Bioenergy Sustainable development in Indonesia and its relation with SDGs goal

Fumi Harahap, Ph.D  
Department of Energy Technology¹, KTH Royal Institute of Technology, Sweden  
Email: harahap@kth.se

Abstract. The global Sustainable Development Goals (SDGs) are now converging to address the economic, social and environmental dimensions. Bioenergy can play a significant role in achieving the agreed SDGs on climate change, thereby advancing climate goals, food security, better land use, and sustainable energy for all. Bioenergy is essential in the past, present and future energy systems. At least 10% of global energy supply comes from bioenergy source, of which two-thirds is used in developing countries for cooking and heating. Compared to other renewable energy sources, bioenergy is the most problematic area due the multitude of biomass feedstock, technology pathways, and end products which encompass the biomass to energy conversion. The use of biomass for bioenergy is expected to increase driven by several SDGs (goals: 2, 7, 8, 9, 11, 12, 13, 15), but bioenergy also act as sustainability safeguards. By exploring bioenergy in a context of multi-sectoral objectives and synergies, pathways can be found to promote the transition to sustainable modern bioenergy. This paper explores pathways to enhance resource efficiency, particularly for bioenergy production in the palm oil industry in Indonesia for meeting the SDGs.

1. Introduction

The Paris Agreement on climate change and the Sustainable Development Goals (SDGs) create momentum for international joint forces to combat climate change. Bioenergy, which represents a significant type of renewable energy is key to supporting the agreed SDGs, particularly in the context of energy security, sustainability, and economic development. Bioenergy is considered the most problematic area among renewable energy sources – with multi feedstock, technology and diverse energy carriers. However, biomass (feedstock) availability is abundant. Biomass in the form of forest products and agricultural crops along with residues is available in almost every country around the world, while municipal waste is available in every city.

Currently, bioenergy is the largest renewable energy source globally and accounts for more than two-thirds of the renewable energy mix [1]. However, it is essential to note that most of the contribution of biomass supply worldwide is from the traditional use of biomass for cooking and heating in rural areas in Asia and Africa. With the increasing use of modern biomass solutions like wood pellets, biogas and liquid biofuels, the contribution of modern bioenergy sources will be an important part in the future renewable energy mix. Speeding up the sustainable bioenergy deployment is crucial, moving forward the transformation towards a low carbon energy system, most notably in the transport sector.

¹ web: https://www.energy.kth.se/
This paper summarises the key research findings from the Indonesian-Swedish Initiative for Sustainable Energy Solutions program on Strategies for Sustainable Bioenergy Development in Indonesia 2015-2020. The research carried out by Harahap et al. [2–5] explores the synergies between the palm oil industry and bioenergy production in Indonesia. The research investigates how enhanced resource efficiency for bioenergy production in the palm oil industry in Indonesia can support the attainment of SDGs, among other things, through more efficient use of land biomass resources, improve access to electricity, create opportunities for emissions reduction, and increase the share of renewable energy in the country’s energy mix.

This paper is organised as follows. Section 2 describes the SDGs supported by deploying bioenergy in sustainable manners. The bioenergy outlook in Indonesia present in Section 3. Section 4 presents the key research findings of the impacts of enhanced resource efficiency in the palm oil industry. The final section provides conclusions.

2. Linkages between SDGs and sustainable bioenergy deployment

The 17 SDGs provides a normative framework for future global development. Although the SDGs do not make any specific reference to the use of biomass for food, feed or energy systems. The use of biomass is expected to grow globally, driven by several SDGs while at the same time safeguarding the sustainability elements of other SDGs [6]. Fritsche et al. [6] and Müller et al. [7] highlighted direct linkages of SDG 2, 7, 8, 9, 11, 12, 13, 15 with biomass utilisation for bioenergy. In SDG 2, the promotion of sustainable agriculture and improving the integration of bioenergy into agriculture system, such as agroforestry and intercropping systems, can simultaneously end hunger (biomass use for food and feed). Bioenergy provides access to affordable, reliable, sustainable and modern energy for all and ultimately increase the share of renewable energy in the energy mix (SDG 7). Sustainable economic growth through employment and decent work creation can achieve by deploying sustainable bioenergy (SDG 8). Bioenergy system promotes industry modernization, such as through biorefinery application, and foster innovation (SDG 9). Sustainable bioenergy production and use throughout the entire supply chain is a driver for climate change mitigation (SDG 13). Furthermore, bioenergy provides opportunities to restore degraded land and making possible use of it (SDG 15).

