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GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE

Sustainable Bioenergy in the Triangle of Climate Change, Energy Systems and Land Use

Main Results of a Global Bioenergy Analysis

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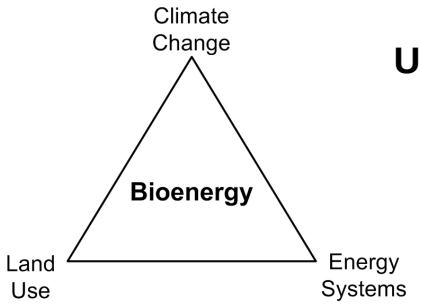
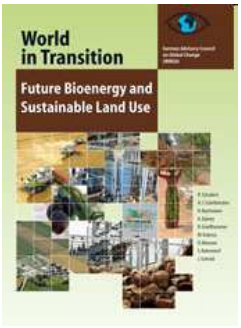


International Energy Workshop
Venice, 17.06.2009



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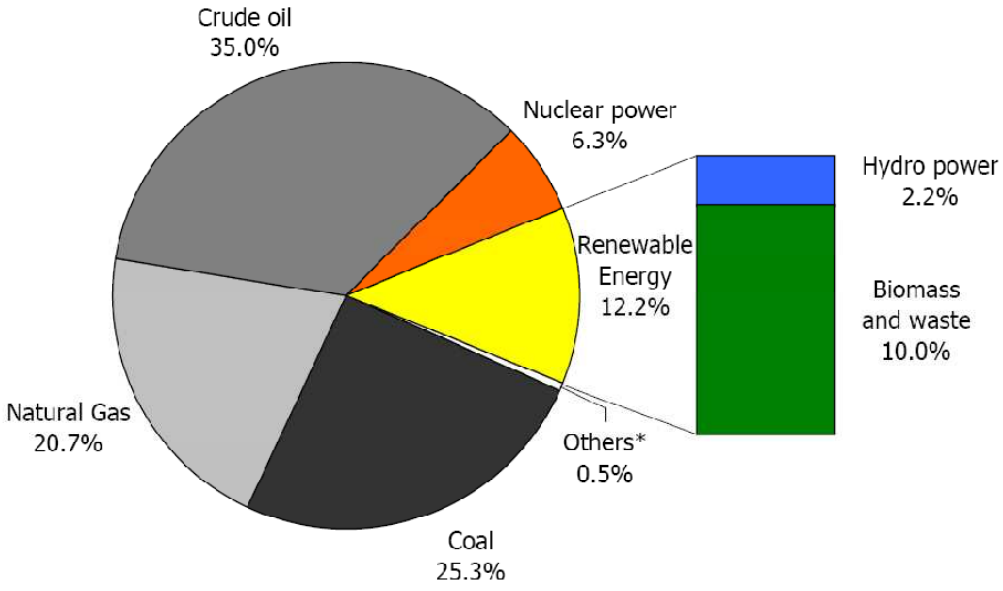
Bioenergy – Status Quo – Global Primary Energy Supply



Efficiency-Method (thermodynamically incorrect) - Source: IEA, 2008, * other renewables

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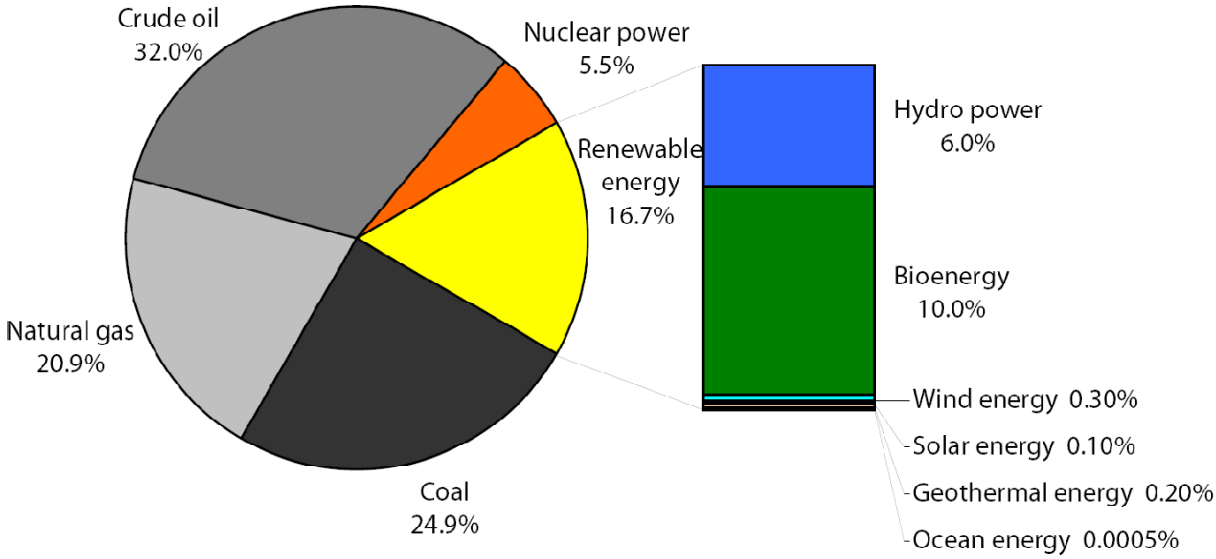
Bioenergy – Status Quo – Global Primary Energy Supply



Substitution-Method (thermodynamically correct) Source: BP, 2008; REN21, 2008; GWEC, 2008

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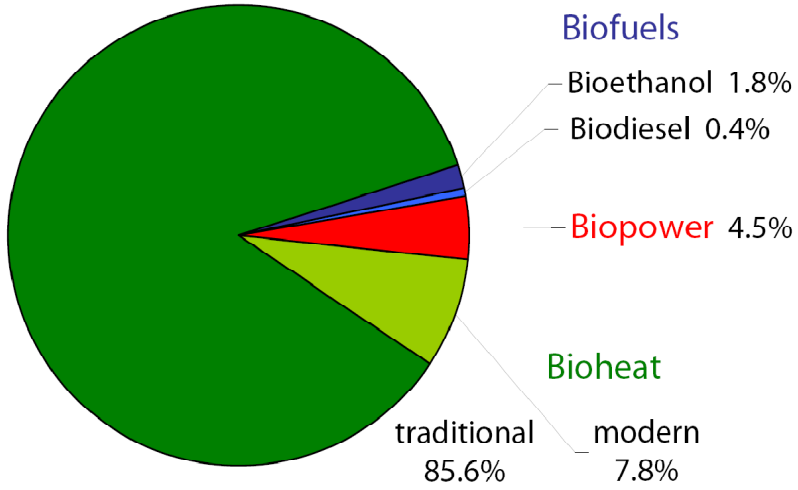
Global uses of bioenergy – shares and categories



- Energy crops
- Residues and waste
- Traditional biomass

Source: BP, 2008; REN21, 2008; GWEC, 2008

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Global potential of bioenergy

Calculation of energy crop potential - excluding

- Areas for biodiversity conservation (beyond existing protected areas)
- Existing cropland or potential new cropland
- Areas whose conversion must be expected to cause GHG emissions that can not be compensated within 10 years

