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Risks, barriers and responses to Indonesia's biogas development

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Photo (above): A farmer in Sarasedu, in the East Nusa Tenggara Province of Indonesia, prepares the gas line that will connect the village's new biogas digester with a stove. © SU-RE.CO

Indonesia's energy needs and policy ambitions

Indonesia's continued reliance on fossil fuels to meet increasing domestic energy demand has made it the world's eighth largest greenhouse gas (GHG) emitter (Friedrich et al. 2015). In 2016, following ratification of the Paris Agreement, Indonesia published its Nationally Determined Contribution (NDC) targets of 26% and 29% GHG emission reductions by 2020 and 2030, respectively, in comparison to a business-as-usual scenario. However, over the past five years, coal capacity has increased by around 12.2 GW, compared to only 1.6 GW of renewable energy, and planned capacity additions for renewables have been slashed in favour of coal (Climate Action Tracker 2019). A high-carbon pathway, evidenced in these energy plans and GHG emission trends, is far from being consistent with NDC targets. Indonesia's policies are currently rated as "highly insufficient" to meet its NDC (Climate Action Tracker 2019). Like other countries, it faces several challenges to mainstreaming and integrating climate change into national planning and development processes.

Indonesia's main strategy for development is formulated in the National Long-Term Development Plan, which is divided into four 5-year National Medium-Term Development Plans. The current medium-term plan applies from 2015 through 2019. One of its aims is to increase the contribution of renewable energy to 23% of total primary energy supply by 2025, as indicated in the NDC. Although the target for the renewable energy share exists, there is no clear implementation plan from the government for how the country will meet the goal. Moreover, other policies in the energy sector often run counter to these commitments.

Shifting to a more sustainable economic pathway, including clean energy production, faces many barriers as economic growth is prioritized over other issues. Indonesia's expansion of coal mining, a sector which attracts large export earnings, also risks the potential lock-in of carbon-intensive infrastructure and financial assets if global markets decarbonize; yet as far as the government is concerned there are "...no futures imagined in which coal mining does not feature centrally..." (Atteridge et al. 2018). This articulation of support for the fossil fuel economy summarizes one of the challenges for pursuing renewable energy transitions in Indonesia.

Rethinking renewable energy solutions in Indonesia

Renewable energy solutions, including bioenergy, need to be: low-cost, clean, and geographically and culturally appropriate fuels that meet energy needs and are reasonably easy to implement and use.

Biogas produced through agricultural waste is one viable alternative since it can be implemented in rural, and sometimes remote, areas where many Indonesians live. Biogas provides GHG emission mitigation benefits by reducing demand for conventional energy. Potentially, two million small biogas digesters could be installed in Indonesia, equivalent to a reduction of 6.4 million tons CO_2/year as estimated by an initiative called BIRU, a domestic biogas promotion programme of the Yayasan Rumah Energi NGO (Devisscher et al. 2017). Meanwhile, the estimated potential capacity for large-scale biogas-to-electricity production is 2.6 GW (Government of Indonesia 2017). Co-benefits include reducing unmanaged firewood collection, helping manage animal waste and providing biogas slurry as organic fertilizer (Bedi et al. 2017).

Overall, biogas offers some promising practical and feasible alternative energy options for Indonesia. This briefing investigates the potential of biogas to help meet domestic energy needs and to comply with Indonesia's climate mitigation commitments and development planning. A better comprehension of the risks and uncertainties associated with biogas development pathways can support future dialogue and planning on climate, energy and development.

