Alternative Aviation Jet Fuel Sustainability Evaluation Report

Task 3: Sustainability Criteria and Rating Systems for Use in the Aircraft Alternative Fuel Supply Chain

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Sustainability Criteria and Rating Systems for Use in the Aircraft Alternative Fuel Supply Chain[1]

Table of Contents

[1] See also "Alternative Jet Fuel Environmental Sustainability Overview," prepared by the Environment Committee of the Commercial Aviation Alternative Fuel Initiative, version 2.0, March 1, 2013.

Executive Summary

This report identifies criteria that can be used to evaluate the sustainability of biofuels introduced into the aviation fuel supply chain. It describes the inputs, criteria and outputs that can be used in a sustainability rating system. It identifies two methodological approaches for assessing lifecycle biofuel sustainability from feedstock production to an airport's fuel tank farm.

The report describes three categories of sustainability principles, criteria and indicators: environmental, social and economic. Elements of rating systems are analyzed, including outputs that can provide useful information to purchasers of aviation biofuel. It concludes with recommendations for policy makers and purchasers of aviation biofuel.

Research for the report revealed a long historical context for the consideration of sustainability by U.S. government policy makers stretching back to the enactment of the National Environmental Policy Act of 1969 which itself echoed sentiments prominent in the conservation movements of the nineteenth and earlier twentieth centuries.

Bio-based aviation fuels have been certified for use in commercial aviation in concentrations of up to 50% and currently present a feasible alternative to the use of fuels derived purely from petroleum. This report asserts that biofuel producers should be prepared to disclose sustainability performance information about the biofuels they sell. Because the primary appeal of biofuel is its environmental preferability to fossil fuels, biofuels need to demonstrate that their life cycle greenhouse gas emissions are less than those the of the fossil-based aviation fuels they displace. In addition, biofuels should be able to demonstrate that their carbon-reduction advantages are not countered by significant environmental drawbacks, or shortcomings associated with social or economic criteria.

Potential negative environmental impacts associated with biofuel production may include conversion of forest and agricultural lands to biofuel feedstock production, unsustainable consumption of water, adverse biodiversity impacts, introduction of invasive species, and excess air and water pollution. Social impacts may include decreased availability of and higher prices for food, use of child labor, and disregard for land rights. Economic impacts that may be unfavorable to biofuel production can include a high ratio of energy inputs, negative economic impacts on residents where biofuel feedstocks are produced or converted, and failure to improve local human capacity when making biofuel investments. Biofuel stakeholders have a need for information about the sustainability characteristics of biofuel production that can provide assurance that accepted standards of sustainability will be met in every consignment of supplied fuel.

Biofuel production is not the only economic sector that has dealt with issues of sustainability. Forest products and organic farming, for example, have implemented mechanisms to provide government regulators, customers, and end-users with assurance of sustainability. Labeling and chain-of-custody auditing have played a role in both of these sectors.

Sustainability Criteria and Rating Systems for Use in the Aircraft Alternative Fuel Supply Chain

Sustainability standards typically are organized in a hierarchy that includes principles, criteria and indicators in ascending order of specificity. Environmental, social and economic principles and criteria are standard components of sustainability in standards as well as in codes for socially responsible conduct. Ultimately, sustainability metrics require benchmarking against what can be called “sustainability condition indicators” that are measured on local, regional, national or global scales. Moreover, these sustainability condition indicators may be influenced by such dynamic factors as population change, land use change, aggregate impacts of pollution, and climate change. Under these conditions the level of performance deemed acceptable for an organization five years ago may not be deemed sustainable ten years from now.

Several sustainability frameworks have defined greenhouse gas emission thresholds for renewable energy. Frameworks generally agree on a limit or screening approach for other important sustainability criteria, such as land conversion. Social metrics generally include food security and human and labor rights. This report compare metrics established by the Global Bioenergy Partnership (GBEP), a consortium of governments working in conjunction with the U.N. Food and Agriculture Organization, to those defined by the Roundtable on Sustainable Biofuels (RSB), a voluntary consensus-based standards organization that is hosted by the Ecole Fédérale Polytechnique de Lausanne in Switzerland. GBEP data are collected for analysis by policymakers at the national level, while RSB data inform conclusions about changes in the economic status of the communities most directly affected by biofuel operations and are used for certification purposes.

Sustainability rating systems have in common a “life cycle inventory” approach which evaluates all relevant material and energy inputs and outputs including the product plus waste streams and emissions. The “engine” of sustainability rating systems may be provided by environmental life cycle assessment performed in accordance with ISO 14040 and ISO 14044, or by conformity assessment activities (i.e. audits). A rating system operator may be anyone, but typical operators represent organizations involved in the biofuel supply chain, policy makers and regulators, or independent third party organizations.

This report assesses some benefits and drawbacks associated with environmental life cycle assessment (E-LCA) performed using ISO 14040 and ISO 14044 standards. It concludes that E-LCA is a valuable analytical tool for quantifying environmental impacts from products from “cradle to grave.” Manufacturers use it to ensure that major upstream or downstream environmental impacts that may otherwise not be fully quantified are recognized. E-LCA is also used by policy makers to inform policy choices and to justify rule-making decisions. U.S. EPA uses E-LCA, and the life cycle approach was written into the Energy Independence and Security Act of 2007. Some drawbacks to the use of E-LCA are identified, such as the time and cost required to perform E-LCA studies, the use of aggregated versus site-specific data, and the role of value judgments in reaching conclusions. By contrast, the conformity assessment approach audits specific biofuel production supply chains and certifies fuel from the feedstock production phase to its delivery to end users.

The report concludes that the operation of a sustainability rating system can result in one of five outputs: an E-LCA study report, supplier certification, a supplier's declaration of conformity, a product label, or a sustainability product declaration.

On the basis of the research conducted, Futurepast offers the following ten recommendations to policy makers and purchasers of aviation alternative fuel.

1. Sustainability of biofuel should be assessed on a life cycle basis, i.e. taking into account environmental, social and economic impacts of the phases of feedstock development, feedstock processing, refining, blending, transportation and consumption.

2. Sustainability of biofuel should be assessed at the facility level to ensure that each economic operator in the supply chain meets sustainability criteria.

3. Biofuel should not be developed when it fails tests of sustainability. Biofuel development can have significant impacts on land resources, water use and availability, biodiversity, and food security, and may have unacceptable social or economic impacts in the communities where it is produced.

4. Information about the sustainability attributes of the biofuel supply should be communicated to policy makers, biofuel purchasers, and the public.

5. Sustainability information should be fact-based and accurately presented. Disclosure should be made where material uncertainties exist in the accuracy of information, and the principle of conservativeness applied when communicating claims of sustainability (i.e., in the face of uncertainty, err on the side of overreporting, rather than underreporting, sustainability impacts).

6. Sustainability information should be verified, or capable of verification.

7. Third-party certification of the economic operators in the biofuel supply chain should be the preferred method used by biofuel purchasers to obtain assurance that supplied fuel was produced in conformity to sustainability criteria.

8. Chain-of-custody information about supplied biofuel should be third-party verified.

9. Sustainability life cycle interpretation should present results separately for environmental, social and economic impact categories.

10. National governments should monitor sustainability indicators at the country level so that impacts related to changing scale of biofuel development can be monitored over time.

General Sustainability Frameworks

Concerns about climate change and energy independence have prompted governments around the world to look to bioenergy as an alternative to petroleum-based transportation fuels. In the United States, Congress renewed its commitment to transportation biofuels in the Energy Independence and Security Act in 2007 (EISA),[2] and the European Commission launched its Renewable Energy Directive (RED).[3] Brazil, an early leader in the promotion of transportation biofuels, has long mandated the retail sale of pure as well as blended biofuels.[4] Although policy initiatives initially focused on road transportation, governments and the aviation industry have embraced policies and aspirational goals that encourage the deployment of alternative aviation fuels as well. The approval of fuel certification standards for "drop-in" renewable jet fuel and successful testing of biofuels in commercial and military aircraft have proven the concept. Yet, despite the progress achieved, barriers to the widespread adoption of biofuels remain. Chief among them are availability and cost, both of which are being addressed through government incentive programs.[5] A third issue associated with the widespread commercialization of biofuels is "sustainability." If biofuels are to be confirmed as a climate-preferable alternative to continued growth in aviation industry fossil fuel emissions, the biofuel supply chain must meet standards of sustainability.[6]

This report discusses sustainability as it relates to bioenergy used as transportation fuel, including aviation biofuel. It defines sustainability, describes general sustainability frameworks, and identifies interested parties. The report explains sustainability principles, criteria and indicators. It identifies common environmental, social and economic sustainability principles in two prominent frameworks. Two conceptual approaches for evaluating sustainability are described, conformity assessment and life cycle assessment. The report describes elements of rating systems, including outputs that can provide useful information to purchasers of aviation biofuel. It concludes with recommendations for policy makers and purchasers of aviation biofuel.

What Is "Sustainability"?

The term sustainability came into prominence worldwide with the publication in 1987 of a UN Commission on Environment and Development report titled "Our Common Future." The report stated that "humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their needs."[7] This definition of sustainable development informed the 1992 United Nations Conference on Environment and Development and has gained widespread acceptance. When the International Organization for Standardization (ISO) published its "Guidance on social responsibility" in 2010, it used the Commission's definition and added this note:

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2 EISA 2007.
3 EU RED 2009.
4 Beck 2004.
5 Gerrard 2011. "Federal Incentives and Subsidies," p. 449 ff. The economics of biofuel development is outside the scope of this research report.
6 Hawkins 2009.
7 UN Commission on Environment and Development 1987.

> "Sustainable development is about integrating the goals of a high quality of life, health and prosperity with social justice and maintaining the earth's capacity to support life in all its diversity. These social, economic and environmental goals are interdependent and mutually reinforcing. Sustainable development can be treated as a way of expressing the broader expectations of society as a whole."[8]

The U.S. Congress in 1969 anticipated sustainability in its National Environmental Policy Act (NEPA). The law declared that that "it is the continuing policy of the Federal Government . . . to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."[9] In furtherance of its policy, Congress established the Environmental Protection Agency in 1970 and over the next three decades enacted or strengthened numerous federal laws aimed at protecting, enhancing or restoring the environmental conditions of the nation's air, water, land and biological resources.

In 1980, the International Union for Conservation of Nature (IUCN) published its "World Conservation Strategy: Living Resource Conservation for Sustainable Development."[10] According to a National Academies of Science committee, the strategy represented the "integration of conservation and development" in the form of "sustainable development." It defined conservation as the "management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations."[11] The IUCN acknowledged the difficulty of merging the two concepts: "Conservation and development have so seldom been combined that they often appear—and are sometimes represented as being—incompatible." It nonetheless concluded that "integration of conservation and development" is needed to "ensure that modifications to the planet do indeed secure the survival and well-being of all people."[12] Modern scholarship has demonstrated that civilizations destroy their natural resources at their peril.[13]

Addressing environmental issues became increasingly important to corporations in the 1980s and 1990s. Integrating social considerations into business planning and decision making also gained management attention.[14] Governments and industry both supported the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. Two consensus documents from that conference, Agenda 21 and the Rio Declaration, received U.S. Government approval. "Together, these agreements modify the definition of development by adding a third pillar—environmental protection and restoration—to the economic and social pillars of development, and is also known as the 'Triple Bottom Line' approach in the corporate sector."[15]

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[8] ISO 26000:2010.
[9] NEPA 1969.
[10] IUCN 1980.
[11] NRC 2011, p. 20.
[12] Ibid.
[13] Diamond 2005.
[14] Spreckley 1981.
[15] NRC 2011, p. 21

The importance of protecting and conserving the natural environment for the benefit of humankind has deep roots in American ecological literature and in public policy. In the decade following Henry David Thoreau's *Walden*, George P. Marsh wrote that "Everything that humans require for their survival and well-being depends, directly or indirectly, on the natural environment."[16] In the late nineteenth century a conservation movement arose in reaction to indiscriminate clearing and burning of forests. In response, presidents Benjamin Harris and Grover Cleveland withdrew from public entry millions of acres of forest. President Theodore Roosevelt built upon these acts of stewardship by designating Gifford Pinchot as the first professional manager of the new national forest system.[17] As the U.S. Forest Service developed, it balanced recognized need for conservation with a doctrine of multiple use of forest resources.

