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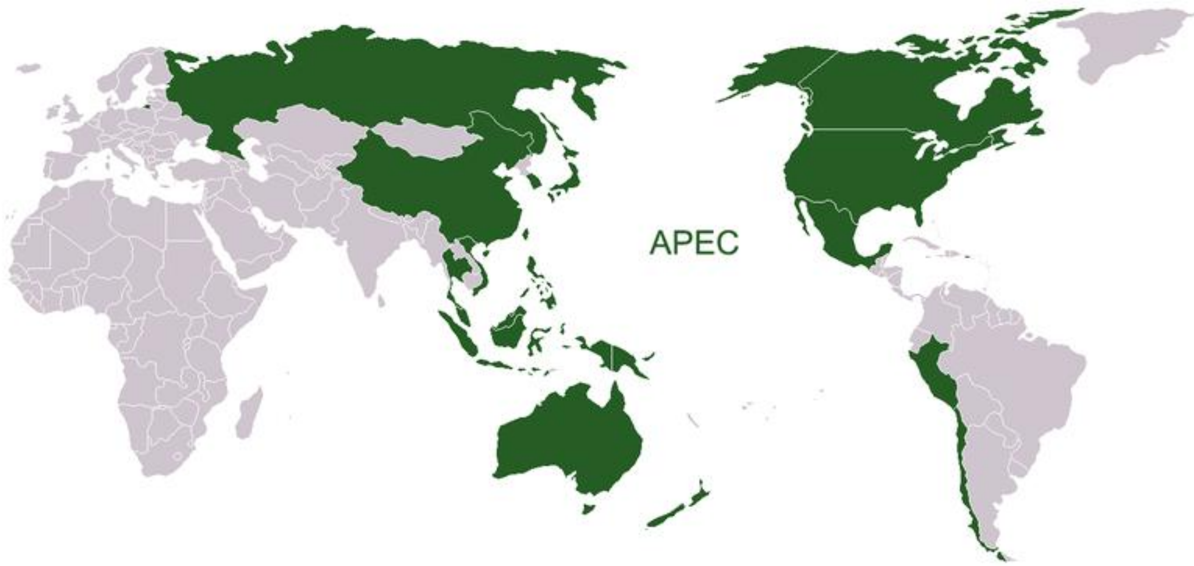
Sustainable Biofuel Development Policies, Programs, and Practices in APEC Economies



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Asia-Pacific Economic Cooperation

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Putting Ideas to Work

Winrock International is a nonprofit organization that works with people in the United States and around the world to empower the disadvantaged, increase economic opportunity, and sustain natural resources

In its bioenergy work, Winrock International aims to support the efficient development of sustainable biofuels by assisting in providing access to relevant information on the technical, social, economic, and environmental characteristics of biofuels.

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Table of Contents

List of Figures

List of Tables

List of Boxes

Executive Summary

The concept of "sustainable biofuels" has emerged and gained importance in recent years as biofuel production has surged in response to biofuel targets and mandates enacted in economies worldwide. Many activities to promote biofuels have explicit sustainable development objectives. Nevertheless, increased biofuel production poses potentially negative impacts. Efforts are needed to ensure that biofuel targets and mandates provide real sustainability benefits to the economies in which they are implemented.

Most definitions of sustainable biofuels require that the biofuels improve, or at least not harm, each of the following: the local environment, atmospheric greenhouse gas balances, society and social well-being, and the economy. In reality, all activities to achieve sustainable biofuels encounter tradeoffs among sustainability criteria. Policies, programs, and practices aimed at achieving sustainable biofuel production inevitably must balance the tradeoffs in a manner that optimizes the result from a sustainability perspective.

APEC economies are in various stages of producing, consuming, and/or trading biofuels. Many APEC economies have expressed concern about the potentially negative impacts of biofuels. Major biofuel consumers in APEC and around the world are beginning to screen their biofuels for sustainability criteria through regulatory or voluntary standards. As a result, even APEC economies that do not apply sustainability criteria to their own biofuels are considering sustainability issues and their potential to affect terms of trade. Terms of trade are affected when economies that may import feedstocks or biofuels from APEC economies require that products meet established criteria.

This report presents current policies, programs, and practices in APEC economies that aim to ensure that biofuels are sustainable. Information was gathered through a survey of those involved with biofuels in APEC economies,[1] follow-up interviews, and an extensive literature review. Identified activities are divided into the following categories:

- Planning and research
- Policy and regulation
- Voluntary programs and initiatives
- Monitoring

Fundamental to the success of sustainable biofuel development is keeping in mind that the process of conducting planning and research, developing policy and regulation, implementing voluntary programs and initiatives, and monitoring outcomes is not strictly linear. In reality, the process should be a continuous feedback loop: when monitoring exposes new problems or shows that intended outcomes are not achieved, the planning, regulations, and practices should be reevaluated with sustainability in mind and adjusted to better achieve those outcomes.

[1] Questionnaires were distributed to members of the APEC Biofuels Taskforce and to Winrock contacts in APEC economies. Direct follow-up contact was also made with a number of the recipients.

Planning and research activities in APEC economies cover the following topics:

- Assessing the sustainability of land use
- Assessing the GHG emissions of the biofuel supply chain through lifecycle assessments
- Assessing the water footprint of biofuels
- Conducting research and development for biofuels with improved sustainability characteristics
- Developing sustainable biofuel plans

Conducting research and development for more sustainable biofuels is one of the most common sustainable biofuel activities in the APEC region and was identified in 15 of the 21 APEC economies. Major areas of research in APEC include the development of advanced biofuel technologies, improved feedstocks, overall approaches to biofuel sustainability, and socioeconomic outcomes. Cellulosic ethanol, jatropha biodiesel, algae, and waste cooking oil (WCO) biofuels are of particular research interest in the APEC region (research on these feedstocks was found in 12 economies). These planning and research activities can be used as the basis for policy decisions and are critical for structuring biofuel programs that deliver sustainable outcomes.

Policies and regulations guide and provide incentives and boundaries for programs and practices, thereby influencing sustainable biofuel activities. In 10 of the 21 APEC economies, policies or regulations were identified that directly address biofuel sustainability (as distinct from environmental, agricultural, or other policies that affect biofuels but do not directly address them). Regulations and policies that directly address biofuel sustainability include:

- Mandated volumes of biofuels with required sustainability criteria
- GHG reduction-based targets for fuels
- Sustainability regulations that apply to all biofuels in an economy

Policies and regulations related to biofuels were identified both in APEC economies as well as among their trading partners, affecting APEC economies that want to export to those economies. GHG emissions reduction-based targets appear unique to California and deliver GHG reductions at least cost.

Voluntary programs and initiatives identified in APEC economies include activities that:

- Reduce GHG emissions
- Protect and enhance environmental quality
- Address socioeconomic issues
- Comply with voluntary standards

Many of the voluntary programs and initiatives span more than one area listed above. They are initiated by private companies, non-governmental organizations, or individuals working in various elements of the biofuels supply chain. In some cases they are undertaken to comply with policies and regulations, and in other cases they are initiated to achieve specific sustainability outcomes. Although planning and research for initiatives was more common than implementation, many voluntary activities were identified, especially in economies where biofuels have faced the most scrutiny. Among the activities identified, most common are those to reduce land use change (both direct and indirect), improve crop yields, manage and reuse waste products, and ensure that various stakeholder groups realize the benefits of biofuel production and consumption.

The last category, *Monitoring,* identifies efforts that improve the accountability of biofuel activities and ensure achievement of sustainability outcomes. In some cases monitoring is required by legislation with sustainable biofuel objectives, and in other cases it is required by voluntary standards or certification schemes. Tools and techniques for monitoring include remote sensing, sampling, reporting tools, personal digital assistants, and new phone technology. The issue of traceability throughout the supply chain presents a significant challenge in monitoring and some traceability schemes are presented. The scarcity of monitoring may be attributable to the fact that biofuel development and the concept of biofuel sustainability are in early stages in APEC, and monitoring and accountability are often introduced in later stages.

The report concludes with three recommendations. Because of the early stage of biofuel development in most APEC economies, the identified activities are more heavily weighted towards research and planning, with much less activity found in the monitoring category. The report recommendations build on this observation to take advantage of activities that are currently underway and build capacity for the ones that are less common.

- <u>Recommendation 1:</u> Collaborate on sustainable biofuels activities and share lessons learned.
- <u>Recommendation 2:</u> Promote all areas of sustainability simultaneously, rather than look at a select few elements of sustainability.
- <u>Recommendation 3:</u> Incorporate more performance-based approaches to monitoring compliance with, and impacts of, sustainable biofuel policies, programs, and practices to ensure that their intended outcomes are realized and negative unintended consequences are addressed.

1.0 Introduction

Once proposed as a green solution for transport fuels, biofuels have experienced a rollercoaster of public opinion over the last six years. At first a wave of excitement surrounded their potential as a clean alternative to fossil fuel. This view was accompanied by targets and mandates for their use, which led to a boom in global production. Biofuels were incorporated as elements of sustainable development schemes because of their promise to achieve social, environmental, and economic benefits. Opinions later shifted, however, with the realization that biofuels did not inherently achieve such benefits and, in fact, could potentially cause more problems than they solved. This realization sparked widespread backlash against biofuels; investors pulled out of projects and governments approached biofuels with increased skepticism.

A more nuanced look at the pros and cons of biofuels reveals that biofuels are neither a hero nor a villain, but rather another item in the tool box for addressing global energy issues. The concept of "biofuel sustainability" is emerging to ensure that biofuels deliver their potential benefits. The term "sustainable biofuels" refers to liquid fuels made from biomass feedstocks that are produced, processed, delivered, and consumed in a way that addresses energy, environmental, social, and economic concerns and connects them in a system designed for the biofuels' on-going delivery.

Biofuel sustainability is especially relevant among members of the Asia Pacific Economic Cooperation (APEC). It is a cause of concern to producers because major importers, such as the European Union, are beginning to require that imports meet strict sustainability criteria. Most APEC members are already biofuel producers and/or consumers. Some economies produce solely for their own consumption, some economies produce primarily for export, and some primarily import from other economies. The biofuel imports and exports may be either the finished biofuel product (e.g., biodiesel, bioethanol), an intermediate product (e.g., molasses, biocrude), or a feedstock (e.g., sugarcane, corn) that the importing economy processes into a liquid biofuel. Although APEC economies vary greatly, they share the desire to reduce fossil fuel dependence, greenhouse gas (GHG) emissions, and air pollution and to stimulate economic development. Many APEC economies consider biofuels a potential pathway to achieve these objectives. A majority of APEC economies now have biofuel mandates or targets expected to deliver a dramatic increase in biofuel production, use, and trade in the APEC region over the coming years.

APEC economies also share concerns about the potential impacts of biofuels: biofuel feedstock may compete for land, drive up food prices, affect sensitive ecosystems, reduce water availability, or use negative labor practices. Addressing the sustainable development of biofuels in the region is critical to achieving the targeted growth and recognizing potential impacts of biofuels.

This report presents an overview of the policies, programs, and practices undertaken in APEC economies and beyond to ensure that the liquid biofuels they produce and consume achieve desired sustainability objectives.

1.1 Report Objectives and Layout

The objective of this report is to survey policies, programs, and practices that can contribute to development of liquid biofuels that are beneficial to the environment, society, and economy. In theory, sustainable development of biofuels would be cost effective, would not compromise the security of food supplies, would not deplete available water resources, and would not result in a net increase of GHG emissions. In practice, the ability to develop sustainable biofuels reflects evolving efforts to balance goals and to deploy systems that help meet energy needs, are affordable, and address social and environmental risks. In reality, zero-risk or zero-impact options do not exist.

This report outlines activities currently underway in APEC economies and, where relevant, outside APEC, ranging from planning for sustainable biofuels to practices that result directly in sustainable development. A questionnaire was used to identify sustainable biofuel activities in each of the APEC economies. The questionnaire was distributed to members of the APEC Biofuels Taskforce as well as to other Winrock contacts in APEC economies. Further information was gained about the activities through follow up interviews with questionnaire respondents and their recommended contacts, as well as through an intensive literature review.

While efforts have been made to identify the main policies, programs, and practices that specifically address biofuel sustainability in APEC economies, the identification process has relied on desk-based research and the use of questionnaires. Consequently, the report cannot claim to be a comprehensive survey of all activities in all APEC economies. Therefore, the relative lack of activities presented in any one economy does not indicate the degree to which biofuels produced or consumed in that economy are sustainable or unsustainable. Furthermore, some economies have no plans – or limited plans – to produce or consume biofuels, thereby obviating the need in those economies for policies, programs, and practices aimed at the sustainability of such fuels. This report may be particularly helpful to this group if circumstances change and lead to a stronger desire to produce or consume biofuels.

By identifying the activities that different economies are applying within the APEC region, individual economies can learn from one another and select approaches best suited to their conditions and objectives. It is important to keep in mind, though, that activities that lead to positive outcomes in some locations may not be appropriate in others and could lead to negative impacts. Understanding the social, environmental, and economic context in which biofuel production takes place is critical, as is a focus on delivering outcomes rather than promoting specific activities.

The report aims to describe and put into context activities that have been undertaken to address sustainability concerns, as a means of presenting the range of practical options. However, many outcomes are not yet clear, partly because of the infancy of activities and partly because monitoring information is lacking. The report therefore provides information on potential strengths and challenges of the type of activities identified, but it does not evaluate the strengths and weaknesses of the particular policies, programs, and practices underway in APEC economies. Further evaluation of specific policies, programs, and practices adopted within APEC economies would be worthwhile when more experience has been gained and further information is available.

Section 2.0 of the report provides the background on biofuels, sustainability, and what biofuel sustainability means in the APEC context. This discussion includes the types of biofuels produced and consumed, the quantities produced and consumed in each economy, and the drivers for their continued growth. The section provides an overview of the different areas of opportunities and challenges, introducing the complexity of the concept of a sustainable biofuel. Section 2.0 ends with an overview of the various standards that exist to evaluate biofuel sustainability.

Sections 3.0 through 6.0 present the sustainable biofuel policies, programs, and practices identified through the questionnaire, communication with experts, and literature review. The four sections cover: planning and research, policy and regulation, voluntary programs and initiatives, and monitoring. Each of these sections concludes with a compendium table of the types of activities listed in the section along with the strengths and challenges of each type of policy, program, or practice.

Section 7.0 concludes the report and provides thoughts on the future outlook of sustainable biofuels in the APEC region. It reviews the patterns in activities identified in Section 3.0 and their strengths. It provides recommendations on logical next steps in advancing biofuel sustainability across the region.

Appendix A and **Appendix B** list 1) sustainable biofuel research and 2) policies and regulations, respectively, identified for each economy. Many of these activities are noted in the discussion in the main body of the reporrt, but the complete lists are provided in the appendices.

2.0 Background: Biofuels, Sustainability, and APEC

The present biofuel boom began around 2004 with policies in the United States and Europe to increase biofuel consumption in those economies. Biofuels are fuels developed from organic matter, most commonly from forestry and agricultural products. The two main types of liquid biofuels in use are ethanol and biodiesel. Ethanol is used in gasoline engines and is derived from grains and sugar crops, whereas biodiesel is used in diesel engines and is derived from oil producing crops, such as oil palm and rapeseed. Another distinction in types of biofuels is between “first generation” biofuels and “advanced” biofuels (sometimes referred to as “second” or “third” generation). First generation biofuels come from agricultural crops and processes. Production processes for these biofuels are mature – fermentation/distillation for ethanol and transesterification for biodiesel. Advanced biofuels come from non-food crops or residues, such as trees and grasses, agricultural and forestry residues, or algae; production processes for advanced biofuels vary from laboratory scale to commercial scale pilots. Although advanced biofuels are promising for future biofuel production, at present the production processes need to be validated at commercial scale. Figure 1 diagrams the biofuel production pathways for various biomass feedstocks.

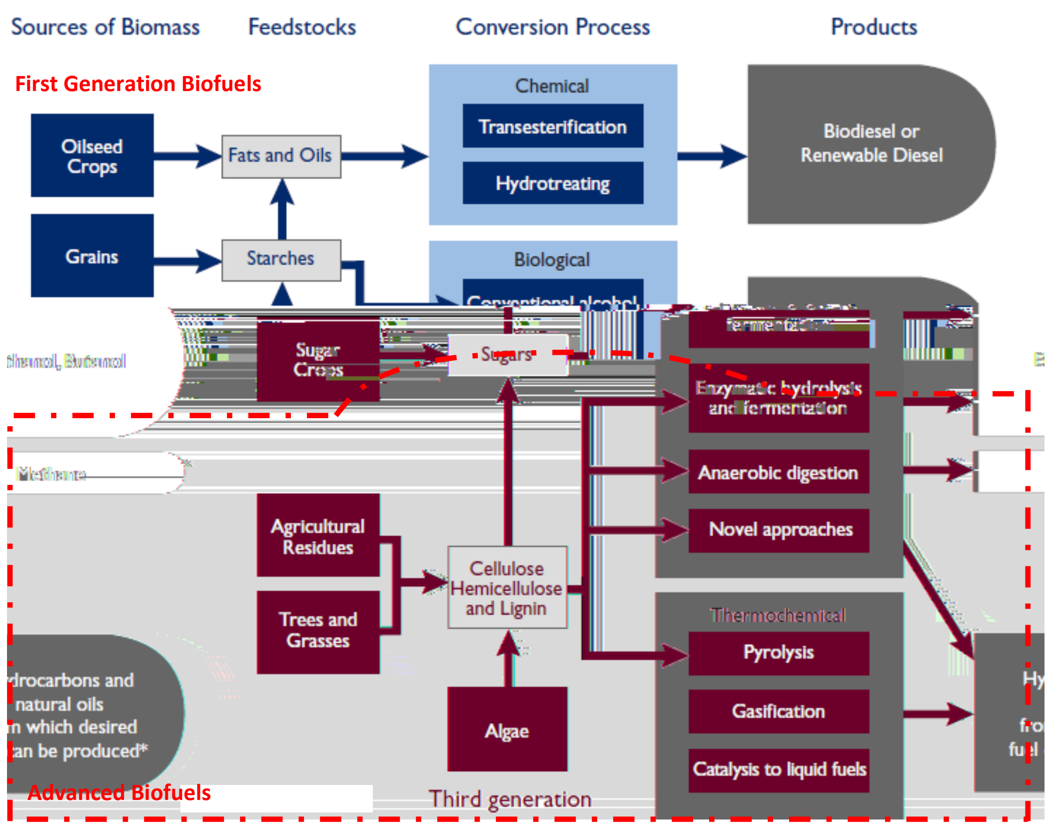


Figure 1. Pathways for biofuel production from various biomass feedstocks

Source: Pena and Sheehan, 2007, in USAID, 2009

2.1 Biofuels in APEC

The Asia Pacific Economic Cooperation (APEC) is an organization of 21 Asia-Pacific economies in Asia, North America, South America, and the South Pacific, as shown in Figure 2. APEC economies span a range of demographics, economic activities, climate regimes, levels of development, levels of urbanization, and energy demands, including demand for transportation fuels and resources to meet that demand. In 2005, the APEC region as a whole used 1,235 million tonnes of oil equivalent (MTOE), on an energy basis, of which energy for transportation accounted for about 24% (Minns, 2005). Transportation energy demand in APEC is projected to increase at an average rate of 1.3% per annum, rising to 1,718 MTOE by 2030. Each individual APEC economy's transportation energy demand is also expected to rise, with the exception of Japan and the United States after 2010 (APERC, 2009).

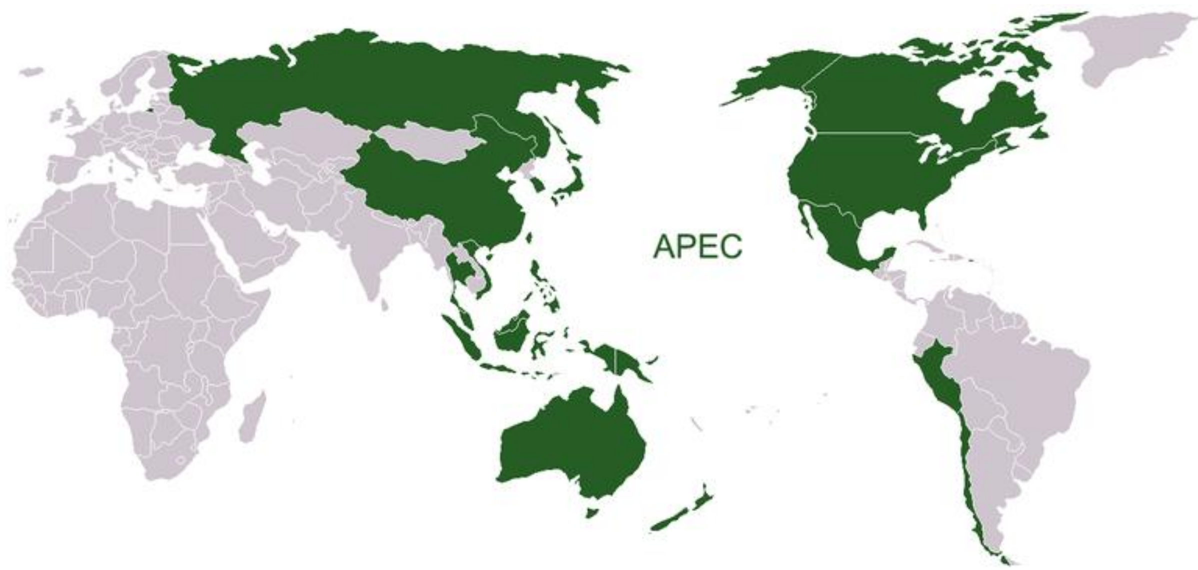


Figure 2. Map of the APEC economies

Collectively, APEC economies produced 23.4 MTOE and consumed 22.8 MTOE of biofuels in 2008, with the United States accounting for the majority of those figures (EIA, 2010). Figure 3 through Figure 6 show how much liquid biofuel (ethanol and biodiesel) each APEC economy produced and consumed in 2008 (in liters), both in total and on a per capita basis. Since the energy content of ethanol is about 64% the energy content of biodiesel on a volume basis (EIA, 2007), the following figures are not intended to compare ethanol and biodiesel quantities. Nevertheless, considerably more ethanol than biodiesel is produced and consumed in APEC. In Figures 3 through 5, the scale for the United States is presented on the right-hand axis, whereas the scale for all other economies is on the left-hand axis. For Figure 6, all economies are presented on the same scale.

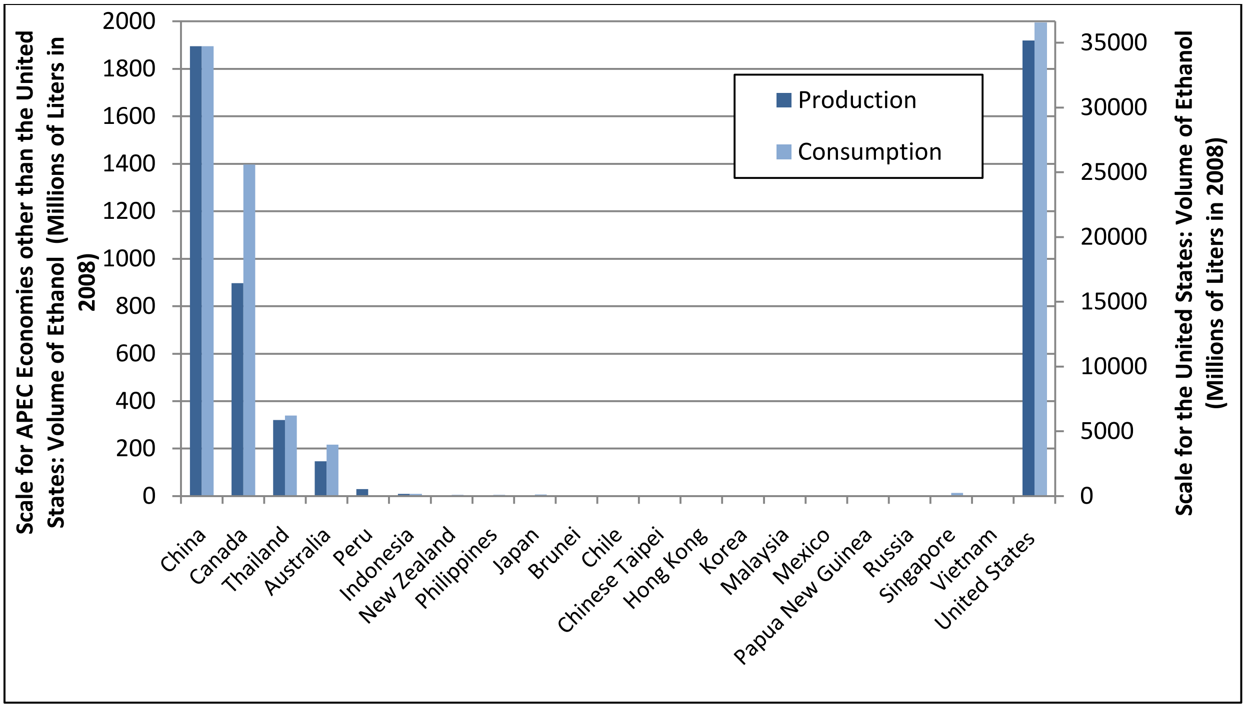


Figure 3. Ethanol production and consumption in APEC economies
Data source: EIA, 2010

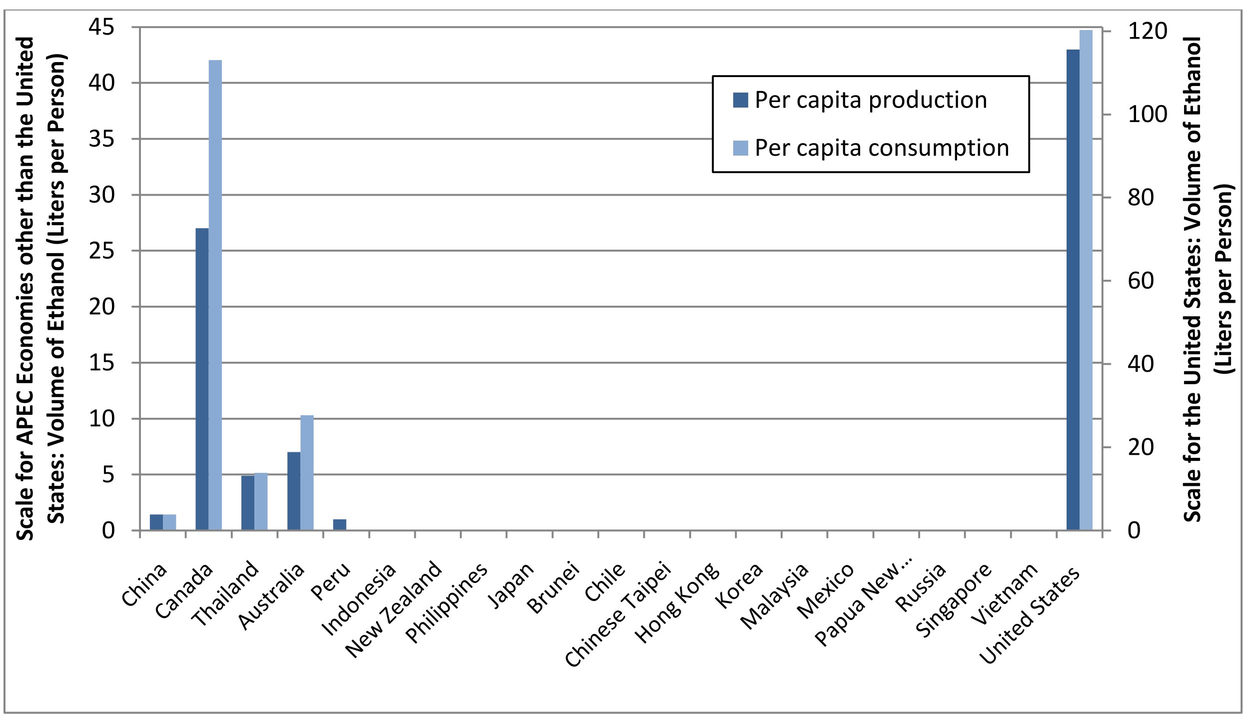


Figure 4. Per capita ethanol production and consumption in APEC economies
Data source: EIA, 2010

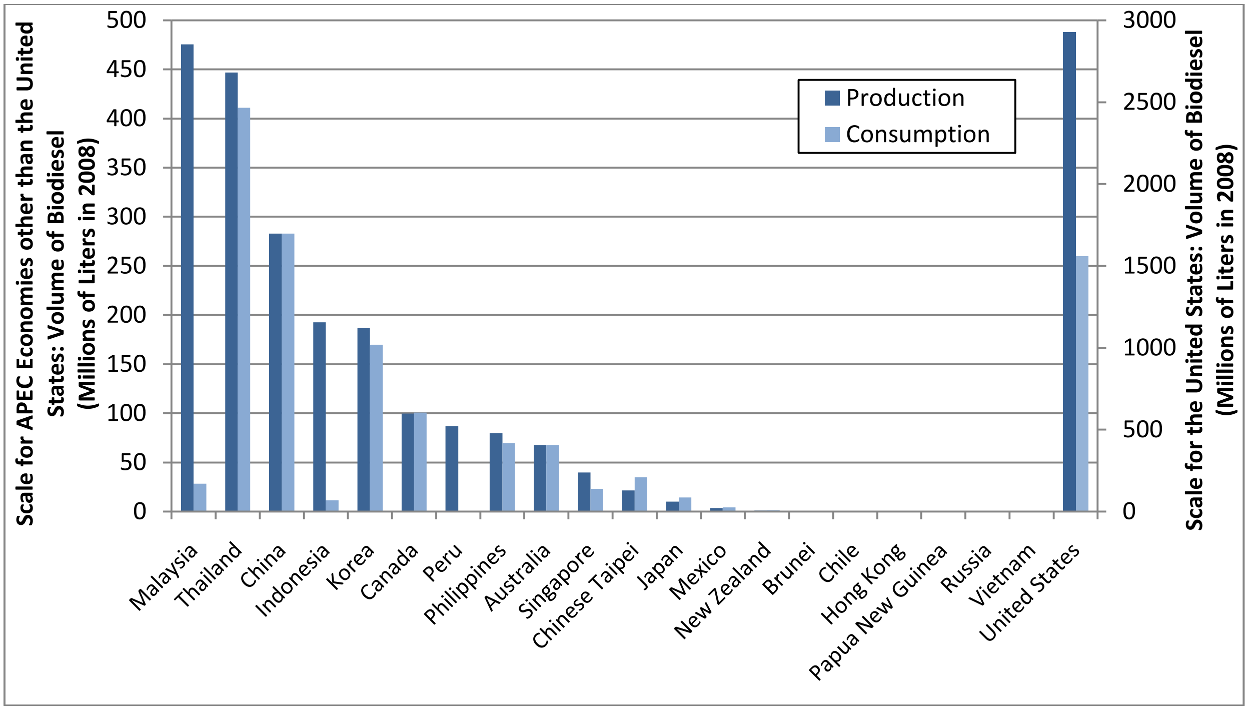


Figure 5. Biodiesel production and consumption in APEC economies

Data source: EIA, 2010

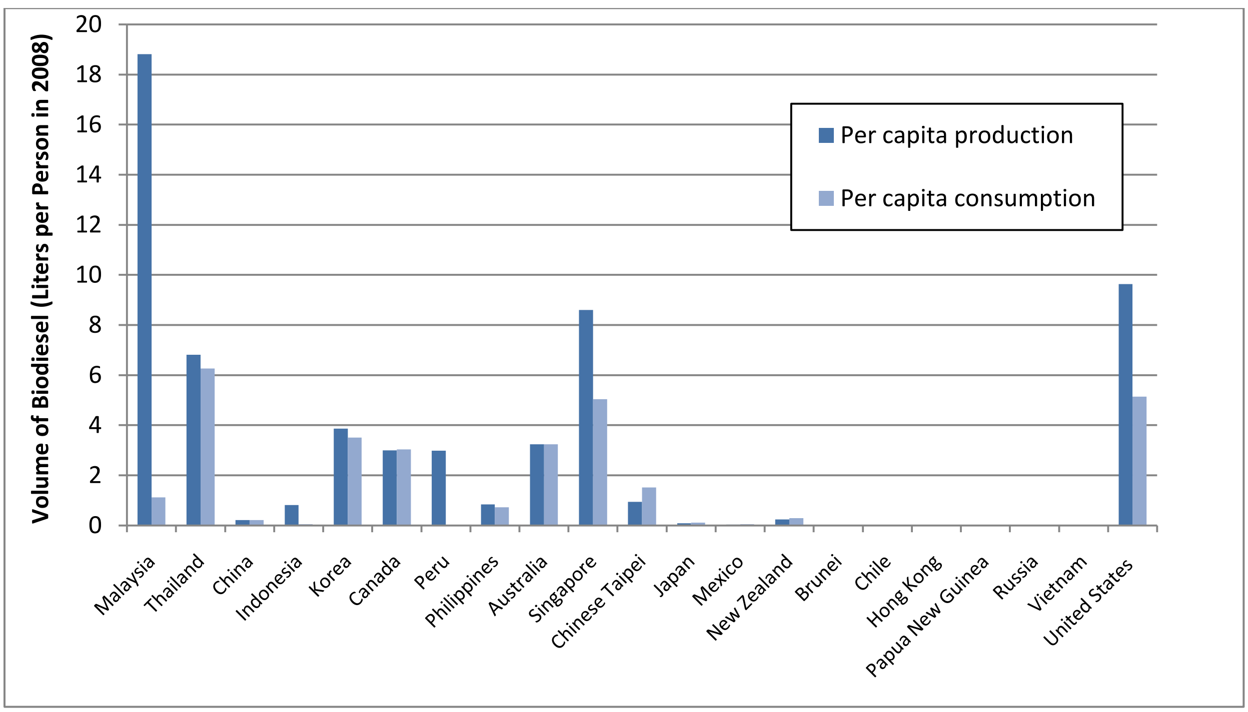


Figure 6. Per capita biodiesel production and consumption in APEC economies

Data source: EIA, 2010

Looking ahead, APEC biofuel consumption is projected to increase from 22.8 MTOE in 2008 to 132.2 MTOE by 2030, indicating an annual average growth rate of 8.3% (EIA, 2010 and APERC, 2009), shown in Figure 7.

