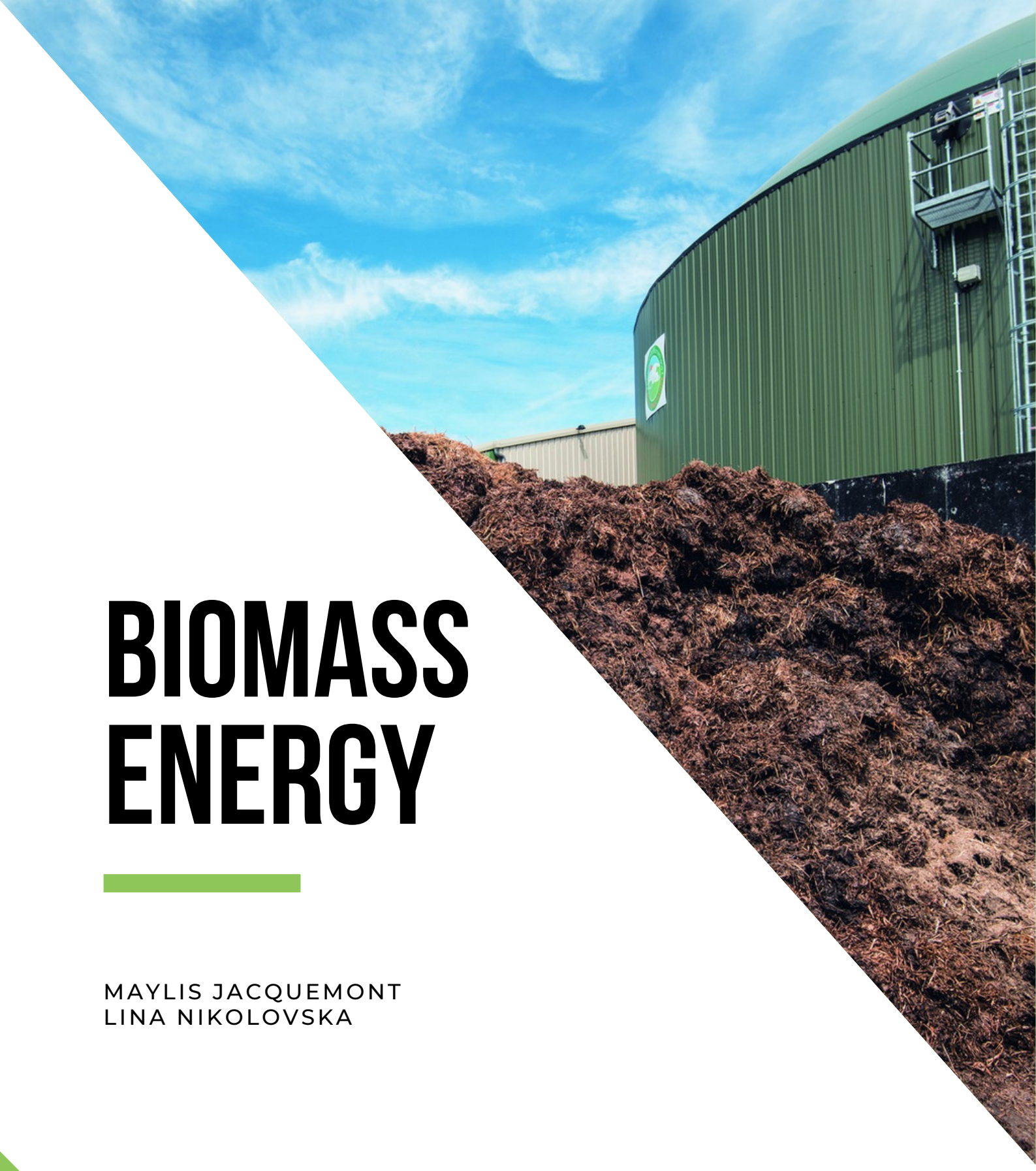

BIOMASS ENERGY

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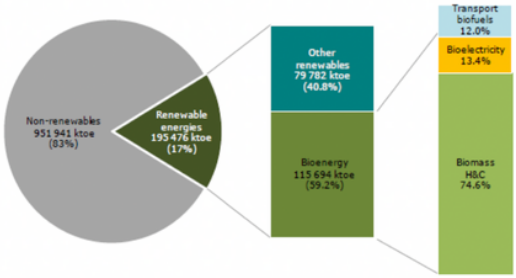
GREEN LIGHT FOR BUSINESS

Biomass: a renewable energy



From the invention of fire until the discovery of oil, biomass has been the main source of energy for our ancestors. It is undeniable that biomass is an abundant resource: it surrounds us, from forests to landfills. In the case of wood, most of this organic matter initially derives its energy from the sun through the photosynthesis process. Thus, compared to fossil fuels which require hundreds of millions of years to refill, biomass resources may be generated in an exceptionally short amount of time. Looking at it this way, it is a sustainable and clean energy source which may replace polluting ones. Therefore, bioenergy is considered today one of the most straightforward renewable energy sources and amounts to 59% of renewable energy and over 6% of global energy supply. However, its production is quite contentious regarding its approach to sustainability. Indeed, too vast a demand in this sector may lead to overexploitation of ecosystems and detrimental effects on biodiversity and soil quality. We will attempt to understand the prerequisites for biomass to be a sustainable fuel by examining the three main sources of biomass, namely wood, municipal solid waste and animal waste.

Wood Bioenergy

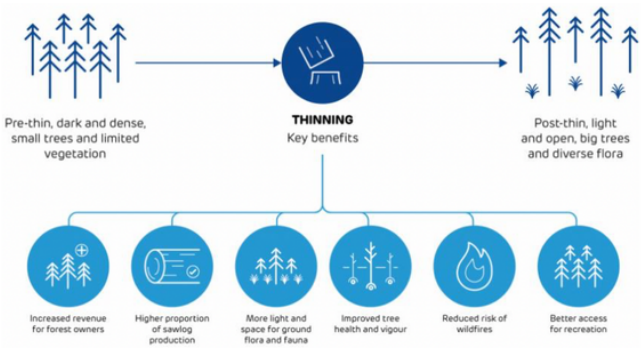
