Overview on 1st and 2nd Generation of Transportation Biofuels

G. Jungmeier, J. Spitzer

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

International Workshop in Cooperation with the Salzburg State Government

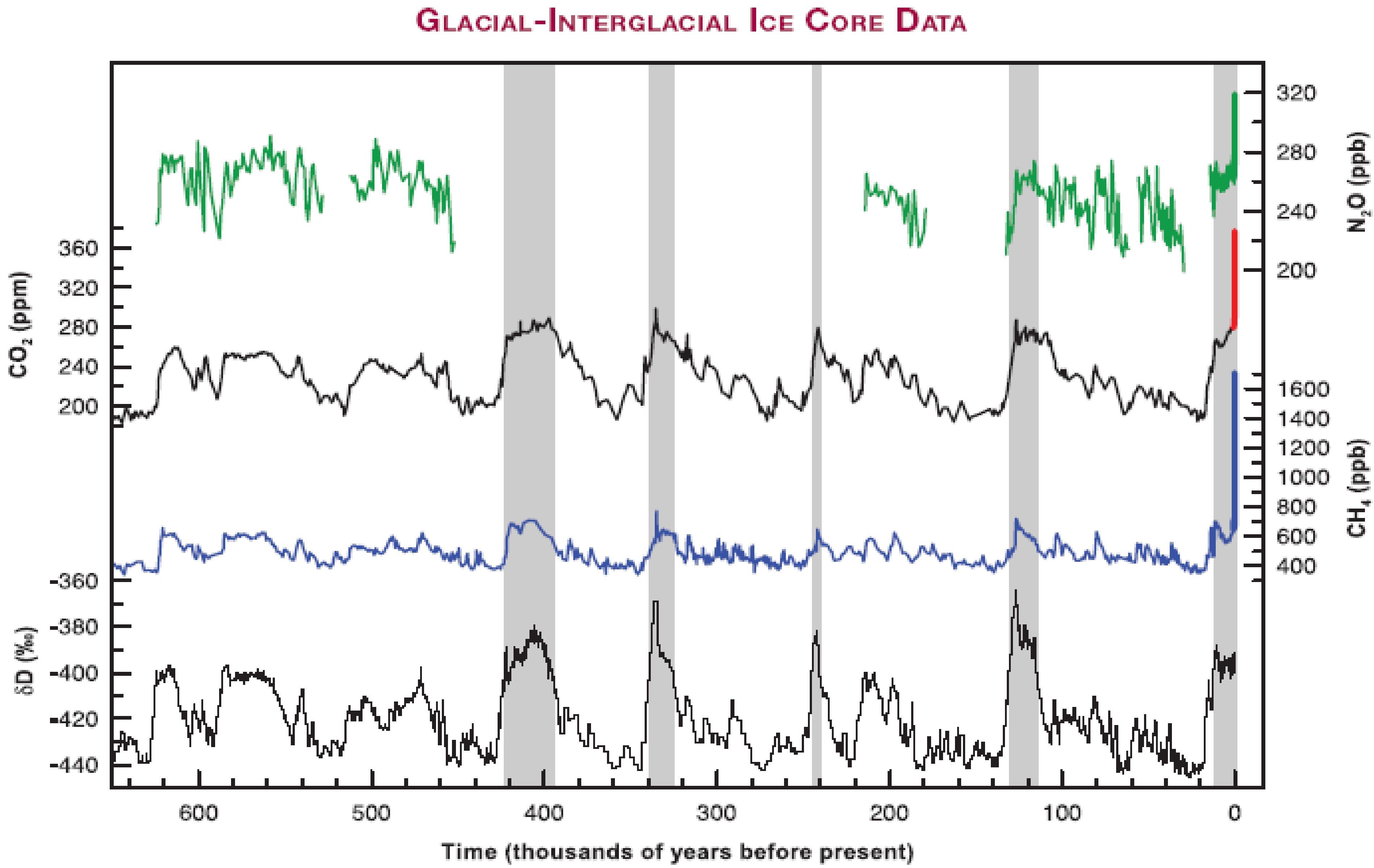
“Transportation Biofuels: For greenhouse gas mitigation, energy security or other reasons ?”

5 February 2008, Salzburg, Austria

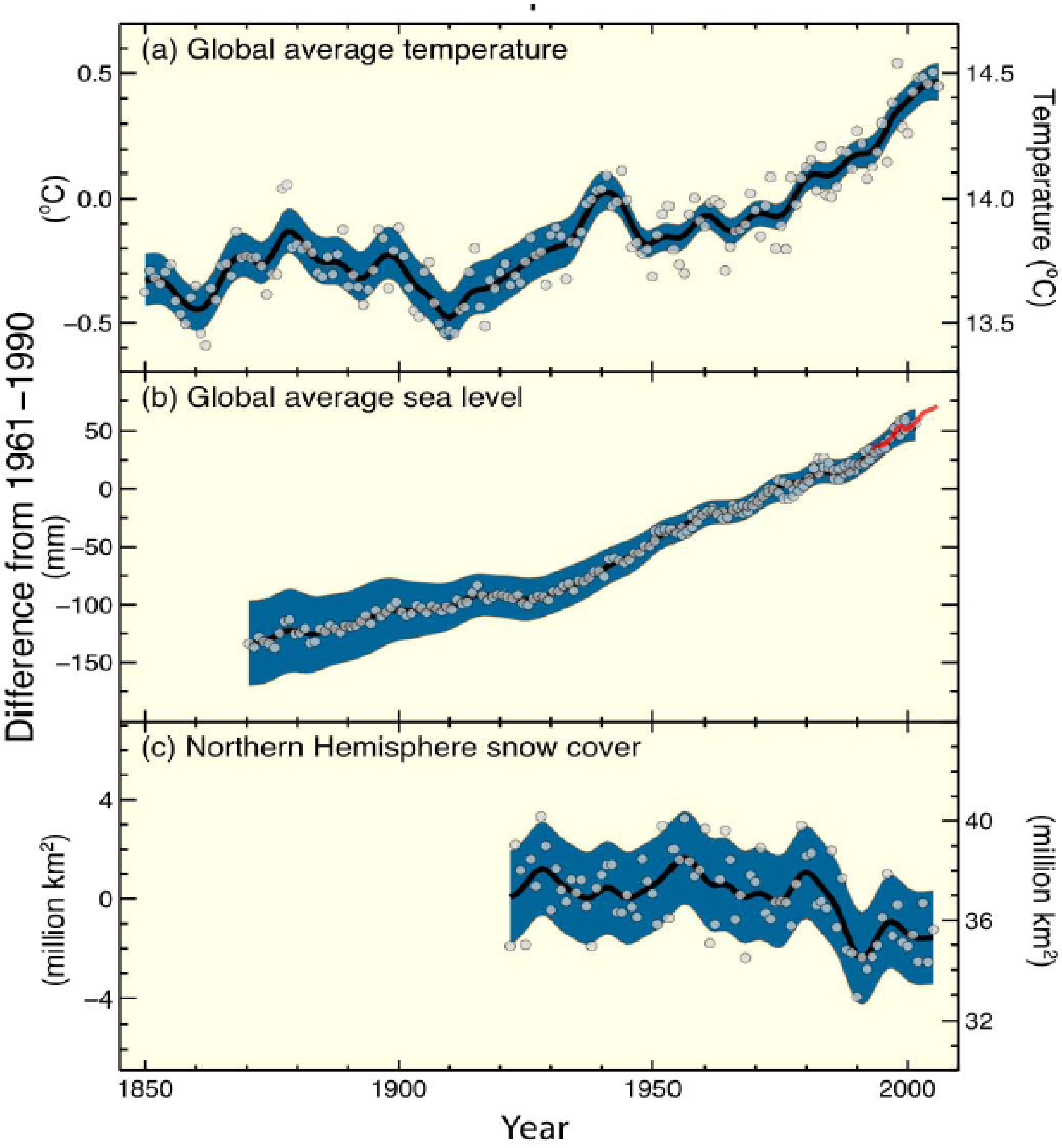
Outline

- Introduction
- Overview Biofuels
- Assessment of Biofuels
- Examples Polygeneration
- Outlook

