Local and Global Biodiesel Production:

A Carleton County, New Brunswick Perspective

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Introduction

The Canadian federal government has announced its plans to dramatically increase Canada's renewable fuel production to 5% by 2010. Achieving this goal will require dramatic increases in biofuel production, particularly in biodiesel, which significantly lags behind Canadian ethanol production. Presently, Canada only produces around 15.5 million litres of biodiesel per year ((S&T)^2 Consultants, 2004), whereas Germany, the world's largest producer, consumed 1.920 million litres in 2005 (Worldwatch Institute, 2006). Over the past few years there has been increasing interest in growing crops for biodiesel around Canada, including in New Brunswick. Local farmers in Carleton County have begun field tests to measure the feasibility of growing canola for biodiesel. But what is biodiesel and is it really such a "green" and renewable fuel? Will growing biodiesel feedstocks, the materials that are transformed into biodiesel, revitalize rural communities? Where can farmers and communities look for models of biodiesel production that allow for financial security, community vitality, and environmental protection? Answering these questions requires analysing the environmental, economic, and social strengths and weaknesses of biodiesel production from the field to the fuel, particularly as they are related to the local community, but also in terms of international implications.

Biodiesel is touted as a panacea to our present oil shortages and the environmental problems of climate change associated with petroleum fuel use. However, although biodiesel does reduce greenhouse gas emissions (GHG) in comparison with fossil fuels, a wide range of concerns must be addressed as governments and agri-energy corporations around the world move toward a bioenergy economy. Diversifying sources of renewable fuels is an integral component of reducing dependency on fossil fuels; however, there are four facets of biodiesel production that will ensure its sustainability (adapted from Kleinschmit and Smith, 2006) and increase energy self-sufficiency:

- dramatic reduction in energy consumption;
- local production and ownership of feedstocks, fuels, and processing plants;
- foundation on sustainable agriculture; and
- certification of sustainable production practices.

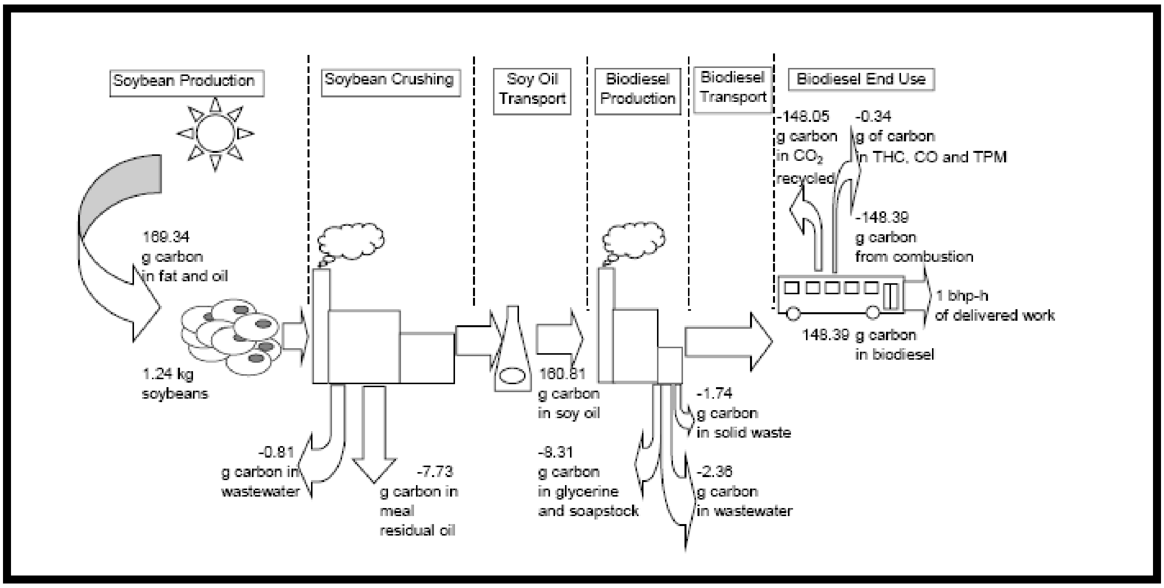
At the local scale, Carleton County, New Brunswick is presently researching the feasibility of biodiesel production. As a region that presently grows no commercial oilseeds, it is important to carefully develop a bioenergy industry that will sustain the environment and local communities for future generations.

Biodiesel: From the Field to the Fuel

Biodiesel forms part of a larger group of fuels known as biofuels, which also include ethanol, or biorefineries, which include by-products such as biolubricants and biopesticides. Ethanol is an alcohol, produced from sugar cane in Brazil and corn in the United States, and is used to replace or supplement gasoline. Biodiesel is used in diesel engines and is derived from vegetable oils, animal fats, or waste vegetable oils. New technology, called cellulose conversion technology, allows for ethanol and biodiesel to be produced from any biomass, for instance, willow trees, switchgrass, and agricultural or forestry residues; however, this technology is presently too expensive for commercial production. Since Carleton County is primarily interested in biodiesel production, this report looks at the biodiesel lifecycle, or, the process of growing a biodiesel feedstock to producing a fuel for transportation or heating, in order to develop an understanding of the underlying environmental, economic, and social benefits and costs of this renewable fuel.

Biodiesel, if made from virgin oils, has a lifecycle that, in Canada, begins with the process of growing a feedstock such as canola or soybeans (Figure 1). Feedstock production is the most expensive and environmentally-damaging stage in the biodiesel lifecycle, mainly due to the use of fossil fuel-based fertilizers and chemical in-puts such as pesticides. However, the primary source of energy at this stage is solar. The plant also consumes carbon dioxide, a greenhouse gas, during its growth. Transforming solar energy and carbon dioxide into a fuel source is the reason biodiesel is considered a renewable fuel with low greenhouse gas emissions. Once harvested, the oilseeds are transported to a crushing facility to produce vegetable oil and meal (an animal feed that Canada currently imports). This oil is then transported to a biodiesel facility to be chemically converted into biodiesel through a process called transesterification. The process requires approximately 10% per volume methanol or ethanol (alcohols presently derived from fossil fuels), a catalyst (sodium or potassium hydroxide), energy for heat, and water for cleaning the final product. The waste products are crude glycerine, which can be refined and sold as a by product, and contaminated water. Energy sources for biodiesel processing also play an important role in determining the environmental impacts of the fuel; whether coal, nuclear, hydro, fossil fuels or renewable energies are used dramatically influence biodiesel's overall sustainability. Distances between the stages of processing are important considerations in the feasibility of biodiesel production, since transporting the feedstocks or the final product result in higher costs, energy inputs, and GHG emissions.