The competing goals of protecting and restoring natural resources while maintaining economic activity and ensuring social justice have gained greater prominence in the early twenty-first century. Scientific assessments of the threats from climate change have increased calls for action to slow global warming. Moreover, disruptions in the stable delivery of petroleum and increased competition for resources have highlighted the value of diversifying sources of fuel supplies. Now that bio-based aviation fuels present a feasible alternative to petroleum derived fuels, it is important to address sustainability issues in order to prevent the environmental and energy independence remedies from being worse for the planet than the ills they were intended to cure. Key sustainability issues include the extent to which biofuels reduce carbon dioxide emissions below those of petroleum-based fuels, the effect of biofuel feedstock cultivation on food prices and availability, growing strains on water resources, impacts on biodiversity, and ensuring that human and labor rights are respected as the biofuel industry rapidly expands.

In addition to understanding and addressing sustainability issues at the level of feedstock producer, feedstock processor, and biofuel refiner, the nascent biofuel supply chain and distribution systems will need to develop mechanisms to ensure that sustainability information is collected, checked for accuracy, and aggregated and then forwarded from upstream producers to downstream distributors and end users. This information will provide assurance to seller, purchaser and interested parties, including, in many cases, government regulators, that sustainability requirements for the delivered fuel have been met throughout the supply chain.

While some participants in the biofuel industry have recognized the need for adherence to sustainability standards throughout the supply chain and for demonstrating conformity to these standards for biofuel brought to market,[18] widespread agreement on the standards and practices for documenting and accounting for sustainably produced biofuel has not yet been achieved.[19] Although the necessary steps for implementation may be complex, especially when considered across the full extent of a biofuel

[16] NRC 2011, p. 15, citing G. P. Marsh, Man and Nature; or, Physical Geography as Modified by Human Action. Cambridge, MA: Belknap Press of Harvard University Press, 1864.
[17] Shideler 1991, p. 22.
[18] SAFUG 2010.
[19] Hawkins, 2009, p. 23: "One problem with sustainability standards is their implementation and enforcement. Standards organizations, biofuel developers and the aviation industry have not developed, and do not understand, a clear path to implementation." Progress has been achieved since Hawkins wrote this comment in late 2009, but standards development is still ongoing and implementation and enforcement is in very early stages.

supply chain, experience in other economic sectors has shown that strict environmental and social standards can be developed and implemented.

Supply Chain Management in Other Economic Sectors

The food industry provides an example of responding to consumer demands for food that is produced with fewer chemicals and uses agricultural practices that are less harmful to the land and to water resources. Farmers responded with "organic" products that claimed environmental benefits when compared to "conventional" ones. After controversy about organic claims in the United States led to the enactment of national legislation in 1990, the U.S. Department of Agriculture established uniform standards enforced on all but the smallest sellers of produce.[20] Under the National Organic Program, a "USDA Organic" label can be placed on products containing at least 95 percent organic ingredients that have been certified by independent certification bodies. The U.S. Department of Agriculture has accredited some 56 U.S. based organizations and 41 foreign organizations to offer organic certification services.[21] Organic produce uses the "segregation" chain-of-custody method to ensure that organic product is not mixed with conventional product in the supply chain. In addition to organic labeling, concern for fair treatment of agricultural workers led to the additional labeling of some food products as "Fair Trade" certified. The United Nations Conference on Trade and Development (UNCTAD) has published requirements for fair-trade labeling.[22] UNCTAD's website provides 33 examples of fair-trade labels issued by organizations around the world.[23]

Another example of defining sustainability standards and certifying products can be found in laws designed to end illegal importation of fish, wildlife and plants. In both the United States and in Europe, conservation laws implement the international Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).[24] Banning illegal exports is one matter, but distinguishing legal exports is quite another. The European Union addressed this problem in the hardwood trade through its Forest Law Enforcement, Governance and Trade (FLEGT) directive.[25] FLEGT requires exporting states to enter into Voluntary Partnership Agreements (VPAs) with the EU that define criteria for legal exports. This has resulted in countries passing laws requiring forest resource management, sustainable harvesting, and certification of product sustainability and legality. Under VPAs, exporting states are required to create systems of verification for establishing legality and traceability, and to adopt transparency measures in dealing with stakeholders. The VPAs also require the performance of audits and the establishment of an authority to deliver FLEGT product certifications. In Africa, VPAs have been

[20] The Organic Foods Production Act (Title 21 of P.L. 101-624) was enacted in 1990. The U.S. Department of Agriculture adopted regulations under the name of the National Organic Program in 2000.

[21] Wikipedia 2012 b.

[22] UNCTAD 2012 a.

[23] UNCTAD 2012 b.

[24] In the U.S. the Lacey Act implements CITES in part by banning the importation of certain plants and plant products without an import declaration.

[25] Adopted as a European Council regulation in 2005. An implementation regulation was adopted in 2008. See FLEGT Voluntary Partnership Agreements (VPAs), accessed on 2012-02-16 at http://ec.europa.eu/environment/forests/flegt.htm.

negotiated for the Congo, Ghana, Liberia, Cameroun, and the Central African Republic, with more African states to follow. Outside Africa, Indonesia is a signatory, and Vietnam and Malaysian are in preparation. In addition to controls in producer countries, FLEGT puts a positive obligation on the seller of imported wood in Europe to perform due diligence on its sourcing, and to ask questions such as "What is its provenance?", "Is it from a sensitive region?", "What kind of wood is it"?, "Is its supply chain known"?, and "Are the furnished documents credible?"[26] In Liberia, trade in *azobé* trees from the country's rainforest has been revitalized as a result of FLEGT, after the government implemented rules for sustainable harvesting and export of the resource. Under former president Charles Taylor, the United Nations had banned trade in Liberian *azobé* trees, which are used for construction and decking, on grounds that Liberia was using the proceeds of timber sales to fund war. Now, with product traceability to track timber from stump to port, the illegal export of logs should be curtailed.[27]

A third model is offered by the nongovernmental Forest Stewardship Council (FSC). The vision of FSC is that "The world's forests meet the social, ecological, and economic rights and needs of the present generation without compromising those of future generations."[28] FSC addresses this "triple bottom line" of environmental protection, social responsibility and economic development through the publication of standards developed using a stakeholder consultation process. FSC's standard promotes sustainable forest management practices, mandates that forest resources benefit local people and society at large, and supports economic returns "without generating financial profit at the expense of the forest resource, the ecosystem, or affected communities."[29] A separate affiliated organization of FSC, Accreditation Services International, oversees the accreditation and annual surveillance of independent third-party certification bodies.[30] Beginning with their harvest in certified forests, sustainably produced forest products are tracked from woodlot to mill and beyond to the distribution networks that supply retail hardware stores and the printing industry. Certified chain-of-custody controls ensure that FSC-compliant wood and fiber are marked in accordance with the FSC standard. FSC exercises strict control over the use of its trademarks so that only wood and paper products that use fiber derived from FSC-managed forests can bear the FSC mark. FSC certification of forests is widespread in North America and Europe (each with more than 60 million hectares of certified forests), representing more than 80 percent of forest lands certified to FSC standards. Smaller shares of certified forests are found in South America (9.5 million hectares), Africa (7.5 million hectares), Asia (5 million hectares), and Oceania (2.2 million hectares).[31]

Sustainability and Bioenergy

Sustainability is an important issue for the biofuels industry because the main appeal of the fuel is its environmental preferability to fossil fuels. The use of biofuels can reduce anthropogenic emissions of carbon dioxide by making use of energy stored in plants and diverted from natural methods of short-term carbon recycling to higher valued uses. Accurate carbon accounting methods are needed to ensure

[26] Châtel 2012, p. 15.
[27] Ryan 2011.
[28] FSC 2012 a.
[29] Ibid.
[30] ASI 2012.
[31] FSC 2012 b.

that biofuels deliver the carbon emission savings that represent one of their primary benefits. Moreover, biofuels need to demonstrate that their carbon-reduction advantages are not countered by significant environmental drawbacks, or shortcomings associated with social or economic criteria. Potential negative environmental impacts may include conversion of forest and agricultural lands to biofuel feedstock production, unsustainable consumption of water, adverse biodiversity impacts, introduction of invasive species, and air and water pollution. Social impacts may include decreased availability of and higher prices for food, use of child labor, and disregard for land rights. Economic impacts that may be unfavorable to biofuel production could include a high ratio of energy inputs, negative economic impacts on residents where biofuel feedstocks are produced or converted, and failure to improve local human capacity when making biofuel investments.

The consequences of failing to produce biofuel sustainably can be grave. Invasive species infestations can cause large economic and environmental damages. Water scarcity can impact both the production of biofuel feedstock and diminish availability for other users. Publicity about the use of biofuels that fail tests of sustainable production can include damage to corporate reputations and loss of public support for the development and adoption of aircraft alternative fuels. For these reasons, the biofuel industry, the biofuel workforce, users of biofuels, government policy makers and regulators, communities affected by biofuel development, and the general public have an interest in ensuring that biofuel production is managed sustainably.[32] Moreover, bioenergy stakeholders have a need for information about the sustainability characteristics of bioenergy production that can provide assurance that accepted standards of sustainability will be met in every consignment of supplied fuel.

Support for integrating sustainability considerations in U.S. government decision making is growing. In 2009 President Obama issued Executive Order 13514, “Federal Leadership in Environmental, Energy and Economic Performance,” which instructed federal agencies to adopt multiyear strategic sustainability performance plans. The order reiterated the definition of sustainability used in the 1969 National Environmental Policy Act. At the request of the U.S. EPA, the National Academies of Sciences formed a “Committee on Incorporating Sustainability into the U.S. Environmental Protection Agency.” In its report, the committee recommends that U.S. EPA adopt a framework for making sustainability decisions. The framework includes an assessment and management approach throughout the agency as a process complement to its traditional “risk assessment/risk management” approach.[33]

According to the NRC committee, the framework also requires new forms of knowledge. Sustainability science “is problem-driven and interdisciplinary.” The demands for a more holistic and systems-based approach to sustainability decision making could lead U.S. EPA to engage professionals drawn from a wider array of academic disciplines, such as law, engineering, and social sciences in addition to the natural sciences. As the NRC committee that studied how to integrate sustainability into the practices of U.S. EPA phrased it, “Sustainable development also raises questions that are not fully or directly addressed in U.S. law or policy, including how to define and control unsustainable patterns of production and consumption and how to encourage the development of sustainable communities,

[32] SAFN 2011, p. 39.
[33] NRC 2011, p. 3.

biodiversity protection, clean energy, environmentally sustainable economic development, and climate change controls. Each of these questions needs to be addressed across government agencies."[34] The NRC committee did not provide answers to the questions it so provocatively raised, but rather suggested that U.S. EPA integrate a sustainability framework as "a process and a goal."[35]

Business and industry have also participated in the trend to broaden impact analysis to include social and economic considerations. Larger numbers of businesses now issue sustainability reports. The Global Reporting Initiative, which publishes a Sustainability Reporting Framework, reported that "from 2006 to 2011, the yearly increase in uptake ranged from 22 to 58 percent."[36] One analyst estimates that between 80-90 percent of SAP 100 companies "report on at least some sustainability data."[37] Since 2009 Wal-Mart Stores has asked its supply chain partners to complete sustainability questionnaires, and it provided initial support for the creation of The Sustainability Consortium, an academic-led multistakeholder project focused on developing mechanisms for sustainability reporting. A study released in early 2012 found that two-thirds of executives surveyed said "sustainability is necessary for competitiveness, up from 55 percent a year before," and that "seventy percent said that their companies have made sustainability a permanent fixture on the management agenda."[38]

Information Needs for Bioenergy Sustainability's Interested Parties

Different interested parties have needs for varying types of information about bioenergy sustainability. In bioenergy, at least eight separate categories of interested parties may be identified. They include:

- Standards developers
- Bioenergy industry representatives representing biofuel supply chain operators (feedstock cultivators, processors, refiners, blenders and distributors)
- Government policy makers
- Communities affected by the bioenergy industry
- Bioenergy industry workers
- Government regulators
- Bioenergy users, and
- The general public.

