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Life-cycle greenhouse gas emissions of transportation fuels

Issues and implications for unconventional fuel sources

Climate change
2010

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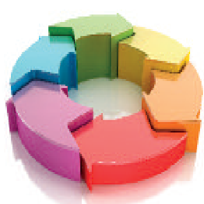
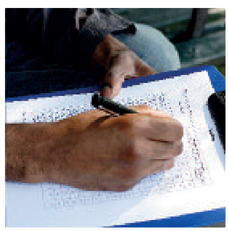
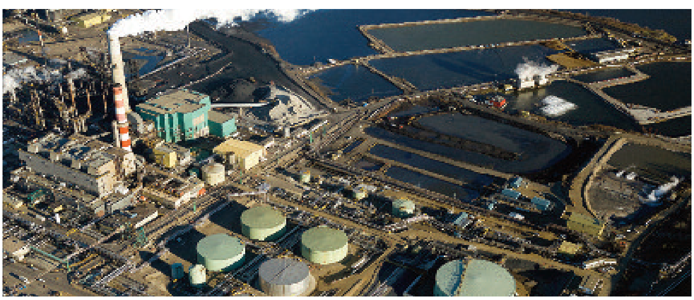

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IPIECA

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Contents

Executive summary

Emerging regulation of life-cycle greenhouse gas (GHG) emissions for transportation fuels has raised urgent questions about both definition and evaluation of life-cycle emissions, and the effectiveness, efficiency and equity of regulatory approaches which use such analyses. For petroleum-based transportation fuels, the use of the fuel results in about five times[1] the greenhouse gas emissions released during in its production. The net emissions from a transportation fuel system depend on the system boundaries that have been defined; these should be defined appropriately, whether the estimated emissions are intended to provide insight or for a specific regulatory application. For example, inclusion of emissions from the production of vehicles would add to the system GHG emissions (or life-cycle emissions) of a transportation fuel. Consistent application of aggregation, accuracy and transparency of data are also important when making a comparison between any two production pathways. Critical issues arise in the regulatory use of life-cycle emissions when comparing different types of fuels, for different types of vehicles.

It is important to note that life-cycle assessment is not needed for regulatory use if there is a comprehensive policy on GHG emissions across all regions and sectors of society—the cost of GHG emissions would be accounted for where they occur. In the absence of a comprehensive policy, accurate and consistent life-cycle assessment can have a useful role when accounting for emissions from the life cycle of a fuel.

Some argue that a comprehensive and high carbon price would not be enough to incentivize consumer behaviour on transport fuels, and that further policy interventions such as fuel mandates would still be necessary. Nevertheless, a uniform carbon price is commonly favoured by economists as it would ideally result in the reduction of emissions at the lowest cost. And cost matters, given the immense scale of emission reduction goals. In a less comprehensive system—for example, one that addresses transportation fuels in one region—the effects of system boundaries become important. In such cases, the inclusion of life-cycle emissions is essential to address boundary effects, but compromises in equity, economic efficiency and effectiveness remain. Analyses show these compromises to be severe for poorly-designed policies.

The life-cycle emissions of transportation fuels differ between different fuels, and the pathways to produce those fuels. For a fuel such as gasoline, the carbon intensity of the fuel itself is roughly uniform but the emissions generated in producing that fuel (i.e. through oil production, transport, refining and distribution)—which constitute a small fraction of the life-cycle emissions—do depend on how it is produced.

The life-cycle emissions of biofuels include emissions produced by growing, harvesting and transporting crops, as well as the carbon taken up as crops grow and released when the fuel is used. Biofuels are the most land-use

[1] See: EU Joint Research Council study:
http://ies.jrc.ec.europa.eu/jec-research-collaboration/downloads-jec.html; and
National Energy Technology Laboratory, USA study:
www.netl.doe.gov/energy-analyses/pubs/NETL%20LCA%20Petroleum-based%20Fuels%20Nov%202008.pdf

intensive fuel and their production can affect land-use change (e.g. deforestation) beyond the boundaries of the farms where biofuel crops are grown, resulting in *indirect land-use change*. Existing biofuel systems can result in either lower or higher life-cycle emissions than conventional fuels, depending on how the biofuel is produced and how the life-cycle analysis (LCA) is carried out. Some pre-commercial biofuel technologies are estimated to have low estimated life-cycle emissions, but these have yet to be proven in the marketplace.

Fuels from unconventional sources such as oil sands result in about 5–15% higher life-cycle emissions than an average fuel, although some unconventional pathways do better and some conventional pathways do worse.

A number of critical issues arise for the use of life-cycle analysis in regulation:

- **Uncertainty in life-cycle emissions:** Differences in estimates of the life-cycle emissions for one fuel can exceed the differences in estimates for different fuels; boundaries, accounting, aggregation and accuracy of life-cycle analysis are each determining factors and critical issues in its application in regulations.
- **Many flexible pathways:** In order to incentivize innovation in fuel production, many pathways are needed to map production from each individual agent who will have their own process. Pathways must also be allowed to be revised or added.
- **Matching mandates to available supply:** Given the limited differences in life-cycle emissions from different available fuels, a seemingly small mandated reduction in average fuel life-cycle emissions may outstrip the available supply of low-carbon fuels. For example, applying a 10% reduction in greenhouse gas intensity would require blending conventional petrol with around 50% sugarcane ethanol. In California alone this would require around 0.6 million barrels per day of sugarcane ethanol—more than Brazil currently produces.
- **Energy security:** Regulation to lower the life-cycle emissions is often also intended to improve energy security (e.g. by increasing supplies of indigenous biofuels); however, in the case of unconventional sources of oil, such regulations may aggravate energy security.
- **International trade:** Mixes of different climate policies in different countries can lead to trade advantages or disadvantages for industries that differ across borders; policies in one country that disadvantage industry in another may be challenged based on trade agreements.

