FACTSHEET – BIOENERGY

BACKGROUND

The energy transition requires a massive increase in investments. According to the 'Net Zero Emissions by 2050' (NZE) scenario[1] of the International Energy Agency (IEA), which is the most referenced scenario with low or no overshoot and limited reliance on negative emissions technologies, yearly investments in the "clean" energy transition must more than double and reach US$4.2 trillion by 2030. Meanwhile, investments in fossil fuels must decrease, and any support to their expansion must be stopped immediately. However, the role of certain energy sources and technologies should be nuanced. Consideration is particularly required when development is uncertain or associated with damaging social, environmental and climate impacts or risks, or poses too great a threat to the 1.5°C objective and global biodiversity protection targets.

This document debates the potential of bioenergy in the power sector transition. It is part of a series of factsheets that aim to guide the decisions of financial players wishing to contribute to a rapid and fair energy transition.

Bioenergy is produced from organic material, known as biomass, which contains carbon. When this biomass is used to produce energy, carbon dioxide (CO_2) is released during combustion and enters the atmosphere.[2] In simple terms, bioenergy encompasses solid biomass (mainly derived from wood), biogas, and biofuels (liquid fuels such as biodiesel or aviation fuels). This factsheet addresses the impacts of the different types of bioenergy and the place of bioenergy in the energy transition.

KEY ELEMENTS – BIOENERGY IN THE NZE

In 2023, modern bioenergy[3] accounted for 42 exajoules (EJ) or 7% of total global energy supply, according to the IEA.[4] Of this total, solid biomass amounted to 36 EJ, biofuels 5 EJ, and biogas 1 EJ. In the same year, traditional biomass[5] represented 19 EJ or 3% of the total global energy supply. In the electricity and heat sectors, biomass supplied 10 EJ or 4% of the total electricity and heat supply. Biofuels conversion losses accounted for 6 EJ.

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[1] IEA, World Energy Outlook, 2023.
[2] IEA, Bioenergy overview, accessed in November 2023.
[3] According to the IEA, "modern" bioenergy refers to the recovery of residues in industrial processes, biomass combustion (mainly wood pellets) for heating or electricity generation, and biofuels for the transport sector.
[4] IEA, World Energy Outlook, 2024.
[5] According to the IEA, "traditional" biomass refers to solid biomass as wood, wood waste, charcoal, agricultural residues, and other bio-sourced fuels as animal dung, used for heating and cooking with basic technologies, often with no or poorly operating chimneys, in low-efficiency processes (open fires, etc.), usually in emerging economies. However, according to its critics, this classification is problematic because what distinguishes "traditional" from "modern" bioenergy is simply that the former relies not on commercial exchanges but on the "commons", whereas the latter involves commercial interactions. DeSmog, The IEA's New Net Zero 'Roadmap' is Dangerously Reliant on Destructive Bioenergy, 2021.

The IEA's NZE scenario is one of the 1.5°C scenarios with low or no overshoot and limited reliance on negative emissions technologies that relies most heavily on bioenergy.[6] In this scenario, traditional biomass falls to zero by 2030, as universal access to modern cooking solutions is achieved.[7] The use of modern bioenergy is projected to increase to 71 EJ in 2030 and 100 EJ in 2050, representing 18% of the total global energy supply in 2050. Of this total, around a third is used in the electricity sector. Biofuel conversion losses would account for 14 EJ.

In comparison, the One Earth Climate Model (OECM) from the Institute for Sustainable Futures (ISF) at the University of Technology Sydney foresees 85 EJ of bioenergy supplied in 2050, primarily for process heat and aviation.[8] The Energy Transitions Commission (ETC) analyzed various studies to estimate the amount of bioenergy that could be supplied in terms of competition for land, lifecycle emissions,[9] and environmental and social considerations.[10] Its "prudent scenario" estimates the amount of sustainable biomass available for energy supply by 2050 at about 30-50 EJ per year. This is well below the NZE's estimation of 100 EJ supplied by 2050. One of the reasons behind the ETC's conclusions is that, given the negative impacts associated with bioenergy production, its application should be prioritized in sectors where there are no sustainable alternatives. In the case of bioenergy for residential heat and electricity generation, the ETC considers that its use should be minimized and phased out.[11]

KEY ELEMENT – SOLID BIOMASS

Solid biomass is primarily obtained from wood and is used mainly in the form of wood pellets and, in some cases, wood chips. This solid biomass is burned to produce electricity or heat. In the IEA's NZE scenario, modern solid biomass would account for 76 EJ (13%) of the total global energy supply in 2050, more than double the current 36 EJ (6%).[12]

