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Research Article

Regulatory Limits of Empowering Biogas Digester Integrated with Indonesia's Local Wisdom

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ABSTRACT: This paper analyses the international and domestic regulatory framework for managing waste-to-energy in Indonesia's rural areas to support climate mitigation. The countryside is known to be the most significant contributor to organic waste due to the high productivity of the agricultural and livestock sectors. In contrast, organic waste is left without proper management and contributes to global greenhouse gas emissions. Indonesia has agreed to contribute to the Paris Agreement to reduce emissions by 29% in 2030 or 41% with international assistance, but its follow-up to switch to renewable energy appears insufficient. This study uses a socio-legal approach to unpack the waste-to-energy problems in one of Indonesia's villages: Tawangsari Village, Pujon District, Malang Regency, East Java Province. The study results reveal that the biogas program launched by the government through the "Program BIRU" was not aligned with local conditions in Tawangsari Village because not all farmer households had sufficient land to build a fixed dome. Thus, it is necessary to build a community-based centralized biogas digester. However, there are no provisions in the regulations governing the mechanism for funding renewable energy development in villages, as mandated by Article 20(2) of the Energy Law. The village can use village funds to carry out development based on local wisdom, but the limited number of village funds causes limited growth. There are no standard rules for bio-slurry processing and maintenance of biogas digesters to ensure the sustainability management of biogas. This paper recommends enacting national and/or domestic regulations to support the energy-independent village program, aligning with the government's commitments to reduce global emissions from the agricultural and waste sectors.

KEYWORDS: Climate Mitigation; Energy Transition; Regulations; Small-Scale Biogas.

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I. INTRODUCTION

This paper analyses the applicability of the frameworks of international and national policies regarding the management of waste to energy from biogas, especially in regions with high contribution of waste or organic waste due to the productivity in both the agricultural sector and livestock. It highlights the relevant measures to investigate organic waste issues by bringing a waste-to-energy concept to a rural area of Tawangsari Village in Malang Regency, Indonesia. Tawangsari Village is about 1,200 meters above sea level, making it rich in agricultural and livestock commodities due to the cool temperature and weather.[1] However, the high commodity is also accompanied by a high waste problem as having approximately 1,000 dairy cows and produces 30 tons of carrots daily and 50 tons of shallots every harvest season.[2] Livestock and agricultural activities produce organic waste in the form of livestock manure and vegetable waste. This waste was not appropriately managed which contributes to climate change due to the decomposition process. It releases methane gas, one of the greenhouse gases that cause global warming and climate change.

As a member state of the Paris Agreement, Indonesia ratified the commitment to reducing climate change in Law 16/2016 on the Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change. The country has also set the Nationally Determined Contribution (NDC), then updated into Enhanced Nationally Determined Contribution (ENDC), which involves mitigation and adaptation of greenhouse gas emission reduction.[3] Waste management represents a form of mitigation as part of ecosystem resilience, and organic waste has been the

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1 Novita Ratna Satiti & Tatag Mutaqqin, "Kajian Kearifan Lokal Masyarakat Desa Tawang Sari Kecamatan Pujon Kabupaten Malang dalam Pelestarian Mata Air Sungai Konto Sub Das Brantas" (2016) SENASPRO 2016 | Seminar Nasional dan Gelar Produk.

2 Sri Suhartini, et al., *Laporan Kegiatan Program Dosen Berkarya Konsultasi dan Fasilitas Kajian Potensi Pengembangan Circular Economy Biogas Menuju Desa Mandiri Energi (Studi Kasus di Desa Tawangsari Kecamatan Pujon di Kabupaten Malang)*, Final Report (Kabupaten Malang: Universitas Brawijaya, 2021).

3 Nur Masripatin, *Strategi Implementasi NDC (Nationally Determined Contribution (NDC),* (Jakarta: Direktorat Jenderal Pengendalian Perubahan Iklim, 2017).

contributing factor to the emission of greenhouse gases, including methane, that have not been optimally cultivated.[4] In ENDC, manure is something that must get special treatment to overcome greenhouse gas emissions from methane.[5]

This paper argues that the global and national waste problem seems endless. Each year greenhouse emission gases from human activities increased by 43% from 1990 to 2015, in addition to carbon dioxide as a contributor of 3 per four of total emissions. It has increased by 51% in the 21st century caused by transportation, electricity generation, and non-renewable forms of energy production other.[6] The Indonesian Ministry of Environment and Forestry reported it to be 67.8 million tons annually at a national level.[7] The enormous contribution of waste comes from organic waste, accounting for 60% compared to only 14% of the total plastic waste nationally.[8] This data indicates that organic waste poses a threat to national aspects. The immediate response is crucial since this increasing amount of organic waste is likely to injure the rights of the citizens to welfare,[9] as well as a better and healthier environment, as outlined in Article 28H of the 1945 Constitution.[10] This constitutional provision reflects the state obligation to protect, respect, and fulfil so that the governments, both central and local,

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4 Mirza Satria Buana et al, "The Nusantara Capital City Project: Why Development and Human Rights Do Not Always Mix" (2023) 16:1 Law and Development Review 185–223.

5 Kementerian Lingkungan Hidup dan Kehutanan, *Enhanced Nationally Determined Contribution Republic of Indonesia* (Kementerian Lingkungan Hidup dan Kehutanan, 2022).