3. Bioenergy outlook in Indonesia

The International Energy Agency [8] defines bioenergy as "energy derived from the conversion of biomass, where biomass may be used directly as fuel or processed into liquids and gases". Various biomass feedstock can use as sources of bioenergy, including wet organic wastes, sewage sludge, animal wastes, organic liquid effluents, the organic fraction of municipal solid waste, residues from agriculture and forestry, energy crops, and vegetable oils [9]. Modern bioenergy can use for electricity, heat, and as liquid fuels. Biofuels usually represent liquid biofuels (e.g., biodiesel and ethanol) and gaseous fuels (e.g., biogas and syngas). The diversity of energy carriers bioenergy can deliver gives bioenergy a flexible energy sources.

Increasing energy demand and concerns over energy security and global warming have motivated the Indonesia government to set specific targets for bioenergy in the form of electricity, liquid biofuels (biodiesel and ethanol), biomass and biogas. The targets are specified in national energy planning to meet 23% renewable energy in 2025 and 31% in 2050 in the total energy mix [10]. Figure 1 shows the country's primary energy supply by type of energy source. Bioenergy feedstock in Indonesia is generated from the industrial processes (e.g., palm oil mills and paper mills) as well as from rural farming. The target realization for mandatory biodiesel program in 2019 is on track, fulfilling 60% of the 2025’s target [11]. In Indonesia, 100% of the feedstock used for biodiesel production comes from palm oil and produced from crude palm oil and palm fatty acid distillate. However, the uncertainty on the availability of generous financial supports currently given to biodiesel producers (to compensate the price difference with fossil diesel) may jeopardize the ultimate goal of biodiesel program [3]. Direct subsidy to the final product creates a market as long as the subsidy is applied. But it does not necessarily encourage long-term market sustainability [12]. The funds available for the support is directly correlated to the volume
of the export of palm oil products, implying that a smaller proportion of export volume will reduce the number of funds. Meanwhile, due to the lack of production infrastructure and feedstock—economic and political reasons—the ethanol blending program ended in 2010 [13]. Furthermore, the current fossil fuel subsidy in Indonesia is perceived as a significant barrier for renewable energy development.

![Figure 1 Indonesia’s primary energy supply by energy source, in Mtoe [10]](image)

Despite the provision of special electricity tariff for electricity generated from biomass, the progress is slow, lagging 3.6 GW of installed capacity to meet the 2025’s target [11]. The government of Indonesia will continue to explore the synergies between bio-based industry (palm oil and paper industries) and bioenergy production. Besides, the government explores the opportunities for biomass co-firing in the existing coal power plants using feedstock from municipal solid waste and residues from agriculture and wood processing. Policies to promote the biomass co-firing system are under investigation. Apart from the progress made on biodiesel and bioelectricity generation, the achievement for biogas (incl. biogas for clean cooking, and industrial biogas such as Bio-CNG and biogas to fuel) is only 5% from the 2025’s target [11].

4. Improved resource efficiency in the palm oil industry

As the largest palm oil producer in the world, immense opportunities exist for Indonesia to develop a palm-oil-based bioenergy system, and possibly to become a leading palm-oil-based biodiesel producer. Regulations are in place to harness the potential from biomass residues in palm oil mills and reduce Greenhouse gases (GHG) emissions. Ministerial Regulation 11/2015 mandates the conversion of unused biomass residues into value-added products such as electricity and organic fertilizer. To uptake the bioelectricity, the government provides special electricity tariffs from biomass and biogas sources (Ministerial Regulation 21/2016). However, the adoption rate of the policies remains low, which is illustrated by the low percentage of biomass and biogas power plants installed compared to the total technical potential [14–16]. The remaining residues are left to decay on-site, emitting GHG emissions from the decomposition process.

4.1. Efficient use of land

Demand for biomass is projected to increase due to population growth, changing food consumption patterns, increasing average income, and active policy interventions. The land is needed to grow biomass. Biomass production from agriculture sector comes with forest area conversion [17]. Agriculture is found to be the significant driver of deforestation globally, and agricultural, forestry and land policies are often contradicting [17]. How can we afford to use the available land for forest and agriculture to provide modern bioenergy services? The Land is needed to meet various sectoral policy goals. Sectoral policy coherency to administer the use and allocation of land is important to reduce pressure on it. Harahap et al. [2] measured the degree of horizontal coherence of sectoral policy
interactions, i.e., biofuel, agriculture, climate, and forestry sectors, concerning land allocation. Through document analysis, the impacts of sectoral policies on land allocation in Indonesia may lead to ineffective policy implementation. Indonesia recognizes dual land classification based on the legal status of land and the land coverage. The recognised land use classifications are not always found in the policy documents. Consistent land use classification and standardised definition of the type of land can facilitate the policy coherency. Clarity on the definition of degraded land can provide opportunities for bioenergy to restore the degraded land and reduce losses in the food chain.

