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Biofuels and Developing Countries

- with a focus on sub-Saharan Africa

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Executive Summary

1. *Biofuels*[1] are combustible material derived from the growth of green plants; as such they are a way to utilise solar energy and to absorb the major global warming gas, carbon dioxide.

2. Biofuels, and particularly the expansion of *liquid biofuel* production and use, are relevant to developing countries for the following reasons:

- They can supply substitutes for diesel and petrol fossil fuels from local plant resources.

- They could add to the often meagre incomes people get from the land.

- There are ways to pay developing countries for their projects which absorb *greenhouse gases* through the *Kyoto Clean Development Mechanism.*

- Policies in some developed countries to expand production and consumption of liquid biofuels have increased demand for the grains and oilseeds used in their manufacture. This has been one of the forces lifting international prices for maize (corn), wheat, soya beans and rapeseed. The overall effect has been to double the food import bill of the 82 *Low Income Food Deficit Countries* between 2004 and 2007. Rising food prices have hit poor people hardest, particularly in towns, while they can raise incomes of farmers with surplus food to sell.

3. Recent attention to liquid biofuels mainly reflects the concerns of the developed countries to make their energy supply more secure, to reduce their greenhouse gas emissions and to bolster incomes in agriculture.

4. Technology also has an important role and its evolution could have profound effects. Key technologies are:

- Motive power for transport, at present *biodiesel* and *ethanol* are the only practical renewable sources of energy to substitute for petrol and diesel oil.

- Production of biodiesel - now largely from soya beans, rapeseed and other oilseeds.

- Production of bioethanol – at present mainly from sugar cane, maize and other grains.

- Conversion of grasses, willow and other leafy or woody material into liquid biofuels with further development of *second generation biofuel technologies* to make them commercially viable. Similarly production from algae and other microscopic organisms could come with advances in *third generation biofuel technologies.*

5. Liquid biofuels differ enormously in their delivery of fuel savings, greenhouse gas reductions and other impacts on the environment, depending on the raw material used and where it is produced.

6. Land use is affected by all current sources of biofuels. In using land biofuel production may displace food production. However, a reduction in food output could be avoided by increasing output per hectare and by producing biofuels from plants that do not compete for land with food crops. These scenarios have major implications for agricultural product markets, greenhouse gas emissions from the soil, water resources and the biosphere, each with its socio-economic consequences too. Processing of the biofuel raw materials can also be demanding especially of water and of how the supplying farmers are funded and organised.

1 Terms in italics are defined in the Glossary in front of the list of abbreviations at the back of the paper.

7. Biofuel policies have been made when relatively little was known about the various effects and ramifications of biofuel production and use. Does this explain why the impacts of some biofuel policies on food prices, greenhouse gas emissions, land use, the biosphere and water consumption seem to negate the stated objectives of these or other policies? Thus, should not the precautionary principle be invoked and a comprehensive review of liquid biofuel systems be done quickly before going further with current policies?

8. International agreements, the Kyoto Protocol for instance, recognise the global reach of environmental issues. However, key agreements are uneven in geographical coverage and in control over the issues they address. This raises important questions including:

- Will trade in biofuels and in emission reductions reduce, or just relocate, greenhouse gas emissions?

- Will sustainability certificates for biofuels provide adequate protection for the biosphere in exporting countries?

- Might these problems be addressed more effectively through international agreements, with mutual support between agreements on the environment, trade and on achievement of the Millennium Development Goals?

9. Most research on biofuels is in Developed Countries. What further provisions could increase the development and application of innovations relevant to Developing Countries? This is a particularly pressing question for the countries of sub-Saharan Africa in the context of recent fuel and food price shocks.

10. Action Research in developing countries is proposed as a way to accelerate farm adoption of productivity-raising innovations for food and biofuels too.

11. Developing country success in agriculture will also require comprehensive support strategies with assistance from the international community.

Policy Coherence in Ireland (Section 4.7)

12. This paper specifically refers to developing countries and energy concerns. The key question is thus: how might biofuel policies in Ireland work for or against achievement of the Millennium Development Goals (MDGs)? This immediately explains the emphasis on sub-Saharan Africa in this report, and in Irish Aid, as it is in these countries that levels of poverty, hunger and child malnutrition are the highest in the world.

Elements of energy policies that could favour achievement of the MDGs include:

- Energy research programmes, both Irish and EU, should do more to include research and development partners in developing countries and provide some benefits to these countries, particularly in sub-Saharan Africa.

- Review of the impacts and potential impacts of energy policies should include impacts on developing countries.

- Use of the Clean Development Mechanism to benefit, in particular, countries in sub-Saharan Africa and to include building capacity to enable partnerships to formulate successful project applications (Section 4.6).

- Enable developing countries to adapt to increased prices for petroleum and food including support for increasing the productivity and output of agriculture and biofuels, as well as adaptation to threats posed by climate change.

Elements of energy policies that could work against achievement of the MDGs include:

- Enforced use of liquid biofuels, including their mandatory incorporation into the fuel supply, when enforcement would risk increasing the occurrence of hunger and malnutrition in the world.

- Importation of biofuels, or their raw materials, or purchase of greenhouse gas emission credits from outside the EU without adequate safeguards to ensure that this trade would not cause serious degradation for poor people or of the environment.

1. Introduction – Biofuels, Energy and the Environment

1.1 The what and why of biofuels

Biofuels[2] are combustible material derived from the growth of green plants; as such they are a way to utilise solar energy and to absorb the major global warming gas, carbon dioxide. Raw materials for biofuels are usually solid *biomass*, including grains and wood. These are increasingly transformed into *liquid biofuels* or *biogases*. Prominent liquid biofuels are *biodiesel* and *ethanol*, the petrol substitute, with sources of biomass used to produce them listed in Annex I . Many other plants are used to produce ethanol other wise known as alcohol. However, these plants are used more for producing alcoholic drinks than powering engines.

By reducing dependence on fossil fuels and emissions of *greenhouse gases* (GHGs[3]) biofuels can be said to kill two birds with one stone. Measures of reductions in greenhouse gas emissions delivered by liquid biofuels in current use are reported in the next sub-section. Future technological possibilities are noted in Section 4. Section 1 then concludes with a reminder of the daunting scale of the problems of energy supplies and of global warming induced by rising levels of greenhouse gases in the atmosphere. Section 2 deals with the use and prospects for biofuels in developing countries. The emphasis here and throughout this report is on sub-Saharan Africa where Irish Aid is largely focused and where levels of poverty, hunger and child malnutrition are amongst the highest in the world.

Section 3 considers the situation in developed countries, especially EU and US government policies to increase the production of biofuel and its use. Section 4 focuses on interrelations between developing and developed countries from international commodity markets to international agreements and the wider repercussions of some national policies. Funds applicable to expansion of biofuels in developing countries are also noted before discussion of policy coherence issues that have emerged from this brief survey of the field.

1.2 Biofuel impacts

Government interest in promotion of biofuels has evoked numerous studies. In contrast, many would share the view that too little is yet known of their potential productivity and widespread environmental and economic impacts. Results outlined below should thus be seen as tentative and incomplete. In addition, impacts have been considered one at a time to build up a more comprehensive account of current knowledge in succeeding sections. We start with accounts of the energy, fuel and greenhouse gas inputs and outputs of the major biofuels currently used industrially, namely sugarcane and grains for bioethanol, oilseeds and palm oil for biodiesel, and wood for electricity production. No similar data was found on the use of wood for cooking, though in Africa this 'traditional biomass' accounts for nearly half of the energy from all sources (IEA, 2008).

Life Cycle Analysis (LCA) is the general term applied to measurement of all the energy inputs and outputs involved in the production and use of biofuels. One way to summarise the results is as the **Net Carbon Reduction (NCR).**[4] This is 'the net reduction in carbon emissions resulting from consumption of a unit of biofuel' (Rajagopal and Zilberman, 2007 p.27.). NCR results in Table 1 compare the biofuel under test with emissions from the use of petrol or diesel oil to deliver the same amount of work, e.g. propel a test car one kilometre.

2 Terms in italics are defined in the Glossary in front of the list of abbreviations at the back of the paper.

3 Abbreviations are spelt out in the list of Abbreviations at the back of the report.

4 Other measures of the efficiency of biofuels are given in the Glossary in entries beginning 'Net…'

Table 1: Net Carbon Reduction with liquid biofuels

Feedstock	Location	Net Carbon Reduction (percent)
Range of results for ethanol		
Sugar cane	Brazil	91%
Wheat	UK	47%
Maize E85	USA	14%
Maize E10	USA	1%
Range of results for biodiesel		
Waste cooking oil	Australia	92%
Soya beans	Australia	65%
Rapeseed	Germany	21%

Source: Kojima et al.(2007)

Results from assessment of liquid biofuels on the three criteria of energy delivery, fuel savings and reduction in greenhouse gas emissions show that gains from using them in place of petroleum products were very dependent on how and where the biofuel was produced. Also, larger gains from the use of solid biofuels to produce electricity make this a preferred use for biomass, particularly in temperate zones.

