Renewable energy for agriculture: Insights from Southeast Asia

A focus on heating and cooling needs

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Abbreviations

GDP	gross domestic product
GWh	gigawatt hour
kt	kilotonnes
kW	kilowatt
LPG	liquified petroleum gas
mtoe	million tonnes of oil equivalent
NDC	nationally determined contribution
TJ	terrajoule
USD	United States dollars

1. Introduction

The agriculture sector, comprising farming, fisheries and forestry, is a key economic sector in Southeast Asia. It contributed to 10.5% of the region's gross domestic product (GDP) in 2020, with the sector playing a much stronger role in economies such as Myanmar and Cambodia (Table 1). The sector is also a significant source of employment. In Cambodia, Myanmar and Lao PDR, the sector accounts for 33%, 50% and 45% of employment, respectively (ASEAN, 2021a). Agri-commodities also play a crucial role in exports, with agricultural products accounting for the largest share of total exports in Myanmar (24%), Lao PDR (23%), Indonesia (19%) and Thailand (14%) in 2019 (ASEAN, 2020).

The agriculture sector is an important driver of socio-economic development in the region. A key infrastructure input to enable growth in the sector is access to modern, reliable and affordable energy. At each step of the value chain – from primary production to post-harvest processing, storage, transport and retailing – energy helps to increase yields, enable value addition, reduce losses and improve market access. It is also important in the face of rising climate impacts that particularly affect smallholder farmers. Adaptation and resilience measures to facilitate resource access (*e.g.* water) or enhance the adaptative capacity of farmers and agri-enterprises (such as through processing and storage) require access to energy, among a host of other infrastructure and soft supports.

Table 1 Role of agriculture in GDP and employment, by country and year

	Contribution of agriculture sector to GDP (%, 2020)	**Share of employment in agriculture (%, year of latest data)**
Brunei Darussalam	0.8%	1% (2020)
Cambodia	17%	33% (2019)
Indonesia	12%	30% (2020)
Lao PDR	14%	45% (2017)
Malaysia	7%	11% (2020)
Myanmar	22%	50% (2019)
The Philippines	10%	26% (2020)
Singapore	Negligible	Negligible
Thailand	6%	35% (2020)
Viet Nam	14%	33% (2020)

Source: ASEAN (2021a). Figures are rounded.

This brief analyses energy use in the agriculture sector of Southeast Asia and examines the role of renewables in meeting growing energy needs in an inclusive and environmentally sustainable manner, while contributing to regional and national socio-economic development objectives. It specifically focuses on meeting heating/cooling needs[1] given that this end-use sector is often overlooked in conventional discussions on energy transition. The brief uses detailed case studies, as well as numerous shorter examples, to extract lessons learnt from on-the-ground experience with insights into how to finance these technologies and how to design programmes for maximum impact.

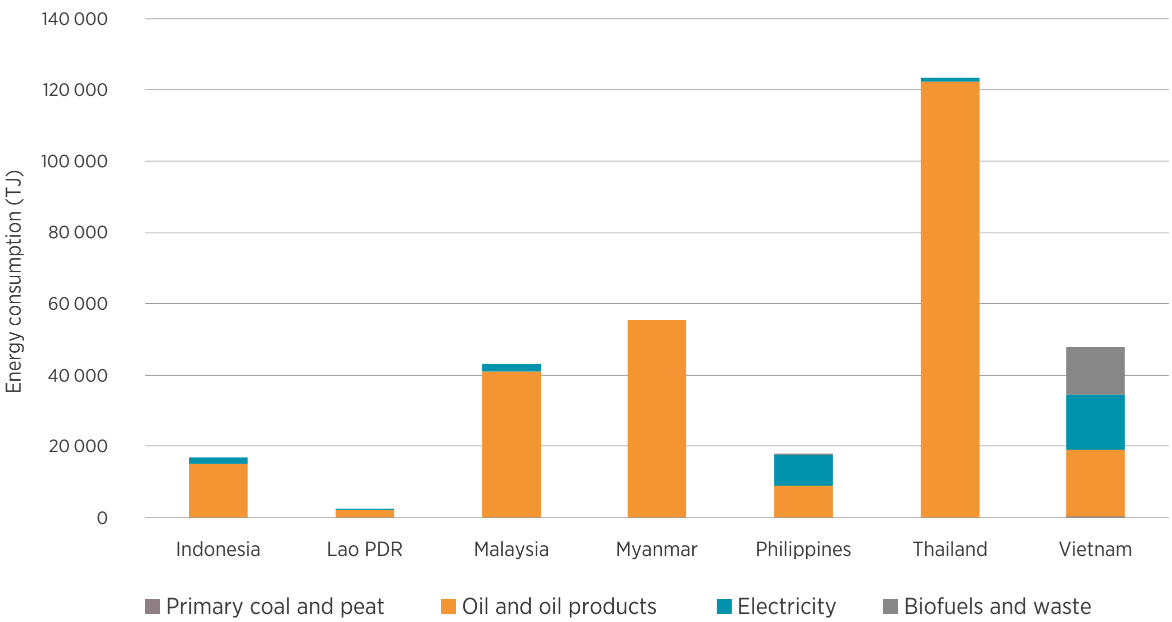
[1] *For the purposes of this brief, both direct (e.g. solar thermal, biomass combustion) and indirect (e.g. powering cold storage infrastructure) use of renewables are considered for providing heating/cooling services in the agriculture sector. Heat from electric technologies powered by renewables, for instance, can be used to pasteurise milk, dry foods, sterilise crops to reduce post-harvest losses from contamination and spoilage, and help smallholder farmers transform raw produce into more valuable products (IRENA, OECD/IEA and REN21, 2020).*

2. Energy use in agriculture

Growth in energy use in agriculture takes place alongside the mechanisation of on-farm activities, increase in inputs (*e.g.* fertilisers), and building of processing and storage infrastructure, which can enable the development of inclusive supply chains culminating in equal access to food and nutrition for all. The sector accounted for about 2% of the region's total final energy consumption in 2019 (UNSD, 2021). Between 2009 and 2019, energy consumption in the sector grew 35% to reach over 8 million tonnes of oil equivalent (mtoe). As the agriculture sector develops, energy use is anticipated to continue to grow in line with trends seen in other regions.[2]

At present, a significant share of the energy used in the agriculture sector in the region is fossil fuel-based. This mainly comprises oil products and electricity mainly for powering on-farm equipment such as pumps and agro-processing equipment (Figure 1). Beyond the farm gate, energy use in the sector can also be significant, for example for processing. In the Philippines, for instance, the food and tobacco sector accounted for over a quarter of all energy consumed in industry, the majority of which was biofuels and waste, followed by electricity and oil products (UNSD, 2021). Biomass is extensively used in the agriculture sector to meet thermal energy needs, including the use of bagasse as boiler fuel for co-generation, rice and coconut husk for crop drying, and fuelwood and residues for oven kilns (Shead, 2017). Traditional biomass continues to be extensively used for cooking. While significant progress has been made in recent years, at least 210 million people lacked access to clean cooking fuels and technologies in the region in 2019 (ESMAP, 2021).

Figure 1 Energy consumption in agriculture, forestry and fishing, by country



Source: UNSD (2021).

[2] *As a comparison, in the European Union with a population comparable to the Association of Southeast Asian Nations (ASEAN) (445 million vs 660 million in 2020), agriculture contributed to about 1.3% of GDP in 2020 and over 3% of final energy consumption, or 28 mtoe.*

Enhancing access to reliable, affordable and environmentally sustainable energy is crucial to support the development of the agriculture sector in the region, particularly for smallholder farmers in rural and remote areas. Sustainable energy use along agricultural value chains improves energy access and security, diversifies farm and value addition earnings, reduces produce waste and accelerates the energy transition. Energy needs can vary along various value chains (see Box 1 for examples from Myanmar). With abundant resources in the region, renewable energy solutions can meet many of the energy needs in agriculture for electricity, heating/cooling and transport in a manner aligned with sustainability, development and climate objectives (IRENA and FAO, 2021).

Agriculture has a dual role as an energy user and as an energy supplier in the form of bioenergy (ADB, 2021a). The high productivity of the region's agriculture sector and the presence of large agri-industries generates considerable volumes of under-utilised residues (IRENA, 2022). In fact, the ASEAN Strategy on Sustainable Biomass Energy for Agriculture Communities and Rural Development in 2020-2030 links modern bioenergy production through the management of agricultural residues, organic wastes and fuel wood plantations, with energy security for rural communities (ASEAN, 2021b). Alongside support for climate-smart agriculture technologies, access to capital and markets by providing extension services and aggregation mechanisms, among others, is also crucial (ADB, 2021a).

