

# IEA Bioenergy

## Task 38

### Climate Change Effects of Biomass and Bioenergy Systems

The main drivers for bioenergy are the mitigation of global climate change, the increase in fossil fuel prices, and the concerns about energy security. The reduction of greenhouse gas (GHG) emissions has become an issue of great international importance. Ever increasing evidence of climate change and its impacts, together with the adoption of the Kyoto Protocol and other regional, national, bilateral and multilateral agreements, have greatly augmented interest in reducing GHG emissions and enhancing sequestration by natural systems.

The primary goal of *IEA Bioenergy Task 38 on Climate Change Effects of Biomass and Bioenergy Systems* is to investigate all processes involved in the use of bioenergy and land-based carbon sequestration systems, with the aim of assessing net climate impacts and supporting decision makers in the selection of GHG mitigation strategies.



## IEA Bioenergy

IEA Bioenergy is an international collaborative agreement, set up in 1978 by the International Energy Agency (IEA) to improve international cooperation and information exchange between national bioenergy research, development and demonstration (RD&D) programs. IEA Bioenergy aims to accelerate the use of environmentally sound and cost-competitive bioenergy on a sustainable basis, thereby providing a substantial contribution to meeting future energy demands.

The work of IEA Bioenergy is undertaken through a series of Tasks, overseen by the IEA Bioenergy Executive Committee. Each Task has a defined work program, coordinated by the Task Leader. In each participating country, a National Team Leader is responsible for coordination of the national participation in the Task. Each participating country pays a contribution towards the Task administration, and provides in-kind contributions to enable national experts to participate in the Task.

This collaboration fosters progress in RD&D of new and improved bioenergy technologies, and development of policy for promotion of sustainable bioenergy systems.

## Task 38

*IEA Bioenergy Task 38 on Climate Change Effects of Biomass and Bioenergy Systems* (previously titled *Task 38 on Greenhouse Gas Balances of Biomass and Bioenergy Systems*) focuses on understanding the climate change mitigation benefits of bioenergy and carbon sequestration systems. It brings together the work of national programs on GHG balances for a wide range of

biomass systems, bioenergy technologies and terrestrial carbon sequestration. The Task considers questions of GHG accounting in the land-use, land-use change and forestry (LULUCF) sector, with application to requirements of the Kyoto Protocol and contributes to the work of the Intergovernmental Panel on Climate Change (IPCC).

## **Objectives**

Task 38 builds on the achievements of predecessor Tasks (Tasks XV and 25) which concentrated on scientific-technical issues and method development. Task 38 focuses on the application of these methodologies to mitigation projects and programs.

Objectives of the Task are:

- increase the understanding of GHG outcomes, on a life-cycle basis, of bioenergy and carbon sequestration, especially for bioenergy technologies approaching a break-through, such as second generation biofuels;
- foster international collaboration and common views of key technical and methodological issues;
- develop, improve, compare and promote methodology for assessing GHG balances of bioenergy and carbon sequestration systems on the project, activity, and regional levels;
- aid decision makers in selecting mitigation strategies that optimise GHG benefits, e.g. allocating biomass to energy vs. use as raw material; considering costs and benefits, as well as the practicalities of different mitigation strategies; and
- assist in the development and implementation of climate change policy, through methodological work for greenhouse gas accounting in the energy and LULUCF sectors.

## **Standard Methodology for GHG Balances**

Task 38 has developed a systematic framework for estimating the net effect on GHG emissions of bioenergy systems. The major aspects of this “standard methodology”, and a schematic structure, are introduced below.

