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Study: Bill C-33, Act to amend the Canadian Environmental Protection Act, 1999

BRIEF BY REAP CANADA

ANALYZING BIOFUEL OPTIONS: GREENHOUSE GAS MITIGATION EFFICIENCY AND COSTS

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I. INTRODUCTION

REAP Canada is pleased to be invited to participate in the current study of Bill C-33, Act to amend the Canadian Environmental Protection Act, 1999. With over 17 years of experience in bio-energy systems research and development in Canada, REAP is a leading expert in the science and economics of the renewable fuels sector.

The development of new renewable fuel regulations through amendments to the Canadian Environmental Protection Act requires a comprehensive critical review prior to implementation. According to a recent government news release, the primary objectives of these regulations will be to: a) reduce greenhouse gas (GHG) emissions by approximately 4 megatonnes per year in the transportation sector; and b) benefit Canadian agricultural producers by generating demand for feedstocks and opening new markets for Canadian agricultural crops[1]. It is on the basis of these two major objectives that the new regulations must be evaluated; both in terms of their absolute capacity to achieve said results, as well as their relative effectiveness when compared to other agricultural biofuels.

II. 2008 BIOFUEL OPTIONS STUDY SUMMARY

Bill C-33 regulations require average annual renewable fuel contents of at least 5% for gasoline and 2% for diesel and heating oil by 2012, creating demand for 2.1 billion litres and 600 million litres of renewable gasoline fuel alternatives and diesel/heating oil alternatives, respectively[1]. This brief summarizes the comparative cost-effectiveness of these transportation sector incentives, as well as other potential federal and provincial energy policy incentives in mitigating GHG emissions in the province of Ontario. This analysis is based on a 2008 study by REAP-Canada undertaken for the BIOCAP Canada Foundation entitled *Analysing Ontario Biofuel Options: Greenhouse Gas Mitigation Efficiency and Costs*[2]**.**

2.1 <u>What Makes a Good Bio-Fuel?</u>

When comparing GHG offset capacity, there are two main factors to consider:

- <u>GHG reduction potential</u>: The efficiency of GHG offsets (%) determined by the net GHG savings gained by replacing a fossil fuel with a biofuel option (kg CO_2e/GJ); and

- Cost-effectiveness: The incentives required to offset 1 tonne of CO_2e (\$/tonne) determined by the subsidy for each unit of energy produced (\$/GJ) and its mitigation impact.

The *Analysing Ontario Biofuel Options* study provided a direct comparison of the relative costs and benefits for climate change using strategies in three energy sectors - transportation fuel, electricity generation, and thermal energy applications - using the province of Ontario as the test case. The study concluded:

1. Programs to reduce GHG's through alternative liquid transportation fuels (ethanol, biodiesel) are expensive; and
2. Renewable transportation fuels offer low GHG mitigation effects when compared to green power generation (wind, biogas) and renewable heating alternatives (grass pellets).

2.2 BioEnergy Life Cycle GHG Emissions

Life-cycle analysis of the GHG emissions produced during production of the different bio-energy alternatives from 'cradle to grave' demonstrates that renewable transportation technologies produce the highest GHG emission profiles, followed by electrical power generation from renewable energy or "green power". Heating applications from renewables or "green heat" produce the lowest GHG emission profiles (Figure 1).