Energy crops: 30 – 120 EJ

Residues and waste: ca. 50 EJ

Traditional biomass: ca. 40 EJ

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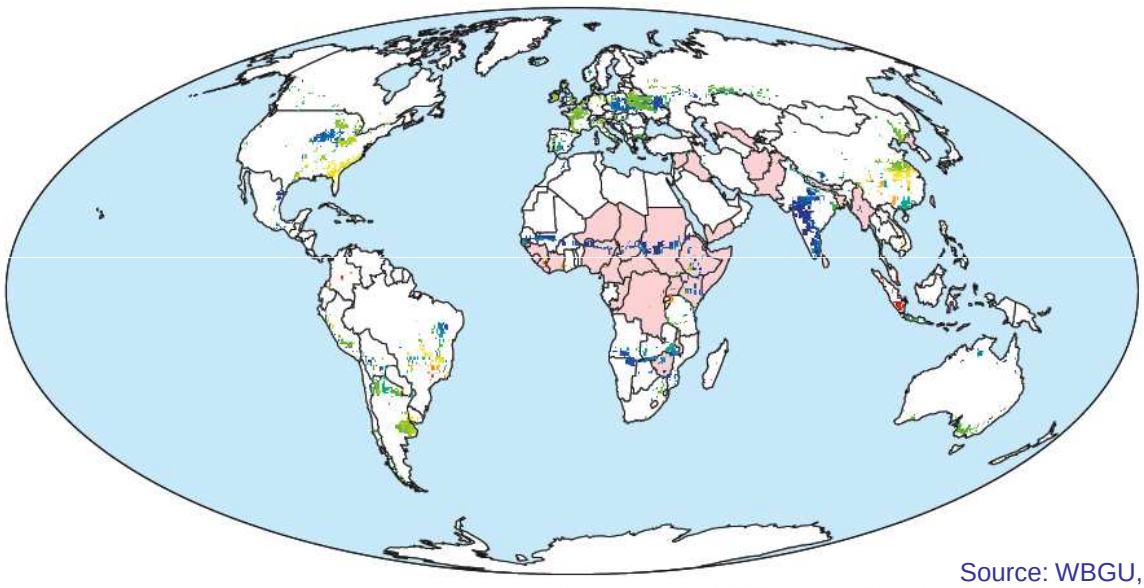
Potential regions for bioenergy (fragile states)



Source: WBGU, 2008

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Risks of energy crop production

- Food security
  - Competition with other land uses, price effects, more land for food required, area-intensive nutrition patterns
- Biodiversity
  - Monocultures, deforestation
- Soil and water
  - Degradation, exploitation, soil carbon, water use competition
- Climate
  - GHG emissions due to land-use changes, land use competition (afforestation, black carbon)

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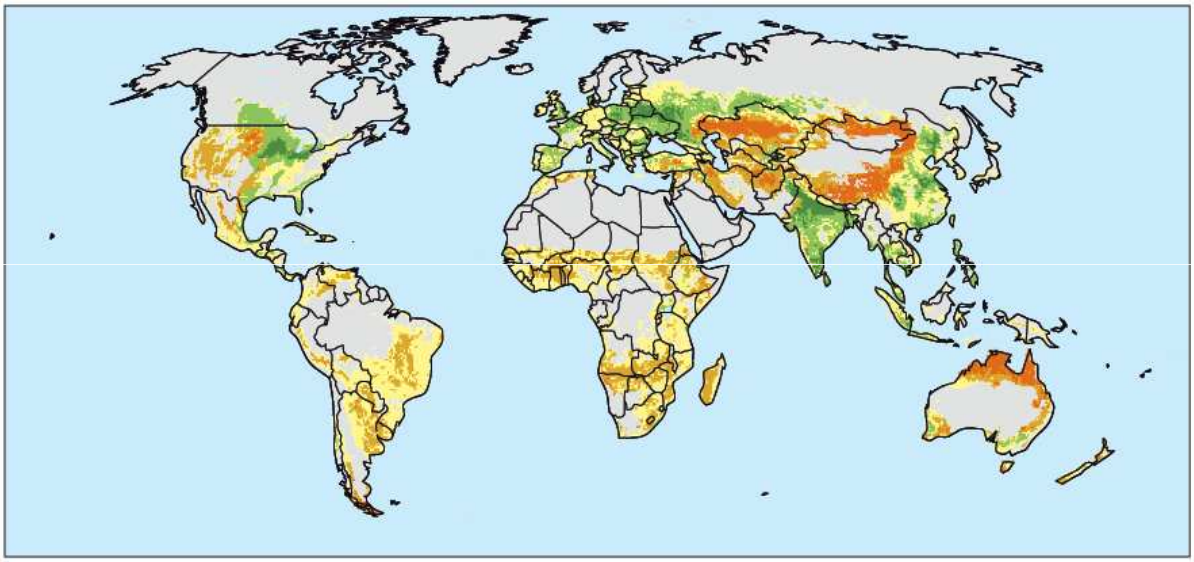
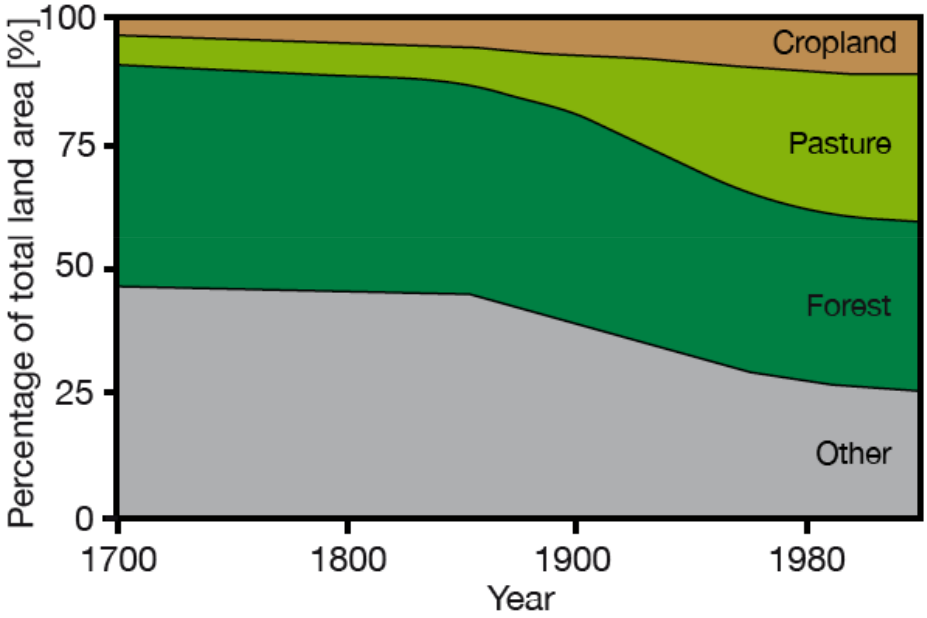
Extent of cropland and grazing land