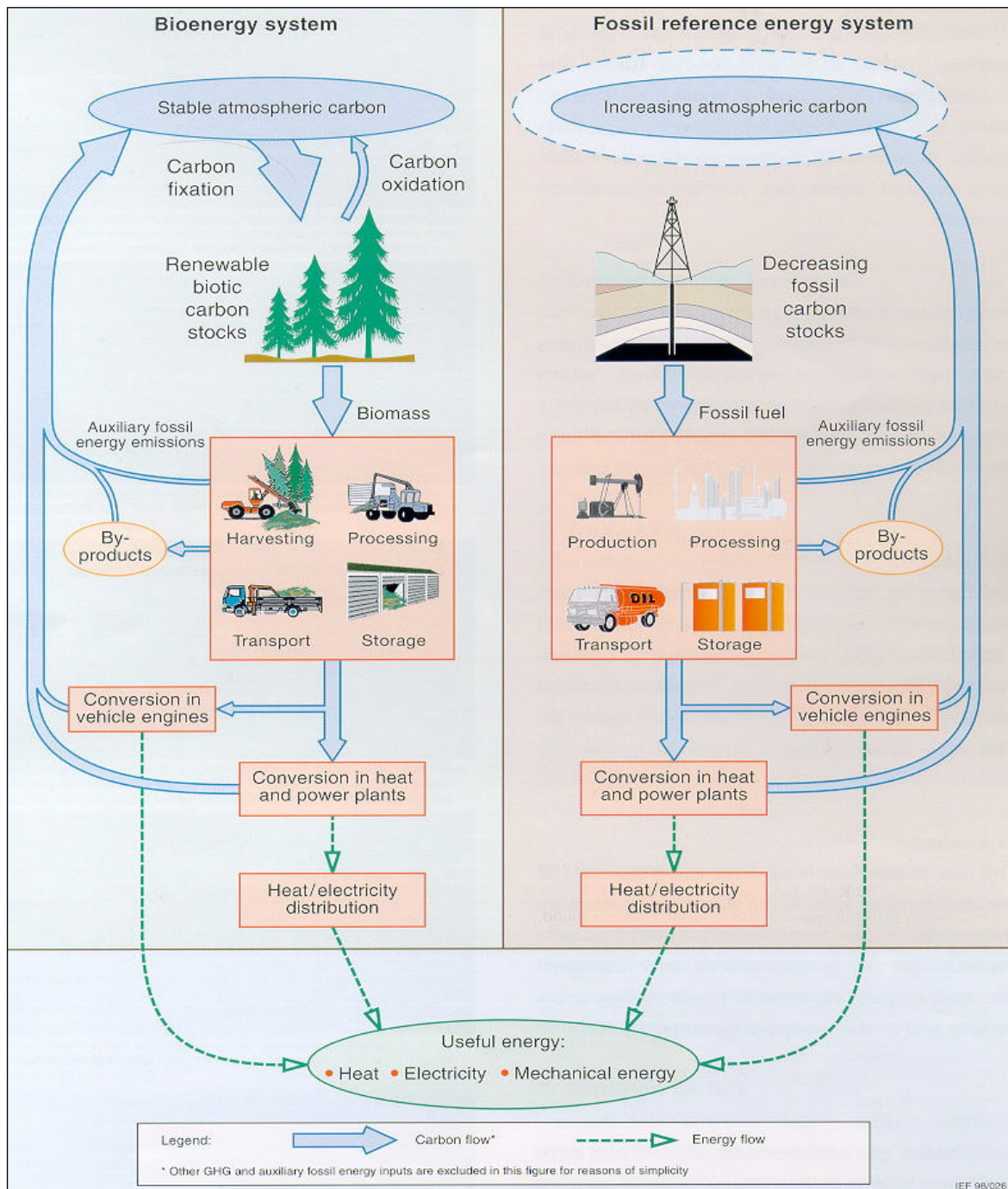
## **Carbon storage dynamics**

The carbon stock in plants, plant debris and soils can change when biomass is grown and harvested. Such changes in carbon stock might extend over long periods of time, after which a new equilibrium is approached, thus necessitating time-dependent analyses.

## **Trade-offs and synergies**

Afforestation or forest protection measures can be effective measures for mitigating the rise of CO<sub>2</sub> in the atmosphere, but may compete with biomass production on limited land resources. In such cases trade-offs between biomass harvest and carbon storage in biomass must be considered. An example of synergy is that found in afforestation or reforestation with an integrated production system for wood and bioenergy, in which the stand is thinned to maximize value of wood production, and thinnings are utilized for bioenergy.

**Figure 1: Standard Methodology**



**Permanence**

Bioenergy provides an irreversible mitigation benefit when it displaces energy consumption from fossil fuels. Mitigation benefits of afforestation or forest protection will be lost if deforestation occurs.

**Emission factors**

Biomass fuels can have higher carbon emission rates (amount of carbon emitted per unit of energy) than fossil fuels (e.g. oil, or natural gas) due to generally lower energy density of biomass. This fact is only relevant, when biomass fuels are derived from unsustainable land-use practices (the carbon emissions from combustion of sustainable biomass are excluded from calculations because they are counterbalanced by the uptake of CO<sub>2</sub> as the feedstock is grown i.e. the photosynthetic and combustion stages of the life cycle are carbon neutral).