Figure 1: Biodiesel lifecycle in carbon equivalents (multiply number by 3.67 for actual CO_2 emissions)

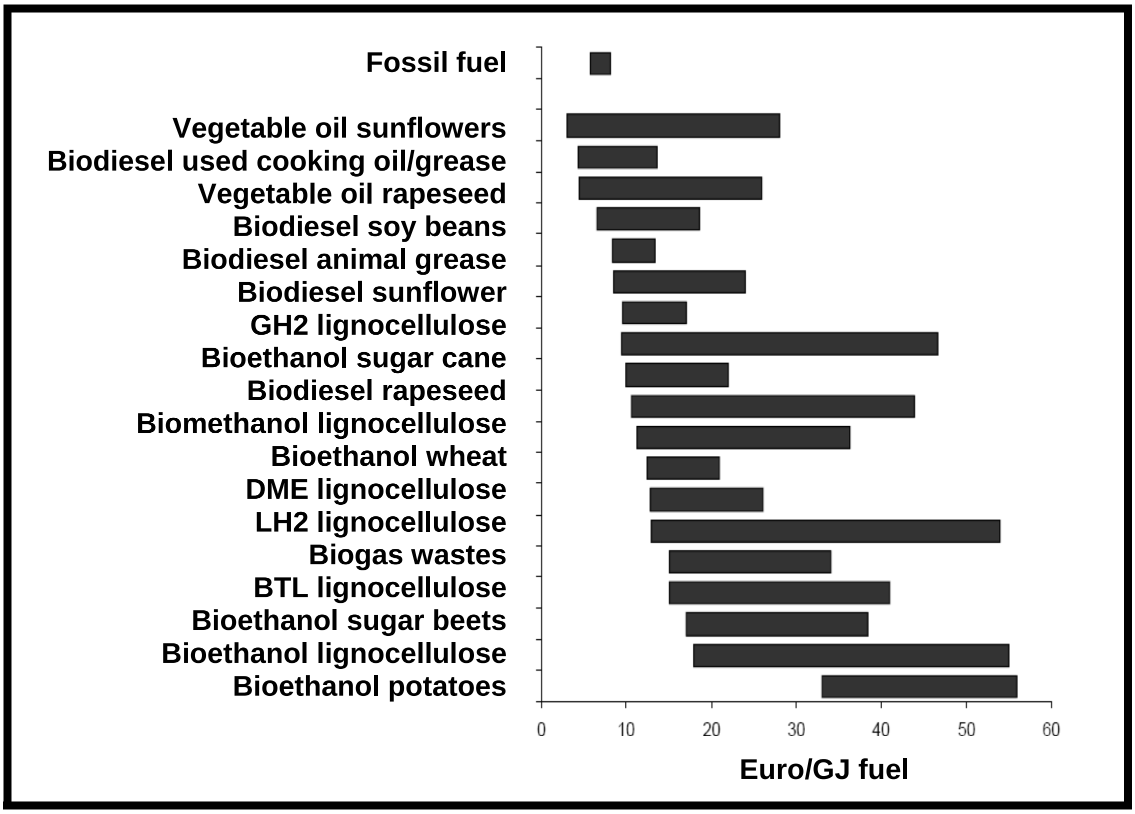


Costs of Shifting from Food to Fuel

Biodiesel production presently remains more expensive to produce than petroleum diesel production ((S&T)[2] Consultants, 2004; IFEU 2004). However, since petroleum prices are predicted to continue increasing due to dwindling reserves, and biodiesel production costs will decrease as the technology becomes more efficient and available, the price of biodiesel may in fact become more competitive. The most economically feasible and environmentally sound way of producing biodiesel presently is to use waste vegetable oils (WVO) as a feedstock (Figure 2). Examples of small-scale biodiesel processing from waste vegetable oils can become sustainable models of energy production that minimize the environmental, economic, and societal risks of large-scale biodiesel production.

The full cost for producing biodiesel is a complex question and the research done on this topic indicates that absolute values cannot be generated since there are too many variables that require consideration. Fluctuating grain prices play an important role here, since they are a global commodity and fluctuate much the same way oil prices vary. For that matter, biodiesel requires inputs of energy and fossil fuels, which means that production costs depend on global oil prices and the type of energy used to process the biodiesel (coal, nuclear, hydro, renewables, etc.). Evidently, agricultural practices play an important role in determining costs. No studies were found to demonstrate that biodiesel could be more effectively produced using organic agricultural practices; however, this is a direction that merits research, since organic agriculture requires fewer fossil fuel in-puts than conventional farming. According to IFOAM, organic agriculture is well-positioned to participate in the growing biofuel economy to replace fossil fuels (IFOAM, 2004: 25).

Figure 2: Production costs of biofuels compared to the production costs of fossil fuels in Euro/GJ fuel content (IFEU, 2004: 28)



Assessing the full cost of biodiesel production requires applying a lens to the entire lifecycle of biodiesel's production and analysing the environmental, economic, and social implications of this fuel source. Compartmentalizing biodiesel production into the three pillars of sustainability allows for a more holistic understanding its benefits and drawbacks. This compartmentalization, however, can also reduce the complexity of an issue. For instance, land use change can be considered an environmental concern because of deforestation or the impacts of intensive agriculture. On the other hand, land use changes are also social changes, with the potential of benefiting rural communities, perpetuating colonial north-south relations, or resulting in other social changes. This is particularly the case when agricultural lands in developing countries are diverted from food into fuel production. The following sections analyse biodiesel production from the perspective of environmental, economic, and social benefits and concerns; wherever possible, solutions are also presented.

Environmental Benefits

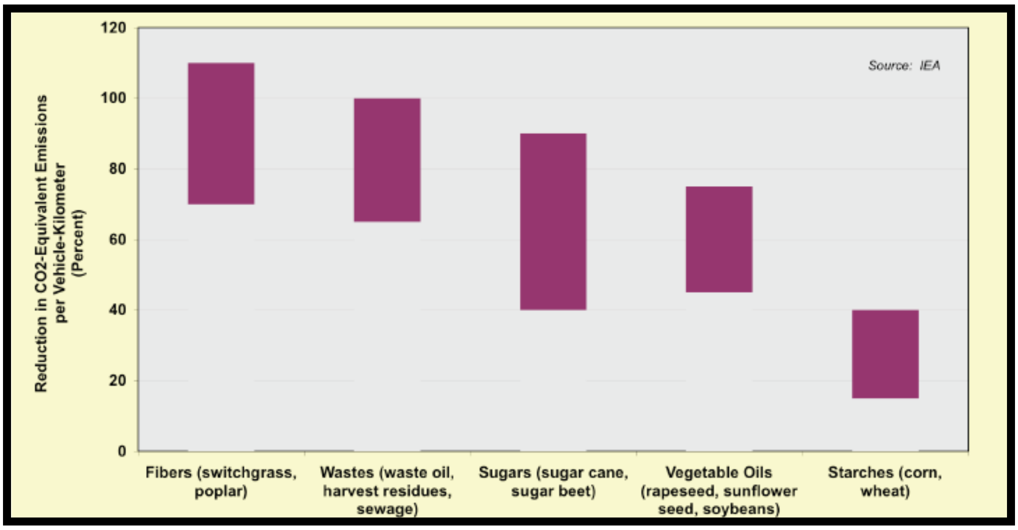
Biodiesel is promoted as a renewable fuel source since it is produced primarily from crops grown annually, instead of relying on non-renewable fossil fuels. The environmental benefits of biodiesel in comparison with petroleum diesel are generally considered to be:

