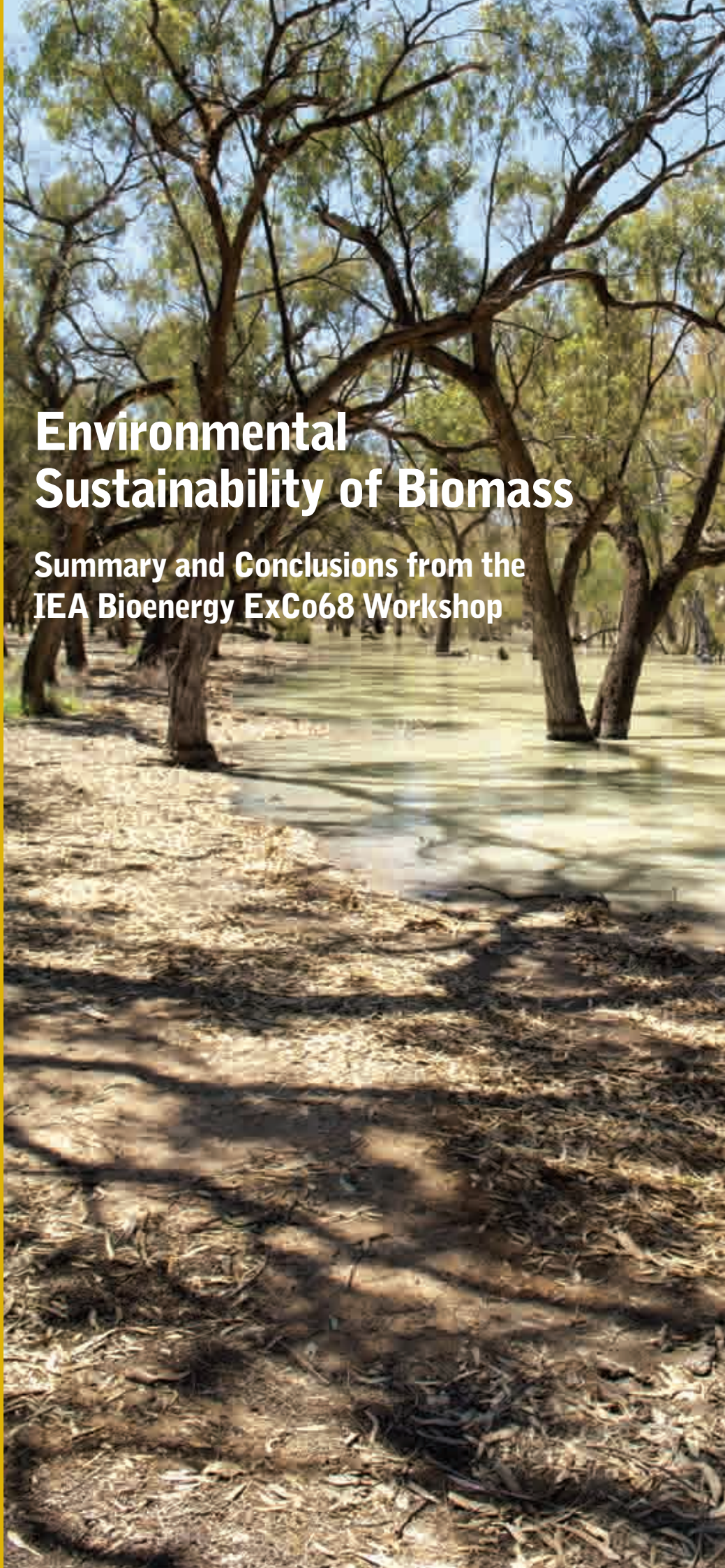


This publication provides the summary and conclusions from the workshop 'Environmental Sustainability of Biomass' held in conjunction with the meeting of the Executive Committee of IEA Bioenergy in Twin Waters, Queensland, Australia, on 24 November 2011.

The purpose of the workshop was to provide the Executive Committee with perspectives on sustainability aspects such as GHG emissions, feedstock production, certification, soil conservation and governance. The aim was to stimulate discussion between the Executive Committee, Task Leaders and invited experts, and thereby enhance the policy-oriented work within IEA Bioenergy.

# Environmental Sustainability of Biomass

## Summary and Conclusions from the IEA Bioenergy ExCo68 Workshop





## INTRODUCTION

The IEA Bioenergy workshop on environmental sustainability of biomass was initiated by Tasks 38, 40 and 43, all three dealing with sustainability aspects such as GHG emissions, feedstock production, certification, soil conservation and governance. The workshop was an integral part of the 12th Bioenergy Australia Conference 'Towards 2020: Growing Our Sustainable Future'. It was held in Twin Waters, Queensland and attended by 300 delegates. The programme featured over 100 presentations covering many bioenergy-related topics, policies and programmes.

## OPENING

The workshop was opened by the Australian ExCo Member and conference organiser Steve Schuck. He highlighted Australia's interest in biomass and participation in IEA Bioenergy's Tasks. He briefly discussed the Australian Government's upcoming Draft White Paper on energy<sup>1</sup> which reviews Australia's future energy needs to 2030 and defines a comprehensive strategic policy framework. Energy production will primarily be based on Australia's large resources of coal, uranium and gas (including coal seam gas).

Electricity production is likely to be based increasingly on gas. The legislated 20% by 2020 Renewable Energy Target Scheme secures an additional 45,000 GWh a year of renewable electricity generation by 2020 and continuing to 2030, through the creation of a regulated market for tradable renewable energy certificates. From 2011 the Renewable Energy Target Scheme has been divided into large and small-scale renewable energy targets. The carbon pricing mechanism will be the principal clean energy deployment incentive mechanism, with the Renewable Energy Target acting as transitional support for eligible renewable energy generators. In addition to supporting renewable energy through carbon pricing and the Renewable Energy Target, the Australian Government is streamlining and building on the funding support available for emerging technologies. Government support for the Solar Flagships Programme and geothermal energy are other focus areas through the Emerging Renewables Programme. Liquid biofuels have been supported through the AUD\$14 million Gen 2 Biofuels Programme and excise exemption to compliant biofuels.

The Australian Government has developed a comprehensive plan to move to a clean energy future. Central to that plan is the introduction of a carbon price that will cut pollution in the cheapest and most effective way and drive investment in clean energy sources.

## WORKSHOP

The workshop was chaired by Birger Kerckow, Chairman of IEA Bioenergy. In his introduction he pointed out that biomass is and will play a major role in the development of energy sources according to the Road Map of the International Energy Agency.

The discussions of the morning and afternoon session of the workshop were moderated respectively by Josef Spitzer, Austria, and Brendan George, Australia.

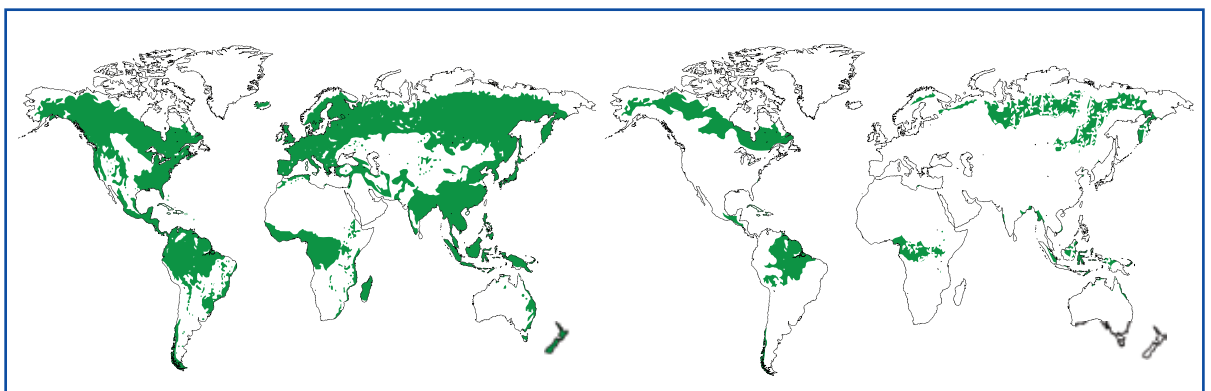
The workshop started with overarching contributions on biophysical global potential by Göran Berndes, Task 43; on international attempts to define sustainable bioenergy, and international trade by Andre Faaij, Task 40; followed by multiple themes, particularly in relation to the management of 'risk'. While industry concentrated on technical risks, it is the sovereign risk, reflecting societal demands that is also very important.

### Expanding Bioenergy: Global Potentials and Regional Challenges - Goran Berndes, Chalmers University, Sweden and IEA Bioenergy Task 43 Leader, Göteborg, Sweden

This presentation provided an overview of studies that have assessed global and regional bioenergy potential (2050 time frame) and the factors identified as critical determinants of this potential. Based on this overview, options for realising potential were presented, including a discussion on risk.

One of the major factors limiting agricultural growth is nitrogen. However, human needs are equally, if not even more important. One third of the protein we eat is related to oil. The production of 1kg of nitrogen (ammonium sulphate) requires an equivalent of one litre of oil (approximately 10 kWh).

Original virgin forests are disappearing mainly due to crop production for animal feed (Figure 1). Most of today's existing forests are managed and have a much lower density.



**Figure 1.** Frontier forests 8000 years ago (left) and today. (right).

<sup>1</sup> Australian Government. Department of Energy, Resources and Tourism. [www.energywhitepaper.ret.gov.au](http://www.energywhitepaper.ret.gov.au)

According to FAO, food production will have to at least double by 2050. At the same time the bioenergy demand to maintain CO<sub>2</sub> at < 440ppm will be far higher. To fulfil both needs the following goals must be achieved:

- Produce more food on a significantly smaller area with lower impacts, i.e. increase plant efficiency
- Increase the biomass output from forestry while keeping the forests healthy and respecting biodiversity requirements
- Expand bioenergy production in ways that are acceptable from the perspectives of resources (energy, water, etc.), the environment, and the socio-economy.



**Figure 2.** Integration of *Eucalyptus* with cattle production in Brazil. Combined bioenergy-food production systems may become more common in the future as a way to diversify and optimise the productive use of land, water and other resources. Courtesy: Laércio Couto, RENABIO.

In particular more forest-grown biomass and alternative energy crops are needed that are environmentally compatible (fast growing, low water consumption, heat or cold resistant, etc.) and compete as little as possible for land used for food and feed production. Food and fuel production requires high productivity agriculture. In the long term human dietary habits need to be changed to eating less meat and more plant proteins. Wild fish is not an alternative since global fish stocks are already suffering from overfishing.

The expansion of land based biomass has to be guided towards combining large carbon stocks with high levels of biodiversity in order to avoid problems of indirect land use change (iLUC). This all sounds reasonable but the crucial question is how to expand biomass production systems? One solution is multi-level agriculture such as in southern China with rubber trees, tea and pepper plants or like in Brazil with *Eucalyptus* spp., grass and dairy cows (Figure 2), or production of winter feed for cattle on sugarcane land.

In other areas of the world such as India the focus is on the use of waste (degraded) land. In central and northern European countries like Sweden, forestry can be integrated into agricultural production e.g. by planting willow along water ways or around infrastructure installations (e.g. WWTP) where willows will absorb pre-cleaned water. Using agricultural, industrial and municipal wastes is a necessity to start with, but in the longer term will not be sufficient (potentially about 300 EJ).

