Towards sustainable production and use of resources:

Assessing Biofuels

UNEP

A summary presentation
from a report conducted by the
International Panel
for Sustainable Resource Management

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for Sustainable
Resource Management

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International Panel for Sustainable Resource Management

The Resource Panel was established to :

- provide independent, coherent and authoritative scientific assessments of policy relevance on the sustainable use of natural resources and in particular their environmental impacts over the full life cycle
- contribute to a better understanding of how to decouple economic growth from environmental degradation.

It currently has **four working groups**:

- Decoupling
- Biofuels
- Prioritization of products and materials
- Global metal flows

Report: ‘Towards sustainable production and use of resources: Assessing Biofuels’

Content:

- provides an overview of the key problems and perspectives toward sustainable production and use of biomass for bioenergy purposes
- describes options for more sustainable use of biomass and measures to increase resource productivity – towards a sustainable “bio-economy”
- focuses on first generation biofuels while considering further lines of development
- focuses on the global situation, recognising regional differences
- marks uncertainties and addresses the needs for research and development

Process:

- based on an extensive literature study
- prepared by the biofuels working group
- underwent extensive internal review, incl. by the Steering Committee, and peer review

The key question that occurred is whether significant expansion of biofuel production is

‘too much of a good thing’

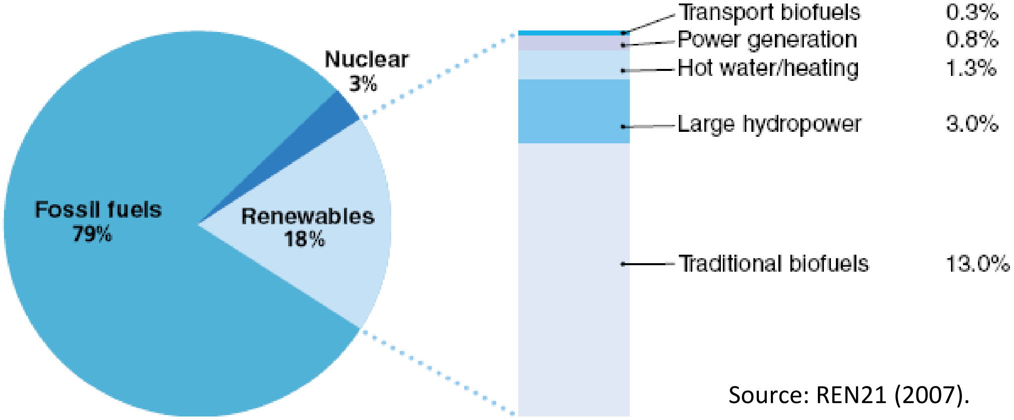
Outline of the report

- Trends and drivers
- Life cycle wide environmental impacts of biofuels
- Land use change and implications
- Options for more efficient and sustainable resource use
- Strategies and measures to enhance resource productivity

Bioenergy is part of the energy mix

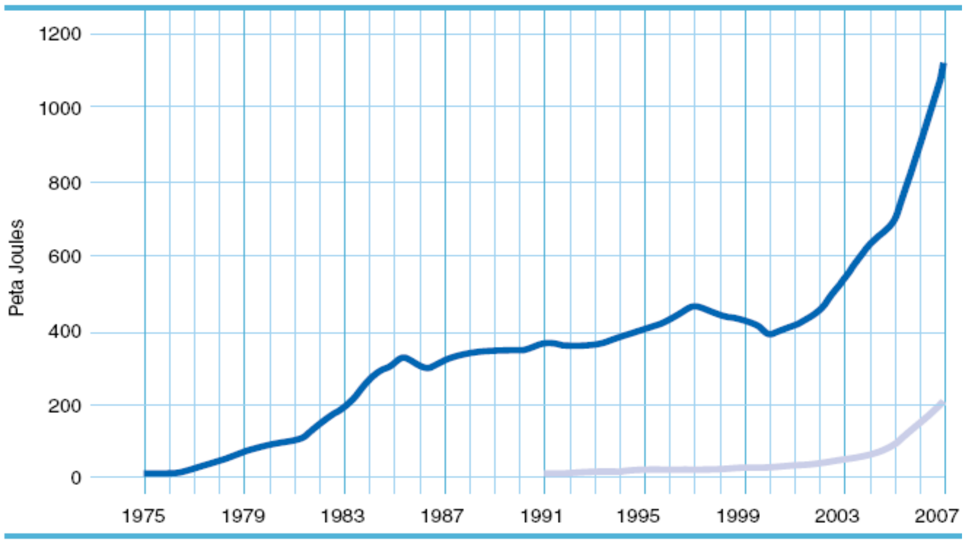
- **Traditional biomass** accounts for 13% of global final energy demand.
- **Liquid biofuels provided 1.8%** of the world's transport fuel by energy value in 2008 with a **strong upward trend,** mainly in USA, EU, Brazil and China.
- Due to more favourable climatic conditions, growth in production is expected to occur in tropical countries. As a result, **international trade in ethanol and biodiesel will grow significantly**.
- **Main triggers for the increase in biofuel development are policy targets and blending quotas**. In combination with high oil prices, they pulled large private sector investments.

