IEA Technology Roadmap: Delivering Sustainable Bioenergy

- Summary Paper -

Updated version prepared for PlanetEnergy, Jan. 2018

by Uwe R. Fritsche, Scientific Director, IINAS

Based on a thorough analysis of future development of bioenergy, the recently published new "*Technology Roadmap: Delivering Sustainable Bioenergy*" from the International Energy Agency (IEA 2017a)[1] provides an excellent "guide" addressing future needs for bioenergy, its resource potential, the various technology pathways to all end uses, and – last but not least – the sustainability issues of biomass.

The roadmap also formulates respective policy recommendations – both for research and development, and for implementation. In addition, the roadmap discusses financing requirements for sustainable bioenergy.

Bioenergy is a complex issue: the new IEA roadmap addresses the many possible feedstocks from agriculture, forestry and waste management, covers a multitude of conversion processes, and considers how bioenergy prospects are linked closely to the development of the broader bioeconomy (see Figure 1).

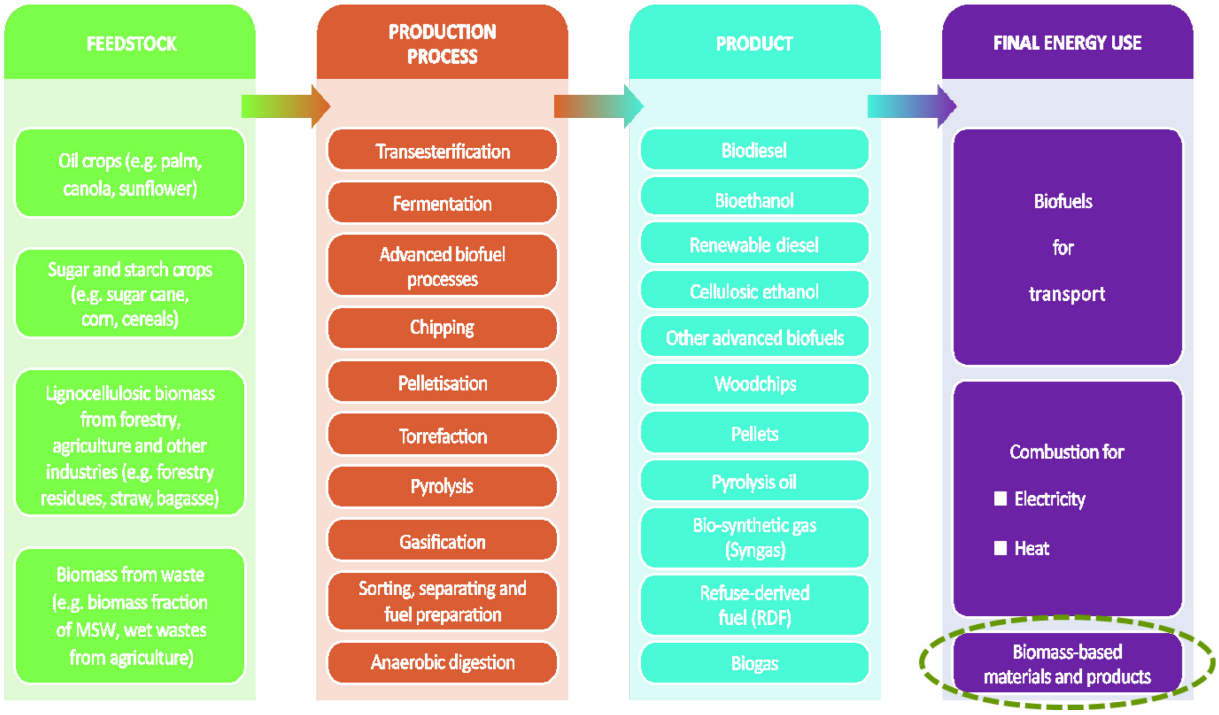
The real value of the new roadmap is that IEA recognizes only bioenergy supplied and used in a sustainable manner can play a role in a low-carbon energy future, and provides recommendations on the best way forward to ensure sustainable biomass is mobilized.

