Assessment of Environmental, Social and Economic Impacts of Biofuels in the Republic of Belarus

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List of Acronyms

BIG/CC biomass integration gasification using combined cycle
Bq a unit of radioactivity
BRISSA Belarusian Research Institute for Soil Science and Agrochemistry
BtL biomass to liquid
\(^{137}\text{Cs}\) Caesium-137
CHP combined heat and power
CSP concentrating solar thermal power
EC European Commission
EJp Exajoule per annum
EU European Union
FAO Food and Agriculture Organisation of the United Nations
GBEP Global Bioenergy Partnership
GEF Global Environment Facility
GHG greenhouse gas
Gt gigatonne
GW gigawat
GWP global warming potential
ha hectare
IAEA International Atomic Energy Agency
IEA International Energy Agency
IPCC Inter-governmental Panel on Climate Change
K2O potassium oxide
lge liter of gasoline equivalent
RME rape methyl ester
LCA life cycle assessment
Mmol millimole
Mha million hectares
N\(_2\)O nitrous oxide
OECD Organisation for Economic Co-operation and Development
p.a. per annum
pH a measure of the acidity or basicity of an aqueous solution
RD&D research, development and demonstration
RSB Roundtable on Sustainable Biofuels
\(^{90}\text{Sr}\) Strontium-90
t/ha tons per hectare
UNEP United Nations Environment Programme
UNIDO United Nations Industrial Development Organisation
WHO World Health Organization
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Executive Summary

Introduction

Biofuel production and use has been receiving increased global attention. The increased attention has been on the part of governments looking for ways to mitigate climate change, ensure energy security, strengthen the agricultural sector and promote development; and investors seizing business opportunities that occur largely due to government support in the form of targets and mandates.

At the same time, concerns have been raised regarding potential impacts on food security and the environment related to the rapid expansion of biofuel feedstock production, and in particular, competition between different land uses.

Biofuel development must be consistent with a country’s overall policies and strategies. In the initial phase of national strategy development, due consideration should be given to assess how biofuel fits into existing overall development strategies, including strategies for poverty reduction, economic development, and conservation. The strategy should also align with sectoral policies and strategies in energy, agriculture, forest management, natural resources, industry and technology, rural development and the social sector.

Purpose of the Report

The purpose of this report is to respond to an inquiry to the United Nations Environment Programme (UNEP) from the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus (Ministry of Environment) regarding the biofuel potential in Belarus, and particularly the extent to which the Chernobyl affected lands could be used to grow crops for conversion to biofuels.

The UNEP, in partnership with the United Nations Development Programme (UNDP) and the International Atomic Energy Agency (IAEA), have prepared this report to provide the Government of the Republic of Belarus with an objective assessment of environmental, social and economic impacts of biofuels to support an informed decision on a suitable biofuel strategy for the Republic of Belarus.

The report provides an overview of the key problems and perspectives towards sustainable production of biofuels. It is based on an extensive literature study, considering a wide range of different views from eminent experts worldwide, as well as consultations and interviews held with the local stakeholders in Belarus.

The report describes current and future predicted trends in a broad range of categories including:

- Biofuel use;
Global production;
Global demand;
Development of agricultural yields;
Food demand;
Life cycle wide environmental impacts (LCA) and greenhouse gas emissions;
Life cycle impacts;
Methodological constraints;
Impacts through increased demand and land use changes;
Land requirements for biofuel production;
Impacts of growing demand;
Increased yields and optimum production;
Formerly degraded land;
Use biomass for power and heat;
Second generation biofuels;
Use waste and production residues;
Cascading use of biomass;
Biofuel policies generally; and
More efficient use of biomass.

**Types of Biofuels**

In order to establish a context for Belarus biofuel production, it is important to review the general state of biofuel production and demand at global scale.

Instrumental in the biofuel discussion is recognition that presently world production and use represents so-called first-generation biofuels. However many countries are actively exploring how to generate increasing amounts of biofuel from non-food sources. These efforts will eventually lead to what is being referred to as Second-generation or Advanced biofuels.

In summary, *first-generation biofuels* are commercially produced using conventional technology. The basic feedstocks are seeds, grains, or whole plants from crops such as corn, sugar cane, rapeseed, wheat, sunflower seeds or oil palm. These plants were originally selected as food or fodder and most are still mainly used to feed people. The most common first-generation biofuels are bioethanol (currently over 80% of liquid biofuels production by energy content), followed by biodiesel, vegetable oil, and biogas.

Current biofuel productions, at the global level and in Belarus, are examples of First-generation production efforts.

*Second-generation biofuels* can be produced from a variety of non-food sources. These include waste biomass, the stalks of wheat, corn stover, wood, and special energy or biomass crops (e.g. Miscanthus). Second-generation biofuels use biomass to liquid (BtL) technology, by thermochemical conversion (mainly to produce biodiesel) or fermentation (e.g. to produce cellulosic ethanol).
Biofuel Trade

Investment into biofuels production capacity probably exceeded $4 billion worldwide in 2007, and seems to be growing rapidly. Industry, generally with government support, also invests heavily in the development of advanced biofuels.

International trade in ethanol and biodiesel has been small so far (about 3 billion liters per year over 2006/07), but is expected to grow rapidly in countries like Brazil, which reached a record-high of about 5 billion liters of ethanol fuel export in 2008.

Policies have essentially triggered the development of biofuel demand by targets and blending quotas. Mandates for blending biofuels into vehicle fuels had been enacted in at least 36 states/provinces and 17 countries at the national level by 2006. Most mandates require blending 10–15% ethanol with gasoline or blending 2–5% biodiesel with diesel fuel. In addition, recent targets define higher levels of envisaged biofuel use in various countries.

Germany's mandatory blending quota since 2010 is 6.25%, which is to be kept till 2014. However the earlier adopted high targets at the 17% level allow the assumption that based on the up-dated scientific evidence and improved technologies the mandatory quota may raise significantly in the coming years.

The EU has adopted a new EU-wide binding target of 10% of transport energy from renewable sources by 2020. The EU is the largest importer of biofuels and represents a potential market for the biofuels produced in the neighboring countries, including in Belarus.

Current biofuel production in Belarus, by the State Concern of Oil and Chemistry (Belneftekhim) focused on the use of rapeseed, produces biodiesel fuel that is blended with conventional diesel at 5%.

Impact on Land Use

The long-term biofuel potential depends critically on the availability of agricultural land for non-food production. Land is not only a critical factor for biomass production but also the change in land use for expanded agricultural production may lead to increased green-house-gas (GHG) emissions and loss of biodiversity.

To avoid tradeoffs between expanding biofuel cultivation and food security as well as conservation of biodiversity three types of lands have been suggested for potential agricultural expansion: "marginal" land, degraded land and abandoned land.

"Marginal" land comprises all non-cultivated area (not used as crop land) where actual primary production is too low to allow competitive agriculture. Degraded land has been cultivated before and become marginal due to soil degradation or other impacts resulting from inappropriate management or external factors. Abandoned land comprises degraded land with low productivity plus land with high productivity (e.g. where forest is regrowing).
Since land use is a critical factor for the sustainability of biofuels, one of the main arguments against the expansion of biofuel production is the potential adverse effects on food security, because land, water and agricultural resources (such as machinery, fertilizers, seed, feed, fuel) are withdrawn from food production and used instead to grow energy crops (Schubert et al., *Future Bioenergy and Sustainable Land Use*, 2010).

**Biofuels in Belarus**

Belarus with nearly 20% of its territory affected, with different levels of severity, by the accident at the Chernobyl nuclear station appears to have an opportunity to develop a significant biofuel potential while avoiding to a large extent tradeoffs with the food industry. Such development would also bring new life in the territories largely abandoned after the accident by creating new job opportunities in the agricultural sector which has been the traditional form of economic activity in the affected regions.

Certain crops, rapeseed among them, may even restore productivity of degraded land. Nevertheless, crop and location specific challenges and concerns exist, especially regarding possible yields, required inputs and side effects on water and biodiversity. Rapeseed also has the advantage of expediting recovery of degraded land, as demonstrated by the IAEA/Belarus government project that was implemented from 1996 to 2001. Last, rapeseed has substantial capacity to absorb contaminants, primarily in rapeseed straw but also in pods, roots and seeds.

The request to UNEP from the Ministry of Environment focused on providing assistance in defining a sustainable solution to economic challenges of the rural communities of Belarus affected by the Chernobyl accident, through establishment of a biofuel industry with potential environmental, social and economic benefits.

**Potential EU Market for Biofuel Export**

The EU is currently the world’s largest importer of biofuels, having imported, in the latest year for which figures are available, over 1.1 billion liters.

EU biofuel regulations are drafted with the knowledge that transport fuels are traded easily, so that Member States with low endowments of relevant resources will easily be able to obtain biofuels from elsewhere.

The EU has developed sustainability criteria for the production of biofuels. In summary, the criteria include those related to:

- Securing greenhouse gas savings;
- Minimizing the use of land with high biodiversity value; and
- Avoiding the use of land with high carbon stock and agro-environmental practices.

Further, the EU has concluded that in order to minimize carbon stock losses, it is appropriate to introduce accompanying measures to encourage an increased rate of productivity on land
already used for crops, the use of degraded land, and the adoption of sustainability requirements, comparable to those laid down in the 2009 Directive.

Policies designed to reward environmental performance and sustainability of biofuels, as well as to encourage provision of a more abundant and geographically extensive feedstock supply, could see second-generation products begin to eclipse first-generation alternatives in the medium to longer-term, especially in the EU, given its increasing inclination to develop rigorous standards that favor biofuels that minimize greenhouse gas contributions and are sustainably produced.

While it would technically be possible for the EU to meet its target for the use of energy from renewable sources in transport solely from domestic production, it is, according to the EU “both likely and desirable” that the target will in fact be met through a combination of domestic production and imports. In light of that understanding, the EU will propose relevant measures as needed to achieve a balanced approach between domestic production and imports, taking into account, among other things, the development of multilateral and bilateral trade negotiations, environmental, social and economic considerations, and the security of energy supply.

There is good reason to expect that the EU market for biofuels is and will continue to be an excellent market for sale of biofuels that are sustainably produced and are considered overall to be “environmentally friendly.” Should Belarus Government policy favor export of biofuel, the production of biofuel through use of formerly degraded land may have special appeal for the EU market, as suggested by current EU biofuel policy.

**Review of Belarus Biofuel Related Policy and Activity**

There is a history of interest in using Belarusian lands for the production of biofuel. According to the Food and Agriculture Organization (FAO), the first experimental batch of biodiesel in Belarus was produced in 2006.

Further, the Belarusian government website currently contains an updated statement that “Of all renewables, biofuel is most attractive to Belarus because of the vast areas of forest and farmland across the republic.”

Other earlier published quotes from high level Belarus officials indicate that Belarus has sufficient agricultural land to grow the rapeseed, and the Government was working to attract foreign investment in the Belarusian biofuels industry and eventually would want to export biofuels to the EU.

**State Program for production of biodiesel fuel in the Republic of Belarus for 2007–2010**

In December of 2007, in an attempt to provide the economy of Belarus with a source of
automotive fuel at stable prices, a guaranteed market for vegetative raw materials, and reduce energy imports, the Council of Ministers established for Belarus a program (Program) for the production and use of biodiesel from rapeseed processing products, subject to a system of economic policies and regulatory framework to promote biofuels production, improve yield and increasing the area of rapeseed planting.

The aim of the Program was to:

...improve environmental and energy security of the Republic of Belarus, reduce the national economy’s dependence on oil imports, provide competitive transport biodiesel by establishing domestic raw material base of industrial production of the new type of fuel from a renewable source of energy, as well as internationally competitive chemical products obtained via processing by-products of biofuel production.

While it is unclear the exact extent to which all targets specified in the Directive were met, there is no question that biodiesel production in Belarus, through the use of rapeseed, is now an established enterprise as a result of the Program.

The Program did not address the use of Chernobyl affected lands for the production of biodiesel.

The Directive, as made clear in its title, expired in 2010. There does not appear to be at present a replacement Directive or other coordinated policy instrument for the production of biofuel in Belarus.

**Feasibility of Using Chernobyl Affected Lands for Biofuel Production**

Consistent with government support for biofuel production generally, there were two UN/Belarus initiatives undertaken to determine whether Chernobyl affected lands in particular could be profitably used to develop biofuel. The UN agencies that cooperated directly with Belarus were the IAEA and the FAO.

The IAEA/Government demonstration study and the FAO/Government project proposal, detailed in this report, as well as statements made by government officials and others, indicate that the use of Chernobyl affected lands for the production of biofuel would yield socio-economic benefits through creation of jobs in the agricultural sector associated with the cultivation of energy crops and through expansion of other services associated with the biofuel industry.

**Use of Chernobyl Affected Lands for Biofuel Production: Current Belarus Policy**

However, it now seems clear that the Government of Belarus, through statements by national and local level officials, is no longer supportive of designating Chernobyl contaminated lands for the production of biofuel. These statements also indicate clearly that Chernobyl contaminated lands, that portion of contaminated lands suitable for agricultural production,
are to be part of a new, efficient system of land use aimed at the formulation by 2015 of an optimized structure of agricultural lands for sustainable development of food products for food production and cattle breeding.

The Ministry of Agriculture has stated that they would oppose any use of agricultural lands, including Chernobyl contaminated, for the production of biofuel. Representatives of the Ministry of Agriculture indicated to the joint UNEP/IAEA Mission, in May 2011, that they have been directed by the Council of Ministers to increase crop production for human consumption by 50% over the next five years. This Directive no doubt has shaped Ministry opposition to the use of agricultural land for purposes other than food production or cattle breeding.

Following is a summary of UNEP’s assessment of the perceived advantages and disadvantages of using Chernobyl affected lands for the biofuel production, which in turn is followed by the overall conclusions of the study.