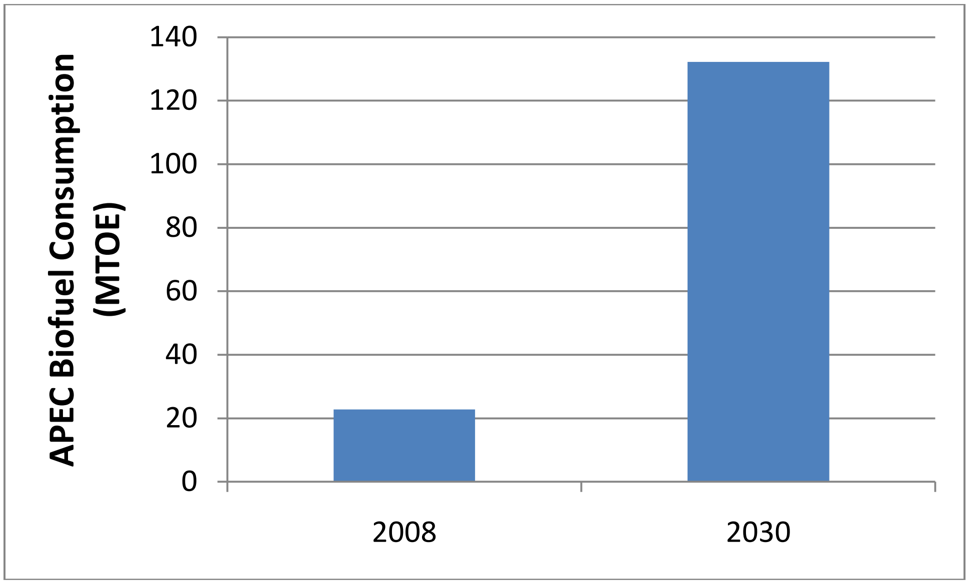


Figure 7. Projected increase in biofuel consumption in the APEC region from 2008 to 2030
Data Source: EIA, 2010 and APERC, 2009

This rapid growth was instigated by a number of policies and mandates that created targets and incentives for biofuel production and use. Table 1 lists the amount of biofuel that each economy consumed in 2008 and their respective targets.

Table 1. Biofuel baselines and targets in the APEC economies

Economy	Biofuel Targets or Mandates	2008 Consumption Baseline
Australia	350M liters in 2010	285M liters
Brunei Darussalam	-	0
Canada	5% ethanol in gasoline by 2010, 2% biodiesel in diesel fuel by 2012	1.4 billion liters ethanol 101M liters biodiesel
Chile	-	0
China	10M tonnes ethanol (45M liters), 2M tonnes biodiesel (9M liters) by 2020	1.9 billion liters ethanol 283M liters biodiesel
Hong Kong, China	-	0
Indonesia	2% biofuels by 2010, 5% by 2025	20M liters
Japan	500M liters ethanol by 2010	7M liters ethanol 14M liters biodiesel
Republic of Korea	3% biodiesel in diesel fuel by 2012	0 ethanol 170M liters biodiesel
Malaysia	5% biodiesel in diesel fuel mandated but not yet introduced due to high palm oil prices	0 ethanol 28M liters biodiesel
Mexico	-	0 ethanol 4M liters biodiesel
New Zealand	3.4% of fuels sold by 2012	6M liters of biofuel (5 ethanol, 1 biodiesel)
Papua New Guinea	-	0
Peru	Optional blend 7.8% ethanol in gasoline and 5% biodiesel in diesel fuel are available. Plans to introduce 2% biodiesel in diesel fuel mandate, becoming 5% in 2011, and 7.8% ethanol in gasoline for 2010	0
Philippines	10% ethanol in gasoline by 2011, 2% biodiesel in diesel fuel by 2009	5M liters ethanol 70M liters biodiesel
Russia	-	0
Singapore	-	14 M liters ethanol 23M liters biodiesel
Chinese Taipei	3% ethanol in gasoline mandate planned for 2011 and compulsory goal of 2% biodiesel in diesel fuel planned to be available nationwide by 2010	2M liters ethanol 35M liters biodiesel
Thailand	5% biodiesel in diesel fuel by 2011	339M liters ethanol 411M liters biodiesel
United States	36 billion gallons (136 billion liters) of biofuels by 2022	38 billion liters
Viet Nam	500M liters of ethanol, 50M liters of biodiesel by 2020	0

Source: EIA, 2010 and APEC, 2008

The majority of ethanol in the APEC region is currently produced from corn and sugar cane. Other ethanol feedstocks in the APEC region include: cassava, molasses, sorghum, wheat, and whey. The majority of biodiesel in the APEC region is currently produced from palm oil and soybean oil. Other biodiesel feedstocks include: animal fats, coconut oil, rapeseed, and waste cooking oil (WCO) (Doyletech, 2010). Looking to the future, many APEC economies consider advanced biofuels to hold more potential than first generation biofuels for meeting their fuel needs, and many economies are putting research funds towards advanced biofuels based on cellulosic ethanol and algae. Additionally, many economies are looking towards, or already utilizing, non-food crops for biofuels such as WCO and animal fats. Jatropha is a feedstock to which many countries are turning for growth on lands less suited for food crops. Table 2 lists the feedstocks currently used for biofuels in each economy, along with the feedstocks that are considered for future production.

Table 2. APEC economies' current and potential feedstocks

Economy	Primary biofuel feedstocks	Future feedstocks considered
Australia	Animal fats, canola, molasses, sorghum, waste cooking oil, wheat	Indian mustard, jatropha, pongam
Brunei Darussalam	None	Jatropha
Canada	Animal fats, canola, corn, waste cooking oil, wheat	Cellulosic from prairie grain crops, cellulosic from straw
Chile	None	Algae, animal fats, cellulosic from forestry resources, corn, jatropha, lignocellulosic (e.g., agricultural waste and wood), rapeseed, sugarbeet
People's Republic of China	Acid oil, animal fats, cassava, corn, paper pulp, rice, sugarcane, synthetic production, waste cooking oil, waste residue, wheat	Cellulosic, particularly crop residue, jatropha, lignocellulosic
Hong Kong, China	None	Animal fats, waste cooking oil
Indonesia	Cassava, p, Palm oil	Coconut oil, jatropha
Japan	None	Corn (unsuitable for food), molasses, rice straw, wooden biomass, wheat (unsuitable for food)
Republic of Korea	Palm oil, soybean (from Argentina and the United States), waste cooking oil	Cassava, jatropha, rapeseed
Malaysia	Palm oil	Cellulosic material from palm biomass
Mexico	None	Animal fats, cassava, corn, sorghum (grain), sugarcane, sorghum, waste cooking oil, wheat
New Zealand	Animal fats, corn, whey	Algae, canola, forestry harvesting by-products, shrubby willow saplings, rapeseed
Papua New Guinea	Straight vegetable oil	Cassava, coconut oil, palm oil
Peru	None	Algae, castor, jatropha, palm oil, pine, sugarcane
Philippines	Coconut oil	Cassava, jatropha, palm oil, sugarcane, sweet sorghum
Russia	None	Rapeseed, wood
Singapore	Palm oil, soybean oil, waste cooking oil	Algae, forest residues, jatropha
Chinese Taipei	Soybean, sunflower, waste cooking oil (primary feedstock)	Agricultural wastes, molasses, sugarcane, sweet sorghum
Thailand	Cane molasses (90% of ethanol), cassava (10% of ethanol), palm oil, waste cooking oil	Jatropha, sweet sorghum
United States	Corn, soybean oil	Algae, lignocellulosic biomass from agricultural and forestry residues, milo, waste cooking oil
Viet Nam	Molasses	Cassava, castor oil, elephant grass, fish fat, jatropha, lubricants, rubber seed, seaweed, sugarcane, waste cooking oil

2.2 Biofuel Sustainability – Drivers for Biofuel Development

Among the myriad of definitions for sustainable development, the most widely cited comes from the Brundtland Commission, which says sustainable development is "meeting the needs of the present without compromising the ability of future generations to meet their needs" (Brundtland Commission, 1987). Put into action, policies, programs, and practices are sustainable only if their implications for society, the environment, and the economy are taken into consideration to ensure that they enhance, or at a minimum do not harm, all three. Figure 8 illustrates this concept:

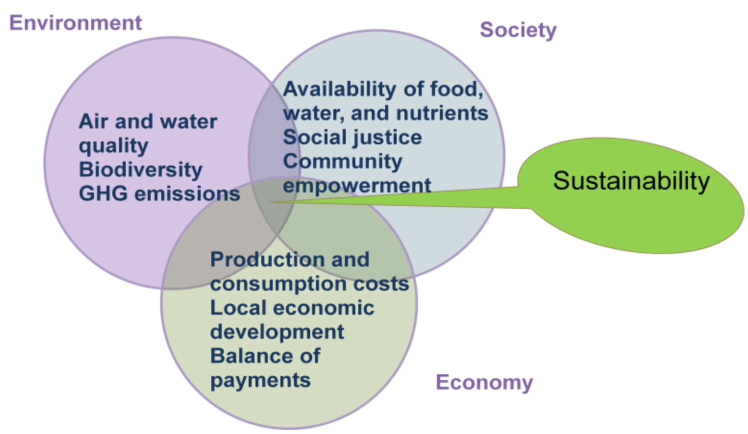


Figure 8. Biofuel sustainability: at the intersection of a biofuel's impact on society, the environment, and the economy

Because, in theory, biofuels produced sustainably do not harm society, the environment, or the economy, and may contribute to progress in each, many economies have included the promotion of biofuels in sustainable development plans. In the right circumstances, biofuels can positively affect climate change, agricultural biodiversity, energy security, food security, and economic development. In a period of relatively high and rising oil prices, using biofuels for transportation fuel is expected to provide financial savings and stabilize fuel costs and commodity prices. Domestic production reduces an economy's vulnerability to dependence on other economies for supplying their fuel. Biofuels can achieve greater reductions in GHG emissions compared with fossil fuels, slowing climate change and helping an economy to meet Kyoto Protocol obligations or creating financial benefits from carbon reductions through carbon markets. Other possible environmental benefits include reducing toxic air pollutants. Socioeconomically, the creation of a biofuel industry can increase employment and rural incomes. The main motivations for biofuel development in each APEC economy are listed in Table 3**.**

Table 3. Drivers for biofuel development in APEC economies

Economy	Biofuel driver
Australia	• Climate change and environment • Energy prices • Health
Brunei Darussalam	• Economic opportunity
Canada	• Energy independence
Chile	• Energy independence

People's Republic of China	• Air pollution • Increased transport fuel demand • Rural economic development • Use of surplus grain stocks
Hong Kong, China	• Air pollution
Indonesia	• Economic growth • Employment opportunities • Energy security, economic growth • Environmental benefits • Poverty alleviation
Japan	• Kyoto commitment
Republic of Korea	• Air pollution • Economic growth • GHG reduction
Malaysia	• Environmental benefits • Foreign exchange savings • Increased demand for palm oil • Stabilization of fuel prices • Depleting supply of fossil fuels
Mexico	• GHG emissions • Declining oil reserves • Rural economic development
New Zealand	• Balancing current account deficit • Energy security • Kyoto commitment
Papua New Guinea	• Economic opportunity
Peru	• Attracting investment • Balance of payments (improved with exports) • Climate change • Employment opportunities
Philippines	• Augmenting farmer incomes • Energy independence • Rural employment
Russia	• Export opportunity • Kyoto commitment
Singapore	• Energy independence • Trade opportunity
Chinese Taipei	• Energy independence • GHG emissions
Thailand	• Energy independence • GHG emissions • Rural development • Trade opportunity
United States	• Energy security and fuel diversification • MTBE replacement • Rural development
Viet Nam	• Diversification of energy portfolio • Socioeconomic development

Source: APEC, 2008

The potential benefits are not inherent outcomes of biofuel development. Rather, as described in the following section, several tradeoffs must be considered in the context of sustainability.

2.3 Biofuel Sustainability Opportunities and Challenges

Biofuels present both opportunities and challenges for sustainable development, and the tradeoffs between them must be weighed. The opportunities and challenges are related to GHG emissions; water, soil, air, and biodiversity impacts; and socioeconomic impacts. The opportunities and challenges are location specific; therefore, the sustainable biofuel response must be as well.

Greenhouse Gas Emissions

Biofuels were promoted until recent years as a method to reduce GHG emissions by avoiding the emissions from the fossil fuels they replace. The theory was that net emissions are zero because when biofuels are consumed they emit the same quantity of carbon dioxide that is absorbed during the growth and regrowth of the feedstock. More recently, however, GHG emissions attributable to biofuels have been acknowledged as more complex. The comparison requires a much larger spatial and temporal boundary than simply substituting the energy equivalent amount of a biofuel for a fossil fuel and considering the carbon dioxide emissions from the replaced fossil fuel as avoided. The so-called *lifecycle* GHG emissions of a biofuel are comprised of emissions from cultivation, harvest, transport, and processing, as well as emissions saved from utilization of co-products. More recently, emissions from changes in land use have been introduced (see next section for details). Figure 9 illustrates the lifecycle of a biofuel.

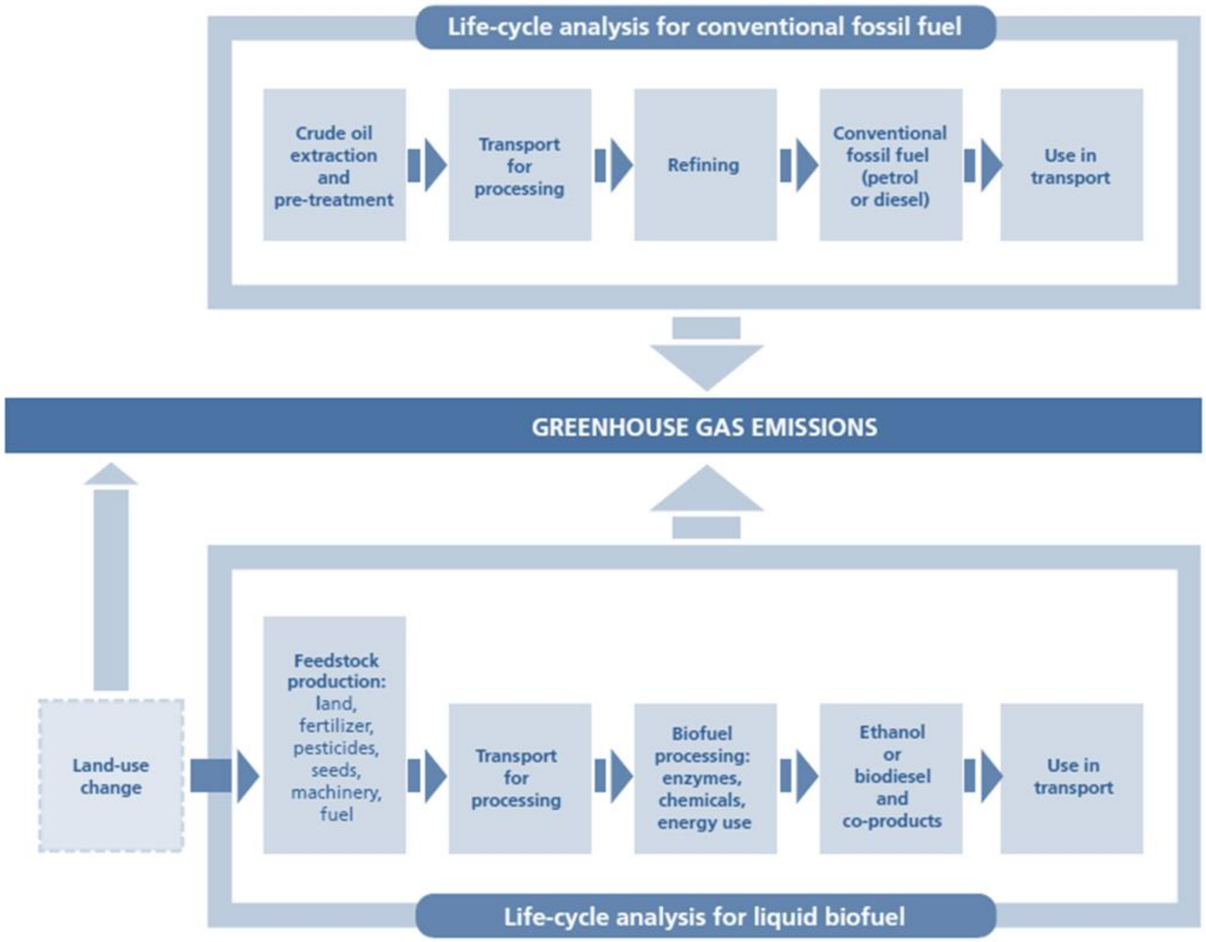


Figure 9. Stages of biofuel lifecycle
Source: FAO, 2008

Different studies have produced different results in terms of predicted overall GHG emissions reductions. Figure 10 illustrates the ranges of predicted GHG emissions reductions for a variety of biofuel feedstocks based on different cultivation techniques, processing technologies, and other factors. Figure 11 illustrates how estimates of emissions reductions can vary for an individual feedstock (in this case ethanol from corn) based on site-specific conditions, processing methods, and fuel selection.

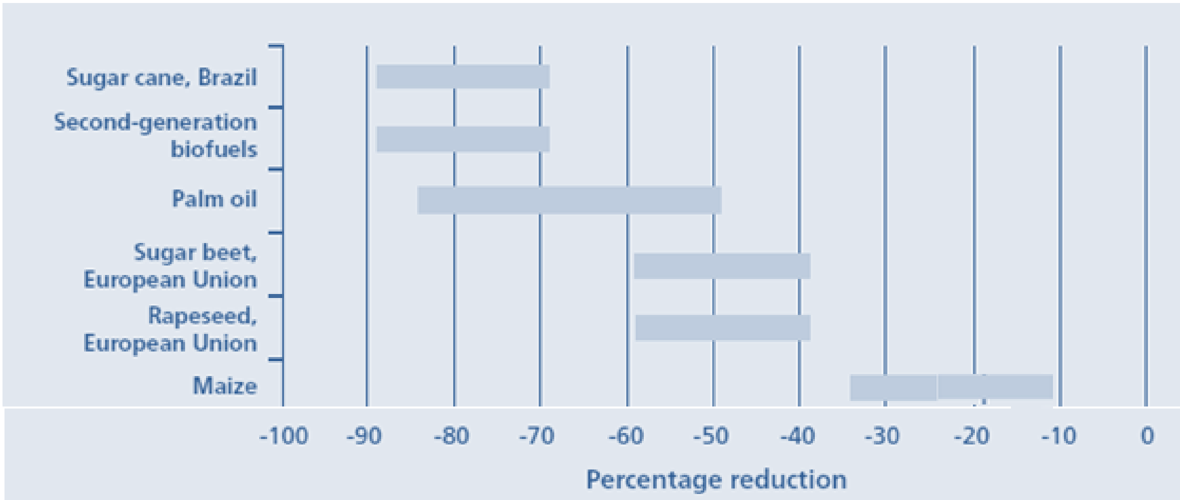


Figure 10. Comparison of greenhouse gas reductions of biofuels with fossil fuels

Note: Excludes land use change emissions

Source: FAO, 2008, from IEA, 2006 and FAO, 2008d

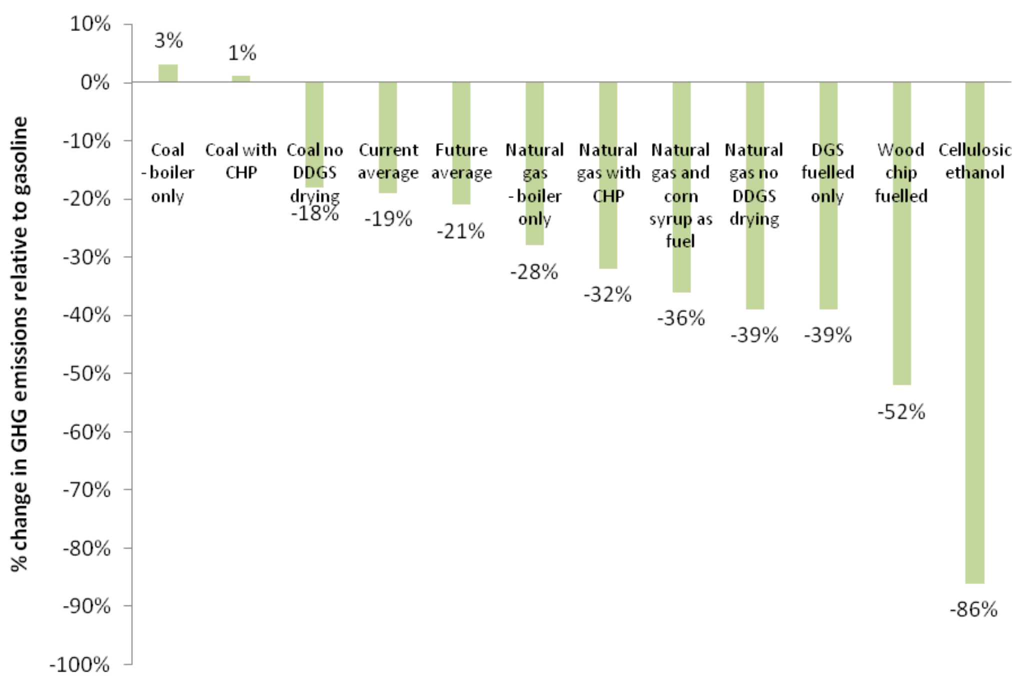


Figure 11. Well-to-wheels greenhouse gas emissions changes for corn ethanol under various processing scenarios, shown in comparison with cellulosic ethanol

Source: Redrawn from Wang et al, 2007

Once the lifecycle emissions of a particular biofuel have been established, they can be compared with the GHG emissions of the replaced fossil fuel to determine the emissions reduction. The quantity of GHG emissions is unique to the production process, including what and how much fuel is used in the process, how the feedstock is grown, and the historical use of the land on which it is grown. The same feedstock grown in one location will have a different emission profile than if grown in another. Although in many instances using biofuel in place of fossil fuel represents a net reduction of GHG emissions, it is possible for the emissions from a specific biofuel to be greater than would have been produced using a fossil fuel. For example, analyses conducted in the UK, using conservative values, illustrate that some biofuels, such as sugarcane ethanol from Pakistan and South Africa, may emit greater GHG emissions on a lifecycle basis than the fossil alternative (RFA, 2010a). Consequently, it is necessary to consider the full cycle of emissions for a true picture of the benefits a biofuel provides.

Land use change can be a significant source of GHG emissions from biofuels. Emissions from land use change come from reductions in carbon stored above and below ground in soils and plant life. Different types of land store more or less carbon, otherwise known as “carbon stocks.” For example, forests and peatland have very high carbon stocks, whereas pastureland has much lower ones. When land conversions decrease carbon stocks, significant amounts of carbon may be emitted.

Land use change may occur directly or indirectly. ***Direct*** land use change occurs when an area of land is converted to grow biofuel feedstock. Depending on the type of feedstock used, the area of land required to produce a given amount of fuel can vary widely. The area of land required to produce one billion liters (ethanol equivalent) of biofuel from different feedstocks is illustrated in Figure 12. ***Indirect*** land use change (ILUC) has a less apparent effect, but one that has been the source of much recent controversy for biofuels. ILUC occurs when an area of land is converted from one use to biofuel production, diverting the original service or product. Provided the demand for the original product remains the same, the conversion creates a supply shortfall that will drive a change in land use elsewhere to meet the demand.

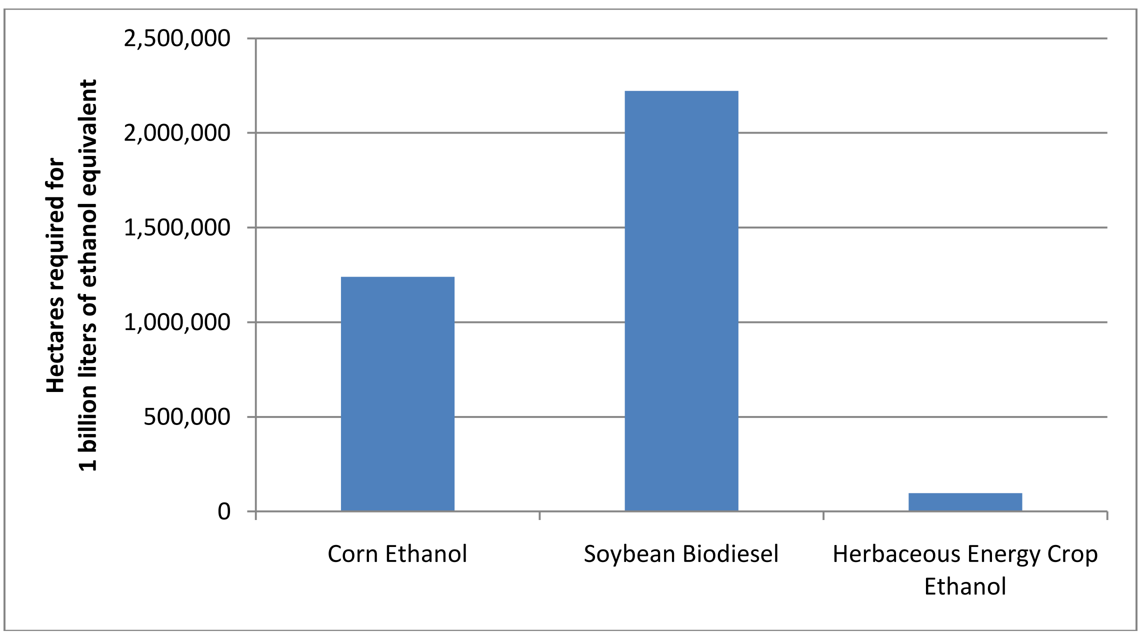


Figure 12. Land area requirements for biofuel production
Source: Wimberly, personal communication 2010

Gibbs et al (2008) conducted an assessment of the length of time it takes to pay back the carbon lost as a result of land use change for biofuels. This payback time depends on the carbon stocks of the type of land converted and the GHG emissions associated with the remainder of the biofuel lifecycle. For lands such as grasslands, the payback time is on the order of tens of years, which could be reduced with emissions-reducing management practices. For instance, Gibbs, Kim, and Dale (2008) estimated that no-till cultivation and the use of cover crops could reduce carbon payback time of maize ethanol from converted grasslands from 10 years to four years. Higher carbon stock lands, however, such as peatlands, could have payback times of hundreds of years. Although the Gibbs predictions are highly dependent on assumptions, many of which cannot be made with confidence, the general principle of longer carbon payback times corresponding to higher carbon stocks of converted lands is critical for biofuel sustainability considerations. Figure 13 illustrates the results of the Gibbs calculations. Gibbs (2008) assumes no well-to-wheel emissions, no benefits of land management or co-product residue optimization (land use change emissions and displaced liquid fossil fuel only). Background N_2O emissions from natural vegetation are not included.

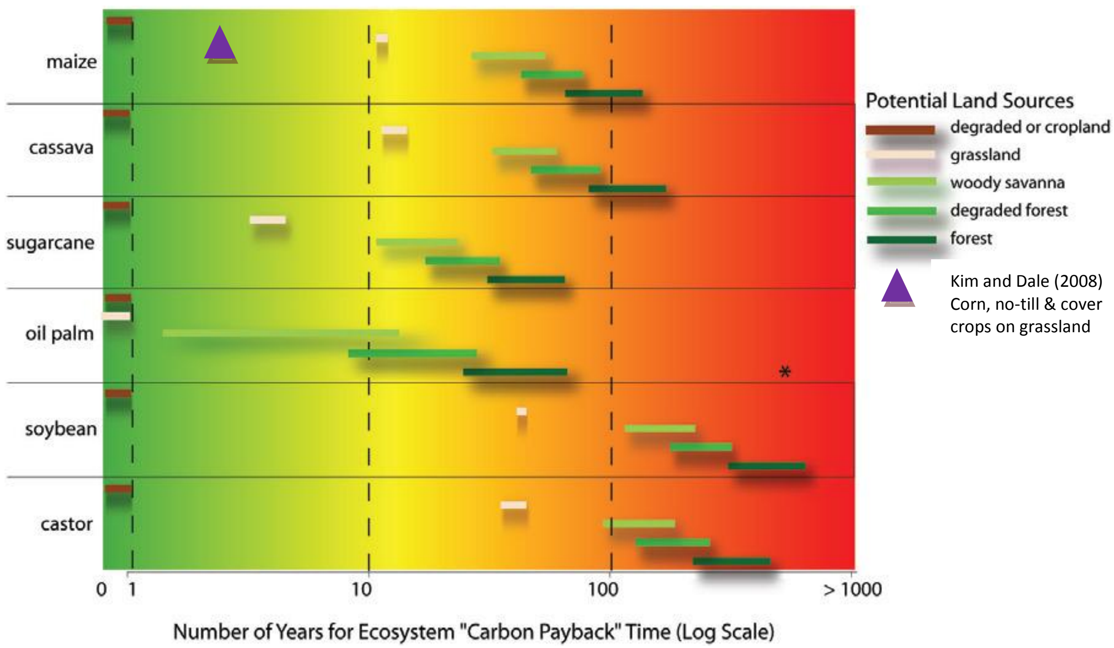


Figure 13. Carbon payback times for different feedstocks and reference land uses (illustrative only)
Asterisk refers to peatland conversion payback period of 918 years
Source: Gibbs et al, 2008 and Kim and Dale, 2008

Land use change affects more than GHG emissions. Environmental impacts occur when the converted lands have sensitive ecosystems or high levels of biodiversity. Socio-political impacts also arise; land is a finite resource and, as the world's population grows, decisions on how to use land become increasingly important. Social, economic, environmental, and political tensions related to competition for land are exacerbated by increased pressures to meet food, water, and energy demands. Further discussion on the non-GHG impacts of land use change can be found in later sections of this report.

Co-products of the biofuel lifecycle can also influence GHG emissions and other sustainability parameters. In some cases, the biofuel feedstock is actually a co-product of another process. Residues from crops can be used on fields to improve soil conditions and increase water retention and carbon stocks, or may be gathered and used as an energy source in boilers for heat and power for the biofuel production process, replacing other sources of energy. Effectively using other co-products, such as Distiller's Dried Grains with Solubles (DDGS) from corn-ethanol production for animal feed, can improve the GHG emissions savings over the biofuel lifecycle by displacing other animal feed products and thereby avoiding the emissions in their production. Their use can also reduce a biofuel's competition with food; when biofuel co-products are used for food or animal feed, their supply is decreased by less than might otherwise have been the case. Co-products from different biofuel production chains are listed in Table 4.

Table 4. Typical productivity of one hectare for different crops processed for biofuel (Illustrative only)

Feedstock	Feedstock Yield (t /ha)*	Primary co-product (per ha)	Intermediate processing (t/ha)	Biofuel production (per ha)	Secondary co-products (per ha)
Ethanol					
Sugarcane	78.8	21t bagasse & trash (dry)	-	8.6t ethanol	7250 MJ $electricity_{eq}$ Vinasse (fertilizer) CO_2
Corn (wet mill)	9.5	9.5t corn stover	-	4.7t ethanol	0.56t - corn oil 0.69t - gluten meal 2.99t - gluten feed CO_2
Corn (dry mill)	9.5	9.5t corn stover	-	4.6t ethanol	2.4t – DDGS CO_2
Miscanthus[1]	14[2]	-	-	4.4t ethanol	Electricity CO_2
Switchgrass[1]	13.5[2]	-	-	6.5t ethanol	Electricity CO_2
SRC e.g. willow[1]	8.8	-	-	3.7t ethanol	Electricity CO_2
Biodiesel					
Palm (fresh fruit bunches)	17.7	3.2t - Empty fruit bunches 7.2t - Old stems & fronds	3.5t – CPO 1.1t - palm kernel 2.8t – palm olein 0.6t – palm stearin	2.7t biodiesel	0.3t - glycerin 0.1t - potassium sulphate
Soybeans	2.8		0.48t - soy oil 2.06t – soymeal	0.45t biodiesel	0.05t - glycerin 0.01t - potassium sulphate
Rapeseed	3.1	3.1t - straw	1.26t rape oil 1.66t rapemeal	1.2t biodiesel	0.13t - glycerin 0.05t - potassium sulphate

** Yields vary substantially by crop variety, climate, soil, and other factors. These are indicative figures only.*
[1] Lignocellulosic crops can also produce diesel through Fischer-Tropsch conversion technology.
[2] Yields can be as low as 5.8t/ha for switchgrass and 9t/ha for miscanthus which would substantially alter results. Those reported here are based on relatively high yields reported for each crop.
Source: Winrock (2009b), from IGBE (2008), RFA (2008b), Macedo et al (2008), CA-GREET model, Woods et al (2006)

Environmental Quality Impacts

The environmental impacts of biofuels in general and feedstock growth in particular are location specific. They depend on the environmental resources at the location and their sensitivity to agricultural and forestry activities.