Greenhouse Gas Concentration in Atmosphere

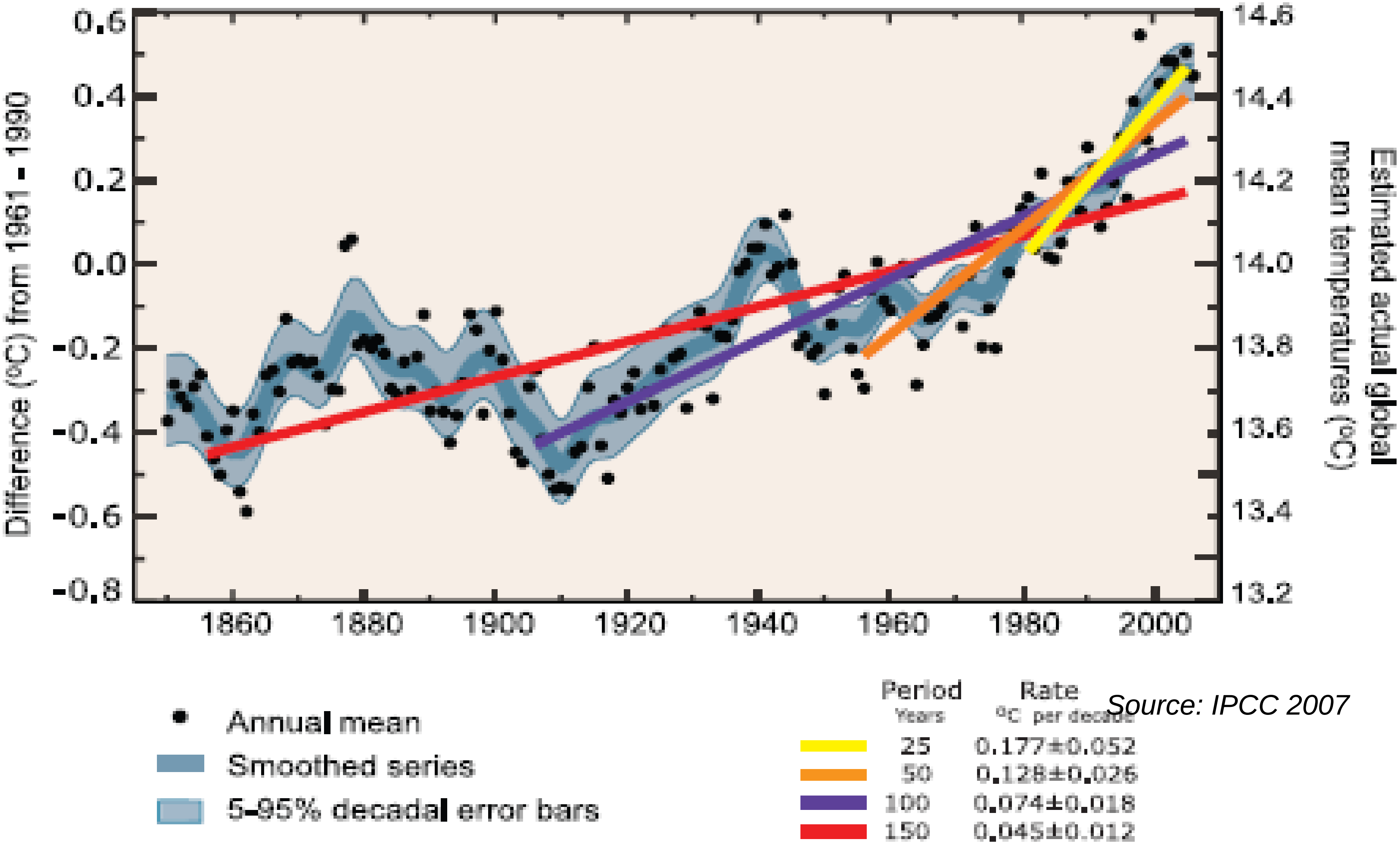


Observed Changes



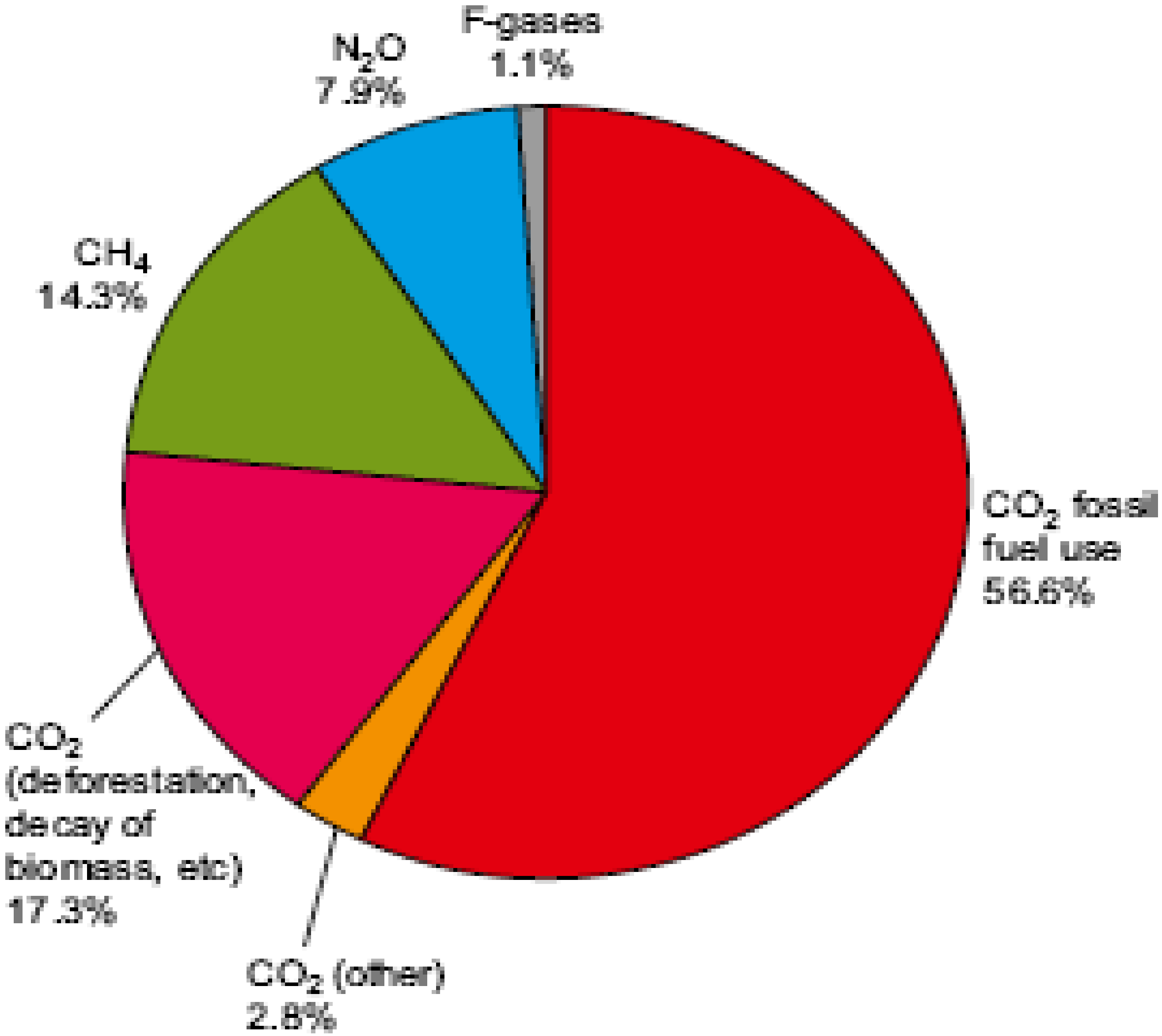
Source: IPCC 2007

Global Temperature Trends



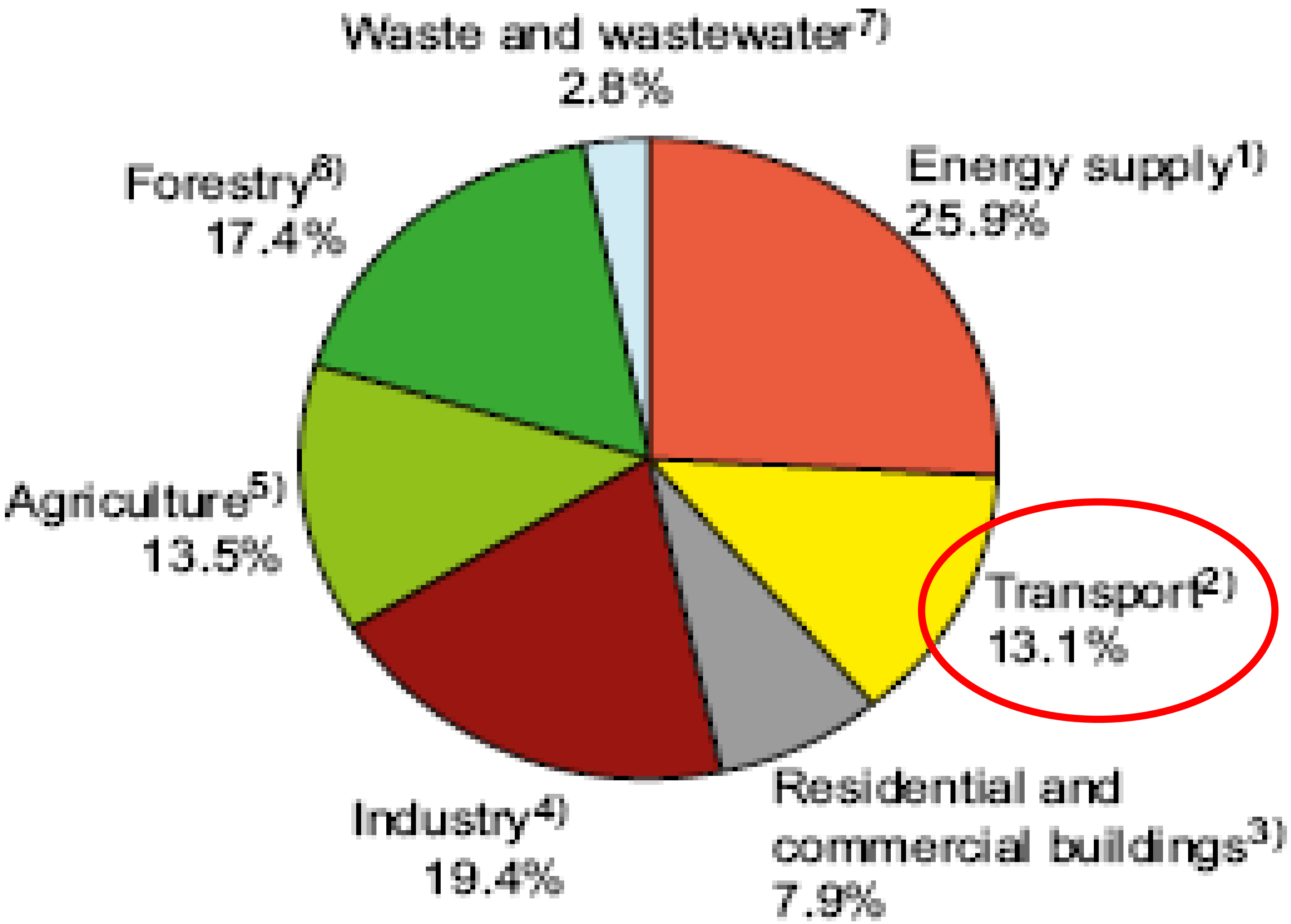
Source: IPCC 2007

Global Anthropogenic Greenhouse Gas Emissions 2004



Source: www.ipcc.ch

Greenhouse Gas Emissions per Sector 2004

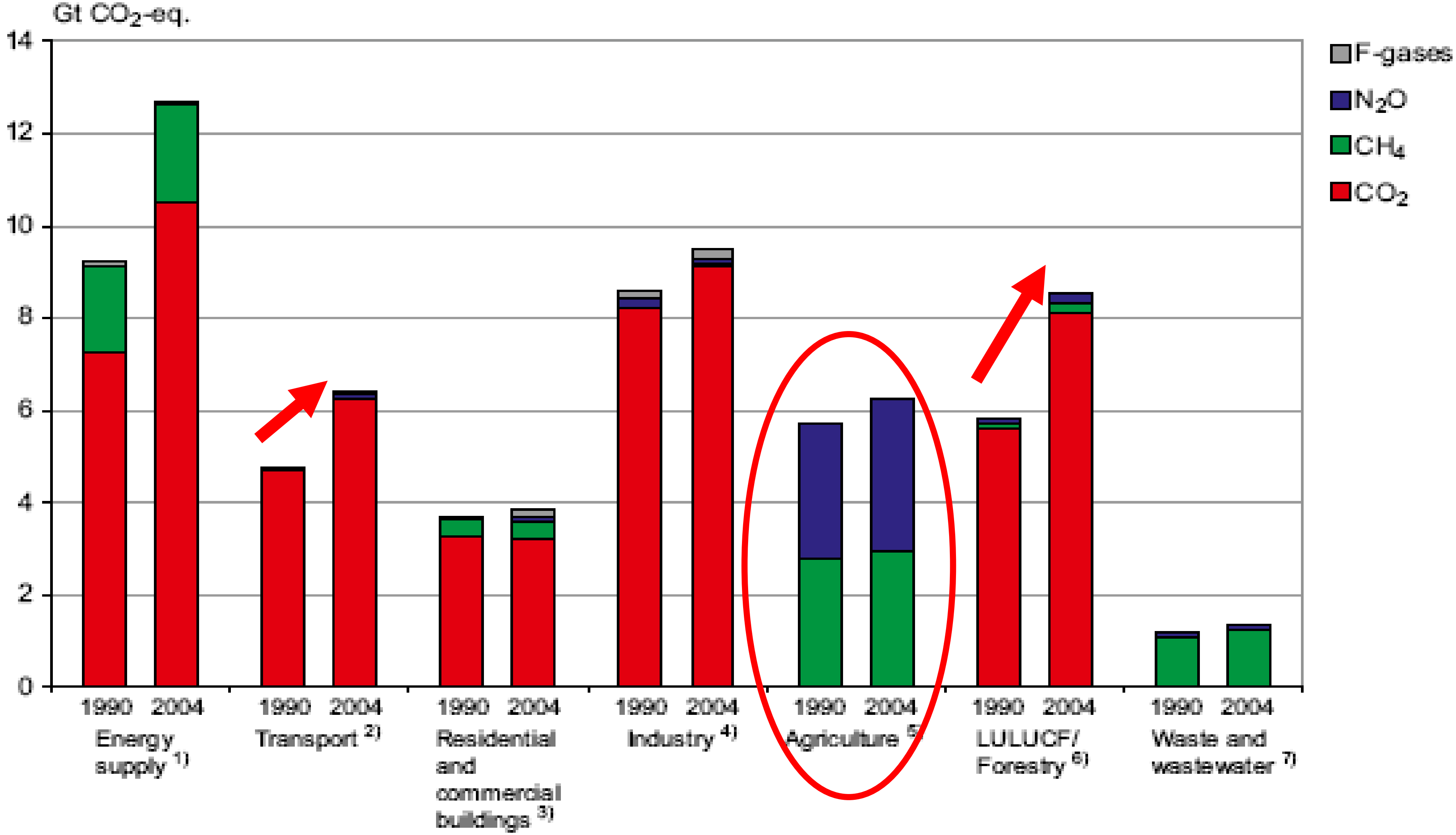


Notes to Figure TS.2a and 2b:

1) Excluding refineries, coke ovens etc., which are included in industry.
2) Including international transport (bunkers), excluding fisheries. Excluding off-road agricultural and forestry vehicles and machinery.
3) Including traditional biomass use. Emissions in Chapter 6 are also reported on the basis of end-use allocation (including the sector's share in emissions caused by centralized electricity generation) so that any mitigation achievements in the sector resulting from lower electricity use are credited to the sector.
4) Including refineries, coke ovens etc. Emissions reported in Chapter 7 are also reported on the basis of end-use allocation (including the sector's share in emissions caused by centralized electricity generation) so that any mitigation achievements in the sector resulting from lower electricity use are credited to the sector.
5) Including agricultural waste burning and savannah burning (non-CO_2). CO_2 emissions and/or removals from agricultural soils are not estimated in this database.
6) Data include CO_2 emissions from deforestation, CO_2 emissions from decay (decomposition) of above-ground biomass that remains after logging and deforestation, and CO_2 from peat fires and decay of drained peat soils. Chapter 9 reports emissions from deforestation only.
7) Includes landfill CH_4, wastewater CH_4 and N_2O, and CO_2 from waste incineration (fossil carbon only).

