

Overview of Biorefinery Concepts and Basics for Their Greenhouse Gas Balance

G. Jungmeier, F. Cherubini

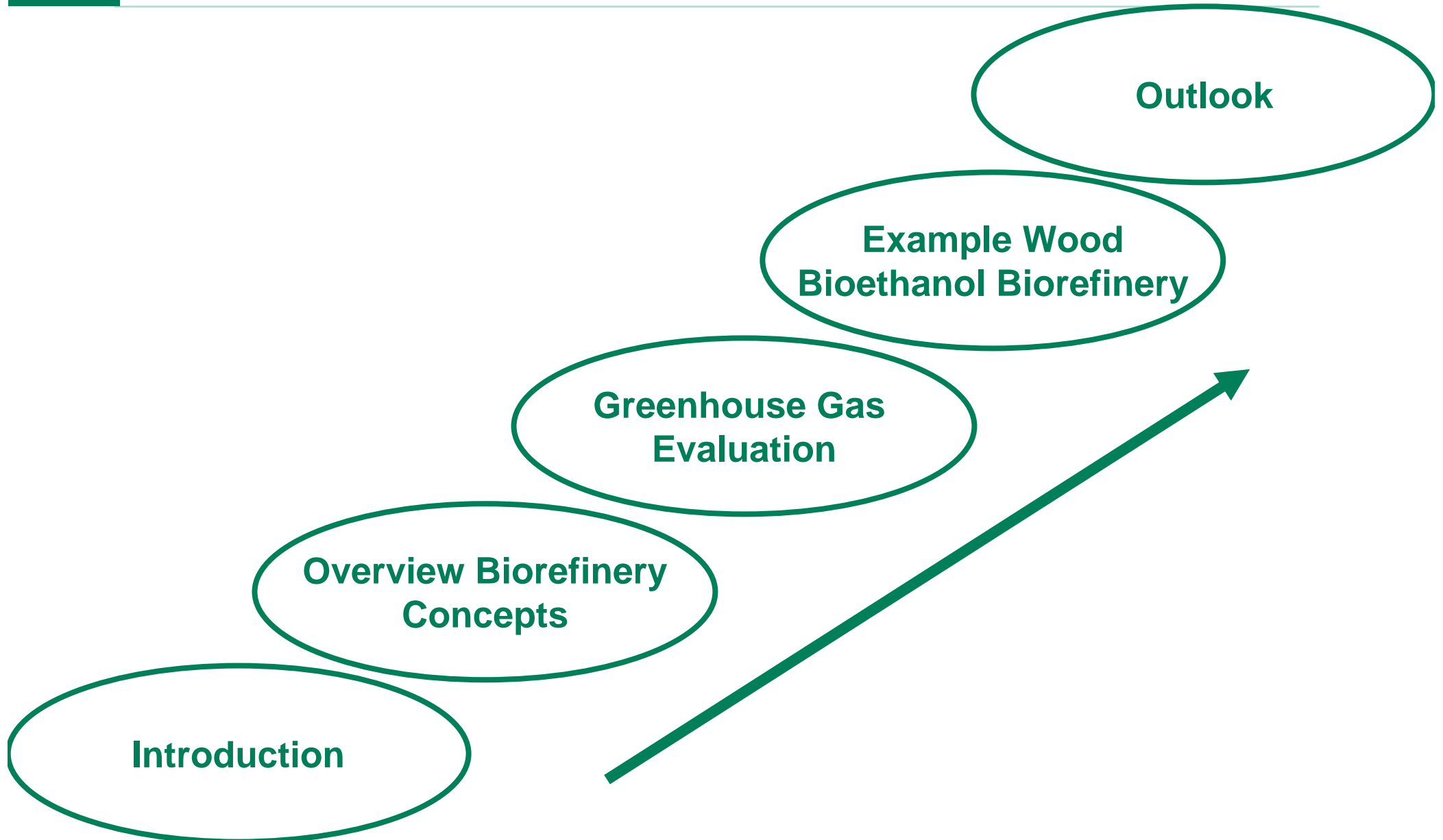
IEA Bioenergy Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems

International Workshop in Cooperation with the Salzburg State Government

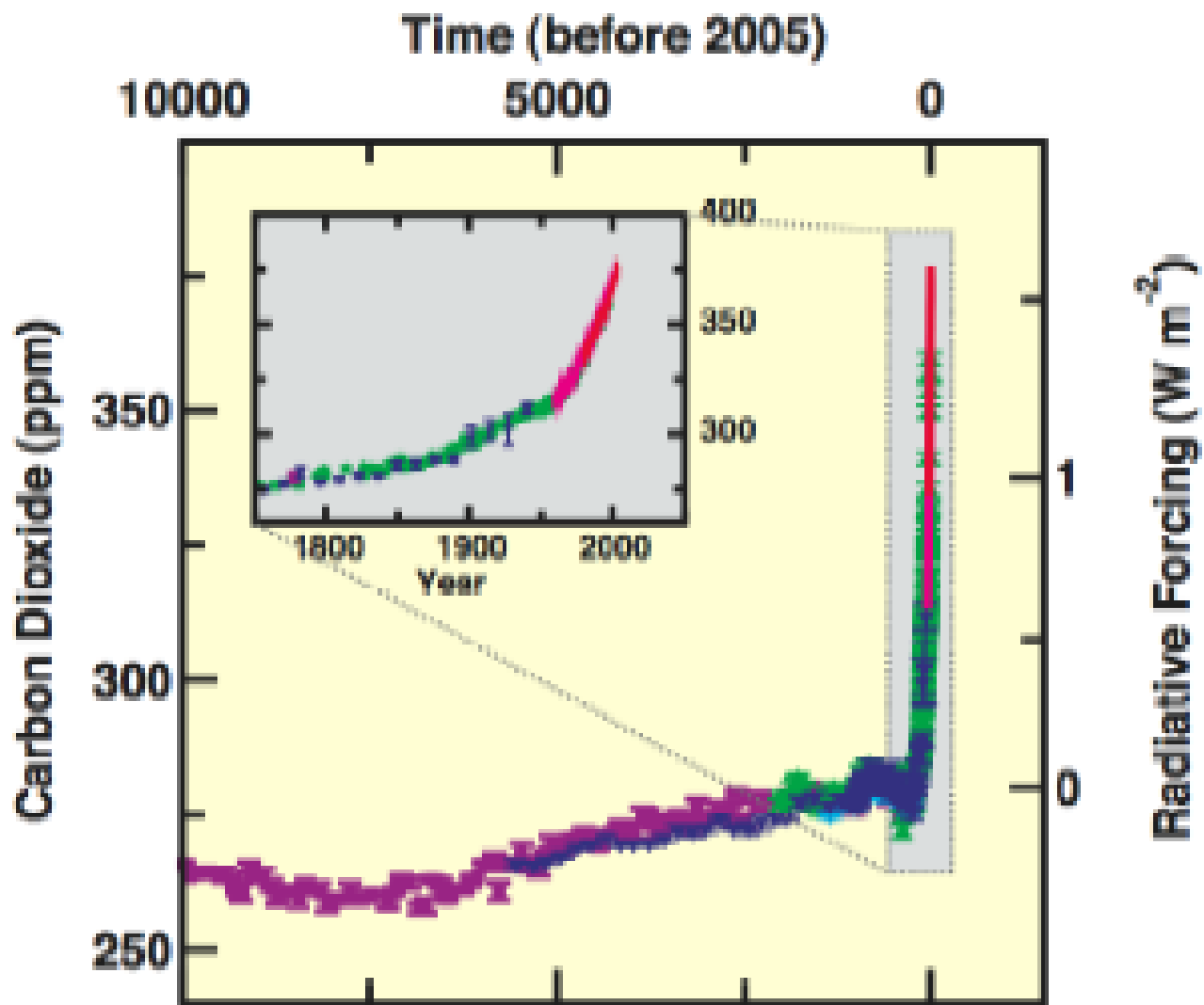
“Transportation Biofuels: For greenhouse gas mitigation, energy security or other reasons ?”

