Response to the C.D. Howe Institute Commentary, No. 268, July 2008, 'The Ethanol Trap: Why Policies to Promote Ethanol as Fuel Need Rethinking', by Douglas Auld.

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About the Author

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Mr. O'Connor has been President of (S&T)2 Consultants Inc for the past ten years. He is a mechanical engineer with over thirty years of experience in alternative energy and environmental consulting, and in industry. Mr. O'Connor's background includes over 15 years of manufacturing and marketing experience with Western Canada's largest independent fuel retailer. He has successfully developed and commercialized environmentally sound transportation energy alternatives.

Other aspects of Mr. O'Connor's background include:

- Extensive experience with production of biofuels.
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Mr. O'Connor has recently provided advice on fuels, transportation issues, and greenhouse gas emissions to a number of Provincial governments, several Canadian Federal Government departments, and international agencies and governments. Mr. O'Connor has also consulted for a number of companies developing new technologies for alternative fuelled vehicles and companies developing new transportation fuel processes and facilities.

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Executive Summary

The C.D. Howe Institute report by Douglas Auld contains a number of fundamental errors and questionable assumptions that lead to erroneous conclusions. It is clear the author does not understand, or misrepresents, some of the fundamental principles of life cycle assessments, the impact of fuel properties on vehicle performance and taxation, the ethanol production process, global agricultural policy, and other critical issues related to the subject.

Proper life cycle assessment (LCA) studies must compare systems that have similar system boundaries, utilize appropriate function units, compare system in the same region, and at the same time in order for the results to be valid; the author fails on all four key criteria.

The author cites studies by Pimental and Patzek, which purport to be LCA studies, to suggest there is uncertainty regarding the energy and environmental benefits of biofuels, but these individuals do not follow any of the International Standards Organization (ISO) guidelines for undertaking high quality LCA work.

The author also cites studies by Samson on the GHG emissions of gasoline and corn ethanol. These studies are based on other studies, which in turn use secondary sources of data. Neither the methodology nor the data used by Auld or his referenced sources of information follow accepted LCA procedures. The GHG emissions reported by Samson for the two fuels were undertaken with different system boundaries (what is included and what is not), different methodology, in different parts of the world, and with data from different time periods.

On the issue of program costs, the most critical flaw the author makes in the calculations is the failure to consider the volumetric energy differences between gasoline and ethanol. These were properly considered in the GHG emissions calculations but not in the program costs. Taxing ethanol on the same volume basis as gasoline results in an energy tax rate of about 150% of the rate of gasoline. This increases government revenues and under some circumstances can make program costs negative.

The author projects the producer credit to be 21.8 cents per litre (cpl), while considering actual conditions in the market and the volumetric caps of some programs, a more realistic value is probably less than 10 cpl. Flaws also exist in assumptions made by the author on capitalized costs of research programs and capital assistance programs.

Based on the extra tax revenue generated (ignored by the author), which lowers programs costs, the real GHG cost effectiveness is about $40/tonne when appropriate GHG values for Canada are combined with the actual net program costs. This is in the range of the costs of current CO_2 allowances in Europe, and far below the future offset costs of $200/tonne identified by the author; biofuels remain one of the most cost-effective methods of reducing GHGs in the transportation sector.

On the issue of ethanol production and food prices, the paper not only ignores the primary and fundamental global agricultural problems of the past several decades, but it also ignores or misrepresents obvious relevant issues of today.

Over $5 trillion in the past 20 years have gone directly from western governments to their agricultural producers, leading to below-cost surplus production being dumped on the world market, devastating producers in the developing world (whose governments do not have the deep pockets to subsidize them), leading to their need for food aid. Canadian grain producers have had incomes far below those of other

OECD countries, as the level of direct government support is quite low in Canada compared to other OECD countries, so Canadian producers have been in desperate need of higher commodity prices if they were to stay in business.

Global agricultural policy issues has led to a huge gap in agricultural productivity between the developed and developing world (the world has an opportunity to produce about 50% more food and feed than it currently does without bringing a single new hectare of land into production, simply through applying best practices to all production – not just in developed countries). The world already produces more than enough food for all people (it has a significant distribution problem, created in part by existing over production and market distortion), so there must be new markets for this production, or prices would again collapse far below the cost of production. Biofuels provide this market to help reduce productivity gap-led surplus production while keeping commodity prices of grains above the cost of production.

Auld raises the issue of Mexican tortillas. These are made from white corn (not yellow corn as used in ethanol production), issues related to white corn acreages, commodity prices, quotas, and tariffs related to this specific commodity were not referenced in the paper. Also left out of the paper were the complaints from Mexican governments, only a couple of short years ago, directed at US agricultural subsidies driving the price of corn down and devastating their own farmers with low commodity prices.