Envisioning a future with biogas

Research, carried out by the Stockholm Environment Institute (SEI) and su-re.co (Sustainability & Resilience.co), a Bali-based environmental think tank, aimed to understand how biogas alternatives could effectively contribute to a low-carbon energy transition and what changes are required to achieve it. A transition pathway is a description of how such a transition might unfold that includes technological innovations implemented in an existing or new market, policy interventions that shape how this technology is used, and the social setting where the consequences are felt and where support or opposition originates (Lieu et al. 2019). The two pathways in this brief explore options for a low-investment/short-term scenario and a high-investment/long-term scenario. The first is an easily implementable, low-cost household-scale option supplying household energy needs through individual or communal installations. This pathway also foresees the transfer of these systems and the know-how to other geographical areas. The second pathway focuses on large-scale biogas systems that produce electricity, require higher investment, and generate high benefits in the long run.

Household biogas for cooking pathway

Four biogas programmes are operating in the study region in Bali, Indonesia. These programmes were implemented by Bali Provincial Agricultural Agency (SIMANTRI), the Agency of Public Works, the West Bali National Park, and BIRU (Table 1). All programmes installed individual biogas digesters except SIMANTRI, which carried out communal installations. Also, the government's programmes provided fully subsidized biogas while the BIRU programme used a market-based approach with partial subsidies (Devisscher et al. 2017).

Renewable energy solutions, including bioenergy, need to be: low-cost, clean, and geographically and culturally appropriate fuels that meet energy needs and are reasonably easy to implement and use.

The household biogas transition pathway is concerned with meeting domestic energy needs for cooking and lighting that intersect with issues of health in rural areas, community social structure and smallholder productivity. These issues are important for understanding the pathway. Nearly one-third of Indonesia's working population consists of farmers in rural areas (BPS 2017), where solid fuels are mostly used for cooking and are often associated with health problems (Gall et al. 2013). Indoor pollution in the home from solid fuels utilization contributes to respiratory infections and diseases. Biogas for household cooking and lighting is clean and safe, while also fitting the profile of the rural areas.

In addition, biogas offers a potential means to increase farmers' resilience by, for instance, the use of biogas slurry (bioslurry) as organic fertlizer. These could generate new sources of supplementary or additional income for the smallholder, who may trade organic fertilizer or roasted coffee beans produced on the premises. These benefits to the smallholder farmers should be added to the savings gained from reducing reliance on fossil fuel-based energy.

Large-scale biogas-for-electricity pathway

Currently, large-scale biogas plants operate successfully in some areas of Indonesia as waste management reactors and energy generators, but the technology is not as well known as household- or smallholder-scale biogas. The large-scale biogas-for-electricity transition pathway concerns longer-term expansion of production capacity that would contribute to Indonesia's 2025

Table 1. Current biogas programmes operating in Bali (and in Indonesia)

	SIMANTRI*	PUBLIC WORKS	BIRU*	WEST BALI NATIONAL PARK
Year of Introduction	2009	2015	2009	2013
Description	Integrated farming that includes installation of communal biodigesters. Farmer associations receive the biodigesters as well as cattle. Guarantee period: 3 months.	Individual biogas digesters are installed in farmer households that own livestock and show potential and interest. Guarantee period: 3 months.	Individual biogas digesters are installed in farmer households that own livestock. Guarantee period including maintenance services: 3 years.	Pilot project provides livestock and biodigesters to farmers around the West Bali National Park in Jembrana Regency.
Implementing Agencies	The project was initiated by the governor of Bali. The Bali Provincial Agricultural Agency is the lead implementing agency.	Public Works is the lead implementing agency. Receives support from the Agricultural and Livestock agencies at the regency level.	SNV Netherlands and Hivos* launched the programme. In 2012 Hivos created Yayasan Rumah Energi to operationalize the programme.	The West Bali National Park authority is the lead implementing agency, with support from the forestry agency in Jembrana Regency.
Funding	Provincial budget pays for communal installation (incl. biogas). Programme is 100% subsidized and farmers do not pay for the biodigester installation.	Funded by national government. Provinces budget allocation for biogas projects. Programme is 100% subsidized.	Multiple donors: Hivos, EU carbon market and Indonesian government. Partly subsidized and partly paid for by farmers.	Ministry of Environment and Forestry provides funds that go directly to Jembrana Regency.
Biogas Installations	632 biodigesters installed as of Oct 2016. Farmers also produce bioslurry as part of the integrated farming.	57 biodigesters installed in Jembrana Regency.	16,000+ biodigesters installed as of November 2016 in 9 provinces of Indonesia.	Only a few pilot projects have been implemented around the national park.