### Governing Bioenergy: An International Perspective on Attempts to Define and Promote Sustainable Bioenergy Development - Jonathan Reeves, Programme Officer, Global Bioenergy Partnership (GBEP), FAO, Italy

The sustainable development of bioenergy requires evidence-based, integrated governance with a strong international dimension. This requirement is a consequence of the large range of positive and negative impacts – generally externalities – to which bioenergy production and use can give rise. These impacts cross both sectoral and national borders and therefore attempts to govern them, namely to promote potential positive and mitigate potential negative impacts, must do the same. In this governance, there are important roles for governments, the private sector and civil society and there is a strong need for coordination and cooperation in policy development, implementation, and monitoring and evaluation, extending beyond the bioenergy sector.

The Global Bioenergy Partnership (GBEP) was launched in 2005 by a G8 decision. (Gleneagles plan of action). It consists presently of 36 partners (23 governments and 13 organisations) and 34 observers (23 governments and 11 organisations). It has been fully operational for three years. GBEP is currently chaired by Italy and co-chaired by Brazil. The Secretariat is hosted at FAO headquarters in Rome. An increasing number of developing countries are attracted to GBEP.

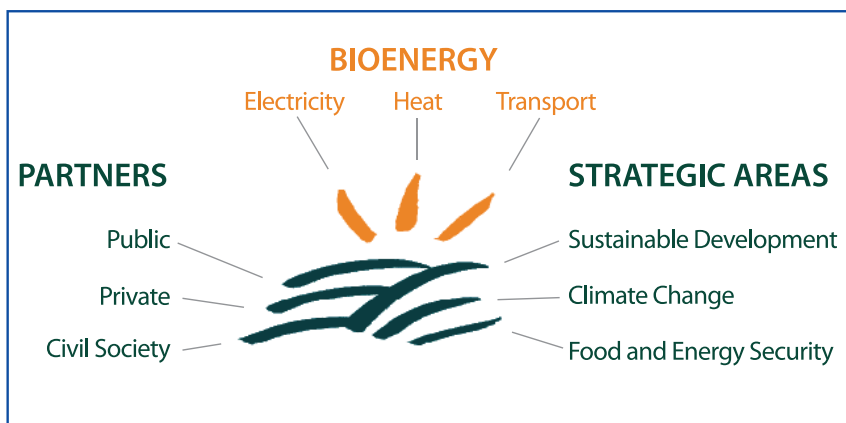
The main objectives of the Global Bioenergy Partnership are to:

- promote global high-level policy dialogue on bioenergy and facilitate international cooperation;
- support national and regional bioenergy policy-making and market development;
- encourage more efficient and sustainable biomass use; and
- foster the exchange of information, skills and technologies through bilateral and multilateral collaboration.

Internationally, there are many fora that discuss biomass/biofuel issues. GBEP is the organisation that brings these together to discuss the sustainable development of bioenergy and its contribution to climate change mitigation, within the framework of a voluntary cooperative, working towards consensus amongst its partners (Figure 3).

In general terms, there are three steps required to govern bioenergy or guide its sustainable development:

- *knowing* the right thing to do, which requires:
  - an analytical framework that can be applied to specific settings
  - information, evidence and the technical capacity to gain these
  - inclusive, participatory decision-making
- *enabling* people to do the right thing, which requires:
  - dissemination of information, transfer of knowledge, extension services, capacity building



**Figure 3.** The role of GBEP in a nutshell

- an enabling legal, policy and institutional environment (clear, transparent, stable, low administrative burden)
- *incentivising* people to do the right thing, which may involve:
  - reinforcing and changing behaviour through incentives (internalising the externalities/payment for ecosystem services/carbon taxes/certification) or obligations (biofuel mandates/polluter pays/thresholds).

The focus of GBEP is on the two first steps.

With the goal of transforming the use of biomass towards more efficient and sustainable practices a Task Force has developed a checklist that comprises ten steps in the full life cycle analysis of GHG emissions from bioenergy production and use. Based on these parameters a set of 24 sustainability indicators have been evolved, which were agreed by all the partners in May 2011 (Table 1). These factors are in line with the major certification schemes for biofuels (mainly liquid) and their feedstocks at the operator level, established by various multi-stakeholder roundtables and biofuel producers. Some of these have been shaped by

The GBEP sustainability indicators for bioenergy need to be pilot tested in a diverse range of national contexts to establish their feasibility and enhance their practicality as a tool for policymaking. These pilot tests are organised in the framework of a capacity building programme sponsored by different countries, e.g. tests in Thailand and Colombia by Germany or in Ghana by The Netherlands. The Netherlands and Germany intend to pilot the indicators in their own countries too, whilst Japan has already started. The scope of the working groups on capacity building are activities and projects for sustainable bioenergy, through collaborative work among GBEP Partners and Observers.

**Prospects for Developing Sustainable International Bioenergy Markets and Trade - Andre Faaij, Copernicus Institute, Utrecht, the Netherlands**

Bioenergy currently contributes around 10% (around 50 EJ) to total global primary energy supply<sup>2</sup> (Figure 4). While the majority of this share is for traditional cooking and heating applications, 38% is regarded as 'modern' usage i.e. with higher conversion efficiency and for the production of high temperature heating, power, or road transportation. Current

the environmental sustainability criteria of EU legislation, with which 7 of the schemes can now be used to show compliance. An ISO process has also been established, which should deliver a standard containing sustainability principles, criteria and measurable indicators for assessing the sustainability of bioenergy by May 2014.

Coupled with policy and market-based instruments, these tools can be used to help promote sustainable bioenergy.

**Table 1:** GBEP's 24 sustainability factors

PILLARS		
Environmental	Social	Economic
INDICATORS		
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 section	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 requalification 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

<sup>2</sup>Lamers, P. et al. 2012; Global wood chip trade for energy. Task 40. [http://www.bioenergytrade.org/downloads/t40-global-wood-chips-study\\_final.pdf](http://www.bioenergytrade.org/downloads/t40-global-wood-chips-study_final.pdf)

policy frameworks imply a trend towards increased utilisation of modern bioenergy. This includes further replacement of traditional with modern bioenergy usage. Increasing use of modern bioenergy will inevitably be intertwined with large-scale international trading of bioenergy commodities. A recent global review by Lamers *et al.*<sup>3</sup> of international solid biofuel trade showed that net global solid biofuel trade grew six fold from 56.5 PJ (3.5 Mtonnes) to 300 PJ (18 Mtonnes) between 2000 and 2010. Over this period, wood pellets have clearly become the dominant solid biofuel commodity on international markets, whereas trade streams of wood waste, round wood and wood chips for energy have been significantly smaller and practically limited to Europe. Europe remains the key region for international solid biofuel trade, covering around two thirds of global net solid biofuel trade by 2010.

Ethanol, vegetable oils, fuel wood, charcoal, and wood pellets are the most important products currently traded internationally for energy purposes. Nevertheless, the international trade of these products is much less than the international trade of biomass for other purposes (forestry and agricultural commodities). Most of the biomass products reviewed are mainly consumed locally in the countries of production, but in the case of products such as sawn timber, paper and paperboard, palm oil, and wood pellets, a considerable proportion of the total production is exported.

While practically no liquid biofuels or wood pellets were traded in 2000, world net trade of liquid biofuels amounted to 120-130 PJ in 2009, compared to about 75 PJ of wood pellets. Trade flows have been highlighted in recent years in a number of studies carried out by Task 40<sup>4</sup> (Table 2).

Global fuel ethanol production grew from around 375 PJ in 2000 to over 1,600 PJ in 2009<sup>5</sup>. The two leading ethanol producers and consumers were the United States and Brazil, accounting for about 85% of world production. In the EU,

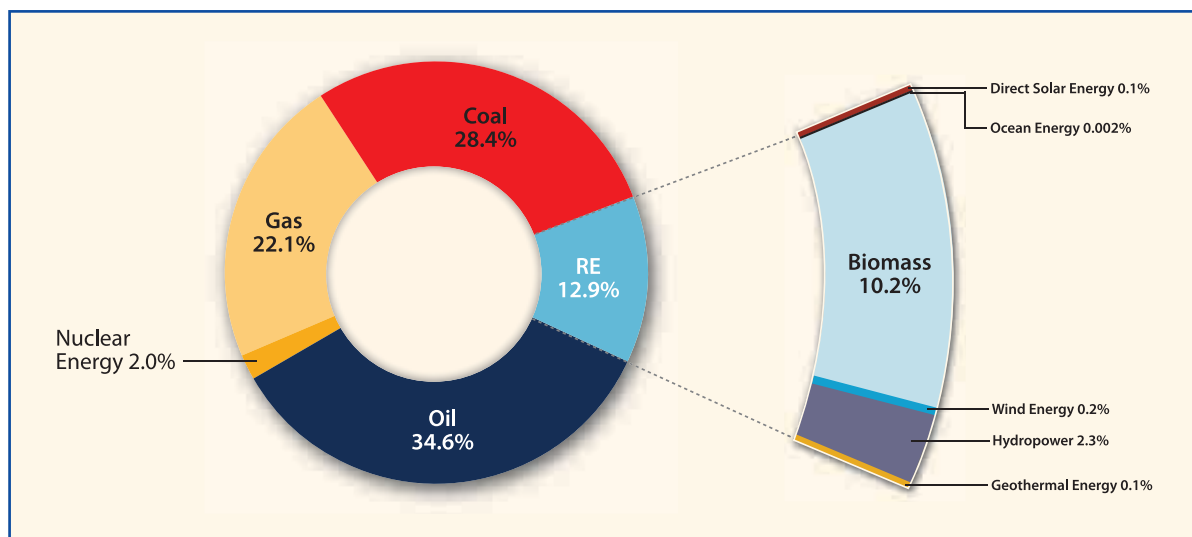
**Table 2:** Global production and trade of the major biomass commodities<sup>7</sup>

Mton in 2008	Bioethanol	Biodiesel	Wood pellets
Global production	52.9	10.6	11.5
Global net trade	3.72 (*)	2.92	Approx. 4
Main exporters	Brazil	US, Argentina, Indonesia, Malaysia, EU	Canada, USA, Baltic countries, Finland, Russia
Main importers	USA, Japan, EU	EU	Belgium, Netherlands, Sweden, Italy

(\*) An estimated 75% of the traded bioethanol is used as transport fuel

total consumption for transportation in 2011 was 2.9 million tonnes, the largest users being France, Germany, Sweden and Spain<sup>6</sup>. Data related to fuel bioethanol trade are imprecise on account of the various potential end uses of ethanol (i.e. fuel, industrial, and beverage use) and also because of the lack of proper codes for biofuels in global trade statistics. As an estimate, a net amount of 40-51 PJ of fuel ethanol was traded in 2009.

World biodiesel production started below 20 PJ in 2000 and reached around 565 PJ in 2009<sup>5</sup>. The EU produced about two-thirds of this (334 PJ), with Germany, France, Spain and Italy being the top EU producers. EU27 biodiesel production rates levelled off towards 2008. The inner-European biodiesel market has become more competitive. Other main biodiesel producers include the United States, Argentina and Brazil. Net international biodiesel trade was below 1 PJ before 2005, but grew very fast from this small base to more than 80 PJ in 2009.