The roadmap integrates and updates the earlier roadmaps for biofuels (IEA 2011) and bioenergy (IEA 2012), adequately taking into account the broader context of the emerging bioeconomy to avoid resource competition.

---

[1] The new roadmap was developed in collaboration with the IEA Bioenergy TCP (Technology Collaboration Programme)

Figure 1 Biomass Pathways in the IEA Bioenergy Roadmap



Source: IEA (2017a); green dashed circle added

The question of 2°C

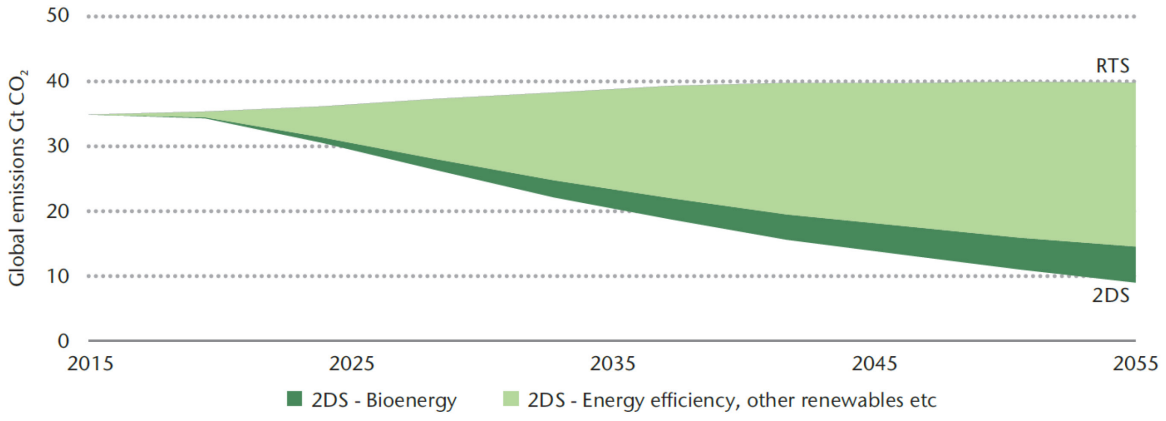
The roadmap clearly plots a path for the future development of sustainable bioenergy, based on IEA's most recent scenario work (IEA 2017b). The roadmap identifies technology milestones and policy actions needed to unlock its potential in a sustainable global energy system that stays within the 2 °C limit of the Paris Agreement.

It presents two scenarios with different levels of "climate ambition":

- 2DS (two degree scenario) aims at limiting global average temperatures from rising more than 2°C by 2100, while
- B2DS (below two degree scenario) aims at a "below 2°C" world.

A very relevant finding from comparing these scenarios is that the higher the climate ambition, the more bioenergy is needed to decarbonize (see Figure 2).

Figure 2 Bioenergy Contribution to CO_2 Reduction in the IEA Bioenergy Roadmap



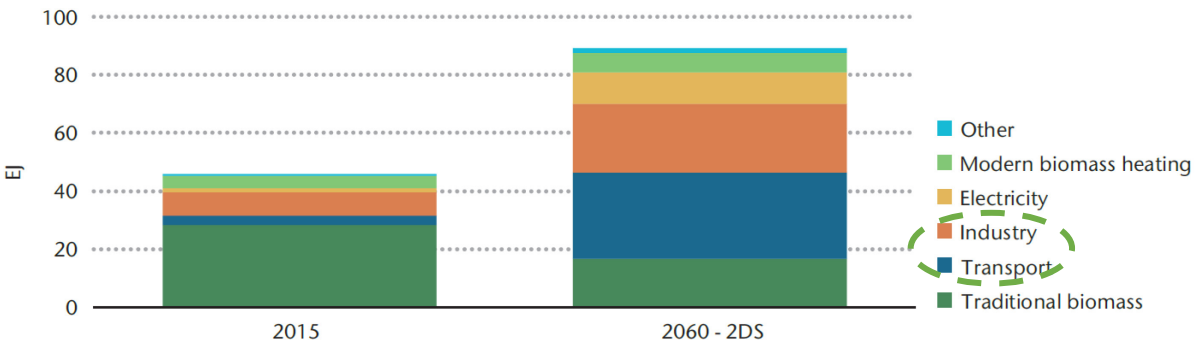
Source: IEA (2017a)