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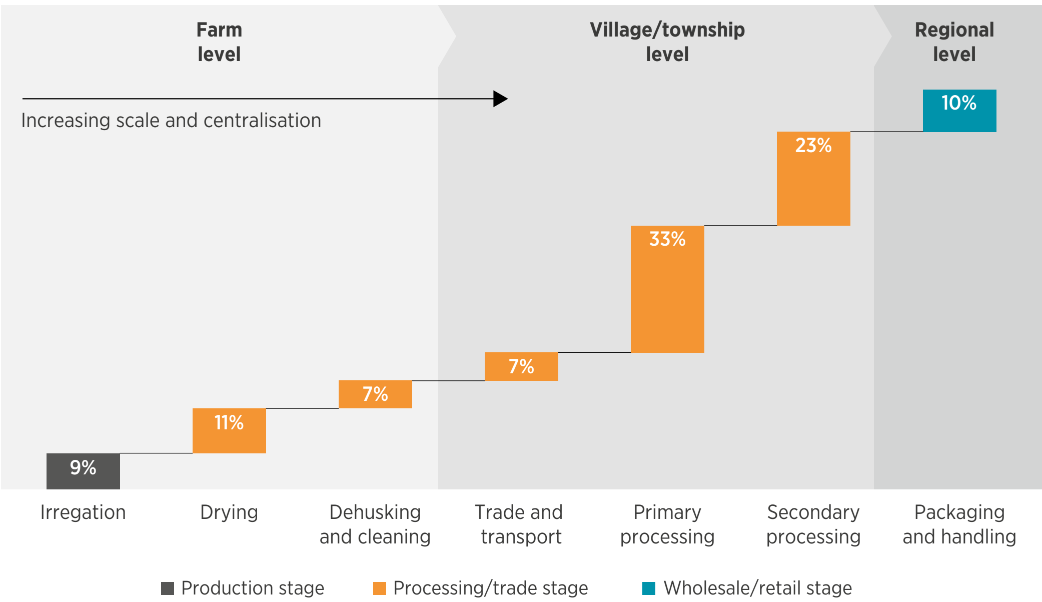
Box 1 Energy use along rice, beans and pulses value chains in Myanmar

Rice, beans and pulses dominate agricultural production in Myanmar, accounting for nearly 70% of crop output in 2016 and three-quarters of cultivated land.

During the production stage of the **rice value chain**, energy is needed for land preparation, seeding, irrigation, weeding, pesticide spraying, harvesting and stubble cutting. While small-scale farmers largely rely on manual and animal labour, as well as diesel-powered machinery, medium-scale farmers usually have electricity access (as a result they use more electricity-powered equipment), although reliance on fuel-powered water pumps and tractors is common. In the processing stage, activities usually involve drying, threshing, dehusking, polishing and colour sorting. Post-harvest drying is done to remove excess moisture from the paddy before threshing, with many farmers and processors relying on sun-drying or dryers powered by burning rice husk. Improved drying facilities prevent kernel cracking, preserve the quality of grains and attract higher value in the market (Figure 2).

Figure 2 Value addition of activities in the rice value chain



Source: Smart Power Myanmar (2021).
Note: Primary processing refers to dehusking, sorting and basic polishing (transforming brown rice to white rice). Secondary processing refers to advanced polishing, wet-milling (for flour) and colour sorting. Farm inputs and fuel-powered farm activities are excluded in this analysis.

For the **beans, pulses and oilseeds** value chain, the production stage involves energy for insecticide spraying machines, water pumps, combine harvesters and tractors. Although the need for drying is lower compared to rice value chains, access to drying machines is known to make threshing easier. Due to a lack of access to energy, farmers typically sell produce to processors or traders following threshing, which is usually fossil fuel-powered. The processing stage involves the operation of grading machines, colour sorters and oil milling equipment, most of which is electricity-based, thereby requiring transport to cities with adequate energy access and thus limiting value generation upstream.

3. Renewables for energy needs in agriculture: A focus on heating/cooling

Energy is needed along each step of the agri-food, fisheries and livestock value chains. This section discusses the role of renewable energy solutions for meeting heating/cooling needs at each stage.

In the **primary production** stage, the direct energy needs are largely for traction and electricity or fuel for operating machinery such as irrigation pumps. Some agri-food value chains have heating/cooling needs at this stage. In Cambodia, for instance, modern pig farms consume large amounts of electricity for lighting and water pumping for evaporative cooling systems (Long and Louie, 2019). This leads to high operational expenditures, particularly in areas where diesel generators are used to meet all, or part, of the energy needs. Solar-based solutions have been supported through the Clean Energy Revolving Fund in one on-grid and six off-grid pig farms to reduce energy costs for cooling and improve access to water for livestock, irrigation and drinking water (see Case Study 1 for further details). In Viet Nam, where livestock production, particularly poultry, has been among the fastest-growing sectors in agriculture, energy costs for heating, incubation and ventilation equipment can be significant. In the Lao Cai province, solar-based solutions are deployed to improve energy efficiency and reduce energy costs for smallholder farmers and unlock new opportunities for livestock rearing, agro and herbal product and noodles processing, and fish and fruit drying (UNEP, 2021). For the majority of the most vulnerable people of the Southeast Asia region, dried fish is of important nutritional, economic, social and cultural importance.

In the **post-harvest processing** stage, thermal energy requirements grow, particularly for drying, cooling and various other processing activities. Drying crops is an important step to ensure high-quality output and to cut losses by reducing moisture content. In the case of rice, post-harvest drying is done to remove excess moisture from the paddy before threshing. Many farmers and processors relying on sun-drying or dryers powered by burning rice husk. There is need for better drying facilities (*e.g.* mechanical dryers) that preserve grain quality. Where waste heat or heat from residues can be harnessed, significant thermal energy needs in agriculture can be met (Box 2).

In Cambodia, where the market for dried products is significant, solar dryers have been deployed on farms to dry produce (*e.g.* moringa leaves and other herbs and spices such as ginger, turmeric, lemongrass, etc.) on-site. The dried produce is then sold for further processing. The drying reduces losses during transport (which can be up to 30%). Further, the use of solar dryers in place of sun-drying speeds up the process, while ensuring quality and hygiene (ADB, 2021b). In the Philippines, solar-assisted dryers are being installed for seaweed drying in the municipalities of Sitangkai, Sibutu, Panglima Sugala and Tandubas (see Case Study 3).

Compared to other regions, the use of geothermal energy in agriculture to meet thermal energy needs has been limited in Southeast Asia, with examples emerging from Thailand and Viet Nam largely for crop drying (FAO, 2015; IRENA, 2019). In Thailand, a cold storage plant powered with geothermal has also been constructed to test the cooling of lemons, onions and lychees. In Thai Binh, Viet Nam, operators of fish breeding ponds and chicken farms are beginning to use water for warming in the winter (Lund and Toth, 2020).

The Philippines aims to tap into small-scale geothermal to meet energy needs in the agri-fishery sector (Richter, 2020) and has reported its use for drying coconut meat, distilling vetiver oil, pasteurising mushrooms, processing brown sugar, farming catfish and drying coffee beans and tea leaves (Lund and Toth, 2020). In West Java, geothermal energy was successfully used as a substitute for oil fuel in the sterilisation stage of the mushroom cultivation process, leading to reductions in costs and emissions (Surana *et al.*, 2010). Beyond drying, renewables can also provide thermal energy needs for other processing techniques. In Lao PDR, solar concentrating solutions have potential in industrial applications, including food processing and milk pasteurisation (Pillai, 2014).

The need for temperature-controlled **storage** may emerge along different stages of the agri-food value chain depending on the nature of the commodity. In the fishery sector, an accessible cold chain is necessary to preserve catch, reduce losses and access markets for value extraction by fishers. The energy-intensity of ice-making, cold storage and refrigeration is a key challenge, particularly in off-grid/island contexts where access to reliable and affordable energy may be non-existent or limited. Increasingly, renewables-based cold storage solutions are being rolled out to improve access to cooling services for fishers (see Box 3). Beyond fishery, to reduce post-harvest losses, stand-alone renewables-based modular, on-farm cold storage infrastructure is also being deployed for perishable goods, such as fresh fruits and vegetables, in the Philippines (Manila Times, 2021).

Box 2 Residues for meeting energy needs in agriculture: The case of Thailand

Bioenergy is extensively used in Thai industries to generate heat, steam and power. For instance, more than 80% of the process heat in the sugar, pulp and paper, rice milling, timber, and palm oil industries is provided by residues and wastes. Many small-scale plants focusing on agro-processing and food processing use solid biofuel for their process heat. Larger-scale plants producing sugarcane, cassava and palm oil use both solid biofuels as well as biogas in co-generation plants that produce heat and electricity for their operations. Some applications of bioenergy in industry include:

- Sugar mills use bagasse to produce thermal energy for the distillation process. Some mills use steam from the combustion of bagasse in steam turbines for electricity generation, while others use steam in the operation of rollers used to extract the cane juice.
- Rice mills commonly use rice husks as fuel for drying the paddy, further processing such as the parboiling and production of rice noodles, as well as for power generation.
- Oil palm mills often use the fibre and shells from fruits as fuel to produce thermal energy for the sterilisation of fresh fruit. In addition, most oil palm mills have provision for electricity generation.
- It is common practice for pulp and paper mills to use wood waste and black liquor as fuel for the production of thermal energy and electricity. Sawdust, wood chips and other wood residues (called "hog fuel") are also used on-site.