- 40-70% reduction in GHG emissions
- Reduction in air pollution, particularly in comparison with lead-based diesel
- Classification as non-toxic
- Biodegradable (blending biodiesel with petroleum diesel accelerates the rate at which the latter biodegrades)
- The use of biodiesel/petroleum blends make petroleum diesel burn better
- Sulphur-free
- Use in heavy machinery for agriculture and construction can have major environmental benefits as these are important sources of GHG emissions and pollution

(National Resources Canada, 2004; I-SIS, 2006; National Biodiesel Board; Worldwatch Institute, 2006)

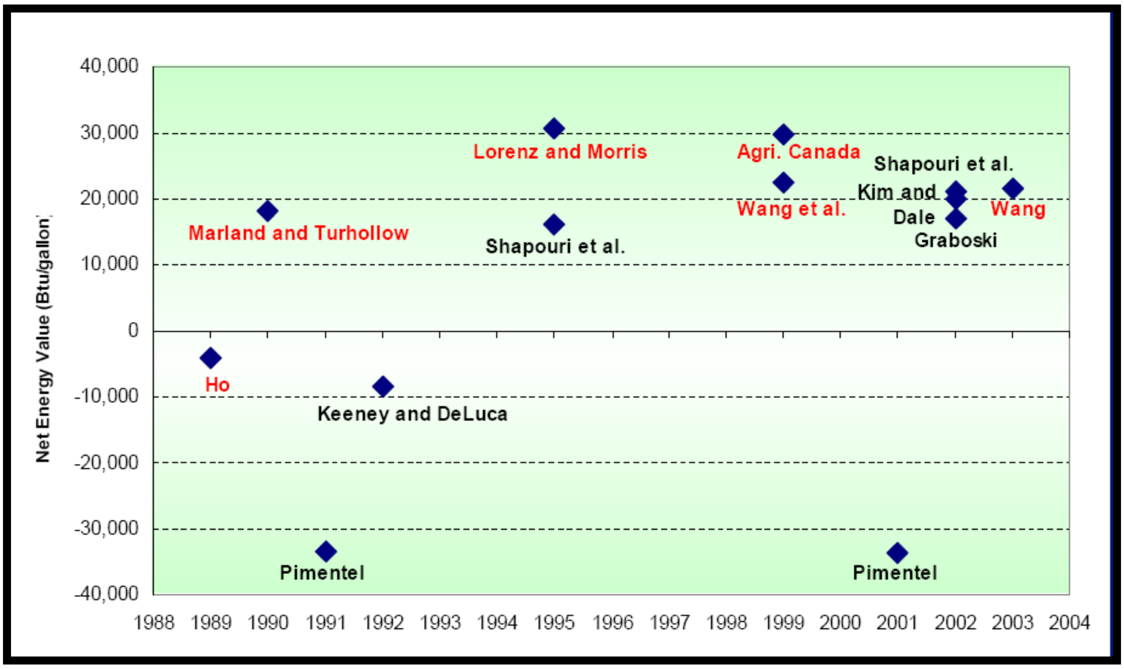
Most studies reveal that biodiesel feedstock plants absorb the majority of the carbon that is emitted when biodiesel is combusted. This means that no "new" carbon is released into the atmosphere, which is what occurs when fossil fuels, which have stored carbon for billions of years, are combusted. However, society must at this point in time reduce its GHG emissions, not just maintain a net balance of zero emissions per year. Also, as long as biodiesel requires fossil fuels for its production and is only used in blends (most blends with fossil petroleum fuels are between 5-10%), biodiesel will in fact continue contributing to GHG emissions and global climate change (Figure 3). Figure three demonstrates that WVOs and ethanol (from sugar cane, etc) contribute to higher GHG emissions reductions than biodiesel produced from vegetable oils. However, the conversion of fibers through cellulose conversion technologies into biofuels, technologies coined "Second Generation Biofuels", are the most effective at reducing GHG emissions. Presently, cellulose conversion technology is too expensive to be competitive with other forms of biofuel production and remains at an experimental stage.

Figure 3: Greenhouse gas emissions reductions by feedstock type (Worldwatch Institute, 2006)



The debate about net energy gains from biodiesel, or biofuels in general, is heated and controversial. Overall, studies demonstrate that biofuels are excellent sources of energy; however, various studies demonstrate a wide range of net energy balances (Figure 4).

Figure 4: Corn ethanol net energy values according to various researchers, since 1988 (Wang, 2003)



The most commonly cited statistic is that it takes one unit of energy to produce 3.2 units of energy from biodiesel (USDA/DOE, 1998: 13). This is in contrast with findings from Pimentel and Patzek, which reveal that biodiesel production from soybeans requires 27% more fossil energy than is contained in the biodiesel produced. The types of modelling used and the vested interests of some of these researchers strongly influence their results.

As fossil fuel dependency and use is reduced, biodiesel can offer a locally-produced fuel that displaces the negative environmental impacts associated with current fossil fuel dependency, such as climate change, oil spills and other impacts of long-distance transportation, habitat destruction (through the construction of pipelines, etc.), and, increasingly, the negative social and environmental impact from wars and terrorism.

Environmental Concerns

Biodiesel is not a panacea, however, for the negative environmental impacts associated with fossil fuel consumption. There is considerable debate on its overall environmental benefits. The National Biodiesel Board, which is funded by the state soybean commodity groups, and the Canola Council of Canada support biodiesel's use as a renewable fuel, whereas other organisations, such as the Flemish Institute for Technological Research and the Institute for Science in Society, paint another picture entirely. Compared with findings presented by the United States Department of Agriculture and the National Biodiesel Board (see environmental benefits above), research conducted at the Flemish Institute for Technological Research, sponsored by the Belgian Office for Scientific, Technical, and Cultural Affairs and the European Commission, tells a very different story. In a paper presented at an international conference sponsored by the US EPA in 2000, it stated: "…biodiesel fuel causes more health and environmental problems because it created more particulate pollution, released more pollutants that promote ozone formation, generated more waste and caused more eutrophication." Hence, "the benefits biodiesel fuel offers in terms of reducing greenhouse gas emissions do not justify its use in light of the other environmental damage it causes" (I-SIS, 2006).