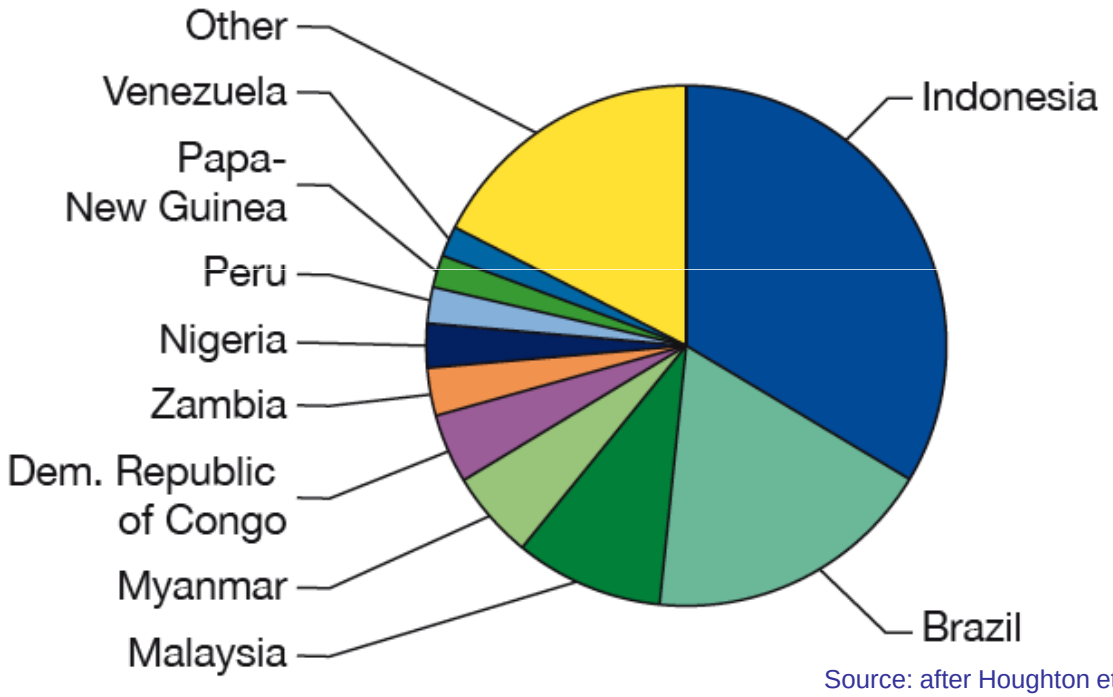
Source: UNEP, 2007

Changes in land use 1700-1995



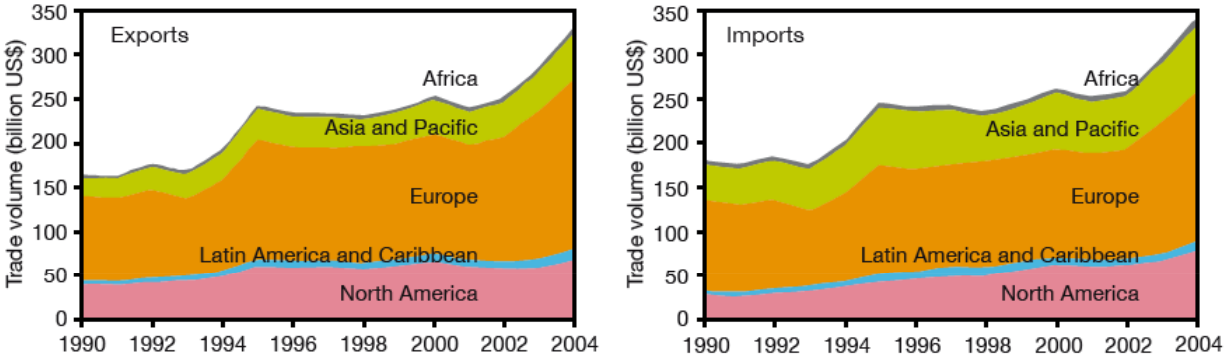
Source: Klein, Goldewijk and Battjes, 1997

Emissions from deforestation



Source: after Houghton et al., 2003

Trade in forest products



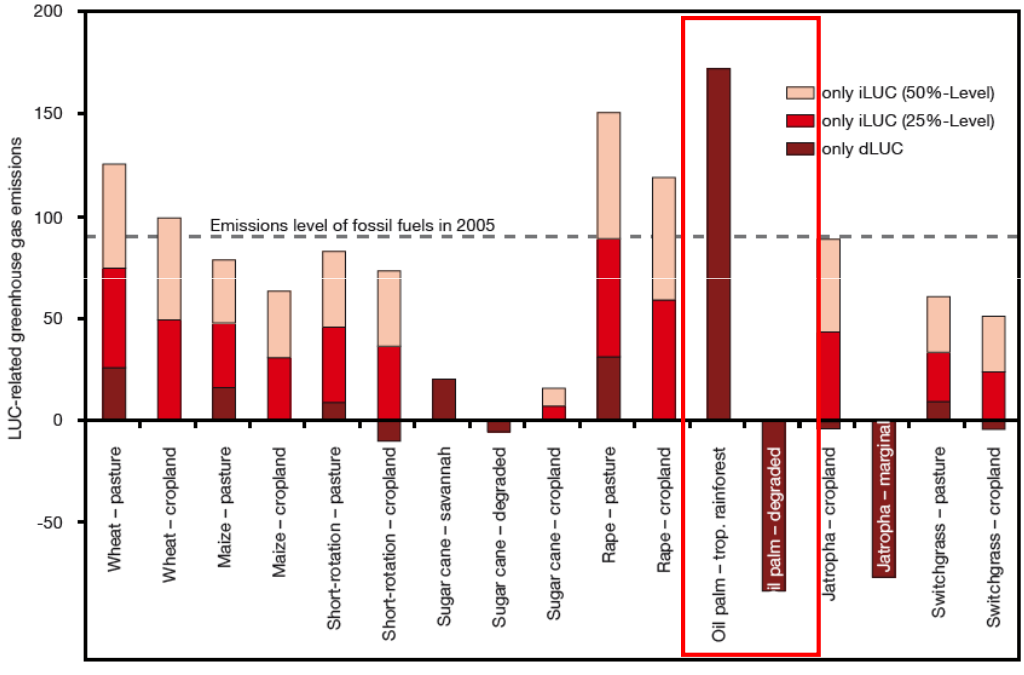
Although there is potential, **biomass is a limited resource**

→ **strategic use,** oriented at

Climate mitigation / GHG reduction potential
Technical supply security
Overcoming energy poverty

Source: FAO, 2007

GHG emissions purely from direct/indirect land-use change



Source: Fritsche and Wiegmann, 2008

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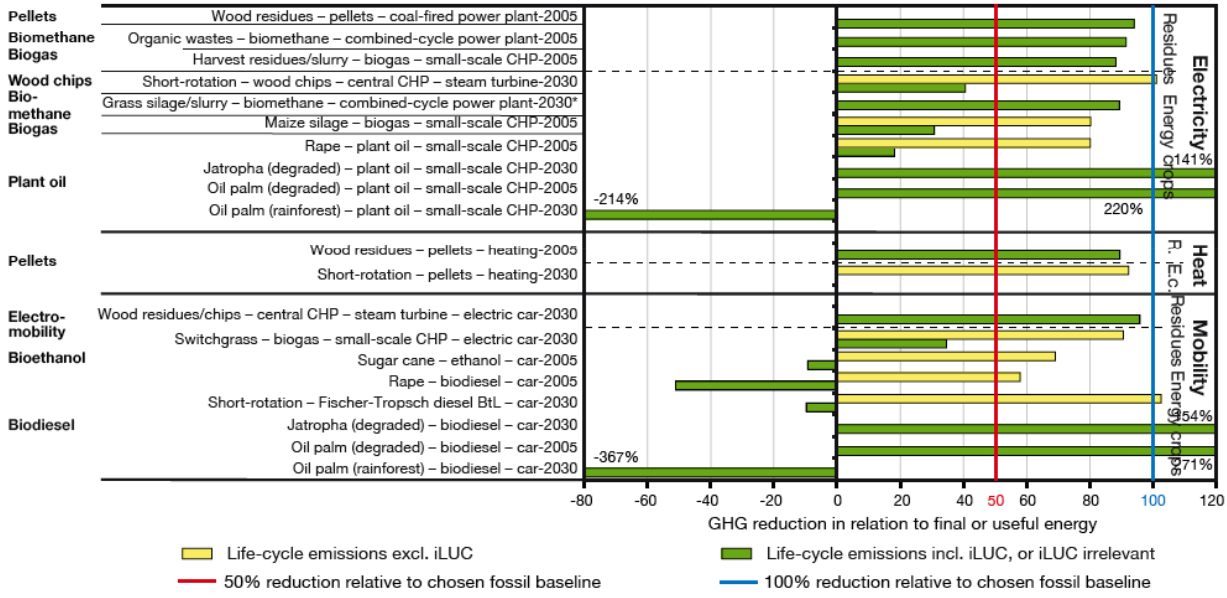
Reduction of GHG emissions in relation to final or useful energy, in % compared to fossil baseline



Presently under discussion in legislative process, but not purposeful as standard, as it is not apparent how much biomass was deployed.