**Figure 4.** World energy consumption

<sup>3</sup>Lamers P, Junginger M, Hamelinck C, Faaij A (2012). Developments in international solid biofuel trade - an analysis of volumes, policies, and market factors. *Renewable and Sustainable Energy Reviews*.16 (5) p. 3176-99.

<sup>4</sup>See <http://www.bioenergytrade.org/> for more details

<sup>5</sup>Lamers, P., Hamelinck, C., Junginger, M., Faaij, A., (2011) International bioenergy trade – a review of past developments in the liquid biofuels market. *Renewable and Sustainable Energy Reviews*, 15 (2011) 2655–2676

<sup>6</sup>EurObserv'ER, *Biofuels Barometer 2011*

<sup>7</sup>Heinimö, J. and Junginger, M. (2009), Production and trading of biomass for energy – an overview of the global status. *Biomass and Bioenergy* 33 (9), pp. 1310-1320, doi:10.1016/j.biombioe.2009.05.017



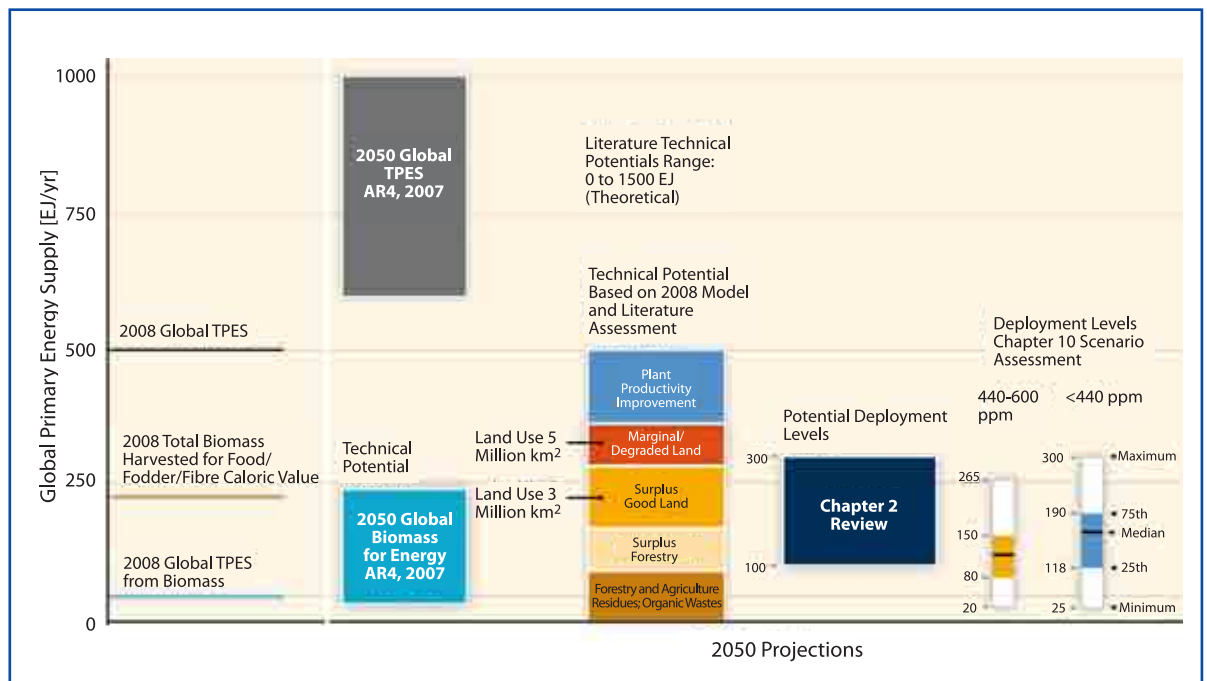


**Figure 5.** Global wood pellet trade 2009<sup>8</sup> [1 PJ = 60,000 tonnes]

Production, consumption and trade of wood pellets have all grown strongly within the last decade, and are comparable to ethanol and biodiesel in terms of global trade volumes. As a rough estimate, in 2009 more than 13 million tonnes of wood pellets were produced, of which the large majority was in 30 European countries, the USA and Canada. Consumption was high in many EU countries and the USA (Figure 5). The largest EU consumers were Sweden (1.8 million tonnes), Denmark, the Netherlands, Belgium, Germany and Italy (all roughly one million tonnes). The main wood pellet trade routes lead from Canada and the US to Europe (especially Sweden, the Netherlands and Belgium) and to the USA.

In 2009, other minor trade flows were reported, e.g. from Australia, Argentina and South Africa to the EU, however, these quantities remained negligible. Canadian producers also started to export small quantities to Japan. Total imports of wood pellets by European countries in 2009 were estimated to be about 3.9 million tonnes, of which about half can be assumed to be intra-EU trade.

Biomass is expected to be the major primary energy source. The actual volume of bioenergy is still modest at 50 EJ when compared to the necessary 500 EJ (Figure 6).



**Figure 6.** 2050 Bioenergy Potentials and Deployment Levels<sup>9</sup>

<sup>8</sup>Faaij, A.P.C., Moreira, J.R., Chum, H., (convening lead authors chapter 2), IPCC special report on renewable energy sources, 2011, O. Edenhofer, R. Pichs Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

<sup>9</sup>IPCC-SRREN, 2011, chapter 2

**Table 3:** Projected production costs estimated for selected developing technologies<sup>9</sup>

Select Bioenergy Technology	Energy Sector (Electricity, Thermal, Transport)	2020-2030 Projected Production Costs US\$ (2005)/GJ
Integrated Gasification Combined Cycle (IGCC) <sup>1</sup>	Electricity and/or transport	12.8-19.1 (4.6-6.9 cents/kWh)
Renewable diesel and jet fuel	Transport and electricity	15-30
Lignocellulose sugar-based biofuels <sup>2</sup>	Transport	6-30
Lignocellulose sugar-based biofuels <sup>3</sup>		12-25
Lignocellulose sugar-based biofuels <sup>4</sup>		14-24 (blend stock)
Gaseous biofuels <sup>5</sup>	Thermal and transport	6-12
Aquatic plant derived fuels, chemicals	Transport	30-140

1: Feed cost \$3.1/GJ, IGCC (Future) 30-300 MW, 20 yr life, 10% discount rate;

2: Ethanol, butanols, microbial hydrocarbons and microbial hydrocarbons from sugar or start crops

3: Syndiesel, methanol and gasoline, etc.; syngas fermentation routes to ethanol

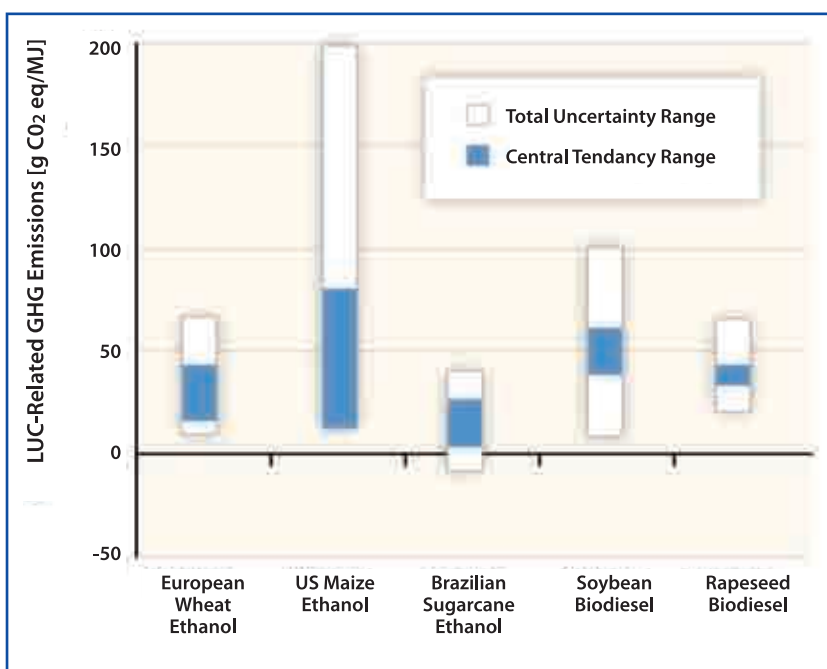
4: Biomass pyrolysis (or other thermal treatment) and catalytic upgrading to gasoline and diesel blend stocks or to jet fuels

5: Synfuel to SNG, methane, dimethylether, hydrogen from biomass thermochemical and anaerobic digestion (larger scale)

The question is, how much of this potential can be deployed in reality? Some 164 studies on long term energy scenarios have been evaluated. Some of these make much less optimistic predictions and estimate a realistic potential of only 100 EJ. However, it is generally agreed that with a reasonable improvement in agriculture and forestry, an increase in production of up to 300 EJ or more is possible.

Economically, in 2050 a factor of 20 or more in bioenergy utilisation seems feasible. Bioenergy is financially competitive when compared to fossil energy (Table 3). Expectations are high for technologies such as gasification, advanced generation biofuels and gaseous biofuels. However, algae are something of a wild card – so far scientific evidence on the cost-effectiveness of biofuels production is still limited.

Another component influencing future biomass and biofuel markets is the implication of sustainability criteria. The GHG emissions of bioenergy are usually lower than for fossil fuels; however taking direct and indirect land use change into account might become difficult for some of the applications. A firm answer on the amount of iLUC contribution cannot be given yet as scientific evidence is still limited. The first estimates of iLUC were very high. More recent detailed studies show that iLUC is directly related to best agricultural practice (management) and might be far lower than shown in earlier calculations (Figure 7). The definition of iLUC factors based on current technologies and know-how has received most attention compared to a very limited focus on mitigation of iLUC and the future practice of biomass management.



**Figure 7.** Estimates of direct and indirect LUC GHG emissions of first generation biofuels<sup>10</sup>

In conclusion, bioenergy trade has rapidly become more important in total biomass supplies (for pellets in particular). Markets are still immature, with ethanol getting closest to commodity trading. Rapid growth is very likely to continue, in particular in concentrated biomass pellets from torrefied biomass. Plantation-grown wood crops may become more important in the near future.

More markets will emerge for lignocellulosic biomass, such as advanced biofuels, biochemical, etc., but there will only be a future for biomass when growth and transport is sustainable. This is somewhat contradictory given the fact that at the same time renewable energy and GHG mitigation targets cannot be met without large scale bioenergy deployment.

<sup>10</sup>Searchinger *et al.* (2009) [http://rsb.epfl.ch/files/content/sites/rsb2/files/Biofuels/Further%20Reading/BrUSsels%20Forum%20Paper%20-%20Searchinger%20\(2009\).pdf](http://rsb.epfl.ch/files/content/sites/rsb2/files/Biofuels/Further%20Reading/BrUSsels%20Forum%20Paper%20-%20Searchinger%20(2009).pdf); Al-Riffai, *et al.* (2010) Global Trade and Environmental Impact Study of the EU Biofuels Mandate. International Food Policy Research Institute, Washington, DC, USA; Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. EPA, United States Environmental Protection Agency, Washington, DC, USA; Fritsche, *et al.* (2010) The "ILUC Factor" as a Means to Hedge Risks of GHG Emissions from Indirect Land Use Change. Oeko-Institute, Darmstadt, Germany; Hertel *et al.* (2010) <http://www.aibs.org/bioscience-press-releases/resources/Hertel.pdf>; Tyner, *et al.* (2010) Land Use Changes and Consequent CO<sub>2</sub> Emissions Due to US Corn Ethanol Production: A Comprehensive Analysis. Center for Global Trade Analysis. Purdue University, West Lafayette, IN, USA.