Source: Devisscher et al. 2017 - Interviews, focus group discussions, programme websites.
** SIMANTRI is the Bali Provincial Agricultural Agency. BIRU is a domestic biogas promotion programme of the Yayasan Rumah Energi NGO . Both SNV Netherlands and Hivos are international aid/development organizations based in The Netherlands. The SNV Netherlands Development Organisation, a non-profit group, focuses on international development.*

renewable energy and 2030 carbon emission targets. It is also a means of addressing the near-term development goals of providing electricity access in remote areas and jobs in renewable energy-generating enterprises.

Since 2014, the government has focused on increasing electricity access to rural areas, including remote islands. As it stands, Indonesia has achieved above 94% of its electrification ratio target of 92.75% in 2017 through the Solar Powered Efficient Lamp (LTSHE) programme in rural areas (Kementerian ESDM 2017; Kementerian ESDM 2018). To further develop the sector new approaches may be needed. In this regard, promising new regulation has been introduced that offers private companies the opportunity to generate and sell electricity in currently unelectrified regions - although the delivery and pricing models need to be carefully thought out (Susanto 2016).

Currently, many private-sector actors are working on renewable energy initiatives, but they are less active in biogas-to-electricity enterprises. Stakeholders observed that the current policy is not totally supportive of the biogas-for-electricity pathway. Biogas power plants have high initial set up and operating costs, and therefore companies selling electricity generated by biogas face strong economic challenges in view of the low feed-in tariff – the price at which companies may sell electricity to Indonesia's state-owned electricity corporation. There was, however, some political support for making the policy more favourable to renewable power companies via strengthening the feed-in tariff legislation and implementation.

Risks and uncertainties

To successfully navigate a transition pathway, it is important to understand the kinds of risks and uncertainties that might come into play. Risks and uncertainties are closely related concepts; however, risks are often understood in a more context-specific way, and they also more often carry negative connotations (Hanger-Kopp et al. 2019). It is also important to note the subjectivity of risk perception. What may pose a risk for one group of stakeholders may be totally satisfactory and unproblematic for another. Similarly, uncertainty stemming from the different viewpoints among stakeholders on the value and meanings of biogas, together with an overall lack of consensus, can make it difficult to find solutions.

To get a clearer picture of the situation in Indonesia, researchers held policy dialogues and workshops with a wide range of stakeholders: district, provincial and national government officials [from the Ministry of National Development Planning (Bappenas); the Ministry of Energy and Mineral Resources, and the National Electricity Company (Perusahaan Listrik Negara)]; private-sector actors; university- and government-based researchers, representatives of NGOs and banks, and coffee and cacao farmers. Two main uncertainties raised by the stakeholders in the workshops included: the unclear role of public and private sectors and the unspecified national biogas target. It is worth unpacking these uncertainties further in order to contextualize the main risks and barriers discussed later in this brief.

First, the roles and responsibilities of the public and private sectors in accelerating development of the sector, and bearing the financial risks, are unclear. This is an issue of regulatory uncertainty: the private sector is expected to invest in and manage bioenergy assets, but it is not clear to what extent the government will be prepared to support this through favourable regulation, to de-risk the sector on the basis of the wider public benefits from low-carbon pathways. This situation hinders businesses investment and may undermine the willingness of public and private sector actors to collaborate effectively.