To achieve the CO_2 reductions in the roadmap, the bioenergy share in the global energy system will have to increase in both scenarios to about 140 EJ of primary energy from biomass (i.e. 2.5 times compared to 2015), and final energy from biomass to 1.5 times compared to 2015. The IEA roadmap assumes a significant overall improvement of efficiency in using biomass for energy[2].

The shift towards modern bioenergy

The IEA roadmap projects significant shifts from traditional uses such as firewood and charcoal to modern bioenergy and a massive increase of bioenergy use in the industry and transport sectors (see Figure 3).

Figure 3 Bioenergy Use for Final Energy in the IEA Bioenergy Roadmap

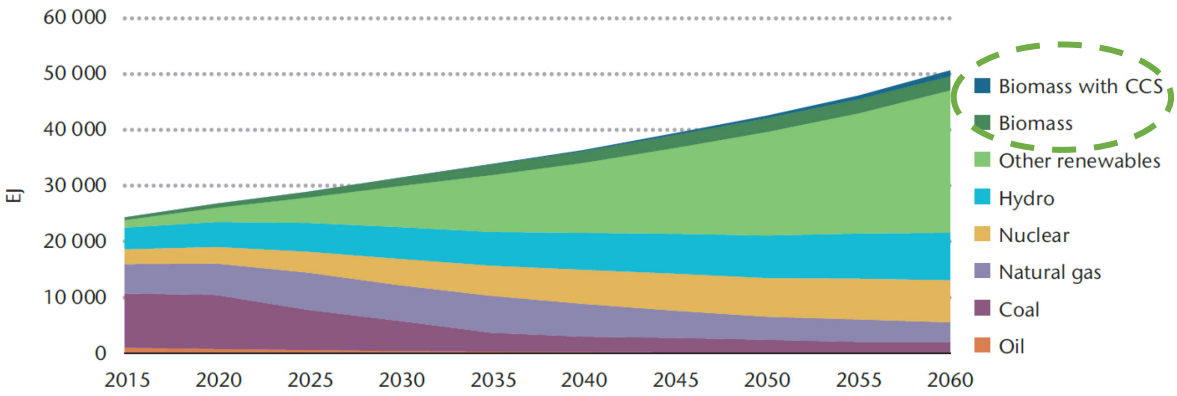


2 For this, the IEA assumes that "traditional" biomass use for cooking (mostly in developing countries) can be reduced and replaced by modern bioenergy systems (e.g. improved cookstoves, biogas, renewable electricity).

Source: IEA (2017a); green dashed circle added

According to the IEA roadmap, bioenergy use will also increase in future electricity generation – but its role will remain comparatively small, while other renewables such as solar and wind will become the dominant contributors (see Figure 4).

