A Growing Debate: Bioenergy in the 21st Century

Recent increasing demand for biofuels and other forms of bioenergy has sparked vigorous debate, particularly about their impact on food availability and pricing. Although such debate is necessary to create good policy, bioenergy presents complex issues and tradeoffs that are not easily reduced to a choice such as "food vs fuel".

What are the key elements to assess the global impacts of bioenergy? In this paper, UNEP discusses how bioenergy is neither a 'silver bullet' nor a human tragedy. If produced and used under the right conditions, bioenergy is one of several energy options that can deliver sustainable energy for a range of applications to a growing human population.

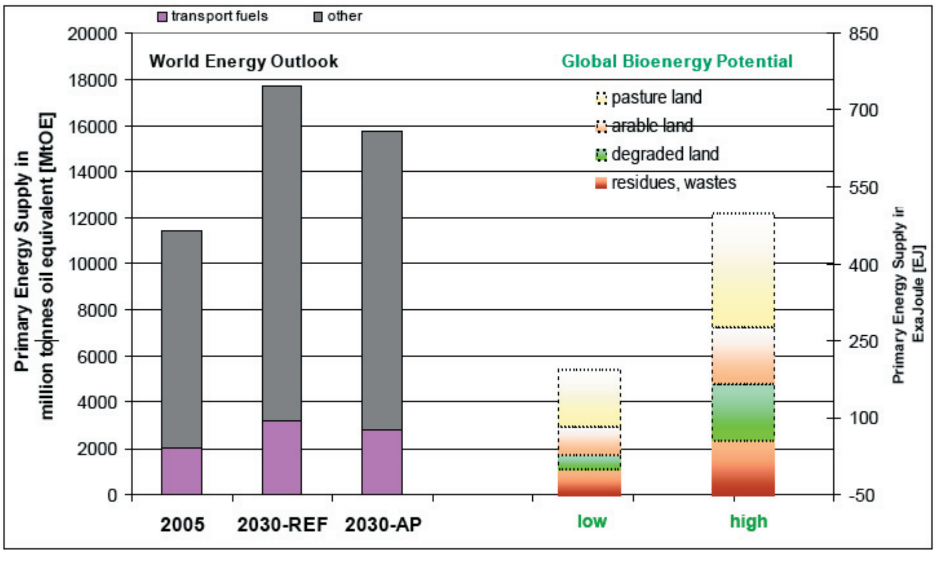
Bioenergy is an essential energy option

In a world facing growing energy demand, high oil prices and an urgent need to reduce greenhouse gas emissions, *bioenergy is an essential energy option for a range of applications as part of a mix that includes energy efficiency, renewable energy, and changed patterns of production and consumption.*

Since the discovery of fire, human societies around the globe have converted the bioenergy of plants and animals to provide light, heat and motive power. Today, bioenergy provides about 14% of global primary energy, although the share in some developing countries can be as high as 90%. In many developing countries, however, bioenergy is currently derived from poor quality sources and used inefficiently, resulting in harmful impacts on the environment and human health.

Many nations have the ability to produce their own efficient and sustainable bioenergy from agriculture, forestry and urban wastes. Produced locally, bioenergy can reduce the need for imported fossil fuels – often a serious drain on government budgets. Furthermore, by diversifying the sources of energy, bioenergy can increase the energy security of a country or region.

Global Energy Supply and Sustainable Bionergy Potential (Source: IEA, 2007, and Best et al, 2008)



Triggered by high oil prices and biofuel targets put into place by a number of governments around the globe, investment into bioenergy increased from US$ 2.6 billion in 2005 to $21 billion in 2006, according to a report by the Sustainable Energy Finance Initiative (SEFI). In addition, a number of government and companies are heavily investing in R&D for so called 2nd generation technologies (see 'Useful Terms'). These investments will lead to an increase in the share of bioenergy to overall energy supply. The International Energy Agency has estimated that bioenergy could supply up to 25% of world primary energy by 2050.