**Sustainable Bioenergy in Australia: An Overview - Deborah O'Connell, CSIRO, Australia**

Sustainability credentials for bioenergy are now seen as a necessity by many governments and the community. Bioenergy is one area where the principles of sustainability are rapidly being put into practice internationally, including, more recently, in Australia. As a first step, in 2009 the Australian government initiated a comprehensive review of international sustainability frameworks and their application, with a focus on policy linkages. Even though harmonisation of international schemes through the ISO process is in progress, many challenges in terms of the science and assessment remain.

Sustainability impacts arise at each stage of the value chain, as well as across the whole chain. Issues arising directly from the biofuel value chain are reasonably well-defined and understood. There are some established methods to measure and analyse many aspects of sustainability, particularly those which impact at a local scale. However, reliable data to set parameters for the analyses, and robust metrics to summarise the impacts are either still lacking or under development. For example, biodiversity is difficult to survey, because it is fundamentally related to scale and connectivity in the landscape and it is therefore hard to develop universal metrics. Indirect effects are caused by multiple steps of causality which often means that the impacts are manifest in a different region – for example, expansion of the biodiesel market in Europe has caused an increase in the production of palm oil in Asia, and indirectly led to deforestation to make way for more palm oil plantations. Causality is difficult to deal with. Indirect effects are less manageable by a biofuel enterprise, industry or a national government, because they usually do not have jurisdiction over the regions where the impacts are expressed.

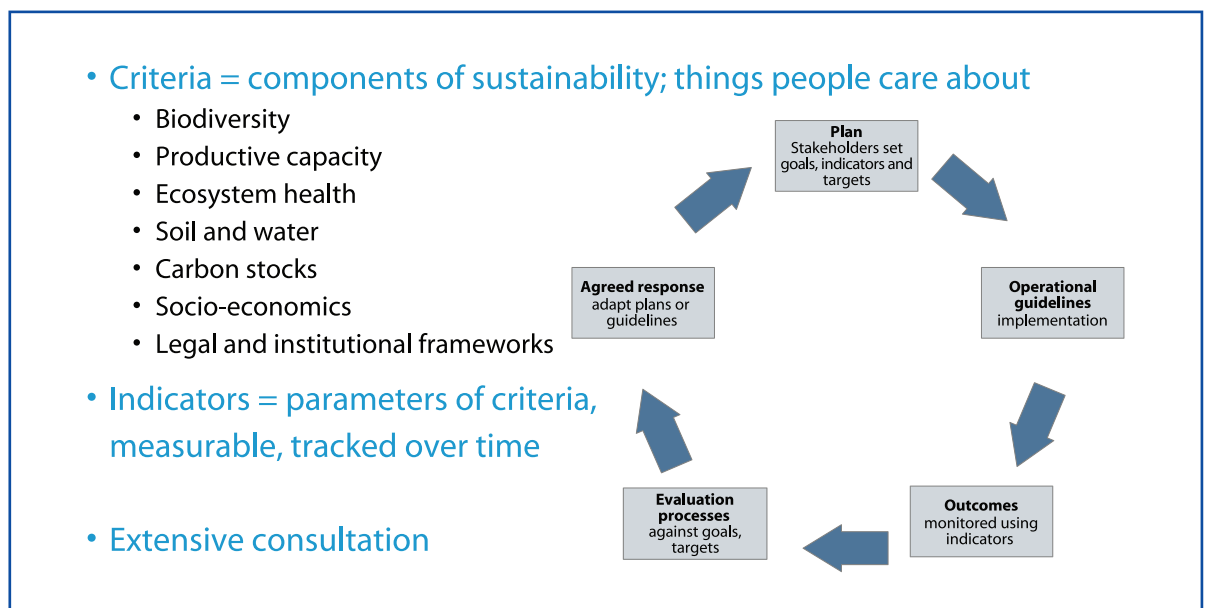
In Australia sustainability is legislated as part of the Environment Protection and Biodiversity Conservation (EPBC) Act with the clear principles of maintaining key

ecological processes, and enhancing total quality of life now and in the future. The challenge remains to operationalise these principles. However, Australia does not need to start from scratch. Forestry provides a good example of where sustainability has been addressed and codified – maybe not perfectly, but with measurable, positive outcomes. Native forests were recognised as scarce resource 20 years ago. The 1992 'Rio Earth Summit' led to a set of Criteria and Indicators, which are reported every five years at regional, state, national and international levels.

Criteria are the key components of sustainability, the things that society cares about (Figure 8). Indicators are the parameters of those criteria which are measurable, and tracked over time. They aim to be sufficiently sensitive to detect changes in key ecosystem processes. They can be embedded in an adaptive management framework, so that the management of the forest ecosystems is continuously improved via a cycle of planning, guidelines (which often manifest as Codes of Practice in Australia) outcomes, evaluation and agreed responses. Even though there are outstanding issues such as scientific methods for cost effective monitoring, recent reviews of the efficacy of sustainable forest management frameworks and certification have demonstrated that in those countries which do have adequate governance to report and comply, there have been provable positive sustainability outcomes for the forest industry. These are not achieved in those countries where robust governance and compliance instruments are not in place.

Key issues to be addressed in Australia over the next five years are:

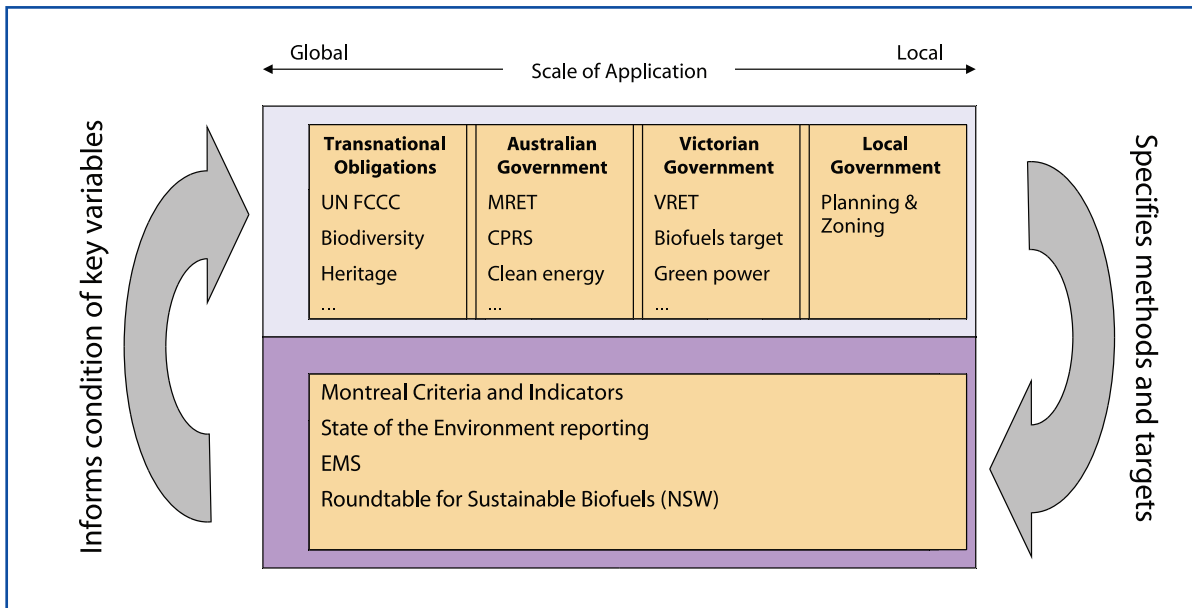
1. Science development: currently fragmented, needs structured approach to the science of sustainability
2. Science-policy linkages
3. Engagement: develop of standards, on ground assessment, policy and also fora for negotiation and discussion
  - Governments: State and Federal



**Figure 8.** Sustainable Forest Management: Criteria and Indicators<sup>11</sup>

<sup>11</sup>O'Connell, D. et al (2009) Sustainable Production of Bioenergy: A review of global bioenergy sustainability frameworks and assessment systems





**Figure 9.** Linking Science and Policy in Sustainability

- Industry: growers, conversion of industry, distributors, users
  - Communities: consumers, green groups, CMAs
  - International engagement for science, harmonisation of standards, learning and practical experience but also for trade – GATT and WTA
4. Implications for other industries.
- Forestry and biofuels formal standards and certification; agriculture has 'best practice' approach.

There are many science challenges outstanding, even in forestry let alone for other biomass production systems, such as developing meaningful indicators across complete value chains as they emerge, including for indirect effects where the chain of 'cause and effect' is difficult to prove.

Scaling up for aggregate effect is not something that can be done at enterprise level – for example, the impact of production on a per unit basis might remain the same, but when looking at landscape or market effects the first few units do not have the same impact as the billionth one in aggregate.

In most countries, data is hard and expensive to measure, especially with shrinking research budgets. Much of it is therefore what we call input-based, i.e. data relying on specifying parameters such as activities, rules or targets. Outcome-based sustainability assessment uses robust science to identify and monitor key system variables and assess condition and trends. This is more expensive, but essential where the risk of damage is high and little is known about natural systems which are very prone to threshold, irreversible changes. Most international frameworks are currently based on input-based methods.

LCA is one way of analysing sustainability dimensions through the value chain. It is an important tool, however data is often sparse, uncertain or even unavailable. System boundaries are critical and mostly methods are complex

and interpretation difficult. This often makes it impossible to directly compare different studies. But above all, it must be recognised that an LCA is not a sustainability assessment.

Figure 9 shows what is required for an effective sustainability framework in the case of bioenergy. This framework is comprised of two major elements: Firstly, institutional systems i.e. the collection of laws, regulations, and other policy mechanisms which helps to drive or limit industry growth, and resource use. Institutional systems are the means by which sustainability goals can be achieved. The second element is the assessment component, which provides the science to monitor key system variables and indicators over time, to evaluate conditions and trends.

In a well-functioning system, there would be feedback between the institutional and the assessment systems. Many countries are now specifying in great detail the method by which greenhouse gas accounting must be undertaken.

Without the engagement of all stakeholders involved, especially industry, all sustainability approaches remain mere paper work. A project on the sustainability of aviation fuel might serve as a good example for the engagement of stakeholders where Australia took some leadership. The development of the sustainable aviation fuels road map<sup>12</sup> was a unique planning exercise, with a range of industry participants including the airlines Qantas, Virgin, and Air New Zealand, as well as the aircraft manufacturers Boeing and Airbus, engine makers General Electric, Rolls Royce, Pratt & Whitney, oil companies such as Caltex, and Brisbane Airport, as well as green groups. It showed that biofuel is the only option for the Australian aviation industry to reach its GHG reduction targets and carbon neutral growth by 2020 as well as an aspirational goal of 50% below 2005 levels by 2050.

<sup>12</sup>Graham, *et al* 2011, Flight path to sustainable aviation: towards establishing a sustainable aviation fuels industry in Australia and New Zealand, CSIRO

It was estimated that by 2030 sufficient biomass can be supplied to meet nearly half the total fuel consumption of aviation by 2020 and 100% by 2050.