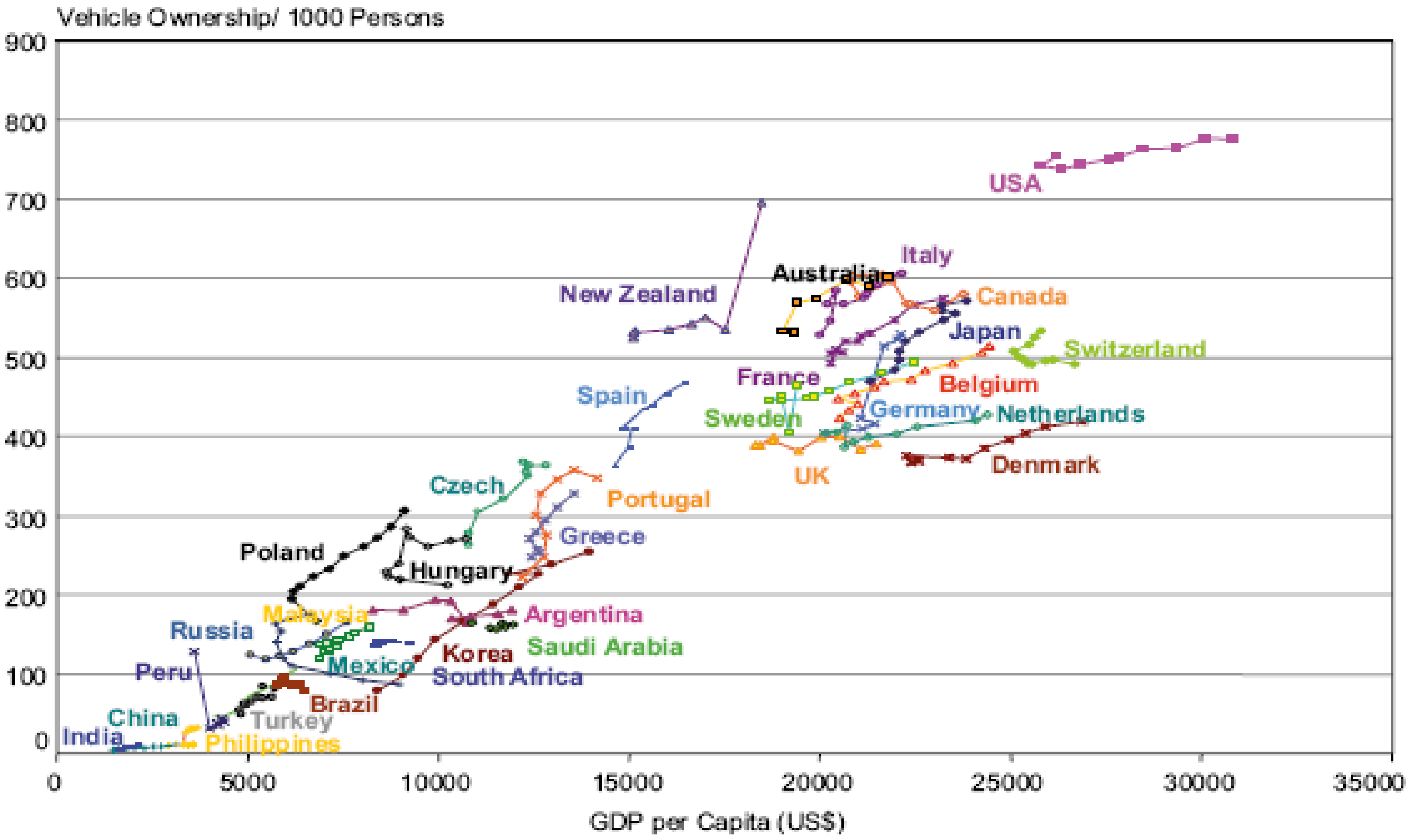
Source: www.ipcc.ch

Development Greenhouse Gas Emissions per Sector 2004



Source: www.ipcc.ch

Vehicle Ownership 1900 - 2003



Source: www.ipcc.ch

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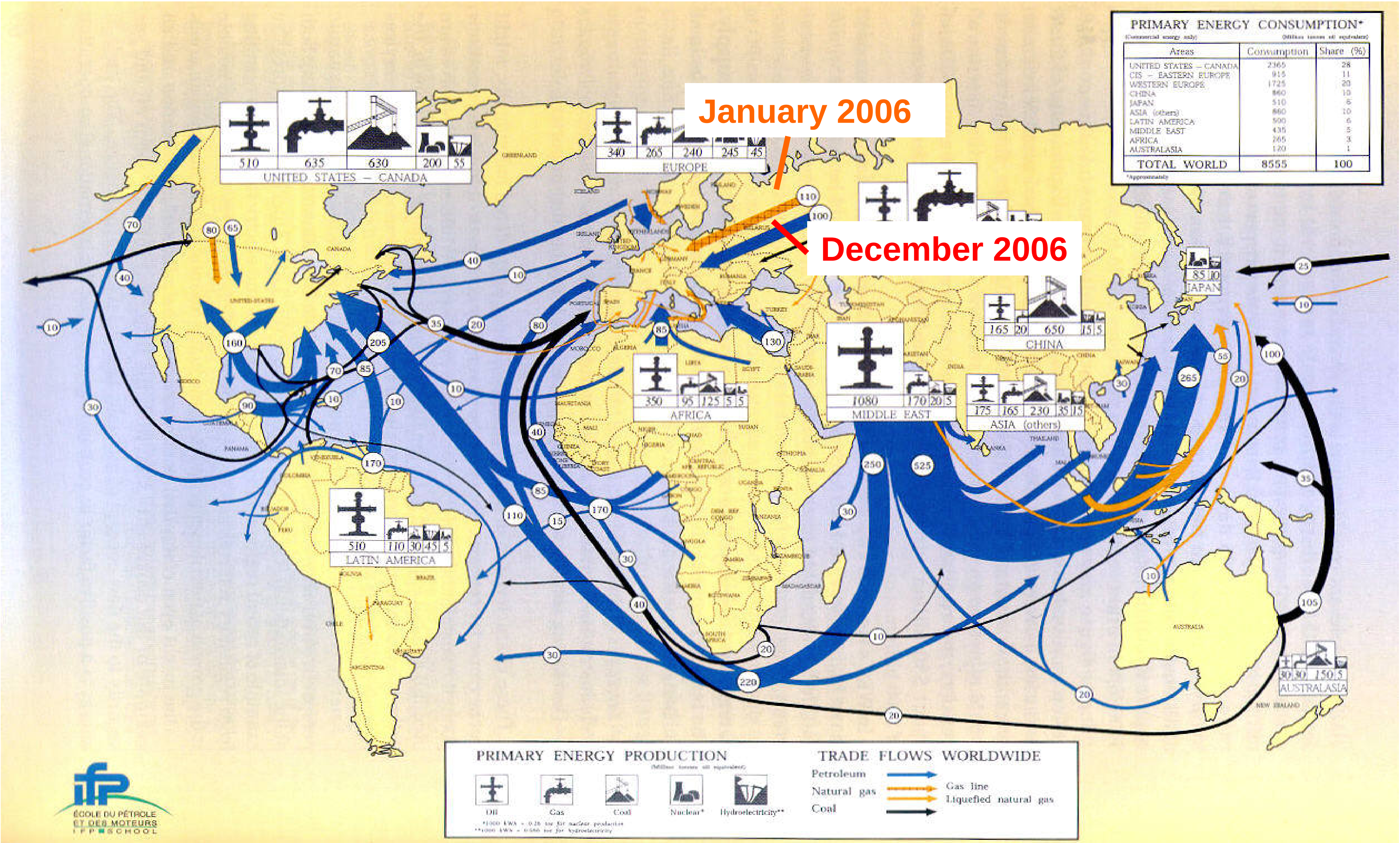
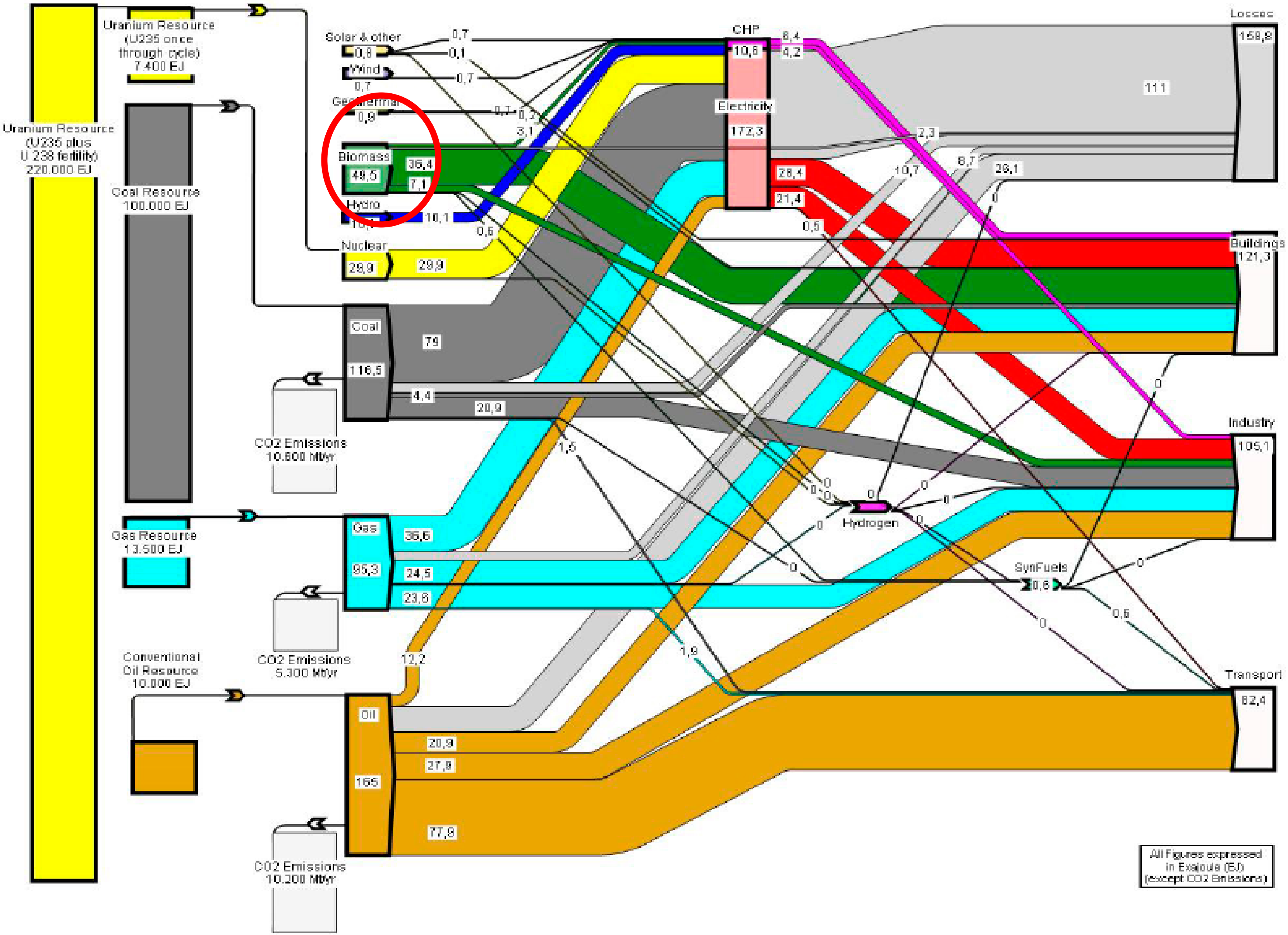
Energy Worldwide and Energy Supply Security