Biofuel production can affect the quality and availability of water. Well-designed sites of feedstock growth can reduce direct surface runoff, trap sediment, enhance infiltration, reduce the risks of landslides, reduce erosion, and improve water quality. On the other hand, the chemicals used in growing the crops can run off into local water bodies, and activities promoted as sustainable, such as increasing yields to minimize land use change or growing crops on marginal lands to avoid competition with food, may add to water stress and water pollution in a region. The full effects of biofuels on water systems, from feedstock growth through fuel production and consumption, are not fully understood (Winrock, 2009a). Different crops in different environments have different water consumption requirements (see Figure 14). To better understand the potential consequences of promoting biofuels, the impact on water across an entire basin would have to be evaluated (Winrock, 2010a). The consequences of biofuel production should be considered in economic terms as well as environmental terms (discussed later). With regards to irrigation, conducting site-specific cost-benefit analyses of different systems, such as irrigation versus rain-fed, would be beneficial. Such analyses ought to consider current and future water resources (Wimberly, pers.comm 2010).

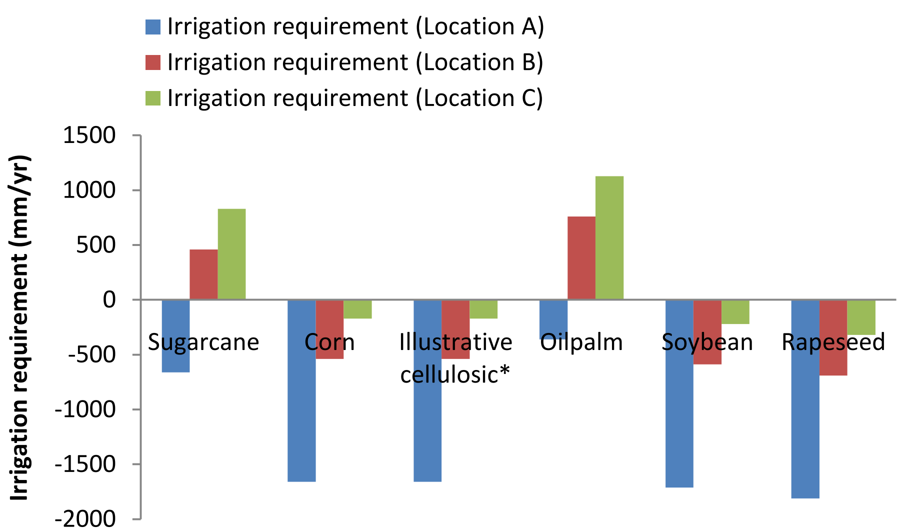


Figure 14. Illustrative irrigation requirements for crops under different precipitation conditions
Note: Location A is Padang, Indonesia; Location B is Mato Grosso, Brazil; Location C is Surabaya, Indonesia. Negative irrigation requirements indicate that the location has more rainfall than needed to satisfy the requirements of that crop.
Source: IWMI World Water and Climate Atlas and water requirements based on Rajagopal & Zilberman, 2008

Similarly, the type and quantity of fertilizer used can have varying sustainability outcomes. Demand for fertilizer is dependent on the type of crop, the land characteristics, and the production and management systems. Fertilizers can improve yields, reducing pressure to expand croplands. In some cases, however, fertilizers can harm soil, water, and air quality. Manufactured fertilizers may produce large amounts of GHG emissions. Without careful management, fertilizer may run off to harm neighboring lands. On average, 60% of nitrogen used in fertilizers either enters water systems or is emitted to the atmosphere as nitrous oxide, a GHG with a global warming potential nearly 300 times that of carbon dioxide per unit weight. When nitrogen enters water bodies, it threatens the quality of drinking water and may harm life in the water by creating "dead zones"[2] with low oxygen (USAID, 2009).

Water and fertilizer use, along with other agricultural management practices such as crop rotation patterns, impact soil quality, which in turn impacts feedstock production and surrounding ecosystems. Unsustainable practices can reduce soil nutrients, increase soil acidity, and increase erosion. These impacts lower the capacity of the soil to sustain crops and the environment.

In many APEC economies, especially in urban areas, biofuels are promoted to reduce air pollution associated with fossil fuels. Biofuels offer the potential to mitigate air pollution by substituting for fossil fuels, as in some cases biofuels have lower tailpipe PM_{10} emissions than fossil fuels and generally lower volatile organic compounds (VOCs) emissions. However, improved air quality is not inherent in the switch to biofuels. Biofuels may produce toxic air pollutants in engines, or air pollution may result from burning to clear lands for feedstock growth. Burning has been an especially significant source of air pollutants across southeast Asia. Furthermore, some biofuels may have higher nitrous oxide (NOx) tailpipe emissions than fossil fuels (Winrock, 2009c). For a biofuel to be sustainable with regards to air pollutants, care must be taken to ensure use of feedstocks that lower air pollutants in the engines in which they are used.

Biodiversity considerations are also critical for sustainable and healthy ecosystems. Biofuel feedstock growth can increase biodiversity in areas where degraded lands are brought into production. The environments in which feedstocks tend to grow best, however, are often areas of high biodiversity because they have climates and soils that are conducive to plant growth. This is especially relevant in APEC because of the number of economies lying in tropical areas. Promoting biofuels can place these habitats at risk of conversion if appropriate cautionary measures are not in place. Mono-cropping represents a further threat to biodiversity through the reduction in agricultural biodiversity (USAID, 2009).

The water, soil, air, and biodiversity impacts of a biofuel activity are specific to the conditions at the activity site. Promoting "marginal" lands for biofuel feedstock growth is a case in point. Lands that are considered "marginal" or "degraded" are often promoted as lands good for biofuel feedstock growth because of the lack of competition with food production and other land uses. In theory, marginal land is of limited value in its original state, because the costs of producing sufficiently high yielding crops, through the addition of fertilizers and irrigation, are generally greater than the income generated by the crop. Land may be classified as marginal because it is too wet, too dry, too steep, or it has another technical or agronomic constraint. In reality, however, even if the land appears marginal from an economic perspective, it may still provide a social or environmental service. For this reason, the definition of marginal land is a hotly discussed subject. The impacts of agricultural activities on such lands, including biofuel feedstock growth, are not fully known; hydrological impacts and the environmental effects of agricultural inputs such as fertilizers to obtain economically acceptable yields may be especially problematic.

[2] Dead zones are bodies of water that are deprived of oxygen and therefore cannot sustain marine life, such as fish and crabs, causing a ripple effect throughout the marine food chain. Runoff carrying nutrient-rich fertilizers is a prime cause of the growing number of dead zones worldwide (Diaz, 2008).

Socioeconomic Impacts

A number of economies are dependent on agriculture for a significant portion of their Gross Domestic Product (GDP) and employment. Biofuels have the potential to improve the economy-wide balance of payments and can lead to economic development and poverty alleviation in rural areas by nurturing new industries or supporting struggling ones. In the case of energy insecure communities, biofuels can provide a local energy source. However, several tradeoffs must be balanced.

The food versus fuel debate has drawn much attention in recent years and is discussed primarily in simple terms of displacement. Many first generation biofuels are produced from feedstocks that are also used for food and feed. When farmers' returns on growing biofuel crops exceed food or feed crop returns on the same land, farmers will naturally tend towards growing a biofuel crop. Many have accused this of happening with corn in the United States because the price of corn rose in parallel with the rise in biofuel production. However, many complex factors affect food prices, including increased use of marginal land when crop prices rise; increased costs of fertilizer, which are connected to crude oil prices; lower returns from other crops; and increased crop productivity.

While the attention has been largely on perceived negative impacts, biofuels' food security impacts can sometimes be positive. Poverty leads to food insecurity and is linked to income, productivity, and employment. Distribution systems that connect food reserve institutions, markets, production centers, and settlement areas are very important for achieving household and regional food security. Therefore, a food versus fuel assessment that addresses only land competition for biofuels is too simplistic (Winrock, 2009c). For example, in regions with a good climate for crop production but insufficient rural infrastructure, villages may have more than sufficient production to meet their food needs but limited access to markets in which to sell excess. If diversifying crops away from food becomes an option, incomes could increase. In this case, biofuels may have a positive impact on food security by increasing incomes and enabling increased food purchases on the market. Biofuel production in a region can also improve energy security by decreasing reliance on fossil fuels, enhancing fuel availability and reducing price volatility, which could mitigate negative food security impacts (Cotula et al, 2008).

Smallholders can benefit from a biofuel industry if they are able to grow feedstocks competitively and have access to a stable market in which to sell. In these cases, the incomes of smallholders increase and, in the best scenarios, trigger economic development in their communities. Biofuel development may hurt smallholders, though, for two reasons. First, smallholders are at risk of being left behind as the industry develops, because they may not receive the same financial incentives as larger plantations or have access to improved varieties, fertilizers, training, or financing. To benefit smallholders, specific programs and policies must target them with financial and technical assistance. Second, as the value of biofuels increase, demand increases for land on which to grow the feedstocks. Hence, smallholders, as well as marginalized populations living on potential agricultural land, are vulnerable to losing the land on which they live or depend for food or income.

Laborers on farms and in plants may be vulnerable to negative labor practices as the demand for labor rises with increased biofuel production. Where proper protections are not in place, improper working conditions and exposure to harmful chemicals are a possibility (Schott, 2009).

Economics is a key driver for biofuels: whether the objective is to reduce an economy's balance of payments, stabilize fuel prices, or stimulate economic development, cost effectiveness is central to the viability of a biofuel industry. Biofuel policies and programs commonly focus on financial incentives to stimulate and support the industry. However, biofuel costs are closely connected to the price of food and oil, making biofuels both a threat to food prices and vulnerable to changes in food and oil prices. Biofuel economics is also closely tied to policies and regulatory incentives, which may change quickly. Nonetheless, creative ways exist to increase the financial viability and accessibility of biofuels.

2.4 Multilateral Activities to Support Sustainable Biofuels

In order to ensure biofuel sustainability, several organizations, companies, and economies are developing or enforcing the use of sustainability standards for biofuels and feedstocks that set minimum requirements for sustainability outcomes and certify that they have been met. Specific sustainability criteria fall into categories such as land use change, GHG emissions, waste management, rural and social development, energy security, participation, transparency, and food security. Regulatory standards, such as those under development in the United States and Europe, will apply to all biofuels in those economies, and voluntary standards will certify sustainable biofuel activities economy-wide or at an organization or project level.

Although not developed in most APEC economies, multilateral activities affect biofuel production in many of them by setting terms of trade for biofuels and biofuel feedstocks. More detailed discussion on regulatory standards is found in Section 4.0 Regulatory and Policy Initiatives and on voluntary standards in Section 5.0 Voluntary Programs and Initiatives. Table 5 presents selected sustainability frameworks and standards and the sustainability criteria that each addresses.

Table 5. Biofuel sustainability frameworks, standards, and scorecards

	REGULATORY FRAMEWORKS	Biomass Sustainability Order (BioNachV) - Germany	EU Renewable Energy Directive (RED)	Renewable Transport Fuel Obligation (RTFO) - UK	Social Fuel Seal - Brazil	Testing Framework for Sustainable Biomass ("Cramer Criteria") - The Netherlands	VOLUNTARY STANDARDS / CERTIFICATION SCHEMES	Basel Criteria for Responsible Soy Production	Better Sugarcane Initiative (BSI)	Council on Sustainable Biomass Production (CSBP)	Global Bioenergy Partnership (GBEP)	Green Gold Label 2: Agriculture Source Criteria (GGLS2)	International Sustainability & Carbon Certification (ISCC)	Roundtable on Responsible Soy (RTRS)	Roundtable on Sustainable Biofuels (RSB)	Roundtable on Sustainable Palm Oil (RSPO)	SEKAB Verified Sustainable Ethanol Initiative	SCORECARDS	IDB Biofuels Sustainability Scorecard	WB/WWF Biofuels Environmental Sustainability Scorecard
1. ENVIRONMENTAL																				
1.1 Land-use changes (both direct and indirect)			√			√				√	√	√	√	√	√	√	√		√	√
1.2 Biodiversity and ecosystem services		√	√	√		√		√	√	√	√	√	√	√	√	√	√		√	√
1.3 Productive capacity of land		√	√	√	√	√		√	√	√	√	√	√	√	√	√	√		√	√
1.4 Crop management and agrochemical use		√		√		√		√	√	√	√	√	√	√	√	√			√	√
1.5 Water availability and quality		√	√	√		√		√	√	√	√	√	√	√	√	√	√		√	√
1.6 GHG emissions		√	√	√		√			√	√	√		√	√	√	√	√			√
1.7 Air quality		√	√	√		√		√	√		√		√	√	√	√			√	√
1.8 Waste management			√	√		√		√	√	√	√	√	√	√	√	√			√	√
1.9 Environmental sustainability (cross-cutting)			√		√	√		√	√	√	√	√	√	√	√	√	√		√	
2. SOCIO-ECONOMIC																				
2.1 Land tenure/access and displacement			√	√		√		√	√		√	√	√	√	√	√			√	√
2.2 Rural and social development				√	√	√		√	√		√	√	√	√	√	√	√		√	
2.3 Access to water and other natural resources				√				√	√	√	√		√		√				√	
2.4 Employment, wages and labor conditions			√	√		√		√	√	√	√		√	√	√	√	√		√	√
2.5 Human health and safety				√		√		√	√	√	√		√	√	√	√			√	√
2.6 Energy security and access						√			√		√			√	√	√			√	
2.7 Good management practices and continuous improvement						√		√	√	√	√	√	√	√	√	√			√	√
2.8 Social sustainability (cross-cutting)			√		√	√		√	√		√		√	√	√	√			√	
3. GOVERNANCE																				
3.1 Compliance		√	√	√	√	√		√	√	√	√		√	√	√	√	√		√	√
3.2 Participation and transparency			√	√	√	√		√	√	√	√	√	√	√	√	√			√	√
4. FOOD SECURITY																				
4.1 Food availability			√			√					√	√	√		√				√	√
4.2 Food access			√			√					√		√	√	√				√	√
4.3 Food utilization				√		√		√	√		√		√	√	√	√			√	
4.4 Food stability					√						√				√				√	
4.5 Food security (cross-cutting)					√						√				√					

Source: FAO, 2010a

3.0 Sustainable Biofuel Planning and Research

Planning for a sustainable biofuel industry is the first step in ensuring that biofuels are sustainable. This category of sustainable biofuel activities covers assessing the potential sustainability impacts of a biofuel or location and outlining how to proceed with biofuel development so that it is sustainable. Such activities occur before the feedstock is grown or the biofuel is produced or consumed. Planning and research activities in the APEC region fall into the following categories:

- Assessing the sustainability of land use
- Assessing the potential greenhouse gas emissions of the biofuel supply chain
- Assessing the potential water impacts of the biofuel supply chain
- Conducting research and development for biofuels with improved sustainability characteristics
- Developing sustainable biofuel plans

These activities do not automatically lead to the sustainability of biofuels, but planning and research for sustainability is a critical first step towards achieving it.

3.1 Assessment of Land Use Sustainability

Knowing where biofuels can be grown sustainably requires knowing where the feedstock can grow physically, as well as where its growth will not cause high GHG emissions from converting land, compete with food and other uses of the land, or interfere with current land holdings. Different sustainability assessments have different criteria for determining lands on which biofuels can be grown sustainably, but most (including the EU Renewable Energy Directive) require that lands of high carbon stocks not be converted for biofuel feedstock production.

Mapping exercises can be used to visualize the locations that meet specific requirements for sustainable biofuel growth, and mapping techniques are becoming ever more sophisticated. Remote sensing data uses aerial photographs and satellite images to measure data such as water consumption, land cover, and vegetation types. These data can be paired with independent sources of data (such as trade data and site observations and measurements), statistical sampling, and data stratification exercises to enhance the understanding of the mapped land. These data sources can be connected with Geographic Information Systems (GIS) that capture, store, analyze, manage, and present data linked to a spatial location. GIS can be used at regional levels to define agro-ecological zones for crop suitability or at site levels to establish baselines and identify environmentally vulnerable areas.

Remote sensing is an especially useful technique to measure carbon stocks and to monitor land cover changes and thus to figure out where to grow biofuel feedstocks with minimum starting carbon deficit. Coarse- and medium-scale remote sensing data can calculate above-ground carbon stocks. Traditional techniques for collecting information on carbon stocks rely heavily on field-based measurements. In regions with heterogeneous biomass stocks over large areas, substantial resources would be required to ensure a high degree of accuracy and precision in reported estimates using traditional techniques. The use of remote sensing data provides an alternative method that reduces the costs of measuring carbon stocks (Winrock, 2009d).

Moderate Resolution Imaging Spectroradiometer (MODIS) is a type of coarse resolution remote sensing for land cover identification. MODIS data are available and published using global land cover categories identified by the International Geosphere Biosphere Program (IGBP). IGBP categories consist of 17 cover classes: 11 classes of natural vegetation, three classes of developed and mosaic lands, and three classes of non-vegetated lands. Medium resolution remote sensing, such as with Landsat, can be useful for regional assessments (Winrock, 2009d).

Box 1. Innovative tools for above ground carbon stock data

Capacity for monitoring changes in land cover is improving rapidly with advances in remote sensing technology. In many developing economies, however, reliable carbon stock data are scarce and allocating significant resources for monitoring may be difficult.

An illustration of the use of M3DADI to measure carbon stocks

High resolution images, such as IKONOS, are usually used for a particular site rather than across a region. Thenkabail et al (2004) used IKONOS imagery to determine the above ground carbon stocks of oil palm in West Africa and to monitor changes over time. The plantation locations were mapped with an overall accuracy of 88%-92%.

A multispectral, three-dimensional aerial digital imagery (M3DADI) system has been designed to use high-resolution overlapping stereo imagery (≤10 cm pixels) that can distinguish among individual trees and shrubs (Pearson et al, 2005). However, the differentiation of various age groups of oil palms is limited, influencing the accuracy of the carbon stock results. In Belize, 77 aerial-imagery plots were measured and assessed with a variety of vegetation cover: trees, shrubs, palmettos, and grasses. The study estimated that a conventional field approach would take around three times as many person-hours as the aerial approach. High resolution optical imagery such as this can distinguish among savanna land cover types and densities, which can be used to improve carbon stock inventories substantially (Brown, 2004).

GIS techniques for sugar cane zoning in Brazil: The State of Sao Paulo in Brazil has used mapping techniques to guide sugarcane zoning through an agro-ecological approach for sugarcane expansion. The zoning shown in Figure 15 is a first of its kind effort in land use planning. A larger survey, the National Agro-Ecological Zoning for Sugarcane (ZAE Cana) study, defined lands suitable for sugarcane production based on environmental, economic, and social criteria. ZAE Cana has led to the proposal of new legislation to restrict sugarcane farming and processing on lands of native vegetation in the Amazon, Pantanal, and Upper Paraguay River Basin regions.

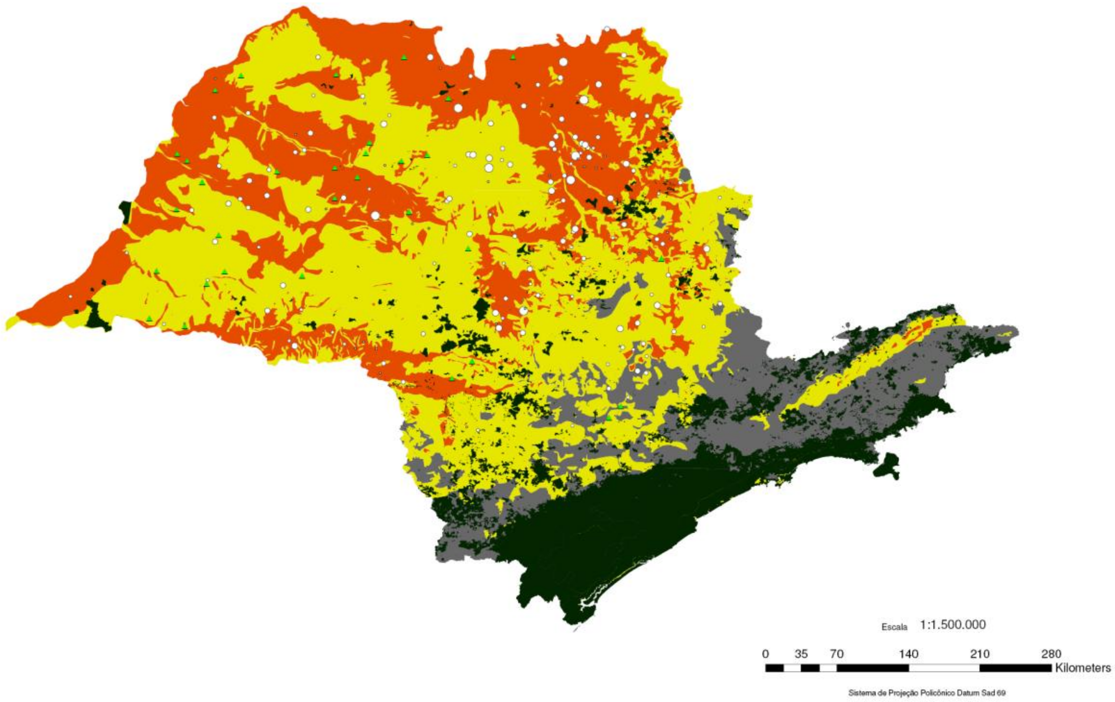


Figure 15. Agro-ecological zoning for sugarcane in Sao Paulo state
Orange indicates land considered adequate for sugarcane, yellow indicates medium-adequate, and grey indicates inadequate. Areas in dark green have environmental constraints.
Source: Walter et al, 2008

Mapping areas for sustainable oil palm growth in Indonesia: Figure 16 offers an example of steps that could be followed to map areas that are geophysically suitable for biofuel feedstock growth and meet sustainability criteria. Using this approach in Indonesia for palm oil can produce maps like the one in Figure 17. Areas of red on this map illustrate where lands that meet specified sustainability criteria are in line with current concessions. The blue areas illustrate where land meets sustainability criteria but is not covered by existing land concessions for oil palm. It must be noted that the criteria for this assessment are limited to carbon stock only and have not considered other issues such as biodiversity or social impacts (Winrock, 2009c).

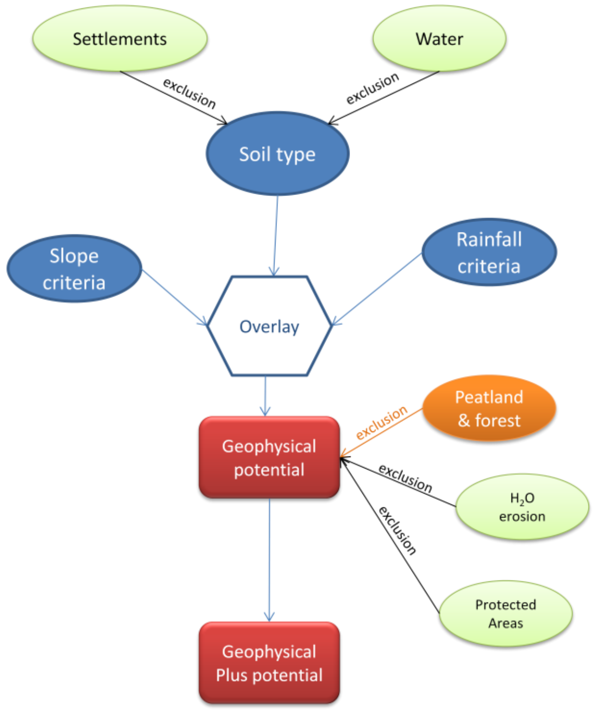


Figure 16. Spatial analysis for identifying area with geophysical and sustainability potential for oil palm cultivation in Indonesia

In this figure, blue ovals represent geophysical criteria; green ovals represent land cover criteria excluded in analysis (water bodies, settlements); and orange ovals represent sustainability criteria excluded in the analysis (high carbon stocks).

Source: Winrock, 2009c

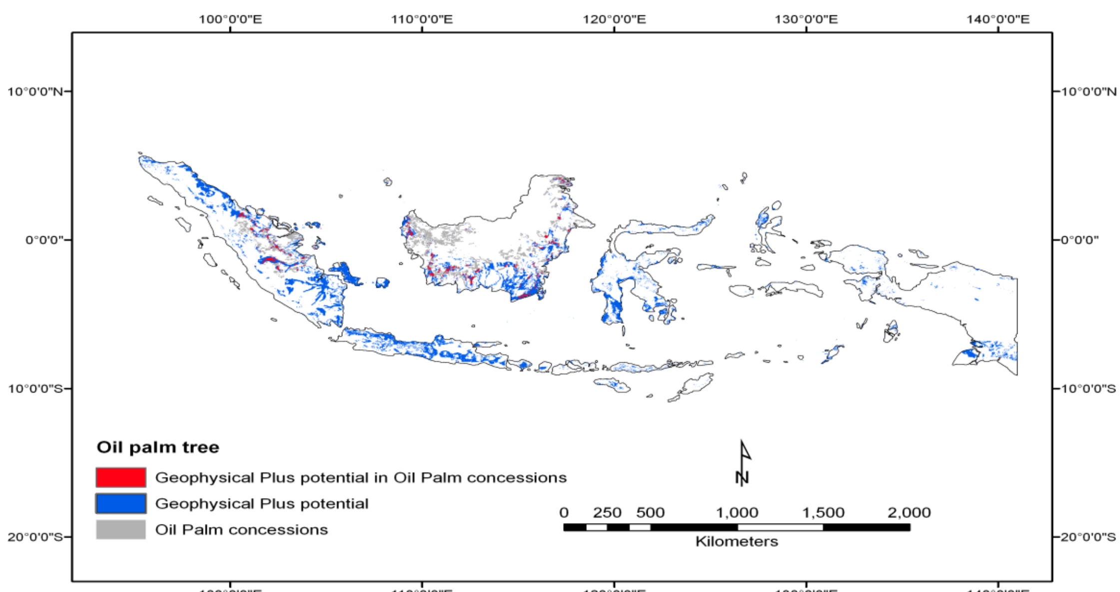


Figure 17. Areas identified with sustainability potential and existing oil palm concessions

Source: Winrock, 2009c

On a site scale, larger oil palm companies and research institutes in Indonesia (such as PT Musim Mas and IOPRI) use GIS techniques to manage their operations and address environmental considerations such as soil type and water availability. Using GIS and remote sensing techniques for environmental monitoring in the forestry sector is increasingly common in Indonesia but has not been applied in policy planning for biofuels to address environmental issues within agriculture (Winrock, 2009c).

Application of the High Conservation Toolkit: Examples of sustainability assessments involving mapping have taken place in APEC using the High Conservation Value (HCV) Toolkit to identify and protect land areas with high environmental or socioeconomic values. The concept for the HCV toolkit, which is a method for identifying lands of high environmental and social value, emerged from the Forest Stewardship Council's well-managed forest standard in 1999. This toolkit is required under the Roundtable for Sustainable Palm Oil (RSPO) certification (see Voluntary Standards section): RSPO criterion 7.3 requires that "new plantings since 2005 … have not replaced primary forest or any area containing one or more High Conservation Values" (RSPO, 2006).

Six high conservation values are considered in the HCV toolkit assessment. An HCV area contains one or more of these values and must be managed to protect and enhance them. The six values are as follows:

> ***HCV1:*** *Areas containing globally or regionally significant concentrations of biodiversity values.*
> ***HCV2:*** *Large landscape-level areas of global, regional, or economy-wide significance, where viable populations of most, if not all, naturally occurring species exist in natural patterns of distribution and abundance.*
> ***HCV3:*** *Areas that are in, or contain, rare, threatened, or endangered ecosystems.*
> ***HCV4:*** *Areas that provide basic ecosystem services in critical situations.*
> ***HCV5:*** *Areas fundamental to meeting basic needs of local communities.*
> ***HCV6:*** *Areas critical to local communities' traditional cultural identity.*

For an area under analysis, the first step is to determine which of the values are present. The next step is to develop a management strategy to protect or enhance those values. Lastly, a monitoring regime is established (HCV Network, 2005). In this sense, the methodology is a planning tool.

Interpretations by individual economies are key to implementation of the HCV toolkit. Within APEC, Canada, Chile, China, Indonesia, Malaysia, Papua New Guinea, Russia, and Viet Nam have completed economy-wide interpretations. In 2003 Indonesia became the first economy to complete an economy-specific interpretation (Consortium to Revise the HCV Toolkit for Indonesia, 2008), and several palm oil mills and plantations have been RSPO certified in that economy. To conduct HCV assessments on a local and site scale, and to develop management plans, GIS techniques and tools have been used. These techniques enable the identification of better choices and practices within a specific context (Winrock, 2009c).

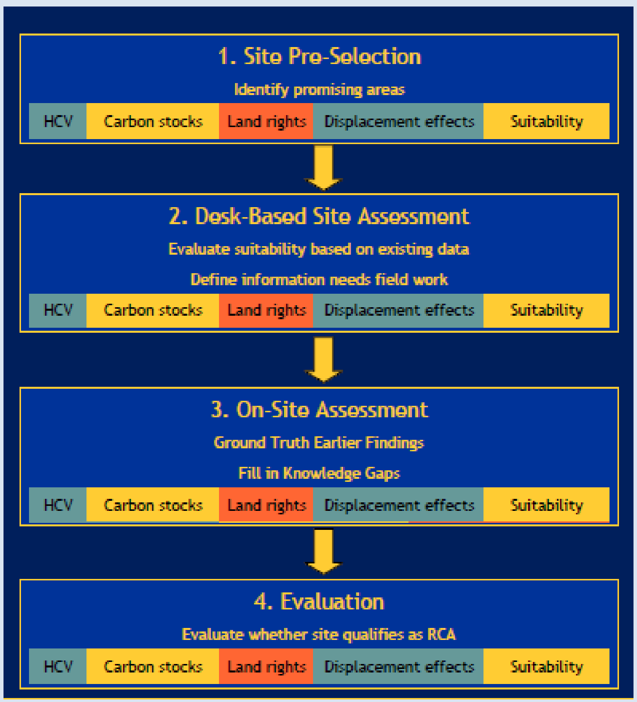
These techniques are cost-effective first screening steps for assessing potentially suitable areas for biofuels using sustainability criteria. They are currently being used in Indonesia to assess "Responsible Cultivation Areas," described in Box 2.

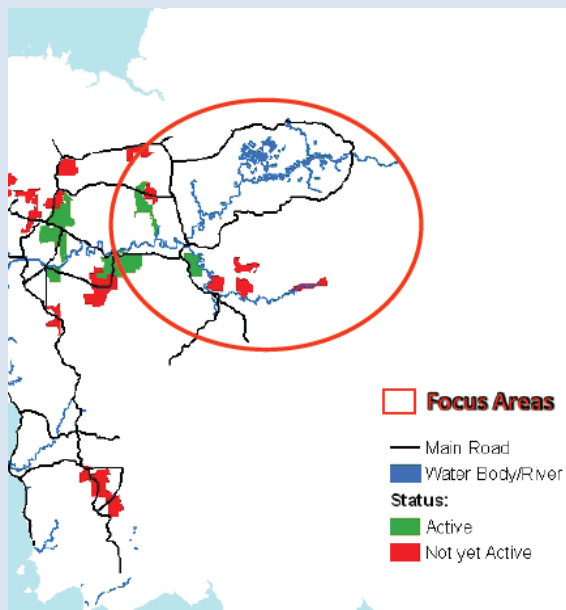
Box 2. Establishing "Responsible Cultivation Areas" in Indonesia

One project in Indonesia is developing and field-testing a practical definition and methodology to determine the locations of "Responsible Cultivation Areas" (RCAs). RCAs are areas where energy crops can be produced with minimum risk of indirect land use change. WWF Indonesia and Ecofys have developed principles for RCAs of energy crop plantations:

1. Maintains or increases High Conservation Values
2. Does not significantly decrease above or below ground carbon stocks
3. Respects formal and customary land rights
4. Does not cause unwanted displacement effects

The methodology for establishing RCAs has four steps, as shown below. After the desk-based assessment in step two, a map like the one below on the right would be produced to show areas on which to focus.





Source: Dehue, n.d.

Application of the Biomass Inventory Mapping and Analysis Tool in Canada: Another example of a mapping exercise in APEC has taken place in Canada, where an online tool is available for biomass resource mapping. The Biomass Inventory Mapping and Analysis Tool (BIMAT) was developed to identify and characterize biomass sources potentially available for bioenergy conversion. BIMAT is based on internet map server technology that allows users to view spatially explicit inventory of biomass sources across the economy. The model includes harvest operations in all provinces and territories (Bradley, 2009). It models woody and herbaceous biomass (both in terms of quantity and quality), woody waste in the urban environment, and agricultural residues (Stumborg, 2008). The tool is available on the internet to enable processing plants looking for biomass to establish the quantity and type of biomass that is available. An image from the BIMAT tool is shown in Figure 18.

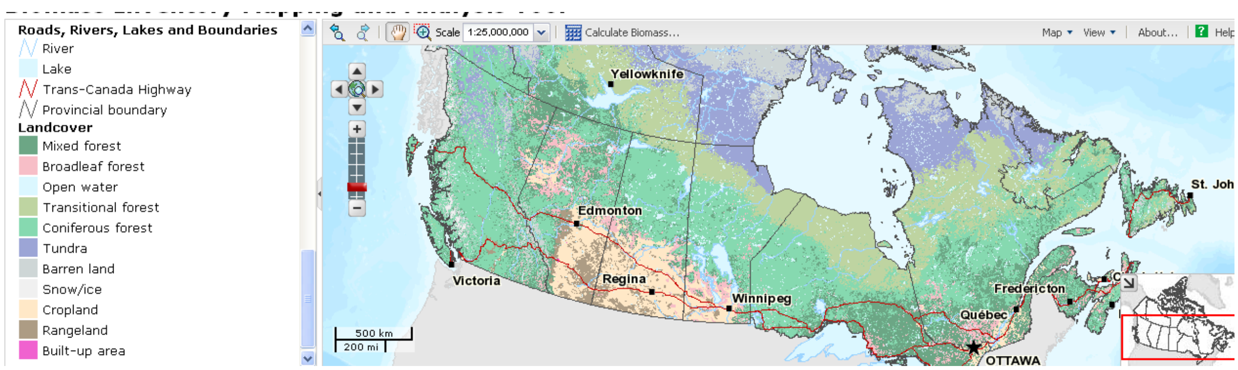


Figure 18. Image from the BIMAT tool showing land cover over Canada
Source: Agriculture and Agri-Food Canada, 2010

Development of BIMAT is taking place in three phases. Measurements of sustainability indicators are to be established in Phase II. Saskatchewan is an experimental province for creating the sustainability framework. In addition to assessing sustainability, the model will assess the environmental impacts of biofuel systems, including impacts on climate, landscapes, and crop residues (Stumborg, 2008).