These assessments are incomplete. Even in terms of the cycling of carbon, Life Cycle Analyses did not include emissions from the soil when it is cultivated and the even greater emissions when virgin land is opened up to produce the biofuels or products to replace those used for biofuels. These emissions too vary considerably between locations and between methods of cultivation, including 'no-till' (Montgomery, 2007).

One way of looking at the net effects on emissions of expanding the area under specific crops is to calculate how long it would be before they would show an overall net reduction in emissions. A recent estimate shows that net emission reduction from expanding sugar cane output through opening land for production in Brazil would start after 17 years and it would take 93 years to reach this point with ethanol production from corn on the central grasslands of the US (Fargione et al., 2008 quoted by von Braun 2008).

Other impacts to be considered are those on water use at both growing and processing stages, eutrophication or greening of water courses, biodiversity and air quality where the fuels are used. These and other environmental problems have been noted and need to be addressed in LCA studies. Even taking account of these potential impacts still leaves questions as to whether a specific system is profitable and adds to the welfare of society.

All this could change with development of *second generation biofuel technologies* to the point of commercial viability. These convert grasses, willow and other leafy or woody material into liquid biofuels rather than using grains or other foods (Section 4.3). Similarly production from algae and other microscopic organisms could come with advances in *third generation technologies*.

1.3 Petroleum supply and climate change

The current trajectory of fossil fuel use and its related emissions of greenhouse gases is unsustainable (IEA, 2008). However, the current mode of economic growth feeds on energy, especially from oil. Depletion of oil reserves and increases in its price are likely to have particularly adverse effects on developing countries relying on it to power economic growth. In addition, the effects of climate change may be particularly severe on many developing countries. Already there is evidence of the impact of extreme weather on poorer countries and the difficulties they have in dealing with the ensuing emergencies, as in Bangladesh. One of the predicted effects of climate change is to increase the frequency and severity of extreme weather, others are increased sea levels and desertification.

Radical changes to move towards sustainability would include massive growth in the use of *renewable sources of energy.* At present biofuels account for 10 percent of the global *Total Primary Energy Demand (TPED),* far more than all the other sources of renewable energy. In developing countries it provides 20 percent of TPED and reliance on biofuels in Africa is put at 47 percent, largely from wood. (IEA, 2008). In this context it is noteworthy that reliance on biofuels, principally wood, increases with poverty (Karwkezi, 2006 and Rajagopal and Zilberman, 2007, Figure 9 page 97 also Barnes, 1996).

2. Liquid Biofuels in Developing Countries

2.1 Key questions

In this section we go beyond the overall influences noted in Section 1 and consider the following key questions about conditions in developing countries:

- How far have liquid biofuels helped poor developing countries to offset the effects of steep oil price increases? How could the poorer members of their populations generate more income from agriculture and, particularly, from biofuel production?

- Do the concepts of landlocked economies and shifts in the domestic terms of trade help to identify the most profitable locations for the decentralised production of liquid biofuels in developing countries?

- How could applied research on the multiple factors involved in a transition from fossil fuel to liquid biofuels deliver swift results?

How far have liquid biofuels helped developing countries to counter the impact of oil price shocks? Only three southern countries – Brazil, Malawi and South Africa – have been producing significant quantities of biofuel relative to the size of their national economies[5]. Both Malawi and Brazil began with ethanol production from sugar cane at the time of the first OPEC oil price shock in 1973/4 and Brazil has diversified into soya beans for bio-diesel production from 2005, as the current oil price shock gathered momentum.

5 In Africa, in addition to Malawi, significant production of ethanol from sugar cane is reported for South Africa, and much smaller amounts for Ghana, Zimbabwe and possibly Kenya, where the only conversion plant – in Kisumu, western Kenya – has been non- operational for long periods. In 2006 the only biodiesel was being derived from jatropha plantations in South Africa; see Dufey, A. (2006).

The income distributional effects in all three countries have been much less pro-poor than might have been possible. In Malawi, the government of Dr. Banda ignored the recommendation of a UK government project mission to place the 8,000 hectare Dwangwa Delta in an outgrower sugar cane scheme farmed largely by small-holder producers. Instead, private benefits to the poor were confined to an addition to the agricultural sector wage bill. In Brazil, land reform in the Northeast by the present government of President Lula appears to have lost momentum, with incremental soybean output benefiting a mix of latifundistas and foreign commercial investors in monocrop plantations producing biodiesel, rather than enhancing incomes on smallholder family farms (minifundios). In South Africa, irrigated sugar cane is produced for ethanol on commercial estates or large-scale mechanised family farms. Small-holdings in the former 'homelands' have been left to produce subsistence crops and animals, with most young people migrating to towns.

The potential impact on poverty of decentralised biofuel production substituting for imported fossil fuel would be significantly enhanced in land-locked countries and provinces, listed in Annex Table A.2. In such cases, oil and other imports have to cross one neighbouring country or in some cases two (e.g. Rwanda). In sub-Saharan Africa there are 15 land locked states out of the present 50.

More than 30 different plant sources for liquid biofuel are listed in Annex Table A.1. Reliable physical and financial performance data are available for only some of these crops in only a handful of developing/middle income countries namely: Brazil, South Africa, Malawi, Ghana, Kenya and possibly China too, but not for all potential agro-economic zones within each of these countries. Even less Life Cycle Analysis data is available to show the efficiency of these systems in terms of reductions in fossil fuel use and in greenhouse gas emissions.

Better information is thus urgently needed if developing countries are to take a fair share of the opportunities these new biofuel cash crops will provide for pro-poor growth. Turning these crops into biofuel could reduce poverty. Sub-section 2.2

below describes how action research could be initiated on a combination of promising plant sources and farming systems in complementary agro-economic zones, initially in 25 to 30 developing countries. This would be coupled with appropriate production, processing and distribution technology and rapid enterprise-to-enterprise demonstration.

The importance of research on the technical and socio-economic aspects of biofuels has been heavily stressed in recent writings, as in Zeller and Grass (2007). The need for rapid generation of insights to take advantage of the potentially large pro-poor net benefits underlines the need for an action research approach. Here, participating family farms would test the performance of a full farm system incorporating new biofuels and traditional subsistence food crops and animals over two or three seasons; the so-called 'unit farm' research approach[6]. The better-performing biofuels would then be demonstrated across the larger agro-economic zone, with crude manufacture of biofuels to meet local energy demand before additional output would be moved by surface transport to their urban energy markets and, possibly, outwards to be sold in the adjoining parts of the national and global markets.

After the initial patterns of profitable smallholder biofuel production have been established, long-term statistical and scientific research studies can be launched to identify and exploit further potential gains in technical and economic efficiency in this sector, where this would appear to be justified. For example, at the present time, the Indian Government's agricultural plant-breeding specialists are selecting higher oil-yielding jatropha plants after early experience suggested that the low and variable yields of unimproved varieties in the 1990s were insufficiently attractive financially for commercial-scale production.

6 Unit farms were first used as holistic experiments in the West Indies in the 1930s, and were successfully demonstrated on a small-scale in Uganda in the period 1967-72 in an action research project funded by a Rockefeller Foundation research grant made to the Department of Rural Economy and Extension at the University of East Africa (Makerere).

2.2 Biofuels as crops for smallholders: farm upgrading versus food production decline

Of the several types of biofuel crops already grown in developing countries, the majority are grown on large-scale, highly-mechanised commercial estates or plantations. These include: sugar cane, maize, cassava and sweet potatoes for ethanol, also palm oil, soya beans and a wide variety of legume and oil seed crops for biodiesel. But the anti-poverty criterion favours the involvement of smallholdings or family farms in diversified farming systems. Against this, a commonly heard objection is that total output from smallholdings is likely to remain static, with the new output of biofuels replacing some of the cheap staple food crops and livestock used for subsistence consumption and sale to poorer consumers in national and global markets. This argument runs on to say that famine and malnutrition, already serious problems in some developing countries, especially in sub-Saharan Africa, will become even more severe, in addition to any effects via adverse climate change arising from man-made carbon dioxide and other emissions.

On the other hand, there is considerable evidence that small-scale farming systems have been largely omitted from development programmes since the beginning of the second OPEC oil price shock (1979). Many of the needed appropriate technologies, institutional reforms and infrastructure investments are more likely to be adopted with the prospect of new high value income-earning opportunities in the form of fossil fuel substitutes. Some of these are already recognised in specific locations but are not yet widely adopted; others require transfer from similar situations in other regions, countries or continents, or basic exploratory research.

In summary, farmers will raise their total output in response to increased prices, with technical assistance where needed. They will adopt new ways to be more productive. Thus their production of biofuel need not depress food consumption.

