SUSTAINABLE BIOENERGY

LATIN AMERICA AND AFRICA

THE WORLD FACES A CHALLENGE: How to expand energy use and access without cutting forests or mining and drilling for fossil fuels. Using fossil fuels to provide transport, power industries, agriculture and cities threatens the climate with anticipated consequences for ecosystems, the economy and society as a whole. Yet, access to energy improves lives and is necessary for social development. This is especially important for less developed regions in Africa and Latin America, but also to maintain the standard of living in developed countries. This leads to big questions. Can we replace oil, coal and natural gas while also providing an economically strong base from which to grow? Can a renewable energy option provide for energy and food security, be environmentally sound, promote economic development and also be affordable and politically viable in developing regions?

WHAT'S THE ANSWER?

Along with other renewable energies such as wind, solar and hydropower, bioenergy can play a critical role in supporting sustainable development, particularly in Latin America and Sub-Saharan Africa, and strengthen resilience in managing climate change. There are several bioenergy options that can help reduce greenhouse gases, bring access to secure, reliable energy and improve infrastructure and essential services to cities and rural areas. New technologies or systems employing biomass for energy are constantly being developed, tested and introduced.

Energy from solar and wind can provide electricity, but bioenergy is an especially interesting option, as it can provide fuels that fit in the present infrastructure, while using renewable agricultural resources, including residues or parts of crops from sugarcane, corn, canola, soybeans, oil palms and aquatic plants. Forestry residues, by-products from crops and wastes from animal, urban and industrial origin are also used. Bioenergy can be used to provide heat, make liquid fuels and generate electricity alongside food and other bioproducts.

The development of bioenergy is critical to help mitigate the impact of climate change because it produces far fewer net emissions from greenhouse gases than fossil fuel. During their life cycle, plants capture carbon from the atmosphere. Even though burning plant biomass releases this carbon dioxide back to the atmosphere, replanting crops the following season absorbs carbon dioxide during photosynthesis.

ENERGY ACCESS

Energy is urgently needed for more than 1.4 billion people who have no access to electricity and an additional 1 billion people whose access is unreliable.[1] In Sub-Saharan Africa as a whole, only 290 million out of 915 million people have access to electricity and the total number without access is rising.[2] Four out of five people in Sub-Saharan Africa rely on the traditional use of solid biomass, mainly fuelwood, for cooking.[2]

Energy access is a prerequisite for key development goals such as education and income as well as advancing overall productivity and health.[3]

In a world that is moving away from fossil fuels, energy access goals call for affordable, modern and reliable renewable energy for all in order to maintain sustainable growth and development.

Modern bioenergy offers improved energy access for developing countries because:

- biomass can be stored to produce continuous rather than intermittent energy, making it easier to use and to integrate into unreliable power grids
- it uses a locally available resource
- it comes in many forms such as gas, solid, liquid, heat and electricity, providing versatility for various applications

Additionally, improved energy access through the production of bioenergy in rural regions can:

- improve agricultural productivity
- enhance land use management and reduce land degradation (for example when agricultural waste is used as a feedstock for charcoal production)[4]
- increase economic gains by adding energy products to the agricultural value chain
- improve family income
- create employment

In the developing world, most people use biomass in the traditional way: burning wood, charcoal or animal dung for cooking and heating. This causes indoor air pollution, resulting in respiratory problems, particularly among women and children. In Africa, for instance, more than 10% of children under the age of five suffer from acute respiratory illness associated with smoke from biomass burning.[5]

Just as significantly, the scarcity of wood in some rural areas means women and children spend much of their time collecting wood. Shifting to more efficient stoves and modern biofuels reduces time spent gathering wood and gives women more time to earn money and children more time for study, reducing poverty and increasing education levels.

Modern biofuels, such as biogas, offers other important benefits. Biogas can be produced in small-scale anaerobic digesters that turn animal and organic household waste into a clean fuel. Conversion to gas allows 24% of the energy content in dung and crop residues to reach the cooking vessel, while more than 90% of the nutrients and more than 80% of the humus are returned to cropland.[6] In Africa in early 2017 a commercial farm became the first company run on biogas to return electricity to their national power grid.[7]