3.2 Assessment of Potential Greenhouse Gas Emissions

Reduced GHG emissions are often considered a proxy for sustainability. While sustainability encompasses much more, reducing GHG emissions is an important element of sustainability. Planning for lower GHG emissions from biofuels compared to fossil fuels requires understanding the quantity and source of all emissions. Lifecycle assessments (LCAs) measure the emissions associated with a biofuel from growth of the feedstock to the biofuel's final use (see Figure 9). In the past, previous land use was not considered; however, given the potentially significant GHG impacts of land use change, it is now becoming part of the analysis.

A multilaterally agreed on and accepted methodology for conducting a biofuel LCA does not currently exist (Winrock, 2009b). However, the Global Bioenergy Partnership (GBEP) has developed a framework that can be used by those developing methodologies to identify key questions for conducting an LCA (GBEP, 2009). The GBEP framework contains 10 steps to guide LCA calculations of bioenergy. Calculations will differ, but a common set of questions makes the process more transparent and the outcomes and methodologies more comparable. The 10 steps address the following topics:

1) Greenhouse gases covered
2) Sources of biomass
3) Land use change
4) Biomass feedstock production
5) Transport of biomass
6) Processing into fuel
7) By-products and co-products
8) Transport of fuel
9) Fuel use
10) Comparison with replaced fuel

LCAs have been used primarily as academic tools requiring substantial time and expertise; only recently have they been adapted for policy and regulatory purposes in some economies (such as the United States, European Union, and some of its individual Member States such as the United Kingdom). Some LCAs determine impacts of a policy at an economy scale, but others include adaptations for use by supply chain actors to drive improvements within the supply chain. This use has included the development of default values for specific activities to reduce the administrative burden and allows users to enter information such as mode of transport, transport distance, fertilizer type, and amount or type of fuel used in the boiler. In some cases the default values are conservative to encourage users to enter their own information and obtain improved GHG balances (Chalmers, pers.comm 2010).

Regulators such as the U.S. Environmental Protection Agency, the California Air Resources Board, and the European Commission are using LCA approaches, combined with general equilibrium models, to estimate the overall impacts of biofuel policy and to create regulatory incentives for biofuels on the basis of their GHG emissions (see Section 2.0). The European Commission is also required to undertake relevant research as part of a planned biofuel policy review in 2012 (Winrock, 2009b). This work is relevant to APEC economies that may export to the United States or Europe, or to other economies and companies that require meeting a sustainability standard. Table 6 lists several sustainability standards that require LCAs and their required GHG savings.

Table 6. Examples of LCA requirements of biofuel sustainability standards

Standard	GHG Saving Stipulation
EU Renewable Energy Directive	GHG emissions savings from biofuels and bioliquids shall be at least 35% by 2009, 50% by 2017, and 60% by 2018 for installations in service from 2017.
UK Renewable Transport Fuel Obligation (non-mandatory targets)	Targets of 40% for 2008/9, 50% for 2009/10, 60% for 2010/11
California Low Carbon Fuel Standard	10% reduction of average fuel carbon intensity. One of the first policies to be based on an LCA.
U.S. Renewable Fuel Standard	Different levels of reduction compared to the baseline (2005 emissions level) are required for each of the four established renewable fuel categories: 20% for renewable fuels, 50% for advanced biofuels, 50% for biomass-based diesel, and 60% for cellulosic biofuels.
Global Bioenergy Partnership	Taskforce on GHG Methodologies has produced a draft methodological framework, consisting of 10 analytic steps, to use in LCAs of bioenergy systems. Aims to provide a consistent manner for economies to evaluate GHG emissions.
Roundtable for Sustainable Biofuels	Lifecycle GHG emissions of the biofuel must meet the "minimum GHG emission reduction threshold" below the applicable fossil fuel baseline. During the pilot test period, not to exceed 9 months, testing will be done against minimum GHG emission reduction thresholds set at 10%, 40% and 70%. At the conclusion of the test period, the initial minimum GHG emission reduction threshold shall be set such that it is significant and ambitious.
Roundtable on Sustainable Palm Oil	An assessment of all polluting activities must be conducted, including gaseous emissions, particulate/soot emissions and effluent. Significant pollutants and emissions must be identified and plans to reduce them implemented.
World Bank/World Wildlife Federation Biofuels Environmental Sustainability Scorecard	A qualified assessor must conduct a project feasibility study and GHG LCA concluding that the project feasible and is carbon negative (including emissions from direct and indirect land use change). In the case of short cycle annual crops, the project must be carbon negative at the end of the growing season. If those requirements are met, the project is scored in this category according to how long it takes for the initial carbon deficit incurred by the project to be made up by subsequent carbon savings: **0 Points**: The payback period in terms of carbon, including carbon lost above and below ground during project establishment and operation, is 75% to100% of the economic life of the project. **1 Point**: Payback period is 50% to 75% of the project's economic life. **2 Points**: Payback period is 25% to 50% of the project's economic life. **3 Points**: Payback period is less than or equal to 25% of the project's economic life.

The lifecycle GHG emissions of biofuels vary among feedstocks, locations, and practices. The importance of GHG LCAs is understood in the APEC region as a whole, and several economies have completed, or are in the process of completing, LCAs of their key biofuels. Economies in which data are scarce and LCA expertise is lacking can benefit from working with those who have the experience and capacity to carry out LCAs. For example, the Indonesian Palm Oil Commission worked with World Agroforestry Center (ICRAF), IOPRI, and the Netherlands on a new project, "Reducing GHG emissions associated with oil palm in Indonesia: Accounting for greenhouse gas emissions over the full lifecycle on peat and mineral soils and building capacity for and industry response to emerging environmental regulation in European markets" (IPOB, 2008). Table 7 lists some examples of LCAs carried out in APEC economies.

Table 7. Examples of biofuel LCAs carried out in APEC economies

Economy	Organization	Fuel	GHG Savings
China	Tianjin University	Corn bioethanol	Not available
	Shanghai Jiao Tong University	Cassava ethanol	Not available
	Joint Research Activity	Sweet sorghum ethanol	Not available
Japan	NEDO	High-yield rice with no change in water management	30%
	NEDO	Minimum access rice	27%
	NEDO	Irregular wheat	46%
	NEDO	Sugarbeet	52%
	NEDO	Construction waste	90%
	NEDO	Waste molasses	32%
Malaysia	MPOB and MPOC	Palm biodiesel	51%
	MPOB and MPOC	Palm biodiesel, with methane capture	66%
New Zealand	Project: Bioenergy Options for New Zealand - Pathway Analysis	Canola biodiesel	62%
	Project: Bioenergy Options for New Zealand - Pathway Analysis	Wood residue biodiesel (Fischer Tropsch gasification)	83%
	Project: Bioenergy Options for New Zealand - Pathway Analysis	Wood residue ethanol	75%
	Project: Bioenergy Options for New Zealand - Pathway Analysis	Purpose-grown forest biodiesel (Fischer Tropsch gasification)	89%
	Project: Bioenergy Options for New Zealand - Pathway Analysis	Purpose-grown forest ethanol	80%
	CRL	Tallow biodiesel	
Chinese Taipei	New Energy Technology Division, Energy and Environment Research Labs, Industrial Technology Research Institute	Waste cooking oil	78%
United States	EPA	Corn ethanol from newer plants	7-32%
	EPA	Switchgrass derived ethanol	110% (biochemical) 72% (thermo-chemical)

LCA calculations have limitations in determining GHG balances of biofuels. The indirect consequences of biofuels often are not taken into account, which has been a major criticism of approaches so far. Additionally, LCA calculations of nitrous oxide, which has a global warming potential nearly 300 times greater than carbon dioxide, have large uncertainties. For example, modeling in the European Union shows that nitrous oxide emissions can vary by a factor of more than 100 from one wheat field to another (JRC, 2008) because of varying environments and management practices (Stehfest & Bouwman, 2006). At present, LCA methodologies rely largely on default data for nitrous oxide emissions that are based only on the level of fertilizer application (Winrock, 2009b).

3.3 Assessment of Potential Water Impacts

Large-scale investments in biofuel plantations can have significant impacts on water availability for other users. A water footprint is a measure of the amount of water that goes into the production of a product or collection of products used by an organization or economy. Water footprints of biofuels can be estimated per unit of crop or biofuel. Several methodologies exist for calculating water footprints, but different methodologies yieldhfferent results.   The stages of water consumption throughout the biofuel lifecycle from agriculture to industry are illustrated in Figure 19.

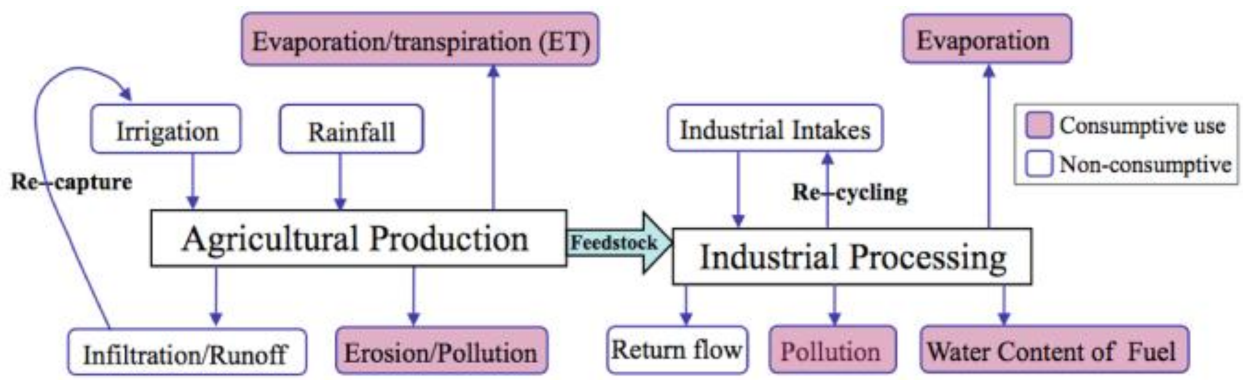


Figure 19. Water consumption in the biofuel lifecycle
Source: Fingerman, 2010

Some examples of water footprint analyses and other types of water impact analyses for biofuels are presented here:

- A recent study by Wu et al (2009) describes a LCA assessment for consumptive water use and illustrates substantial variations in water consumption for ethanol production from crops in different regions. The study examined water requirements for five fuel pathways. The results of the study for corn ethanol in three regions of the United States are presented in Figure 20. They show that water consumption in the crop production stage varies greatly among regions and, in the three regions shown, is much greater than the water consumed in the crop processing stage. It must be noted that results of water footprints do not take local water availability into account.

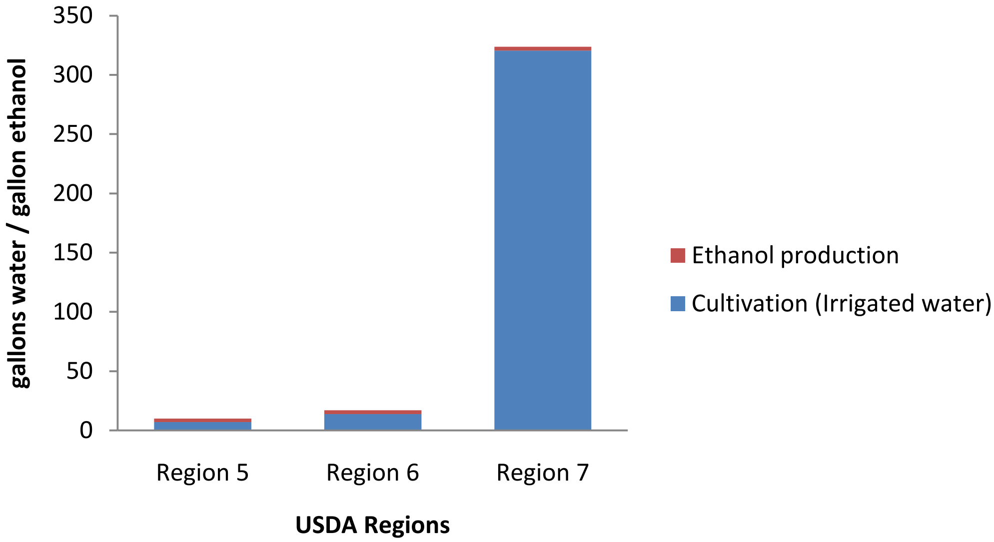


Figure 20. A water footprint analysis of corn ethanol in three U.S. regions based on irrigated water use

Note: The series in red, "Ethanol production," refers to the water consumed in the crop processing stage, and the series in blue, "Cultivation (Irrigated water)," refers to the water consumed in the crop production stage.

Source: Wu et al, 2009

- Fingerman (2006) conducted an experimental water footprint calculation for ethanol production in the U.S. state of California. County-level evapotranspiration calculations were used and four feedstocks were analyzed. The research found that 99% of the water consumption occurred in the agricultural phase for all feedstocks. The different feedstocks in different locations had varying levels of water consumption and yields.

- The International Water Management Institute (IWMI) conducted a basin analysis of the impacts of biofuels in China, an economy of water scarcity where most agriculture occurs in irrigated areas. IWMI used a model called WATERSIM to analyze the impacts of increased biofuel production in China. IWMI found that the global average water use for biomass production of one liter of biofuel was between 1,000 and 3,500 liters. It found that in China the potential strain of biofuels on water resources may be enough to persuade policy makers to abandon biofuel production altogether (Fraiture, 2008).

- Perry (2007) proposes the use of remote sensing technologies, specifically the Surface Energy Balance for Land (SEBAL) tool, to estimate the consumption of water for different land uses and hence the effects of alternative cropping patterns on water balances at local and basin scales. The SEBAL algorithm relates surface temperature to the incoming solar radiation and the surface albedo, which together define what the "natural" temperature of the surface would be in the absence of evapotranspiration. The difference between the calculated "natural" temperature and the actual temperature allow for an estimation of the actual evapotranspiration independently of the actual land use. Further combining the evapotranspiration estimates with information about the vegetative state of the land provides an indicator of yield for many well-documented crops.

Figure 21 is an example of a remote sensing analysis of the Inkomati basin in South Africa, combining annual evapotranspiration with satellite-based information about annual rainfall (derived from the Tropical Rainfall Measurement Mission). The area in blue indicates a region with excess moisture (i.e., the rainfall amount is greater than the evapotranspiration rate), which suggests that rainfall is sufficient to support increased agricultural growth. The red area indicates that too little water is available to support increased agricultural growth relying on rainfall alone for water supply. However, such results must be viewed with care and assessed in the context of basin management. Without land cover details it is not possible to understand why there is excess water production (blue).

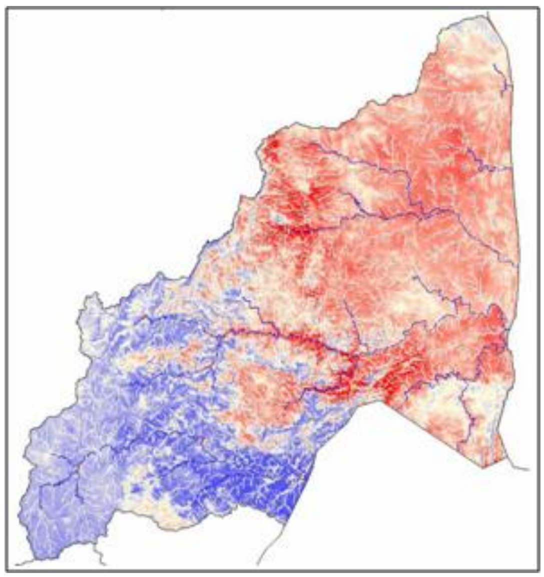


Figure 21. Net spatial water production (blue) and consumption (red) on a per pixel basis for the Inkomati catchment, South Africa (July 2004 June 2005)
Source: Perry, 2007

SEBAL can also assist in the siting and design of biorefineries. While water consumption by biorefineries is a relatively small portion of total crop embedded water, it may have a large local effect (Fingerman, 2008). Regulating placement and design of biorefineries may also ensure that waste streams from plants have minimum impact on the environment and human health.

3.4 Research and Development for More Sustainable Biofuels

Research activities for more sustainable biofuels were identified in 15 of the 21 APEC economies. Major areas of research include the development of advanced biofuel technologies, improved feedstocks, overall approaches to biofuel sustainability, and socioeconomic outcomes. Cellulosic ethanol, jatropha biodiesel, algae, and waste cooking oil (WCO) biofuels are of particular interest in the APEC region – research on these feedstocks was found in 12 economies, shown in Table 8. Some examples are described in this section, but Appendix A provides more detailed information on sustainable biofuel research activities underway in each economy where such activities were identified.

Table 8. APEC economies researching cellulosic, jatropha, algae, and waste cooking oil feedstocks

Economy	Cellulosic Biofuel Research	Jatropha Biodiesel Research	Algae Research	Waste Cooking Oil Research
Australia			X	
Canada	X			
Chile	X	X	X	
China	X	X		
Indonesia		X		
Japan	X		X	
Korea	X		X	
Malaysia	X			
Singapore				X
Chinese Taipei				X
United States	X		X	
Viet Nam		X		X

Research on Advanced Biofuels

One of the most common research areas identified in APEC is development of technology pathways for advanced biofuels (see Box 3 for a description of some advanced biofuel feedstocks). In economies where biofuel competition with food is a major concern, a research objective for advanced biofuels is to produce feedstocks that minimize that competition (i.e., that balance the use of feedstocks and land between food and energy). Economies with especially limited agricultural land area pursue advanced biofuels for their potentially lower land requirements. Advanced biofuels are promising energy sources for APEC economies, but the technologies to utilize them are in various stages of development. Because of the United States' requirement to produce 21 billion gallons of "advanced biofuels,"[3] the majority of which are expected to come from cellulosic sources, much research in this area is underway in that economy. Only a few systems are nearing commercial deployment. One such example is the Dynamic Fuels facility in Louisiana. This facility is a joint venture between Tyson and Syntroleum that will use animal by-products to produce biodiesel (Dynamic Fuels, 2010). Other examples of advanced biofuels research in APEC economies are listed here:

- BP is providing $500 million over 10 years to the Biosciences Energy Research Laboratory in California for establishing a dedicated biosciences energy research laboratory attached to the University of California, Berkeley, the University of Illinois at Urbana-Champaign, and the Lawrence Berkeley National Laboratory. This institute, known as the Energy Bioscience Institute, is initially concentrating on three key areas of energy bioscience (CLS, 2010):
    - New biofuel components and improved efficiency and flexibility of current biofuels
    - New technologies for enhanced and accelerated conversion of organic matter to biofuels to increase the amount of a crop that can be used as a feedstock

[3] Advanced biofuels in the United States refers to biofuels with a minimum GHG savings, rather than to biofuels from a particular feedstock.

  - Species development using modern plant science to produce species with higher energy yields, and which can be grown on land not suitable for food production

- In Australia, the Department of Resources Energy and Tourism budgeted AUD$15 million for a Second Generation Biofuels Research and Development Program for research, development, and demonstration of advanced biofuel technologies (O'Connell, 2009).

- In Canada, Sustainable Development Technology Canada dedicated CAD$500 million for developing large-scale demonstration plants for a NextGen Biofuels Fund (Bradley, 2009). The four-year, CAD$200 million EcoAgriculture Biofuels Capital Initiative provides grants for the construction or expansion of transportation biofuel production facilities, primarily for cellulosic ethanol (Milbrandt, 2008).

- In New Zealand, leadership support for biofuels is only for research and development in advanced biofuels (Natusch, 2010).

- Research in the United States on acid hydrolysis to produce ethanol from lignocellulosic material has been on-going for over 20 years (Wimberly, pers.comm. 2010). Recent research on the same topic in China has resulted in the discovery of a new process route for cellulosic ethanol production under the project, Use of Cellulosic Waste to Produce Ethanol (Eisentraut, 2010).

Box 3. Advanced biofuels: Some cellulosic feedstocks under consideration

Dedicated Energy Crops

Dedicated energy crops for biofuels have been promoted on the basis of avoided competition with food crops and better GHG performance. The ever-present roots of perennial energy crops can conserve and enhance soil productivity by reducing soil erosion and retaining nutrients. The same asset can improve soil carbon stocks; Anderson-Teixiera (2009) report that miscanthus and switchgrass, two such energy crops, increased soil carbon by an average of 0.1 to 1.0 tonnes of carbon per hectare per year (0.367-3.67 tonnes of carbon dioxide equivalent per hectare per year) in the top 30 centimeters of soil. These dedicated energy crops require less land area for the same amount of biofuel production than first generation feedstocks; however, they may require more water and do not produce valuable co-products. In addition, agronomic characteristics that make some dedicated energy crops attractive also increase risks of invasiveness (e.g., the ability to survive drought, low fertility, and high competitive nature) (Winrock, 2009a).

Forest residues

There is substantial interest in using forest biomass and residues for biofuels. In the western United States, biomass buildup as a result of fire suppression and insect and disease outbreaks on federal lands drives forest residue removal. Removing these residues and using them for cellulosic biofuel could help suppress unmanaged wildfires, improve forest health, and meet cellulosic feedstock needs (U.S. DoE, 2009). However, increased removal rates represent potential risks to soil and water quality by increasing soil compaction and erosion and harming biodiversity through the loss of niche habitats.

Jatropha Curcas

Jatropha curcas is a tree that has been recently promoted as a biofuel feedstock because of its potential to be produced sustainably:

- Jatropha is drought-resistant and therefore able to grow on lands that cannot sustain other crops (e.g., food crops) due to low rainfall.
- Jatropha can be integrated with other crops or livestock to provide shade and thereby improve their productivity.
- Jatropha oil is inedible and therefore its use for biodiesel does not detract from food resources.
- Lifecycle assessments of jatropha biodiesel have shown a GHG emissions reduction.
- The jatropha biodiesel production chain is labor-intensive and therefore could contribute to rural employment and economic development.

However, jatropha's oil yield and sustainability outcomes (such as GHG emissions savings) are site-specific. There are fears that although jatropha can grow on lands that may be considered "degraded," intensive agricultural practices and inputs will be used to maximize yields on those lands, resulting in further environmental degradation and water stress. Furthermore, in worst-case scenarios, increased values for jatropha may drive conversion to jatropha of lands with sensitive ecosystems or high carbon stocks, without proper precautions in place (Achten, 2007).

Research on Improved Feedstocks

Improved feedstock research focuses on utilization of waste products as feedstock and on improving first generation feedstocks that are already used for biofuels. Research into the utilization of waste products as biofuel feedstocks takes place for some of the same reasons as research into advanced biofuels (and many types of waste products are considered advanced biofuels): to avoid competition with food and to allow economies with limited land area to produce biofuel feedstocks. Such research is also undertaken in economies where industries exist that produce underutilized waste products, such as forestry and food industries. Some examples of research on waste products as feedstocks are listed here:

- The Inter-American Development Bank awarded a USD$1 million grant to build a demonstration plant to produce fuel from wood industry waste in Chile. In this plant, waste gases from the wood industry will be converted via a Fisher Tropsch process into biodiesel (IDB, 2009).

- Waste wood residues are utilized in pilot projects in Japan, an economy that has the world's first bioethanol plant using food residues as well as the first plant using wood residues (Edwards, 2007).

- Although waste cooking oil (WCO) may not be able to provide a significant portion of an economy's fuel needs, WCO research is underway in a number of economies as a partial solution (Wimberly, pers.comm. 2010). The issues of food security and limited land area have driven Chinese Taipei to research the potential to use its WCO for biofuels. Domestic WCO currently provides 70% of the economy's biofuels (Lee, pers.comm 2010).

- Singapore, with similar limitations in land area, also researches the potential for WCO as a feedstock. BIOFuel Research was the first to conduct this research in Singapore and established waterless processes for producing biodiesel from vegetable oil byproducts and for producing biofuel using ethanol rather than fossil fuel-derived methanol (BIOFuel Research, 2010).

- A research project in the United States on the "Impact of Residue Removal for Biofuel Production on Soil" examines the optimal residue levels to leave on fields after harvesting and management techniques to preserve soil carbon and make residue harvesting sustainable (Winrock, 2010a).

Research into improving first generation feedstocks is also underway. In Indonesia and Malaysia, research on palm oil biodiesel is on-going (for Malaysia, see Box 4). In Japan, much first generation biofuel research aims to support the agricultural sector. For example, a model ethanol plant in Niigata uses rice that is higher yielding than the varieties used for food and grows on fallow lands set aside under the Ministry of Agriculture, Forestry and Fisheries (MAFF) Acreage Reduction Program (Iijima, 2009).[4]

[4] MAFF's Acreage Reduction Program restricts the area of land on which rice for food is grown to prevent oversupply of the product.

Box 4. Malaysia's Palm Oil Research

The Malaysian Palm Oil Board (MPOB) leads palm oil and palm biodiesel research. It has several divisions that conduct research directly related to the sustainability of palm biodiesel, some of which are listed here:

Biology Research Division:

- Integrated pest management for plant protection
- Precision agriculture equipment and technologies for oil palm management to enhance profitability and improve environmental quality
- Advanced biotechnology and breeding including: metabolics, Gene Expression, transformation, Genomics, Tissue culture, Breeding & genetics, and palm genes

Engineering Process Division:

- Improved utilization of liquid and solid palm biomass for the generation of energy and reduction of GHG through energy efficiency and environmental management programs to promote energy efficiency and create new business opportunities for the industry
- Application and introduction of clean and emerging technologies for the processing of palm oil and for the extraction of minor components from palm oil and its products

Advanced Oleochemical Technology Division:

- R&D in non-food applications of palm oil and palm oil products, including energy applications
- R&D to add value to palm-based basic oleochemicals
- Provision of advisory and technical services

Source: MPOB, 2010

Research on Approaches to Sustainability

In a handful of economies, sustainable biofuel research takes the form of programs to research overall approaches to sustainability. Some programs are listed here:

- The Bioenergy, Bioproducts, and Energy program is being undertaken through the Rural Industries Research and Development Corporation (RIRDC) in Australia. An early part of this program involved developing a list of research priorities for the RIRDC. Of the 10 recommended research areas, one is sustainability and several others are sustainability-related, such as Economic and Policy Analysis and Biomass Resources. The sustainability research area will address “assessment methods, accreditation schemes, LCA case studies and inventories, biophysical and socioeconomic analyses at regional, economy-wide, and multilateral scales, quantifying benefits and impacts across economic and environmental value chains, obtaining community approval and consumer demand” (O’Connell, 2007). These recommendations were incorporated into a five year plan for the RIRDC (RIRDC, 2007).

- Overall approaches to biofuel sustainability research are laid out in a major project called Bioenergy Options for New Zealand. This project is comprised of three reports: the Situation Analysis, the Pathways Analysis, and a Bioenergy Research Strategy. The research strategy focuses on bioenergy from plantation forests, biomass waste utilization, biomass residuals for distributed generation, next generation feedstocks and conversion technologies, and first generation biofuels. For first generation biofuel research, the priority is to assess sustainability in the short term and conduct a science-based assessment of biofuel environmental impacts. For the second generation feedstocks, the research priorities are to review and develop current and new technologies (Jack, 2009).

- The United States addresses sustainable biofuel production from a number of perspectives. Research, development, and demonstration related to use of cellulosic ethanol are a main focus. Additionally, the National Biomass R&D Board conducts research on defining and evaluating biofuel sustainability criteria, benchmarks, and indicators (Biomass Research and Development Board, 2008).

Research for Socioeconomic Outcomes

Finally, an important category of biofuel sustainability research among APEC economies is research to achieve socioeconomic benefits. Biofuel research in Peru, for example, emphasizes sustainable outcomes for the rural poor. Much of Peru's biofuel research is coordinated by non-governmental organizations (NGOs), such as Practical Action and Oxfam. Practical Action has partnered with the Universidad Nacional Agraria La Molina (UNALM) since 2000 to research small-scale biodiesel. This research partnership received funds from the National Council for Science, Technology, and Technological Innovation (CONCYTEC) to support several projects, including the first scientific research on biodiesel in the economy. The following research projects are supported by CONCYTEC and carried out by the Practical Action-UNALM partnership (Coello, 2009):

- Small-Scale Biodiesel Production Using Amazonian Oil-Yielding Produce (2003-2005)
- Design of a Sustainable System for Biodiesel Production and Use Appropriate to Isolated Communities in the Amazonian Jungle (2004-2005) (with participation by the Universidad Nacional de Ingeniería)
- Start-up of a Model Biodiesel Production Plant (2005-2006)
- Dehydration of Ethanol on a Small Scale for Biodiesel Production in Isolated Communities in the Amazonian Jungle (2006-2007)

Inter-Economy Research

With so much overlap in research activities in APEC economies, opportunity exists for multilateral collaboration. Some collaboration already takes place under the Bioenergy Implementing Agreement of the International Energy Agency (IEA), which includes the APEC economies of Australia, Canada, Japan, Korea, New Zealand, and United States as well as a wide range of other economies. Recent tasks have focused on topics such as biomass production for energy from sustainable forestry, greenhouse gas balances of biomass and bioenergy systems, and sustainable bioenergy trade (IEA Bioenergy, n.d.).

The Economic Research Institute for ASEAN and East Asia (ERIA) offers another example of cross-economy research efforts. This organization aims to analyze, and make recommendations on, policy to advance economic integration across East Asia. One category of its research is Sustainable Economic Development, which includes projects on Biomass Energy Development. In 2008, ERIA's research led to report number 8-2, Guidelines to Assess Sustainability of Biomass Utilisation in East Asia (Sagisaka, 2008). A working group conducted research to provide guidelines for sustainability assessments. The developed methodology involves an assessment of environmental impact (with a lifecycle approach for developing greenhouse gas inventories), economic impact, and social impact. The report presents several indicators for each assessment and makes recommendations on how to integrate the indicators.

Lastly, the Food and Agriculture Organization of the United Nations has the Bioenergy and Food Security Project, which conducts research to inform policy makers of the real impacts of bioenergy on food security. The project is conducted with the understanding that bioenergy may compromise food security in some scenarios, but enhance it in others. An analytical framework is used for analyses in different economies, two of which are APEC economies: Peru and Thailand. In both of these economies, in-economy research institutions have been partners in the research (FAO, 2010c).

3.5 Sustainable Biofuel Plans

In the broadest sense of planning for sustainable biofuels, several APEC economies have sustainable development and clean energy plans put forth by their leadership, businesses with an interest in the biofuel market, or NGOs. Such plans list the main sustainability concerns of an economy and objectives for how to address them.

- First, in 2007 the Chilean Office of Agricultural Studies and Policies (ODEPA) produced a report on the Contribution of Agriculture Policy to the Development of Biofuels in Chile. A section of the document is devoted to instruments for the productive development of biofuels, which include instruments to support production, a sustainable environment, and social inclusiveness (ODEPA, 2007).

- Viet Nam held a seminar on Development of Biofuels by 2015, Vision 2020. Participants agreed to propose strategies for ensuring the sustainability of biofuels (Diep, 2009). Additionally, the Netherlands Development Organisation, SNV, is helping to develop a Vietnamese action plan that emphasizes sustainability standards for biofuels (Janssen, 2009).

- One plan developed in the United States is for algae-based biofuels. The plan began at a Department of Energy National Algal Biofuels Technology Roadmap Workshop, which convened more than 200 experts and stakeholders in 2008. The workshop results were collected into what later became the Roadmap by the same name. The Roadmap nominally addresses sustainability issues (EERE, 2010).

Sustainable biofuel development plans are limited in their impact as there is no guarantee that the listed activities will be carried out or that the desired outcomes will be achieved. Hence, this report focuses mainly on more concrete actions. However, a sustainable biofuel development plan can serve as the economy’s first step towards sustainable biofuels development.

3.6 Sustainable Biofuel Planning and Research Compendium

Table 9 lists the types of planning and research activities identified in this section along with the general strengths and challenges of each approach.

Table 9. Types of sustainable biofuel planning and research activities underway in APEC economies

Activity	Strengths	Challenges
Land use sustainability assessment: Remote sensing *Examples:* *MODIS* *IKONOS* *M3DADI*	Provides a cost-effective way to analyze land cover over a large area and can be combined with other data to determine land use. Data provided is repeatable and transparent and collected without bias.	Limited by the resolution of data, and spatial and temporal availability of data.
Land use sustainability assessments: Mapping and GIS *Examples:* *Sao Paolo's ZAE Cana Study* *Canada's BIMAT* *Indonesia Oil Palm Research Institute*	Provides cost-effective first screening step to assess potentially suitable areas for biofuels using sustainability criteria.	Desk based assessments may be cost effective but do not address all issues at present (e.g., water availability) and should be further assessed at field scale.
Land use sustainability assessments: High Conservation Value framework *Examples:* *RSPO requirements*	Addresses social and environmental issues. Is adapted for economy-specific situations.	Many economies lack the capacity to undertake assessments according to the specific framework.
Greenhouse gas assessments: Life Cycle Assessments *Examples:* *GBEP Methodological Framework* *Examples in six APEC economies*	Illustrates the contribution of each production step to GHG emissions and allows effective targeting of action to largest GHG producing activity.	Wide range of uncertainty in key parameters such as nitrous oxide emissions and land use change. Does not always account for indirect effects. No multilaterally agreed methodology. Use of different methodologies can produce wide range of results.
Water footprints *Examples:* *Wu et al study* *IWMI's analysis for China*	Illustrates the contribution of each production step to the balance of water inputs and outputs and allows effective targeting of action to activities that consume the most water.	Results do not take into account local water availability and may be interpreted as negative because of high water consumption even though sufficient water may be available. No multilaterally agreed methodology. Use of different methodologies can produce wide range of results.