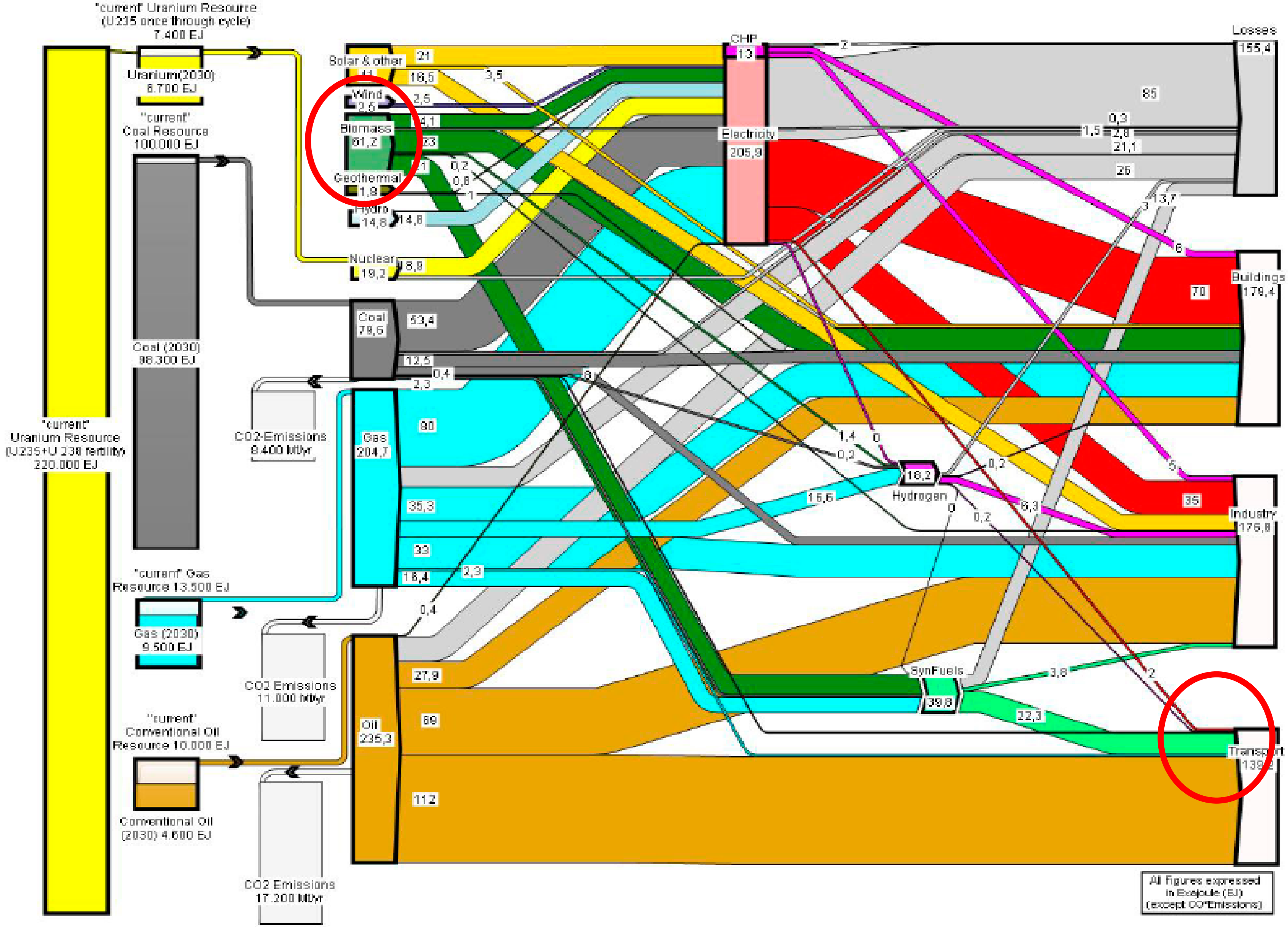
Source: WEC 2000

Global Energy Flow 2005



Source: www.ipcc.ch

Global Energy Flow Outlook 2030



Source: www.ipcc.ch

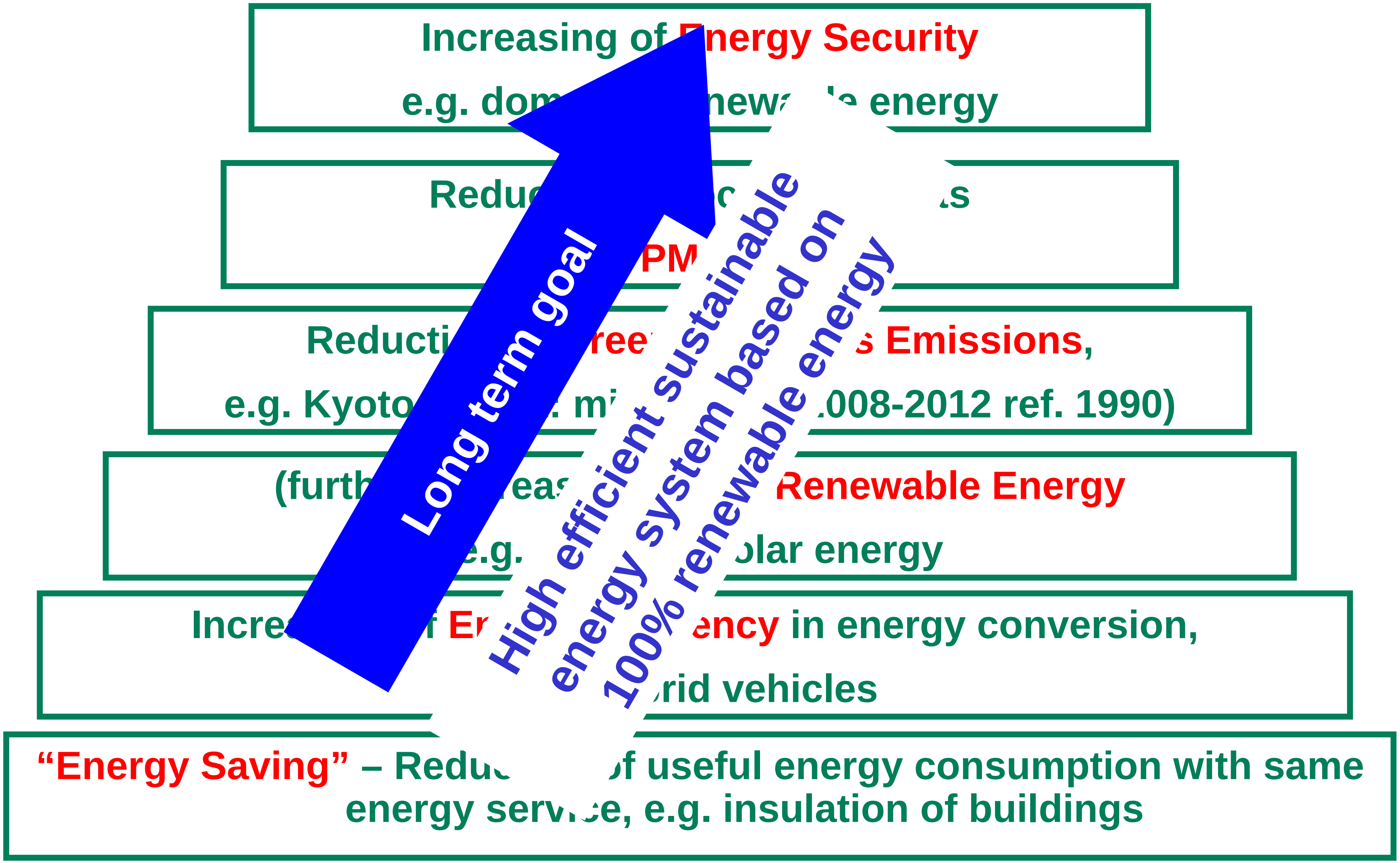
Overview of the Global Potential of Biomass for Energy

Biomass category	Main assumptions and remarks	Energy potential in biomass up to 2050
Energy farming on current agricultural land	Potential land surplus: 0-4 Gha (average: 1-2 Gha). A large surplus requires structural adaptation towards more efficient agricultural production systems. When this is not feasible, the bioenergy potential could be reduced to zero. On average higher yields are likely because of better soil quality: 8-12 dry tonne/ha/yr* is assumed.	0 – 700 EJ (more average development: 100 – 300 EJ)
Biomass production on marginal lands.	On a global scale a maximum land surface of 1.7 Gha could be involved. Low productivity of 2-5 dry tonne/ha/yr.* The net supplies could be low due to poor economics or competition with food production.	<60 – 110 EJ
Residues from agriculture	Potential depends on yield/product ratios and the total agricultural land area as well as type of production system. Extensive production systems require re-use of residues for maintaining soil fertility. Intensive systems allow for higher utilisation rates of residues.	15 – 70 EJ
Forest residues	The sustainable energy potential of the world's forests is unclear – some natural forests are protected. Low value: includes limitations with respect to logistics and strict standards for removal of forest material. High value: technical potential. Figures include processing residues	30 - 150 EJ
Dung	Use of dried dung. Low estimate based on global current use. High estimate: technical potential. Utilisation (collection) in the longer term is uncertain	5 – 55 EJ
Organic wastes	Estimate on basis of literature values. Strongly dependent on economic development, consumption and the use of bio-materials. Figures include the organic fraction of MSW and waste wood. Higher values possible by more intensive use of bio-materials.	5 – 50 EJ
Combined potential	Most pessimistic scenario: no land available for energy farming; only utilisation of residues. Most optimistic scenario: intensive agriculture concentrated on the better quality soils. In parentheses: average potential in a world aiming for large-scale deployment of bioenergy.	40 – 1100 EJ (200 - 400 EJ)

* Heating value: 19 GJ/tonne dry matter.

World Primary Energy consumption (2006): 400 EJ/a

Role of Biofuels in the Energy Economy System



Overview Transportation Biofuels 1st and 2nd Generation

1) **(pure) vegetable oil**
2) **Biodiesel**
   a) conventional biodiesel via esterification
   b) hydro-treated biodiesel via hydration
3) **Bioethanol**
   a) conventional bioethanol from sugar and starch
   b) lignocellulosic bioethanol
4) **Biobutanol**
5) **Biogas**
6) **Synthetische Biotreibstoffe**
   a) Fischer-Tropsch biofuels (z.B. FT-Diesel)
   b) Synthetic natural gas (SNG)
   c) Dimethylester (DME)
   d) Methanol
   e) Synthetic hydrogen
7) **Biological hydrogen**
8) **(upgraded) Pyrolyses oil**
9) **Biofuels from direct liquifaction**
   a) HTU-Biofuels from hydro-thermal upgrading
   b) CLC-Biofuels from catalytic low temperature conversion

Overview Transportation Biofuels
1st Generation

1) **(pure) vegetable oil**
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    a) conventional biodiesel via esterification
    b) hydro-treated biodiesel via hydration
3) **Bioethanol**
    a) conventional bioethanol from sugar and starch

5) **Biogas**

Overview Transportation Biofuels
2nd Generation

3) **Bioethanol**

   b) lignocellulosic bioethanol

4) **Biobutanol**

6) **Synthetische Biotreibstoffe**
   a) Fischer-Tropsch biofuels (z.B. FT-Diesel)
   b) Synthetic natural gas (SNG)
   c) Dimethylester (DME)
   d) Methanol
   e) Synthetic hydrogen

7) **Biological hydrogen**

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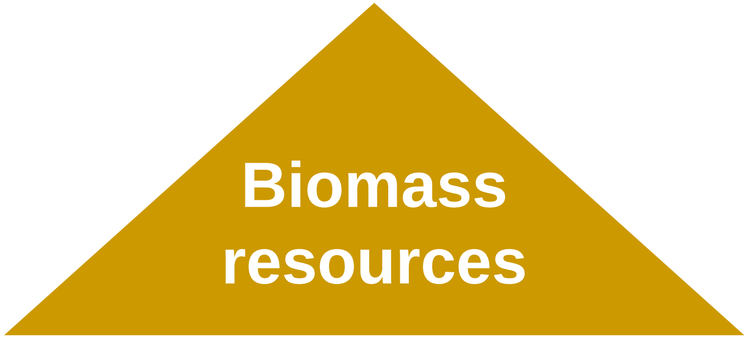
Overview
Biomass Raw Materials

- oil crops e.g. rape, sunflower
- sugar crops: e.g. sugar beet, sugar cane
- starch crops: e.g. wheat, maize
- lignocellulosic-crops: e.g. short rotation forestry, miscanthus
- residues: e.g. straw, manure, grass

Agriculture



Trade & Industry

- sawn industry residues: e.g. bark
- wood industry wastes: e.g. shavings
- food and feed industry residues
- bark
- black liquour:
- organic fraction of MSW
- sewage sludge