Farmers working in the fields in Bali, Indonesia. Farm plant and animal wastes are used to power the biodigesters, and the waste (bioslurry) from the biodigesters provides fertilizer for crops. © TAHIA DEVISSCHER

Second, the current lack of biogas development targets is problematic. Targets – together with policies to meet those targets - are an important way to reduce risks and uncertainty. In their absence stakeholders face uncertainty and this may negatively affect their commitment to biogas. A national biogas target might help to motivate ministries and other actors to better coordinate biogas programmes to pursue a common objective. Critically, the government also needs to have the capacity to implement the measures to achieve such targets. Moreover, there are ways to move along the pathway without targets. Other changes supporting a transition may include: implementing experimental pilot projects to deliver lessons for feasibility of options; institutional and social reconfiguration through activities such as the creation of multi-stakeholder learning networks and spaces; or conducting Technology Needs Assessment exercises to move forward with transition planning for a specific priority technology.

Residents of an Indonesian village install a cylindrical plastic biogas digester. © MASNARANG / FLICKR

Main risks of biogas development in Indonesia

We now discuss seven of the most significant risks across both pathways identified by policy stakeholders. Note that while many stakeholders had background experience in household programmes and held strong views about this pathway, fewer had a background in biogas-to-electricity. Therefore, risks associated with the latter were discussed in less detail and may have been underestimated.

1. Investment risks (Household and electricity pathways)

Chief among the risks is the high initial investment requirement for both pathways. For the investor, upfront cost is a barrier regardless of government support. Household biogas is not affordable for most farmers, and for others may be difficult to justify given the small savings involved. However, strong interest has emerged in cheaper PVC alternatives to concrete dome digesters. Stakeholders also mentioned investment risks hindering entrepreneurship in the electricity pathway; private investment may grow if incentivized through appropriate regulation and redistribution of risks. In terms of government support, it is expected that public investment would need to be considerable in either pathway, however this was perceived by some as an additional risk due to the low reliability of public finance.

2. Inadequate monitoring and maintenance (Household pathway)

A risk specific to the household pathway was the lack of standards for biogas monitoring procedures. Weak monitoring can be attributed to the different motivations underlying biogas programmes and lack of consensus on monitoring (Devisscher et al. 2017). Many digesters had been abandoned when farmers faced difficulties operating biogas or technological faults, as they had no warranty and were not technically trained. A low sense of ownership was another factor in disuse of subsidized biodigesters: farmers who contributed financially to the purchase were more likely to continue to use the equipment than those who had received full subsidies. Generally speaking, when the capacity of the farmer (finance, skills, knowledge) is lower, there is a greater risk of not fully benefiting from the installation.

3. Complicated and bureaucratic distribution and management (Household pathway)

Government-run programmes often present barriers in the distribution of biogas systems to individual farmers. These farmers encountered difficulties with the process; they felt it was particularly bureaucratic and time-consuming. There are various stages farmers need to pass through to obtain the digesters and each stage could prevent their participation. On the other hand, with communal biogas installations in the SIMANTRI programme, barriers arose around management issues (Devisscher et al. 2017). Low attachment to biogas technology and difficulty coordinating as a team were factors in many cases. There was more interest in the biogas slurry and waste and less interest in biogas use.

4. Price and reliability of electricity from biogas (Electricity pathway)

Discussions about technology development for the electricity pathway revealed concerns about the reliability of supply. The output of biogas-fuelled power plants might not be .as stable as

Farmers and residents at the installation of a biogas digester in Sarasedu, a village in the Ngada District in the East Nusa Tenggara Province in Indonesia. © SU-RE.CO

the existing commercial elecricity generators (including hydroelectricity, thermal, diesel, natural gas, and geothermal sources). Nor might the biogas generators be as efficient. Unreliability of biogas technology could ultimately harm its commercial feasibility. Further, the high costs associated with the technology might also necessitate a high production cost that is passed on to consumers, which could be damaging for demand. Under this scenario, electrification in remote areas would become very difficult to achieve.