The aviation biofuel industry will need some support during establishment, but will be economically competitive in the longer term (depending of course on oil prices). For the scenarios modelled, GHG can be cut by 17%, create >12,000 jobs, and save \$2 billion p.a. in imports. There are, however, significant challenges to investment e.g. risk of new technologies, capital rising, and an uncertain policy environment.

Sustainability assessment is complex and evolving. There are many countries and organisations and some industry bodies attempting to deal with it, and they are scattered along a development pathway. Most of these initiatives clearly recognise the indirect impacts, and in some cases assign default carbon burdens on biofuel products factoring some of these assumptions into the calculations. It is even more provocative to attribute direct causality in terms of the actions of one jurisdiction, such as Australia, to another jurisdiction. The area is fraught with scientific challenge, let alone institutional challenge.

There is no doubt that much work needs to be done in Australia to engage internationally, develop and apply scientific methods and assessment production systems, and build industry capacity.

**The Utilisation of the RSB Scheme across the World – Victoria Junquera, Roundtable on Sustainable Biofuels, Switzerland**

The Roundtable on Sustainable Biofuels (RSB) is an international initiative hosted within the Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland. The mission of the RSB is to develop and implement the RSB Global Sustainability Standard, a global standard for sustainable production, conversion and use of biomass. More

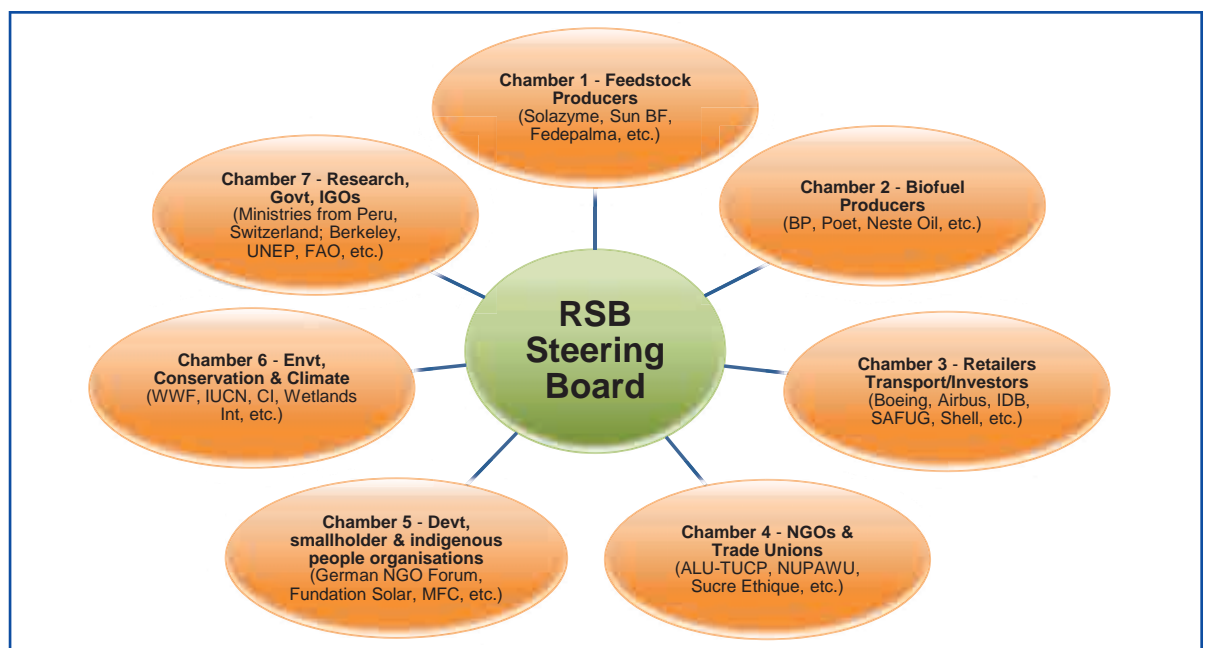
than 120 organisations from 35 countries representing all sectors are registered RSB members. Participation in the RSB is open to any organisation working in a field relevant to bioenergy.

The implementation of sustainability systems is a fundamental human and environmental requirement for the long term development of biofuels. Biofuels’ potential impacts include:

- Degradation of water, air and soils.
- Loss of biodiversity and wildlife habitat.
- Infringement of the land and water rights of indigenous peoples.
- Unacceptable working conditions and lack of benefit sharing for local communities.
- Potential effects on food security.
- Increased greenhouse gas (GHG) emissions.

However, achieving a global definition of sustainability is a difficult task. There are top down and bottom up methods. The top down approach gives the big picture and includes land productivity (competition for bioenergy, agriculture, livestock production, fibres, bioproducts, etc.), climate change, energy security, etc. Bottom up approaches are assessments at the operator level, including certification and verification. Boundaries can be wider than the scope of the operator but limited to a same perimeter. There are several elements that make certification an important tool. The question whether a biofuel is sustainable can never be answered with a simple yes or no: unfortunately it depends on a number of factors. Certification is a driver for structured evaluation.

The RSB standard as a bottom up approach was developed by more than 100 organisations worldwide through an open, transparent, and multi-stakeholder process. The development took more than four years and was accepted in October 2010. RSB requires a strong stakeholder engagement. The RSB governance system gives equal decision-making weight to the private sector, public sector and civil society. All the stakeholders are grouped in seven chambers (Figure 10) Decisions are made by consensus.



**Figure 10.** The RSB Governance

The RSB standard is universal and provides a comprehensive and rigorously-tested basis for the RSB certification system for sustainably-produced biomass and biofuels. The RSB Global Sustainability Standard applies to all types of biomass feedstock in every region of the world and at every point of the supply chain. It provides certainty amid the growing patchwork of voluntary certification schemes. Governmental support is mandatory for its application. The core of the standard is a set of 12 Principles and Criteria (P&Cs), which define the requirements to achieve sustainable biomass and biofuel production. The P&Cs address:

- Legality
- Planning, monitoring and continuous improvement
- Greenhouse gas emissions
- Human and labour rights
- Rural and social development
- Local food security
- Conservation (biodiversity and ecosystem services)
- Soil, water and air protection
- Use of technology, inputs and management of waste
- Land rights

The RSB has adopted an ambitious threshold of at least a 50% cut in GHG emissions for a blend of biofuels compared to the fossil fuel baseline (e.g. gasoline). In addition, the RSB Standard requires that operators meet any applicable regulatory GHG requirements in the region where they operate (e.g. the EU RED requirements). GHG calculations are made accessible and practical through the RSB Tool (<http://rsb.f2.htw-berlin.de/>). An expert group on indirect impacts was formed and continues to discuss the issue; however no consensus has been reached on requirements to be included in the Standard at this point.

The continuous development and implementation of the standards is an important job. RSB members shape and refine the content and the implementation of the RSB certification system to make it match both their aspirations for sustainable biofuels production and the reality of modern agriculture and industry practices.

All standards are public and can be downloaded from the website (<http://rsb.epfl.ch/page-67254.html>). There is a series of standards and guidelines:

- Standards on rules and interfaces for adaptation of the RSB Principles and Criteria including crop specific conditions, adaptation to geographic conditions and biomass production standards, modification of RSB P&Cs and other standards.
- Standards for Chain of Custody such as generic chain of custody, 'Identity of product preserve', 'Segregation of product', 'Mass balance of product' and 'Content ratio accounting' chain of custody.
- Standard for participating operators.
- Standard on communication and claims.
- Standard for risk management.
- Standard for dispute resolution.
- Standards for Certification Bodies including general requirements, requirements for auditor qualification, requirements for evaluation of and reporting on participating operators, requirements for Certification

Bodies risk management and a standard on requirements for adaptation during the start-up phase.

- RSB Policy for certification of biofuels based on end-of-life-products and wastewater.

The first operation was certified by the end of 2011. In 2012 the standards will be adapted to different regions in the world and to enable this they have been translated into Spanish, Chinese and French.

RSB is different from other certification systems in so far as they collaborate with governments on their own certification schemes without necessarily adapting the RSB standards.

### **Sustainable Investment in Forestry for Timber and Biomass Production - Nick O'Brien, New Forests Asset Management, Sydney, Australia**

Environmental sustainability is vital to long term forestry production. The life cycle of a forest plantation is much longer than one crop rotation and therefore nutrient balancing is of crucial importance. No nutrients should be lost, i.e. biomass management has to not only manage C-stock but also minerals.

Community acceptance is of high importance. Investment in forests is only feasible with the support of the local population. Unfortunately, in Australia the government supports forest plantations that are driven by money (tax exemption) and not by environmental and social impacts.

Next to environmental and social factors, for an industrial enterprise the economic factor is of high importance in the development of a long term sustainability scheme. Investment in plantation forestry for bioenergy production of any significant scale is dependent on satisfying the expectations of the institutional investment sector, particularly in terms of achieving a return that is appropriate to the level of risk involved. A low level of income is accepted by investors as long as there is a low risk.

Investors are interested in large investments in one place. Therefore sustainability criteria are important to secure the investment. Achieving large scale while matching social, ecological and economical outcomes is a challenge. It is also difficult matching growers' expectation with those of processors.

The level of technical forestry risk is greater for greenfield developments and for projects developed outside traditional plantation forestry areas, both of which are likely for dedicated bioenergy plantings. The integration of bioenergy supply with timber production from existing plantations can mitigate some of this technical risk, but this has implications for the regional supply of bioenergy feedstock (in terms of location and amount).

The combination of new markets with large scale investment is risky, hence policy development is important and might decide overall success. There is currently strong legislative support for non-production (conservation, amenity, etc.) forestry in Australia but not for production



forestry. Integration into agricultural systems may help considerably and also help in achieving scale.

Stable demonstration business models and management systems are required.

Diversification of market exposure is a key strategy in reducing the market risk for forestry investments, and in this regard the supply of biomass feedstock can assist in reducing risk through product diversification. However, the bioenergy sector must compete with other markets (particularly the pulp sector) for material from plantations, at a rate that meets the commercial expectations of the forest operator. One competitive advantage that the bioenergy sector may have in this regard is the ability to implement distributed processing systems that can increase the efficiency of transport through in-field processing.

There is a potentially significant opportunity to combine revenues from carbon sequestration, bioenergy (including REC payments) and traditional timber products to extend the geographic boundary of investment in plantation forestry. A key step in attaining this outcome is to achieve greater certainty in domestic carbon and renewable energy policy and markets. In addition, work is required to reduce the technical forestry risk in these (generally) lower productivity areas, as well as to further develop systems for the integration of forestry (for timber and bioenergy) into the wider agricultural landscape.

### Quantifying the Mitigation Potential of Bioenergy Systems – Annette Cowie, University of New England, Armidale, Australia

The problem has been clearly set out by IEA: 'We are currently on track for a warming of 4 to 7° over pre-industrial levels by 2100. This level of temperature rise threatens the stability of the global ecosphere as we know it'. The IPCC - impacts of a 4° rise, describes: 'Hundreds of millions of people affected by water stress, 30–40% of species at risk of extinction, 30% of global coastal wetlands lost'. Biomass, if sustainably grown and widely adopted might be one possibility to fight against climate change.