4.2. **Biorefinery for efficient use of biomass**

The Biorefinery system can help to improve the overall profitability of biodiesel produced in Indonesia. Better integration between the upstream, midstream and downstream of palm oil industry segments would contribute to reduced financial risk in the biodiesel business. Biorefinery brings opportunities for securing feedstock supply, reducing transport, and making a whole integrated system more energy and carbon-efficient [3]. Nevertheless, the trend shows that biodiesel is currently feasible only when the price of oil is at its lowest, meaning that biodiesel production is still dependent on financial support [18]. The production cost of biodiesel in Indonesia is considerably higher than that of conventional fuels, which is why it requires support subsidies. In this context, biorefinery could play a role in making biodiesel production more competitive. Harahap et al. [3] compare the profitability of producing biodiesel in the present system and in a conceptual biorefinery plant (integration between palm oil mill and energy plant unit in the same facility). Fifty-three sites in Sumatra and Kalimantan are optimal for biorefineries, it produces bioelectricity, ethanol and biodiesel [5]. Palm oil-based biorefineries could meet up to 98% and 34% biodiesel and ethanol blending targets if biorefinery investment costs are lowered [5].

4.3. **Improved access to modern bioenergy services and increase the share of renewable energy in the energy mix**

Improving the current practices on palm oil biomass utilization is significant for meeting the national bioenergy targets. Harahap et al. [4,5] analyzed the requirements for residue treatment (i.e., methane capture from palm oil mill effluent - POME, power generation from solid biomass, and biofertilizer production from empty fruit bunch and POME) set by the Indonesian government. The research on exploring pathways for harnessing the palm oil biomass potential, enhancing resource efficiency, and meeting national energy and climate goals illustrates the multiple benefits of a sustainable palm oil-based industry [5]. The analysis can be used to identify optimal options (technology conversion and location), thus providing alternatives for policies and incentives to promote investments in biorefineries. The palm oil-based biorefineries in Sumatra and Kalimantan can produce 1–1.25 GW of electricity, 4.6–12.5 billion liter of biodiesel, and 2.8–4.8 billion liter of ethanol in 2030 [5]. It implies that the industry can meet 15%–19% of the target for bioelectricity installed capacity in 2025. Not surprisingly, there is a higher potential to generate excess electricity when all mills are connected to the power grid. Improvement in grid connections in Sumatra can provide the basis for an installed capacity of bioelectricity plants equivalent to 2.8 GW, meeting 50% of the national bioenergy target by 2025 [4]. It also means covering 50% of the electricity demand of Sumatra, helping the island to reduce its dependence on highly fossil fuel-based electricity. The biomass-to-electricity potential is significant. It could play a significant role in the developing electrification in Sumatra and Kalimantan. The current electrification rate is below 90% on these islands [19].

4.4. **Opportunities for emissions reduction**

The utilization of palm oil biomass residues is also included in the government's commitment to reducing GHG emissions. When it comes to the climate mitigation target, up to 5% of the national GHG emissions reduction target for 2030 can meet with more efficient utilisation of palm oil biomass residues in Sumatra [4]. It is not very substantial because the largest share of emissions in Indonesia comes from
forest and peatland conversion. However, from the point of view of emissions reduction in the waste sector, the contribution is tremendous. Emissions avoided through efforts to manage POME in Sumatra only can be up to 22 MtCO$_2$eq/y. It demonstrates that efforts to improve POME treatment and management in Sumatra can help to achieve the emissions reduction target set for the waste sector in the unconditional mitigation scenario (i.e., 11 MtCO$_2$eq/y) and nearly all of the emissions reduction in the conditional mitigation scenario (i.e., 26 MtCO$_2$eq/y) by 2030 [20]. It might indicate that there are opportunities to set a higher target for reducing emissions from the waste sector.

