IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH

Sustainability of Bioenergy:

Key Issues

Uwe R. Fritsche

Scientific Director, IINAS

International Institute for Sustainability Analysis and Strategy

presented at the
PhD Symposium 2012: Plants replacing fossil fuels?
ETH Zurich, Nov 8, 2012

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Project Context

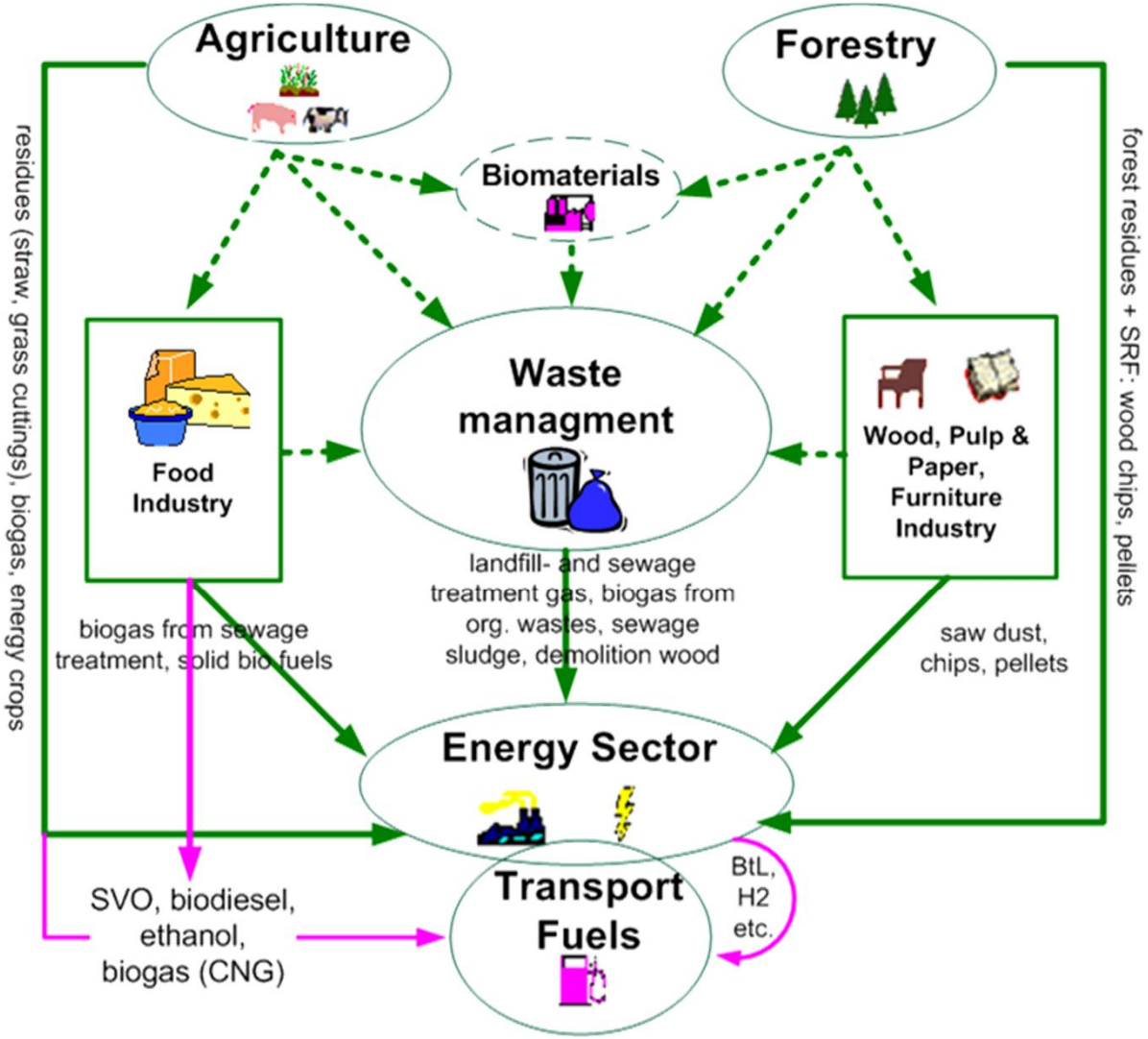
IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