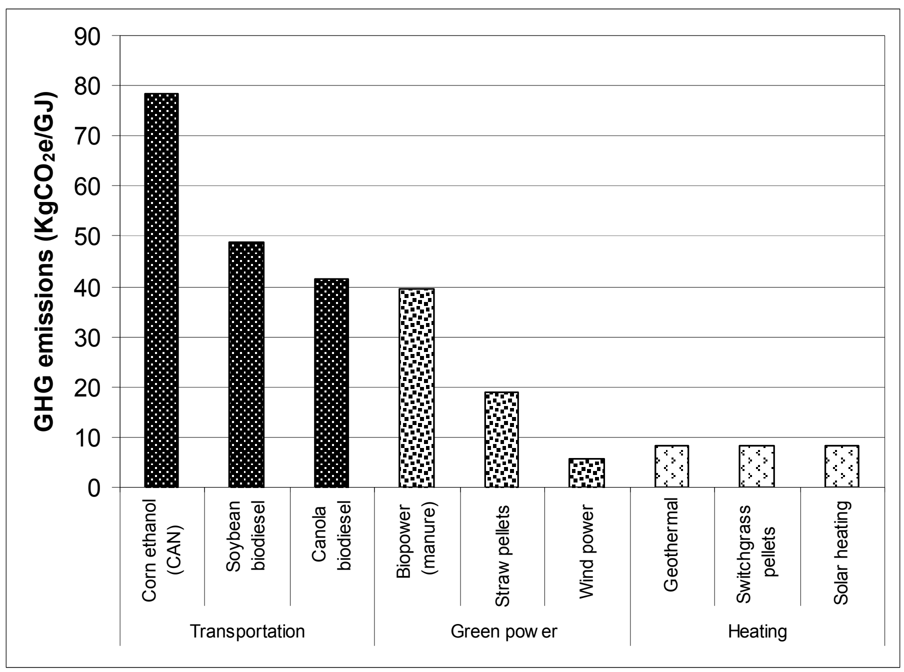

Figure 1. Life cycle GHG emissions for production of bioenergy fuel technology by energy use sector[2]

2.3 GHG Offsets From Ontario Farmland Using Biofuels

GHG offsets are the total net GHG emissions prevented when a renewable fuel is 'switched' with a non-renewable option (i.e. fossil fuels), including life-cycle emissions produced during the renewable fuel production. In general, the higher the GHG emissions required to produce a biofuel, the less offset potential it can offer. The GHG estimates reported in *Analyzing Ontario Biofuel Options* are based on Natural Resource Canada's GHGenius modeling program, as well as a number of highly respected scientific journals. Canola biodiesel and soybean biodiesel were found to reduce emissions by 58% and 50% when replacing regular diesel fuel, while corn ethanol was found to reduce emissions by only 21% when it replaced gasoline (Figure 2). By comparison, green power strategies were found to be more efficient, by reducing GHG's by 87-98% relative to coal power generation. Overall, the most effective fuel-switching opportunities were found to be geothermal heating, switchgrass pellets, straw pellets, and wind power. Solid biofuel pellets were found to be the most efficient GHG mitigation option that can be generated from Canadian farms.

"Canola biodiesel and soybean biodiesel were found to reduce emissions by 58% and 50%, while corn ethanol was found to reduce emissions by only 21%."

One of the key lessons emerging from this study and others is *the need for further research and analysis on life-cycle emissions* – current accounting systems are often inadequate and underestimate the GHG's emitted from a given technology, particularly landscape emissions involving N_2O and land conversion.

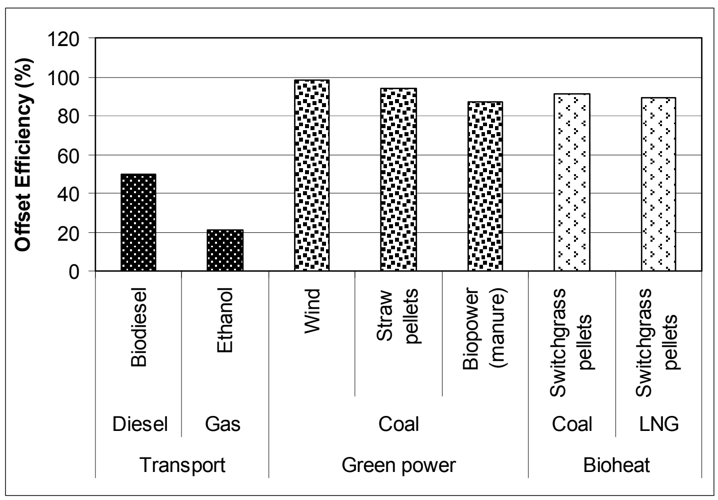

Figure 2. Offset efficiency of biofuel options by energy use sector[2]
(note:LNG-liquefied natural gas)

2.4 The Cost of GHG Mitigation

Governments at the federal and provincial levels have recognized the need for incentives to help renewable energy technologies to become comparable with fossil fuels in the market. At present, existing Ontario and federal incentives for green power generation from wind, biomass, and biogas total $15.28/GJ, while liquid biofuel incentives are approximately $8.00/GJ for corn ethanol and $5.64/GJ for biodiesel. There are no significant incentive programs for green heat although thermal energy such as heat for space, water heating, and process energy applications represent Ontario's largest energy demand. As such, a hypothetical green heat incentive of $2.00-$4.00/GJ was examined for switchgrass, wood and straw pellets in order to determine the potential effect that such a subsidy would have on GHG mitigation costs from green heat. Based on these different incentives, the cost to offset one tonne of GHG's was calculated in the three sectors (Figure 3).