Swift appraisal of opportunities could be provided by the use of action research. Its components would include:

- Production from areas of unused arable or grazing land, the extensive agricultural margin, as a first priority. Rural population growth is often associated with such extensification, but settlement and production can be accelerated by public investment in social infrastructure: surface transport, land rights surveys, housing, domestic water supply and assisted resettlement are examples of supportive measures. Several sub-Saharan African countries have large, potentially viable, areas outside the tropical rain-forest zones which are only lightly populated at present.

- A complementary factor is the organisation of water supplies for biomass production through irrigation technology, either large-scale projects in under-populated areas or the use of micro-irrigation on existing farms to increase the length of the cropping season. Bangladesh is a successful example of crop intensification on the same area of cultivated land. In sub-Saharan Africa only 2.5 percent of cultivated land is irrigated, most of that within South Africa, compared with some ten times that proportion in South, South-east and East Asia. There are at least 12 distinct irrigation technologies to choose from for storing and distributing water to crops and other cultivated biomass and to ensure sustainability of the system.

- Inter-cropping systems, crop residues, green manuring and specific crop rotational systems help to ensure that plant biomass residues are present to make soil moisture available over the growing season, an objective rarely attained in traditional farming systems.

- *Agro-forestry* is another system for intensification of crop production through plant synergies in specific suitable contexts.[7]

In the wider farming systems, trees may be extended onto otherwise less well-used areas, either as 'farm forestry' under single user ownership or as 'social forestry' under group or whole community ownership and/or management.

An important component of whole farm action research is finding the credit package dimensions, number of family farms and the total areas and outputs of crop and livestock enterprises which will achieve profitability in the overall enterprise mix.

Finally, the integration of livestock and crops in alternate husbandry or mixed farming, and the build-up of nutrient levels on part of the farm system, 'infield-outfield' systems, may be attainable at later stages of innovation.

There are thus numerous opportunities to raise the productivity and output of agriculture including expansion of biofuel feedstock production. However, achievement of growth and poverty reduction targets would require synchronised national and sub-national strategies for energy, environment (including water), transport, trade, aid and investment as well as for agriculture and businesses supplying credit, production requisites and output processing.

2.3 Investment in appropriate technology and its support

Dependence on manual labour sets a low limit on how much crop land can be prepared, sown and weeded at the right times to get an adequate yield. A contemporary example of escape from the limits of manual labour is that provided by use of power tillers (rotovators) with a power take-off (PTO) feature. This innovation spread in China with the switch to the 'Household Responsibility System' (HRS) in 1978 and has also spread in Southeast Asian countries. Adopting this piece of technology in sub-Saharan African villages would allow the following operations to be carried out with greater competitive efficiency.

7 Brief descriptions of each of the main types of 'Agro-forestry' are at this entry in the Glossary.

- Expansion or intensification of land cultivation;
- Use of the engine's power take-off (PTO) to drive a pump to supply water for household use and irrigation and in addition generate electricity for businesses, homes and community services, including lighting;
- Moving loads to and from market with a trailer attached to the machine;
- Production of pure plant oil biodiesel by driving a small oil extraction press and machinery with its power take-off (PTO).

Some evidence of the arrival of this system in Africa was the sight, in 2007, of Chinese power-tillers being delivered to a South African farm machinery importer. There, small-scale production of biodiesel also seems likely to be taken up in several provinces particularly Eastern Cape, Limpopo and Northwest.

Adoption of liquid biofuel production by small scale farmers might be fostered by supply of the equipment or fuel production services through cooperative societies and unions or a 'nucleus estate' system with small-holder 'outgrowers' either in traditional settlement patterns or close to a commercial nucleus estate and its machinery.

2.4 Land rights and credit

Uncertainty over access to land with recognised ownership or use rights, and ability to raise credit in adequate quantities for acquisition of 'lumpy' production and processing equipment and buildings, could inhibit or retard biofuel production orientated to benefit poorer members of rural societies. The recent decision to reallocate land rights to small-holders in Northeast Brazil, on the one hand, or the failure in Zimbabwe to take advantage of a donor-funded land reform after achieving independence in 1980, lie at the opposite ends of a profound contrast in the spectrum of outcomes. Protection of smallholder land rights is a major concern in many countries as it is feared that expansion of demand for food and biofuels will increase the dominance of large scale farming and latifundistas.

The practices of micro-credit and micro-finance have had significant successes for small mainly urban businesses, beginning in Bangladesh and spreading through to many developing countries. Some features of micro-credit would be relevant to small liquid biofuel producers, e.g. a forced savings component and group lending and borrowing responsibilities. A distinct credit type could be initiated for the medium term loans required for asset formation with a generic name such as 'meso-finance'.

2.5 Conclusions on roles for biofuels in the Developing Countries

Brazil pioneered widespread production of a liquid biofuel, ethanol, and its use to replace petrol. This example has been followed in other countries in Latin America. A wide range of crops grown in developing countries can be used to produce ethanol and biodiesel, 30 are listed in Appendix Table A.1. However, production of these liquid biofuels is not widespread and little seen in Africa.

Production of liquid biofuels is attractive in widening the market for agricultural produce and can add to incomes, including those of poor people. It is also practical to have small scale extraction of oil from crops to make pure plant oil biodiesel. Its greatest significance could be in providing a fuel supply in remote areas and landlocked countries. One use of this fuel would be in power tillage machines to release farmers from the limitations of reliance on cultivation by hand. In addition where a power tiller replaces draught animals some land may be switched from feeding these animals to feeding people.

Securing benefits from these opportunities will need support. Research based knowledge of liquid biofuel production systems in Africa or elsewhere in the developing world is meagre and needs to be built up. Action research is suggested

as a way to accelerate learning and to spread adoption of production systems that are viable on typical farms. It would also show what other research was needed to ensure sustainability, including environmental and socio-economic aspects. Also noted was the importance of having local conditions that are supportive of related businesses ranging from delivery of small scale machinery services to credit, rural transport and consumer goods.

Success would depend on ensuring that development of liquid biofuel production was in keeping with local conditions. In fact there is no simple 'one size fits all' solution which will both minimise the ongoing global climate change problems while at the same time achieve pro-poor benefits for people in low-income developing countries. Another key requirement is national leadership supported by knowledge and expertise in multi-lateral development agencies (UN, World Bank and EU), in specific bilateral agencies, often focused on smaller groups of countries, and in the private sector. The suggested approach can benefit from a period of high energy prices enabling 'catch-up growth'. This follows the neglect of agricultural and livestock development, especially in sub-Saharan Africa but also in specific rural areas in the higher growth rate economies of China, India and Brazil. Given the prospective importance of the energy sector and related research, it is also surprising that so few Country Strategy Papers are reported to include energy as an area for policy coherence nor did renewable energies and energy efficiency feature as focal sectors (European Commission, 2007a, p.278).

3. Biofuels in Developed Countries

3.1 Issues and types of policy

Biofuels are seen as addressing the following concerns in developed countries:

- High dependence on fossil fuels, particularly petroleum, for most forms of transport;
- Generation of high levels of greenhouse gas emissions;
- Provision of support for agricultural incomes through biofuel production.

Concerns about access to petroleum supplies have risen steeply from the start of the 21st century. In 2004 the share of imports in the energy supplies of the US was 31 percent (Global Bioenergy Parnership, 2007 p.219). Imports were even more important for the EU. 'With current trends and policies the EU's energy import dependence will jump from 50 percent of total EU energy consumption today to 65 percent in 2030' (European Commission, 2007). Concern about security of these supplies was heightened by the doubling of the international price of oil between January 2001 and mid-2005 and more recently by the price of petroleum going above US$130 per barrel.

Commitments to reduce emissions of greenhouse gases were embodied in the UN Framework Convention on Climate Change (UNFCCC) that entered into force on 21 March 1994. The Kyoto Protocol to this convention was adopted in 1997 and ratified in 2005.

Kyoto poses a challenge to the EU Member States and other countries to reduce greenhouse gas emissions to fulfil their commitments. This also means cutting consumption of petroleum and other fossil fuels. For vehicles the only practical alternatives to petrol and diesel oil have been biofuels. However, even in 2004, production of biofuels in Europe and the US would not have paid. This was shown by comparisons with the cost of petroleum products after allowing for differences in energy content of the fuels (Global Bioenergy Parnership, 2007 pp.40-41). In 2004 one hundred litres of petrol cost €32 before tax while it cost €70 to replace it with ethanol from wheat in Europe and €36 using maize in the US. Similarly diesel was €32 for 100 litres before tax, but producing it from rape seed in Europe cost €56 while producing it from soya beans in the US cost €50. Only in Brazil was it then profitable to use biofuels. There, petrol was €32 for 100 litres but could be replaced by ethanol costing just €27. Thus it seemed that production and use of biofuels in the EU and US would not expand much without government intervention. Such intervention would also provide additional receipts for their farmers and employment too. In this brief survey attention will focus on policies in the EU, with special mention of Ireland, followed by a section on the US.