Technical research: current feedstock production and conversion *Examples:* *Palm oil in Malaysia*	Positive impacts for sustainability outcomes are possible and can be delivered in the short and medium term.	Potential for overlapping areas of research and lack of central coordination through research body.
Technical research: emerging feedstock production and conversion *Examples:* *Cellulosic* *Algae*	Potential to produce fuels with greater GHG emission reductions, less/no competition with food and cropland, reduced costs and other sustainability benefits, compared with current biofuels.	Potential for overlapping areas of research and lack of central coordination through research body. Benefits likely to be delivered in the longer term.
Research: socioeconomic outcomes	Can identify barriers to and means by which benefits of biofuels can reach key stakeholder communities.	Difficult to encompass all socio-economic relationships and effects.
Research: Multilateral collaboration *Examples:* *IEA Bioenergy* *ERIA*	Economies are able to learn and build on knowledge from other economies and pool resources to do more than one could do on its own. Reduces research redundancies.	By increasing the numbers of researchers and institutions involved, processes may take longer or be more complicated than otherwise.
Sustainable biofuel plans *Examples:* *Contribution of Agriculture Policy to the Development of Biofuels in Chile* *Development of Biofuels by 2015, Vision 2020* *U.S. National Algal Biofuels Technology Roadmap*	Consider sustainability from a holistic perspective on the range of sustainability concerns and ways to address them. May pull together outcomes of research initiatives. Lays out steps for moving forward and can be used as a guide for biofuel development.	Not tied to policy, incentives, or mandates and therefore no guarantee that the plans will be implemented or considered in guiding biofuel development.

4.0 Regulatory and Policy Initiatives

Regulations and policies guide and provide incentives and boundaries for programs and practices, thereby influencing sustainable biofuel activities. Policies can promote and create incentives for more sustainable biofuels, whereas regulations set the constraints and parameters to ensure that biofuel programs and practices are sustainable. This section will discuss regulations and policies in APEC economies that directly address elements of biofuel sustainability, such as the GHG emissions from biofuels or their social and environmental impacts. Policy makers can steer the biofuel industry through import tariffs, fuel excise exemptions, mandates and targets, production subsidies, and support for production, distribution, infrastructure, and research and development (Bauen, 2009). Each of these tools can include sustainability criteria for the biofuels affected.

The absence of biofuel-specific legislation in an economy does not always mean the absence of regulation and policies that affect biofuel sustainability. Rather, biofuel sustainability regulations may be unnecessary where broader regulations address particular sustainability issues. Policies that are relevant to biofuels include more general agricultural, forestry, land use, trade, labor, and environmental policies. For example, Table 10 outlines the various policies that influence biofuel sustainability in the Australian state of Victoria across the biofuel lifecycle.

Table 10. Existing policies, legislation, and other activities related to sustainability along the bioenergy value chain in Victoria, Australia (not comprehensive)

Grow and Harvest Biomass Feedstocks	Transport and Processing	Processing Multiple Conversion Technologies	Multiple Product Streams	Distribution	Consumption
Forestry Robust institutional and sustainability assessment systems implemented • Montreal Process Regional Forest Agreements Forestry Codes of Practice. State of the Forests reports • AFS FSC certification **Agriculture** Fewer institutional and agreement systems implemented • Victorian State of the Environment Report indicators, voluntary EMS Regional Catchment Management Strategies **Native vegetations** • Permits required for clearing **Waste** • Waste management hierarchy-avoidance, waste to highest order use. Energy recovery to a lower order use • Supported by multiple practices	**Transport** Institutional systems well implemented e.g. • *Roads Management Act 2004* • Freight Futures : Victorian Freight Network Strategy • Local Government plans • *Planning and Development Act 1987*	**Construction of new production facility** Sustainability assessment and institutional systems in place. Assessment focused on impacts of facility and mitigation strategies • Planning approval- *Planning and Environment Act 1987. Heritage Act 1995. Aboriginal Heritage Act 2006* • Environment Effects Statement (EES)- *Environment Effects Act 1987* • Works Approval- *Environment Protections Act 1979* Victorian Government Assistance • Vic Renewable Energy Target • Victorian Energy Technology Innovation Strategy • Biofuels Infrastructure Programs	**Transport Fuels** Institutional systems at State and Australian government levels specifying emissions targets. • *Fuel Quality Standards Act 2000* for diesel, biodiesel blends: ethanol petrol blends: ethanol petrol labeling: ethanol quality • *Victorian Environment Protection (Vehicle Emissions) Regulations 2002* **Bio-electricity** • Specification of feedstocks to be eligible for RECs e.g. high value test for forestry	**Transport** Institutional systems well implemented e.g. • *Roads Management Act 2004* • Freight Futures Victorian Freight Network Strategy • Local government plans • EES-*Planning and Environment Act 1987*	**Retailers** • Labeling under national *Fuel Quality Information Standard (Ethanol) Determination 2003* • Greenpower products- accredited provider **Consumers** • Tailpipe emissions regulations under the *Victorian Environment Protection (Vehicle Emissions) Regulations 2003* • Fuel excise rebate under the Commonwealth Energy Credits Grants Scheme • Electricity- Victorian feed in tariff

Source: O'Connell, 2009

4.1 Domestic Policies and Regulations on Biofuel Sustainability

In 10 of the 21 APEC economies, policies or regulations directly addressing biofuel sustainability were identified. These economies are Australia, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Peru, and the United States. A more detailed description of the policies and regulations can be found in Appendix B. Regulations attached to financial incentives are the most common approach identified, with examples found in Australia, Japan, New Zealand, and the United States.

Biofuel Mandates with Sustainability Criteria

- In Australia, biofuel sustainability regulations apply to biofuels that count towards biofuel supply targets and qualify for financial incentives. Two pieces of legislation restrict the biomass that can be counted towards receiving tradeable Renewable Energy Certificates: the 2000 Renewable Energy (Electricity) Act and the 2001 Renewable Energy (Electricity) Regulations. These laws define municipal solid waste, wood waste, weeds, agricultural residues, and forestry that can be used according to sustainability principles. If wood is taken from a native forest, for example, the primary purpose for harvesting the wood cannot have been for energy production and must be for a high value product, accounting for at least 51% of the revenue. However, this test has received criticism for not having clear evidence of sustainability thresholds (O'Connell, 2009).

- In New South Wales, Australia, the 2007 Biofuel Act has required that biofuels counting towards that state's biofuels obligation (mandatory E6 starting in 2011 and B5 starting in 2012 sold by primary wholesalers) meet sustainability standards (in effect since 2009). The Roundtable on Sustainable Biofuels (RSB) Version Zero Principles and Criteria for Sustainable Biofuel Production are supposed to guide the sustainability assessment, but since they are not ready to be put into practice, compliance is demonstrated through environmental assessments or other evidence of sustainability (McDowall, pers.comm. 2010) (see Box 5).

Box 5. Shoalhaven Starches's compliance with New South Wales biofuel sustainability requirements

Shoalhaven Starches Pty Ltd, a wheat processor, qualified towards the NSW biofuel mandate through an Environmental Assessment to increase its ethanol production from 126 million liters per year to 300 million. The assessment contained several elements of sustainability, including GHG emissions, acoustics, water management issues, scenic qualities of the locality, waste management measures, riverbank stability and riparian corridors, probability of site contamination, indigenous and non-indigenous cultural heritage, and flora and fauna (including impacts on critical habitats and threatened species).

Source: Shoalhaven Starches, 2008

- In Japan, the Biomass Nippon Strategy also sets a target for biofuels in that economy, and sustainability criteria are under development for the biofuels that meet its target. Although the standard is not yet enforced, it is expected to require that biofuels reduce emissions by at least 50% compared to fossil fuels and to exclude biofuels from feedstocks grown on wetlands, high density forests, or peatlands. Biofuel producers outside Japan as well as domestic producers will be held to these standards (Ikeda, 2010).

- The United States has GHG emissions requirements for biofuels that count towards its Renewable Fuel Standard (RFS). The RFS is the main regulation driving biofuel development in the United States. It was established under the Energy Independence and Security Act (EISA) of 2007 and requires consumption of 36 billion gallons of biofuels annually by 2022. The second version of this standard, the RFS2, came into effect in July 2010. It has specific provisions for advanced biofuels, such as cellulosic ethanol and biomass based diesel contributions, that pave the way for advanced technologies. Of the 36 billion gallons of biofuels, 21 billion gallons must come from cellulosic biofuel or advanced biofuels derived from feedstocks other than cornstarch. They must meet a 50%-60% GHG reduction target compared to their fossil equivalent. Conventional biofuels must meet a minimum GHG savings of 20%. The RFS was amended to be one of the first standards to include a factor for indirect land use change. Inclusion of this factor has proved to be quite controversial (Winrock, 2010a). The renewable feedstock must come from land that was cultivated or fallow as of December 2007. The biofuel refinery must be registered with the U.S. EPA, and biofuel manufacturers or importers must generate a renewable identification number (RIN) for each gallon of renewable fuel and pass the documentation along the supply chain.

Greenhouse Gas Requirements for Fuels

- In China, the Innovation Center for Energy and Transportation (iCET) is developing a Low Carbon Fuel Standard and Policy. Experts from various research institutions, along with iCET and the China National Institute of Standardization (CNIS), have drafted Fuel Carbon Emission Lifecycle Assessment Principles and Requirements. The CNIS is leading the standard's development, which will set the methodology for determining lifecycle GHG emissions from all fuels in China (iCET, 2009).The standard is based on the same methodology used for the Renewable Transport Fuel Obligation (RTFO) in the United Kingdom, except that it does not take land use change into account. In future reviews of the standard, land use change will be re-considered (Earley, pers.comm. 2010).

- The GHG reduction requirements of the U.S. RFS were discussed earlier. In the U.S. state of California, however, the California Low Carbon Fuel Standard (LCFS) also sets GHG requirements for fuels. It sets a carbon reduction target, which is unusual among fuel standards since most standards specify volumes of biofuels for integration into fuel mixes and assume this will lead to GHG reductions. The LCFS was issued by an executive order in 2007 and approved by the California Air Resources Board in 2009. It is a performance-based standard that aims to reduce California's greenhouse gas emissions from passenger vehicle fuels by 10% by 2020. Like the U.S. Renewable Fuels Standard, the LCFS accounts for indirect land use change (ILUC); it includes an ILUC factor in its GHG calculations for biofuels. Additional sustainability provisions are anticipated by December 2011 (CARB, 2010).

Sustainability Regulations for All Biofuels in an Economy

The Mexican Biofuels Promotion and Development Law applies to all biofuels produced in this economy. The law is now in its second version[5] and incorporates several sustainable development objectives (Chavez, 2009):

- Protect food security and sovereignty
- Foster rural development
- Reactivate the rural sector
- Reduce GHG emissions

The law incorporates environmental protection by referencing mechanisms in environmental legislation and multilateral treaties on reducing GHG emissions and air pollutants. It requires the Secretary of the Environment and Natural Resources (SEMARNAT) to apply regulations from the Law on Biosafety and Genetically Modified Organisms to ensure sustainable use of natural resources and biodiversity protection. Under this law, SEMARNAT is also responsible for ensuring that no forest lands are converted to agriculture to grow biofuels and for evaluating the sustainability of programs the law establishes. Two other departments also receive sustainability mandates under the law: The Secretary of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA) and the Secretary of Energy (SENER) are charged with supporting research on bioenergy production that is not harmful to the environment (FAO, 2010b).

This law also explicitly supports the most marginalized rural communities by stating that biofuels should not threaten food security and referencing the law on Sustainable Rural Development. To monitor adherence, the law requires that the agriculture secretariat, SAGARPA, review the impact of bioenergy developments on food and publicize the results. It also includes a caveat that allows corn to be used as a biofuel feedstock only when a surplus exists (FAO, 2010b).

Other regulations in APEC economies that guide sustainable biofuel production aim to prevent competition with food and harm to sensitive lands. For instance, China has banned new corn-based ethanol plants and prevents food grains from use as biofuel feedstocks (Milbrandt, 2008). Similarly, Malaysia restricts the amount of palm oil that can be used for biofuels at six million tonnes to ensure its availability for other products (Schott, 2009). Indonesia and Malaysia both have regulations limiting palm oil plantings on sensitive lands. In Indonesia, oil palm can be planted on peatlands only if it is on community cultivated land, the peatland is less than three meters deep, the subsoil is not silica sand or acid sulfate, and the maturity of the soil is somewhat or mostly decomposed (Winrock, 2009c). Malaysia protects forestlands from conversion to oil palm plantations by committing to maintain 55.6% of permanent forests for wildlife habitat and biodiversity conservation (Wahid, 2010).

Multiple economies also have regulations that guide sustainable biofuel consumption by setting quality control standards. Because Hong Kong's primary motivation for biofuel development is to reduce air pollution, an amendment to its Air Pollution Control Regulation sets the standards for biofuel use and

[5] In Mexico, as in many economies, competition with food is a major concern. When the first version of this law was passed in 2007, it was vetoed by President Felipe Caderon because of its emphasis on corn and sugarcane for biofuels. Calderon said the law did not sufficiently emphasize new technologies, such as cellulosic biomass and algae, which may be more sustainable (Chavez, 2009).

labeling requirements to ensure that substandard fuels are not used (L.N. 233, 2009). Similarly, in Korea, the Ministry of Commerce, Industry, and Energy tested B10 and B20 for air pollutants and subsequently set standards for biodiesel similar to the European standard (Suk Lee, pers.comm. 2010).

4.2 Biofuel Policies and Regulations of APEC Trading Partners

Multilateral policies and regulations can drive the development within APEC of sustainable biofuel programs and practices by regulating biofuel trade. The largest relevant regulatory framework outside the APEC region is that of the EU Renewable Energy Directive. In January 2008, the European Parliament agreed that biofuels must represent 10% of Member States' transport fuel sales and that the biofuels, including those imported, must meet the following criteria to count towards the target:

- Represent at least 35% GHG emission reduction compared to fossil fuel (increasing to 50% reduction in 2017)
- Conserve carbon stocks by not including raw material from:
    - wetlands covered with or saturated by water permanently or for a significant part of the year
    - "continuously forested area," defined as >1 hectare with trees higher than 5 meters and a canopy cover of more than 30%, or trees able to reach these thresholds in situ; or >1 hectare with trees higher than 5 meters and a canopy cover of between 10% and 30%
- Conserve biodiversity by not including raw material from:
    - forest undisturbed by significant human activity
    - highly biodiverse grassland
    - nature protection areas

Biofuels can receive a GHG bonus of 29 grams of carbon dioxide equivalent per megajoule of energy under the EU criteria for production on degraded land and can therefore contribute to the minimum cut-off of 35% GHG savings. The credit is attributed if evidence is provided that the land was not in use for agriculture or any other activity in January 2008 and falls into one of the following categories: (i) severely degraded land, including such land formerly in agricultural use; (ii) heavily contaminated land.

Prior to the EU scheme, the United Kingdom introduced the first biofuel-specific sustainability program within an economy-wide policy framework scale. The volume of biofuel sold is monitored to track progress against mandated volumes. In addition, the GHG savings and sustainability characteristics of the biofuel are reported by obligated parties, such as oil companies. The program mainly identifies sustainable biofuels by requiring biofuel feedstocks to be grown and certified to an existing standard (e.g., the Roundtable on Sustainable Palm Oil), which has been benchmarked against the United Kingdom's principles and judged to meet the required performance (Winrock, 2009c). The volumes identified entering the UK in 2008/2009, as reported in this scheme, are shown in Figure 22.

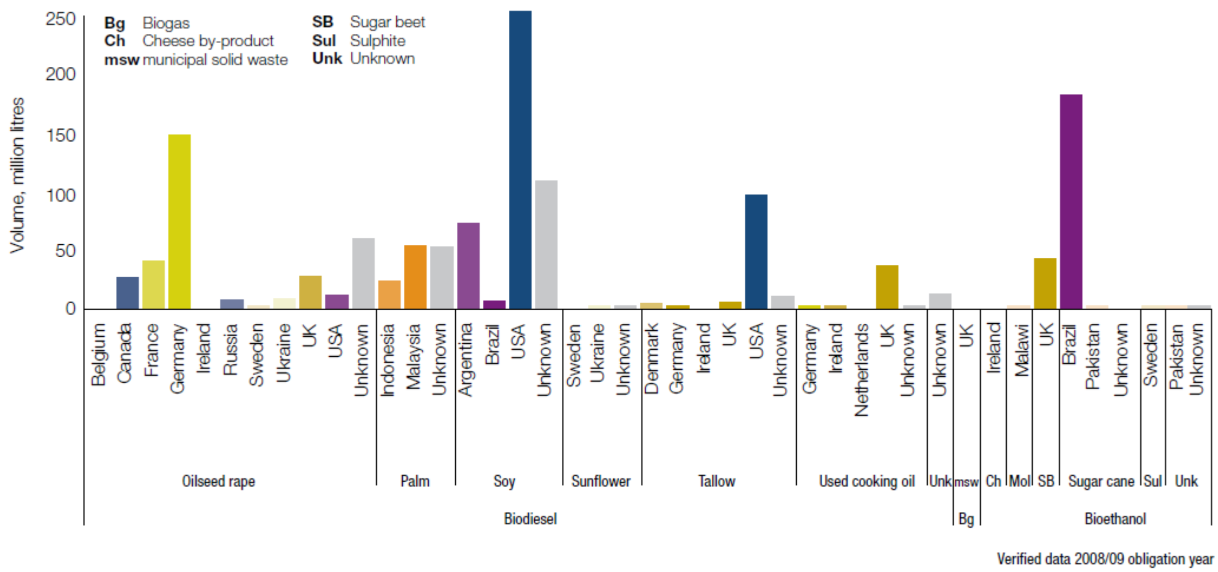


Figure 22. Volumes of biofuels entering the UK in the 2008/09 obligation year, by feedstock and country of origin
Source: RFA, 2009

4.3 Regulatory and Policy Initiatives Compendium

Table 11 summarizes the types of regulations and policies identified in this section as directly addressing biofuel sustainability, along with the general strengths and challenges of type.

Table 11. Types of sustainable biofuel regulations and policies in APEC economies

Initiative	Strengths	Challenges
Volume or energy targets for biofuels	Provides certainty of a market for biofuels.	Reliance on legislation to deliver sustainable outcomes depends on strong enforcement. Tradeoffs may exacerbate some issues such as yield increases and water availability.
Volume or energy targets with specific sustainability requirements	Reporting on the requirements delivers transparency in the marketplace about the biofuels sold, forces sustainability issues to be addressed, and may create a price premium for biofuels with sustainability outcomes.	Complex supply chain and lack of traceability causes substantial data provision problems. Potential problem with lack of availability of “certified” material.
Carbon reduction-based targets	Produces carbon savings at least cost.	Does not address wider sustainability issues and consequently, the drive for

Examples: *California's Low Carbon Fuel Standard*		greater carbon savings could come at the expense of other sustainability criteria, such as water availability.
Prohibition of specific unsustainable activities. *Examples:* *China's ban on corn-based ethanol plants* *Malaysia's limitation on amount of palm oil used for biofuel* *Indonesia's restrictions on oil palm planting on peatlands*	Addresses sustainability issues of greatest concern and mandates specific criteria be protected.	Does not address wider sustainability issues and consequently, addressing certain issues could come at the cost of other sustainability elements.

5.0 Voluntary Programs and Initiatives

The following section addresses programs and practices that result in more sustainable biofuels. These activities fall under the categories of reducing GHG emissions; protecting and enhancing air, water, soil, biodiversity, and ecosystems; and addressing socioeconomic issues. Although separated here, many activities fit into multiple categories. The activities are initiated by private companies, non-governmental organizations, or individuals working throughout the biofuels supply chain. In some cases they are undertaken to comply with policies and regulations and in other cases they are initiated to achieve specific sustainability outcomes. Although planning and research for the initiatives was found to be more prevalent than implementing those activities, many programs and initiatives were identified, especially in economies where biofuels have faced the most scrutiny.

5.1 Practices to Reduce Greenhouse Gas Emissions

Lifecycle analyses (LCAs) are used to calculate GHG emissions from biofuels and verify that they are lower than GHG emissions from fossil fuels otherwise used. LCAs identify various sources of emissions associated with biofuel production and use, which can then be targeted to further reduce emissions. Some examples of emissions sources that APEC economies are targeting for reductions are:

- Land use change (both direct and indirect)
- Transport of feedstocks and fuels
- Waste products
- Fertilizers

Reduced Emissions from Land Use Change

One of the earliest sources of emissions in the biofuel production process is land use change. Land use change can produce enough GHG emissions to cancel out any GHG benefit otherwise derived from biofuel use, depending on the carbon stock of the land before and after conversion. Land use change can also have other environmental or social impacts, depending on the services the land provided before conversion. Land use change can be prevented if biofuels add to rather than displace existing production or provision of services. Activities that reduce the risk of land use change fall into three main categories:

1) Promoting the use of underutilized lands
2) Improving productivity on lands through a systems approach by integrating bioenergy feedstock growth with other land services
3) Improving bioenergy yields on land already cultivated[6] (Dehue, 2009)

[6] As noted previously, caution must be used in assuming that all yield increase activities are inherently sustainable; the impact of any additional water, nutrients, and energy to produce the yield increase must be considered in the evaluation.

These activities also have some sustainability risks, but if the risks are appropriately managed, sustainability can be enhanced. The examples provided in this section demonstrate that the potential exists to increase production of biofuel feedstocks without causing indirect effects.

Use of Underutilized Lands

In theory, by growing feedstocks on lands that are underutilized (sometimes called "marginal" or "degraded"), impacts of indirect land use are less likely to occur as fewer land services may be compromised if the land use changes. A clear definition of underutilized land does not exist, and there is controversy over the concept of "degraded" lands. Because all land provides some level of economic, social, or environmental service, the reality is that all land use changes may lead to indirect effects. Hence, using underutilized land to reduce GHG emissions through biofuels requires close examination of the land use change impacts of each site to ensure reduction of GHG emissions.

In Indonesia, studies have found that oil palm production on imperata grassland is possible and can be cost effective. *Imperata cylindrica (L.) Raeuschel var major* has been ranked as one of the world's 10 worst weeds. Many natural tropical forests have become fallow or waste land after being cleared and burned and – as a result – have been overgrown by imperata, which is low in biodiversity (Dehue, 2009). Eradication of the imperata, followed by oil palm cultivation, requires a precisely timed combination of mechanical and biological control steps (Chalmers, pers.comm. 2010). The project described in Box 6 promotes the use of underutilized lands through land swaps.

Box 6. Project POTICO

The World Resources Institute (WRI) and NewPage Corporation have developed a land swapping program called Palm Oil, Timber, and Carbon Offsets in Indonesia, or project POTICO. Project POTICO works to avoid direct conversion of forest lands by swapping degraded lands for virgin or primary forest areas, which are then sustainably managed. The protected forests contribute to sustainable livelihoods through provision of food, water, medicine, and building materials. They also contribute to the environment by being biodiversity hot spots and sequestering carbon. To conduct a swap, WRI partners with a private company that already has a forested land concession. The company gets a similar size piece of degraded land and sets up an RSPO certified plantation. The private company, supported by WRI, identifies lands on which palm can be grown sustainably, obtains free prior and informed consent of local entities, and engages relevant government officials.

Source: WRI, n.d

Planting oil palm on imperata grasslands does not lead to increased GHG emissions from conversion of the land and can have several other sustainability benefits, such as increased biodiversity and carbon sequestration, reduced fire and flood risks, increased ground cover that protects soils, and increased employment leading to economic development. In a project in West Kalimantan, Indonesia, oil palm plantations and mills were created on 19,000 hectares of this grassland. The project was certified under the RSPO and supports smallholders through a cooperative program that includes 3,000 farmers (Dehue, 2009).

In some cases when biofuel feedstock has been grown on underutilized lands rather than converted peatlands or forests, carbon offsets have been claimed, improving the cost effectiveness of such activities. The UN Reducing Emissions from Deforestation and Forest Degradation (REDD) program creates a financial incentive to protect forests and their carbon stocks. The Borneo Orangutan Survival Foundation (BOSF) and Shell Canada initiated the Mawas Conservation Project (MCP) to prevent the conversion of approximately 18,000 hectares of tropical peat swamp forest to plantations and to prevent additional areas of degraded peat swamp forest from uncontrolled peat fires. The MCP is one of the few contiguous blocks of lowland forest left where wild orangutans still live. High resolution digital aerial imagery over the project area was used in combination with field data to estimate forest carbon stocks remotely (Harris, pers.comm. 2010).

Improving Productivity through a Systems Approach

Brazil offers some examples of avoiding land use change through a systems approach for increased productivity of land, and the principles could be applied elsewhere. Integrating crop production with activities that already take place on the land not only prevents land use change, but can also increase the productivity of the initial activity. Two examples are integrating sugarcane and soy production with cattle farming. In both cases, farmers' incomes grew and the integration of biofuel crops raised cattle productivity (Dehue, 2009).

Sugarcane expansion often encroaches onto pasture land, forcing off cattle that would be raised there, and in some cases leading to deforestation if the cattle move to forested areas. Cattle farming is the main source of income for many ranchers. In examples identified by Dehue (2009), sugarcane bagasse was used for cattle feed, which increased the capacity of lands to sustain cattle. Being able to raise the same number of cattle on a smaller area of land (increased cattle productivity per hectare) allowed land to be freed for sugarcane crops without decreasing the productivity of the cattle. Only sugarcane residues were used, so the full ethanol production potential of the sugarcane was met. Consequently, the same area of land now supports the same number of cattle but additional sugarcane production as well.

Soy growth has also been integrated in a rotation system with cattle production in Brazil. In a system known as integrated crop-livestock zero tillage (ICLZT), the soybeans are planted and retain nitrogen in the soil, thereby improving the soil quality. Soybeans go through a few harvests and then the land is used for pasture once again, but with a capacity for more cattle than originally could be sustained. Once the pastureland is degraded, the soil is fertilized and soybeans are replanted, improving the soil quality (Dehue, 2009).

Improving Bioenergy Yields on Lands Already Cultivated

Improving yields of a biofuel crop on lands where it is already grown is a straightforward way to increase the production of the feedstock without bringing additional land areas into production. Yield has a profound impact on all aspects of bioenergy: economic, energy, environmental, and societal. One way to improve yields is to select high yielding crops, particularly with regard to cellulosic feedstocks, or to select higher yielding crop varieties, allowing more of a feedstock to be produced in a given area. High yield varieties of oil palm have been developed through a systematic and continuous breeding program in Indonesia and have resulted in a doubling of productivity in some cases. The average annual crude palm oil yield is between two and three tonnes per hectare per year in Indonesia. New varieties, though, have annual yields of between 7.5 and 7.9 tonnes per hectare (IOPRI, 2008). Average yields in Malaysia are about four tonnes per hectare (Skeer, pers.comm. 2010). Of the more than six million hectares of oil palm plantations in Indonesia, nearly 50% have been using these higher yielding varieties, developed by the Indonesia Oil Palm Oil Research Institute (Winrock, 2009c).

In the Philippines, better management practices are used to improve environmental outputs and reduce GHG emissions. In that economy, the San Carlos Bioenergy, Inc (SCBI) project used better management practices, including drip irrigation and a raised bed planting system, to nearly double yields from 70 to 136 tons of sugarcane per hectare. The details of these better management practices are in Box 7.

Box 7. Better management practices at the San Carlos Bioenergy Inc.

Changing planting practices: A permanent raised bed system ensures that seeds are at a level higher than the inter rows to prevent submersion, water logging, and rotting during heavy rains. Since germination during the wet season is normally low due to water logging and lower temperatures, this cultural practice ensures higher germination.

Irrigation: Water requirements are high during specific growth phases. Despite suitable rainfall on a year round basis, supply of water at the right time is critical to optimize yield, but rainfall at the right time cannot be guaranteed. Drip irrigation is the application of water directly to the root zone of the crop. Application of fertilizer with the irrigation water (fertigation) takes place over a seven-month period, minimizing leaching and volatilization of the nutrients and allowing more efficient utilization by the plants.

Variety: The cane maturity period differs among varieties but is key to ensuring the best yields. SCBI uses a soil management program to determine the most appropriate cane varieties in different areas to maximize yield.

Increasing yields of other crops through a legume fallow rotation system: During wet months of the year, a legume fallow system can be introduced. Legumes provide a direct economic benefit to sugarcane farmers as a source of nitrogen, thus reducing the cost of nitrogen fertilizer and other fertilizers. Legumes also provide a synergy with sugarcane production by breaking the monoculture cycle and improving soil health and cane ratooning ability.

Using sub-surface drip-irrigation, yields have increased by 50% to 101%, with an average of 63%. Original yields ranged from 54 to 75 tonnes per hectare before drip-irrigation and reached a maximum of 136 tonnes per hectare after installing drip irrigation.

Other sustainable practices: The project also had other components that contributed to overall GHG reduction. An integrated ethanol distillery and power cogeneration plant uses the otherwise waste heat. Another plant recovers up to 50 tons/day of carbon dioxide. An anaerobic digestion plant collects biogas to use as additional fuel for the boiler. Lastly is an integrated waste water treatment plant.

Reference: Dehue, 2009

Reduced Emissions from Feedstock and Fuel Transport Distances

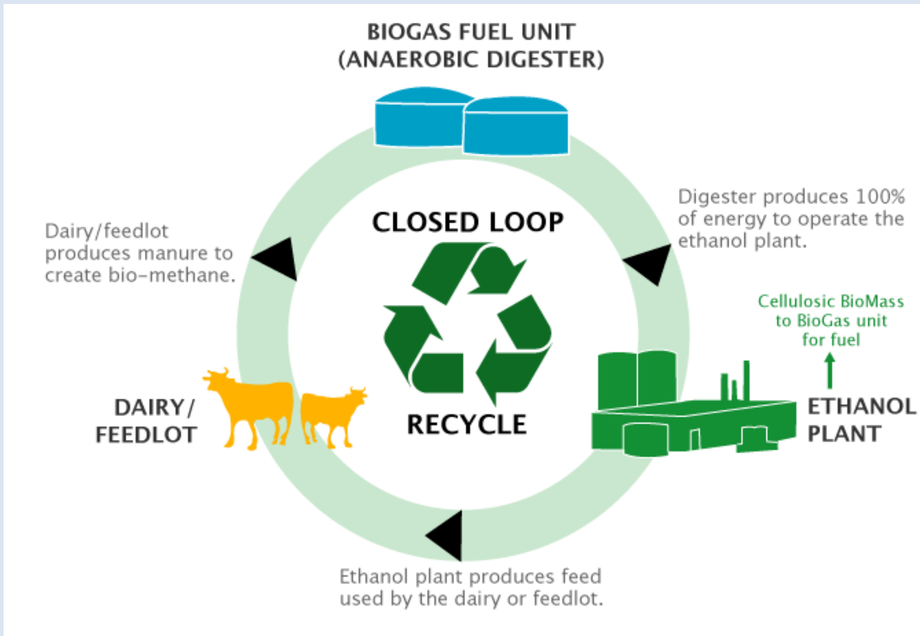
The average distance to haul the feedstock from where it is cultivated to where it is processed and to haul the fuel from where it is produced to where it is consumed affects biofuel LCA GHG emissions. This is true for all feedstocks and fuels and depends on the transportation method. The hauling distance is affected by the capacity of the transport unit (both the vehicle and the roads/bridges), crop yield, the proximity of the farmland providing feedstocks to the bioenergy facility, and the proximity of the biofuel consumers to the bioenergy facility. When the hauling distance decreases, not only do the GHG emissions from transport decrease, but costs decrease as well, improving overall biofuel economics (Wimberly, pers.comm. 2010).

Reduced Emissions through Waste Treatment and Waste Reutilization

Another way to reduce GHG emissions and generate additional energy is to capture and utilize certain waste streams from some biofuel production processes. Palm oil mills, for example, produce a Palm Oil Mill Effluent (POME), which, when left untreated, releases large amounts of methane – a greenhouse gas about 21 times more powerful than carbon dioxide. To avoid release of methane emissions, a mill can capture them by adding covers to open lagoons or building enclosed tank digesters. About 5% of the palm oil mills in Malaysia trap methane from POME (Wahid, 2010). An LCA, which is currently under peer review, found that trapping the methane increases the overall GHG savings from replacing fossil diesel with palm oil biodiesel from 51% (no methane trapping) to 66% (with methane trapping) (Wahid, 2010). Box 8 provides a diagram of a biogas capture system.

Box 8. Biogas capture and utilization

The diagram below shows an example of a process in which biogas (in this case from a dairy or feedlot in the United States) is utilized for energy to power a biofuel production plant. A similar cycle could be envisioned for biogas captured from POME. The waste from the plant is reutilized in the process for biogas production (in this case for animal feed, but a similar cycle could be envisioned for biofertilizer).