Given the current options for renewable energy incentives, *green power and green heat were found to be the least expensive farm-derived options* to reduce GHG emissions. These options could reduce GHG's at a cost of about $25.00-$50.00/ tonne CO_2e given the aforementioned hypothetical incentive. The most expensive alternatives are liquid biofuels, costing $98.00, $114.00 and $378.00 per tonne of CO_2e abated for canola biodiesel, soybean biodiesel and corn ethanol, respectively. From the standpoint of costs to the Canadian taxpayer, transportation fuels have been found to be, on average, the most expensive option for reducing GHG emissions.

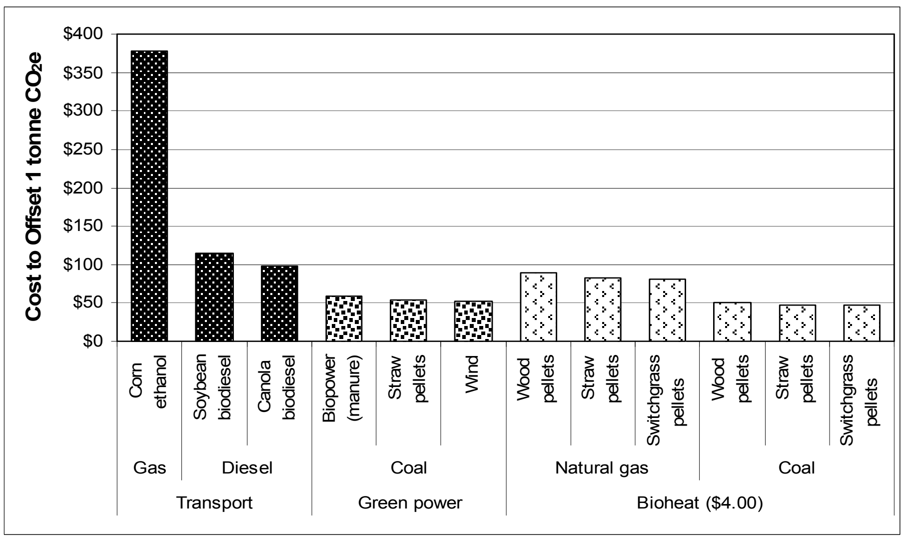

Figure 3. Cost to offset 1 tonne of CO_2e for selected renewable fuels using existing and proposed incentives in Ontario[2]

The *Analyzing Ontario Biofuel Options* study highlights additional policy strategies which could be developed to more effectively encourage GHG abatement than those outlined by Bill C-33. Specifically, a portfolio of opportunities involving green power and green heat have yet to be considered, while the least effective strategy of renewable transportation fuels is receiving vast government resources for both research and implementation. Current policies are based on the quantity of renewable energy produced with limited emphasis on the actual effectiveness of the technology on GHG emissions and reductions. A more effective approach is to focus policy efforts on CO_2 abatement. In doing so, bioenergy systems that aim for both high output of renewable fuel per hectare and efficient GHG offsets from each unit of renewable fuel produced are encouraged. Large reductions in GHG emissions are possible in Canada using *existing* technologies. The major need is to create an effective policy framework for technologies to serve the desired outcome of GHG mitigation.

III. EMERGING ISSUES

3.1 The Biofuels Carbon Debt Problem

If Bill C-33 is proposed to be part of the government efforts to create a "Made in Canada" GHG solution to create rural development, it has serious challenges. A major impact of the legislation could be the conversion of carbon rich grasslands into annual crop cultivation. Canada is currently a net importer of about 2 million tonnes of corn per year. Imports of corn are forecasted to increase in Canada as a result of the increase in demand generated by the expanding ethanol industry[3]. Currently, about 1.0Mt of corn and 0.5Mt of wheat are used to produce 0.6 billion litres of ethanol in Canada. Given the current/proposed policy, Canada will require approximately 4.6Mt of corn per year for ethanol production by 2010. Surplus cropland does not exist in eastern Canada for this production.

Western Canada has a limited surplus of low value feed wheat suitable for ethanol production. In 2002, economists at the University of Manitoba estimated that 670,000 tonnes of surplus feed grains are available annually in western Canada[4]. Feed wheat produces modest ethanol yields of 365 litres/tonne versus 400 litres/tonne for corn. The conclusion of the Manitoba study was that the likely impact of ethanol legislation would be imports of U.S. corn for ethanol and/or livestock production in Manitoba. It also concluded that western crop producers were likely to continue to concentrate on more lucrative high quality wheat exports. Now that wheat prices have reached record prices of $10/bushel, this is all but a certainty. From the standpoint of providing economic opportunities for Canadian farmers, the primary objectives of Bill C-33, the benefits will be limited as opportunities to increase production of feed wheat or corn-based ethanol are limited.