**Advantages of Using Chernobyl Affected Lands for Biofuel Production**

- There is the potential for 5.5 thousand hectares of Chernobyl affected lands to be committed to agricultural use.
- These lands would be suitable for growing biomass that could be converted to biofuel nominally free of radiation.
- There is the potential for both a domestic and an international market.
- The technological capacity for production of biodiesel is already present in Belarus and that capacity is located close to the Chernobyl affected area.
- Given an over capacity of technology to produce biodiesel, using Chernobyl affected lands for biodiesel generating crops (rapeseed) would help close the gap between capacity and rapeseed production levels.
- Given the desire of the Ministry of Agriculture to have an increased supply of biodiesel for agricultural equipment, using Chernobyl affected lands for biodiesel generating crops (rapeseed) would help close the gap between the Ministry’s desired volume of biodiesel capacity and current levels of production.
- The use of Chernobyl affected lands for biofuel production would likely meet the sustainability criteria established by the EU.

**Disadvantages of Using Chernobyl Affected Lands for Biofuel Production**

- Arguably negligible amount of land in relation to expressed needs for greater volumes of rapeseed-derived biodiesel.
- High cost of land preparation, and fragmented nature of the 5.5 thousand hectares of potentially available lands makes production difficult and cost inefficient.
- Existing policy is to maximize use of any available land for the production of crops for human consumption.
- The Ministry of Agriculture, Ministry of Emergency Situations, and the Deputy Chairmen of the Gomel and Mogilev Districts do not favor the use for Chernobyl affected lands for biofuel production.
Potential difficulties in securing safe disposal of contaminated wastes and the view of some experts that there is potential for worker exposures.

**Overall Study Conclusions**

- The technology is available to produce biodiesel from Chernobyl affected lands.
- There is a domestic demand for increased amounts of biodiesel from the Ministry of Agriculture.
- The Government of Belarus continues to be committed to the use rapeseed for the production of biodiesel. This commitment is being fortified by ongoing research at the Research Institute of Physical and Chemical Problems of the Belarus State University, which, in cooperation with the scientific company “Trantechnika”, has developed a modern and effective method for obtaining biofuel and associated products from rapeseed.
- Biodiesel production capacity in Belarus will, by mid-2012, be sufficient to satisfy not only domestic demand but to have excess product for potential export (likely to EU markets).
- The production of biofuel through use of formerly degraded land may have special appeal for the EU market, as suggested by current EU biofuel policy.
- There is a socio-economic imperative to return Chernobyl affected lands to productive use as soon as possible.
- The fragmented and limited amount of Chernobyl affected lands that are potentially available for the production of biofuels appears to further constrain the commitment of these lands to that use.
- In view of current government policy that emphasizes the use of all potential agricultural lands for the production of crops for human consumption, the use of Chernobyl affected lands for the production of biofuels appears to be of low priority.
- These statements also indicate clearly that Chernobyl contaminated lands, that portion of contaminated lands suitable for agricultural production, are to be part of a new, efficient system of land use aimed at the formulation by 2015 of an optimized structure of agricultural lands for sustainable development of food products for food production and cattle breeding.
- However, to suggest that the use of Chernobyl affected lands may not offer sufficient opportunity for Belarus is not to suggest that opportunity does not exist at national level for increased focus on biofuel production.
- Indeed, there is both capacity and opportunity for Belarus to take advantage of the rapidly growing international market for biofuels. In order to take maximum advantage of this opportunity there would need to be a comprehensive strategy towards the development of biofuel trade, including development of technological and production capacities for second generation biofuels.
- Given the enormity of the EU market as a future consumer of imported biofuel, especially the current EU requirement that biodiesel constitute 10% of diesel content by 2020, and a growing insistence that imported biofuel be sustainably derived, the proximity of the EU market to Belarus provides it with a ready and lucrative market should it choose to become a biofuel exporting country.
Introduction

A Short History

Biofuel has been in use since humans learned how to control fire, which in turn led to the use of wood for cooking and heating. Indeed, until the very first part of the twentieth century (1900) biofuel continued to constitute the main human source of energy production and use. In 1900 Rudolph Diesel, the inventor of the diesel engine, used peanut oil to drive his creation. And in the United States, at around the same time, Henry Ford used ethanol derived from corn to drive his first Model-T automobiles.

As fossil derived fuels became readily available in the twentieth century, and at reasonably low cost, the production and use of biofuels lost favor. And with the exception of increased attention to the use of biofuels during World War II, biofuels were largely seen as unnecessary given their ready availability through the growth of sophisticated production and global delivery systems.

Serious attention to the production and use of biofuels was regenerated in the early 1970’s in the United States due to the Arab Oil Embargo of 1973-1974, and the Iranian Revolution in 1978-1979. By January of 1981, the world price of crude oil had increased by 125% over what prices had been in 1979.

Since that time major users of fossil fuel, in particular the EU and the United States, have been increasingly aware that fossil fuel supplies, in addition to the risk of interruptions in supply during periods of political instability in key supplying regions of the world, were shrinking. Further, as he EU and the United States began to incorporate environmental considerations into their legislation and regulatory structures, especially on the need to reduce carbon emissions, the attractiveness of biofuel production and use increased.

Currently, the current literature on biofuels identifies two categories:

First-generation biofuels are commercially produced using conventional technology. The basic feedstocks are seeds, grains, or whole plants from crops such as corn, sugar cane, rapeseed, wheat, sunflower seeds or oil palm. These plants were originally selected as food or fodder, and most are still mainly used to feed people. The most common first-generation biofuels are bioethanol (currently over 80% of liquid biofuels production by energy content), followed by biodiesel, vegetable oil, and biogas.

Current biofuel productions, at the global level and in Belarus, are examples of first-generation production efforts.

Second-generation biofuels can be produced from a variety of non-food sources. These include waste biomass, the stalks of wheat, corn stover, wood (bark, and other material not used in current commercial timber production), and special energy or biomass crops (e.g.
Miscanthus). Second-generation biofuels use biomass to liquid (BtL) technology, by thermochemical conversion (mainly to produce biodiesel) or fermentation (e.g. to produce cellulosic ethanol).

**First-generation Biofuels**

A primary reason for increasing support of biofuel production and use was the belief that biofuels would have the following advantages:

- They would help decrease reliance on costly fossil fuel use, thereby reducing dependence on foreign sources of energy, an important step toward increasing national and regional energy independence;
- They would reduce green house gas emissions and other pollutants that derive from fossil fuel sources;
- They would prove beneficial to rural communities by producing employment opportunities with consequent improvements in quality of life and poverty reduction; and
- Over time, they would become cost competitive with fossil fuels, thereby obviating the need for initial, and in many cases substantial government subsidies.

It has become apparent that first-generation biofuels, produced primarily from food crops, have not entirely met these earlier expectations, and they are now seen to:

- Contribute to higher food prices due to competition with food crops;
- Are an expensive option for energy security taking into account total production costs, excluding government grants and subsidies that characterize first-generation biofuel production;
- With the exception of sugarcane ethanol, provide only limited GHG reduction benefits and at very high cost;
- Do not meet their claimed environmental benefits because the biomass feedstock may not always be produced sustainably;
- Are accelerating deforestation;
- Potentially have a negative impact on biodiversity;
- Compete for scarce water resources in some regions; and
- In general, create doubts about their overall sustainability leading consumer nations and regions, the EU in particular, to establish standards for sustainable production.

**Second-generation Biofuels**

The cumulative impacts of the production and use of first-generation biofuels have increased interest in developing biofuels produced from non-food biomass, now commonly referred to as second-generation biofuels. These second-generation biofuels are likely to:

- Avoid many of the concerns facing first-generation biofuels; and
- Potentially offer greater cost reduction potential in the longer term, thus obviating or at least lessening the need for current government subsidies that make first generation biofuels economically viable.
Second-generation biofuels can be manufactured from agricultural and forest residues and from non-food crop feedstocks, thereby reducing and in some cases eliminating competition with food producing land, especially if so-called marginal lands are placed into biofuel production.

Some nations, for example Canada and Sweden, are making substantial investments to improve second-generation biofuels technology, with the likely result that commercial scale production could be achieved in the next ten to twenty years. However, for the near-term expectations are that second-generation biofuel production and use will slowly become incorporated with the production and use of first-generation biofuels, with those that increasingly meet emerging sustainability criteria having a distinct marketing advantage.

The production of biofuels from ligno-cellulosic feedstocks is achieved through two very different processing routes, both currently at the demonstration phase:

- **Biochemical** — in which enzymes and other micro-organisms are used to convert cellulose and hemicellulose components of the feedstocks to sugars prior to their fermentation to produce ethanol; and
- **Thermo-chemical** — where pyrolysis/gasification technologies produce a synthesis gas (CO + H2) from which a wide range of long carbon chain biofuels can be created, such as synthetic diesel or aviation fuel.

These are not the only second-generation biofuel pathways, and several variations and alternatives are under evaluation in research laboratories and pilot-plants including dimethyl ether, methanol or synthetic natural gas. However, currently these alternatives do not represent the main thrust of research, development and deployment investment.

Based on the announced plans of companies developing second-generation biofuel facilities, the first fully commercial-scale operations could possibly be seen as early as 2012, if demonstrations have prove successful. However given the complexity of the technical and economic challenges involved, in reality and as suggested earlier in this report, the first commercial plants are unlikely to be widely deployed before 2020.

The International Energy Agency (IEA), in a major report on second-generation biofuels, has calculated that the commercial-scale production costs of second-generation biofuels will be in the range of US $0.80 - 1.00/liter of gasoline equivalent (lge) [US $3.02-$3.79 per gallon] for ethanol; and at least US $1.00/liter [$3.79 per gallon] of diesel equivalent for synthetic diesel. The present widely fluctuating oil and gas prices therefore make investment in second-generation biofuels at current production costs a high-risk venture.

Further the IEA has concluded that:

- Policies to support first or second-generation biofuels should be part of a comprehensive strategy to reduce CO2 emissions;

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Enhanced RD&D investment in second-generation biofuels is needed;
Accelerating the demonstration of commercial-scale second-generation biofuels in different regions is required;
Deployment policies for second-generation biofuels are either blending targets or tax credits; and
Environmental performance and certification schemes need to be developed.
Technical barriers remain for second-generation biofuel production;
Production costs are uncertain and vary with the feedstock available, but are currently thought to be around US $0.80 - 1.00/liter [US $3.02-$3.79 per gallon] of gasoline equivalent;
There is no clear candidate for "best technology pathway" between the competing biochemical and thermo-chemical routes;
The development and monitoring of several large-scale demonstration projects is essential to provide accurate comparative data;
Even at high oil prices, second-generation biofuels will probably not become fully commercial nor enter the market for several years to come without significant additional government support;
Considerably more investment in research, development and deployment is needed to ensure that future production of the various biomass feedstocks can be undertaken sustainably and that the preferred conversion technologies are identified and proven; and
Once proven, there will be a steady transition from first to second-generation biofuels, with the possible exception of sugarcane ethanol that will likely continue to be produced sustainably in several countries, Brazil being the prime example.

The IEA report is arguably the most definitive report to date on the extent to which second generation biofuels can command commercial level success in the future. However, the conclusions of the report are not without critics. The report, as with any report that attempts to predict future commercial viability of a product in the context of highly fluctuating global economic realities and assumptions, must make assumptions that, should they be wrong, would alter the extent to which second generation biofuels could be cost efficient at a future time.

Nonetheless, it seems clear that global demand for sustainably derived biofuels will continue to increase, especially within the EU. It also seems clear that countries that are willing to invest in second-generation biofuel research and development, and consequent production, will gain a potentially quite lucrative market advantage. Belarus seems positioned, both geographically and through its natural resource base, to take advantage of what will undoubtedly be a strong external market for sustainably derived, second-generation biofuels.

Main Report

Report Structure

The remainder of this report on biofuels consists of three parts:
Part I establishes the global context for biofuel production and use. Establishment of the global context for biofuels production and use is necessary to better understand the opportunities for biofuel production and use in Belarus. As volumes of fossil fuel continue to decline globally, with consequent price increases, the global demand for biofuel has increased dramatically, especially in the European Union as discussed and demonstrated later in this report.

Part II investigates the Belarus context, the policy and history of biofuel production and use in Belarus. Attention is given to past efforts to use Chernobyl affected lands for the production of biodiesel, and edible rape oil, through the planting and harvesting of rapeseed. It also describes current policy and production and use patterns of biofuel in Belarus generally, and speaks to the possibility of use of Belarusian lands for the possible export of biofuels as domestic production capacity increases and as second-generation biofuels reach commercial scale.

Part III of this report includes a set of conclusions in the form of the advantages and disadvantages of the use of Chernobyl contaminated lands for the production of biofuels, and other conclusions regarding future prospects for biofuel production and use generally in Belarus.

Part I. The Global Context

This section summarizes UNEP’s assessment of biofuels at the global level\(^2\). The UNEP global biofuel assessment is based on an extensive literature review, taking into account recent major reviews and considering a wide range of different views from eminent experts worldwide. The sections below include summaries of that assessment.

The focus of the review is on first generation biofuels, while considering further lines of development. This focus is due to state-of-the-art and data availability until the end of 2008. Potential benefits and impacts of second, and even third generation biofuels – referred to as ‘advanced biofuels’ – are only partially included, and may be the subject of a separate report by the UNEP at a later stage.

Important Trends and Drivers/Current and Projected Use of Potentials of Biofuels

Global biofuel production and use is a rapidly growing enterprise. In 2010, the last year for which figures are available, the biofuel industry was valued at US$ 76 billion. By the year 2020 the industry expects is expected to generate revenue in excess of US$ 247 billion. There is no question that global biofuel production and use is a very rapidly growing enterprise, and one that holds great economic profit for countries willing to sustainably produce and sell sustainably derived first-generation biofuels and make research and development

commitments to produce commercial levels of second-generation biofuels.