Life-cycle assessment is a tool that provides insight into the environmental performance of different fuel systems. For climate policies that apply only to transportation fuels, it is necessary to include the life-cycle emissions if the policy is to reduce overall greenhouse gas emissions. However, there remain outstanding issues, in particular the broad, overarching issue of the economic efficiency and effectiveness of a fuel policy relative to a more comprehensive policy.

For complex policies, such as those involving LCA—especially where there are international ramifications—a much broader dialogue is needed to improve the policy's effectiveness, efficiency and, ultimately, the policy's credibility.

Introduction

Transportation fuel systems result in the emissions of greenhouse gases at different stages of their production and use. These emissions can be estimated using life-cycle analysis (LCA). The effectiveness and efficiency of regulatory and other policy approaches intended to reduce the greenhouse gas emissions from transportation fuels can, moreover, hinge on transportation fuel LCA.

This IPIECA-organized workshop brought together experts from academia, business, government, and international and non-governmental organizations to consider the implications of transport fuel LCA for climate change policy and fuels regulation. The workshop reviewed LCA for transportation fuels from unconventional hydrocarbon sources and associated regulatory issues and implications, and examined these in the context of experience gained in the study of conventional hydrocarbon sources, biofuels, electric vehicles and other alternatives.

This document summarizes the IPIECA Climate Change Working Group's understanding of the presentations and discussions at the workshop. This publication and the workshop are part of an ongoing effort by IPIECA and its members to raise understanding and provide constructive input on key climate change issues. The workshop presentations are available for download from the IPIECA website (www.ipieca.org) along with all of the publications in the IPIECA climate change workshop report series (see page 15).

Carbon and transport fuel policies

When considering policies which would lead to a reduction of greenhouse gas emissions to the Earth's atmosphere, economists will argue that policies that would result in the largest emission reduction for the least cost would be those that apply a uniform cost to emitting greenhouse gases. This sends a price signal to the marketplace, and being comprehensive in its scope means that it benefits from simplicity and efficiency, removing the need for multiple, potentially overlapping smaller policies focused on specific sectors of the economy. Regional or even local policies, where policy makers wish to control goods and services, often focus on particular sectors. One such approach is a low carbon fuel standard (LCFS). At this level a policy will be less efficient due to its limited scope. The limited scope will also mean that goods and services outside the region may not be affected by the regulations—potentially gaining a competitive advantage—and/or 'carbon leakage' may occur as the penalized activities simply move outside of the region.

Life-cycle analysis can be a useful tool in creating a detailed picture of the composition of any goods from one or more perspectives, such as greenhouse gases. This can be of benefit, for example, in forecasting how the costs of various goods might increase under a carbon price, and which of the key inputs to a product are most affected. However, the complexity of

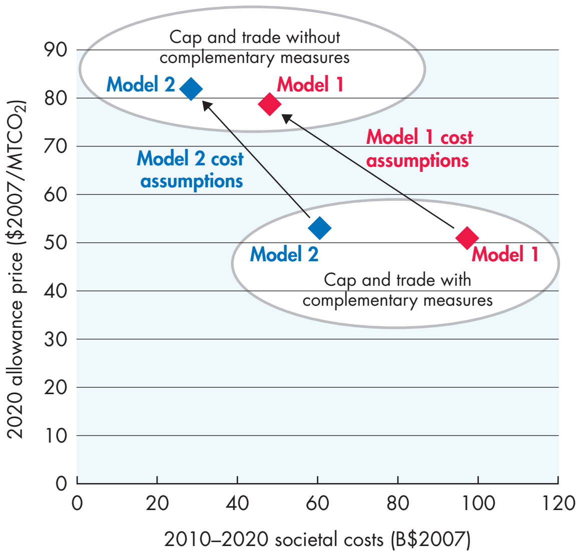
Measures additional to a carbon price increase costs

A uniform carbon price provides an economically efficient way to reduce emissions. Additional and complementary measures such as an LCFS will add to that cost through the addition of administration costs and restricting flexibility in mitigation measures across the economy.

Where additional measures to a uniform carbon price are removed, this can lower overall societal costs significantly. Figure 1 shows modelling of the California LCFS and Renewable Energy Standard which are complementary to the Western Climate Initiative cap-and-trade scheme. Whilst these standards reduce the allowance price of the trading scheme, they also increase the overall societal costs. The additional regulations are forcing emissions reductions in certain sectors, rather than allowing the market to find the least expensive reductions.