ENERGY SECURITY AND STABILITY

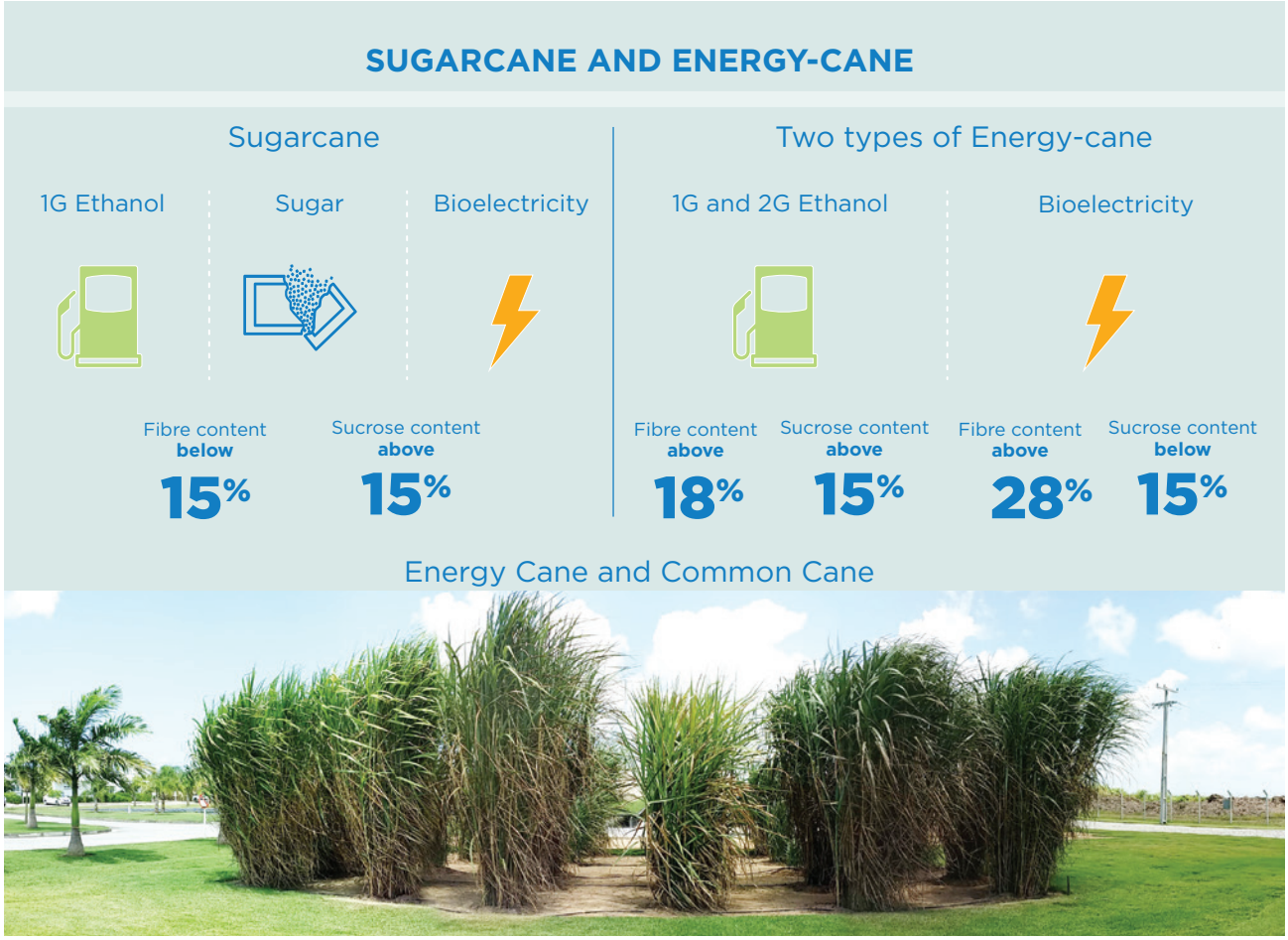
Energy security means ensuring a reliable, affordable and sustainable supply of energy for households, communities and nations.[8] Sustainable bioenergy is an attractive option because it can address multiple energy needs, such as power, fuel and heat with locally available feedstocks. Also, bioenergy helps to balance volatile energies such as solar and wind power and most importantly it is able to be deployed in scale and provide energy security in the transportation sector in a short period of time.

Many countries depend on imported oil and refined petroleum fuels for transport, making them vulnerable to events beyond their control. For example, there are growing concerns over the geographical concentration of oil, increasingly hard-to-reach reserves, restrictions on delivery or access, and high and fluctuating prices.