5. Conclusions

Modern bioenergy services provide opportunities to enhance regional energy access and reduce reliance on fossil fuels if it developed and deployed in a sustainable manner. The sustainability criteria for bioenergy deployment is likely to be tightened in the future, driven by the debate around food security and biodiversity losses. Therefore, enabling bioenergy promotion that supports SDG implementation requires that policies and measures promote best practices (along the production and use of bioenergy) put in place. The Government of Indonesia has introduced several policy supports for expanding bioenergy technology. However, special attention has to be put on the consistency and coherency of those policies for effective implementation and achievement of sectoral objectives.

References

[1] World Bioenergy Association. Global Bioenergy Statistics 2019. 2019.
[2] F Harahap, S Silveira, D Khatiwada, 2017. Land allocation to meet sectoral goals in Indonesia—An analysis of policy coherence. Land Use Policy; 61, 451–65. https://doi.org/10.1016/j.landusepol.2016.11.033.
[3] F Harahap, S Silveira, D Khatiwada, 2019. Cost competitiveness of palm oil biodiesel production in Indonesia. Energy; 170:62–72. https://doi.org/10.1016/j.energy.2018.12.115.
[4] F Harahap, S Leduc, S Mesfun, D Khatiwada, F Kraxner, S Silveira. 2019. Opportunities to Optimize the Palm Oil Supply Chain in Sumatra, Indonesia. Energies; 12, 420. https://doi.org/10.3390/en12030420.
[5] F Harahap, S Leduc, S Mesfun, D Khatiwada, F Kraxner, S Silveira, 2020. Meeting the bioenergy targets from palm oil based biorefineries: An optimal configuration in Indonesia. Appl Energy; 278, 115749. https://doi.org/10.1016/j.apenergy.2020.115749.
[6] UR Fritsche, U Eppler, H Feihrenbach, J Giegrich, 2018. Linkages between the Sustainable Development Goals (SDGs) and the GBEP Sustainability Indicators for Bioenergy (GSI).
[7] A Müller, J Weigelt, A Götz, O Schmidt, Alva, I Lobos , I Matuschke, et al, 2015. The Role of Biomass in the Sustainable Development Goals: A Reality Check and Governance Implications:6–11.
[8] IEA. Technology roadmap: bioenergy for heat and power. 2012. https://doi.org/10.1108/meq.2013.08324aaa.005.
[9] IEA. Technology Roadmap: Delivering Sustainable Bioenergy. 2017.
[10] Government of Indonesia. Rencana Umum Energi Nasional 2017. https://www.esdm.go.id/assets/media/content/content-rencana-umum-energi-nasional-ruen.pdf. (Accessed: July 2018).
[11] Heviati E. Bioenergy Development in Indonesia: Policy and Implementation. Ministry of Energy and Mineral Resources, Republic of Indonesia: 2020.
[12] Harahap F. An evaluation of biodiesel policies - The case of palm oil agro-industry in Indonesia.
Licentiate Thesis, KTH Royal Institute of Technology, Sweden, 2018.

[13] S Silveira, D Khatiwada, 2019. Sugarcane Biofuel Production in Indonesia. Sugarcane Biofuels, p. 285–300. https://doi.org/10.1007/978-3-030-18597-8_13.

[14] IRENA. Renewable Energy prospects: Indonesia, a REmap analysis. Abu Dhabi: 2017.

[15] MEMR. Statistik EBTKE 2016 2016:68. http://ebtke.esdm.go.id/post/2017/03/07/1583/statistik.ebtke.2016.

[16] Rahayu AS, Karsiwulan D, Yuwono H, Trisnawati I, Mulyasari S, Rahardjo S, et al. Handbook POME to Biogas Project Development in Indonesia 2015. https://www.winrock.org/wp-content/uploads/2016/05/CIRCLE-Handbook-2nd-Edition-EN-25-Aug-2015-MASTER-rev02-final-new02-edited.pdf (accessed January 2016).

[17] FAO. State of the world's forests. 2016.

[18] USDA. Indonesia Biofuels Annual 2018 2018. https://gain.fas.usda.gov/Recent GAIN Publications/Biofuels Annual_Jakarta_Indonesia_8-13-2018.pdf (accessed November 9, 2018) (accessed September 11, 2018).

[19] PLN. RUPTL PLN 2018-2027 2018. https://www.pln.co.id/statics/uploads/2018/04/RUPTL-PLN-2018-2027.pdf (accessed November 18, 2019) (accessed November 18, 2019).

[20] GoI. Nationally Determined Contribution Republic of Indonesia. Jakarta: 2016.