Figure 1 *The effect of complementary measures on market-based approaches to pricing carbon*

Modelling of Californian climate legislation AB32 shows that excluding complementary measures can cut costs by 50%



- Overall policy costs cannot be inferred from the CO_2 allowance price because AB32 combines a market-based programme to reduce carbon emissions (e.g. cap-and-trade) with command-and-control mandates (e.g. the complementary measures).
- Under either Model 1 or Model 2 assumptions, the complementary measures prescribe more expensive carbon emission reductions than a cap-and-trade programme alone—resulting in lower allowance prices but higher total compliance costs.

Source: David Montgomery's presentation[2]

[2] From Charles River Associates study 'Economic and Energy Impacts of a Low Carbon Fuel Standard' for Consumer Energy Alliance. See: http://tinyurl.com/cra-lcfs-report

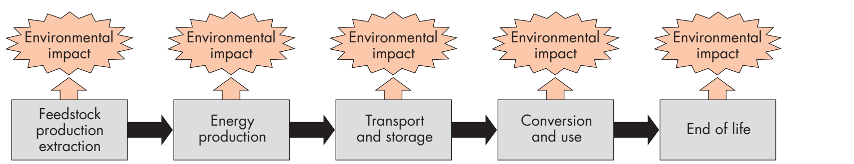
the analysis can mean that much depends on the boundaries of the LCA, and the assumptions that are made.

When regulators wish to affect regions beyond their control, they can also use life-cycle analysis as a means to do this. This calculation tool allows them to assess the amount of carbon up and down a product's value chain, and to attach values to goods manufactured outside the jurisdiction. However, using LCA for regulating inputs/emissions can bring with it a number of additional issues, including:

- the incentive problem—the production pathways monitored under life-cycle analysis must be capable of revision and addition in order to allow new, more efficient process pathways to be recognized;
- the agency problem—the recognized pathways must be manifold enough to distinguish between the different agents involved who, in turn, will have different efficiencies;
- the market impacts problem—even then a regulation can have unseen consequences on markets, which occur through agents not

Using life-cycle analysis for an LCFS

LCA is a tool used to evaluate net quantities of energy or emissions arising from the inputs and outputs surrounding the production and consumption of specific goods over their lifetimes. An LCFS uses LCA as the main tool in calculating carbon intensity across the range of fuels. Assessing the greenhouse gas emissions associated with a transport fuel can be broken down into the following stages:



Source: Thomas McKone's presentation

Only when considering the impacts at each stage of the chain, do we get a more accurate picture of the overall impact of a product. Each transport fuel on the market (e.g. petrol, liquefied natural gas, biofuels) has a different carbon intensity, depending on the pathways involved in its lifetime. Competing near-identical products will also have different carbon intensities based on their feedstocks and processes. The carbon intensity of an electric vehicle will vary depending on the time of day at which the car is charged, and therefore which power generation units have been used to supply the electricity.

Life-cycle analysis is complex, and the values returned can often be a factor not only of the inputs, but of the boundaries selected for the LCA. For example, selecting whether to include the direct emissions from transporting a fuel, or even from the production of the vehicle involved in transporting the fuel, are boundary issues that will have an impact on the magnitude of the calculated life-cycle emissions.

acknowledged by the policy. This is best illustrated by the example of biofuels and land-use change. The pressures of a growing market for biofuels can have knock-on impacts, changing the use of lands, e.g. land which is woodland may be converted into arable land to meet the demand for alternative land required for growing food crops.

These problems would persist even if there were no uncertainty in the evaluation of life-cycle emissions.

Implications of LCFS for carbon policy

There are a number of transport fuels on the market, each with varying systemic carbon values. In considering ways to reduce the amount of GHGs emitted from transport fuels and incentivize low-carbon fuel choices, regulators are developing low-carbon fuel standards. These standards mandate a cap or a reduction in the relative intensity of carbon dioxide emissions from fuels sold. An LCFS uses LCA as a way of calculating the carbon emitted over the lifetime of a fuel. As such, the LCFS instrument suffers from the problems associated both with non-universal carbon policies and with using LCA for regulating emissions, as noted above.

When considering carbon policy instruments, an LCFS can increase the cost of mitigating climate change compared to a policy that imposes a global price on greenhouse gas emissions, implemented either as a cap-and-trade style emissions trading scheme, a carbon tax, or similar. The use of LCA to prevent carbon leakage from an LCFS can be considered very similar to a border carbon adjustment. These adjustments appear to have only limited effects on reducing leakage, and are dependent on the scheme having large coverage. Additionally, they appear to inflict disproportionately large societal costs outside of the region in order to achieve their effectiveness.

Why have an LCFS?

Although cap-and-trade measures are, theoretically, the most efficient tools, they are also politically challenging, and in their absence, other policy tools may be considered. Whilst, over shorter time scales (less than a year), it is known that consumers have low elasticity in response to price variability of fuels, over longer periods they have greater elasticity and are more responsive to price changes. If an emissions trading scheme is in operation, it may not provide a strong enough price signal to strongly affect either consumer choices relating to transport (vehicle miles travelled or fuel used) or low-GHG vehicle/fuel production. A carbon price of $100 per tonne might only add $1 per gallon to the cost of petrol, with a gallon costing around $2.90 (Dec 2010). Additionally, the cost of driving will continue to decrease, partly through responses to other carbon saving measures such as improved vehicle efficiency. This means that despite fuel cost increases, overall running costs may stay the same. A low-carbon fuel standard will overcome these trends, and will both incentivize and increase alternative fuel use, and also lower carbon emissions compared to business as usual. For some regions, the increased use of alternative fuels will lead to a reduced reliance on imported oil, increasing the diversity of energy supply.