- **Sustainability criteria for "RED-plus" (IEE)**
  BIOMASS FUTURES www.biomassfutures.eu
- **Sustainability criteria for non-food feedstocks (FP7)**
  Crops2Industry www.crops2industry.eu
- **Joint Workshop series focusing on extending the RED to forest bioenergy**
  www.iinas.org/Work/Projects/REDEX/redex.html
- **Resource-Efficient Bioenergy in EU27 (EEA report – forthcoming)**

research sponsored by
UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Consider all Biomass Flows

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH



research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Sustainable Bioenergy…

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH

- **Key Issues**
  - **resource** efficiency: make the most out of **limited** resource
  - GHG emissions from iLUC (**agricultural** bioenergy) + carbon debt (for **forest** bioenergy)
  - biodiversity: high-biodiverse areas and **management** practice (all cultivation systems, incl. forestry)
  - air, water and soil quality impacts
  - (global) food security, employment, land rights, rural income
- **Coherence for all bioenergy (electricity, heat, transport) and biomaterials needed**

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Sustainability Standards

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH

- Principle rules by which sustainable development of biomass systems (crops, residues,…) should play
- Criteria and indicators derived from these standards to "measure" compliance
- Implemented via voluntary or legal systems such as product labelling and certification, and (governmental) support schemes (e.g. subsidies, preferential treatment of products, quota) → preferably mandatory (e.g. RED extension)

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Sustainability Certification

IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

- **woody biomass**

  FSC + PEFC

  Blue Angel for wood chips, pellets (in DE)

  activities in BE, CH, NL, UK…

- **liquid biofuels**

  ISCC (all); RSB, feedstock-specific BS, RSPO…

  (CEN & ISO)

- **biogas**

  some (local) initiatives in DE, SE…

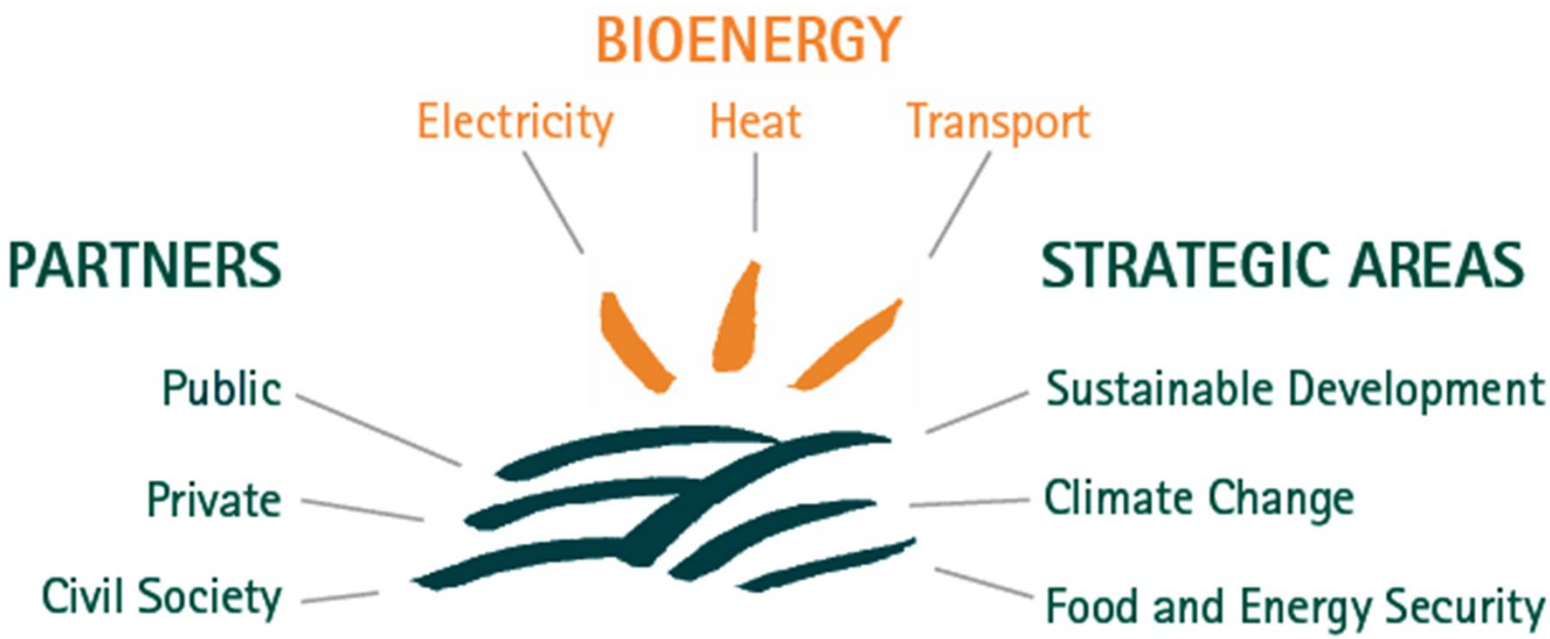
→ **all voluntary**

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Global Bioenergy Partnership (GBEP)