Renewable Energy Share
of Global Final Energy Consumption (2006)



Source: REN21 (2007).

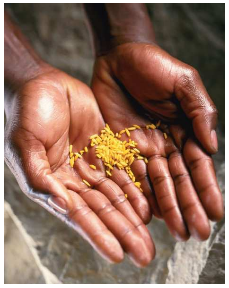
Global bioethanol and biodiesel production, 1975-2007



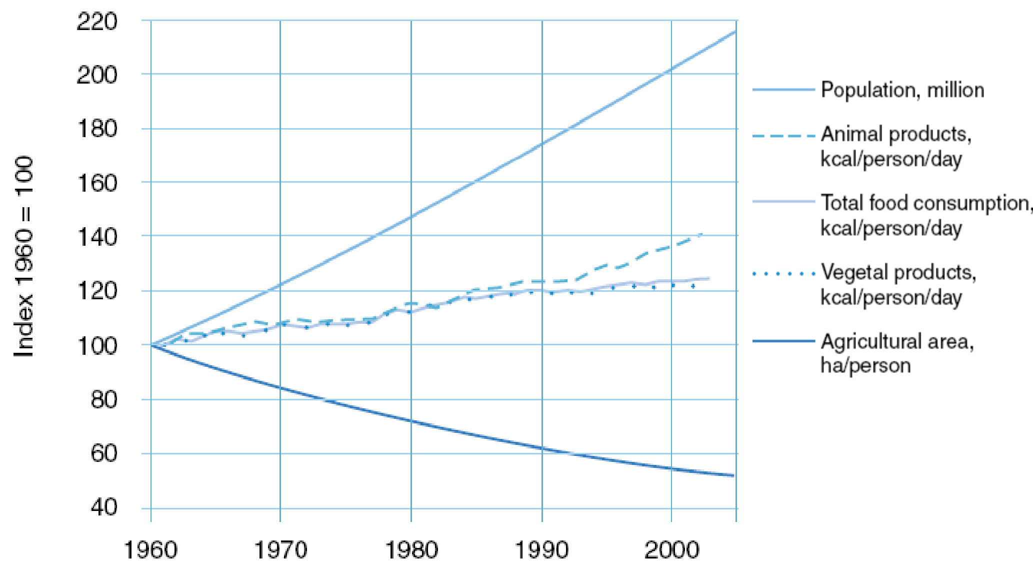
Source: SCOPE (2009).

Bioenergy potential has to be assessed in light of global trends: population growth, nutrition, yields

- **Global population** is expected to grow by 36% between 2000 and 2030 (medium projection of UN/FAO).
- **Average crop yields** are expected to increase at about the same rate. However, relative yield increases have in general weakend (estimates for global yields in the next decade predict 1-1.1% p.a. growth for cereals).
- **Meat consumption** is expected to increase by 22% per capita between 2000-2030, which requires more cropland for feed.
- **Effects of climate change** will put further pressure on yield improvements and availability of arable land.
- **Feeding the world population will require the expansion of global cropland. Additional demand for non-food biomass will add on top of this**.