Source: WBGU, 2008

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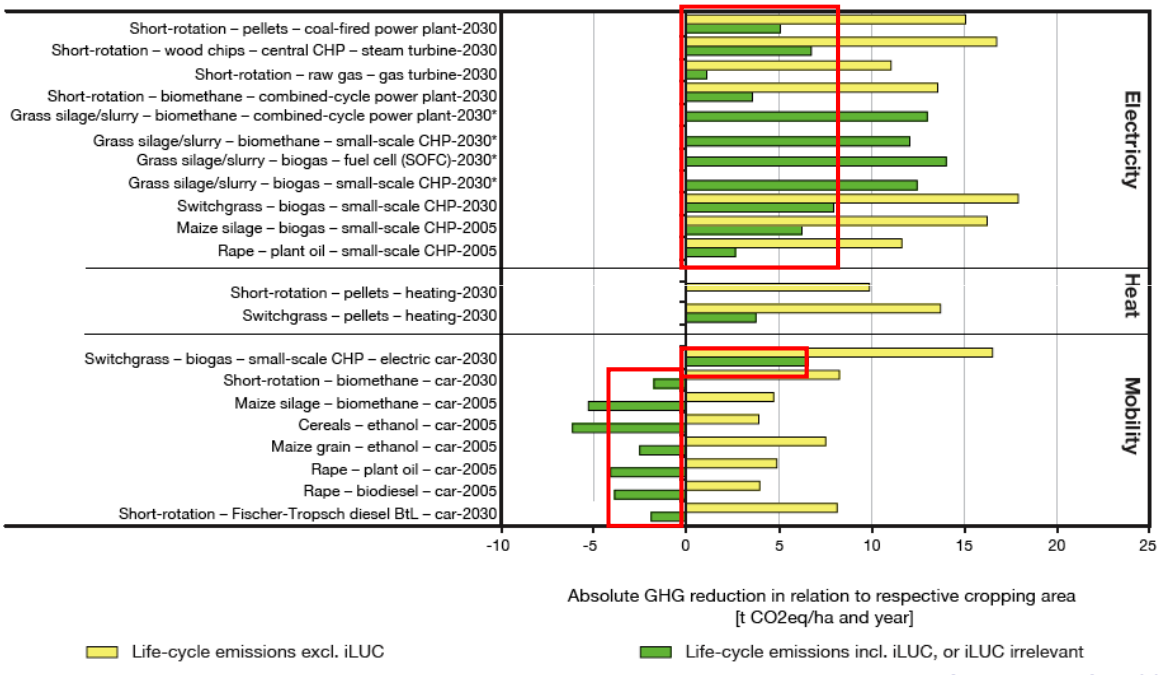
Absolute abatement of GHG emissions for temperate energy crops, in relation to cropping area in t CO_2-eq. per hectare and year



Source: WBGU, 2008

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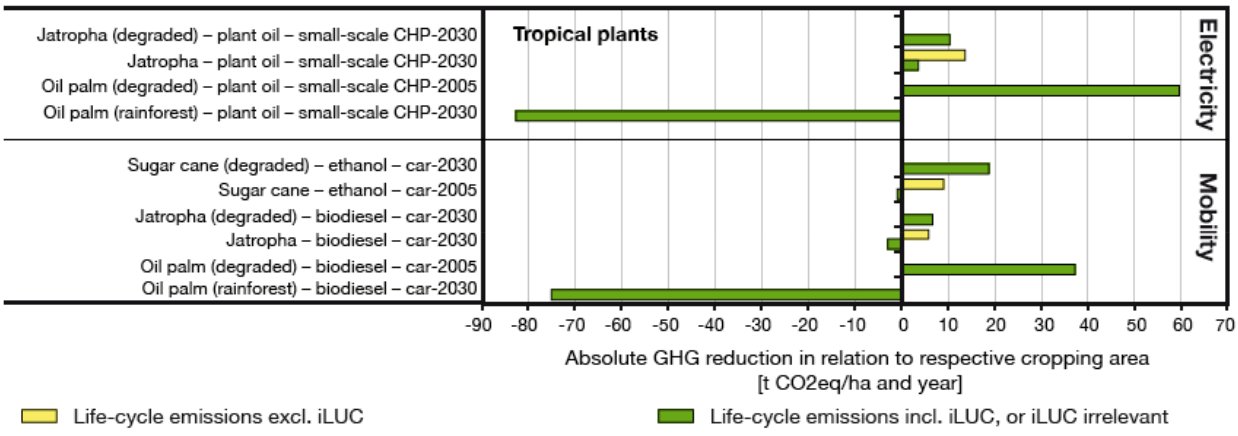
Absolute abatement of GHG emissions for tropical energy crops, in relation to cropping area in t CO_2-eq. per hectare and year



Weaknesses of this parameter:
- It cannot be applied to residues and waste
- The hectare yields and heating values of energy crops vary widely

Source: WBGU, 2008

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Why a new GHG criterion?

Greenhouse gas standards discussed in the past:

Reduction of GHG emissions per litre petrol or diesel (in %)

It is not asked how much biomass is needed in each case to produce the fuel.

Problem:

- limited quantity of sustainably producible biomass
- maximum climate change mitigation effect?
- area-related standard neither serves the purpose (varying hectare yields, missing residues)

WBGU proposal for standard:

→ level of GHG reduction with a given quantity of biomass.

Minimum standard: 30 t CO_2eq reduction per TJ biomass feedstock deployed.

The outcome: in electricity generation → much greater mitigation effect than in transport sector with the same quantity of biomass

Source: WBGU, 2008

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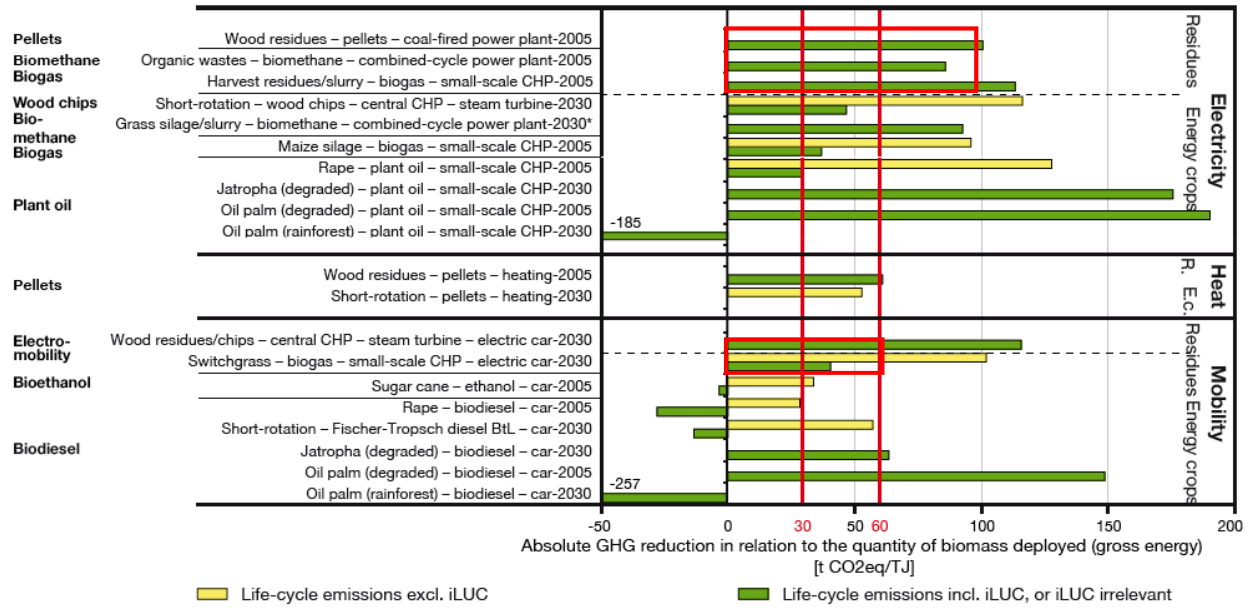
Absolute reduction of GHG emissions in relation to the energy content of biomass feedstock, in t CO_2-eq. per TJ raw biomass