"Recent studies estimate that U.S. corn ethanol will *double* greenhouse gas emissions over the next 30 years by increasing the carbon debt from land conversion."

Canada will either be forced to import U.S. corn or to convert Canadian grasslands into annual crops - if 2.1 billion litres of ethanol are to be produced. New sources of corn land will be required for expanding ethanol production in both Canada and the U.S., which will include the conversion of pasture, hay and conservation reserve programs. The land conversion of carbon rich grassland to corn production could present a substantial risk to the global carbon cycle.

Recent studies report that previous corn ethanol analyses have failed to include carbon emissions resulting from converting forest and grasslands to corn production. Using a global model, Searchinger *et al.* estimates that corn-based ethanol will double greenhouse gas emissions over the next 30 years and increase greenhouse gases for 167 years[5]. Similarly, Fargione *et al.,* estimates that land conversion to corn ethanol will generate a 'biofuel carbon debt' of 48-93 years[6].

If the primary objective of Bill C-33 is to reduce GHG emissions, the land conversion issue means that this renewable fuel legislation will not decrease GHG emissions. The crucial point is that agricultural technologies using marginal lands are available that can more effectively fight climate change. Canada's policy needs to forward the best possible land-use options for biofuel production and GHG mitigation to create a genuine "Made in Canada" solution.

3.2 Liquid Natural Gas Imports

Currently, the main producers of ethanol are in eastern Canada and the major source of energy to both grow the corn and operate the ethanol plants is natural gas. Recent data released by the National Energy Board indicates that within 20 years time, Canada will be a net natural gas importer[7]. Advanced plans for importing liquefied natural gas (LNG) plants are in place in order to meet part of the future gas demand for both British Columbia, and eastern Canada from a foreign nation such as Qatar or Russia. However, GHG emissions associated with natural gas imports using LNG have been projected to be 28% higher than conventional natural gas[2]. In the future, ethanol plants in eastern Canada could potentially find themselves in the position of increasing GHG emissions by producing biofuels that are dependent on foreign grains and foreign natural gas. In November 2007, the Quebec government abandoned corn ethanol as a policy. The government of Canada should also recognize that large scale expansion of ethanol in Canada will largely result in taxpayers' money going to support markets for U.S. corn producers and foreign natural gas exporters. It must also be recognized that the GHG profile of biofuels from imported corn and LNG will be worse that conventional gasoline because of the additional carbon burden associated with the biofuel carbon debt and carbon intensive LNG used to process ethanol in these plants.

3.3 What About Cellulosic Ethanol?

The *Analyzing Ontario Biofuels Options* report focused on technologies that were commercially ready, and therefore did not review cellulosic ethanol in detail. Given the fact that Bill C-33 regulations will take effect over the next five years, it is expected that cellulosic ethanol has limited potential to impact during this term. In fact, there are serious concerns as to whether cellulosic ethanol will emerge as a viable technology in the next decade.

Cellulosic ethanol has a poor track record in terms of predicting commercial viability. In 1991, leading cellulosic ethanol scientists wrote an overview paper in the journal Science on cellulosic ethanol, projecting that a commercially viable technology would emerge and be: a) competitive with the rack price of gasoline at $1/gallon by the year 2000; and b) well below rising gasoline prices by 2008[8] (Figure 4). Seventeen years later, the rack price of gasoline is now $2.25 gallon, but cellulosic ethanol is not yet cost competitive; despite the fact that generous incentive programs are in place for ethanol in North America.

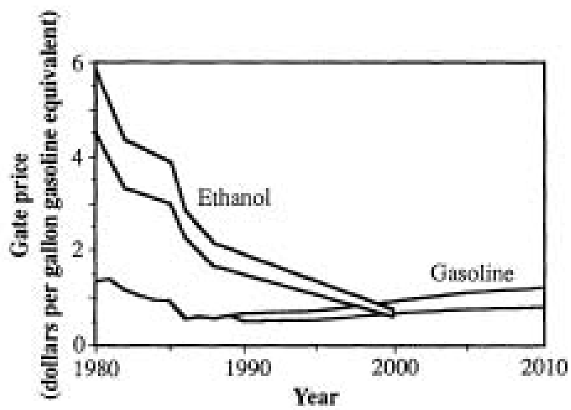

Figure 4. 1991 projections for future cellulosic ethanol and gasoline costs[8]