When burned, wood emits at least as much CO_2 as coal per unit of energy produced, since it is less energy-dense.[13] Nevertheless, proponents of solid biomass claim climate benefits on the basis that carbon emissions from combustion are potentially recovered as the trees grow back. However, it would take decades for the released carbon to be potentially reabsorbed by forest growth. Scientists speak of the creation of a "carbon debt" that will increase as more trees are cut down to produce bioenergy.[14] This carbon debt occurs regardless of whether forest management is "sustainable" or not. As such, solid biomass is incompatible with the urgent need to reduce absolute carbon emissions in the short term.

To counter these arguments, solid biomass proponents often argue that pellet production from "residual" or "low value" wood has less impact on forests and greenhouse gas emissions. However, the definitions of "low value" wood and "residues" are largely based on economic considerations designed to limit competition between sectors, and take no account of the ecological, climate or cultural value of trees and pruning residues. As a result, it is often justified to use whole trees to make pellets.[15]

Similarly, promoters of solid biomass often point to the use of sustainability certifications as proof of sustainability. Yet, such certifications are not sufficient to guarantee supply chains free from

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[6] Reclaim Finance, NZE analysis, December 2021.
[7] IEA, World Energy Outlook, 2024, p.227
[8] University of Technology Sydney - Institute for Sustainable Futures, One Earth Climate Model 2021.
[9] Bioenergy accounts for 7% of methane emissions of the energy sector: IEA Methane Tracker.
[10] ETC, Bioresources within a Net-Zero Emissions Economy, July 2021.
[11] Ibid.
[12] IEA, World Energy Outlook, 2024
[13] Chatham House, Woody biomass for power and heat research paper, February 2017.
[14] Euractiv, Letter from scientists to the EU parliament regarding forest biomass, January 2018.
[15] Biofuelwatch, Briefing on wood residues, November 2020 and European Commission, Enterprise and Industry Directorate General, Study on the Wood Raw Material Supply and Demand for the EU Wood-processing Industries, December 2013.

deforestation and human rights violations, as many are based on weak principles and definitions.[16] Even if some have good principles in theory, several cases demonstrate that certifications can be flawed at different stages of the value chain, the certification process, or in the field.[17]

In short, as its combustion releases CO_2 and other atmospheric pollutants, solid biomass offers no benefits for the climate and generates health problems for populations living nearby.[18] Moreover, its production increases pressure on ecosystems and has negative effects on biodiversity and land use.

KEY ELEMENTS – BIOGAS AND BIOMETHANE

Biogas is a mixture of methane (45-75%) and carbon dioxide produced by the degradation of organic matter in an anaerobic environment. It can be used in its basic form or purified to produce biomethane (>95% of methane). Despite an important growth in recent years,[19] biogases represented only 1% of natural gas demand worldwide in 2023.[20] According to the NZE scenario, modern gaseous bioenergy could account for 15 EJ (3%) of the total global energy supply by 2050. This would be 15 times more than its supply in 2022 (1 EJ, less than 0.2% of global energy supply).[21]

Most biogas/biomethane is produced via methanization. Fermentable inputs such as manure, organic waste, and crop residues are collected in a digester, producing both digestate and biogas. The digestate can be used as fertilizer, and the biogas can be directly used for heat and/or electricity or be purified to produce biomethane with valorizations comparable to natural gas. In 2023, 50% of global biogas consumption by end use was for electricity and heat production, 26% for buildings (mainly for cooking), 7% for industry, and 17% upgraded to biomethane.[22] The most common feedstocks are livestock effluents (manure), agricultural residues, landfill gas, energy crops, sewage sludge (on-site), municipal solid waste, and industrial waste. Whether biogas can be beneficial to the climate depends largely on the feedstock used for its production, and the conditions of production.