In developing countries, over 500 million households still use traditional biomass for cooking and heating. But already 25 million households cook and light their homes with biogas and a growing number of small industries, including agricultural processing, obtain process heat and motive power from small-scale biogas digesters.

Biomass contributed about 1% to the total global electric power capacity of 4,300 GW in 2006. It is to a growing extent employed for combined heating and power (CHP), with recent increases in European countries and developing countries like Brazil.

Many countries have set policy targets for renewable energy, but only a few specify the role of biomass. As Table 1 below demonstrates, world ethanol production for transport fuel tripled between 2000 and 2007 from 17 billion to more than 52 billion liters; and biodiesel expanded eleven-fold from less than 1 billion to almost 11 billion liters.

**Table 1: Global bioethanol and biodiesel production 1975 to 2007**

![Graph showing bioethanol and biodiesel production from 1975 to 2007.](image)

Altogether biofuels provided 1.8% of the world’s transport fuel. Recent estimates indicate a continued high growth. From 2007 to 2008, the share of ethanol in global gasoline type fuel use was estimated to increase from 3.78% to 5.46%, and the share of biodiesel in global diesel type fuel use from 0.93% to 1.5%.
The main producing countries for transport biofuels are the USA, Brazil, and the EU. Production in the United States consists mostly of ethanol from corn, in Brazil of ethanol from sugar cane, and in the European Union mostly of biodiesel from rapeseed.

As Table 2 below shows the EU is currently far and away the largest consumer region for biofuel and all projections indicate that this will continue to be the case for the foreseeable future, as the EU continues to increase the current mandated mix of biodiesel from the 2012 target of 10% to 20% by the year 2020.

Other countries producing fuel ethanol include Australia, Canada, China, Colombia, the Dominican Republic, France, Germany, India, Jamaica, Malawi, Poland, South Africa, Spain, Sweden, Thailand, and Zambia. Rapid expansion of biodiesel production occurred in Southeast Asia (Malaysia, Indonesia, Singapore and China), Latin America (Argentina and Brazil), and Southeast Europe (Romania and Serbia). The international trade in biofuels is summarized in Table _ below:
Investment into biofuels production capacity probably exceeded $4 billion worldwide in 2007, and seems to be growing rapidly. Industry, generally with government support, also invests heavily in the development of advanced biofuels.

International trade in ethanol and biodiesel has been small so far (about 3 billion liters per year over 2006/07), but is expected to grow rapidly in countries like Brazil, which reached a record-high of about 5 billion liters of ethanol fuel export in 2008.

Policies have essentially triggered the development of biofuel demand by targets and blending quotas. Mandates for blending biofuels into vehicle fuels had been enacted in at least 36 states/provinces and 17 countries at the national level by 2006. Most mandates require blending 10–15% ethanol with gasoline or blending 2–5% biodiesel with diesel fuel. In addition, recent targets define higher levels of envisaged biofuel use in various countries.

Belneftekhim has been using rapeseed to produce biodiesel to the standards described above, and there may be other producers in Belarus.

Regarding global long-term bioenergy potential, estimates depend critically on assumptions, particularly on the availability of agricultural land for non-food production. Whereas more optimistic assumptions lead to a theoretical potential of 200-400 EJ/a or even higher, the most pessimistic scenario relies only on the use of organic waste and residues, providing a minimum of 40 EJ/a. More realistic assessments considering environmental constraints estimate a sustainable potential of 40 – 85 EJ/a by 2050. For comparison, current fossil energy use totals 388 EJ.

In the short to medium term, projections expect biomass and waste to contribute 56 EJ/a in 2015 and 68 EJ/a in 2030. As Tables 3 and 4 below demonstrate, global production of and demand for bioethanol and biodiesel will nearly double from 2005-2007 to 2017. Most of this increase will probably be due to biofuel use in the USA, the EU, Brazil and China. But other countries could also develop towards significant biofuel consumption, such as

---

**Table 2: International Trade in biofuels - 2007**

<table>
<thead>
<tr>
<th>Country</th>
<th>Exports</th>
<th>Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>1,200</td>
<td>800</td>
</tr>
<tr>
<td>USA</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>Indonesia</td>
<td>500</td>
<td>300</td>
</tr>
<tr>
<td>Malaysia</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Argentina</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Korea</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Source: Data compiled from LMC (2007a)*
Indonesia, Australia, Canada, Thailand and the Philippines.

Table 3: Increase of biofuel use from 2005-2007 to 2008 and projection to 2017

<table>
<thead>
<tr>
<th>Country</th>
<th>Fuel ethanol plus biodiesel</th>
<th>2005-07 to 2008</th>
<th>%</th>
<th>2005-07 to 2017</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>26</td>
<td>323%</td>
<td>46</td>
<td>582%</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>104</td>
<td>36%</td>
<td>435</td>
<td>150%</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>20</td>
<td>117%</td>
<td>63</td>
<td>371%</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>12</td>
<td>37%</td>
<td>98</td>
<td>297%</td>
<td></td>
</tr>
<tr>
<td>Columbia</td>
<td>9</td>
<td>156%</td>
<td>12</td>
<td>206%</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>0.02</td>
<td>32%</td>
<td>0.83</td>
<td>1240%</td>
<td></td>
</tr>
<tr>
<td>EU Total</td>
<td>135</td>
<td>60%</td>
<td>520</td>
<td>231%</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>5</td>
<td>30%</td>
<td>20</td>
<td>137%</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>3</td>
<td>180%</td>
<td>71</td>
<td>4522%</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>2</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>0.05</td>
<td>163%</td>
<td>0.54</td>
<td>1617%</td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td>0.04</td>
<td></td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>1</td>
<td>255%</td>
<td>4</td>
<td>1010%</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>0</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>0.24</td>
<td>175%</td>
<td>1.44</td>
<td>1085%</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>2</td>
<td>71%</td>
<td>26</td>
<td>925%</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>0.32</td>
<td>35%</td>
<td>0.42</td>
<td>47%</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>361</td>
<td>76%</td>
<td>759</td>
<td>160%</td>
<td></td>
</tr>
<tr>
<td>World Total</td>
<td>870</td>
<td>83%</td>
<td>2071</td>
<td>193%</td>
<td></td>
</tr>
</tbody>
</table>

Source: own compilation based on OECD/FAO 2008
Development of Agricultural Yields

Future development of global agricultural yields will determine the degree to which demand for food and non-food biomass can be supplied from existing cultivated land. Commodity prices are very likely to be significantly influenced by future yield developments. Although the overall development seems rather uncertain, various influences (such as water supply, climate change, environmental restrictions, the evolution of agricultural markets) make it rather unlikely that the growth rates of past decades will continue globally. A declining tendency in the yearly percentage of yield increases of major crops has been observed over the past decades.

A higher potential for yield improvements is commonly seen for developing countries, and often especially for Africa. However, the FAO assumes future yield increases for cereals in developing countries that are closer to lower global average rates of recent years, i.e. around 1% per year. Plausible estimates from international institutions for global yields in the next decade are 1-1.1% p.a. for cereals, 1.3% p.a. for wheat and coarse grains, 1.3% p.a. for roots and tubers and 1.7% p.a. for oilseeds and vegetable oils. These rates of increase are significantly below average rates of the past four decades.

Recent findings show that climate change has already reduced average crop yields. Future development may widen the gap between developed and developing countries, by decreasing production capacity in particular in semi-arid regions and increasing capacity in temperate

### Table 4: Global demand and area for biofuel feedstocks until 2017 (2008 projection)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>absolute</td>
<td>%</td>
<td>% p.a.</td>
<td>absolute</td>
<td>%</td>
</tr>
<tr>
<td><strong>Wheat and coarse grains</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total demand, Mt</td>
<td>1622</td>
<td>1702</td>
<td>1930</td>
<td>80</td>
<td>4.90%</td>
</tr>
<tr>
<td>of which, biofuel Mt</td>
<td>46</td>
<td>93</td>
<td>172</td>
<td>47</td>
<td>102.20%</td>
</tr>
<tr>
<td>of which: biofuels, %</td>
<td>2.80%</td>
<td>5.50%</td>
<td>8.90%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total production, Mt</td>
<td>1615</td>
<td>1661</td>
<td>1906</td>
<td>46</td>
<td>2.80%</td>
</tr>
<tr>
<td>Area harvested, Mha</td>
<td>525</td>
<td>531</td>
<td>539</td>
<td>6</td>
<td>1.10%</td>
</tr>
<tr>
<td>Yield, t/ha</td>
<td>3.08</td>
<td>3.13</td>
<td>3.536</td>
<td>0.65</td>
<td>1.70%</td>
</tr>
<tr>
<td><strong>Oilseeds and vegetable oil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total demand, Mt</td>
<td>96</td>
<td>105</td>
<td>143</td>
<td>9</td>
<td>9.40%</td>
</tr>
<tr>
<td>of which, biofuel, Mt</td>
<td>4</td>
<td>9</td>
<td>21</td>
<td>5</td>
<td>125.00%</td>
</tr>
<tr>
<td>of which: biofuels,%</td>
<td>4.20%</td>
<td>8.60%</td>
<td>14.70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total production, Mt</td>
<td>99</td>
<td>106</td>
<td>143</td>
<td>7</td>
<td>7.10%</td>
</tr>
<tr>
<td>Area harvested, Mha</td>
<td>145</td>
<td>142</td>
<td>164</td>
<td>-3</td>
<td>-2.10%</td>
</tr>
<tr>
<td>Yield, t/ha</td>
<td>0.68</td>
<td>0.75</td>
<td>0.872</td>
<td>0.06</td>
<td>9.30%</td>
</tr>
<tr>
<td><strong>Biofuel feedstocks total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total demand, Mt</td>
<td>1716</td>
<td>1807</td>
<td>2073</td>
<td>89</td>
<td>5.20%</td>
</tr>
<tr>
<td>of which, biofuel, Mt</td>
<td>50</td>
<td>102</td>
<td>193</td>
<td>52</td>
<td>104.00%</td>
</tr>
<tr>
<td>of which: biofuels,%</td>
<td>2.90%</td>
<td>5.60%</td>
<td>9.30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: own compilation after OECD/FAO 2008
zones. A higher frequency of extreme weather events will further increase uncertainty.

**Development of Food Demand**

In the past, agricultural yields grew faster than the world population. More food could be produced on existing cropland. In the future, the trends might become less favorable, as average crop yields may compensate for population growth but not for an increasing demand of animal based food. Between 2000 and 2030 the global population is expected to grow by 36% (medium projection of UN/FAO). This would be about the same rate that average crop yields are expected to increase. At the same time, however, food demand is changing towards a higher share of animal based diets, particularly in developing countries. The FAO expects the meat consumption of the world population to increase by about 22% per capita from 2000 to 2030; the milk & dairy consumption by 11%; and that of vegetable oils by 45%. Commodities with lower land requirements like cereals, roots and tubers, and pulses will likely increase at lower rates per capita.

As yield increases will probably not compensate for the growing and changing food demand, cropland will have to be expanded if only to feed the world's growing population. So far no explicit projection of global land use change induced by changing food demand seems to be available. One published report indicates there will be an estimated additional requirement of 144 to 334 Mha of global cropland for food in 2020 can be derived. Any further requirements, for instance for fuel crops, will be added on top of this.

**Life-cycle Wide Environmental Impacts and Greenhouse Gas Balances of Biofuels**

Life-cycle-assessments (LCA) of biofuels show a wide range of net greenhouse gas savings compared to fossil fuels, as Table 5 illustrates. This mainly depends on the feedstock and conversion technology, but also on other factors, including methodological assumptions. For ethanol, the highest GHG savings are recorded for sugar cane (70% to more than 100%), whereas corn can save up to 60% but may also cause 5% more GHG emissions. The highest variations are observed for biodiesel from palm oil and soya. High savings of the former depend on high yields, those of the latter on credits of by-products. Negative GHG savings, i.e. increased emissions, may result in particular when production takes place on converted natural land and the associated mobilization of carbon stocks is accounted for. High GHG savings are recorded from biogas derived from manure and ethanol derived from agricultural and forest residues, as well as for biodiesel from wood (BtL, based on experimental plants).
There is of course a substantial variety of crops used in the production of biofuels, and each crop, and the land conditions in which each crop is grown, has certain environmental advantages and disadvantages as compared to fossil fuel equivalents, as is demonstrated in Table 6 in relation to greenhouse gas emissions.
Table 6: Advantages and disadvantages for greenhouse gasses for biofuels from agriculture compared to their fossil counterpart per hectare of cropland

And finally, Table 7 below provides a comparison of a life-cycle impact assessment various biofuel crops as compared to fossil fuels.
The clear environmental benefit of rapeseed based biofuel, as demonstrated in Tables 4 and 5, and the current emphasis in Belarus for the use of rapeseed as a preferred crop for the development of biodiesel, is of potential benefit to Belarus should it decide to export its biodiesel. Importing countries, the EU principal among them, as demonstrated in Table 9 later in this report, are increasingly interested in purchasing biofuels that are sustainably derived and are the least damaging in the way of GHG emissions and other detrimental environmental effects. Use of degraded lands for the production of biodiesel would further enhance this potential comparative advantage.

