IEA BIOENERGY TASK 38
TEN YEARS OF ANALYSING THE GREENHOUSE GAS BALANCES OF BIOENERGY SYSTEMS

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ABSTRACT: IEA Bioenergy is a collaborative network under the auspices of the International Energy Agency (IEA) that promotes international co-operation and information exchange between national bioenergy RD&D programmes. IEA Bioenergy Task 38 integrates and analyses information on greenhouse gases, bioenergy, and land use, thereby covering all components that constitute a biomass or bioenergy system. In 1997, Task 38 published the standard methodology for greenhouse gas balances of bioenergy systems. The standard methodology includes the carbon losses and gains from all terrestrial pools within the system in a transparent manner. This point, specifically soil carbon, has been a point of discussion in the recent EU-Directive on energy from renewable sources. The benefits of a standard methodology are that it allows for a transparent and balanced comparison of the greenhouse gas balances from different systems. Since the standard methodology was published members of Task 38 have used this methodology to analyse the greenhouse gas balances of more than 15 different bioenergy systems in participating countries. The paper will summarize the results of these analyses and discuss the need for updating the "standard" methodology to account for the EU-Directive and greenhouse gas emissions from indirect land-use changes and other environmental effects. The case study work plan for the period 2010 – 2012 will also be presented
Keywords: bioenergy, greenhouse gases (GHG), life cycle assessment (LCA)

1 INTRODUCTION

Bioenergy has been identified as a relatively inexpensive climate change mitigation strategy because it is considered to be a CO_2 neutral energy source, if the bioenergy is sustainably produced (i.e. from a renewable biomass source)[1]. For this reason, there has been a large interest in the greenhouse gas balances (GHG) of bioenergy systems. About ten years ago, a task of IEA Bioenergy was formed to study this topic. This paper briefly summarises results of the past ten years and discusses future directions for the next three years.

2 WHAT IS TASK-38?

IEA Bioenergy Task-38 is a group of researchers from various developed countries that work on the specific theme: "GHG Balances from Biomass and Bioenergy Systems". Task 38 is part of IEA Bioenergy, which was set up in 1978 by the International Energy Agency (IEA) as an international network for coordinating national R&D programs and exchanging information. Currently, 21 countries or organizations are members of IEA Bioenergy.

Countries participating in Task-38 have changed over the past ten years. In 2009, Australia, Austria, Belgium, Croatia, Finland, Germany, Sweden and the United States participated in the Task. Previously, Canada, England, Ireland, the Netherlands and New Zealand have also played a role.

Task 38 has the objective to:

1. Promote the sustainable use of biomass and bioenergy through increased understanding of the GHG and other impacts;
2. Improve and modify the "standard methodology" for the calculation of GHG balances based on life-cycle analysis by incorporating new issues, technologies and topics as they appear;
3. Work in cooperation with other IEA Bioenergy Tasks to assess GHG balances of new technologies;
4. Assess and report on best practices in participating countries for reducing GHG emissions using biomass and bioenergy; and
5. Aid decision makers in selecting mitigation strategies that optimise GHG benefits by disseminating the results of the above-mentioned activities.

3 RESULTS FROM THE PAST TEN YEARS

3.1 The standard methodology

The Task uses a "standard methodology"[2] to estimate the emissions and removals of the three main greenhouse gases (CO_2, CH_4, and N_2O), over the entire life cycle of biomass and bioenergy systems. The standard methodology (

Figure **1**) is a systematic framework for comparing the full fuel chains of a bioenergy and a fossil system.

The bioenergy chain starts with carbon fixation from the atmosphere via photosynthesis. The fossil energy chain starts with the depletion of fossil carbon stocks. There are six processes in a biomass/bioenergy system:

1. land resource conversion,
2. biomass production,
3. transportation,
4. conversion to energy,
5. distribution and
6. end-use.

The assessment is compared with a reference system (usually the business-as-usual activity).