Although the categories are distinct, overlap exists among them. For example, a bioenergy standard and a regulation may have considerable overlap in scope and application. Both define requirements and both may be subject to conformity assessment. The main distinguishing factor is that a regulation is a legal requirement, while standards may be developed by voluntary consensus outside the framework of any government. "International Standards" are published by ISO, a network of the member bodies of 161 countries. International Standards represent a consensus of the views of multiple stakeholders, and may include normative ("shall") and aspirational ("should") statements. Regulations implement laws

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[34] NRC 2011, p. 26.
[35] Ibid., pp. 28-29.
[36] GRI 2012 a.
[37] Grubb 2012.
[38] Kiron 2012.

by defining requirements. Additional overlap may exist between the roles of government policy makers and government regulators. They are distinguished for the purpose of this discussion because their information needs may vary. While government policy makers track trends and identify future needs, government regulators' information requests from the regulated community usually focus more narrowly on current performance. Communities affected by the presence of the bioenergy industry constitute another category of interested party. Communities may include bioenergy industry workers, and the members of communities may also fall in the category of the general public.

Bioenergy Standards Developers. Bioenergy standards developers need information from a broadly representative group of parties interested in the subject of the standard. Standards development involves compromise among interested parties in order for a standard to be widely adopted and implemented. Standards sometimes set performance standards, other times they define processes that should result in the achievement of the outcome defined by the standard. The broader the base of interested parties contributing to the writing of a standard, the greater the difficulty standards writers may have agreeing on performance thresholds or standardized processes. Compromise may lead to the inclusion of aspirational statements, or to requirements subject to multiple interpretations in their implementation. The most successful international standards reflect best practice, are widely used, and in some countries are incorporated in government regulations. ISO, through its "Sustainability criteria for bioenergy" standard,[39] is attempting harmonization in a field where nongovernmental organizations have already delivered standards. With extensive stakeholder consultation, the Energy Center at the Ecole Fédérale Polytechnique de Lausanne (EPFL) in Switzerland launched the Roundtable on Sustainable Biofuels[40] in 2007. Its goal was to write a standard that would enable feedstock producers in many countries to avoid having to obtain multiple sustainability certifications. The Council on Sustainable Biomass Production began a similar effort in the United States in the same year.[41]

Bioenergy Industry Representatives. Bioenergy industry representatives are the persons most directly involved in documenting sustainability information, in tracking it, and in ensuring that it is delivered to bioenergy purchasers in specified formats. Developing, managing and checking information costs money, so bioenergy industry representatives may perceive burdens to be less onerous when requested information is already compiled for other management purposes besides assessment of sustainability. Flexible rules for information management are generally preferred, as are minimal administrative burdens and self-policing rather than oversight by regulatory bodies or independent third parties. Industry participates directly in standards and regulatory policy development and also often is represented through trade associations whose policy positions are themselves the result of a consensus-based consultation process among members.[42]

Government Policy Makers. Government policy makers need information to assess the impact of their decisions. In the bioenergy field, governments in 2008 tasked the Global Bioenergy Partnership to define

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[39] Work on ISO 13065 is being undertaken in Project Committee 248.
[40] RSB 2012.
[41] CSBP 2012.
[42] See IPIECA 2010. IPIECA, an oil and gas industry trade association, examined chain-of-custody methods and recommended book-and-claim for its lower cost to industry and less disruption of current supply chain practices.

common metrics for measuring sustainability indicators in the three themes of environment, social and economic. The metrics GBEP published in 2011 should permit national governments to collect country-level information that quantifies performance at the national level on 24 defined indicators. An objective of the GBEP initiative is to enable comparisons of country performance across the globe through the use of standardized metrics. GBEP did not propose performance standards or thresholds, which were left to individual countries and their regulatory bodies.[43]

Communities Affected by the Bioenergy Industry. Communities affected by the bioenergy industry typically are interested in knowing the economic benefits of the proposed activity and the associated environmental, social and economic costs. Most communities actively welcome economic development that provides jobs for local residents and tax revenues for their governments. But they are also interested in knowing what potential downsides exist, and what kind of an employer and member of the community the industry will be. For example, the impacts of an employer's failure to comply with environmental or social legal requirements are often felt most intensely at the local level. Environmental impact assessments are common tools for organizing and presenting information about the magnitude of environmental impacts likely to be felt by a community over the long term. Such assessments help community leaders develop inputs to formal siting and regulatory approval processes, where these exist.[44] Health risk assessment information is also particularly relevant to local communities who may be impacted by pollution from new industrial facilities. Disputed land rights and allocation of scarce resources, such as water, are issues that typically require community-level assessments.

Bioenergy Industry Workers. Bioenergy industry workers are a specific demographic subset of many communities surrounding new agricultural or industrial facilities. Compared to nonemployees in their communities, they benefit disproportionately from wages paid by employers and may value more highly the economic benefits of their jobs. Workers also may benefit from opportunities for training that lead to human development and capacity building benefits. On the negative side, workers may be more directly impacted by increased exposure to occupational illness and injury. Additional impacts can arise where human and labor rights are not respected.

Government Regulators. Government regulators have the specific responsibility to transform policy objectives of governments into enforceable regulations that are uniformly and fairly administered across the regulated community. The design of regulatory programs may be well defined by policy makers, but a certain amount of discretion inevitably falls to the staff of regulatory agencies which may provide guidance and exercise discretion over enforcement. Government regulators seek well-defined performance metrics grounded in natural science principles whose measurement and reporting results are not subject to interpretation. Performance metrics that are both pertinent to regulatory objectives and feasible to monitor are preferred.

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[43] GBEP 2011.

[44] International guidance for preparing environmental assessments was published by the World Bank in 1991 and has evolved steadily since then. See also ADB 2001 for the African Development Bank's Environmental and Social Assessment Procedure (ESAP), and UNEP 2004 for its integration of social and economic impact assessment in "sustainability assessments."

Bioenergy Users. Bioenergy users are primarily concerned about receiving product that meets technical specifications (outside the scope of this report) and has the additional product characteristic of "sustainably produced." Bioenergy users also have a stake in the efficiency of compliance and conformity assessment processes, as these will be reflected in product cost. For a biofuel user, the data and information that accompanies the product should provide unambiguous and reliable evidence that the purchased fuel has met sustainability requirements. Sustainability certifications must be credible and to the extent possible, the number of sustainability certifications minimized, so that the administrative burdens of tracking sustainable fuel purchases and use are reduced.

The General Public. Public concerns about product characteristics may be elevated when allegations are made that contradict public expectations and beliefs. An allegation that a product designated as "sustainably produced" is responsible for rising food prices would likely trigger public concern, as would an allegation that the life cycle greenhouse gas emissions of biofuel were no more favorable to climate change mitigation than those of fossil fuels. Such allegations are more likely to diminish the credibility of biofuels in the public's esteem than episodic reports of unsustainable performance by one operator in a supply chain, though the cumulative effect of many episodic reports of the same type could damage the image of bioenergy products.

Sustainability Principles, Criteria and Indicators

Sustainability standards typically are organized in a hierarchy that includes principles, criteria and indicators in ascending order of specificity. Principles are general statements, such as "Biofuels shall contribute to climate change mitigation by significantly reducing lifecycle GHG emissions as compared to fossil fuels."[45] Criteria identify the conditions that must be met by participating operators in order to demonstrate implementation of the principle. For example, a criterion in RSB's soil principle states that "Operators shall implement practices to maintain or enhance soil physical, chemical and biological conditions."[46] Criteria may also specify requirements that need to be met. Finally, indicators provide evidence that criteria and requirements have been met. Under its soil principle, for example, RSB presents eight indicators for the first of its soil criteria. Feedstock producers are expected to demonstrate fulfillment of the criterion with evidence showing that they have met at least the first five indicators. In this example, indicators six through eight are designed to provide additional evidence when the RSB screening exercise has triggered the development of a soil impact assessment.[47]

GBEP sustainability indicators for bioenergy are organized differently, because the document is not designed to be used for conformity assessment.[48] Normative statements are not used in either GBEP "themes" (e.g. "Greenhouse gas emissions," or "Productive use of the land"), and criteria are absent. Instead GBEP presents "indicators," which are described and assigned "measurement units."[49] For example, greenhouse gas emissions are a theme in the environmental pillar. The indicator is "lifecycle

[45] RSB 2010, p. 11.
[46] RSB 2010, p. 21.
[47] RSB 2011 a, pp. 52-53.
[48] The topic of conformity assessment is discussed below in further detail. See p. 20.
[49] GBEP 2011, pp. 15-18.

greenhouse gas emissions." The measurement unit is "grams of CO_2 equivalent per megajoule."[50] Consequently, GBEP's methodology produces data about sustainability, but does not include performance standards.

RSB criteria imply the existence of performance standards, so that product characteristics[51] can be rated with respect to their sustainability. Some RSB criteria incorporate quantified performance standards, such as "biofuel blends shall have on average 50% lower lifecycle greenhouse gas emissions relative to the fossil fuel baseline."[52] Other criteria express performance standards in qualitative terms, such as "operators shall implement practices to maintain or enhance soil physical, chemical and biological conditions."[53] RSB criteria also include pass/fail screening tests. This is a form of a quantified performance standard, where the only acceptable performance indicator is zero (e.g. "areas with conservation value(s) of local, regional or global importance shall not be converted after January 1, 2009.")

Three Pillars of Sustainability

Environmental, social and economic principles and criteria are standard components of sustainability both in standards,[54] as well as in codes for socially responsible conduct.[55] The logic of adding social impact assessment to environmental impact assessment became apparent in the evaluation of large construction projects, such as dams, which not only projected significant environmental impacts but also the displacement of hundreds or thousands of people. The addition of the economic pillar has not always followed the impact assessment model, as some articulations of economic themes have focused as much on the economic performance of the studied option rather than on economic impacts to persons affected by the development. For example, ARB stated in an update on its progress in integrating sustainability in the Low Carbon Fuel Standard that "Economic sustainability overlaps previously mentioned social concerns regarding food prices and food security, but it also includes creating an economic environment in which alternative fuels can be produced and distributed on a long-term basis. Economic incentives, such as grants and tax credits, initially help in this regard; however, any market is more likely to thrive when uncertainty is removed to the greatest extent possible and robust business plans can be created." The view expressed here by ARB represents quite a different understanding of what it means to be "economically sustainable."[56] In most impact assessment frameworks, the financial feasibility of a project is viewed as a factor outside the scope of an impact assessment. Financial feasibility is not included in the economic criteria considered in this report.

Many social responsibility and sustainability standards include compliance with laws and regulations as a separately defined expectation. Examples include ISO 26000, the RSB Criteria and Principles, the CSBP Provisional Standard for Agriculture, and the International Sustainability and Carbon Certification standard. Regulations do not need such statements (e.g. in the RFS2 or the EU RED), because

[50] GBEP 2011, p. 33.
[51] For a discussion of product characteristics, see the section on "Rating Systems" below, p. 18.
[52] RSB 2010, p. 11.
[53] RSB 2010, p. 21.
[54] To cite only a few examples, see GRI 2012 b, UNEP 2004, RSB 2010 and GBEP 2011.
[55] ISO 26000:2010.
[56] See ARB 2010, p. C-3.

governments take for granted that applicable laws and regulations will be followed by economic operators in the bioenergy supply chain as well as by other members of regulated communities.

Despite differences in approach and scope, there is greater similarity than disagreement among definitions of bioenergy sustainability principles, criteria and indicators. GBEP indicators are presented as metrics that will provide statistical information to national policy makers. RSB principles and indicators are presented as requirements that bioenergy economic operators must meet. In the following sections, the principles of the GBEP Task Force on Sustainability are compared to those provided by the RSB for economic operators in the supply chain.

Environmental. The principles and criteria included in the environmental component of sustainability focus on calculation of the life cycle emissions of greenhouse gases (GHGs); pollution impacts to water, air, and land; biodiversity; and land use.