LCA is used to quantify the environmental impacts of products or services, from cradle-to-grave, along the supply chain. LCA can be applied to assess the climate change impacts of bioenergy, with emissions of the greenhouse gases (GHGs) CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O of primary concern. To determine the climate change impacts of bioenergy, the bioenergy system being analysed should be compared with a reference energy system, e.g. a fossil energy system that is likely to be displaced by the bioenergy system. The scope of the analysis (system boundary) should include all processes along the value chain including upstream processes of extraction or biomass production, and end-of-life processes. The system boundary should be defined so that the bioenergy and reference fossil systems provide equivalent products and services (Figure 11).

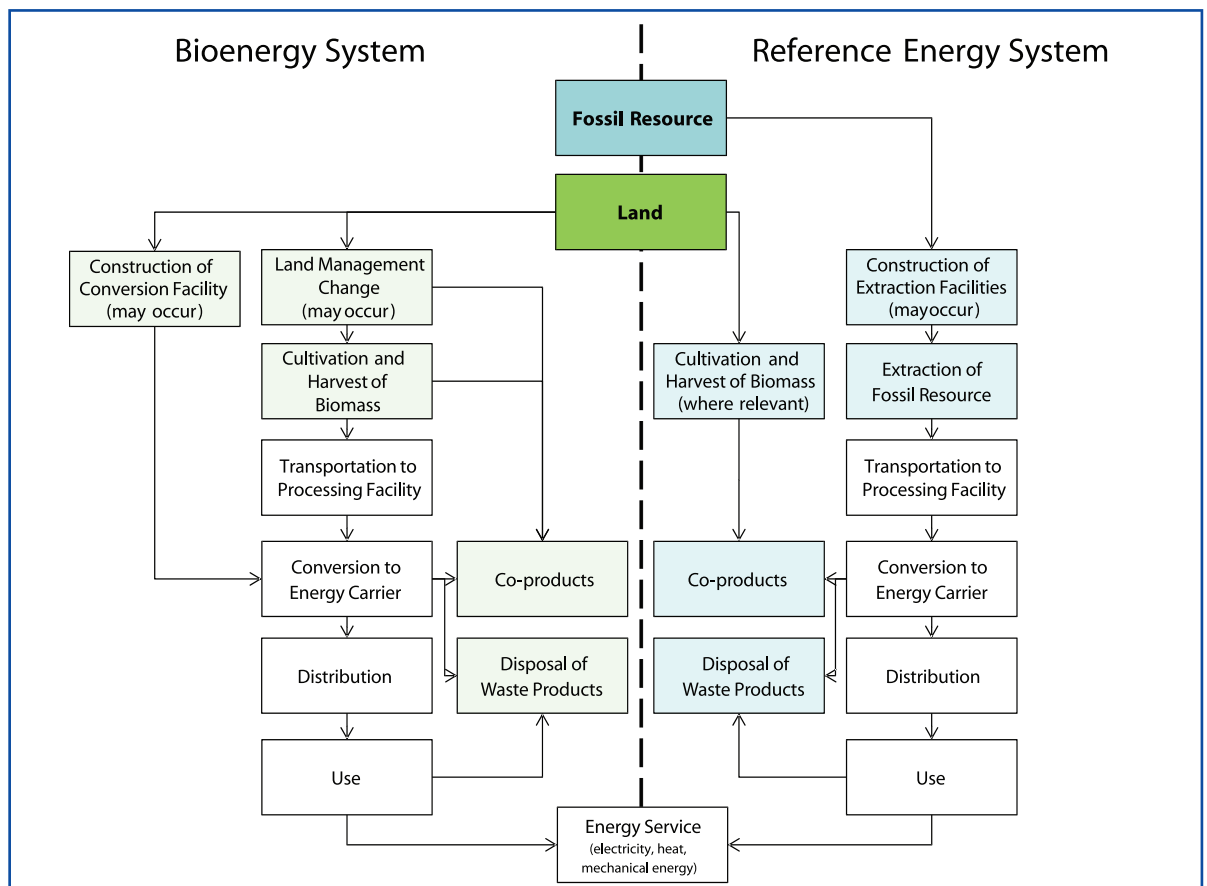


Figure 11. Comparison of a biomass system to a fossil system to achieve the same energy service

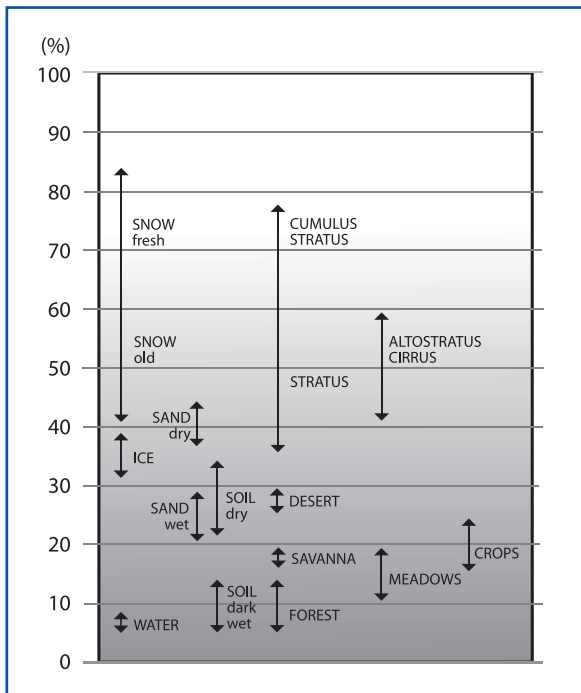


Figure 12. Albedo effect on global warming potential

The impact of albedo (i.e. reflection of radiation by white or absorption by dark surfaces, or by cumulus in the stratosphere and cirrus in the alto-stratosphere) is not considered so far by the different models, (figure 12).

LCA is usually not concerned with the time at which the environmental impacts occur. However, some bioenergy systems can cause short term GHG emissions due to the accelerated oxidation of carbon stocks through combustion in comparison with natural decay. The effect of forest biomass utilisation has a far stronger effect on short term GHG targets; over a longer term perspective sustainable bioenergy has lower emissions than comparable fossil energy systems. The type of technology, scale of plant, and co-products in both the bioenergy and reference energy system can influence the GHG mitigation benefits of a bioenergy system. The question of timing is important, especially when we look at a very local scale. In fact, when we assume that an existing forest is harvested and used for energy, then emissions (or corresponding temperature increase) might temporarily be equal or even higher than fossil fuel (Figure 13a). However, if we assume that our model starts with the planting of the forest, then the net emission over 60-100 years will never be higher than that of fossil fuel (Figure 13b). Bioenergy is

If it is not possible to achieve this through expansion of the system boundary then the impacts can be allocated amongst energy and non-energy co-products of the bioenergy system (such as biodiesel and rapeseed cake from processing rapeseed oil), based on their share of physical or financial contributions. Changes in carbon stocks in biomass, soil and landfill can cause GHG emissions or removals which should be included in the analysis. Similarly, carbon stock changes due to indirect land use change should be considered. In recent times serious doubts have been expressed as to whether bioenergy really does have an emissions reduction potential compared to fossil sources when all the factors are accounted for. In the context of the Kyoto Protocol, bioenergy is considered CO<sub>2</sub> neutral. It assumes that fossil energy inputs in the energy sector are counted and that non-CO<sub>2</sub> emissions are included in agriculture. It also assumes that C stock changes are included in the land sector (Figure 14), but in reality C stock changes are usually not included.

Should carbon neutrality therefore be taken out of the equation? This is not a useful solution because it doesn't reflect atmospheric impacts, and disadvantages all bioenergy. It would also ignore the future benefits of sustainable bioenergy.

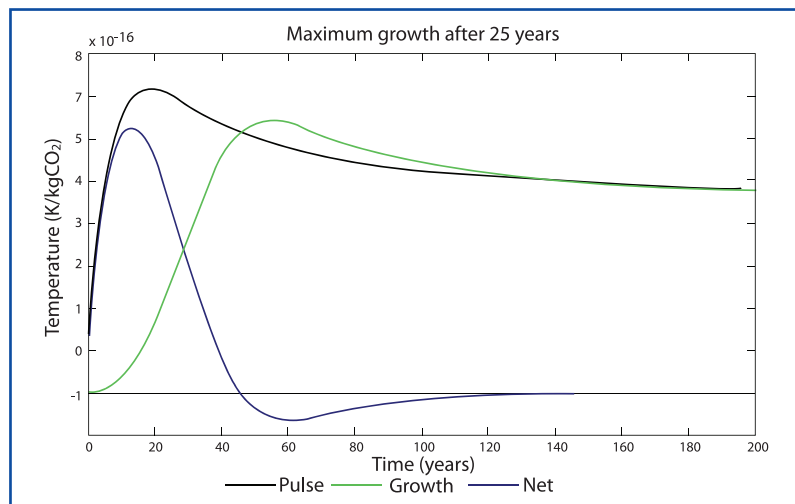


Figure 13a. Timing of (net) emission starting with utilisation of biomass

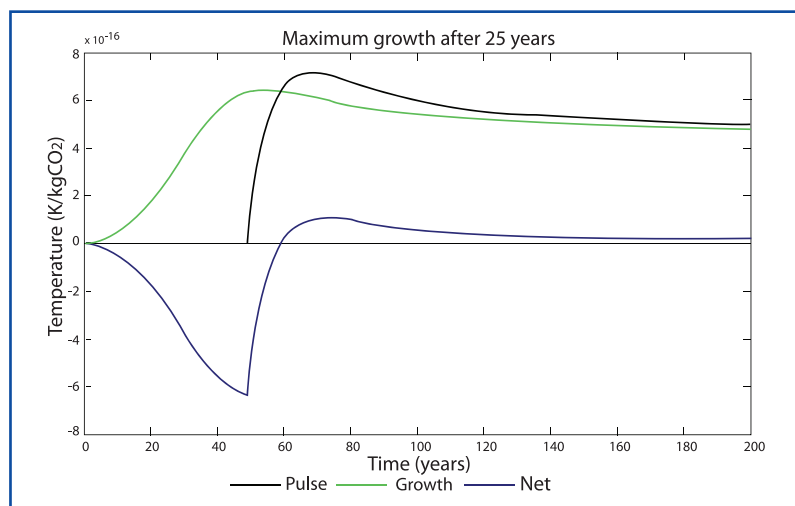
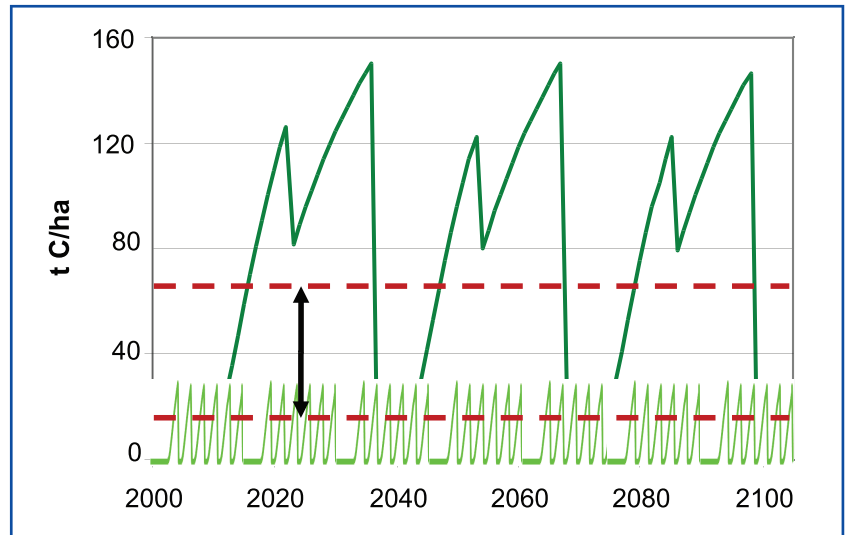