Source: WBGU, 2008

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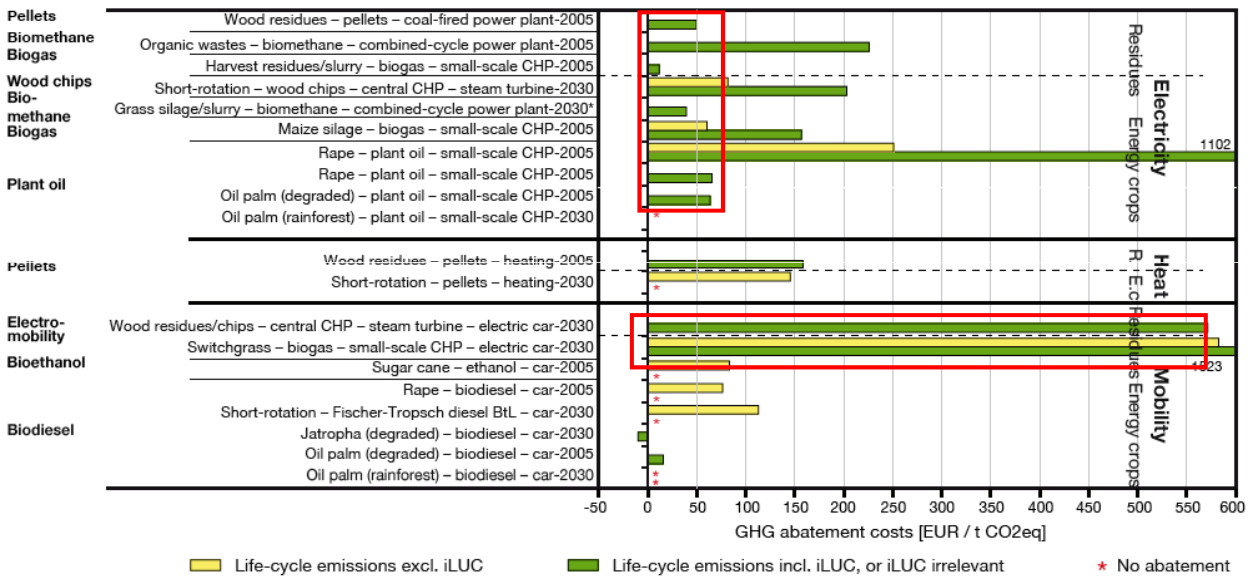
GHG mitigation costs in EUR per t CO_2-eq.



Source: WBGU, 2008

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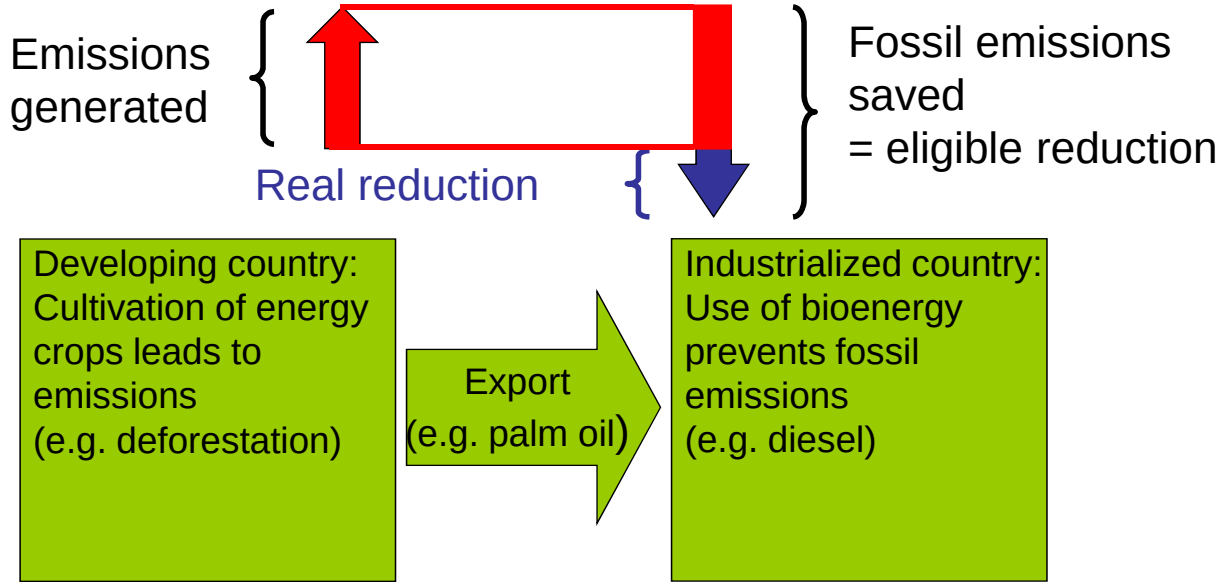
False incentives created by the Kyoto Protocol



Eligible reduction > real reduction

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Climate change mitigation potential

- Sustainable technical bioenergy potential: 80 - 170 EJ per year, economic: roughly half
- Using this full potential with the best pathways 60 t CO_2eq per TJ biomass feedstock
  → saving GHG emissions of 2-9 Gt CO_2eq per year
- *Compared:* Present global GHG emissions about 50 Gt CO_2eq, of which 32 Gt CO_2 are fossil energy and 6 Gt CO_2 from land-use changes.

-> WBGU promotion standard can only be met if no land-use changes are caused and biomass is deployed in the electricity sector (exception: use of degraded land).

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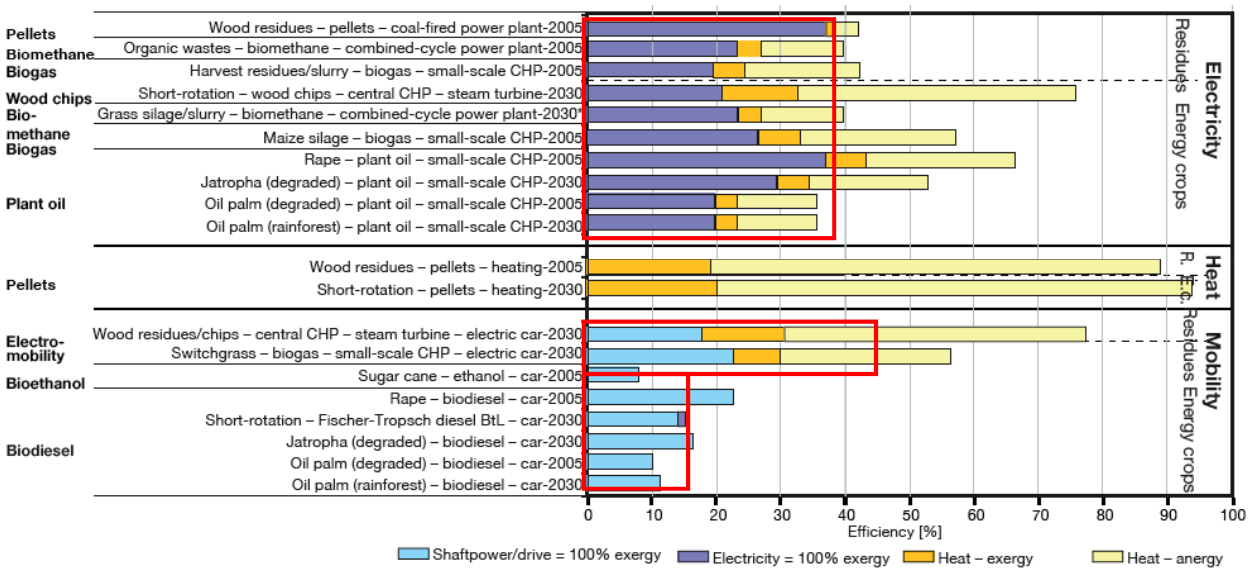
Efficiencies of bioenergy pathways in %



