Bioenergy for Sustainable Development

Bioenergy represents a major type of renewable energy. As such, it is key to supporting the UN Sustainable Development Goals (SDGs) in the context of climate change and energy security. As summarized by the IPCC 5th Assessment Report, integrated assessment modelling indicates a high risk of failing to meet long-term climate targets without bioenergy. Global assessments by REN 21, IEA and IRENA find that bioenergy accounts for three-quarters of all renewable energy use today and half of the most cost-effective options for doubling renewable energy use by 2030. Bioenergy is part of a larger bioeconomy, including agriculture, forestry and manufacturing.

Bioenergy has a role in every energy sector

In the power sector, bioenergy can provide flexibility to balance expansion of intermittent and seasonal wind and solar resources. For industry, biomass can efficiently supply high-temperature process heat, in conjunction with a wide variety of valuable bio-based chemicals and materials. In the building sector, biomass provides the feedstock for highly efficient district heating systems, furnaces and cook stoves. In transport, liquid and gaseous biofuels can, together with electrification and vehicle energy efficiency, help achieve rapid and deep reduction in fossil fuel use. Biofuels are moreover the only current practical alternative to fossil fuels for aviation, marine shipping and heavy freight transport.

Opportunities and challenges of bioenergy

Bioenergy typically enhances regional energy access and reduces reliance on fossil fuels. It can vitalize the forestry and agriculture sectors and support increased use of renewable resources as feedstocks for a range of industrial processes. It can contribute to our global climate change mitigation goals as well as other social and environmental objectives.

But bioenergy can also have negative impacts if not developed and deployed properly. Three key concerns are food security, risks that land use and land use change from bioenergy expansion may increase carbon emissions or reduce biodiversity, and challenges in achieving economic competitiveness and providing high quality and affordable energy services.

Bioenergy is multifaceted. Specific bioenergy options (such as biofuels produced from edible vs. non-edible feedstocks) are not good or bad per se; sustainability impacts are context specific and depend on the location and management of feedstock production systems. Fortunately, significant knowledge and competence are available to govern bioenergy expansion so as to harness opportunities and minimize risks of negative impacts.

Options for sustainable bioenergy expansion

Inclusive multi-stakeholder processes can **identify areas best suited** for bioenergy production (such as for agro-ecological zoning) as well as appropriate arrangements for promoting positive effects of production and development while avoiding or mitigating possible negative impacts. As an example, **contract farming** can provide an opportunity for small-scale farmers to diversify their land use and gain new incomes from selling part of their produce for bioenergy.

Sustainable intensification and **landscape planning** – increasing output per unit of land while maintaining or improving ecosystems' health and productive capacity – can make land available for additional production while enhancing ecosystem services. So can **restoring degraded land** and **reducing losses in the food chain**. Biomass demand for energy can be met by integrating novel biomass production systems into agriculture and forestry landscapes. Such systems may use crop rotations, flexible crops (which can be used for multiple purposes), intercropping, and agroforestry approaches (such as use of nitrogen-fixing energy crops to boost yields of neighboring food crops). Integrated systems can produce food, feed, bioenergy feedstocks and other bio-based products from the same land area. They can also enhance biodiversity and mitigate land use impacts such as soil erosion, soil compaction, salinization, and eutrophication of surface waters related to excess fertilization.

As food production expands to feed growing populations, this will induce more **organic residues**, both on the field and in processing. A portion of crop residues is typically required for soil management, depending on local circumstances such as climate, soil conditions, topography and crop type. Other crop residues are used for animal bedding or feed. The remainder (including residues currently burned in the field, with high air pollution and climate change impacts), along with nearly all processing residues, can be removed for bioenergy production.

Similarly, as wood production in forests expands to meet growing demand for traditional forest products such as lumber and pulp and paper, there are significant opportunities to utilize **process and manufacturing residues**. Furthermore, significant volumes of **forest wood** that currently have no industrial use (such as wood of inferior quality and wood generated in natural disturbance events) can be used for bioenergy. Applying **sustainable forest management** principles will enhance the health and productivity of forests.

Furthermore, population growth and urbanization results in larger quantities of **post-consumer waste** – not only food waste but also construction waste and discarded goods with substantial energy content. Converting waste to bioenergy or higher value materials reduces the need for landfills and can also substantially reduce associated emissions of methane, which is a much more potent greenhouse gas than carbon dioxide.

UN Sustainable Development Goals and Paris Agreement

Bioenergy can play an important and constructive role in achieving the agreed UN Sustainable Development Goals (SDGs) and implementing the Paris Agreement on Climate Change, thereby advancing climate goals, food security, better land use, and sustainable energy for all:

- SDG-13: take urgent action to combat climate change and its impacts,
- SDG-7: ensure access to affordable, reliable, sustainable and modern energy for all,
- SDG-2: end hunger, achieve food security and improved nutrition and promote sustainable agriculture,
- SDG-15: protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- The Paris Agreement reiterates the "need to promote universal access to sustainable energy" while calling for "action to conserve and enhance … sinks and reservoirs of greenhouse gases" and for "reducing emissions from deforestation and forest degradation."