Forestry

- Residues from thinning
- Residues from harvesting

From Raw Material to Transportation Biofuels

Raw materials

- Oil crops
- Sugar crops
- Starch crops
- Lignocellulosic crops
- Residues

Conversion processes

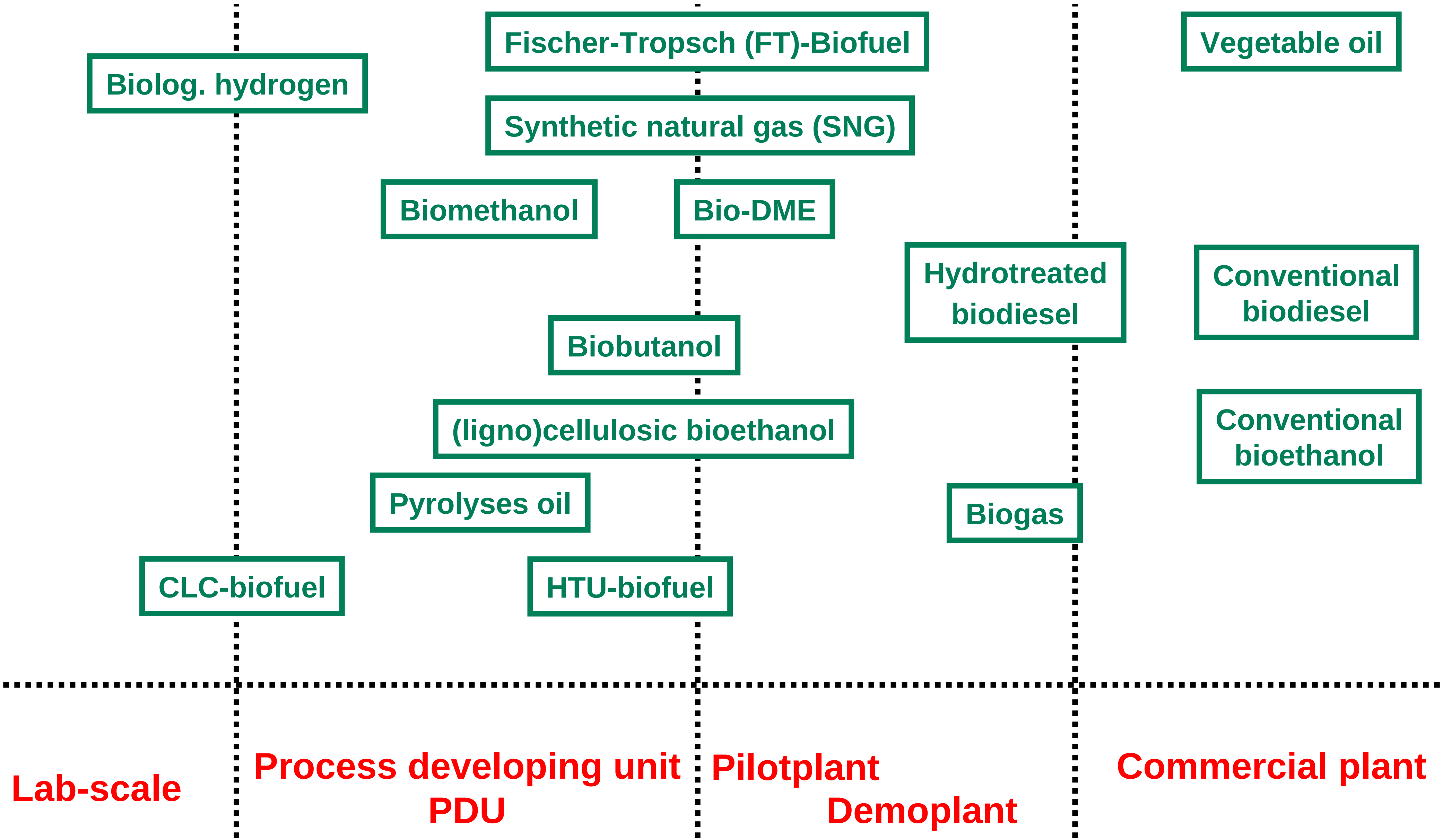
- Bio-chemical
- Thermo-chemical
- Physical-chemical
- others e.g. hydration

Transportation Biofuels

1) (pure) vegetable oil
2) Biodiesel
3) Bioethanol
4) Biobutanol
5) Biogas
6) Synthetic biofuels
7) Biological hydrogen
8) (upgraded) Pyrolyses oil
9) Biofuels from direct liquifaction

Currently about 40 combinations
Raw material/Conversion/Biofuel under discussion

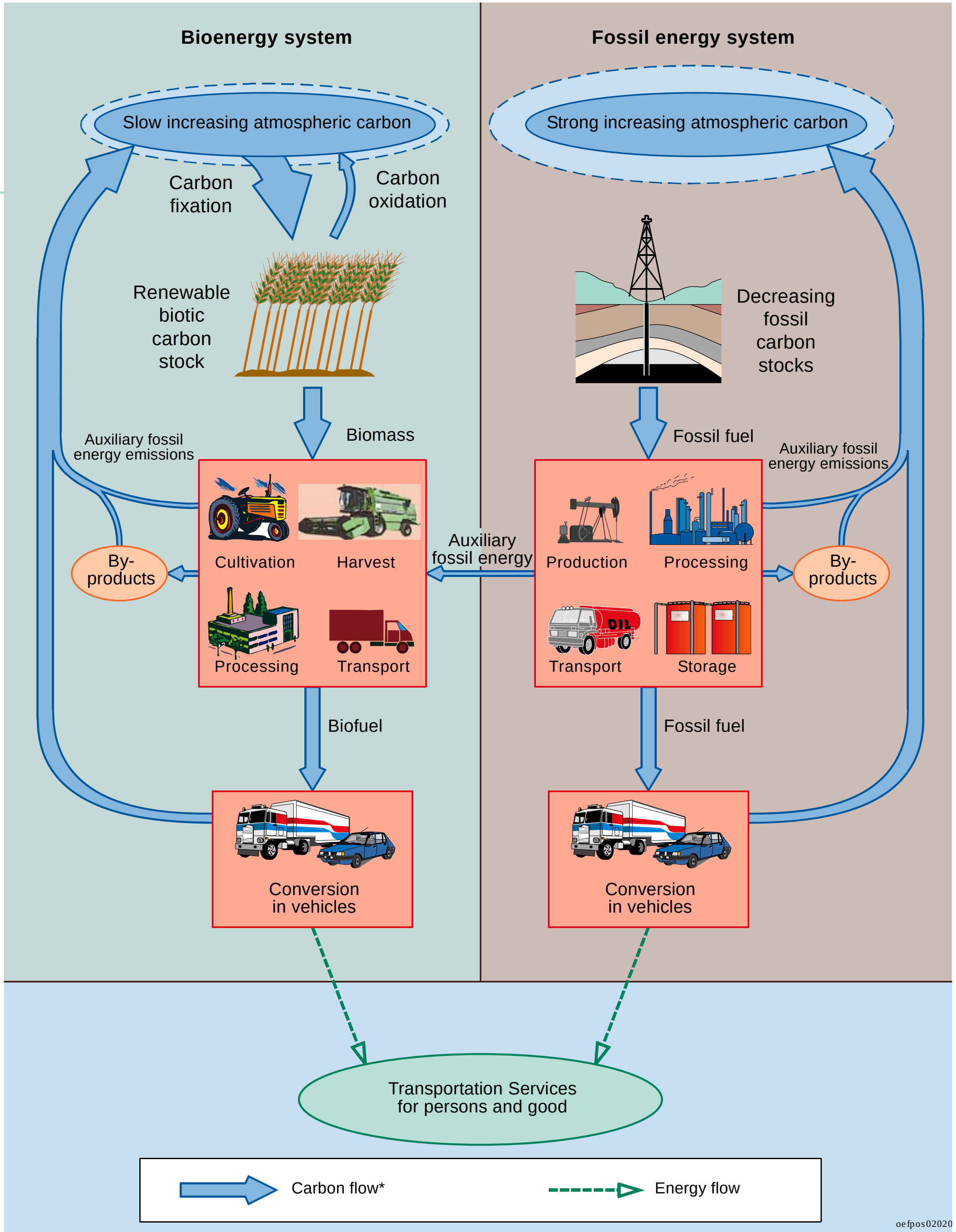
State of Technology



LCA Methodology

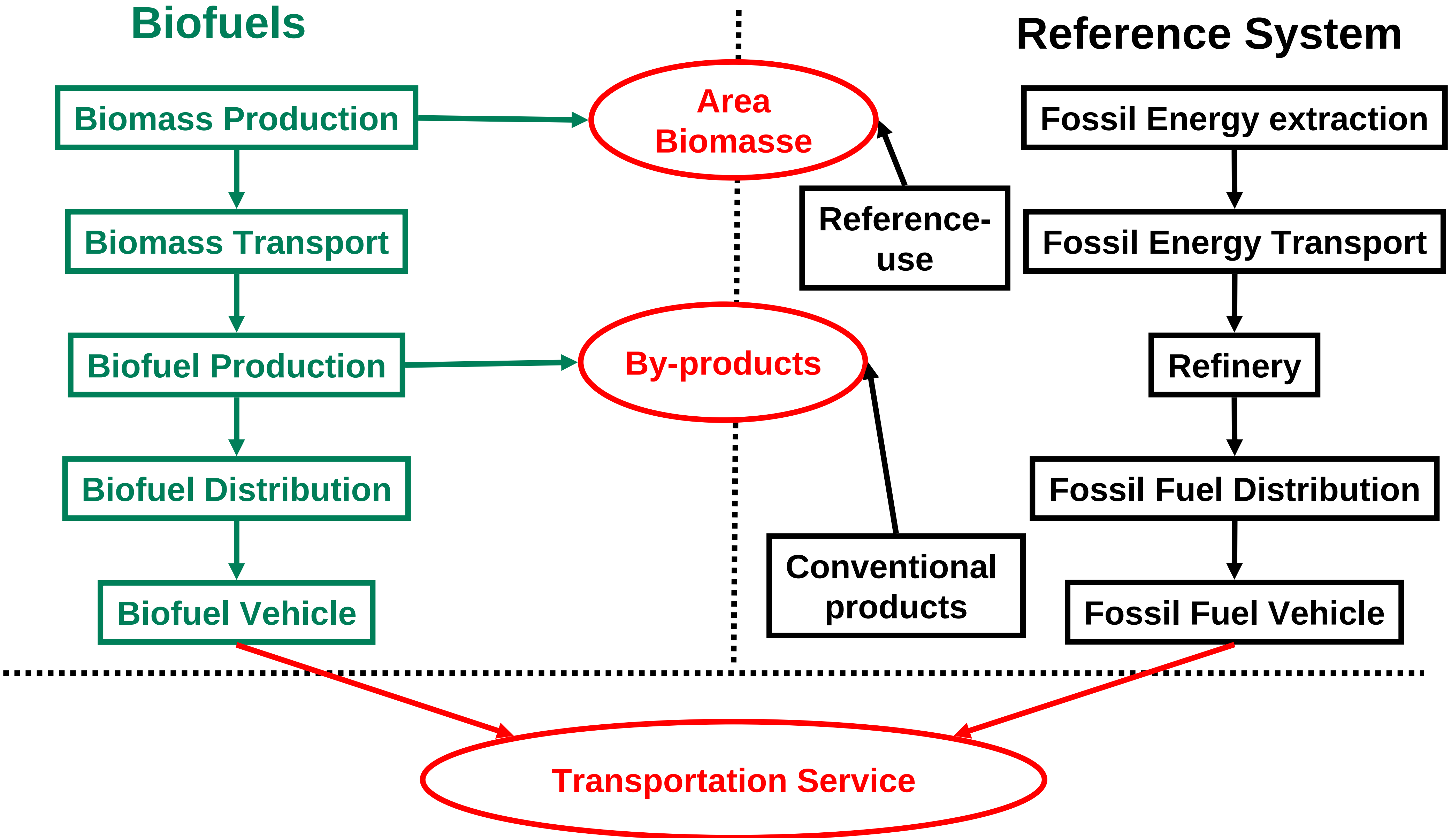
According to

- ✓ 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“*
- ✓ *JRC/CONCAWE/EUCAR: Well-to-Wheels analysis of future automotive fuels and powertrains in the European context*