Primarily, environmental concerns are linked to the agricultural stage of biodiesel production, particularly due to the use of fertilizers and chemical in-puts. Processing biodiesel, however, also results in negative environmental impacts, especially if energy sources such as coal or nuclear are used for electricity. The environmental concerns of biodiesel compared with petroleum diesel can be summarized as follows (Figures 5 and 6):

- Increases inorganic raw materials, the mineral feedstock for making fertilisers, by 100 percent

- Increases non-radioactive wastes, primarily gypsum, a by-product of phosphate fertilizer, by 98%
- Increases radioactive wastes due to electricity supplied by nuclear power plants by 90%
- Increases eutrophication from fertiliser run-offs by 75 percent
- Increases photochemical oxidants due to volatile organic compounds released during the production of biodiesel, especially hexane in solvent-based oil extraction, by 70%
- Increases water use (in the esterification process for creating biodiesel) by 30 percent
- Increases acidification from nitrogen and sulphur oxides and ammonia released during the growth of rapeseed crop, also from nitrogen oxides emissions from burning biodiesel, by 15 percent
- Fugitive emissions of methanol
- Disposal of the by-product glycerine
- Generation and disposal of wastewater containing free fatty acids that have a high biochemical oxygen demand, or BOD, which removes oxygen from water bodies and harms aquatic life

(I-SIS, 2006; New Hampshire Department of Environment Services, 2006)

Figure 5: Environmental impact categories of biodiesel production (De Nocker et al., 1998)

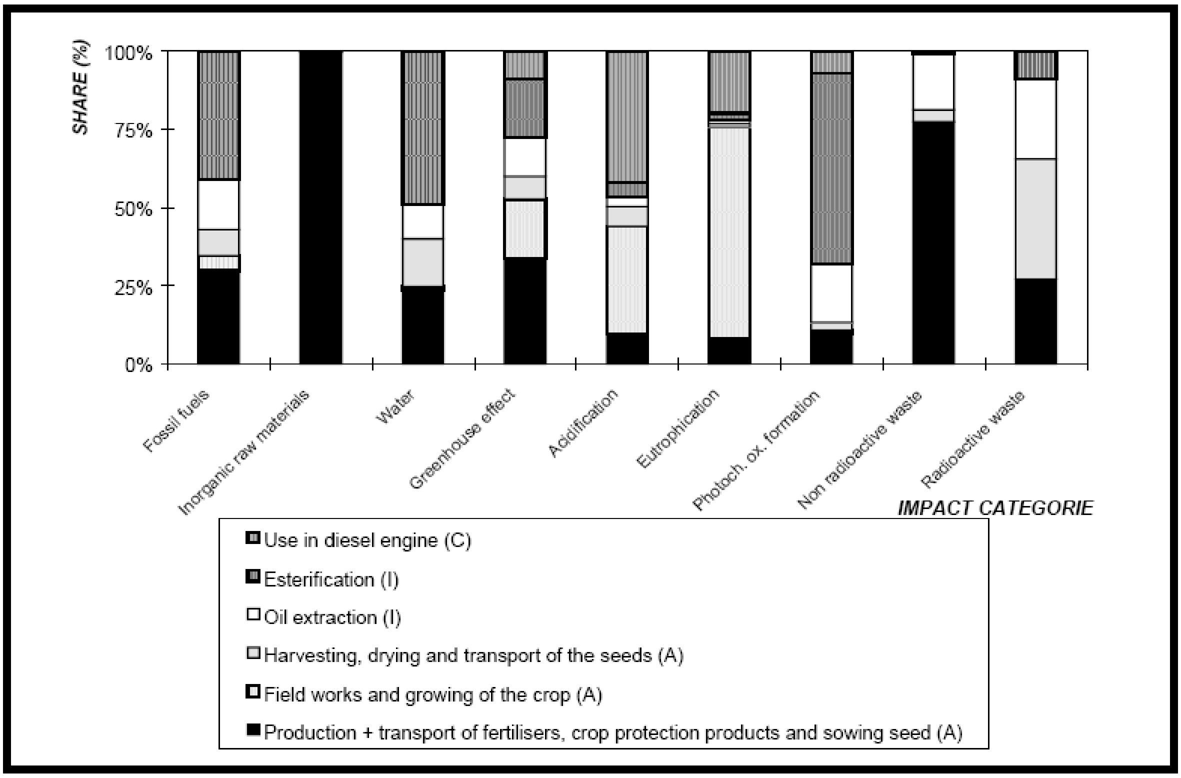
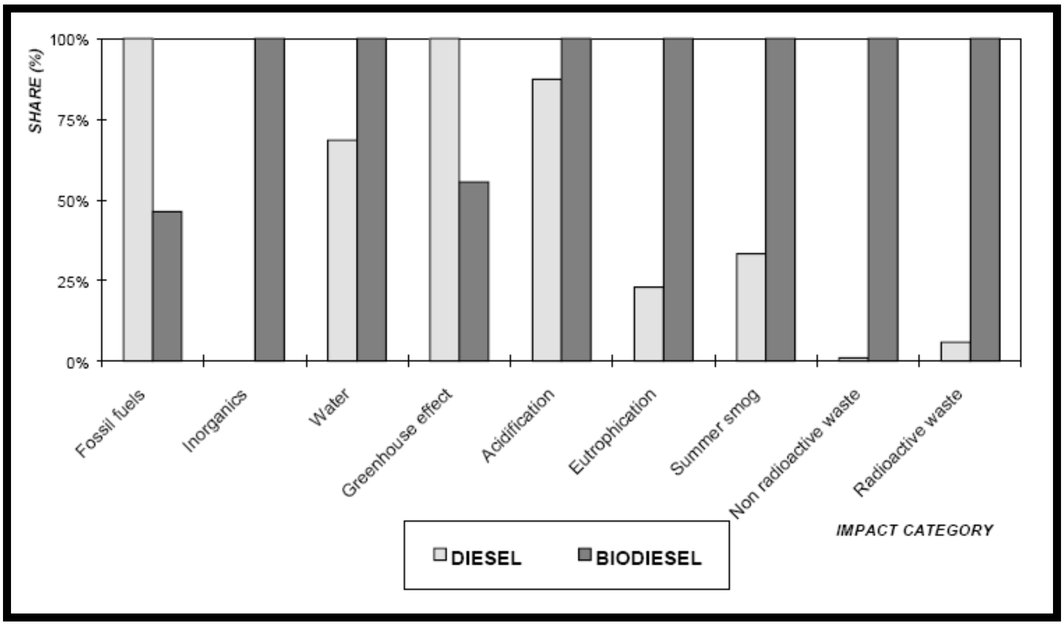


Figure 6: Comparison of environmental impacts out of 100% between biodiesel and diesel (De Nocker et al., 1998).