3.2 The European Union

Various steps to increase the proportion of EU energy obtained from renewable sources, including biofuels, are embedded in a succession of decisions of various EU organs. These reflect a commitment under the Kyoto Protocol to reduce the amount of greenhouse gases emitted in the EU-15 by 8 percent between 1990 and 2012. In discussions of reductions between 1990 and 2020 the EU made a unilateral commitment to achieve a minimum 20 percent reduction in emissions of the 27 Member States in total. The EU has also pledged to do more and go to a 30 percent reduction were sufficient greenhouse gas reduction commitments to be made by other parties. Commission proposals on ways to reach the 20 percent reduction in emissions included a binding target that 20 percent of its overall energy mix will be sourced from renewable energy by 2020 (European Commission, 2006). In 2007 the Commission took the view that:

> *'This will require a massive growth in all three renewable energy sectors: electricity, biofuels and heating and cooling. This renewables target will be supplemented by a minimum target for biofuels of 10 percent. In addition, a 2007 renewables legislative package will include specific measures to facilitate the market penetration of both biofuels and heating and cooling.* (European Commission, 2007)

By 2050 the global cut in these emissions should be 50 percent in the Commission's view (European Commission, 2008). To meet these targets the EU and its member states have introduced numerous measures[8]. Replacement of fossil fuels used by the transport sector is a major strand in the Commission's proposals. Key targets are for liquid biofuels to have a 5.75 percent share of this market by 2010 and at least a 10 percent share by 2020 (EC, 2003/30, and European Commission, 2005). Some member states, including Ireland and the UK, are moving to oblige suppliers of transport fuel to ensure that on average their products include the proscribed share of biofuels.

Most Member States will not be able to meet their targets without buying in carbon emission credits, biofuels and biofuel feedstocks (Banse and Grethe, 2008). The repercussions of these imports on international markets will be considered in the next section.

The expected impacts of these commitments could well change in future, especially were *second and third generation liquid biofuel technologies* to become commercially viable. However, in the next decade these commitments are likely to impose considerable costs, particularly in the transport sector, unless oil prices stay considerably above US$100/barrel in which case policy measures to support biofuels might not be necessary. Production costs of biodiesel and bioethanol from EU grown oilseeds and grains are considerable. These costs, coupled with Lifecycle Analysis of their performance, show that they tend to be an expensive way to reduce usage of fossil fuels and emissions of greenhouse gases. The cost per unit of energy supplied by EU biofuels was estimated to be approximately four times that from imported bioethanol or biodiesel in 2004 (Siemons, R. et al., 2004 p.18). Similarly, reduction of emissions of the main greenhouse gas, carbon dioxide, by using EU biodiesel has been estimated to be at least five times the price of buying carbon emission credits, alias offsets. The corresponding calculation for use of EU bioethanol showed that it would cost fourteen times the price of buying carbon emission credits through the Kyoto *emissions transfer* mechanisms (Steenblik, 2008).

The EU as a whole will thus be a major buyer of biofuels and carbon emission credits if it is to meet its targets. These purchases can be a source of earnings for some developing countries.

3.3 Ireland

In 2005 total production of solid biomass, mainly associated with forestry operations, accounted for one percent of energy supplies and half of the total for energy from renewable sources (Sustainable Energy Ireland, 2008). Production of liquid biofuels was negligible.

Policy measures in Ireland

'Ireland's energy policies are framed in the context of the European Union' (Ireland, 2007, *Delivering a Sustainable Energy Policy for Ireland: The Energy Policy Framework 2007 – 2020)*

The *'Bioenergy Action Plan for Ireland'* (Ireland, 2007a) lists the measures that the seven leading Departments of Government have undertaken to deliver. These measures include targets agreed in the EU. Some measures relevant to this paper are as follows;

Subsidies: The 'Biofuel Excise Relief Scheme' provides relief of excise duties on a range of liquid biofuels for use in vehicles. The scheme runs for five years and will put 151,000 tons of biofuels on the market each year. This will provide a further one percent of the energy supplies and two percent of fuels used in transportation. It seems likely that much of the feedstock will be imported. There are also tax incentives to invest in vehicles suited to biofuels.

8 Implication of the rejection of the Lisbon Treaty in the referendum of 12th June are not discussed in this report as they seem unlikely to affect biofuel policies.

Mandatory blending of petroleum products: In 2009 the Government proposes to legislate to oblige fuel supply companies to have, on average, a 5.75 percent biofuel content in transport fuels, the EU target for 2010. A 10 percent content is to be mandatory by 2020 and there will be a fixed penalty levied for every litre of shortfall (Ireland, 2007a).

'Cap and Trade' schemes cover major industrial sources of greenhouse gases including electricity generation and cement production.

Schemes are available in agriculture and forestry to expand the area of arable crops for biofuel production and support development of the market for liquid biofuels.

Research: The Government has allocated considerable funds for research particularly on ways to reduce demand for energy and the use of fossil fuels, in addition to EU supported research. Topics would include research on biofuel technologies.

For Ireland to meet its EU obligations to reduce greenhouse gas emissions and to increase use of renewable energy there will have to be purchases of emission allowances from outside the country, at least over the next few years. These purchases are likely to involve use of all the available mechanisms, described in Section 4 below, from carbon trading and use of the Clean Development Mechanism (CDM), to purchases of biofuels and related feedstocks.

3.4 The United States

The US is putting considerable resources into reducing its use of fossil fuels, even though it did not undertake to reduce greenhouse gas emissions under the Kyoto Protocol and commitments post 2012 are still under negotiation. A variety of instruments have been deployed to increase the production and use of bioethanol as part of a strategy to reduce consumption of petrol and greenhouse gas emissions. Funding for research on biofuels and establishment of pilot plants were commenced ahead of most of the major initiatives. The country started from a low level of use of energy from renewable sources as they accounted for under five percent of supplies, over half of it from biofuels, mainly wood. This is set to change in a drive summed up by the President's 2007 slogan of '20 in 10' meaning 20 percent less petrol consumption in 10 years. Some key instruments in this drive are mentioned below. In addition there is the Energy Independence and Security Act (EISA), the energy bill signed into law in December 2007[9].

Subsidies, in the form of tax credits, provide a major inducement to use of biofuels. Every litre of bioethanol produced and sold for fuel in the US earns the seller a tax credit of $0.51 per US gallon (€0.13 per litre). For biodiesel the tax credit is $1.00 per US gallon (€0.26 per litre). For electricity generation there are tax credits for using biomass guaranteed for the first ten years' operation of the power stations (Global Bioenergy Partnership, (2007) p222). These are expensive measures estimated to cost US$4,000 million in 2007 rising to US$6,800 million in 2010 though even then the ethanol produced would only replace three percent of the total consumption of petrol (Steenblik, 2008 and Global Bioenergy Partnership, 2007) p222). In addition, several states have introduced tax incentives for the use of biofuel.

Mandatory blending of petroleum products and liquid biofuels is not in federal law but 26 states have legislated in favour of biofuels and some have mandatory blending of ethanol with petrol and biodiesel with diesel (Global Bioenergy Partnership, (2007) p.220).

'Cap and Trade' schemes are largely confined to states and private arrangements.

Compensation schemes under the US farm bills have been used to support investment in biofuel facilities and research.

In these early years of the 21st century the biofuel initiatives in the US have tended to lift prices of agricultural commodities particularly those of maize to produce ethanol. In addition there has been considerable importation of ethanol from Brazil and latterly some biodiesel too. However, it is expected that with the research and development that has been financed on production of ethanol from switch grass and other

9 This is analysed in FAPRI, 2008.

cellulosic material, this second generation technology will eventually be used on a large scale. This would shift biofuel production from land used for food crops to grass land otherwise used for extensive ‘cow-calf’ enterprises.

4. Interactions between Developed and Developing Countries

4.1 Introduction and overview of areas of interaction

Global interdependencies are very evident in both the forces that have brought biofuels to prominence and in the measures needed to address the issues that have emerged. This concluding section will thus look at global interactions and at the scope for greater policy coherence for development within relevant EU and Irish policies.[10]

4.2 Impacts of biofuel policies on international markets

This topic has only recently featured in the literature and results must be viewed as tentative. Results from the International Food Policy Research Institute (IFPRI) link impacts of two biofuel scenarios on world markets with impacts on food consumption in sub-Saharan Africa and other regions using a computer simulation of world markets. In the first scenario, biofuel use expands in line with investments in biofuel production. Simulation of world market response to this scenario showed that by 2020 maize prices would increase by 26 percent, oilseeds by 18 percent and sugar by12 percent relative to their levels were there to be no investment in biofuel expansion. The impact on average availability of food calories in sub-Saharan Africa was a fall of 4 percent. The impact of the second scenario, doubling expansion of biofuels, was to increase international food prices at a rate more than twice that in the first scenario with commensurate losses in food calorie availability (von Braun, 2007 pp.8-9).