Development of global population, agriculture land and consumption per person in the past (1960-2005)

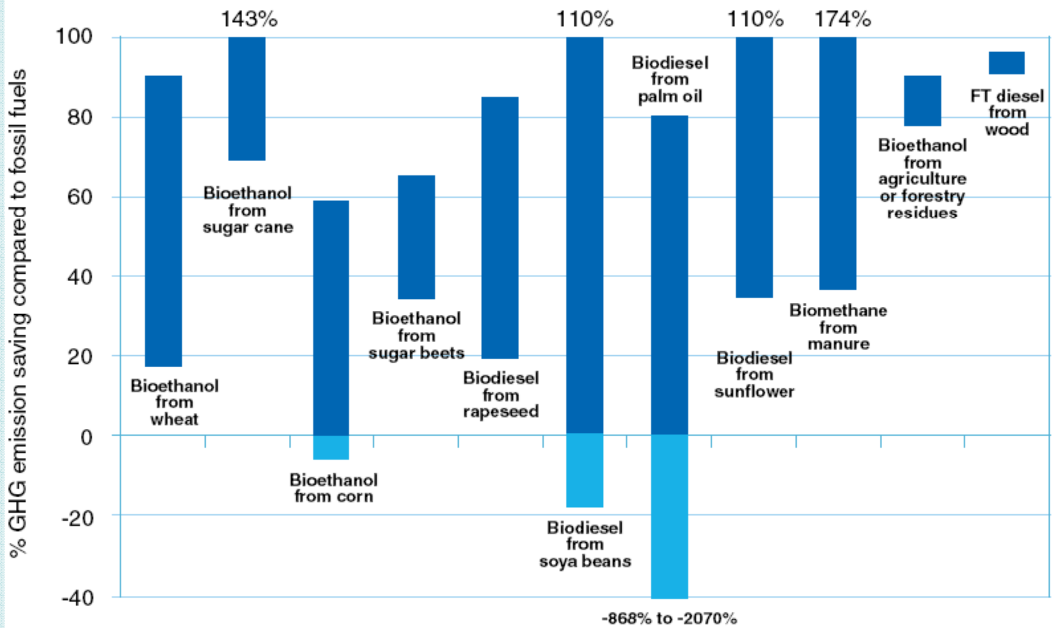


Sources: UN population statistics online; FAOSTAT online

Biofuels may make a difference – life cycle wide GHG emissions vary

- **Life-cycle assessments (LCA) of biofuels show a wide range of net GHG balances** compared to traditional fuels, depending on feedstock, conversion technology, and methodological assumptions.
- Highest GHG savings are for sugar cane (70 to +100%), biogas from manure, and ethanol from residues.
- Lowest savings, and sometimes even higher GHG emissions than fossil fuels occur when production takes place on **converted natural land.**

Greenhouse gas savings of biofuels compared to fossil fuels

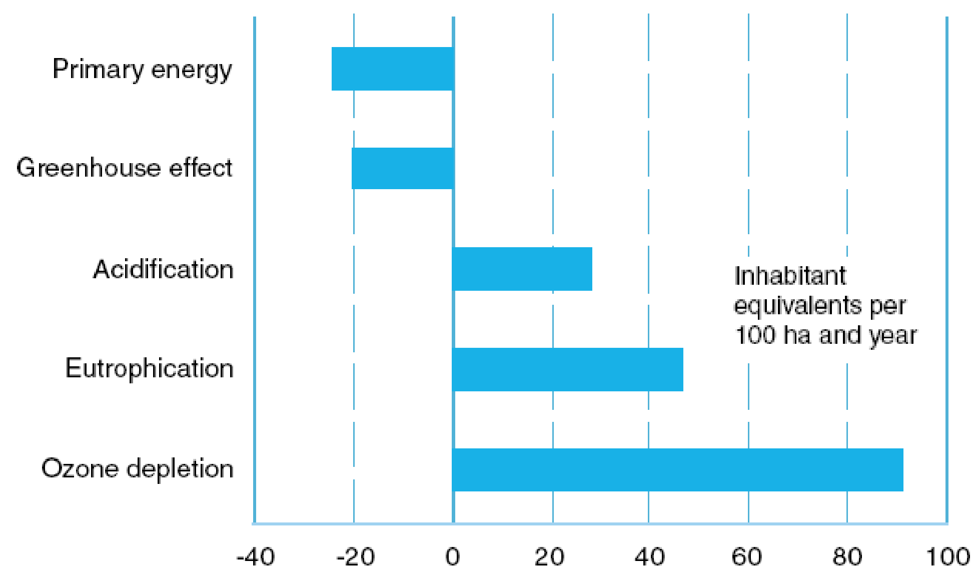


Sources: own compilation based on data from Menichetti/Otto 2008 for bioethanol and biodiesel, IFEU (2007) for sugar cane ethanol, and Liska et al. (2009) for corn ethanol; RFA 2008 for biomethane, bioethanol from residues and FT diesel