**Efficiency**

The efficiency of bioenergy systems (e.g. energy output per unit of feedstock energy or mass) may in some cases be lower than that of fossil energy systems. Recent technological developments have increased the efficiency of bioenergy systems (e.g. Integrated Gasification Combined Cycle – IGCC).

**Upstream energy inputs**

Production, transport and conversion of biomass fuels require auxiliary inputs of energy, which must be included in the assessment, as must the energy requirements for the supply of fossil fuels on which the reference energy system is based.

**By-products**

Bioenergy systems often produce other products besides energy. Bioenergy may be a by-product, for example from a forestry system. In other cases, bioenergy is the main product and non-energy by-products are produced, such as the residue ('distillers dried grains') resulting from the corn-to-ethanol process. The emissions and offsets associated with both products and by-products must be estimated and allocated.

**Leakage**

The use of biomass fuels does not always reduce GHG emissions to the extent suggested by the amount of bioenergy actually used, but rather may increase the total GHG emissions due to increases in emissions outside the system boundary, a phenomenon commonly referred to as "leakage". Leakage may result from increase in the total energy use, due to greater energy availability, or indirect land use change, where land used for food or feed is converted to bioenergy use, and land use change occurs elsewhere to provide for the displaced agricultural production. Leakage, though difficult to estimate, should be included in assessing the net effect on GHG emissions of bioenergy systems.

**Other greenhouse gases**

Greenhouse gas emissions associated with both fossil and bioenergy fuel chains include not only CO<sub>2</sub>, but other gases such as CH<sub>4</sub> and N<sub>2</sub>O that must also be considered.



## Highlights of Task 38 Activities

### Frequently Asked Questions

The “*Answers to Ten Frequently Asked Questions about Bioenergy, Carbon Sinks and Their Role in Global Climate Change*” (FAQ) is a paper that aims to inform industry, scientists, policy makers and interested public about some key issues surrounding these topics.

The FAQ explain:

1. The difference between CO<sub>2</sub> emissions from bioenergy and from fossil fuels.
2. How trees and forests act as a carbon sink.
3. The effect of harvesting on carbon sinks.
4. The area of land required to supply bioenergy to a power station.
5. The area of forest required to offset CO<sub>2</sub> emissions from a power station or from running a car.
6. The types of trees and crops that are best as carbon sinks or for bioenergy and wood production.
7. Land management for carbon sinks, bioenergy and fibre production.
8. How the management of land as a carbon sink or for bioenergy production affects other environmental values.
9. The potential to reduce greenhouse gas emissions by using bioenergy and through terrestrial carbon sequestration.
10. The current availability of technology to allow bioenergy to play a role in reducing atmospheric CO<sub>2</sub>.



## Case Studies

Task 38 applies the standard methodology to specific projects to increase understanding of the mitigation value of bioenergy and sequestration projects. Case studies assess and compare the GHG balances of different bioenergy and C-sequestration projects in the participating countries. Examples of case studies include:

- GHG balance of two alternative bioenergy conversion systems (30 MW wood-fired power station, co-firing in a 500 MW black coal-fired power station) in north-east New South Wales, Australia, utilizing biomass produced through conventional plantation forestry;
- GHG balance of a sawmill in New Zealand, equipped with a combined heat and power (CHP) plant utilising sawmill residues of bark and sawdust. The current bioenergy system is compared to the use of natural gas (reference fossil fuel system);
- GHG balances of sequestration from a forest management program in Canada and emissions reductions for a pyrolysis plant which uses thinnings and sawmill residues as feedstock and produces bio-oil for use in either a pulp mill lime kiln or for export;
- GHG balances of bioenergy and carbon sequestration projects in Finland and Sweden, demonstrating links between increased use of construction wood and the use of biomass-fired cogeneration plants to replace fossil fuels;
- GHG balance of small scale bioenergy solutions providing heat, from *Miscanthus* and from wood chips in the United Kingdom;
- GHG emissions reduction potential of biodiesel production in Croatia in the context of Joint Implementation;
- GHG budget for use of peat in Ireland;
- GHG mitigation through import of wood pellets from Canada and palm kernel shell from Malaysia for bioenergy in the Netherlands;
- GHG emissions reduction from anaerobic digestion of dairy waste in California, USA;
- GHG emissions from biogas system utilising maize silage in Austria;
- GHG impacts of pellets produced from woody biomass in British Columbia, Canada, and transported to Europe, USA and Canada, substituting fossil fuels in electricity production;
- GHG mitigation value of biochar used as a soil amendment (Australia);
- GHG and energy balance of a biorefinery creating ethanol from forest residues (Austria);
- GHG and energy balance for systems producing biofuels (DME and Fischer-Tropsch) from pulp & paper mill residues, black liquor and other biomass sources (harvest residues and peat) in Finland and Sweden; and
- Comparison of FISCHER-TROPSCH-diesel and CHOREN process for liquid biofuels from woody biomass (short rotation coppice, post-consumer wood and industrial roundwood) (Germany).