Source: Papong *et al.* (2004), IEA (2017), IRENA (2017, 2019).

Box 3 Use of renewable energy for ice production for fishery: The case of Indonesia and the Philippines

Fisheries represent a key sector in **Indonesia**, the second-largest fish producer in the world. Small-scale fishers, who make up about 80% of the fishermen and women, continue to use traditional fishing methods. The lack of infrastructure, in particular of cold chains, leads to losses and prevents broader market access and competitiveness against industrial fishers.

In remote and island contexts, where access to reliable and affordable energy for cooling may be limited or non-existent, decentralised renewable energy-based facilities can bridge this important gap. In the fishing village of Sulamu in the southeast of Indonesia, a solar-based ice block machine was deployed to generate up to 1.2 tonnes of ice blocks per day. Fish packed in ice attracts higher market value – over 50% or more in the case of tuna – boosting incomes for fishers and resulting in annual increases in value added for each village equivalent to an estimated USD 123 000. Each solar icemaker further saves 40 tonnes of carbon dioxide (CO_2) and around 14 000 litres of diesel fuel per year. While funded with support from development partners, a local enterprise (Selaras Mandiri Tehnik, AIREF) operates and manages the production facility.

In the province of Mindanao in the **Philippines**, where 36% of the country's farm area and 43% of total food production lies, a dedicated programme has been launched to improve access to energy in the agriculture sector. The Mindanao Development Authority, in co-operation with the National Electrification Administration and with funding from the European Union, has launched the project Integration of Productive Uses of Renewable Energy for Inclusive and Sustainable Energisation (I-PURE Mindanao). A key component of the I-PURE project is to support a portfolio of renewable energy investments to foster development in rural areas, particularly in agriculture. This includes deploying 22 fish centres in off-grid areas that will be equipped with solar-powered facilities and biomass-based processing equipment.

Source: GIZ (2020, 2021); IRENA and FAO (2021).

At the **final consumption** stage, the use of modern renewables to displace the use of traditional biomass for cooking/heating, as well as liquified petroleum gas (LPG) fuels, is increasingly relevant. Biogas-based solutions have significant potential in Southeast Asia due to its abundant feedstock, including agricultural residues and animal manure. Several countries in the region have introduced dedicated programmes to deploy household-based biogas digesters to replace wood, charcoal and biomass. In Viet Nam, for instance, over 290 000 biogas digesters were constructed between 2003 and 2020, improving energy access for cooking for over 1.7 million people while also addressing the waste management challenge of the growing livestock population. In Cambodia and Indonesia too, programmes were initiated to support the adoption of biogas digesters (see accompanying case studies). With the mechanisation of agriculture and reduced livestock at the household level, the feedstock supply may be at risk. Large production facilities that can produce biogas on a commercial scale may offer significant potential.

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4. Measures to scale up renewables-based heating/cooling in agriculture

The case studies and examples presented here highlight the potential of renewable energy solutions to meet diverse energy needs in the agriculture sector. The decentralised nature of the solutions enables them to be deployed in remote areas and strengthens energy access to support each stage of the value chain, from primary production to processing, storage and final consumption. Building on the experiences in the region so far, this section presents a set of measures necessary to scale up the deployment of renewable energy solutions in the agriculture sector.

1. Follow a value chain approach to identify high-impact renewable energy opportunities

Agri-food chain structures are diverse and can be highly complex, involving multiple actors and interactions with varying products involving crops, livestock, forestry, fisheries and aquaculture. Using a value chain[3] approach to assess energy needs and gaps offers several advantages (IRENA and FAO, 2021). First, it enables the identification of energy needs and gaps at each stage, making possible a "whole-of-system" intervention design to unlock maximum value and benefits. For instance, the household biogas digester programme in Viet Nam aimed to mainly utilise livestock waste to produce biogas for clean cooking and, in some cases, electricity production, with the bio-slurry being used on-farm as organic fertiliser or fish feed, or to be traded.

Second, a value chain perspective considers the enterprises and stakeholders operating at each stage, offering insights into where incentives already exist and where they can be most useful in encouraging the use of renewable energy. For instance, adopting renewables-based cooling and water pumping within the milk value chain will directly benefit dairy farmers; additional value may also occur for milk processors, transport businesses and retailers from reduced losses and improved quality (FAO, 2018). In Cambodia, where a contract farming model is followed, the aggregator farm offers solar dryers to surrounding farms to dry their produce (moringa leaves) on-site to reduce losses during transport while ensuring quality (ADB, 2021a).

Third, value chain mapping makes it possible to trace the path of a product, as well as financing and information, between actors, thus helping to identify suitable delivery models and the points at which non-energy-related challenges (*e.g.* access to financing and gaps in awareness and skills) need to be addressed. These are crucial inputs to unlock value, particularly through local processing with improved energy access given that the viability is highly conditional to the throughput and cost-efficiency of technology solutions.

[3] *A value chain is the full range of activities that are required to bring a product or service from its conception to the final consumers.*

2. Develop targets, strategies and measures for heating/cooling applications in agriculture

Based on comprehensive value chain-level assessments, targets can be devised for the integration of renewables in the agriculture sector accompanied by enabling measures to facilitate adoption. Renewable energy targets in the region focus predominantly on the power sector, with a strong emphasis needed on end-user sectors such as heating/cooling. Linkages to the agriculture sector can help leverage synergies to increase the share of renewables in the overall energy mix and the sustainable utilisation of residues to meet energy needs in agriculture and across the economy. Tailored targets for heating/cooling applications in agriculture can also inform climate mitigation and adaptation commitments, embedded within the Nationally Determined Contributions (NDCs), cutting across both the energy and agriculture sectors. Indonesia's NDC submission, for instance, includes manure management for biogas as one of the areas of actions in agriculture sector (UNFCCC, 2021). Cambodia's NDC too includes the construction of small, medium and large bio-digestors as key mitigation actions led by the Ministry of Agriculture, Forestry and Fisheries (UNFCCC, 2020).

3. Strengthen cross-sector planning and partnerships

Cross-sectoral and multi-stakeholder co-ordination among agriculture and energy policies, the private sector, and civil society – both nationally and sub-nationally – is crucial to attract investments in renewable energy for use in agri-food systems. In the Philippines, for example, the Department of Energy and Department of Agriculture in 2021 announced the Renewable Energy Program for the Agri-Fishery Sector to promote renewable energy technologies in agri-fisheries through measures to boost research and development (R&D); standards development and enforcement; human resource development; and assistance to local manufacturers, fabricators and suppliers (Philippines Department of Agriculture, 2021). A specific focus is also needed on policies regarding heating/cooling applications of renewables, which have so far received less attention compared to applications for electricity.

A joint policy approach to energy and agriculture helps to address data and information gaps, utilise geographic information system (GIS) tools to guide decision making,[4] as well as identify synergies – for instance, those between energy access programmes and agricultural development initiatives.

The success of programmes operating at the intersection of energy and agriculture has in the past relied on strong co-ordination among different actors. The household biogas digester programme in Viet Nam involved a continuing partnership among development partners, the Ministry of Agriculture and Rural Development, the provincial Vietnamese governments, and the private sector. Similarly, a cornerstone for the Sumba Island Initiative in Indonesia has been close co-ordination among the Ministry of Energy and Mineral Resources, development partners (Hivos, Winrock International), the utility (PLN) and private-sector practitioners (IBEKA and Yayasan Rumah Energi).

[4] *IRENA's Global Atlas for Renewable Energy offers a range of tools, including the bioenergy simulator, to assess renewables potential globally. More details here: https://globalatlas.irena.org/tools.*

4. Tailor financing products – crucial for scale-up

Experience gained from several programmes in the region has indicated that a key barrier to scaling up is the lack of access to financing for end users (*e.g.* farmers, agri-enterprises) and technology providers. Renewable energy solutions are usually capital-intensive, with lower operational costs requiring financing products tailored to the local end-user contexts (*e.g.* in terms of seasonal cash flows, land holdings) to bridge the affordability gap. Depending on local conditions and the presence of financing infrastructure, a combination of instruments is usually needed. In the case of biogas programmes, for instance, experience from Indonesia suggests that subsidies are essential for uptake (Bedi *et al.*, 2017). These may be in the form of capital subsidies delivered directly to end users or be available in tandem with results-based financing support for enterprises, as seen in Viet Nam (*i.e.* enterprises are offered a fixed grant per verified installation). As with other renewable technologies, experience from these biogas programmes demonstrates that significant cost reductions could be achieved through economies of scale such as large numbers of installed biogas digesters.