E3 Biofuels' Patented Closed-Loop System in the United States

Source: E3 Biofuels, 2007

Biogas capture and by-product utilization could also contribute to rural electrification, but energy supply does not always match local demand and may not justify investment costs. The capital costs and amount of biogas production are the key parameters that influence payback times. The initial challenge is to find a business case for the investment. For mills that have a palm kernel crushing plant as well as a crude palm oil (CPO) plant, the energy requirements could be sufficient to make the investment worthwhile. Carbon credits can assist in improving payback periods and making such projects more financially attractive (Winrock, 2009c).

FELDA is one of Malaysia's largest palm oil plantation and milling companies and is majority government owned. The company operates 70 palm oil mills and processed 15.2 million tonnes of fresh fruit bunches (FFB) in 2009 to produce 3.1 million tonnes of CPO, which is 18% of Malaysia's total CPO production. Six of the company's mills have systems to capture methane from POME. These plants are projected to create 135,975 tonnes of carbon dioxide equivalent per year in carbon reductions (CDM, 2010).

Reduced Emissions through Reduced Requirements for Conventional Fertilizer

Nitrogen-based fertilizers produce nitrogen oxide, which is a GHG 310 times more powerful than carbon dioxide. Fertilizers are the largest contributor to GHG emissions from agriculture and can also pollute soil and water. Some biofuel crops have much higher demand for fertilizers than others (USAID, 2009). Thus, selecting crops with lower fertilizer requirements, applying biofertilizers, and using more efficient fertilizer systems can reduce pollution and lower GHG emissions associated with biofuels.

Indonesia has programs to promote organic fertilizers by subsidizing their production costs. In 2008, 68,400 tonnes of organic fertilizer were used in that economy (Soepardjo, pers.comm. 2010). The 2010 budget allocates IDR 11.86 trillion (USD$1.3 billion) for fertilizer subsidy, which will yield a total of 11.75 million tonnes of bio and organic fertilizer (BAPPENAS, 2009).

The availability of fertilizer at reasonable prices is critical for cost-effective biofuel and food production. Upward pressure on fertilizer prices raises both biofuel costs and the financial burden on economies for fertilizer subsidies. To help keep fertilizer costs low on oil palm plantations, Indonesian growers are applying empty fruit bunches (EFBs) incorporated with Palm Oil Mill Effluent (POME) as fertilizers or applying POME directly to fields as an organic fertilizer after treatment (IOPRI, 2007).

5.2 Practices to Protect and Enhance Environmental Quality

Programs and practices to protect and enhance the environment vary greatly among economies. In some economies, the quality of land, water, soil, air, ecosystems, biodiversity, and other aspects of the environment is fairly well protected by national and local environmental legislation. In other economies, however, additional programs and practices may be needed to ensure biofuel sustainability.

Improved Soil Quality

Soil quality improvements can affect soil structure, water and oxygen content, nutrients, and erosion, among other elements. One example of an activity to improve soil quality and reduce GHG emissions is *no-till cultivation*. No-till is generally defined as planting crops in unprepared soil with at least 30% mulch cover. No-till cultivation does not involve preparation of a seedbed prior to planting and therefore leaves crop residues on the surface of the soil. Some benefits of no-till cultivation include increased carbon sequestration, reduced labor, reduced wear to machinery, less fossil fuel consumption, reduced erosion, improved water quality, and improved habitats for wildlife (Pollock, 2009). Some perennial energy crops do not require tillage whereas annual options may necessitate it (Wimberly, pers.comm. 2010). Over 62 million acres are cultivated with no-till in the United States, and it is a common practice in Brazil and Argentina, particularly for soybean cultivation. No-tillage has revolutionized agricultural systems because it allows individual producers to manage greater amounts of land with reduced energy, labor, and machinery inputs. No-till cultivation is also an effective erosion control measure and improves water and fertilizer use efficiency (Triplett, 2008).

No-till cultivation also can reduce soil erosion as mulch cover remaining on the soil surface absorbs energy from raindrops and water runoff that may otherwise erode soil particles. Where rainfall is low, the extra soil cover can improve crop yields. For the benefits of no-till cultivation to be realized, crop rotation systems are necessary (Triplett, 2008).

Crop rotation is widely regarded as critical for sustainable agriculture. The greater the number and the higher the diversity of crops involved in a rotation, the higher the biodiversity and the greater the potential for biological control of diseases, pests, and weeds (Landers, 2007). In Brazil, pasture in no-till rotations with annual crops can be regenerated more profitably and with less risk than the older systems, in which pastures were ploughed out before being resown (Landers, 2007). Furthermore, a sustainable, no-till, crop rotation system may reduce GHG emissions. Adler et al (2007) modeled the GHG implications of two rotations involving corn and/or soy in Pennsylvania, in the United States. The modeling included conventional and no-tillage systems. The results illustrate that the most diverse rotation with no tillage has the greatest net reduction in GHG emissions, as shown in Table 12.

Table 12. Net greenhouse gas emissions of crop rotation systems

Modeled Rotation Scenario	Net GHG emissions (gCO2eq/MJ ethanol consumed)*
1) corn-soybean rotation with conventional tillage	-8.1
2) corn-soybean rotation with no-tillage	-8.6
3) corn-soybean-alfalfa rotation with conventional tillage	-8.6
4) corn-soybean-alfalfa rotation with no tillage	-9.0

**** Note that this is a net reduction in GHG emissions per MJ of ethanol consumed.***
Source: Adler et al, 2007

Sustainable residue harvest is a key component of reducing soil erosion and maintaining or improving soil carbon. Biofuels based on crop residues commonly have positive GHG emission profiles. However, over-harvesting crop residues can lower the accumulation rate of soil organic carbon and contribute to higher fuel consumption in on-farm operations. Harvesting corn stover, for example, may lower soil organic carbon levels and soil nitrogen content and may increase soil erosion (Kim, 2005). Planting winter cover crops following harvesting of residue can compensate for some disadvantages (e.g., soil organic carbon levels and soil erosion) and can increase subsequent crop yields as soil fertility is improved (Kim, 2005). For corn cultivation, planting cover crops could also significantly reduce soil emissions of nitrous oxide compared to continuous corn cultivation without a winter cover crop.

Several resources and programs in the United States address sustainable harvests in agriculture to maintain soil quality. The Renewable Energy Assessment Project (REAP) has assessed sustainable removal options and concluded that recommendations vary by location. Tools have been developed to determine safe removal rates (e.g., RUSLE, WEQ, and the Soil Conditioning Index), and the spatial variability in the sustainable volumes of harvests to maintain soil organic carbon will influence the sustainable residue potential for different crops in different regions (Andrews, 2006).

Improved Water Quality

Many programs for controlling agricultural nonpoint source pollution consist of best management practices. Some, such as those in the United States, compensate farmers for idling selected areas of land to protect water quality. While these programs are important tools, they may not encourage farmers to use the most cost-effective actions or inspire new and innovative solutions to reduce pollution from farming operations (Winrock, 2009a). Some other practices that can improve water quality are listed here:

- Establishing a riparian buffer strip (a vegetated area between land and water that protects the water from land use effects such as sediment runoff or pollutants) at the edge of a field or planting winter crops are practices to improve water quality impacts of agriculture, which can have widely varying water quality outcomes. The benefits of riparian buffer strips are greater on steeper fields, fields nearer to water bodies, and fields with high phosphorous contents because these characteristics affect the amount of pollutants that run off a field (Winrock, 2009a).

- Adopting no-till techniques on specific farms can also reduce non-point source water pollution and reduce soil erosion. A pilot project estimates an average soil loss avoidance of 1.01 tons per acre per year in Vermont and 1.58 tons per acre per year in Iowa. Soil erosion rates vary considerably and may reach up to 10 tons per acre per year (Winsten and Kerchner, 2009).

- Applying Integrated Pest Management (IPM) practices to manage pests rather than using synthetic pesticides that may run off into water bodies. IPMs rely on knowledge of pests' lifecycles and interactions with the environment to reduce crop damage from pests while minimizing economic, environmental, and health costs. Some IPM techniques are mechanical pest trapping, use of natural predators, use of insect growth regulators, application substances that disrupt pest mating, and use of biological pesticides (EPA, 2007).

Reduced Water Consumption

Reducing water use per se may not necessarily lead to a sustainable outcome, for example, if the total abstractions for biofuels are greater than the total available water (biofuel production exceeds the carrying capacity of the basin). Different crops in different environments have different water consumption requirements; productive switchgrass may consume as much water as corn in some regions. Therefore, to determine the true consequences of promoting biofuel production, including the impacts of converting "degraded" or underutilized land to dedicated energy crop, a basin scale assessment would have to be carried out. Understanding the interconnectedness and interdependence of water use within river basins is essential to understanding sustainable outcomes for biofuels.

Precaution for Potentially Invasive Species

Depending on location, water availability may increase the risk that some feedstocks will become invasive by out-competing other crops for resources. For example, switchgrass may be recommended as a buffer strip along riparian zones, but its seeds are fertile and buoyant; thus, planting switchgrass along stream banks may pose a downstream risk (Winrock, 2009a). Much non-factual information is circulated regarding the invasiveness of biofuel feedstock, and consideration of candidate crops for biofuels should be evaluated with an open mind and based on science. The risk of invasiveness depends on the crop, environment, and climate, and it is therefore impossible to categorize a single crop as invasive. Thus, site-specific analyses are required to evaluate the potential invasiveness of a given crop. In the United States, federal agencies have been undertaking risk assessments of invasive species. They have been using Geographic Information Systems (GIS) to facilitate site selection and risk assessment, develop predictive modeling that could be a powerful tool in monitoring the spread of potentially invasive species, and design control strategies (Winrock, 2009a).

Waste as Feedstock or Input for Biofuel Production

Using waste as biofuel feedstock has numerous environmental benefits, including:

- Treating what would otherwise be pollutants
- Capturing waste emissions
- Reducing needs for other material and energy inputs
- Avoiding competition for land and other resources when new feedstock is grown for biofuels

Most biofuel production in Hong Kong is from waste products: waste cooking oil and waste animal fat are utilized to produce biofuels in that economy (Milbrandt, 2008; Yan, pers.comm. 2010).

Biofuel production waste and co-products can also be reintegrated into the biofuel production process. The palm oil industry in Malaysia, for example, reuses wastes to produce steam and electricity to run the production process. It also uses biogas from the POME and cellulosic biomass from the palm (New, 2010). Similar efforts are underway in Indonesia to encourage the use of the cellulosic components of feedstocks to produce heat for biofuel production (Ariati, 2010). POME and empty fruit bunches (EFBs) are wastes of palm diesel production and can be reused as a variety of inputs, listed in Table 13.

Table 13. Palm oil mill effluent (POME) usage options

"Waste" product	Technology	Energy use	Residue use
POME	Mixed with EFBs		Compost fertilizer
POME			Liquid fertilizer
POME	Biogas from POME	Fuel for gas engine, steam boiler, mill trucks	Effluent used as fertilizer
POME	Biogas from POME	Fuel for gas engine, steam boiler, mill trucks	Effluent mixed with EFBs and used as fertilizer
POME + EFB	Biogas from POME mixed with EFB's	Fuel for gas engine, steam boiler, mill trucks	Effluent used as fertilizer

Source: IRG, 2009

5.3 Practices to Address Socioeconomic Issues

Biofuel development can be driven by socioeconomic concerns, such as the desire to create jobs, boost income (especially in rural areas), revitalize struggling agricultural sectors, and provide energy to those without access. Sustainable biofuel activities may promote one or more of these objectives and should not harm livelihoods.

Access to Food and Land

Securing the availability of food at stable and affordable prices is one of the most common sustainability concerns in APEC economies. This issue is primarily socioeconomic, although it also affects the environment and GHG emissions. Programs and practices to avoid impacts on food supplies include using non-food crops, growing crops on lands that are poorly suited to food production, and restricting the quantities of food crops allowed for fuel use. Examples discussed earlier are the measures to prohibit use of food grains for biofuels in China, to encourage use of underutilized lands in Indonesia, to increase the productivity of lands in the Philippines, and to promote jatropha (a non-food crop that can grow on lands not suitable for food crops) in Viet Nam.

Protection of land rights and rights of indigenous populations is also an important consideration for biofuel development in the APEC region. These rights are protected through legal measures, such as the Malaysian law to protect indigenous rights to the land. Land rights could be mapped and translated into GIS data for use in planning or decision-support tools.

Biofuel Cooperatives

Several programs and practices to advance socioeconomic outcomes of biofuel activities in APEC economies concern the promotion of equitable participation in the biofuel industry. One identified method is to promote and support workers' cooperatives, which are organizations owned by their members. In a cooperative, surplus revenue is returned to the members. Agricultural cooperatives for biofuel feedstock producers may allow participating farmers to pool their resources to share equipment or services and thereby to access greater resources than they could as individuals. Processing facilities and marketing resources may also be shared. Furthermore, the farmers' collective union gives them greater influence in the market (Downing, 1998). Some cooperative programs in APEC economies are listed here:

- Canada's Agricultural Cooperative Development Initiative ran from 2006 to 2009 under Agriculture and Agri-Food Canada, the Canadian Co-operative Association, and the Conseil Canadien de la Coopération et de la Mutualité. The initiative operated "with a mandate to promote sustainable livelihoods for Canadian farmers by assisting the development of biofuel and value-added agricultural co-operatives." Of the 63 cooperatives supported under the initiative, 27 worked with biofuels and bioenergy. Continued support is provided under the more recent Cooperative Development Initiative (CCA, 2008).

- Indonesia provides another example of cooperatives within the oil palm sector. The Indonesian leadership introduced the Koperasi Kredit Primer Anggota (KKPA), or the Primary Credit Cooperative scheme. Landowners in the KKPA give one third of their land to the "nucleus estate." The remaining "satellite" areas become palm oil smallholdings under contract to sell fresh fruit bunches to buyers at a set price. Under the KKPA, cooperatives can borrow up to IDR50 (USD$5,000) at a subsidized rate for small business development (Winrock, 2009c).

- In Malaysia, public and private cooperative schemes, such as the Federal Land Development Authority (FELDA) and the National Land Finance Cooperative Society, establish cooperatives for crops, including palm oil, rubber, and coconut. Cooperative members in these schemes receive a share of the ownership and profits from the land. They also have access to loans for education, housing, medical care, and business development support (Lopez, 2008).

Biofuels Employment for Women

Another focus in ensuring equitable participation in the biofuel industry is to promote women's participation. Women do not have as much opportunity to participate in this industry as men, so although employment opportunities are created, women may not benefit. They are at a disadvantage because of social norms of land ownership, gender discrimination in accessing credit, lack of access to training for more skill-oriented jobs, lower literacy levels in some economies, and rules preventing women from signing contracts (Doyletech, 2010).

Papua New Guinea has efforts underway to ensure that employment benefits of the biofuels industry reach women. The Oil Palm Industry Corporation established the Mama Lus Frutas Scheme in recognition of the disadvantages women face in the oil palm industry (Schott, 2009). This scheme pays women for harvesting oil palm. They previously were involved in the harvest, but all payment went to men. This scheme gave women "Mama Cards" that allowed them to be paid independently for collecting loose fallen fruit (Doyletech, 2010).

Direct Support to Small Landholders

Other activities underway in APEC economies involve direct support to small landholders (smallholders):

- In Canada, the Biofuels Opportunities for Producers Initiative (BOPI) helped farmers and rural communities to access expert assistance on business proposals, feasibility studies, and other studies to build their capacity to produce biofuels (Agriculture and Agri-Food Canada, 2008). The aim of BOPI, which ran through 2008, was to ensure that Canada's biofuel producers benefited from the economy's biofuel mandate (AAC, 2008).

- Malaysia supports smallholders through a Federal Land Development Authority (FELDA). FELDA gives cooperative land ownership rights to low income and landless settlers. Settlers receive a plot of land for housing and another for cultivation. After paying for the development costs of the land, the settler gains ownership and receives a guaranteed minimum income. In 2006, 30% of palm land area in Malaysia was under federal and state land development programs. FELDA represented the highest share of these holdings. FELDA also works to rehabilitate palm oil sites. This program is credited with reducing poverty among agriculture smallholders in Malaysia from 68% in 1970 to 21% in 1990, and among palm oil smallholders from 30% in 1970 to 8% in 1980 (Lopez, 2008).

- In the Philippines, cooperatives and smallholders benefit from the Agrarian Reform Program, which has a small-scale jatropha project to provide energy for municipal government buildings (Schott, 2009).

- The World Bank initiated an effort in Papua New Guinea in 2007 through a multi-million dollar loan for the Smallholder Agriculture Development Project. The main objective of this project was poverty alleviation through community-based agriculture development. It was primarily aimed at oil palm agriculture (Schott, 2009).

Improving Livelihoods

Biofuels can improve the livelihoods of industry employees and surrounding communities by connecting poverty reduction and job creation to biofuels activities. In Malaysia, for example, the palm oil industry creates a large number of jobs and has narrowed the rural-urban income gap. The industry creates townships where the workers live and care for various elements of their livelihood. The townships reduce urbanization pressures. From 1980 to 2008 the numbers employed in the palm oil industry increased from 92,352 to 570,000. Including related industries, 1.4 million people are employed, accounting for more than 5% of the economy's GDP (Wahid, 2010).

Biofuel schemes can improve livelihoods by ensuring that biofuels produced reach those most in need of energy. As discussed elsewhere, the focus of biofuel development in Peru has been to produce biofuels for remote Amazonian communities that currently do not have access to fuel. In Indonesia, biomethane captured from POME is sometimes used for rural electrification (Winrock, 2009c).

Community-Based Biofuels Initiatives for Community Benefits

Several APEC economies have community-based biofuels initiatives to serve the communities where the fuel is produced:

- In Indonesia, where 45% of villages are below the poverty line, the Program of Energy Self Sufficient Villages began to stimulate biofuel production on a small scale and make the rural poor less vulnerable to volatile fuel prices. The program aims to create 1,000 energy self-sufficient villages. In 2009, 123 villages were part of the program (Winrock, 2009c). Participating villages use local resources to produce the biofuels, which are then consumed locally. The program encourages women's participation in all phases of biofuel production (Ariati, pers.comm. 2010).

- In Thailand, a Community Based Biodiesel Project targeted 60 communities in 2006 to reduce fossil fuel dependency and encourage locally produced alternatives. Some of the feedstocks used in this program are waste cooking oil, jatropha, and palm oil (Dutta, 2006).

- Japan has a Biomass Towns program that aims to enable towns to become energy self-sufficient by using their own biomass resources. This program is described further in Box 9.

Box 9. Japan's Biomass Towns Program

A Biomass Town in Japan is a community that currently practices, or is expected to practice, sustainable biomass activities, with the cooperation of local stakeholders. The objective is for a municipality to establish effective, community-based systems for utilizing biomass from production to disposal that involve local residents, industries, NGOs, and academic institutions. The program was launched under the Biomass Nippon Strategy in 2002, which aims to: (1) combat global warming, (2) achieve a recyclable society, (3) develop new industries, and (4) revive agricultural communities via comprehensive utilization of biomass. The 2006 New Biomass Nippon Strategy set a goal of creating 300 Biomass Towns by 2010.

Biomass Towns must: (1) utilize over 90% of waste biomass or over 40% of unused biomass in Communities; (2) accelerate biomass utilization under an agreement of concerned bodies, local residents, and industries; (3) abide by all laws; and (4) ensure the safety of biomass use.

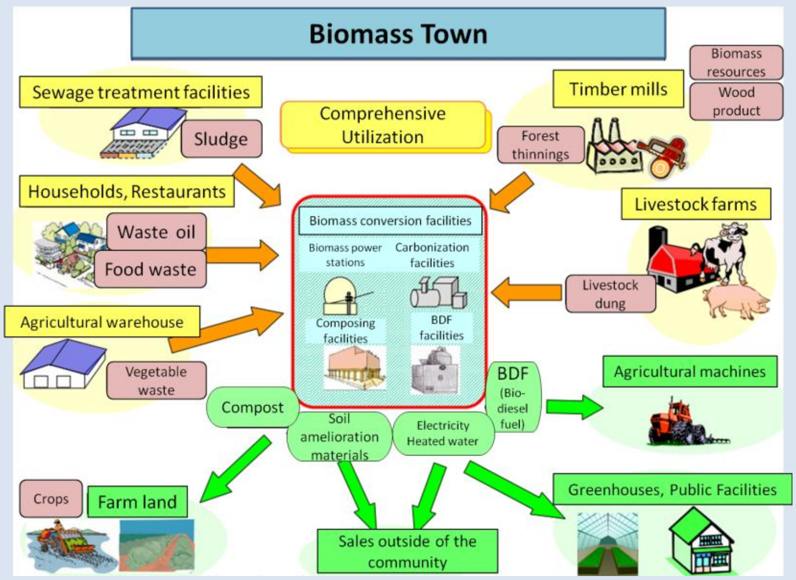


Diagram of a Biomass Town

Source: Haywakari, 2005

The diagram to the left shows how Biomass Towns circulate resources. There were 13 Biomass Towns in 2004 and 237 by February 2010. In addition to creating 300 Biomass Towns countywide, Japan will also introduce this program to other East Asian economies.

Motegi Biomass Town

The Motegi Biomass Town was established in 2006 and was praised for its "Organic Matter Utilization Center Midori-Kan," a community-based core facility that turns biomass generated in Motegi into compost. Midori-Kan annually produces 4,400 ton of biomass from five sources: 512 tons of raw waste in households/businesses, 250 tons of withered leaves, 250 tons of rice husk, 200 tons of thinned wood, and 3,228 tons of livestock dung. From these local biomass resources, Midori-Kan produces 1,117 tons of compost and 894 tons of liquid fertilizer per year to sell for local farms and schools. This utilization of biomass is estimated to reduce waste processing costs by $150,000 while saving $262,000 for forestry management and protecting 80 hectares of farm land from soil contamination annually.

About 60% of local farmers have currently participated in this biomass utilization system. Motegi aims to achieve its resource utilization rate of 99% for waste biomass and 65% for unused biomass.

Sources: MAFF, 2009a, MAFF, 2009b, MAFF, 2010a, MAFF, 2010b, Kanto Committee for Biomass Utilization, 2010

Making Biofuels Economical

In order for any biofuel or biofuel policy, program, or practice to be sustainable, it must be economically feasible. The cost of sustainable biofuels includes not only the cost of producing and consuming the biofuels but also the cost of pursuing specific sustainability outcomes. For sustainable biofuels to be cost-effective, they must be able to compete economically with conventional petroleum-based fuels and other sources of energy in the transport sector.

Feedstock costs are typically the largest cost component of biofuels. For example, feedstock costs typically account for about 80% and 65% of total fuel costs for first generation biodiesel and ethanol, respectively (Walden, pers.comm. 2010). Where the cost of biofuels exceeds the cost of fossil fuels, reducing feedstock costs while maintaining sustainable production is critical for producing cost-effective biofuels. Factors that influence the cost of feedstocks include:

- Agronomic yields (the relationship between agronomic yield and cost per liter of fuel is shown in Figure 23, which illustrates the strong influence of increasing crop yields on lowering costs)
- Cost of agricultural inputs
- Crop planting / establishment costs
- Time between plantings (for perennial crops)
- Cost of transporting feedstocks and fuel
- Value of the land
- Value of farmers' labor

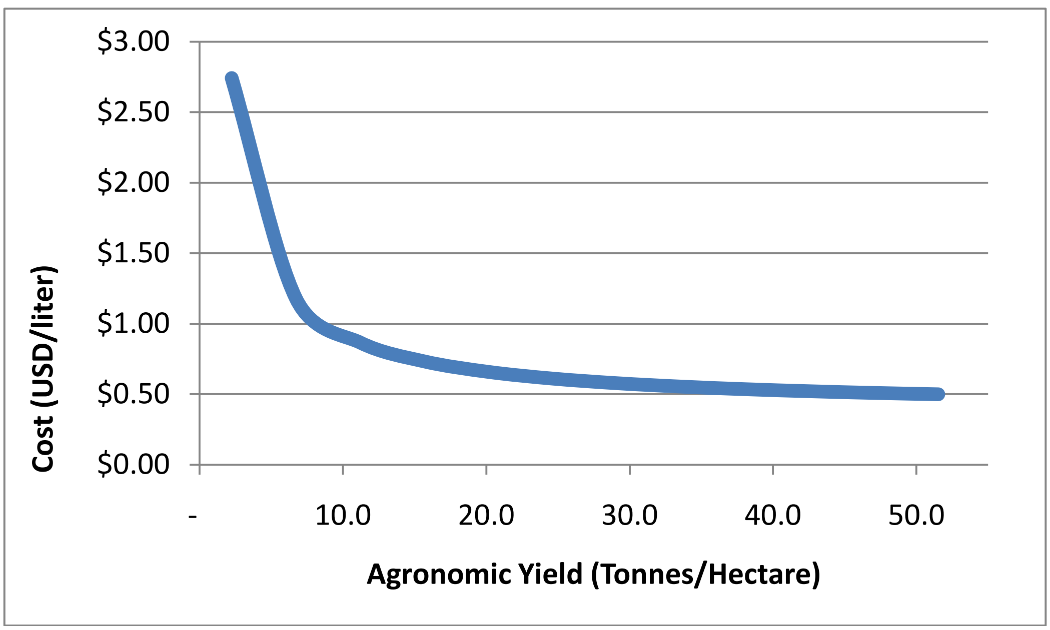


Figure 23. Relationship between biofuel cost and agronomic yield (illustrative only)
Source: Wimberly, personal communication 2010

Strategies for improving the sustainability of biofuels from an economic perspective include:

- Recognizing the value of specific sustainability outcomes
    - Provide financial rewards on the basis of carbon reduction or other sustainability outcomes (e.g., through carbon markets, tax credits, and other mechanisms)
- Reduction of the costs of feedstock production
    - Select high-yielding crops
    - Improve yields (e.g., improved varieties, effective irrigation and management practices)
    - Reduce fertilizer costs (e.g., recycling of nutrients from processing plants, use of precision agricultural techniques, and improved application practices such as fertigation)
    - Utilize co-products
- Reduction of the costs of processing
    - Improve processing efficiencies
    - Utilize co-products and waste
- Reduction of transport costs of feedstock and fuel
    - Produce energy crops within close proximity of the processing facility
- Funding research and development as an investment in future biofuels to identify feedstocks and production and processing systems that lower costs
    - Agronomic research and development (e.g., to improve the efficiency of biomass cultivation, to improve feedstock yields)
    - Pre-processing, storage, and conversion technologies (e.g., to improve the efficiency of biofuel conversion technologies)

APEC economies have undertaken a variety of activities that impact the economics of biofuels. Several measures have been discussed in earlier sections of this report that support some of the options noted above (e.g., improving yields, utilizing co-products and waste products, funding research and development). Additional measures from APEC economies include:

- The economics of biofuels may be improved if the attendant environmental benefits can be monetized. For example, revenues may be realized from sales of credits in carbon markets due to soil carbon sequestration or revenues from practices that reduce GHG emissions. For monetizing the environmental benefits of improved fertilizer use, the International Panel on Climate Change (IPCC) has established nitrous oxide emissions reporting guidelines, and Pearson (2010) studied the development of a methodology for improved fertilizer activities to earn carbon credits in the voluntary carbon market, based on activities in the United States.

- The Mawas Conservation Project (MCP, discussed in the section on using underutilized lands) took advantage of carbon markets to improve the economics of that project. Two new UN methodologies for Reducing Emissions from Deforestation and Forest Degradation (REDD) were initiated as part of the MCP, and project documents for generating voluntary carbon credits were completed. As of July 2010, one of the methodologies was in the final stages of the Voluntary Carbon Standard's Double Approval process (Harris, pers.comm. 2010).

- Yields can have a profound impact on biofuel economics and on land use, as shown in Figure 23, and crop selection is a key factor in achieving high crop yields. Figure 24 depicts the wide range of biofuel production (both gross and net) from various types of crops in the southern United States. However, it is important to note that the yields of first-generation biofuels depicted in

Figure 24 have been widely validated, whereas yields from second-generation biofuels (e.g., from herbaceous energy crops) have not yet been demonstrated at commercial scale.

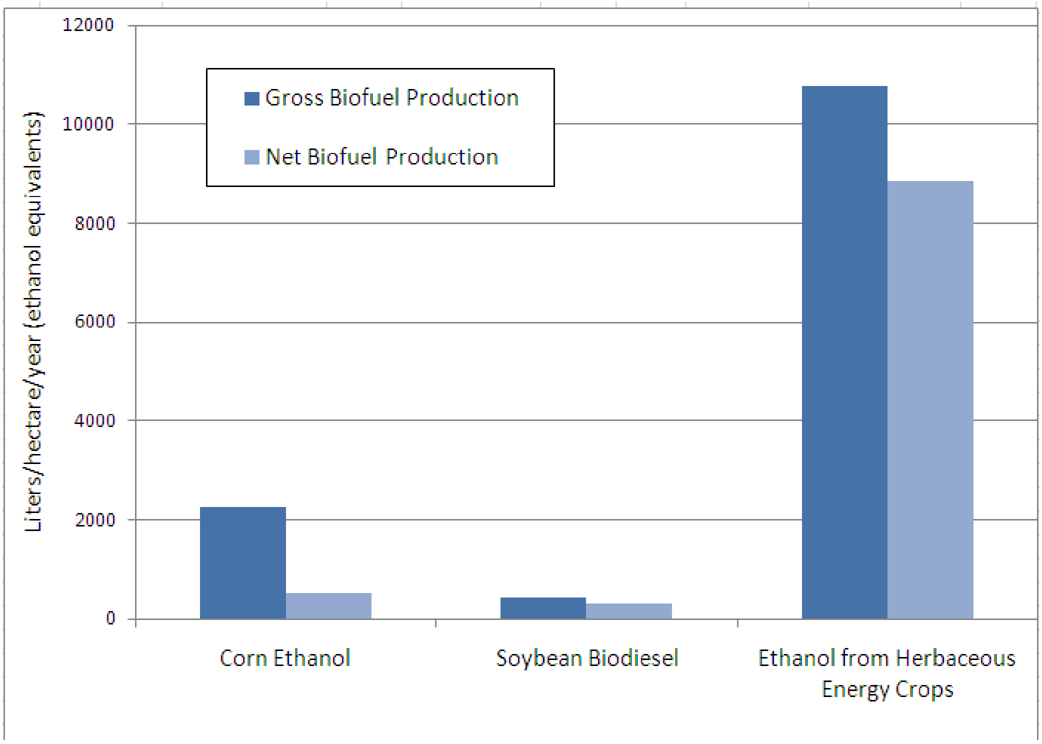


Figure 24. Biofuels production of first generation corn and soybean biofuel and second generation herbaceous energy crop ethanol
Source: Wimberly, personal communication 2010

- The economics of fertilizer was discussed in the section on improved fertilizers. It was emphasized that the availability of fertilizer at reasonable prices is critical for cost-effective biofuel and food production (although it is also recognized that inorganic fertilizer production is energy intensive and often derived from fossil fuels). Organic fertilizers, such as animal manures and biomass processing residues, can reduce fertilizer costs and net carbon emissions, thereby increasing system sustainability. Indonesia promotes the use of such fertilizers through subsidies (BAPPENAS, 2009).

- The economic benefit of utilizing co-products and waste is demonstrated in Malaysia. In that economy, the biofuel companies with the best economic returns are those that produce multiple products, including biofuel and crude palm oil, as part of their business, and capture and utilize methane gas through anaerobic digestion of various organic waste streams. For these facilities, other co-products include Vitamin E, carotene, and glycerin (Cotrell, 2010).

  In addition, several mills in Malaysia are benefiting from carbon markets. Under the Clean Development Mechanism (CDM) of the UN Framework Convention for Climate Change, several mills are earning Certified Emissions Reductions for reducing emissions through palm oil mill effluent (POME) methane capture and electricity production (Winrock, 2009c). As discussed in the section on POME methane capture, FELDA, one of Malaysia's largest oil plantation and milling companies, has six mills with systems to capture methane from POME. Collectively, these facilities are projected to offset 136,000 tonnes of carbon dioxide equivalent per year. Four are registered with CDM, as shown in Table 14 with additional details on mill properties (CDM, 2010).

Table 14. CDM-registered palm oil mills in Malaysia (not comprehensive)

Properties	Besout	Maokil & Kemahang	Serting Hilir	Jerangau & Chalok
Capacity (tonnes FFB/Year)	204,503	417,725	275,940	408,800
Emission Reduction (tonnes CO2/Year) projected when fully operational	22,803	42,779	37,694	32,679
Biogas Capture Systems Used	Covered lagoons	Covered lagoons	Enclosed Tank System	Enclosed Tank System
Installed Biogas generator sets	450 kW	2 x 500kW	2 x 650 kW	1 x 500kW 1 x 375kW
Use of captured biogas	Biogas engine generating 573 MWh/y for on-site use. Balance of biogas to boiler.	Biogas engines generating 1,016MWh/y for on-site use. Balance of biogas to boiler.	Biogas engines generating 6,520 MWh/y with 5,450 MWh/y to grid.	Biogas engines Generating 321MWh/y Balance of biogas to boiler.

Source: CDM, 2010

5.4 Voluntary Standards

Several organizations and alliances are involved in developing voluntary sustainability standards for biofuels and biofuel feedstocks. Voluntary standards are separate from regulatory standards, which were discussed previously. The aim of voluntary sustainability standards is to achieve specific sustainability outcomes. These outcomes are measured by indicators that fall into two categories:

- Performance-based standards (e.g., percent reduction in GHG emissions, percent reduction in soil erosion)
- Practice-based standards (e.g., practice of drip irrigation, practice of no-till cultivation)

A party may be certified as meeting the standard if certain indicators are met. Most standards fall under the practice-based category, but it is widely acknowledged that performance-based indicators are a better approach to understand whether sustainable outcomes have been delivered.

