

Sustainability and ethical aspects of bioenergy – a macroscopic view

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Nordic Committee on Bioethics
Meeting on “The bioethics of bioenergy”

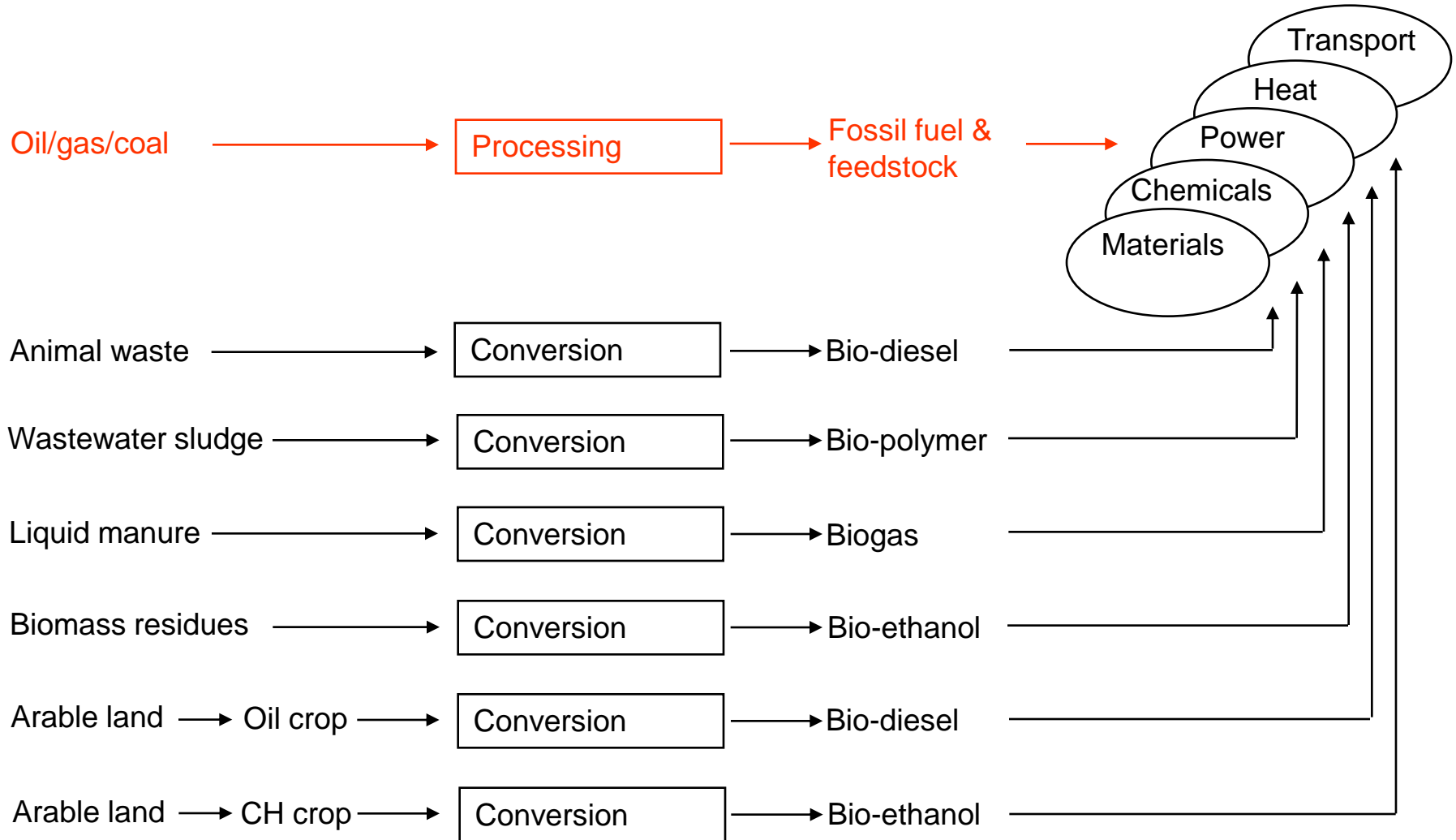
November 17th, 2009
The Finnish Parliament, Helsinki, Finland

Presentation overview

- New customers for biomass
- Constraints and framework conditions
- Land and biomass constraints
- Environmental constraints
- Social/ethical constraints
- Carbon constraints
- Conclusion



New customers for biomass



Two types of references:

- Functional reference: Alternative provision of same product/service
- Resource application reference: Alternative use of the constrained waste/resource

Constraints and framework conditions

– in the design of future energy systems

Resources	Environment	Social/ethical
Fossil fuels	Global warming	Food/hunger
Arable land	Biodiversity	Local societal structure
Biomass	Nutrients	Supply security
Water	Pesticides	Conflicts & wars
Phosphorus	Water	...
Money	...	
Political attention, time, focus		
Carbon - the forgotten resource constraint		
...		