In Brazil, the significant share of ethanol that substitutes for gasoline shows how quickly the transition to renewables can be made. Nowadays sugarcane contributes 17% of the country's energy matrix meeting 25% of its gasoline needs.[9] [10] Furthermore, this can be expanded significantly. The Brazilian ethanol production by 2045 could displace up to 13.7% of crude oil consumption and 5.6% of the world's CO_2 emissions relative to 2014. This can be achieved without using forest preservation areas or land necessary for food production systems in the country.

Locally-produced transportation fuels made with local biomass allow countries to do an "end-run" around energy security challenges. Currently, bioethanol and biodiesel provide about 3% of the world's transportation fuels, but biofuels could provide up to 30% by 2060 with projected improvements in technology.[11]

The technologies for the transition from fossil fuels to renewable energy are within reach. Bioenergy has an important role to play in this transition in Latin America and Africa specifically because the plants and waste material used to create bioenergy are widely available or under development throughout these regions. For example, sugarcane and 'energy-cane' can readily be adapted to local conditions and address the demand for heat, bioelectricity and liquid biofuels.[12]



Sugarcane (middle) and energy-cane varieties developed for different applications. (Photo credit: Gonçalo Pereira)

ENERGY SECURITY NEEDS NOT BE MADE AT THE EXPENSE OF FOOD SECURITY

Since the 1970s "Oil Crisis," Brazil and Argentina have substantially increased the area of and yield from crops that can be used for food, feed, bioenergy and other purposes. More recently, and driven largely by the demand for food and feed from China, other Latin American countries have followed this trend and increased crop production. Latin America currently produces more food than it needs and exports food products to the rest of the world (for example, Argentina has a population of 40 million yet its export capacity can feed more than 400 million people). This scenario is likely to continue as Latin America's population is not expected to grow dramatically. In Africa, population is expected to grow and developing bioenergy should not be made at the expense of food security.

The concomitant increase in the production, use and export of bioenergy and other bio-products has directly contributed to improved economic development, infrastructure and employment opportunities and increased income in both rural and urban areas that help aid food security. The option to use their feedstocks for bioenergy or other bio-products has helped farmers to stabilize their income. This option has also had indirect social benefits to these countries:

- Technological gains (e.g. know-how, improvement in academic performance, technology jobs, patents)
- GDP and education improvements (in Brazil, in areas where the sugarcane industry is established).[13]
- Increased resilience to economic disruption (in Argentina, switching to using sugarcane for biofuel helped farmers in Tucuman Province withstand the economic disruption of low sugar prices and create resilience in the community).

R&D TARGETED AT BIOENERGY CAN BENEFIT FOOD PRODUCTION AND LAND PRESERVATION

A large percentage of land that is suitable for growing bioenergy crops is in Latin America and Sub-Saharan Africa. Some of this land is also suitable for growing food crops. Globally, one in four people[14] do not have reliable access to affordable, nutritious food. Consequently, there is a tendency to believe that land should be prioritized solely for food production in food insecure countries. But is it a matter of either/or?

Food insecurity is generally not caused by land scarcity but is more often due to underdeveloped institutions, lack of agricultural investment, low family income, poor infrastructure, and food waste.[15] This can result in land degradation, inadequate soil management, low yields and deficient food transport

and storage which leads to food loss. Since the population of Sub-Saharan Africa is expected to double by 2050, without a dramatic improvement in economic development and food production and distribution, the number of people who will be food insecure is likely to increase. The use of modern bioenergy in these areas can be part of the solution rather than being seen as competition for available land.[16]

- **Agroecological zoning can help reduce impacts**
  The expansion of the modern sugarcane-ethanol industry helped to improve the general infra-structure in the rural areas, which positively impacts other agricultural activities. Research targeted at a proper agroecological zoning, which has been implemented in Brazil, has limited the occupation of inadequate areas and reduced the impacts on the environment.[17] In addition, the enforcement of the Brazilian Forest Code might help to implement the concept of multifunctional agricultural landscapes in areas dominated by sugarcane plantations. Multifunctional agricultural landscapes have a primary mission of biological production, but a secondary yet fundamental mission is biological conservation, the two are actually complementary not antagonistic.[18]

Multifunctional landscape (Photo credit: Luciano M. Verdade).

- **Bioenergy crops can use land unsuitable for food crops**
  In Sub-Saharan Africa and Latin America there is substantial land available suitable for bioenergy expansion.[19] If water-scarce, marginal and degraded land is considered, there is an estimated 500 to 900 million hectares of land available without compromising food security or biodiversity.[20] [21] Bioenergy crops such as sweet sorghum, energy-cane, and other crops can tolerate these conditions, but further technological development must be pursued to make possible economic production of energy.

