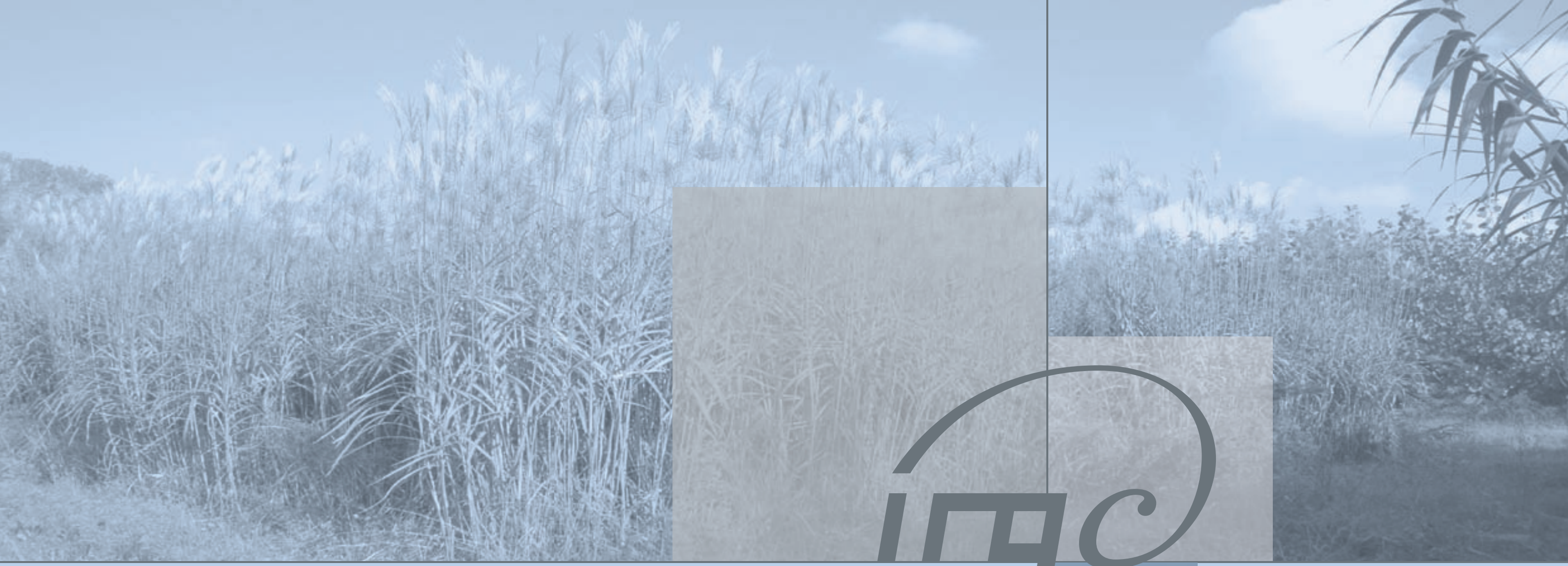

Policy Brief

Risk Governance Guidelines for Bioenergy Policies

international risk governance council

Abbreviations used in the text:

BEFS	Bioenergy and Food Security Project
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
EIA	Environmental Impact Assessment
EU	European Union
FAO	United Nations Food and Agriculture Organization
GBEP	Global Bioenergy Partnership
GHG	Greenhouse Gas
GW	Gigawatt (one billion watts)
GMO	Genetically Modified Organism
IPCC	Intergovernmental Panel on Climate Change
IRGC	International Risk Governance Council
IUCN	International Union for Conservation of Nature
LCA	Life-Cycle Assessment
LIHD	Low-Input, High-Diversity
MSW	Municipal Solid Waste
MW	Megawatt (one million watts)
NGO	Non-Governmental Organisation
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WTO	World Trade Organization

Dedication

Everyone involved in this project was deeply saddened to learn in April 2008 of the sudden death of Alex Farrell, a member of the project's Advisory Board. Alex was a world-renowned expert on energy and transport systems and their sustainability. His contribution to this project was considerable, both as an active participant in the two workshops and through the many insightful and practical comments he made during the drafting of this policy brief.

This policy brief is dedicated to the memory of Alex Farrell.

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Foreword

This policy brief comprises an overview of current bioenergy developments and policies, a commentary on these developments which highlights some of the opportunities and risks of bioenergy, and presents the International Risk Governance Council's risk governance guidelines for bioenergy policies.

The International Risk Governance Council (IRGC) is an independent foundation based in Switzerland whose purpose is to identify and propose recommendations for the governance of emerging global risks.

Because many emerging risks are associated with new technologies and usually accompany significant economic and public benefits, different governance approaches and policy instruments must often be developed to maximise those benefits while minimising the identified risks. Important opportunities for social and economic development can be foregone where the public perceives inadequate risk governance measures.

To ensure the objectivity of its governance recommendations, the IRGC draws upon international scientific knowledge and expertise from both the public and private sectors in order to develop fact-based risk governance recommendations for policymakers, untainted by vested interests or political considerations.

This policy brief on risk governance guidelines for bioenergy policies is an example of such fact-based objective analysis. It is the result of an IRGC project which has been led by Jeff McNeely, Chief Scientist at the International Union for Conservation of Nature (IUCN). Project work has involved a multidisciplinary team of experts and members of the project's Advisory Board (listed in the Acknowledgements). This policy brief elaborates upon discussions held at two expert workshops, in September 2007 and in February 2008, which generated the issues raised and the proposals suggested in this document. The workshops were attended by experts from North America, Brazil, Europe, India and China, and included representatives from governments, industry, research organisations and non-governmental organisations.

IRGC hopes that these guidelines can help realise the potential of bioenergy to enhance energy security, reduce greenhouse gas emissions and contribute to sustainable development. Crude oil prices reached US$ 147 a barrel in July 2008 and, although they have fallen somewhat at the time of writing this foreword, it seems fairly certain that the days of cheap oil will not return. It is therefore understandable that a number of governments have focused much attention on positioning bioenergy – in the form of biofuels – as central to how they develop their national energy mix.

IRGC hopes that these guidelines can help realise the potential of bioenergy to enhance energy security, reduce greenhouse gas emissions and contribute to sustainable development

However, as this report makes clear, there are considerable risks and uncertainties presented by current biofuel technologies, and these need to be better understood if we are to take full advantage of bioenergy's potential in the future.

Thus, current efforts to use biofuels to enhance energy security in the short term need to be seen as the beginning of a longer-term effort to develop bioenergy that emphasises resource efficiency, care of the environment, climate change mitigation and opportunities for sustainable development. There is also the need to position bioenergy amongst the full range of renewable energy options, accounting for its advantages as well as its shortcomings as compared to other policy and technology options.

Bioenergy is a rapidly-evolving field, in terms of both policy and technology, with many uncertainties remaining. IRGC recognises that bioenergy offers different opportunities and risks in different parts of the world, and that all governments are seeking energy security. IRGC offers these guidelines as a means for helping to achieve this elusive goal.

Donald Johnston
Chairman
International Risk Governance Council

Geneva, 30 July 2008

Contents

INTRODUCTION

Biomass has been a source of energy for millennia. Since the 1970s, in many countries – particularly Brazil – targeted government policies and programmes have led to the increased use of a broad range of biological resources as feedstocks for bioenergy (including sugar cane, maize, soya, rapeseed, jatropha and wood).

This trend has accelerated recently. Oil price increases are now recognised as a source of worldwide economic, social and political distress, and bioenergy – in the form of biofuels – is a part of how at least some governments are dealing with oil supply constraints. Policymakers have also recognised the role bioenergy can play in mitigating climate change through reducing greenhouse gas (GHG) emissions, and many governments are providing financial support to producers (through subsidies) and mandating the use of biofuels. As a result, the production of bioenergy is increasing rapidly.

This rapid increase has implications for business, civil society and the environment. It has also led to greater attention being paid both to the potential opportunities offered by bioenergy as well as to the negative direct and indirect effects of bioenergy production, particularly when using current technologies.

This attention is currently focused mostly on biofuels for transportation, which is the primary reason why IRGC has chosen to focus on bioenergy in its broadest sense. From this broad perspective the advantages of bioenergy can be significant, including energy security (a source of electricity, heat and gas as well as liquid fuels), GHG emission reductions and sustainable rural development. IRGC believes that these advantages are far from assured, as bioenergy development also involves substantial risks that are receiving inadequate attention. It appears to IRGC that, in at least some parts of the world, policies are being decided before sound scientific knowledge about the risks has been considered, or even generated. IRGC intends that the risk governance recommendations proposed in this policy brief will help decision-makers to develop and implement policies and promote investments that take account of longer-term considerations, and so ensure that the full potential of bioenergy is realised without causing some or all of the associated risks to occur.

Opportunities related to bioenergy development

There is no doubt that, under the appropriate conditions, bioenergy can contribute to important global needs such as enhancing energy security, reducing GHG emissions, and, particularly in developing countries, promoting sustainable rural development. In particular, biofuels can help compensate for the oil price increase, avoiding many economic and social problems that unaffordable oil prices would generate. However, bioenergy is just one way to meet these needs and it has value to society only if the benefits it provides exceed its costs, including the opportunity cost of its development, in the long term. IRGC believes that, in the short term, most win-win opportunities appear to be optimal at a small, local scale, primarily due to the low energy density of biomass resources. These include niche applications such as farm-scale biogas plants or biomass for combined heat and power (CHP). As biomass also tends to be bulky, making it more suited for processing close to where it is produced, it is better suited to multiple, small bioenergy facilities rather than large, centralised ones.

Bioenergy alone cannot achieve the objectives of energy security, GHG emission reductions and sustainable development. It needs to be seen as a part of a comprehensive, sustainable energy policy in which all the various options are employed optimally, including energy efficiency, conservation, and appropriate technologies. But, by taking full account of the associated risks, bioenergy can make a significant contribution to a number of the world's most pressing problems.

RISK ASSESSMENT

Economic and structural risks

Risks associated with current levels and techniques of production (particularly of liquid biofuels) are largely the result of economic incentives and market mechanisms such as subsidies, mandates and protective trade barriers, many of them counter-productive in the long term. These seek to promote investment by providing a degree of certainty to investors, but they can also distort markets and are subject to political decisions that may make them unsustainable.

Industry also faces regulatory and economic risks related to capital investment, due to the lack of clarity and focus of public policies. Although the resulting uncertainty is partly due to industry itself lobbying for policy changes, IRGC believes that the lack of a clear regulatory framework is an issue that needs to be addressed.

Additional risks associated with bioenergy stem from underlying institutional and structural problems, especially in countries with insecure land tenure and access to resources.

Environmental and social risks

Risks such as soil degradation, biodiversity loss, stress on water resources, the trade-off with food supply, and the direct and indirect impacts of land-use change on GHG emissions, demand attention. IRGC considers that research is urgently needed to develop scientific knowledge of the full environmental impacts throughout the life-cycle of the various forms of bioenergy.

Land-use change

Recent studies have highlighted land-use change as a potential environmental risk that may be exacerbated by bioenergy development. Where forested land is cleared or food crops are displaced to make way for bioenergy feedstock crops, bioenergy production may directly or indirectly increase GHG emissions and loss of biodiversity. Studies of these indirect impacts question the environmental rationale for bioenergy if large areas of land are required, regardless of location and production methods employed. The uncertainties associated with the effects of land-use and land-use change suggest the need for a conventional risk-based approach to decision-making. IRGC recommends the use of full life-cycle assessments (LCAs) to help assess the net direct and indirect impacts of land-use change, but other more strategic measures that consider land-use more broadly are also needed.

Given the considerable uncertainty about both the risks involved and the scientific data that underpin current understanding of bioenergy and its risks, IRGC believes governments first need to “take their foot off the accelerator” to provide time to consider carefully the risks involved in developing bioenergy. Given the necessity of mitigating climate change and improving energy security, investment in research and development is an urgent priority in order to minimise the time needed to assess the various options.

POLICY ASSESSMENT

Bioenergy policies are currently designed to pursue specific objectives such as agricultural support, rural development, reduced dependence on foreign sources of energy, environmental rehabilitation, and climate change mitigation. However, pursuing diverse multiple objectives with a single policy is rarely efficient. Moreover, bioenergy policy typically is shared among several parts of government, such as ministries dealing with energy, environment, climate change, economic development, trade and agriculture. This suggests to IRGC that, while an integrated approach to developing policy is needed, achieving it may be institutionally challenging.

Dealing with the trade-offs

Several indicators lead IRGC to conclude that the local, regional and global competition between food and fuel is not being adequately addressed, with severe negative side-effects in some developing countries, particularly for the poor. In many cases the food-fuel conflict is being exacerbated by policies that favour the diversion of food crops into biofuel production (in order to compensate for the oil price increase and its impact on food prices), at a time when other demands on finite land resources – for food production, housing, recreation, nature conservation, and so forth – are also increasing. Bioenergy technologies are developing quickly, and innovations that will reduce the competition between food and fuel are likely to make bioenergy more attractive in the future.

Climate change further complicates the demands on bioenergy. IRGC considers that insufficient attention is being given to the energy-climate change trade-off throughout the bioenergy value chain, particularly with regard to the overall GHG emission balance and the indirect impacts of land-use change.