At the end of both chains, an amount of useful energy (electricity, heat and mechanical energy) is supplied. Along the both chains, changes in all biomass pools (above and below-ground biomass, dead wood, litter, soils, and wood products in service and in landfills) – in particular soils, all energy inputs and GHG emissions must be accounted for in a life cycle perspective. Utilization of by-products should also be considered, since such they can displace other materials and thus have a GHG and energy implication. If compared in this manner, the differences between the two systems can be presented.

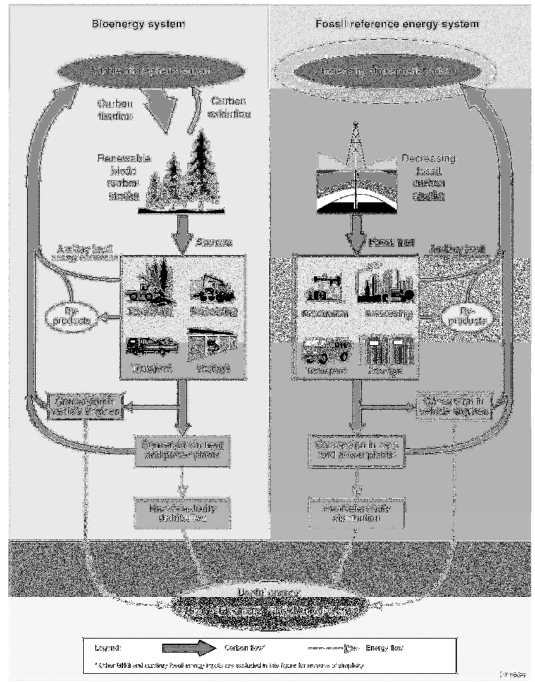

Figure 1: the standard methodology for comparing bioenergy and fossil energy systems

The standard methodology stresses the importance of the clear and concise description of the system and system boundary, by-products and potential leakage (emissions that occur outside the system boundary). The standard methodology also stresses the importance of comparing the systems on the basis of functional unit: t CO_2-eq/output unit, t CO_2-eq/input unit and GJ energy/input unit. Typical output units are km-driven, GJ heat or MWh electricity produced. Input units for comparison should be tonne (t) of biomass or area under production (ha).

3.2 Case studies

Using the standard methodology, the Task has analyzed 18 case studies, over the last 10 years, selected based on the interest of the participating countries. All case studies are available on the Task website (www.ieabioenergy-task38.org).

A good example looks at integrated plantation forestry in North East NSW, Australia[3].This study assesses the potential GHG emission reduction from biomass used in two energy conversion options: co-firing in black coal power plants located far from the biomass source, or in stand-alone wood-fired plants located near the biomass source. The biomass used for energy comes from thinning, harvest and sawmill residues from plantation forests in northern New South Wales (NSW). The reference system is electricity generated from burning black coal. Emission reduction per ha, and per unit electricity produced are calculated for two levels of plantation productivity. Co-firing gave higher emissions reduction per ha, and per unit of biomass, due to the greater efficiency of energy conversion by co-firing.

The analysis found that the co-firing system reduced emissions by 850 t CO_2-eq / kWh electricity produced and the wood-fired plants saved 910 t CO_2-eq / kWh electricity produced. On a per hectare basis, the co-firing system saved 16.1 t CO_2-eq / ha and the wood-fired plants reduced emissions by 11.8 t CO_2-eq / ha.

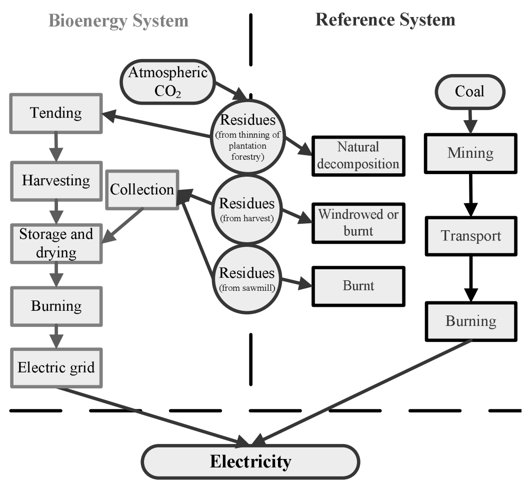

Figure 2: system diagram for integrated plantation forestry in North East NSW, Australia [4]