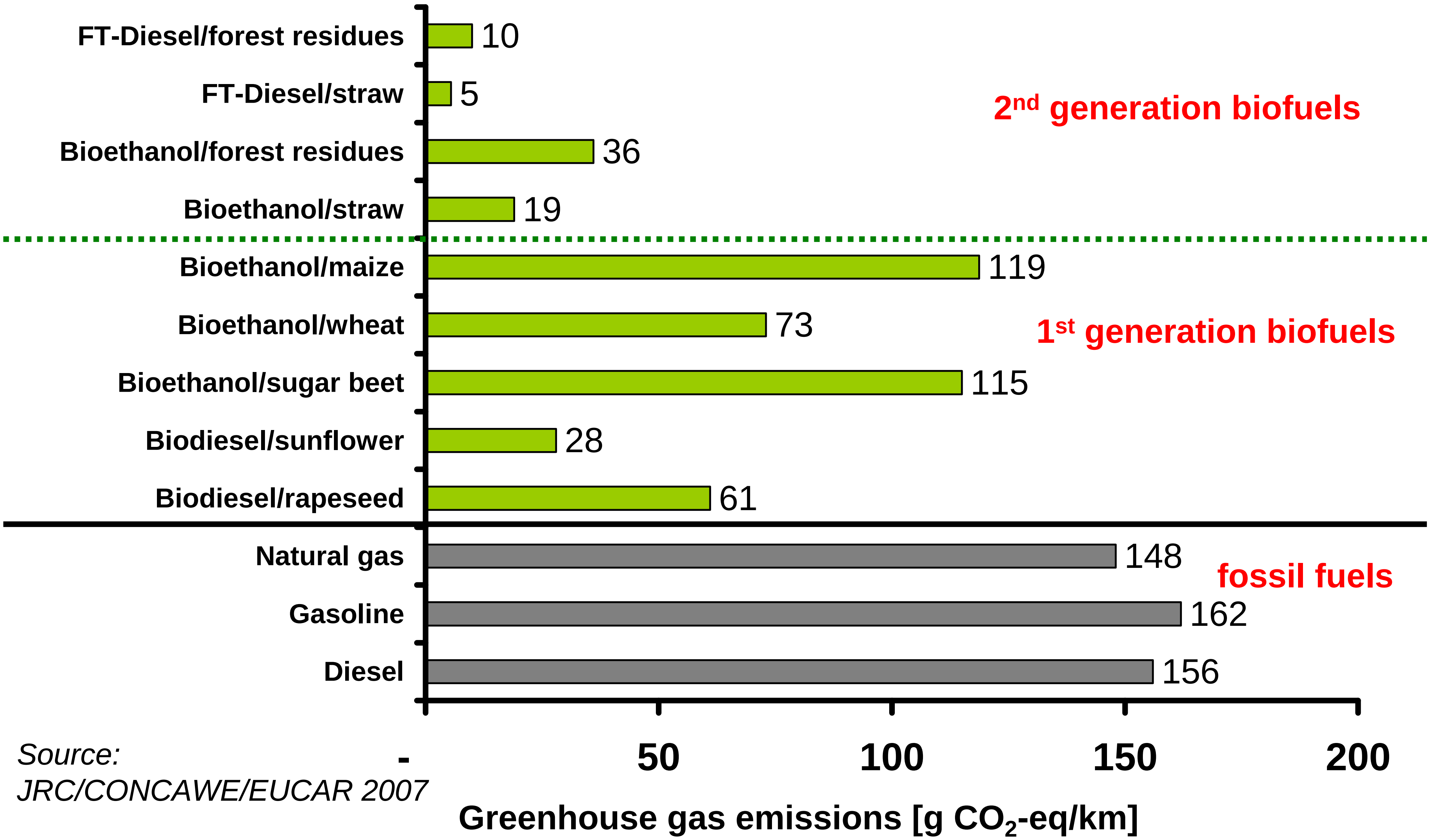


Common methodology available

Prozess-Schritte der Treib-stoffe zur Umweltbewertung

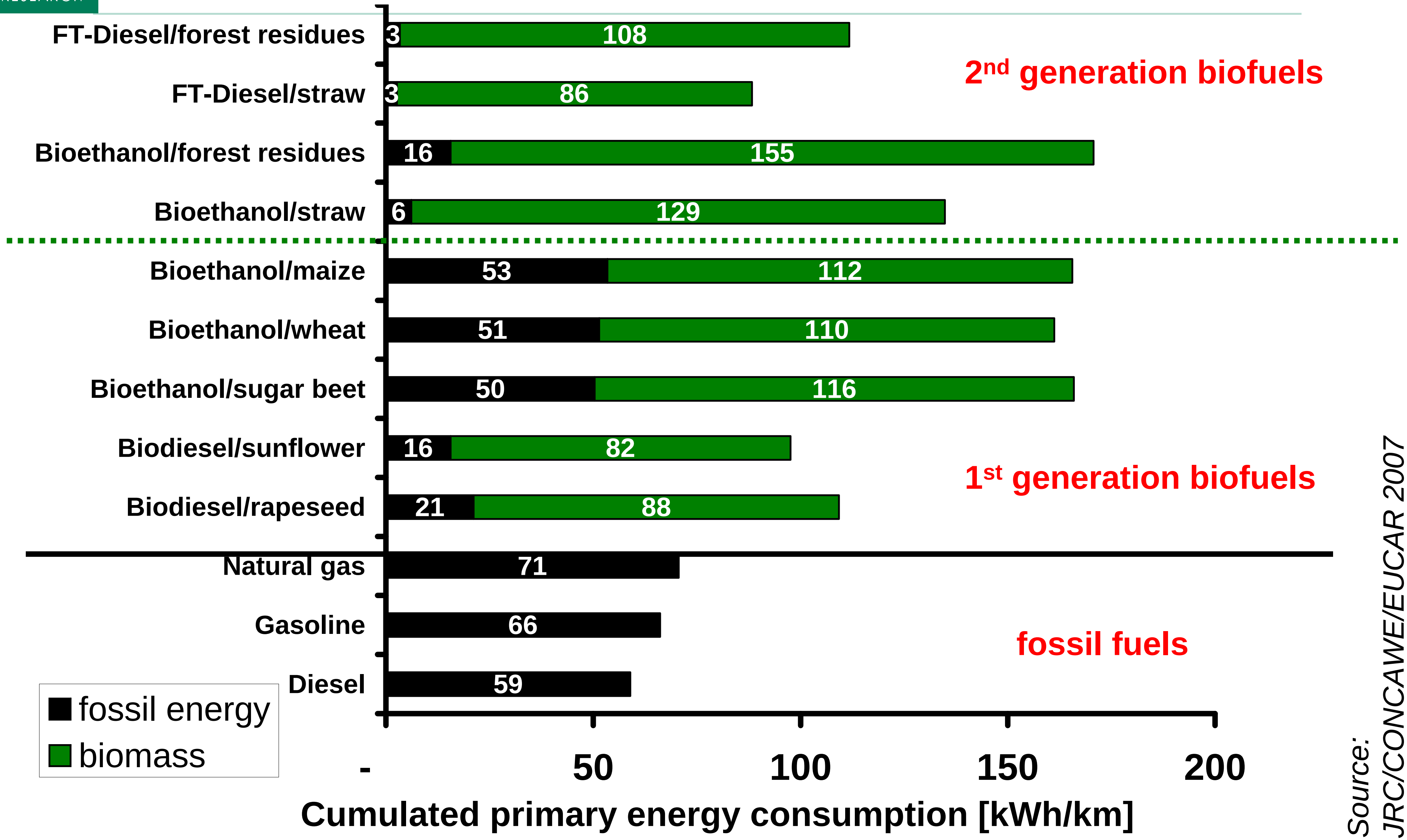


Greenhouse Gas Emissions Technology 2010 - 2020



Source: JRC/CONCAWE/EUCAR 2007

Primary Energy Consumption Technology 2010 - 2020



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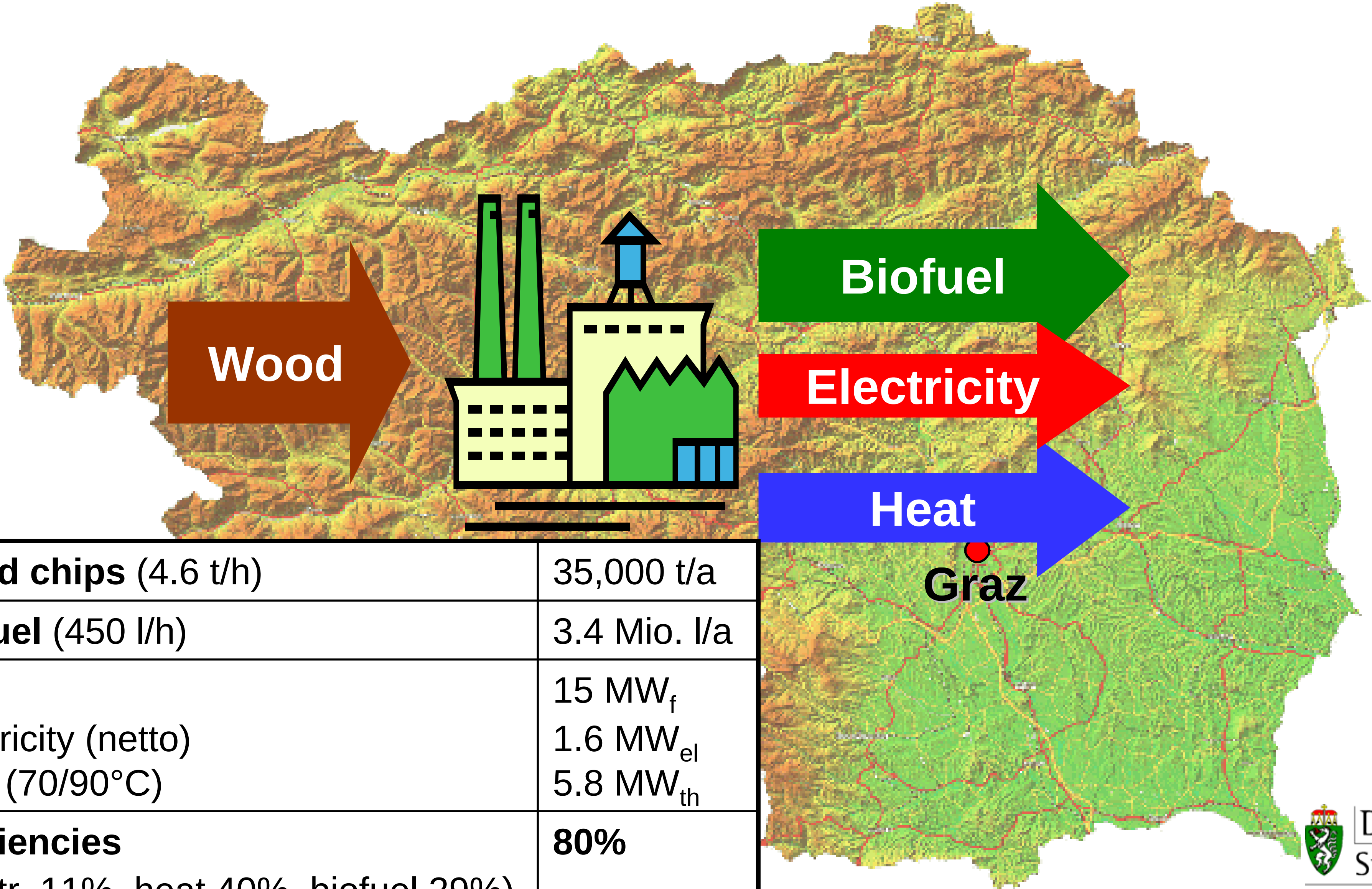
Polygeneration of Wood FT-Diesel Demonstration-Plant

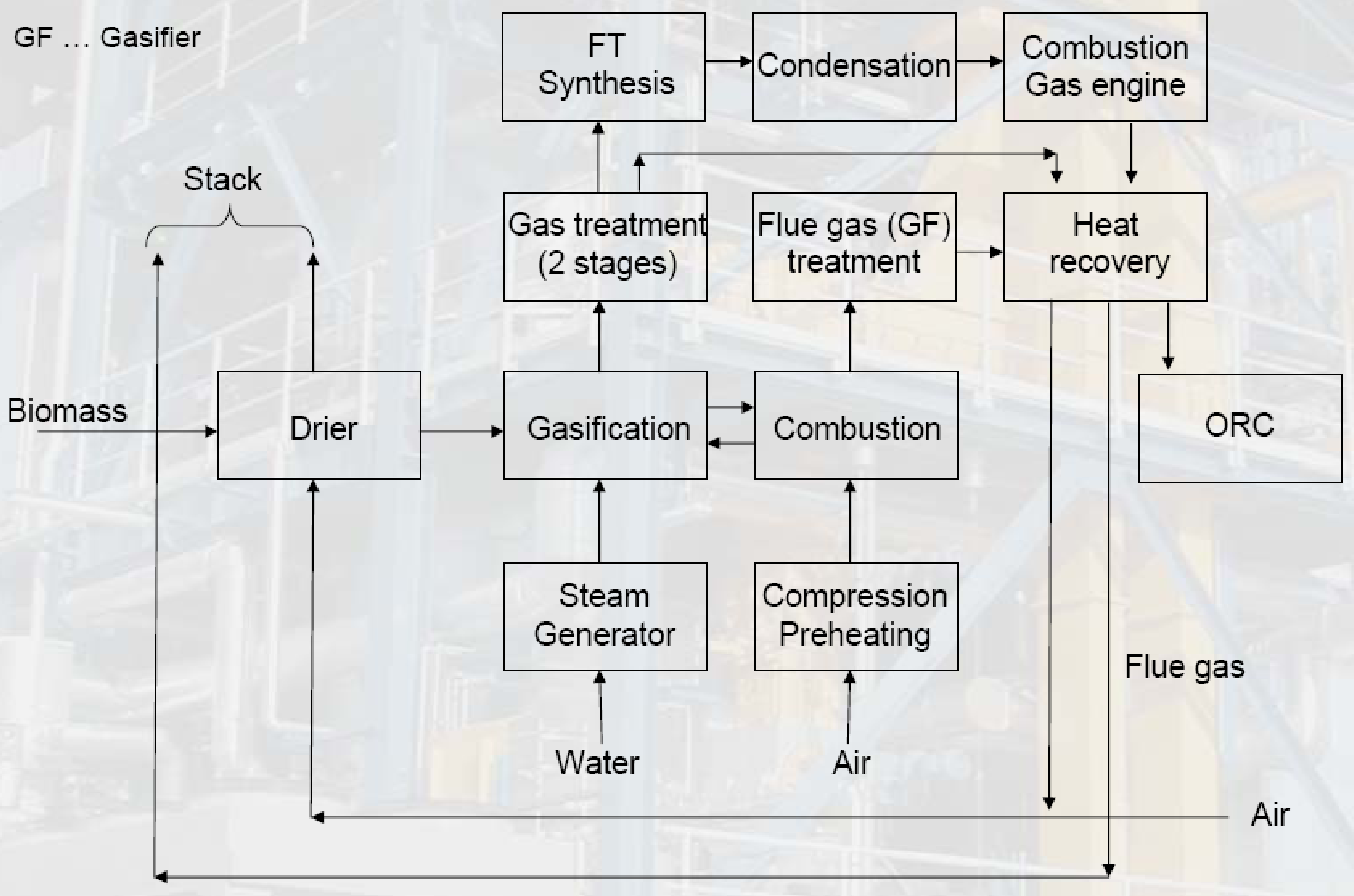
TU WIEN
Institute of Chemical Engineering