While improvements to cellulosic ethanol technology can be expected in the coming years, the technology appears to be facing two major problems: a) it is thermodynamically inefficient; and b) it is highly capital intensive. At present, it is assumed cellulosic ethanol plants convert lignocellulosic biomass into ethanol at 330 litres per tonne[9]. This results in 39% conversion efficiency, assuming 18.0 GJ/tonne of solid biomass converts into 7 GJ of liquid fuel (330l x 0.021 GJ/l). Cellulosic ethanol is a high capital cost technology, both on a per plant basis and per unit of renewable energy produced. A typical commercial cellulosic plant (such as the proposed Iogen facility in Idaho) would have an estimated cost of 250 million USD for facilities processing an average of 210,000 tonnes of biomass into approximately 68 million litres (18 million US gallons) of cellulosic ethanol each year[10]. Assuming plants are operating 330 days of the year, this equals production of 325 litres of ethanol per tonne of biomass feedstock. Overall, the proposed plant results in a capital investment requirement of $175/GJ of energy production capacity.

In contrast, pellet plants which convert essentially all the energy in dry agricultural biomass into a solid fuel pellet cost approximately 3-10 million dollars for 30,000-100,000 tonne per year plant. The capital cost of plants, based on recent estimates, is approximately $5/GJ of output energy[11]. While it is evident that there is a difference in the energy quality of these two biofuel products, pellets can replace high quality fossil fuel energy forms including natural gas and heating oil when used in advanced pellet boilers.

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3.4 Biodiesel Issues

The utilization of animal fats, off-specification oilseeds and recycled vegetable oils is largely advantageous to both the Canadian economy and the environment. However, biodiesel will be extremely difficult to scale up in Canada from domestically produced agricultural crops.

There are several fundamental problems with growing biodiesel from oilseeds in Canada as a dedicated energy crop. The first problem is that oilseed crops are protein crops and inefficient converters of solar energy. In eastern Canada, oilseeds (prior to processing for oil extraction) capture 25% of the energy that whole plant lignocellulsoic biomass crops like whole plant corn silage or switchgrass capture[12]. This low energy production per hectare from oilseeds, make them extremely expensive on farm sources of energy. Current market prices for soybean and canola vegetable oil are well beyond their economic viability as biodiesel crops, with canola oil prices reaching almost $1000CDN/tonne and canola seed prices over $400CDN/tonne in the fall of 2007[13]. Soy oil is equally expensive, trading at over $1300USD/tonne[14]. Prices for high quality wheat and canola seed crops are prohibitive for their development as viable feedstocks for the bioenergy industry, particularly considering that carryover stocks of grain have fallen to 54 days of world consumption, the lowest on record[15].

Growing switchgrass pellets is the most efficient use of farmland to offset GHG's, displacing 8-10 times the GHG's of corn ethanol.

Biodiesel from Canadian sources is likely to remain uneconomic unless massive government subsidies are created to support the industry. Virgin crops of canola and soybean should not be considered as energy sources as they are both poor performers as a renewable energy production system and an ineffective means to use farmland to mitigate GHG's. Furthermore, as annual crops they create the same biofuel carbon debt problems as was discussed with expanding corn use.

3.5 How can Canadian farmland most effectively be used to offset GHG's?

Canada is a resource-rich nation, with the capacity to produce *all* its energy from renewable sources; however, this requires optimization of our resource potential. Excellent opportunities exist to grow our own bioenergy crops, but we must focus on the most efficient options for doing so (Table 1).

Table 1: Potential GHG offsets per hectare for various renewable fuel options

Renewable fuel option	**Crop yield** (tonnes/ha)	**Fuel yield from crop** (litres or GJ/tonne	**Total energy produced** (GJ/ha)	**GHG offset per unit of renewable fuel** ($kgCO_2e$ /GJ)	**Net GHG offset of renewable fuel** ($kgCO_2e$/ha)
Soybean biodiesel	2.67	193	18.04	49.73	**897**
Corn ethanol	8.4	400	70.56	21.23	**1,498**
Switchgrass cellulosic ethanol	9.0	330	62.4	76.16[a]	**4,753**
Switchgrass pellets	9.0	18.8	169.2	79.73[b]	**13,490**

[a]Cellulosic ethanol offset is equivalent to a value of 76.5%[16]
[b]When replacing coal, switchgrass pellet offsets are equivalent to 79.73 $kgCO_2e/GJ$[2]

Thus, in terms of efficiency, switchgrass pellets can displace approximately **8-10 times** the GHG's of corn used for ethanol.