Challenges presented by an LCFS

Although there is significant momentum to address transport GHG emissions through low-carbon fuel standards, it must be noted that this approach has some limitations. Firstly, an LCFS does not provide an overall cap to reduce carbon emissions. As the policy focuses on the carbon intensity of fuels, it cannot decrease emissions absolutely; it can only do so relatively. Secondly, the policy focuses on a single sector of the economy, meaning that the market for emissions reduction solutions is reduced, and thus the societal costs for abating carbon are increased.

Additionally, the cost and effectiveness of meeting an LCFS depends on a number of factors including:

- the choice of carbon baseline and target;
- assumptions around resource availability, carbon intensity of fuels, changes in supply and demand; and
- system boundaries and accounting for the LCA (affecting leakage, fairness and environmental integrity).

Conventional transport fuels would meet carbon quotas by blending with low-carbon alternatives such as biofuels. Arguably the most significant problems for LCFS are the consequences of mandating lower-carbon fuels if there are insufficient technologies or fuel substitutes available to meet demand at the lower carbon intensity. Some of the key constraints to realizing adequate supplies of alternative fuels are:

- ethanol 'blend wall'—how much ethanol fuel can be mixed in, and burnt with, regular petrol without causing damage to current engines?
- fleet turnover—what levels of penetration can be achieved for plug-in hybrid, full electric, flex fuel or compressed natural gas vehicles?
- infrastructure—how fast can infrastructure for fuels such as CNG or electricity be built up?
- production—how much low-carbon fuel can be produced?

Constraints on the amount of low-carbon fuel that can be consumed forces an increase in prices to achieve the target by the only path remaining, i.e. by reducing overall fuel consumption. This price increase is likely to result in changing the driving habits and vehicle choices of consumers, rather than further incentivizing fuel innovation. In effect the LCFS then becomes a carbon tax on fuel, but with much additional complexity and uncertainty, at a level that is potentially much higher (and therefore less economically efficient) than in other sectors of the economy.

An LCFS targeted at a national scale will struggle to address problems associated with carbon leakage and fuel shuffling. As the schemes incentivize low-carbon crude oil, this is likely to change the nature of crude imports to the region under control. For example, in America this may result in products derived from Canadian oil sands being replaced with fuels from further afield, such as the Middle East. This 'fuel shuffling' may lower the carbon intensity of products entering the region but will do little to alter global consumption because the fuels will simply be consumed elsewhere ('carbon leakage'). An additional impact of 'fuel shuffling' is on energy security—traditional and trusted trading partners may be dropped for new and less dependable partners elsewhere. This might create significant problems with the security of supply.

The environmental and social sustainability of an LCFS is not guaranteed. It is difficult to obtain accurate and fair results from LCA. Ensuring that boundaries and accounting measures are set correctly is greatly important in addressing this uncertainty surrounding consistency and accuracy. Additionally, there is the issue of indirect land-use change (iLUC). The market impacts of incentivizing fuel use can lead to actions to convert land from other uses to growing biofuels. This can increase greenhouse gas emissions, which are not accounted for under the scheme's LCA. Additionally, it can place other environmental and social pressures on wider sectors, such as cattle and arable farming, leading to food shortages, increasing food prices and changing social patterns.

Results of life-cycle analysis and issues for use

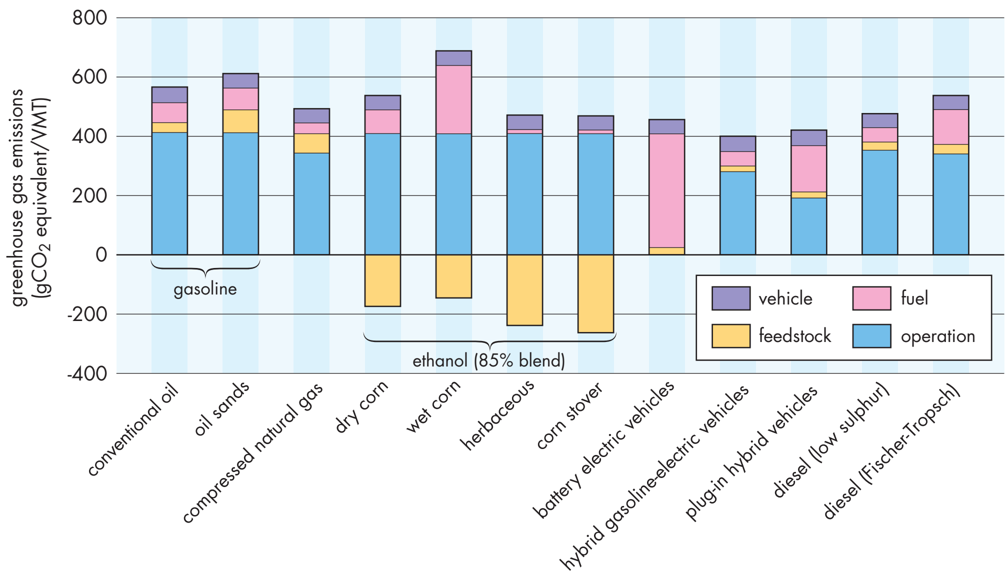
Results of LCA

Considering the results from a number of life-cycle analysis studies can help to illustrate some of the problems discussed above. Similar studies can give comparable or differing results, depending on assumptions and boundaries.