Source: WBGU, 2008

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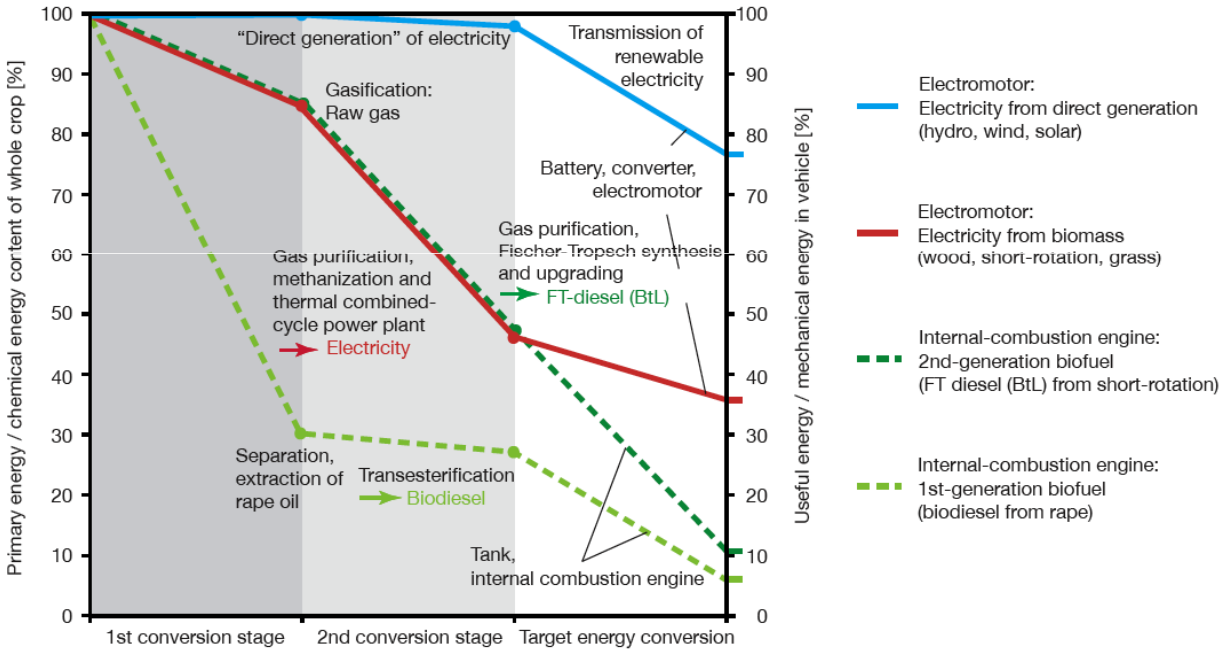
Bioenergy in the transport sector - Efficiencies



Source: WBGU, 2008

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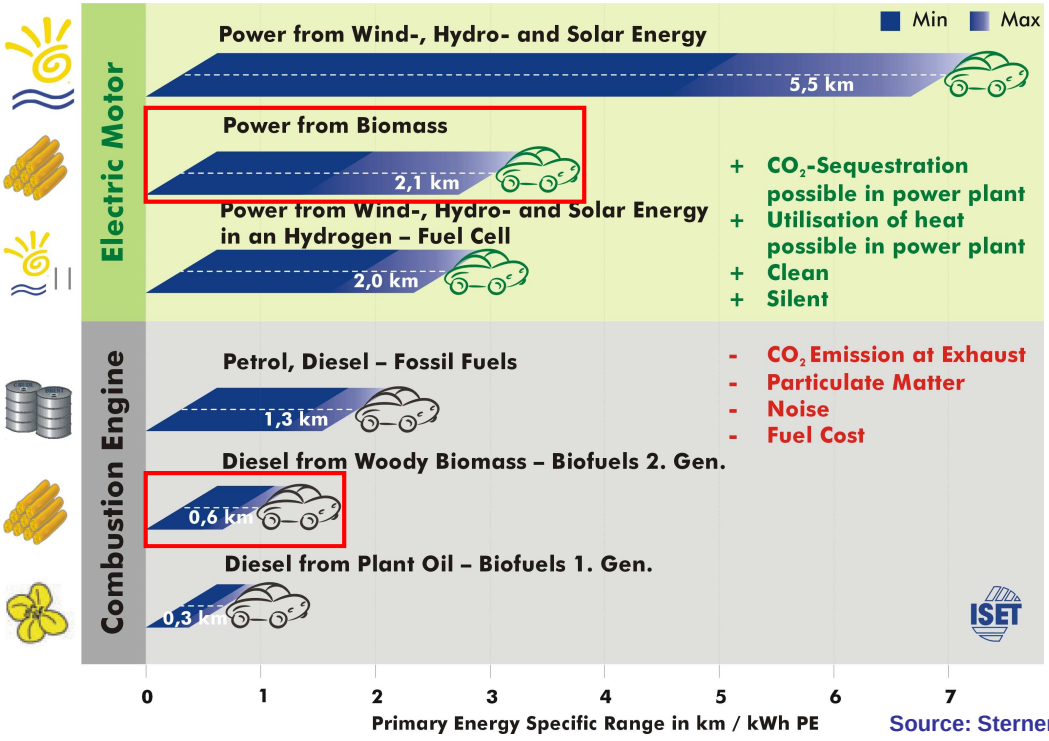
Electromobility – Range of a car



Source: Sterner, Schmid, 2008

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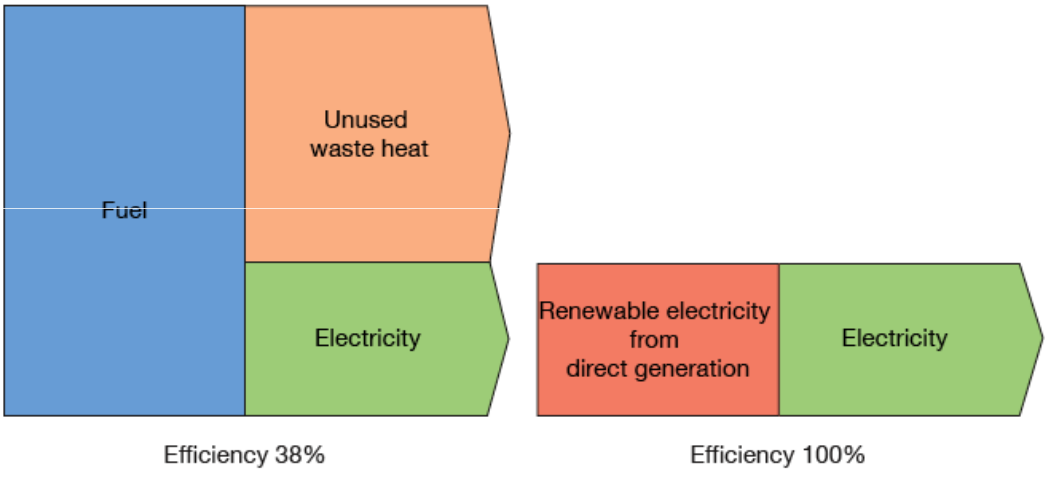
Energy efficiency – Transformation of Energy Systems

Increase of direct renewable generation



Source: WBGU, 2008
+ Sterner et al, 2008

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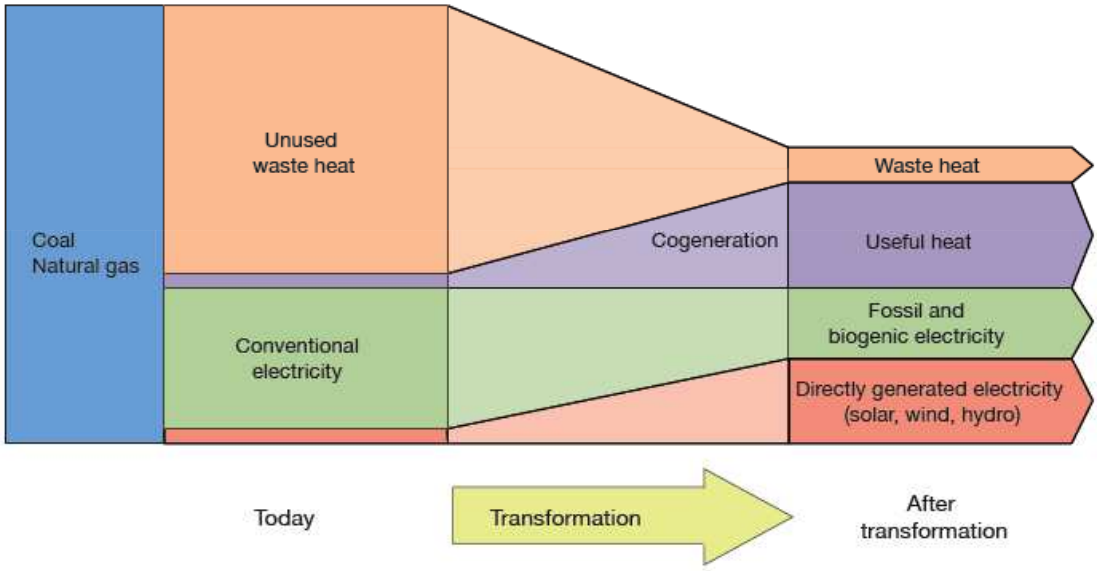
Energy efficiency – Transformation of Energy Systems