Table 7: Life-cycle impact assessment of biofuels compared to fossil fuels for different environmental pressures

<table>
<thead>
<tr>
<th>Scenario</th>
<th>GWP in %</th>
<th>SMOG in %</th>
<th>EUTR in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane methane, optimized</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methane methane = sustainable, optimized</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Recycled plant of ME FR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol maple Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Recycled plant of ME Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol switch Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol fuelized Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol sugar Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol sugar Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol sewage sludge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol gas (biomethane)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Soy ME US</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol bio waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Palm ME MY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Rape ME CH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol switch = sustainable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol methane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Rape ME FER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol cane Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol rye FRT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol potatoes Ck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Soy ME ER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural gas, EURO3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel, low sulphur EURO3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GWP: global warming potential. SMOG: summer smog potential, EUTR: excessive fertilizer use.
Reference (100%) is petrol EURO3 in each case. Biofuels are shown in diagram at left ranked by their respective GHG emission reductions.
- Fuels that have a total GHG emission reduction of more than 50% as versus petrol.
- Those with GHG emissions reductions of more than 30%.
- Those with GHG emissions reductions of less than 30%.
- Production paths from waste materials or residue.

In other diagrams:
- Better than reference.
- Worse than reference.
- Production paths from waste materials or residue.
Table 5 also demonstrates a substantial environmental advantage to the use of sugar beet for biofuel development, a crop that has been heavily planted and harvested in Belarus, but a substantial amount of which has been earmarked for export.

**Impacts Insufficiently Covered by LCA**

Besides GHG emissions, other impacts such as eutrophication and acidification need to be considered. The available knowledge from life-cycle-assessments, however, seems limited, despite the fact that for those issues many biofuels cause higher environmental pressures than fossil fuels, as demonstrated in Table 7. From a representative sample of LCA studies on biofuels, less than one third presented results for acidification and eutrophication, and only a few for toxicity potential (either human toxicity or eco-toxicity, or both), summer smog, ozone depletion or abiotic resource depletion potential, and none on biodiversity.

Increased eutrophication is a key characteristic of biofuels from energy crops when compared with fossil fuels. The life-cycle-wide emissions of nutrients depend critically on the application and losses of fertilizers during the agricultural production of biofuel feedstocks.

There is an obvious link between environmental impacts estimated by life-cycle impact assessments and water quality problems described at the regional scale. For instance, in the Mississippi drainage basin (USA), increased corn acreage and fertilizer application rates, due to growing biofuel production, have been shown to increase nitrogen and phosphorus losses to streams, rivers, lakes and coastal waters, particularly in the Northern Gulf of Mexico and Atlantic coastal waters downstream of expanding production areas, leading to serious hypoxia problems.

These observations indicate that besides GHG emissions, other impacts of biofuels, such as eutrophication, are indeed relevant and already contribute to significantly worsened environmental quality in certain regions. Changing agricultural practices with the relevant feedstock crop may mitigate some of the pressure, but will most probably not be sufficient to improve regional environmental conditions, such as water quality. This also indicates a limitation of the product life-cycle assessment approach, which does not account for the spatial pattern of environmental impacts resulting from the combined effects of increased biomass production.

Table 8 below summarizes the greenhouse gas savings of selected crops versus the greenhouse gas contribution of fossil fuels.
Methodological Constraints Influencing Results

The wide variation in LCA results reflects the plurality of technologies studied, and is also to a considerable extent due to varying assumptions and methodological constraints. Significant variation results from uncertainty about nitrous oxide (N2O) emissions, which is a particularly strong GHG.

Many life-cycle analyses have used the IPCC assessment methodology for estimating N2O fluxes, which tends to give estimates only somewhat over 1% of the nitrogen applied in fertilizer. However, atmospheric balance calculations from Crutzen and colleagues have indicated that total emissions could range between 3 and 5%. If those values are corroborated, results of many LCA studies will have to be considered.

There are various other constraints that limit the comparability of LCA results and need to be considered when interpreting the results. For instance, results of life-cycle GHG balances may critically depend on the way land conversion related impacts are attributed. For instance, when oil palm plantations are established on converted natural forests and the associated emissions are depreciated over 100 years, GHG savings may result per hectare and year. Additional emissions will result if a depreciation period of 30 years is applied.

Improvement of the product chain oriented life-cycle approach seems necessary, and is ongoing, but basic deficiencies may be overcome only through the use of complementary analytical approaches that capture the overall impacts of biofuels in the spatial and socio-economic context. This is necessary in particular to account for the indirect effects of land use change induced by increased demand.
Impacts Through Increased Demand and Land Use Changes

Most of the currently used crops for transport biofuels are also food crops. Global land use for the production of fuel crops recently covered about 2% of global cropland (about 36 Mha in 2008). This development is driven by volume targets rather than by land use planning. The extension of cropland for biofuel production is continuing, in particular in tropical countries where natural conditions favor high yields. In Brazil, the planted area of sugar cane comprised 9 million hectares in 2008 (up 27% since 2007). Currently, the total arable land of Brazil covers about 60 Mha. The total cropping area for soybeans, which is increasingly being used for biodiesel, could potentially be increased from 23 Mha in 2005 to about 100 Mha.

Most of the expansion is expected to occur on pastureland and in the savannah. In Southeast Asia, for example, palm oil expansion – for food and non-food purposes – is regarded as one of the leading causes of rainforest destruction. If current trends continue, in 2030 the total rainforest area of Indonesia will have been reduced by 29% as compared to 2005, and would only cover about 49% of its original area from 1990.

Land Requirements for Projected Biofuel Use

Estimates of land requirements for future biofuels vary widely and depend on the basic assumptions made - mainly the type of feedstock, geographical location, and level of input and yield increase.

There are more conservative trajectories that project a moderate increase in biofuel production and use, which have been developed as reference cases under the assumption that no additional policies would be introduced to further stimulate demand. These range between 35 Mha and 166 Mha in 2020. There are various estimates of potentials of biofuel production that calculate cropland requirements between 53 Mha in 2030 and 1668 Mha in 2050. About 118 to 508 Mha would be required to provide 10% of the global transport fuel demand with first generation biofuels in 2030 (this would equal 8% to 36% of current cropland, incl. permanent cultures).

Impacts of Growing Demand

A special concern is land use change induced by the growing demand for biofuels and the subsequent GHG emissions and consequences for biodiversity. Clearing natural vegetation mobilizes the stocked carbon and may lead to a carbon debt, which could render the overall GHG mitigation effect of biofuels questionable for the following decades.

The total CO2 emissions from 10% of the global diesel and gasoline consumption during 2030 was estimated at 0.84 Gt CO2, of which biofuels could substitute 0.17 to 0.76 Gt CO2 (20-90%), whereas the annual CO2 emissions from direct land conversion alone are estimated to be in the range of 0.75 to 1.83 Gt CO2. Even higher emissions would result in the case of biodiesel originating from palm oil plantations established on drained peatland.
Current biofuel policies aim to implement production standards that require minimum GHG savings and assure that production land does not consist of recently converted natural forests, or other land with high value due to carbon storage or biodiversity.

However, for net consuming regions like the EU, and countries such as Germany, models have shown that an increased use of biofuels would lead to an overall increase in absolute global cropland requirements. This implies that if biofuels are produced on existing cropland, other production - in particular for serving the growing food demand beyond the capacities to increase yields - will be displaced to other areas (“indirect land use”).

As long as the global cropland required for agricultural based consumption grows, displacement effects, land conversion and related direct and indirect impacts may not be avoided through selected production standards for biofuels.

Increased biofuel production is expected to have large impacts on biological diversity in the coming decades, mostly as a result of habitat loss, increased invasive species and nutrient pollution. Habitat loss will mainly result from cropland expansion.

Species and genotypes of grasses suggested as future feedstocks of biofuels may become critical as invaders. Nutrient emissions to water and air resulting from intensive fuel cropping will impact species composition in aquatic and terrestrial systems.

Modeling the future biodiversity balance for different crops on different land types has shown that GHG reductions from biofuel production would often not be enough to compensate for the biodiversity losses from increased land use conversion, not even within a time frame of several decades. Beneficial effects for biodiversity have only been noted under certain conditions, when abandoned, formerly intensively used agricultural land or moderately degraded land is used. On such land, biofuel production can even lead to gains in biodiversity, depending on the production system used.

**Increasing Yields and Optimizing Agricultural Production**

The potential to increase yields differs among regions. In developing countries, crop and land productivity can be improved to increase production on existing cropland. Large potentials for increased yields seem to exist for instance in sub-Saharan Africa, where local cases have shown progress when both the use of agricultural technologies and the institutional setting have been improved.

However, while increased investment into biofuels may result in gains in agricultural productivity that could also spill over to food production, this remains to be proven, and exacerbating the food versus fuel debate remains a concern.

In countries with high crop yield levels, a constraint of rising importance is the increasing level of nutrient pollution. Adjusting crops and cultivation methods to local conditions may lead to efficiency increases and reduce environmental load. Genetic manipulation may be able to increase the lignocellulose yield for 2nd generation biofuels, although risks to the
ecosystem remain uncertain and the precautionary principle should be considered.

Altogether, the overall development at the global level will probably be a rather moderate increase of agricultural yields.

**Restoring Formerly Degraded Land**

To avoid tradeoffs between expanding biofuel cultivation and conservation of biodiversity, three types of land have been suggested for potential agriculture expansion: “marginal” land, degraded land, and abandoned land.

Marginal land comprises all non-cultivated area (not used as cropland) where actual primary production is too low to allow competitive agriculture. Degraded land has been cultivated before and become marginal due to soil degradation or other impacts resulting from inappropriate management or external factors (e.g. climate change). Abandoned land comprises degraded land with low productivity plus land with high productivity (e.g. where forest is regrowing).

Of particular relevance to Belarus, degraded, “marginal”, and abandoned land can be used for biofuel production. Certain crops, such as switchgrass or, as is the case in Belarus, rapeseed may even restore productivity of degraded land. Nevertheless, crop and location specific challenges and concerns exist, especially regarding possible yields, required inputs and side-effects on water and biodiversity.

While large potential areas have been suggested for both degraded and abandoned land, more research seems necessary to clarify the realistic production potentials, and to provide guidance for land management, in particular to balance the environmental costs and benefits of any land conversion against natural regeneration.

Halophytic crops thrive in relatively high saline areas, such as some deserts and in coastal areas, where major crop species are unable to grow. During their growth, salt is taken up. Such crops could clean soils of high salinity, although saline agriculture is still in its infancy and research on ecologically sound cultivation of marsh crops is ongoing.

Finally, growing energy crops that take up heavy metal pollutants can restore soil contaminated with these contaminants. For example, Lewandowski et al. (2006) performed a case study in Germany regarding the potential of willow to clean contaminated soils, and later be burned as a fuel, finding that there was an economic benefit for farmers under certain conditions.

Lower yields mean that the use of degraded lands is generally less profitable than the use of productive land. If mechanized cultivation is required for restoration, the required investment can act as a disincentive. Nevertheless, restoration could benefit from low land rents. This is thought to provide an opportunity, especially in developing countries with low labor costs (GEF 2006).
Altogether, it is fair to conclude that there is a certain potential to expand agriculture through the restoration of degraded land in order to produce biofuels, but possibly also food. This may also enhance rural development.

The overall global and regional potential for adequate areas still need to be determined. Higher uncertainties regarding the potential exist for “marginal land”, which has never been under cultivation. In cases of abandoned land with high productivity (regrowing forests), the net environmental effect of biofuel production on climate and biodiversity would need to be assessed on a case-by-case basis.

While production may be less profitable, examples of small-scale biofuel projects, for instance with jatropha or rapeseed, demonstrate the potential for local energy provision. Nevertheless, crop and location specific challenges and concerns exist, especially regarding possible yields, required inputs and side-effects on water and biodiversity.

The issue of yearly fluctuation of yield of rapeseed in Belarus has stymied, at least for now, efforts to produce sufficient rapeseed to meet existing and future technological capacity in Belarus to produce biodiesel.

While large potential areas have been suggested for both degraded and abandoned land, more research seems necessary to clarify the realistic production potentials, and to provide guidance for land management, in particular to balance the environmental costs and benefits of any land conversion against natural regeneration. Figure 4 summarizes the potential for use of abandoned lands for the production of biofuels.

**Figure 2: Worldwide potential of abandoned land**

![Worldwide potential of abandoned land](image)

Source: Campbell et al. (2009)

**Using Biomass for Power and Heat**

Stationary use of biomass — to generate heat and/or electricity — is typically more energy efficient than converting biomass to a liquid fuel. It may also provide much higher CO2 savings at lower costs. Indeed, even when considering advanced biofuels such as BtL, substituting fossil fuels for power and heat generation with wood may still save more GHG
emissions. Stationary use technologies provide promising options for energy provision in developing countries for the community and households.

The substitution of traditional biomass use for heating and cooking, for instance, may help overcome energy poverty and improve health conditions. In developed countries, state-of-the-art technology provides multifunctional services, for example by combining waste treatment with energy provision.

Biogas is an example of a stationary use application thought to have particularly good potential as a renewable energy source with good GHG savings, especially when waste is used. Still, when energy crops are used for biogas, ecological and land use concerns need to be considered.

**Second Generation Biofuels**

As described earlier in this report, the IEA has concluded that due to an improved understanding of total greenhouse gas (GHG) emissions as a result of detailed life cycle analyses, and related direct and indirect land use change issues, their perceived environmental benefits have more recently been brought into question. It has become evident that some “good” first generation biofuels, such as sugarcane ethanol, have GHG emission avoidance potential; are produced sustainably; can be cost effective without government support mechanisms; provide useful and valuable co-products; and, if carefully managed with due regard given to sustainable land use, can support the drive for sustainable development in many developing countries.

Other “less good” first-generation biofuels, such as vegetable oil-based biodiesel, are being criticized with regard to their relatively low GHG emissions avoidance; unsustainable production relating to deforestation, water use, and land management; competition for food crop feedstocks pushing up food commodity prices; and the need for generous government support schemes to remain competitive even after the technologies have become mature.

Also as previously mentioned, commercialization of either biochemical or thermo-chemical conversion routes for producing second-generation biofuels appears to remain some years away. This is in spite of several decades of research and development, and more recent investment in several pilot-scale and demonstration plants in US, Europe and elsewhere.