Comparison of Frameworks for Environmental Sustainability

GBEP Environmental Principle	
1	Life cycle GHG emissions
2	Soil quality
3	Harvest levels of wood resources
4	Emissions of non-GHG air pollutants, including air toxics
5	Water use and efficiency
6	Water quality
7	Biological diversity in the landscape
8	Land use and land-use change related to bioenergy feedstock production
---	

RSB Environmental Principle	
3	Greenhouse gas emissions
8	Soil
---	---
10	Air
9	Water
9	Water
7	Conservation
3	Greenhouse gas emissions
11	Use of technology, inputs & management of waste
1	Compliance with applicable laws and regulations

Social. The principles and criteria included in the social component of sustainability focus on human and labor rights, safety and health in employment, food security, and respect for the rule of law. Many of the principles and criteria in this category are addressed by the International Labor Organization (ILO)[57] or are included in the recent social responsibility guideline standard published by ISO.[58] Many of the issues addressed in the social "pillar" of sustainability appear to have greater pertinence in developing countries, though even advanced economies are not immune to the need for continued oversight of the application of fair labor rights protections.[59] Moreover, food security remains an issue capable both of affecting vulnerable segments of populations and raising public concern in countries with varying levels of prosperity. One U.S.-based organization noted that "This principle is primarily aimed at developing

[57] ILO 2009.
[58] ISO 26000:2010.
[59] U.S. DOL 2012.

nations. The Northwest is not regarded as a food insecure region. Nevertheless, we have included this principle in the screening evaluation because of the extensive concern about food-fuel conflicts."[60]

Comparison of Frameworks for Social Sustainability

GBEP Social Principle		RSB Social Principle	
1	Allocation and tenure of land for new bioenergy production	12	Land rights
2	Price and supply of a national food basket	6	Local food security
3	Change in income	5	In regions of poverty, the socioeconomic status of local stakeholders impacted by biofuel operations shall be improved
4	Jobs in the bioenergy sector	5	In regions of poverty, the socioeconomic status of local stakeholders impacted by biofuel operations shall be improved
5	Change in unpaid time spent by women and children collecting biomass	4	Baseline social survey data
6	Bioenergy used to expand access to modern energy services	---	
7	Change in mortality and burden of disease attributable to indoor smoke	4	Baseline social survey data
8	Incidence of occupational injury, illness and fatalities	4	Occupational health and safety conditions follow internationally recognized standards
---		4	Absence of: slave/forced labor, wages paid below legal minimum wage, child labor
---		4	Workers enjoy freedom of association, right to organize, and right to collective bargaining
---		4	No discrimination or sexual harassment; equal opportunity employment, especially for women
---		4	Worker rights and protections flow down to third-party contractors
		5	In regions of poverty, special measures that benefit and encourage the participation of women, youth, indigenous communities and the vulnerable in biofuel operations shall be designed and implemented
---		1	Compliance with applicable laws and regulations

[60] SAFN 2011, p. 41.

Economic. Economic sustainability may be the pillar of sustainability subject to the widest range of interpretation, because the phrase has been used, on the one hand, to describe the ability of organizations to “survive” economically, and on the other hand, to catalog the impacts of projects and policies on affected populations. In some cases both meanings are intended. One organization which has exercised considerable influence on measures of economic sustainability is the Global Reporting Initiative.[61] According to GRI, “The economic dimension of sustainability concerns the organization’s impacts on the economic conditions of its stakeholders and on economic systems at local, national, and global levels. The Economic Indicators illustrate:

- “Flow of capital among different stakeholders; and
- “Main economic impacts of the organization throughout society.”[62]

GRI expresses the distinction between financial reporting and the organization’s economic results, and the impact of an organization on measures of economic sustainability this way: “Financial performance is fundamental to understanding an organization and its own sustainability. However, this information is normally already reported in financial accounts. What is often reported less, and is frequently desired by users of sustainability reports, is the organization’s contribution to the sustainability of a larger economic system.” The economic principles of both GBEP and RSB reflect the ambiguity of the economic pillar, though RSB’s treatment of the theme leans considerably more in the direction of economic impacts on affected populations than does GBEP’s.

Comparison of Frameworks for Economic Sustainability

GBEP Economic Principle		**RSB Economic Principle**	
1	Productivity	2	Business plan*
2	Net energy balance	2	Business plan*
3	Gross value added	5	Social Impact Assessment: Economic benefits and economic losses
4	Change in consumption of fossil fuels and traditional use of biomass	5	Baseline social survey data
5	Training and requalification of the workforce	5	Measurable improvements in socioeconomic conditions
6	Energy diversity	---	
7	Infrastructure and logistics for distribution of bioenergy	5	Social Impact Assessment: Infrastructure and general effects
8	Capacity and flexibility of use of bioenergy	---	
---		1	Compliance with applicable laws and regulations
		* RSB does not prescribe specific content for the required business plan. However, productivity measures and net energy balance ratios may be expected to be tracked by management.	

[61] Brown 2007 documents the story of the rise to prominence of the GRI.
[62] GRI 2012 b, p. 25.

Sustainability Metrics and Baselines

Metrics provide a means for assessing the degree to which sustainability principles and criteria are fulfilled. When compared against a baseline, they provide information that help organizations determine whether their performance supports sustainability or not. Sustainability metrics resemble those used in environmental or financial management, but have one unusual characteristic: their impact cannot be assessed at the scale of a single organization. They are unlike financial metrics, which may reliably indicate the profit or loss of an enterprise. Similarly, they do not always behave as environmental management metrics, which may track the efficiency of fuel use and the volumes of waste sent to a landfill with the confidence that higher and lower respective trend lines signal improved performance. Ultimately, sustainability metrics require benchmarking against what can be called "sustainability condition indicators"[63] that are measured on local, regional, national or global scales. Moreover, these sustainability condition indicators may be influenced by such dynamic factors as population change, land use change, aggregate impacts of pollution, and climate change. Under these conditions the level of performance deemed acceptable for an organization five years ago may not be deemed sustainable ten years from now.

The Roundtable for Sustainable Biofuels partly addressed this point in introducing their principles and criteria: "Finally, the Principles & Criteria do not attempt to quantify an amount of biofuels which could be sustainably produced, or whether, as a whole, biofuels are sustainable. Biofuels cannot replace all of our fuel consumption and must be accompanied by significant changes in lifestyle and efficiency of use; we hope that these Principles & Criteria will be used in conjunction with an increasing awareness of the importance of efficient energy use to meet humanity's needs."[64]

GBEP's sustainability indicators are intended to provide policy makers with information suitable for the establishment of "sustainability condition indicators" applicable at the national level. Although GBEP authors do not use the term "sustainability condition indicator," the indicators they describe are analogous. GBEP authors describe them as "starting points from which policy-makers and other stakeholders can identify and develop measurements and domestic data sources that are relevant to their nationally-defined needs and circumstances. The GBEP indicators do not provide answers or correct values of sustainability, but rather present the right questions to ask in assessing the effect of modern bioenergy production and use in meeting nationally-defined goals of sustainable development."[65] Additional research could then be conducted to compile national information and reach conclusions about sustainability trends at the continental and global levels. But because this information "looks back" at results achieved, only the expected impacts of biofuel feedstock cultivation and biofuel production facility operations that are assessed for sustainability during planning and managed during implementation phases will affect the direction and magnitude of the chosen indicators.

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[63] In ISO 14031:1999, 3.5, the term "environmental condition indicator" is defined as a "specific expression that provides information about the local, regional, national or global condition of the environment."

[64] RSB 2010, p. 3.

[65] GBEP 2011, pp. 2-3.

Several sustainability frameworks have defined threshold criteria for greenhouse gas emissions for renewable energy. All agree on the relative efficiency metric of grams of carbon dioxide–equivalent (CO_2-e) per megajoule of energy, calculated on a feedstock source-to-tank life cycle basis, compared to the greenhouse gas emissions profile of petroleum fuel from well-to-tank. Frameworks generally agree on a limit or screening approach for other important sustainability criteria, such as land conversion. RFS2, RED, and RSB all include cut-off dates after which no conversion to biofuel crop production is permitted on lands with specified conservation values. Frameworks generally also agree on the need to prohibit conversion of land with high values in biodiversity. Other environmental metrics are defined by best practices that vary with the feedstock production methods and specific geographic conditions present at the local level.

Social metrics generally include food security and human and labor rights. Monitoring food security metrics at a highly aggregated level (e.g. national) provides little help for determining whether a specific biofuel operation would contribute or not to local food insecurity. RSB addressed this issue by requiring a local impact analysis. In the case where local food insecurity is found, RSB requires the implementation of a mitigation plan. Localizing the impact assessment and tailoring a mitigation plan to the effects most likely to be associated with the implantation of a bioenergy facility does not take directly into account changes in price and availability of global commodity food crops such as corn and soybeans. On the other hand, SAFN includes the indicator in its sustainability screening of feedstock alternatives but notes in each case that it is not applicable in the Pacific Northwest.[66]

A common approach to the human and labor rights criteria in some frameworks (e.g. GBEP, RSB) is to use legal compliance as a proxy indicator. In this case the metric for legal compliance may be the number of instances of *non*-compliance recorded by the operator. In a similar fashion the metric representing the provision of a workplace that is safe and healthy for workers may be measured by the number of instances of reportable injuries and occupational illnesses, normalized annually per 100 full-time workers.

GBEP economic metrics differ primarily from RSB metrics in the level of aggregation and framework for comparison. GBEP data are collected for analysis at the national level, while RSB data inform conclusions about changes in the economic status of the communities most directly affected by biofuel operations.

Because sustainability consists of achievement of criteria of three separate types (environmental, social and economic), methodological limitations make it difficult to interpret and compare the three types of data on a single scale. There is no direct comparability on an environmental impact assessment scale of data regarding the use of child labor or the presence of food insecurity. In 2011 UNEP published "Towards a Life Cycle Sustainability Assessment: Making informed choices on products"[67] which promotes the use in combination of environmental, economic and social assessments to improve decision-making. It proposes the use of Life Cycle Costing (LCC), environmental LCA, and social LCA to develop a fuller representation of sustainability than can be achieved by the use of environmental LCA alone. While promoting the concept of Life Cycle Sustainability Assessment (LCSA), the UNEP publication

[66] SAFN 2011, p. 41 and *passim*.
[67] UNEP 2011.

also cautions that "aggregation and weighting of results of the three techniques used are not recommended because of the early stage of LCSA research and implementation and because the individual aims of each of the techniques applied are not directly comparable to the other."[68]

Evaluating Sustainability

The sustainability of biofuels may be evaluated at many levels. The indicators developed by the Global Bioenergy Partnership are designed to provide statistical information that will enable policy makers to benchmark sustainability at a national scale. A supply-chain focus is provided by sustainability standards that analyze the specific "pathways" that biofuels take from farm to tank. The word pathway implies that there is both an origin and a destination, so that sustainability evaluation takes into account cultivation, transportation of feedstock, oil processing, fuel production and blending from a designated supply chain to a particular market. This method may be further disaggregated in distinct "subpathways" which allow, for example, for consideration of differences in performance among specific biofuel processing plants.

Greenhouse gas emissions occupy a special place in the evaluation of biofuel sustainability. Policy makers and others want to know what the life cycle GHG emissions are for each biofuel pathway, and how these emissions compare to the fossil fuel the bioenergy option is intended to replace. The common metric for GHG emissions for a given biofuel pathway is grams of CO_2-e per megajoule of fuel produced. This single number can then be compared to an equivalent normalized GHG emissions pathway number for fossil-based fuels. Life cycle GHG emissions for biofuels are determined using internationally standardized approaches to life cycle assessment.[69]

There are divergent approaches for dealing with other life cycle environmental impacts. On the one hand, an environmental life cycle practitioner, using internationally agreed methods for attributional life cycle assessment, may include all relevant environmental aspects when studying a particular biofuel pathway. In addition to GHG emissions, relevant environmental aspects may include those related to other air emissions, water use and quality, soil quality change, biodiversity loss, energy and resource consumption, and land use change. This results in a life cycle "inventory" of material and energy inputs as well as outputs that include the product, plus waste and emissions. A second step involves life cycle impact assessment, where the consequences of the inventoried environmental aspects are evaluated. Life cycle impact assessment permits comparisons of the relative overall environmental impact of one option compared to another (e.g. biofuel option compared to fossil fuel option, or comparison of several biofuel feedstock options). Comparison is based on the normalized effect of each environmental stressor on impact categories such as human and ecological health. The output of the analysis may be used in risk assessment or other decision-making processes. Comparison may also be based on a single score for all environmental impacts of a studied option using a weighting process that assigns relative values to the different impact categories.