The mutual strength of the constraints governs the composition of the future energy systems

Land and biomass constraints

- some key aspects and figures

How big are the new customers for biomass?

Earth land area: 15 Gha; global agricultural area: 5 Gha
– of which 1.5 Gha arable land and 3.5 Gha pastures

World average food intake: 2700 kcal/pers/day	≈	25 EJ/year
Agricultural biomass today	≈	100-150 EJ/year
Fossil energy consumption today	≈	400 EJ/year
Biomass for full fossil substitution today	≈	500-600 EJ/year

→ we need ≈ 5 times more biomass than today's agricultural output for full fossil substitution

Can agricultural yield increases reduce the gap?

Yield increase in agriculture	≈	1% per year	→	0.8 %
Consumption growth (GDP/capita)	≈	3% per year	→	?? %
Land use increase from trend towards more meat on the menu	≈	??% per year		

Land and biomass constraints

- some key aspects and figures

How much new land can be cultivated?

New cultivable land: Biophysical maximum \approx 2 Gha more
– most of which is in South America and Africa
(Ramancutty et al., 2002).

BUT: cultivating new land can imply a 2-9 times higher release of CO₂ than energy crops can save over 30 years by substitution of fossil fuels (Righelato and Spracklen, Science 2007) – meaning pay back of 60 – 300 years.

Sustainable new land cultivation

30-40% more (Danish Ministry for Food and Agriculture, 2008)
- and we need 500% more if biomass should fully substitute fossil fuels