3.3 Workshops

Task-38 annually organizes one workshop on a current issue facing bioenergy. The goal of these workshops is to bring together researchers, policy and decision makers to discuss the current issue of interest and to provide a concrete summary of these discussions. Of note, in 2007, the Task co-organized a workshop, in co-operation with other IEA Bioenergy Tasks, entitled: "Sustainable Bioenergy" (www.ieabioenergy-task38.org/workshops/dubrovnik07/). An output from this workshop was a four-page statement on the sustainability of bioenergy. In 2009, another very interesting workshop addressed the issue of "land use changes due to bioenergy: quantifying and managing climate change and other environmental impacts" (www.ieabioenergy-task38.org/workshops/helsinki09/)

3.4 Policy briefs and position papers

The Task has also prepared numerous policy briefs and position papers. The most accessed of these are : *The Role of Bioenergy in Greenhouse Gas Mitigation*, *Frequently asked questions about bioenergy*, and *Does soil carbon loss in biomass production systems negate the greenhouse benefits of bioenergy?*. All are available at www.ieabioenergy-task38.org

4 LOOKING AHEAD – THE NEXT TRIENNIUM (2010 – 2012)

In the next three years, the Task will continue to organize an annual workshop (usually in 1Q) and prepare case studies, but the emphasis will be more on policy briefs and position papers than case studies. Specifically, the Task plans to revitilize the standard methodology to include the latest standards from the life cycle assessment community. As well, the Task will investigate a standard method for incorporating indirect land use change, albedo change and the issue of timing and stabilization targets.

4.1 Case Studies

The Task has already identified potential case studies for the next triennium. Of course these may change during this period depending on the needs of the participating countries. These include:

- Ethanol from sorghum and lignocellulosic feedstocks in Australia;
- Charcoal production from a cascaded biomass system in Croatia:
- Soil carbon emissions from long term switchgrass cultivation in the United States;
- Combined improved forest management and material substitution; and
- GHG balances and sustainability of whole tree harvesting and stump harvesting

4.2 Indirect land use change

Indirect land use change is defined as land use change that occurs outside the system boundary as a result of the land use change within the system boundary. For example, the increase of corn for ethanol in the United States causes an increase in soy bean production in Brazil to provide feed for cattle in the United States and elsewhere. The land use change within the system boundary (corn from cattle feed to bioenergy crop) causes in an indirect land use change (forest to soy bean cultivation) outside the system boundary in Brazil. As a result the greenhouse gas emission benefits from bioenergy system must overcome a carbon debt due to the deforestation that may last for years [5, 6].

In terms of the "standard methodology", indirect land use change was considered a form of leakage. It can be reduced by project design by:

1. using biomass residuals and wastes that do not have other uses and would otherwise decompose naturally on site or in landfills;
2. selecting lands for bioenergy that do not displace other production;
3. increasing production or improving efficiency so that bioenergy crops and food are grown on the existing land.

Emissions from indirect land use change can be estimated by:

1. expanding the system boundary to include the land use change (i.e.: making indirect land use change direct land use change); or
2. estimating the amount of indirect land use change by economic models or other means.

The current focus in scientific literature is on indirect land use change caused by the conversion of agricultural crops to bioenergy crops, but indirect land use change could occur any time biomass is used for bioenergy that previously had some other use (for example, wood pulp).

Previous case studies included discussion about leakage but may not have properly assessed impacts of indirect land use change in a methodological manner. The Task plans to develop a consistent method for the incorporation of the emissions from indirect land use change over the next year.

4.3 Albedo change

Land use change that converts non-forest land to forest land removes carbon dioxide from the atmosphere and stores it in trees and shrubs in the form of carbon.

The land use change can also cause a change in surface albedo that can contribute significantly to radiative forcing if the non-forest land had deep snow in winter and coniferous forests are created [7, 8].