Differentiated objectives with clear priority and focus

For the above reasons IRGC believes that, in addition to improving energy efficiency and managing energy demand:

- Industrialised countries and major exporters of bioenergy among the developing countries should encourage the development of bioenergy only where it can be demonstrated that doing so will significantly reduce GHG emissions over the whole life-cycle. Having met this basic criterion, governments can then encourage new investments to develop sustainable and economically-viable forms of bioenergy that contribute to energy security.
- Other developing countries and countries with economies in transition should develop bioenergy primarily to benefit local livelihoods through providing heat and electricity as well as affordable, safe and more efficient fuels, and so support wider sustainable development goals without, in doing so, jeopardising food security. In such countries, communities may need help to find appropriate ways to harness and exploit waste biomass and bioenergy crops at suitable scales.

IRGC also believes that, in all countries, policies should be developed in such a way as to not deplete biodiversity and other natural resources. Policies should use the principles of adaptive management, being revised as new scientific knowledge emerges that can help reduce uncertainty (for example, from full LCAs which take full account of bioenergy's many secondary impacts and which reflect different geographic, climatic, feedstock and production factors). Policies should also adapt to future technologies that may shift bioenergy production to new feedstocks, such as algae or municipal waste, which may be produced with a more favourable cost-benefit ratio.

RISK MANAGEMENT STRATEGIES

From its research and the discussions held at the two workshops IRGC has concluded that risk management strategies should strike a balance between the case-specific opportunities offered by bioenergy and the risks it poses. IRGC has identified the following as practical actions and instruments that could help policymakers and industry develop sustainable bioenergy production and policies in the long term:

- Assess realistic capacities to produce domestic feedstock for bioenergy, avoiding over-optimistic projections about the potential contribution of bioenergy to the energy mix.
- Implement land-use policies which will reduce the risk of land with recognised high biodiversity value or high carbon stocks being converted to grow biomass feedstock, and encourage the use of marginal land, but only when environmentally, economically and socially appropriate.
- Promote more sustainable agricultural practices, both for food and fuel production.
- Foster research and development that enables a faster move toward new forms of bioenergy (including so-called second-generation, but also transitional technologies), which may require less land and may enable the more efficient use of wastes and non-food feedstock.
- Minimise any negative impact of bioenergy production (and in general of all agricultural practices) on water resources.
- Maximise the use of waste, particularly sewage, in bioenergy generation but only deliberately use food crop residues when doing so does not lead to soil erosion or humus depletion.
- To ensure that their scope includes the full "cradle-to-grave" bioenergy life-cycle and that current limitations in methodology are overcome, further develop and use risk assessment methodologies such as LCAs and Environmental Impact Assessments (EIAs), and apply them locally.
- Adopt internationally agreed sustainability standards and criteria for certification that would be recognised under international trade rules.
- Develop adaptive regulatory frameworks that set the conditions for transparent and balanced markets for producing and exporting countries to meet, first, their domestic needs, and, second, the needs of international trade.
- Employ only technology-neutral economic instruments to assure technological diversity in how environmental, economic and social performance standards are met.
- Engage consumers with transparent communication and thereby help them to make well-informed choices so that they, too, can contribute to promoting sustainable bioenergy and managing the associated risks.

I Introduction

This policy brief identifies ways to deal with the risks involved in the development of bioenergy while also maximising the opportunities it offers

This policy brief proposes guidelines for the governance of the risks and opportunities of modern bioenergy, whether used for heat, electricity, or transport fuel. It identifies ways to deal with the risks involved in the development of bioenergy while also maximising the opportunities it offers. The document's primary target audience includes policymakers responsible for energy, agriculture, climate, environment, trade, transport and development policies. The proposed guidelines may also be relevant and helpful for industry in the energy, agriculture and food sectors, particularly in suggesting risk assessment tools that may be used to develop comprehensive risk management strategies.

IRGC's role in the context of current scientific knowledge, technological change and political debate is to:

- Focus on risk governance, on how to best manage risks in order to maximise opportunities. IRGC's risk governance approach involves the identification, framing, assessment, management and communication of risks in a broad context; it includes the totality of actors, rules, conventions, processes and mechanisms and is concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken;
- Emphasise what science says, knows and does not know, and how scientific knowledge should inform risk governance and the policymaking process. In this document IRGC provides science-based recommendations to those policymakers and industry managers responsible for designing balanced strategies for reducing GHG emissions and meeting energy needs; and
- Accentuate the importance of clearly defining an issue globally – in this case bioenergy and its potential impacts, both positive and negative – in order to provide context for decisions that may be regional or local and which require adaptability and the need for further research and study.

IRGC has deliberately addressed bioenergy from a broad perspective, rather than focusing only on current biofuel production and use. This broad focus means that its recommendations acknowledge both short-term and long-term opportunities and risks.

IRGC fully understands that policymakers face the extremely difficult task of having to provide employment and energy to their populations, while dealing with national security concerns. Many have chosen to support bioenergy, mainly in the form of liquid biofuels with their many advantages (including energy self-reliance, rural employment, more affordable energy than oil currently, and support to the transport industry). IRGC is, however, concerned that current policies may, in the longer-term, be detrimental to other fundamental challenges (such as deforestation, water management and food security).

IRGC is concerned that current policies may, in the longer-term, be detrimental to other fundamental challenges

Energy security – particularly security of oil supplies – is a crucial factor in current policy decisions, many of which focus on increasing the use of biofuels for transportation. Together with agricultural policies (particularly in the US and EU), it creates a political coalition that is hard to counter-balance and favours short-term initiatives. This may make it more difficult for governments to adequately diversify their sources of energy supply in the future, not least because investments and incentives related to liquid biofuels reduce the potential for supporting the development of other sources of energy, including renewables.


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Jatropha flower

II Bioenergy – definitions and uses

In 2006, bioenergy (primarily for cooking and heating) accounted for 14% of total global primary energy consumption. Modern bioenergy made up less than 2% of this total and only 0.3% was derived from biofuels [IEA, 2007]. The bioenergy industry, however, is growing rapidly, especially in the area of biofuel production capacity, which expanded at an average annual rate of approximately 40% over the period 2002-2006. In 2006 alone worldwide production of biofuels increased by more than 50% relative to the previous year, not least as a result of deliberate policies in the US targeted at mitigating the impacts of tight supplies and volatile prices of crude oil. Biomass power and heat also expanded, albeit at a slower annual rate of between 3 and 5% over the past 5 years [REN21, 2007].

However, despite the recent enthusiasm evidenced by industry trends, investment flows and government policy targets, bioenergy alone cannot be expected to solve the climate crisis, the energy security predicament or the condition of the world's rural poor. While bioenergy development presents some promising opportunities on all three fronts it also involves some serious risks that, if not carefully identified and sufficiently addressed, will result in negative consequences that can counteract many of its prospective benefits.

Bioenergy alone cannot be expected to solve the climate crisis, the energy security predicament or the condition of the world's rural poor

Bioenergy refers to energy produced from non-fossil organic matter (biomass). Bioenergy exists in several forms including solid biomass, liquid fuels and gases. These in turn can be used to produce electricity, heat, or fuels for transportation.

Biofuels

Bioenergy for liquid fuels is derived from recently-living organisms and their metabolic by-products. The International Energy Agency expects global biofuel production to quadruple between 2006 and 2026, ultimately accounting for about 10% of the world's motor fuel. David Tilman and colleagues at the University of Minnesota have calculated that, even if the US turned all of its maize and soyabeans into biofuel, the amount produced would replace only about 12% of its gasoline and 6% of its diesel fuels [Hill, 2006]. (Note that comments made in the document that relate to biofuels may be subject-specific and should not be understood as applying to bioenergy in general.)

Biofuels include:

Bioethanol

Bioethanol is an alcohol used primarily as a petrol replacement and additive. Accounting for roughly 90% of all biofuel production, ethanol is currently produced by fermentation of sugar and starch-rich feedstocks such as sugar cane, maize, wheat, sweet sorghum, sugar beet and potatoes. It can be used in varying percentages in petrol-driven cars with minor design changes. Ethanol is suitable as a petrol replacement only for spark-ignition internal combustion engines. Projected global production of ethanol for 2007 was approximately 60 billion litres, with the largest producers being Brazil (primarily from sugar cane) and the US (primarily from maize [corn]) [Steenblik, 2008].

Biodiesel

Biodiesel is composed of fatty acid methyl esters that can be processed from animal fat, pure vegetable oils such as rapeseed, soya and palm oil, non-edible oils such as jatropha, pongemia, or neem, and oil derived from algae. In Europe, the biggest biodiesel market, oilseeds are pressed for their oil which is then processed via transesterification with methanol. Co-products of biodiesel that can improve the economics of its production include glycerine and animal feed. Biodiesel is most commonly sold blended with diesel at low percentages. In Europe biodiesel is commonly blended at 2 to 5% by volume and sold as regular diesel, but higher blends such as 20% (B20) and pure biodiesel (B100), which are labelled as biodiesel, are increasingly entering the market [Pahl, 2005]. 2007 production of biodiesel was forecast at 6 billion litres [Steenblik, 2008].

Second-generation biofuels

New, advanced "second-generation" technologies for producing ethanol, biodiesel and other fuels such as butanol from a wider range of non-edible biomass are developing rapidly, but are not yet widely commercialised. They use cellulosic feedstocks such as agricultural and forestry wastes, grasses, algae, short-rotation woody crops such as willow and hybrid poplar, and municipal solid wastes (MSW).

Advocates contend that perennial and deep-rooted second-generation energy crops, such as prairie grasses and fast-growing trees, would reduce water surface runoff, use fewer fertilisers and pesticides, increase water infiltration and retention, bring higher levels of biodiversity and wildlife habitat, and enhance carbon sequestration. Using diverse feedstocks, including organic waste, could also reduce pressure on current agricultural land (by not requiring the displacement of crops for food production) and provide a market for materials that now are of negligible value or even involve disposal costs.

Using diverse feedstocks and organic waste could reduce pressure on current agricultural land

Second-generation bioethanol will greatly increase the range of suitable feedstocks and improve conversion efficiencies and per hectare biomass yields...

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... but efficient first-generation biofuels are here to stay. Both old and new technologies are likely to co-exist

Second-generation bioethanol will greatly increase the range of suitable feedstocks and improve conversion efficiencies and per hectare biomass yields. Together, these factors may considerably reduce the land requirement of bioenergy production and improve the GHG and energy balances of the fuels produced. However, second-generation technologies are still not proven to be cost-effective. Industry expects them to displace some of the feedstocks used for first-generation technologies within ten years or less. Iogen Corporation, an Ottawa-based company, has since 2004 operated the world's first demonstration facility that converts waste materials – primarily wheat straw – to ethanol on a commercial basis, using a tropical fungus that has been genetically modified to produce enzymes to break down cellulose. China is expecting to open a full-scale commercial cellulosic ethanol facility in 2008, with Europe following a year or so later. However, some claim that large-scale production and market deployment will not be possible for at least 15 years [WRI, 2008]. As a result, IRGC believes that efficient first-generation biofuels are here to stay. For example the low-cost and highly efficient bioethanol produced in Brazil will certainly not be replaced by more expensive technologies, and both old and new technologies are likely to co-exist.

Bioenergy for heat

Burning biomass for heat is by far the oldest use of bioenergy and is the dominant form of domestic energy in many developing countries. Burning wood is still very common. Some countries, especially in the Middle East, use much of their roundwood production for domestic fuel wood. Modern stoves and furnaces greatly improve the efficiency of heat conversion, making them ideal for domestic and district-scale heating systems where a sustainable supply of suitable biomass is available. For example, in Austria, approximately 800 such systems currently operate, producing a combined total of 1 GW of energy.

Biomass can also be used to provide process heat for other applications. An example commonly employed in Brazil is the combustion of waste sugar cane bagasse to provide the heat for fermentation and distillation in bioethanol plants. This process heat is often surplus to requirements and can be used for on-site electricity co-generation.

Bioenergy for electricity

Biomass may be used to generate electricity in a number of ways. Solid biomass, such as sugar cane residues, wood chips, wood pellets or MSW can be combusted alongside traditional fossil fuels in existing thermal power plants (co-firing), or in specialised biomass power plants. Biogas is also commonly used for power generation, either in gas engine generators or by co-firing with natural gas. Small biogas facilities are common in some remote areas, as in parts of China and India.

Generating electricity from well-managed, sustainable biomass employs a relatively mature set of processes and provides an affordable, consistent and low-carbon source of renewable electricity. Bioenergy is suitable for providing constant baseload in a mixed renewable electricity system, adapting output depending on the availability of other sources such as wind, wave, solar, geothermal, and tidal energy. Intermittency of supply has been one of the key limiting factors to large-scale implementation of many of the other renewable energies.

Generating electricity from well-managed, sustainable biomass can provide an affordable, consistent and low-carbon source of renewable electricity

Bioenergy for combined heat and power

Combined heat and power (CHP) systems are a mature technology that greatly improves the overall efficiency of energy use where both heat (and in some cases cooling) and electrical power are needed. CHP plants that run on biomass are increasingly popular and cost-effective [Gustavsson and Madlener, 2003; Madlener and Vögtli, 2008]. Due to the relatively dispersed nature of biomass resources such as agricultural and forest residues, and low efficiency of transporting hot water, fully biomass-fuelled CHP plants lend themselves to community-scale operations of less than 50 MW [IEA, 2005].

3.1 Current bioenergy policies and their objectives

The current focus of attention – and policies – on liquid biofuels means that it is easy to forget that biomass has been a source of energy for a very long time. It also obscures other existing and potential uses as are explained in the previous section. However, the current bioenergy industry would not have grown so rapidly were it not for targeted government interventions aimed at achieving specific objectives. In Brazil in particular, integrated policies sustained over 30 years have seen the growth of a major and successful industry (see Box 5).