5 February 2008, Salzburg, Austria

Outline



Human Influence on Atmosphere

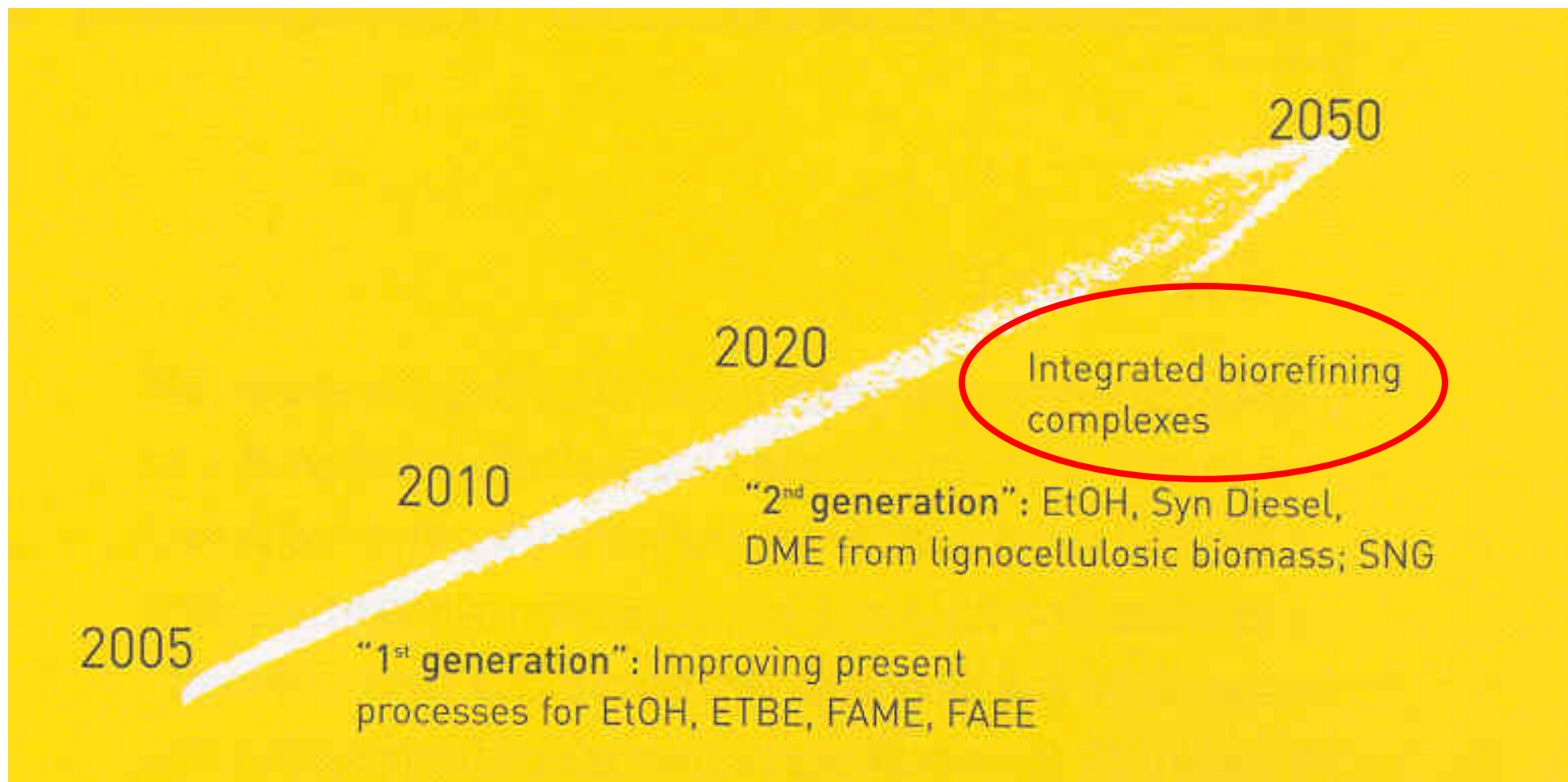


Greenhouse Gas Emissions in Austrian Transportsector

- **24 Mio. t GHG/a from transportation sector**
- **26% Share of total Austrian GHG-emissions**
- **83% Increase between 1990/2006**
- **Most rapid increasing sector**

European Roadmap for Biofuels

Vision 2030: 25% Biofuels

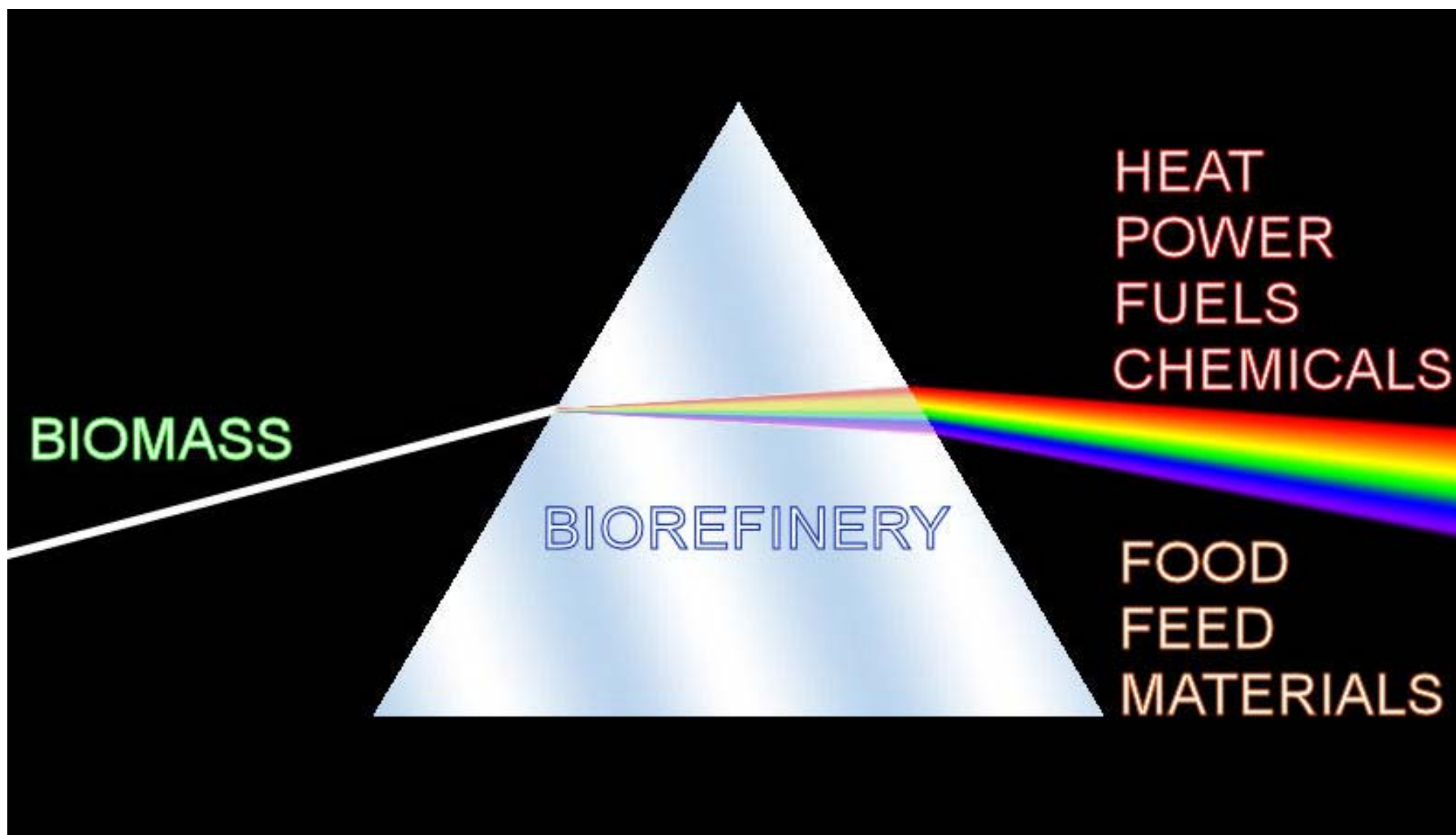


Source: Biofuels in the European Union – A vision for 2030 and beyond, Final report of the Biofuels Research Advisory Council, June 2006

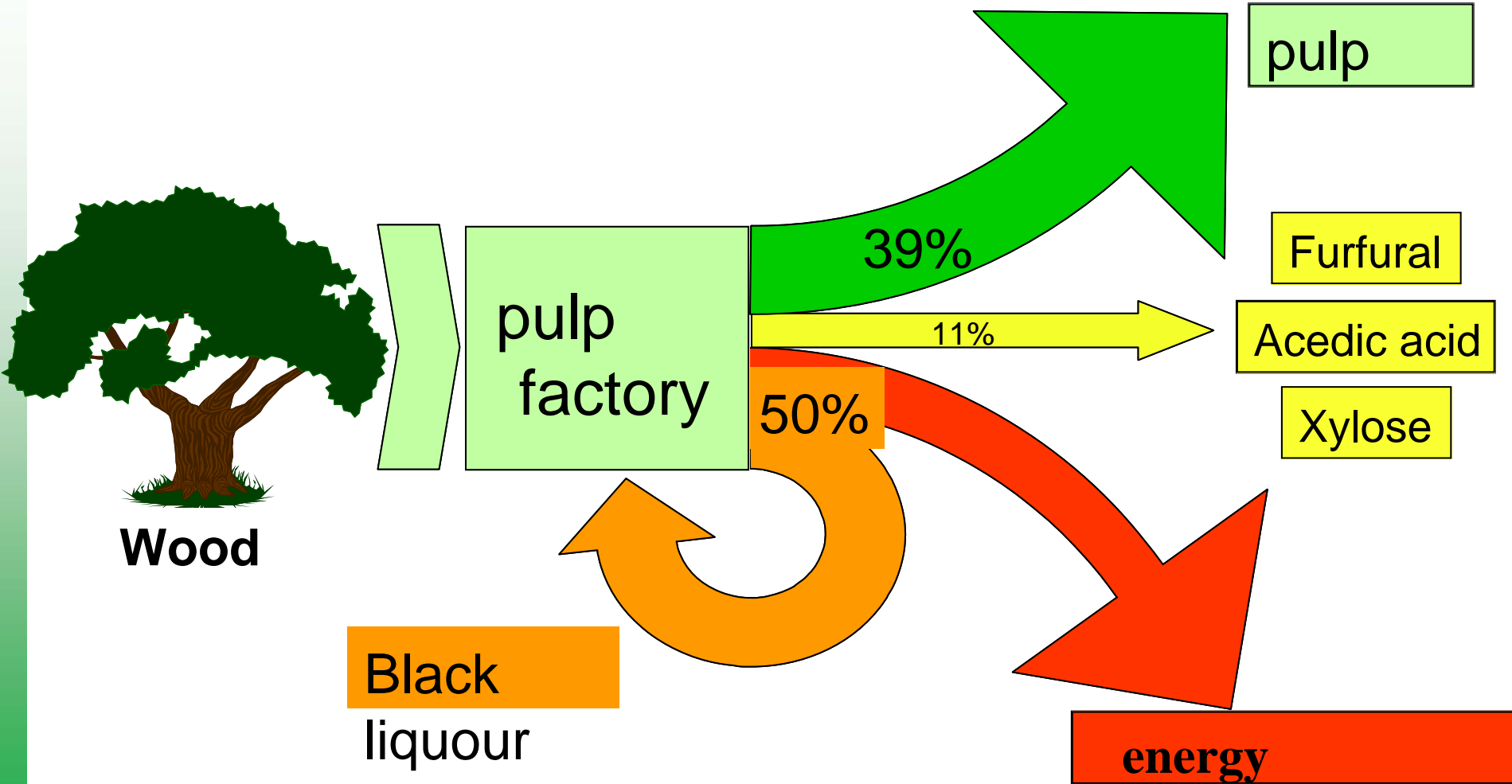
What is a “Biorefinery”?