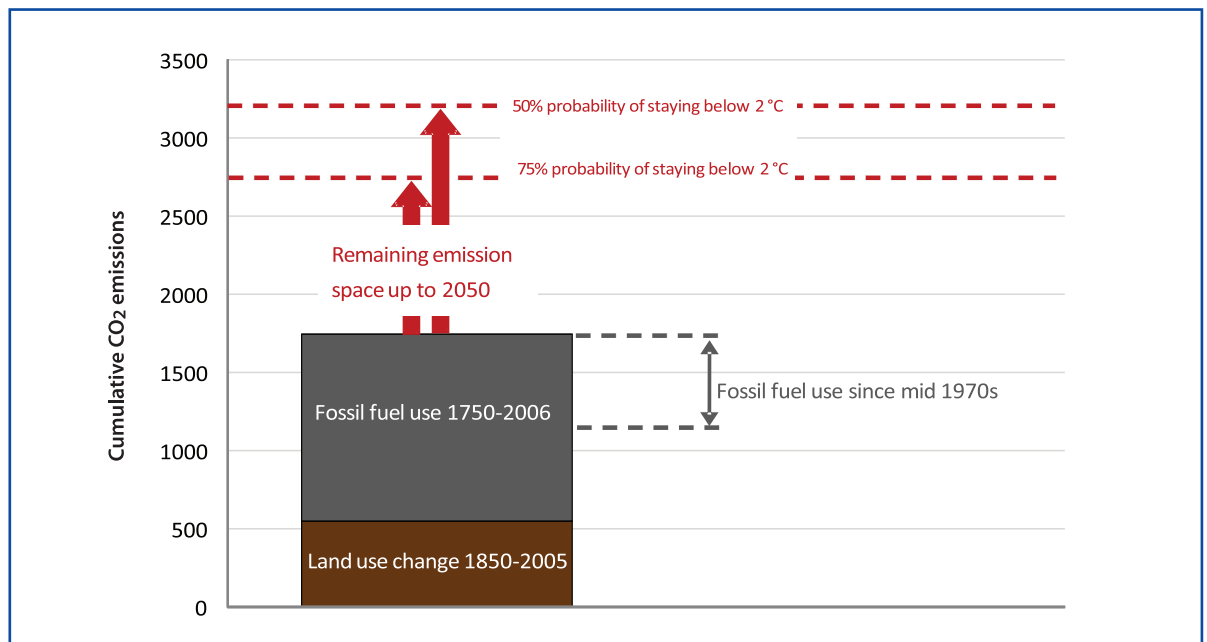
Figure 13b. Timing of (net) emission starting with growth of biomass

certainly not neutral, not even over a long period. However in comparison to fossil fuels, emissions are marginal if biomass is properly grown and used (Figure 14).

In order to stabilise the climate, global GHG emissions must be curbed. The ceiling on GHG that can be released over the coming decades, in order to minimise the risk of a temperature rise greater than 2°C, can be calculated as illustrated in Figure 15, which considers CO<sub>2</sub> emissions up to 2050. Society could agree to invest some of this emissions space in the establishment of renewable bioenergy systems.



**Figure 14.** Change of C stock when converting from timber plantation to short –rotation biomass crop (lower green curve) should be included in calculating the impacts of bioenergy.



**Figure 15.** Cumulative CO<sub>2</sub> emissions (GtCO<sub>2</sub>-e) and indicative remaining emission space in relation to a 2°C target, based on Meinshausen *et al*, 2009.

**Bioenergy Production in Water Scarce Countries – Daniel G. Neary, USDA Forest Service, USA**

Seventy percent of the earth’s surface is water; 97.5% of which is salt water and only 2.5% of it fresh water.

From this relatively small amount of fresh water 70% is in the form of ice and 29% is located in the soil or deep aquifers. Only <1% of fresh water is accessible, i.e. <0.007% of all water on earth. We can say that we live ‘On the Edge’.

With such a limited amount of water, all societies face the dilemma of how to use it: for domestic or industry use, for food, fibre or energy production? Water is a critical consideration in bioenergy production systems, because it

creates demands and impacts on water resources. This is especially true in water short regions of the world. Plant growth for biofuel or electrical generation feed stocks requires water that is in direct competition with water demands for municipal supplies, food agriculture, and fibre production. This resource conflict is part of the ‘water footprint of bioenergy, or of food’. Two examples graphically illustrate this foot-print. To produce 300g of steak on the plate, 4,500 litres of water is needed, and some 120 billion cubic metres of water is used per year so that mankind can drink coffee<sup>13</sup>. This is equivalent to 1.5 times the annual Rhine runoff.

Because of the exploding human population and the impact of climate change, water shortages are expected to increase in the water scarce regions of the world during the 21<sup>st</sup> Century.

<sup>13</sup>www.waterfootprint.org





**Figure 16.** Chile as an example with a mix of drought and water rich areas

Already today, a large number of countries withdraw more water than is naturally renewed<sup>14</sup>, i.e. they are pumping the water from (deep) ground that cannot be replaced. In the short term, this is called water mining. Berndes defined a limit of 25% of water replaced as compared to the actual consumption as scarcity. It might also be defined by arid or semi-arid climates, prolonged drought, poor geographic distribution or poor water quality. A more detailed definition came from Raskin *et al.*<sup>15</sup>:

Absolute water scarcity	=	<500 m <sup>3</sup> /person/year
Water scarcity	=	500-1000 m <sup>3</sup> /person/year
Water stress	=	1000-1700 m <sup>3</sup> /person/year

Thirty-five countries with a total of 726.4 million people are in arid or semi-arid areas with 70 to 700 mm precipitation (average 179 mm). 41 to 99% of the water is used for agriculture. Ten countries have an absolute water scarcity but five of them have large oil reserves and can upgrade sea water to drinking water quality. However, average values per country do not reflect the whole truth as there are countries with both drought and wet areas spatially separated like those in Chile (Figure 16). However, often the water is in the wrong place, as it is in the southwest of the USA.

But even if there is water present, diversion, evaporation and leaking create serious challenges. In some cities up to 25% of the water leaks out of the piping. Diversion is mainly a problem in dams that have been built to improve distribution and utilisation of water. Evaporation occurs in rivers, aqueducts, lakes and irrigated fields. The worst example is Lake Aral (Figure 17), a salt lake that does not receive runoff because of agricultural irrigation diversions that in the past 15 years have evaporated so much, that today it covers only 10% of its original surface area.

Another challenge is population growth, which directly effects water consumption. India and Pakistan are already far exceeding the water stress line. The OECD predicts that 47% of the world's population will face severe water shortages by 2030. Water recycling will become a big issue. Israel is already a major user of recycled water.

Climate change will further aggravate the situation by changing yearly and seasonal precipitation. Regions with water will increasingly see flooding and coastal erosion risks – dry areas will receive even less rain fall. In water rich areas climate change might affect water quality.

Current water management practices may not be robust enough to cope with the impacts of climate change on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems. In many locations, water management cannot satisfactorily cope even with current climate



**Figure 17.** Lake Aral is disappearing due to evaporation

<sup>14</sup>Berndes, G. (2002). Bioenergy and water – the implications of large-scale bioenergy production for water use and supply.

<sup>15</sup>Raskin, P.D., Hansen, E. and Margolis, R.M. 1996. Water and sustainability: Global patterns and long-range problems. *Natural Resources Forum* 20: 1–15.

variability, so that both major flood and drought damage occurs. As a first step, improved incorporation of information about current climate variability into water-related management would assist adaptation to longer term climate change impacts. Climatic and non-climatic factors, such as growth of population and damage potential, will exacerbate problems in the future<sup>16</sup>.

The major issues for water quality are salinity, turbidity, nutrients and micro-organisms. Reasons for increasing salinity are land use change (intensification of agriculture), precipitation decline and salt loads often created by over fertilisation. Increasing turbidity is often created by overgrazing in dry periods, whereas bacterial loading might be worsened by flooding – either by direct pollution of open waters with contaminants flushed from surfaces or by spilling waste water into clean water ponds, streams, and lakes.

In the face of increasingly frequent droughts the question has to be raised whether there is still a chance for bioenergy? The spectrum of bioenergy potential in water scarce countries ranges from virtually none to substantial because of variations in energy, water supplies, human population, agricultural needs, and potential feedstock sources. Forests in water scarce countries range from 0% (Bahrain) to 21% (Iran) with an average of 6.4%. Many water scarce Middle East countries have a dominant role in global petroleum energy supplies but fuel wood and charcoal are also a major source of energy in their rural households (>50%). About 66% of the wood in the region is used for fuel, compared to the global average of 40%. Reforestation projects are under way but need (desalinated) water to be successful.

In water scarce countries, use of combustible renewable energies and waste make up from 1.1 to 72.8% of energy, with most <10% (Table 4).

**Table 4:** Renewable Energy Sources in %

Yemen	1.1
Egypt	2.2
Morocco	3.1
Turkey	5.1
Tunisia	13.6
Pakistan	33.9
Sudan	72.8

Source: World Bank 2010

The bioenergy feedstocks emphasis is on agricultural, industrial, and municipal wastes such as bagasse (from sugarcane), rice straw, cotton stalks, and animal manure but also includes MSW and food and industrial wastes. In 2011, Israel approved a plan to meet 10% of the nation's energy from renewables by 2014 – viz. 10 MW from biogas, biomass, and waste materials (source: Bioenergy Insight).

There is also some EtOH production involved such as in Egypt (Table 5), leaving significant unused potential for bagasse. Oman is evaluating palm dates for production of 90,000 L/day of ethanol for biofuel (FAO 2011). Tunisia is establishing a 500,000 ha oil tree plantation (*Jatropha curcas* and *Simmondsia chinensis*) to produce a bio-oil to power cement plants.

**Table 5:** Availability of Bagasse [in thousand dry tons]

Egypt	1,902
Morocco	138
Sudan	1,063
Pakistan	8,135
Iran	660

Source: World Bank 2010

### Maintaining Soil Fertility in Biomass for Bioenergy Production Systems – John Raison, CSIRO Ecosystem Sciences, Canberra, Australia

Bioenergy offers many new opportunities but if not managed carefully it may also carry significant risks. Bioenergy can contribute to achieving several policy objectives such as agricultural and rural development, climate change mitigation and energy security. But it is the manner in which bioenergy development is supported and regulated that determines whether or not bioenergy will be sustainable and how impacts are distributed. Sustainable production is a pre-condition for 'renewable' energy. A major component of the sustainability of the entire production system is maintaining the capacity of the soil to sustain acceptable rates of biomass production. Soil fertility is determined by nutrient, water and oxygen-supplying capacity relative to plant needs, and an ability to provide a suitable rooting environment. Soil organic matter is very important for all aspects of soil fertility. Soil organic carbon changes (SOC) are modelled (Table 6) and can describe, for example, different harvesting methods and utilisation of timber. Maintaining soil carbon stocks and the ability of soils to regulate hydrological flows is also important. Microbes are very good indicators of the general condition of a soil. Soil fertility can be adversely affected by intensive biomass production systems, especially where crop rotations are short and the degree of biomass utilisation is high. This needs to be managed carefully, especially when the same crop is grown repeatedly on the same field.