6 EPA, "Climate Change Indicators: Greenhouse Gases", (26 July 2023), online: *United States Environmental Protection Agency* <https://www.epa.gov/climate-indicators/greenhouse-gases>.

7 Pusat Inovasi Agroteknologi Universitas Gajah Mada, "Buku Saku Masyarakat Tangguh Sampah", (8 February 2021), online: <https://piat.ugm.ac.id/file/buku-saku-masyarakat-tangguh-sampah/>.

8 *Ibid*.

9 Zaka Firma Aditya & Sholahuddin Al Fatih, "The Legalization of Medical Marijuana: A Human Rights Law Perspective" (2022) 1:2 HRGS 115–127.

10 Ahmed M A Hamad, Jacklyn Jannial & Rachma Indriyani, "Mechanisms of the Legal Protection of Human Rights in Global Regulation" (2022) 1:2 HRGS 145–157; Saru Arifin, "Abuse of Human Rights in Myanmar: An Urgent Appeal to Reinterpret the ASEAN Non-Interference Principle" (2022) 1:2 HRGS 128–144.

have the duty and responsibility to fulfil them. One of the efforts to realise the mandate is to manage the transformation of waste into energy in villages.[11] The management to transform waste into energy should be the breakthrough in villages. This transformation is in progress, intended to replace fossil fuel-oriented energy with new and renewable energy (NRE). This energy transformation is part of integrated waste management, allowing for conversion to NRE and a healthier environment. This objective is outlined in Government Regulation 79 of 2014 on the National Energy Policy (NEP) which represents the ambition of Indonesia for energy transformation from fossil fuel energy to renewable energy.[12] Article 9 point f number 1 of NEP states that NRE is required to contribute at least 23% by 2025 and 31% by 2050 to the national energy supply.

Previous research on this topic focused more on technical, economic, and social aspects of biogas production in Indonesia, while this paper specifically focuses on studying regulations and policies for communal-scale biogas[13] generation to manage waste-to-energy at the village level.[14] This research

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11 PT Mercy Tria Consult, *Naskah Akademik dan RAPERDA Penyelenggaraan Rumah Kos Kabupaten Kulon Progo* (Wates, 2020).

12 Prischa Listiningrum et al, "Juridical analysis of policy concerning oil palm estate management in Indonesia" (2021) 29:1 LJIH 16–26.

13 Putra Endi Catyanadika, "Optimasi Lokasi Instalasi Digester Biogas Skala Komunitas Desa Pudak Wetan Ponorogo" (2020) 10:2 Forum Agribisnis : Agribusiness Forum 106–117.

14 Henry Wasajja et al, "Improvement of Biogas Quality and Quantity for Small-Scale Biogas-Electricity Generation Application in off-Grid Settings: A Field-Based Study" (2021) 14:11 Energies 3088; Ahmad Romadhoni Surya Putra, Søren Marcus Pedersen & Zhen Liu, "Biogas diffusion among small scale farmers in Indonesia: An application of duration analysis" (2019) 86 Land Use Policy 399–405; Ricardo Situmeang, Jana Mazancová & Hynek Roubík, "Technological, Economic, Social and Environmental Barriers to Adoption of Small-Scale Biogas Plants: Case of Indonesia" (2022) 15:14 Energies 5105; I Putu Dody Lesmana & Beni Widiawan, "Small Scale Biogas Production in a Dairy Farming at Kaligondo Sub-district, Banyuwangi, East Java" (2018) Proceeding of the 1st International Conference on Food and Agriculture; Fatih Tufaner & Yaşar Avşar, "Economic analysis of biogas production from small scale anaerobic digestion systems for cattle manure" (2019) 2 Environmental Research; Mariana Silaen et al, "Lessons from Bali for small-scale biogas development in Indonesia" (2020) 35 Environmental Innovation and Societal Transitions 445–459; Stefan Bößner et al, "Barriers and opportunities to bioenergy transitions: An integrated, multi-level perspective analysis of biogas uptake in Bali" (2019) 122

will provide policy recommendations through the evaluation of existing policies at both national and rural levels to allow for the implementation of circular economy-based organic waste management into waste to energy. This measure should also help reduce environmental pollution to prevent climate change globally as the implementation of the mandate outlined in the Constitution of Indonesia for a cleaner environment and as an effort to realize the idea of energy self-sufficient village (*Desa Mandiri Energi*) in Indonesia that complies with the 7th principle: clean and affordable energy, the 11th principle: sustainable city and community, the 12th principle: accountable consumption and production, and the 13th principle: climate change handling in Sustainable Development Goals (SDGs).

Against this background, this paper contains three main parts of the discussion. The first part will explain the legal framework of waste-to-energy in Indonesia which started with a discussion on international regulations ratified by Indonesia regarding the use of waste-to-energy and the regulations at the national level. The second part will explain the empirical conditions of Tawangsari Village, specifically how they managed their