Some of these standards will serve as tools for guiding public policy decisions at the economy-wide level (such as those under the Global Bioenergy Partnership), while others are intended for application at the field or project level (e.g., the Roundtable for Sustainable Palm Oil – RSPO). Some are created with multilateral stakeholders (e.g., the Roundtable for Sustainable Biofuels), and others are created privately (e.g., the standard applied by the Swedish company, SEKAB).

APEC economies are paying attention to such standards because sustainability standards affect terms of trade for biofuels and feedstocks. In some cases, certification by these standards could result in a price premium for a biofuel. In other cases, meeting a standard will be required to export to certain economies and companies. Experience to date has proved that the standards can be prohibitively complex or detailed for the participation of many economies, organizations, farmers, and producers, regardless of their compliance with the requirements. Efforts are underway in several economies and among standard setting organizations to build capacity and make the task of demonstrating compliance more reasonable (New, 2010).

Voluntary biofuel sustainability standards are at different stages in their development; some are being implemented and others are at initial stages of sustainability criteria development (Winrock, 2009c). Standards also vary by the criteria they encompass, as was shown in Table 5. Several voluntary standards have been mentioned previously in this document, but are also described here:

- The most advanced multilateral voluntary standard is from the Roundtable for Sustainable Palm Oil (RSPO), a multi-stakeholder body specifically for palm oil. Fifteen APEC economies have organizations within them that are RSPO-certified for the palm oil they produce, as shown in Table 15. The majority of these APEC RSPO-certified organizations are in Indonesia and Malaysia, where the majority of palm oil is produced. RSPO presence in Singapore is presented in Box 10.

Box 10: Singapore and the Roundtable on Sustainable Palm Oil (RSPO)

Although there are no sustainable biofuel policies or regulations in Singapore, much of the biofuels industry has volunteered for international regulations. Several companies import feedstocks from other economies in Asia, produce biofuels, and export them to other economies such as Europe.

Neste Oil is building a biofuel plant in Singapore. It will produce a fuel called NexBTL, which uses palm oil, vegetable oil, and animal fat. Neste Oil is committed to using only RSPO-certified palm oil in its plant. Neste has a sustainability policy, belongs to an alliance working to ban rainforest felling, and has a system for tracking the source of its palm oil, including third party auditors to check the plantations. Neste also has a set of sustainability principles for biofuels relating to feedstock, processing and manufacturing, end products, and criteria for suppliers (Neste Oil, 2010).

Continental Bioenergy, one of the largest biodiesel producers in Singapore, is also RSPO-certified. Nexsol, a palm oil biodiesel brand produced by CremerOleo, is RSPO-certified as well. Natural Fuel in Singapore requires all of its palm oil to be RSPO-certified and is committed to researching and developing high-yield oil crops and alternative biodiesel technologies (RSPO, 2009).

- The Roundtable on Sustainable Biofuels (RSB) has developed Principles and Criteria for Sustainable Biofuels that are intended to be developed into a certification scheme. The RSB will benchmark other standards (such as the RSPO) against its own to determine whether they meet the requirements. Other commodity standards have been developed primarily for the food industry, which has traditionally focused on health and safety issues; therefore, some criteria such as carbon stocks are absent. The Roundtable on Sustainable Biofuels, while using existing voluntary standards, intends its certification system to fill these gaps. RSB does not aim, therefore, to replace other standards but will enable certification of "missing criteria" relevant to biofuels, such as those related to carbon stock and GHG emissions (Winrock, 2009c).

- The Global Bioenergy Partnership (GBEP) is working on a consensus basis among its 29 partners to develop a voluntary set of sustainable bioenergy production indicators. This is a policy-making or policy-assessment tool rather than a field-based standard.

- The Roundtable on Responsible Soy is a voluntary initiative developed by the main stakeholders in the soy value chain. It has developed a standard for sustainable soy production comprised of 27 criteria and 91 indicators.

- The Better Sugarcane Initiative has produced a performance-based standard for sugarcane production. This standard is not yet at a certifiable stage. It is a performance-based standard unlike many other commodity standards that are practice-based.

- SEKAB provides an example of a voluntary standard established by a private company. SEKAB, a Swedish bioenergy company, worked with Brazilian bioethanol producers to bring independently verified sustainable bioethanol from Sao Paulo to Sweden. The sustainability of this biofuel was determined by meeting the following requirements (FAO, 2010c):

    - At least 85% reduction in carbon dioxide emissions compared with traditional fuel, on a well-to-wheel basis
    - At least 30% mechanization of the harvest now, later increasing to 100%
    - Does not contribute to rainforest felling
    - Does not utilize child labor
    - Rights and safety measures in practice for all employees in accordance with UN guidelines
    - Ecological consideration in accordance with UNICA's environmental initiative; and
    - Continuous monitoring that the above criteria are being met

- The Nordic Ecolabel is an independent organization that certifies biofuels and allows them to be sold with their "The Swan" ecolabel in Nordic economies. The criteria include GHG emissions reductions and energy used in producing the biofuel, as well as considerations of competition with food. The label allows consumers to make decisions based on the ecological impacts of a product (BEST, n.d.).

Table 15 lists the participation of APEC economies and organizations within them in GBEP, the RSB, and the RSPO, three very active standard-setting bodies.

Table 15. APEC economy participation in voluntary multilateral biofuel standards

Economy	GBEP Status	Number of RSB Members in Economy	Number of RSPO Members in Economy
Australia	Observer	4	7
Brunei Darussalam		0	0
Canada	Partner	2	1
Chile	Observer	0	0
People's Republic of China	Partner	1	1
Hong Kong, China		0	0
Indonesia	Observer	0	72
Japan	Partner	1	7
Republic of Korea		0	1
Malaysia	Observer	3	79
Mexico	Partner	0	1
New Zealand		0	2
Papua New Guinea		0	2
Peru	Observer	1	0
Philippines		5	1
Russia	Partner	0	1
Singapore		1	21
Chinese Taipei		0	0
Thailand		0	15
United States	Partner	38	21
Viet Nam		0	0

Practice versus Performance

Practices are often identified by standards as indicators of positive outcomes because of the ease of verification (Clay, 2008). However, the outcomes of practices vary between sites. Furthermore, the cost effectiveness of the prescribed practice may vary from one location to another, or the collective impact of a suite of actions may have tradeoffs or no beneficial impact at all. For example, while no-till cultivation has been proven to reduce GHG emissions by lowering machinery use and increasing soil carbon sequestration, in specific cases of long-term practice or when applied to waterlogged soils, this practice could actually increase GHG emissions. Practices labelled as “sustainable” do not always result in sustainable outcomes. Hence, evaluating performance is a more meaningful monitoring technique for evaluating sustainability.

Given the relative infancy of most of the biofuel and feedstock standards, few monitoring programs have been established thus far, and most current voluntary standards that require monitoring are based on practice because practice is easier to verify than performance. However, one notable exception is the

Better Sugarcane Initiative, which is a performance-based standard. Examples of performance-based indicators are provided in Table 16.

Table 16. An illustration of performance-based indicators and monitoring tools for biofuel sustainability standards (not comprehensive)

Criteria	Indicator	Tools or techniques
Reduced GHG emissions	Reduced GHG emissions compared to baseline (gCO2eq / MJ biofuel)	• Environmental Impact Assessment (EIA) with GIS to identify and avoid nitrous oxide hotspots in field e.g. soil type, slope, and precipitation • LCA assessment
Soil quality	Soil erosion (ton/ha.yr)	• EIA with GIS to identify soil erosion risks • High Conservation Value assessment
Water quality	Nutrient run off avoided	• EIA with GIS to identify risk of run-off & appropriate practice with data on slope, elevation, soil type • Use existing water quality monitoring programs
Water use	Water scarcity No water rights conflict Reduced water use per unit of product (m3/ unit)[1]	• Remote sensing to determine availability on a regional level • Remote sensing for local water consumption & High Conservation Value assessment • LCA for consumptive water use
Conservation of carbon stocks	Carbon payback time[2] (years) Soil carbon sequestration (tC/ha.yr)	• Remote sensing to identify land cover changes and above ground carbon stocks • Modeling (with calibration) for soil carbon e.g. COMET-VR
Land rights respected	No violation of legal boundaries & free prior, informed consent.	• GPS mapping to define GIS map of land title, tenure, customary rights • Guidance book on 'Free Prior Informed consent'
No contribution to food insecurity	Increased crop yield (t/ha) Production on 'idle/degraded' land Increased income ($/ha or $/family/yr)	• Leverage existing monitoring programs (e.g. GEOSS) • Remote sensing for yield and land cover changes • Social LCA (impact assessment)
Contributes to rural & general economic development	Increased crop yield (t/ha) Increased income ($/ha or $/family/yr) Number of jobs	• Remote sensing • Income data with GIS for spatial links • Social LCA (impact assessment)
Conservation of biodiversity	Number of & spatial extent of species or critical species	• High Conservation Value assessment

5.5 Voluntary Programs and Initiatives Compendium

Table 17 presents the types of voluntary programs and initiatives identified for more sustainable biofuels in APEC economies, along with the general strengths and challenges of each type.

Table 17. Types of voluntary sustainable biofuel programs and initiatives

Activities	Strengths	Challenges
Produce feedstocks on underutilized lands *Examples:* *Oil palm on Imperata grasslands* *Mawas conservation project*	Reduces conversion of lands (directly or indirectly) with high economic value, and potentially with high carbon stocks, biodiversity, vulnerable ecosystems, or socioeconomic services.	Risks compromising other services the land provided. Crops may have lower yields or require higher inputs to achieve economic yields than on other lands.
Improve productivity of lands *Examples:* *Crop-livestock integration* *SCBI better management practices*	Increases production without causing indirect land use change and emitting corresponding GHG emissions, but may have side effects from additional inputs).	May lead to water stress or increased pollutants runoff because of additional agricultural inputs.
Increase bioenergy yields *Examples:* *SCBI better management practices in the Philippines*	Reduces land "footprint" of biofuels and need for land conversion elsewhere. Increased economic returns.	May increase water consumption. May require more fertilizer therefore risks for water quality and GHG emissions.
Reduce feedstock and fuel transport distances	Improves GHG balance and results in better utilization of co-products or increased access to fuel as processing location is closer to site of feedstock growth or location of fuel users.	Locations of already existing processing plants not easily moved and may not have land nearby suitable or available for feedstock cultivation or locations of fuel users.
Biogas capture *Examples:* *Methane trapping from POME*	Reduced GHG emissions, biogas can be reused for energy.	May not be cost effective.
Use of improved fertilizers *Examples:* *EFBs from palm in Malaysia and Indonesia*	Reusing what would otherwise be waste products lowers costs. Replacing chemical fertilizers reduces soil and water pollutants as well as GHG emissions.	Improved fertilizers may not be exact substitute for traditional fertilizers.
No-till cultivation *Examples:*	Improved soil quality, reduced labor, reduced wear to machinery, less fossil fuel	On certain soils (e.g., waterlogged soils), may actually increase GHG emission. Not all

Conservation tillage system in the United States	consumption, reduced erosion, improved water quality, and improved habitats for wildlife.	crops can grow in no-till conditions.
Sustainable residue harvest *Examples:* *U.S. Renewable Energy Assessment Project*	Can create optimum soil organic matter conditions, reduce soil erosion, and maintain or improve soil carbon. The residues may be used as biomass energy sources.	Too much residue harvesting can negatively impact each of the positive impact areas listed.
Establish riparian buffer strips	Protect water quality from runoff of sediments and agricultural chemicals. Can shade the water from the sun, controlling temperature.	Buffer zones may not be the most cost-effective solution to deliver water quality improvements
Integrated Pest Management	Reduce synthetic pesticide runoff into water bodies. Minimizes economic, environmental, and health costs.	Requires more time and effort than traditional pest management. May initially be more expensive.
Use of waste products as feedstocks	Does not require production of new feedstocks that require land and resource inputs to grow. Potential to produce fuels with greater GHG emission reductions, less/no competition with food and cropland, reduced costs and other sustainability benefits, compared with current biofuels.	Might not provide sufficient quantities of biofuels in some cases. May require high inputs for processing. Defining a true “waste” is often complex.
Biofuels cooperatives *Examples:* *Canada’s Agricultural Cooperative Development Initiative* *Indonesia’s Koperasi Kredit Primer Anggota (KKPA)*	Allows participating farmers to pool their resources to share equipment or services and thereby to access greater resources than they could as individuals. Processing facilities and marketing resources may also be shared. The collective union gives members a greater influence in the market.	May be difficult to organize and run effectively.
Extend employment to women *Examples:* *Mamas las Frutas scheme in Papua New Guinea*	Improves women’s incomes, which can translate to household incomes. Decreases women’s economic dependency. Allows for better control women’s labor.	May subject women to negative labor practices or create new forms of dependency.

Direct support to smallholders *Examples:* *Canada's Biofuels Opportunities for Producers Initiative (BOPI)* *Malaysia's Federal Land Development Authority (FELDA)*	Improves opportunities for smallholders to participate as a biofuel industry develops.	May be costly to implement compared with investments in larger systems.
Community-based biofuels initiatives for community benefits *Examples:* *Indonesia's Program of Energy Self Sufficient Villages* *Thailand's Community Based Biodiesel Project*	Ensures benefits of biofuels reach key stakeholder communities.	Difficult to coordinate. Difficult to ensure the benefits are achieved – usually focuses on practice rather than performance.
Fiscal and other incentives	Useful for kick-starting a program or activity and making them more economically competitive in early stages of development.	In the long term may distort the market and promote a non cost-effective option.
Carbon Financing for Biofuels *Examples:* *Pearson (2010) study* *Mawas Conservation Project*	Monetizes specific sustainability outcomes, i.e., GHG emissions reductions.	Market may be too complex or costly for many biofuels producers to enter.
Participation in voluntary practice-based standards	Clear and relatively easy to monitor whether activities being performed	Not all practices are suitable in all locations and may not deliver sustainable outcomes.
Participation in voluntary performance-based standards	Results orientated - allows least cost routes to achieve results	Not yet widely practiced therefore little experience to draw on.

6.0 Monitoring for Sustainability

Monitoring is a critical step to ensure that programs and practices achieve intended outcomes. Monitoring *performance* to determine what the outcomes of specific actions or combinations of actions are and how they contribute to sustainability goals is the essential feedback loop that enables a sustainable biofuel activity to remain meaningful and adapt where necessary to changing circumstances.

Although no universally adopted sustainable biofuel standards exist at this time, datasets, tools, and techniques for monitoring programs in other sectors (such as agriculture and forestry) may be applicable for monitoring the outcomes of biofuel and feedstock production. For example, several economies are already engaged in monitoring sustainable forestry activities. APEC economies already conducting these types of monitoring activities could leverage them to apply to biofuels (Winrock, 2009d). This section identifies monitoring practices and technologies applied to biofuel sustainability programs and introduces new techniques that may offer robust and cost-effective approaches in the near future.

6.1 Monitoring as Part of Regulatory and Voluntary Standards

Several regulatory and voluntary standards have monitoring components. These standards put forth criteria and indicators that may provide metrics for use in monitoring for sustainability. Given the relative infancy of most of the biofuel and feedstock standards, few monitoring programs have been established thus far. Although assessments have taken place on potential land use change and biodiversity issues, for example, the frameworks for sustained data collection and analysis have yet to be developed.

Regulatory and voluntary standards have adopted a variety of methods for monitoring compliance:

- The mechanism to monitor compliance with the sustainability standard of the EU Renewable Energy Directive is to "encourage the development of multilateral and bilateral agreements and voluntary international or national schemes that cover key environmental and social considerations, in order to promote the production of biofuels and other bioliquids worldwide in a sustainable manner. In the absence of such agreements or schemes, Member States shall require economic operators to report on these issues." (European Commission, 2008).

- The volume of biofuel sold in the UK is monitored to track progress against mandated volumes; in addition, the GHG savings and sustainability characteristics of the biofuel are reported by obligated parties. The program predominantly relies on identifying sustainable biofuels by requiring biofuel feedstocks to be grown and certified to an existing standard (e.g., the Roundtable on Sustainable Palm Oil), which has been benchmarked against the UK principles and has been judged to meet the required performance. This "meta-standard" approach (creating an overarching standard upon which others are benchmarked) is also being developed by the Roundtable on Sustainable Biofuels.

- The U.S. RFS has requirements to ensure that increasing amounts of biofuels do not threaten food security and do reduce GHG emissions. As part of the monitoring scheme of this legislation, the U.S. Environmental Protection Agency (EPA), Department of Agriculture (DoA) and Department of Energy (DOE) are required to report to congress on the domestic environmental and social impacts of biofuels (Winrock, 2010a).

- The second principle of the RSB's *Principles and Criteria for Sustainable Biofuel Production* is: "Sustainable biofuel operations shall be planned, implemented, and continuously improved through an open, transparent, and consultative Environmental and Social Impact Assessment (ESIA) and an economic viability analysis" (RSB, 2009).

Meeting voluntary standards for biofuel feedstock is increasingly used as a proxy for sustainable biofuels. It is therefore crucial that voluntary standards have effective monitoring schemes to ensure confidence in their effectiveness as they are increasingly adopted voluntarily and through legislative frameworks. Monitoring as part of regulatory and voluntary standards may not cover a comprehensive range of issues. In the case of voluntary schemes, the effectiveness of monitoring may depend on incentives. In the case of mandatory schemes, the effectiveness of monitoring depends on enforcement.

A comparison of three legislative tracking systems used for monitoring purposes is provided in Table 18.

Table 18. A comparison of existing and emerging economy-wide tracking mechanisms

Features	U.S. Renewable Fuels Standard (RFS) Tracking and compliance system	UK Renewable Transport Fuel Obligation (RTFO) Tracking and compliance system	California Low Carbon Fuel Standard (LCS) Tracking and compliance system
Obligated or regulated parties (for liquid fuels)	Oil refiners, importers and blenders.	Oil refiners, importers and blenders.	Oil refiners and importers. Generally, allows the regulated party to transfer its compliance obligations by written instrument to another party under specified conditions.
The "tracking" tool	The Renewable Identification Number (RIN) is a 38-character code generated at the point of biofuel production by the manufacturer.	Renewable Transport Fuel Certificate (virtual) issued upon submission of carbon and sustainability report.	Credits and deficits (virtual). LCFS Reporting Tool (LRT) and Credit Tracking System (CTS). For biofuels that are covered under the U.S. RFS, RIN number will be generated.
Mechanism control point	RIN must be assigned at point of renewable fuel production or at point of import if fuel is imported fuels.	At the excise duty point.	Differs between fuels and is based on regulated party.
Purpose of the system	Track compliance with the RFS that requires obligated parties to blend a proportion of renewable fuel.	Track compliance with the RTFO that requires obligated parties to blend a proportion of renewable fuel.	Track compliance with the requirement of regulated parties to reduce carbon intensity of all transportation fuels sold in California by 10% by 2020.
Data collected	Year of production, producer ID, facility ID, batch number, cellulosic/non-cellulosic,	Type of biofuel, feedstock, country of feedstock origin, volume, environmental and/or	Type of fuel, RIN numbers, feedstock, feedstock origin, production process, carbon

	equivalence value.	social standard to which the feedstock was grown, carbon intensity of the fuel, and the level of detail of the carbon calculation.	intensity of blendstock and reference fuel, amount of each blendstock, amount of each fuel used as fossil replacement, credits/deficits of carbon dioxide equivalent.
Monitoring frequency	Quarterly (and annually)	Monthly (and annually)	Quarterly (and annually)
Challenges	Many renewable fuel producers are small business and do not necessarily have the resources required to maintain the RIN program. The commercial registries for RINs are not able to catch all duplicates. The system has not been automated yet which has resulted in substantial numbers of administrative errors.	The traceability (or chain of custody systems) for transferring carbon and sustainability systems are not established. Any break in the fuel supply chain results in carbon and sustainability information unable to be reported. The mass-balance approach changes the nature of the fuel market that is often based on spot-trading.	Traceability system not tested.

6.2 Tools and Techniques for Monitoring

Monitoring requires tools and techniques for data collection, analysis, and reporting. The following list is not exhaustive but provides a limited overview of tools and techniques. One of the most challenging aspects of monitoring compliance with standards and impacts of biofuels is the ability to trace the end product back to its source as a feedstock. The final section on traceability provides an overview of this issue.

- *Remote sensing* capabilities were discussed in the chapter on planning and research. For the same methods that remote sensing is useful as a planning tool, it is useful as a monitoring tool. Land cover change, carbon stocks, and water cover can be monitored with different remote sensing products. Baselines can be established and changes recorded over time. This approach, which requires technical capacity for monitoring, has the potential to cost effectively capture and process information over large areas.

- *Reporting* tools improve the ability to communicate, store, and analyze data collected in the monitoring process. When developed for use by the parties within the supply chain, they may influence behavior to improve performance.

    - The Century Model (a plant-soil nutrient cycling model that simulates carbon and nutrient dynamics) has been combined with a decision support tool and web-friendly interface to value carbon sequestration for crop cultivation in the United States. The resulting Voluntary Reporting of Greenhouse Gases-CarbOn Management Evaluation

Tool (COMET-VR) allows landowners and others to get rapid estimates of carbon sequestration rates on land in the United States. It also shows how land management changes affect carbon sequestration rates. Users input a history of agricultural management practices on one or more parcels of land. The output information can be used for reporting to the U.S. Department of Agriculture's voluntary greenhouse gas reporting system (Winrock, 2009d).

  - In Europe there are a number of GHG calculators developed or under development. In the UK the carbon calculator is used within the legislative framework. It enables users to input qualitative data and then uses default emission factors to calculate the amount of GHG emissions avoided by use of a given batch of fuel. The calculator also allows users to enter more detailed information if it is available (e.g., energy source, transportation distances) to get more accurate results (RFA, 2010b).

- *Personal digital assistants* are handheld computers useful for remote data collection. They can be integrated with *Global Positioning Systems*, which will significantly improve monitoring capacity by allowing georeferencing of collected data. The data collection software can be developed or modified to ensure a user-friendly interface that allows the results to be analyzed and displayed in a spatial manner with maps. Icons and pictures can also be used to overcome the potential barriers of low literacy levels. Geographical Information Systems are a key tool in integrating and modeling this spatial information.

- *New mobile phone technology for data collection and processing* has been used to deliver the market prices of feedstocks to the cell phones of farmers, allowing efficient and optimized sales with the highest profit. Opportunity alert services enable information to be transferred directly to a mobile phone without the need for internet access. Information that could assist in meeting sustainability standards could include opportunities to connect sellers of sustainable product with buyers, training days or programs, guidance on compliance activities, or reminders of key requirements and prices for biofuels or feedstocks in markets of interest (Winrock, 2009).

  The increased availability of cell phones in remote areas and the advancement of mobile software and its growing compatibility with web interfaces have revolutionized data collection. A new mobile technology "Rapid Android" has been developed that enables a mobile/cell phone to be used as a data entry tool and data aggregation platform. The Rapid Android software works as an operating platform and is expected to make field-based short messaging service (SMS) data collection systems both easier and more affordable (Dimagi, 2009).

Traceability of Data throughout Supply Chains

Traceability refers to the ability to identify and verify information at each step in a process chain. Traceability systems within biofuel supply chains can be complex, with hundreds of steps that include the mixing and blending of feedstock and biofuel; therefore, a lack of available and accurate data for collection is a key issue (Winrock, 2009d).

Generally three traceability systems are defined (Winrock, 2009d). The traceability system chosen by standards reflects the balance between the need or desire to track individual batches back to the source versus the costs of doing so. Some parties wish to ensure that the biofuel they are consuming has been produced sustainably (ensuring sustainable consumption). Others simply want to create demand for a sustainable product to ensure it is produced, but do not necessarily need to consume it themselves (driving sustainable production):

- A *book and claim* scheme allows product and certificate to be decoupled. The product enters the global supply chain without any traceability, but the certificates are registered on a trading platform. End-users can buy certificates to match the products bought from the global supply chain. The disadvantage of this system with respect to the monitoring is that it skips several important steps in the supply chain that are key to monitoring GHG performance; i.e., only the farm and the fuel supplier are part of the system. No information on transport distances, energy use and type at feedstock, or biofuel processing facilities is collected.

- A *mass balance* scheme allows for mixing of certified and non-certified material at any stage in the supply chain, provided that overall quantities are controlled and claims of certified "sustainable" material never exceed that supplied to the end user (% in = % out). It requires that every actor in the supply chain participate, or no claims about the material can be made.

- A *bulk commodity* scheme or a *track and trace* scheme requires segregation of certified and non-certified material throughout the supply chain. For liquid materials blended many times prior to final processing, this system is challenging and the highest cost option. It also requires that every actor in the supply chain participate or no claims about the material can be made.

6.3 Monitoring for Sustainability Compendium

Table 19 presents the monitoring activities, tools, and techniques identified in APEC economies, along with the general strengths and challenges of each.

Table 19. Types of sustainable biofuel regulations and policies in APEC economies

Activities	Strengths	Challenges
Monitoring as part of voluntary standards	Monitoring is incentivized.	May not cover a comprehensive range of issues. Incentives may not be sufficient.
Monitoring as part of regulatory standards	Monitoring is required by legislation.	May not cover a comprehensive range of issues. Vulnerable to corruption or weak enforcement.
Monitoring tools and techniques: Remote sensing	Provides a cost-effective way to analyze land cover over a large area and can be combined with other data to determine land use. Data provided is repeatable and transparent and collected without bias.	Limited by the resolution of data, and spatial and temporal availability of data. Requires technical capacity for monitoring.

Monitoring tools and techniques: Reporting tools *Examples:* *COMET-VR* *European GHG calculators*	Improve the ability to communicate, store and analyze data collected in the monitoring process.	Requires some incentive for parties to utilize.
Monitoring tools and techniques: Personal Digital Assistants, Global Positioning Systems, and Geographical Information Systems	Allows georeferencing of data which is critical for assessing sustainable outcomes.	Requires (limited) training.
Monitoring tools and techniques: Phone technology	Key data for biofuel sustainability could be collected cost-effectively and rapidly from the field as part of a monitoring program. Enables information to be transferred directly to a mobile phone without the need for internet access which is a key requirement in many remote areas.	Requires reliable access to mobile phones.
Traceability system: Book and claim	Allows the product and certificate to be decoupled and cost-effective trading systems to be developed. Creates demand for sustainable product.	Skips several important steps in the supply chain that are key to monitoring GHG performance.
Traceability system: Mass balance	Allows for controlled mixing of certified and non-certified material which reduces cost of operation.	In reality is no clearer in traceability terms than book and claim system but is a greater administrative burden and more expensive to operate. Requires that every actor in the supply chain participates or no sustainability claims about the material can be made.
Traceability system: Bulk commodity	Provides clear traceability of biofuel from feedstock to product. Allows each step/party to be identified and therefore suitable for collecting GHG data.	Requires segregation of certified and non-certified material throughout the supply chain which is expensive.

7.0 Conclusions and Recommendations

Driven by economic, energy, and environmental needs, policies, mandates, and targets for biofuel consumption around the world have resulted in a dramatic growth in biofuel demand. While production and use of biofuels have the potential to improve social and economic well-being and benefit the environment, when poorly planned and managed, biofuels can adversely impact ecosystems, livelihoods, and economics. The concept of “sustainable biofuels” has emerged as a development approach that optimizes outcomes by maximizing the social, economic, and environmental benefits of biofuels while minimizing the risks of negative impacts. APEC economies are initiating biofuel policies, programs, and practices with the explicit purpose of implementing this concept. This report has presented sustainable biofuel activities in the APEC region that fall under the following categories:

- Planning and research
- Regulatory and policy initiatives
- Voluntary programs and initiatives
- Monitoring

Examining the scope of activities planned and implemented within APEC and more broadly can provide guidance regarding options that other APEC economies may wish to consider.

A number of current and potential policies and measures encourage sustainable development of biofuels. However, no single feedstock, production process, or activity can be promoted as a universally sustainable solution. An activity in one region may deliver benefits that, when applied to another region, cause detrimental impacts.

Planning and Research activities are critical to identifying appropriate feedstocks and practices in different locations and are the precursor to implementing policies and regulations to deliver those benefits. Research at present is dominated by technological developments, and further work on impacts of biofuels and mitigation techniques at micro- and macro-scales is required; tools and techniques to research and plan sustainable biofuel development are available.

Policies and Regulations related to biofuels have largely promoted specific volumes of biofuel production or consumption and, in some cases, specific feedstocks. These approaches cannot guarantee sustainable outcomes, however. Policies and regulations that aim to promote sustainable biofuels generally address specific sustainability objectives. In some cases, incentives such as financial rewards for GHG emissions reductions have been used to encourage more sustainable biofuel characteristics. In other cases, restrictions such as land use zoning have been enacted to prevent unsustainable activities. These policies have not been in force long enough for their impact to be understood. Performance-based approaches (e.g., the California Low Carbon Fuel Standard) are likely to deliver goals at least cost, but in all cases, focusing on one goal, such as yield improvement for reduced land competition and improved food security, may come at the expense of other sustainability objectives, such as water availability.

Voluntary Programs and Initiatives for sustainable biofuels were found in a handful of economies; the majority were identified in economies whose biofuels have been most scrutinized (e.g., palm biodiesel in

Indonesia and Malaysia because of accusations that lands of high carbon stocks and biodiversity were being converted, and corn ethanol in the United States, which has been accused of driving increases in global food prices). In addition to those already underway, many more programs and practices are under development, as indicated by sustainable biofuel plans and new policies coming into effect. Programs and activities include defining a methodology for "responsible cultivation areas," promoting the use of underutilized lands, improving productivity through a systems approach, waste treatment and reutilization, improving fertilizer application, and developing community based bioenergy projects. Voluntary sustainability standards have been developed by both private organizations and international stakeholder groups to certify biofuels as meeting certain sustainability criteria. However, the majority of voluntary standards define practice-based rather than performance-based indicators to measure compliance, and these are less likely to encourage sustainable outcomes.

Monitoring to ensure that sustainability outcomes are achieved is critical. As sustainability does not have a universally accepted definition or assessment criteria, monitoring for sustainability outcomes must take place against established sustainability metrics. These metrics are usually practice-based, owing to ease of verification, but performance-based indicators better represent outcomes. The tools and techniques identified for research and planning could also be relevant for monitoring impacts and performance of sustainable biofuel activities. Traceability presents a significant monitoring challenge; collecting and supplying data throughout the lifecycle of a biofuel is challenging owing to a complex supply chain. The scarcity of monitoring activities in APEC economies may be attributable to the fact that biofuel development and the concept of biofuel sustainability are in early stages in APEC, and monitoring and accountability are often introduced in later stages.

Fundamentally important to successful, sustainable biofuel development is keeping in mind that the process of conducting planning and research, developing policy and regulation, implementing voluntary programs and initiatives, and monitoring outcomes is not strictly linear. In reality, the process should be a continuous feedback loop; when monitoring exposes new problems or shows that intended outcomes are not achieved, the planning, regulations, and practices must be reevaluated against the end goal of sustainability and adjusted to better achieve those outcomes.

One recommendation for advancing sustainable biofuel development in the APEC region is to exchange experiences and lessons learned within APEC so that member economies can benefit from the scope of activities underway and leverage the advances each has made towards sustainable biofuel production and consumption. There are numerous vehicles for collaboration (e.g., in shared research interests such as advanced biofuels); opportunities for studying the advances made in other economies (e.g., those economies concerned about competition with food can learn from China's policy banning grain ethanol and Chinese Taipei's activities reusing waste cooking oil); and potential for capacity building through direct assistance from those who have developed successful policies, programs, and practices.

A second recommendation is that future sustainable biofuel activities should simultaneously promote all areas of sustainability – taking a more holistic approach – rather than examine each component in isolation. "Sustainable biofuels" is an ideal scenario in which all areas of sustainability are positively affected, but in reality the concept involves optimizing tradeoffs between various sustainability criteria. Care must be taken to understand the tradeoffs associated with biofuel activities.

A third recommendation is to incorporate more monitoring, specifically through performance-based approaches, of compliance with, and impacts of, sustainable biofuel policies, programs, and practices to ensure that their intended outcomes are realized and negative unintended consequences are addressed. The contexts and solutions for sustainable biofuels are dynamic, and the approach to sustainable production merits an emphasis on flexibility. Sustainability standards are beginning to incorporate feedback loops, and some identified research has already served this purpose. Good research and planning can minimize negative impacts, but ways to incorporate feedback loops into all stages of the biofuel lifecycle need to be identified and tested to ensure early detection of issues that inhibit sustainable outcomes and enable appropriate corrective action.

Appendix A. Sustainable Biofuel Research Activities in APEC Economies

Australia:

Several organizations in Australia are conducting biofuels research with sustainability implications. The Australian Commonwealth Scientific and Research Organization (CSIRO) is conducting research under a project known as "Sustainable Biomass Production," developing integrated methodologies to explore elements of sustainable biomass production, the range of feedstock options, and the sustainability impacts of different biofuel pathways. Different management practices, locations of biomass growth, and varieties of biomass will be considered. The outcome feeds into a plan for the development and use a sustainability framework for the production and consumption of biofuels in Australia, develops technologies and techniques for producing advanced biofuels, and develops methods for increasing production while decreasing energy inputs and costs (National Research Flagships, n.d.).

As part of the Department of Resources Energy and Tourism, under a Clean Energy Initiative, budget of May 2009, there is a $15 million Second Generation Biofuels Research and Development Program for research, development and demonstration for advanced biofuel technologies (O'Connell, 2009).

