# BIOENERGY AND SUSTAINABILITY

**Bioenergy**, a renewable energy source, has the potential to move the planet into a more sustainable future. Today fossil fuels supply almost 82% of the world's energy demand. The resulting green house gas emissions (GHG) impact Earth's systems and human health and wellbeing.

Currently bioenergy contributes approximately 10% of the world's primary energy supply. Bioethanol and biodiesel provide about 3% of the world's transportation fuels, but biofuels could provide up to 30 % by 2050 with projected improvements in technology. Bioenergy - developed knowledgeably and implemented considering local and regional needs - can help:

- increase resilience in food supply both locally and globally
- decrease pollution
- preserve biodiversity
- improve human health
- rehabilitate degraded land
- mitigate climate change
- provide economic and business oportunities

## WHAT IS BIOENERGY?

Bioenergy is produced from plant biomass and plant-derived residues and wastes. Photosynthesis converts solar energy and $CO_2$ into biomass. Conversion processes of the biomass provide energy in convenient forms - heat, fuel, or electricity - and, together with utilization, return $CO_2$ to the atmosphere in a sustainable cycle. Wood, sugar, starch or oil-rich plants (corn, sugarcane, oil palm, soy, rapeseed) are the most widely used raw materials for bioenergy today. Utilization of additional feedstocks such as grasses and more complete utilization of plants and residues (e.g. lignocellulosics from forestry and agriculture) are anticipated in the future.

## LIQUID BIOFUELS

Liquid biofuels – bioethanol and biodiesel – are helping to meet our growing transportation needs. The need for greener fuels continues to grow. In 2010 there were around 800 million cars in the world. By 2050 that number is expected to reach 1.7 to 2.1 billion. By then biofuels could be supplying up to 30% of the demand for liquid fuels.

Brazil and the US are the two largest producers and users of bioethanol as a transportation fuel. Lifecycle analysis of ethanol fuels indicates GHG reductions of about 76% for sugarcane ethanol in Brazil and 42% for corn ethanol in the US. Blends of 5-27% ethanol in gasoline are being used in more than 50 countries and advanced automotive technology has expanded the conditions for using ethanol. In Europe, biodiesel is the most important biofuel for transportation. Lifecycle analysis of rapeseed biodiesel in Europe indicates a GHG reduction of about 40%.

There is great potential for the expansion of traditional biofuels. Over 100 countries in the world grow sugarcane to produce sugar. These countries could also be producing bioethanol from sucrose and bioelectricity from the waste bagasse of the sugarcane industry. As new technologies mature, traditional biofuels are making way for the new "lignocellulosics" biofuels. These modern technologies not only use the biomass more efficiently, but can also produce a range of marketable co-products and bio-based chemicals. The profits from the sale of these chemicals could be used to help decrease costs of advanced biofuel production.

## BIOELECTRICITY AND HEAT

Bioelectricity is generated primarily from the combustion of biomass often in co-generation with other processes. It can also be produced when the biomass is burned together with coal.

In 1957, Mauritius became the first country to supply electricity from a sugar factory to the electricity grid by using bagasse, the fibrous matter that remains after sugarcane stalks are crushed. When burned in a cogeneration plant, enough energy is produced from bagasse to run the sugar mills, with enough surplus electricity that is sold back and fed into the utility's distribution grid. In 2012, the amount of electricity co-generated by sugar factories supplied 16% of Mauritius's electricity needs.

Traditionally, heat is produced from biomass in low-efficiency stoves and fireplaces.

However, in Scandinavia and some communities in the northern parts of Europe, central thermal plants are increasingly using wood, wood pellets and municipal solid waste (MSW) to produce hot water or steam. The hot water and steam are then distributed through district heating systems to office and apartment buildings. Some of these plants are also used for co-generation, producing both heat and electricity for the national electricity grid.

The use of bioenergy has increased steadily in this part of the world, contributing to about 23% of the total energy supply in Sweden. Currently, this use of bioenergy is more important than the use of liquid biofuels. The demand for MSW in the Nordic countries is now so large it must be imported from other parts of Europe.

GHG emissions can be decreased by up to 95% when wood, wood pellets and agricultural waste replace and are co-fired with coal in thermal power stations.

## BIOGAS

Biogas is well suited for both developed and developing economies. The capital investment can be small, the facilities can range from single-family units to industrial scale, and the technology is already available. Biogas is a mixture of methane and $CO_2$ produced by anaerobic digestion using organic waste (urban, agricultural or industrial) as the raw material or "feedstock".

The two main sources for biogas production are organic wastes, such as manure or landfill organics, and harvested biomass, such as dried or ensiled grasses.

Conversion to gas in family-size biogas plants allows up to 24% of the energy content in the dung and crop residues to reach the cooking vessel, while organic fertilizers are returned to the cropland.

In Asia, where biogas facilities are abundant, the feedstock is usually based on waste. In 2012 Germany reported more land area used for energy crops for biogas - primarily corn silage and grasses, digested with or without manure - than for production of biodiesel or ethanol.