Experience also suggests that grants must be complemented by access to affordable debt to cover the remaining capital cost of installation. As seen in Cambodia's case, the utilisation of development funds to establish local financing facilities for farmers and agri-enterprises to access renewable energy technologies can stimulate adoption. In the long term, however, local financing must be unlocked for market development enabled through risk mitigation using development funds (*e.g.* first loss pools), aggregation instruments and capacity building. Intermediaries can play a crucial role in extending the reach of financial services in rural areas for farmers and agri-enterprises to access solutions (Smart Power Myanmar, 2021). Climate financing seeking mitigation and adaptation outcomes could also play a crucial role in bridging the funding gap, while carbon markets offer a source of revenue generation for programmes and enterprises as seen in Viet Nam's case.

Beyond project-level financing, technology providers and appliance distributors require high-risk capital for innovation and R&D to adapt products to end-user needs, as well as equity and working capital to scale up distribution and provide consumer financing. It is also important to note that interventions at different stages of the value chain require different investments and deliver different outcomes (Smart Power Myanmar, 2021). Interventions closer to the farm will be more resource-intensive, with development capital playing a stronger role, but are also likely to deliver the greatest social impact. Funding, predominantly from public sources, is also needed for market development, including awareness raising, market linkages, skills development and capacity-building efforts that cover energy and other productive end-use sectors.

5. Facilitate technology innovation and piloting

While several examples of renewable energy applications to meet heating/cooling needs in the agriculture sector are emerging in Southeast Asia, targeted efforts are needed to support technology innovation to tailor solutions to meet end-user needs. On-farm activities, including drying and processing, as well as provision of thermal energy in centralised infrastructure (*e.g.* milk pasteurisation plants, cold storage, solar greenhouse dryers) require adaptations to technology that account for the required throughput, local environmental conditions and the overall economic viability of solutions. Dedicated funding to support technology design and piloting with end-user feedback and demonstration until the commercialisation stage can ensure the long-term sustainability of renewable energy solutions and facilitate their uptake.

6. Emphasise inclusivity in programme design and implementation

Agriculture supports the livelihoods of a significant share of the region's population, many of whom live in poverty and are the most vulnerable to economic and environmental shocks. Integrating renewable energy solutions in agriculture development programmes offers an opportunity to improve energy access, particularly in remote areas, with co-benefits for productivity, value addition and loss reduction. As discussed in this brief, several examples of renewable energy applications in the agriculture sector are emerging in the region, including those for meeting heating/cooling needs.

Policy frameworks and programmes to strengthen adoption of renewable energy solutions, including extension of financial support, training and awareness raising, must ensure that these solutions are equitably accessible by women, youth and other marginalised communities. Dedicated targets can ensure inclusive outcomes. In the I-PURE project, for instance, being implemented in Mindanao, Philippines, a gender-specific target has been introduced to involve women groups in the planning, design and operation of the post-harvest agri-fishery livelihood projects (see Case Study 3).

Further, maximising the job creation impact requires training and capacity building, which in turn contributes to the sustainability of interventions in the long term. In the case of Viet Nam's biogas digester programme, for instance, more than 1000 government technicians were trained in biogas technologies, and more than 1700 masons were trained in the construction of the various designs of the brick, dome-shaped, domestic biogas digester. Furthermore, 355 teams have been supported in establishing their biogas digester businesses. Over its 18-year lifetime, the programme resulted in over 20000 person-years employment in some 250 enterprises (see Case Study 2).

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CASE STUDY 1

FINANCING OF RENEWABLE ENERGY FOR FARMERS AND AGRI-ENTERPRISES IN CAMBODIA

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PROJECT SNAPSHOT

Location: Cambodia

Starting year: The Renewable Energy and Energy Efficiency Partnership (REEEP): 2015; Nexus for Development: 2016

Implementing agencies: REEEP, Austrian Federal Ministry for Sustainability and Tourism, Blue Moon Fund, Nexus for Development

Beneficiaries: Farmers, agri-enterprises, local renewable energy enterprises

Key takeaways: A tailored financing product for farmers and agri-enterprises is necessary to scale up renewables use in agriculture. Donor funding must be aligned with mobilisation of local capital in the long term.

Policy and regulatory support: Enabling regulatory conditions for grid-tied and off-grid solar installations, as well as for lending to the sector, are necessary to reach scale.

Agriculture is a key economic sector in Cambodia, accounting for over 20% of GDP in 2020 (World Bank, 2021a) and employing over a third of the total employed population (World Bank, 2021b). Farming is heavily dependent on monsoon rains and floods to meet water needs, making them extremely sensitive to a changing climate. While electricity access rates have seen significant improvements over the past ten years, from 48% in 2011 to 93% in 2019 (ESMAP, 2020), there remain close to 5 million people – the vast majority of whom are farmers – who still have no access to the grid, instead using wood, batteries and other traditional fuels for energy (ADB, 2018). Many farms and agri-enterprises continue to rely on fossil fuel-based generators, making them susceptible to price shocks and contributing to emissions (Long and Louie, 2019). In recent years, solar and biogas-based solutions have shown great promise, although they face challenges associated with high upfront costs and a lack of appropriate financing products.

The Biogas Powered Agricultural Processing Initiative and the Clean Energy Revolving Fund (CERF) were two separate initiatives launched in Cambodia to facilitate efficient renewable energy generators and improve access to financing for renewable energy solutions for farmers and agri-enterprises, respectively. The biogas initiative facilitated the adoption of rice husk gasifiers, which use agricultural residues to produce combustible gas used for cooking, lighting or electricity generation. The CERF was a revolving fund that provided loans without traditional collateral requirements, targeting the financing challenges farmers and agri-enterprises face to make investments in capital-intensive renewable energy technologies (namely solar-powered water pumps and solar systems) and enabling them to compete in the regional export economy.

TECHNOLOGY

Energy needs vary depending on the nature of the agricultural activity. Solar-based solutions find wide applicability, particularly for vegetable, fruit, spice and pig farms. Modern pig farms, for instance, consume large amounts of electricity for lighting and water pumping for evaporative cooling systems (Long and Louie, 2019). This leads to high operational expenditures, particularly in areas where diesel generators are used to meet all, or part, of the energy needs. The CERF supported the installation of solar-based solutions in one (Kampong Speu) on-grid and six off-grid pig farms to reduce energy costs for cooling and improve access to water for livestock, irrigation and drinking water.

The abundance of biomass resources, including livestock manure and rice husks, also makes it an attractive option to locally produce energy. The biogas digester programme focused on the use of rice husks – a by-product of rice milling – which are otherwise disposed of, creating waste issues. The syngas produced from gasification can be used as a fuel. It is estimated that the combined potential for biomass energy is approximately 15 000 gigawatt hours (GWh) per year, due to Cambodia's vast forests and abundance of agricultural residues (ADB, 2018).

FINANCE AND DEPLOYMENT MODEL

The Biogas Powered Agricultural Processing Initiative provided rice farmers with loans to switch from diesel-powered electricity to rice husk gasification-based energy. This was financed through two channels. The first was going through local investment banks, whereby mill owners were coached by REEEP on developing investment-worthy project proposals. Coaching involved basic financial management training and information loan requirements. In cases where this was not possible, given that the interest rate was too high or the conditions were unfavourable, mill owners were given a loan from a revolving fund that covers 80% of the investment cost (usually between USD 10 000 and 15 000), with a payback period of three years and an interest rate of 8%.

The CERF aimed to leverage a blended finance model to offer appropriately sized loans – ranging from USD 7 000 to USD 50 000 – without the need for traditional collateral. Traditional financing institutions provided expensive and fully collateralised loans (usually land titles). CERF loans covered up to 90% of the capital cost, mobilising a total of over USD 330 000 across 15 projects using renewable energy technology as collateral. Nexus for Development was responsible for carrying out an extensive due diligence process on each customer, analysing and outlining a unique rate of interest, repayment schedule and flexibility of each individual loan, based on the financial background and cash flows of the potential borrower. Over 90% of loan payments have been paid back and on schedule. Local technology providers also undergo a due diligence process for accreditation. Moreover, accredited businesses could also recommend beneficiaries for the CERF, thus supporting an expansion of the project pipeline.

OBSERVED IMPACTS

Economic

Access to renewable energy technologies through both the biogas initiative and the CERF significantly reduced farm and processing costs and improved the resilience of agri-enterprises. Households and farmers benefiting from funding from CERF reported a 34% reduction in operational costs, largely due to a decrease in diesel fuel use by 80% for water pumping and other applications. The use of renewables improved farmers' resilience to changing rainfall patterns. Both the solar-powered technology financed by CERF and the gasifiers introduced through the biogas initiative run independently to the central grid. They experienced much less downtime and were more resilient to different weather conditions. CERF loans also helped farmers to build a credit history, expanding opportunities for getting loans in the future.