No other estimates of the market impact of a global expansion of biofuel production and use was found. Biofuel developments in Canada, China, EU, Japan and US were included in the scenario for 2016 reported in the 2007 OECD-FAO projections, but their likely impact was not shown as there were no results for a scenario that excluded these developments. Even including biofuel expansion, the projected increases in nominal prices from 1996 to 2016 were less than 10 percent for all the main crop products except maize and vegetable oil - the two products that are most used for liquid biofuel production (OECD-FAO, 2007). A simulation of the impact of EU biofuel policies on world agricultural and food markets found that the additional EU demand for imports might slow down or reverse the long term decline in agricultural prices (Banse, M. et al., 2008).

4.3 Technological innovation globally

Second generation biofuel technologies seem to offer the Midas touch of turning lower value leafy and woody material into liquid fuels while third generation technologies would produce fuel from algae. These prospects have galvanized research and development in the US, as noted in Section 3. Success would seem to provide for a major expansion in production of liquid biofuels, particularly ethanol. In addition, each litre of second generation fuel could do far more to reduce greenhouse gas emissions than use of bioethanol produced with today's technologies. Use of switch grass leaves and the like would also move biofuel production off arable land and thus reduce competition with production of grains and oilseeds for food. Some developing countries also have considerable amounts of leafy and woody material which, if used to produce fuel, may add more value to the output of the land and labour there than at present. Two relevant questions are:

10 The Advisory Board for Irish Aid publication entitled *Policy Coherence for Development* provided background for this approach.

- What impact might second generation biofuel technology have on food prices?

- What access will developing countries have to this and other innovative ways to produce biofuels?

IFPRI projected what the widespread production of biofuels from leafy material might mean for the world market. Results were derived by an extension of the scenario used in the study mentioned above. The tentative outcome was that widespread use of second generation cellulosic technology would tend to lessen the rise in crop product prices associated with production of liquid biofuels from grains and oil seeds. Food price rises due to expansion of biofuel production would be less again if agricultural productivity were to increase along with the use of this second generation biofuel technology (Rosegrant, M.W., 2006). This underlines the general conclusion that a comprehensive programme of technological and productivity improvement in land based activities could be of great benefit, especially to poor rural and urban people in developing countries (von Braun, J. 2007, p.9).

Productivity gains in agriculture and land based activities in developing countries have been slow, particularly in sub-Saharan Africa. This is reflected in rural poverty, also particularly widespread in sub-Saharan Africa. Current conditions greatly strengthen the case to take a fresh look at ways to include developing countries in programmes to increase the productivity of all efforts applied to the land, particularly in the agriculture of sub-Saharan Africa. In this there seems to be a role for locally produced liquid biofuels, as noted in Section 2 above. Furthermore there are a number of facilities under international agreements and organisations to achieve this goal. In particular, in the UNFCCC and Kyoto Protocol there are finance and technology transfer commitments.

4.4 International agreements

Biofuels raise a number of issues where nations can gain by co-ordinating their policies. However, being a 'free rider' by avoiding commitments while getting the benefits of an international agreement is also attractive. The welfare calculus is complicated still further by the large differences between countries in wealth, standards of living and rates of greenhouse gas emissions. These are recognised in 'special and differential' treatment provided for specific groups of countries in many agreements. Thus, in the Kyoto Protocol there are 'common but differentiated responsibilities' and no greenhouse gas emission reduction commitments were required of developing countries. Some of these countries now seem to recognise that going beyond the Kyoto Protocol will require them to make commitments and, as China is on the point of emitting more greenhouse gases than the US, the need for a more comprehensive coverage is urgent.

Risks of emission displacement rather than reduction could be reduced were the relevant agreements and protocols to achieve universal coverage. At present Ireland, for example, might fulfil its commitment by buying biofuels, or their feedstocks, from countries without emission reduction commitments[11]. Whether such trade actually reduces global emissions may well depend on how the imported biofuel was produced. As a result many would say that there is a need to have production sustainability certification for biofuels, similar to Forest Stewardship Council (FSC) certificates for timber. Certifying the way a specific biofuel delivery was produced has to be backed by a credible and verifiable guarantee involving inspections in the producing country. Further, were a country to ban the importation of non-certified products, or even apply to them a standard higher than that applied domestically, it could risk breaching rules of international trade under the World Trade Organisation (WTO). There remains the question of whether certification of sustainability could cover all the ramifications of international trade in biofuels, or any other agricultural product. This is

11 There is a possibility that these imports may be counted as part of the importing country's emissions and thus not count towards fulfilment of its commitments (Fitz Gerald, 2008, Box 5.5, pp.113-114)

clearly illustrated by considering the potential repercussions of switching the use of a crop from providing food to producing a biofuel. Where then would the food be produced? What further land use changes may follow? There has thus been a call to co-ordinate international arrangements made for trade and those covering the environment (Eickhout, B et al., 2007, and 2008).

Other problems are likely to arise in international trade in biofuels as they were not important when most of the bodies and agreements regulating international trade were established (Howse, 2007). Biofuels, for example, need to be distinguished from their non-bio counterparts in the Harmonized Commodity Description and Coding System, the HS, to facilitate application of any special tariffs and controls and for their identification in trade statistics.

If these various concerns were addressed in international agreements there would be a stronger case for reduction or removal of import duties and other barriers to biofuels imports by EU, US and other countries. Such a liberalisation of the trade would favour the location of biofuel production in the most efficient places. One significant move would be to cut the tariffs on denatured ethanol and other biofuels as this would bring down biofuel prices without disturbing the sugar market (Stevens, 2008). The same argument applies to trade in grains, soyabeans and other agricultural feedstocks where import barriers can be greater than those for biofuels. However, were import taxes to be removed by the EU and US, their financial support for biofuels and their producers, noted in Section 3, would be transferred to other countries, explaining EU and US reluctance to do so.

The points noted above show potential problems with international trade in biofuels. The relevant fora to resolve these problems would be the UN Framework Convention on Climate Change and the WTO, including negotiations in the Doha Development Round.

4.5 The Clean Development Mechanism and international aid

The Kyoto Protocol provided a Clean Development Mechanism (CDM) to enable countries to fulfil part of their greenhouse gas reduction commitments through GHG reduction projects in developing countries[12]. An example would be through support for a project to reduce emissions from charcoal production and use. Funding for such a project would be provided as a payment per ton reduction in carbon dioxide emission and come from countries, including Ireland, or from companies with emissions in excess of their reduction commitments. Approval for such projects is subject to fulfilment of technical and financial requirements under the supervision of the Kyoto Protocol Secretariat. In March 2008 there were 3,000 CDM projects in the pipeline of which nearly 1,000 were registered and had Certified Emission Reductions equivalent to over 2,700 million tons of carbon dioxide for the period to 2012[13]. Of the registered projects only 25 were in Africa, mainly North Africa and Republic of South Africa where a project with Denmark manufactures diesel fuel from fresh and waste vegetable oils and waste fats. Lack of participants from Africa has prompted the Parties to the Protocol to make a special request for more to be done in capacity building activities in Africa. This would include support from governmental organisations and the private sector for 'learning by doing' and in the identification, development and implementation of project activities (United Nations, 2007b, Decision 6/CMP.2). Support for this kind of work has been provided by the European Commission through the SYNERGY programme (European Commission, 2006b), soon to be succeeded by another programme.

Use of the CDM does offer financial benefits to the participant in a developing country and their EU government or business partner. Partners in developing countries can get money for fuel saving projects and those in the EU can satisfy part of their greenhouse gas reduction commitments. The price per ton of carbon dioxide reduction is likely to be somewhat lower than that on the market for

12 Article 12 of the Kyoto Protocol (United Nations, 1998).
13 http://cdm.unfccc.int/Statistics/index.html

Emission Trading Allowances (ETAs) due to differences in risks and costs between the two methods of obtaining emission credits (Bakker, 2006). In March 2008 the ETA price was close to €21 per ton of carbon dioxide (CO2).

Aid for increasing output from renewable energy sources, including biofuels, is provided by a number of facilities. Specific facilities are the large Global Energy Efficiency and Renewable Energy Fund (GEEREF), ACP-EC Energy Facility and also European Commission's COOPNER II Programme. Further funding is provided through the Global Environment Facility (GEF). As the financial mechanism of the Climate Convention it allocates and disburses about $250 million per year to projects in energy efficiency, renewable energies and sustainable transportation. In addition, it manages two special funds under the UNFCCC: the Least Developed Countries Fund and the Special Climate Change Fund.

Research on renewable energy and specifically energy from biomass is supported by the European Commission's programme of Research, Development and Technology (RDT). The 2007 - 2013 programme has an overall budget of over €50,000 million of which over €6,000 million is devoted to themes that include the production and use of energy from biomass. (Council of the European Union, 2006). Projects in the current programme aim to overcome the technological and cost barriers to the use of biomass to provide heat and motive energy. There is provision for participation of non-EU researchers. However, while current research on energy from biomass does include related problems in non-EU countries, this seems to focus on suppliers of liquid biofuels to the EU.