Other environmental impacts of biofuels are so far insufficiently covered by life cycle assessments

- Biofuels tend to have **impacts on** eutrophication, acidification, and ozone depletion.
- Impacts such as water consumption and effects on biodiversity are hardly considered by LCA. **A harmonized set of impact indicators is lacking.**
- **LCA is a useful tool, but has methodological constraints that should be taken into account when analysing and comparing results:** varying assumptions. For instance, results of life-cycle GHG balances depend on the way land conversion related impacts are attributed.
- LCA, as a product-oriented approach, needs to be **complemented by analytical approaches that capture larger spatial and socio-economic contexts** in order to account for effects such as indirect land use change.

Example of biodiesel from rape seed: impacts compared to fossil fuels



Source: Reinhardt et al. 2008

Water is a limiting factor for biofuels development

- **Water quality:** For instance in the Mississippi drainage basin increased corn acreage and fertilizer application for biofuel production, increase nitrogen and phosphorus losses to water bodies, particularly in the Northern Gulf of Mexico and Atlantic coastal waters, leading to serious hypoxia problems (shortage of oxygen).
- **Water consumption:** feed-stock production for biofuels in water scarce regions requires irrigation. This may compete with food production.
- Extreme weather events (inundation, droughts) due to **climate change** might increase uncertainty.

Land is a limiting factor for biofuels development

- **Conservative estimates of projected land use for biofuel crops vary between 35-166 Mha for 2020.**
- Estimates of long-term potential land requirements for biofuels vary widely and depend on the basic assumptions made - mainly type of feedstock, geographical location and level of input and yield increase.
- Ravindranath et al (2009) estimated that 118-508 Mha would be required in 2030 to provide 10% of transport fuel demand with 1st gen biofuels. For comparison, total cropland is about 1,500 ha.
- **Land use change has a range of potential implications, including on GHG balance and biodiversity.**

The drive to meet the demand for palm oil is resulting in conversion of forested areas into palm oil plantations.

These satellite images reveal how a combination of transmigration, logging interests, and palm oil plantation development have transformed an area that was previously tropical lowland rain and swamp forest.

Source:
UNEP Atlas One Planet - Many People

Land conversion for biofuel crops can lead to significant GHG emissions

- **Clearing the natural vegetation mobilizes the stocked carbon and may lead to a carbon debt, which could render the overall GHG mitigation effect of biofuels questionable for the following decades.**