The main objective of bioenergy policy varies between countries as a result of their specific contexts, including level of energy security and independence, socioeconomic variables, and the availability of land, water resources and biomass. Most countries consider bioenergy as a partial replacement for fossil fuels and other energy sources, including traditional biomass (e.g. firewood, dung, charcoal), in order to achieve policy objectives such as:

- Developing energy security and independence, by improving national control of supply, price and energy diversity. For example, the 2007 US Energy Security and Independence Act states as the first of its aims to "move the US toward greater independence and security" and introduces the Renewable Fuel Standard in Title IIa of the Act which is headed "Energy Security Through Increased Production of Biofuels" [Library of Congress, 2007].
- Rural development, by providing jobs, income and other benefits to rural populations and supporting agricultural policies. For example, the United Nations Development Programme (UNDP) has stated that bioenergy "can contribute directly to poverty alleviation by helping to meet basic needs, creating opportunities for improved productivity and better livelihoods, and preserving the natural environment on which the poor depend" [UNDP, 2000].
- Climate change mitigation, by reducing GHG emissions, particularly to meet commitments under the Kyoto Protocol. For example, the opening paragraph of the explanatory memorandum for the European Commission's proposed Directive on Energy from Renewable Sources states: "The Community has long recognised the need to further promote renewable energy given that its exploitation contributes to climate change mitigation through the reduction of greenhouse gas emissions, sustainable development, security of supply and the development of a knowledge-based industry creating jobs, economic growth, competitiveness and regional and rural development" [Commission of the European Communities, 2008].

In IRGC's opinion, promoting the development of modern biomass for energy is highly political. Many governments have deliberately chosen to address the most pressing needs for oil security and economic development, especially to provide jobs and affordable energy to their citizens. However, some countries also develop biofuels for other objectives such as providing benefits to politically powerful farm, energy and environmental lobbies, in the guise of meeting the other more generally acceptable objectives mentioned above.

In the remainder of this section, IRGC provides an illustrated commentary on the policy initiatives that have been taken and some of their associated complexities.

3.2 A matter of trade-offs

The challenge for bioenergy is to be a competitive substitute, in terms of availability, efficiency, sustainability and price, for oil (mainly for liquid fuel for transport), and coal and gas (for heat and power generation), while being sustainable on the environmental, social, economic and climate dimensions. Energy security is a key dimension in bioenergy policies.

However, the development of effective, sustainable and efficient bioenergy policies that support bioenergy's contribution to sustainable energy supply as well as to reducing GHG emissions and rural development requires consideration of many issues and, in IRGC's opinion, particularly the resolution of important trade-offs associated with the opportunities and risks described in Section 4 of this document. These trade-offs include:

- Energy vs. food;
- Land used for energy vs. for food, forestry, wilderness and other ecosystem services, industrial or residential uses, and leisure;
- Energy security and supply vs. climate change mitigation;
- Short-term vs. long-term; and
- Competing interests at the global, national and local levels.

IRGC considers that a thorough evaluation of these trade-offs is necessary in order to develop policies that maximise the opportunities offered to society by bioenergy while minimising and mitigating risk.

The development of effective, sustainable and efficient bioenergy policies requires the resolution of important trade-offs associated with the opportunities and risks

BOX 1: A carbon-free economy: the case of Sweden

While bioenergy can only be part of the energy mix, some countries are seeking to become both energy-independent and carbon-free. Sweden, for example, has established a goal of achieving total independence from oil by 2020, using bioethanol to fuel its automobiles and wood to fire its power plants. Sweden is rich in both forests and water, two of the critical inputs into sustainable renewable energy. Its strategy is based on decentralisation, using a large number of small power plants rather than a highly-centralised system. This reduces transmission costs and makes the system less vulnerable to disruption. The Swedish town of Enköing is so far the only European town powered by bioenergy, using willow trees as its source of energy. Sweden already has tens of thousands of Flexible Fuel Vehicles (FFVs) that can run on both ethanol and gasoline. It has reduced its reliance on petroleum to only 34%, and its use of renewable energy has reached almost 25% of total energy use. About a quarter of bioethanol in Sweden is obtained from fermented wheat and has a high octane rating of 104.

Bioenergy is changing rapidly, not least in the light of research providing new scientific knowledge and the development of new technologies. This research is enabling a better understanding of the potential negative impacts of current bioenergy technologies and provides evidence that many current technologies for liquid biofuels are likely to cause more environmental harm than good if they are simply expanded in scale. IRGC strongly recommends that, in view of more promising technologies under development and moving closer to commercialisation, today's policy decisions should provide guidance towards overall long-term objectives, while stimulating new research, case-by-case analysis and innovation.

3.3 Bioenergy objectives need to be considered within broader policy strategies

■ In general, bioenergy can play only a marginal role

IRGC believes that each country with the means to develop bioenergy should assess the comparative advantage for domestic production of bioenergy, relative to other sources of energy, taking into account the opportunity cost of developing bioenergy relative to fossil fuels, nuclear, other renewables, and imported bioenergy.

On a global scale, bioenergy cannot be considered a significant alternative to fossil fuels

On a global scale, bioenergy cannot be considered a significant alternative to fossil fuels – at least not if environmental, economic, social and sustainability limitations are taken into account (see Box 2). Bioenergy cannot be produced on the very large scale needed to replace a major proportion of the fossil fuels used today, especially in industrialised and rapidly-industrialising countries. However, bioenergy may play a relatively important role in some specific situations due to climate, soil type, land-use intensity, water availability, etc. in different parts of the world. Tropical regions (Brazil and Sub-Saharan Africa in particular) are the most favourable for many biofuels. Assessments of the relative potential of bioenergy and of policy decisions should therefore be location-specific. Well-managed and sustainable bioenergy production can provide significant co-benefits and can thus be very advantageous in some local settings.

BOX 2: How much of total world energy demand can be met by bioenergy?

The "optimistic" estimates, provided by the International Energy Agency [IEA, 2007] indicate that bioenergy could meet 20% to 50% of world energy demand by 2050. The IEA gives little indication of how much land would be required to meet such ambitious targets, how sustainable that would be, what it would cost, or what technologies would need to be developed. The United Nations Food and Agriculture Organization (FAO)/Global Bioenergy Partnership (GBEP) joint report [GBEP, 2007] offers a figure of 20% by 2030 rising to between 30% and 40% by 2060, when the world's population may have reached over 9 billion. Such estimates rely heavily upon scenarios such as those developed by the Intergovernmental Panel on Climate Change (IPCC) to predict future energy demand and potential supply from various sources, as well as demographic, economic and technological developments. Most of these estimates were developed before the most recent literature on impacts on secondary land-use and on food prices became available.

Earlier studies emphasised the difficulty of estimating the possible contribution of biomass to future global energy supply, highlighting land availability and yield levels in energy crop production as the main parameters of uncertainty [Berndes et al., 2003].

Global estimates also mask large regional and national variations, and do not take into account sustainability criteria that could moderate the use of biomass for energy production. Also, issues such as competition with food, energy prices, time-scale, and pragmatism about the real-world benefits relative to other options may affect the actual share that bioenergy could represent in the global energy mix. Food riots in Haiti, Egypt, Mexico and elsewhere may indicate that there are limits to land and water availability, as well as the social and economic acceptability of food price rises.

As a result, it is very difficult to provide a "best" estimate for the role that bioenergy could play in the future. Other qualitative factors need to be taken into account, many of which will lower the overall estimate. More importantly these factors introduce a level of uncertainty, which is unfavourable to capital investment. Over-optimistic and unrealistic predictions for bioenergy's potential should be avoided, in order to manage investors' expectations. Equally, the social, economic and environmental impacts of bioenergy should not be exaggerated, as doing so could undermine support for modern bioenergy and its use.

Assessments of the relative potential of bioenergy and of policy decisions should be location-specific

Bioenergy policies need to be coordinated with other policies

Bioenergy is at the intersection of many policies and a broad range of political, economic, environmental and social interests

Bioenergy is at the intersection of many policies and a broad range of political, economic, environmental and social interests. It raises questions concerning the environment, agricultural production, technological capabilities, energy needs, climate change, rural development, international trade and poverty alleviation, among many others. It is a global and systemic issue that is subject to many objectives and constraints, and a significant number and variety of individuals and organisations may face positive or negative consequences from bioenergy development. All of these factors combine to create a complex decision-making arena involving significant trade-offs, in which there is the potential for conflict and where choices with potentially wide-ranging implications must be made. Coordination between the different branches of policymaking is essential.

For example, Brazil opposes the inclusion of Carbon Capture and Storage in the Clean Development Mechanism under the Kyoto Protocol, to avoid funds being diverted from biomass activities. Therefore, bioenergy policies need to be carefully coordinated with these other policies and, particularly, with those for agriculture, transport, environment, energy, population, land-use planning, economic development, trade and fiscal policy. Bioenergy policies should also be aligned with the goals of rural development as well as those of sustainable development [UN Energy, 2007].

© Ian Calder

Jatropha plantation, India

An added complexity faced by policymakers is how bioenergy is viewed so differently by different key stakeholders. One example of this complexity is the interaction of domestic agricultural policies and lobbies with biofuel policies: in the US, corn ethanol is mostly described as an energy issue but the politics and policies suggest to IRGC that it is actually a farm subsidy programme.

Bioenergy policies need integration of global, regional, national and local levels

Like policies for energy, agriculture and forestry, bioenergy policies are usually decided and implemented at the national level. Most of the current discussions and policy decisions on bioenergy focus on biofuels for transportation and are focused on single countries (e.g. Brazil, the US) or regions (e.g. the EU).

However, sub-national (local) situations require that national policies be developed on a bottom-up basis, to account for the variety of different local contexts. National policies need flexibility in their local implementation.

On the other hand, many of the associated risks have global implications and therefore can only be approached from a global perspective, requiring international cooperation, particularly in assuring the sustainability of international trade, if bioenergy is to play a role in achieving the global goals of sustainable development and climate change mitigation.

To address this particular governance dimension, IRGC recommends that bioenergy policies allow for full consideration of global, regional, national and local perspectives and also reflect the different capabilities and needs of industrialised and developing countries.

▪ Bioenergy policies need a clear focus or goal orientation

Bioenergy policies should be developed with a clear focus and have a transparent and deliberate objective. Trying to achieve too many (sometimes conflicting) goals simultaneously may prevent policies from achieving balanced trade-offs and lead to confusing and negative outcomes.

3.4 Bioenergy policies need to result from a multi-stakeholder approach

Intergovernmental organisations such as the United Nations Framework Convention on Climate Change (UNFCCC) or the World Trade Organization (WTO), the EU, national and regional governments, industry, and non-governmental organisations (NGOs), must all be part of a multi-stakeholder collaboration leading to the development of sustainable bioenergy policies, regulations and standards. International organisations must assume responsibility for ensuring common standards in support of sustainable development, ecosystem protection and international trade [ICTSD, 2006]. They should expect governments to implement internationally-coherent policies.

International organisations must assume responsibility for ensuring common standards in support of sustainable development, ecosystem protection and international trade

▪ Governments

IRGC considers that the leading role must be taken by national governments. National policies must be flexible enough to accommodate local conditions and contexts. Governments need to benefit from industry's willingness to share the same global challenges and make the necessary investments.

National governments need assistance from international organisations and the scientific and civil society communities in setting appropriate standards that can be promoted as acceptable to the widest possible range of interested stakeholders, including the general public, and that create the framework for industry investment and operations.

Governments need to benefit from industry's willingness to share the same global challenges and make the necessary investments

The role of government intervention has been and remains paramount to the development and use of biofuels. Governments have a role in regulating biofuels, but they are also responsible for managing many of the risks that their development generates. A large proportion of current liquid biofuel production – most biodiesel produced from virgin vegetable oils, for example – would cease if it were not for government mandates, subsidies and other incentives including tax and duty concessions. IRGC believes that policy frameworks need to provide the right incentives over suitable timescales. Governments also have a key role in funding research, both of new technologies and of bioenergy's full environmental impact.

Regional and local governments need a decision-making process that allows for sub-national decisions that reflect local circumstances and, particularly, the local environment.

Industry

Industry is a key player in bioenergy production, through its investments in research and development and commercial deployment of new technologies and infrastructures. It needs clarity, predictability and consistency from policy and regulation, as well as access to well-organised markets.

Although industry with a stake in transport and transport fuels has been researching biofuels for many years, mostly as a means to address the future decline of oil, industry does not play the lead role in promoting bioenergy but instead primarily responds to government incentives. However, industry regards bioenergy as a business opportunity and to this end it needs reasonable predictability in policy development in order to provide a basis for investment decisions. Under current circumstances, industry seeks to maintain and develop a comparative advantage in supplying biofuels, in response to government mandates. Both now and in the future industry has a critical role to play in mitigating and reducing the risks involved in large-scale deployment of biomass production for energy [WBCSD, 2007b].

3.5 Bioenergy policies need to be clearly focused and tailored to specific national and regional contexts, needs and capacities

All countries need a policy on bioenergy that is appropriate for their specific needs

Risk governance guidelines should meet the specific needs of decision-makers who may be facing widely differing scenarios for the development and use of bioenergy. The suitable technologies, scale of deployment and priorities that bioenergy can address vary greatly, depending upon factors such as available land resources and whether a country is industrialised or developing. Initial assessments along these dimensions should allow policymakers to focus their efforts on developing policy well-suited to their specific context.

Industrialised, developing and emerging economies are faced with common but differentiated responsibilities as they address the climate change challenge. IRGC recommends that bioenergy policies should follow this principle and be differentiated according to the level of development.