## Scientific and Technical Support

The Task supports development and implementation of climate change policy through contribution to methodology for project and national scale greenhouse gas inventories, and sustainability assessment, for example regarding approaches for estimating net GHG emissions of from harvested wood products, from afforestation and reforestation and from bioenergy.

## Workshops

Each year, one to two workshops on topical issues are organized, attracting experts in the field from around the world, enabling the exchange of ideas and experiences, and providing a creative forum to facilitate collaborative work.

## Other Activities

### Papers on Special Topics

The Task prepares papers and reports on topical issues. Examples include:

- *'The Impact of Soil Carbon Change on GHG Balance of Bioenergy Systems'*, and
- *'Options for Trading Bioenergy Products and Services'*.

### Collaboration With Other Tasks

Task 38 addresses a cross-cutting issue, relevant to the range of bioenergy technologies that are addressed by other specific tasks. Task 38 works with other tasks to provide expertise on GHG assessment. For example, Task 38 has worked with Task 40 (on biomass trade) and Task 29 (on socio-economic drivers) to consider issues of sustainability of bioenergy.

As the use of biomass increases, especially in more densely populated areas, biomass will be transported and traded over longer distances. Pressure on land use will increase and indirect land use may result. Task 38 is working with other tasks to investigate the GHG aspects of trading biomass in various forms, its role in national policies to reduce net greenhouse gas emissions, the role of biomass trade in fulfilling Kyoto Protocol targets, and how mitigation benefit of traded biomass fuels is included in national GHG inventories and bioenergy policies.



# Task Publications

## Workshop Proceedings and Presentations

Available from:

<http://task38.org/html/workshops.html>

**Impact of timing of GHG emissions.** Vienna, Austria. November 2012.

**How to present the timing of emissions from bioenergy in LCA and GHG accounting.** Argonne, France. April 2012.

**Quantifying and managing land use effects of bioenergy.** Campinas, Brazil. September 2011.

**Greenhouse gas emissions from bioenergy systems: impacts of timing, issues of responsibility.** Brussels, Belgium. March 2010.

**Land use changes due to bioenergy quantifying and managing climate change and other environmental impacts.** Helsinki, Finland. March 2009.

**The woodfuel supply chain: Sharing experience.** Task 31/38/40 Workshop. Warwick, UK. September 2008.

**Transportation biofuels: For greenhouse gas mitigation, energy security or other reasons?** Salzburg, Austria. February 2008.

**Expert consultation on sustainable bioenergy.** Dubrovnik, Croatia. October 2007.

**Policies and instruments to promote bioenergy and bioproducts for GHG mitigation.** Berlin, Germany. May 2007.

**Greenhouse gas credits trade versus biomass trade - weighing the benefits.** Trondheim, Norway. April 2006.

**Greenhouse gas aspects of biomass cascading - reuse, recycling and energy generation.** Dublin, Ireland. April 2005.

**Forest carbon accounting, carbon offset trading and opportunities to enhance bioenergy.** Victoria, Canada. September 2004.

**Efficient use of biomass for greenhouse mitigation.** Östersund, Sweden. September – October, 2003.

**Biomass trade: Economic and greenhouse gas considerations (biotrade).** Amsterdam, The Netherlands. June 2002.

**The economics of substitution management to reduce net GHG emissions & Forest-based carbon mitigation projects: dealing with permanence, leakage, additionality, uncertainties, and socio-economic and environmental issues.** Graz, Austria. April 2002.

**Successful strategies for biomass-based GHG emissions reduction and mitigation: Translating research into policy and implementation.** Edinburgh, UK. November 2001.

**Carbon accounting and emissions trading related to bioenergy, wood products and carbon sequestration.** Schlamadinger B., Woess-Gallasch S. and Cowie A. (eds). July 2001. *Proceedings of the Task 38 Workshop in Canberra, Australia.* 26-30 March 2001.