4.6 EU policy coherence

'The primary and overarching objective of EU development cooperation is the eradication of poverty in the context of sustainable development, including pursuit of the Millennium Development Goals' (MDGs). The European Consensus on Development (European Commission (2005b).

'Internal policies are sometimes developed without regard to the collateral effects they may cause. Policy coherence particularly concerns the effects of the Union's internal policies on the southern countries and how these policies contribute to development.' Louis Michel, DG Development (European Commission, 2007a).

The EU drive to reduce use of fossil fuels, particularly imports of petroleum, would benefit most developing countries by tending to reduce the price of their oil imports. However, it is when some measures to achieve these ends increase the prices of maize, wheat, soya beans and other food imports of Low Income Food Deficit countries that achievement of one set of EU policies seems to be at the expense of another EU policy, that of achieving the Millennium Development Goals. This seems to be true of the policy of raising the share of biofuels in transport fuels to 5.75 percent by 2010 and 10 percent by 2020.

Another important aspect of this policy is the risk that the outcome might be to relocate emissions to non-EU countries rather than their reduction. Such relocation may even increase emissions and damage the biosphere. These effects could arise through opening up of cultivation of virgin land or even more destruction of forests.

Were the EU to give more weight to the cost to developing countries, particularly the Low Income Food Deficit Countries, of biofuel production from grains and oil seeds, what measures might it re-visit? Topics for re-consideration, more vigorous action and swifter delivery could include:

a) Reduction of fuel use in transportation;

b) Replacement of petroleum and its products in electricity generation and heating;

c) Control of the environmental impacts of biofuels offered on the international market, possibly including use of international standards for production of biofuels, currently under discussion, and cohesion between international agreements on trade and on the environment;

d) Negotiations to move to near universal coverage of commitments to control greenhouse emissions, in particular inclusion of mechanisms to reduce the current risk that trade relocates emissions from one country to another without reducing global emissions;

e) Reduction of barriers to trade in biofuels, especially as settlement of the issues at (c) and (d) would strengthen the case to reduce import duties and other barriers to trade in biofuels in the WTO Doha Round;

f) Greater support for development of food and biofuel production in developing countries, especially those in sub-Saharan Africa, including attention to other forms of renewable energy too.

Research, development and technology (RDT) are of particular significance for the evolution of biofuels and other ways to produce energy from renewable resources. This raises the following questions: Could more be done to facilitate collaboration with researchers in developing countries? A recent survey suggests that the decline in capacity of research institutes and universities in the least developed countries makes such collaboration difficult to implement (EC 2007b). The Commission's services and the Member States are addressing this issue and it may need further support from Irish research institutions. In brief, it seems that RDT on biofuels is an area where there is a strong case for increasing coherence between the EU research programme and achievement of MDGs. In particular, there seem to be special opportunities to address issues surrounding development of biofuels in the EU Food Security Thematic Programme.

Other areas that seem to call for increased policy coherence could be tackled in the proposed Global Climate Change Alliance (GCCA) between the EU and its developing partners, particularly the Least Developed Countries (LDCs) and other vulnerable developing countries.

4.7 Ireland's policy coherence

'The Millennium Development Goals will guide Ireland's development co-operation programme' (Ireland (2007) White Paper on Irish Aid.)

Raising incomes to eradicate extreme poverty and hunger is the focus of MDG Goal 1 and the means to achieving many of the other goals as well, including Goal 4 – to reduce child mortality. A role for biofuels in raising incomes is described in Section 2.

This section will focus on how policies and their implementation by the government are likely to advance achievement of the Millennium Development Goals or may actually work against their achievement. In particular, attention will be given to aid, energy and greenhouse gas emission control policies as well as their performance.

Irish Aid's commitment to sub-Saharan Africa is in keeping with data showing that it is there that poverty, hunger and child mortality are the highest in the world (UN, 2007c). Further, the commitment to Africa is reflected in the choice of priority partner countries, seven out of nine in Africa, and in aid allocations. In contrast, there is little readily available analysis to show that the goal of increasing agricultural productivity and income has been one of the leading efforts or achievements of Irish aid. This may change with a recommendation from the Advisory Board for Irish Aid that a start be made with a pro-active approach to the agricultural sector in Malawi.

Ireland's energy policies and their alignment to the goals of EU policy were noted in Section 3.3. In particular, the government is soon to enforce the blending of biofuels into the supply of fuel for transportation at the rate of 5.75 percent raising to 10 percent by 2020. Implementation of these policies in EU and other developed countries were shown to increase the cost of food bought on the world market (Section 4.2). They have thus contributed to the doubling of these prices between 2004 and 2007, a lift that continued in the first half of 2008. These measures in developed countries thus seem to work against achievement of the Millennium Development Goals. There have

thus been calls for reconsideration of current policies and incentives to use biofuels to replace petrol and diesel oil (Eickhout et al., 2008). These moves have been reinforced by a chorus of outcry from Low Income Food Deficit Countries against the high cost of food imports.

Research and development work is a major part of current energy policy including Sustainable Energy Ireland's R&D programmes and participation in the EU 7th Framework Programme. Some of the projects in these programmes could well be relevant to developing countries. However, no mention was found of incentives to include developing countries in these projects in Ireland.

On **Bioenergy** *'Ireland would be in favour of development of overall EU sustainability standards for bioenergy in general and biofuels in particular ..'* (Ireland, 2007a, p19).

This statement provides an opportunity for a comprehensive analysis of the overall effects of biofuel production and use. In addition, the breadth and geographical reach of these effects seems to call for an elaboration of this commitment so that it clearly extends to exporters of liquid biofuels and includes effects on developing countries.

In **greenhouse gas emissions** Ireland has targets to meet within the overall EU commitments in the Kyoto Protocol for the period 2008 to 2012. In addition, the EU commitment to reduce emissions to 80 percent of 1990 levels by 2020 is also reflected in a 2020 target to be met by Ireland. The Government's projections for emissions in 2008 to 2012 puts them at 27 percent over the target for that period if no action were to be taken (Ireland, 2007b, Table 2, p.7.). Success with measures in the Government programme would still leave projected emissions 6 percent over target, amounting to 3.6 million tons CO2 a year. Investments in emissions reduction projects in developing economies will provide a credit large enough to offset this excess, according to the Government's Climate Change Strategy (Ireland, 2007b, p.7.). This could be done through the Clean Development Mechanism (CDM). Projections to 2020 show an even higher reliance on buying emission credits through the CDM or the *EU Emissions Trading Scheme (ETS).* Any of the developing countries that manage to participate in the CDM would thus expect to find a buyer in Ireland for credits from their emission reduction projects.

Use of the **Clean Development Mechanism (CDM)** for the benefit of developing countries, particularly those in sub-Saharan Africa, will require much capacity building to produce proposals that fulfil its requirements, as noted in Section 4.3 above. Approval for public and private entities to participate in the CDM has been delegated to the Environmental Protection Agency (Ireland, 2006 and Ireland, 2007b, p.15). The buyer will be the National Treasury Management Agency using funds in the vote of the Department of the Environment, Heritage and Local Government. Could these institutions and Irish Aid devise, assess and possibly implement, schemes to facilitate creation of projects in developing countries that would generate CDM credits? This would contribute to achievement of the Millennium Development Goals as well as enabling Ireland to meet its greenhouse gas emission reduction targets.

Liquid biofuel's potential to cut Ireland's greenhouse gas emissions was assessed in the latest ESRI *Medium Term Review 2008-2015* as follows:

'Given the uncertainty surrounding all stages of international trade in biofuels, our best guess is that carbon emissions for countries like Ireland will not change significantly even if biofuel targets are met..' (Fitz Gerald, et al., 2008, p. 114).

On the other hand use of soya beans and other foodstuffs as feedstock to produce these biofuels has started to raise the cost of food to Low Income Food Deficit Countries. Thus it seems that implementation of the policy for biofuels is likely to work against achievement of the Millennium Development Goals. However, this could be resolved as there is provision for the National Bioenergy Action Plan to be reviewed regularly (Ireland, 2007, section 3.12.2, p. 39). Inclusion in these reviews of the impacts of the Action Plan on developing countries would be in the interests of increasing coherence between policies on energy, emissions and aid.

In summary, elements of energy policies that could favour achievement of the MDGs include:

- Energy research programmes, both Irish and EU, should do more to include research and development partners in developing countries and provide some benefits to these countries, particularly in sub-Saharan Africa.

- Review of the impacts and potential impacts of energy policies should include impacts on developing countries.

- Use of the Clean Development Mechanism to benefit, in particular, countries in sub-Saharan Africa and to include building capacity to enable partnerships to formulate successful project applications.

- Enable developing countries to adapt to increased prices for petroleum and food including support for increasing the productivity and output of agriculture and biofuels, as well as adaptation to threats posed by climate change.