Much attention has recently been focused on bioenergy in the form of liquid biofuels that – despite a doubling over the past five years (UN Energy, 2007) - currently supply just 1.5% of global transport fuels. In light of growing demand for transport services, particularly for motor vehicles in a number of fast growing developing countries, alternative fuels and drive systems will have to be examined in terms of their resource efficiency, *fuel efficiency of vehicles will have to be improved, and changes of modes of transport will have to be considered.*

Biomass resources can be used most efficiently if they are grown and used for a primary purpose, such as food or fibre, and energy is subsequently extracted from their field or manufacturing residues. With oil prices continuing to rise, materials derived from fossil fuels, such as plastic textiles, will become more expensive and create higher value opportunities for products based on biomass. Converting residues and other organic waste streams into biogas and other fuels is already underway in several countries, and will increase with 2nd generation technologies and feedstocks.

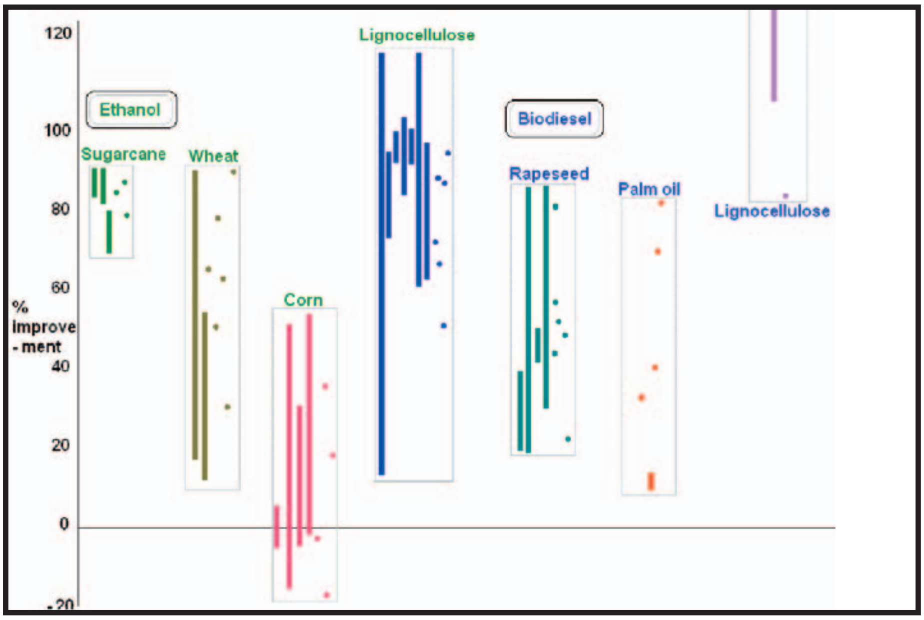
Identifying and reaching a sustainable potential of bioenergy depends on several factors, including:

- The resolution of environmental and social concerns about food security, vulnerable communities, water resources, and deforestation;
- Increased production from technical innovation in agriculture and forestry:
- The overall dynamics of the food, feed and fiber markets; and
- Regional measures that address climate change impacts.

Bioenergy has the *potential* to lower greenhouse gas emissions

Unlike fossil fuels, bioenergy can be a carbon-neutral or even carbon-negative energy option, but only if the emissions of greenhouse gases produced during the use of biofuels are re-absorbed from the atmosphere during the growth of feedstocks. This is not always the case, however, and *some bioenergy options can even lead to higher greenhouse gas emissions over the entire life-cycle from production, conversion, transport and end use.* Net GHG emissions will depend on the type of land used, choice of crops in different geo-climatic conditions, agricultural practices (including whether carbon-intensive chemical fertilizers are used and the level of mechanization requiring fossil fuel input), and end-use efficiency.