IEA Bioenergy

Task 42 on Biorefineries



Existing “Lignocellulosic Biorefinery”



Source: Lenzing, 2007

WOOD: First Process it - then Burn it

The final products are

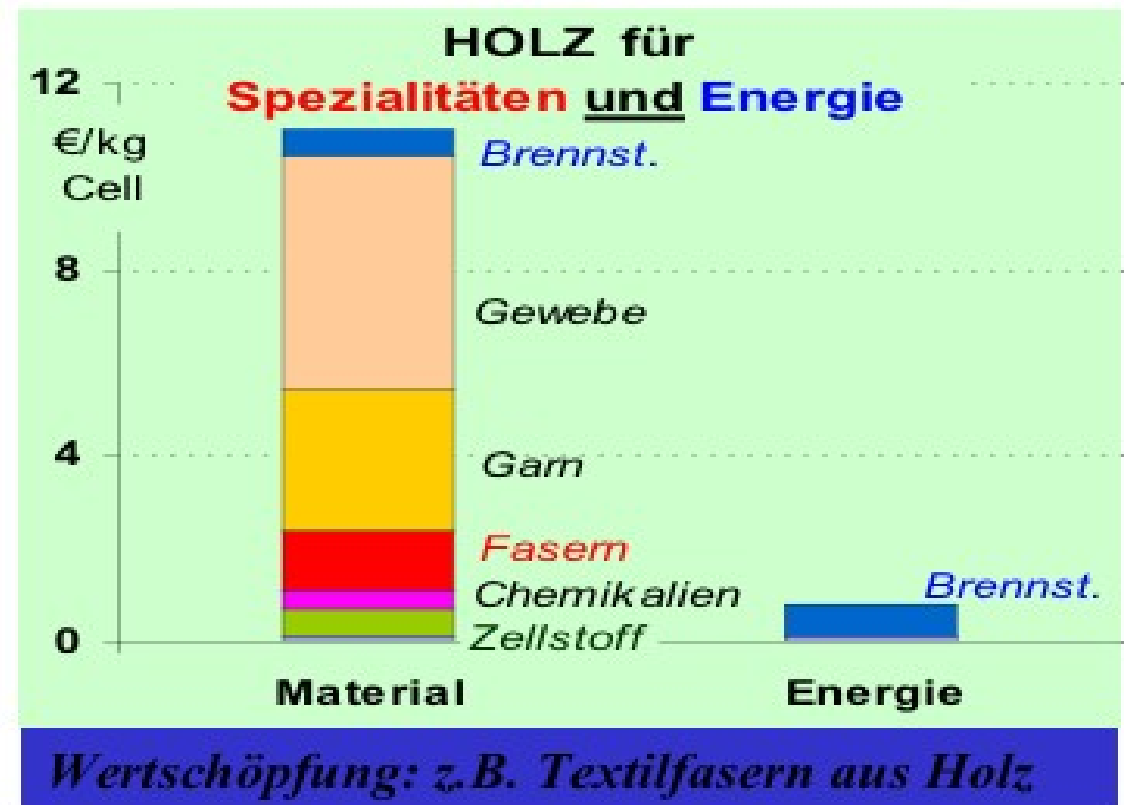
- technology-intensive!
- capital-intensive !
- labour-intensive!
- export-intensive!

Lignin:

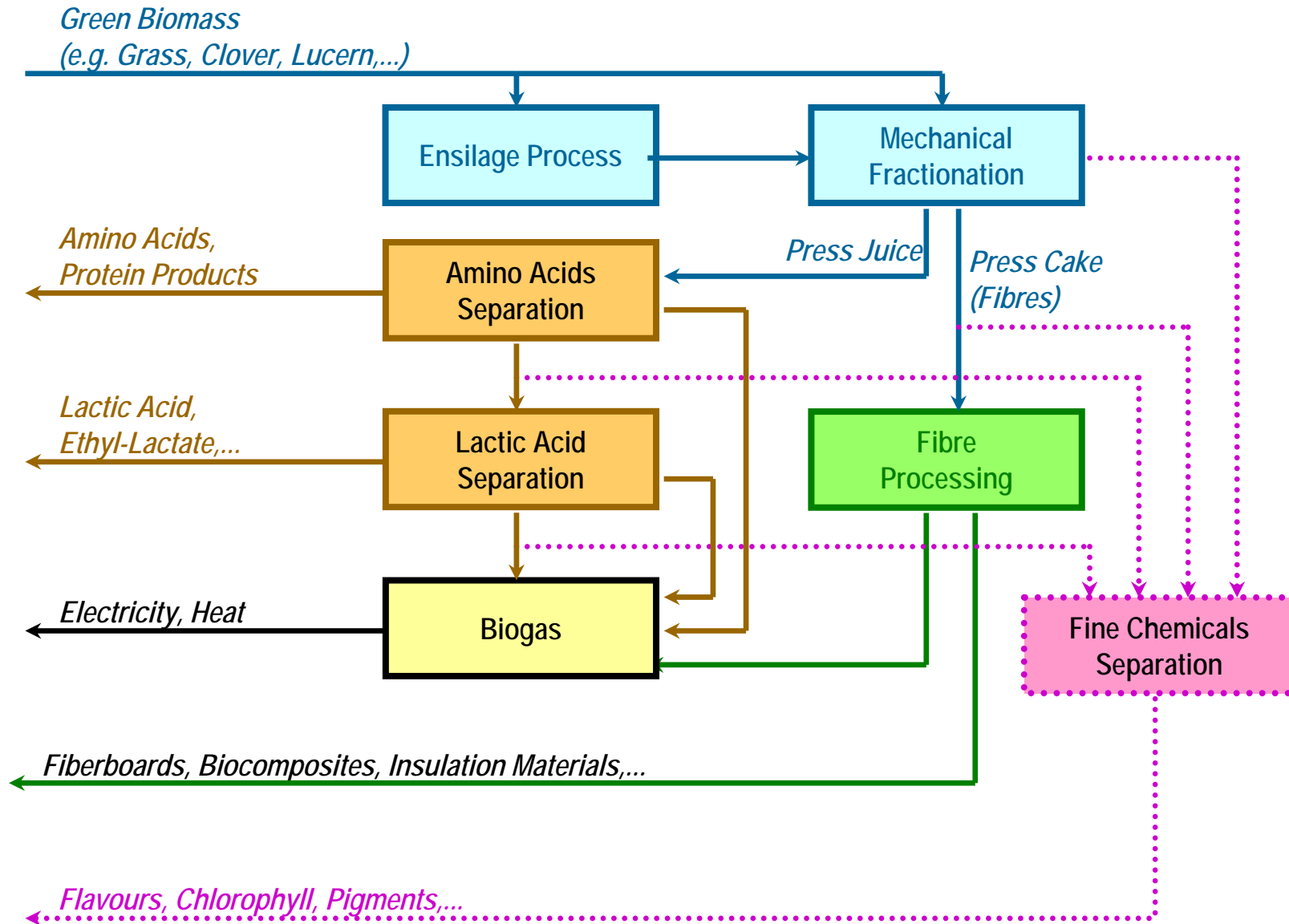
calorific value 25 – 26 MJ/kg
(aromates)

Cellulose, hemicelluloses:

calorific value 16 – 18 MJ/kg
(hydrocarbons)

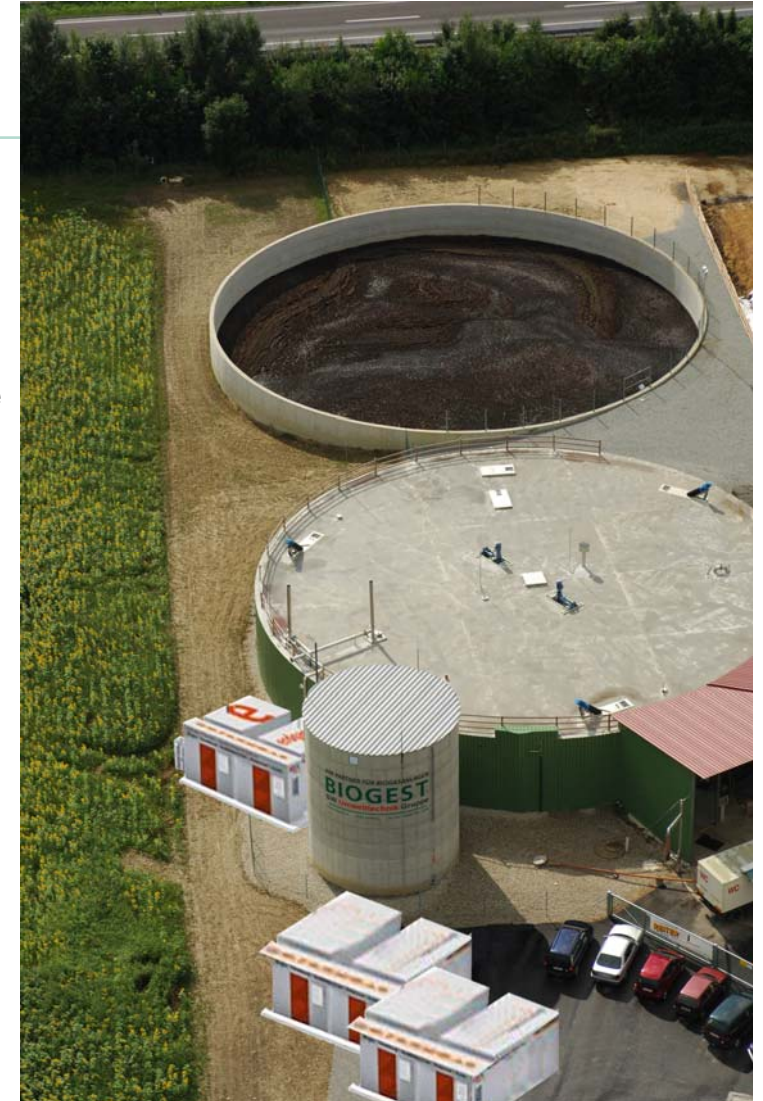


Austrian Concept „Green Biorefinery Austria“



Demonstration-Plant „Green Biorefinery“

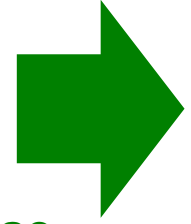
- Location: Uztenaich in Upper-Austria
- Attached to existing biogas plant 500 kW_e
- Capacity: processing silage from 100 ha with 10 t_{DM}/(ha*a)
- Investment: 1.7 Mio. €
- Operating costs for 3 years: 1.5 Mio. €
- Start up: 2008