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Biomass and Bioenergy 457–465; Arjun S Bedi, Robert Sparrow & Luca Tasciotti, "The impact of a household biogas programme on energy use and expenditure in East Java" (2017) 68 Energy Economics 66–76; Sri Atmaja P Rosyidi et al, "Lessons Learnt from the Energy Needs Assessment Carried out for the Biogas Program for Rural Development in Yogyakarta, Indonesia" (2014) 20 Procedia Environmental Sciences 20–29; Arjun S Bedi, Robert Sparrow & Luca Tasciotti, "Indonesia's Domestic Biogas Programme – Household panel survey data" (2018) 17 Data in Brief 1388–1390; Ening Ariningsih et al, "Dairy cattle manure utilization by smallholder dairy farmers in West Java, Indonesia" (2022) 361 E3S Web Conf 03013; Putra, Pedersen & Liu, "Biogas diffusion among small scale farmers in Indonesia", *supra* note; Munawar Khalil et al, "Waste to energy technology: The potential of sustainable biogas production from animal waste in Indonesia" (2019) 105 Renewable and Sustainable Energy Reviews 323–331; Dian Andriani et al, "A Review of Recycling of Human Excreta to Energy through Biogas Generation: Indonesia Case" (2015) 68 Energy Procedia 219–225; Natarianto Indrawan et al, "The biogas development in the Indonesian power generation sector" (2018) 25 Environmental Development 85–99; R Ahmad Romadhoni Surya Putra, Zhen Liu & Mogens Lund, "The impact of biogas technology adoption for farm households – Empirical evidence from mixed crop and livestock farming systems in Indonesia" (2017) 74 Renewable and Sustainable Energy Reviews 1371–1378; Aulia Ulfah Farahdiba et al, "The present and proposed sustainable food waste treatment technology in Indonesia: A review" (2023) 32 Environmental Technology & Innovation 103256.

organic waste and the problems in developing renewable energy using biogas. The third part will discuss about village's capability to develop centralised biogas. This part will review legal regulations relating to the development of biogas in the villages, as well as the obstacles to the development of biogas from legal and empirical aspects in villages.

II. METHODOLOGY

This study used a socio-legal research method which, according to Wheeler and Thomas, is the alternative method of interdisciplinary studies between legal and social science to observe the position and effectiveness of the law as an entity in which the law is enforced.[15] Within the research context of this article, the socio-legal method was used to see that the existing laws already have specific rules regarding funding and technical standards for biogas digester management for biogas development in villages.[16] This paper has a target to contribute to the development of the legal study field through a legal understanding of problems that occur directly in the community related to the lack of regulations that provide legal certainty in terms of funding and standardisation of biogas management at the village level.

The community was involved as a primary subject to review how waste management has been carried out so far to realise an energy-independent village with a qualitative method to provide comprehensive descriptive data and a conclusion with the participation of the people as the supporting data was used. The primary data were obtained from interviews, field observation, and questionnaires. Then, the secondary data were extracted through a desk review of the related legislation and supplementary literature.[17]

Data collection was carried out through several stages. First, interviews and discussions used purposive sampling techniques to determine samples or

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15 Reza Banakar & Max Travers, eds, *Theory and method in socio-legal research*, Oñati international series in law and society (Oxford ; Portland, Or: Hart Pub, 2005).

16 Cekli Setya Pratiwi, Prischa Listiningrum & Muhammad Anis Zhafran Al Anwary, "Critiques on Contemporary Discourse of International Human Rights Law: a Global South Perspective" (2022) 1:1 HRGS 1–12.

17 *Ibid.*

informants by considering certain variables.[18] The interviewed parties were the Tawangsari Village Government through the Village Chief, the Environmental Agency of Malang Regency, and the Dairy Management Association and Biogas Provider (*Koperasi SAE Pujon*), as well as the work unit in charge of animal husbandry to obtain data and information about the waste management system in Tawangsari Village. Second, field observations examined the method of disposing of organic waste from livestock and agriculture at the household level and communally in the Tawangsari Village landfill. Eventually, questionnaires were distributed to the local community to find out the culture of organic waste management in village communities. The questionnaire participants were 155 residents, as the representation was determined using the Slovin formula with a margin of error of 10%.

Those of the data that had been collected were analysed through several steps. First was data reduction, to sort out important things that focus on themes and patterns according to research needs. In this study, data reduction was carried out on data obtained from various data sources. Then, all data was sorted and analysed comprehensively. Third, concluding, all data that had been shorted and analysed was taken as the main idea of the findings. In this stage, findings was formed in the form of policy recommendations so that policymakers can use them.

III. LEGAL FRAMEWORKS FOR WASTE-TO-ENERGY IN INDONESIA

To deal with the emergence of greenhouse gas emissions from waste, UNFCCC, through the International Energy Agency (IEA), held an event called "The IEA Bioenergy Workshop on Waste to Energy" in Cape Town, South Africa, in May 2013.[19] It was elaborated in the workshop that back in 2013, Municipal Solid Waste (MSW) or waste from cities at a global level, especially organic waste, was predicted to hit 1.3 billion tons annually and is

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18 Sugiyono, *Metode penelitian pendidikan: (pendekatan kuantitatif, kualitatif dan R & D)* (Bandung: Alfabeta, 2008).