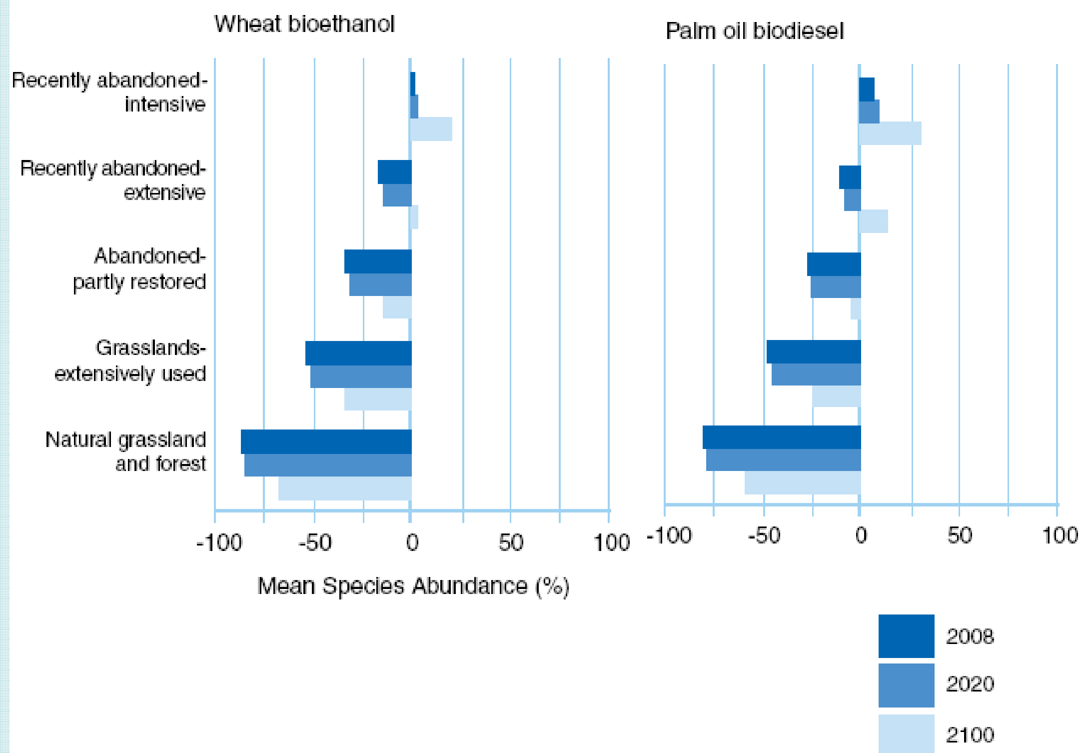
- GHG balance estimate*, in 2030:
  - 10% biofuels world-wide could substitute fossil fuels emitting 0.84 Gt CO2
  - substitution potential 20-90%: 0.17-0.76 Gt CO2
  - LUC induced additional emissions: 0.75 to 1.83 Gt CO2

*Ravindranath, N.H. et al. (2009) *GHG Implications of Land Use and Land Conversion to Biofuel Crops.* In: R. W. Howarth and S. Bringezu (editors), *Biofuels: Environmental Consequences and Interactions with Changing Land Use.* Report of the Internatinal SCOPE Biofuels Project. (http://cip.cornell.edu/biofuels/)

Land conversion for biofuel crops can lead to significant loss of biodiversity

- **In particular habitat loss through land use change might have a large impact on biological diversity.**
- **Invasive species** as feedstocks, and nutrient pollution through intensive agriculture may further impact on biological diversity.
- **Benefits from mitigated climate change** can not compensate losses by habitat conversion for decades.
- However, utilizing **recently abandoned and degraded land** could lead to beneficial effects for biodiversity.

Biodiversity loss due to biofuel feedstock production



Source: Eickhout et al. 2008.

Options
for more efficient and sustainable resource use

Improving the production of biomass :
- Increasing yields and optimizing agricultural production
- Restoring formerly degraded land

More efficient use of biomass:
- Use of waste and production residues
- Cascading use of biomass
- Stationary use of bioenergy

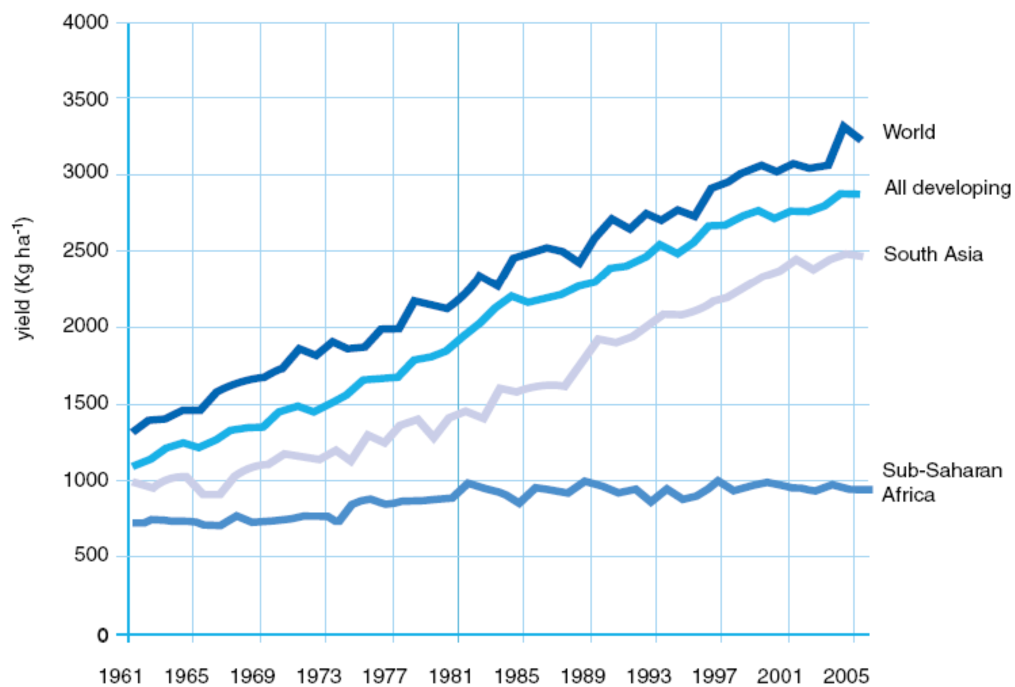
Considering different pathways:
- Mineral based solar energy systems