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH



research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

GBEP Partners and Observers

IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

36 Partners (23 governments – 13 organizations):

G8 Governments (CA, DE, FR, IT, JP, RU, UK, US) plus AR, BR, CH, CN, CO, ES, FJ, GH, MR, MX, NL, PY, SD, SE, TZ and ECOWAS, EU, FAO, IDB, IEA, UNCTAD, UNDESA, UNDP, UNEP, UNIDO, UNF, WCRE and EUBIA.

32 Observers (22 governments – 11 organizations):

AO, AT, AU, CL, EG, GM, IN, ID, KY, LA, MA, MG, MY, MZ, NO, PE, RW, SV, TH, TN, ZA, AfDB, ADB, ECLAC, EEA, GEF, IFAD, IRENA, OAS, UEMOA, World Bank, and WBCSD.

Italy and Brazil are currently Chair and co-Chair of the Partnership.
The Secretariat is hosted at the FAO in Rome.

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

24 Sustainability Indicators

agreed by 23 countries & 13 international organizations

involving a total of 45 countries and 23 int. organizations

Environmental	Social	Economic
1. Life-cycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and re-qualification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

GBEP
Global Bioenergy Partnership

Land-Use of Energy Systems

IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

electricity from	land use m^2/GJ_{el}	Note
el-mix EU27	0,29	Excluding transmission and distribution
lignite	0,10	Lignite in Germany, new steam-turbine powerplant
coal	0,06	import coal (surface mining), new steam-turbine powerplant
nuclear	0,04	German supply mix, steam-turbine powerplant
natural gas	0,02	EU supply mix incl. imports, new combined-cycle powerplant
hydro	0,03	100 MW_{el} run-of-river plant
wind onshore	0,26	10 x 2 MW_{el} onshore wind park
solar-PV	2,7	1 kW_{el} (peak) system, full land use
solar-CSP	1,9	80 MW_{el} concentrating solar power system in Southern Spain
geothermal	1,2	1 MW_{el} ORC system
biogas-maize ICE	106	Biogas from maize in internal combustion engine cogeneration plant (energy allocation)
SRC cogen	112	Woodchips from short-rotation coppice in steam-turbine cogeneration plant (energy allocation)
bio-SNG SRC cogen	164	Biomethane from short-rotation coppice in gas-turbine cogeneration plant (energy allocation)
bio-SNG SRC CC	128	Biomethane from SRC in CC powerplant

Source: own computation with GEMIS 4.8; ORC= organic rankine cycle; ICE = internal combustion engine; SRC = short-rotation coppice; CC = combined-cycle

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Resource Efficiency: a new kid…

IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

feedstock (EU production)	bioenergy output	land productivity GJ_{bio}/ha
rapeseed	1G biodiesel	87
short-rotation coppice	2G biodiesel (BtL)	116
switchgrass	2G biodiesel (BtL)	75
wheat (grain)	1G EtOH	128
switchgrass	2G EtOH	80
short-rotation coppice	pellets	183
switchgrass	pellets	198
short-rotation coppice	biomethane	126
for comparison: non-EU production		
sugarcane	1G EtOH	207
palm	1G biodiesel	154

Source: own computation with GEMIS 4.8; calculated using energy allocation for by- and co-products; 1G = 1st generation; 2G = 2nd generation; BtL = biomass-to-liquid; EtOH = ethanol