**Land use, land-use change and forestry: the road to COP6.** Robertson K.A. and Schlamadinger B. (eds). October 2000. *Proceedings of the Task 25 workshop in Joensuu, Finland.* 28 September 2000.

**Bioenergy for mitigation of CO<sub>2</sub> emissions: the power, transportation, and industrial sectors.** K.A. Robertson and B. Schlamadinger (eds). January 2000. *Proceedings of the Task 25 Workshop in Gatlinburg, USA.* 27-30 September 1999.

**Between COP3 and COP4: The role of bioenergy in achieving the targets stipulated in the Kyoto Protocol.** R. Madlener and K. Pingoud (eds). November 1998. *Proceedings of the Task 25 Workshop in Nokia, Finland.* 8-11 September 1998.

**Effects of the Kyoto Protocol on forestry and bioenergy projects for mitigation of net carbon emissions.** B. Schlamadinger and R. Madlener (eds). April 1998. *Proceedings of the Task XV/25 Workshop in Rotorua, New Zealand.* March 1998.



**Greenhouse gas balances of bioenergy from forestry and wood industry.** Schlamadinger, B. and Spitzer, J. (eds). *Biomass & Bioenergy*, 1997 Special Issue, 13(6). *Proceedings of the Task XV Workshop in Stockholm, Sweden*. May 1996.



## Brochures and statements

Available from:

<http://task38.org/html/publications.html>

**Case studies:** As listed on page 5

**Answers to ten frequently asked questions about bioenergy, carbon sinks and their role in global climate change.** R. Matthews and K. Robertson. September 2001. Revised 2006.

**Editorial: Land use impacts of bioenergy. Selected papers from the IEA Bioenergy Task 38 meetings in Helsinki, 2009 and Brussels, 2010.** S. Woess-Gallasch, N. Bird and A. Cowie. December 2011.

**Alternative GHG accounting systems for bioenergy: Descriptions and evaluations.** N. Bird, N. Pena, G. Zanchi and D. Frieden. June 2011.

**The influence of Emissions Trading Schemes on bioenergy use.** A. Tuerk, A. Cowie and A. Leopold. March 2011.

**Emissions from bioenergy: Improved accounting options and new policy needs.** D.N. Bird. et al. 2010.

**Bioenergy: Counting on incentives. Response to the paper by D. Searchinger et. al.** K. Pingoud, A. Cowie, N. Bird, L. Gustavsson, S. Rüter, R. Sathre, S. Soimakallio, A. Tuerk and S. Woess-Gallasch. *Letters to Science*. Vol 327 (2010), p. 1199 - 1200.

**Sustainability of bioenergy.** *Joint IEA Bioenergy Task29/38/40 Expert Consultation, Dubrovnik, 25-26 October, 2007 and Task 38 workshop on direct and indirect land use change.* Helsinki 30 March-1 April 2009.

**Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations.** Francesco Cherubini et al. Elsevier, June 2009.

**Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations.** Francesco Cherubini et al. Elsevier, June 2009.

**Incorporating changes in albedo in estimating the climate mitigating benefits of bioenergy projects.** N. Bird, S. Woess-Gallasch.

**Bioenergy: the relationship with greenhouse gases in agriculture and forestry.** N. Bird et al.

**Special Issue: Efficient use of biomass for mitigating climate change.** *Mitigation and Adaptation Strategies for Global Change*. Vol. 11, Nos. 5-6, September-November 2006.

**T 38 and 40 Brochure on bioenergy trade.** B. Schlamadinger, A. Faaij, M. Junginger, S. Woess-Gallasch and E. Daugherty.

**The role of soil carbon in the GHG balance of bioenergy systems.** Annette Cowie.

**Options for trading bioenergy products and services.** B. Schlamadinger, A. Faaij, M. Junginger, S. Woess-Gallasch and E. Daugherty. *IEA Bioenergy Annual Report*, 2005.

**Key terms used in greenhouse gas reporting and accounting for the land use, land use change and forestry sector.** A. Cowie, K. Pingoud, K. Robertson, B. Schlamadinger, et al.

**Optimizing the greenhouse gas benefits of bioenergy systems.** (Paper and Poster). 14<sup>th</sup> *European Biomass Conference*, Paris, 2005.