Alternatively, biogas can be used to generate electricity or can be upgraded to methane, which can replace natural gas in transportation. Worldwide, there are about 17 million natural gas vehicles that can use upgraded biogas, including 1.7 million in Brazil, 1.5 million each in India and China, and 2.2 million in Argentina.

Currently, biogas is underutilized in most regions. Rural communities without access to conventional energy could particularly benefit from biogas initiatives.


**USA** Corn ethanol represents ~10% of the volume of gasoline used in cars

**Brazil** 1.0% of its land is planted with sugarcane providing 18% of the country's energy

**UK** Woody biomass is increasingly co-fired in coal-fired thermal power stations

**Sweden** Bioenergy is the 2nd largest energy source as wood pellets and household waste provide heating in most major towns

**Germany** 3x more agricultural biogas facilities than the rest of the EU combined

**Malawi** Africa's longest running biofuel program started in 1982 producing ethanol from sugarcane

**Kenya** 1.4 million new cooking stoves protect health and save a million metric tons of firewood annually

**Mauritius** 1st country where a sugar factory supplied bioelectricity to the grid; now sugarcane supplies 16% of the country's electricity

**China** Biogas units, running on animal and human waste, fuel 15 million homes

Courtesy: NREL

# BIOENERGY POTENTIAL AND BENEFITS

## Energy Security

Securing energy for the developing world means moving away from traditional inefficient bioenergy and its negative impact on the environment and human health.

Bioenergy in various forms plays an important part in the energy mix in both the developing and developed regions of the world. For over 1.3 billion people with no access to electricity, bioenergy can help improve energy security. It can lift rural areas out of poverty, ultimately securing a sustainable and equitable future. Access to reliable and affordable energy is essential for economically and environmentally sustainable development.

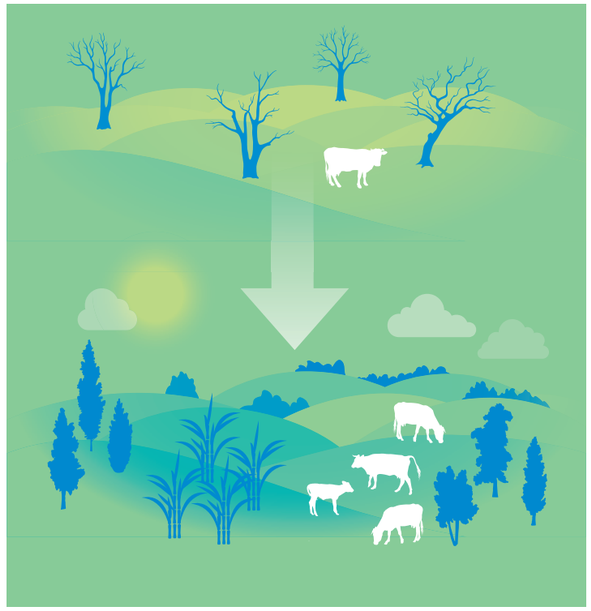
Today 2.8 billion people in the world burn wood and agricultural waste for cooking and heating. This inefficient 'traditional' bioenergy source causes respiratory illness and close to 1.6 million deaths per year, primarily of women and children. In India, solid fuels account for about 63% of the total household energy consumption, contributing significantly to both $CO_2$ emissions and hazardous indoor air quality. Cambodia, which had an estimated 1,304 deaths per million people in 2004 and India with some 954 deaths per million, occupy the top two positions in deaths attributed to indoor pollution, one of the leading causes of mortality in the world.

Redesigned cooking stoves that use wood or biogas with more complete combustion are now available that can help move away from traditional burning of biomass into modern bioenergy.

## Food Security

Modern bioenergy can help improve food security by optimizing land productivity and agricultural management, building synergies throughout the biomass and food supply chain. Around 70-80% of food insecurity problems occur in rural areas where energy insecurity or energy poverty are also concentrated.

Bioenergy can contribute to sustainable energy supplies, even with increasing food demands, with rising urbanization, and alongside preservation of lands and forests.



Pasture Intensification: Courtesy NREL

Future food security requires sufficient productivity, efficiency and land. Looking globally, enough land is available. However, availability is concentrated in two main regions, Latin America and Sub-Saharan Africa. Currently, this land is predominantly being used for low intensity animal grazing.

Bringing the poorest-performing pastures up to 50% of the maximum attainable density by using land more effectively would more than double the global stock of grazing animals. Sustainable pasture intensification has the potential to provide large amounts of land for bioenergy expansion.

Arid lands cover 30% of the Earth's land surface and could be used to produce hardy drought-resistant plants like agave for ethanol production. The development of marginal land for the production of cellulosic biofuels could improve land fertility and provide means for social development without using land suitable for food crops.



## Environmental and Climate Security

Bioenergy can play a critical role in mitigating climate change and addressing pressing environmental issues. However, consideration must be given to the sustainability and efficiency of bioenergy systems including the impact of GHG emissions from land use changes, food security, water resources, biodiversity conservation and livelihoods.