What is a „Biorefinery“

Biomass Resources

- oil
- starch
- sugar
- lignocellulose
-



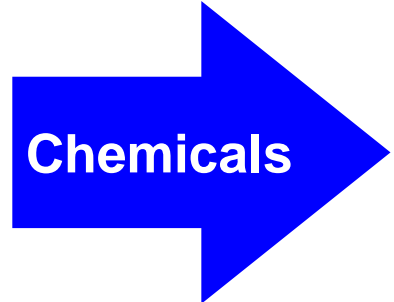
Biorefinery

Transportation biofuel orientation



Energy

- liquid/gaseous transportation fuels
- electricity
- heat
- solid fuels



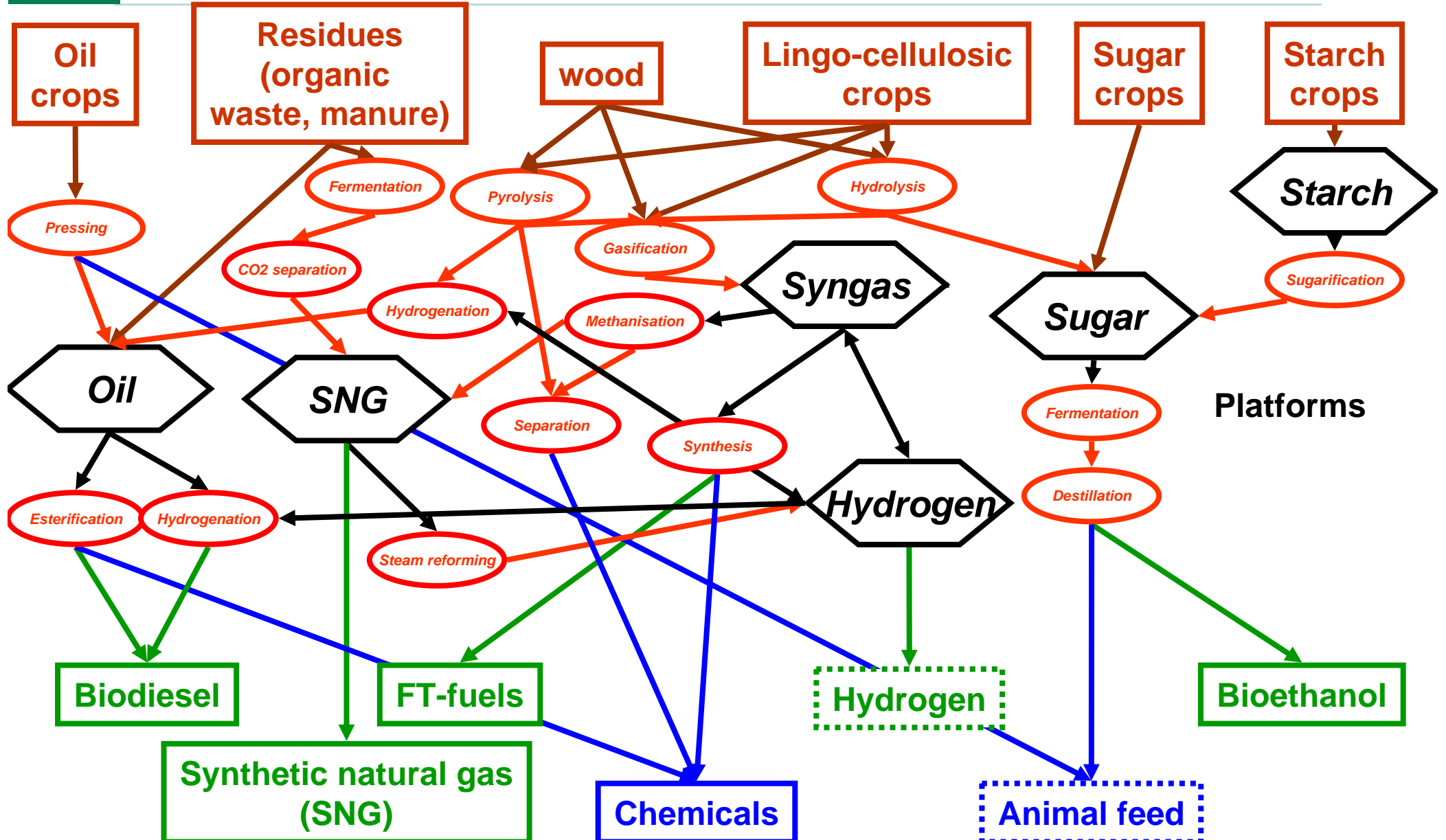
Chemicals

- bulk chemicals
- fine chemicals
- animal feed
- materials
- fertilizer
-

Based on different conversion processes

- Bio-chemical
- Thermo-chemical
- Physical-chemical
- Others

“Multi-Platform” Transportation Biofuel Oriented Integrated Biorefinery Concepts



Biorefinery-Systems with Main R&D Focus

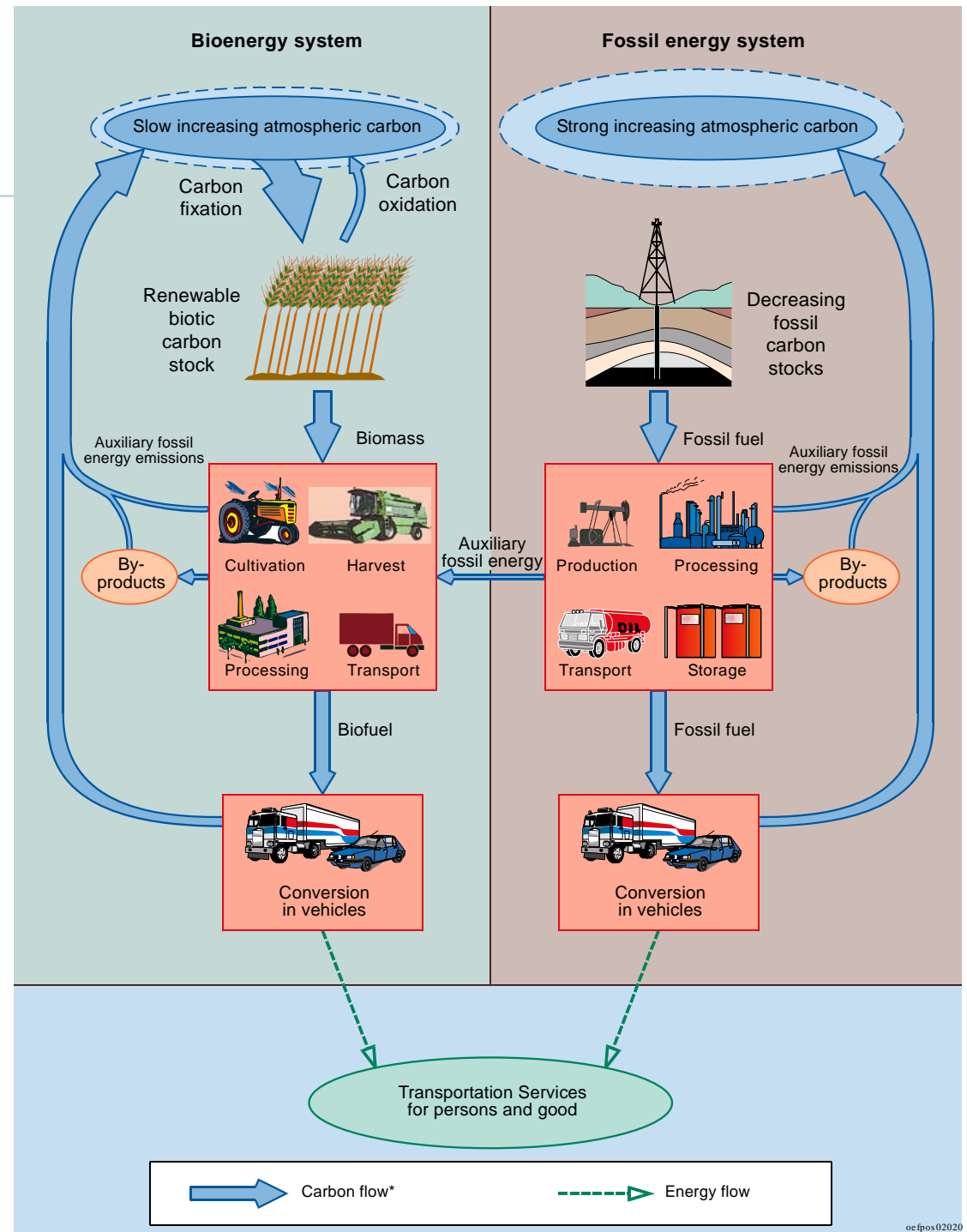
IEA Bioenergy

Task 42 on Biorefineries

1. **“Lignocellulosic biorefinery”, based on wood and straw**
2. **“Whole crop biorefinery”, based on raw materials like grains and maize (whole crop)**
3. **“Green biorefinery”, based on Grass**
4. **“Two-platform-biorefinery”, with sugar and syngas platforms**

According to

- ISO 14 040
„Life Cycle assessment“
- Standard Methodology of IEA Bioenergy Task 38
„Greenhouse Gas Balances of Bioenergy systems“
- Recommendations of COST Action E9 „Life Cycle Assessment of Forestry and Forest Products“