None of these agricultural matters were considered in this obviously flawed paper.

Introduction

In July 2008, the C.D. Howe Institute published a paper entitled 'The Ethanol Trap: Why Policies to Promote Ethanol as a Fuel Need Rethinking'. The paper has received considerable media attention. Unfortunately, it contains a number of fundamental errors and questionable assumptions that lead to erroneous conclusions.

In order to arrive at the conclusions reached by the author, Douglas Auld, a number of reasonably complex issues must be addressed, including: lifecycle greenhouse gas analysis of different fuels, estimates of future demand, prices, and market responses of a variety of commodity and other factors. In order to do this properly, forecasts of what might happen in the future are required, which no one can accurately predict with 100% confidence. However, in other cases, a very good understanding of the issues and the analyses is necessary, and there is significant evidence in the report that the author does not understand some of the fundamental principles of life cycle analyses, the impact of fuel properties on vehicle performance, and other critical issues.

Life Cycle Analyses

Life cycle assessment (LCA) is a "cradle-to-grave" (or "well to wheels") approach for assessing industrial systems. "Cradle-to-grave" begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth.

LCA evaluates all stages of a product's life from the perspective that they are interdependent, meaning that one operation leads to the next. LCA enables the estimation of the cumulative environmental impacts resulting from all stages in the product life cycle, often including impacts not considered in more traditional analyses (e.g. raw material extraction, material transportation, ultimate product disposal, etc.). By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product selection.

The term "life cycle" refers to the major activities in the course of the product's life span from its manufacture, use, maintenance, and final disposal; including the raw material acquisition required to manufacture the product.

The LCA process is a systematic, iterative, phased approach, and consists of four components: goal definition and scoping, inventory analysis, impact assessment, and interpretation.

The concept of life-cycle assessment emerged in the late 1980's from competition among manufacturers attempting to persuade users about the superiority of one product choice over another. As more comparative studies were released with conflicting claims, it became evident that different approaches were being taken related to the key elements in the LCA analysis:

- boundary conditions (the "reach" or "extent" of the product system);
- data sources (actual vs. modeled); and
- definition of the functional unit.

In order to address these issues, and to standardize LCA methodologies and streamline the international marketplace, the International Standards Organization (ISO) has developed a series of international LCA standards and technical reports under its ISO 14000 Environmental Management series. In 1997-2000, ISO developed a set of four standards that established the principles and framework for LCA (ISO 14040:1997) and the requirements for the different phases of LCA (ISO 14041-14043).

By 2006, these LCA standards were consolidated and replaced by two current standards: one for LCA principles (ISO 14040:2006) and one for LCA requirements and guidelines (ISO 14044:2006). Additionally, ISO has published guidance documents and technical reports (ISO 14047-14049) to help illustrate good practice in applying LCA concepts.

Numerous LCAs for bioethanol and other biofuels have been published (reviews include Fleming et al. 2006 and Larson 2006). Most studies have followed ISO standards (ISO 2006), but a wide range of results has often been reported for the same fuel pathway, sometimes even when holding temporal and spatial considerations constant. The ranges in results may, in some cases, be attributed to actual differences in the systems being modeled, but are also due to differences in method interpretation, assumptions, and data issues.

Key issues in biofuels' LCAs have been differing boundaries being adopted in studies (i.e. what activities are included/excluded from the study), differences in data being collected and utilized, and disparities in the treatment of co-products. In addition, LCAs, more generally (not solely limited to those of biofuels), have often included limited or no analysis of uncertainty and validation of model results. Boundaries in prior LCAs have often differed due to resource constraints. Data requirements in LCA are significant. Studies have not always used up to date data or data that reflect the inputs in the relevant process under study (i.e. utilization of electricity generation data for another jurisdiction rather than the one under study). There are also gaps in scientific knowledge surrounding key variables. For example, these include implications of land use change, N2O emissions related to feedstock production, and nutrient depletion and erosion due to agricultural residue removal. Utilization of different co-product methods, and in some studies, ignoring co-products entirely, has had major impact on results of LCA studies (Kim and Dale 2002, Larson 2006, Farrell et al. 2006).

Life cycle assessment is a useful tool for comparing on a functional unit basis, the relative environmental performance (based on a specific set of metrics) of different feedstock/fuel pathways. However, LCA should be utilized along with other information in decision-making regarding biofuels. Decision-makers should be aware of both the strengths and limitations of LCA.

