GLOBAL BEST PRACTICES IN LOW-CARBON FUEL STANDARDS

A TECHNICAL BRIEF

SAVANT Technical Consulting

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INTRODUCTION:

A low carbon fuel standard (LCFS) is a regulatory tool that requires mandatory reductions in the annual average greenhouse gas (GHG) intensity of fuels sold within a given jurisdiction. Typically, fuel providers earn credits or generate deficits based on the GHG intensity of fuels sold; these credits can be traded on an open market. The Canadian and Ontario governments are considering adopting LCFS-type policies, respectively known as the Clean Fuel Standard and the Renewable Fuel Standard for Gasoline. These policies would join the ranks of other prominent LCFS and related policies, summarized in Table 1. While Canada and Ontario have renewable fuel mandates (e.g., Canada's Renewable Fuels Regulations require 5% of gasoline and 2% of diesel to be sourced from renewable sources), introduction of LCFS policies will cover more fuels and will require more detailed emissions accounting. Pollution Probe and Savant Technical Consulting are undertaking a critical review of key issues related to sustainability criteria, GHG accounting and approaches to quantifying emissions from land use change for LCFS policies. The present brief summarizes interim findings, in preparation for release of a report in late 2017. Emissions from land use change are among the most important and most controversial aspects of LCFS regulations, and so are a key focus of the work.

TABLE 1. OVERVIEW OF EXISTING LCFS AND CLOSELY RELATED POLICIES.

Jurisdiction & Policy Name	Goal	Fuel Eligibility	Land Use Change Included?	Other Sustainability Criteria[e]
British Columbia LCFS	10% reduction in carbon intensity of transport fuels by 2020; 15% by 2030 (relative to 2010)	All fuels used in on-road motor vehicles are eligible, as well as heating oil	Direct[b] only	No
California LCFS	10% reduction in carbon intensity of transport fuels by 2020 (relative to 2010)	All fuels used in on-road motor vehicles are eligible	Direct and Indirect[c] Based on[d] GTAP-BIO model	No, but includes an unspecified requirement for future sustainability provisions
Oregon Clean Fuels Program	10% reduction in carbon intensity of transport fuels by 2025 (relative to 2015)	All fuels used in on-road motor vehicles are eligible		No
US Renewable Fuel Standard (RFS2)[a]	36 billion gallons of biofuels produced annually by 2022	Biofuels used in motor vehicles or in non-road engines. The biofuels must meet GHG reduction thresholds of 20% to 60% for different fuel types (relative to fuel replaced – gasoline or diesel)	Direct and Indirect Based on[d] FASOM and FAPRI models	Yes, excludes biofuels from non-agricultural land or from trees on federal land. Rulemaking also analyzed, but did not account for economic impacts, and likely impact on non-GHG pollutants and water use.
EU Fuel Quality Directive (EU FQD)	6% reduction in carbon intensity of transport fuels by 2020 (relative to 2010)	Fuels used for road transport and non-road mobile machinery. The fuel must meet a GHG reduction threshold of 35% relative to the fuel it replaces; increased to 50% (2017) and to 60% (2018)	Direct only. Indirect emissions must be reported, but are not included in calculations. MIRAGE-BioF and GLOBIOM-EU models have been used[d]	Yes, restricts biomass feedstock from land with high biodiversity or high carbon stock; limits biofuels produced from cereal, sugar, and oil crops

a. This policy is not an LCFS policy but includes relevant GHG accounting methods and land use change modeling.

b. Direct land use change refers to land converted specifically to grow the biofuel in question.

c. Indirect land use change refers to land conversions that occur throughout the global agricultural system in response to biofuel production.

d. Listed models are primarily for predicting land changes; calculating the resulting emissions generally requires use of a separate carbon accounting model.

e. Refers to whether the policy includes sustainability criteria other than GHG emissions.

HOW ARE GREENHOUSE GAS EMISSIONS QUANTIFIED?

Life cycle assessment (LCA) is a method that aims to account for environmental impacts across a product's life cycle. In the case of fuels, a typical LCA study would include activities related to feedstock production (oil extraction; growing biomass feedstock), fuel manufacture (oil refining; biofuel production), transportation and distribution stages, and fuel combustion. An LCA therefore includes both the **use-phase emissions** related to fuel combustion as well as the **supply chain emissions** associated with the production and distribution of the fuel (e.g., energy and material inputs to production processes; fuel consumption for fuel distribution). Traditional ('attributional') LCA focuses on quantifying environmental flows directly associated with a given product. Some researchers and policy makers have suggested a need to analyze broader system changes that occur when a new product is introduced or its production is increased ('consequential' LCA). Thus, some LCA methods also include **indirect emissions** associated with the economy-wide response to policies or product adoption. For example, biofuels can increase demand for agricultural products and thereby induce changes in global land use patterns with important emission consequences (see below, *What is Land Use Change?*).