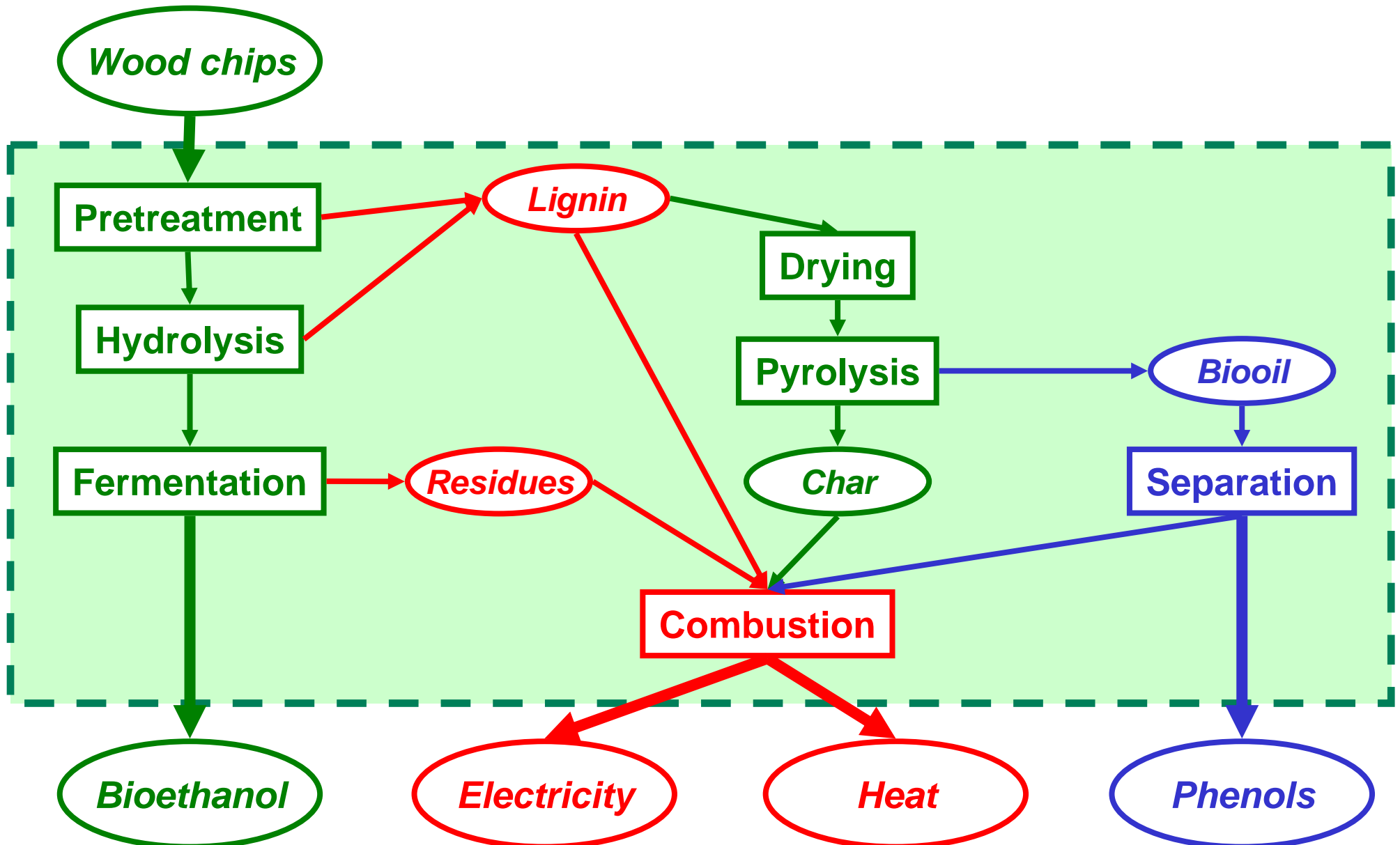
Criteria for Environmental Evaluation

- **Greenhouse gas emissions** [t CO₂-eq.] including
 - ✓ Carbon dioxide (1 kg CO₂ = 1 kg CO₂-eq)
 - ✓ Methane (1 kg CH₄ = 23 kg CO₂-eq)
 - ✓ Nitrous oxide (1 kg N₂O = 296 kg CO₂-eq)

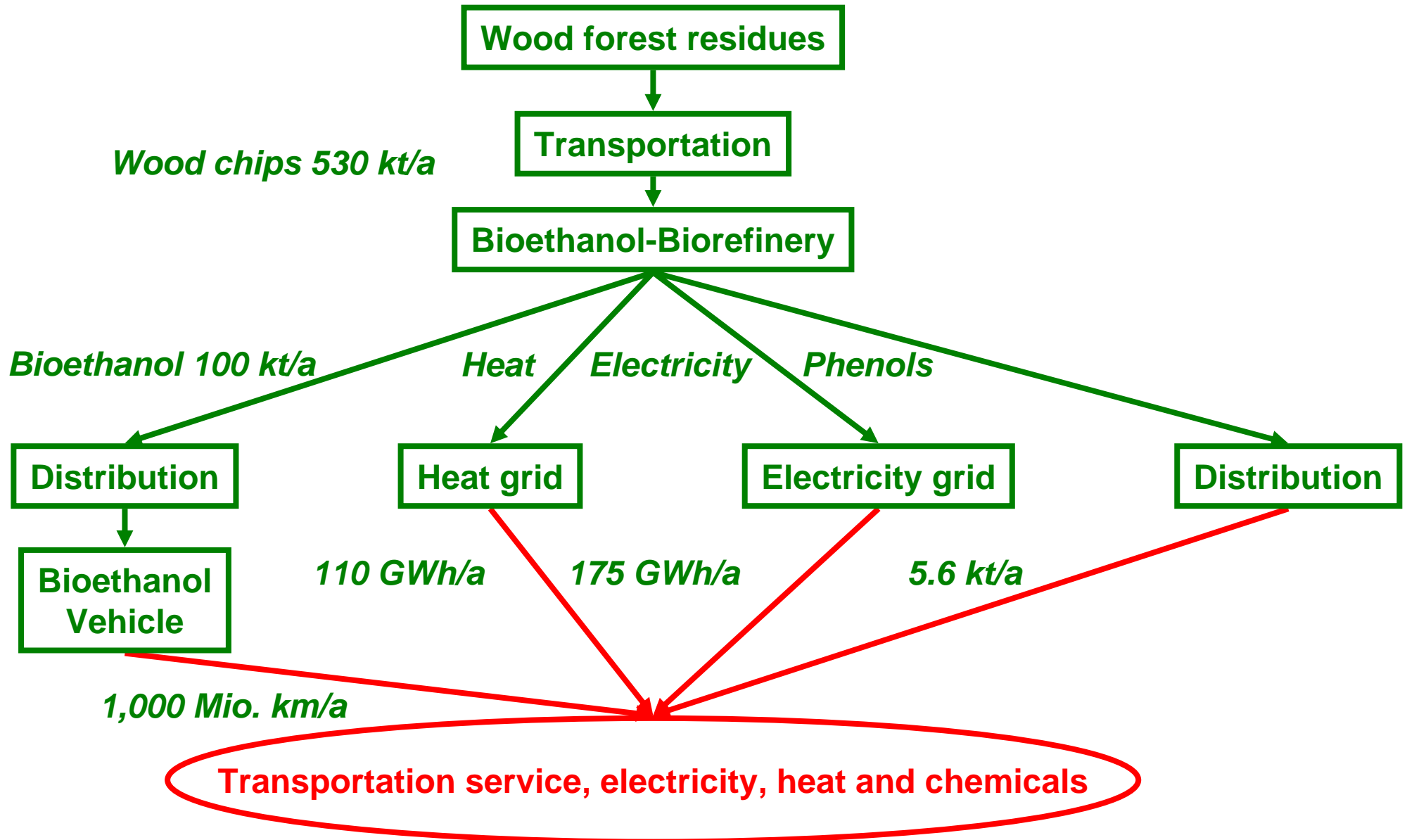
- **Cumulated primary energy demand** [PJ_{primary energy}] shared in
 - ✓ Biomass (e.g. wood, straw)
 - ✓ Fossil energy (e.g. oil, coal, natural gas)
 - ✓ Others (e.g. hydro power, waste, nuclear)

- **Indicators for environmental evaluation**
 - ✓ Specific GHG reduction [t CO₂-eq/t_{biomass}] or [t CO₂-eq/ha]
 - ✓ Specific fossil energy reduction [TJ_{fossil energy}/t_{wood}]

Process System: Wood Bioethanol Biorefinery



LCA of Wood Bioethanol Biorefinery



System Description for Example Environmental Evaluation

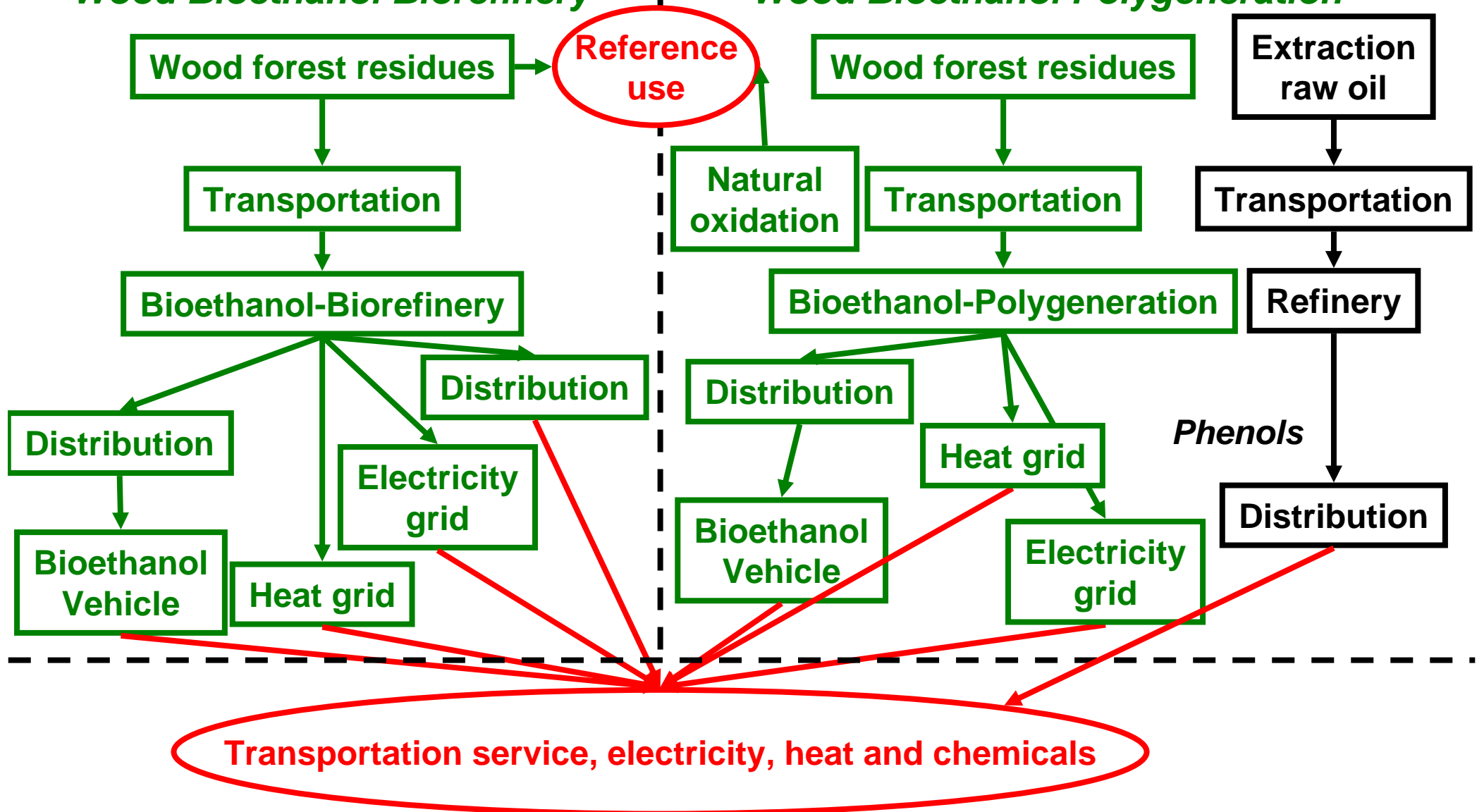
Systems	Supplied energy services			
	Heat 110 GWh/a	Electricity 175 GWh/a	Transportation service *) 1,000 Mio. km/a	Phenols 5,600 t/a
Wood bioethanol biorefinery	wood			
Wood polygeneration, con. phenols	wood			oil
Wood CHP **), gasoline, con. phenols	wood		gasoline	oil
Wood heating, natural gas, gasoline, con. phenols	wood	natural gas	gasoline	oil
Fossil reference system	oil	natural gas	gasoline	oil