Renewables and CHP heat



Source: WBGU, 2008
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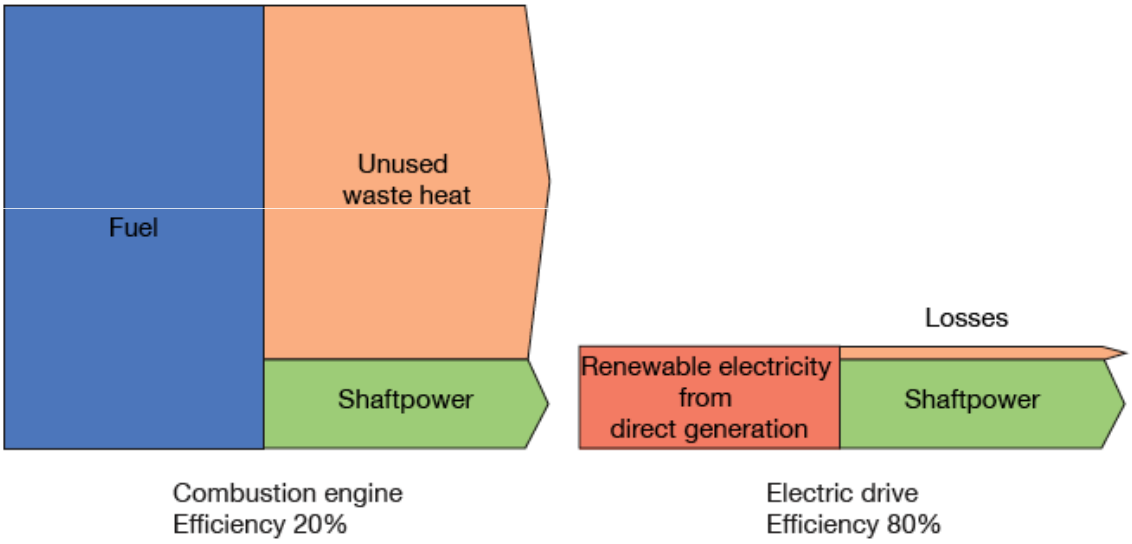
Energy efficiency – Transformation of Energy Systems

Increase of renewable electromobility



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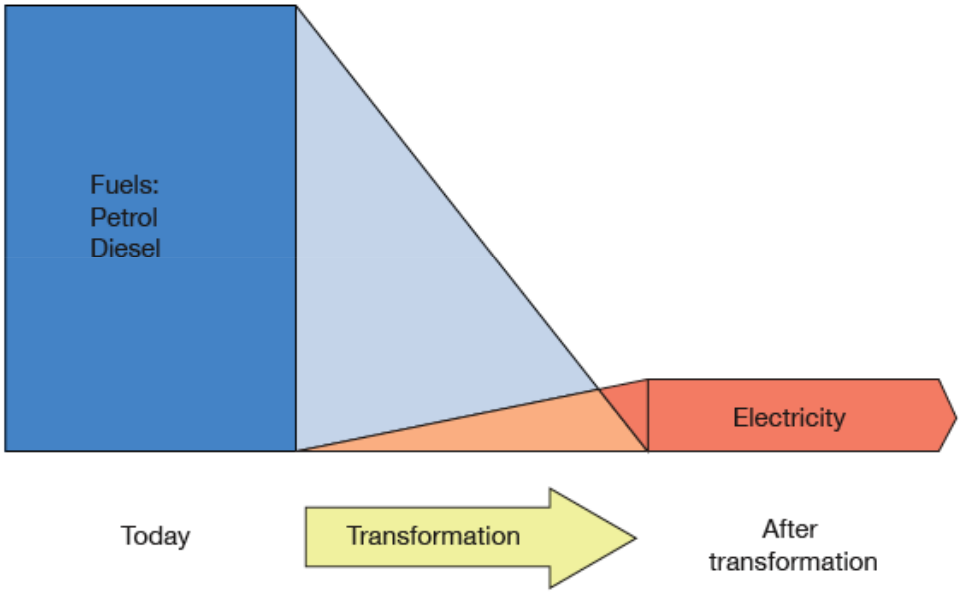
Energy efficiency – Transformation of Energy Systems

Renewable electromobility



Source: WBGU, 2008
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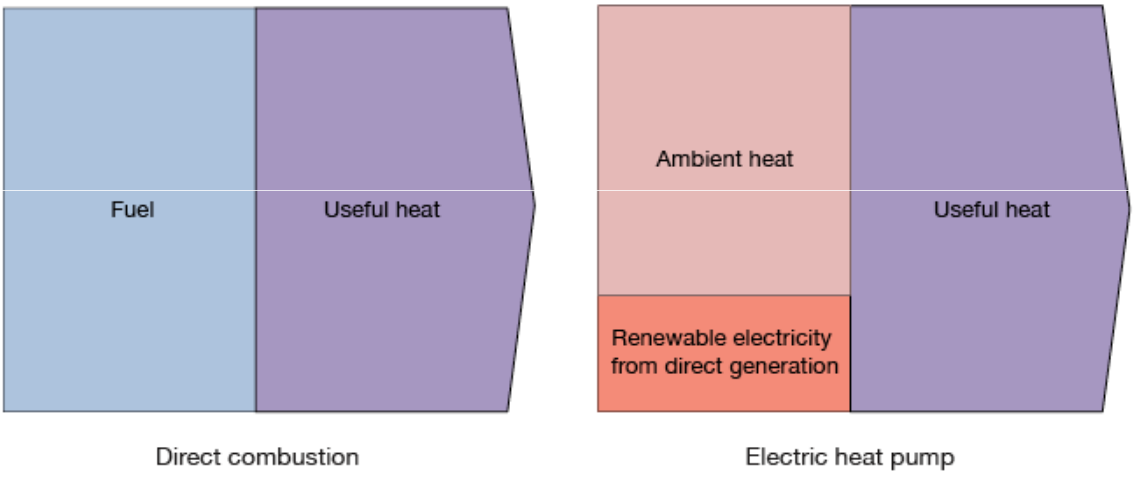
Energy efficiency – Transformation of Energy Systems

Geothermal energy: renewable heat pumps



Source: WBGU, 2008
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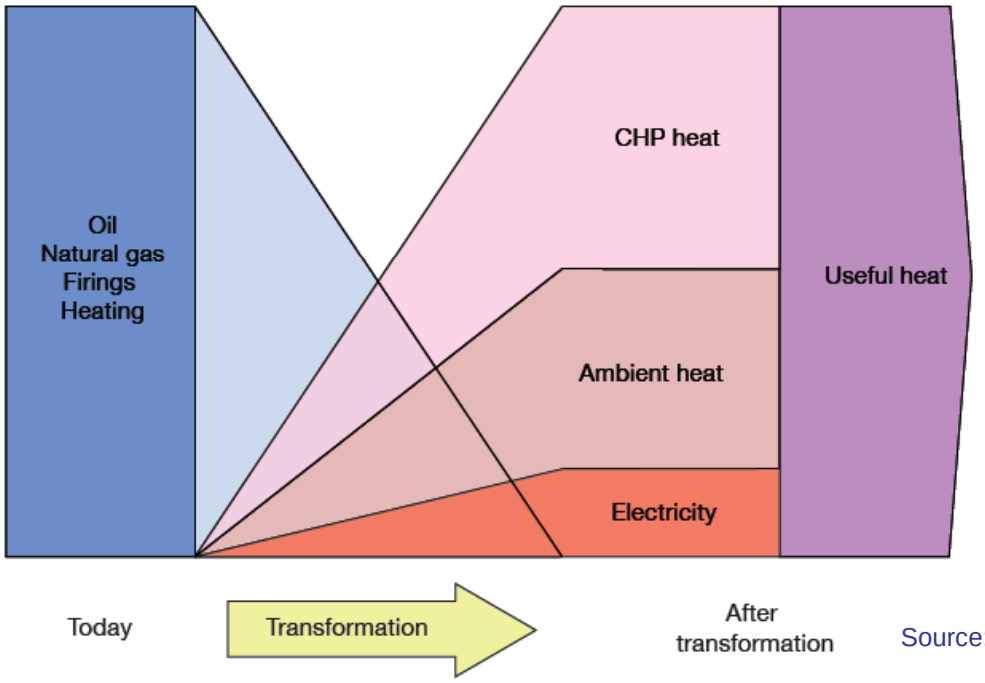
Energy efficiency – Transformation of Energy Systems