19 IEA Bioenergy, *Waste to Energy* (Cape Town, 2013).

still predicted to increase further to 2.2 billion tons every year by 2025.[20] The practice of waste management in the world was mapped into several ways, such as landfilling technology that has cultivated 340 million tons of MSW annually and serves as the technology of waste management commonly used worldwide.[21] Moreover, the waste-to-energy concept managed to produce 120 million tons of MSW annually, dumping contains 70 billion tons of MSW annually, and composting/digestion cultivated 50 million tons of MSW annually.[22] Of those waste mentioned above management techniques, dumping is responsible for the global contribution of methane, accounting for 10%.[23] Therefore, the primary aspect of waste management needs to involve changing the open dumping system because it has a higher potential to cause environmental pollution, such as air pollution from methane gas and leachate.[24] This waste management method is commonplace in developing countries like Indonesia due to the large number of final landfill capacities. there is still no standard for sanitary landfills or a waste treatment system where the system is disposed of in a concave area and then compacted.[25]

This workshop was focused more on the measures in implementing the policy in formulating a strategic plan of waste-to-energy management by regulating institutions for better governance, effective leadership, and environmental-friendly waste management. [26] Developing countries are principally required to focus more on transforming dumping into sustainable management techniques. [27] In this workshop, developing countries are directed to establish a system of waste-to-energy-based management

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20 *Ibid*.

21 *Ibid*.

22 *Ibid*.

23 *Ibid*.

24 Ayesha Siddiqua, John N Hahladakis & Wadha Ahmed K A Al-Attiya, "An overview of the environmental pollution and health effects associated with waste landfilling and open dumping" (2022) 29:39 Environ Sci Pollut Res 58514–58536.

25 L Darmawan, "'Open Dumping' Sampah Harus Segera Ditinggalkan, Bagaimana Langkahnya?", (22 February 2019), online: *MONGABAY* <https://www.mongabay.co.id/2019/02/22/open-dumping-sampah-harus-segera-ditinggalkan-bagaimana-langkahnya/>.

26 *Ibid*.

27 *Ibid*.

technology that is commercially applicable and congruent with the composition and volume of MSW waste generation in each country. The technology should also be sustainable, affordable, locally manageable, or environmentally friendly, and user-friendly.[28]

The results of the recommendation of the workshop serve as references for waste-to-energy management in all countries worldwide, especially the developing ones. The relevance of the realisation of the efforts in environmentally friendly waste management is included in the UNFCCC initiatives regarding climate change mitigation. In the Conference of Parties (COP) 15 of UNFCCC, held in Paris in 2015 and resulting in an international treaty regarding the mitigation of global climate change, the Paris Agreement marked a vital outcome made by UNFCCC in the effectuation and improvement of the multilateral policy-based international law regime to tackle climate change. Still, the strategy's effectiveness and implementation depend on how well member states can fulfil their responsibilities.[29]

With the principle of Common but Differentiated Responsibility and Respective Capabilities, the NDC indicates that the contribution of the member states brought the Earth's temperature down below 2°C and kept it at 1.5°C during the pre-industrial era.[30] The energy sector plays a vital role in achieving the global climate mitigation target. In its NDC, Indonesia mapped two types of greenhouse gas emission reduction, unconditional and conditional methods. The former requires energy conservation and should promote clean and renewable energy and more environmentally friendly

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28 IEA Bioenergy, *supra* note 19.

29 International Institute for Environment and Development, "The Paris Agreement : Options for an Effective Compliance and Implementation Mechanism", (1 November 2016).

30 Christoph Böhringer, Jared C Carbone & Thomas F Rutherford, "Embodied Carbon Tariffs" (2018) 120:1 Scand J of Economics 183–210; Matthias Honegger & David Reiner, "The political economy of negative emissions technologies: consequences for international policy design" (2018) 18:3 Climate Policy 306–321; Michael A Mehling et al, "Designing Border Carbon Adjustments for Enhanced Climate Action" (2019) 113:3 Am j int law 433–481; Kuok Ho Daniel Tang, "Climate change in Malaysia: Trends, contributors, impacts, mitigation and adaptations" (2019) 650 Science of The Total Environment 1858–1871.

waste management.[31] The unconditional way, however, indicates that Indonesia is voluntarily committed to reducing the emission of greenhouse gasses independently by as much as 29% and being updated become 31.89% in 2030.[32] In terms of conditional reduction, Indonesia can contribute more to reducing greenhouse gas emissions by as much as 41% and be updated become 43.20% in 2030, along with the availability of international aid in terms of technology, capacity building, and funding.[33]

To contribute and realise those global targets, Indonesia has shown a commitment to set waste-to-energy management through several national regulations. The main legal basis for national energy management is Law Number 30/2007 concerning Energy (Energy Law). Energy generation in Indonesia refers to the efficiency, justice, sustainability, and environmental principles of conservation to achieve sustainable development and national energy resilience that intended to foster energy independence, energy supply, and improved access for the poor living in remote areas by enhancing the availability of energy and the development of energy infrastructure and environmental sustainability that is justice and welfare oriented as written in Article 2 of Energy Law.[34] In this law, the energy source is divided into two types, fossil-based energy and NRE, all controlled and regulated by the state through the central government per Article 4(3) of Energy Law. This Law has recognised the existence of bioenergy as an alternative energy source that should be developed. This Energy Law also elaborates on the role of central and regional governments. The central government's power in the energy sector includes formulating national regulations and policies and establishing and enforcing standards and procedures. Meanwhile, the provincial government can form provincial-scale regulations, foster, and supervise inter-regency/city cross-regional business, and establish energy management policies across districts/cities. The authority in the energy sector for

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31 Ditjen PPI, *NDC Indonesia* (Jakarta: Direktorat Jendral Pengendalian Perubahan Iklim Kementerian Lingkungan Hidup dan Kehutanan, 2016).

32 *Ibid*.

33 *Ibid*.