*) Bioethanol: 100.000 t/a
 **) Combined heat and power

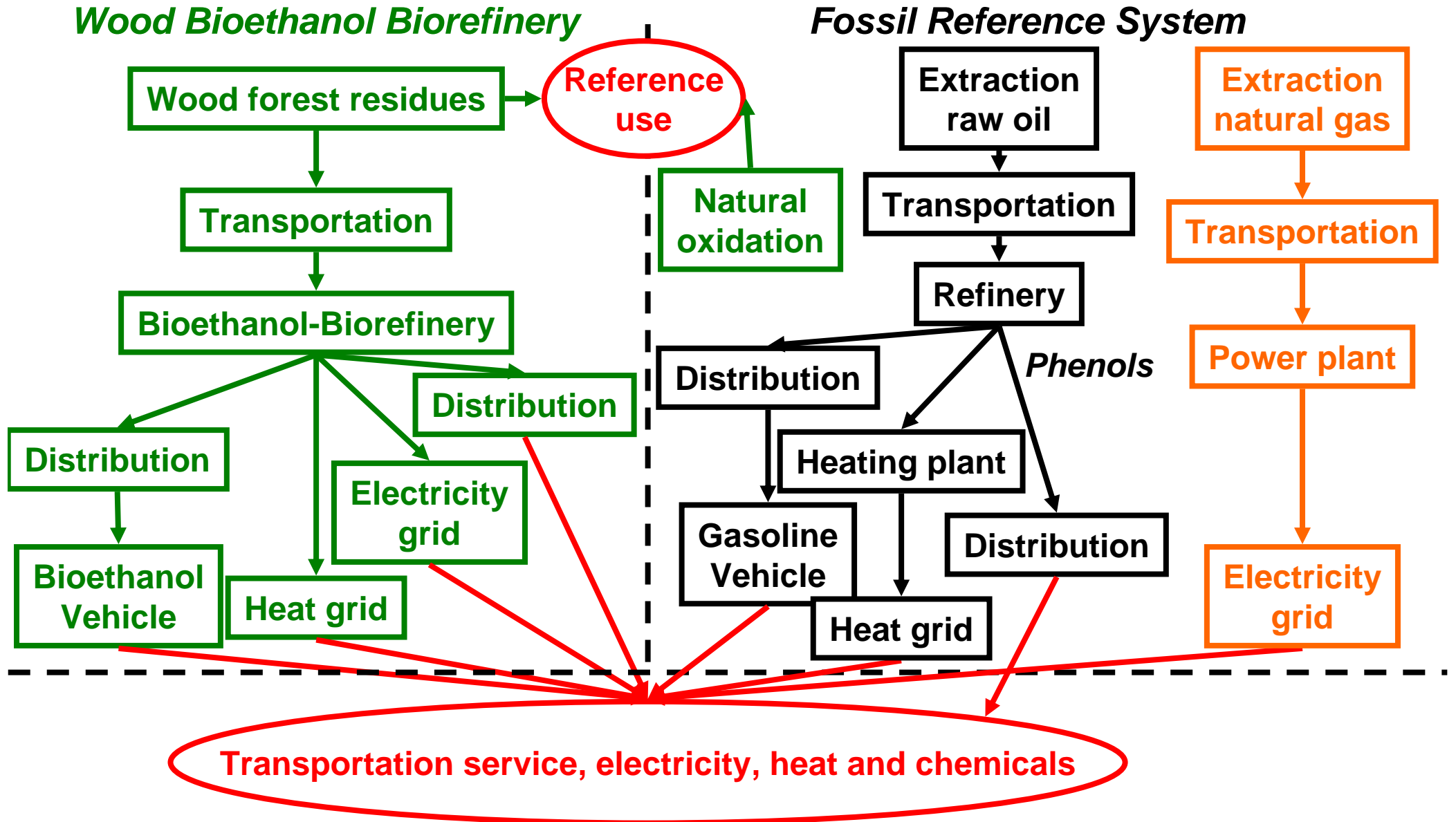
Comparison Wood to Bioethanol Biorefinery and Polygeneration