Particularly, land use changes can lead to significant GHG emissions if new land is brought into production by converting forests and wetlands into cropland. This creates a



Relative net life cycle GHG emission improvement of selected biofuel pathways as compared to gasoline and diesel fuels. (Source: UNEP/IEA 2008)

'carbon debt' that may not be 'paid back', even over a long period of time. If land use changes are direct, the impact can be calculated and traced back. In the case of 'indirect land use changes', i.e. where bioenergy feedstocks do not directly replace forests, wetlands or other areas with high carbon storage capacity, but push into other usages which in turn replace carbon storing areas, both within a country or even across boarders, the effect is more difficult to assess and to trace.

Assessment of the net GHG effect of a bioenergy pathway or project is currently done under several methodologies. To enable choices for the most GHG efficient option in a given context, a common methodology is urgently needed for different pathways over their entire life cycle, including direct and indirect changes in land use. This is particularly important for an evolving carbon market that can promote bioenergy pathways with substantial net greenhouse gas reductions.

While bioenergy development should generally lead to significant GHG emission reductions, some bioenergy pathways in developing countries, however, may be pursued for their development and environmental benefits, even if they do not produce significant greenhouse gas reductions.

Finally, with expected impacts of climate change on agricultural productivity (IPCC), *crop choices need to be made in light of the need for adaptation measures.*

Bioenergy can have both positive and negative environmental impacts

As with every other energy option, the production and use of bioenergy can produce both positive and negative impacts on the environment, and present a complex challenge of land use and natural resource management. Consequently, the most efficient methods of bioenergy production and use will produce the maximum benefits and least costs. Monitoring and management of these impacts are essential activities to both minimize negative impacts, and maximize positive ones.

Water

Because current production is based principally on agriculture, bioenergy tends to have similar environmental impacts, particularly on water resources. Agriculture accounts for more than 70% of total water used in most countries, so cultivating energy crops can put further pressure on scarce water resources. Farmers may pump 250 billion-litres of underground water to raise the corn feedstock for an ethanol production facility. If managed poorly, energy crops can lower sub-surface water tables, as well as rivers and lakes, particularly if these crops are irrigated. To avoid this potential problem, particularly in countries with scarce water resources, crops need to be carefully matched to available water resources. Efficient irrigation and rainwater harvesting can help reduce negative impacts.

Considerable amounts of water are also required to convert bioenergy feedstocks into fuels. A 200 million-litre ethanol plant, for example, might use 600 million-litres of water to make fuel - more water than some small towns use in a developed country. Hence, the choice of the end product should be influenced also by the considerations on water availability, e.g. straight vegetable oil requiring less water than biodiesel.

Bioenergy can also improve water resources. For example, the roots of some energy crops can reduce rainwater run off, and the energy 'harvested' can be used to power pumps and purifying water.

Biodiversity

One of the potential major impacts of bioenergy production – and one of the most serious threats to biodiversity – is the conversion of grasslands and tropical forests and other biodiversity rich zones into monoculture croplands. The Convention on Biodiversity target to halt the loss of global biodiversity requires the protection of land with high conservation values and ecosystem services. The cultivation of feedstocks should be excluded from such areas unless it can be proven they protect or enhance biodiversity.

Two particular issues with bioenergy and biodiversity are the use of genetically modified organisms (GMOs), and the introduction of feedstock plants that may be considered invasive species. GMOs for producing bioenergy are part of a wider GMO debate (and outside the scope of this paper), while invasive species may present a formidable challenge for countries and regions wishing to plant non-indigenous species. For both issues, careful assessment of possible consequences and their risks is essential.

Soil

As with all agriculture production, growing bioenergy feedstocks can degrade soil fertility if not managed sustainably, particularly tilled monoculture that can leach and acidify soils. There are some plants, however, that may help to recover degraded land, or improve marginal lands by reducing wind and water erosion.