By including impacts across the full fuel life cycle, LCA aims to comprehensively identify and quantify sources of environmental impact. However, variability and uncertainty in data, as well as inconsistencies in modelling approaches, can result in LCA models returning different results. Selection of data to best represent the system in question is critical, taking into account potential sources of variability (varying in time, by location, or by producer) and uncertainty (data may be aggregated, incomplete, out of date, not representative, or not available). Ideally, data should be selected to best represent the system being evaluated; however, given the large number of required inputs and their associated variability and uncertainty, results will always have some degree of uncertainty.

A number of publicly available software tools have been used to evaluate the life cycle GHG emissions of fuels to support LCFS regulations: The Greenhouse Gases, Regulated Emissions, and Energy use in Transportation Model (GREET) in US regulations (California LCFS and Oregon LCFS), GHGenius in Canada (BC LCFS), and BioGrace in Europe.

WHAT IS LAND USE CHANGE?

Biofuels often play a prominent role in meeting LCFS standards, but leave the policies vulnerable to indirect emissions. Policies that encourage the use of biofuels or other land-intensive energy sources can cause emissions through the repurposing of land. For example, if forests or grasslands are converted to cropland in response to an increased demand for agricultural products then these land conversions can increase GHG emissions, most notably through the release of stored carbon (e.g., due to decomposition of removed biomass, or changes in soil carbon stocks). Often, a substantial portion of these emissions are indirect, being driven by economy-wide crop price changes that incentivise the establishment of new croplands.

Some studies have historically differentiated between *direct* and *indirect* land use change, depending on whether the new emissions occur on the land that is directly used to grow biofuels or elsewhere in the global agricultural system in response to diverting land or crops to biofuel production. For the purpose of assessing the consequences of biofuel policies, this distinction is often not useful as the net impact is the same. Increasingly, experts rely on blanket terms, such as *induced* land use change (ILUC[1]), to capture the emissions from all land transformations resulting from increased use of biofuels. Although there exist land use impacts from other fuel sources (e.g., due to the exploitation of oil fields) these have generally been found to be small relative to the land transformations required for some biofuels.

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[1]Acronyms for land use change are used inconsistently in the literature. 'ILUC' has been used to represent the international component of indirect land use change, all indirect land use change, or all induced land use change (including direct and indirect). This brief uses the latter, broadest definition of induced land use change.

ILUC is beyond the scope of traditional LCA, but is often a deciding factor as to whether biofuel policies are likely to achieve their stated goals in terms of net reductions in GHG emissions. Various studies have projected ILUC emissions due to biofuel production, with estimates ranging from below 0 (i.e., removing carbon dioxide from the atmosphere) to over 200 g CO2e/MJ, more than double the emissions of gasoline production and use (~90 g CO2e/MJ), depending on the biofuel source and ILUC model employed. For U.S. corn ethanol, ILUC emissions used in US policies (RFS2, California LCFS, Oregon LCFS) range from 8 g CO2e/MJ to 26 g CO2e/MJ; values are typically lower for some biofuels, like sugarcane ethanol, and higher for some biofuels, like soybean biodiesel. To our knowledge, no study has quantified ILUC emissions for biofuels produced in Canada.

Although ILUC is an important emission category, there remain common arguments against its inclusion in a regulatory context. First and foremost, ILUC estimates are inherently uncertain and difficult/ impossible to verify empirically, being derived from global-scale economic and emission factor models with coarse resolution. When disagreement exists between models, it can be challenging to assign a single value to ILUC. Further, many of the assessed land transformations are likely to occur outside the jurisdiction of the country/region implementing the biofuel policy, raising important questions about accountability for these emissions. Despite these concerns, excluding ILUC from assessment results in incomplete emissions accounting and may lead to ineffective policies, resulting in an increase rather than decrease in global GHG emissions.

HOW ARE ILUC EMISSIONS QUANTIFIED?

ILUC models typically begin by estimating the amount, type, and location of global land transformations induced by biofuel production. The predicted land cover changes are linked with carbon stock and emission factor databases to estimate resulting GHG emissions. The resulting estimated emissions are then amortized over a period of time, typically 20-30 years of future biofuel production. Because ILUC stems from economy wide interactions, the resulting emissions are attributed to different fuel types (e.g., corn ethanol), and do not depend on the specific production process from any given company. Thus, while use-phase and supply chain emissions from LCA models can be specific to local fuel production processes, ILUC is a characteristic only of the fuel type and policy under which that fuel is produced.