Enabling bioenergy expansion that supports SDG implementation requires that policies and measures to promote best practices are put in place. These should consider the variation in conditions across continents, ensure biodiversity safeguards, and promote multiple ecosystem services in landscapes. This requires coordinated land management and involvement of individual farmers, landowners, policy makers and other local and national stakeholders.

Trade-offs and synergies need to be discussed with relevant stakeholders who can also provide necessary information about the current land use and social, economic, and practical preconditions for on-going as well as suggested new land uses. Knowledge and management experience in use of biomass for energy should be shared across regions to promote best practices. This would facilitate the development of locally adapted management guidelines.

Measures to support sustainable bioenergy expansion

Several measures can help **boost yields and promote multi-functional land uses**, providing sufficient food and animal feed for a growing population, as well as biomass for bioenergy and other valuable bio-based products. Agricultural extension services can promote adoption of modern farming techniques and development of good management practices at a local level, including agroforestry strategies for growing a mix of high-yielding food and fuel crops in different soils and climates. Secure land tenure can give farmers financial incentives to manage their land for high yields while sustaining soil productivity. Logistical approaches for cost-effective harvesting and transport of agricultural and forest residues can be disseminated.

Other steps can support **better use of residues and waste from agriculture and forestry value chains**. Examples include incentives for sustainable use of residues, supported by guidelines to promote appropriate residue extraction rates in different conditions. Soft loans for machinery can further support the ramping up of bioenergy systems that use residues and waste as feedstock.

Use of degraded or marginal land is an option for biomass production that helps restore soil productivity and avoids or mitigates competition for higher quality land. Economic incentives to use such land should be combined with dissemination of information on suitable production systems and experience from previous initiatives, while protecting vulnerable communities.

Food chain losses could be reduced by promoting good harvesting techniques, investing in storage and refrigeration facilities, developing transportation infrastructure to safely deliver food to markets, discounting imperfect food items to encourage their sale, modifying labels so food is not discarded prematurely, and educating consumers to better match food purchases to their needs. Guidelines and support packages for governments and practitioners exist which show a number of practical approaches to sustainably meet food, feed and biofuel demand in the coming decades.

Bioenergy integrated in the bioeconomy

Bioenergy is part of a larger bioeconomy, also including agriculture, forestry, fisheries and the manufacture of food, paper, wood and agricultural fiber products, biomaterials, bio-based chemicals and medicines. This broader bioeconomy accounts for about USD 2 trillion of annual trade and one-eighth of overall global trade volume. Policies to **promote the bioeconomy** may include intensified efforts to map global soils, systematic monitoring of contributions to SDGs, development of skills and knowledge for using bio-based materials in manufacturing and consumer products, biorefinery demonstration projects combining production of energy and higher value materials, and research on new food systems, sustainable aquaculture, and artificial photosynthesis. They may also include specific renewable energy targets, mandates, loan guarantees and financial incentives.

The attitude towards biomass production for food, bioenergy and other purposes should evolve from single end-use orientation to **integrated production systems** that ensure high resource use efficiency and reward sustainable production and use. The output of such systems should be used with great care, striving to minimize waste and maximize efficiency while maintaining a healthy resource base for future generations.

Contributing organizations:

- *IRENA – International Renewable Energy Agency* www.irena.org/
- *IEA Bioenergy – IEA Technology Collaboration Programme on Bioenergy* www.ieabioenergy.com/
- *FAO – Food and Agriculture Organization of the United Nations* www.fao.org/

Further reading:

- *Mobilizing sustainable bioenergy supply chains: Opportunities for agriculture. Summary and Conclusions from the IEA Bioenergy ExCo77 Workshop, Rome, 17 May 2016.* www.ieabioenergy.com/publications/ws20-mobilising-sustainable-bioenergy-supply-chains-opportunities-for-agriculture/
- *Boosting Biofuels - Sustainable Paths to Greater Energy Security. IRENA, 2016.* www.irena.org/DocumentDownloads/Publications/IRENA_Boosting_Biofuels_2016.pdf
- *FAO's Bioenergy and Food Security (BEFS) approach – Implementation Guide. FAO, 2014.* www.fao.org/docrep/019/i3672e/i3672e.pdf
- *FAO Sustainable Bioenergy Decision Support Tool.* http://www.bioenergydecisiontool.org/
- *UN Sustainable Development Goals – 17 goals to transform our world.* www.un.org/sustainabledevelopment/sustainable-development-goals/

IEA Bioenergy, also known as the Technology Collaboration Programme (TCP) on Bioenergy, operates under a co-operative framework created by the International Energy Agency (IEA).