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Key Criteria & Indicators

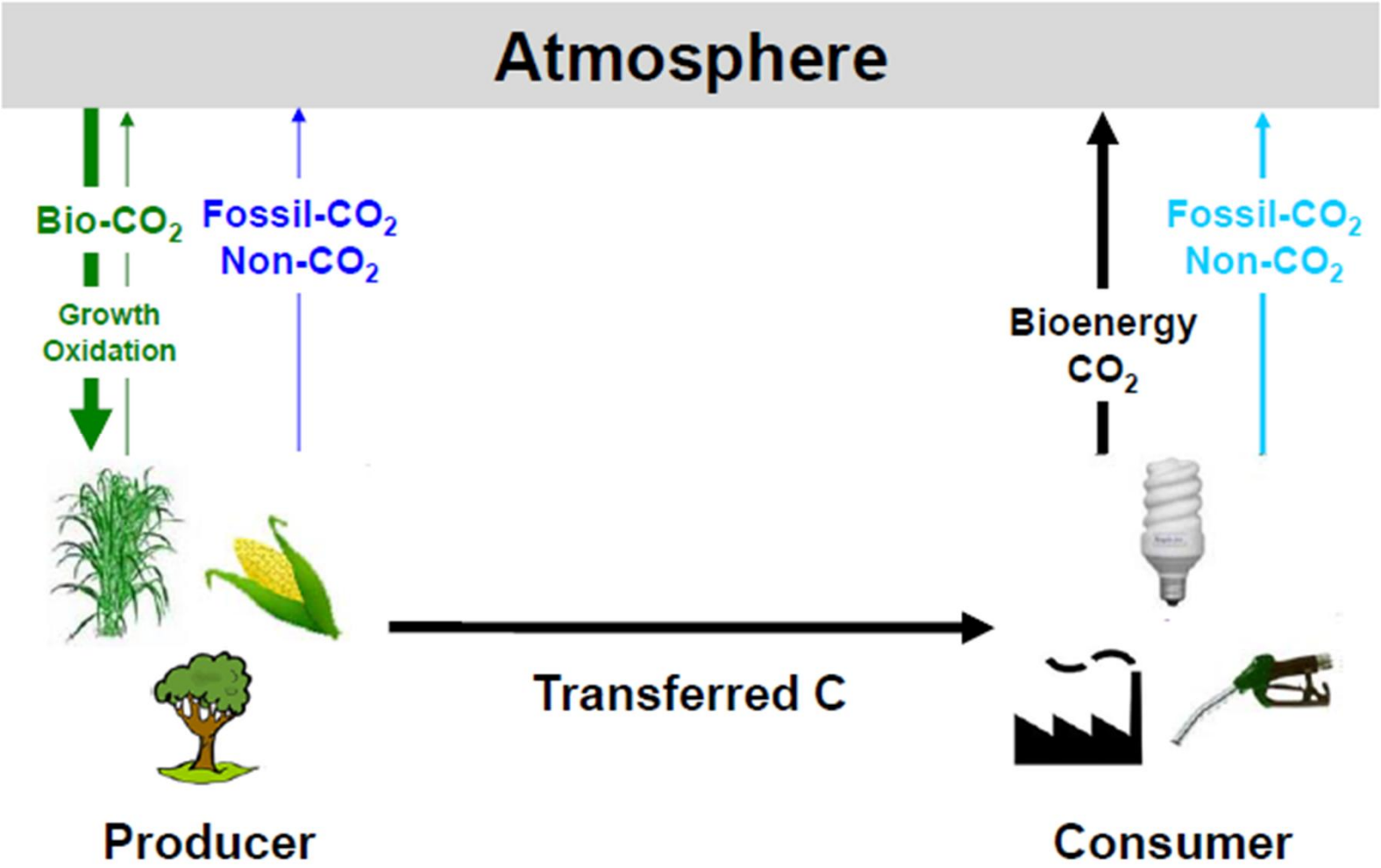
IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

- **Resource efficiency: land (>100 GJ/ha), residues (> 60%)**
- **GHG** (> 60% reduction), **include** iLUC
  + consider "C debt" (< 20 years payback time)
- **biodiversity**: more than "no go" areas – require agro-biodiverse cultivation, restrict forest residue extraction
- **soil:** maps of nutrient depletion risk ("go")
- **water:** buffer zones, restrict agrochemicals
- **social**: global **food** security is key (FAO!)

research sponsored by
UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

GHG Emissions and Global Warming

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH



research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Carbon Neutrality and C Debt