Options

Increasing yields and optimizing agricultural production

- The past trends and the potential to increase yields differs among regions.
- Unused potential for yield increase seem to exist in regions such as Sub-Saharan Africa.

Global trends in cereal yields by region (1961 – 2005)

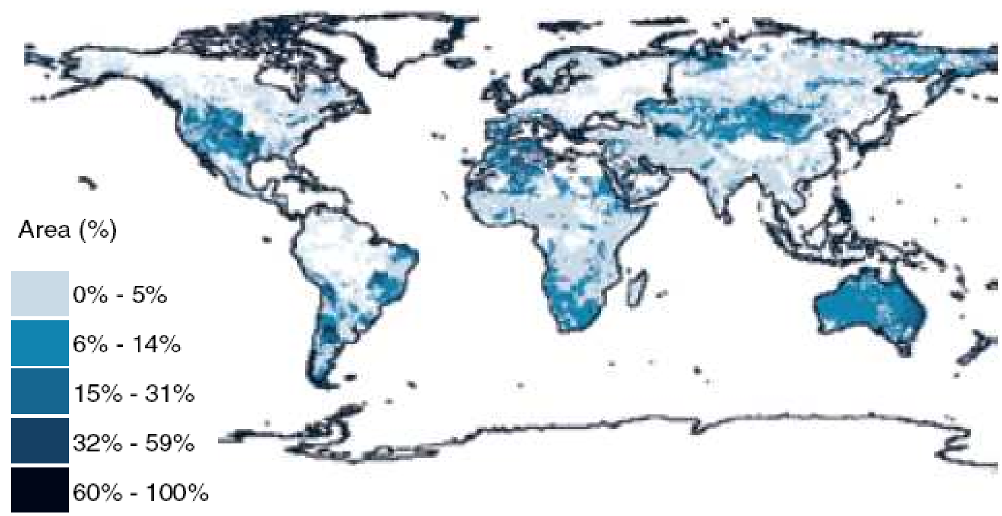


Source: Hazel and Wood (2008)

Options
Restoring formerly degraded land

- Abandoned, marginal and degraded land may be used for biofuel production.
- Certain crops can restore productivity of degraded land.
- However, use of abandoned, marginal and degraded land may :
  - compete with nature restoration
  - require higher inputs
  - save less GHG than forest regrowing naturally on abandoned land

Worldwide potential of abandoned land



Source: Campbell et al. 2007

Options
Use of residues and waste

- Utilization of waste and residues
  can save significant amounts of GHG emissions without additional land use.
- Further research is needed on sustainable residue balance for nutrient recycling and soil fertility.