Land and biomass constraints

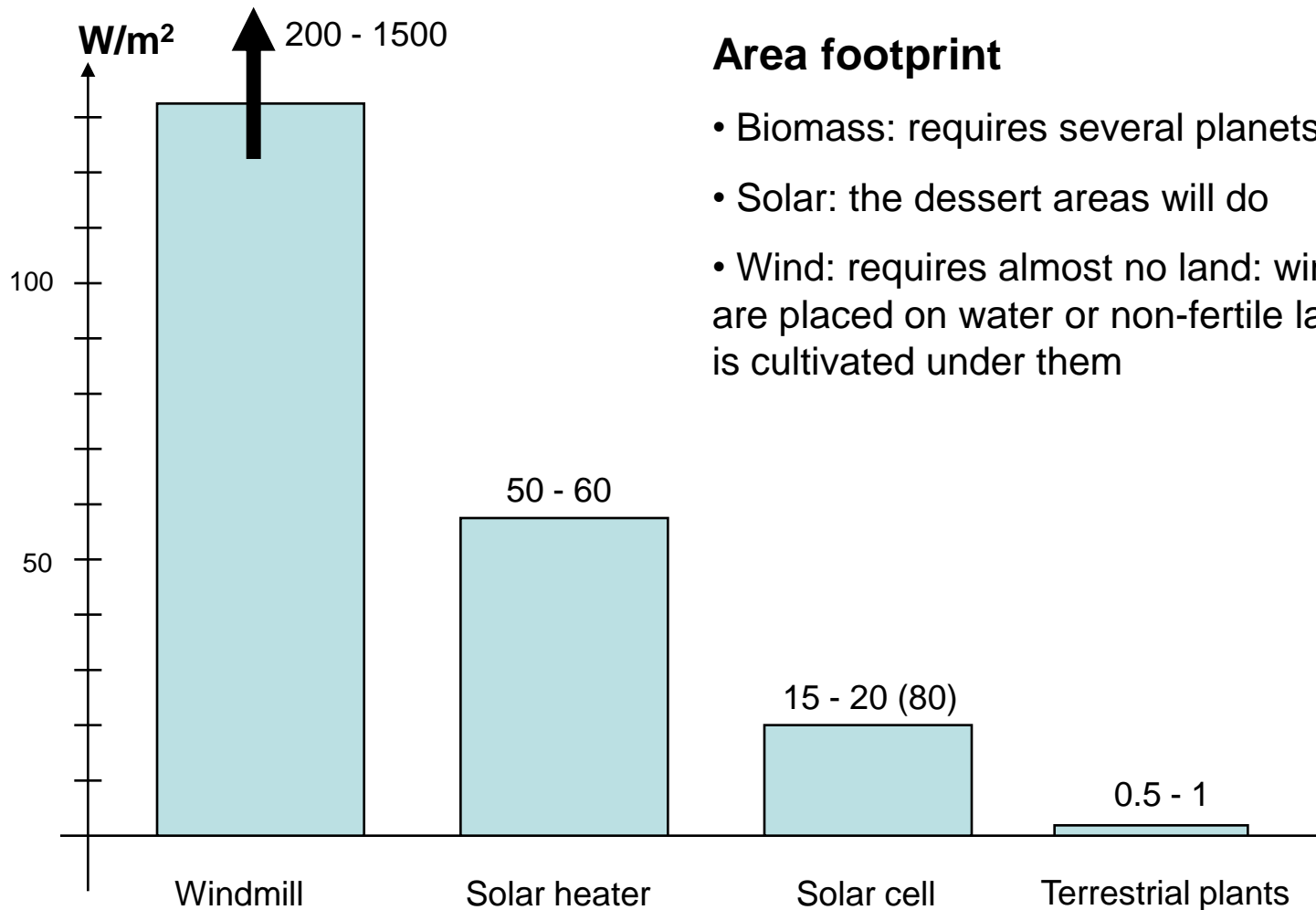
- some key aspects and figures

Study	Scope	Time	Supply	Demand	Scenario	Biomass potential (EJ/y)			Demand Potential	
						Residue	Crops	Total	EJ/y	%
(26)	EU25	2030	X			6.7	5.2	11.9	80-90	16-18%
(27)	EU27	2015-2025	X			2.8	1.8	4.6	90-100	4-5%
	EU27	2025-2045	X		Low	2.9	5.6	8.5	90-100	8-9%
	EU27	2025-2045	X		High	3.5	7.2	10.7	90-100	10-12%
	EU27	>2040	X		Low	2.5	15.4	17.9	90-100	17-19%
	EU27	>2040	X		High	3.1	19.9	23	90-100	21-25%
(22)	Global	2030	X		Low	96	219	315	630-720	42-48%
	Global		X		High	96	315	411	630-720	55-62%
(28)	Global	2030	X			87	151	238	630-720	32-36%
(29)	Global	2025-2050	X			31	267	298	630-720	40-45%
(30)	Global	2020	X			15	112	127	630-720	17-19%
(31)	Global	2025		X				74	630-720	10-11%
(35)	Global	2025	n.d	n.d				85	630-720	11-13%
(32)	Global	2025	X ^b	X ^b	BI	56	17	74	630-720	10-11%
(33)	Global	2030		X	FFES			91	630-720	12-14%
(34)	Global	2025	X ^b	X ^b	RIGES	65	80	145	630-720	19-22%

Ref.: Hedegaard K, K Thyø and H Wenzel, Env Sci Tech, 2008

Land constraints

- the area footprint of renewable energy technologies



Biomass constraints

- proportions in potentials for demand and supply in 2030

Demand type	Fuel demand (EJ/year)	Biomass demand (EJ/year)
Jetfuels	25	50
Chemicals	30	60
Long distance road (20% of road)	20	40
Heat & electricity fuel buffer (20%)	90	90
Short distance road (80% of road)	80	160
Heat & electricity bulk (80%) + other	350	350
	≈ 600	≈ 750
Supply type	Demand driven (EJ/year)	Supply driven (EJ/year)
Residues (non-food)	56-65	15-96
Crops (food competition)	17-80	112-411

Environmental constraints

- the good, the bad and the ugly LCA

Three categories of system delimitations found in existing LCA studies of biofuels:

- the good
- the bad
- the ugly

Environmental constraints

- the good, the bad and the ugly LCA

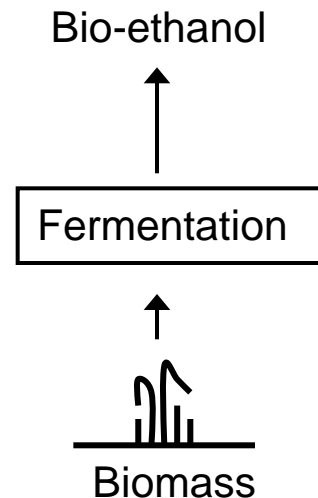
The ugly

Energy 'balance'

Fossil energy consumption : heat value

21.3 MJ/l : 21.6 MJ/l \approx 1 : 1

(Nielsen and Wenzel 2005)