For example, Figure 2 shows results from the National Research Council (NRC) study on the hidden costs of energy. Here, we see the life-cycle emissions of various fuels compared by grams of CO_2 equivalent per vehicle mile travelled (VMT). In this study, life-cycle emissions include not only the emissions from fuel combustion but also emissions associated with producing the fuel, growing crops (in the case of biofuels), generating electricity (in the case of electric vehicles) and manufacturing vehicles. All of the fuel pathways shown lead to net GHG emissions that are compared in the Figure. LCA emissions for some of the pathways are lower, and some higher, than for petroleum-based fuels (either gasoline or diesel); and some of the LCA emissions are estimates for pre-commercial systems whereas others are for systems that are in widespread commercial use. There is greater uncertainty in, and a weaker basis for, estimates for technologies that have yet to become commercial.

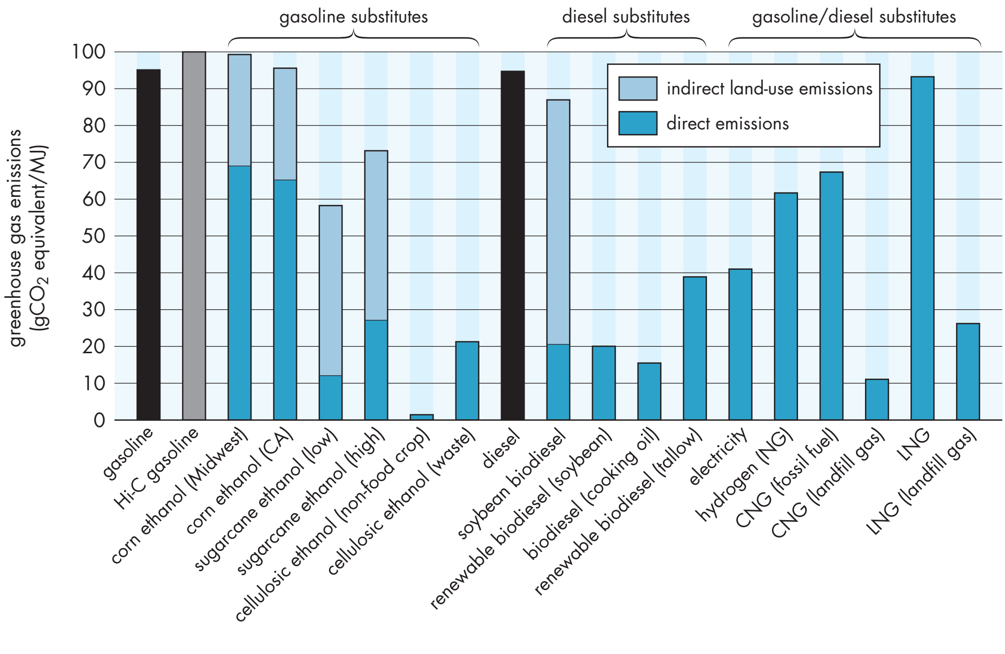
When comparing the LCA results from Figure 2 to those published by the California Air Resources Board in 2009 (Figure 3), we see marked differences between seemingly the same fuel pathways. For example, the NRC study includes the emissions required to produce vehicles, whereas the CARB report does not. Electric vehicles in the NRC study portray higher emissions than for CARB, which is at least partly due to the lower emissions assumed for California power generation compared to the US average assumed in the

Figure 2 *US light-duty vehicle GHG emissions (2005)*



Source: Thomas McKone's presentation, from US NRC study 'Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use'. See: http://www.nap.edu/catalog.php?record_id=12794

Figure 3 *Life-cycle GHG emissions of fuels in California*

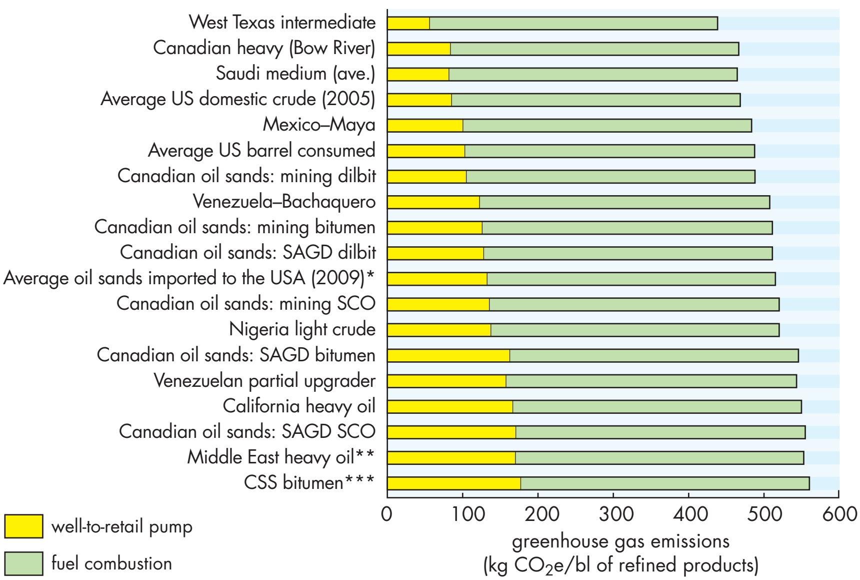


Source: Sonia Yeh's presentation (from CARB 2009 report)