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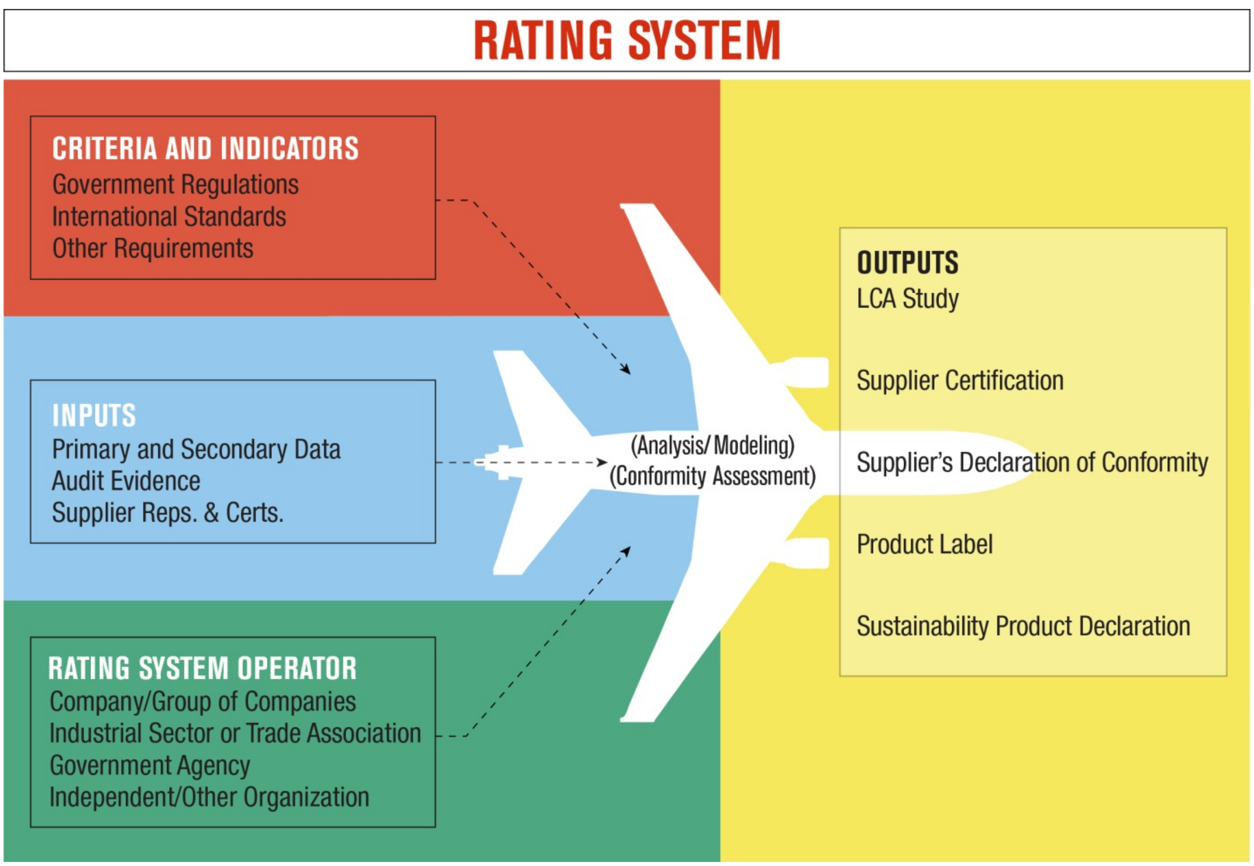
[68] Ibid., p. 38.
[69] See ISO 14040:2006 and ISO 14044:2006.

Conformity assessment provides a second method for evaluating sustainability. Conformity assessment is defined in international standards as a "demonstration that specified requirements relating to a product, process, system, person or body are fulfilled."[70] Conformity assessment typically is carried out by means of an audit. Evidence reviewed during the audit forms the basis for conclusions concerning conformity or nonconformity to the specified criteria (e.g. RSB standards). When carried out by an accredited third party, audit conclusions often result in the issuance of a certificate of conformity.

Rating System

A "rating system" may be understood as a process for classifying or ranking processes or products according to their quality characteristics.[71] In this case, sustainability criteria and indicators are the quality characteristics evaluated in accordance with a standardized method. A rating system includes inputs and outputs, criteria and indicators used for determining the classification or ranking, a set of process steps, and a rating system operator.

Rating System Operator. The rating of biofuel sustainability implies the existence of a rating system "operator." An operator may be anyone, but typically operators represent organizations involved in the biofuel supply chain, policy makers and regulators, and independent third party organizations. An



[70] See ISO 17000:2004, 2.1.

[71] ISO 9000:2005, 3.5.1, p. 12.

operator representing an organization in the supply chain may perform the rating process for internal purposes, such as planning or quality assurance, or for external purposes such as business-to-business communication or business-to-consumer communication. Independent third-party organizations that operate rating systems include certification bodies and product labeling organizations. Finally, government policy makers and regulators may operate rating systems in order to inform decisions or implement regulatory programs. Industrial sector or trade associations sometimes operate rating systems to provide information to their members or for the purpose of implementing a labeling program.

Criteria and Indicators. Biofuel sustainability rating systems rely upon criteria for assessing sustainability. In this report, a criterion is defined as a "condition to be met to achieve a principle."[72] Criteria are derived from principles, and may be further subdivided in requirements. The word indicator means "evidence of achievement of requirements."[73] Individual indicators may not provide complete information necessary for establishing conformity to a criterion, but they do provide information that can support a conclusion about conformity or nonconformity. Some indicators rely on qualitative determinations (e.g. "was the impact analysis adequately performed?"); others permit quantitative assessment (e.g. "did the volume of water withdrawals exceed the aquifer recharge rate?"). Metrics associated with indicators can be compared against threshold or limit values where government policy, standards or best practice guidelines have set them, or measure the efficiency of a unit of production in meeting a requirement.

Inputs. A rating system receives information inputs relating to quality characteristics from three types of sources. Primary and secondary data and Information may be provided by supply chain economic operators or obtained from data bases. Auditors develop audit evidence, which may include data, through the review of documents and records, and from interviews and observation. Economic operators and their suppliers may make representations and submit certified statements about conformity to sustainability criteria and indicators.[74] These categories of inputs are not mutually exclusive, but rather illustrate three types of sources for data and information used in biofuel sustainability rating systems.

Rating System. The rating system itself is comprised of a set of rules for collecting, processing and interpreting data and information, and the mechanisms that are used to classify and rank. The "engine" of a rating system may be dominated by life cycle assessment techniques or conformity assessment practices, or it may be a hybrid. The rating system may also include administrative requirements (e.g.

[72] RSB 2010, p. 2. In ISO standards, e.g. ISO 9000:2005, 3.9.3, p. 17, "audit criteria" are defined as a "set of policies, procedures or requirements."

[73] RSB 2010, p. 2. In the context of environmental performance evaluation standards, an "environmental performance indicator" is a "specific expression that provides information about an organization's environmental performance." See ISO 14031:1999, 3.5.1, p. 2.

[74] An example of representations may be a supplier's statement that a product has met applicable legal requirements for the jurisdictions in which it was cultivated, produced and sold, or that a product has, in addition to meeting legal requirements, been produced in accordance with the requirements of national or international standards, or third-party developed protocols. "Certification" in this context can mean that a supplier attests that the product representations are, to the best of his knowledge and belief, true.

who can request assessment by the rating system operator and how) and rules governing the use of rating system outputs. In ISO environmental labeling standards, the functions of a rating system are included in descriptions of roles and responsibilities assigned to "program operators."[75]

Outputs. There are five potential outputs for a biofuel sustainability rating system: an LCA study, supplier certification, a supplier's declaration of conformity, a product label, and a sustainability product declaration. More information about rating systems outputs is provided below in the section titled "Communicating Sustainability."

Conformity Assessment

Conformity assessment is one of two primary methods for evaluating sustainability. Typically, either demands of the market or regulations require conformity assessment activities to be carried out by independent accredited third-party organizations. Alternatively, a supplier's declaration of conformity may be feasible where neither a regulation nor market demands require the higher level of confidence that independent third-party certification bodies offer. In the biofuel sector, the RED has recognized a number of standards as RED-equivalent with respect to determinations of biofuel sustainability. Organizations such as the Roundtable on Sustainable Biofuels, the International Sustainability and Carbon Certification, and REDcert are authorized to certify compliance to RED requirements for biofuel sold into the European market. However in the United States, the Renewable Fuel Standard does not require independent third-party conformity assessment. Instead, RFS2 requires obligated parties to self-certify their compliance and maintain records to demonstrate upstream compliance by supply-chain partners.

Independent third-party certification is a multibillion dollar worldwide industry. In most cases, certification firms are accredited to international standards and employ certified personnel to conduct product, management system, and supply-chain audits. Conformity assessment bodies (CABs) generally are accredited by accreditation bodies (ABs) operating in the country where the CAB maintains its home office, though accreditation of CABs by multiple ABs is not uncommon. ABs initially screen applicant CABs and, after favorable accreditation decisions, provide annual oversight through witness audits to observe the CABs' continuing conformity with standards. In addition, most country-level ABs are members of the International Accreditation Forum (IAF). The IAF issues supplementary guidance to ABs concerning the interpretation of international standards that apply to CABs. In this way, IAF "guidance" becomes, for all practical purposes, another level of requirements that CABs must meet in order to maintain accreditation.

The conformity assessment infrastructure is designed to provide numerous checks and balances to ensure that certification services are provided independently, competently, and fairly. ISO maintains a standing Committee on Conformity Assessment (CASCO), which publishes standards defining requirements for the operation of both CABs and ABs. In addition, some ISO technical committees have published conformity assessment documents related to their areas of technical expertise.[76]

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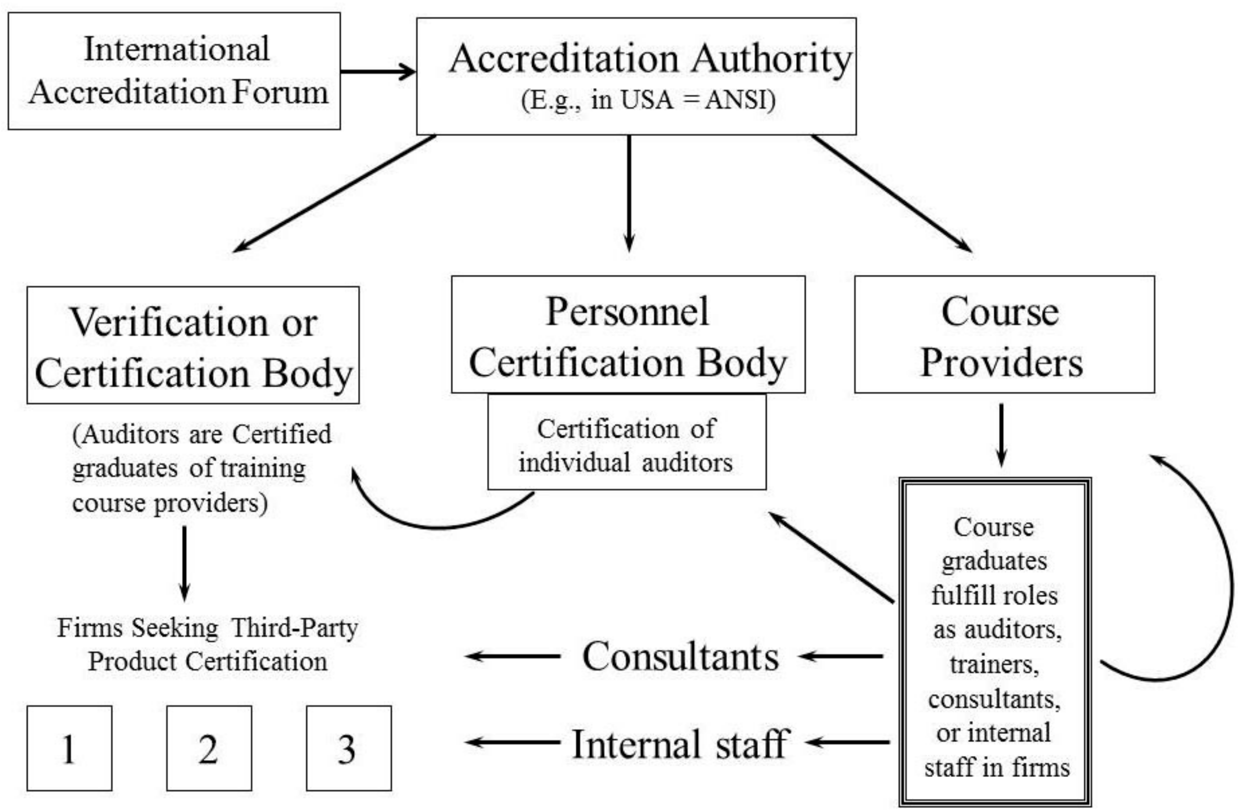
[75] See ISO 14024:1999 and ISO 14025:2006. See also *infra,* p. 32.