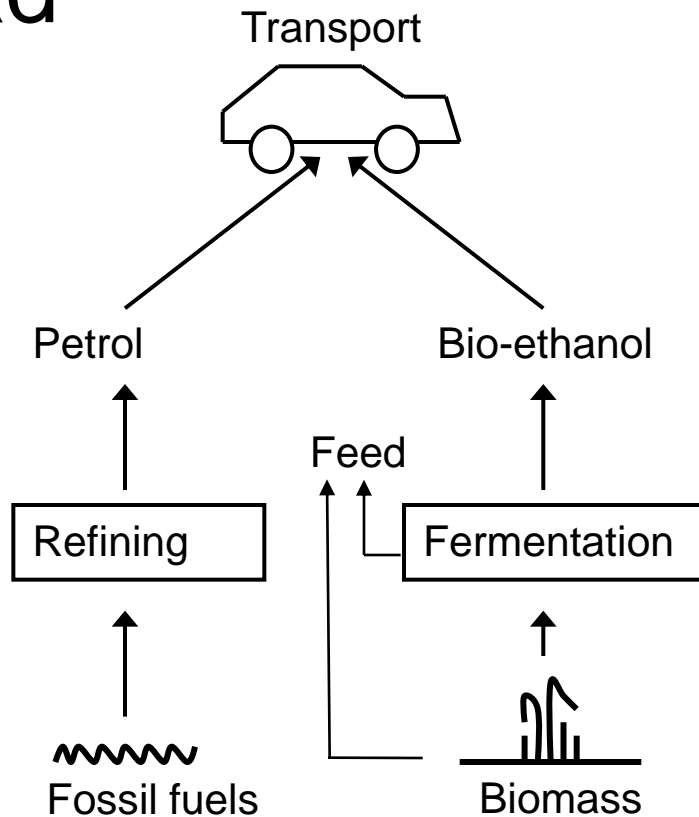


- seeing bio-ethanol in isolation

Environmental constraints

- the good, the bad and the ugly LCA

The bad



Fossil energy balance

Fossil energy consumption for bio-ethanol :
displaced fossil energy consumption for petrol
and feed