Air

Some forms of bioenergy can help improve air quality during the use phase, depending on feedstocks and combustion methods. Just a 20% blend of biodiesel can reduce asthma causing particulate matter by 30% and acid-rain forming sulphur dioxide by virtually 100%. However, during the production of some forms of bioenergy, air pollution can be increased. The burning of cane fields for harvesting and the burning of crop wastes, for example, can increase local air pollution.

Bioenergy can support rural development and the Millennium Development Goals (MDGs)

Bioenergy provides an opportunity for developing countries to utilize their own resources and attract the necessary foreign and domestic investment to achieve sustainable development goals.

Particularly in developing countries where 75% of the world's poor depend on agriculture for their livelihoods, producing bioenergy can harness agricultural growth for broader rural development, reducing poverty and the drain on government budgets to pay for fossil energy imports.

Employment is a key element of rural development. In many developing countries, bioenergy has a large potential to create jobs in their labour intensive agricultural sectors. Additional job creation opportunities can also be found in the conversion process from feedstock to bioenergy as this process generally takes place close to where the feedstock is produced.

The additional income from new jobs is likely to have a multiplier effect when spent locally, which can further spur development. Access to cheaper energy from local bioenergy sources, particularly higher quality energy forms, can help increase agricultural yields and efficiency, particularly through some forms of mechanization, and enable crop preservation. In addition, additional businesses and services requiring energy can be developed.

Higher quality energy such as biogas and electricity can reduce the time women and girls spend in a number of manual activities, such as fetching water and firewood. Electricity generated from biofuels can contribute to the goal of universal education by providing light for learning and power for telecommunications. Electricity can improve the health of rural households by purifying water, refrigerating medicine, sterilizing equipment, and powering health care centres.

The job creation, education and health benefits from improving access to higher quality energy can also help reduce the disparity between rural and urban amenities, thus lowering the migration rates to urban centres.

Achieving these benefits, however, depends substantially on the way in which the bioenergy is produced. A poorly managed bioenergy expansion can impact social values such as local customs, and may undermine traditional sustainable agricultural and land-use practices. In many regions, economies of scale and global trade tend to favor large, highly mechanized producers that provide higher skilled and better-paid jobs but less overall employment.

If bioenergy crops become more valuable, the consolidation of land into larger holdings may favour larger landowners and displace small farmers. There is inherent in this argument the concept of scale – what's good for a large multinational corporation may not be appropriate for smaller communities or regions.

This is particularly difficult as scale relates directly to the economics of biofuel production. However, most economic assessments only look at return on investment, and do not take into account the side-benefits for local development. *To obtain the maximum development benefits, however, a focus on small farmers is crucial,* and needs to be strengthened, through both policies and measures helping them to participate in this new business directly, through organization in cooperatives and through participatory concepts in large scale operations.

The impact of bioenergy on food security and prices is complex

Assessing the impact of bioenergy production on food prices requires careful analysis of many variables. It is certainly true that bioenergy production can change the availability and price of food by competing for land with food crops or livestock for land. Although this "fuel versus food" competition is widely recognized, the extent of the impact needs further research as current estimates vary widely and depend on the type of crop and region.

Crops currently used specifically for biofuels utilize 0.025 billion hectares – approximately 2% of the 1.5 billion hectares used to produce arable crops. In Brazil, over 40% of total gasoline demand is provided by ethanol produced from sugarcane grown on 1% of the 320 million hectares of arable land.

A number of recent studies have attempted to estimate the impact of biofuels on the 40% rise in food prices during 2007 (FAO). Although the World Bank has estimated this share at 80%, the IEA reports that increased demand for biofuels has contributed about 10% of the recent rise in grain prices, while the International Food Policy Research Institute estimates the overall share at 30%.

Food prices have been affected by higher oil and fertilizer prices, record bad harvests due to weather events, commodity speculation and changing to meat based diets with higher energy input. Further, food prices themselves have previously been on a long-term downward trend, and have not reflected the true cost of production. Price rises now are starting to reflect market realities, and higher prices can have both positive and negative effects.