[76] For example, ISO TC 207 (Environmental management) maintains ISO 14065:2006 and ISO 14066:2011.

The primary method for performing conformity assessment of systems, processes and products is an audit. The main methodology standard for management systems auditing is ISO 19011:2011, "Guidelines for auditing management systems." The applicability of this document has expanded in recent years from quality and environmental management systems to management systems in general. Apart from its focus on management systems auditing, the document provides general good practice guidance for the auditing of many types of nonfinancial assertions. A complement to ISO 19011 is ISO 14064-3:2006, "Greenhouse gases – Specification with guidance for the validation and verification of greenhouse gas assertions." Together the two ISO standards provide a sound methodological approach for auditing assertions of conformity with sustainability standards.

At this date ISO has not published any International Standard describing competence requirements for sustainability auditors. Individual programs, such as the Roundtable on Sustainable Biofuels, have set requirements for auditors who perform certification audits using the "RSB Principles and Criteria for Sustainable Biofuel Production." Auditors with experience auditing chain-of-custody requirements for the Forest Stewardship Council have relevant transferable skills, as do auditors who have verified greenhouse gas assertions. So, too, do other auditors with management system certification experience, especially in environmental and occupational health and safety management systems.

The following diagram illustrates several components of the conformity assessment infrastructure defined in ISO/CASCO standards and used by the certification industry.



Environmental Life Cycle Assessment

Environmental Life Cycle Assessment (E-LCA) is the second primary method for evaluating sustainability. E-LCA began with attempts in the early 1960s to quantify the energy requirements for manufacturing chemical intermediates and products, and has grown into a standardized analytical methodology for understanding the environmental impacts of a product, process or system from "cradle to grave." This includes extraction of raw materials, the addition of energy inputs, transformation into products, packaging and distribution, use and disposal or recycling—the full cycle of the product's life. Following important methodological work by the Society for Environmental Toxicology and Chemistry, ISO undertook harmonization of standards and published a series of documents from 1997 to 2002.[77]

In the last decade, E-LCA practitioners have developed a methodology called "consequential LCA," which is contrasted with the "attributional" LCA described in ISO 14040 and ISO 14044. Consequential LCA adds a dynamic dimension to the evaluation of impacts, by using economic models to forecast changes in economic behavior that are predicted to result from changes in supply and demand of analyzed goods and services. Modeling results are then used in the life cycle impact assessment to estimate changes in the magnitude of life cycle environmental impacts over time.

Uses and Advantages of Environmental LCA

E-LCA is a valuable analytical tool for quantifying environmental impacts from products. Manufacturers use it to ensure that major upstream or downstream environmental impacts that may otherwise not be fully quantified are recognized. The information is useful during product design and modification, and for substantiating product environmental claims. E-LCA is also used by policy makers to inform policy choices and justify rule-making decisions. And it can be used by purchasers of goods to make more environmentally friendly choices about product selection.[78] A report by SAIC prepared for the U.S. EPA listed the following results that analysts can achieve using environmental LCA.

- "Develop a systematic evaluation of the environmental consequences associated with a given product.
- "Analyze the environmental trade-offs associated with one or more specific products/processes to help gain stakeholder (state, community, etc.) acceptance for a planned action.
- "Quantify environmental releases to air, water, and land in relation to each life cycle stage and/or major contributing process.
- "Assist in identifying significant shifts in environmental impacts between life cycle stages and environmental media.
- "Assess the human and ecological effects of material consumption and environmental releases to the local community, region, and world.
- "Compare the health and ecological impacts between two or more rival products/processes or identify the impacts of a specific product or process.

[77] SAIC 2006, pp. 4-5.
[78] In 1998 Executive Order 13101, "Greening the Government through Waste Prevention, Recycling and Federal Acquisition," directed U.S. federal agencies to base purchasing decisions on life cycle assessment. See Federal Register Vol. 63 Num. 179, Wednesday, September 16, 1998, pp. 49643-49651.

- "Identify impacts to one or more specific environmental areas of concern."[79]

Application of Environmental LCA in Biofuels Regulations

E-LCA is widely used in biofuels regulations both in the United States and in Europe for the calculation of greenhouse gas emissions.

U.S. EPA. In the United States, the U.S. EPA adopted a life cycle assessment from the National Energy Technology Laboratory as its baseline calculation of GHG emissions from the production of fossil fuels.[80] For its evaluation of GHG emissions from biofuels, U.S. EPA used the E-LCA tool GREET developed by Argonne National Laboratory that analyzes greenhouse gas emissions from more than 30 different fuel-cycle pathways.[81] The use of E-LCA stemmed from the Energy Independence and Security Act (EISA) of 2007, which amended the Renewable Fuel Standard first enacted in the Energy Policy Act of 2005. EISA specified that advanced biofuel "has lifecycle greenhouse gas emissions . . . that are at least 50 percent less than baseline lifecycle greenhouse gas emissions."[82] The same legislation established authority for the U.S. Department of Agriculture and the U.S. Department of Energy to issue grants for "the improvement and development of analytical tools to facilitate the development of life-cycle energy and greenhouse gas emissions, including emissions related to direct and indirect land use changes, attributable to all potential biofuel feedstocks and production processes; and the systematic evaluation of the impact of expanded biofuel production on the environment, including forest lands, and on the food supply for humans and animals.''

The definition of lifecycle greenhouse gas emissions established by Congress states that: "The term 'lifecycle greenhouse gas emissions' means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential."[83]

In its Regulatory Impact Analysis, U.S. EPA concluded from the language of the statute that "consequential" LCA should be used, rather than the standard "attributional" LCA of ISO 14044. The consequential approach "provides information about the GHG emitted, directly or indirectly, as a consequence of changes in demand for the product. This approach typically describes changes in GHG emissions levels from affected processes, which are identified by linking causes with effects."[84]

U.S. EPA used the Forestry and Agricultural Sector Optimization Model (FASOM) to determine GHG emissions from agriculture and to model the consequences of indirect land use change.[85] FAPRI-CARD

79 SAIC 2006, p. 3.
80 U.S. DOE 2008.
81 ANL 2010.
82 EISA 2007, p. 1519, Title II, E
83 Ibid.
84 U.S. EPA 2010, p. 299.
85 Ibid., p. 301.

was used "to estimate the impacts of biofuels feedstock production on international agricultural and livestock production."[86] Also, U.S. EPA "examined biofuel land use change impacts with the Global Trade Analysis Project (GTAP) model, a multi-region, multi-sector, computable general equilibrium model that estimates changes in world agricultural production."[87] Their lifecycle methodology, "as developed for the RFS2 proposal, required breaking new scientific ground and using analytical tools in new ways."[88]

U.S. EPA's methodology was not designed to identify facility-by-facility differences in GHG emissions impacts, but rather, to construct a model on the basis of the characteristics of a typical facility and to extrapolate from that, taking into account the effects of the dynamic changes predicted by the use of their general economic equilibrium models. U.S. EPA explained the approach this way: "We did not calculate the emission impacts for each gallon of fuel based upon its unique production characteristics which could vary widely across the nation (e.g., a gallon of ethanol produced using corn grown in Iowa may have different direct lifecycle emissions impacts than a gallon of ethanol produced at an identical facility in Nebraska using corn grown in Nebraska due to regional differences in agricultural practices. However, on a lifecycle basis, considering the indirect impacts in the context of the entire corn market they are not different). Rather, we determined the overall aggregate impacts across sections of the economy in response to a given volume change in the amount of biofuel produced. In the case of agricultural impacts, we assessed the impact on the entire U.S. agricultural system that would result from expanded demand for biofuel feedstock. We then normalized those impacts to a gallon of fuel by dividing total impacts over the renewable fuel volume change between our business as usual case and the EISA volumes. Similarly, we estimated the typical emissions impact of a type of biofuel production facility (e.g., a plant that uses the dry mill process to turn corn starch into ethanol). The emissions assessment from a typical facility was then ascribed to all biofuel produced across facilities using that same basic technology."[89]

U.S. EPA considered other environmental flows besides GHG emissions in its regulatory impact analysis, such as criteria and toxic air pollutants and water quality and consumption. The agency highlighted the water consumption impacts from biofuel feedstock growth: "With growth of ethanol production, water supply reliability related to crop demand for biomass feedstock will remain an issue. The amount of water needed to grow feedstocks for biofuels can be considerable – for example, the ratio of water consumed to produce the corn itself for ethanol is nearly one thousand gallons per gallon of corn ethanol. Large scale production of perennial energy crops involving tens of millions of acres, even when rain-fed, can have water resource impacts and unintended local consequences due to alterations of hydrologic flows. The timing of the water demand may also be critical; water is often plentiful in one season but scarce in another."[90] Compared to feedstock production, water demands from biofuel refineries are relatively modest. However, "biofuel refineries create additional local scale demand for water withdrawals and consumption. It is difficult to generalize about the impact on local water

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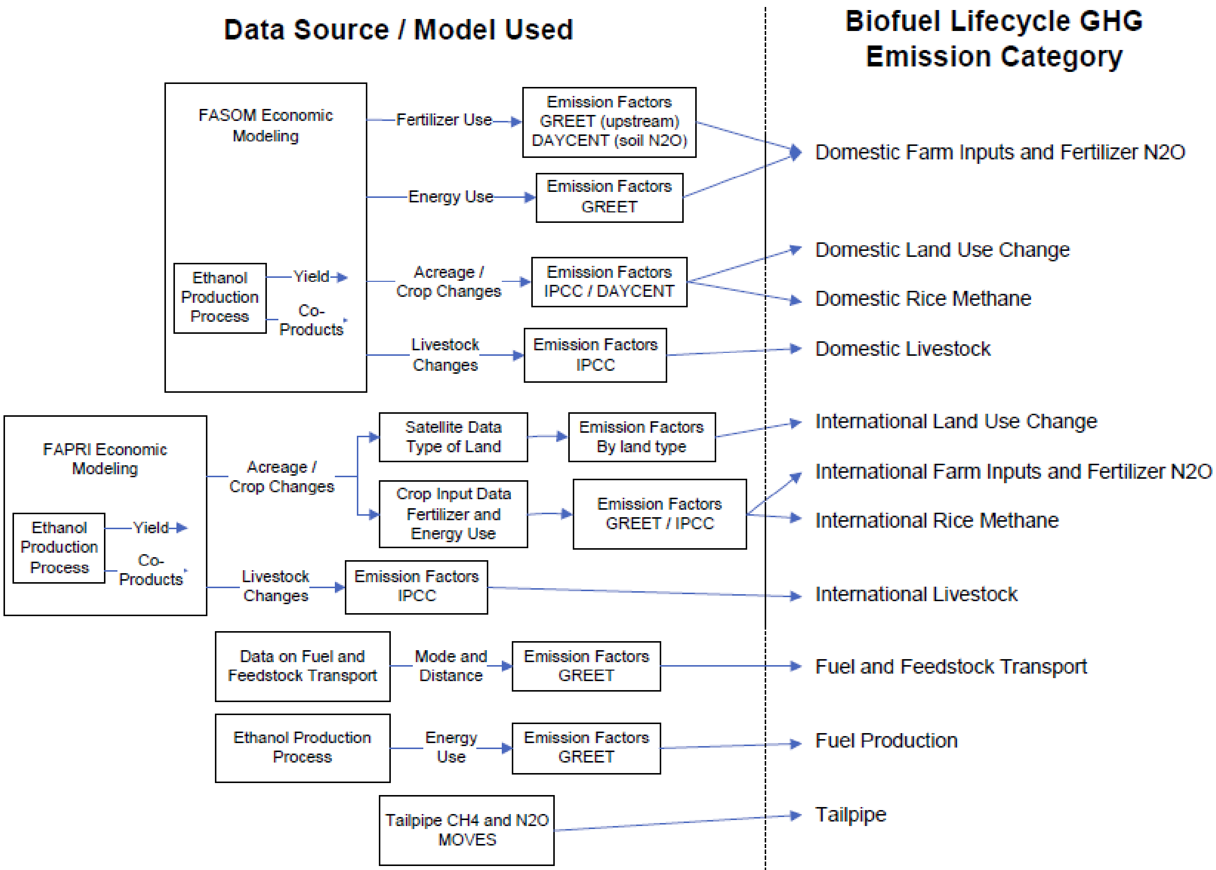
[86] Ibid., p. 303.
[87] Ibid.
[88] Ibid., p. 304.
[89] Ibid., p. 309.
[90] Ibid., p. 985.

supplies, however, some community supplies have been stressed by the water requirements of ethanol facilities."[91] The following diagram, included in the Regulatory Impact Analysis, illustrates the methodological approach.[92]

Figure 2.2-1 System Boundaries and Models Used



California Air Resources Board. California's Air Resources Board (ARB) uses a modified version of the GREET model (called "CA-GREET") for determining carbon intensity of fuel pathways. As described above, the California version of the model was customized for use in California but retains the main features of the generic version developed by Argonne National Laboratory. The primary difference between U.S. EPA's use of GREET for its RFS2 analysis and the application of CA_GREET is that U.S. EPA supplemented the model with the outputs of a general equilibrium economic model to forecast over time the effects of land use change, whereas California uses a standard default factor for land-use change emissions (30 g of CO_2-e/MJ for corn ethanol; 46 g of CO_2-e/MJ for sugarcane ethanol) which is added to the results of each fuel pathway carbon intensity number.