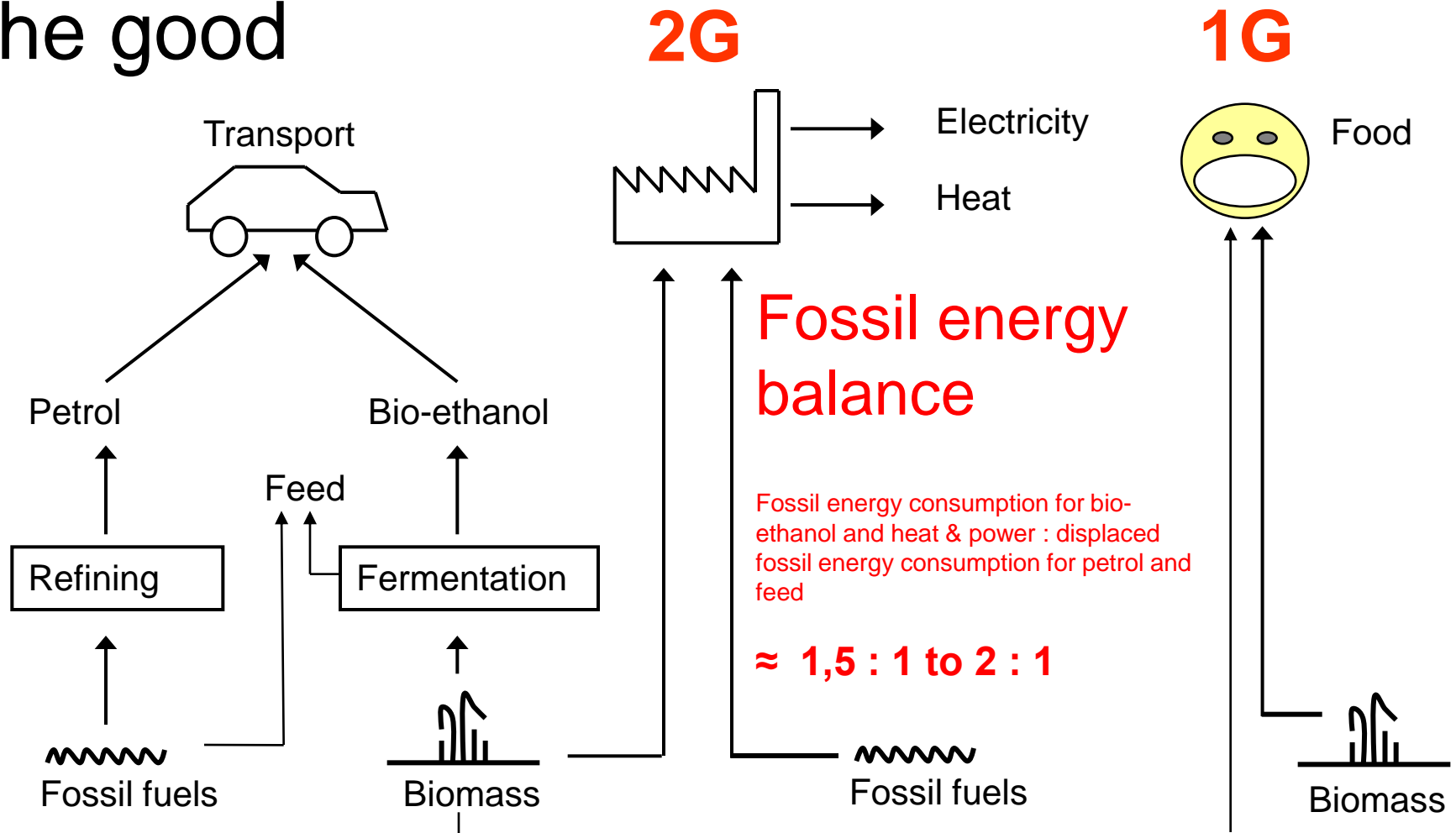
≈ 1 : 1,5

- seeing transport in isolation

Environmental constraints

- the good, the bad and the ugly LCA

The good

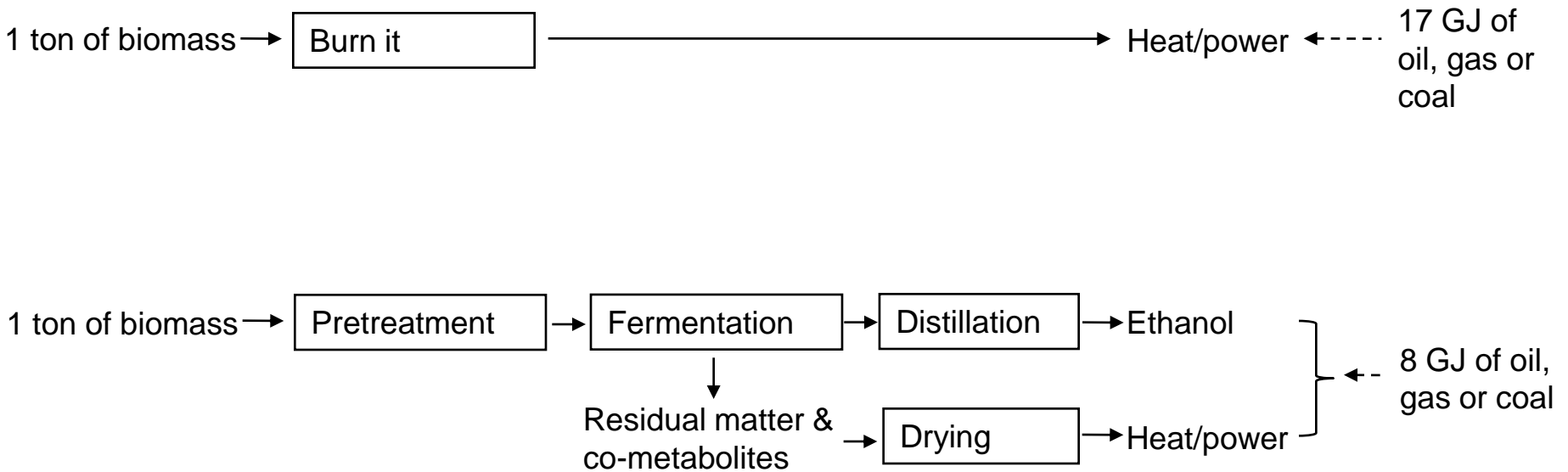


- seeing transport in correlation with competitive biomass and land uses

Environmental constraints

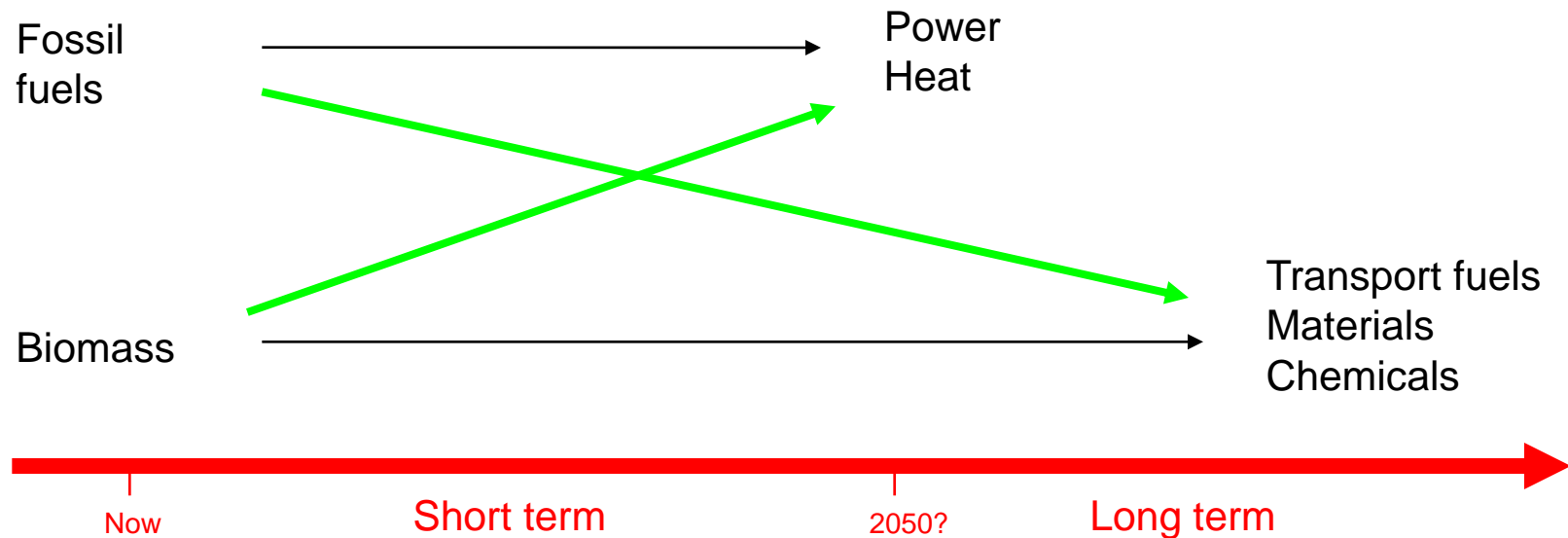
- understanding the bad environmental performance of bioethanol

Net fossil fuel savings



Environmental constraints

- understanding the time perspective



On the short term: don't cross the river to fetch water:

Do not convert biomass to transport fuels. Instead exchange biomass to transport fuels in heat and/or power sector

On the longer term: we run into the carbon resource constraint:

Recycle CO_2 , i.e. use biomass in stationary applications and produce transport fuels from the CO_2

Social/ethical constraints

- influencing food availability and prices?

Can the food sector be influenced?

POLITIKEN.DK

Torsdag 10. januar kl. 12:55



Increasing production of biofuels make beer prices rise

By [Michael Rothenborg](#)



Crop prices have almost doubled, to some extent catalysed by USA's production of bio-ethanol (USA's bio-ethanol being 30-70 % of the reason says World Bank report, USA says something else).

USA's bio-ethanol \approx 0.15 % of world energy consumption

Carbon constraints

- prioritizing biomass in the non-fossil system

1. Biogas from manure
2. Biomass for boosting manure biogas

Carbon-based fuels/feedstock needed for

3. Organic chemicals
4. Jetfuels
5. Electricity & heat system buffering?
6. Long distance road?

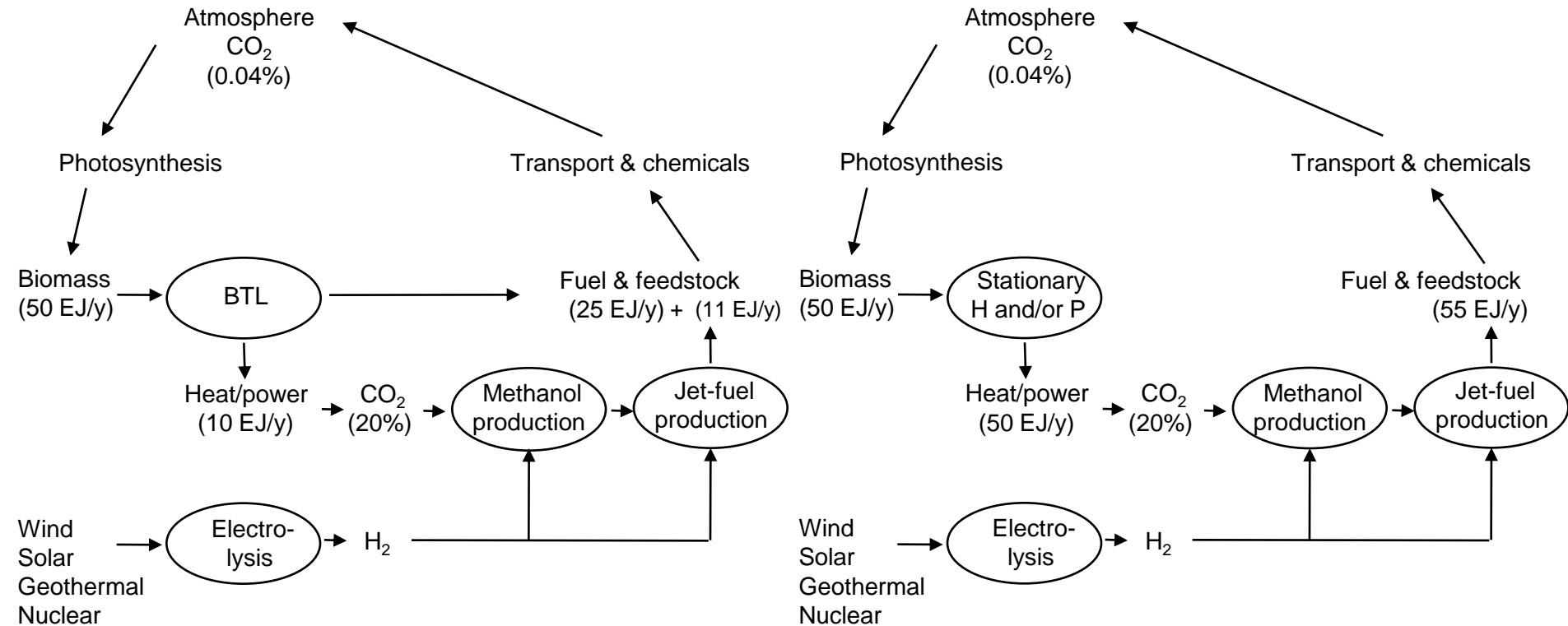
In any case, **fuels for mobile applications** need to be GHG low/free:

- H_2 (NH_3 ?)
- CH_3OH or other fuels from H_2 and CO_2/CO
- CH_4 from H_2 or e^- and CO_2
- Algae oil from sunlight and CO_2

Carbon recycling: more than doubling the use of biogenic carbon

Carbon constraints

- boosting the carbon cycle by recycling CO₂

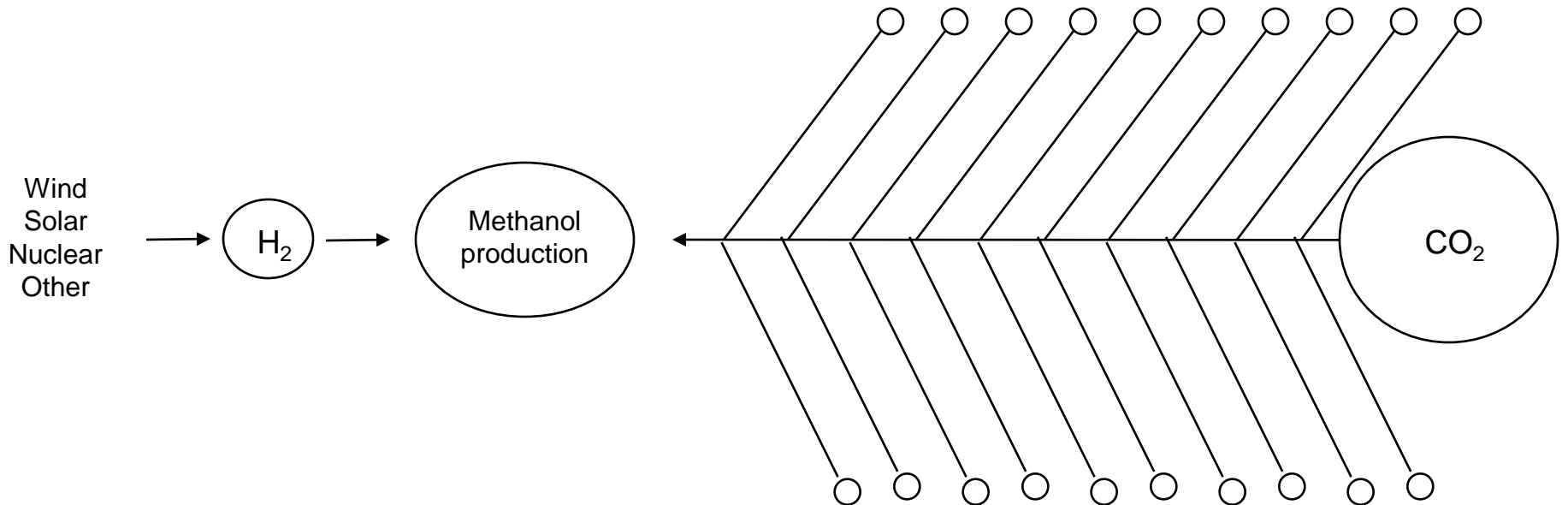


Fuel & feedstock: 36 EJ/y
 Heat & power: 10 EJ/y
 Total: 46 EJ/y

Fuel & feedstock: 55 EJ/y
 Heat & power: 50 EJ/y
 Total: 105 EJ/y

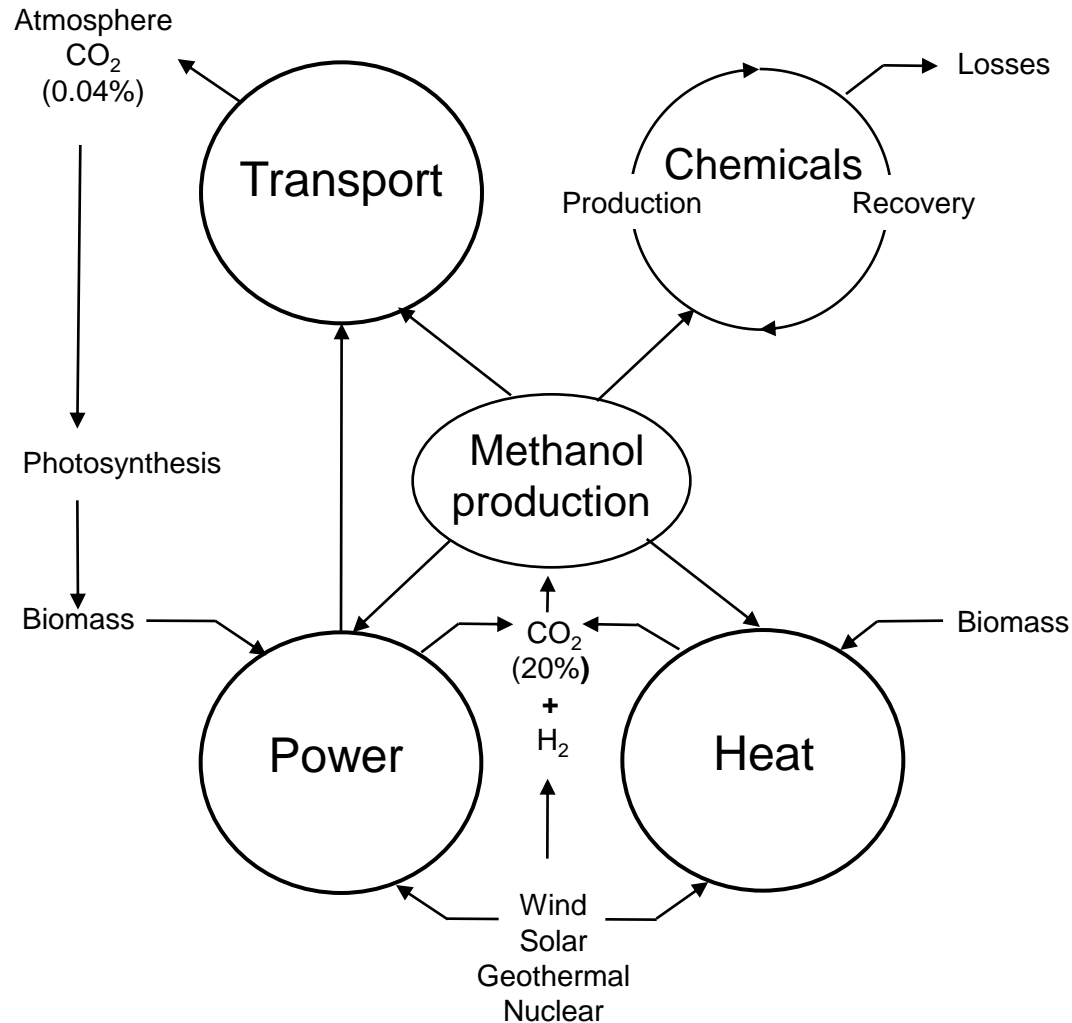
Carbon constraints

- boosting the carbon cycle



Carbon constraints

- boosting the carbon cycle



Conclusion

Use of biomass in stationary appliances is by far the most eco-efficient and cost-efficient solution on the short term. It is, moreover, a good platform for the long term development.

Making transport fuels from CO₂ is a sustainable solution. But the conventional route by terrestrial plant photosynthesis is:

- Too slow – much too low carbon flow rate*
- Too inefficient*
- Too costly, and*
- Too land intensive and, thus, interfering with food production (with respect to 1G)*

The present liquid biofuel technologies will, thus, take us no-where. And while doing that, they may create a lot of misery and offset the right development for an in-affordably long period of time.

The technologies for methane, methanol and other fuel productions from CO₂ and electricity/H₂ can prove to be real sustainable solutions.

A tuc tuc on CNG...



**Thank you for the attention
Questions and comments?**