Elements of energy policies that could work against achievement of the MDGs include:

- Enforced use of liquid biofuels, including their mandatory incorporation into the fuel supply, when enforcement would risk increasing the occurrence of hunger and malnutrition in the world.

- Importation of biofuels, or their raw materials, or purchase of greenhouse gas emission credits from outside the EU without adequate safeguards to ensure that this trade would not cause serious degradation for poor people or of the environment.

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Annex I

Classification of EU policies for Biofuels

Government measures may be classified after Rajagopal and Zilberman (2007 p.105), as follows:

Type of policy	Some examples
1. Incentive - Tax or Subsidy	Excise tax credit for renewable energy, Carbon tax, Subsidies for flex fuel vehicles, Price supports and deficiency payments, Tariffs or subsidies on imports/exports
2. Direct control	Renewable fuel standards, Mandatory blending, Emission control standards, Efficiency standards, Acreage control, Quotas on Import/export
3. Property rights	Cap and trade (an emissions 'cap' is set for companies with large emissions and they can trade in emission allowances within the limit set by their 'cap'.)
4. Compensation Schemes	Payment for environmental services, planting trees, for example, as a way to absorb greenhouse gases
5. Educational and informational programs	Labelling
6. Improving governance	Certification programs

Policy measures in the EU

1. Subsidies: A number of concessions have been authorized by the EU including tax concessions to favour the use of biofuels and the setting of special tariffs to be paid for electricity from renewable sources, the so called *'feed-in tariffs'* (EC 2003/96 and EC, 2001).

2. Mandatory blending of petroleum products was introduced in the 2001 directive that obliged Member States to establish national targets for use of energy from renewable sources to generate electricity (EC, 2001). The EU-wide target for 2010 was set at 22 percent of electricity to be generated from renewables. This creates a demand for energy from all sorts of renewable sources from wind to solid biomass, including woody materials. Furthermore, use of these sources in Europe tends to yield greater savings in fossil fuel and greenhouse gas emissions than has been achieved from use of grains or oilseeds to provide liquid biofuels.

3. 'Cap and Trade' mechanisms were established in the EU with a Directive in 2003. It enables each company likely to exceed its cap on CO2 emissions to buy allowances from companies or countries not using their allowances to the full. The EU Directive provides penalties for emissions in excess of surrendered allowances of €100/ton CO2.

4. Compensation schemes favouring biomass production and use have been provided by the EU particularly under the Common Agricultural Policy (CAP).

Annex Table: A.1

Current and Potential Liquid Biofuel Sources from Crop Plants by Fuel Type, Climatic Zone, Mode of Production and Plant Species.

Fuel Type	**Biodiesel (Fossil Fuel Substitutes)**		**Bioethanol (Fossil Fuel Substitutes)**	
Cropping Systems	**Tropical Zones**	**Temperate/ Mediterranean Zones**	**Tropical Zones**	**Temperate Zones**
Annual Cropping	**Soya Beans (N)** Groundnuts (N) Cotton Seed Oil Sesame Seed Oil Legumes var. (N) Lentils (N) Winged beans	**Soya Beans (N)** Sunflower Oil **Rapeseed Oil** Linseed Oil Hempseed Oil Legumes var. (N	Maize (Corn) Sorghum Sweet Sorghum Cassava Sweet Potatoes Sugar Beet	**Maize (Corn)** Sugar Beet Wheat Oil
Ratoon Cropping (Plant Crop + 2-3 ratoon crops)	Pigeon Peas (N) Cotton Seed OIl	-	**Sugar Cane**	-
Perennial Cropping	**Palm Oil** Coconut Oil Shea Butter Nut Brazil Nut Oil **Jatropha*Oil** Castor Oil Pongamia+ Oil	Olive Oil Walnut Oil	-	-

Notes:

1. Multiple tree and shrub (woody biomass) species are additional candidates for fossil fuel substitution, depending on future proven performance in different agro-ecological zones.
2. N: Nitrogen-fixing.

* Jatropha Curcas

\+ pongamia pinnata

Annex Table: A.2

Landlocked Developing Countries and Provinces:

Sub-Saharan African Countries					
West	**Eastern and Central**	**Southern**	**Asian Countries**	**Latin American Countries**	**Totals**
Mali Burkina Faso Niger Chad (FO) Central African Republic	Ethiopia Uganda (FO) Rwanda Burundi Malawi Zambia Zimbabwe	Botswana Lesotho Swaziland	Afghanistan Nepal Bhutan Tibet Laos	Bolivia Paraguay	
5	7	3	5	2	22
Sub-Saharan African Province					
West	**Eastern and Central**	**Southern**	**Asian Provinces**	**Latin American Provinces**	**Totals**
Mauritania **(N,E,S)** Guinea (N,E) Nigeria (N)	Sudan (S&W) Kenya (W) DRC (N,E,S) Tanzania (W)	Angola (E) Namibia (N,E) RSA (N,E)	India (N,C,E) Burma (N) Thailand (NW,E) P.R China (N,C,W)	Colombia (E) Peru (E) Brazil (W,C) Argentina **(N,W)**	
3	4	3	4	4	18
8	11	6	9	6	40

Notes:

F.O.: Fossil Oilfields

Glossary of Terms Used

Agro-forestry types[14]

- Multi-storey cropping: Leaf canopies at different complementary heights maximise total plant use of insolation while different rooting depths may achieve a similar complementarity below ground level;
- Alley cropping: Interplanting a perennial or tree crop on the contour to improve anti-erosion control on hill slopes and to create beneficial micro climates, complementary soil nutrient requirements and soil moisture uptake is another way to intensify production in difficult-to-use environments;
- 'Taungya': A Malay-Indonesian word to signify short-term cropping systems to help establish longer-term forestry systems through the challenges of weed competition, lack of shade and available soil moisture while creating additional farming land for self-employed farm families:
- Silvo-pastoral systems: Here, trees suitable for dry-season feed supply for grazing livestock (leaves, seedpods, etc., supplemented by pollarding – or coppicing for a separate forestry product) are growing with natural, inter-sown or cultivated grasses and other grazing plant species.

Agrofuels is another name for biofuels, its use in Latin America draws attention to the involvement of agri-business and oil multinational corporations.

Biodiesels are secondary biofuels, they include:

- biodiesel (a methyl-ester produced from vegetable or animal oil, of diesel quality),
- biodimethylether (dimethylether produced from biomass),
- Fischer Tropsh (Fischer Tropsh produced from biomass),
- cold pressed bio-oil (oil produced from oil seed through mechanical processing only) and
- all other liquid biofuels which are added to, blended with or used straight as transport diesel.

Biodiesel includes the amounts that are blended into the diesel – it does not include the total volume of diesel into which the biodiesel is blended (IEA).

Bioenergy: Energy derived from biomass (SEI.ie website).

Biofuel: fuels derived from biomass, which can be as solid biomass, liquid biofuels or biogas.

First generation biofuels[1]: these are liquid biofuels produced from sugar, starch and oils in soya beans, rapeseed and other oil bearing plants including palm oil as well as from animal fats and used fats and oils using conventional technology.

Second generation biofuel technologies[1]: liquid biofuels derived from lignocellulosic materials including agricultural residues, woody crops, grasses, etc. using advanced processes.

Third generation biofuel technologies: liquid biofuels derived from minute green organisms growing in water, particularly algae, using advanced processes.

Biogas[1]: a gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass, comprising:

- landfill gas;
- sewage sludge gas;_
- gas generated from dedicated energy crops such as wheat, maize, etc;

14 Referenced in Section 2.
1 Entry from Global Bioenergy Partnership, (2007).

- other biogas e.g. from anaerobic fermentation of animal slurries and of wastes in abattoirs, breweries and other agro-food industries (IEA).

Biohydrogen[1]: hydrogen produced from biomass for use as an energy carrier by several routes including:

- Gasification or pyrolysis of solid biomass;
- Reforming of biogas;
- Novel technologies based on use of photosynthetic algae or bacteria, or on fermentative bacteria.

Biomass: organic material, an example being plant matter that is either the direct product of photosynthesis, for example plant matter – leaves, stems, etc. or the indirect product of photosynthesis, for example animal mass resulting from the consumption of plant matter. (SEI.ie website). Peat and other fossil fuels are excluded.

Carbon neutral, or **carbon neutrality,** means that a unit, be it household or nation, emits greenhouse gases with the same global warming potential as the greenhouse gases it sequesters, adjusted to allow for any amounts that were transferred out of the unit through emissions trading.

Clean Development Mechanism (CDM) allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries under Article 12 of the Protocol. Such projects can earn saleable Certified Emission Reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

Co-product credits: energy obtained from byproducts of main biofuel.

Emissions Trading Scheme (ETS) is set out in Article 17 of the Kyoto Protocol and allows countries that have emission units to spare - emissions permitted them but not “used” - to sell this excess capacity to countries that are over their targets.