Implications of LCA for oil sands

The implications of LCA for various pathways and sources of petrol products are actually to reduce the size of the range of emissions associated with them. Figure 4 shows that the emissions from refined products across a diverse range of crude sources varies very little, in fact only around 550 kg CO_2 equivalent/barrel (CO_2e/bl) down to 440 kg CO_2e/bl. This ~20% difference is comparable to the differences between the fuels in either of the previous studies, and in fact also the change in performance of a fuel between the previous two studies.

Figure 4 *Well-to-wheels greenhouse gas emissions for oil sands and other crudes*



Results of a meta-analysis of 13 publicly available life-cycle studies. Assumptions:
*Assumes 55 per cent of exports to the United States are dilbit blends and 45 per cent are SCO (source: NEB 2009 oil sands exports).
**Steam injection is used for production. ***Assumes SOR of 3.35. 12 per cent loss of volume upgrading bitumen to SCO. All SAGD crude production cases assume an SOR of 3. All oil sands marked 'dilbit' assume that the diluent is consumed in the refinery, with no recycle of diluents back to Alberta, and only 70 per cent of the barrel is from oil sands. All oil sands marked 'bitumen' assume that the diluent is recycled back to Alberta, and all of the barrel processed at the refinery is from oil sands.

Source: Jackie Forest's presentation (from IHS Cambridge Energy Research Associates (CERA) study)

In fact, not all LCFS will differentiate between different sources of crude, instead setting a single value for petrol and diesel (possibly to ameliorate the energy security implications of shifting sources). However, we can see that oil sands products, for example, are situated throughout this league table, and fair better than some other crudes. In fact the average well-to-wheel increase in greenhouse gas emissions from oil sands compared to regular crude is only around 5–15%. It can also be noted that unconventional crude exploration and production is still immature and has greater room for efficiency improvements going forward than conventional crudes.

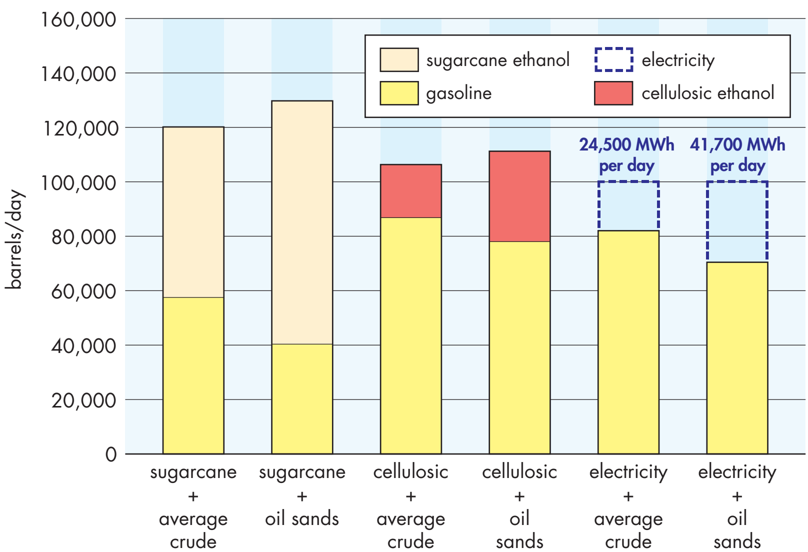
NRC study. Also, ethanol results in lower emissions in the NRC study, where indirect emissions from biomass land use are not fully included, compared to the CARB report where emissions from indirect land use have a stronger contribution. (An exploration of the uncertainties around the impacts of indirect land-use change was the focus of an IPIECA workshop in 2009[3].)

This comparison helps to demonstrate that the choice of boundary and accounting methods can have a large impact on the end results of the LCA studies, making it difficult to accurately distinguish between fuel types. It is important for the choice of boundary conditions to be appropriate for the use of the analysis, and for the rationale for the choice to be transparent.

The issues for use, and impacts, of an LCFS

An LCFS effectively results in a requirement for fuel portfolios—various fuels can be supplied in varying volumes to achieve the given standard. Sales of regular petrol or diesel augmented with sales of bioethanol and biodiesel, together with increasing use of electricity in plug-in electric vehicles, is likely to make-up the overall picture. However, this can create onerous requirements for low-carbon alternative fuels, especially where the demand for transport is still rising. Further, many of these new fuels or technologies are immature, with minimal production capacity, poor infrastructure provision or limited uptake by consumers. Subsequently, if the supply of low-carbon fuel

Figure 5 *Example petrol portfolios that comply with the California LCFS in 2020 (100,000 barrels per day equivalent)*



Notes:

Compliant portfolios can consist of multiple alternative fuels, and combining multiple fuels is the most likely compliance strategy.

Volumes of portfolios that contain ethanol are larger than 100,000 barrels because of ethanol's lower energy density.