Some countries, such as the EU, the UK and the US, consider wood bioenergy to be a “climate-friendly” fuel, especially when compared to burning coal. Thus, they subsidize it heavily to meet their renewable energy targets. It represents a significant industry: global production of wood pellets reached 29 million tonnes in 2021. However, those countries often fail to take into account the amount of carbon dioxide emitted from wood pallets combustion. In fact, manufacturing and burning wood pellets leads to massive deforestation, air pollution, and eradicates woodlands that are essential for wildlife habitat, water filtration, oxygen production, and carbon dioxide sequestration.

I - A SOURCE OF DEFORESTATION

The manufacturing of wood pallets for bioenergy production can be seen as a massive contributor to deforestation. In the process, it is likely to disrupt the plants and animals’ habitats, on top of impacting the health of the surrounding soil, which requires biomass for compost and fertilization.
In terms of carbon emissions, deforestation implies the release back into the atmosphere of the carbon stored by trees, thus contributing to climate change. Moreover, as a result of deforestation and forest degradation, certain forests currently produce more carbon than they absorb, changing them from carbon "sinks" to carbon sources.

The process of thinning

To address those issues, it has become necessary to develop some ecologically responsible



strategies and techniques of production. The importance of sustainable forest management has been highlighted, namely the fact that sustainably managed forests do absorb more CO_2 compared to average. The practice of “thinning” has become widely established: “weaker trees" are cut down or trimmed, allowing the remaining forest to develop, while some younger trees are reintroduced.