As the charts in Figures 5 and 6 demonstrate, agriculture is an important source of GHG emissions and pollution in biodiesel production. Evidently, the types of crops grown, the climate, soils, and agricultural methods used strongly influence biodiesel's overall environmental impact. Growing rapeseed or canola, for instance, is a relatively expensive crop to grow, requiring frequent rotation and extensive use of expensive fossil-fuel fertilisers. Fertilisers are fossil fuel by-products and also require considerable amounts of energy for their production. According to the International Federation of Organic Agriculture Movements (IFOAM), 1kg of Nitrogen as ammonium nitrate fertilizer results in 40.61 MJ of fossil fuel energy consumed, or the release of 6.7 kg CO_2 equivalents into the atmosphere (IFOAM, 2004). The most well-known critic of biofuel production, David Pimentel, argues that there is a net energy loss in the production of biodiesel, primarily as a result of the use of chemical fertilizers. In his article with Tad W. Patzek, "Ethanol Production Using Corn, Switchgrass, and Wood: Biodiesel Production Using Soybean and Sunflower" they demonstrate that, although biofuels consume more energy than they produce, soybeans are a preferable crop to sunflowers (and canola) because they are a legume and therefore do not require nitrogen-based fertilizers (Pimentel and Patzek, 2005).

Also linked with agriculture and potentially negative impacts of biodiesel are changes in land use as a result of a growing biodiesel industry. Clearly, deforestation for the sake of developing crops for fuel would have significant impacts on the environment (soil erosion, habitat destruction, loss of biodiversity, etc) and would undermine biodiesel's claim as a means of reducing GHG emissions. Transforming forests, or even fallow fields and other marginal land, into croplands for biodiesel would "result in large releases of carbon from the soil and existing biomass, negating and benefits of biofuels for decades. Therefore, governments must prioritize the protection of virgin ecosystems and should adapt policies that compel the biofuel industry to maintain or improve current management practices of land, water, and other resources" (Worldwatch Institute, 2006).

Genetically Modified Organisms

Increasingly, biodiesel production goes hand in hand with the widespread use of genetically modified organisms (GMOs). In Canada, the main biodiesel feedstocks are canola and soybeans, both crops that are often grown using genetically engineered seeds. There are serious environmental and social concerns linked to the use of GMO in agriculture (for more information, see: http://www.greenpeace.ca/). The European Union continues to ban GMOs on the grounds of environmental and human-health related concerns. Through the case of Percy Schmeiser, Canada has become internationally recognized as an example of why genetically modified seeds are problematic for farmers and consumers. As the Schmeiser case revealed, one of the major concerns associated with the use of GMOs is that the genes can be spread to other plants. This poses serious economic, social, and environmental concerns, many of which are still unknown. Due to human reluctance for GMO in foods, some countries are seeing biofuels as a valid means of using feedstocks derived from genetically modified seeds. For instance, in Brazil, President Lula has declared that GM soya is to be used for biofuels and "good soya" for human consumption. Argentina also has plans to transform GM soya into biodiesel (I-SIS, 2006). Other countries and regions (such as the EU), however, may reject Canadian oilseeds precisely because they contain GMOs.

Using GMO in biofuels does not eliminate their environmental impact. However, researchers are presently studying more ways of integrating gene technology into the biofuels industry rather than less. Second generation biofuels, for instance, are produced from cellulose conversion technology which requires genetically modified industrial organisms, such as yeasts, to break down the cellulose and lignin in biomass derived from forest or agricultural residue. These next generation biofuel feedstocks are predicted to use cellulose-rich organic material such as willow, eucalyptus, tall grasses, and municipal waste.

Researchers are presently developing GM trees that are fast-growing, disease-resistant, and low in lignin for these second generation biofuel feedstocks (Ragauskas, Arthur et al., 2006). There are many concerns about the risks of using such a procedure on forest ecology and on community control of local forests. Wind-dispersed pollen from many types of trees travel hundreds of kilometers, and it is almost certain that genetically engineered pollen will contaminate wild trees. When this happens, there will be no more control over the effects that it could have on the environment, including changes to tree health, soil biology, water quality, insect ecology, nutrient break-down, and general forest structure. In addition, engineered trees may become patented, continuing the trend that we see in the world today of corporations being able to own life forms, the issue which is at the heart of the GMO controversy in agriculture.

However, not all proponents of biofuels see need to use GMOs. Although GMOs are often promoted as “environmentally friendly” because they can reduce pesticide use and tillage (for example, Monsanto’s Roundup Ready soybeans), the Canada Clean Fuel Association, on the other hand, believes that crops grown for fuels will be cheaper and require fewer chemical and pesticide in-puts, without using GMOs. A developing biodiesel industry must address its relationship with GMO in its feedstocks. The risks of this technology need to be assessed and appropriate safeguards are also necessary (Worldwatch Institute, 2006).

Solutions

Presently, there is some concern that crops grown for fuel will be faced with fewer regulations because they will not be considered food crops for human consumption. Since biodiesel and other biofuels such as ethanol are already rapidly developing, regulations are necessary to protect the environment and, ultimately, the people that depend on a healthy environment. Two strategies, beyond overall reductions in fuel consumption, are therefore necessary to ensure that biodiesel is sustainable:

- Small scale, sustainable agriculture
- Government policies, nationally and internationally

Small-scale sustainable agriculture offers numerous solutions to the high GHG emissions and environmental degradation related with the large-scale intensive monocultures that presently characterize feedstock growing practices around the world. For instance, “in Germany, organic farms have 48-66 percent lower CO_2 emissions per hectare compared to conventional systems” (IFOAM, 2004). According to Pimentel et al., “among the benefits of organic technologies are higher soil organic matter and nitrogen, lower fossil energy inputs, yields similar to those of conventional systems, and conservation of soil moisture and water resources (especially advantageous under drought conditions). Conventional agriculture can by made more sustainable and ecologically sound by adopting some traditional organic farming techniques" (Pimentel et al., 2005). These findings are the result of a 22-year study conducted at the Rodale Institute and highlight the important role that sustainable agriculture can play in producing renewable fuels.

National and international environmental regulation will be necessary to ensure the development of biodiesel production that reduces environmental impacts. Government leadership and public participation will be important in setting ecological and social standards for forestry (for biomass production from residues) and farming practices. In the Worldwatch report to the German Ministry of Food, Agriculture, and Consumer Protection, recommendations are made for agricultural policies that "monetize" environmental agricultural practices. For instance, reducing erosion and runoff for payments or tradable credits would encourage commercialization of new crops. Overall, in order to protect the environment, Worldwatch recommends that governments: enforce bans on wild land conversion for biofuel feedstock production and impose strong penalties for non-compliance; tie tax incentives, carbon credits, sustainable production certification, etc. to the maintenance of natural ecosystems; and require land preserves, particularly to compensate for large-scale production (Worldwatch, 2006). Increasingly, governments and non-governmental organizations are pushing for standardization and certification of biofuel production to ensure minimal environmental and social risks.

