)

Strong policy instruments are needed for many concepts (40-70 Euros/ton CO2?)

Decisions on large scale concepts are normally strategic and must be taken against a very uncertain future regarding policy instruments, energy and biomass prices, etc

In e. g. integrated large-scale biorefinery concepts, several stake holders must cooperate, making decisions and business models complicated

Output ENPAC- New policys and 450 PPM

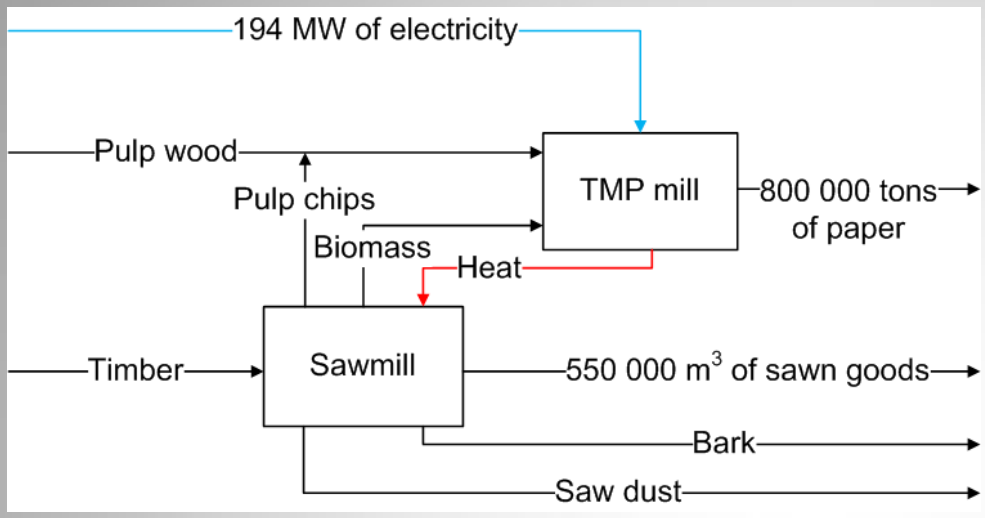
SCENARIOS		2020	2020	2030	2030	2040	2040	2050	2050
		New	450	New	450	New	450	New	450
POLICY INSTRUMENTS									
CO2 charge (ETS)	[€/ton]	16	27	26	74	35	117	43	144
FOSSIL FUEL PRICES									
EO1	[€/MWh-fuel]	65	63	69	60	75	56	78	55
EO1 incl CO2 charge	[€/MWh-fuel]	69	71	76	81	85	90	90	96
EO5	[€/MWh-fuel]	47	46	50	44	54	42	55	41
EO5 incl CO2 charge	[€/MWh-fuel]	51	54	57	65	64	76	68	83
Natural gas	[€/MWh-fuel]	41	39	42	36	44	32	45	31
Natural gas incl CO2 charge	[€/MWh-fuel]	44	46	48	52	52	58	54	63
Coal	[€/MWh-fuel]	12	12	13	10	13	8	13	8
Coal incl CO2 charge	[€/MWh-fuel]	18	22	22	37	25	51	28	60
MARGINAL ELECTRICITY									
Build margin		Coal	Coal	Coal	NGCC	Coal	Coal, CCS	Coal	Coal, CCS
Electricity price (Incl. CO2 charge)	[€/MWh-el]	60	68	66	92	70	81	73	82
CO2 emissions	[kg/MWh-el]	856	856	805	376	761	246	733	240

Time Perspective

The time perspective is important for several reasons, e. g.:

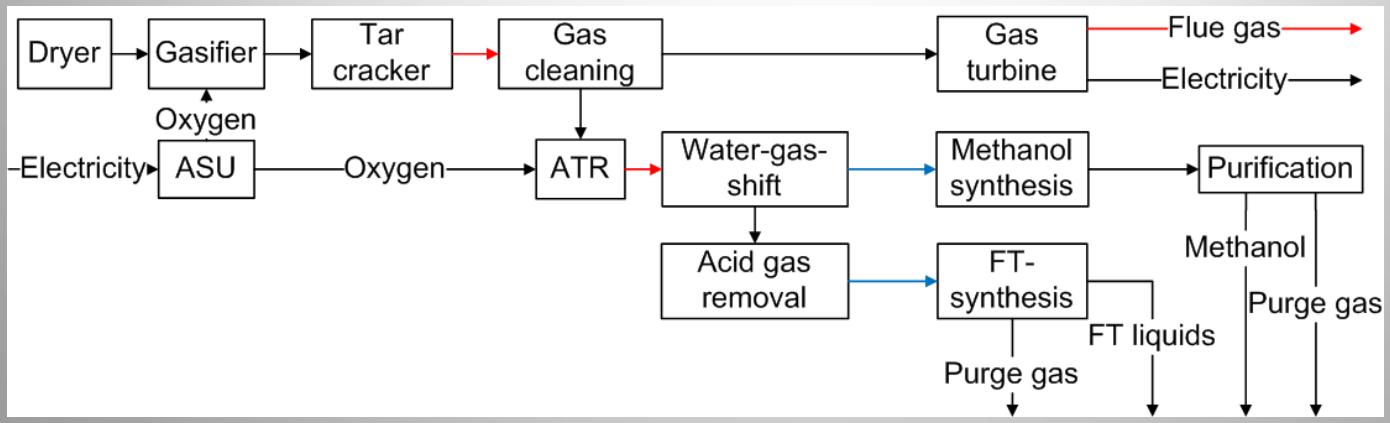
- policy instrument and energy/product price development (sensitivity analysis important)
- sustainability of a biorefinery product (time dependent and must consider policy instrument development)
- Two parameters of highest importance for climatic sustainability is what fuel/raw material the biomass replaces and the future build margin for grid power production

Host site: TMP mill and co-located Sawmill

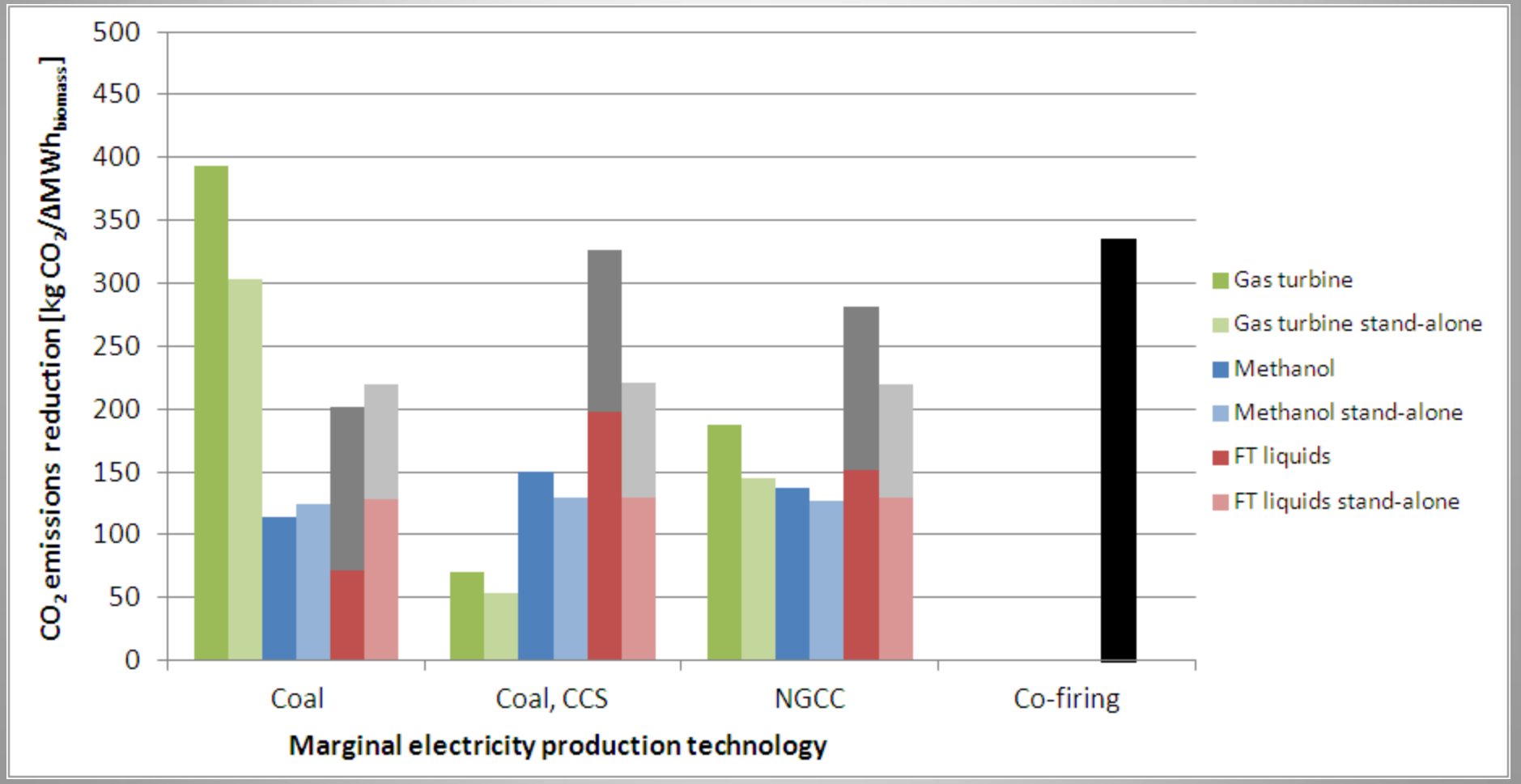


- Biomass residues corresponding to 94 MW_{LHV}
- In addition, about 1.55 TWh (177 MW_{LHV}) of forest residues is available within a 100 km radius.