Compared to mature trees, whose growth is moderate, young trees absorb higher levels of CO_2, counterbalancing the emission of CO_2 by deforestation. “Thinning” also helps in protecting the forest as a whole from incidents like fire and diseases, as well as improving habitat conditions for wildlife species. According to experts, the fires in Australia at the end of 2019 were intensified by poor forest maintenance: the denser the forest and the more debris left on the forest floor, the faster a fire may spread.

II - ISSUES RELATED TO REPLANTATION

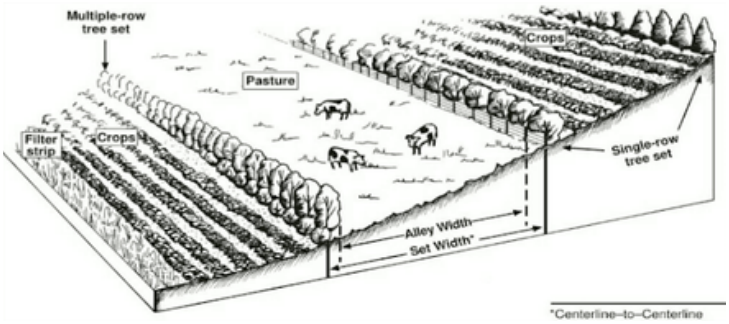
One increasingly popular practice is the replantation of trees in previously deforested areas. While this idea might sound as an intriguing strategy to battle the rising carbon emissions in the atmosphere in the short term, it has been shown to have devastating impacts on the environment. Indeed, it poses huge threats for the rising famine and droughts in the world due to increased water usage and land use. To demonstrate the negative impacts that the act of replantation poses for the environment it is crucial to examine recent real life examples.

Brazil's, South Africa’s and India’s Replanting Efforts

South Africa, India and Brazil are one of countries where the replanting efforts are present on the largest scales. In particular Brazil, known to be the world's largest producer and exporter of soybeans and beef, has been undergoing significant deforestation for almost a decade. In 2021, the country launched a replanting campaign aimed at restoring the Amazon rainforest. Environmentalists from all over the world criticized this act as they argue that the plantations meant for replanting trees occupy valuable finite resources such as land and water that could be utilized to reach other objectives laid down by the UN SDGs.Overall, in order to ensure proper minimization of negative impacts, it is of utmost importance to consider the ecological context of the specific practices, taking in account the ecological methods used, the species planted, and the surrounding landscape.

Diversified agroforestry systems

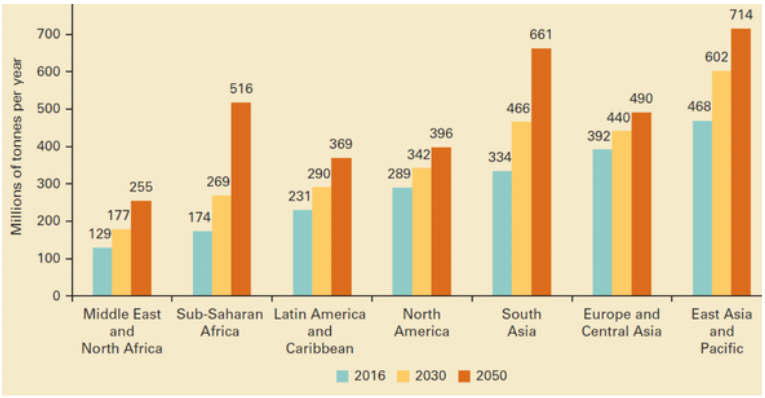
One attainable solution is to develop diversified agroforestry systems which include a specific arrangement of different tree species and crops, coupled with sustainable land management practices that encourage soil health and ecosystem resilience. For example, agroforestry systems can provide multiple environmental and economic benefits, like carbon sequestration, biodiversity conservation, and increased crop yields.