[91] Ibid., p. 986.
[92] Ibid., p. 304.

European Union Renewable Energy Directive. Life cycle analysis is used to calculate the amount of CO_2-e (g/MJ) in biofuel. Default values for direct land-use change were not included in the initial directive, though direction was given to the Joint Research Center to develop them. In the interim the following equation was provided in Annex V, Part C:

$$e_l = (CS_R - CS_A) \times 3.664 \times 1/20 \times 1/P - e_B$$

Where

e_l	= annualized greenhouse gas emissions from carbon stock change due to land-use change (measured as mass of CO2-equivalent per unit biofuel energy);
CS_R	= the carbon stock per unit area associated with the reference land use (measured as mass of carbon per unit area, including both soil and vegetation). The reference land use shall be the land use in January 2008 or 20 years before the raw material was obtained, whichever was the later;
CS_A	= the carbon stock per unit area associated with the actual land use (measured as mass of carbon per unit area, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to *CSA* shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier;
P	= the productivity of the crop (measured as biofuel or bioliquid energy per unit area per year); and
e_B	= bonus of 29 gCO2eq/MJ biofuel or bioliquid if biomass is obtained from restored degraded land under the conditions provided for in point 8.

Annualized emissions from carbon stock changes caused by land-use change, e_l, were to be calculated by dividing total emissions equally over 20 years. Look-up values were provided for different types of crops *P*.

The value obtained for e_l was then used in the following equation to obtain total greenhouse gas emissions:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee},$$

Where

E	= total emissions from the use of the fuel;
e_{ec}	= emissions from the extraction or cultivation of raw materials;
e_l	= annualized emissions from carbon stock changes caused by land-use change;
e_p	= emissions from processing;
e_{td}	= emissions from transport and distribution;
e_u	= emissions from the fuel in use;
e_{sca}	= emission saving from soil carbon accumulation via improved agricultural management;
e_{ccs}	= emission saving from carbon capture and geological storage;
e_{ccr}	= emission saving from carbon capture and replacement; and
e_{ee}	= emission saving from excess electricity from cogeneration.

RED Appendix V Part C selectively provided look-up values for terms in the second equation.

United Kingdom Renewable Transportation Fuel Obligation (RTFO). From 2012 the UK's RFTO has implemented the RED. Guidance stated that "The life cycle analysis methodology set out in the RED (described in detail in Part C of Annex V of the RED) must be used for all GHG calculations carried out for reporting under the RTFO."[93] Land-use change (direct) emissions are calculated as the difference in the carbon stocks in the reference case and the actual case. Indirect land-use change is not considered.

Limitations of Environmental LCA

E-LCA may be informed by primary data for each of the identified environmental aspects, and to the extent these measured data are grounded in natural science principles they are generally preferred to secondary sources of data. However, an E-LCA practitioner may not have access to primary data for all environmental aspects identified, and thus may need to rely upon data sets that aggregate data from multiple sources. Whether this limits the accuracy of the results depends upon which primary data are substituted for by secondary data, and the purpose for which the E-LCA is performed.

In the case that a policy maker or industry trade association wishes the E-LCA result to portray the "average" case for a product, the use of secondary data may be consistent with the E-LCA's goal and scope. On the other hand, if a particular manufacturer of a product wishes to benchmark its operation to that of industry peers, only the use of primary data relevant to the circumstances of that manufacturer's operating environment will return relevant results. In the latter case the use of secondary data, especially for significant environmental aspects under the control of the subject organization, limits the validity of the results.[94]

E-LCA results may be compromised in other ways. When the goal of the methodology includes converting results to a single score, which may occur when selecting among alternatives, value judgments must be made by the LCA practitioner. These value judgments cannot be fully grounded in natural science principles.[95] Due to the complexity of most E-LCA studies, and the number of decisions that must be made about life cycle inventory design, assumptions play an important role. A practitioner may be called upon to make assumptions about the average distance traveled for transport providers of raw materials or finished products, or about the grade of materials used in packaging. Loss rates for products, especially perishable ones, may be significant. Practitioners lower the risk of skewing results from the use of assumptions in E-LCAs by conducting sensitivity analyses to determine their importance. Nonetheless, the validity of the outcome of E-LCA results may be impacted by the cumulative effect of assumptions, especially where bias exists in their formulation.[96]

Bias may also be introduced from the use of secondary data derived from North American, European or Japanese experience in E-LCA studies for products manufactured in other parts of the world. Although the developed country data generally are more available, they may not be representative of conditions found in developing countries.[97] Care also should be taken when comparing the results of one E-LCA to

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[93] RTFO 2012, Paragraphs 6.12, 6.60 ff.
[94] SAIC 2006, p. 9-10.
[95] SAIC 2006, p. 6.
[96] SAIC 2006, p. 27.
[97] See SAIC 2006, p. 41.

another, as practitioners may use differing characterization factors when evaluating impacts to human and ecological health.[98]

Environmental life cycle impact assessment (LCIA) provides a means for evaluating the potential human health and environmental impacts of the environmental resources and releases identified during the life cycle inventory stage of the study. While many of the steps in LCIA are based on the objective results of the inventory stage of the LCA, one step in particular, weighting—or valuation—explicitly involves value judgments. SAIC explained the issue as follows:

> "Weighting is important because the impact categories should also reflect study goals and stakeholder values. As stated earlier, harmful air emissions could be of relatively higher concern in an air non-attainment zone than the same emission levels in an area with better air quality. Because weighting is not a scientific process, it is vital that the weighting methodology is clearly explained and documented."[99]

Evaluating and documenting the results is the final LCIA step. LCIA is performed in a systematic way but is based on the use of assumptions and simplifications as well as subjective value judgments. According to SAIC, key limitations may include:

- "Lack of spatial resolution – e.g., a 4,000-gallon ammonia release is worse in a small stream than in a large river.
- "Lack of temporal resolution – e.g., a five-ton release of particulate matter during a one month period is worse than the same release spread through the whole year.
- "Inventory speciation – e.g., broad inventory listing such as "VOC" or "metals" do not provide enough information to accurately assess environmental impacts.
- "Threshold and non-threshold impact – e.g., ten tons of contamination is not necessarily ten times worse than one ton of contamination."[100]

With sustainability, another important limitation can be scalar – e.g., as the volumes of biofuels produced increase, the importance of the same incremental additional impact on a stressor may change.

Environmental life cycle interpretation, the last phase of the LCA process, is subject to the same types of limitations as encountered earlier, especially when comparing alternatives. The use of assumptions, engineering estimates, and value choices may raise the level of uncertainty of the results to the point where it is impossible to conclude that one alternative is really better than another, despite the results showing numerical separation on an impact scale. Moreover, E-LCA presents only the environmental impacts of the subject studied, and cannot take into account other factors such as technical performance, cost, or political and social acceptance.[101]

E-LCA practitioners have answers at the ready for the limitations described above. A properly done E-LCA clearly states its purpose and audience in the definition of goal and scope, is transparent in the use of assumptions, acknowledges uncertainties associated with data, and explains the selection of value

[98] SAIC 2006, p. 51.
[99] SAIC 2006, p. 52.
[100] SAIC 2006, p. 53.
[101] SAIC 2006, p. 54.

choices. It is peer reviewed prior to finalization, and the final E-LCA report includes a section on the limitations of the study.

Nonetheless, the development of a "full" E-LCA can be time and resource intensive, and the approach outlined in ISO 14040/14044 standards may not be appropriate in all circumstances. U.S. EPA pondered this in the late 1990s when developing purchasing guidance to inform federal agencies implementing Executive Order 13101. In their "Final guidance on the implementation of environmentally preferable purchasing," U.S. EPA wrote: "Although most people would agree that considering life cycle impacts in purchasing decisions is desirable, there are disagreements on how to make purchasing decisions that best reflect a life cycle perspective. Even the term "life cycle" is interpreted differently by different people. To some, it connotes an exhaustive, extremely time-consuming, and very expensive analysis. To others, a life cycle perspective is possible in an abbreviated process, in which a long list of potential environmental attributes and/or impacts is narrowed to a few, allowing for comparison across a particular product category."[102] U.S. EPA concluded its discussion on the desirability of taking life-cycle considerations into account by promoting "the use of a range of practices, from life cycle considerations to a more rigorous, scientifically defensible life cycle assessment methodology."[103]

In revising its Green Guides, the Federal Trade Commission "decided not to propose guidance about the use of life cycle information either in marketing or as substantiation for environmental claims." It made the decision for two reasons: "First, the Commission lacks information about how consumers interpret life cycle claims in marketing. Moreover, due to the complexity and variability of these claims, general advice is unlikely to be useful in any particular case. Therefore the Commission will continue to analyze these claims on a case-by-case basis."[104] Second, the Commission declined to propose advising marketers "either to conduct an LCA to substantiate environmental claims or to follow a particular LCA methodology."[105] The Commission noted that "most environmental claims do not consider each phase of the product's life cycle, and for that reason the Commission does not find a basis for advising marketers to perform an LCA. However, marketers may rely upon LCA results as long as the can ensure that the results form scientific evidence to support their claims. The Commission will continue to evaluate whether any substantiating studies were performed in an objective manner by qualified persons, and whether the LCA is sufficient in quality and quantity according to standards generally accepted in relevant scientific fields to evaluate the truth of the marketer's claims."[106]

Communicating Sustainability

The operation of a sustainability rating system can result in one of five outputs: an LCA study report, supplier certification, supplier's declaration of conformity, product label, or sustainability product declaration. Each is treated in the sections that follow.

[102] U.S. EPA 1999, p. 45820.
[103] Ibid.
[104] FTC 2010, p. 63560, in section "3. Analysis."
[105] Ibid.
[106] Ibid.

LCA Study

An E-LCA study documents the methods and results of the life cycle assessment. This includes inventory information, impact assessment, and the interpretation of results. The amount of detail contained in the study is determined by its goal and scope, and by the intended audience. E-LCA studies intended for communication to the public should contain sufficient detail so that methodologies employed are transparent, assumptions are identified, uncertainties are acknowledged, and data quality issues are recognized. The E-LCA study should explain the basis for any limitations of the applicability of its conclusions. The findings and the resolution of any peer reviewer comments should also be described. Public policies may be developed and justified on the basis of E-LCA studies, and default values developed for use in quantification of GHG emissions and other environmental impacts.

Environmental life cycle analysis informs other forms of communication, such as environmental labeling. International standards require environmental claims and declarations to consider all relevant aspects of the life cycle of a product.[107]

Supplier Certification

Programs like the Roundtable on Sustainable Biofuels result in the certification of "participating operators" in the biofuel supply chain. The participating operator may be "legal entities or natural persons producing, converting, processing, blending, trading, using or otherwise handling biomass and/or biofuels and participating in the RSB certification systems."[108] Certification is defined in ISO conformity assessment standards as "third-party attestation related to products, processes, systems or persons." An attestation is defined as the "issue of a statement, based on a decision following review, that fulfilment of specified requirements has been demonstrated."[109] An alternative to certification is a "supplier's declaration of conformity," described in a subsequent section.[110]

Sustainability certification may be extended to one participating operator in the case of a vertically integrated entity, or to individual participating operators forming a supply-chain group. Where a participating operator has commercial relations (contracts) with other upstream and downstream participating operators who also have been RSB certified, and the chain of custody information has been verified, the biofuel supplied by the group may be marketed as RSB-compliant. In the contrary case, the fuel produced at the end of the biofuel supply chain might be renewable, but without an unbroken supply chain of certified participating operators, the seller cannot claim that the biofuel is "RSB-compliant." Where traders are involved, they do not need to be certified by RSB, but they may have

[107] See ISO 14020:1998, ISO 14021:1999, ISO 14024:1999, and ISO 14025:2006.