IV. RECOMMENDATIONS FOR THE COMMITTEE

<u>This bill should be withdrawn for 3 reasons:</u>

1. **It won't appreciably reduce GHG emissions.** It is evident that the 4 million tonnes of CO_2 anticipated by this proposed legislation has no solid scientific support of being achieved. Using the petroleum GHG displacement values for corn ethanol at 21% and canola biodiesel at 58% reported in *Analyzing Ontario Biofuels Options* study, only 2.1 million tonnes of CO_2 will be displacement. If the land conversion necessary to produce the 4.5 million tonnes of corn annually to meet this target is included there will be no mitigation realized.

2. **It is not a "Made in Canada" solution**. The legislation primarily will support markets for U.S. corn growers. (In eastern Canada it will also help create markets for imported LNG required for the energy intensive corn ethanol processing industry). Western wheat and oilseed producers will not divert virgin crops to these industries because $10/bushel wheat and $1000/per tonne canola oil do not make for economically viable biofuels.

3. **The legislation does not demonstrate fiscal responsibility**. CO_2 offsets from corn ethanol are in the order of 6-10 times more expensive that other available renewable energy alternatives. Current biodiesel incentives of 20 cents per litre, totaling $98/tonne of CO_2 abated, will not be sufficient for producers to divert vegetable oils to biodiesel markets, requiring higher incentives by the government to achieve the 2% blend level as proposed.

To create effective GHG mitigation from biofuels that will support rural Canada the federal government should:

1. **Implement results based management** throughout its' research and incentive programs to ensure the desired outcomes of GHG mitigation and rural development are achieved. The combination of effective carbon offset efficiencies and high energy output per hectare will produce the greatest offset per hectare. Large reductions in GHG emissions are possible in Canada using existing bioenergy and renewable energy technologies but lack an effective policy framework.
2. **Embrace perennial energy crops and abandon the use of annual crops as biofuels.** It should be recognized that there is limited surplus arable land in Canada. The main opportunity for biofuels is from perennial energy crops on marginal lands which have a high net energy gain/ha, effective carbon storage in the landscape, and low N_2O emissions. Using annual food crops as fuel will cause land conversion problems, increase food inflation, and unduly stress world food security. Agriculture Canada has had a long bias towards funding research on existing food crops for fuels rather than investing research dollars in more efficient whole plant lignocellulosic perennial crops. This deficiency needs to be corrected.
3. **Create parity in the bioenergy marketplace.** The Canadian government should not "pick winners". Instead, a more effective approach is to focus policy efforts on CO_2 abatement through uniformly applied incentives. By using marketplace principles to mitigate CO_2, the government would encourage bioenergy systems that both produce a high output of renewable fuel per hectare and create efficient GHG offsets from each unit of renewable fuel produced. One possible approach could be to create a $25.00/tonne CO_2e carbon tax and a $25.00/tonne green carbon incentive. This would create greater parity in the renewable energy marketplace, limit impacts on fossil energy users, and provide incentives for industry to fuel switch to green carbon sources.

ENDNOTES

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REAP-Canada **www.reap-canada.com**

Resource Efficient Agricultural Production (REAP) –Canada, based in Montreal Quebec, is one of the worlds most experienced agencies in sustainable biofuels systems research and development. The agency has 22 years of research and development experience in sustainable farming systems development in Canada. REAP-Canada is also recognized internationally as a leading agency in biofuels and biomass feedstock development having worked with partners in Brazil, China, The Philippines, and several nations in West Africa. Within Canada, REAP was the first agency to begin working to develop switchgrass as an energy crop for the bioheat and bioethanol industry in 1991. REAP is also recognized within the global biofuels community as the pioneering agency in the development of grass pellets for thermal energy applications.

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Roger Samson is the Executive Director of Resource Efficient Agricultural Production. Mr. Samson is a leading world expert in biomass energy development. He has authored over 70 publications on bioenergy, ecological farming, and climate change mitigation. Mr. Samson holds a B.Sc. (Crop Science) from Guelph University and a M.Sc. (Plant Science) from McGill University in Montreal. Mr. Samson has worked as an evaluator for the US Department of Energy programs and was an evaluator for the 6^{th} and 7^{th} European Framework programs.