Even with generous government subsidies the commercial risks remain high, especially with recent widely fluctuating oil prices and global financial turmoil adding to the investment uncertainty.

There is no doubt that good progress in RD&D has been made during the past decade following increasing public and private investments. Successful outcomes include development of improved microorganisms and the evaluation of innovative conversion technologies with improved performance and efficiencies.

There is also a better understanding by the industry of the overall feedstock supply chain,
whether from crop and forest residues or from purpose grown crops, necessary to provide consistent quality feedstock delivered all-year-round to the conversion plant gate.

There has also been successful developments relating to the construction of pilot-scale bio-refineries to produce a range of co-products, some being small-volume, high-value products, and others, like biofuels, being high-volume, low-value.

Overall, unless there is a technical breakthrough in either the biochemical or thermo-chemical routes that will significantly lower the production costs and accelerate investment and deployment, it is expected that successful commercialization of Second-generation biofuels will take another decade or so. During this period, demonstration and industrial-scale second-generation plants will be continually improved in order that the biofuel products become competitive with petroleum fuels as well as with first-generation biofuels.

**Use of Waste and Production Residues**

Energy recovery from waste and residues can save significant GHG emissions without requiring additional land. Specifically, municipal organic waste and residues from agriculture (both crop production and animal husbandry) and forestry provide a significant energy potential which is still largely unused. Further research is necessary to determine the proper balance of residues that should remain on the field or in the forest to maintain soil fertility and soil carbon content, and the amount that can be removed for energy, as well as with regard to nutrient recycling after energy recovery.

**Cascading Use of Biomass**

Using biomass to produce a material first, and then recovering the energy content of the resulting waste, can maximize the CO2 mitigation potential of biomass. Through reutilization more fossil fuel feedstock can be displaced with a smaller amount of biomass, and therefore also reduce the demand for land. This is particularly relevant as biomaterial production is expected to grow, and unchecked growth could lead to similar land use change concerns and constraints as biofuels.

While cascading use may reduce competition between energetic and material biomass use, competition between uses may also hamper the prolongation of cascading chains. This can already be seen with certain forestry products and wood energy. Further research is required to determine the potential for cascading with regard to biomass uses (food, fiber, fuel and plastic) and resource requirements (land, primary materials and energy).

**Mineral-based Solar Energy Systems**

Like biomass, solar energy systems also transform solar radiation into useable energy, albeit much more efficiently. In particular, they have a significantly lower land requirement and may also be associated with less environmental impacts. While solar power is still subject to a cost disadvantage, this is expected to decrease and off-grid applications are already economically feasible.
Further technologies, such as solar cookers, can substitute ‘traditional biomass’ use in developing countries. As such options provide services similar to biofuels, their application as potentially more beneficial alternatives for the local socio-cultural and ecological environment should be examined.

**Recent Transport Biofuel Policies**

Development of a biofuel industry has been largely fuelled by governments through mandates, targets and other various mechanisms of support, including subsidies, and is largely driven by a desire to achieve energy security. As negative environmental consequences of biofuels have come to light, these have come under scrutiny as being insufficiently supported by science.

In particular, while mitigating climate change is a major driver behind biofuel support, the mitigation potential of biofuels to-date are rather minimal overall and the costs so far seem disproportionally high. For instance, according to OECD, subsidization in the US, Canada and the EU represent between US$ 960 -1,700 per ton of CO2eq avoided in those countries. This level far exceeds the carbon value at European and US carbon markets. Although trade has been limited so far, it is expected to grow as a result of targets that cannot be met with domestic production in most countries.

To cope with rising concerns of unwanted side-effects of biofuels, some countries have started to promote criteria for sustainable bioenergy production. These standards and certification schemes, described in Tables 7 and 8 below, rely on LCA based methods and often account only for selected impacts along the production chain. Further efforts are needed to fully consider not only GHG effects, but also other impacts such as eutrophication more comprehensively. Initiatives designed to protect small-scale farming in large-scale biofuel production, such as the social label in Brazil, also seem necessary.

Whereas the improvement of the life-cycle-wide performance of biofuels (the “vertical dimension” at the micro level) may be fostered by certification, such product standards are not sufficient to avoid land use changes through increased demand for fuel crops (the “horizontal dimension” at the macro level). For that purpose, other policy instruments are needed which foster sustainable land use patterns and adjust demand to levels which can be supplied by sustainable production.
Table 9: Certification schemes and performance standards for biomass and biofuels

<table>
<thead>
<tr>
<th>Certification</th>
<th>Affiliation</th>
<th>Sector</th>
<th>Scope</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>Australian Forestry Standard</td>
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<tr>
<td>Canadian Standards Association - Sustainable Forest Management</td>
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<td>●</td>
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<tr>
<td>Forest Stewardship Council – P&amp;C Standard</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Green Gold Agriculture/Forest Label (standard when no certification system is available)</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Indonesia Eco-labeling Institute - Sustainable Forest Management</td>
<td>●</td>
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<tr>
<td>International Federation of Organic Agriculture Movements – IFOAM Accreditation Criteria</td>
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<tr>
<td>Naturland Association for Organic Agriculture - Standards</td>
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<tr>
<td>Rainforest Alliance – Sustainable Agriculture Network</td>
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<table>
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<tr>
<th>Performance standards</th>
<th>Affiliation</th>
<th>Sector</th>
<th>Scope</th>
<th>Criteria</th>
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<tbody>
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<td>Climate, Community &amp; Biodiversity Alliance (CCBA) – OCB Standard</td>
<td>●</td>
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<tr>
<td>Fairtrade Labelling Organization – Fairtrade standards</td>
<td>●</td>
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<td>●</td>
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<tr>
<td>International Standards Organizations (biofuel standard in development)</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Netherlands – Agency for Energy &amp; Environment (currently discussing certification of biofuels)</td>
<td>●</td>
<td>●</td>
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<td>●</td>
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<tr>
<td>Roundtable on Sustainable Biofuels (RSB) – Sustainability standards</td>
<td>●</td>
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<tr>
<td>Roundtable on Responsible Soy</td>
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<tr>
<td>Roundtable on Sustainable Palm Oil</td>
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<tr>
<td>Sustainable Forestry Initiative</td>
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</table>

Note: This table only includes some key certification and standards for bioenergy, although not all are shown.

Source: after compilation by UNEP-DTIE

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Table 10: Initiatives to enhance sustainability of fuels
Fostering Sustainable Land Use for Biomass Production

Increasing agricultural yields will be required for both food and non-food production. Key is mobilizing potential in regions where productivity increases have lagged, such as sub-Saharan Africa. While a number of measures are required to overcome current constraints, the accelerated foreign investment in biofuel crops may lead to broader progress, although the benefit for local populations may also remain limited and should be monitored.

Cropland expansion, whether for food or nonfood production, should not occur at the expense of high value natural ecosystems, also in light of ecosystem services. Various mechanisms are under development to shelter such lands, for example by providing them with an economic value, or agroecological zoning as currently being employed in the Brazilian Amazon. Limiting new fields to degraded land is another important strategy, but further research on the potential environmental costs and benefits is required.

Comprehensive land use management guidelines that consider agriculture, forestry, settlements/infrastructure/ mining and nature conservation are needed on the regional, national and international levels for sustainable resource use. Countries need to monitor their actual and potential land use, taking the impacts of national resource consumption on the domestic and, where relevant, the global environment into account (incl. induced global land use change and subsequent GHG emissions).

Fostering More Efficient Use of Biomass

In the future, advanced biofuels, such as cellulosic biofuels derived from timber processing residues, straw or corn stover, may be able to improve the resource efficiency of biofuels. However, more research on actual potentials, environmental impacts and land use requirements is needed. As stationary use of biofuels for heat, power and CHP is generally more resource productive than for transport, policies may be devoted to prefer support of the
Microfinance for stationary applications is a policy approach often employed in developing countries and feed-in tariffs have been used extensively in some developed countries. There is a need to research the possible global environmental consequences of increased stationary use, especially regarding the growing demand for forestry products for energetic use.

In various countries, policies have been established to promote recycling and energy efficiency of waste management. Feed-in tariffs can be used to foster market entry of power generated by waste and residues, or market-oriented measures, such as green pricing, can be used. As the criteria for what constitutes “green” is sometimes rather vaguely defined, such policies should be based on a comprehensive biomass strategy that considers both material and energetic use of non-food biomass.

**Increase Energy and Material Productivity in Transport, Industry and Households**

Global resources do not allow simply shifting from fossil resources to biomass while maintaining the current patterns of consumption. Instead, the level of consumption needs to be significantly reduced for biofuels to be able to substitute for relevant portions of fossil fuel use. For that to occur, resource efficiency in terms of services provided per unit of primary material, energy and land would need to be drastically increased. To this end, various developed and developing countries and international organizations have formulated goals and targets for increased resource productivity.

Designing a policy framework by setting incentives for a more productive use of resources might be more effective and efficient in fostering a sustainable resource use than regulating and fostering specific technologies. For instance, economic instruments, such as transport fuel taxes, have reduced overall fuel consumption and GHG emissions in some countries.

Developing countries are challenged in finding the balance between increased energy supply and enhanced access on the one hand, and growing environmental impacts on the other hand. Increasing energy and material productivity is expected to approach that balance. For instance, China has set an ambitious target to enhance energy productivity by reducing energy intensity by 20% from 2005 to 2010. The search for alternatives needs to go beyond alternative fuels.

Automotive industries are challenged to drastically reduce the fuel consumption of the car fleets they produce. Some countries have set regulatory standards towards this end. The automotive industry also has an interest to reduce fuel consumption and GHG emissions of their products. A concerted action could drive the worldwide development more quickly towards sustainability.

A decisive step to this end could be a voluntary commitment of global automotive industries to reduce the GHG emissions and resource requirements of their products altogether by a significant amount within the years to come.
Altogether, various strategies and measures can be used to further develop policies that can effectively contribute to a more efficient and sustainable use of biomass and other resources.

**EU Biofuel Directives**

Two EU Directives have addressed EU policy regarding biofuel use.

The first was Directive 2003/30/EC, issued on 8 May 2003, and established the goal of reaching a 5.75% share of renewable energy in the transport sector by 2010. This created conditions for an expanded market for biodiesel, and biodiesel is currently the most common biofuel in Europe. This is due to the fact that, while biodiesel can be used in vehicles in pure form, it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide and hydrocarbons powered vehicles.

The second Directive, issued on 23 April 2009, raised the percentage of biofuel in diesel to a minimum 10% in every Member State in 2020. Provision is made for the 10% target to be an aggregate target, recognizing that each member state will have different capacities to reach the target. Whether it is electricity or hydrogen from renewable energy sources, or first or second-generation biofuels, the Directive states that there “is an urgent need to ensure we meet this goal.”

The Directive also aims to ensure that as the use of biofuels in the EU expands be consistent with an objective of ensuring a clear and net GHG saving and that there be no negative impact on biodiversity and land use.

Energy efficiency in the transport sector is seen as necessary because a mandatory percentage target for energy from renewable sources is likely to become increasingly difficult to achieve sustainably if overall demand for energy for transport continues to rise. The mandatory 10% target for transport to be achieved by all Member States is thus defined as that share of final energy consumed in transport that is to be achieved from renewable sources as a whole, and not from biofuels alone.

**EU Sustainability Criteria**

The EU has developed sustainability criteria for the production of biofuels. In summary, the criteria include those related to:

- Securing greenhouse gas savings;
- Minimizing the use of land with high biodiversity value; and
- Avoiding the use of land with high carbon stock and agro-environmental practices.

Further, the EU has concluded that in order to minimize carbon stock losses, it is appropriate to introduce accompanying measures to encourage an increased rate of productivity on land already used for crops, the use of degraded land, and the adoption of sustainability requirements, comparable to those laid down in the 2009 Directive.
Finally, EU regulations are drafted with the knowledge that transport fuels are traded easily, so that Member States with low endowments of relevant resources will easily be able to obtain biofuels from elsewhere. While it would technically be possible for the EU to meet its target for the use of energy from renewable sources in transport solely from domestic production, it is both likely and desirable that the target will in fact be met through a combination of domestic production and imports.

In light of that understanding, the EU will propose relevant measures as needed to achieve a balanced approach between domestic production and imports, taking into account, among other things, the development of multilateral and bilateral trade negotiations, environmental, social and economic considerations, and the security of energy supply.

Standards of sustainability for biofuel production have also been developed by the Roundtable on Sustainable Fuels (RSB)\(^3\). The RSB is an international initiative by the Energy Center of the Ecole Polytechnique Federal de Lausanne, or EPFL. The development of these standards was an effort undertaken jointly by farmers, companies, non-government organizations, experts, governments, and international government agencies concerned with ensuring the sustainability of biofuel production and processing, which, among other things, includes social protection standards.

As previously mentioned, there is good reason to expect that the EU market, far and away the largest market in the world for biofuels is, and will continue to be, an excellent market for sale of biofuels that are demonstrably sustainably produced and are considered overall to be “environmentally friendly”, as the Table 9 below clearly illustrates.

**Part II. Belarus Context**

*Background and History – 1995-2010*

There is a history of interest in using Belarusian lands generally, and specifically Chernobyl affected lands for the production of biofuel. In general, Belarusian policy, until roughly 2010, focused on producing biofuel for domestic as well as an export commodity. More recently, however, practice if not policy seems to focus more on biofuel production for domestic use, and is targeted primarily to the production of biodiesel.

Further, the Belarusian government website currently contains an undated statement that:

> Of all renewables, biofuel is most attractive to Belarus because of the vast areas of forest and farmland across the republic. Biofuel facilities are being constructed in the southern towns of Mozyr and Bobruisk to produce 650 million liters of bioethanol a year, and chemical company Azot is experimenting with the production of methyl ether from rape oil.”