Social

During and even after the payback period of the loan, CERF managers stayed in contact with the farmers, developing a relationship and teaching them about clean energy technologies and their implementation, and financial services. In regard to the biogas initiative, for the first year after the installation of rice husk gasifiers, monthly visits were made to both the mills and gasifiers, conducting maintenance as well as teaching the local employees how to maintain and operate the machines.

Environmental

CERF-funded projects produce 160 000 kilowatt hours (kWh) of electricity annually and avoid the emission of 168 tonnes of CO_2 equivalent. The fund also supported associated infrastructure that could further increase the environmental benefits of renewables. For instance, drip irrigation systems have also been co-financed along with solar water pumps to increase energy and water use efficiency (Long and Louie, 2019). Moreover, the rice husk gasification market brought about by the introduction of bio-gasifiers could displace up to 80 000 tonnes of CO_2 equivalent per year. It could also contribute to solving the problem of disposing of rice husk residue.

LESSONS LEARNT AND CHALLENGES

The experience of both projects demonstrates that offering affordable and unsecured loans is a viable option for small-scale renewable technology investments. The low percentage of defaults and timely payments show that the due diligence process selects appropriate customers and prices in the risks of an unsecured loan. However, moving forward, the cost and efficiency of the due diligence process[5] (the backbone of the CERF initiative) must be improved upon – the current cost is too high relative to the size of the loan and the customisation needed for different types of borrowers. This can be achieved by growing the size of the investment portfolio and integrating medium- and large-sized loans, thereby meeting the considerable demand for unsecured loans in the region and reducing the mismatch between due diligence cost and loan sizing. Lastly, Nexus and REEEP are both trying to popularise this method for unsecured loans among local financial institutions, using data to demonstrate the viability of the CERF initiative. Ideally, local investment banks and enterprises could also start giving out unsecured loans in the style of CERF, thereby mitigating the current shortage of these loans.

For funds like CERF to scale up, local regulations require that these funds be registered as financial institutions to continue lending. While CERF closed to new applications in 2019, it highlighted the demand for tailored, affordable debt-financing products for renewable energy applications in the agriculture sector. Local financing institutions (FIs), including commercial banks, microfinance institutions (MFIs) and rural credit agencies, have been reluctant to design renewable energy financial products due to low awareness of and confidence in technologies. Small investment ticket sizes were also a challenge, with usual project lending for local financing institutions being upwards of USD 500 000. The local FIs also were not in a position to match the terms of CERF owing to higher operational costs and cost of capital.

[5] *It was found that standardisation of the due diligence process is challenging given that borrowers represent different agricultural subsectors such as fruit, pepper, vegetables and livestock farms, therefore requiring specific market knowledge of each loan underwritten (REEEP, 2018).*

To mobilise local capital, public financing is necessary to offer risk guarantee instruments to mitigate lending risk and encourage lending for the renewable energy sector. Engagement of local FIs is important for the long-term sustainability and reach of the sector. FIs have existing robust credit processes and a wide network across provinces to reach farmers and agri-enterprises with tailored financing products, resulting in economies of scale and optimal risk distribution across their lending portfolios. Some positive developments are emerging with FIs, such as the state-owned Agriculture and Rural Development Bank, showing interest in green lending. Targeted programmes to strengthen the lending capacity of local FIs can play an instrumental role in unlocking the value of renewable energy solutions in Cambodia's agriculture sector.

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CASE STUDY 2

THE BIOGAS DIGESTER PROGRAMME IN VIET NAM

PROJECT SNAPSHOT

Location: Viet Nam

Starting year: 2003

Implementing agencies: SNV, Ministry of Agriculture and Rural Development, provincial Vietnamese governments, the Dutch government

Beneficiaries: Livestock farmers and private enterprises

Key takeaways: Biogas programmes focusing on long-term market development can unlock local capacity at scale. The benefits cut across sectors contributing to multiple socio-economic and environmental objectives.

Policy and regulatory support: Investment subsidies supported by the Vietnamese government and provincial governments

The Biogas Programme for the Animal Husbandry Sector in Viet Nam was founded in 2003 with the objective of developing a commercially viable biogas digester market to increase sustainable lighting and heating services and to provide fuel for household cooking in rural areas. Up to the end of 2020, and combined with several spin-off projects, the programme facilitated the construction of over 290 000 digesters. Figure CS2.1 provides the cumulative number of household digesters under various programmes over the period 2004-2020.

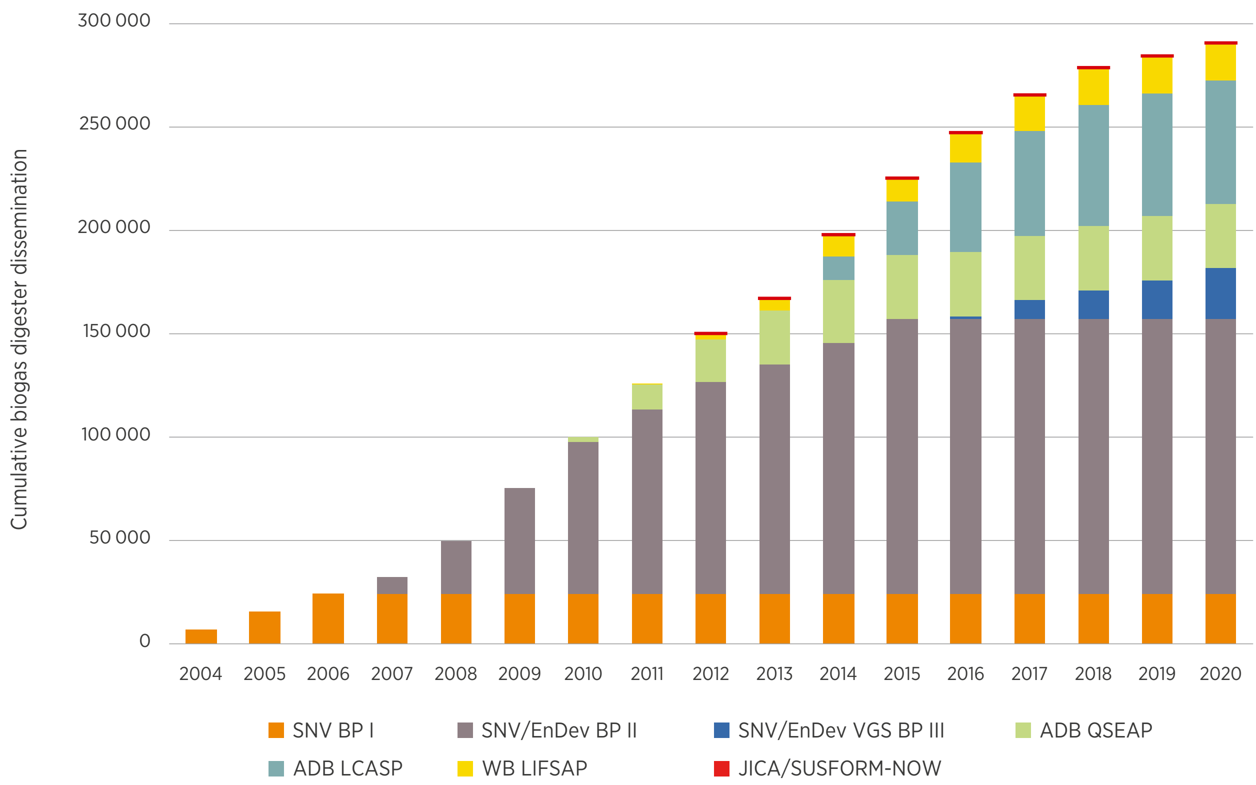
Combined, the biogas digesters resulted in access to clean, renewable and reliable energy while addressing the waste management challenge[6] of Viet Nam's growing livestock population and improving the living conditions of over 1.7 million people.

TECHNOLOGY

Biogas digesters produce biogas and bio-slurry from organic waste by means of anaerobic fermentation. Biogas can be used for cooking or water/space heating and as a fuel for electricity production that can provide power for lighting or income-generating activities, such as egg hatching and the production of rice wine and tofu.

[6] *Smallholder livestock farmers are obliged to operate a biogas digester to minimise environmental impacts, including foul smell and surface water pollution.*

Figure CS2.1 Cumulative household digester installed in Viet Nam, 2004-2020



Where applicable, bio-slurry used as a fertiliser can result in increased yields of better-quality crops that can be sold at higher prices. It should be noted, however, that not all farming households with a biogas digester have agricultural land (nearby) to apply their bio-slurry, in which case it is either traded in the neighbourhood or discharged to surface water. Bio-slurry can also be used as fish feed. Due to its low biological oxygen demand, it consumes less oxygen out of water in comparison to other feeds, allowing the fish to grow larger. When diluted, bio-slurry can even be used as livestock feed, as a nutritional source of mineral. Valorisation of bio-slurry (fortification, pelleting, marketing) further expands its usage.