Due mainly to land use change, biomethane from energy crops has greenhouse gas intensities comparable to those of fossil gas over its life cycle.[23] It also has potential impacts on biodiversity and soil quality, and can be in competition for land use with food and feed crops. When backed by conventional practices, it is likely to result in an increase of chemical inputs (fertilizers, pesticides…) and irrigation.[24] Biogas from waste can be beneficial in terms of waste management, as seen in emerging markets and developing economies in Asia.[25] Organic waste and animal manure provide benefits in several African countries when used for cooking and local electricity generation, preventing energy shortages, reducing deforestation and improving waste management. However, strong limits[26] and barriers related to cost, infrastructure, and expertise are hindering its development.[27]Manure has

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[16] Canopée, PEFC label analysis, February 2023 and Greenpeace, Destruction: certified, March 2021.
[17] YaleEnvironment360, Greenwashed Timber: how sustainable forest certification has failed, February 2018 and Dogwoodalliance, On The Ground, August 2018.
[18] Harvard, Health consequences of using biomass for energy, April 2022.
[19] The production of biogas worldwide has almost doubled between 2010 and 2023 and is currently growing at around 20% per year. IEA, Outlook for Biogas and Biomethane, A global geospatial assessment, May 2025, p.9, p.18
[20] IEA, Outlook for Biogas and Biomethane, A global geospatial assessment, May 2025, p.18
[21] IEA, Net Zero Roadmap, A Global Pathway to Keep the 1.5°C Goal in Reach, 2023 Update, p.194
[22] Ibid
[23] ICCT, Life-cycle GHG emission of biomethane and hydrogen in the EU, October 2021. The study shows that crop-based biomethane is unlikely to help achieving the EU emissions reduction goal.
[24] Agostini, A., Battini, F., Giuntoli, J., Tabaglio, V., Padella, M., Baxter, D., Marelli, L., & Amaducci, S. (2015). Environmentally Sustainable Biogas? The Key Role of Manure Co-Digestion with Energy Crops. Energies 2015
[25] For example, waste from cassava starch, biofuel industry, and pig farms in Thailand.
IEA, Outlook for Biogas and Biomethane, A global geospatial assessment, May 2025, p.20
[26] 20 to 30 kg of fresh manure are needed to prepare one family meal, along with quite the same amount of water. IEA, Outlook for Biogas and Biomethane, A global geospatial assessment, May 2025, p.20
[27] IEA, Outlook for Biogas and Biomethane, A global geospatial assessment, May 2025, p.20

considerable potential for reducing GHG emissions and is widely available. However, its methane yields are low compared to other biogas feedstocks,[28] and the huge risk of upstream methane leakage makes the reduction of GHG emissions very uncertain.[29] This raises even further questions, since supporting biogas from manure often comes down to supporting industrial farms and, therefore, their considerable impact on climate and forests.[30]

Methane leaks are another black spot of biogas and biomethane. It is estimated that important leaks may occur at different stages of the production, storage (biogas and digestate), upgrading, transport, and consumption processes.[31] The high uncertainties in methane leak rates make their potential to reduce GHG emissions unreliable. Improvements in practice along the biogas and biomethane production supply chain are needed to ensure climate benefits. In any situation, using biogas/biomethane, as a methane-based energy, has the same climate-related problem as fossil gas.[32] A synthesis analysis of existing biomethane and biogas supply chains leads to emission profiles similar to natural gas.[33]

Considering all these aspects, biogas production should be limited to livestock manure, agricultural residues (except for dedicated energy crops), and food waste to reduce direct and indirect changes in land use and provide higher GHG reduction potential. But specific conditions must be met, limiting methane leaks and other environmental impacts. Focusing on these feedstocks significantly reduces the production potential of biogas. For example, the International Council of Clean Transportation (ICCT) analyzed this question for the EU to 2050 and concluded that "*there simply is not nearly enough cow manure, garbage, and agricultural residues to meet gas demand without relying heavily on the continued use of natural gas*".[34] It estimated that the maximum potential production of "renewable gas" could only replace 12% of projected EU gas demand in 2050, or 3% of energy demand for electricity generation.

The cost-competitiveness of biogas is another issue often raised. For example, in the case of biomethane produced from livestock manure, a common challenge is that farms are often located a significant distance from the gas grid, meaning notable additional costs to establish the transportation infrastructure from farm to point of use.[35]

Furthermore, biomethane development relies on current fossil gas infrastructure, particularly gas transportation and distribution networks. Besides, additional gas networks are built to connect the new biomethane plants. New gas power plants are built under the mention that they will use biomethane instead of fossil gas in the future, without any details of when it will effectively occur. Therefore, it contributes to maintaining and developing this infrastructure and supporting a continued use of fossil gas.