\(^3\) The report titled *Global principles and criteria for sustainable biofuels production* appears as Annex 3 of this report.
Resolution of the Council of Ministers

State Program for production of biodiesel fuel in the Republic of Belarus for 2007–2010

In December of 2007, in an attempt to provide the economy of Belarus with a source of automotive fuel at stable prices, a guaranteed market for vegetative raw materials, and reduce energy imports, the Council of Ministers established for Belarus a program (Program) for the production and use of biodiesel from rapeseed processing products, subject to a system of economic policies and regulatory framework to promote biofuels production, improve yield and increasing the area of rapeseed planting.

The aim of the Program was to:

...improve environmental and energy security of the Republic of Belarus, reduce the national economy’s dependence on oil imports, provide competitive transport biodiesel by establishing domestic raw material base of industrial production of the new type of fuel from a renewable source of energy, as well as internationally competitive chemical products obtained via processing by-products of biofuel production.

The Program established objectives for research and development (R&D), and utilization and development of rape-based biodiesel.

The main objectives of the Program in terms of R&D were to:

- Create new technological processes for obtaining biodiesel and chemical products by processing by-products of biofuel production;
- Develop technology for obtaining fertilizer and solid fuels from rape straw, feed from the cake and commodity chemical products in the production of biofuels;
- Approve the necessary standards of the Republic of Belarus on created processes and products;
- Establish pilot production of biodiesel and competitive chemical materials based on by-products of biodiesel production; and
- Implement effective organization and coordination of activities of the leading research organizations of the country and industrial organizations within the framework of implementation of the program.

The main objectives of the Program in terms of utilization of development were to:

- Establish commercial production of biodiesel (not less than 100 tons per year) and mixed fuels (at least 2 million tons per year), as well as chemical-based materials based on by-products of biofuel production;
- Set for producers of biofuel long-term plans of biofuel production volumes and monitor observance of the plans; and
- Develop the system to encourage use of biofuels.
The Program was interdisciplinary in nature, since a number of its activities were to be implemented in the interests of the Belarusian State Concern for Oil and Chemistry (Belneftekhim), the Ministry of Agriculture and Food, Ministry of Transport and Communications, Ministry of Education, the National Academy of Sciences of Belarus, the Belarusian state food industry concern "Belgospischeprom", and the Ministry of industry.

What was termed the “State Customer of the Program” was Belneftekhim, which brought together the main organizations of chemical and petrochemical plants in Belarus, as well as specialized design organizations (Open Joint Stock Company "GIAP" Open Joint Stock Company "Belgorchimprom"). Belneftekhim also possessed the appropriate production capacities and highly qualified staff, and managed an established system of production and marketing of chemical products for fuel and energy use.

Belneftekhim, it was also observed, ensured implementation of Program activities in terms of production and marketing of biodiesel and development of specific measures to ensure production of biodiesel. Raw materials for production of biodiesel (rapeseed oil) were already being provided under the State program of development of oil and fat industry of the Republic of Belarus for 2007-2010, approved by the Council of Ministers on May 14, 2007 № 588.

Organizations to utilize the results of development Programs, specifically the biodiesel the program was intended to produce, included not only Belneftekhim but also the Ministry of Transport and the Ministry of Agriculture and Food that was consuming biofuels while also producing renewable raw materials. Co-implementing organizations for the Program were leading chemical research institutes such as the National Academy of Sciences of Belarus, the Ministry of Education, sub-organizations of Belneftekhim, the Ministry of Agriculture and Food, and Regional Executive Committees.

The Program was quite specific in elaborating detailed activities and targets regarding:

- The Proposed scheme of biodiesel production and sale;
- Scientific Support for the Program;
- Activities to achieve target indicators of the State Program for the production of biodiesel fuel; and
- Target indicators of the State program for the production of biodiesel fuel in the Republic of Belarus.

While it is unclear the exact extent to which all targets specified in the Directive were met, there is no question that biodiesel production in Belarus, through the use of rapeseed, is now an established enterprise as a result of the Program.

The Program did not address the use of Chernobyl affected lands for the production of biodiesel.
The Directive, as made clear in its title, expired in 2010. There does not appear to be at present a replacement Directive or other coordinated policy instrument for the production of biofuel in Belarus.

Other Past Government of Belarus Biofuel Policy and Initiatives

In addition to the Council of Ministers Directive, in 2008 there were statements at the highest levels of government that biofuel policy would favor the use of agricultural product for biofuel production for domestic use as well as for export, and that Belarus would be constructing new biofuel plants in the near future.

It was noted by high level government officials at that same time stated that Belarus had sufficient agricultural land to grow the rapeseed, and that the government was working to attract foreign investment in the Belarusian biofuels industry and eventually would want to export biofuels to the EU.

Greenfield Project

Government interest in using Belarus lands generally for biofuel and other energy development, and specifically targeted to Chernobyl affected lands, was also apparent in an attempted public/private partnership between the government and an Irish company called Greenfield Project Management Limited (Greenfield).

In 2007, the Government signed a business cooperation agreement (Agreement) with Greenfield to procure raw materials for bioethanol fuel production. The Belarusian Vice Premier signed the Agreement. According to the Agreement, Belarus was to procure for Greenfield sufficient raw materials, including vegetable raw materials, grain and sugar beet for production purposes.

The project was to have included construction of what would have been one of Europe’s largest bioethanol plants that would have converted rapeseed crop grown on contaminated land into bioethanol.

The Belarusian partners of Greenfield were to have been the Mozyr-based Ethanol factory and the Bobruisk Hydrolysis Plant, producers of spirit-containing products. The Greenfield project would have then started building ethanol-making facilities, with capacities of 10 million decaliters and 55 million decaliters, respectively.

The initial total value of the project was to have been EUR 220 million, mostly covered by loans from the ABN Amro Bank in the Netherlands. Greenfield was expected to have an 80% stake in the shareholding structure of both joint ventures, with 20% controlled by Belarus. Eventually the investment was to be EUR 2 billion.

The venture was also intended, in part, to use Chernobyl affected lands to grow the raw materials necessary for biofuel production. Fifty thousand square kilometers of Chernobyl affected lands were to have been targeted, and it was hoped that eventually Chernobyl
affected lands in Russia and Ukraine would also be incorporated into the venture. While still contaminated, they were still fertile lands for growing crops that could be converted, safely it was argued, into biofuel.

Growing crops on these contaminated lands would have assisted in cleansing the affected lands as they absorb toxins in the soil. Greenfield, and the government, planned to use the project to study how crops can help return contaminated land back to full use, and would have used Chernobyl affected lands as part of a wider study of environmental benefits of biofuel production on contaminated lands.

The Agreement was seen as being beneficial to Belarus because, among other things, it would have:

- Increased Belarusian energy security;
- Not conflicted with the growing of crops for human consumption in targeted Chernobyl affected regions;
- Have been consistent with existing Belarusian policy declaring development of biofuels to be an important government priority; and
- Have been consistent with the wishes of the Council of Ministers.

By 2008 the planned project had become more detailed. The intent was to refine four biofuels:

- Biodiesel;
- Bioethanol;
- Biogas; and
- “Green” electricity.

In addition to the 1.5 million tons of surplus grain to be provided for the joint venture, the government was to guarantee the ongoing biomass needs of the project, and guarantee the oil supply needed for mixing with the biofuel. Agreement would be sought to blend the biofuel and the oil at the Kaliningrad (Russian Federation) terminal, and agreement would also be sought with an unspecified Russian oil company for the so-called “offtake” of the refined, final product.

The major part of the Greenfield commitment was to raise international funding for the project, including direct investments and bank loans, but Greenfield was not able to do so, and for this reason, among others, the project and Agreement were never implemented.

**Joint UN Agency/Belarus Chernobyl Targeted Initiatives**

Consistent with government support for biofuel production generally, there were two UN/Belarus initiatives undertaken to determine whether Chernobyl affected lands in particular could be profitably used to develop biofuel. The UN agencies that cooperated with Belarus were the IAEA and the FAO.
Joint IAEA/Belarus Biofuel Development Initiative

From 1995-2001 the IAEA, in cooperation with the State Chernobyl Committee, the Ministry of Agriculture and Food, and the Institute for Soil Science and Agrochemistry, undertook a study\(^4\) to determine the potential for use of Chernobyl affected lands to produce biofuel from rapeseed. It included an IAEA investment of US$ 819,000, and US$ 1,900,000 from the Government of Belarus. The study objectives included activities to:

- Evaluate soil climatic suitability of contaminated lands for rapeseed cultivation; Evaluate high-yielding varieties of spring rapeseed with the minimum accumulation of radionuclides;
- Elaborate on effective fertilization aimed at reducing the contamination of rapeseed;
- Create a routine testing laboratory to achieve quality control; and
- Reconstruct the pilot plant for rapeoil refining and deodorizing.

Rapeseed was at the time a relatively new oil plant for Belarus, but from the mid-1980’s it had been increasingly planted for use in the production of oil for human consumption and biodiesel.

More specifically, the sowing of rapeseed in Belarus had grown from an area of 35 thousand hectares in 1994 to 129,000 hectares in 2001, and on Chernobyl lands from 6,000 hectares to 25,000 hectares over the same timeframe, as seen in Table 11 below.

Table 11: Increase in Belarus rapeseed production – 1994 to 2001

The Study was organized in project stages, with the results of each stage carefully reviewed and findings summarized. The stages included studies of and observations concerning:

- **Soil convenience**

According to Study investigations and calculations, and taking into account soil climatic conditions of land contaminated with $^{137}$Cs deposition higher than 185 kBq m$^{-2}$ and $^{90}$Sr more than 11 kBq m$^{-2}$, it was determined that there were approximately 200,000 hectares of arable land suitable for rapeseed cultivation or 40,000 hectares per year. It was also determined that the expansion of winter, and especially spring rapeseed, would completely resolve the problem of maintaining these crops with current resources and improve efficiency of land use.

- **Radionuclides in the food chain**

In a unit area it was determined that the straw part of rapeseed plants accumulate 64.3% of $^{137}$Cs and 81.8 % $^{90}$Sr, the pods 5.9 and 6.5 %, and the roots 26.5 and 5.9 % respectively of the total of the absorbed radionuclides in the biomass. Only 3.2 % of $^{137}$Cs and 5.8 % of $^{90}$Sr contained in rapeseed from this overall uptake are potentially involved in the food chain.

- **Phytodecontamination**

The study results noted that rapeseed is a plant that has a high ability to accumulate $^{90}$Sr. In experiments, the annual accumulation of $^{90}$Sr in rape straw, pods and roots reached approximately 3 % of the $^{90}$Sr content in soil. The radionuclides incorporated in the rape straw would be unavailable for green plants at least during 1-2 years, up to the final mineralization of the straw in the soil. It was determined that the size of $^{90}$Sr immobilization by straw is comparable with “self-weeding” of soil as a result of annual decay of radionuclides and is valuable, considering the saturation of crop rotations with rapeseed may be at range 10-20%.

- **Agrotechnical counter measures**
Variety differences of spring rapeseed were apparent both in productivity and radionuclide accumulation in the seed. The average yield of the varieties of spring rapeseed amounted to 2.0 tons ha-1 of seeds, equivalent to 0.87 t ha-1 of oil. The variation of seed productivity of the studied rape varieties was from Hanna, which was previously introduced from Sweden and which amounted to 12% to +26 % of the yield of a standard variety for Belarus. The yield of rape oil from 1 ha of crop area depended on both the seed yield (varying between 1.71-2.44 t/ha according to the varieties) and the oil percentage in seeds, which varied between 38.9-47.5 %.

In general, the rapeseed varieties of German origin were determined to have the higher oil percentage than varieties of Belorussian selection.

For development of crop rotations on the contaminated lands the important value was deemed to be an estimation of radionuclide accumulation by different varieties of the crop species. During experiments, there were observed differences in accumulation of $^{137}$Cs by rapeseed varieties between years of 1.8-2.7 times, and $^{90}$Sr 1.8-4.0 times. However it was seen as necessary to note that a variety which is less accumulating of radiocesium would not necessarily accumulate less $^{90}$Sr.

Results obtained allowed a deduction that cultivation of the varieties having the minimum accumulation of radionuclides should be recommended as a simple and economically feasible method for reducing the contamination of food crops, and the efficiency of such agrotechnical counter-measures would not be reduced significantly over time after the accident.

The study concluded that soil acidity (pH) influences the availability of dissolved nuclides and their uptake by plants. As a result of liming with dolomite or chalk at the rate 6 ton ha-1, acidity of soil in the experiment changed from pH (KCl) 5.12 to pH 5.85-6.04, and the content of exchangeable Ca has increased from 26 to 39-45 mmol kg-1 of soil. This contributed to a decrease in the accumulation of $^{90}$Sr by seeds of 42 %, and in combination with fertilizers by up to 59%.

Increasing rates of potassium, up to 180 kg K2O ha-1, decreased the uptake of $^{137}$Cs by rapeseed by up to 45%. The minimum radioactivity of the spring rapeseed was found in the treatment with N90P90K180 along with dolomite or chalk application.

- Initial filtration of oil

The main product - oil itself - had a very low level of radioactivity. The transfer of radioactivity into the oil is not so much of a physiological mechanism but, rather, is mostly caused by contamination during oil extraction.

The oil radioactivity was many times lower then national permissible level (40 Bq l-1) after proper clearing from crude oil of solid particles in the process of filtration. Samples of crude oil from various stages of oil processing and clearing/filtration were taken and analyzed. The
correlation analysis showed the close relationship (R² = 0.80) between the ¹³⁷Cs activity of oil and the percent of solid particles in oil (Fig. 3). According to control measurements at oil mill “Pripyat” in Mozyr, the ¹³⁷Cs activities of crude oil were normally significantly below 0.5-0.8 Bq l⁻¹.