- **Pastureland can be used more efficiently**
  Pasturelands are more abundant than croplands and have the potential to provide large amounts of land for bioenergy expansion. Sustainable intensification of pasturelands with the integration of crops and/or trees can improve livestock production and spare land for other uses. This involves adopting improved varieties, and management practices that enhance soil fertility (e.g. crop rotation and irrigation) as well as exploring synergies – multipurpose species such as sweet sorghum and macauba palm, or pasture-forestry for instance, which provide not only bioenergy but also valuable co-products including animal feed.[26] It also involves training farmers in how best to apply these strategies.

	LATIN AMERICA	SUB SAHARAN AFRICA
Total land area (km^2)	19,197,000[22]	19,529,768[23]*
"Spare & usable" marginal land (km^2)[24]	3,600,000	4,500,000
Total population in 2015 [25]	640 million	1.1 billion
Projected population medium-fertility scenario in 2050[25]	780 million	2.2 billion
% undernourished 2014-2016[25]	< 5	23.2
GDP in 2014 in trillion US$ [25]	5.6	1.6

* This is the area of land in sub Saharan Africa on the continent of Africa, i.e. excluding small neighboring islands and larger very distant Indian Ocean islands like Madagascar, Mauritius and Seychelles that are sometimes lumped together as sub Saharan Africa.

- **Bioenergy crops can help stop land degradation or even restore depleted soils**
  Bioenergy crops with high biomass yield protect the soil from erosion and add organic matter. Different food crops can be rotated with energy crops. For instance, soybeans and peanuts, or green manures are cultivated after energy crops such as sugarcane. They provide food and help to restore soil fertility.[27]

Harvest residues protect the soil, recycle nutrients and increase soil carbon (Photo Credit: Heitor Cantarella).

- **Bioenergy crops offer good opportunities for nutrient recycling**
  In Brazil, sugarcane mills return residues such as ash, filter cake and vinasse from ethanol production to the field, which reduces the need for synthetic fertilizers.[18] [28] In Colombia, the sugarcane industry recycles its residues as compost.

- **Bioenergy can help create new markets for residues**
  In many cases, it's not even necessary to cultivate new land. Agricultural waste and residues such as sugarcane bagasse, corn stover and rice straw can be used for bioenergy, saving land otherwise used to produce bioenergy crops. Transforming waste, such as livestock manure and vinasse into biogas is also an option. The residue of biogas production can be further used as organic fertilizer. In both cases, there is an important added benefit: creating markets for agricultural waste products that can add to farmers' earning potential. Additionally, bioenergy and its feedstocks can be traded.

PRESERVING BIODIVERSITY, ECOSYSTEMS AND HUMAN HEALTH

In Sub-Saharan Africa where agriculture is 98% rain-fed, stagnant yields relative to the region's population growth have led to a fall in per capita food availability since the 1970s.[29]

In Latin America, agricultural lands in some areas are very likely to be subjected to desertification and salinization by 2050.[30]

Any time land is used, climate and environmental security may be affected.

Biomass production attracts biodiversity. Puma and anteater in biomass agricultural regions (Photos credit: Luciano M. Verdade).

Agriculture is a major user of water and competition for water will occur in some areas, requiring careful management of bioenergy feedstocks. Land use change requires effective monitoring. This will help protect biodiversity, wildlife habitat and the ecosystems that deliver services such as clean water or crop pollination. Changes in land use can also have social equity or human rights implications, such as when people are forced from their land. Such effects can be addressed through appropriate choice of bioenergy crops and management practices accompanied by methods of informed consent and good governance.

Additionally it is important to note that it is possible to combine forest preservation/recovery and ethanol production for sugarcane. Forests store 18 times more carbon than sugarcane and the combination of both, plus the expected increases in productivity due to technology improvement, would probably keep ethanol production stable along with the benefits of sustainable use of biodiversity.[31]

Air pollution in urban areas affects millions of people worldwide. Recent estimates indicate that 92% of the world's population lives where air pollutants exceed WHO limits.[32] Emissions of CO, NOx and ultrafine particles that can cause health problems including cancer are lowered when ethanol is substituted for gasoline.[33]