Industrialised countries that wish to promote bioenergy should do so only if it is a way to mitigate climate and environmental risks

Reducing GHG emissions

For industrialised countries, IRGC is of the opinion that the primary policy objective for bioenergy should be to reduce GHG emissions. For example, the EU stipulates in its proposed Directive on Energy from Renewable Sources (January 2008) that the GHG emission saving from the use of biofuel and other bioliquids must be at least 35% in order for the use of biofuel to be eligible for financial support or counted towards mandatory compliance targets [Commission of the European Communities, 2008]. Governments are expected to develop bioenergy according to environmental sustainability criteria and indicators (see Box 3). As these countries have the capacity to invest sufficiently in the energy sector to achieve the transition to a low-carbon economy, they should support or promote their development and import of bioenergy only if it is a way to mitigate environmental and climate risks. For these countries, bioenergy may never be a major source of primary energy supply at the national scale, but bioenergy could make a valuable marginal contribution and, like any other renewable source of energy, has the potential to become quite significant in certain locales and circumstances.

Anaerobic digester

IRGC also believes that industrialised countries and major exporters of bioenergy among the developing countries must re-evaluate the ways in which they assess the environmental and social impacts, as well as the GHG balances of bioenergy production (to include potential emissions from indirect impacts such as land-use change due to displacement of production into areas that currently act as significant carbon sinks).

BOX 3: Principles for sustainable biofuel production

The "Cramer Report"

A Commission on "Sustainable production of biomass", headed by Professor Jacqueline Cramer, was assembled at the request of the Dutch government to develop concrete criteria and indicators for assessing the sustainability of biomass production. The final report [Cramer et al., 2006] defines social and ecological criteria for sustainable production of biomass:

- Net GHG emission reduction compared with fossil fuels of at least 30% (calculation method and standard values, including interference in existing carbon sinks);
- No decrease in the availability of biomass for food, local energy supply, building materials or medicines (reporting obligation);
- No deterioration of protected areas or valuable ecosystems (compliance with local requirements);
- No possible negative effects on the regional and national economy (reporting obligation);
- No negative effects on the social well-being of the workers and local population, including working conditions, human rights, property rights and land-use rights (compliance and reporting obligations);
- No negative effects on the local environment (compliance with local and national legislation and/or reporting obligation).

The Cramer Commission subsequently developed a methodology to estimate indirect land-use change [Cramer et al., 2007].

The Roundtable on Sustainable Biofuels

The Roundtable on Sustainable Biofuels, an international initiative led by the Ecole Polytechnique Fédérale de Lausanne [EPFL], has also addressed sustainability criteria in its proposed Standard for Sustainable Biofuels. Principle 3 (version zero of August 2008) states that: "Biofuels shall contribute to climate change mitigation by significantly reducing GHG emissions as compared to fossil fuels. (…) Emissions shall be estimated via a consistent approach to lifecycle assessment, with system boundaries from land to tank. (…) GHG emissions from direct land use change shall be estimated using IPCC Tier 1 methodology and values. (…) GHG emissions from indirect land use change, i.e. that arise through macroeconomic effects of biofuels production, shall be minimized."

Developing countries and countries with economies in transition should develop bioenergy with the primary objective of providing affordable energy and support to rural development

Fostering development and reducing poverty

Developing countries need energy to support their economic development. Bioenergy has the potential to support significant economic and social development, especially for the rural populations of developing or emerging countries, leading to much-needed improvements in the standard of living and welfare. For these countries, creating the conditions for a stable energy supply in order to foster development and reduce poverty is essential and is likely to be a more important policy objective than the reduction of GHG emissions. At a local level, additional environmental benefits are available from small-scale bioenergy development and the use of technology best practice, such as reduced depletion of forests and indoor and urban air quality improvements (see Box 4).

The Chinese government is drafting a new rural energy strategy to establish a vision for China's future rural energy development and to offer more opportunities for the poor to access sustainable energy [Ministry of Science and Technology PRC, 2007]. Bioenergy is an important component of this policy.

The "National Policy on Biofuels" that the Indian government is pursuing outlines a strategy to achieve energy security in the country through sustainable production, conversion and applications of biofuels. Biofuel policy is seen as a tool to utilise waste and degraded lands, control erosion, replenish the soil and provide employment opportunities to rural families [Ministry of New and Renewable Energy, India, 2006].

BOX 4: Bioenergy for rural development

Carefully-designed bioenergy development projects present several opportunities at the local scale. They can reduce work burdens related to wood and dung fuel collection, reduce health impacts from indoor smoke inhalation (which is responsible for approximately 5% of all death and disease in some of the poorest countries [WHO, 2007]) and provide crucial access to off-grid electricity, which is a key factor that could support development in many remote rural areas.

In south-eastern Tanzania, the United Nations Environment Programme (UNEP) has conducted a trial as part of the Jatropha Roundtable [Diligence/UNEP, 2006] to use jatropha oil to power infrastructure for mobile telephones in off-grid rural communities. The relatively low energy requirements and substantial benefits of modern communication networks create an ideal synergy. Mobile telephone networks are increasingly important in developing countries for improving information flows, which provide farmers with better and more timely access to markets, improve productivity (e.g. from weather services) and increase engagement with the wider population.

Biogas produced in household-scale biogas anaerobic digesters provides energy for cooking and lighting to about 25 million households in the world (20 million in China and 4 million in India). Also, small-scale thermal biomass gasification is a growing commercial technology, notably in China and India, with gas from a gasifier being burned directly for heat and used in gas turbines or gas engines for electricity and/or motive power [REN21, 2007].

The risks and opportunities summarised in this section are those that IRGC believes to be the most important and demanding of attention when developing modern bioenergy.

4.1 Opportunities

Bioenergy production provides numerous opportunities, such as:

▪ Improved energy security

Local production and use of bioenergy reduces the level of dependence on conventional energy imports and thereby increases the diversity and security of energy supply. One reason for the increase in the production of biofuels in Brazil and the US is that it is a substitute for imported oil. This can help reduce demand for – and the price of – crude oil, and enhance energy self-sufficiency. Biofuels are one of a number of possible substitutes for conventional crude oil, and it is likely that their environmental impact will be less than other plausible alternatives, such as coal to liquids, tar sands, oil shale, and coal-based hydrogen.

▪ Rural economic, energy and development opportunities

© Anthony Christopher Shehal

Biomass gasifier

Bioenergy offers opportunities for growth of the agricultural and forestry sectors. Developing bioenergy may lead to increased demand for locally-grown feedstocks (both agricultural and forestry), which would increase utilisation of agricultural land, promote investment in forestry and agriculture and create jobs. Increased demand would have a positive effect on forestry and agriculture by adding value to traditional crops and giving farmers the choice to grow crops for food or fuel markets and to sell surpluses or crops that do not meet the requirements for food or timber markets. These opportunities may be greatest in developing countries, where other potential benefits include off-grid electrification in rural areas and health benefits (for example, from improved indoor air quality through the use of cleaner fuels and efficient stoves), thereby reducing poverty. Much depends on the way that biofuels are developed and, specifically, on who are expected to be the major beneficiaries. Biofuels can help the rural poor, but only if they are specifically designed and managed to do so.

Some bioenergy crops can help improve soil and water quality

■ Environmental improvement

GHG emissions from the transport, electricity and heating sectors can be reduced by replacing some fossil fuels with bioenergy. The use of more efficient and modern bioenergy sources could also reduce pressure on forests in developing countries, where reliance on traditional biomass for energy is a major driver of deforestation and degradation. Bioenergy may also improve soil, air and water quality. Research at the University of Minnesota has indicated that biofuels derived from low-input high-diversity (LIHD) mixtures of native grassland perennials can provide more usable energy, greater GHG reductions, and less pollution per hectare than can ethanol from maize or soyabean biodiesel. Studies found that high-diversity grasslands have increasingly higher bioenergy yields, exceeding monoculture yields by 238% after a decade. They are also net sequesters of carbon (0.32 megagrams per hectare per year). Furthermore, LIHD biofuels can be produced on agriculturally-degraded lands and thus need to neither displace food production nor cause loss of biodiversity via habitat destruction [Tilman et al., 2006].

Trade opportunities are likely to emerge

■ International trade

Sugar cane is by far the most productive of the energy/biomass crops. Australia, Colombia, Guatemala, India, Mexico and Thailand are amongst countries seeking to expand their exports, and Brazil is negotiating with these countries to improve production through using industrial biotechnology in growing and producing ethanol [Orellana, 2006]. As bioenergy production is heavily influenced by environmental and climate factors, meaning that not all countries will have the same scope for production, other trade opportunities are likely to emerge.

■ Economically and environmentally beneficial use of waste organic matter

Waste biomass, including MSW, which would otherwise require costly disposal or treatment, can be efficiently used to produce bioenergy and other by-products. For example, in Sweden, organic waste from households, restaurants, grocery shops, sewage, wastewater treatment plants and agriculture is being used to produce biogas for heating, cooking and electricity (see Box 1).

■ Technological advancement

The development of bioenergy is a catalyst for research and development of technological innovation, which may spread to a range of broader applications.

4.2 Risks

Many of the risks associated with bioenergy are interlinked and vary in scale, probability and impact, depending on the location, technology and scale of bioenergy operation.

ENVIRONMENTAL AND CLIMATE RISKS

▪ Biodiversity and ecosystem services

Feedstocks for liquid fuels are, currently, generally grown as intensive monocultures (as is the case for many important food crops). The conversion of extensive agricultural systems and natural habitats such as grasslands and tropical forests into intensive monocultures is one of the major threats to biodiversity. Many non-native feedstocks are also potentially invasive and may have negative impacts on ecosystems if they escape cultivation [GISP, 2007]. With biodiversity a major factor in adapting to climate change, the risks to biodiversity introduced by the development of bioenergy production become crucial. Ecosystem services such as soil regeneration, carbon sequestration, natural chemical cycles, pollination and protection against flood may be affected. However, many of the biodiversity impacts of bioenergy feedstock production are not inherent to bioenergy alone but are symptomatic in general of inappropriate agricultural production systems (such as extensive monocultures) and policies.

With biodiversity a major factor in adapting to climate change, the risks to biodiversity introduced by the development of bioenergy production become crucial

▪ Water quantity and quality

Many row crops require significant levels of agrochemicals and, in some regions, irrigation, which can pollute and deplete water resources. Pollution from excess agricultural fertilisers may damage areas far beyond the zone of cultivation, for example through marine eutrophication (leading to “dead zones” where fisheries production is severely compromised). Large amounts of water are also required in processing bioethanol and biodiesel.

▪ Soil erosion and degradation

Monocultures, especially of arable crops requiring annual tillage, are typically associated with high rates of soil erosion. Some crops, such as maize, also deplete soil nutrients more rapidly than others (for example soyabeans, sugar cane or sweet sorghum) and require energy-intensive fertilisers to maintain year-on-year yields.

Land-use changes can result in significant GHG emissions that render uncertain the net carbon benefit of bioenergy use

Direct and indirect impacts of land-use change: "displacement effects"

The increased cultivation of certain crops as biofuel feedstocks can displace other food crops and increase global prices of these crops. This may result in the clearing of wilderness land, forest and grassland elsewhere (lands which would normally act as a carbon store or sink) in order to grow these displaced and increasingly profitable crops. Such land-use changes can result in significant GHG emissions that are not being included in conventional LCAs and render uncertain the net carbon benefit of bioenergy use (see Box 6 for more details). However, the extent to which this "leakage" happens is still poorly understood and deforestation has many other causes as well.

Greenhouse gas emissions

The Royal Society has reported that biofuels risk failing to deliver significant reductions in GHG emissions from transport and could even be environmentally damaging [Royal Society, 2008]. The UK's Renewable Transport Fuel Obligation [UK Department for Transport, 2008], which came into force in April 2008, requires fuel suppliers to ensure that 5% of all UK fuels sold are from a renewable source by 2010, but does not contain a target to reduce GHG emissions. The Royal Society report recognises that the GHG savings of the various potential biofuels depend very much on which crops are grown, how they are converted and how the fuel is used.

Air pollution

The sugar cane industry, especially in developing countries, routinely carries out pre-harvest burning of cane fields to prepare the crop for hand-cutting. Bioethanol production is increasing the land area devoted to sugar cane. The burning causes air pollution, which has been linked to increased incidence of respiratory illnesses. Brazil has passed legislation to phase out this practice by 2014 and voluntary actions accompany the measure. One of them is the incentive to sell bioelectricity produced from crop residue to the grid, which improves farmers' income.

Genetically modified hybridisation

As with any genetically modified organisms (GMOs), so-called "energy-designed" crops may raise concerns related to cross-pollination, hybridisation, and other potential impacts on biodiversity such as pest resistance and disruption of ecological food chains.

SOCIAL RISKS

▪ Food security

The diversion of edible crops from food markets to bioenergy production has already resulted in increased competition for agricultural land and led to concerns about impacts on food prices (see also Section 5.2 of this document). If not properly managed globally, additional expansion of the use of agricultural crops for bioenergy could further worsen global food security, which is already at risk due to population and consumption growth requiring more food and more energy.

Additional expansion of the use of agricultural crops for bioenergy could worsen global food security

▪ Land rights and displacement

Poorly-managed expansion of bioenergy production may undermine traditional sustainable agricultural and land-use practices and can lead to adverse societal impacts. If bioenergy crops become more valuable, industrialisation of production and land consolidation may favour large landowners and displace small farmers.