The main feedstock for biogas digesters is pig slurry (ranging from 64% in the north to 85% in the south), followed by cow dung and poultry droppings. The vast majority (84%) of the households use the biogas for meal preparation while, in addition, 40% and 26% of households use biogas for water boiling and the preparation of animal feed, respectively. The effluent of the digestion process, bio-slurry, is commonly (59% of the households) used for agricultural purposes (application both dried and composted, for fertiliser for gardens, mixed in irrigation systems and/or as an animal feed supplement).

Traditionally, the most popular digester model was the brick-made fixed-dome system, since it requires relatively little maintenance and can be built with local materials and by local masons. However, the project also supported the supply chain of composite, pre-fabricated biogas digesters that offer the advantages of a much faster installation time, reduced skilled labour needs and the ability to deal with areas with high water levels. During the last few years, the market share of composite biogas digesters increased significantly, from 10% of market share in 2016 to 82% in 2020.

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FINANCE AND DEPLOYMENT MODEL

The biogas programme was initiated by the Dutch government and the Vietnamese Ministry of Agricultural and Rural Development (MARD) in partnership with SNV Netherlands Development Organisation – which acted as the technical advisor – and was implemented by the Department of Livestock Production. This institutional framework helped ensure that the programme was nationally owned and managed. Between 2003 and 2014, the programme costs were funded by the Dutch government and the Vietnamese provincial governments, but the lion's share was paid for by the farmers themselves.

Since 2013, Energising Development (EnDev), an energy access partnership of six countries, has been the key donor. Around the same time, the programme started generating revenue from the sale of carbon certificates (managed in partnership with Nexus for Development).[7] In 2012, the project was registered under the Gold Standard for emissions reduction.

Initially, a flat-rate (*i.e.* independent of the biogas digester size of model) subsidy of approximately USD 50 (VND 1.1 million[8]) per digester was offered, incentivising households by reducing the initial investment required. On average this subsidy amounted to 10% of total investment costs (VND 11 million/USD 500), making households by far the largest investors. Farmers financed their investment mainly through informal

[7] *Over time, the financing model has been split evenly between government/donor grants and emissions reduction revenue through the Gold Standard Project, an initiative that builds the legal infrastructure for a carbon market. As of 2020, carbon certificate sales had reduced 3 million tonnes of CO_2 and generated approximately USD 8 million in revenue.*
[8] *USD 1 = VND 22 650 (Vietnamese dong).*

credit channels or retained cash savings. SNV facilitated access to financing for farmers as well as coaching on business development and financial management to extend the reach of the programme and ensure long-term market development.

From mid-2016 onwards, the project phased out the household subsidy in favour of a results-based financing (RBF) incentive for enterprises. Aligned with the vision for building a self-sufficient market, the RBF incentive encouraged enterprises to take additional risks and execute extra tasks and responsibilities that are otherwise undertaken by the programme. Between mid-2016 and the end of 2020, nearly 25 000 biogas digesters were constructed under this mechanism. This compares to over 157 000 digesters installed between 2004 and 2016.

Properly installed and maintained digesters can be expected to have a technical lifetime of well over 15 years. The long-term dis-adoption (abandonment) rate of digesters is estimated to be less than 5% per annum, indicating that over 204 000 (75%) of all the digesters installed since 2003 are still in operation. The main reasons reported for dis-adoption were absence of livestock[9] (74%), technical issues (18%) and other causes (16%). Of the people reporting not using their digesters, over half indicated an interest in restarting the biogas digester once they have restocked their stables.

The market for biogas digesters has matured significantly, with strong incentives to take on financial risk aided by the valorisation of biogas and bio-slurry for domestic and productive use, as well as the emergence of medium-scale digesters that can utilise a wider range of organic feedstock and monetise excess energy.

OBSERVED IMPACTS

The biogas digester programme has resulted in significant economic, social and environmental benefits since its inception (Table CS2.1).

Table CS2.1 Biogas digester programme benefits

Biogas digesters	*Constructed* *Functional to date*	290 496 204 143
Energy	*Production to date* *Installed power*	9 505 GWh 2 656 kW
Agriculture	*Organic fertiliser*	829 301 t(DM)
Environment	*GHG emission reduction*	12 646 kt CO_2eq
Fuel substitution	*Biomass* *Fossil fuel*	6 468 kt 41 kt
Socio-economic	*Persons reached* *IAP exposure reduced* *Employment generation*	1 742 976 persons 1 452 280 women and children 20 335 person-years

GHG = Greenhouse Gas; IAP = Indoor Air Pollution; kW = kilowatt; t (DM) = tonnes (Dry Matter); kt = kilotonnes; CO_2eq = Carbon dioxide equivalent.

[9] *Most of the reported dis-adoption among respondents occurred 2017 and 2019, with a peak in 2019. Plausible causes include dwindling pork prices in 2018 and the African swine flu epidemic starting in 2019.*

Economic

Reduced fuel spending and increased energy affordability: the use of biogas and bio-slurry replaced fuels for cooking (firewood, agricultural residue, LPG, coal and sawdust), as well as mineral fertilisers and in some cases pesticides and animal feeds. Annual monetary savings per household are reported at USD 90.

Income generation and poverty alleviation: the programme has generated many sources of income, especially for the workers directly involved in the construction process, such as trained masons and untrained assistants, who earn around USD 2 000 and USD 1 500 per year, respectively, assuming a full-time basis of 220 working days. A biogas digester results in annual time savings of 234 hours for households – mainly in time spent on cooking and collecting firewood and agricultural residue – equivalent to 30% of an average full-time job per family.

Job creation: over its 18-year lifetime, the programme has resulted in over 20 000 person-years employment in some 250 enterprises. This is a conservative estimate because it does not account for biogas digester construction outside of the programme, which is happening in significant numbers.

Social

Gender equality: the use of bioenergy and bio-slurry has reduced the time required for meeting daily fuel needs, enabling women to carry out different activities and contributing to improved gender equality. Of the women surveyed, 35% spent the extra time on farm-related activities and only 3% had income-generating activities outside of the farm; 26% spent the extra time on domestic responsibilities such as cleaning the house, 16% on childcare and 19% on leisure. Moreover, it has been observed that men have taken more interest in cooking since biogas was introduced.

Improved education and skills: more than 1 000 government technicians have been trained in biogas technologies, and more than 1 700 masons have been trained in the construction of the various designs of the brick, dome-shaped, domestic biogas digester. Furthermore, 355 teams have been supported in establishing their biogas digester enterprises.

Health

Prevention of diseases and health hazards: as a result of reduced indoor air pollution (measured as concentration of particulate matter [PM] 2.5), the programme averts approximately 27 700 DALYs (disability-adjusted life years) and 750 premature deaths. Sanitation is also improved when toilets are connected to the digesters for biogas production.

Environmental

Reduced emission and impact on climate change: each digester reduces 6.7 tonnes of CO_2 equivalent per year (tCO_2eq/yr) by displacing fossil fuels, such as LPG and those used in the production of fertilisers, and from improved manure management, which reduces considerable methane emissions. The programme as a whole reduced approximately 1.4 million tonnes of CO_2 per year. This is a conservative estimate, as it does not account for medium- to large-scale digesters that have a greater impact.

By the end of 2020, the biogas project reduced Viet Nam's greenhouse gas (GHG) emissions by over 3 million tonnes of CO_2eq, becoming one of the projects with the highest volumes for voluntary carbon credits available on the market. The biogas programme's carbon component earned over USD 8 million (SNV, 2020).[10]

Waste management: one of the most important benefits for farmers is managing livestock manure by using it as feedstock and thus reducing water and air pollution, thereby avoiding the diffusion of water-related diseases caused by untreated manure.

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WAY FORWARD

Data suggest that over 1.4 million households in Viet Nam are keeping a combination of pigs, cows and/or buffaloes.[11] With the MARD preparing for further growth in the volume as well as the quality of livestock production, the market for small biogas digesters for the coming decade likely remains attractive. Quantity, quality and management requirements, however, will change the character of Viet Nam's livestock sector; production will increasingly shift to larger farms at the cost of traditional household livestock farms. The biogas digester sector, consequently, will expand its attention towards medium- and large-size biogas digesters and the valorisation of biogas (heat and energy production) and bio-slurry (processing, pelletising, etc.). Larger and more efficient operation will decrease the price of biogas and bio-slurry as these enterprises will enjoy economies of scale and competition becomes fiercer with new entrants in the market. In addition, biosecurity will increasingly become an integrated element of waste treatment systems.