Alley Cropping: Alley cropping involves planting densely contracted rows of trees or shrubs or seasonal plants in between rows of annual crops, such as maize or beans in order to utilize the nutrient dense soil. The trees among other things provide shade and optimal sun exposure for its surrounding biodiversity, while the crops aid in adding to the agricultural GDP of the country and food for the local community.

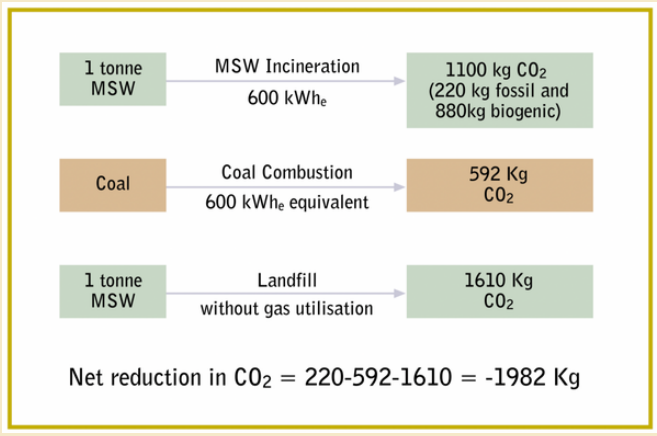
Silvopasture: A similar yet different technique to the previous one is Silvopasture, which encompasses combining trees and livestock grazing on the same land. The tree’s positive function is once again to provide shade and shelter for the animals, while the livestock act as a natural source of fertilizer and to help to control vegetation through the act of grazing.

MSW Bioenergy



As a consequence of the increasing global population and economic development, the amount of Municipal Solid Waste (MSW) is escalating, leading to environmental, social, and economic concerns. Indeed, according to the World Bank, 3.4 billion metric tons of municipal solid waste will be generated globally by 2050. However, amidst this challenge, bioenergy presents a promising opportunity to transform MSW from a burden into a valuable resource. By converting organic and non-organic waste materials, such as food waste, paper, and plastic, into biogas, bioenergy offers a potential solution to address the growing waste crisis while simultaneously proposing a substitute for polluting energy.

To show the environmental benefit of producing biogas from MSW, namely the reduction of gaseous pollutants, the International Energy Agency (IEA) has conducted a study taking into account the entire life cycle of the systems. It was found out that for MSW energy recovery systems (for e.g. mass burn), the total emission of CO2 is 1100 kg per tonne of MSW and 1833 grams of CO2 per kWh. Approximately 20-40% of the carbon in MSW comes from fossil sources (such as plastics), meaning that the non-renewable portion of the emissions is estimated to be around 367 grams of CO2 per kWh. Thus 80% of the carbon content of MSW, which is biomass derived, is renewable. Consequently, energy recovery from MSW leads to important savings of greenhouse gas emissions when compared to conventional production of energy from fossil fuels.



Moreover, bioenergy from MSW also prevents many other potential consequences of waste dumps , such as leachates/groundwater contamination and longer- term pollutant liabilities, on the nearby communities and local environments.

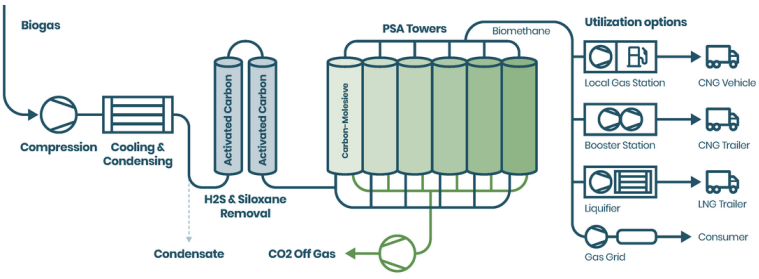
Converting MSW to energy can be done in several different ways, involving either thermochemical processes (such as incineration, gasification and pyrolysis) or biological processes (such as anaerobic digestion). Through all those treatments of MSW result in an upgraded fuel, most likely the Solid Recovered Fuel (SRF). It can be co-utilised with several other solid fuels such as coal and/or biomass in co-combustion or co-firing processes.
The European Commission has established European standards for SRF to facilitate its trading in the energy market as it offers significant environmental and market opportunities, while being relatively clean.