▪ Employment

Bioenergy may not provide an adequate diversity and quality of employment opportunities in the long term. Initial employment opportunities may be short-term and superseded by mechanised production and processing. On the other hand, modern bioenergy, as currently generated, is more labour-intensive than any other form of energy. In both cases, scale is important. Industrial-scale bioenergy production also raises health and safety concerns related, for example, to workplace air quality, particle emissions and increased transport requirements.

▪ Public perception

The increasing public concern regarding the sustainability and environmental impact of current biofuel production and use may lead to an adverse perception of bioenergy in general. Currently, public opinion of bioenergy and biofuels in particular is polarised between those supporting it and those who criticise its potentially negative effects. The media play an important role in generating this discussion.

ECONOMIC RISKS

■ Rising prices

Biofuels are already contributing to increased food prices, though this relationship remains controversial and no doubt varies with the feedstock involved. In 2006, 20% of the US corn harvest was used to produce ethanol, but that figure may rise to 50% if all the planned distilleries are actually constructed [Baker, 2007]. With the US providing almost 40% of the world supply of corn, the demand for ethanol could have a significant economic impact globally [Runge and Senauer, 2007]. Competition between different land-uses, bioenergy feedstocks and food products, agricultural wastes, wood fibre and other products in the forestry sector is driving many other prices upwards. With feedstock cost representing a significant proportion of the overall cost of first-generation biofuel production, it is even arguable that further large increases in feedstock costs could undermine the market attractiveness of biofuels; in July 2008 a number of US ethanol plants closed down when corn prices rose to US$ 8 per bushel as a result of severe storms and floods [Gardner, 2008].

■ Cost-effectiveness

Subsidising biofuels and bioenergy with the aim of reducing GHG emissions is a less effective and more costly way of achieving this goal than many other more cost-effective solutions, such as improving energy efficiency and conservation or encouraging more effective renewable energy options where feasible.

■ Market distortions

Mandates and production-linked subsidies create lock-ins to technologies, impose costs on taxpayers and are difficult to reverse once established

Subsidies have been instrumental in driving the development and growth of the biofuel industry, particularly in industrialised countries. For example, almost all countries started off exempting biofuels from fuel-excise taxes. These subsidies have been allocated at almost all parts of the value chain, from subsidies to growers and refiners to reductions in fuel duties. These have been complemented by mandates such as the EU's targets for biofuel use (now under review). Such subsidies have often had perverse effects, creating distortions in the market for grains and oilseeds. In IRGC's opinion, mandates and production-linked subsidies create lock-ins to technologies and uses, impose costs on taxpayers and are difficult to reverse once established, because their withdrawal may impose politically unattractive losses on biofuel producers.

▪ Trade distortions

International trade is being distorted through country-specific subsidies, as in the US or the EU. Trade barriers both protect inefficient biofuel industries and prevent developing countries from exploiting their comparative advantage in producing biomass [Steenblik, 2007].

▪ Risks related to policy and regulatory frameworks

In the context of changing or unclear policy development and related regulation, investors face an economic risk. Regulatory frameworks have yet to be adopted, especially at the international level, to provide sufficient certainty for capital investment planning. The profusion of proposed regulatory frameworks and labelling schemes may, ironically, obstruct rather than enhance the likelihood of any single option being adopted globally.

OPPORTUNITY COST

Inadequate accounting of the opportunity cost of developing bioenergy is a general risk that can apply to any of the risks discussed above. IRGC believes that bioenergy should only be developed where it is the best option for using the resource in terms of biomass produced, land needed to produce the biomass, and waste diverted from other uses.

IN SUMMARY

Despite the opportunities bioenergy development offers for positively contributing towards achieving objectives such as supporting sustainable rural development, improving energy security and reducing GHG emissions, bioenergy is associated with many kinds of risks. Understanding and managing these risks will require more thorough and holistic analysis and a greater consideration of trade-offs than has informed policymaking so far.

IRGC believes that bioenergy should only be developed where it is the best option for using the resource in terms of biomass produced, land needed to produce the biomass, and waste diverted from other uses

BOX 5: Opportunities and risks in context: the case of Brazil

Many proponents of large-scale biofuel production highlight the success Brazil has had in creating a productive and cost-competitive market for ethanol from domestic sugar cane. Brazil produces as much ethanol as the United States but with less land and carbon emissions and with a significantly better energy return on investment. This success is due to a unique combination of high land productivity, water availability, careful selection of sugar cane strains, low labour costs and the use of waste bagasse to provide process heat and surplus electricity during conversion to ethanol. Brazil also has extensive areas of land available for cane production that are close to centres of ethanol demand, as in the state of Sao Paulo.

The country's success has also been made possible by the long-term support of government through the National Alcohol Program ("Proalcool"). Established in 1975 in response to high prices for imported oil and petroleum products, Proalcool has resulted in Brazil's development of an integrated programme which includes a production and distribution network for ethanol (installed capacity supports the production of 18 billion litres per season, equivalent to 100 million barrels of petrol), the ongoing development and promotion of ethanol-fuelled vehicles, blending mandates, and other incentives.

Ethanol now accounts for approximately 40% of Brazil's driving fuel, and its automobile fleet is the only one in the world that can use 100% of either ethanol or gasoline. Its major source of ethanol is sugar cane, and biotechnology research groups based in Sao Paulo have been producing transgenic sugar cane varieties with higher productivity, resistance to drought and ability to grow in poor soils. Some 90% of the sugar cane genome has already been sequenced, and Brazil is constantly seeking improved varieties [Orellana, 2006].

However, any policy has associated weaknesses and risks. In Brazil, concerns remain about agricultural working conditions, the potential for ecosystem impacts resulting from large-scale expansion of current ethanol production and its direct impact on the Cerrado ecosystem, secondary impacts on land-use elsewhere resulting from displacement effects, and migration of rural populations, among others. Brazil may already be suffering from the consequences of increased deforestation for soya production to fill the supply vacuum caused by US farmers switching to lucrative and heavily-subsidised corn production. Thus, domestic policy, even if successfully implemented, may ultimately be strongly influenced by the global nature and development of bioenergy and agricultural markets.

Governance deficits and market failures may prevent bioenergy policies from mitigating or avoiding the environmental, social and economic risks related to bioenergy development. These governance deficits are related to:

- Inappropriate resolution of trade-offs of which policymakers need to be fully aware, and which vary depending upon the policy driver and scale of deployment; and
- Failure to adequately account for secondary and long-term impacts.

In general, bioenergy production interacts with many other domains and secondary impacts need to be carefully considered. From a broad risk governance perspective, this includes social impacts, urban and rural development, and sustainability and equity issues for which adequate legislation must be developed.

5.1 Unrealistic expectations of bioenergy potential

The process of converting biomass into an energy carrier is often inefficient, particularly when using biomass feedstocks with low energy densities, and may potentially have severe and widespread ecosystem impacts if pursued on a large scale [Smil, 2003]. This is true on the basis of power density alone (available energy per unit area) and even more valid when the complete energy pathway is taken into account, except in some specific cases (such as when waste biomass is used, as analysed by EMPA [Zah et al., 2007]).

The process of converting biomass into an energy carrier is often inefficient

In terms of the overall energy return on investment, when compared to fossil fuels and other energy sources (e.g. nuclear), some bioenergy technologies such as current corn ethanol have a better energy return on investment (EROI) than gasoline [Hammerschlag, 2006], but the GHG and environmental impacts are uncertain [Farrell et al., 2006].

IRGC has concluded that bioenergy is unlikely to be more than a secondary source of energy in a modern energy mix, and then only under certain specific conditions. Nevertheless, some countries are creating policies that will significantly raise the proportion of biofuels in their energy source mix. In December 2007, the US Administration signed an Energy Bill which intends to raise biofuel output five-fold by 2022 [US Energy Independence and Security Act, 2007] and the EU is currently proposing a 10% binding minimum target for biofuels in transport fuel by 2020 [Commission of the European Communities, 2008].

5.2 Inappropriate resolution of the trade-off with food

The impact of bioenergy policy and production on food policy and supply is extremely difficult to assess, resulting in widely variable estimates. Estimates vary from as little as 3% [USDA, 2008] to as much as 75% (Don Mitchell, a lead economist at the World Bank's Development Prospects Group [Mitchell, 2008], whose figures are based on a different set of criteria). Other estimates are around 30% [IFPRI, 2008]. There are a number of other important factors involved in the current trend of rising food prices such as: drought and intemperate weather (in Australia, wheat production plummeted by 52% between 2004 and 2006, and grain production dropped by 13% in the United States and 14% in the European Union over the same period); changes in Western eating habits; emerging markets in Asia driving up demand; speculation on food commodities; and, the effect of the increase in oil prices on transport and fertiliser costs [ICRC, 2008].

Whatever the scale of the impact, this trade-off is of vital importance as the positive impacts of bioenergy production in rural areas or developing countries could be reversed through a negative long-term impact on food production, cost, and supply.

However, food-versus-fuel is shorthand for land competition. Adequate land-use policies (see Section 6.8) can provide a means to help resolve this trade-off, provided they are satisfactorily applied locally and coordinated globally, perhaps through the FAO's Bioenergy and Food Security Project (BEFS) which is attempting to model food security impacts globally [FAO, 2008].

5.3 Poor ecosystem management

Bioenergy production is fundamentally linked to land, water, biodiversity and ecosystems. As such, developing bioenergy to replace fossil fuels may merely shift environmental impacts, for example from fossil resource depletion and climate change to soil degradation, water eutrophication and depletion (see Sections 4 and 6 for, respectively, a description of these risks and guidelines for managing them).

Discussion of the quantification of the value of ecosystem services [WBCSD, 2007a] is crucial for bioenergy production. If payment for such ecosystem services were to be recommended and implemented in national policies and regulations, the cost of bioenergy would increase except where bioenergy production can itself become an instrument for the better management of ecosystem services. Appropriate regulatory frameworks should then be adopted to enable markets for these services to emerge.

Bioenergy and water resources

Use of biomass, whether for bioenergy or liquid biofuel production, raises concerns of its impacts on water resources. Many of the processes that convert biomass into fuel require large amounts of water. In locations that already face limited water supply, failure to consider this competition can present serious problems.

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Fast-growing tree species used for biomass production are likely to be high users of green water. Green water is rainfall that infiltrates and remains in the soil, evaporation and evapotranspiration from plants. Blue water is water which can be collected, pumped and transported; it includes runoff, groundwater, and river and lake water. Green water management includes all techniques and approaches to reduce evaporation. Even under present climate conditions, high evaporative water use may preclude the use of such species in regions where water resources are already under stress. Under future climate scenarios of higher temperatures and reduced rainfall in some areas, their use may be even more problematic [Calder and Harrison, 2008].

Crops used for liquid biofuels, for example sugar cane for ethanol or jatropha for biodiesel, will consume (via evapotranspiration) many thousands of litres of green water for each litre of fuel produced. Ethanol processing also requires a substantial additional blue water requirement, and possibly also gives rise to problems in disposing of waste water.

IRGC feels that claims that some bioenergy crops are low water users and suited to wastelands and dry regions need to be treated with a degree of caution. Crops such as jatropha, (widely promoted as a 'wasteland' crop that does not compete for land to grow food crops) may well survive in dry regions, but the yields may be reduced to as little as one-fifth to one-tenth of jatropha grown in higher rainfall regions. Calculations of the areas necessary to support government biofuel mandates tend to make use of the most optimistic yields, attainable only in relatively high rainfall regions. Thus, figures of needing 40 million hectares of jatropha to meet a 2030 biofuel mandate of 12% in India are based on a yield of 5 tonnes of jatropha seeds per hectare. If true 'wasteland' areas were used, this yield may not be attainable and the area may need to be increased by about a factor of five, creating serious conflict with agricultural and grazing land, as some arable land may need to be turned over to biofuel production. However, emerging technologies such as mycorrhizal application can substantially benefit crop production with minimum input resources, and these technologies are being promoted in India at a large scale (30 million saplings in two years).

Calculations of the areas necessary to support government biofuel mandates tend to make use of the most optimistic yields, attainable only in relatively high rainfall regions

Saving and restoring forests offers far greater carbon mitigation benefits than those gained from switching from conventional fossil fuels to biofuels under current scenarios

Failure to acknowledge risks related to deforestation

A recent study [Righelato and Spracklen, 2007] found that saving and restoring forests offers far greater carbon mitigation benefits than those gained from switching from conventional fossil fuels to biofuels under current scenarios. The importance of forests as substantial carbon sinks, and the opportunity cost of pursuing biofuels instead of addressing deforestation, is a serious concern.

Deforestation will be discouraged only if appropriate incentives and disincentives are provided to do so. The pay-and-preserve scheme to help developing countries protect tropical forest, agreed at the UNFCCC December 2007 Bali conference, is seen by IRGC as a first step. Some current national bioenergy policies could conflict with the new agreement, as it enables poor but forested countries to turn rainforest conservation into a tradable commodity, with the potential to earn money by selling carbon credits.

Reducing emissions from deforestation and degradation in developing countries is arguably significant both with respect to the wider deforestation debate as well as for the climate change debate, though social issues, such as the access of the rural poor to forest resources, complicate the issue. Failure to recognise and address the issue of deforestation could result in serious problems of soil degradation, escape of carbon from soils and the loss of forests as natural carbon sinks.

5.4 Underestimation of climate change impacts

When considering bioenergy policies in the context of climate change, it is necessary to assess both the impacts that climate change may have on bioenergy production systems *and* the direct and indirect impacts that bioenergy production systems may have on the climate.