Thus from a radiological point of view, it was found that the rapeseed oil cleared from solids could be used as food oil. According to project calculations, under the most adverse conditions of rapeseed cultivation from a radiological perspective, the maximum contamination of crude oil did not exceed 1.8 Bq l⁻¹ for ¹³⁷Cs and, at the content of impurities limited by the existing standards on production of refined oil, the pollution would be significant less than 1.8 Bq l⁻¹ and would meet the requirements of Belorussian hygienic standards (RDU-99). Figure 3 below illustrates the eventual level of contamination that remains in rapeseed oil after processing.

**Figure 3. Sr-90 allocation in spring rapeseed biomass**

The Study economic analysis, as presented in Table 12 below, demonstrated that rapeseed production and processing could be a profitable technology in Belarus generally and also on Chernobyl contaminated lands, and for both agricultural producers and processors.

**Table 12: Calculation of Expenditures and Profit in the IAEA/Belarus Study**

<table>
<thead>
<tr>
<th>Name of Expenditure</th>
<th>Costs, US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapeseed production</td>
<td></td>
</tr>
<tr>
<td>Total expenditure for production of 1 ton of seeds</td>
<td>102</td>
</tr>
</tbody>
</table>
In summary, the IAEA and its Belarusian partners concluded that the cultivation of processing rapeseed had a positive long-term outlook for Belarusian rural economies and could contribute to improved socio-economic well-being of Chernobyl affected communities.

Of note is that while each of the three of the evaluated scenarios showed a profit margin, the largest profit margin was obtained through the processing of rapeseed into edible oil, by a factor of more than two to one over the processing of rapeseed to produce crude oil. And while current economic evaluations of profit margin are not available, indications are that the use of rapeseed to produce edible oil, either on Chernobyl affected lands or in Belarus generally, continues to promise the higher economic return.

The study results were further documented in paper titled *Remediation Strategy and Practice on Agricultural Land Contaminated with $^{137}$Cs and $^{90}$Sr in Belarus*, authored by Iossif Bogdevitch of the Belarusian Research Institute for Soil Science and Agrochemistry (BRISSA). Dr. Bogdevitch concluded that:

> The priority in countermeasure application should be directed on personal fields and farms to remedial actions that provide the profitable agricultural production as well as provide the dose reduction. The radical and surface improvement of meadows is the most effective countermeasures in husbandry. They provide RF of $^{137}$Cs grass activity about 3 times in average. These countermeasures are profitable. $^{137}$Cs binders (Prussian blue) are also effective with RF 3 and with reasonable requirement

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<table>
<thead>
<tr>
<th>Purchasing price of one ton of raw rapeseed (1 class)</th>
<th>132</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit obtained from realization of 1 ton of rapeseed</td>
<td>30</td>
</tr>
</tbody>
</table>

### Crude rapeoil production

<table>
<thead>
<tr>
<th>Cost of 3 tons of seeds (1 class) for generating 1 ton of crude rapeoil</th>
<th>459</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total expenditure for generating 1 ton of crude oil</td>
<td>120</td>
</tr>
<tr>
<td>(processing 3 tons of seeds)</td>
<td></td>
</tr>
<tr>
<td>Total expenditure (seeds and processing)</td>
<td>579</td>
</tr>
<tr>
<td>Realization of 2 ton of cake</td>
<td>143</td>
</tr>
<tr>
<td>Realization price for 1 ton of crude oil</td>
<td>390</td>
</tr>
<tr>
<td>Profit obtained from realization of 1 ton of crude oil and 2 tons of rapecake</td>
<td>56</td>
</tr>
</tbody>
</table>

### Edible rapeoil production

<table>
<thead>
<tr>
<th>Cost of 1 ton of crude rapeoil</th>
<th>355</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total expenditure for production of 1 ton of edible rapeoil (refining, deodorizing)</td>
<td>96</td>
</tr>
<tr>
<td>Packaging</td>
<td>120</td>
</tr>
<tr>
<td>Total expenditure (crude oil and processing)</td>
<td>571</td>
</tr>
<tr>
<td>Price for 1 ton of edible oil in Belarus</td>
<td>690</td>
</tr>
<tr>
<td><strong>Profit obtained from realization of 1 ton of edible oil</strong></td>
<td><strong>119</strong></td>
</tr>
</tbody>
</table>
for investment.

Soil fertility improvement through liming, manure and NPK application is the basic remediation measure in the long-term period after Chernobyl accident. Balanced fertilizers with K-fertilizer rates up to 160 - 240 kg K2O per hectare are profitable for crop cultivation on soils with low potassium content. Improvement of K supply level of Podzoluvisol loamy sand soil from exchangeable K2O 150 to 250 mg kg-1 allowed to increase crop yields and to reduce of radionuclide 137Cs transfer from soil to crops factor 1.8-2 Only moderate potash fertilizer rates are needed for rich K-supplied soils (K2O 250-mg kg-1 and more) to replace of the crop K-removal. The implementation of project of modern technology of potato growing on personal plots (ETHOS approach) has a high social significance. The involvement of rural inhabitants in processes of self-rehabilitation and self-development could be a way to improve the quality people life on radioactive contaminated territory as a common heritage.

Growing and processing rapeseed allows gains from contaminated territories Food-grade oil practically free from radionuclides. The IAEA TC project BYE/5004 is successful combination of scientific development, technical decisions, maximal use of local resources and productive cooperation Belarus with the international organizations.

The overall conclusion of the IAEA/Government of Belarus project was that realignment of plant production on contaminated lands, to an expansion of rapeseed cultivation for oil processing, can result in an essential positive impact on radio-ecological and economic aspects of life for residents of communities located on Chernobyl contaminated lands. The Study also concluded that then (2001) existing technologies of oilseed processing allowed for gains from contaminated territories of both technical and food-grade oil practically free from radionuclides.

**Joint FAO/Belarus Biofuel Development Initiative**

According to the FAO, the first experimental batch of biodiesel in Belarus was produced in 2006. Noting this experimental production of biodiesel, and, among other things, the positive results reported in the IAEA/Government of Belarus joint study, in 2007 the FAO, in cooperation with the Ministry of Agriculture, initiated a project proposal to examine the feasibility and advisability of producing biofuel on Chernobyl affected lands, with rapeseed as the preferred crop.

As part of the FAO/Ministry of Agriculture project proposal, it was noted that previous studies undertaken by Belarusian scientific and technological institutions, as well as those of international organizations, had shown that oil from rapeseed grown on radio-polluted soils contained practically no radionuclides, and that it was possible to produce biofuel (biodiesel) from the rapeseed oil.

The project document noted that in order to support the efforts of Belarus in the biofuel field,
and specifically in the context of relevant government energy and agriculture sectors and Chernobyl related strategies and policies, it would be necessary to:

- Take a comprehensive, systems approach from variety selection, land preparation and rapeseed production, to rapeseed processing to extract oil and transcertification for biodiesel production, to biodiesel utilization;
- Consider the policy, economic, social, environmental and safety aspects in addition to marketing and technological production issues, including the possibility of community level participation in the project;
- Define the most updated rapeseed production technologies and practices, including the estimation of potential agricultural production levels;
- Define the best technologies and practices to optimize the oil extraction and transcertification processes, including the determination of materials and energy balances and unit costs, as well as potential yields and agro-industrial production levels;
- Determine appropriate safety issues regarding radioactivity both at production as well as processing and utilization stages; and
- Based on the above, describe the viable conditions for biodiesel production with projections into the future.

FAO concluded that the results of implementation of such a project would include:

- Increases in overall knowledge of the production of biofuels from local renewable energy sources;
- Reduction of imports of energy resources in Belarus;
- Sustainable development of Chernobyl affected regions due to increased efficiency of production on lands contaminated by radionuclides; and
- Promotion of agro-industrial development, social and institutional strengthening and environmental protection.

The FAO project proposal was to have involved a two-year effort, from 2007-2009, and was to be implemented by the Ministry of Agriculture and Food.

While the joint FAO/Ministry of Agriculture project was not implemented, the reasons were not substantive, and it is noteworthy that the Project Document was officially endorsed by the Ministry of Agriculture and Food.

**Summary of IAEA/FAO/Government Efforts**

In summary, the IAEA/Government of Belarus study, the FAO/Government of Belarus project proposal, and other studies had clearly demonstrated that Chernobyl contaminated lands could be productively and profitably used for biofuel production, specifically through the cultivation of rapeseed, and possibly through the cultivation of other crops.

The IAEA/Government demonstration study and the FAO/Government project proposal, as well as statements made by government officials and others, also indicated that the use of Chernobyl affected lands for the production of biofuel would yield socio-economic benefits.
Current Belarusian Biofuel Policy and Activities

As part of the two Missions undertaken by the UNEP, with assistance of the IEA and the UNDP, and based on a review of existing documents and interviews with Belarusian stakeholders, we are able to identify, with respect to the use of Chernobyl affected lands for the production of biofuel and the production of biofuel generally in Belarus, the following:

The Ministry of Environment and Nature

The Ministry of Environment and Nature has served as the focal point for this UNEP effort, and the two missions that formed part of the content of this report. The Ministry became involved on the extent to which Chernobyl affected lands might be used for the production of biofuel at the direct request of the Council of Ministers.

Further, the Ministry has been generally very supportive of the use of Chernobyl affected lands to produce biofuel, or the use of those lands for other, sustainable enterprises. They have expressed an interest especially in the use of marginal lands for biofuel production as a means of striking an appropriate balance between land use for agricultural production directed to human consumption and the use of crops for biofuel production.

The Ministry has also been clear in stating that Belarus is in need of greater interministerial cooperation, and an inter-ministerial plan in order to move forward with a biofuel project or projects, whether they are to be situated in Chernobyl affected lands or more generally in Belarus.

The Ministry of Agriculture

Both missions undertaken by the UNEP involved discussions with representatives of the Ministry of Agriculture. In both of those meetings it was made clear that the Ministry opposes the use of not only Chernobyl affected lands for the production of biofuel, but is opposed generally to the use of any available agricultural land in Belarus for that purpose. The Council of Ministers have directed the Ministry to increase its production of agricultural product for human consumption by 50% over a five year period. Thus the Ministry has been, and continues to be resistant to the widespread use of available lands for biofuel production.

Ministry officials have stated that as Chernobyl affected lands become available for crop production, they favor using such land for the production of food for human consumption and for the production of forage for cattle and pigs. They have been and are working in cooperation with the Oblasts of Gomel and Mogilev that would result in a staged transition to a new resource efficient system of land use by 2015.

The Ministry made clear, however, that it is not totally opposed to the use of some lands for biodiesel production. The use of biodiesel in agricultural machinery is much more profitable for the agriculture sector than the use of fossil fuel derived diesel. Consequently, the Ministry sees its support for the production of biodiesel as consistent with its need to cost effectively maximize the production of crops for human consumption. It is working with Belneftekhim
to secure the amount of rapeseed biodiesel it needs for agricultural machinery, but to date there has not been sufficient crops of rapeseed to meet demand.

**The Ministry of Emergency Situations**

In response to a UNEP letter of inquiry dated 3 November 2011, the Ministry of Emergency Situations provided an update on the inventory of lands taken out of the agricultural cycle after the Chernobyl accident, based on their technical and melioration conditions.

According to a preliminary estimate that was given to the May 2011 mission, land potentially suitable for reintroduction in the agricultural totaled 18,383 hectares (as of January 2011), which included 17,066 hectares in Gomel Oblast and 1,317 hectares in Mogilev Oblast. For the full assessment of the suitability of those lands for agricultural production the lands would need to be measured according to radiological and agrochemical indicators. It was also noted that the lands are spread over 19 regions of Gomel and Mogilev Oblasts, which would not allow considering them as a significant reserve for the cultivation of crops for biofuel production.

The letter, signed by the Deputy Minister, further advised that it would be advisable not to link the issues of biofuel production only with the Chernobyl affected lands, but to consider it as applicable to the entire territory of the Republic of Belarus. The Ministry included in its response the following table, Table 13, of lands taken out of agricultural production in the oblasts of Gomel and Mogilev districts:

**Table 13: Chernobyl Affected Lands Taken Out of Production**

<table>
<thead>
<tr>
<th>Region</th>
<th>Areas of land suitable for agricultural activity (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gomel District</strong></td>
<td></td>
</tr>
<tr>
<td>1 Braginskiy</td>
<td>4,276</td>
</tr>
<tr>
<td>2 Buda-Koshelevskiy</td>
<td>559</td>
</tr>
<tr>
<td>3 Gomelskiy</td>
<td>98</td>
</tr>
<tr>
<td>4 Dobrushskiy</td>
<td>586</td>
</tr>
<tr>
<td>5 Zhlobinskiy</td>
<td>5,897</td>
</tr>
<tr>
<td>6 Kalinkovichskiy</td>
<td>226</td>
</tr>
<tr>
<td>7 Kormanskiy</td>
<td>2,130</td>
</tr>
<tr>
<td>8 Loyevskiy</td>
<td>213</td>
</tr>
<tr>
<td>9 Mozirskiy</td>
<td>815</td>
</tr>
<tr>
<td>10 Narovlanskiy</td>
<td>58</td>
</tr>
<tr>
<td>11 Octyabrskiy</td>
<td>129</td>
</tr>
<tr>
<td>12 Petrikovskiy</td>
<td>23</td>
</tr>
<tr>
<td>13 Rechitskiy</td>
<td>351</td>
</tr>
<tr>
<td>14 Rogachevsiy</td>
<td>6</td>
</tr>
<tr>
<td>15 Checherskiy</td>
<td>1,699</td>
</tr>
<tr>
<td><strong>District Total</strong></td>
<td><strong>17,066</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mogilev District</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td></td>
</tr>
</tbody>
</table>


The Ministry updated its response during the second mission of the UNEP to Belarus on 1 February 2012.