Figure 4 Electricity Generation Mix in the IEA Bioenergy Roadmap

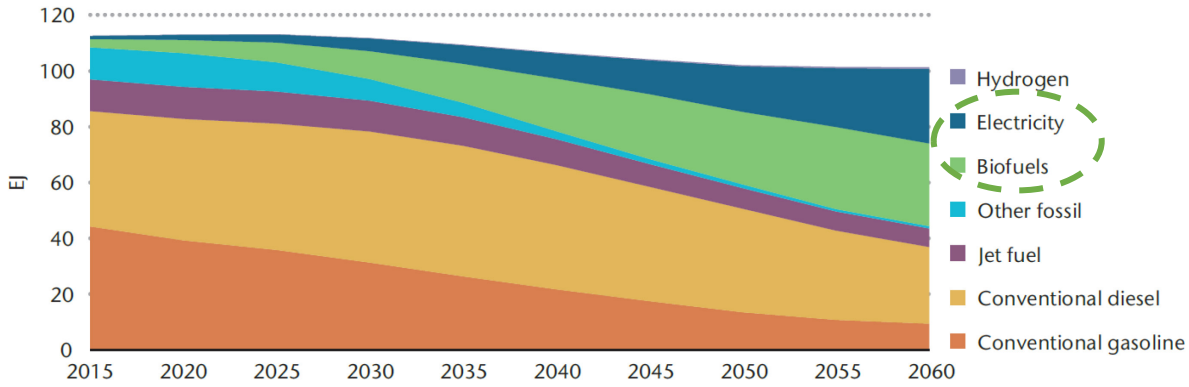


Source: IEA (2017a); green dashed circle added

Bioenergy for transport

The IEA roadmap clearly shows that bioenergy will have a particularly important role to play in the transport sector alongside renewable electricity.

Figure 5 Energy Demand for Transport in the IEA Bioenergy Roadmap

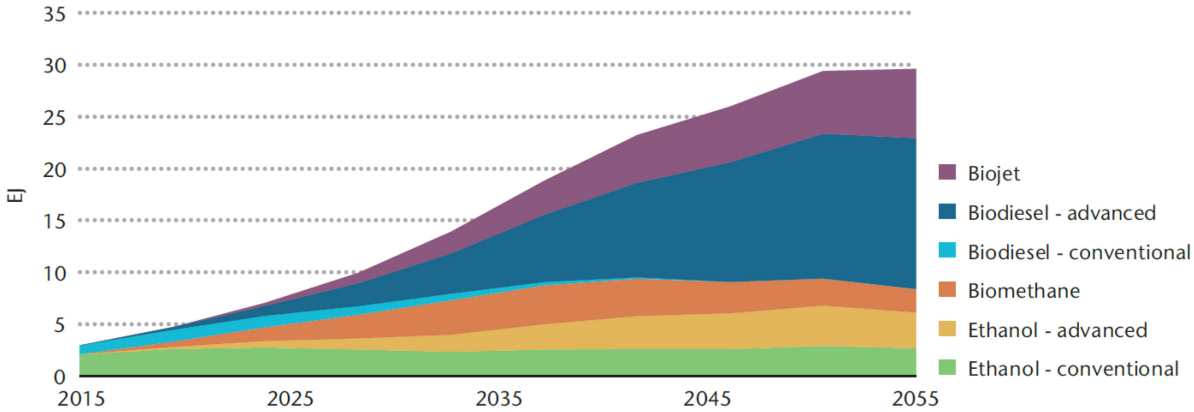


Source: IEA (2017a); data for 2DS; green dashed circle added

Biofuels in the IEA roadmap mainly help to decarbonize long-haul transport modes (aviation, marine and long-distance road freight). The overall contribution of biofuels to the global final energy for transport will have to rise from 3 EJ in 2015 to approx. 30 EJ by 2050, i.e. a ten-fold increase.

Biofuels will also change over time, with "advanced" biofuels from lignocellulose becoming the major contributors after 2030 (see Figure 6).