34 Asrul Ibrahim Nur, "Human Rights Aspect in the Indonesian Energy Transition: The Challenges of Promoting the Right to a Clean, Healthy and Sustainable Environment" (2022) 1:2 HRGS 102–114.

regency/municipal governments is the same as that of the provincial government, but its scope is limited to districts/cities. Even though the provincial government has its respective authorities in carrying out affairs in the energy sector, in terms of supplying renewable energy is the responsibility of the central and regional governments, and priority must be given to development in rural areas as stated in Article 20(2) and (4) of Energy Law. Renewable energy sources in the Energy Law include geothermal, bioenergy, sunlight, water, and ocean layer temperature.

Energy generation from domestic waste, whether in the form of MSW, food waste, or cattle manure, is not mentioned explicitly in the Energy Law. Instead, it could be considered as bioenergy. Presidential Regulation Number 22/2017 on the National Energy Plan (National Energy Plan) outlines domestic waste to be further cultivated into biofuels and biogas, and converted into cooking gas, electricity, or transportation. To foster waste-to-energy development from MSW, the government issued Presidential Regulation Number 35/2018. In this regulation, the autonomous authority is wielded to 12 regions to build a power plant from MSW.[35]

Nevertheless, given how massive the source of organic waste, which ends up as residue and tends to be unmanaged, especially in rural areas, diversification of renewable energy through organic waste is useful to support the realisation of the target of 23% of the NRE mix in Indonesia in 2025.[36] An essential principle in NEP includes maximising the use of NRE by considering the economic level, minimising the use of petroleum, optimising the use of new energy and gas utilisation, and using coal as energy to reduce the need for NRE. In the NEP, the central government and/or local governments are technically responsible for developing energy infrastructure and disseminating access to renewable energy for the community. Appendix of the NRE sub-chapter on National Supply states that waste-to-energy management based on organic waste is targeted to develop its utilisation and

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[35] *Article 3 (1): The Privileged Area of the Capital City of Jakarta, Tangerang, South Tangerang, Bekasi, Bandung, Semarang, Surakarta, Surabaya, Makassar, Denpasar, Palembang, and Manado*.

[36] Sri Suhartini et al, "Food waste to bioenergy: current status and role in future circular economies in Indonesia" (2022) 7:4 Energ Ecol Environ 297–339.

capacity gradually in the next few years, such as 783.5 million m^3 in 2030 and 1,985.9 million m^3 in 2050. To achieve these targets, some of them are compiled with guidelines for providing energy subsidies by regional governments budgeted from the Regional Expenditure Planning Budget and budgeting for sustainable NRE infrastructure development for villages.

The regional government has the authority to organise and develop waste-to-energy infrastructure. In particular, this government is responsible to organise organic waste-based materials, because the NEP is a guideline for preparing and implementing the Provincial Energy Plan (PEP) as written in Article 2(2)b. The potential utilisation of NRE for final energy needs is mapped into several sectors, including transportation, industry, household, commercial, and other sectors. For the final energy needs of organic waste, it is stated that its utilisation is instructed to be carried out in the household sector as a sector that contributes organic waste from other sectors. Therefore, one activity that must be carried out in procuring a biogas digester with a target of 1.7 million households in 2025.[37] The delegation of authority regarding energy down to the regional level is intended so that national energy targets and policies can be implemented and focused on all regions in Indonesia through the regional government.

As delegating authority to manage energy at a regional level is apparent in the Regional Regulation Number 6/2019 on the General Plan of Regional Energy in East Java as a follow-up for the National Energy Plan as part of the strategy in each region area in energy management.[38] Several points in the General Plan of Regional Energy in the Province of East Java are more oriented towards the utilisation of renewable energy resources with the distribution of the energy prioritised across rural and remote areas. One of the missions of the General Plan of Regional Energy in East Java focuses on energy diversification in rural areas based on NRE with the involvement of

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37 Budi Cahyono, *National Energy Policy in Indonesia and Its Alignment to Sustainable Development Goals 7 (SDG7) And Paris Agreement (NDC)* (Bangkok, 2019).

38 Agnes Fitryantica, "Harmonisasi Peraturan Perundang-Undangan Indonesia melalui Konsep Omnibus Law" (2019) 6:3 GK 300–316. - Delegating Authority is the granting or creation of authority to form laws and regulations granted by the Constitution or Law to a State Institution or Government Institution.

provincial governments and the innovation derived from alternative energy resources such as biogas and biomass. This approach is supported by the primary policy concerning the utilisation of energy resources in regional areas, mentioning that increased utilisation of renewable energy in remote and rural areas requires a biogas development program to replace the domestic use of Liquefied Petroleum Gas (LPG) with organic waste obtained from cattle manure, domestic waste, and agricultural waste under the management of Energy and Mineral Resources Agency, Animal Husbandry Agency, and Non-Governmental Organisations (Hivos).

IV. EMPIRICAL CONDITIONS OF TAWANGSARI VILLAGE

Tawangsari village is situated in the Sub-District of Pujon in Malang Regency, East Java. This village having 6,207 residents consists of 5 hamlets, including Manting, Ngebrong, Gerih, Bunder, and Meduran. Geographically, Tawangsari village sits at 7048'30"-7050'13" of South Latitude and 112028'19" East Longitude with an external area of 352.30 Ha.