The second January/February mission of the UNEP included a briefing by officials of the Ministry at which time an update (through 2011) on the status of Chernobyl contaminated lands was received. As Table 14 below demonstrates (developed by the Ministry of Emergency Situations) the total area of Chernobyl contaminated lands that have been decommissioned from agricultural use since the Chernobyl accident stands at just over 265,000 hectares, with the large majority of those lands (just over 80%) being located in the Gomel Oblast.
The Ministry further informed the Mission that as of the end of 2011 18,000 hectares of Chernobyl previously contaminated lands are now available for agricultural use. However, according to the Ministry, only 5.5 thousand hectares of the 18,000 hectares is available for agricultural crops as the remainder, some 13.5 thousand hectares are watersheds that can only be used for cattle grazing and forage. Additionally, the 5.5 thousand hectares are not contiguous but are rather scattered across the entire Chernobyl affected landscape.

Given the above, the Ministry continues to conclude that decommissioned land in the Chernobyl affected area should not be used for the production of biofuel.

**Gomel District**

The Deputy Chairman of the District Authority has advised by letter that consistent with existing legislation lands could be used for agricultural purposes that have the level of contamination with $^{137}$Cs not exceeding 40 kBq/km$^2$ and with $^{90}$Sr not exceeding kBq/km$^2$.

The letter stated that as of 1 January 2011, on the territory of Gomel district, production of raw material and food products was being carried out on 580.7 thousand hectares of lands contaminated with $^{137}$Cs and on 332.3 thousand hectares of lands contaminated with $^{90}$Sr, which is respectively 46.9 and 26.8 percent of the overall agricultural lands of the Gomel
Oblast. On the territory of Oblast, 20 regions had agricultural lands contaminated with cesium, and 17 regions have lands contaminated with strontium.

All contaminated lands were being used for agricultural production. Due to the protective measures on these lands, production of contaminated products above permissible levels was brought to the minimum as far as $^{137}\text{Cs}$ concentration were concerned. Measures undertaken to limit the concentration of $^{90}\text{Sr}$ in the agricultural products have yielded positive results. The contamination of grains with $^{90}\text{Sr}$ is stabilized, and the volume of $^{90}\text{Sr}$ is reducing with every passing year. All grain produced in the District is now suitable for animal feed.

On 15 August 2011, in a joint meeting of representatives of the Ministry of Agriculture and National Academy of Sciences, a plan was adopted that would result in a staged transition to a new resource efficient system of land use by 2015. The proposed system would result in an optimized structure of agricultural lands for sustainable development of food production and cattle breeding.

In order to fulfill the increased target of crop production, and for full provisioning of the population with agricultural products, and food for the cattle breeding industry, it was envisaged to increase the area of planted lands for food and technical crops through the development of non-agricultural lands.

The letter stated that the major part of the radioactively hazardous lands was within the territory of the "Polesye State Radiological and Ecological Reserve."

Some small patches of hazardous lands are spread over the territory of the District, and are under the jurisdiction of the Administration of the Exclusion and Resettlement Zones under the Ministry of Emergency Situations of Belarus. Any form of activity on such lands is regulated by the Law of the Republic of Belarus "On the legal regime of the territories subjected to radioactive contamination as a result of the accident on the Chernobyl Nuclear Power Station".

Taking into account the above, the Gomel District Authority concluded that it does not consider it advisable to allot agricultural lands for the production of biofuel.

**The Mogilev District**

The Deputy Chairman of the Mogilyev District Authority also advised, in response to the UNEP letter of inquiry, that in accordance with the existing legislation, Chernobyl affected lands can be used for agricultural purposes which have the level of contamination with $^{137}\text{Cs}$ not exceeding 40 kBq/km$^2$ and with $^{90}\text{Sr}$ not exceeding kBq/km$^2$.

The Deputy Chairman further stated that all the contaminated lands are currently used for agricultural production with the application of protective measures that result in agricultural products is brought to a minimum, acceptable level.
The Deputy Chairman of the District advised that radioactively hazardous lands are spread over the territory of the contaminated lands in the form of small patches. Any form of activity on those lands is regulated by the Law of the Republic of Belarus "On the legal regime of the territories subjected to radioactive contamination as a result of the accident on the Chernobyl Nuclear Power Station." Such lands fall under the jurisdiction of the Administration of the Exclusion and Resettlement Zones under the Ministry of Emergency Situations of Belarus.

On the basis of the above, the Deputy Chairman of the Mogilyev District was in accord with his colleague from Gomel that it was not advisable to allot Chernobyl affected agricultural lands for cultivation of biomass for biofuels.

**Belneftekhim**

During the first UNEP/IEAE mission to Belarus, in May 2011, mission members received a slide presentation on Belneftekhim use of rapeseed to produce biofuel. The 2006-2010 Council of Ministers Directive on biofuel production mandated this initiative.

The Directive to the Corporation also stated that biodiesel had to be obtained from crops grown in Belarus, and sufficient to create a blend of Belarus diesel fuel supply that is 95% diesel oil and 5% biofuel. Members of the mission asked if the choice of rapeseed had been the subject of any comparative analysis of other potential crop options, but spokesmen for Belneftekhim were not aware that any comparative analyses had been undertaken.

Some advantages of rapeseed were made clear, however. According to Belneftekhim, rapeseed production is continuous over growing seasons (a questionable assumption as it would seem that rapeseed like other crops would need to be rotated to sustain consistent levels of production from targeted hectares), is a low-waste crop, and lends itself to the use of refining technology that can be deployed close to production sites. Rapeseed also produces two crops per year.

The rapeseed chain seems pretty well established. By “chain” is meant identification of lands, the product, its processing, and distribution is well developed. Table 15 below (developed by Belneftekhim) describes the overall schematics of rapeseed processing, while Table 16 describes the more precise process of rapeseed use in the production and mixing of biodiesel with conventional diesel oil.

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6 This is an especially important consideration in the use of Chernobyl affected lands as crops with higher waste volumes would present storage safe issues. This comparative advantage of rapeseed was addressed and the waste issue quantified in the IAEA/Ministry of Agriculture report discussed on PP. 53-54 in this report.
Table 15: Schematics of Rapeseed Processing

RAPE PROCESSING SCHEMATICS

RAPESEED

Straw
- Solid fuel for power stations

Seeds
- Rapeseed oil
- Rape cake
  - Solid fuel for power stations
  - Fodder elements

Liquid fuel for internal combustion engines
- Raw material for further processing
It has been determined by Belneftekhim that 1 hectare of crop yields 0.9 of a tonne of biofuel. Currently, between 5 and 20 thousand tones of oil were being produced each year. The variation is due to seasonal variations such as weather and other growing conditions.

The Corporation communicates its needs to the Ministry of Agriculture, and they assure delivery of the rapeseed product, again all from Belarus sources.

There was in May of 2011 a 2012 target for the production of 105,000 tons of rapeseed earmarked for biofuel production. Further, the Corporation stated that they are interested in meeting a target of having Belarus produced diesel meet a 70/30 percent split of conventional diesel oil and biofuel by 2015.

Belneftekhim also responded to the UNEP letter of inquiry dated November 3 2011, stating that it had reviewed, within the limits of its competence, the report of the first mission of the UNEP and IAEA experts on the assessment of the possibility of using the Chernobyl affected lands for cultivation of energy crops for biofuel production.

The Deputy Chairman of Belneftekhim stated that questions raised in the UNEP/IEAE first mission report regarding the areas of cultivation of rapeseed, and the reasons of preference given to this culture, were beyond the competence of the company to answer. It was
suggested that the answer to the questions about volumes and sources of rapeseed made available to Belneftekhim for the production of biodiesel should be referred to the Ministry of Agriculture.

Belneftekhim informed the UNEP that starting from 1994, the Research Institute of Physical and Chemical Problems of the Belarus State University had been carrying out research on the methods and technologies of obtaining biofuel from plant oils. More specifically, it was stated that a technological process has now been developed for obtaining biofuel from rapeseed oil.

It was also stated that, jointly with the scientific production company "Transtekhnika", research has been carried out on the identification of physical and chemical features and exploitation parameters of the biofuel had been developed, and that technical and economic parameters of production had been developed as well. As a result, a modern, effective way of obtaining diesel biofuel and associated by products from rapeseed has been developed within Belarus.

The UNEP obtained additional information from Belneftekhim during its second mission to Belarus in late January and early February 2012. Mission members were advised that by mid-2012 Belneftekhim will have the technical capacity to produce 90,000 to 100,000 tons of rapeseed derived biodiesel per year, from a new, large plant located close to the Chernobyl affected area (Mogilev District). Mixed with conventional diesel at 5% the overall yield of biodiesel mixed with conventional diesel would yield approximately 1,800,000 tons per year.

The Belneftekhim further advised that the Ministry of Agriculture would receive 40,000 tons of biofuel per year for powering agricultural machinery, and that Belneftekhim would be interested in exporting the remainder of their hypothetical production capacity, likely to the EU. Belneftekhim is currently adapting its chain of production of biodiesel to meet EU sustainability certification.

It was noted by Belneftekhim officials that while they will have the technical capacity to produce 90,000 to 100,000 tons of biofuel per year by mid-2012, current and even projected capacity outstrips the supply of rapeseed. This is due to poor weather conditions resulting in low yields of rapeseed in Belarus. The Ministry of Agriculture is currently endeavoring to develop rapeseed cultivars that are better suited to Belarus growing conditions and thus would give higher yields.

Representatives of UNEP also inquired of Belneftekhim whether they had considered developing ethanol (derived from corn) in addition to biodiesel from rapeseed. Belneftekhim advised that currently ethanol would be 1.5 times more expensive to produce than conventional diesel, and that current plants for the production of ethanol were deemed obsolete. While comparative economic analyses of the use of the economic advantages of other crops (other than rapeseed or corn) in Belarus production do not seem to exist (the UNEP inquired about such analyses but government and Belneftekhim officials were unaware of any), the experience globally is that, with the exception of Brazil, the use of alternative crops for biofuel production require substantial subsidies and remain viable on
energy security grounds rather than economic viability.
Part 3: Conclusions

Advantages of Using Chernobyl Affected Lands for Biofuel Production

- There is the potential for 5.5 thousand hectares of Chernobyl affected lands to be committed to agricultural use.
- These lands would be suitable for growing biomass that could be converted to biofuel nominally free of radiation.
- There is the potential for both a domestic and an international market.
- The technological capacity for production of biodiesel is already present in Belarus and that capacity is located close to the Chernobyl affected area.
- Given an over capacity of technology to produce biodiesel, using Chernobyl affected lands for biodiesel generating crops (rapeseed) would help close the gap between capacity and rapeseed production levels.
- Given the desire of the Ministry of Agriculture to have an increased supply of biodiesel for agricultural equipment, using Chernobyl affected lands for biodiesel generating crops (rapeseed) would help close the gap between the Ministry’s desired volume of biodiesel capacity and current levels of production.
- The use of Chernobyl affected lands for biofuel production would likely meet the sustainability criteria established by the EU.

Disadvantages of Using Chernobyl Affected Lands for Biofuel Production

- Arguably negligible amount of land in relation to expressed needs for greater volumes of rapeseed-derived biodiesel.
- High cost of land preparation, and fragmented nature of the 5.5 thousand hectares of potentially available lands makes production difficult and cost inefficient.
- Existing policy is to maximize use of any available land for the production of crops for human consumption.
- The Ministry of Agriculture, Ministry of Emergency Situations, and the Deputy Chairmen of the Gomel and Mogilev Districts do not favor the use for Chernobyl affected lands for biofuel production.
- Potential difficulties in securing safe disposal of contaminated wastes and the view of some experts that there is potential for worker exposures.

Overall Conclusions

- The technology is available to produce biodiesel from Chernobyl affected lands.
- There is a domestic demand for increased amounts of biodiesel from the Ministry of Agriculture.
- The Government of Belarus continues to be committed to the use rapeseed for the production of biodiesel. This commitment is being fortified by ongoing research at the Research Institute of Physical and Chemical Problems of the Belarus State University, which, in cooperation with the scientific company “Trantechnika”, has developed a modern and effective method for obtaining biofuel and associated products from rapeseed.
Biodiesel production capacity in Belarus will, by mid-2012, be sufficient to satisfy not only domestic demand but to have excess product for potential export (likely to EU markets).

The production of biofuel through use of formerly degraded land may have special appeal for the EU market, as suggested by current EU biofuel policy.

There is a socio-economic imperative to return Chernobyl affected lands to productive use as soon as possible.

The fragmented and limited amount of Chernobyl affected lands that are potentially available for the production of biofuels appears to further constrain the commitment of these lands to that use.

In view of current government policy that emphasizes the use of all potential agricultural lands for the production of crops for human consumption, the use of Chernobyl affected lands for the production of biofuels appears to be of low priority.

These statements also indicate clearly that Chernobyl contaminated lands, that portion of contaminated lands suitable for agricultural production, are to be part of a new, efficient system of land use aimed at the formulation by 2015 of an optimized structure of agricultural lands for sustainable development of food products for food production and cattle breeding.

However, to suggest that the use of Chernobyl affected lands may not offer sufficient opportunity for Belarus is not to suggest that opportunity does not exist at national level for increased focus on biofuel production.

Indeed, there is both capacity and opportunity for Belarus to take advantage of the rapidly growing international market for biofuels. In order to take maximum advantage of this opportunity there would need to be a comprehensive strategy towards the development of biofuel trade, including development of technological and production capacities for second generation biofuels.

Given the enormity of the EU market as a future consumer of imported biofuel, especially the current EU requirement that biodiesel constitute 10% of diesel content by 2020, and a growing insistence that imported biofuel be sustainably derived, the proximity of the EU market to Belarus provides it with a ready and lucrative market should it choose to become a biofuel exporting country.
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