Economic Benefits

Economically, biodiesel can benefit farmers and rural communities first and foremost with increases in markets for agricultural products. For instance, Canada is seeing an increase in canola exports, in part because of European biodiesel production. According to Statistics Canada, total stocks of canola reached a record 5.1 million tonnes, an increase of 1.4 million tonnes from the March 2005 level of 3.7 million tonnes. The rise in stock levels was mainly the result of record production in 2005 that is slowly being coaxed out of the bins as a result of more encouraging market potential from Europe for use in the manufacture of biodiesel fuel (Statistics Canada, 2006). Increased agricultural production means increased employment opportunities in rural communities and rural economic development. A growing biofuel economy also leads to increased innovation and investments in research and development as Canada develops crops and technologies that best reflect its climate and biofuel needs.

Additional economic benefits are linked to biodiesel consumption itself compared with petroleum diesel. For instance, economic modelling found that a large diesel truck using a very low 0.5% canola biodiesel lubricant additive would result in almost $4,000 economic savings over a year (250,000km total) due primarily to reduced engine wear (AAFC, 2002: 16). Further economic benefits can also be calculated if such factors as lower health-related costs due to reduced emissions are included. For instance, the exhaust emissions of carcinogenic aromatic compounds PAH and NPAH are reduced by 75% and 90% respectively by biodiesel combustion (National Biodiesel Board). Until the full cost of fossil fuels on human and ecosystem's health is understood, the economic benefits of biodiesel versus fossil fuels will not be apparent.

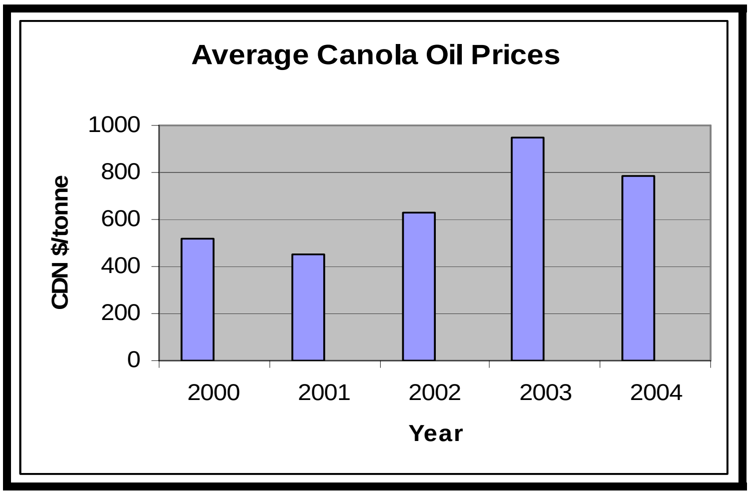
Economic Concerns

Presently, the cost of producing biodiesel remains higher than the cost of petroleum diesel production; this is a major disincentive for biofuel's large-scale production in Canada. The price of feedstock used in the production of biodiesel relative to petroleum prices is a key determinant in the feasibility of biodiesel. According to Biocap's 2004 Biodiesel Report, "established food markets and prices for canola and soy oil, as well as production costs, make their use as a biodiesel feedstock currently financially uncompetitive with petroleum-derived diesel" (Hobein et al., 2004: 8). The most cost and energy effective source of biodiesel is from WVO (waste vegetable oils). However, supplies are insufficient (less than 5%) to meet the growing demand for biodiesel, particularly since the Liberal government, through the Climate Change Action Plan, as well as the present Conservative government have committed to produce 500 million litres of biodiesel by 2010. To achieve this goal, it would require 132,000 tonnes of animal fats (for 150 million litres of biodiesel) and 308,000 tonnes of vegetable oils (for 350 million litres of biodiesel) ((S&T)^2 Consultants, 2004: 6).

Although biodiesel is promoted as a means of improving rural livelihoods and farm incomes, the global fluctuations in feedstock prices result in an unstable foundation for the biodiesel industry. For instance, in Canada between 2000 and 2004, average canola oil prices ranged between $451.86 and $946.06 per tonne of oil (Figure 7).

Moreover, as the biofuels industry grows, production is increasingly taken away from small producers and shifted toward large-scale manufacturing. The O'Connor Report warns that as manufacturing facilities become larger, costs of production may increase due to increased transportation costs for feedstocks once the local capacity to supply feedstock demand has been exceeded ((S&T)^2 Consultants, 2004: 110). There is growing concern that, "of all the participants in the biofuel economy, agribusinesses are most assured to profit, since mechanized harvesting and production chains are the easiest option for rapidly scaling up biofuel production (Worldwatch Institute, 2006). Evidence of strengthening global supply chain alliances in the biofuel industry are between Pioneer Hi-Bred/DuPont, Cargill/Dow, and ICI/National Starch/Novamont. These partnerships could rapidly push out smaller producers who are unable to compete with the large capital investments capable by these giant corporations (AAFC, 2002: ii). Internationally, this pressure is already building, as biofuels traders push the World Trade Organization to liberalize trade in agricultural commodities (Worldwatch Institute, 2006). These developments undermine farmers' and countries' ability to protect local economies and retain the economic benefits of biofuel production.

Figure 7: Canadian canola oil prices per tonne (Canadian Canola Industry, 2006)