[10] *SNV (2020), Carbon Finance as a Driver for Green Innovation, https://snv.org/update/carbon-finance-driver-green-innovation.*
[11] *The assessment included households with more than six pigs, three cows and two buffaloes each.*

CASE STUDY 3

NATIONAL AND LOCAL ACTIONS TO FACILITATE RENEWABLE ENERGY USE IN AGRICULTURE IN THE PHILIPPINES

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PROJECT SNAPSHOT

Location: Mindanao, Philippines

Starting year: 2020

Implementing agencies: Mindanao Development Authority, National Electrification Administration, European Union Access to Sustainable Energy Programme, utilities, research institutions

Beneficiaries: Agricultural households and enterprises

Key takeaways: Dedicated policies and programmes at the national and local levels and partnerships are crucial for renewables scale-up in agriculture sector.

Policy and regulatory support: Mindanao Development Authority, Department of Agriculture and Energy Renewable Energy Program for the Agri-Fishery Sector

Agriculture is a key economic sector in the Philippines, accounting for over 10% of GDP in 2020 and employing a quarter of the working population (Philippine Statistics Authority, 2021). Poverty among farmers and fishers has fallen over time, but it remains far higher than the national average, and nearly three times greater than poverty among urban households (World Bank, 2020).

The lack of reliable energy supply and infrastructure, including cold storage and processing facilities, contributes to losses and farmers selling at lower prices, particularly in rural and remote islands. Post-harvest losses can be as high as 40% among high-value crops alone (Cudis, 2021). The Philippines is also highly vulnerable to the effects of climate change due to its archipelagic geography, which is at high risk of flooding. The expansion of centralised energy infrastructure, including the grid, and distribution of fuels comes at a significant cost given the topographical challenges. The potential for decentralised renewable energy systems is high to meet local energy needs and fits well with the current agricultural population, which is concentrated in rural, remote areas.

In 2021, the Department of Energy and Department of Agriculture announced the Renewable Energy Program for the Agri-Fishery Sector to promote renewable energy technologies in agri-fisheries through measures to boost R&D, standards development and enforcement, human resource development, and assistance to local manufacturers, fabricators and suppliers (Philippines Department of Agriculture, 2021).

Regional initiatives have also emerged. Mindanao – one of three main island regions in the Philippines – is the food basket of the country, accounting for 36% of the country’s farm area and 43% of the food production. More than half of the country’s production of corn (51%), coconut (61%), pineapple (89%), banana (85%) and marine fishery (51%) takes place in Mindanao (Philippine Statistics Authority, 2021). These crops are also major export commodities that enhance economic resilience to shocks such as the COVID-19 pandemic. The growth of the agricultural sector is also closely linked to socio-economic development in the region: nine of the ten poorest provinces in the Philippines are in Mindanao, with majority of the poor working in farming and fishing.

In light of this, the Mindanao Development Authority, in co-operation with the National Electrification Administration and with funding from the European Union's Access to Sustainable Energy Programme, has launched the Integration of Productive Uses of Renewable Energy for Inclusive and Sustainable Energisation (I-PURE) project. The project aims to improve livelihoods in Mindanao by facilitating access to sustainable energy, combining renewable energy solutions for livelihood activities and household energisation. The initiative brings needed energy sustainability and autonomy to the agri-fisheries sector in the Philippines by implementing renewable energy solutions such as solar-powered coffee dryers, icemakers and water pumps, among many other solutions.

TECHNOLOGY

A key component of the I-PURE project is to support a portfolio of renewable energy investments to foster development in rural areas, particularly in agriculture. This includes deploying renewable energy in at least 10 post-harvest agro-fishery processing facilities to produce high-value goods that will command higher prices in the market, thereby raising the revenues of the target facilities. Further, 22 fish centres in off-grid areas will be equipped with solar-powered facilities and biomass-based processing equipment. In the municipalities of Sitangkai and Sibutu, in Tawi-Tawi Province, a total of 1.6 megawatts (MW) of hybrid solar projects are being installed. These solar projects will improve electricity access, particularly for seaweed communities, which comprise 5 000 households. Further, there are plans to install 12 solar-assisted dryers for seaweed farming communities in municipalities of the Tawi-Tawi province. In the municipality of Taraka, in Lanao del Sur Province, solar-powered irrigation and community water systems have also been launched.

FINANCE AND DEPLOYMENT MODEL

The project is being undertaken as a partnership between the Mindanao Development Authority and the National Electrification Administration with EUR 4.5 million funding from the European Unionunder the Access to Sustainable Energy Programme. Implementation further involves co-ordination with various distribution utilities, including the South Cotabato II Electric Cooperative, Inc., Sultan Kudarat Electric Cooperative, Inc., North Cotabato Electric Cooperative, and Tawi-Tawi Electric Cooperative, Inc., and various local governments units.

While the funding for the project is primarily grant-based, various other financing instruments are also emerging in the region. In the municipality of Taraka, for instance, a term loan from the Development Bank of the Philippines has been secured for the installation of six solar-powered irrigation systems to boost agricultural productivity in the region (Caraballo, 2021). As part of the deployment model, the I-PURE project conducts information, education and communication activities to increase awareness on renewable energy among end users, as well as undertakes training and capacity workshops to strengthen local capacity on technology solutions for livelihood activities.

EXPECTED IMPACTS

Economic

The deployment of post-harvest agri-fishery processing facilities is anticipated to produce high-value goods that command higher prices in the market, thereby raising revenues and incomes for local enterprises and communities. Solar-based icemakers for the fishery sector will reduce losses and enable fishers to retain more value. In Tawi-Tawi Province, the solar-hybrid power project together with solar-assisted dryers are expected to strengthen seaweed production by 10%. Over 12 units of solar-assisted seaweed dryers are also expected to be installed for the seaweed farming communities in the municipalities of Sitangkai, Sibutu, Panglima Sugala and Tandubas.

Social

Whereas male fishers are primarily involved in catching fish, women working in the fisheries sector are typically involved in pre-harvest and value-adding activities – the kind that benefit directly from the introduction of solar icemakers. The project also includes a dedicated gender-specific target to involve at least 50% women's groups in the planning, design and operation of the post-harvest agri-fishery livelihood projects.

Environmental

Island municipalities, such as Sitangkai and Sibutu, are particularly vulnerable to the impacts of climate change, seawater rise, natural disasters and economic shocks such as the economic impacts of COVID-19. Strengthening access to distributed renewable energy solutions, supporting a diversification of agriculture and fishery products, and improving market access improve resilience to climate impacts for local communities and enterprises dependent on agriculture.


Solar photovoltaic (PV)-diesel hybrid system to improve electricity access, particularly for seaweed-producing communities in the island municipalities of Sitangkai and Sibutu. © Mindanao Development Authority

WAY FORWARD

The Philippines, and the specific case of the province of Mindanao, offers important insights on the role of government and cross-sector partnerships in strengthening renewables adoption in the agriculture sector. At the national level, a dedicated policy framework has been announced to promote the use of renewables in the agri-fishery sector. At the provincial level, the I-PURE project highlights the role donor funding can play in linking renewables with overall agriculture and socio-economic development initiatives. Implementation requires effective co-ordination among local actors, including government, distribution utilities, research institutions and communities. To ensure sustainability and inclusive outcomes, an extensive focus on awareness raising and local capacity building, including equal participation of women, is important.

The experience of Mindanao demonstrates the need to expand focus beyond household energisation and identify opportunities for renewable energy to support livelihood activities, particularly in the agri-fishery sector. Several energy gaps were identified in the value chains, including for drying and cooling, which can be bridged using the diverse renewable energy solutions being planned under this project. The project offers an important blueprint for other provinces and local governments in the region to pursue a holistic approach to link livelihoods development with renewable energy adoption aided by adequate policies and partnerships.

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CASE STUDY 4

MULTI-STAKEHOLDER PARTNERSHIPS FOR RENEWABLE ENERGY ACCESS IN INDONESIA

PROJECT SNAPSHOT

Location: Sumba Island, East Nusa Tenggara Province

Starting year: 2011

Implementing agencies: Ministry of Energy and Mineral Resources, Hivos, Winrock International, IBEKA, PLN, Yayasan Rumah Energi

Beneficiaries: Households, farmers

Key takeaways: A transition to renewable energies for citizens of rural Indonesia increases energy security, reduces poverty and improves health conditions.

Policy and regulatory support: Passing of Ministerial Decree No. 3051 K/30/MEM/2015

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The agriculture sector in Indonesia contributed about 13.7% to the GDP (in current market prices) in 2020 (BPS, 2021a). Nearly 30% of the labour force is engaged in agriculture, with the majority of households facing poverty relying on agriculture as their main source of income (World Bank, 2021b; Nugraha, 2021). Despite its archipelagic nature, access to electricity and clean cooking fuels for households and enterprises has improved significantly in recent years. The number of people living without electricity access decreased from over 15 million in 2009 to 3.1 million in 2019, the majority of them living in rural areas (World Bank, 2021b). The figure is estimated to have dropped further to about 2.5 million people as of Q1 2021 (ESDM, 2021). In terms of clean cooking fuels and technologies, about 47 million remained without access in 2019, down from 156 million in 2009 (WHO, 2021).