In some regions, the impact of temperature increases and changes in water availability (among other factors) on agriculture and forestry is likely to be high [Peng et al., 2004]. Therefore, policies risk failure if they do not take climate change projections into account, seeking to understand, as far as possible, how changes in temperature, water resources and other factors will evolve and how they will affect bioenergy production systems.

Policies should also account for the potential impacts of large-scale agricultural or forestry bioenergy development on the local and regional climate. For example, increased use of fertilisers for bioenergy feedstock production may contribute to higher overall nitrous oxide emissions which have a warming potential of nearly 300 times that of carbon dioxide [Crutzen et al., 2007].

Bioenergy policies may make a significant contribution to climate change at the global level as well, as a result of increased GHG emissions. These impacts may be direct, for example where land is directly cleared for bioenergy feedstock production, or indirect (see Box 6), in particular due to displacement effects.

BOX 6: Indirect impacts of land-use change

Recent papers in *Science* have ignited a debate about indirect impacts of more land being used for growing bioenergy feedstock:

"Most prior studies have found that substituting biofuels for gasoline will reduce greenhouse gases because biofuels sequester carbon through the growth of the feedstock. These analyses have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices and convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels. By using a worldwide agricultural model to estimate emissions from land-use change, we found that corn-based ethanol, instead of producing a 20% saving, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years. Biofuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%. This result raises concerns about large biofuel mandates and highlights the value of using waste products" [Searchinger et al., 2008].

Indirect impacts (displacement effects) may lead to significantly higher net GHG emissions than can be directly attributed to bioenergy production itself [Fargione et al., 2008]. This is described as the "leakage" effect, as it occurs outside the GHG accounting system. While this is a hotly contested area of research, with conflicting findings [see, for example, Wang and Haq, 2008], policymakers should be aware that no current policy can fully reflect all the impacts of bioenergy development, either geographically or economically, and further research is urgently needed to address this uncertainty. In these circumstances, policymakers would be wise to adopt an adaptive approach, keeping future options open and modifying policy to incorporate new research findings and lessons from experience.

5.5 Inappropriate use of subsidies and other economic instruments

Recent research has concluded that "governments should be far more selective about which biofuel crops they support through subsidies and tax benefits" [Scharlemann and Laurance, 2008].

"Governments should be far more selective about which biofuel crops they support through subsidies and tax benefits"

Subsidies have been a part of government policy for many years. As a short-term policy instrument, they provide a financial incentive to encourage specific behaviours. Within agriculture, they have long been used to raise certain crops and animals and such support is now available within the context of biofuels through e.g., the US Farm Bill and the Common Agricultural Policy. This is just one dimension of a range of incentives that are currently employed at multiple points along the biofuels production chain, although there are differences between national approaches. It has been estimated that total support for biofuels within OECD countries was between US$ 13-15 billion in 2007 and "the production and demand for biofuels has been, and continues to be, shaped profoundly by government policies, both regulatory and directly financial" [Steenblik, 2008].

Subsidising one sector of society in support of policies that may undermine others may be seen as a deficit in risk governance

IRGC considers that, when used too intensively or over too long a period, subsidies, tax incentives and other economic instruments create distortions and market deficits. Subsidies and other incentives that favour agricultural producers also raise questions of distributional effects and the potential risk of inequity. Subsidising one sector of society in support of policies that may undermine others (for example, through increases in food prices) may be seen as a deficit in risk governance.

Examples of appropriate use of financial instruments include:

- Subsidies or grants for capital investments designed to reach broad policy goals (like reductions in GHG emissions) rather than provide support to specific technologies or processes, and that are modified or ended when the goals are achieved, through the inclusion of sunset clauses, so that the market can operate freely thereafter;
- Excise-tax reduction based on relative environmental impact (combined with appropriate performance standards); and
- Incentives for the development of new technologies, for example cellulosic generation of bioenergy or the use of municipal wastes for biofuels; such development can be seen as a public good, justifying a public investment.

Both market mechanisms and regulation are needed to catalyse appropriate behaviours, but these need to be adaptive to new scientific knowledge as it emerges and to fully internalise the many externalities of bioenergy production and use, including their impact on ecosystems and ecosystem services.

5.6 Excessive lock-ins and short-termism

IRGC feels strongly that capital (from sunk costs and/or irreversible investments), technological and policy lock-ins, for example through inappropriate subsidies, should be avoided because they may block the adoption of anticipated future improvements in bioenergy technologies.

IRGC believes that capital, technological and policy lock-ins should be avoided

The significant investments being made in first-generation biofuel production, and the need for companies to earn adequate returns on investment, may act to stifle future switching to potentially improved "second-generation" and advanced bioenergy technologies when they are developed. This represents one of the lock-in risks associated with bioenergy.

To avoid such lock-ins requires two policy initiatives: first, developing and deploying a diversity of technologies in different local contexts; and, second, a thorough evaluation of lock-out costs compared with the cost of being locked-in to an inferior technology or resource. Only with a range of commercially-available bioenergy technologies and knowledge both of their relative performance (as assessed by multiple criteria including energy return on investment, GHG emission reductions and sustainability criteria) and of switching costs will policymakers be able to develop flexible and adaptable policies that encourage transitions to more efficient technologies and to more environmentally- and socially-sustainable practices when they become available.

5.7 Designing bioenergy policies as agricultural policies only

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In IRGC's opinion, in much of the industrialised world, current bioenergy policies are primarily agricultural support policies disguised as energy policy. But, in countries such as India and Brazil, the policy driver is essentially economic: these countries need liquid fuels at a lower cost than available from imported fossil fuels. In both cases, the majority of subsidies and incentives are directed at agricultural producers who are therefore being rewarded for their contributions to the global markets for both fuel and food.

Growing feedstock for energy should be seen as an opportunity for reducing government support to agriculture

Bioenergy production can be a potential new source of work and income to farmers and an opportunity for new products and markets. Therefore, growing feedstock for energy should be seen as an opportunity for reducing government support to agriculture and for implementing more market-based agricultural policies, rather than being driven by subsidies.

Subsidies that fail to properly address the relative needs for food, fuel, fibre or wilderness, as well as the needs of various social groups, will adversely affect the success of both bioenergy and agricultural policies.

5.8 Careless management of biotechnologies

The use of modern biotechnologies such as gene mapping, marker-assisted breeding and genetic modification (GM), offers potentially significant improvements for bioenergy producers through increased yields, reduced requirements for water, agrochemical and other production inputs, and easier processing into energy products such as transport fuels. Researchers around the world are currently seeking to develop "energy-designed" crops that are bred with specific properties that maximise the yield and profitability of bioenergy feedstocks and minimise their environmental impact. For example, Australia is researching GM crops for bioenergy feedstocks that farmers could use in situations of drought.

Researchers are developing "energy-crops", to maximise the yield and minimise environmental impacts

In Europe and in some other countries, the public perception of GMOs has seriously undermined the viability of the technology. If modern biotechnology is to become publicly accepted as a useful and safe tool for improving bioenergy, decision-makers will need to carefully listen to and communicate with key influential stakeholders. One possible policy option in Europe would be for policymakers to introduce a different regulatory regime for those GMOs used for bioenergy, as opposed to GMOs used for food, but this will probably also need guarantees from plant breeders and industry that the two value chains remain entirely separate.

5.9 Inappropriate use of the precautionary approach

As bioenergy production and use increases (and new advanced technologies such as tailored GMOs may provide the impetus for further increases), certain key thresholds may be exceeded. These include impacts on food supply, water use and land-use, among others. These thresholds are linked to the scale of deployment, and exceeding them risks causing long-term harm to vital ecosystems. As the scale of deployment at which each threshold will be reached is uncertain, discussion may be required on whether a precautionary approach should be envisaged in the development of bioenergy.

Impacts on food supply, water use and land-use are linked to the scale of deployment. Exceeding certain thresholds risks causing long-term harm to vital ecosystems

In general, IRGC [IRGC, 2005] suggests that a precautionary approach can be a valid way forward when managing risks which have high levels of uncertainty, that is for which there is a lack of clarity or quality in the data linking cause and effect.

Uncertainty in the case of bioenergy is at least partly the result of the enormous complexity of both the system at risk (bioenergy embraces many of the world's ecosystems as well as such infrastructures as energy and transport) and the risks themselves. Identifying and quantifying causal links between a multitude of potential causal agents and specific observed effects is highly complex, with multiple uncertainties. IRGC recommends that efforts be increased to reduce the uncertainty through, first, developing an approach to LCAs and Environmental Impact Assessments (EIAs) that allows assessment of the full "cradle-to-grave" impact of different bioenergy feedstocks, growing conditions, production techniques and uses and, then, using them to determine the appropriate scale of deployment of bioenergy installations in particular locations. In the absence of data from these assessments, some precaution may be applied by, for example, imposing limits on the scale of production in a particular country or area.

The food-versus-fuel debate has led some to demand a ban on use of food crops for bioenergy. For example, Jean Ziegler, the former UN Special Rapporteur on the right to food called it a "crime against humanity" to divert arable land to the production of crops that are then burned for fuel. Fearing a possible food crisis as the result of biofuel production, he called for a 5-year ban on using food crops for biofuel feedstock, within which time technologies may be developed to allow biofuel production from non-food feedstocks such as agricultural waste [UN News Service, 2008]. IRGC considers this to be an example of a potentially inappropriate precautionary approach since, in moderation, some positive benefits are associated with at least having the option to use feedstocks for food or fuel (see Section 4.1), and such a ban would deny the use for bioenergy of food crop surpluses when they occur.

5.10 Poor governance practices

Implementation of the adaptive approach to managing risks related to bioenergy, which IRGC recommends, requires an inclusive approach to risk governance, including key actors in decision-making. Such an approach would not only ensure the ongoing input of scientific knowledge, but also enable the negotiation and implementation of the sustainability targets and criteria that will underpin the development of bioenergy internationally as well as the trade of feedstocks and bioenergy products.

Policies must be designed so that they can be effectively and transparently implemented in all circumstances, including weak regulatory or governance conditions and situations with strong conflicts of interests between key stakeholders. As some of the trade-offs with bioenergy can only be resolved at a sub-national level, this may require forms of governance that some countries do not currently possess.

Moreover, as bioenergy development will inevitably have negative impacts on some nations, societies and societal groups, governments should build social and economic "safety nets" for short- and long-term losers. The development of bioenergy could be considered as a potential tool for compensating some inequities in the access to energy. This broad issue of equity should be included in the goals of every bioenergy policy.

The development of bioenergy could be considered as a potential tool for compensating some inequities in the access to energy

VI Risk governance guidelines for bioenergy policies

In this section, IRGC proposes risk governance guidelines that policymakers and regulators in governments are invited to consider and implement in the context of their country's overall bioenergy policy objectives (see Section 3). These overall objectives will set the context and the goal; getting them right is the first step in the process. The various tools (metrics for conducting analytical work) and guidelines (recommendations) referred to below should be used with reference to these specific goals.

Alongside the development of bioenergy policies and regulation, decision-makers also need to be fully aware of the importance and potential of alternative available measures to reduce energy consumption, GHG emissions and other environmental impacts from human activities, for example through demand-side management. The opportunity cost of pursuing bioenergy should not be ignored.

An adaptive and flexible approach to policy and regulation is essential, using bottom-up approaches to maximise the benefits and minimise the risks of bioenergy

IRGC believes that every country considering promoting the production and/or consumption of bioenergy should follow certain common guidelines for ensuring that known risks, costs, benefits and opportunities are taken into account, and should also ensure that policies can be modified as necessary, over time. Due to country-specific circumstances, not all of the measures described in this section may be needed by all countries, and the need for policy intervention is by no means presupposed. Indeed, in some situations, deregulation, rather than regulation, may be the most sensible policy option.

Effective risk governance involves an interactive and ongoing approach that monitors changing circumstances and evolving risks, and acts on new scientific knowledge in order to adapt policies to new conditions. Future research findings may significantly improve the efficiency of converting biomass into energy and our understanding of the environmental impacts of bioenergy. Also, experience will be the only way to assess the effects of bioenergy production on land-use, employment conditions and food prices. Therefore, an adaptive and flexible approach to policy and regulation is essential, using bottom-up approaches to maximise the benefits and minimise the risks of bioenergy.

Policies should also account for the assumption that carbon emissions will increasingly face robust and progressive constraints, whether economic (e.g. carbon taxes or cap-and-trade schemes), regulatory (e.g. through the introduction of minimum emission standards) or societal (e.g. through informed consumers rejecting products they believe carry a heavy carbon footprint). Decision-makers should be planning now for a carbon-constrained supply and use of energy.

Carbon emissions will increasingly face robust and progressive constraints

Policymakers and regulators in all countries (whether industrialised or developing) have at their disposal the same tools, or instruments, to design and monitor the impact of sustainable bioenergy regulatory and economic frameworks in line with their specific policy objectives. Between countries, only the relative emphasis and scale will differ. Altogether, these tools provide analytical templates and guidelines for the implementation and assessment of potential policies.

The first elements of these guidelines relate to RISK ASSESSMENT ("analysis first"); the others relate to RISK MANAGEMENT (dealing with trade-offs, consultation and participation).

RISK ASSESSMENT

6.1 Assessing domestic energy needs and demand

Assessing the role that bioenergy can play

Each country should carefully assess its own energy needs. This can be done using suitable scenarios that account for the long-term evolution of energy demand (taking account of economic development, demographic evolution, improvements in energy efficiency and conservation, etc.) as well as of how supply will evolve. This national energy needs assessment should then be extended by deliberately assessing the role bioenergy could play in the context of other sources of energy (and of energy efficiency and conservation).