However, in the field of MSW bioenergy, a lot of technological discoveries and advances are still to be made to make its production accessible.
In France, a promising startup, Waga Energy, has developed in recent years an innovation called the WAGABOX - a breakthrough technology to produce methane from landfill gas.

Animal Bioenergy

Apart from the main sources of bioenergy like wood and MSW, animal waste bioenergy also represents a source for bioenergy plantation. It refers to the energy generated from organic matter that is sourced from animals, such as manure, animal fat, and slaughterhouse waste. Animal waste bioenergy is a cost effective and efficient source for biomass energy especially in areas where the agriculture and farming industries are developed. However, in other regions where this industry is not as developed, animal waste bioenergy may not be a viable source for biomass energy. Due to these socioeconomic reasons, animal biomass energy is a considerably smaller contributor to biomass energy production in comparison to other sources such as wood and MSW.

According to a report published by NREL, the biogas animal conversion process can reduce methane emissions by 85% to 95% compared to other types of open sources. However, several reports suggests that this is not a long term solution, as they put forward its negative consequences: data has shown that the fuel can result in the release of nitrous oxide, which has the potential to contribute to global warming 298 times greater than carbon dioxide over a 100-year period. Indeed, the odor and air pollution that are produced on a mass scale are one of main issues for this type of biomass energy source.
Fortunately, there are several potential solutions that have been proposed, as for instance biogas upgrading. The latter, although a costly alternative, represents a process that removes impurities like carbon dioxide and hydrogen sulfide from biogas to ensure its quality.



Animal waste biomass energy has also proven in many cases to be inefficient, requiring significant amounts of energy and resources to process the waste. A study done by NREL displayed data which showed how the conversion of animal waste into energy was only 40-60% efficient. After more strenuous experiments and collaborations with scholars, the study concluded that further research is required to improve the efficiency and economic viability of animal waste biomass energy, in order for it to be deemed as a viable source of energy. This inefficiency is due to the high moisture content of animal waste, which prevents the conversion process to happen effectively. To address this issue, one solution has been deepened: mix animal waste with other organic materials that have higher energy content, for example food waste or crop residues. Another viable solution would be the use of advanced mechanical technologies, such as membrane separation, which can be used to enhance the efficiency of biogas production from animal waste.

Lastly, using animal waste as a fuel can also pose a challenge in competing with other land uses, one of the most critical being food production, and as an additional negative impact it also leads to increased deforestation. A paper written by BERC found that using animal waste as a fuel 90% of the time leads to land use conflicts, specifically in areas with high population density or limited land availability. One solution brought forward by the Journal of Environmental Management advocates for improved land management practices. The studies showed that this method led to reduced crop yields and significantly decreased long-term damage to soil health. Hence, by implementing these changes and improving land management practices, the dreadful and negative impact of animal waste energy production on soil quality and biodiversity can be severely mitigated.

To conclude...

All in all, the wide range biomass feedstocks, conversion processes, and issues related to its production make bioenergy a very complex and controversial renewable energy source. Nevertheless, the benefits that stem from using bioenergy otherweight the negatives as it is a novel sustainable way of generating green energy from waste and it drastically minimizes our carbon footprint.
We can thus highlight the increasingly crucial role of policymakers in facilitating the energy transition, by giving it priority, creating markets for sustainable, low-carbon technologies, and promoting research and development.

Sources:

- Montanaro Asset Management: Biomass debate: Sustainable forest management
- IEA Bioenergy: Bioenergy Review 2023
- AECID: Argoforestry as a technique for sustainable land management
- BERC
- NREL
- MDPI