Solutions

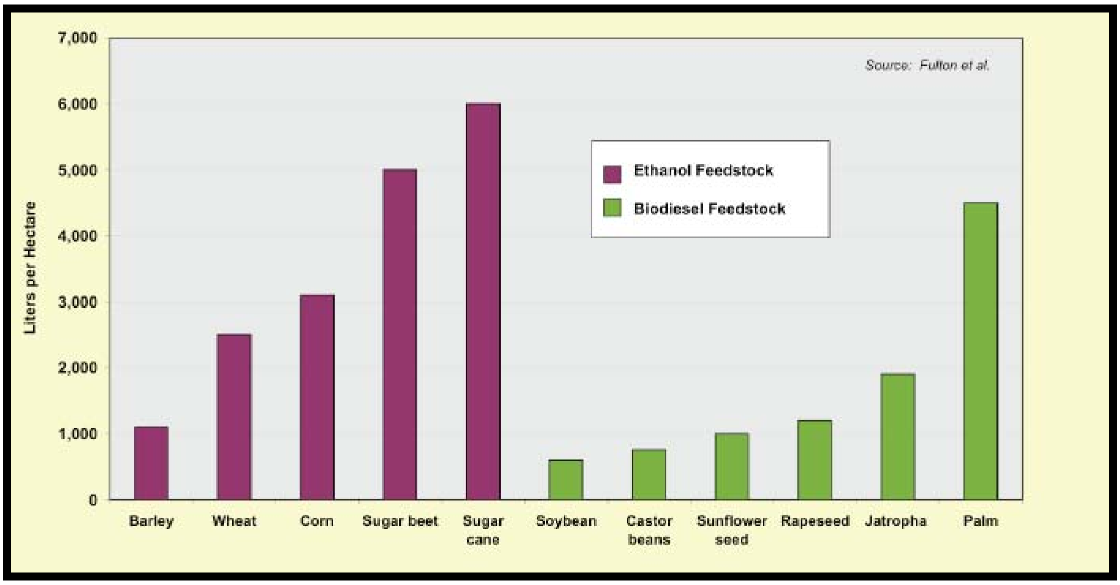
Economically, biodiesel remains unfeasible unless governments create incentives or subsidies to support the growing industry. To date, Canada lags behind other countries, such as the United States, and the European Union in supporting biodiesel development; this has had a direct impact on biodiesel's slow development. All reports in favour of developing biodiesel recommend that the Canadian government demonstrate leadership by creating tax incentives or other forms of subsidies to help make biodiesel competitive with petroleum diesel prices (AAFC, 2002; Holbein et al, 2004; $(S\&T)^2$ Consultants, 2004).

Beyond national economic policies, however, integrating sustainability and community economic development plans into biodiesel development will require holistic models that reflect social and environmental requirements. For instance, to encourage an equal distribution of biodiesel's economic benefits throughout the production process, from farmer to fuel processor as well as indirect beneficiaries in local communities, small-scale facilities linked with growers on the one hand and consumers on the other hand will maximize these benefits. Maintaining this connection is vital, especially for farmers, who fear that large agri-energy corporations may force the prices of oilseeds below production costs and further undermine the vitality of rural communities. This also ties into concerns that large-scale biofuel production would increase demand for biofuel feedstocks, which would lead to increases in food prices (ex. increased corn prices in the United States due to increased ethanol production). However, it is also possible that poor people, particularly farmers, in remote areas can benefit from participating in "value-added" stages of biofuel production, especially if they crush their own oilseeds and produce their own fuel locally (Worldwatch Institute, 2006).

Social Benefits

Biodiesel, or biofuels in general, provide the greatest direct and indirect social benefits as a result of their capacity to provide fuel self-sufficiency. Biofuels are unique sources of energy because they stem from renewable biomass; this makes them a highly localized yet also broadly distributed fuel source around the world. Compared with fossil fuels, biofuels are labour intensive due to the agricultural roots of the fuel source as well as the slightly more complex production process. These factors result in more employment opportunities in rural communities throughout the world, reduced dependency on and exploitation of fossil fuels that largely come from socially-unstable regions, and improved human and environmental health from a less-polluting fuel source. In particular, biofuels can lead to social benefits for developing nations, such as fuel self-sufficiency, employment opportunities, and economic development because biofuel feedstocks, such as palm oil, jatropha, and sugar cane, grow best in tropical countries (Figure 8).

Figure 8: Biofuel yields of common feedstocks (Worldwatch Institute, 2006)



Social Concerns

A common criticism of biodiesel and biofuels is that diverting agricultural land from food production to fuel production will exacerbate world hunger. World hunger, however, is a complex problem caused be numerous factors such as unequal access to and distribution of resources, environmental degradation, and, increasingly, climate change. Increased biodiesel production may increase the barriers to adequate food supplies faced particularly by people in developing countries, especially if significant areas of land in the tropics are controlled by agri-energy corporations producing oils for export to northern countries.

The development of lands for biodiesel production in the south is already underway. For instance, British Petroleum has announced it will fund a $9.4 million project by The Energy and Resources Institute in Andhra Pradesh to produce biodiesel from jatropha, a non-edible oilcrop. The project, expected to take 10 years, would involve cultivating jatropha on about 8,000 hectares currently designated as “wasteland” (I-SIS, 2006). In addition, Wilmar Holdings Ltd. in Indonesia, the world's second-largest palm oil producing country, plans to develop another 3.0 million hectares of forest into plantations in the next five years, partly to meet biofuel demand. The company also has a joint venture plan with Archer Daniels Midland Company (ADM), an American oilseed processing company, to build a biodiesel plant in Singapore, but both companies are still considering the project’s feasibility (Reuters, July 3, 2006). Biofuel production will increasingly be located in southern countries, since “the potential for biofuels is particularly large in tropical countries, where high crop yields and lower costs for land and labour—which dominate the cost of these fuels—provide an economic advantage that is hard for countries in temperate regions to match” (Worldwatch Institute, 2006).

Although large scale projects are promoted as beneficial to developing nations’ economic development, problems arise when they perpetuate colonial relations between the First and Third World. For instance, banana and tea plantations or even mines have been developed to provide the First World countries with cheap resources, mostly without consideration for human rights or environmental protection.

Solutions

Increasingly, non-governmental organizations, corporations, and national governments are recognizing the need for certification and standardization of biofuel production in order for the fuel to fulfill its mandate as a sustainable, renewable resource. For instance, The Roundtable on Sustainable Palm Oil demonstrated how accrediting Palm Oil, one of biodiesel’s key feedstocks, can improve its sustainability, particularly through the reduction of tropical rainforest deforestation. The Roundtable is particularly aware that "better managed plantations and oil palm smallholdings serve as models of sustainable agriculture, in terms of economic performance as well as social and environmental responsibility" (Roundtable on Sustainable Palm Oil).

Small-scale biodiesel production provides the most social benefits; however, governments need to implement strong policies for labour standards and profit sharing. For instance, in São Paulo, Brazil and Minnesota, U.S.A., farmers participate in small-scale production through co-operative models: "Minnesota-based ethanol plants, especially coops, benefit the state economy by spending more of their money on raw materials inside the state, and by keeping more of their profits and dividends inside the state" (New Rules). Maintaining the biofuel industry at the scale of communities and farmer-owners is the most likely model that will benefit rural communities and reduce risks, even when harvests are poor, because communities will benefit directly from producing and using biofuels. Since technologies to convert biomass are becoming increasingly accessible, converting biomass to energy may lead to poverty alleviation, especially in remote oil-dependent communities (Worldwatch Institute, 2006).

Carleton County's Biodiesel Development: Concerns and Potential

New Brunswick, according to Statistics Canada, presently does not grow any significant oilseed crops, such as canola or soybeans, which could be processed for biodiesel ((S&T)^2 Consultants, 2004). This sets it at a considerable disadvantage compared with the Prairie Provinces, which have well-established oilseed crops and export markets. However, biodiesel has the potential to become a localized source of fuel, particularly because transportation costs are some of the most significant reasons for high biodiesel prices. In addition, Canada presently does not grow enough oilseeds to meet its growing demand for biodiesel feedstocks; this situation can allow for the development of new sources of feedstocks from new regions, such as Carleton County, New Brunswick. Before barrelling ahead with biodiesel development, the environmental, economic, and social implications of biodiesel production in the region must first be carefully considered.