6.2 Assessing domestic capacity for bioenergy production

▪ Determining land availability and potential use of waste

Optimising the use of waste and of marginal land

Each country should assess:

- Its own capacity to use land to grow bioenergy feedstock, considering the alternative needs for the same land area for food production and other uses;
- Which of its marginal land areas (see Box 7), such as degraded areas, can be used and how much of such land exists; and
- How much domestic, industrial and agricultural waste can be used in bioenergy feedstock production.

The first assessment should be at a national level but should include a region-by-region (sub-national) breakdown and detailed estimate of the quantity of biomass that can be produced from various crops and technologies under different scenarios. This assessment should, in turn, take account of issues such as land and water availability, soil quality, and variability in the future due to climate change.

Such national assessments have the purpose of understanding both the potential and the limitations of domestic bioenergy production.

BOX 7: "Marginal" land

The term "marginal land" is used in this paper to refer to land that is degraded, abandoned or under-utilised. Such land could be beneficially used to grow feedstocks for bioenergy production, as such use avoids displacing food crops from established farmland and (in principle) minimises the impacts of land-use change. However, marginal land may have unknown value in terms of biodiversity and CO_2 sequestration potential. Many marginal areas are also "commons", which provide subsistence benefits to some of the poorest groups of society. Its usefulness for growing bioenergy feedstocks is also perhaps open to question, given that marginal land is likely to be poor in nutrients, lack water or be for some other reason unlikely to achieve high yields. The lack of knowledge of land-use patterns on a global level, the unknown quantity, quality and productivity of truly marginal land that really exists and the lack of agreement as to the definition of "marginal", "waste", "degraded" or "under-utilised" land mean that caution must be used when developing biofuel policies that rely on such land.

Determining domestic technology capacity

Each country should take into account the level of available technology and its capacity for developing and installing appropriate future technologies:

- Is it able to deploy modern bioenergy technologies domestically?
- Does it have a structured research and development programme to speed up the development and implementation of second-generation technologies that are efficient and economically attractive?
- If neither of the above, can it purchase or license the technologies from other countries?

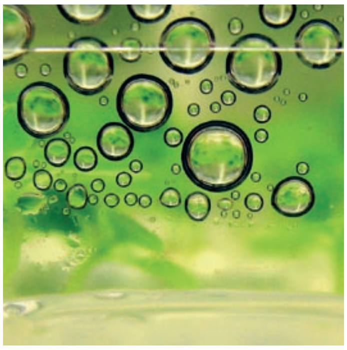
Fostering research and development and technology transfer

Allowing developing countries to benefit from second-generation and transitional technologies

To realise the benefits of, in particular, future second-generation bioenergy technologies, research and development should be a high priority of governments, especially in industrialised countries that have the technical and institutional capacity to support their development. If the resources for such research and development are not available, or in cases where suitable technology exists elsewhere, arrangements with countries, industries or international organisations can provide access to current and future optimum technologies through technology transfers, with associated intellectual property rights. Technology transfer agreements could allow developing countries or countries with little tradition or experience in modern bioenergy to benefit from second-generation and transitional technologies, for example through mechanisms such as the Clean Development Mechanism under the Kyoto Protocol or the Global Environment Facility [GEF, 2007].

Mobilising capital investment

Global investment in bioenergy (biofuels, biomass and waste) in 2006 totalled US$ 25 billion, 36% of global investment in sustainable energy [UNEP, 2007]. Government policies played a key role in influencing this investment. Resource allocation must be optimised in consideration of current as well as future capacity and needs. Industrialised countries should be able to provide for capital investment in new technologies, primarily by the private sector (with the appropriate government incentives). In developing countries, the need will be primarily for public funding in the construction of the infrastructures, notably rural electrification, which will be based on renewable sources of energy [GEF, 2007].



6.3 Consulting stakeholders

Policymakers, regulators and risk assessors need to work together to ensure that risks and benefits are objectively and scientifically assessed. These assessments should precede the finalising of policies and regulatory measures. Only with such factual data can the appropriate decisions regarding trade-offs be made through meaningful, participatory and informed processes that ensure that all stakeholders are aware of the considerations behind the final decisions. Numerous decision-making frameworks are currently available or being developed. For example the Artemis project is a participatory multi-criteria evaluation of renewable energy scenarios in Austria, with particular emphasis on bioenergy (www.project-artemis.net).

Policymakers should also consult with industry, since business will be a major investor and agent for policy implementation. In order to make effective policies that businesses will support, governments should consult with businesses in the design of energy, development and climate policies. In turn, industry should understand the political framing and the societal perceptions that will influence policy and the market's acceptance of bioenergy products.

Business is a major investor and agent for successful policy implementation

Civil society must be fully informed about the risks and opportunities of bioenergy, based on objective, credible and real examples and experiences. Civil society needs to understand the bioenergy agenda from various perspectives, so that it can effectively play its role in safeguarding society's collective interests by helping to ensure that, by making informed choices as consumers, the social benefits of bioenergy are maximised and the risks minimised.

International organisations are likely to benefit from a participatory approach which gives concerned NGOs full access to the process in order that certification schemes and standards can gain the widest possible support.

6.4 Doing case-specific life-cycle assessments of bioenergy production

Countries with sufficient resources should conduct comprehensive LCAs of current and potential biofuel production chains (see Box 8). Ideally, LCAs should include a sensitivity analysis (a systematic procedure for estimating the effects of the chosen methods and data on the study's outcome), and a probabilistic analysis, as a way to incorporate uncertainty into the analysis.

Assessments must be done on a case-by-case basis, to account for the many potential sources of biomass, the various other potential sources of energy (electricity, heat and transport fuel), and the specific hydrological, soil and climate conditions. They should also include the environmental impact of transport within the production and distribution processes, particularly if the biomass or bioenergy product is exported. Countries that do not have the resources to conduct LCAs can still adhere to other guidelines related to inputs and outputs of bioenergy production, for example by giving priority to determining the area of available marginal land.

The development and use of effective risk assessment methodologies is an area which needs greater attention

However, while LCAs are useful tools, they do not tell the whole story and do have limitations. Proposals for more complete analytical methods to assess the full impacts of bioenergy, including indirect impacts, include the Greenhouse gases, Regulated Emissions and Energy use in Transportation (GREET) model developed by Argonne National Laboratory in 1996 and subsequently updated (latest update 25 July 2008 available from Argonne National Laboratory), the EMPA methodology [Zah et al., 2007] and consequential LCAs [Reinhard, 2008]. The development and use of effective risk assessment methodologies is an area which needs greater attention.

BOX 8: Life-cycle assessments and their limitations

Life-cycle assessment (LCA) is a tool used to investigate the environmental impacts of a given product or service by accounting for all inputs and outputs associated with the product/service from its manufacture to its disposal ("from cradle-to-grave") or to its subsequent recycling ("from cradle-to-cradle"). This includes the assessment of raw materials involved in production, manufacture, distribution, use and disposal, plus all intervening transportation steps. LCAs are a standard tool of environmental management and LCA principles, frameworks, guidelines and examples are published by the International Organization for Standardization (ISO).

LCAs are useful for assessing potential bioenergy pathways and for conducting a comparative assessment of energy options and, for example, a considerable number of studies have been undertaken of bioethanol from the energy, GHG and environmental impact perspectives [von Blottnitz and Curran, 2007]. There has recently also been a marked increase in interest in LCAs and their use although, while an LCA "may be simple in concept, the details of its practice are complex and still evolving. Currently there is no single technique to deliver an overall answer with regard to environmental decision-making" [Curran, 2008].

Thus, to be of full value to decision-makers, LCAs need further development with, for example, the use of uncertainty analysis to account for the fact that many of the factors being assessed – soil, feedstock, climate, etc. – are not directly comparable. Provided decision-makers are aware of their limitations, LCAs remain a useful tool to compare, for example, the GHG emissions resulting from different kinds of bioenergy, biofuels made from different feedstocks, or bioenergy versus fossil fuel. Each country that wishes to encourage the production or import of biomass for energy should adopt comprehensive, accurate, transparent and neutral LCAs, which should:

- Be carried out at the local level and be specific to each bioenergy pathway that may be adopted;
- Be comprehensive "cradle-to-grave" or "cradle-to-cradle" analyses [McDonough and Braungart, 2002] and use internationally-agreed, peer-reviewed methodology that is designed in consultation with industry stakeholders. LCAs should have consistent and transparent assumptions and have the flexibility to accommodate verifiable GHG reduction technologies while also being applicable to all fuels to be sold in a given market (the IPCC Guidelines for National GHG Inventories provides detailed guidance on calculating annual emissions from carbon stock changes resulting from direct land-use change);
- Compile and use accurate data and databases;
- Involve stakeholders, particularly through making the results known publicly, to ensure credibility/transparency; and
- Be incorporated into a well-designed and transparent decision-making framework.

With recent developments in LCA methodology, such as with consequential LCAs [Reinhard, 2008], an attempt is made to include direct and indirect displacement and substitution effects in the assessment of biofuels. This couples conventional LCAs with the consequences for global trade.

6.5 Choosing technology, energy crops and agronomic processes

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■ Choice of technology

A key challenge for bioenergy production is to avoid locking in current technologies and so ensure the ability to take advantage of new technologies when they become commercially available while, at the same time, ensuring that the current technologies can provide tangible energy and environmental benefits. The choice of a suitable technology is strongly influenced by the existing infrastructures at the time of its introduction, as well as by knowledge of anticipated future technologies. As a result, governments, business and other stakeholders should pursue bioenergy technologies that interconnect with existing infrastructures. Doing so will help to reduce costs, improve speed of deployment and, where available, support transitional technologies that will ease the shift to more efficient technology options in the future. Another key influence on technology choice is economic, as adequate return on investment is required for business to be able to finance the research, development, installation and operation of new technologies.

■ Choice of energy crops and agronomic processes

Choosing which energy crops will be most beneficial in a specific context

The different biomass feedstocks vary in their physical characteristics (such as its canopy cover [soil cover], the nature of their root systems, and whether they are perennial or annual) and the required husbandry techniques (the amount of tillage, water, agrochemicals and fertiliser required, and the level of mechanisation). It is therefore crucial to consider and assess the environmental impacts of each kind of crop – on soil quality, soil erosion, water use, need for fertilisers and agrochemicals, and water pollution from chemical runoff, as well as their invasive tendencies – when choosing which energy crops will be most beneficial in a specific context. Local factors such as soil type and rainfall patterns must also be considered.

Agricultural row crops, such as maize, are annuals, which require cultivation and fertiliser every year. Although the problems of annual tillage are the same whether these crops are grown for fuel or food, production of biofuel may exacerbate them through more intensive or extensive monoculture. In contrast, some second-generation biomass feedstocks, such as short-rotation coppice and perennial grasses, may stabilise and protect the soil from erosion by providing a continuous soil cover and, in turn, reduce water and nutrient runoff. Furthermore, many perennial biomass crops do not require repeated applications of fertiliser, meaning they can reduce the pollution from runoff [Bioenergy Feedstock Information Network, 2008].

At the current time, when second-generation feedstocks are still in development, guidelines for husbandry techniques of annual crops that minimise soil degradation may help minimise risks. For example, planting winter cover between annual crops can both help prevent soil erosion and reduce soil emissions of nitrous oxide, while also increasing soil organic carbon and crop yields [Kim and Dale, 2005].

■ Water management

Guidelines for integrated land- and water-resource management are important tools for risk assessment and for alleviating sustainability concerns regarding water use [Calder, 2005]. As seen in Section 5.3, analyses of long-term evaporation (green water) and catchment flow (blue water) are important to enabling the appropriate choice of location, feedstock and cultivation method for bioenergy.

■ Environmental Impact Assessments (EIAs)

Once a bioenergy feedstock crop and its bioenergy products have been chosen and a water management plan and other specificities of a proposal have been developed, the proposal should be subject to an EIA. An EIA can be defined as "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made" [IAIA, 1999]. Because bioenergy production can pose important environmental risks (see Section 4.2), which will vary substantially depending on what kind of bioenergy or feedstock is being produced and the environmental context (climate, soil type, etc.), EIAs should be carried out on specific proposals before they are approved and implemented. EIAs and their use are formalised within various laws and international treaties, including the Espoo Convention (1991), which sets out principles for environmental impact assessments in a transboundary context. The Kiev Protocol to the Convention requires that a strategic environmental assessment (SEA) "shall be carried out for plans and programmes which are prepared for agriculture, forestry, fisheries, energy… and any other project… requiring an environmental impact assessment under national legislation" [UNECE, 2003].

Because bioenergy production can pose important environmental risks, environmental impact assessments should systematically be carried out

6.6 Determining the appropriate scale

Scale of production is a key determinant

Each country with the means to do so should assess whether it can engage in domestic bioenergy production and determine the appropriate scale. Scale is a key determinant for its success or failure in sustainability terms.

- At a local scale, biomass is produced and transformed locally and the energy is consumed locally, with the priority being to meet local needs. This would include, for example, developing small biogas production facilities at community level;
- At a regional or national scale, domestic producers contribute to a regional/ national market;
- At a global scale, international trade structures the market for importing countries (those with limited domestic capacity) and exporting (those with excess domestic production capacity).

IRGC believes that some of the largest environmental risks result or would result from global markets which are not supported by adequate sustainability criteria and standards.