Many of the LCA studies cited by the author, including those of Pimental and Patzek, which the author cites to suggest there is uncertainty regarding the energy and environmental benefits of biofuels, do not follow any of the ISO guidelines for undertaking high quality LCA work.

While the author does recognize the energy content of gasoline and ethanol are not the same (and, in fact, gasoline produced by different refineries is not the same either), there seems to be some confusion with respect to the gross and net heating value concepts. While gasoline typically contains almost 33 to 35 MJ/litre of energy when measured on a gross heating value basis, it contains about 30.5 to 32.5 MJ/litre on a net heating value basis. Ethanol contains 23.6 MJ/litre on a gross heating value basis and 21.2 on a net heating value basis. Both methods of reporting energy are acceptable for undertaking system analysis, as long as the same system is used throughout. Some of the references used to support this paper (notably Samson, 2008) switch between measurement systems in the same paper.

The energy content of a fuel does not directly translate into fuel consumption. Different fuels can combust with different efficiencies for a number of valid scientific reasons. Natural gas engines typically suffer a 5 to 10% loss of thermal efficiency compared to gasoline engines. Some hydrogen engines have demonstrated increased energy efficiency compared to the same engine operated on gasoline. Similarly, ethanol blended gasoline has been shown to provide a slightly higher thermal energy efficiency that offsets a portion of the volumetric increase in fuel consumption that one would expect from their lower energy content. The key point here is that any study that reports to be a lifecycle assessment but only compares systems based on their energy content rather than a more appropriate functional unit, such as distance driven, will not reach the appropriate conclusion.

Proper LCA studies must compare systems that have similar system boundaries, utilize appropriate function units, compare system in the same region, and at the same time in order for the results to be valid. The author fails on all four key criteria as will be discussed further in the next section.

Greenhouse Gas Emissions

A key aspect of this paper is the calculation of the cost effectiveness of the greenhouse gas (GHG) reductions provided by corn ethanol. This requires an accurate assessment of the GHG emissions reductions and the overall program costs.

The C.D. Howe Institute paper relies on a paper written by Roger Samson et al. for Biocap that considered several biofuel options and address the GHG emissions benefit of each option. Corn ethanol was one of the options considered. Samson did not undertake his own LCA, but rather relied on a number of other published works. The danger of this approach is that it is not always possible to ensure the same boundary conditions, same region, and time frame are used in a comparison. Interestingly, Samson did use some data from the Natural Resources Canada LCA model GHGenius for some of the systems, but not for all. He also mixed some older studies and some newer GHGenius results. For corn ethanol, Samson ignored the GHGenius data and used a report by Hill et al. that he further modified to arrive at his final results. Neither the Hill paper nor the Samson paper follows ISO guidelines for LCA work.

GHGenius is the only publicly available LCA model that has data on the Canadian energy systems. It is widely used in Canada and has almost 2000 registered users from around the world.

The Hill paper was focused primarily on the energy balance of corn ethanol production in the United States. It then did a very simple estimate of the GHG emissions based on the energy analysis. The GHG emissions were compared to emissions reported by other researchers, but Hill undertook no analysis of gasoline or diesel fuel using the same system boundaries as he employed for ethanol or biodiesel.

The Hill paper undertook to employ the widest system boundaries possible, so they included the energy required to build the biofuel facilities, the energy required to sustain the labourers utilized throughout the lifecycle, the household energy consumption of these labourers, as well as the more normal boundaries of direct energy and materials. While it is not necessarily wrong to use these very wide boundaries, some of the reasons most researchers do not include this, is the difficulty in accessing good and reasonable data, and the implied rational that if these people were not employed producing biofuels they would not exist. The approach taken by Hill to estimate the personnel energy requirements is very broad and, for example, would include energy required to produce export goods that have nothing to do with the production of biofuels. The same very wide system boundary is not applied to the production of gasoline and diesel fuel in the paper, so the GHG emission benefit reported fails the ISO principles by comparing systems with different system boundaries.

The actual energy data used by Hill came from a range of other published papers and is thus all secondary data. There does not appear to have been any attempt to verify discrepancies between various sources, and some of the data is very old. Ethanol plant energy use is reported as 12.73 MJ/litre, whereas recent surveys in the US have reported values of less than 8 MJ/litre. This one difference in input data would have a large impact on the results.

The method used to calculate the GHG emissions by Hill is so simplistic that the validity of the results is questionable. He simply applies an average GHG emissions intensity for all types of energy and applies that to his energy balance results. He then makes further adjustments for non-energy-related GHG emissions. The treatment of the GHG emission benefits of co-products is based solely on the energy balance and is clearly an incorrect approach.