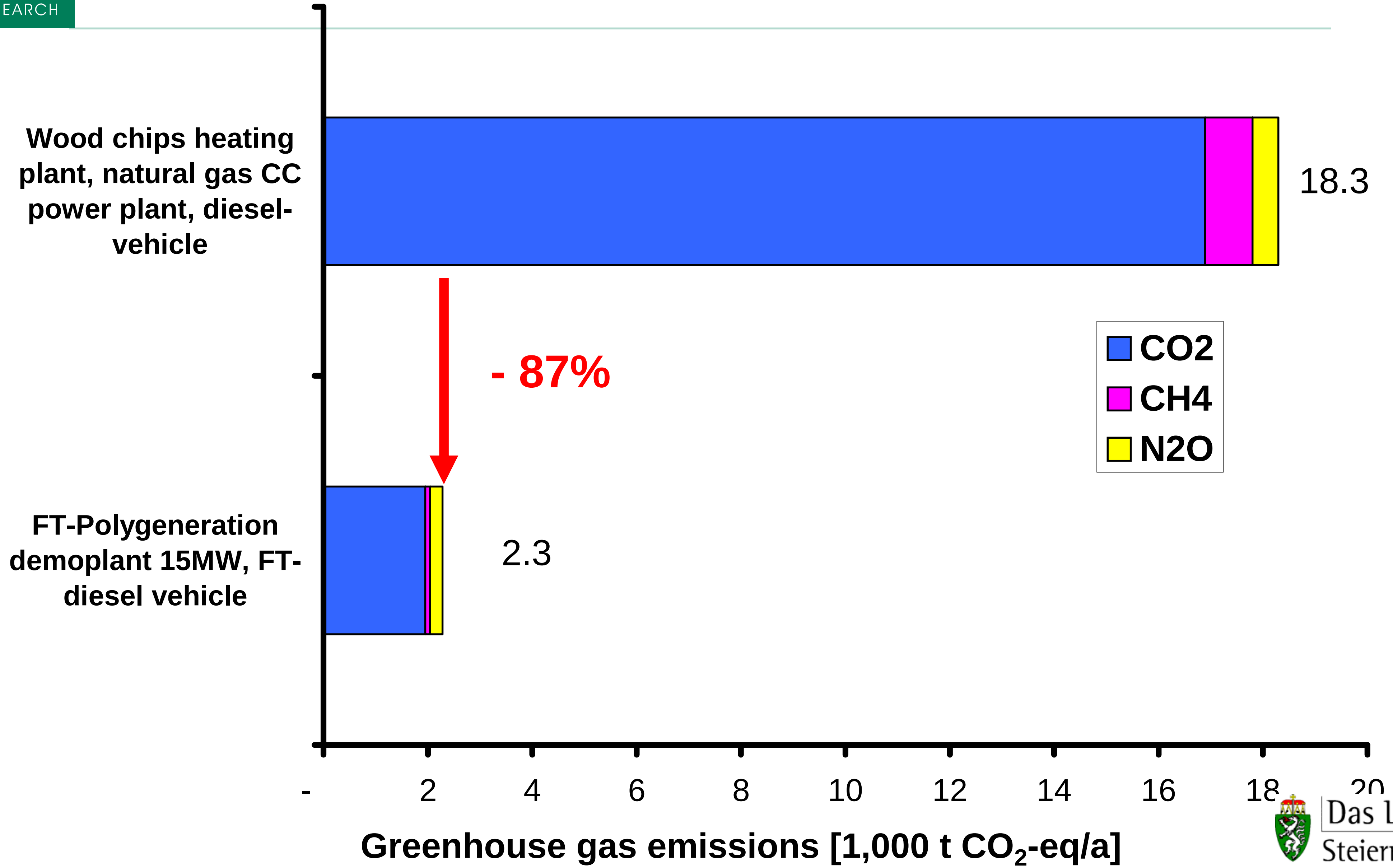
Wood chips (4.6 t/h)	35,000 t/a
Biofuel (450 l/h)	3.4 Mio. l/a
Fuel Electricity (netto) Heat (70/90°C)	15 MW_f 1.6 MW_{el} 5.8 MW_{th}
Efficiencies (electr. 11%, heat 40%, biofuel 29%)	**80%**

Das Land Steiermark
→ Wissenschaft und Forschung

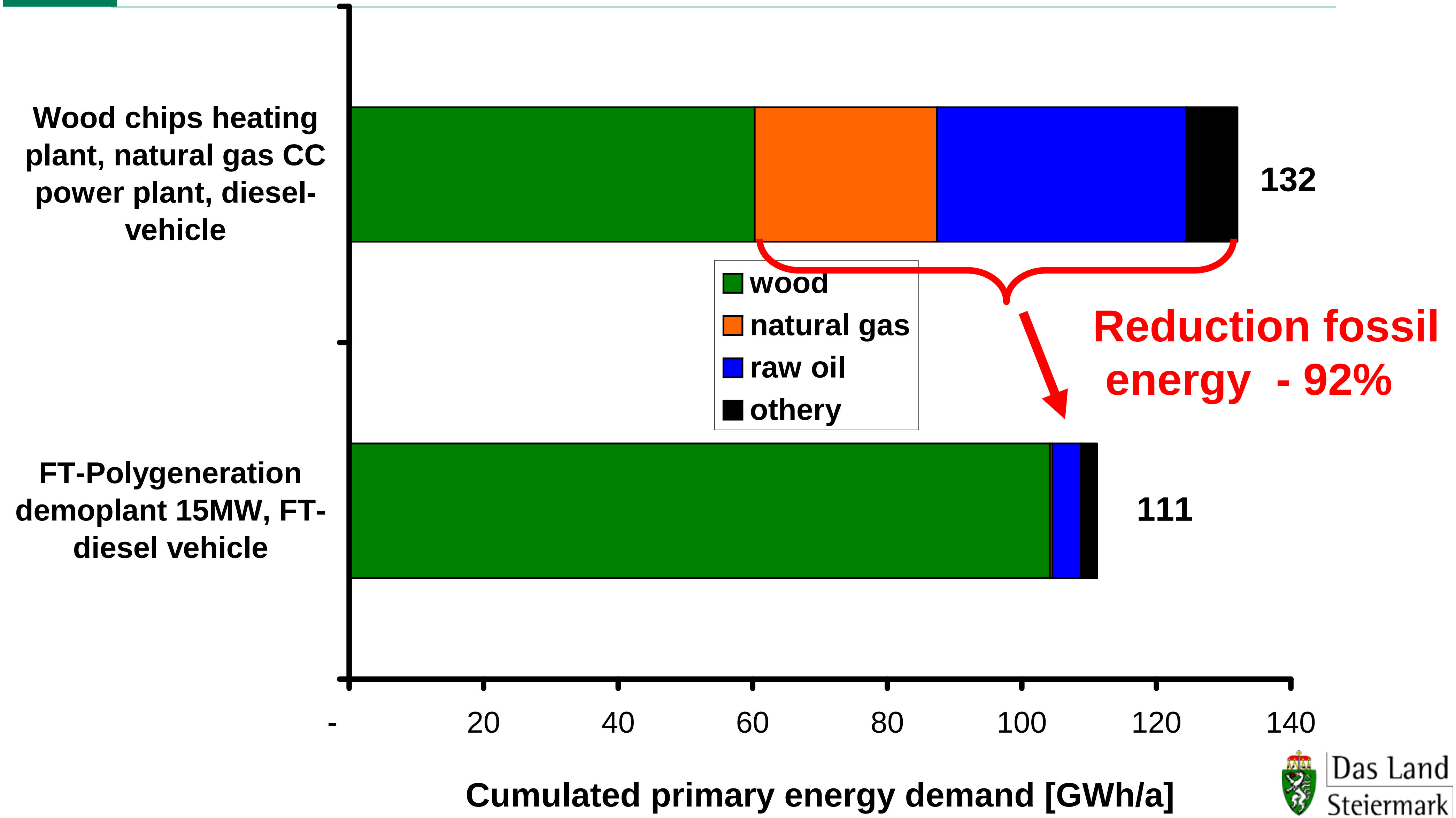
Scheme Polygeneration of FT-Biofuel&Electricity&Heat



Greenhouse Gas Emissions



Cumulated Primary Energy Demand



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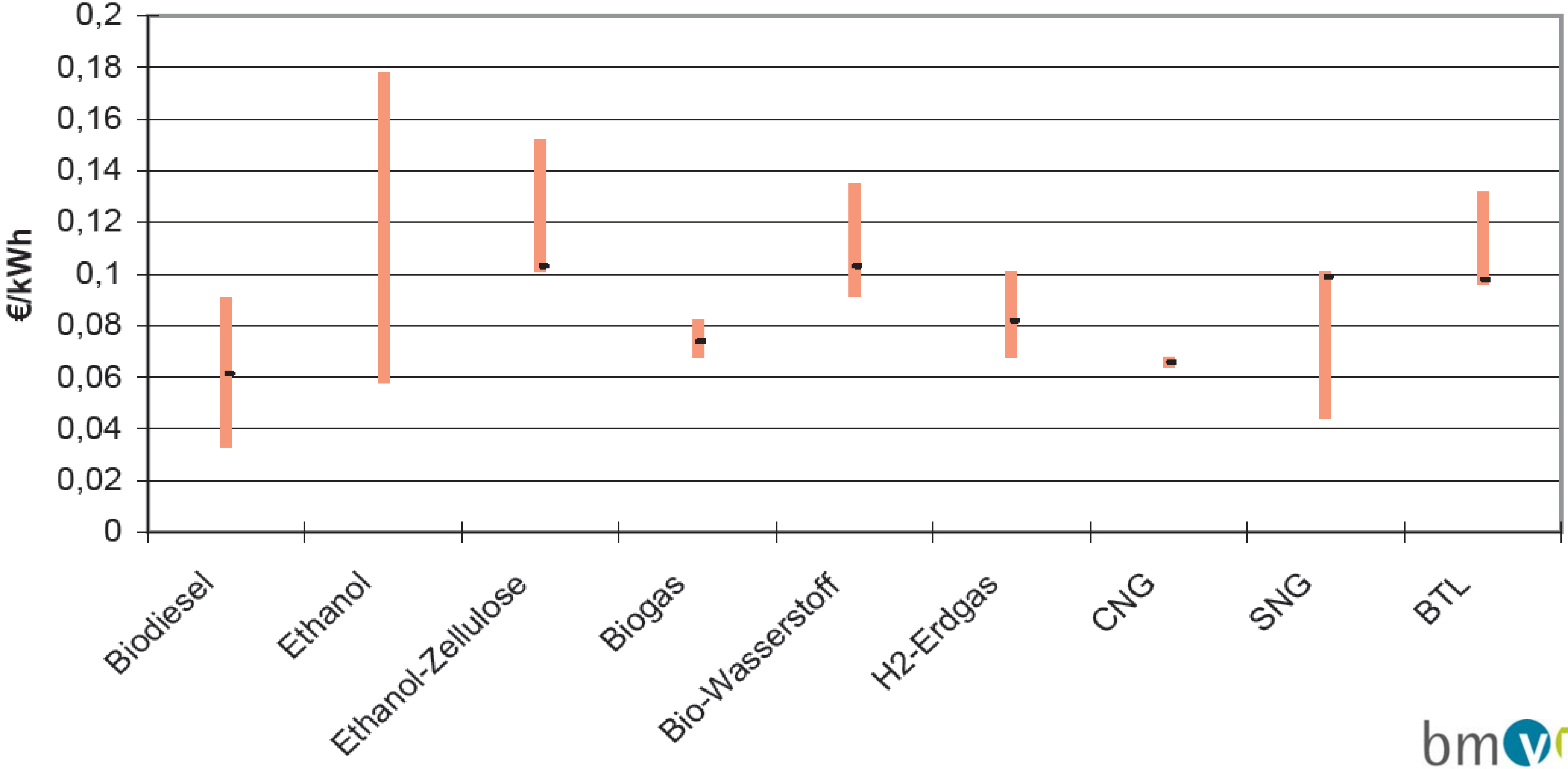
Indicators for „Sustainable Biomass“