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH

- GHG life-cycle balance is only one aspect of climate change – for short-term view (< 100 years), also warming impacts (= radiative forcing) is relevant
- CO_2 balance of bioenergy is neutral for long-term view, but warming impacts of forest bioenergy need consideration
- Not an issue for agriculture and perennials!
- C debt is a measure for GWP of biogenic CO_2 having longer atmospheric residence time

research sponsored by
UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

C Neutrality of Forest Bioenergy

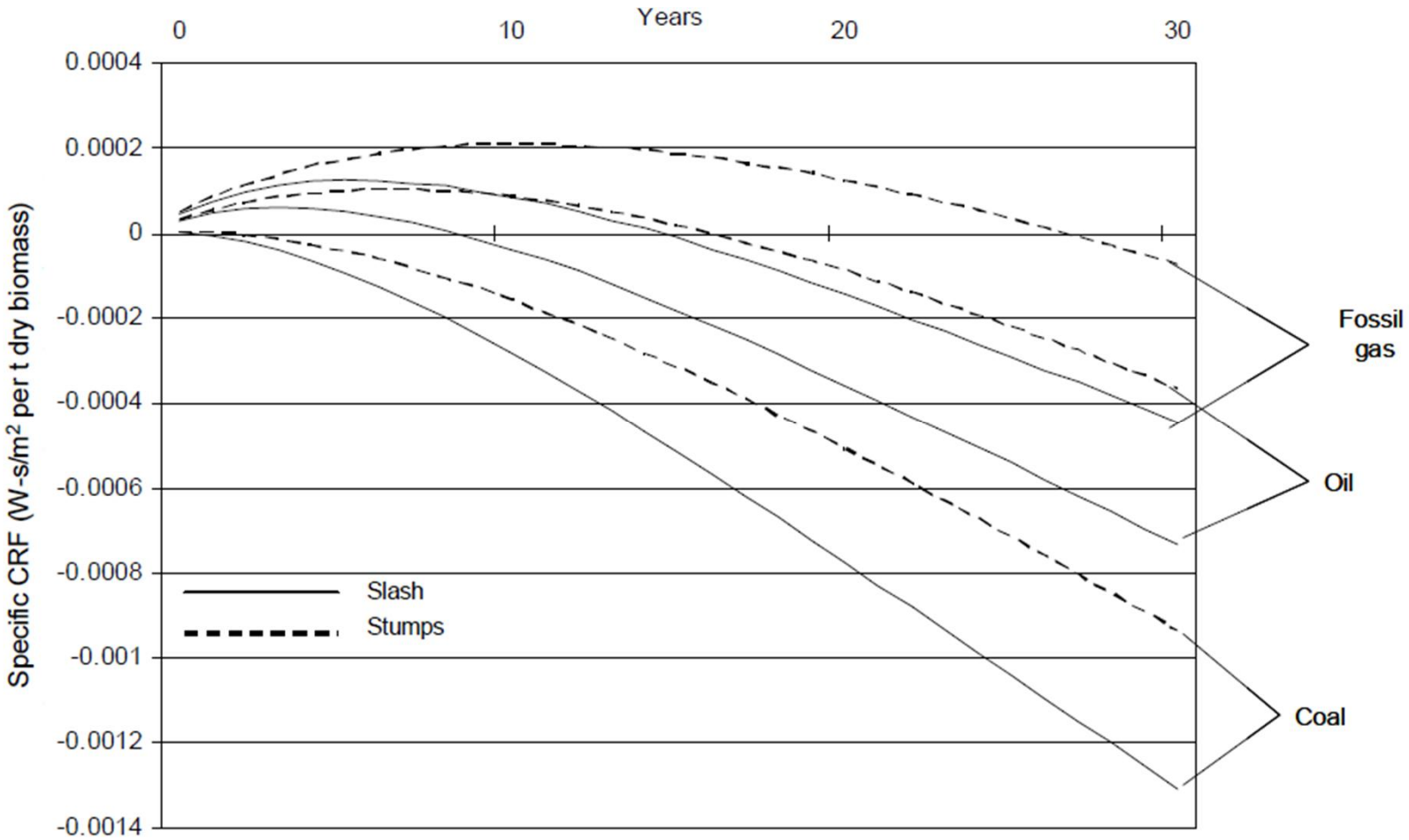
IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

- RED methodology for GHG balances:
  - defines CO_2 from biogenic fuels as C-neutral (i.e. no direct emission)
  - no dynamic warming impacts of C stock changes due to wood harvest, or increased forest residue extraction
- **RED ignores time delay between biogenic CO_2 emissions from fuel use, and CO_2 absorption from forest re-growth**
- **Warming impact of forest bioenergy can be real!**

research sponsored by
UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Carbon Neutrality and C Debt