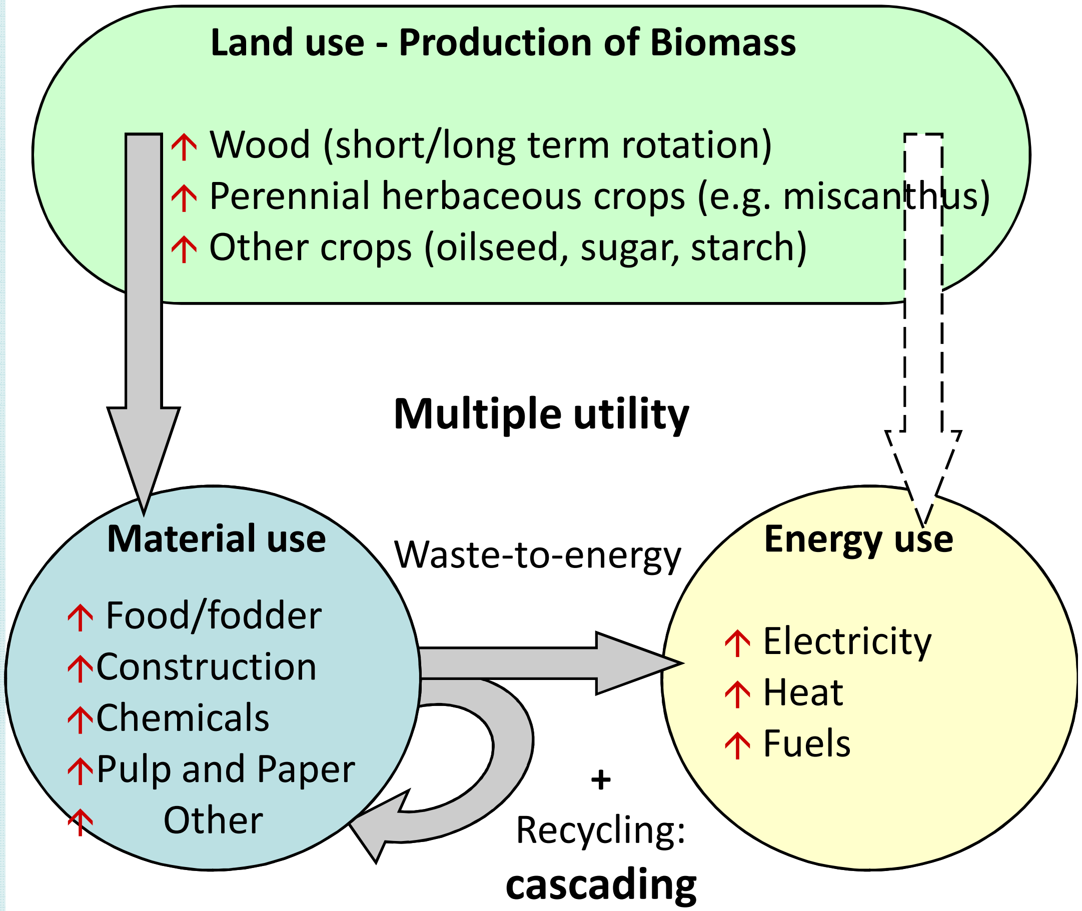
Overview of the IEA estimates of global potential of biomass for energy (EJ per year) until 2050 and some key assumptions

Biomass category	Main assumptions and remarks	Energy potential in biomass up to 2050
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.	15-70EJ
Forest residues	The sustainable energy potential of the world's forest 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

Source: IEA 2007b after Berndes et al., 2003; Smeets et al., 2007; Hoogwijk et al., 2005a.

Options
Cascading use of biomass

- Using biomass to produce a material first, then recover its energy content from the waste can provide multiple benefits and ensures more efficient use of biomass.
- Reutilization of biomass may reduce demand for land and maximize GHG mitigation potential.