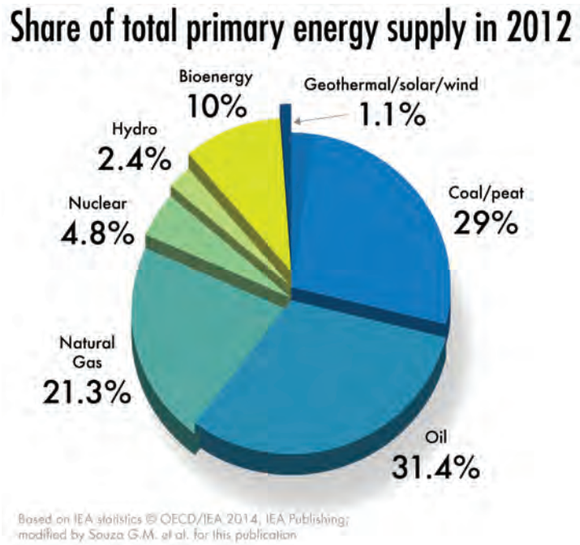
Climate security connects with global issues while environmental security connects to local and regional issues. The impact on local activities requires regulatory input from regional governments.

Bioenergy projects can be economically beneficial, contributing to farm incomes and increasing rural employment. Properly managed, many bioenergy crops can have a positive impact on the environment, helping to maintain soil quality while increasing carbon accumulation mitigating $CO_2$ emissions, and improving water quality. Conversely, poorly-managed projects have the potential to decrease the quality and abundance of both water and soil affecting food security, thus underscoring the need for thoughtful and effective governance.

**The positive implications of bioenergy for land use can be enhanced by:**

- production and utilization of co-products
- increasing bioenergy production from woody biomass, and crop wastes and residues
- integrating bioenergy production with crop production systems and in landscape planning
- increasing cropland productivity especially in developing countries, freeing up crop land for bioenergy crops
- deploying marginal or degraded lands.

The use of agricultural residues and advanced biofuels can help realize the maximum potential of bioenergy with the least negative impacts.




## Sustainable Development and Innovation

It is important to analyze the potential role of bioenergy in an integrated policy framework such as the 2030 UN SE4ALL (Sustainable Energy for All) goals. Modern bioenergy is naturally an integrating energy resource, linked to improving health, livelihoods and education.

Modern bioenergy can be applied from small-scale local use, stand-alone applications or mini-grids, to large-scale production and commoditization. Automotive biofuels and bioelectricity, or the replacement of inefficient traditional burning of biomass are some examples of modern bioenergy.

Sustainable bioenergy production promotes more efficient uses of agricultural and woody biomass, reducing deforestation by replacing the overuse of natural forest firewood, and reducing land degradation that is associated with low-productivity agriculture. Sustainable development can be more easily achieved with bioenergy than without it, but both political and individual will are necessary to enable its advancement.

# BIOENERGY AND SUSTAINABILITY

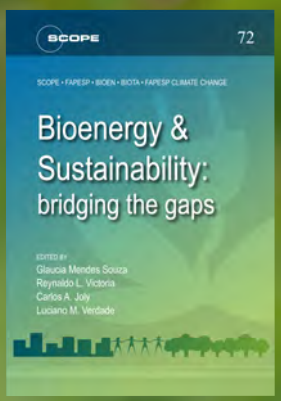
## THE WAY FORWARD

Bioenergy can have an important role to play in a low-carbon economy. Several scenarios indicate that bioenergy will have a share of 25% of the global primary energy supply in 2050. Bioenergy can be a driver to transform the way we use our resources and land. Inefficiently used land, extensive pastures, degraded lands and excess agricultural capacity and residues can be used for energy production and to bring added value and resilience into agricultural economies and human wellbeing. In order to fully realize this potential, policies are needed that will maximize the benefits of bioenergy and diminish potential side-effects.

Considerations include identifying:

- a sustainable and reliable biomass supply at the scale required regionally and locally
- appropriate pasture intensification programs for livestock production
- appropriate crops that can maintain productivity on marginal land
- high-yielding bioenergy crops that are more efficient in their use of water and soil nutrients and more resilient to climate change
- sustainability indicators ensuring adequate water use, land use, biomass choice and social aspects
- ways to integrate bioenergy production into existing activities (forest products, buffer strips, perennial rotations)
- best agroforestry practices and conversion processes, including the use of co-products
- how forestry and agriculture policies can best be harmonized, allowing for the sustainable production and supply of bioenergy in ways that do not compromise food production or other ecosystems services
- market-based incentives for resource and infrastructure development
- R&D driven improvements on conversion processes targeting both applications and underlying fundamentals
- innovative governance structures and business models that foster social and environmental benefits along with financial viability.

## MORE INFORMATION




This policy brief is based on an international workshop held in Paris, France in December 2013 and the resulting report compiled by 137 experts from 24 countries and 82 institutions to analyze a range of issues related to the sustainability of bioenergy production and use.

The full report "Bioenergy & Sustainability: bridging the gaps" is available for free download at: *http://bioenfapesp.org/scopebioenergy/index.php*

See the Bioenergy section in Issue 15/2015 Environmental Development, the transdisciplinary journal of SCOPE (Elsevier).
*http://www.journals.elsevier.com/environmental-development*

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