Figure 6 Biofuels for Transport in the IEA Bioenergy Roadmap



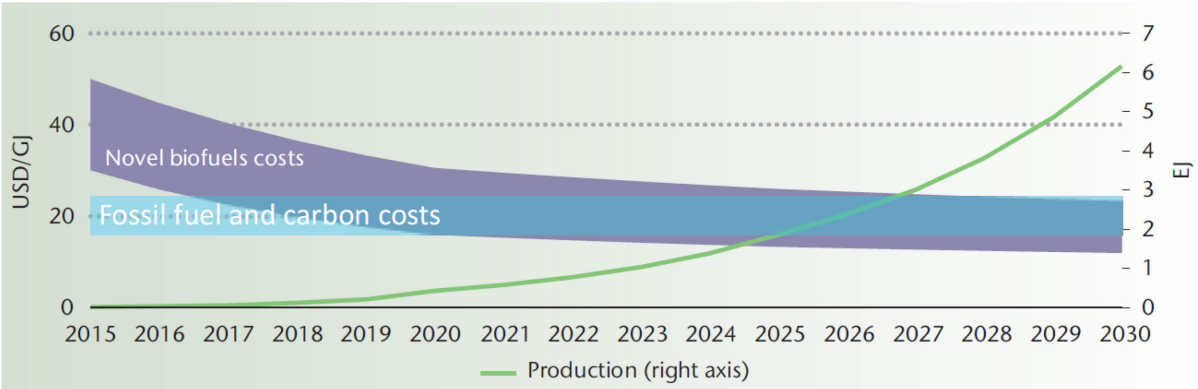
Notes: Conventional biodiesel refers to crop-based FAME biodiesel; advanced biodiesel refers to a range of advanced biofuels suitable for use in the diesel pool.

Source: IEA (2017a)

The role of advanced biofuels

As the major share will have to come from "advanced" biofuels, the IEA roadmap also presents an analysis of future costs for these fuels.

Figure 7 Advanced Biofuel Cost/Supply in the IEA Bioenergy Roadmap

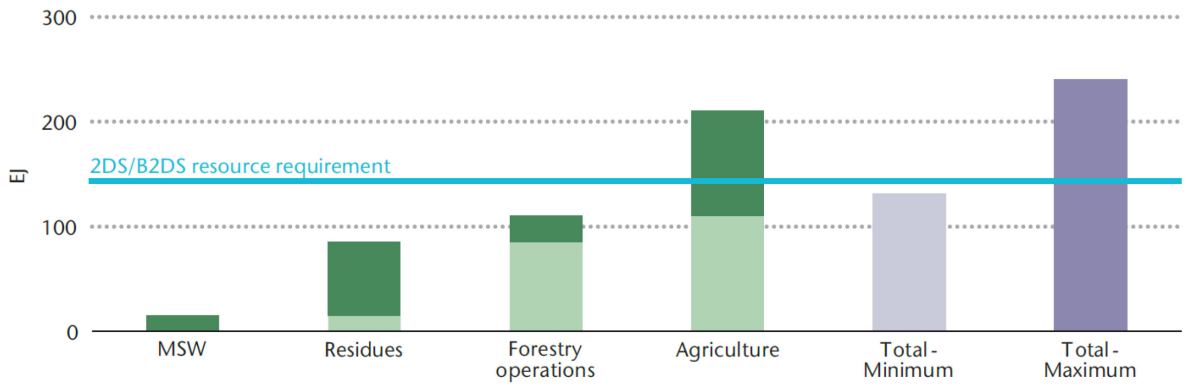


Source: IEA (2017a)

With increasing production of advanced biofuels, their specific costs are expected to decrease due to technological learning over time. For biofuels to become competitive with fossil fuels, a CO_2 price in the order of US$ 50/t is required, either as a tax or other price adder to the fossil transport fuels, though.

All in all, the IEA roadmap implies a massive increase in sustainable bioenergy supply (Figure 3), of which most could be obtained by mobilizing biogenic residues and wastes (see Figure 8).

Figure 8 Global Bioenergy Potentials in the IEA Bioenergy Roadmap



Source: IEA (2017a)

It should be noted that these potentials include possible contributions from rehabilitating marginal and degraded lands, which are substantial in many countries (Fritsche et al. 2017).

Sustainability and policy

The IEA roadmap strongly argues that to achieve the required increase in bioenergy supply and use, an appropriate approach to sustainability governance is needed.

For this, the "Sustainable Development Goals" (SDG) could be used as a normative framework, as the SDGs are quite strongly related to bioenergy (Fritsche et al. 2018).