5. Fossil fuel subsidies (Household and electricity pathways)

Fossil fuel subsidies present another challenge because they work against biogas development. For households, fossil fuel alternatives remain attractive because of their affordability compared to renewable energy alternatives. For example, a 3-kilogram liquefied petroleum gas tank is widely subsidized. Such subsidies mean low-investment costs for farmers and lower technological barriers. Nevertheless, in many rural or isolated areas subsidized fuels are not accessible or are rarely available. Subsidies also affect the electricity pathway; electricity from coal plants is more heavily subsidized than renewables, making it affordable (IISD 2018). At the same time, the low tariff currently makes it very difficult for biogas-fuelled power to compete successfully with fossil fuels.

6. Environmentally harmful leakages (Household and electricity pathways)

Environmental aspects were a central concern for both pathways. For example, some rural biogas digesters were not installed with hydrogen sulphide (H_2S) filtering, which may harm the environment or even human and livestock health according to interviews with local researchers. It also runs the risk of corrosion to the digesters (Chaiprapat et al. 2011). In many cases, the observed biogas digesters were found to be not equipped with filtering. Similarly, some methane leakages in the biogas digesters might occur when users do not burn the biogas produced. Risks of possible leakage of methane emissions and unfiltered H_2S would occur on both pathways, as they are based on similar technological principles.

7. Redistribution of labour for the smallholder (Household pathway)

The women in rural Bali tend to have significant roles in collecting firewood and providing meals, while men's roles are mainly taking care of livestock. Men are also normally responsible for managing organic waste as feedstock for biogas technology. Substitution of biogas for firewood therefore has the effect of reducing the women's working time while increasing the men's time. Such a role reversal has a positive aspect because women and their families can benefit from women spending more time doing other things. However, it was also recognized that this role change relating to unpaid work on the farm also carries a risk of labour imbalance in the household. Similarly, task division among smallholders was fraught according to some experiences with SIMANTRI's communal installations.

Considering risks and responses to risks

Considering the set of seven risks as a whole, it is evident that stakeholders tended to focus on the barriers to uptake, rather than potential negative outcomes of biogas development. This has been observed in other transition pathways work (Lieu et al. 2019). Considering the two transition pathways, clearly the technologies, policies and social issues are very different, and therefore the risks are specific. On the other hand, there are common risks that appear on both pathways: the cost of initial investment, the risks of environmentally harmful leakages, and the prevalence of fossil fuel subsidies. In such cases it could be valuable to consider whether measures can address risks on both pathways simultaneously more effectively than can combinations of more targeted measures.

Biogas development has not yet become a government priority. As a result, biogas is not being developed evenly across Indonesia.

Overall, we found that biogas development has not yet become a government priority and, as a result, biogas is not being developed evenly across the country. This has also led to a tendency to criticize current biogas efforts rather than evaluate them thoroughly. However, both government and businesses are working to address current shortcomings, to build their knowledge and to look for new opportunities. For example, implementation challenges have led su-re.co's clean energy business to design and pilot less expensive and more easily transportable household digester equipment: the removable biogas digester bag. The PVC digesters are well-suited to the even year-round temperature, unlike the concrete digesters which are prone to crack with alternating wet/dry conditions.

Knowledge from activities on the ground, as well as from in-depth research in Bali, and its wider significance were discussed at a national level, and a number of conclusions and recommendations also surfaced at this level.

First, it is important to address uncertainties in government policymaking by formulating renewable energy targets complemented by clear pathways to attain them. It could also be effective to further disaggregate the targets by technology or application and implement the different mechanisms as appropriate. Second, it is necessary to implement supporting actions to mitigate risks, such as strengthening the institutions that manage the national biogas development and implement monitoring standards and other regulations. Third, it is important to further incentivize private investment by introducing favourable lending schemes and feed-in tariffs, as well as enabling supplementary income generation. These steps could make biogas transition pathways very attractive to a majority of stakeholders and would encourage effective collaborations.

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