Rising farm incomes in developing countries from higher prices, for example, can help to reduce poverty and encourage farmers to produce more food, which may thus increase the availability of food in the medium to long term. In the short-term, however, access to food may decrease for poorer urban dwellers who must spend either more of their limited incomes on food, or can afford only insufficient quantities of food.

Biofuels have put additional pressure on grain markets that have had little time to react. Over time, however, improved farming methods, flexible markets and new technologies helping to use marginal land can overcome the current competition between choices of 'food vs. fuel'. In Brazil, for example, production can be flexibly switched between sugar as a foodstuff and ethanol depending on prices.

In addition, agricultural production in much of the world is below potential. Improved management practices can increase yields substantially, which could then release land for a certain amount of bioenergy crops.

In the long-term, however, other forces may push prices higher and increase pressure on land for food production, including a global population that continues to grow towards 9 billion, and changing diets. The current 1% increase in annual crop yields over the past several decades has only barely kept pace with an increasing global population.

The concern over competition between crops for food or fuel is already being reflected in changing investment patterns. Under higher corn prices, investment in the US ethanol industry fell from $1.7 billion in the first quarter of 2007 to just $311m in the first quarter of 2008, while investment outside the US fell by 15%.

Agricultural subsidies and trade restrictions also play an important part and can greatly distort markets and prices, particularly for the poor who often pay 80% of their income for food. Addressing the complex issue of subsidies can produce significant benefits to both the bioenergy, energy, and food sectors.

Much of the food vs fuel debate could be eliminated if bioenergy feedstocks were produced on land that is not suitable for food, or from waste and residues. This is the focus of 'second generation' bioenergy technologies, which can be accelerated through additional support for R&D. Utilizing the one billion hectares of marginal and degraded lands unsuitable for food production (such as land affected by rising salinity levels) may even be able to restore environmental values.

Policy, markets, and other tools can ensure sustainability

Criteria

Sustainability principles and criteria - such as those developed under the Roundtable on Sustainable Biofuels (www.cgfe.epfl.ch) - can guide bioenergy planning by governments, project developers and investors.

Some governments have started to develop principles and criteria. Also, most of the development finance and large finance institutions already apply environmental and social safeguards when making their financing decisions in other areas, such principles can help reduce project risks, and raise corporate social responsibility profiles also in bioenergy development.

For sustainability criteria to be widely adopted and implemented, governments, the private sector, producers, and civil society particularly small farmers and indigenous people need to be involved in their development and application. Transparency will also help to avoid breaching trade under rules of the World Trade Organization (WTO).

From a social perspective, a sustainable bioenergy sector addresses labour and health issues while respecting the rights of indigenous people who may be marginalised by large-scale projects. This is particularly important in developing countries where foreign investment can make biofuel projects so financially compelling that these rights become secondary to the viability of the project. Bioenergy production should also contribute to social and economic development of local, rural and indigenous people, and should not impair food production.

From an environmental perspective, GHG balance, direct and indirect impacts on biodiversity as well as impacts on soil, water and air should be avoided.

Just as wood products can now carry an advanced environmental certification, bioenergy can be internationally certified in line with the developed environmental and social criteria. Certification can protect producers and enable consumers to make informed choices.

Certification also has its limitations, e.g. while direct land use changes can be covered though certification schemes, indirect land use changes (which are more difficult to assess) can only be addressed if all biomass products are certified. Alternatively, additional measures would have to be used, such as prohibiting bioenergy production in designated areas to preserve both biodiversity and carbon storage or market based instruments. These would have to be carefully monitored, however.