3 gasification based biorefinery concepts were considered



Carbon balances incl comparison with stand-alone concepts



Biomass and Industrial CCS

- In the future, CCS will probably be used in industry (from 2030-2040, depending on carbon charge development)
- BECCS (Biomass-based CCS) in industry will have an important role
- Several biorefinery concepts have CO2-rich bystreams, making CCS cheap
- BECCS gives the same carbon footprint as fossil-based CCS (not more, not less)

What Product(s) for Sustainable Use?

Power

If the build margin grid power production is e. g. coal condensing plants, high efficiency power production with biomass means low GHG emissions (hence more short term)

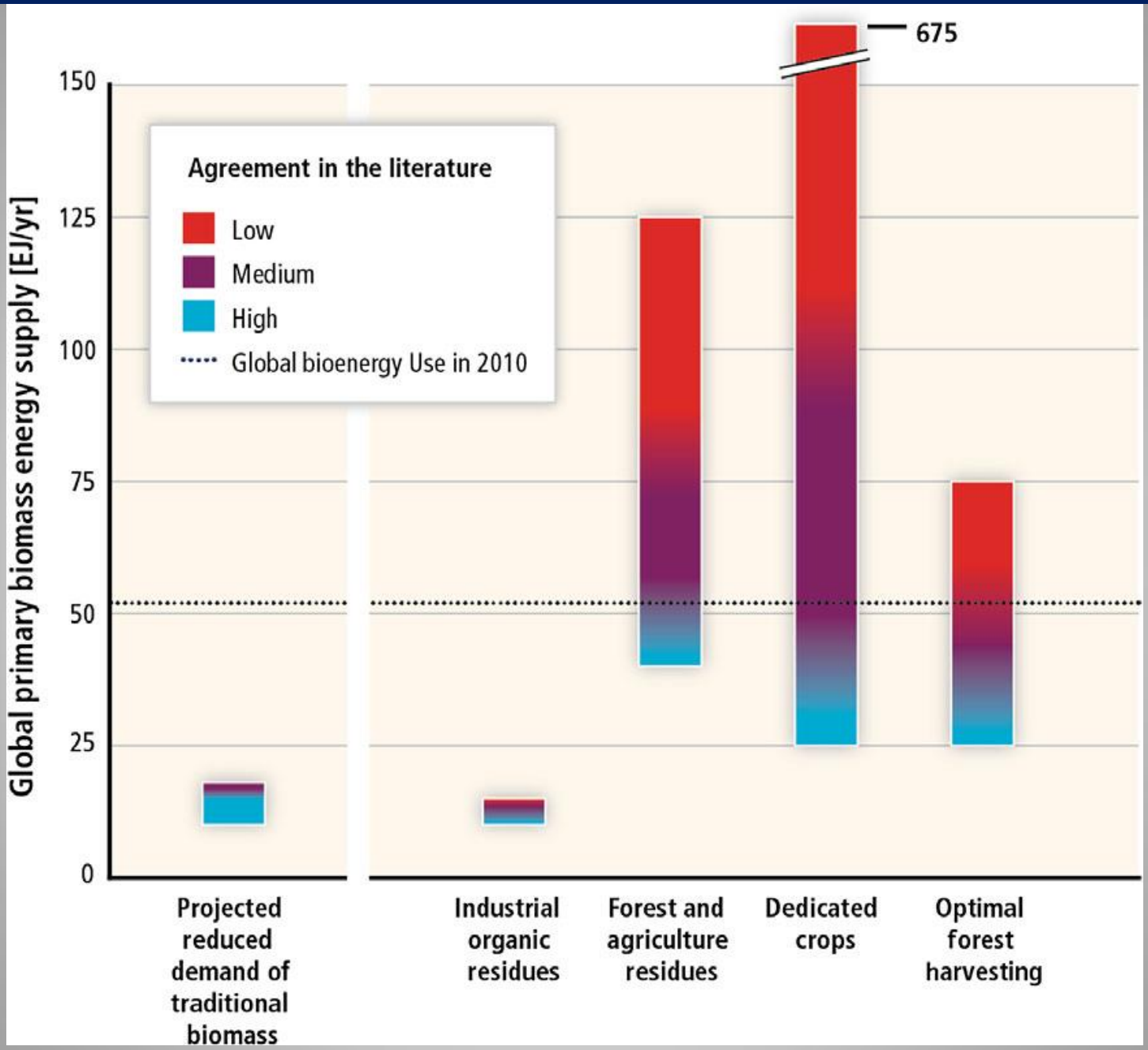
Materials and Chemicals

With lower grid GHG emissions, production of materials and chemicals is more sustainable. Recycling always important but in most cases no carbon footprint advantage with biomass origin compared with a fossil one

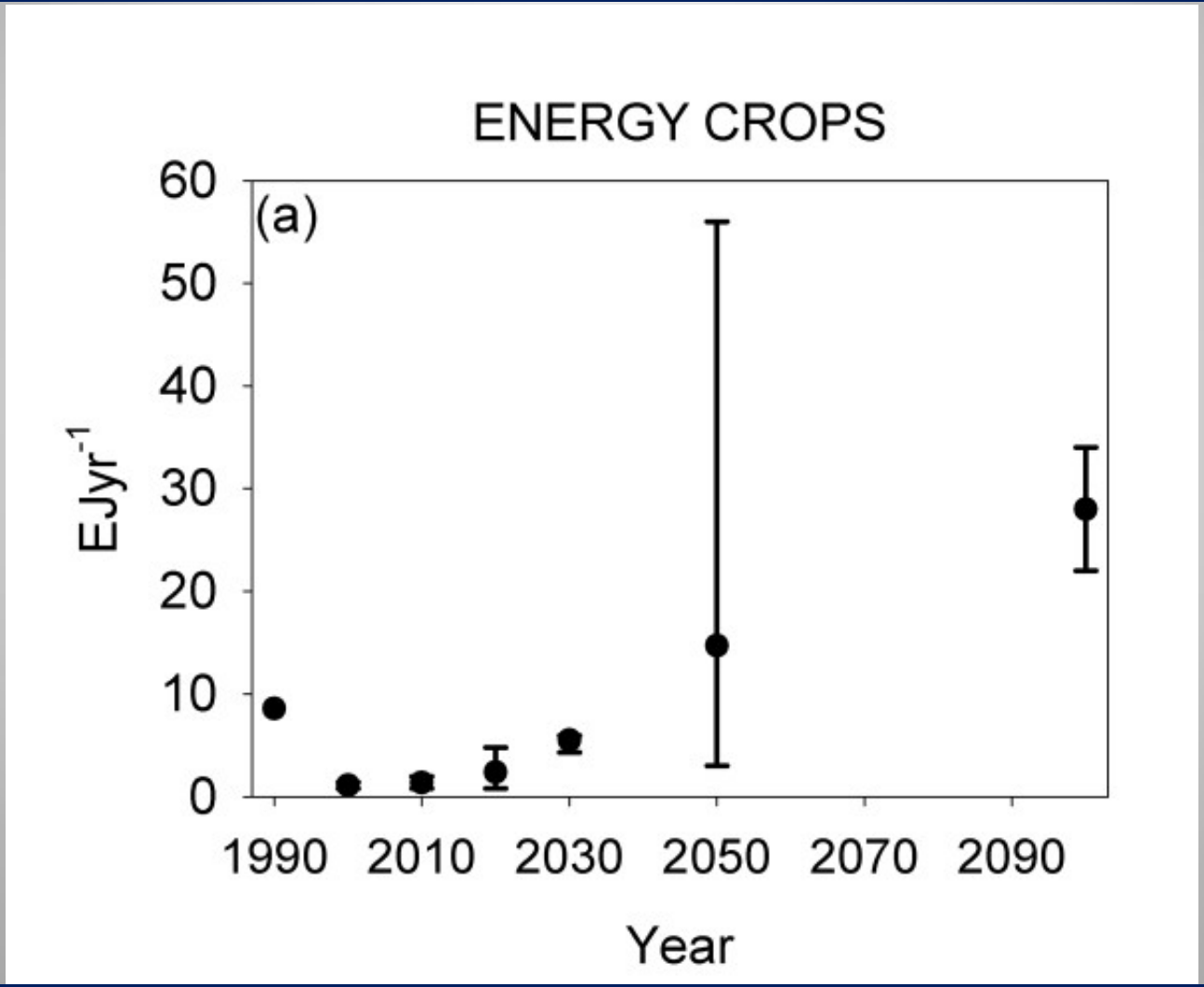
Biofuels

Carbon footprint comparison with materials and chemicals depends on process routes for different products. No general conclusion can be made.