In practical terms, management to protect soil values is often implemented via a set of 'best management practices' or 'codes of practice' that contain a set of goals and guidelines. These give broad direction as to how management practices should be planned and conducted. If not properly managed, soil fertility might be degraded by accelerated erosion,

**Table 6:** Monitoring changes in soil fertility

Soil Indicator	Key Functions	Field Measure
Physical change	root growth	bulk density/soil strength
	aeration	macro-porosity
	water movement	hydraulic conductivity
Chemical change	nutrient supply	SOM, N&P availability
	acidification	pH, base exchange
Erosion risk	many	disturbed soil
	cover, infiltration	
Pollution	soil biology, toxicity	accumulation of chemicals

<sup>16</sup> IPCC, 2008



**Figure 18.** Mallee Eucalypt Harvester. Courtesy Rick Giles, DEC; Richard Sulman, Biosystems Engineering, and The Future Farm Industries Cooperative Research Centre.

disturbance/compaction, nutrient depletion, acidification and biological changes. Bioenergy might bring extra challenges like more frequent harvest leading to greater soil disturbance and increased rate of nutrient removal. There are systems with a more complete (foliage and stems) removal of biomass (C and nutrients) preventing long term rebuilding of humus. One such example is Mallee Eucalypt (Figure 18). The amounts exceed those of a wheat crop.

**Table 7:** Biomass and nutrient export under a 3-4 year regime of Mallee Eucalypt.

Biomass	5.9 - 7.5 t/ha
Nitrogen	46.7 - 50.1 kg/ha
Phosphorus	3.9 - 4.7 kg/ha
Calcium	32.2 - 46.6 kg/ha

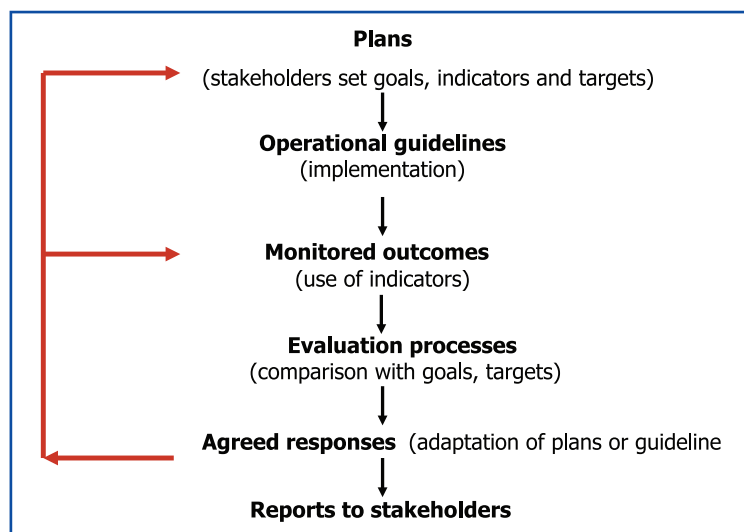
High removal of nitrogen requires high additions of ammonia fertiliser which might lead to soil acidification if the system is not well buffered. Acidification leads to exchangeable calcium depletion and increases exchangeable soil aluminium. It is therefore important to replace all the cations (Ca, Mg) by well buffered fertilisers, e.g. recycling of ash or application of natural fertilisers (e.g. sewage sludge, animal waste).

As an outcome, in addition to best practice, local management prescriptions (guidelines) are also needed, that specify actions needed to protect soils in different situations – e.g. the need to vary practices in relation to risk of soil erosion (which varies with soil type, slope and storm intensities) or soil physical damage (which depends on soil type, water regime, and nature of harvesting operations). Feedstock production can also affect downstream water quality through run off of fertilisers and agrochemicals.

Good farming and harvesting practices for feedstock production are key to maintain a long term soil quality. Practices such as no tillage and direct seeding, retention of soil cover, multiple cropping, appropriate crop choice and crop rotations can mitigate

negative impacts, in particular on carbon, soil and water resources. The application of these practices also can reduce the threat to biodiversity, particularly soil biodiversity, through the retention of crop residues and diversified crop rotations. Promoting integrated local food-energy production systems, by combining feedstock production with crop production and feeding livestock on biomass not used for energy production or soil cover, can avoid waste and increase the overall system productivity for food and energy.

A key question in the biomass production cycle is – have objectives and targets for maintaining soil fertility been met? To answer this complex question requires the monitoring and evaluation of temporal changes in important soil indicators and of rates of biomass production. Monitoring should focus on areas where there is likely to be greatest risk to soil values as a result of intensive biomass harvest. Monitoring (together with supporting research) can test the effectiveness of practices used to mitigate risk (Figure 19), and to progressively adapt and improve site-specific practices over time. Monitoring is difficult and expensive but it has to be done to some extent. The aim is to avoid the need for rehabilitation practices which are usually more expensive and logistically difficult.



**Figure 19.** Framework of adaptive production systems



## DISCUSSION AND CONCLUSIONS

### **Sustainability Issues and Biomass Production – Moderated by Josef Spitzer, ExCo Member, Austria**

The discussion focused on certification and the competition between the different certification schemes. In particular, reference was made to ISO, GBEP and RSB. IEA Bioenergy has started a strategic inter-Task study on monitoring the implementation of different certification schemes, with a preliminary conclusion that the numerous schemes in operation (more than 60) do not necessarily all help the environment, that is they have different focus and methods of operation that are not applicable to all renewable energy systems. There is also a possibility that industry will go 'certificate shopping', looking for the cheapest solution fitting their needs. This does not build confidence among consumers in the value of certification, and whether the products really have been produced sustainably. The NL Agency (Netherlands) has also made a similar comparison. The result can be downloaded from the Agency's website (<http://www.agentschapnl.nl/sites/default/files/Factsheet%20Sustainability%20Certification%20for%20biomass%20-%20november%202012.pdf>). Most participants believed that there is indeed competition between the different systems, and this is not helping the environment. Members of GBEP pointed out that they do not have a problem with schemes like RSB because GBEP is not a certification organisation, so there is no competition. They have identified 24 indicators necessary for a reliable certification system. GBEP considers RSB and the other six initiatives accepted by the European Commission as complementary. The GBEP initiative goes further because it covers three levels – sustainability, financial aspects and policy goals. It also includes energy security at the level of individual nations. An ISO member pointed out that they do not deal with policy issues, unlike GBEP, and warned confusing the two organisations GBEP and ISO, as their goals are different. ISO recommendations are usually accepted by the governments and then enacted through regulation which is not the case for the other initiatives.

The question was raised whether there are some activities under way to overcome the inconsistency of the different certificates. RSB claimed that they are fully transparent because they have started a benchmark initiative together with other organisations. The initiative will be uploaded on the web soon. However, an initiative alone does not really bring transparency. There should be regulations and rules of conduct in order to make the different systems comparable. This will only happen if all certification systems either use the same parameters (e.g. the indicators of GBEP) or can be independently evaluated.

It was stated that the economics of biomass production and utilisation is crucial for the introduction of certification. Without stable markets, sustainability schemes are difficult to establish and maintain. Establishing a market means an economy with end consumer prices comparable to fossil fuels. In that sense it is important that the whole certification process is not too expensive, especially in developing countries. RSB has three different cost levels

– the internal cost (essentially personnel cost), licence fee for the standard (very small, for developing countries < US\$1,000) and the auditing process (cost is a function of the size of the operation from US\$1,000 to around US\$50,000 or more).

The whole system development cost has to be taken into account. RSB was set up with a large grant from Packard (USA). For project related work they get support from governments and from the European Commission.

### **Timing Issues/Water Limitation – Moderated by Brendan George, Alternate ExCo Member, Australia**

This discussion focussed on water issues in relation to bioenergy and also highlighted the comparison (and simplification) of the time dependency of CO<sub>2</sub> emissions from forests. The issue, for C balance, is to recognise multiple products from managed forests and that over an extended time (that is dependent on the forest growth rates, harvesting, and end uses) the forest bioenergy system can have positive C outcomes (i.e. virtually no net CO<sub>2</sub> emission). The discussion highlighted the importance of the forest type and growth rates. If the goal is that a system should be sustainable by 2050 according to IPCC, to avoid passing the 2°C temperature increase, or even by 2020 as requested by the European Directive, then compensation of fossil CO<sub>2</sub> emissions through the use of wood for energy could be problematic if the re-growth of the trees takes longer. (And hence the forest energy system is not considered 'sustainable' within the time frame given). This would be more likely for managed natural forests but not for short rotation forests specifically grown for energy purposes established on previously cleared land. These systems have an accumulated carbon stock 'upfront' that is available for fast oxidation (burning, gasification, etc.). As a result, there will hardly be any so called 'carbon debt'. Several speakers concluded that biomass systems should not be regarded as carbon emission neutral as there are always net emissions for planting, harvesting, transport, etc. But when the other values of wood products are considered (e.g., displacement of C intensive materials such as cement and steel) then there is a clear role for bioenergy systems in forest areas that can sustain biomass removal and regrow i.e. There is a clear benefit of using wood instead of other materials, however, it does not relate to the bioenergy use of wood from forests.

Another proposal was to use CCF of wood incineration from natural forest on a temporary basis. While this was attractive to politicians with short term goals, in the long term it was considered this might be the wrong way to go. A 100 year time frame is probably an appropriate time range for climate change considerations.

Water, by the nature of it having different economic, social and environmental values over space (within and between countries) and time (e.g., winter versus summer) is actually significantly more complicated than C and much discussion and literature to date does not account for the whole hydrological balance. Water scarcity was obviously a new topic for some of the participants. Some requested that certain data presented, such as the fact that only 0.007% of all water in the world is available as fresh water,

should be widely distributed to make people aware of the situation. Even more so because the reality is even worse, in that much of that water is polluted and is not available as drinking water. But for the development of specific bioenergy industries the local availability and quality of water needs to be considered rather than a broad brush national approach.

Discussion also highlighted that water, site nutritional and soil health management and the timing of CO<sub>2</sub> emissions cannot be judged independently. For example, short rotation forestry for wood energy could yield much lower emissions at a single point in time (i.e., harvest) than a single event in a managed native forest. However, intensive forestry leads to lower soil fertility through increased soil compaction, higher nutrient export, less time for rebuilding humus and requires more water for regrowth. The Australian example of a SRF was mentioned where the second crop brought a 30% yield reduction due to water limitation (i.e. the water was not replaced quickly enough and therefore there was increased competition with other annual crops). To avoid nutrient translocation and removal an understanding of the impact of timing of harvest and what foliage is removed is required. More research in this area, especially important to SRC, is required.

It was concluded that there is still a considerable knowledge gap as to how to increase biomass production under a scenario of increasing water scarcity. Will replanting of forests be fast enough to improve the climatic situation by increased rainfall? Far more studies have to be carried out on a regional level, and there is no general answer as yet.

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Arthur Wellinger prepared the draft text. John Tustin, the Secretary, and Danielle Rickard facilitated the editorial process and arranged final design and production.

# IEA Bioenergy

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