Wood Bioethanol Biorefinery

Wood Bioethanol Polygeneration



Comparison Wood to Bioethanol Biorefinery and Polygeneration

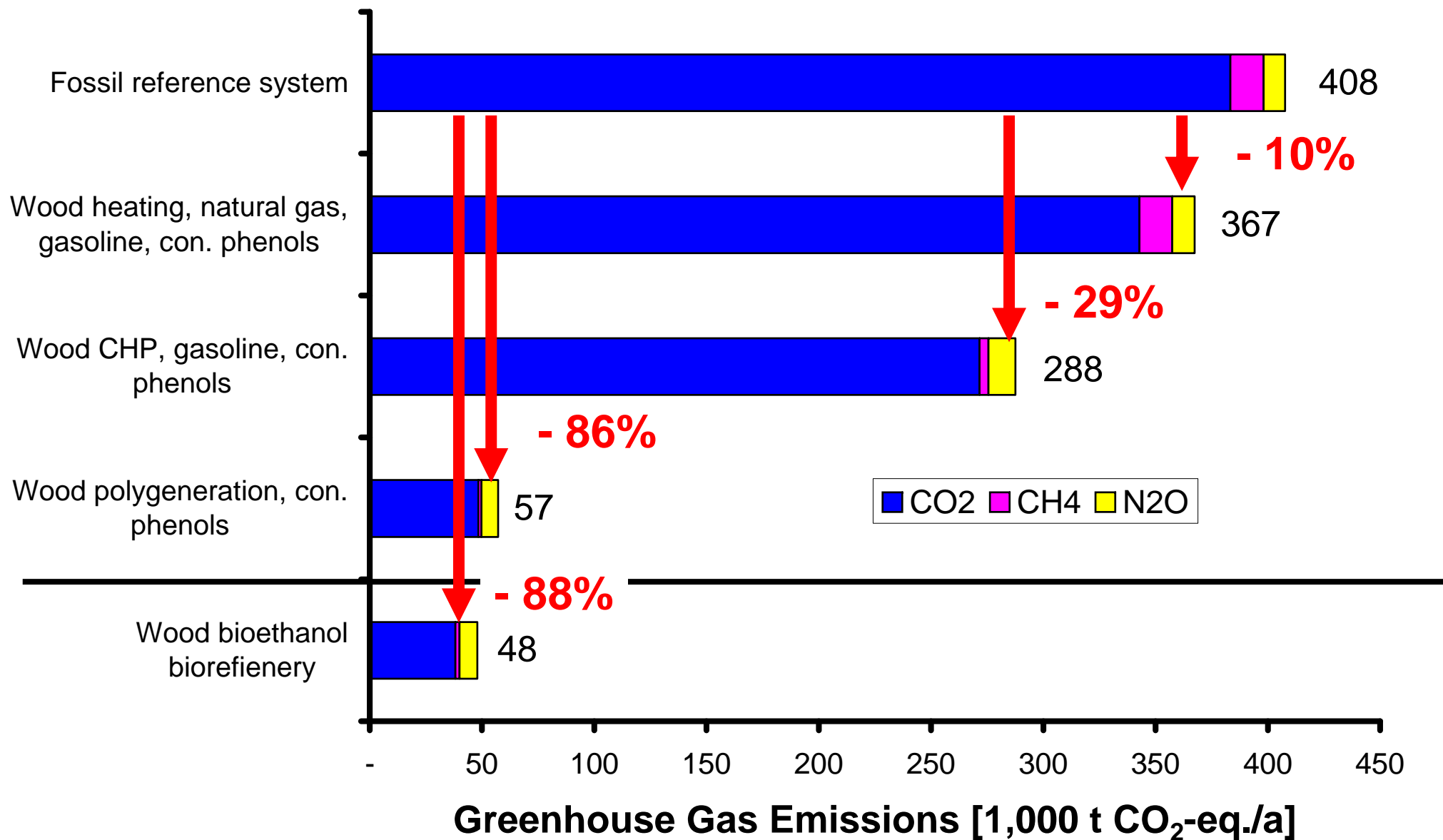


Functional Units for Environmental Evaluation

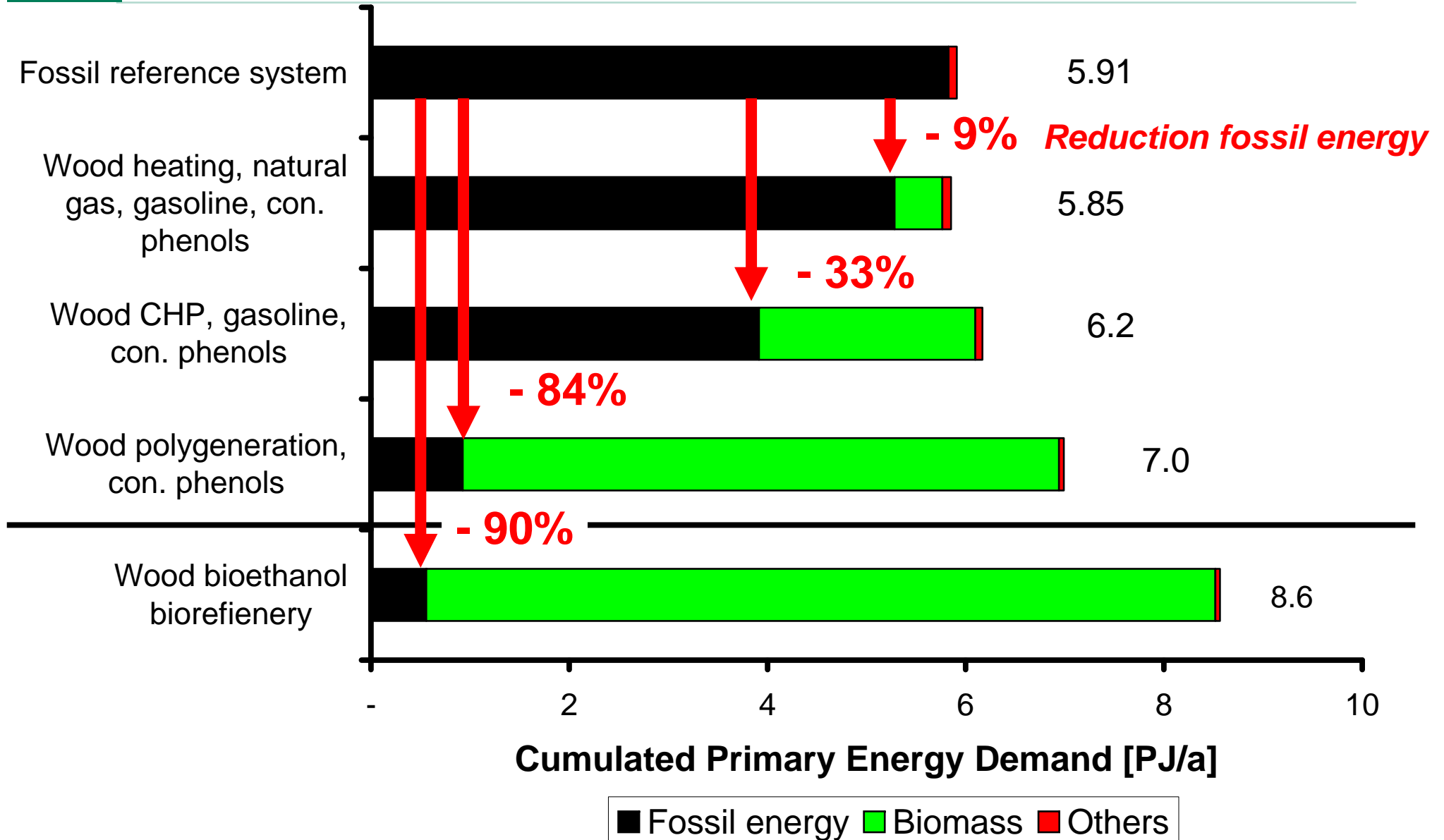
Each system provides:

- ▶ **Electricity:** 175 GWh/a
- ▶ **Transportation service:** 1,000 Million km/a (based on 100 kt/a of bioethanol for passenger car)
- ▶ **Phenols:** 5,600 t/a
- ▶ **Heat:** 110 GWh/a