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[28] Boulamanti, A.K.; Donida Maglio, S.; Giuntoli, J.; Agostini, A. Influence of different practices on biogas sustainability. Biomass Bioenergy 2013

[29] ICCT, Life-cycle GHG emission of biomethane and hydrogen in the EU, October 2021, p.20

[30] Nelson Iván Agudelo Higuita; Regina LaRocque; Alice McGushin, Climate change, industrial animal agriculture, and the role of physicians – Time to act, 2023

[31] Methane leaks during the biogas production process can range from 0% to 12% (Reinelt et al., 2016), and a further 0.2-10% during biomethane upgrading, depending on the technology used (IEA Bioenergy, 2009; Sun et al., 2015; Ardolino et al., 2021; JRC, 2024). Leakage from digestate storage can range from 0.8% to 15%, depending on the storage conditions. Site-specific measurements for whole plants have suggested average leakage rates of around 2.4% for agricultural biogas plants and 7.5% for wastewater treatment plants (Scheutz and Fredenslund, 2019), and around 2% for large-scale plants compared with 5.5% for small- and medium-scale plants.

[32] Reclaim Finance, Methane: an imminent threat for climate, October 2023.

[33] Semra Bakkaloglu et al., Methane emissions along biomethane and biogas supply chains are underestimated, June 2022.

[34] ICCT, Renewable gas is a distraction for Europe, November 2018.

[35] Ibid.

➢ Synthetic biomethane (syngas)

Syngas is different from biogas. However, together with biogas, it is considered by many companies to be a "renewable gas". As such, we think it is important to mention it briefly in this document. Pyro-gasification consists of the pyrolysis of solid biomass followed by an oxidizing gasification stage to produce syngas. To produce biomethane, this syngas is cleaned to remove any acidic and corrosive components. The methanation process then uses a catalyst to promote a reaction between hydrogen and carbon monoxide or CO_2 to produce methane. As a product of solid biomass, syngas raises the same concerns as the use of solid biomass described above.[36]

KEY ELEMENTS – BIOFUELS

Biofuels are liquid fuels derived from biomass or waste, namely ethanol, biodiesel, and hydrotreated vegetable oil, which can be upgraded to aviation fuel. Most biofuel production currently uses so-called conventional feedstocks, such as sugarcane, corn, and soy. Other possible feedstocks include waste, residues, cooking oils, and residual animal fats. Another technology sometimes considered is the cultivation of microalgae, but this solution has not yet been developed on an industrial scale.

In 2050, the NZE scenario projects that modern liquid bioenergy could account for 12 EJ (2%) of the total world energy supply. This would mean more than two times the current supply (5 EJ, 8%).

Biofuel raises similar concerns to biogas, since its climate impact depends on the feedstocks used to produce it. But even in the best-case scenarios, biofuels are not likely to have significant climate benefits.[37] On the contrary, modern biofuels have a higher emission factor than fossil diesel fuel.[38] This is due to emissions from direct and indirect land use change, including deforestation, as well as nitrous oxide emissions from increased fertilizer use and carbon emissions from energy-intensive refining. In addition to the climate impacts of land use change, another concern is that biofuels divert crops from food production to energy production, leading to higher food prices. This has been one of the consequences of first- and second-generation biofuels in the past.[39]

[36] Biofuelwatch, Biomass gasification and pyrolysis report, June 2015.
[37] ICCT, Will someone please tell me if biofuels are good or bad for the environment, December 2019.
[38] Nature, Bioenergy-induced land-use-change emissions with sectorally fragmented policies, June 2023.
[39] FNE, Méthanisation: Définition atouts et enjeux, February 2019.

RECLAIM FINANCE'S POSITION

Reclaim Finance is not in favor of the development of bioenergy in the energy sector, especially for power and large-scale heat generation. Bioenergy comes at the expense of agricultural land, human health, natural ecosystems, and biodiversity, with uncertain gains in terms of climate change mitigation. Although it could be possible to limit the negative impacts associated with some types of bioenergy supply under certain conditions, in practice, it is very difficult to guarantee compliance with these conditions. This is particularly the case if bioenergy is to contribute to meeting the massive demand projected by some climate scenarios.

Regarding power, bioenergy competes with solar or wind for financing. Financial institutions should support sustainable power sources as a priority, such as solar and wind,[40] and not include bioenergy in their energy transition financial and capacity targets, or in their energy transition/sustainable financing frameworks.

The inclusion of carbon capture and storage technologies does not justify bioenergy use. The conversion of coal plants to bioenergy plants for power or heat must not be supported. Similarly, new fossil gas infrastructure should not be developed on the pretext that it will be used with biogas or syngas in the future.

[40] For a detailed definition of sustainable energy, see Reclaim Finance's article The limits of (not so) clean energy, October 2023.