Source: Jackie Forrest's presentation (CERA meta-analysis of 13 LCA studies)

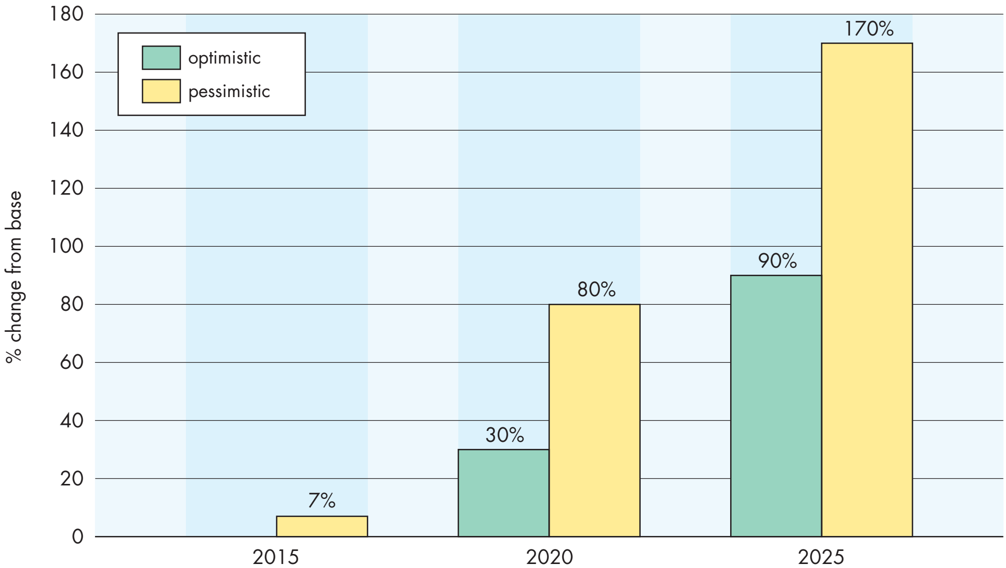
[3] www.ipieca.org/event/20100318/indirect-land-use-change-stakeholder-debate-science-and-policy-impacts-sustainable-bi

cannot be met, this may lead to significant price increases in order to restrict demand. This could significantly impact the political acceptability of an LCFS.

For example, Figure 5 shows the portfolios which would comply with the California LCFS in 2020. To comply with a portfolio based on average crude would require an additional 60,000 barrels per day (b/d) of sugarcane-derived ethanol, or around 20,000 b/d of cellulosic-derived ethanol. Given that total nationwide cellulosic ethanol production by the end of 2011 might be roughly 1,500 b/d, and perhaps roughly 5,000 for sugarcane, enormous growth will be required to achieve these 2020 targets.

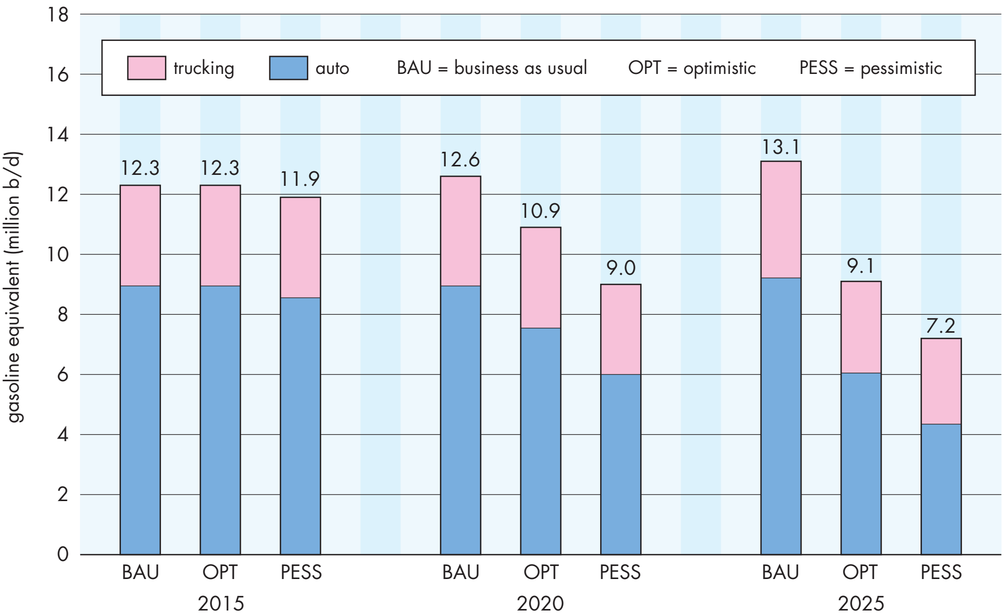
This demonstrates the importance of timing as a key issue for LCFS—enough time should be given to allow sufficient production of low-carbon fuels. If this does not happen then prices are likely to rise to meet supply volumes. This point is illustrated by Figures 6 and 7, from a study by Charles River Associates which projected transportation fuel costs and demand based on a national US emissions reduction target of 10% over 10 years. It can be seen that fuel costs increase by around 55% in five years, with a corresponding drop in demand of around 20% relative to business as usual (BAU). Significantly, after 10 years, costs have increased greatly, to roughly 130% in order to force demand down almost 40% from BAU.