**A review of greenhouse gas emission factors for fertiliser production.** S. Wood and A.L. Cowie.

**Development of standard tool for evaluating greenhouse gas balances and cost effectiveness of biomass energy technologies. BIOMITRE Software Tool Introduction.** *World Conference of Biomass*. Rome 2004.

**Should we trade biomass, electricity, renewable certificates, or CO<sub>2</sub> credits?** *World Conference of Biomass*. Rome 2004.

**Bioenergy and the clean development mechanism.** *World Conference of Biomass*. Rome 2004.

**Harvested wood products in GHG inventories: Approaches for inclusion of harvested wood products in future GHG inventories under the UNFCCC, and their consistency with the overall UNFCCC inventory reporting framework (PDF).**

**Options for trading bioenergy products and services.** *Task 38 and Task 40*. 2005.

**Accounting system considerations: CO<sub>2</sub> emissions from forests, forest products, and land-use change - a statement from Edmonton.** M. Apps, T. Karjalainen, S. Marland, and B. Schlamadinger. July 1997.

**The role of bioenergy in greenhouse gas mitigation.** *A position paper prepared by IEA Bioenergy Task 25.* November 1998.

**Approaches for inclusion of harvested wood products in future GHG inventories under the UNFCCC, and their consistency with the overall UNFCCC inventory reporting framework.** K. Pingoud, B. Schlamadinger, S. Grönkvist, S. Brown, A. Cowie, and G. Marland. 2004.

**Sustainability of bioenergy.** *A Joint Statement from Tasks 29, 38, 40 Resulting from 2007 Workshop, Dubrovnik.* [http://task38.org/html/bioenergy\\_sustainability.html](http://task38.org/html/bioenergy_sustainability.html)

## Journal and conference papers.

**Towards a standard methodology for greenhouse gas balances of bioenergy systems in comparison with fossil energy systems.** B. Schlamadinger, M. Apps, F. Bohlin, L. Gustavsson, G. Jungmeier, G. Marland, K. Pingoud, I. Savolainen. 1997. *Biomass and Bioenergy*, 13: 359-375.

**Land use, land-use change, and forestry in the Kyoto Protocol.** B. Schlamadinger (ed). 1999. *Special Issue of Environmental Science and Policy*, Volume 2, Number 2.

**Project-based greenhouse gas accounting: guiding principles with focus on baselines and additionality.** L. Gustavsson, T. Karjalainen, G. Marland, I. Savolainen, B. Schlamadinger, and M. Apps. 2000. *Energy Policy*, 28: S. 935-946.

**IEA Bioenergy – a summary of 5 years work on “bioenergy and greenhouse gases.** K.A. Robertson and B. Schlamadinger. *Proceedings of the 1<sup>st</sup> Conference on Biomass for Energy and Industry*. Sevilla, Spain. 5-9 June 2000.

**Should we trade biomass, electricity, renewable certificates, or CO<sub>2</sub> credits?** B. Schlamadinger, A. Faaij and E. Daugherty. 2004. *2<sup>nd</sup> World Biomass Conference*. Rome, Italy.

**Optimizing the greenhouse gas benefits of bioenergy systems.** B. Schlamadinger, et al. 2005. *14<sup>th</sup> European Biomass Conference*. 17-21 October 2005. Paris, France.

**Options for trading bioenergy products and services.** B. Schlamadinger, A. Faaij, M. Junginger, S. Woess-Gallasch and E. Daugherty. 2005. *IEA Bioenergy Annual Report*.

**Efficient use of biomass for mitigating climate change.** *Special Issue Mitigation and Adaptation Strategies for Global Change*. Vol 11. 2006.

**Stock changes or fluxes? Resolving terminological confusion in the debate on land-use change and forestry.** A.L. Cowie, K. Pingoud, and B. Schlamadinger. *Climate Policy* 6. 2006. 161–179.

**Bioenergy: The relationship with greenhouse gases in agriculture and forestry.** Neil Bird et al. *16<sup>th</sup> European Biomass Conference and Exhibition*. 2-6 June 2008. Valencia, Spain.

**IEA Bioenergy TASK 38. Ten years of analysing the greenhouse gas balances of bioenergy systems.** Neil Bird et al. *17<sup>th</sup> European Biomass Conference and Exhibition*. 29 June – 03 July 2009. Hamburg, Germany.

**Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations.** F. Cherubini, N.D. Bird, A. Cowie, G. Jungmeier, B. Schlamadinger, S. Woess-Gallasch. *Resources Conservation & Recycling*. 2009. 53(8):434-447.

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