Carleton County is one of North America's largest potato growing regions. If the area were to move toward growing crops for biodiesel feedstocks, it would require a certain amount of transitioning. However, farmers in the area would not transition out of potatoes, which are the region's main revenue generator, toward a biodiesel feedstock. These biodiesel feedstock crops would become part of the potato crop rotation. Since there are presently approximately 50,000 acres of potatoes planted in a 3 year rotation, New Brunswick has the potential capacity of growing 100,000 acres of canola or other feedstocks per year.

In 2005 there were 2,000 acres of soybean trials along with 600 acres of canola and 300 acres of flax grown in a trial in New Brunswick. Soybeans had an average yield of 28 bushels per acre, flax had an average yield of 24 bushels per acre, and canola yielded 32 bushels per acre. Given stable yields across the province, a maximum of approximately 12 % of New Brunswick's farmland would be required to produce enough oilseed to meet the province's potential biodiesel consumption level (Figure 9) (Eber, 2006; 10).

Figure 9: Acres needed to meet New Brunswick's 19 million litre potential biodiesel demand (field test results for soybean, flax, and canola) (Eber, 2004: 11)

	bu/acre	Oil Content	Kg oil/acre	Acres needed	% of total New Brunswick farmland
Soybean	28	19%	153	117860	12.3
Flax	24	45%	218	69670	7.3
Canola	32	42%	305	55980	5.8

Canola, the most popular crop considered for local biodiesel production, in the potato rotation could possibly produce a rotational benefit from possible soil fumigation from the growth and incorporation of straw; however, this is likely not as beneficial as a green manure plow-down of a brassica. One possible disadvantage with canola in the rotation would be with the disease white mold or sclerotinia, which is also a disease in potatoes (Peter Scott, personal communication). On another note, however, biodiesel feedstocks cannot completely replace crops presently grown for livestock feed, this therefore slightly lowers the overall acreage available.

Although crop development is presently underway to develop canola feedstocks, soybeans may in fact offer more benefits for the environmental and local farmers. Soybeans have lower oil content than canola, which make them a less economic feedstock choice; however, they offer the benefit of being legumes and not requiring expensive fertilizers. Canola is a resource-intensive crop to grow, requiring large inputs of fertilizers. As a guideline for New Brunswick growers, canola is predicted to cost $406.32/acre (total operating and total fixed) to grow; this is considerable higher than the cost of growing conventional grain crops in the area (Scott, 2006).

Economically, biodiesel is promoted as a source of rural community economic development; however, concerns exist that pressure from large corporations for cheap feedstocks would force farmers to grow crops below the costs of production. In addition, since Carleton County presently does not grow any biodiesel feedstocks commercially, it is not prepared to rapidly transition to large-scale production. Although economies of scale dictate that large-scale processing facilities are the most economically feasible means of producing biodiesel, the local context indicates that small-scale facilities reflect the needs and limitations of the area better.

New Brunswick is experiencing increasing depopulation of its rural regions, a trend that decreases the sustainability of rural livelihoods. Biodiesel production can become part of the region's strategy to improve rural economic development through increased employment and indirect socio-economic benefits. If Carleton County moves toward biodiesel production, it must carefully weigh the benefits and drawbacks of various models of production. One the one hand, it is possible to develop mega-plants that would require feedstocks from a large region; this model may be in line with future trade agreements arising out of Atlantica, the proposed Atlantic Canada-New England trading area. On the other hand, small scale models linking farmers and biodiesel consumers, similar to Community Supported Agriculture (CSA), are a further possibility for Carleton County to develop biodiesel production with smaller financial risks, greater social benefits, and minimal environmental impacts.

Conclusion

First and foremost, the solution to environmental, economic, and social problems associated with society's dependency on fossil fuels is to reduce fossil fuel consumption. Growing food crops for biofuels is only effective if present fossil fuel consumption is reduced. According to the European Union's Environment Commissioner, Stavros Dimas, "the only long-term sustainable solutions to the energy challenge are to achieve dramatic, indispensable improvements in energy efficiency and, at the same time, to expand renewable energy sources." This statement was made in June 2006 at a conference in Brussels titled "A Sustainable Path for Biofuels in the EU" (http://www.transportenvironment.org/Article186.html). Improvements in energy efficiency can have large implications for biofuel effectiveness: "A recent study found that advanced biofuel technologies could allow biofuels to substitute 37% of U.S. gasoline within the next 25 years, with the figure rising to 75% if vehicle fuel efficiency were doubled" (Worldwatch Institute, 2006). If biofuels are truly to become a solution to mitigating climate change and improving fuel self-sufficiency, society must also make dramatic improvements in vehicle fuel economy, public transportation, urban planning, and local and international transportation systems.

With drastic reductions in fuel consumption, biofuel production based on sustainable agricultural practices and respect for human rights can develop into a sustainable fuel source. To guarantee this, however, governments will be required to implement policies that "compel the biofuel industry to maintain or improve current management practices of land, water, and other resources and ensure strong labour standards. Based on lessons learned from organizations such as the Forest Stewardship Council, the approach used to establish policies and standards for feedstock sustainability should be transparent, independent, and participatory" (Worldwatch Institute, 2006).

Small-scale cooperative models of growing biofuel crops sustainably or recycling waste vegetable oils for biofuel production are steps toward ensuring the benefits from biofuels are maintained in local communities, without jeopardizing food production or the environment. Farmers and consumers are increasingly supportive of sustainable agriculture; the move toward sustainable biofuel production would be a natural next step. For instance, in the United States, a diary farmer is already heading toward growing organic biodiesel feedstock. A Washington State University agricultural analyst's response to this initiative was positive: "organic canola [biodiesel feedstock] looks like a sure-fire money maker as long as organic cattle feed remains in short supply" (Banse, 2006). Commitment to a healthy environment, sustainable economies, and strong communities is at the heart of developing any new project—these decisions must be made with the full participation of farmers, producers, and end-users to be viable. Consideration for future generations will ensure that the path of biodiesel production taken in Carleton County, Canada, and around the world allows for the sustainable production of a truly renewable fuel source.

Acronyms

CO_2	Carbon dioxide
EU	European Union
GE	Genetically engineered
GHG	Greenhouse gases
GMO	Genetically modified organisms
NPAH	Nitro-cyclic Polycyclic Hydrocarbons
PAH	Polycyclic Aromatic Hydrocarbons
WVO	Waste vegetable oils

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