Access to reliable and affordable energy is crucial to increase agricultural production and processing through mechanisation, as well as to improve cooking conditions. The use of renewables in agriculture has grown – for instance, through the use of biomass such as rice husk, wood, pellets and corncobs – to provide thermal heat (Widjaya, Budiharti and Prabowo, 2021). Some locations have also introduced solar photovoltaic (PV)-based water pumps.

This case study focuses on Sumba Island in East Nusa Tenggara, which has a population of about 750 000. Sumba Island is isolated and is one of the poorest provinces in Indonesia, with most of its population working as subsistence farmers under the poverty line. The island enjoys great renewable energy potential, with significant sunlight, wind, hydro and biomass resources. These factors led Hivos, a Netherlands-based non-governmental organisation (NGO), to select Sumba as the location for a renewable energy initiative, with the goal of supporting a transition to a 100% renewable energy supply by 2025. Hivos facilitated renewable energy adoption in Sumba by collaborating with cross-sectoral ministries, local governments, PLN (the state-owned power utility), private-sector enterprises and civil society organisations. Through this collaboration, solar, micro-hydro and biogas solutions were implemented.

In 2015, the Indonesian government passed Ministerial Decree No. 3051 K/30/MEM/2015, recognising the Sumba Island Initiative as a ministry-led national programme, advancing the efforts made by the initiative through institutional support. The transition towards renewables also contributes to the government's objective of reaching 23% renewables in the electricity mix by 2025 (CPI, 2020) and reducing dependence on fossil fuels, which made up 91% of the primary energy supply in 2019 (ADB, 2020). Indonesia is also particularly sensitive to the adverse effects of climate change, given that it is an archipelago with large portions of its population living in lower-elevation coastal zones.

TECHNOLOGY

A mix of technological solutions has been deployed to meet the diverse energy needs in Sumba Island. This includes solar PV systems (primarily covering schools, community micro-grids, solar home systems and solar water pumping), charging lanterns, hydro systems (12 installed totalling 3.5 MW of installed capacity) and biomass gasification units. A total of 9.3 MW of renewable systems were installed from 2011 to 2019 (Dagi Consulting, 2018). In addition, over 1 000 domestic biogas digester units were installed with capacities ranging from 4 cubic metres (m^3) to 12 m^3. The biogas digesters use organic matter, such as livestock and human manure, with the biogas used for cooking and electricity generation. Bio-slurry as the by-product of the digester is used as an organic fertiliser and animal feed.

FINANCE AND DEPLOYMENT MODEL

The Sumba Iconic Island initiative was funded by the Millennium Challenge Corporation, the Netherlands' Ministry of Foreign Affairs' Directorate General for International Cooperation and the Norwegian Embassy, with support from the government, PLN and the Asian Development Bank (ADB), among others.

The biogas initiative was implemented through the Indonesian Domestic Biogas Programme (IDBP), also known as BIRU programme (*Biogas Rumah*), a programme initiated by Hivos in collaboration with the Ministry of Energy and Mineral Resources. Nationwide, 25 000 biodigesters are in operation in 11 provinces. BIRU collaborated with private enterprises in the dairy sector, such as Nestle, as well as banks and financing organisations, such as Bank Negara Indonesia, Rabobank and Kiva, to build a network to connect farmers looking for a loan to financing institutions. The approach was semi-market based.

Hivos, through the biogas carbon fund revenues, provided investment subsidies to farmers covering 20% of the cost of a digester. Farmers without the capacity to pay 80% of the investment upfront were facilitated contact with micro-financing institutions such as the Truka Jaya or Rabobank foundations, which provided loans without collateral. This is hugely important, as many agricultural end users are not yet bankable because biogas is used mainly by women who lack proof of proper legal ownership (less than 50% of surveyed residents of Sumba had legal ownership documentation of their house or farm land) (Hivos, 2013). Moreover, the digesters have Gold Standard certification, meaning part of the financing was also supported by carbon credit revenues. In February 2021, BIRU management and its carbon monitoring was officially handed over to a national entity, Yayasan Rumah Energi, which since 2013 has been preparing both to continue and to upscale the programme.

The micro-hydro station was installed with the support of IBEKA, a social enterprise focused on providing community-based small-scale hydropower to rural parts of Indonesia. IBEKA provided technical assistance for the micro-hydro stations in Sumba, as well as training for end users to operate and maintain the power plants. The micro-hydro facility is owned and operated by Koperasi Kamanggih, a local co-operative. Since 2014, when the power purchase agreement was settled, the electricity has been sold to PLN, utilising the profits to maintain the facility and reinvest into the community. Solar PV systems have been installed and maintained by the local renewable energy service company (RESCO). RESCO leases solar lanterns to kiosk owners and provides charging stations for the lanterns to communities in exchange for an average monthly fee that covers maintenance and operational costs incurred by RESCO. Kiosks charge end users for one full lantern charge.

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OBSERVED IMPACTS

Economic

Disassociating farmers' energy costs from volatile diesel prices led to significant cost reductions, aggregating to about USD 40 in additional household savings a year. Solar lamps are leased by community members for a fee. Kiosk owners who were part of the RESCO scheme reported a 30% to 40% increase in income from lamp leasing. The micro-hydro station operated by the Kamanggih co-operative is able to sell electricity to PLN. Profits from these sales are reinvested into the community, funding clean water and organic fertiliser programmes.

Women in Sumba are typically responsible for cooking fuels. The use of biogas allowed for time savings in both fuel collection and kitchen cleaning (because there is no ash or soot to be washed off pots), allowing women to spend more time on income-generating activities such as weaving. Men also reported time savings because they are typically responsible for collecting wood fuel, with 30% of surveyed male farmers using the extra time on income-generating activities. The use of bio-slurry as crop fertiliser has reduced the time required for manure management. In addition, bio-slurry is rich in nutrients, and has been shown to increase agricultural produce if used as fertiliser, as well as the size of fish if used as fish feed. In a survey conducted of farmers who received biogas digesters, over 80% said their soil was more fertile and the quality of their produce had increased, leading to higher incomes.

Social

Women saved time in fuel collection and short cooking time, potentially increasing time for income-generating activities giving them a greater say in household finances. The increased energy supply to schools has increased attendance, as well as increased the quality of teaching through the introduction of computers, which teachers were taught how to operate along with other technologies such as printers. The increased electrification has allowed small businesses to stay open longer and children to study at night.

The initiative maintained an emphasis on including end users in the energy transition process, coaching them on the operation and maintenance of renewable energy technologies. The micro-hydro station in Kamanggih is operated by a local co-operative, and kiosk owners are in charge of operating charging stations for solar lamps with the support of RESCO for technical repairs.

Health

Sanitation conditions have improved considerably since the start of the project. In 2013, 41% of Sumbanese defecated in open fields on their property. Now, as human waste is used as fuel for digesters, there is considerable waste management, extending to even constructing toilets next to digesters to increase efficiency. Surveys show a 33% reduction in eye redness, a 24% decrease in eye infections and 21% fewer cases of coughing. Clean biogas fuel does not leave harmful pollutants in the air, making eyes and lungs healthier. Additionally, bio-slurry is safer than raw manure, reducing exposure to harmful bacteria. It can also be incorporated into feed for chickens, swine and fish.

Environmental

Each biogas digester annually prevents 2.6 tonnes of CO_2 equivalent from being expelled into the atmosphere. This totals approximately 18 000 tonnes of CO_2 equivalent per year. Moreover, the fall in demand for wood fuels has helped slow deforestation, as well as avoiding pollutants from wood-based cooking. The solar, wind and micro-hydro power generators eliminate the need for using electricity from polluting sources. This keeps Sumba's air and environment clean for its people.

WAY FORWARD

The Sumba Iconic Island initiative must accomplish big tasks if it is to meet its 100% renewable energy target by 2025. Although electrification was increased from 24.5% to 70%, renewable energy accounted for 23% of the total mix.

The initiative faced demand-side challenges that slowed down progress. Although Indonesia has a developed finance sector, it is difficult to find interest in decentralised mini-grids or small-scale renewable energy investment due to challenges with the existing regulatory framework for decentralised solutions. Thus, most of the demand from investment banks and private enterprises is focused on large-scale renewable energy projects for which the policy framework is clearer, a situation that hinders the development potential of mini- and micro-scale energy systems to serve small- and medium-size islands such as Sumba. To increase productive end use of energy in agriculture, a comprehensive demand-side assessment is required to understand whether renewable energy would be well adopted or needed. Moreover, training agricultural end users to develop a market for renewable energies and fostering demand would bridge the disconnect between big finance in Indonesia and end users. In addition, research into loan partner organisations that are willing and able to undertake such investments would mitigate this barrier.

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