Geothermal energy and CHP heat



Source: WBGU, 2008
…er et al, 2008

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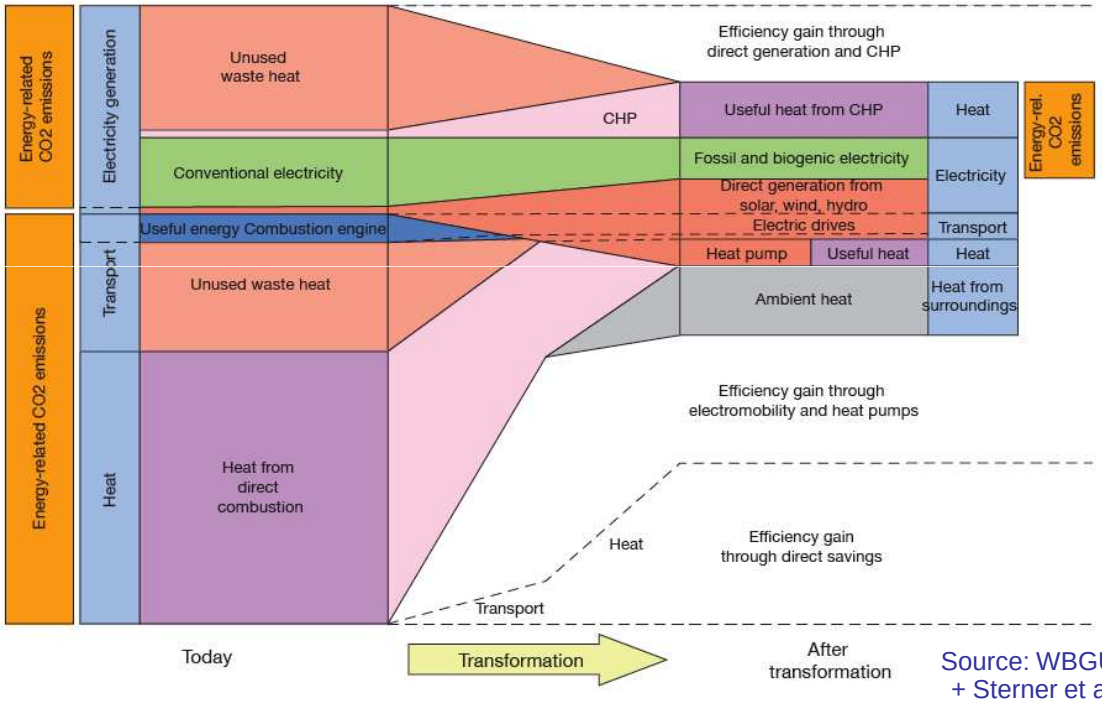
Transformation of the energy system – example Germany

Greenhouse gas reduction by 85% through energy efficiency



Source: WBGU, 2008
+ Sterner et al, 2008

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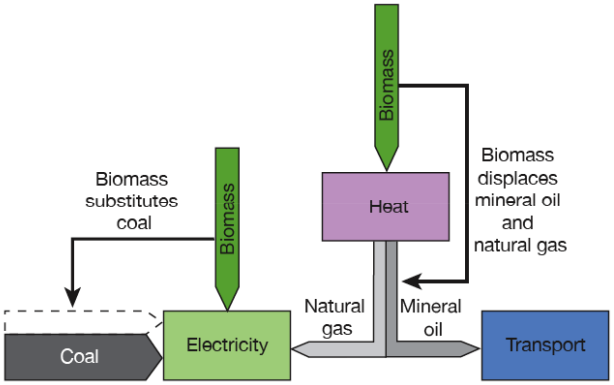
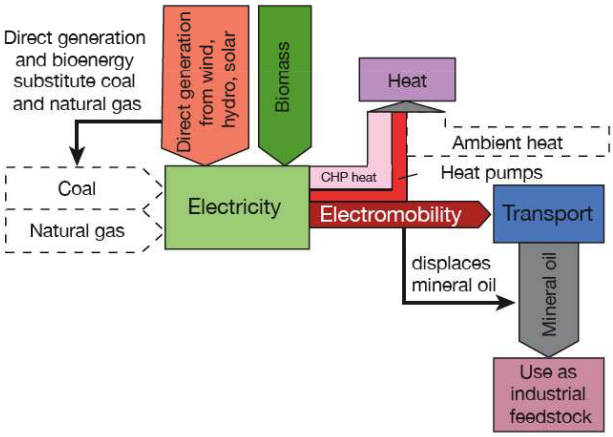
Stages of bioenergy use in industrialized countries



1st stage: Substitution of fossil energy at low cost and without major energy conversion losses (preferably direct combustion)

2nd stage: Biomass (ideally: biomethane) for electricity. Use of waste heat, renewable electromobility and heat pumps



Source: WBGU, 2008

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Bioenergy in developing countries

- **In the past: Inefficient and harmful to health**
  Efficiency: 5–10%
- **Simple alternatives: Improved cooking stoves** (efficiency 30–40%) **and small-scale biogas digesters in households, small-scale plant-oil CHP units, biomass gasification facilities instead of coal-fired power plants for electricity generation**

Source: Private Photos, 2008

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Conclusions on bioenergy (1)

- Climate protection and climate damage are close-up
  → Use of **perennials** and **marginal, degraded land**

- Maximum climate change mitigation by bioenergy
  → **substitute coal**
  → Power generation, **CHP,** not as biofuels in transport
  promote instead **electromobility**

- Prevent emissions from land-use changes:
  Prioritize **use of residues**

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Conclusions on bioenergy (2)

- Main energy efficiency potential: Overcome **traditional bioenergy use** and mitigate health hazards

- Bioenergy (**Energy crops**) are a **‚brigde‘** into a **sustainable energy future** until 2030/2050
  - **All available fertile land** →nurish increased global population (by 2030, 50% more **food** comodities will be required)
  - Future main strategic use of biomass → **material use** in industry to substitute fossil feedstocks (chemicals, plastics, pharmaceutial products, etc.)
    Energy can be provided by other means, carbon not.
  - Future energy demand → met by **other renewable energy sources** in a more economic and climate friendly way
    (almost **no GHG emissions** and **no feedstock costs** of wind, solar, hydro, etc.)

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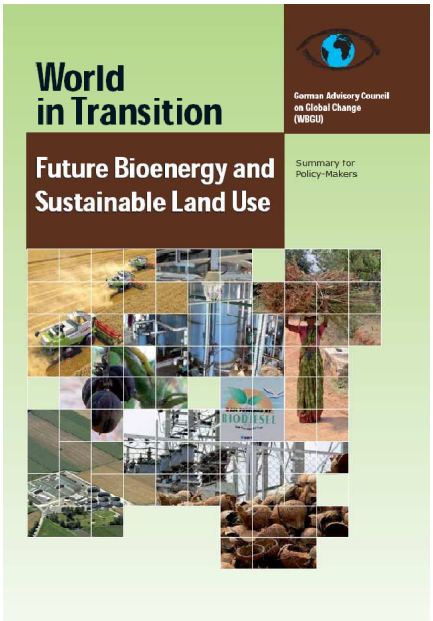

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