Most ILUC modeling approaches are based on economic equilibrium models (EEMs). Though highly uncertain, EEMs are the best available option to provide quantitative support for regulations; they are currently used in the decision-making process in the US policies (Table 1) and to evaluate ILUC in Europe. EEMs start with a baseline supply and demand equilibrium across the world economy or within a set of specified interconnected markets. An economic shock is introduced (i.e., increase in demand of biofuel due to a new policy), and the model forecasts the resulting new equilibrium. EEMs rely on estimated elasticities – key paramters that represent the percentage change in one variable as the result of a percentage change in another variable (usually price). Some examples of required elasticities include: price elasticity of demand for agricultural products, price elasticity of crop yields; and elasticities that drive conversions between land types.

Within EEMs for biofuel ILUC, there are General Equilibrium Models (GEMs) and Partial Equilibrium Models (PEMs). GEMs include demand functions and production functions (i.e., an abstraction of how capital, labour, and other broad input categories are combined to create representative final products) for an aggregated set of sectors that represent the entire economy. PEMs provide supply and demand functions that focus on specific sectors of interest for ILUC. PEMs often provide greater resolution for changes within agriculture and forestry, but hold constant all other sectors. Prominent GEMs include the Global Trade and Analysis Project with Biofuels (GTAP-BIO) and Modeling International Relationships in

Applied General Equilibrium- BioFuel (MIRAGE-BioF). Prominent PEMs include the US-focused Forest and Agricultural Sector Optimization Model (FASOM), the Food and Agricultural Policy Research Institute (FAPRI), and the European-focused Global Biosphere Management Model- European Union (GLOBIOM-EU). Several of these models have been used in existing LCFS regulations (Table 1). To date, no EEM model has been developed to specifically assess ILUC impacts of Canadian biofuel policy; however, existing tools could be adapted to do so.

In addition to differences in economic modeling structure (GEMs or PEMs), existing ILUC models differ in other dimensions such as geographic coverage and resolution, included land cover and management types, treatment of global trade, the possibility of agricultural land expansion, the methods for carbon emissions accounting, and carbon stock and emission factor databases. Aside from the characteristics of the models, many key parameters and assumptions will affect estimated emissions from ILUC. Some key considerations include the biofuel source (i.e., type of crop and origin), elasticities governing product demand, crop yields and trade, potential for double-cropping, and treatment of products co-produced with biofuels. Additional uncertainties may also be introduced with respect to projecting future improvement on crop yields, oil prices, and global macro-economic developments.

SUSTAINABILITY CRITERIA – ACCOUNTING FOR WHAT COUNTS?

LCFS policies focus primarily on GHG emissions. Although climate change is one of our most pressing global challenges, past policy experience has shown that a focus on a single impact has often resulted in unintended negative consequences. How likely is it that fuels viewed as attractive under low carbon fuel standards due to their low GHG intensities actually offer net overall benefits to society? Encompassing the broader concept of sustainability (environmental, economic, and social components) is critical to ensuring a movement to low GHG fuels does not result in net negative impacts but is challenging to implement in practice due to the wide range of potential impact categories, and difficulties quantifying them. Although non-GHG aspects are included/noted in several LCFS-type regulations (e.g., see Table 1), these regulations remain GHG emission policies. Overall, within LCFS and related regulations, the perspective of the LCFS regulator has been; i) that non-GHG aspects are covered under other regulations within the jurisdiction and not within the LCFS (e.g., California LCFS, although it includes an unspecified requirement for future sustainability provisions), or, ii) they include guidance within the LCFS regulation to try to avert the most obvious/major ‘known’ potential negative consequences (e.g., EU FQD), or, iii) that non-GHG impacts be analyzed but not directly influence the rulemaking (e.g., US RFS2), or iv) that available resources and data have so far been insufficient to include non-GHG impacts in the regulation (e.g., BC LCFS).

NEXT STEPS

The success of LCFS policies in Canada will depend on appropriate consideration of sustainability criteria, the use of accurate GHG accounting tools with a suitable life-cycle perspective, and careful treatment of ILUC and other indirect emission sources, among other design elements. The forthcoming critical review by Pollution Probe and Savant Technical Consulting will provide further guidance on these considerations.

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ABOUT POLLUTION PROBE

Established in 1969, Pollution Probe is a national, non-profit organization that exists to improve the health and wellbeing of Canadians by advancing policy that achieves positive, tangible environmental change. Pollution Probe has a proven track record of working in partnership with industry and government to develop practical solutions to environmental challenges.

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ABOUT SAVANT TECHNICAL CONSULTING

Savant Technical Consulting is a small, research-driven consulting company built by world-leading experts in the fields of microbiology and biotechnology, process and bio-process design, and life cycle assessment (LCA).