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH



Source: Sathre, Gustavsson (2011); baseline = natural decay

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

C Neutrality of Forest Bioenergy

IINAS
Internationales Institut für Nachhaltigkeitsanalysen und -strategien GmbH

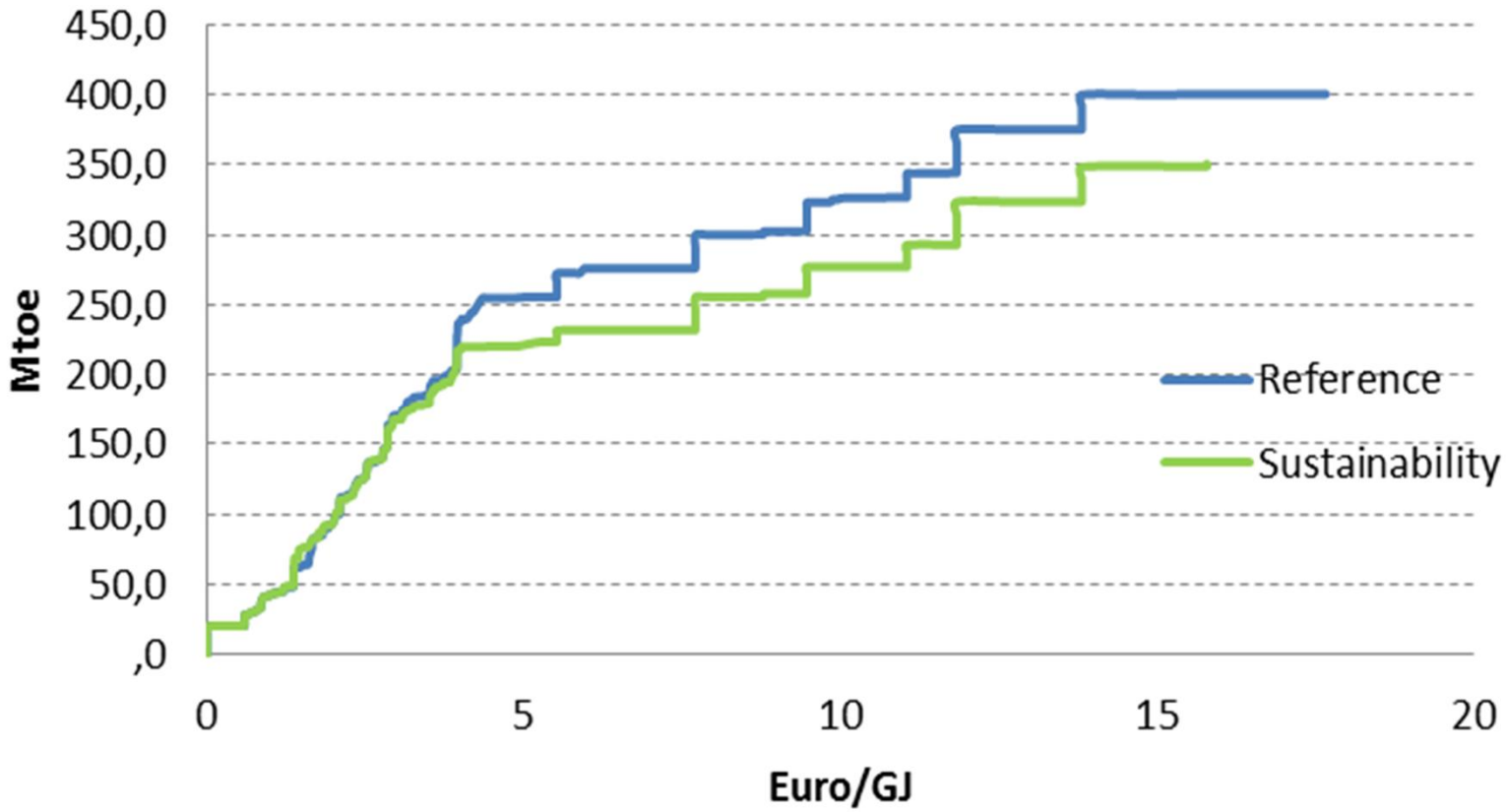
- Models give 5-20 years of payback time for **forest residues** = **nearly carbon neutral**
- Baseline and reference systems are key!
- Differentiation: **not all forests are equal**
- **Long-term**: strengthen **climate convention** to account for CO_2 from **all** LUC from **all** sectors in **all** countries (also for iLUC!)

research sponsored by
UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Sustainable EU Bioenergy Potential

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH

Cost Differences between the Reference and Sustainable Bioenergy Potentials in the EU27 in 2020



Source: Biomass Futures (2012)

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

Long-term: Cascading!