6.7 Assessing the timing issue

Broader questions include how quickly to expand bioenergy production and whether bioenergy is expected to be a long-term source of energy or only transitional

Each country should clearly determine within what timeframe it expects to be able to develop and implement its programme. Many issues related to timing need to be assessed, such as the linkage of policy decisions both to scientific developments (such as the availability of second-generation bioenergy) and to commercial issues (such as the turnover rate of car fleets and the development of refuelling networks or bioenergy plant infrastructure). Broader questions that need to be asked to ensure effective risk governance for bioenergy include how quickly to expand bioenergy production and whether bioenergy is expected to be a long-term source of energy or only transitional. Such questions will greatly influence decisions on the most appropriate pathway for bioenergy development.

RISK MANAGEMENT

6.8 Establishing proper land-use policies

Using land for growing bioenergy feedstock is in direct competition with all other possible land-uses including food and fibre crops, residential and industrial use, tourism and environmental conservation. Globally, it is desirable to reduce the land area occupied by agriculture and to expand protected areas and lands managed for other benefits. The use of marginal land for bioenergy may in some cases be beneficial but this land may currently provide other benefits (see Section 6.2 and Box 7), so its use will still involve trade-offs. Land-use policies need to be able to balance all competing demands including food, fibre, fuel, biodiversity conservation, ecosystem management and GHG emission reduction. These uses are not mutually exclusive, and much research and development is being devoted to ensure mutually supportive land-uses (e.g. intercropping, organic and wildlife-friendly farming/eco-agriculture, ecosystem management and rehabilitation). Bioenergy does not require its own land-use policy but should be integrated with existing policies relevant to forestry, protected areas, agriculture and urban land-use planning.

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Bioenergy does not require its own land-use policy but should be integrated with existing policies relevant to forestry, protected areas, agriculture and urban land-use planning

6.9 Agreeing upon and implementing sustainability criteria and certification schemes

Sustainability criteria and certification schemes can help ensure that bioenergy is sustainably produced, processed and transported

Sustainability criteria and certification schemes can help ensure that bioenergy is sustainably produced, processed and transported. They give buyers – whether a government, a business or an individual consumer – a means of differentiating between products. For bioenergy, the adoption of meta-standards may speed up the introduction of sustainable bioenergy and may be appropriate where the bioenergy feedstock is already subject to sustainability criteria. For example, using Forest Stewardship Council [FSC, 2007] certified wood for wood pellets or wood chips, or Roundtable on Sustainable Palm Oil [RSPO] certified palm oil for biodiesel, means that new standards and criteria may not need to be developed. Conversely, when the use of a new feedstock for bioenergy is likely to greatly increase the demand for that feedstock, new criteria – such as principles appropriate for GHG emissions or which provide protection for particularly vulnerable groups such as women and indigenous peoples – may need to be developed. The key challenge here will be to develop methods that ensure successful traceability – a reliable means to track inputs through the supply chain in order to determine if production is really sustainable. Certification schemes should also be as simple as possible and strike an acceptable balance between inclusiveness and rigidity. The Roundtable on Sustainable Biofuels [EPFL] is proposing to use this approach.

However, such schemes have as yet to demonstrate that they can address the indirect effects caused by the displacement of agriculture that may itself be unsustainable because of the negative impact on food security.

Certification may favour big players and provide incentives for scaling up production to absorb the certification costs

It should be noted that certification may favour big players and provide incentives for scaling up production to absorb the certification costs [UNCTAD, 2008]. Poor farmers may be disadvantaged (an example of the kind of trade-offs that policymakers need to consider). Furthermore, the effectiveness of voluntary standards depends critically on the willingness of consumers to bear the additional costs of buying from certified-sustainable channels, a luxury that remains unaffordable for the majority of the world's citizens. Therefore, although there are considerable benefits that will ensue from transparent certification schemes, there is a need to be aware of their limitations.

6.10 Setting up performance standards and mandates

Performance standards specify a minimum standard for one or a series of criteria that must be met for a product to be eligible to enter the market. At their most basic level, performance standards may ensure that the product meets minimum product quality standards (as with the European EN14214 standard for biodiesel or the EU Fuel Quality Directive). However, performance standards can also be used to ensure that bioenergy meets certain criteria, in order to improve environmental [Turner et al., 2007] or sustainable performance. For example, the EU has proposed that a performance standard be used to ensure that only biofuel with life-cycle emissions 35% lower than those of petrol be counted towards meeting biofuel mandates. Performance standards can be introduced incrementally and in conjunction with other incentives, such as carbon taxes, to improve the ability of suppliers to meet the standards [Farrell et al., 2007].

The establishment of biofuel mandates has proved a popular policy tool in recent times, with regulators mandating that biofuel makes up a certain percentage of petrol sold (for example, the US Renewable Fuel Standard Program, 2008) or a certain proportion of the energy mix (for example, the proposed EU Directive on Energy from Renewable Sources, January 2008). Both aim to promote the market penetration of biofuels. However, governments must be careful not to set sustainability criteria or performance standards in conjunction with inflexible mandates that cannot then be met by industry. For example, if regulators mandate that all liquid transport fuel sold must be a blend of at least 7.76% biofuel (as is the case with the US Renewable Fuel Standard 2008), and this amount of biofuel is difficult to source from certified sustainable producers, then industry may be forced to resort to buying unsustainably produced biofuel to meet the mandated objective.

Governments should recognise the limitations to any country's ability to meet targets and national mandates while addressing performance standards, given that the path towards internationally-agreed standards may be long and difficult. Countries should therefore carefully consider their approach to the creation of targets and mandates until sustainability considerations, technology advances, consumer acceptance of biofuels and risks to budgets can be adequately addressed.

Governments must be careful not to set sustainability criteria or performance standards in conjunction with inflexible mandates that cannot then be met by industry

6.11 Choosing appropriate economic instruments

Under certain conditions (see Section 5.5), subsidies can be powerful economic instruments to encourage the implementation of new policies.

Carbon taxes or cap-and-trade schemes are used by various countries to support reductions in GHG emissions. Although they act to penalise sectors that emit CO_2 they are technology-neutral in that they do not specify which technologies industry should deploy in order to achieve emission reductions and so reduce the associated costs. Instead, they act to encourage industry to select the most emission-efficient technologies, and they focus on the outcome rather than the process, making them relevant regulatory instruments for dealing with bioenergy.

When applied to bioenergy, and as part of a national or international effort aimed at reducing GHG emissions from sectors such as transport and electricity production, both carbon taxes and cap-and-trade schemes could provide strong incentives to improve the net GHG balance of bioenergy. For example, if policymakers pursue a carbon tax on road transport fuel, then the level of tax should reflect the life-cycle GHG performance of the fuel and fuel components (including biofuels), with lower life-cycle GHG emissions corresponding to lower tax rates. This will encourage and reward production of those fuels that make the greatest contribution to GHG reduction.

However, these measures only encourage low carbon emissions and do not ensure that other bioenergy goals are met. Thus, carbon taxes or cap-and-trade schemes are best used in conjunction with more specific sustainability criteria relating to ecosystem impacts, biodiversity, water, etc.

Fuel taxes may improve net GHG emissions from transport more effectively than biofuels can in the short term, as they may influence consumer behaviour more quickly and effectively

Policymakers should be aware that other fiscal incentives may also be effective, including those that operate outside the bioenergy sector. One example is the recently-proposed “feebate” for car purchases in France, which uses fees levied on sales of high-emission vehicles to cross-subsidise the cost of buying low-emission vehicles. Other measures such as pay-as-you-drive (PAYD) insurance schemes [Parry, 2005] or fuel taxes may improve net GHG emissions from transport more effectively than biofuels can in the short term, as they may influence consumer behaviour more quickly and effectively.

All fiscal incentives need to be assessed fairly, within a comprehensive framework that accounts for all costs and benefits.

6.12 Negotiating trade agreements

The international trade in biomass for energy purposes is currently only in its initial stages and has much potential for growth. Local use of biomass for energy is still much more common, with the majority of today's international trade in biomass being in non-bioenergy products.

Trade in biofuels is likely to rise rapidly in the near future

Trade in biofuels is currently quite small. The most internationally-traded bioenergy products today are: vegetable oils (62% of palm oil is traded, 15% of rapeseed oil), wood pellets (25%), ethanol (8.5% of world production is traded), charcoal (2.2%) and fuel wood (0.2%); (2004 figures, see [Heinimö et al., 2007]). It has been estimated that in 2005, approximately 10% of all biofuel production was traded internationally. However, this figure is likely to rise rapidly in the near future, due to industrialised countries setting biofuel mandates and targets that will require a significant increase in biofuel imports for them to be met [Murphy, 2008].

To be efficient, the bulk of the world's feedstock and biofuel production should occur in developing countries with sufficient land to devote to biomass production, a favourable climate to grow feedstocks, and low-cost farm labour. Already, several are or may become efficient producers. For example, in Sub-Saharan Africa, the low domestic demand would enable these countries to become major exporters (though some public opinion in many African countries opposes such a development). While some poor countries are tempted to trade raw material before processing, they should assess whether it is really in their interest to trade agricultural production that may be needed domestically to meet the food and energy needs of their own population.

Each country should assess how much biomass (raw material) and bioenergy (final product) would be available to buy or sell through cooperation with neighbouring countries in order to optimise the energy and GHG balances of bioenergy along with the benefits of equitable trade. However, protectionism, including tariff and non-tariff barriers to trade, such as quotas, standards and technical regulations, is still an obstacle to bioenergy trade in many cases, and the overriding concern for food security in developing countries will remain a critical factor in bioenergy trade.

Another reason why trade rules related to bioenergy need urgent attention at the international level involves sustainable production. With the expected considerable increase in trade in feedstocks and biofuels, sustainable production is becoming a key concern and is currently being considered as a possible requirement for market access. Ensuring that only sustainably produced bioenergy is traded will require the development and implementation of international standards for the broadest possible range of sustainability criteria. These global standards may be in the form of:

- Product quality standards for specific products;
- Performance standards that are not technology- or fuel-specific, but include minimum standards to be tradable; or
- Certification schemes coupled with land-use agreements (see Sections 6.8 and 6.9).

WTO considers ethanol to be an agricultural product and biodiesel to be an energy product

When contemplating the development of any such standards, however, it is important that the legal framework of the WTO and its trading rules be considered. The implications of WTO rules for sustainable trade in bioenergy are not clear, as the WTO does not currently have a trade regime specific to bioenergy (note, for example, that the WTO considers ethanol to be an agricultural product and biodiesel to be an energy product, which has significant implications on which trade regulations apply to each type of fuel). (For a more detailed discussion of trade in biofuels and WTO implications, see [UNCTAD, 2006] and [UNCTAD, 2008].)

It is probable that, under current WTO rules, obligatory biomass certification could at best, and under certain conditions, guarantee GHG savings (including carbon sinks), biodiversity protection and protection of the local environment (e.g. soil, water and chemicals). It could not include criteria related to avoiding competition with food products or to social criteria. Voluntary biomass certification could apply stricter criteria and include social dimensions [BTG, 2008].

VII Conclusions

In view of the many risks and opportunities that bioenergy represents, the experts invited to participate in the work presented in this policy brief have sought an appropriate balance between:

- Scientific data (and uncertainty in many cases);
- Policy options (including policies already in place); and
- Possible regulatory approaches.

Over the course of this project, IRGC has considered the many problems linked to the unsustainable development of liquid biofuels as well as the many opportunities associated with the small-scale development of bioenergy production facilities. At a local scale and in specific situations, these can provide numerous prospects for local and rural development, particularly with regards to meeting energy needs in developing countries. IRGC has concluded, however, that current policies (and economic incentives that accompany them) do not enable a balanced resolution of the trade-offs that need to be made between:

IRGC has concluded that most current policies do not enable a balanced resolution of the trade-offs

- Biomass for fuel versus food;
- Energy security and independence versus climate change mitigation;
- Different uses of land, with direct and indirect impact on GHG emissions, soil degradation and water resources; and
- Local, regional and global needs.

In view of the complexity of the issue, IRGC proposes policy options, with clear-cut targets, summarised as follows:

- Industrialised countries and major exporters of bioenergy among developing countries should encourage the development of bioenergy only where it can be demonstrated that doing so will reduce GHG emissions throughout the entire life-cycle;
- Other developing countries and countries with economies in transition should develop bioenergy that primarily benefits local livelihoods through the provision of affordable, safe and more efficient heat, electricity and fuel for transportation, and to support wider sustainable development goals that do not, in doing so, jeopardise food security.

IRGC hopes that its proposed risk governance guidelines will help in the practical avoidance of major risk governance deficits in bioenergy policies and practices. It also hopes that future public policies will emphasise:

- The long-term opportunities and risks, as well as the appropriate policy objectives and incentives that can either encourage or mitigate them;
- Market-oriented approaches, to reduce existing distortions in liquid biofuel and agricultural markets;
- Environmental sustainability, protecting land and water resources from depletion and environmental damage;
- Adaptive regulation, production and behaviour, to allow rapid improvements in the economic and physical efficiencies in the production and conversion processes such as those implied in second-generation technologies; and
- Priority given to economic concerns for developing countries, with a focus on food, employment and energy needs.

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IRGC's risk governance guidelines are developed as a result of projects which include workshops at which experts contribute their knowledge and opinions. Thus, IRGC assures the scientific basis for its recommendations although these recommendations do not necessarily represent the views of all workshop participants, members of a project's leadership team, or their employers.

For this project, IRGC invited a number of individuals with expert knowledge of the fields of bioenergy and risk governance to form an Advisory Board. The Advisory Board met twice at workshops, contributed to the drafting and revision of all project documents – including this policy brief – and collectively provided the intellectual basis for IRGC's risk governance guidelines for bioenergy policies.

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