Current discussion (stimulated by EU, UK, NL and G)

1. Environment:
   - Greenhouse gas balance (> 35%)
   - Land use change
     - Change of carbon storage pools
     - Loss of biodiversity
     - Competition
       - agriculture for food and feed
       - forestry: construction materials, wooden products, local energy use
     - Others: soil erosion, water resource, plant protection agents, GMOs...
2. Economic prosperity: e.g. labour creation, land owner ship
3. Social welfare: e.g. working conditions, healthiness

result → **Certification of biomasse raw materials and biofuels**

Production Costs of Biofuels



Source: ALTANKRA, TU-Vienna, 2008

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Assessment of Relevance of the different Biofuels I

Biofuel	State of tech-nology	Using existing Infrastructur of fossil fuels	Range of raw materials	Green-house gas reduction	Know-how in Austria
(Pure)Vegetable oil	++	-	-	+	++
Biodiesel via					
Esterification	++	++	-	+	++
Hydration	+	++	-		-
Bioethanol from					
Sugar and starch	++	++	+	-	++
Lignocellulose	-	++	++	++	+
Biobutanol from					
Sugar and starch	+	++	+	-	+
Lignozellulose	--	++	++	+	-

++.....very promissing, +.....promissing

-- .....very unfavourable, - .....unfavourable

Assessment of Relevance of the different Biofuels II

Biofuel	State of tech-nology	Using existing Infrastructur of fossil fuels	Range of raw materials	Green-house gas reduction	Know-how in Austria
Biogas (upgraded)	+	+	++	++	++
Synthetic Biofuels					
FT-Biofuel	+	++	++	++	++
SNG	+	+	++	++	++
others (e.g. DME)	-	--	++	+	+
Biohydrogen	--	--	-	++	+
Pyrolyses oil	--	+	++	+	+
Directliquifaction					
HTU-Biofuel	-	+	+	+	--
CLC-Biofuel	--	+	+	+	+

++.....very promissing, +.....promissing

-- .....very unfavourable, - .....unfavourable

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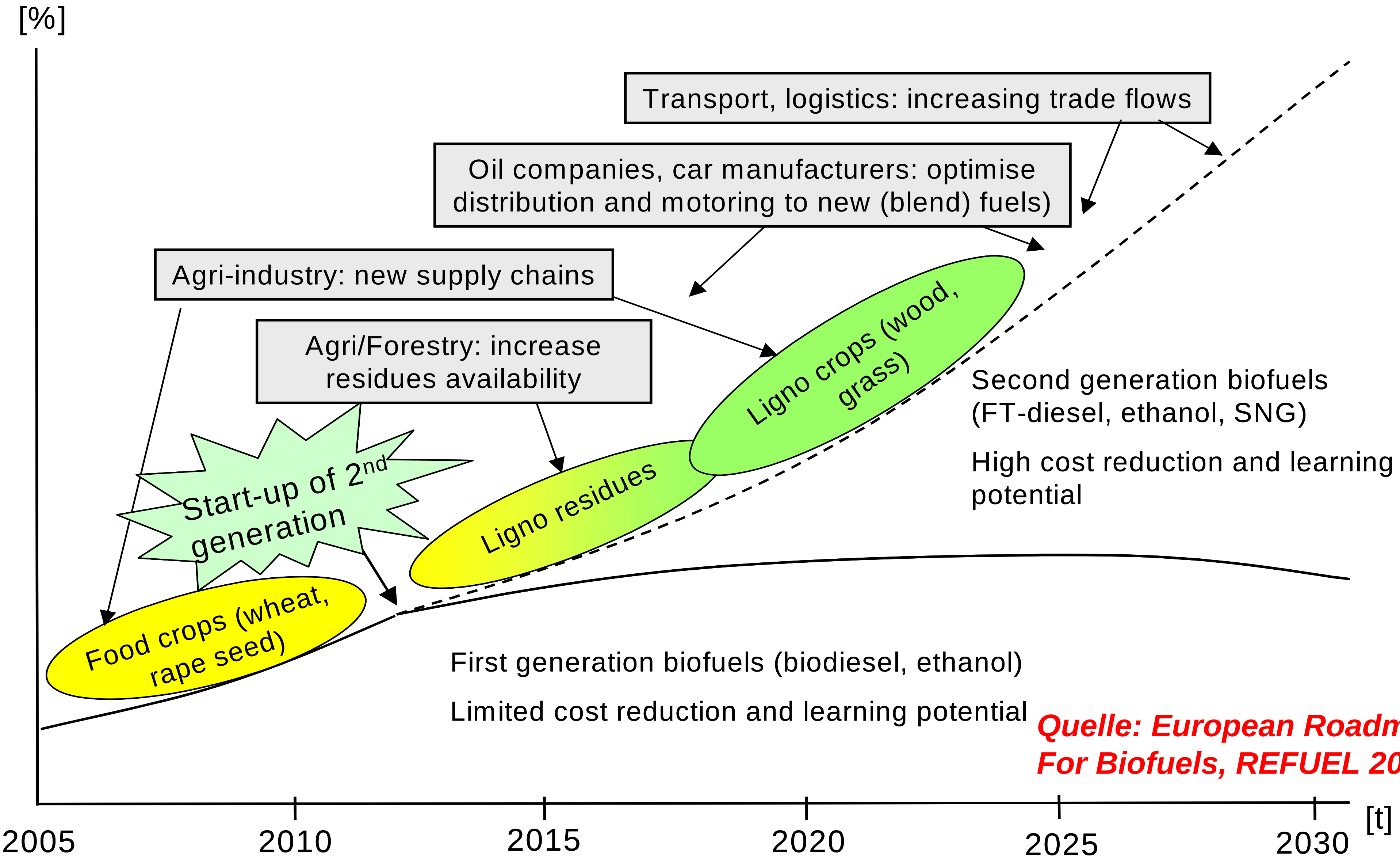
Targets for Substitution of Diesel and Gasoline

Transportation Fuels of Tomorrow	2005	2007	2008	2010	2015	2020	2030
Biofuels	**2.5** [1)] [2% [2)]]	**4.3%** [1)]	**5.75%** [1)]	[5.75%[2)]]	**7%** [3)]	**10 %** [5)]	**25%** [4)]
Natural gas	-	-	-	2% [3)]	5% [3)]	10% [3)]	> 10%
Hydrogen	-	-	-	-	2% [3)]	5% [3)]	> 5%
Total	2.5%	4.3%	5.75%	7.75%	14%	25%	> 40%

1) Österreichische Biokraftstoff-Verordnung, 4. November 2004
2) EU Biofuel Directive, 2003/30/EG
3) EU Greenbook on Energy supply security, KOM (2000)769
4) Biofuels in the European Union – A vision for 2030 and beyond
5) Directive on the promotion of the use of energy from renewable sources, EC 2008

Key Question: When will 2nd Generation Biofuels be on the Market?



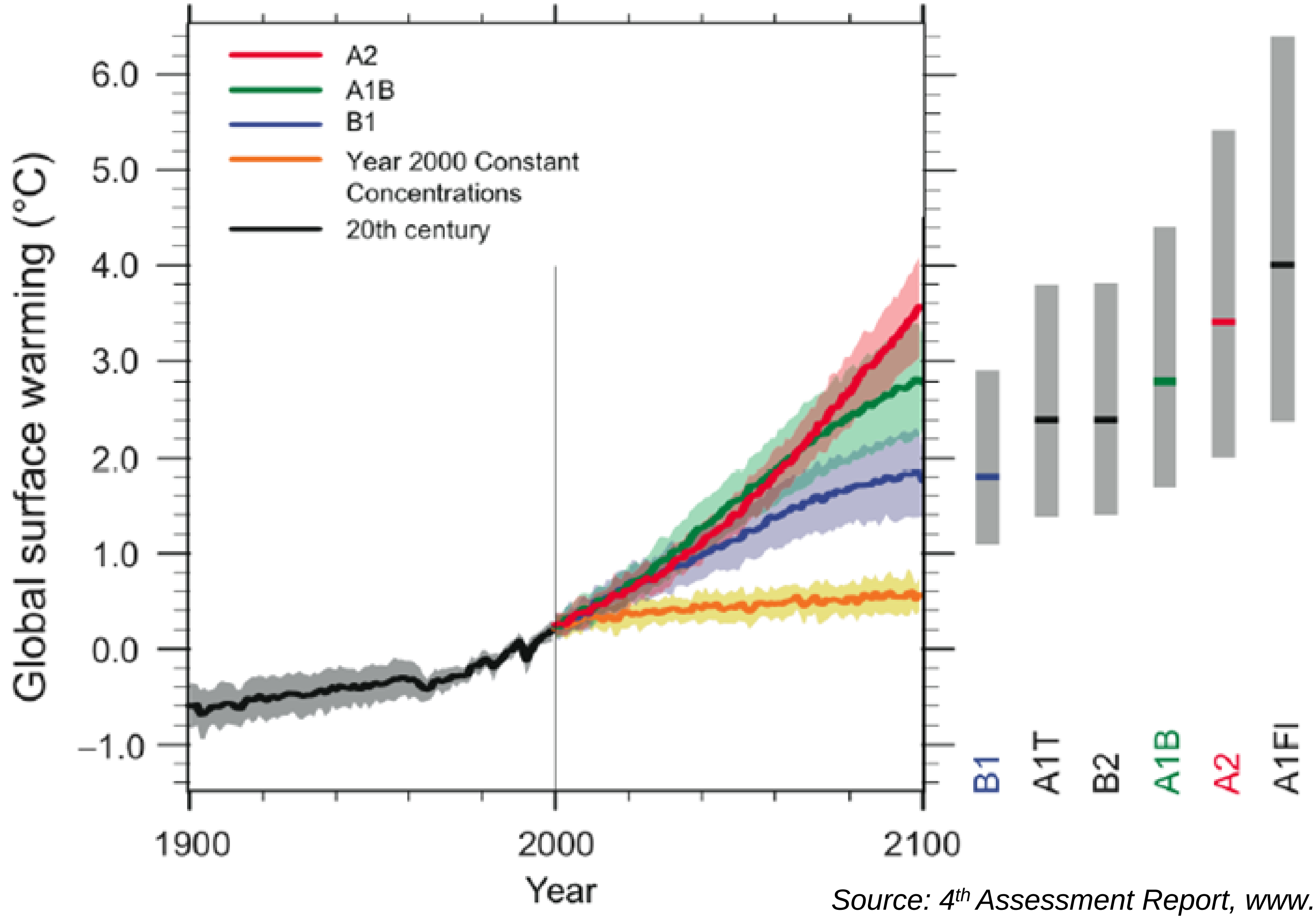
Quelle: European Roadmap For Biofuels, REFUEL 2007

Summary

- 1. Generation: Biodiesel and Bioethanol (f… …r and starch) until 2010 essential
- Biogas and vegetable oil (niche
- 2. Generation: Main focus … …netic biofuels (FT-Diesel) and ligno… …nanol (SNG depend on development … …ucture in transportatio… …2010+
- Long term: h… …r ever

Consideration of biorefinery aspects in all developments

Outlook



Source: 4th Assessment Report, www.ipcc.ch