Samson, in his calculations of GHG emissions, relies mostly on the work of Hill, but does his own estimate of N2O emissions rather than using the Hill value. Samson's approach is a very simplified approach to a complex issue and also fails to allocate these emissions appropriately between the ethanol and the co-products.

Based on the report by Samson, the C.D. Howe Institute paper assumes that corn ethanol provides an emissions benefit of 21 kg of CO2 eq/GJ (net heating value basis) of ethanol consumed. This is equivalent to 0.44 kg/litre of ethanol. The major issues with this value include:

1. It ignores any combustion impacts of ethanol compared to gasoline.
2. The system boundaries for the ethanol and gasoline systems are vastly different.
3. The two fuels are assessed in different regions with different energy infrastructures.
4. The time period that the data is used in the two systems is different.
5. The data sources are largely secondary sources, and in many cases, averaged secondary sources.

If we consider the GHG emissions benefit projected by GHGenius for corn ethanol in Ontario for the year 2008, we have a value of 1.4 kg/litre – more than three times greater than that used by the author. All of the shortcomings identified above (and more) are addressed with the GHGenius result. This will reduce the cost of the GHG emissions benefit alone to 31% of the value calculated by the author, and as will be shown next, there are concerns with the calculation of program costs.

Program Costs

The author has created his own forecast of how much ethanol would be used and produced in Canada, and where it would be produced. From that data, he has calculated what the program costs would be. The costs also include the capitalized costs of research programs and the opportunity costs of federal loans to ethanol producers.

Many of the biofuels support programs in recent years have transitioned to programs that provide variable levels of support based on industry needs. These programs have lower costs to governments and, in many cases, are more valuable to producers and lenders because they address uncertainty with respect to commodity price variation. It is not possible from the paper to determine if the author assumed maximum payouts with these programs or some other more reasonable estimate based on program details. Some of the programs have actual volume caps and others have implied caps. There is no indication in the paper that these were considered by the author.

The inclusion of the capitalized costs of research programs is probably not a valid cost, given the nature of the programs themselves. The programs cover many issues and not all of them have any relationship to corn ethanol production. There is also some evidence this money would have been spent even if there was no federal RFS program.

The capital assistance currently available to the industry is directed to primary agricultural producers to encourage their participation in value-added secondary processing of their commodity products. This money is conditional on these projects developing, which may or may not happen.

The value of both these items is probably small compared to the producer credits and reduced taxation levels in some provinces.

The first payments under the new federal program have not yet been made, so we do not know the exact value of the producer credit, but they are expected to be less than the maximum value of 10 cents per litre (cpl). In Ontario, the provincial payment program has been about 8 cpl in recent times (less than the 11 cpl maximum). There is no Quebec payment, as the price of crude oil remains well above the conditional payment level of $65/bbl. These two provinces are the primary corn ethanol producers in Canada. It is highly unlikely the producer credit will be 21.8 cpl as projected by the author. A more realistic value is probably less than 10 cpl.

However, the most critical flaw in the calculations is the failure to consider the energy differences between gasoline and ethanol, as they were considered in the GHG emissions calculations. The federal, Ontario, and Quebec governments all tax ethanol at the same volumetric rate as gasoline. On an energy basis, this results in tax rates of about 150% of the rate of gasoline. With a combined fuel tax load in Ontario and Quebec of between 25 and 30 cpl on gasoline, the increased revenue from ethanol is between 12 and 15 cents for every litre of ethanol used. This impact drastically reduces the program costs to government and, in some cases, could make the program costs negative.

Cost Effectiveness

It has been shown here that the author has underestimated the GHG emissions benefit for corn ethanol and over estimated the program costs in arriving at the estimate of $368/tonne of GHG emissions avoided.

The inclusion of the extra tax revenue generated by the taxation of ethanol on a volumetric basis alone could reduce the average program costs, from the 18.3 cpl calculated by the author, by 12 cpl to about 6 cpl. This is a similar factor of three that was identified in the GHG emissions estimate.

Therefore, the real cost effectiveness is about $40/tonne when appropriate GHG values for Canada are combined with the actual net program costs. This is in the range of the costs of current CO2 allowances in Europe, and far below the future offset costs of $200/tonne identified by the author.