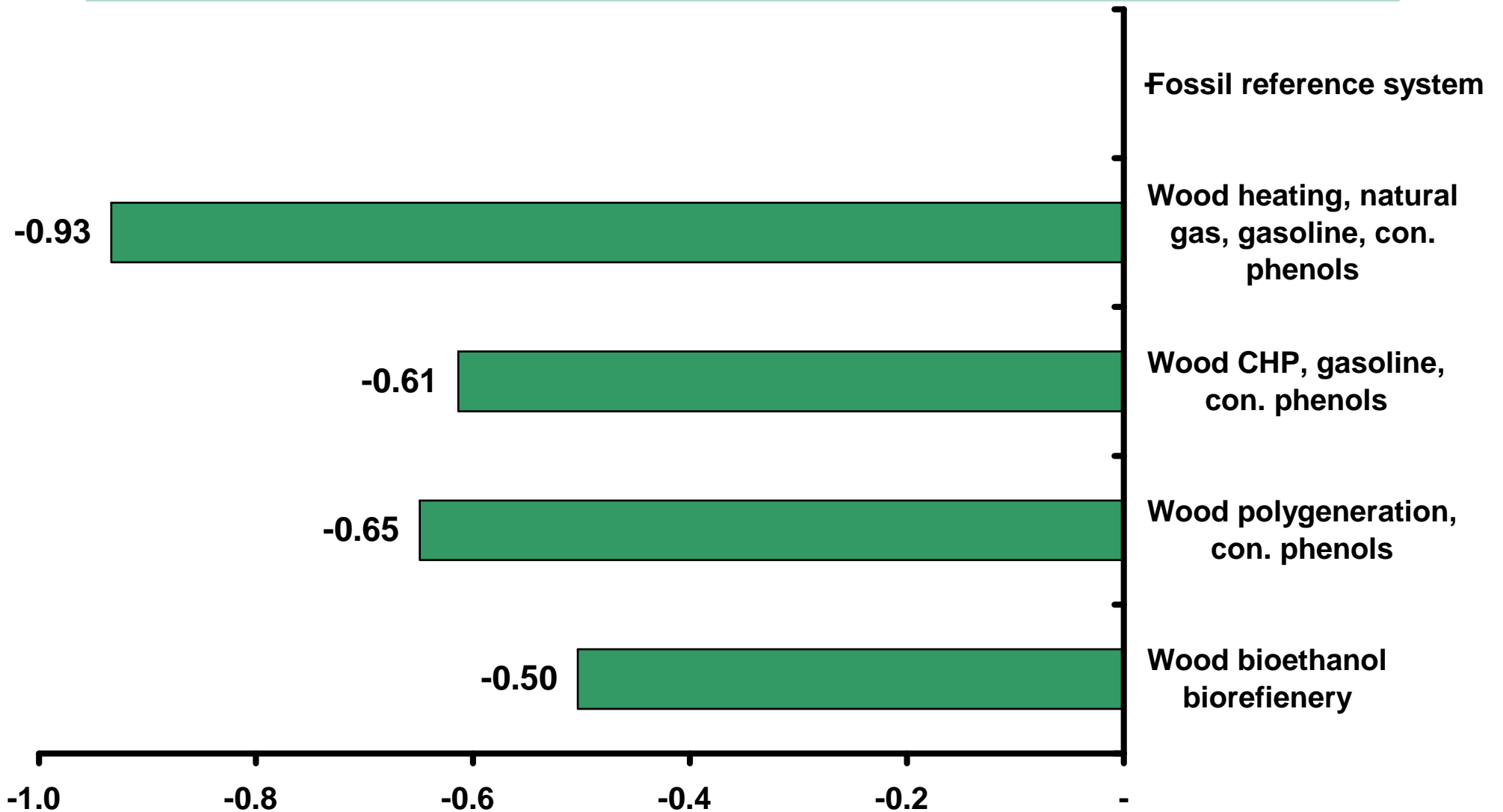
Greenhouse Gas Emissions



Cumulated Primary Energy Demand

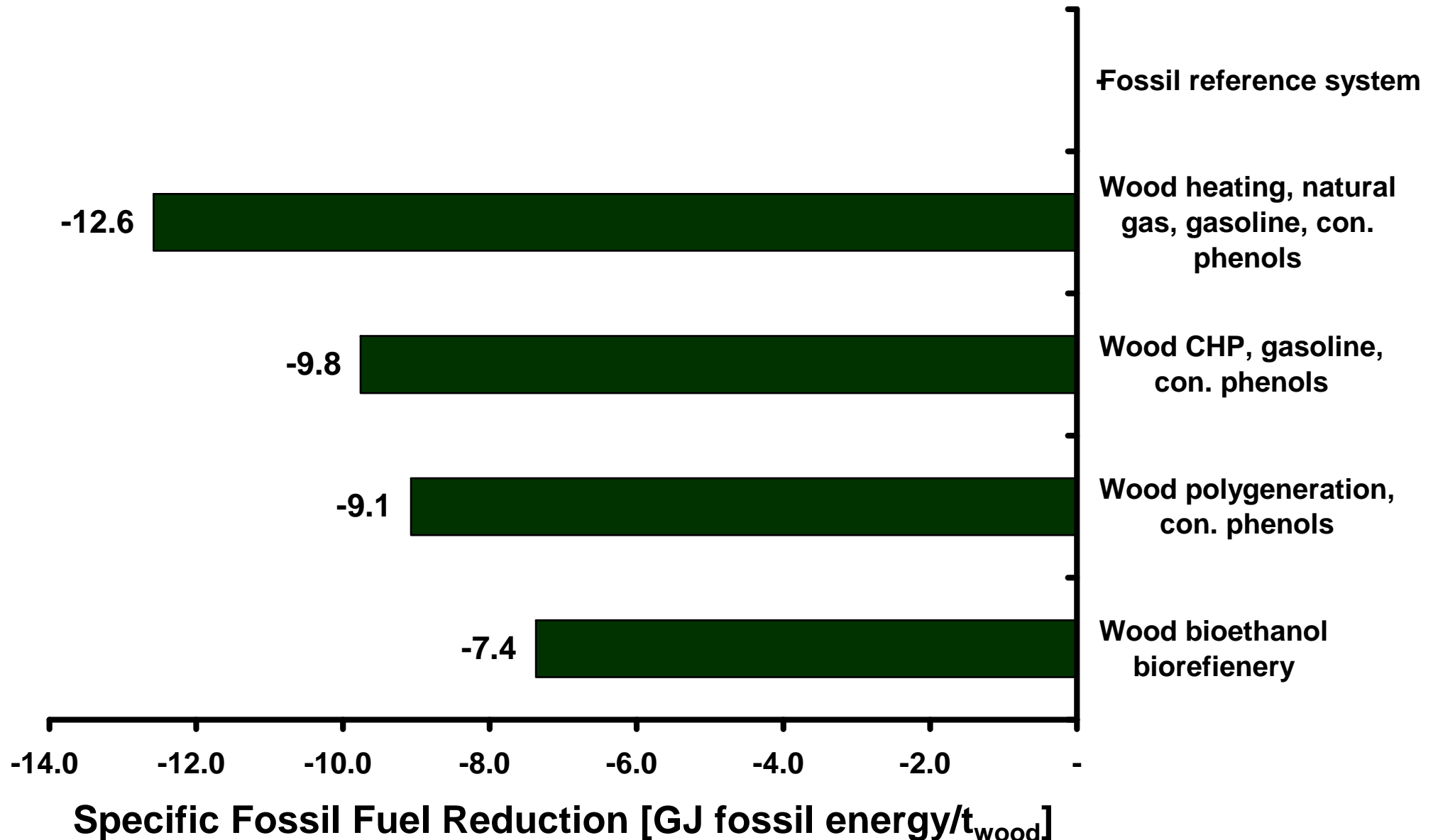


Indicator for Environmental Evaluation: Specific GHG Reduction

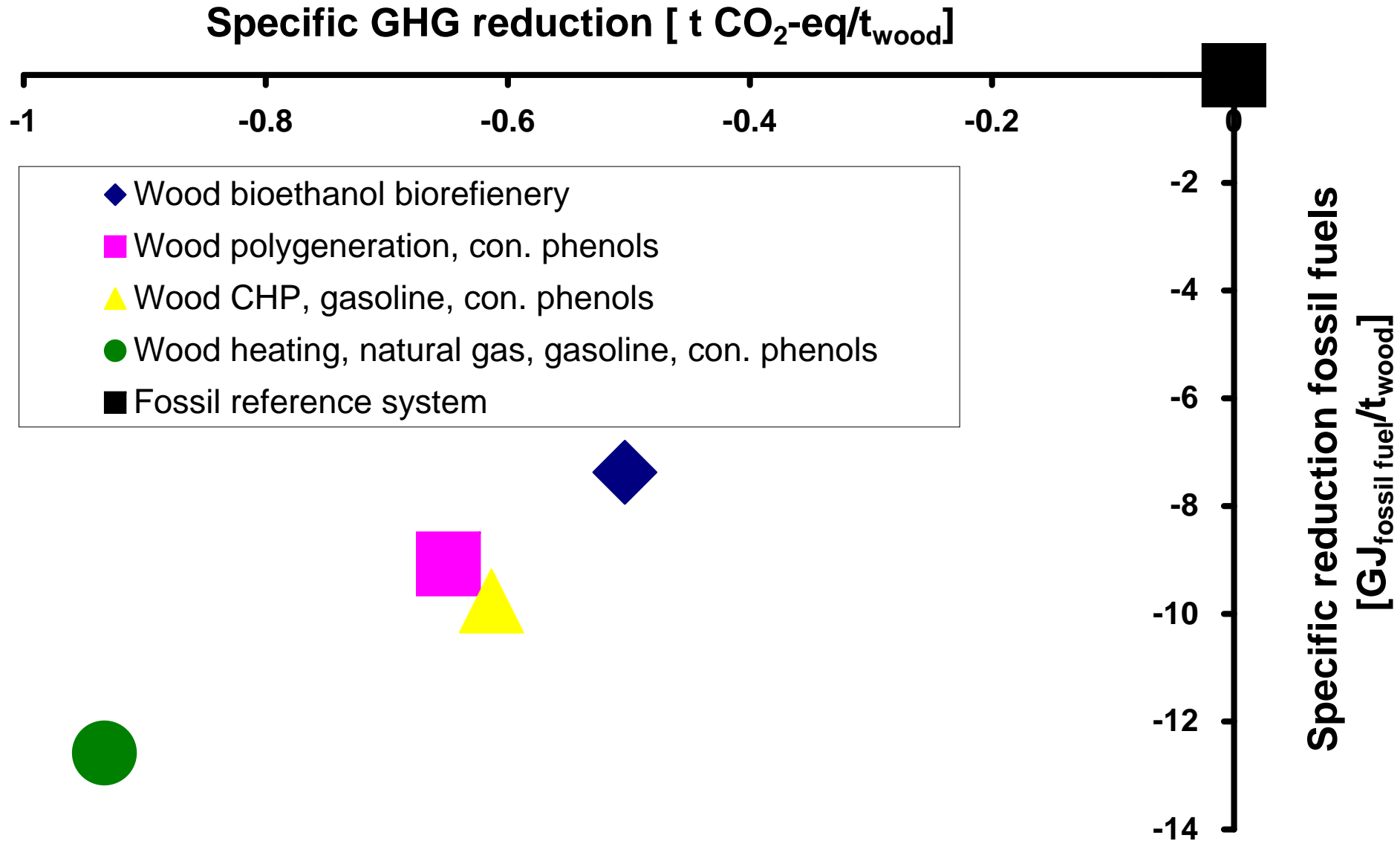


Specific Greenhouse Gas Emissions Reduction [t CO₂-eq./t_{wood}]

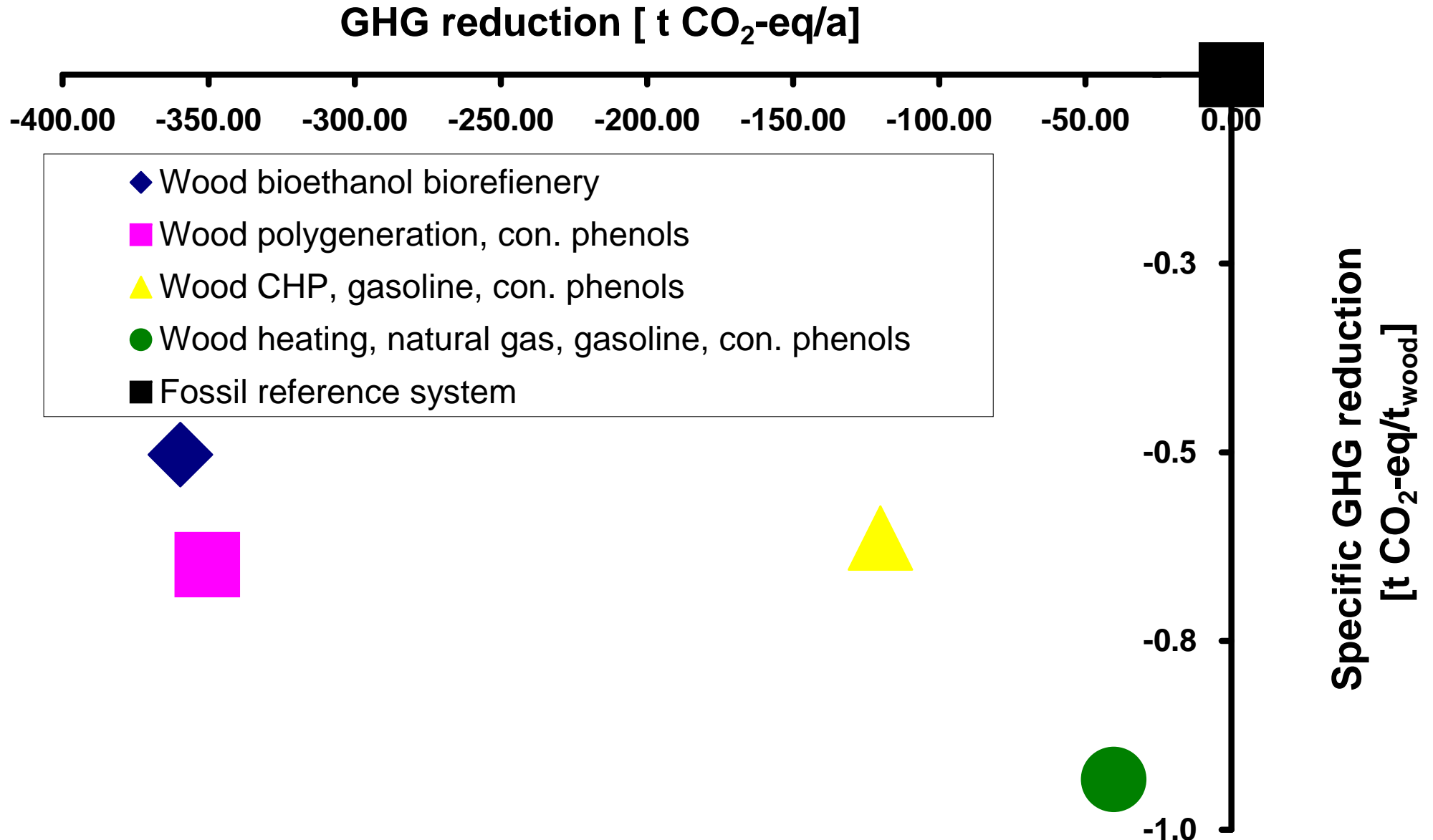
Indicator for Environmental Evaluation: Specific Fossil Fuel Reduction



Indicator for Environmental Evaluation: Trade Off (I)



Indicator for Environmental Evaluation: Trade Off (II)



Conclusions



**Indicators developed for environmental evaluation
CO₂-eq and fossil fuel saving (specific/absolut terms)**

Evaluation of biorefinery systems is complex

**“Multi-platform biorefinery system” might be biorefinery
complex of the future**

**Many different biorefinery systems – focus on transportation biofuels
orientated systems**