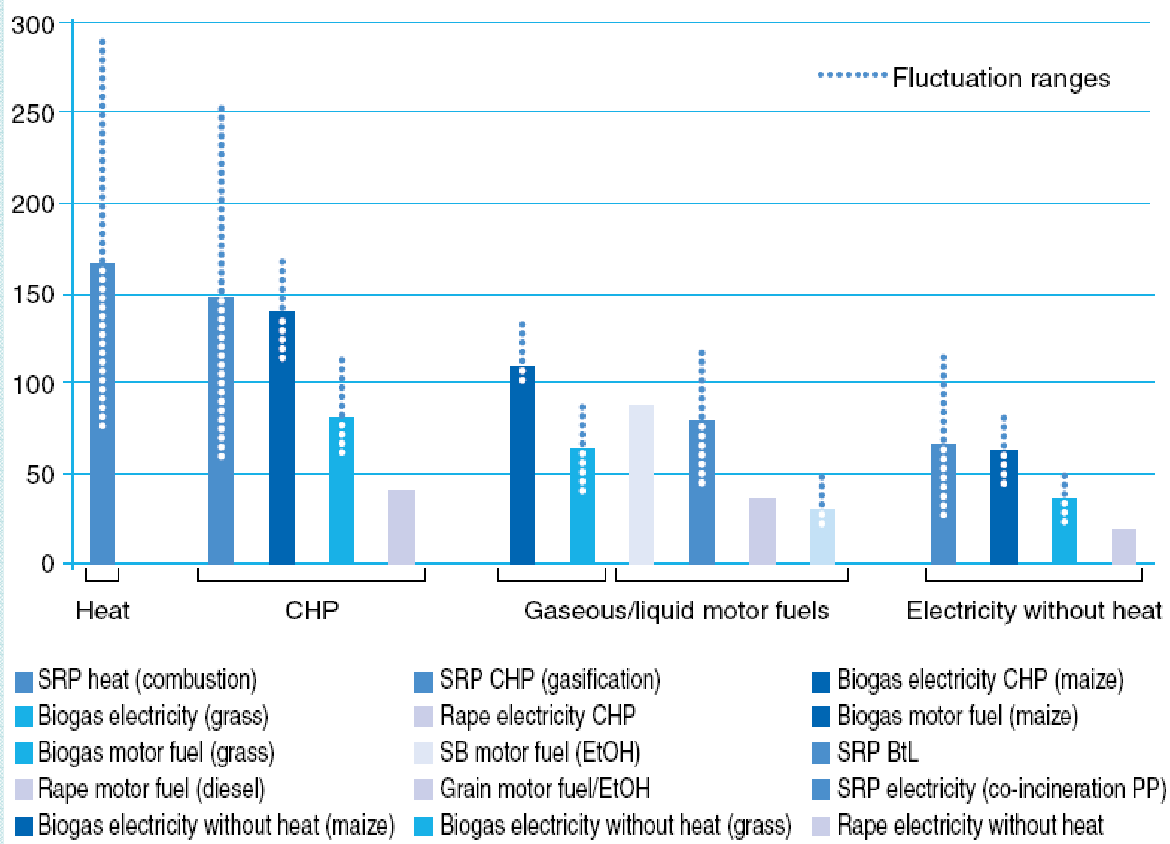


Source: after Dornburg (2004).

Options
Stationary use of bioenergy

- Biomass for heat/power is usually more efficient than converting it to transport fuel. Multifunctional services like waste treatment with energy provision (i.e. biogas) have great potential for a renewable energy source.
- Particularly, in developing countries, decentralized use of biofuels in stationary applications can supply local communities with basic energy to enhance living and working conditions.

Overview of current energy yields (net)
of renewable raw materials
for different usage paths in GJ/ha



Note: SRP = short-rotation plantation, BtL = biomass-to-liquid, PP = power plant, CHP = combined heat and power, EtOH = ethanol, SB = sugar beet. Source: SRU (2007)

Options
Mineral based systems

- Biomass and solar energy systems both make use of solar radiation reaching the surface of the earth:
  - biomass in the open field captures about 1 – 6 % of the solar radiation input, which still requires transformation into usable energy
  - technologies such as photovoltaics and solar thermal power can make use of 9 – 24 %
- Solar systems can be installed on roofs and facades and lands not suitable for other purposes without any additional requirement on land.

Source: German Federal Ministry of Economics and Technology

Key messages (1)

- Mobilize agricultural potentials in regions that have lagged – increase yields in an environmentally & socially benign manner
- Limit expansion of cropland and direct new development to degraded land, considering potential environmental and social impacts
- Explore low input cultivation of perennials to limit eutrophication
- Promote energy from residues/waste rather than energy crops
- Foster cascading use of biomass
- Promote use of bioenergy for stationary application rather than for transport
- Limit overall biomass & energy demand (efficiency in fuel consumption, etc.)

Key messages (2)

- Further develop production standards and product certification

  of biofuels to consider all relevant environmental and social impacts
- For a sufficient assessment of biofuels consider information on both -
  - specific types of products and production conditions, and
  - overall consumption and land use for biomass
- Reconsider current policy mandates, targets, quota
  (limit demand to levels which can sustainably be supplied)
- Develop national and regional resource management programmes
  - incl. climate and biodiversity protection, food and energy security
  - consider land use for domestic consumption (limit burden shifting)
- Use economic instruments to increase resource productivity
  (e.g. reform subsidies including those of fossil fuels)

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The full report, including references can be accessed at the following website:
www.unep.fr

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