Markets

Market-based bi-lateral and multilateral arrangements can support a sustainable bioenergy framework, and address climate change and biodiversity impacts resulting from land use changes. The carbon market is also an important policy driver for bioenergy by potentially valuing the net carbon taken from the atmosphere, and similarly discussions are ongoing under the Biodiversity Convention, valuing ecosystem services and looking into payments for conservation.

The Clean Development Mechanism (CDM) under the current climate regime provides a financial incentive to invest in GHG reductions in developing countries, although there is only one current methodology for bioenergy projects, and financial flows through the CDM will be able to provide only additional revenue to Bioenergy projects, not full financing.

At the Climate COP in Bali in December 2007, governments agreed to develop a mechanism for reducing emissions from deforestation and degradation (REDD). This mechanism might also be of relevance to bioenergy projects, favouring those that are not developed on “carbon-rich” lands, such as tropical rainforests, and high-value conservation areas.

Biofuels may be made from a variety of sources, including shrubs such as Jatropha.

Some smaller and more innovate projects – particularly those with a large social dividend – often do not receive the same level of interest from commercial investors as large scale projects using proven crops and technologies. This investment gap can be overcome through special lending conditions that value the social benefit and improve their economic viability. *Additional benefits can be gained if the cost-benefit analysis of bioenergy projects reflects both external costs and co-benefits, such as access to modern forms of energy that enable new business, employment, health and development opportunities.*

Targets and Policies

Domestic targets or mandates for Bioenergy can promote markets, but such mandates can also distort markets for energy and agricultural products and conflict with other objectives, such as reducing subsidies, import quotas, and non-tariff barriers and other policy areas. Targets based on a solid assessment of the sustainable potential of bioenergy should be phased in gradually, allowing for corrective measures while providing incentives and certainty for the market to develop.

In general, the bioenergy sector will advance more rapidly and sustainably under integrated and coordinated policy frameworks that include agriculture, energy, environment, and transport sectors; and by ensuring trade policies and climate change policies work together.

The market acceptance of biofuels will also accelerate if the price for energy “tells the environmental truth”, including the costs of climate change and pollution. Currently this is not the case, and makes conventional fuels look more financially attractive than they really are. Internalising the cost of pollution and reforming energy and agricultural subsidies would send powerful market signals to encourage a sustainable bioenergy sector. Further, monetizing other elements, such as development benefits, in cost-benefit analyses will enhance the economic viability of bioenergy projects, particularly small-scale projects in areas where access to energy is currently limited.

A moratorium is not needed... if

Producing bioenergy can be an opportunity to reduce greenhouse gas emissions and provide development benefits. The pathway to these outcomes, however, very much depends on a range of factors, including well-structured markets and policies that protect environmental and social values.

Unless the development of biofuels is carefully planned and managed, however, the world can wind up in a ‘zero sum game’ where one environmental problem substitutes for another. It will be difficult - if not impossible - to replace high value agricultural land, forests and habitats lost to an unsustainable biofuels sector. At the same time, governments and industry must think ahead as biofuels present an opportunity for cleaner energy and economic development.

The rush to invest in new bioenergy projects has too often by-passed the best methods to ensure sustainability. The most prudent action now is to develop and implement the necessary policy tools and market mechanisms at the global, regional and national level to ensure bioenergy reaches its full potential as part of an economy based on sustainable forms of energy.

UNEP is fully engaged

UNEP is working in a number of activities to help bioenergy reach its potential. UNEP continues to work in partnership with governments, the private sector and NGOs to:

- Maximize the benefits and reduce the environmental and social costs of producing and using sustainable bioenergy;
- Assure environmental and social sustainability of biofuel production through sustainability principles and criteria;
- Support governments in bioenergy planning and policy frameworks; and
- Help test business models that use energy crops to maximise the development benefits of biofuels.

Current UNEP efforts include the Global Bioenergy Partnership (GBEP), the Round Table on Sustainable Biofuels (RSB), and the International Panel for Sustainable Resource Management.

Further Information

www.unep.fr/energy/act/bio/index.htm

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