The challenge of reducing our nation's GHG emissions is very large. Most observers recognize that transportation emissions must be addressed if we are to meet any of the future emission targets for the country. Transportation emissions can be reduced through improving fuel economy, changing to lower carbon fuels (natural gas, for example), or using biofuels. At the recent Pollution Probe conference in Toronto on low carbon fuel standards, the Canadian Motor Vehicles Manufacturers Association suggested that the cost effectiveness of improving fuel consumption in vehicles would be between $150 and $300/tonne. There is no question that reducing transportation GHG emissions will be a challenge and may be more costly than emissions reductions in some other sectors, but when biofuels are analyzed properly they are clearly one of the more cost effective options available.

Ethanol and Food Prices

The paper ignores the primary agricultural issue of the past several decades: the developed world produced so much food that prices were driven below the cost of production and governments of the developed world have been spending $250 to $300 billion per year on direct support for agricultural producers. These payments totalled $5.4 trillion dollars in the past 20 years and agricultural policy reform has only managed to keep the payments at a stable level rather than reducing them. At the same time, governments have dumped the surplus production on the world market making it extremely difficult for producers in the developing world (whose governments do not have the deep pockets to subsidize them) to remain in business. This disparity between agricultural policies in the developed and developing world is one of the primary drivers behind the need for food aid.

Canadian grain producers have incomes far below those of other OECD countries, as the level of direct government support is quite low in Canada compared to other OECD countries. Canadian producers have been in desperate need of higher commodity prices if they were to stay in business. Arguing that an increase in food prices of 20% over the next 10 years is bad for the economy ignores the food supply security issues which arise when any organization must sell their product below the cost of production and cannot invest in the new technology required to remain competitive.

One of the consequences of this global agricultural policy problem is that a huge gap in agricultural productivity has emerged between the developed and the developing world. This is shown in the following figure for corn, although it exists for essentially all agricultural commodities (UN FAO data).

This gap must be closed if the world wishes to reduce poverty and address food issues in the developing world. One of the consequences of increasing productivity will be increased production of food and feed. In order to ensure that market prices do not collapse, it will be necessary to ensure there is a demand for this additional production. Here, biofuels, rather than being part of the problem, are in fact a key part of the solution. The world has an opportunity to reduce oil consumption and greenhouse gases, reduce the need for food aid, improve the living conditions for farmers in the developing world, and make these countries more self-reliant in food production. Attacking biofuels merely prolongs the real agricultural problems facing the world.

The world has an opportunity to produce about 50% more food and feed than it currently does without bringing a single new hectare of land into production, simply through applying best practices to all production – not just in developed countries. Since the world currently produces more than enough food for all people (it has a significant distribution problem, created in part by existing over production and market distortion), there must be new markets for this production, otherwise prices would collapse far below the cost of production.

Almost all analyses of the future land implications of increased corn for ethanol production ignore the high protein co-products that are produced. This product is used in animal feed (as is almost all corn itself produced today) and it displaces both corn and soybean meal from livestock feed rations. The productivity of producing soybeans is much less than producing corn, and each hectare of land can produce ethanol and the protein normally supplied by growing soybeans. The reality of increasing ethanol production is more corn and fewer soybeans would be grown with hardly any impact on the overall quantity of land required.

The author raises the Mexican tortilla issue and it is implied that it was caused by corn ethanol. Only a few years ago, the issue in Mexico was that free trade was driving corn producers out of business because they could not compete with subsidized US corn. Now, higher US corn prices are supposedly creating a problem. Tortillas are made from white corn and not yellow corn. Production of white corn in the US represents about 1% of total corn production and the US exports very little white corn to Mexico because of existing over-quota import tariffs (36 to 73% between 2004 and 2006). White corn only represents about 2% of US corn exports to Mexico. In contrast, most Mexican corn production is white corn. Mexico suffered from drought conditions in 2006, which reduced the production of white corn, and that combined with high tariffs on imported white corn led to the increase in tortilla prices, not US ethanol production.

In summary, feedstock production must be considered globally, and there are many issues facing global agriculture partially as a result of decades of distorting agricultural and trade policies driven in large part by OECD countries. Maintaining the status quo in agriculture will not address any of the problems facing agriculture throughout the world. The real issue is not the inability to produce enough food and feed, but the ability to produce too much feed and food. Solutions which address both the supply and demand for these products are needed, not reactions to changing the unacceptable status quo.

Conclusion

The paper by Douglas Auld contains a number of fundamental errors and questionable assumptions that lead to erroneous conclusions. It is clear the author does not understand or misrepresents some of the fundamental principles of life cycle assessments, the impact of fuel properties on vehicle performance, the ethanol production process, global agricultural policy, and other critical technical issues the he writes on, all the while using many roundly discredited secondary sources in his inconsistent and unscrupulous use of research methodology, and substandard research.

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