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH

Biomass crops

Material Use

Residues/wastes

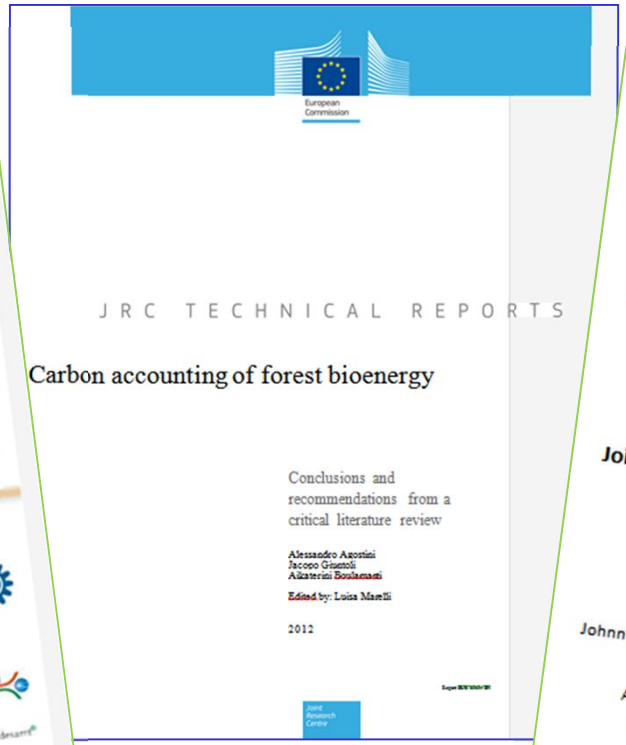
Energy Use

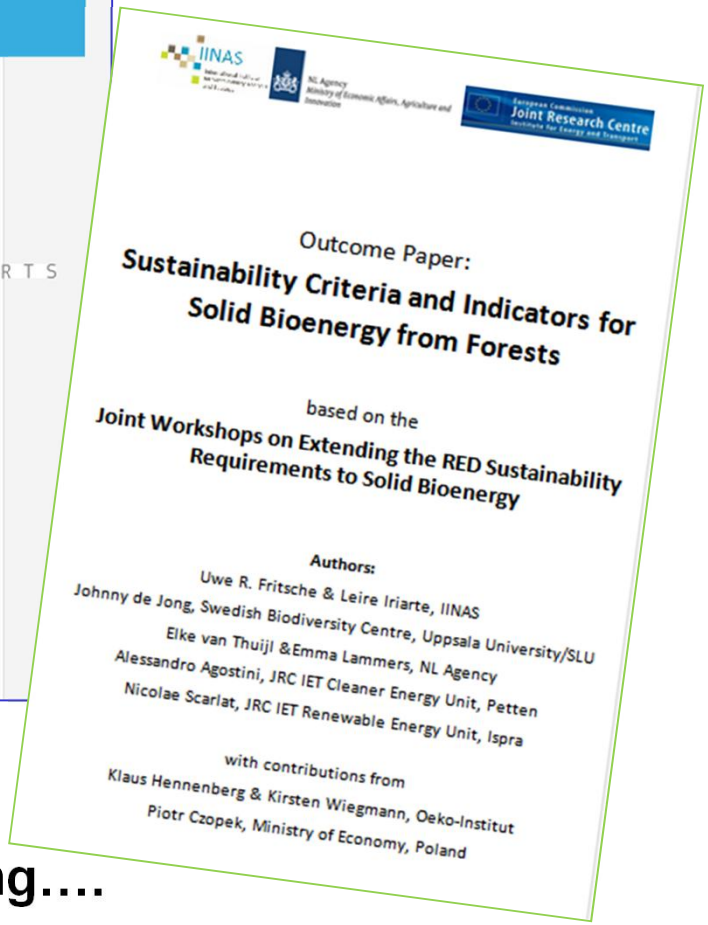
research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt

More Information & Contact

IINAS
Internationales Institut
für Nachhaltigkeitsanalysen
und -strategien GmbH





All reports forthcoming….
Contact: uf@iinas.org

research sponsored by

UNEP
SEVENTH FRAMEWORK PROGRAMME
European Environment Agency
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Umwelt Bundes Amt
Für Mensch und Umwelt