[108] RSB 2011 b, p. 6. G.1.1

[109] See ISO 17000:2004, especially definitions 5.5 (certification) and 5.2 (attestation).

[110] The definition of "certification" with relation to conformity assessment is narrower than its meaning in other contexts. For example, it is common in U.S. law to require parties subject to regulations to "certify" the truth of the information they submit to regulatory authorities, and this meaning is also conveyed in the phrase "representations and certifications" which is a formal way that parties may identify information whose truthfulness is explicitly asserted. In this section of the report, we use the term "certification" with the meaning given to it in international conformity assessment standards.

responsibilities for transmitting necessary documentation about the RSB-certified status of the participating operators and the traded fuel.

In the RSB and similar programs, economic operators[111] are certified. The biofuel they produce is accompanied by a claim of sustainability. Third parties who oversee compliance with sustainability standards by economic operators check chain-of-custody controls to ensure that the biofuel produced by certified operators is properly documented.

Three main types of chain-of-custody systems exist: segregation, mass-balance, and book-and-claim. The "segregation" method resembles the type of chain-of-custody control used for organic agricultural produce, where it is important that organically grown fruits and vegetables not be mixed with conventionally grown produce. For biofuels, the segregation chain-of-custody method handles batches of feedstock, processed oil, or refined fuel separately. Because the product is not mixed with non-compliant product, shipments retain their characteristic of 100 percent sustainable biofuel. Biofuel produced with this type of chain-of-custody control can be labeled as "compliant." A sub-category of the segregation method includes the preservation of the identity of the product, which allows traceability back to the original feedstock.[112] Segregation methods are not commonly used for biofuels, however, because of the need for economic operators to handle both sustainable and nonsustainable feedstocks and fuels.

The "mass-balance" chain-of-custody method solves this problem, by allowing an economic operator during cultivation, processing or refining stages to track only the sustainable proportion of feedstock, oil or fuel. Careful records are maintained and forwarded through the supply chain to ensure that documentation accompanying product accurately reflects the amount of intermediate product or finished fuel that meets sustainability program requirements. This can be done at one of three levels: the company level, the site level, or the tank level. Tank-level chain of custody is the only mass-balance method that results in the documentation of sustainability remaining associated with specific batches of mixed fuels. When site-level or company-level mass-balance accounting is used, the location of the sustainable biofuel molecules is no longer traceable. Under RSB, a "batch" or tank-level method results in refined fuel that is not 100 percent compliant, so the accompanying claim states that the batch "contains" compliant biomass/biofuel. The amount of sustainable biofuel is reported by mass.[113]

Another method of chain-of-custody control is called "book and claim." In this method, economic operators make accounting entries for the amount of sustainable fuel they produce, but do not provide traceability of either product or accompanying documentation through the supply chain. In order to ensure integrity of the method, independent registries may be established to police the booking of claims. In the United States, the book-and-claim method is used for the issuance of Renewable Energy

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[111] "Economic operator" is a generic term referring to a member of a supply chain. The functions of economic operators are equivalent to those of "participating operators" in the RSB standard.

[112] This is the type of chain-of-custody system developed by FLEGT for hardwoods and described above, pp. 4-5.

[113] IPIECA 2010, p. 18, distinguishes "proportionate reporting" from "non-proportionate reporting." Proportionate reporting requires segregation of mass balance claims within a specific feedstock. Non-proportionate mass-balance reporting allows reporting of mass balance claims across different feedstocks.

Certificates (RECs). In this system the claimed environmental attributes of renewable energy are completely decoupled from the physical delivery of electrons to the electricity grid. Book and claim was initially allowed under the UK RTFO system, but from 2012 the RED-mandated mass-balance approach has replaced it. In theory no more fuel is sold as compliant than was produced, but after-the-fact auditing of claims is more arduous, and the risk is higher that fuel would be marketed as compliant when in fact it was not. Neither RSB nor the EU RED allow the book-and-claim method.

Supplier's Declaration of Conformity

In ISO conformity assessment language, a "supplier's declaration of conformity" is an attestation made by a first-party, the supplier himself.[114] This type of declaration may be used for both regulatory and nonregulatory purposes. In the U.S., RFS2 offers an example of the use of a supplier's declaration of conformity. Obligated parties under RFS2 obtain Renewable Identification Numbers (RINs) for the biofuel they introduce into the market, and self-certify that the biofuel meets the requirements of the regulation and that the operator has maintained records required to demonstrate compliance with the regulation.

Suppliers' declarations of conformity generally do not provide the same degree of confidence to interested parties about conformity that third-party certification does.

Product Labeling

International standards recognize three types of "environmental labels and declarations." A Type I label indicates that a product has been evaluated by a "program operator" and found to meet predefined requirements for environmental preferability.[115] As a result of the evaluation, the product is awarded the right to use a label on its products. Type II labeling encompasses self-declared claims that a supplier may make about his products.[116] Finally, Type III labeling provides the results of an assessment of the life cycle environmental impacts of a product quantified in accordance with Product Category Rules (PCRs).[117]

Labels and Declarations, Type I

The primary purpose of Type I labeling is to inform consumers about the environmental preferability of a product. In the United States, at least one organization has developed a Type I label for biodiesel sold at retail outlets to consumers. Market demand for a Type I label for aviation biofuel is not obvious, because most aviation fuel is consumed by commercial airlines and the military. Buyers for these organizations deal in long-term supply contracts and are unlikely to perceive any benefits from point-of-sale labeling.

[114] See ISO 17050:2004, Part 1 and Part 2.
[115] See ISO 14024:1999.
[116] See ISO 14021:1999 and ISO 14021:1999/Amd 1:2011.
[117] See ISO 14025:2006.

Labels and Declarations, Type II

Organizations make self-declared environmental claims to support marketing and public relations objectives and to provide evidence of fulfilling commitments to social responsibility or sustainability principles. On its website Finnair has made a marketing claim under the heading of "Environmentally friendly travel." It asserts that "Between 1999 and 2009, we were able to reduce our emissions by 22 percent per seat."[118] As aviation biofuels become more widely available and used, airlines can be expected to make self-declared claims about the environmental and sustainability benefits they have achieved while sourcing or using them. ISO labeling standards, and in the United States, the "Green Guides" issued by the Federal Trade Commission, provide guidance to organizations on the principles to follow to avoid making deceptive and misleading claims.

The overall goal of environmental labels and declarations is, according to the ISO 14021 standard, "through communication of verifiable, accurate information, that is not misleading, on environmental aspects of products, to encourage demand for and supply of those products that cause less stress on the environment, thereby stimulating the potential for market-driven continual environmental improvement."[119] Fulfilling this kind of objective should not be confused with the need that organizations have to communicate information to a regulatory body in fulfillment of obligations to report. Although regulatory reporting may be considered "self-declared," such information is not the intended focus of ISO standards on environmental labels and declarations.

Labels and Declarations, Type III

Publication of an environmental product declaration (EPD) is one approach to communicating the environmental impacts of a product. Using life cycle assessment, the significant environmental impacts of a product through its life cycle phases of resource extraction, manufacture, packaging, distribution, use, and recycling or disposal can be quantified and presented on a label, much in the same way that nutritional information currently is provided on labels of packaged food items.[120] In order to assure comparability among products of the same category, product category rules (PCRs) are established for guiding the analysis. PCRs are intended to standardize the approach to quantification for a specific product category so that suppliers of similar products calculate environmental impacts in the same way. For example, PCRs may reference standard databases for calculating the transportation impacts of raw material shipment and finished product distribution.

EPDs are more commonly available in Europe than in North America, though attention to EPDs among American firms is increasing. The growth appears to be based on the emergence of European Union requirements for more consumer disclosure of environmental information about products sold to consumers. In addition, consumer interest in information about the carbon footprint of products is growing. A new ISO Technical Specification is nearing publication that adapts the methodology of life cycle assessment to the quantification of a single environmental aspect, greenhouse gases, on a per unit

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[118] See http://www.finnair.com/INT/GB/corporate-responsibility/environmentally-friendly-travel, accessed on 2012-02-25.

[119] ISO 14021:1999, clause 4.

[120] See ISO 14025:2006.

of product basis.[121] The resulting communication is typically presented as grams of carbon dioxide equivalent per product functional unit (kilograms, items, defined service, etc.). The carbon footprint of product approach is thus consistent with the common GHG emissions metric of biofuel sustainability.

Environmental Product Declarations (EPDs) for biofuels are uncommon. An Internet search yielded one for a five percent biodiesel blend marketed in Norway by Statoil, the national petroleum company.[122] Because aviation biofuels are not directly marketed to consumers, the future role for EPDs in the aviation biofuel sector may be limited. Nonetheless environmental life cycle information in the form of environmental LCA or carbon footprint studies of biofuel supply pathways will be communicated to policy makers and industry supply chain partners. Some of this information will become publicly available, and enable interested parties to reach conclusions about the comparative GHG emission reductions of various biofuel sourcing options.

Sustainability Product Declarations

Although EPDs are well established, creating Sustainability Product Declarations (SPDs) using a similar methodological approach is just beginning. The Sustainability Consortium (TSC), an academic institute headquartered in Arizona and Arkansas and supported in part by Wal-Mart Stores, Inc., is working with more than 70 large companies to develop SPDs. TSC's proprietary Sustainability Measurement and Reporting System™ is intended to reduce the time and cost of performing LCA studies and producing product declarations. At a conference in Berlin, Germany, in October 2011, a TSC Research Associate stated that one objective of TSC is to facilitate the exchange of actual supplier data among participating companies so that SPDs do not all use the same proxy data from databases. TSC working groups have not yet fully determined how to address sustainability criteria in its measurement system, and have considered using certification of supply chain operators as a mechanism.[123] If this approach is followed, it would confirm the technical difficulty identified by UNEP of characterizing environment and social indicators on the same scale of relative preferability.[124]

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[121] ISO/TS 14067:2013.
[122] See http://www.nho.no/files/NEPD33stoilE_1.pdf.
[123] Georg Schöner, The Sustainability Consortium, speaking on 25 October 2011 at the 6th PCF World Conference in Berlin, Germany.
[124] See *supra*, pp. 16-17.

Recommendations

On the basis of the research conducted, Futurepast offers the following ten recommendations to policy makers and purchasers of aviation alternative fuel.

1. Sustainability of biofuel should be assessed on a life-cycle basis, i.e. taking into account environmental, social and economic impacts of the phases of feedstock development, feedstock processing, refining, blending, transportation and consumption.

2. Sustainability of biofuel should be assessed at the facility level to ensure that each economic operator in the supply chain meets sustainability criteria.

3. Biofuel should not be developed when it fails tests of sustainability. Biofuel development can have significant impacts on land resources, water use and availability, biodiversity, and food security, and may have unacceptable social or economic impacts in the communities where it is produced.

4. Information about the sustainability attributes of the biofuel supply should be communicated to policy makers, biofuel purchasers, and the public.

5. Sustainability information should be fact-based and accurately presented. Disclosure should be made where material uncertainties exist in the accuracy of information, and the principle of conservativeness applied when communicating claims of sustainability (i.e., in the face of uncertainty, err on the side of overreporting, rather than underreporting, sustainability impacts).

6. Sustainability information should be verified, or capable of verification.

7. Third-party certification of the economic operators in the biofuel supply chain should be the preferred method used by biofuel purchasers to obtain assurance that supplied fuel was produced in conformity to sustainability criteria.

8. Chain-of-custody information about supplied biofuel should be third-party verified.

9. Sustainability life cycle interpretation should present results separately for environmental, social and economic impact categories.

10. National governments should monitor sustainability indicators at the country level so that impacts related to changing scale of biofuel development can be monitored over time.

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