LOCAL JOBS THROUGH SUSTAINABLE DEVELOPMENT AND INNOVATION

Bioenergy can contribute to most of the Sustainable Development Goals (SDGs). In fact, among all renewable energy sources, bioenergy is by far the one with the potential to create more jobs in Latin America and Africa.[16] [34]

In general, the three types of innovative approaches needed to develop bioenergy are also required to meet wider sustainability goals:

1. Technological advancements such as systems to reduce emissions and improve water use efficiency
2. Organizational advancements such as changes in institutional behavior and green financing
3. Social advancements due to job creation, improved capacity building, better paid jobs

Still, each country's needs are different and the focus and scale of bioenergy operations should be tailored accordingly, including the development of local infrastructure. With the vast majority of poor people in Africa and Latin America dependent on agriculture for their livelihoods, producing bioenergy locally can harness growth of the agricultural sector

for broader rural development.[1] In low-income countries, the focus could be on creating jobs for local peoples. Middle-income countries, meanwhile, could develop markets and alternative feedstocks, while also meeting climate change goals. Developed countries could in turn target improved efficiency and climate change goals.

FINANCING

The International Energy Agency estimates US$13.5 trillion in investment will be needed over the next 15 years for low carbon technologies and gains in energy efficiency in order to meet global greenhouse gas emission targets.[35] The total support cost for developing novel biofuels would be some US$84 billion.[11] This sum, while substantial, represents a very small fraction of the total fossil fuel costs from now to 2040, which would total some US$ 33 trillion. Subsidies alone amounted to US$5.3 trillion worldwide in 2015 including both direct fiscal costs and implicit subsidies from the failure to charge for environmental damages or to tax energy at the same rate as other consumption products.[36]

Some of these funds will need to flow from more developed to less developed countries. One mechanism is the Green Climate Fund, established as part of the United Nations Framework Convention on Climate Change to help developing countries adapt to and mitigate climate change. Other options include joint efforts by the multilateral development banks on climate finance (mitigation and adaptation for climate change), that are investing their own funds, but maybe more importantly, mobilizing other sources of funding.

Bioenergy technologies are improving significantly and are becoming each time more competitive compared to oil based energy especially with the increase in biomass productivity. The high energy density of ethanol (around 70% of gasoline) highlights its potential to be used in transportation. It is helping secure a fast renewable energy matrix transition alongside solar and wind energy which are still subject to further development due to the lack of efficient energy storage systems. Bioenergy programs on a national scale may initially require some combination of subsidies, tax breaks, low interest loans and assured markets (mandates). This approach removes market and price uncertainties, allowing individuals and organizations to feel confident about recovering their investments. Governments must set target dates for removing these support mechanisms in order to encourage improved technology and more efficient production.

The production of sugarcane-based fuel ethanol in Brazil is a good example of how this approach could work. Brazil phased out direct subsidies to ethanol production in the mid-1990s. By 2002, the cost of making ethanol in Brazil crossed the world spot price of gasoline.[37] After this learning curve, fuel ethanol made in Brazil is cost-competitive with gasoline.

GETTING IT RIGHT

Bioenergy done right can transform the way we use our resources and land, driving improvements in food and energy production, environmental conservation and climate security. It also holds promise for international cooperation,[38] for reducing poverty and supporting sustainable development. Harmonizing and integrating policies across sectors – especially agriculture, forestry, energy, transport and waste – is fundamental for the sustainable production and supply of both food and biomass for energy. These should include policies for marginal land and coastal areas, where bioenergy expansion might also be expected.

Challenges for such multi-sector policies include rigorous and accurate evaluation of agricultural and forest goods and services, opportunity costs of land use conversion to alternative agroforestry systems, governance and law enforcement, institutional capacities, and safeguarding local user rights and land tenure arrangements. Monitoring and assessing projects will be key.

Considerations include:

- competing uses of biomass, animal wastes, and other residues for bioenergy vs other local needs
- getting local communities on board at the beginning
- promoting South-South and triangular cooperation between Latin America, Africa and developed countries for knowledge exchange and technology transfer
- conducting field trials for understanding how various strategies impact local ecosystems and economies
- improving both short and long-term data collection and reporting of lessons learned
- creating a set of best practices that can be applied across projects
- eliminating counterproductive subsidies
- creating market-based incentives for resource and infrastructure development
- sharing best practices across different countries and regions
- linking efforts of global organizations with similar goals on bioenergy and biomass resources

Getting it right with proper preparation, policies and monitoring can help bring both economic and environmental health and prosperity to Latin America and Africa.

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