Emission Transfers: emission amounts (EAs) that are transferred between parties to the Kyoto Protocol, Article 17. Units, each equal to one metric tonne of emissions in CO2-equivalent terms, which may be transferred under Article 17 (emissions trading), may be in the form of: land use, land-use change and forestry (LULUCF) activities under Articles 3.3 and 3.4 of the Kyoto Protocol, or an emission reduction unit (ERU) generated by a Joint Implementation project under Article 6 of the Kyoto Protocol, or a certified emission reduction (CER) generated from a Clean Development Mechanism project activity under Article 12 of the Kyoto Protocol. http://unfccc.int/kyoto_protocol/mechanisms/emissions_trading/items/2731.php Accessed 26th March 2008.

Ethanol, C2H5OH, also called ethyl alcohol or just ‘alcohol’, is the second member of the aliphatic alcohol series. It is currently the main renewable energy substitute for petrol. Anhydrous ethanol is its undiluted form, however it is quick to absorb water and is quite corrosive. Denatured ethanol is the result of mixing it with another substance to make it undrinkable, an example would be ‘methylated spirits’ where methyl alcohol and a colouring are the additives.

Feed-in Tariffs[1] – Pricing: A feed-in tariff is a regulatory, minimum guaranteed price per kWh of electricity that an electricity utility is obliged to pay to private producers of renewable power that is fed into its existing grid. A feed-in tariff could also refer to the total payment per kWh received by an independent producer of renewable power, including any production subsidies and/or refunds from taxes. In a few cases, a feed-in tariff signifies only the premium paid over and above the market price of electricity.

Feedstock[1]: any material from which fuels are derived.

First Generation Biofuels[1]: see Biofuels.

Fossil energy: Energy derived from sources like coal and petroleum (crude oil and natural gas), which are formed from the fossilized remains of dead plants and animals over millions of years (Rajagopal and Zilberman, 2007, p.91).

Greenhouse Gases (GHGs) are: Carbon dioxide (C02), Methane (CH4), Nitrous oxide (N20), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6), as listed in Annex A of the Koyoto Protocol (United Nations, 1998).

Joule (J) Unit of work and energy equivalent to a watt-second and thus 3,600 J are equivalent to one watt hour (kWh).

Liquid biofuels[1]: liquid fuels derived from biomass, comprising: biodiesel, _biodimethylether _bioethanol, _pyrolysis oil (biooil), _raw vegetable oil and _synthetic diesel.

Life Cycle Analysis (LCA) is the general term applied to accounts of all the energy inputs and outputs involved in the production and use of biofuels.

Low Income Food Deficit Countries (LIFDC) includes 82 'food deficit countries with per caput annual income below the level used by the World Bank to determine eligibility for IDA assistance (i.e. US$1,575 in 2004), which in accordance with the guidelines and criteria agreed to by the CFA should be given priority in the allocation of food aid.' *(Crop Prospects and Food Situation, No. 2, April 2008, p.14).* Of these countries 42 are in sub-Saharan Africa.

Modern bioenergy[1]: relies on efficient conversion technologies for applications at household, small business and industrial scales.

Net Carbon Reduction (NCR) is 'the net reduction in carbon emissions resulting from consumption of a unit of biofuel'.

Net Energy Ratio (NER): the ratio between the energy provided by a fuel to that applied in its production up to the point of final output, as in propelling a test car.

Net Petroleum Offset (NPO) is the percentage 'reduction in petroleum consumption that can be achieved by using biofuel' (Rajagopal and Zilberman, 2007 p.27).

Primary energy[1]: primary energy is energy contained in raw fuels and any other forms of energy received by a system as input to the system. The concept is used especially in energy statistics in the course of compilation of energy balances.

Renewable energy: 'non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydro and bio-energy)'. (EU Directive 2001/77/EC definition of renewable energy also used in Ireland.

Second Generation Biofuels: see 'Biofuels'

Secondary energy: primary energies are transformed in energy conversion processes to more convenient forms of energy, such as electrical energy and cleaner fuels. In energy statistics these forms are called secondary energy.

Solid biomass[1]: covers solid non-fossil material of biological origin which may be used as fuel for bioenergy production. It comprises:

- Purpose grown wood from agriculture or forestry;
- Conventional crops e.g. sugar, oil and starch crops;
- Wood wastes e.g. from forestry or wood processing activities;
- Other solid wastes e.g. straw, rice husks, nut shells, poultry litter, biodegradable fraction of municipal solid waste, coproducts of meat production.

Syngas or 'synthesis gas' a mixture of carbon monoxide and hydrogen from part oxidization of biomass then used to produced synthetic diesel (Schmidt and Dauenhauer, 2007).

Total Final Consumption (TFC) of energy is the sum of consumption by the different end-use sectors. TFC is broken down into energy demand in the following sectors: industry (including manufacturing and mining), transport, other (including residential, commercial and public services, agriculture/forestry and fishing), non-energy use (including petrochemical feedstocks), and nonspecified.

Total Primary Energy Demand (TPED) represents domestic demand only, including power generation, other energy sector, and total final consumption. It excludes international marine bunkers, except for world primary energy demand, where it is included. From IEA (2008).

Traditional Bioenergy[1]: includes fuelwood and charcoal which can only deliver heat.

Traditional Biomass: fuelwood, animal dung and agricultural residues used in stoves with very low efficiencies. From IEA (2008).

Woodfuels[1]: all types of fuels produced directly or indirectly from woody biomass, i.e. fuelwood, charcoal and black liquor (FAO UBET)) are included in IEA's "Primary Solid Biomass" along with other solid fuels of non-woody origin).

Abbreviations, Acronyms and Descriptions

AAUs	Assigned Amount Units
Annex I Parties	List of the parties with obligations in the Kyoto Protocol. (Countries that have made commitments to reduce emissions of greenhouse gases.)
Annex B Parties	Countries included in Annex B to the Kyoto Protocol. (Developed countries with targets to reduce greenhouse gas emissions rather than commitments.)
B20	A blend of 20% biodiesel and 80% diesel(fossil fuel), by volume
B100	Pure biodiesel
CCBA	Climate, Conservation and Biodiversity Alliance
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CO2	Carbon dioxide
CO2eq	Carbon dioxide equivalent
E5	A blend of 5% bio-ethanol and 95% petrol (petrol), by volume
E10	A blend of 10% bio-ethanol and 90% petrol (petrol), by volume
E85	A blend of 85% bio-ethanol and 15% petrol (petrol), by volume
EA	Emission Amounts (each unit equal to one metric tonne of emissions in CO2-equivalent terms).
EEP	Ethanol Expansion Programme
EJ	Exajoule 1,000,000,000,000 million Joules (1018)
ERCs	Emission Reduction Credits (emission amounts (EAs) credited under the Kyoto Protocol Clean Development Mechanism, also called units).
ERs	Emission Reductions
ERUs	Emission Reduction Units (used in Joint Implementation of Kyoto Protocol)
ETA	Emissions Trading Scheme Allowances (euro per ton of carbon dioxide emission)
ETBE	Ethyl tertiary butyl ether
ETS	Emissions Trading Scheme (EU)
EU	The European Union
EUAs	EU Allowances
FCCC	United Nations Framework Convention on Climate Change
FSC	Forest Stewardship Council
GHG	Greenhouse gas
GJ	Gigajoule, or one joule x 10^9 ie one thousand million joules of energy

HFCs	Hydrofluorocarbons
HIPC	Heavily Indebted Poor Countries
HS	Harmonized Commodity Description and Coding System
IEA	International Energy Agency (OECD)
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change: an independent body founded under the auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP).
IPPC	Integrated Pollution Prevention Control, in Ireland the Protection of the Environment Act, 2003 gave effect to the Integrated Pollution Prevention Control Directive.
J	Joule
JI	Joint Implementation
LCA or I	Life Cycle Analysis or Impact
LIFDC	Low Income Food Deficit Counties (FAO definition in Glossary)
LDCs	Least Developed Countries
M	Million
MTBE	Methyl tertiary butyl ether
N2O	Nitrous oxide
NGO	Non-governmental organization
OPEC	Organisation of Petroleum Exporting Countries
RECS	Renewable Energy Certificate System
RECs	Renewable Energy Certificates
RGGI	Regional Greenhouse Gas Initiative (north-eastern U.S. States)
t	Tons (1,000kg)
t.o.e.	Tons oil equivalent
TFC	Total final consumption
TJ	Terajoule, or one joule x 10^{12}
TPER	Total Primary Energy Requirement
TPES	Total Primary Energy Supply
TRCs	Tradable renewable certificates
UN	United Nations
UNFAO	United Nations Food and Agriculture Organization
UNFCCC	United Nations Framework Convention on Climate Change
US(A)	United States (of America)
VCS	Voluntary Carbon Standard
VERs	Verified Emissions Reductions
WEO	World Energy Outlook (IEA)
WTO	World Trade Organization

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