In a previous paper [9], by members of the Task, a model was developed to incorporate the changes in albedo in estimating the climate change mitigation benefits from land-use change projects, and display the results as either radiative forcing or equivalent greenhouse gas emissions. The results of this paper have been updated here to include an improved atmospheric transfer model [10].

Figure 3 shows the modelled combined cumulative emissions from a Robinia reforestation project in Romania. The Robinia sequesters carbon as it grows (negative emissions) but this is offset by the equivalent emissions of the increased radiative forcing caused by the change in albedo. The Robinia is darker in winter than the surrounding fields because there is snow during the months of December to March. The analysis is still preliminary because research is on going. The results are very sensitive to the amount and types of cloud and the relationship between canopy closure and sequestration.

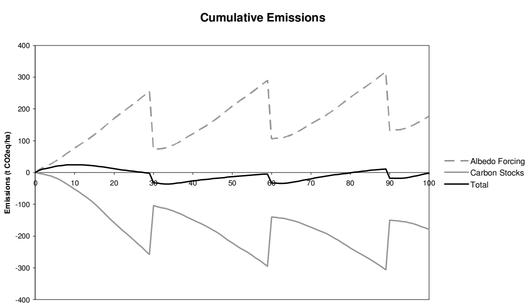

Figure 3: Combined change in biomass and radiative forcing for an reforestation project using Robinia, in Romania

4.4 Timing and stabilization targets

Finally, we plan to revisit the issue of timing of emissions and stabilization targets. With some bioenergy systems, there is a large emission followed by numerous years of emissions savings due to the replacement of fossil fuels with biomass derived fuels. As already noted, the system may require tens of years to repay the original greenhouse gas emission during its establishment. Once repaid, the bioenergy system can go on producing near CO_2 neutral energy for eternity, but does such an emissions profile support climate stabilization targets?

The IPCC Fourth Assessment Report is unclear as to which climate stabilization targets should be adopted [1]. We can choose stabilization of greenhouse gas emissions, radiative forcing, temperature, or change in temperature by a given year, for example.

Figure 4 shows the comparison of the cumulative emissions, radiative forcing and cumulative radiative forcing for a simple bioenergy system. To illustrate the differences, I have assumed that the bioenergy system causes an emission of 1 t CO_2e during establishment with emissions reductions that are paid back over the next 25 years. After 25 years, the system has begins to make net emission reductions. In terms of radiative forcing, the system causes cooling after 20 years since some of the emission at the start of the system is naturally absorbed by the biosphere. If one looks at cumulative radiative forcing, which may be a proxy for temperature, the system only has a negative radiative forcing after 45 years.

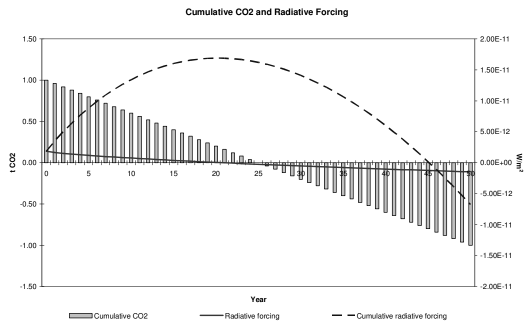

Figure 4: Comparison of cumulative emissions, radiative forcing and cumulative radiative forcing

5 CONCLUSIONS

For ten years, IEA Bioenergy Task 38 has been providing quality analysis of the greenhouse gas balances of bioenergy systems. For a proper comparison of bioenergy systems to other energy systems, the Task has consistently stressed the importance of:

1. Proper system scoping and description;
2. By-products;
3. All carbon pools (specifically soil);
4. Leakage; and
5. Functional unit

As well, the Task has continuously stressed the importance of using biomass residuals and waste streams as the source of biomass.

The “standard methodology” has served us well over the past ten years. Nevertheless, it needs to be revitilized by including the latest thinking from the life cycle assessment community, indirect land use change, albedo change and the effects of timing of emissions with respect to climate stabilization targets. In the next three years, we plan to address these issues.

6 RESPONSIBILITY

Sections 4.3 and 4.4 are the responsibility of the first author alone and do not necessarily represent the views of all authors listed.

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