There are a number of organizations in Australia researching advanced biofuels as an approach to making biofuels in that economy more sustainable. Algae is considered to be the most promising new biofuel feedstocks in the economy because of its high fuel yield per area. The South Australian Research and Development Institute, for example, is researching sustainable production of microalgae and is building a demonstration scale bioreactor for it (BAA, 2010).

The Rural Industries Research and Development Corporation (RIRDC) of the Australian government has multiple sustainable biofuel research initiatives. For example, the Joint Venture Agroforestry Program is an RIRDC program conducting research to provide the knowledge necessary for "profitable, sustainable and resilient agroforestry" in Australia (RIRDC, 2010). A scoping study was done for this Program called the "Bioenergy Sustainability Guide" in 2005 (O'Connell, 2005). This Guide was intended to form the basis of the development of a toolkit for the Australian bioenergy industry.

The RIRDC also reviewed sustainability issues in the multilateral biofuel industry and the subsequent responses. This research was done presuming that demonstration of the potential for a sustainable biofuel industry that advances an economy's sustainable development goals and produces sustainable products would be valuable for the advancement of the Australian industry (O'Connell, 2009).

Bioenergy, Bioproducts and Energy is another RIRDC program, as part of which a list of the priorities for the organization was developed in 2007. One of the ten recommended research areas is sustainability. Several of the other research areas also relate to sustainability, such as Economic and Policy Analysis and Biomass Resources. Specifically, it states that sustainability will cover "assessment methods, accreditation schemes, LCA case studies and inventories, biophysical and socioeconomic analyses at regional, economy-wide and multilateral scales, quantifying benefits and impacts across economic and environmental value chains, obtaining community approval and consumer demand" (O'Connell, 2007). These recommendations were then incorporated into a five year plan for the RIRDC (RIRDC, 2007).

Canada:

Canada is a leader in advanced ethanol technologies, and has put significant effort in researching these technologies. $500 million has been dedicated to developing large scale demonstration plants for next generation biofuels by Sustainable Development Technology Canada for a NextGen Biofuels Fund (Bradley, 2009). EcoAgriculture Biofuels Capital Initiative is a federal $200 million four-year capital grant program that provides funding for the construction or expansion of transportation biofuel production facilities. It appears this funding is focused on cellulosic ethanol (Milbrandt, 2008).

More broadly, Canada's Agricultural Bioproducts Innovation Program promotes research, development, technology transfer, and commercialization activities related to agricultural bioproducts, including biofuels (Bradley, 2009). A component of this program is a research network for cellulosic biofuels (aims to provide Canada with a low-cost economic and environmental plan for ethanol production based on food-crop residues, dedicated biomass crops and the use of marginal lands), sustainable cropping system platforms for biodiesel feedstock quantity and quality (aims to brings together a wide array of agricultural professionals to obtain readily transferable canola production knowledge), and oilseed (provide biodegradable, renewable substitutes for petroleum in specific applications and measure the environmental benefits of these products) (Agriculture and Agri-Food Canada, 2009).

Chile:

In 2006, a multilateral biofuel seminar was held in Santiago, Chile. The seminar participants concluded much more research on bioenergy and biofuels in Chile was needed. Following on that conclusion, alliances between various government departments were created to carry out biofuels studies (García-Huidobro, 2009). The government of Chile is concerned about energy security, but also about competition with food, as Chile is a net importer of both food and fuel. In an effort to develop a sustainable biofuel industry, Chile's biofuel research focuses on advanced biofuels development. There are five technological consortia for future biofuel technologies in the economy; two of the consortia focus on lignocellulosic biofuel and the remaining three focus on algae (Iglesias, pers.comm. 2010).

The first sign of government interest in biofuels research was when the Ministry of Agriculture recently provided $1 million to study the optimal feedstock for a Chilean biofuels industry. A $31.6 million public-private investment was made for research on technological development for biofuels from algae (Leighton, 2010). Additionally, the government issued USD$6 million for research into cellulosic ethanol (Comisión Nacional de Energía, n.d.b).

At the end of 2009, the Inter-American Development Bank awarded a $1 million grant for building a demonstration and research plant for producing steam and hydrogen from wood industry waste products. The waste gases from the wood industry are converted via Fisher Tropsch process into biodiesel. This would not compete with food as the waste is an unused product that already exists (IDB, 2009).

There are universities conducting research on algae, lignocelluloses biofuel and jatropha across the economy (Comisión Nacional de Energía, n.d.a). The University of Tarapaca has planted 1,500 ha of jatropha as a pilot project (Milbrandt, 2008). The Chilean Foundation for Agricultural Innovation and the University of Chile are undertaking a "Development and Validation of Jatropha Cultivation in the

Northern Zone of Chile for Biodiesel Production" project that covers 15 hectares with eight different test segments. This research will involve observing, among other things, the impact on water of the jatropha (García-Huidobro, 2009).

Additionally, the Chilean Institute of Agriculture Research (INIA) has presented a proposal to the Iberoamerican Science and Technology Education Consortium entitled "Low cost fractioning of the lignocellulose used in the production of cellulosic ethanol." This research proposal is coordinated by INIA-Spain. INIA is also researching on the study of forage production for the generation of bioethanol (Donoso, pers.comm. 2010).

Lastly, University of Concepción is also researching bioenergy. Some of their projects are:

- Use of tallow for biodiesel production
- Biogenic methane for vehicles
- Biogenenic gas as a substitue for Natural gas
- Biogas Upgrading and Use as Transport Fuel (Donoso, pers.comm. 2010)

China:

With a growing population and energy demand, China is concerned about biofuels competing with food and consequently much of the biofuel research in China is focused on this topic. The government has supported advanced biofuel research and several universities are involved with biofuels research. The East China University of Science and Technology found a process route for using cellulosic feedstock to produce ethanol through acid hydrolosis. This project is called the "Use of Cellulosic Waste to Produce Ethanol." This new process has been put into practice in a demonstration plant. Other Chinese universities with research on advanced biofuels are Tsinghua University, Shandong University, Zhejiang University, the Institute of Microbiology and Institute of Process Engineering of the Chinese Academy of Science, and Beijing University of Chemical Technology (Eisentraut, 2010).

There are other demonstration activities underway for biofuels that do not compete with food. For instance, there are several jatropha demonstration projects. Additionally, the China National Cereals, Oils, and Foodstuffs Corps is building a cellulosic ethanol plant (European Biofuels Technology Platform, 2009). Additionally, the China National Petroleum Corporation invested over $600,000 for four jatropha pilot projects that will focus on improvements in planting and management (Schott, 2009).

In 2007, two organizations, the China National Institute of Standardization (CNIS) and the Innovation Center for Energy and Transportation (iCET) agreed in 2007 to work together on the development of a LCA methodology for China's fuels and, as part of that development, research an economy-wide standard for life cycle fuel emissions. The research involved examining other LCA methodologies, followed by a forum on low carbon fuel and climate change in China and an outlining of methods to evaluate WCO, corn ethanol, and cassava ethanol (iCET, 2009b).

Hong Kong:

In January, 2010, Hong Kong's first biofuels research center was announced. It will be established as a partnership between Edinburgh Napier University and City University of Hong Kong as part of City

University's School of Energy and the Environment. The research center aims to find a solution to sustainable energy and sustainable handling of the country's waste matter. The Center's focus will be on developing second generation biofuels (Scottish Development International, 2010).

Indonesia:

Research on renewable energy from plant sources (including palm oil and jatropha) was funded by the Indonesian Ministry of Agriculture in 2006 at IDR300 million (USD$33,000). The Ministry of Research and Technology is doing research through a program on agriculture to agro-products throughout the value-chain on biofuels. This Ministry also grants research funds to public universities (Dillon et al, 2008). There are a number of institutes that carry out palm oil and coconut research, but access to this information was limited for this report as available information was not in English.

Japan:

Japan's biofuel research focus is on existing feedstocks (in order to support the agricultural industry) and feedstocks that do not compete with food. There is a research emphasis on cellulosic ethanol, which is better positioned to meet the quantity of biofuel the country aims for (Iijima, 2009). To focus research on cellulosic ethanol, the Biomass Technology Research Center was opened in Hiroshima in 2005. This Center focuses on technologies for using woody biomass, with the goal of reducing Japan's CO2 emissions (AIST, 2010).

Research is also focused on impacts of biofuel use: the economy-wide government has a testing and monitoring scheme to see how the current E3 fuels impact vehicles and the environment (Iijima, 2009).

Japan has several demonstration projects used to research biofuels. One example is a model ethanol plant operating in Niigata. This plant uses rice that is higher yielding than the food crop and uses land that is fallow and set aside under the Ministry of Agriculture, Forestry, and Fisheries' acreage reduction plan.[7] It started producing ethanol in 2009, which is used in E3 (Iijima, 2009). There are currently ten bioethanol pilot projects in Japan (Ikeda, 2010). Among these are included the world's first bioethanol plant using wood residues and the first one using food residues (Edwards, 2007).

Korea:

Korea emphasizes cellulosic ethanol research. This is because of their shared limitation of agricultural land. For this same reason, algae is being considered in both economies. The government has plans for 35,000 hectares of "seaweed forests" offshore, with the goal of using algae to meet 13% of fuel needs in the economy (Schott, 2009).

[7] MAFF's Acreage Reduction program restricts the area of land on which rice for food is grown in order to prevent oversupply of the product.

Malaysia:

Malaysia's main biofuel feedstock is palm oil, which is an important commodity for the economy. Research and development for Malaysian palm oil has been underway since 1982, primarily led by the Malaysian Palm Oil Board (MPOB) and has received tremendous government investment. The research covers all areas of the palm oil sector, many of which relate to making it more sustainable. There are three areas directly related to biofuel sustainability (MPOB, 2010a):

- Biology Research Division
  - Intensifying awareness on integrated pest management for plant protection
  - Researching on precision agriculture equipment and technologies for oil palm management to enhance profitability and improve environmental quality
  - Researching on advanced biotechnology and breeding
- Engineering Process Division
  - Technology development for production palm biodiesel and winter grade biodiesel
  - Utilization of liquid and solid palm biomass for the generation of energy, reduction of GHG through energy efficiency and environmental management programs, to promote energy efficiency program and to create new business opportunities for the industry
  - Developing new and innovative technologies for the extraction of phytonutrients from palm oil, palm fatty acid distillate (PFAD) and palm fibers - this includes the production of vitamin E from PFAD, extraction of carotenes and other phytonutrients from palm oil, glycolipids from palm, etc.
  - Application and introduction of clean and emerging technologies for the processing of palm oil and for the extraction of minor components from palm oil and its products
- Advanced Oleochemical Technology Division
  - R&D in non-food applications of palm oil and palm oil products
  - R&D to add value to palm-based basic oleochemicals
  - Provision of advisory and technical services

In 2007, the Tropical Peat Research Institute was created under the MPOB. This institute was formed with the objective of researching tropical peat soils for growing oil palm on, specifically to address issues of GHG emissions, carbon balances and biodiversity (MPOB, 2010a).

New Zealand:

In New Zealand, a major research project called Bioenergy Options for New Zealand comprised three reports: the Situation Analysis, the Pathways Analysis, and a Bioenergy Research Strategy. The research strategy for bioenergy developed in this project focuses on the following themes: bioenergy from plantation forests; biomass waste utilization; biomass residuals for distributed generation; next generation feedstocks and conversion technologies; and first generation biofuels. For the first generation biofuel research area, the priority is on assessing sustainability in the short term and conducting a science-based assessment of biofuels' environmental impacts. For the second generation feedstocks, the research priorities are around reviewing and developing current and new technologies (Jack, 2009).

The Pathways Analysis Report of this project, which, among other components, includes analysis of the environmental impact and economic viability of different pathways (routes from the biomass resource to the consumer use of the energy product). The project also involved LCAs of canola for biodiesel, forest residues for ethanol, forest residues for Fisher Tropsch liquids, forest product for ethanol, and forest product for Fisher Tropsch liquids (Hall, 2008).

From those reports, several other reports were built, including “Analysis of Large-Scale Bioenergy from Forestry: Productivity, Land Use, and Environmental and Economic Implications” (Hall, 2009). In one extension of the project, environmental and macro-economic impacts of different land use scenarios for a future economy-wide-scale use of forest resources for transportation fuels, among other products (Jack, 2009). The research on forestry potential for biofuels was driven by a belief low-productivity grazing lands on steep slopes could be utilized both to produce bioenergy and also to mitigate environmental problems associated with those lands (Hall, 2009).

It should be noted that in New Zealand, government support for biofuels is only for research and development of advanced biofuels (Natusch, 2010).

Peru:

Biofuel research in Peru emphasizes sustainable outcomes for the rural poor. Much of Peru’s biofuel research is NGO driven. Practical Action and Oxfam both have research underway related to small-scale biofuel production and use.

Practical Action has been partnering with the Universidad Nacional Agraria La Molina to research small-scale biodiesel since 2000. One focus of their work is on biodiesel from oils and vegetable plants in isolated Amazon communities (Coello, 2009). There are 24 known species of oil producing plants in the jungles of Peru (Ocrospoma, 2008).

Another emphasis of their research partnership is on vegetable oil for fuel blending in rural areas. For both, the objective of the research has been to determine how to make these scenarios feasible in a sustainable way. More recent research has focused on access to anhydrous ethanol in isolated communities, which is the main barrier to biodiesel use there. To test the environmental, social, and economic suitability of biodiesel in these areas, Practical Action began a pilot small-scale project in 2008 (Coello, 2009).

This research partnership received funds from the National Council for Science, Technology and Technological Innovation (CONCYTEC) to support several projects. These included the first scientific research on biodiesel in the economy. The following is a list of research projects supported by CONCYTEC and carried out by the Practical Action-UNALM partnership (Coello, 2009):

- Small-Scale Biodiesel Production Using Amazonian Oil-Yielding Produce (2003-2005)
- Design of a Sustainable System for Biodiesel Production and Use Appropriate to Isolated Communities in the Amazonian Jungle (2004-2005) (with participation by the Universidad Nacional de Ingeniería)
- Start-up of a Model Biodiesel Production Plant (2005-2006)
- Dehydration of Ethanol on a Small Scale for Biodiesel Production in Isolated Communities in the Amazonian Jungle (2006-2007)

Practical Action has also conducted research in partnership with Oxfam International. Together, these organizations studied work up until 2008 on the potential for biofuels in Peru, how they impact poor and rural poor livelihoods, and how biofuels may improve those livelihoods (Castro, 2008).

Singapore:

With Singapore's objective to be a regional hub for biofuel production and trade, the research that is taking place in this economy is on finding innovative ways to produce biofuel. BIOFuel Research, a biofuels production technology company, was the first company in Singapore to develop and use technology to convert waste cooking oil into fuel (BIOFuel Research, 2010). This is a sentiment shared throughout the economy, according to a representative of Singapore's Economic Development Board (Kolesnikov-Jessop, 2007).They are committed to using wastes and non-food crops for biofuel production. To improve the environmental impacts of their processes, BIOFuel Research pioneered a waterless process for producing biodiesel from vegetable oil by-products and a waterless biofuel production process that uses ethanol rather than fossil fuel-derived methanol (BIOFuel Research, 2010).

Chinese Taipei:

The government of Chinese Taipei supports various research efforts on biofuels from non food crops, including second generation biofuels (largely, cellulosic biomass) and waste cooking oil (Milbrandt, 2008). Domestic WCO provides 70% of the economy's biofuel (Lee, pers.comm, 2010). Additionally, government agencies, such as the Council of Agriculture and Bureau of Energy, research organizations and universities have research underway for evaluating the use of fallow and set aside lands for biofuel feedstock growth (Lee, pers.comm, 2010).

United States:

Given the United States' requirement of producing 21 billion gallons of "advanced biofuels" by 2022, biofuels research in this economy is focused on various feedstocks and technologies considered "advanced" in the United States. The majority of the "advanced biofuels" are expected to come from cellulosic ethanol. Large scale R&D efforts are underway to develop commercial scale technologies for producing cellulosic biofuels (Koshel, 2008).

Major U.S. corporations such as British Petroleum, Chevron, and Shell Oil have invested in biofuel research for cellulosic and algae ethanol. Chevron has biofuel research partnerships with universities such as the University of California Davis, and economy-wide laboratories, such as the National Renewable Energy Laboratory (Hess, 2009).

BP is providing $500 million over 10 years to the Biosciences Energy Research Laboratory in California for establishing a dedicated biosciences energy research laboratory attached to the University of California Berkeley, the University of Illinois, Urbana-Champaign, and the Lawrence Berkeley National Laboratory. This institute, known as the Energy Bioscience Institute, is initially concentrating on three key areas of energy bioscience (CLS, 2010):

- New biofuel components and improved efficiency and flexibility of current biofuels

- New technologies for enhanced and accelerated conversion of organic matter to biofuels to increase the amount of a crop which can be used as a feedstock
- Species development using modern plant science to produce species with higher energy yields and that can be grown on land not suitable for food production

The "Impact of Residue Removal for Biofuel Production on Soil" is an example of the type of sustainable biofuel related research underway by the Renewable Energy Assessment Project (REAP). This particular study is working to determine the optimal residue levels to leave on fields after harvesting and management techniques to preserve soil carbon and make residue harvesting sustainable. Some examples of management techniques being studied are cover crops, no-till farming, and organic farming (Winrock, 2010a).

R&D efforts are also underway to produce biofuel from new sources, for example biodiesel from various fungi. Among them, Mucor circinelloides is a fungus whose oil is converted to biodiesel without extracting oil from the growth cultures (American Chemical Society, 2010).

The U.S. Biomass Research and Development Initiative funds research projects in the following areas (BR&D, n.d.):

- "Feedstock production through the development of crops and cropping systems relevant to production of raw materials for conversion to biobased fuels and biobased products
- Overcoming Recalcitrance of cellulosic biomass through developing technologies for converting cellulosic biomass into intermediates that can subsequently be converted into biobased fuels and biobased products
- Product Diversification through technologies relevant to production of a range of biobased products (including chemicals, animal feeds, and cogenerated power) that eventually can increase the feasibility of fuel production in a biorefinery"

According to the National Biofuels Action Plan 2008, the National Biomass R&D Board is working on the following key action areas (Biomass Research and Development Board, 2008):

- Sustainability
    - Studies carried out to define and evaluate biofuel sustainability criteria, benchmarks and indicators
- Feedstock Production
    - R&D into high-yield biomass systems and dedicated energy crops that do not disturb current production paradigms and sustain and enhance the critical natural resource assets required for their production (e.g., water, air, and soil)
    - Development of dedicated bioenergy crops through traditional breeding and advanced biotechnology
- Feedstock Logistics
    - Research is taking place in further developing/improving: harvesters and collectors; storage facilities; processing & grinding equipment; and transportation of feedstocks
- Conversion science and technology
    - Current researchers focus is on cellulosic ethanol, which is likely to be the first cellulosic biofuel to become commercially available.
    - Potential also exists to produce other fuels including higher alcohols, "green" gasoline and diesel, and aviation fuels produced via enzymatic and microbial and/or chemical catalytic processing of biomass

- Blending
  - Intermediate Blends Test program to evaluate the potential impacts of intermediate blends on the existing vehicle fleet as well as on smaller engines such as those in lawn mowers, tractors, and other small off-road engines - this program will begin to provide the data needed for Federal fuel registration and approval for the use of intermediate blends of ethanol and gasoline in today's vehicles
- Environment, health, and safety
  - Research on the environment, health and safety impacts of using modern biofuels on a commercial level

Viet Nam:

Like Peru, Viet Nam's sustainable biofuel research is driven by NGOs. This research in Viet Nam primarily relates to biofuel feedstocks that do not compete with food or threaten lands with high conservation values. Green Energy Viet Nam has two waste-oil pilot refineries (JAToil, 2008) and is supporting research on jatropha (Janssen, 2009). One of their projects is with the Centre for Biotechnology in Forestry on cultivation and production methods for jatropha (Hadden, 2009).

Viet Nam also has an agreement, since 2007, with a Brazilian ethanol producer for technology and knowledge transfer. The next year, the Vietnamese government began a "Research, Development and usage of products of Jatropha curcas in Viet Nam in the period 2008-2015 with a vision to 2025" project that is planning for 300,000 hectares of land growing jatropha in 2015 and 500,000 hectares in 2025 (Schott, 2009).

Appendix B. Sustainable Biofuel Regulations and Policies in APEC Economies

Australia:

In Australia, biofuels sustainability regulations apply to biofuels which count towards certain targets, and therefore are tied to financial incentives. There are two pieces of legislation which restrict the biomass which can count towards receiving Renewable Energy Certificates: the 2000 Renewable Energy (Electricity) Act and the 2001 Renewable Energy (Electricity) Regulations. These legislation define municipal solid waste, wood waste, weeds, agricultural residues and forestry that can be used along sustainability principles. If wood is taken from a native forest, for example, the primary purpose for harvesting the wood cannot be for energy production and must be for a high value product, accounting for at least 51% of the revenue. It should be noted though, that there is criticism of this test for not having clear evidence of sustainability thresholds (O'Connell, 2009).

The only policy in Australia that specifically relates to biofuels sustainability is in New South Wales. The 2007 Biofuel Act in that state since 2009 has required that biofuels counting towards their biofuels obligation (mandatory E6 starting in 2011 and B5 starting in 2012 sold by primary wholesalers), the biofuel must meet sustainability standards. The RSB Version Zero Principles and Criteria for Sustainable Biofuel Production is supposed to guide the sustainability assessment, but since it is not ready to be put into practice, compliance is demonstrated through Environmental Assessments or other evidences of sustainability (McDowall, pers.comm. 2010).

For example, the Shoalhaven Starches Pty Ltd, a wheat processor, qualified towards the mandate through an Environmental Assessment to increase their ethanol production from 126 million liters per year to 300 million. The assessment contained several elements of sustainability assessments, including the GHG emissions of the project, an acoustic assessment, water management issues, scenic qualities of the locality, waste management measures, riverbank stability and riparian corridors, probability of site contamination, Indigenous and non-Indigenous cultural heritage, and flora and fauna assessment (including impacts on critical habitats and threatened species) (Shoalhaven Starches, 2008).

The biofuel sustainability requirement in the NSW Biofuel Act is still in the initial stages of use. It began in October, 2009, and at that time was only applied to domestic ethanol producers (because of the lack of ethanol imports and no biodiesel mandate). It has been applied to biodiesel since the biodiesel mandate began in January 2010, but the sustainability reporting for biodiesel has only recently been submitted, so the results are not yet available (McDowall, pers.comm. 2010). Some initial observations that have been made by these initial attempts at using the RSB and other sustainability criteria to qualify towards these biofuels mandates are that Version 1 of the RSB framework appears to be prohibitively more complex than version Zero, but the NSW Office of Biofuels plans on testing it and subsequently providing feedback to the RSB on its usability (McDowall, pers.comm. 2010).

China:

Under China's pilot ethanol program, several pilot public policies have been developed for ethanol, emphasizing energy safety, food safety, and environmental protection (Chaomin, 2007). The Chinese leadership's main concern with biofuels is competition for arable land and food grains and potential negative environmental impacts. Chinese policies enacted in 2007 ban new corn based ethanol plants and prevents food-grains from being used for biofuels feedstocks (Milbrandt, 2008). Although four of the five approved ethanol plants in China, they were all approved before 2004. The non-corn ethanol plant is more recent and uses cassava (Dahong, pers.comm. 2010).

China is considering giving subsidies and tax breaks to demonstration plants that use non-grain feedstock and plantations growing non-food crops (Milbrandt, 2008). Grains that are considered are sweet sorghum, cassava, sweet potato and cellulose (Tian, 2007).

A Low Carbon Fuel Standard is also under development in China. The Innovation Center for Energy and Transportation (iCET) has undertaken the project to develop what they are calling the China Low Carbon Fuel Standard and Policy. As part of this standard and policy development, experts from various research institutions, along with iCET and the China National Institute of Standardization (CNIS) gathered to draft a Fuel Carbon Emission Lifecycle Assessment Principles and Requirements. The CNIS is leading the standard's development, which will set the methodology for determining the lifecycle GHG emissions from all fuels in China (iCET, 2009).The standard is based on the same methodology used for the UK's RTFO, however, unlike the UK's, does not take land use change into account. In future reviews of the standard, land use change will be reconsidered (Earley, pers.comm. 2010).

To control for land use change, China has a land use management policy. There are stringent controls for conversion of cultivated land to residential land in order to protect cultivated land. All levels of government have to obey the policy and implement landuse planning (overall structural plan for landuse). In order to monitor land use change, the Chinese leadership has established an economy-wide land use investigation system, survey systems, and landuse management information system (Chen, pers.comm. 2010).

Hong Kong:

As Hong Kong's primary motivation for biofuel promotion is improved air pollution, policies for sustainable biofuels address quality control for the use of biofuels. An amendment to the Air Pollution Control Regulation sets standards for environmental quality associated with biodiesel in order to ensure substandard biodiesels are not used, causing harm to the environment. This amendment went into effect in July 2010 (L.N. 233, 2009).

Indonesia:

In Indonesia, the Energy and Mineral Resources Ministerial Decree No. 32/2008 requires biofuel producers to ensure feedstock sustainability and prove no harm the environment by way of environmental impact analyses (Ariati, pers.comm. 2010).

The Ministry of Agriculture has recently issued a decree on oil palm planting on peatland. It states that 'due to the lack of [mineral soil], [oil palm planting] can be done on peatland as long as it is done in accordance with the sustainability of peatland functions: (a) carried out only on community cultivation land, (b) on peatland that has depth less than 3 meters, (c) the subsoil under the peatland is not silica sand or acid sulfate soil; (d) the maturity of the soil is sapric (the most decomposed) or hemic (somewhat decomposed); and (e) eutropic peatlands' (Winrock, 2009c).

Additionally, an agreement between Norway and Indonesia was established entitled "Cooperation on Reducing Greenhouse Gas Emissions from deforestation and Forest Degradation." This included a declaration of a two-year suspension on new land concessions that convert natural forests into palm oil plantation between 2011 and 2013. In October of 2010 the details of the mechanism banning palm expansion into forests should be finalized (Soepardjo, pers.comm 2010).

Japan:

The primary policy covering biofuels in Japan is the Biomass Nippon Strategy. It was first introduced in 2002 with the aim of recovering waste biomass. In 2006 it was revised to set a target of consuming 500,000 kL of biofuels annually by 2010. A majority of that target would have to be met through imports, for which Brazil is seen as the most reliable source of feedstock (Edwards, 2007).

Sustainaiblity criteria for biofuels in Japan are under development as part of the Non Fossil Energy Act. A meeting was held and several working groups formed to discuss these criteria. The basic idea for sustainability requirements was published in March 2010 by a private gathering that involved the oil, car, and agriculture industries and think tanks. The gathering is observed by three ministries and funded by the Ministry of Economy, Trade and Industry (Ikeda, pers.comm. 2010). The working groups cover: assessing GHG emissions, competition with food, biodiversity, economy and supply availability. The GHG working group is developing a GHG LCA methodology. It will prohibit feedstocks grown on wetlands covered with water for most of the year, high density forests that are larger than one acre, and peat land. It will require that the LCA show at least a 50% emissions reduction. Sustainability requirements are not yet enforced or enacted in law (Ikeda, 2010). Food prices will be used as a major indicator for assessing the impact of biofuels on food production. Japan will use quantitative models to assess this relationship. In discussions about biofuel sustainability criteria, Japan has decided to examine impacts of biofuels producers in economies it will import from. Where there are negative social or environmental impacts, Japan will work on capacity building for good governance and sustainability certifications. Efforts will also be made within Japan to encourage the import of only biofuels which are produced sustainably (METI, 2010).

Korea:

In Korea, the Ministry of Environment conducted emissions tests on different biofuels and based on the results, recommended biodiesel as the biofuel for Korea. The Ministry of Commerce, Industry and Energy is now tasked to set the standards for biodiesel used in the economy. B10 and B20 were tested for air pollutants, and a subsequent standard for biodiesel was developed, similar to EN14214 (the European Standard for biodiesel) (Suk Lee, pers.comm. 2010).

Malaysia:

Malaysian biofuel policies began in 2005 because the government viewed it as a major market opportunity for palm oil, one of the country's biggest exports (Lopez, 2008). The National Biofuel Policy was enacted in 2006. The main objective of this policy is to reduce dependence on foreign oil and to increase palm oil demand. It also though has a vision of sustainability (MPOB, 2010b). It has five strategic objectives, the last of which is "Biofuel for a cleaner environment." This objective more specifically is to "enhance the quality of the ambient air, reduce the use of fossil fuels and minimize emissions of greenhouse gases (mainly carbon dioxide), carbon monoxide, sulphur dioxide and particulates through increased use of biofuels" (Lopez, 2008).

There is also a policy that restricts the amount of palm oil that can be used for biofuels. As palm oil is used for many other products, to assure that those industries (especially food) are not threatened, a maximum of six million tonnes of palm oil can be used for biodiesel annually (Schott, 2009).

To protect forest lands, which have been converted to palm oil plantations in the past, Malaysia made a commitment to maintain 55.6% permanent forests for wildlife habitat and biodiversity conservation. As one way of monitoring this, the Malaysian Palm Oil Wildlife Conservation Fund patrols the jungles surrounding palm oil plantations, improves riparian zones and has orangutan protection activities. To ensure that indigenous populations are not forced off their land, there is a law to protect them from palm oil expansion by law (Wahid, 2010).

Lastly, to address the highly polluting technique of burning to clear land vegetation in order to establish palm oil plantations, the government banned this practice in 1997. There is high compliance with this regulation because of a combination of strict law enforcement and high penalties (Lopez, 2008).

Mexico:

The Mexican Biofuels Promotion and Development Law is now in its second version, which contains additional provisions to take sustainability into account. In Mexico, as in many economies, competition with food is a major concern. The first version of this law passed in 2007 but was then vetoed by President Felipe Calderon because of its emphasis on corn and sugarcane for biofuels. Calderon said that the law did not sufficiently emphasize new technologies, like cellulosic biomass and algae that may be more sustainable (Chavez, 2009).

The second version of the bill came out in 2008 and sets the framework for all biofuel policy in Mexico. This law incorporates several sustainable development objectives (Chavez, 2009):

- Protect food security and sovereignty
- Foster rural development
- Reactivate the rural sector
- Reduce GHG emissions

It incorporates environmental protection by referencing mechanisms in environmental legislation and multilateral treaties on reducing GHG emissions and air pollutants. It requires the Secretary of the Environment and Natural Resources (SEMARNAT) to apply regulations from the Law on Biosafety and Genetically Modified Organisms to ensure sustainable use of natural resources and protect biodiversity.

Under this law, SEMARNAT is also responsible for ensuring that no forest lands are converted to agriculture for growing biofuels. Additionally, this organization is required to evaluate the sustainability of programs that come under this law. Two other departments also receive sustainability mandates under the law: the Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) and the Secretary of Energy (SENER) are charged with supporting research that allows for bioenergy production to be not harmful to the environment (FAO, 2010b).

The law also explicitly supports the most marginalized rural communities. It states that biofuels should not threaten food security by referencing the law on Sustainable Rural Development. To monitor this, it requires that the Secretary SAGARPA to review the impact of bioenergy developments on food and publicize the results. There is also a caveat to the law that only allows corn to be used as a biofuel feedstock when a surplus exists (FAO, 2010b).

New Zealand:

The New Zealand Biofuel Bill was put forward in 2008 contained sustainability criteria for the biofuels that counted towards it. However, this bill was repealed by the Energy Biofuel Obligation Repeal Act after the National Party gained power. Instead, there is now a subsidy for biofuels, not associated with sustainability criteria. The criteria that existed in the original bill were that the fuels not come from food crops, did not destroy biodiversity, and do significantly reduce GHG emissions. The criteria applied to domestically produced and imported fuels. The Green Party of Aotearoa New Zealand is attempting to put the bill forward again (Green, 2010).

Peru:

To support the development of biofuels in Peru, the government adopted Law 28054 “Ley de Promoción del Mercado de los Biocombustibles” in 2003. The main objectives of the Law is to diversify the fuel market, stimulate farming and agribusiness, promote sustainable development, and offer an alternative market in the fight against drugs (Milbrandt, 2008).

United States:

In the United States, the main regulation driving biofuel development is the Renewable Fuel Standard (RFS), established under the Energy Independence and Security Act (EISA) of 2007. The RFS requires 36 billion gallons per year of biofuels by 2022, and includes specific provisions for advanced biofuels, such as cellulosic ethanol and biomass based diesel contributions that pave the way for advanced technologies. Of the 36 billion gallons of biofuels, it requires that 21 billion gallons must come from cellulosic biofuel or advanced biofuels derived from feedstocks other than cornstarch and must meet a 50%-60% GHG reduction target compared to their fossil equivalent. Dedicated energy crops such as switchgrass and miscanthus have been targeted for biofuel production and other opportunities for willow and poplar exist. For conventional biofuels, there must be a minimum GHG savings of 20%. The RFS was amended to be one of the first standards to include a factor to account for Indirect Land Use Change. Inclusion of this factor has proved to be quite controversial (Winrock, 2010a).

These requirements are to ensure that increasing amounts of biofuels does not threaten food security and does reduce the economy's GHG emissions. The Environmental Protection Agency (EPA), Department of Agriculture (DoA) and Department of Energy (DOE)are required to report to congress on the domestic environmental and social impacts of biofuels (Winrock, 2010a).

The U.S. state of California has its own fuel standard, the Low Carbon Fuel Standard (LCFS). An executive order for the LCFS was issued in 2007. The LCFS was then approved by the California Air Resources Board in 2009. It is a performance-based standard that aims to reduce California's emissions from passenger vehicle fuels by 10% by 2020. Like the RFS, the LCFS includes and ILUC factor in its GHG calculations for biofuels. Additional sustainability provisions are currently being prepared and are anticipated to be ready by December, 2011 (CARB, 2010).

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