For economic sustainability, the economic performance for the different types of product depends totally on future carbon charge development (level, product specigic, etc)


675
150
125
100
75
50
25
0
Global primary biomass energy supply [EJ/yr]
Agreement in the literature
Low
Medium
High
Global bioenergy Use in 2010
Projected reduced demand of traditional biomass
Industrial organic residues
Forest and agriculture residues
Dedicated crops
Optimal forest harvesting

Median and range of the potential from three major sources of biomass for energy in Europe. Source: Biotechnology for Biofuels 2012, 5:25



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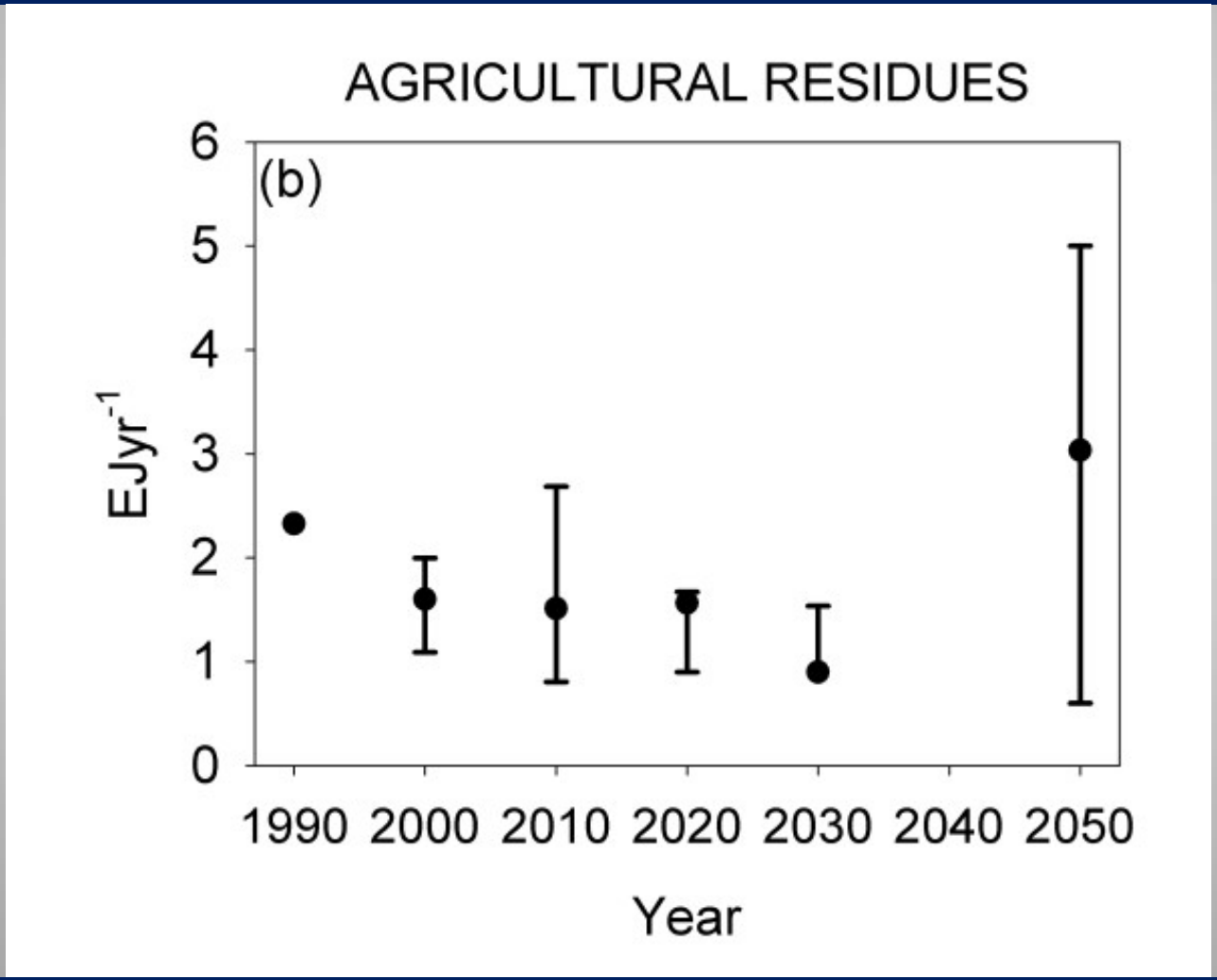

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