The roadmap identifies several respective "actions" from for technology R&D, sustainable feedstock supply, and policy and finance. Policy recommendations are depicted in Figure 9.

Figure 9 Policy Recommendation of the IEA Bioenergy Roadmap

Action	Timing
Continue efforts to understand the role of forests as a carbon sink and interactions with sustainable forestry management and bioenergy.	2017-25
Continue efforts to understand interactions between bioenergy and land use, including work to establish real impacts of large-scale bioenergy deployment.	2017-25
Improve ongoing biomass potential analysis with particular emphasis on detailed regional and national studies, including the potential associated with low productivity agricultural land.	2017-22
Promote efforts to improve overall agricultural yields and production efficiency, especially in developing economies, through dissemination of best practice via international development initiatives.	Ongoing
Develop and demonstrate at scale co-production of energy alongside food and other agricultural products via agro-forestry and intercropping.	2017-30
Continue research on likely impacts of climate change on food production and availability of biomass for energy purposes.	
Develop, trial and produce energy crops with higher yields, such as "energy cane".	2017-25
Continue work to evaluate the potential of novel energy feedstocks such as algae and aquatic biomass.	2017-40
Develop and implement internationally recognised sustainability governance systems that cover all bioproducts, and which support sustainability best practice and stimulate innovation.	2017-25

Source: IEA (2017a)

The IEA has, in collaboration with partners, recently published further guidance documents (see IEA & FAO 2017; IRENA, IEA & FAO 2017) which should help policy makers to engage more prominently in establishing sustainable governance for bioenergy.

Last but not least, the IEA roadmap also calls for a more prominent role of

- international cooperation,
- building technical and institutional capacity, and
- enabling more investment.

This reflects the specific dynamics and conditions in emerging economies (Asia) and developing countries (Africa, Latin America) which will determine the global future use of biomass in general, and of bioenergy in particular.

References

Fritsche, Uwe R. et al. (2017) Energy and land use. Working Paper for the UNCCD Global Land Outlook. Darmstadt etc. https://global-land-outlook.squarespace.com/s/Energy-and-Land-Use__U_Fritsche-t9tw.pdf

Fritsche, Uwe et al. (2018) Linkages between the Sustainable Development Goals (SDGs) and the GBEP Sustainability Indictors for Bioenergy (GSI). Technical Paper for the GBEP Task Force on Sustainability. IINAS & IFEU. Darmstadt & Heidelberg http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/IINAS_IFEU__2018__Linkages_SDGs_and_GSIs_-_final.pdf

IEA (2011) Technology Roadmap - Biofuels for Transport. International Energy Agency. Paris http://www.iea.org/publications/freepublications/publication/Biofuels_Roadmap_WEB.pdf

IEA (2012) Technology Roadmap: Bioenergy for Heat and Power. International Energy Agency. Paris http://www.iea.org/publications/freepublications/publication/bioenergy.pdf

IEA (2017a) Technology Roadmap: Delivering Sustainable Bioenergy. International Energy Agency and IEA Bioenergy TCP. Paris http://www.iea.org/publications/freepublications/publication/Technology_Roadmap_Delivering_Sustainable_Bioenergy.pdf

IEA (2017b) Energy Technology Perspectives (ETP) 2017. International Energy Agency. Paris

IEA & FAO (2017) How2Guide for Bioenergy - Roadmap Development and Implementation. International Energy Agency & Food and Agriculture Organization of the United Nations. Paris, Rome https://www.iea.org/publications/freepublications/publication/How2GuideforBioenergyRoadmapDevelopmentandImplementation.pdf

IRENA, IEA & FAO (2017) Bioenergy for Sustainable Development. International Renewable Energy Agency, IEA Bioenergy Technology Collaboration Programme & Food and Agriculture Organization of the United Nations. Bonn, Rome http://www.irena.org/eventdocs/Bioenergy%20Side%20Event%20-%20Brief%20on%20BIOENERGY%20AND%20SUSTAINABLE%20DEVELOPMENT%2020170105.pdf