Village Condition	**Detail**
Total Area (km2)	325.2
Paddy Field Area (Ha)	97
Dry Land Area (Ha)	63
Building and Land Area (Ha)	141
Area for other purposes (Ha)	24.2
Population	6207
- Males	2983
- Females	3224
- Head of Family	1677
Dairy and Beef Cattle	956

Table 1. *Profile of Tawangsari Village*[39]

[39] Badan Pusat Statistik, *Kecamatan Pujon Dalam Angka 2021* (Badan Pusat Statistik Kabupaten Malang, 2021).

Tawangsari village is located on high land with an altitude of 1,200 meters above sea level. Therefore, the livelihood of the people in the village, as reported by the Malang Regency Statistics Agency 2021, is sourced chiefly from agriculture (2110 residents) and cattle farmers (1614 residents).[40]

Most agricultural lands are for farming activities and plantations. The primary income earned in the village comes from milk, meat, and vegetables. Most people in Tawangsari Village work as farmers and cattle farmers. Due to the considerable potential for livestock and agriculture in Tawangsari Village, the real impact is the generation of large organic waste as well, so it is estimated that the amount of organic waste generation from household or agricultural waste reaches 2-3 tons per day and cattle manure is estimated to reach 10 tons per day.

As mentioned earlier, animal waste, agricultural and plantation waste, and domestic waste seem to contribute to environmental pollution since all this waste is not adequately treated. Tawangsari village already has a Temporary Landfill, where the Temporary Landfill is not only used as a garbage disposal site but also functions as a place for sorting inorganic waste, which is sorted according to the characteristics of waste to be traded because it still has economic value. However, until now, the Tawangsari Village's Temporary Landfill has not been able to process organic waste, both agricultural waste and household waste. Organic waste is immediately thrown away or just piled up. The organic waste ends up as residue that is not treated because the final landfill does not accept to manage this type of residue. So that this has an impact on the unpleasant smell of garbage, and when it is just piled up without being processed, it will produce methane gas, where methane gas has greater power in trapping heat in the atmosphere than carbon dioxide. Of course, this will damage the Earth's ozone layer because the gas Methane is a greenhouse gas that causes climate change. The lack of understanding of proper waste management among the locals and the garbage collectors causes this issue.

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[40] *Ibid.*

Treatment	Percentage (Total Respondents=103)
Buried or piled in an open space	25%
Disposed of/released into ditches or river	92.7%
Sold to third parties	0%
Turned into compost (conventional composting)	0%
Turned into biogas material	4.2%
Untreated	1%

Table 2. *Processed Primary Data from Questionnaires of Cattle Manure Treatment by Cattle Farmers*

Two hundred seventy-seven households in Tawangsari Village work as animal farmers but based on the table above shows that 92.7% of the animal farmers directly dispose of their cattle manure in rivers or ditches, and 25% is buried or piled in open space. Surprisingly, no single local uses this manure as something valuable in their day-to-day life. Furthermore, 69.9% of agricultural and plantation waste is disposed of into rivers, 63.1% is for animal food, 13.6% is left in an open space, and 6.8% is buried (table 3).

Treatment	Percentage (Total Respondents = 103)
Turned into animal food	**63.1%**
Discharged	**69.9%**
Piled in an open space	**13.6%**
Turned into planting media	**0%**
Turned into fertiliser	**1%**
Buried	**6.8%**

Table 3. Processed Primary Data from Questionnaires on Agricultural or Plantation Waste

In terms of domestic waste treatment in Tawangsari village, most of the people (98.1%) in the village dispose of their garbage into one garbage container to be further transported to an integrated dump, while some others (5.2%) cultivate the domestic waste and to use it to feed their cattle. However, the garbage collector of the village has not appropriately cultivated the garbage dumped (Tables 4 and 5).

Treatment	Percentage (Total Respondents = 154)
Moved into one garbage container	98.1%
Sorted out into different plastic bags	0.6%
Turned into compost	0.6%
Turned into animal food	5.2%
Collected by the person in charge	0.6%

Table 4. *Processed Primary Data from Questionnaires of Domestic Waste Use*

Treatment	Percentage (Total Respondents = 154)
Collectively dumped into the last dumping area	100%
Released into river	1.3%
Buried	4.5%
Burned	5.8%

Table 5. *Processed Primary Data from Questionnaires of Domestic Waste Treatment*

The interview results show that almost all the locals of the village have not given maximum treatment to all three types of waste. Manure waste, for example, is still dumped into the rivers and ditches, causing serious clogging and flooding, flooding yards, and resulting in unpleasant smells. The ditches and rivers in the village are polluted with cattle manure, spreading unpleasant odours in the area, and some still pile or bury animal waste in the yards.

The local farmers prefer organic waste from agriculture since they think it can be used to feed their animals, while the rotten remains can be dumped away. Most of the locals in Tawangsari village work as farmers and cattle farmers at the same time, and they manage their waste in a way that does not pollute the neighbourhood. Almost all people collectively dump their household garbage at the dump. One of the interview sections reveals that they have no choice but to dump their trash at the public landfill as they see it as effective, as this service only costs Rp. 10,000 monthly.

The above statistical report indicates that although many people are doing so, there is still a 10% gap between the results or the answers given by the

respondents and different types of waste, where the percentage of waste/cattle manure is higher than that of domestic and agricultural waste. This discrepancy lies in the practical aspect because the existing system of biogas processing on a communal scale in the village is mainly obtained from animal waste. Therefore, the percentage representing the confidence of the locals believing that domestic waste and agricultural waste have a quality equal to the quantity and quality of biogas from animal waste in economic, social, and environmental scopes is lower.