Figure 6 *Change in transportation fuel costs, 2015–2025*



Source: David Montgomery's presentation (from a Charles River Associates study)

Figure 7 *Change in demand for transportation fuels, 2015–2025*



Source: David Montgomery's presentation (from a Charles River Associates study)

Reflections

Life-cycle analysis is not a precise science. Whilst it does have a role in directing technology research, it provides great uncertainty when being used as a regulatory tool. The boundary and accounting choices are critical, changing the outcomes, when comparing across studies. Additionally, the margins of error in a study can actually be greater than the percentage reduction in emissions required under an LCFS, raising serious questions about their validity.

The impacts of an LCFS force greater amounts of low-carbon fuel substitutes into portfolios, but this means that timing of targets and fuel production is critical. If low-carbon fuels cannot be produced then the price increases to reduce demand.

Currently, LCFS are being proposed to encourage uptake of alternative fuels. But they require a large infrastructure built around life-cycle analysis, and the results do not yet provide the necessary certainty and accuracy to be able to discern relatively small differences between some fuels. Is there a better policy as an alternative? Would straightforward carbon taxes produce similar results at much lower societal cost? Policy dialogues should be encouraged in the discussion around low-carbon fuel standards.

Workshop programme

- **Workshop Scene Set**

  Wishart Robson, Nexen

- **Session 1: Transport fuels policies: Issues and opportunities**

  Chair: Terry Killian, Marathon

  - Implications of transportation fuel LCA on climate change policy (John Reilly, MIT)
  - The hidden costs of energy (Thomas McKone, Lawrence Berkeley National Laboratory)
  - Implications of LCA on fuels regulation (Dr Sonia Yeh, University of California, Davis)
  - The economics of fuel carbon standards (David Montgomery, Charles River Associates)

- **Session 2: LCA results and issues for regulatory use**

  Chair: Wishart Robson, Nexen

  - LCA of transportation fuels (Jackie Forrest, CERA)
  - LCA of unconventional transportation fuels (Eddy Isaacs, AERI)

- **Panel discussion:**
  Regulatory use of LCA for conventional, alternative and unconventional fuels

  Moderator: Haroon Kheshgi, ExxonMobil

  Participants: Eddy Isaacs, Thomas McKone, David Montgomery, Dr Sonia Yeh

- **Closing discussion**

  Haroon Kheshgi, ExxonMobil

- **Conclusions and close**

  Wishart Robson, Nexen

All presentations are available from the workshop webpage:
www.ipieca.org/event/20100723/lca-ghg-emissions-transport-fuels-and-impacts-unconventionals

IPIECA Climate Change Working Group

The Climate Change Working Group (CCWG) was established in 1988. Its efforts focus on three strands of work—greenhouse gas emissions best practice, greenhouse gas metrics, and science and policy including the two major intergovernmental processes: scientific assessments by the Intergovernmental Panel on Climate Change (IPCC); and negotiations under the United Nations Framework Convention on Climate Change (UNFCCC).

The CCWG aims to provide members with reliable and timely information, issues analysis, technical guidance, education and involvement in international processes dealing with global climate change.

Climate change publications

- *The Oil and Gas Industry and Climate Change* (2007)
- *Saving Energy in the Oil and Gas Industry* (2007)

Best practice guidelines

- *Oil and Natural Gas Industry Guidelines for Greenhouse Gas Reduction Projects* (2007)
- *Oil and Natural Gas Industry Guidelines for Greenhouse Gas Reduction Projects: Carbon Capture and Geological Storage Emission Reduction Project Family* (2007)
- *Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions* (2003)

Guide series

- *The United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol: A Guide to the Climate Change Negotiations* (2008)
- *Climate Change—a Glossary of Terms (4th Edition)* (2007)
- *A Guide to the Intergovernmental Panel on Climate Change (4th edition)* (2006)

Workshop report series

- *Climate Change and Energy to 2020 and Onwards* (2008)
- *Natural Gas as a Climate Change Solution: Breaking Down the Barriers to Methane's Expanding Role* (2007)
- *Increasing the Pace of Technology Innovation and Application: Enabling Climate Change Solutions* (2007)
- *Greenhouse Gas Emissions Estimation and Inventories: Addressing Uncertainty and Accuracy* (2007)
- *International Policy Approaches to Address the Climate Change Challenge* (2006)
- *Transportation and Climate Change: Workshop Summary* (2005)
- *Carbon Dioxide Capture and Geological Storage Workshop Summary* (2003)
- *A Practical Approach to Identifying Emission Reductions Opportunities, Workshop Summary* (2003)
- *Energy Development and Climate Change: Considerations in Asia and Latin America* (2002)
- *Development and Climate Change: Issues and Approaches in Asia* (2002)
- *Long-Term Carbon and Energy Management—Issues and Approaches* (2001)
- *Opportunities, Issues and Barriers to the Practical Application of the Kyoto Mechanisms* (2000)
- *Technology Assessment in Climate Change Mitigation: A Workshop Summary* (1999)

IPIECA

IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares and promotes good practices and knowledge to help the industry improve its environmental and social performance, and is the industry's principal channel of communication with the United Nations.

Through its member-led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

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