However, all those figures show that most people in Tawangsari village understand the importance of appreciation for the environment simply by understanding that there is still a chance where they can benefit from animal, domestic, and agricultural waste in their village. McCarty and Shrum argue that people's awareness of a particular matter is not always in line with the behaviour that supports the understanding.[41] In other words, the level of people's attention in Tawangsari village regarding the economic potential of using biogas from different types of waste does not always significantly affect the real practices when there is a chance to do so.

The central government, through the Ministry of Energy and Mineral Resources, together with *Hivos*, a non-governmental organisation based in the Netherlands, initiated a program called the *Program BIRU* (Small-Scale Biogas for Household) which distributes and provides biogas financing to communities through collaboration with 34 cooperatives in Indonesia, one of which is the *Koperasi Sae Pujon*. Since its first launch in 2009, this program has been expected to achieve the development of 1 million biodigesters.[42]

This program becomes a good opportunity for animal farmers in Tawangsari Village to build a small-scale biogas digester. So far, at least, five farmers in Tawangsari Village already have a household biodigester, which was built with a scheme of loan. They paid monthly through an income deduction from the sale of milk to the *Koperasi Sae Pujon*. However, the problem is that

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41 M F Shellyana Junaedi, "Pengaruh Kesadaran Lingkungan Pada Niat Beli Produk Hijau: Studi Perilaku Konsumen Berwawasan Lingkungan" (2005) 9:2.

42 Kementerian Energi Sumber Daya Mineral, "Strategi Pengembangan Biogas Menuju Target 1 Juta Biodigester", (24 March 2021), online: <https://ebtke.esdm.go.id/post/2021/03/25/2829/strategi.pengembangan.biogas.menuju.target.1.juta.biodigester>.

this program runs on a limited budget, so it can only cover not until 2% of the number of farmers. More than 98 of the cattle manure remains untreated properly. According to the data in Table 2, almost all the cattle manure produced in Tawangsari Village is still dumped into the river. The other problem is also the shortage of land. This program usually builds biodigester with a type of fixed dome which requires at least 18 m^2 of land per household.[43]

In addition, the biodigester is only used to process cattle manure. According to Table 3 and Table 5, the organic waste is not only cattle manure, but there is organic agricultural waste and unmanaged domestic food waste disposed of in open dumping at the village temporary landfill. As for animal farmers who already have biodigester technology at home, the residue from processing biogas, bio-slurry, still tends to be disposed of into rivers and not reprocessed into fertiliser because the treatment requires more effort.

V. VILLAGE CAPABILITY IN DEVELOPING CENTRALISED BIOGAS

According to Article 20(2) of Energy Law, villages become priority targets for the application of waste-to-energy technology as an implementation of equitable energy availability and distribution. This intention is enforced by the efforts to ensure the availability of renewable and clean energy, considering that these areas have abundant amounts of feedstocks from cattle manure, agricultural, and food waste. In addition, this is also in accordance with the implementation of the General Plan of Regional Energy in East Java as a follow-up to the NEP, which focuses on energy diversification in rural areas. With renewable energy potential, remote or rural areas will be precisely prioritised to gain energy from local renewable energy resources. This is in accordance with the mandate of Article 81(3) Law Number 6 of 2014 concerning Villages where the village government carries out village development through local wisdom and potential natural resources with an environmental perspective. For example, Tawangsari Village utilises local

[43] Pusat Penyuluhan Pertanian, "Membangun Instalasi Biogas", online: *Cyber Extension* <http://cybex.pertanian.go.id/artikel/65872/membangun-instalasi-biogas/>.

wisdom in the form of agricultural and livestock commodities that can be processed into biogas from the waste produced from these commodities.

Utilisation of agricultural and livestock commodity waste in Tawangsari Village is by the General Plan of Regional Energy in East Java targets which plan to develop biogas in all regencies/cities in East Java that have livestock potential for the 2019-2050 period which are aimed at substituting the use of kerosene/Liquefied Petroleum Gas (LPG) energy for cooking in the household sector. The development of biogas is the authority of the regional government as written in the NEP. The regional government develops biogas using funds from the National Revenue and Expenditure Budget (*Anggaran Pendapatan dan Belanja Negara* - NREB), Regional Revenue and Expenditure Budget (*Anggaran Pendapatan dan Belanja Daerah* - RREB), and the private sector. Allocation funds for infrastructure development in the regions are obtained from the balancing fund scheme obtained from the Specific Allocation Fund (*Dana Alokasi Khusus* - SAF).

SAF is funds transferred from the NREB to certain regions to give funds for specific regional activities according to national priorities based on the central government's work plan program from a fiscal year. SAF is divided into 2, namely physical SAF and non-physical SAF. Specifically for physical SAF covering 17 sectors, starting from education, and sanitation, until NRE infrastructure. It should be remembered that SAF will be given according to the special needs of the regions, and, for the 2023 SAF budget, only one region has been allocated funding for EBT infrastructure, namely the Province of East Nusa Tenggara. So that other provinces, especially East Java and the regencies/cities in it, do not get funds for NRE infrastructure. However, the allocation of funds in the NRE infrastructure sector is only for increasing connectivity and electrification, so 2023's SAF budget does not cover the development of biogas infrastructure.

From the perspective of legal politics, developing renewable energy at the national level seems slow to develop due to high development costs and the concern of priority. Even for the conventional energy industry, this cost is too high for renewable energy development. International Renewable Energy Agency (IRENA) reported that in 2019, the cost of renewable

energy was equal to the cost spent on conventional energy utilisation. For instance, the utilisation of conventional power costs $0.05/kWh - $0.15/kWh, while the electricity coming from offshore wind only costs $0.13/kWh, $0.10/kWh for biomass- and geothermal-powered electricity, and $0.05/kWh for water-powered electricity. According to IRENA, renewable energy is decreasing year by year up to the cheapest point of conventional energy, and it is all contingent upon the development of technology that should be continuously implemented.[44] The high cost is attributed to the utilisation of new technology, which necessitates a training program for the personnel responsible for operating it. However, the problem remains in the cost paid to the consumers. This cost should not be higher than conventional energy, and this condition has become a concern for the policymakers and decision-makers in Indonesia.

Hitherto, biogas development has been carried out by an NGO Hivos or the Energy House Foundation. Most digesters built are on a household scale, while Hivos has only two digester development schemes: fixed dome and mini home biogas.[45] The digester development scheme by Hivos is not applicable to be installed in Tawangsari Village because many cattle farmers did not have sufficient land to build a household-scheme biogas digester. Further, there is still a lack of knowledge among cattle farmers about the maintenance of biogas digesters because they do not have a background in engineer. Most cattle farmers generally also work as farmers, so they spend their daily working in the fields and do not have time to manage the digester. Therefore, it is necessary to have a community-based digester that accommodates various feedstocks in a certain area.

The biogas development using a community-based scheme must be supported by funding from the central and regional governments either through the NREB, RREB, or other funding schemes. This is due to the limited village funds which according to Village Ministry Regulation Number 8 of 2012 on Priority for the Use of Village Funds in 2023, Village funds are allocated for three main priorities, which are: (a) for national

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44 IRENA, *Renewable Energy Statistics 2019* (Abu Dhabi: The International Renewable Energy Agency, 2019).

45 Biru, "Biru Program", online: <https://www.biru.or.id/en/about-biru-program>.

economic recovery according to village authority, (b) for national priority programs according to village authority, and (c) for natural and non-natural disaster mitigation affairs. Meanwhile, 71% of the village budget is allocated for Direct Financial Aid, food and animal security programs, funding support to handle COVID-19, and staff salaries.[46] So, only 29% of the funds are used for the allocation of village development matters, such as waste management facilities, telecommunication towers, drainage construction, clean water supply, and others. Therefore, it is necessary to have specific regulations governing organic waste-based biogas processing that accommodate funding schemes, financing flow, incentives, technical standards for processing biogas and bio-slurry (residual of biogas processes), as well as biogas digester maintenance standards.

In terms of political will, the Tawangsari Village Government has shown its intention to manage the environment sustainably by making Tawangsari Village Regulation Number 4 of 2021 on Tawangsari Village Waste Management. In addition, the village government also has legal awareness to process biogas using local wisdom. However, the limited funding, no incentive schemes from the regional government, and no bottom-up initiative funding in Tawangsari Village become an obstacle to its development. If there is any regulation mentioning the financial scheme or incentives for developing a village community-based biogas plant, it is expected that there will be massive development in biogas infrastructure in rural areas in Indonesia. Moreover, it is also necessary to strengthen the institutional system and village government services, for example through Village-Owned Enterprises as legal business entities to be able to manage financial benefits from the results of biogas production.

VI. CONCLUSION

This study found that legal structures in Indonesia still need to accommodate waste-to-energy development from organic sources such as animal manure,

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[46] *Article 5(4) of Presidential Regulation Number 104 of 2021 on Details of the National Revenue and Expenditure Budget for Fiscal Year 2022 as amended by Presidential Regulation Number 98 of 2022*.

food waste, and agricultural waste. The Energy Law has recognised the existence of bioenergy as an alternative energy source that should be developed. Furthermore, the provisions of Article 20, paragraph (2) of the Energy Law highlight the importance of developing renewable energy based on local sources at the village level. Thus, in the NEP and PEP, it is planned to develop bioenergy in the form of biogas from livestock manure as organic waste. In line with this, ENDC also mentions the treatment of manure into biogas as one of the climate change mitigation plans. More regulations are needed to allow biogas development following local wisdom or local conditions. This is what was found in Tawangsari Village. This village is rich in organic waste but has the problem of limited land, which has made small-scale household-based biogas projects initiated by the government and NGOs ineffective. Organic waste is polluting the environment. Therefore, it is necessary to have a centralised biodigester managed communally by the village to ensure the sustainability of mass biogas production. However, no rules explain the mechanism for developing and funding bottom-up renewable energy development projects adapted to local conditions.

Household digesters in several houses in Tawangsari Village tend to dispose of the slurry into the sewer, which eventually settles and pollutes the river. Therefore, it is necessary to have regulations at the national and regional levels to regulate technical standards for digesters so that they do not pollute the environment. Because this sociolegal research elaborates on various social sciences and empirical facts to help analyse legal issues, there must be further research to review, conceptualise, and design this idea's business model and techno-economics.

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CONFLICT OF INTEREST

The authors declare no competing interests.

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