Smart Power
Myanmar

# Energising Agriculture in Myanmar

## A Guide To Prioritising Energy Access Investments into Agricultural Value Chains

**SUMMARY** | September 2021

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Smart Power Myanmar

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# List of abbreviations

| | |
|---|---|
| **ADS** | Agricultural Development Strategy |
| **API** | Application programming interface |
| **ASEAN** | Association of Southeast Asian Nations |
| **BOO** | Build-own-operate |
| **BPO** | Bean, pulses and oilseeds |
| **CAPEX** | Capital expenditure |
| **CDZ** | Central dry zone |
| **DRD** | Department of Rural Development |
| **DRE** | Distributed renewable energy |
| **EAC** | Electricity Authority of Cambodia |
| **EPC** | Engineering, procurement and construction |
| **GDP** | Gross domestic product |
| **GIS** | Geographic Information System |
| **IEC** | International Electrotechnical Commission |
| **IFPRI** | International Food Policy Research Institute |
| **ha** | Hectare |
| **kg** | Kilogram |
| **kWh** | Kilowatt hour |
| **LCOE** | Levelised cost of energy |
| **MADB** | Myanmar Agricultural Development Bank |
| **MIMU** | Myanmar Information Management Unit |
| **MJ** | Megajoule |
| **MFI(s)** | Microfinance institution(s) |
| **MMK** | Myanmar kyat |
| **MOEE** | Ministry of Electricity and Energy |
| **MSME(s)** | Micro, small and medium enterprise(s) |
| **NEP** | National Electrification Project |
| **O&M** | Operations and maintenance |
| **OPEX** | Operational expenditure |
| **oz** | Ounce |
| **PAYG** | Pay-as-you-go |
| **PV** | Photovoltaic |
| **QAF** | Quality Assurance Framework |
| **RBF** | Results-based financing |
| **SPAM** | Spatial Production Allocation Model |
| **t** | Tonne |
| **V** | Volt |
| **VAT** | Value added tax |
| **VEC** | Village Electrification Committee |
| **VIDA** | Village Data Analytics |

# Glossary

| | |
|---|---|
| **Agri-processor** | An entity specialised in the processing of agricultural produce. |
| **Captive power** | An off-grid or behind-the-meter grid-connected energy system designed for a single offtaker. |
| **Carding** | A cotton processing step whereby fibres are disentangled to produce continuous strips called slivers. |
| **Colour sorting** | A processing step in the rice and bean value chains. Similar to grading, colour sorting involves the separation of low-quality produce from high quality produce. |
| **Combine harvester** | A mobile machine used to harvest a variety of crops. Most combine harvesters perform a variety of steps at once, including cutting crops, threshing and winnowing. |
| **Crop production** | For the purposes of this report, crop production is a geospatial data layer that signifies total annual crop production in tonnes. |
| **Crop yield** | For the purposes of this report, crop yield refers to production per area, measured in tonnes per hectare. |
| **Downstream processing** | In the chronology of agricultural processing activities, downstream processing takes place after upstream processing. These are typically more sophisticated processes and are geared towards quality-conscious markets. |
| **Dehulling** | A processing step in the beans, pulses and oilseeds value chain whereby the skin of the kernel is removed. |
| **De-husking** | A processing step in the rice value chain whereby the rice kernel is separated from its husk. |
| **Deshelling** | A processing step in the beans, pulses and oilseeds value chain whereby the kernel is removed from its casing. |
| **Destoning** | A processing step in the rice and beans, pulses and oilseeds value chains whereby unwanted materials such as stones are removed from the harvest. This forms part of the cleaning process. |
| **LCOE** | The cost of generating energy, calculated by dividing CAPEX and discounted annual expenses by discounted energy generation. Expenses and generation are discounted using a discount rate. |
| **Loom** | A device used to perform weaving of cotton. |
| **Micro-utility** | A grid-connected captive power system owned by the developer which sells electricity units to one or more customers through a behind-the-meter network. |
| **Milling** | Milling is a loosely defined term that can be used in a variety of ways in different contexts. In this report, it refers to a series of rice processing steps to make rice suitable for human consumption. This includes threshing, de-husking, destoning, grading, sorting, polishing and parboiling. |
| **Mini-grid** | A distributed renewable energy system that supplies electricity generated by one or more energy sources to a variety of off-takers through a low voltage network. Mini-grids can be connected to the main grid, but are typically isolated. |
| **Productive use of energy** | Energy used for the purpose of performing agricultural, commercial or industrial activities. Energy demand from productive uses typically exceeds that of household use. |
| **Upstream processing** | In the chronology of agricultural processing activities, upstream agricultural processing follows harvest. Except in cases of vertically integrated processing, upstream processing typically takes place on farms and in villages in rural areas. |
| **Paddy** | Rice before harvest |
| **Parboiling** | An optional rice processing step whereby rice is partially boiled in the husk. This is done to increase the nutritional value of rice and to reduce breakages during polishing. |

| | |
|---|---|
| **Polishing** | Polishing either refers to the conversion of brown rice to white rice by removing the bran and the germ, or to advanced polishing, whereby the texture of white rice is smoothened. |
| **Roving** | A processing step in the cotton value chain whereby the slivers (generated through carding) is thinned out in preparation for spinning. The output of roving is yarn. |
| **Spinning** | A processing step in the cotton value chain whereby yarn is winded onto a spool. |
| **Threshing** | A processing step in the rice and beans, pulses and oilseeds value chains whereby kernels are removed from the ear (the grain-bearing tip of the stem). |
| **Throughput** | The amount of output that a processing machine can deliver within a given timeframe. Throughput is typically measured in kg/hour. |
| **Value chain continuum** | A continuum illustrating the chronology of value chain activities, from production to wholesale and retail. Upstream activities are typically performed on farms and in villages in rural areas while downstream activities typically take place in grid-connected towns and cities. |
| **Viss** | A Myanmar unit of weight measurement equaling 1.63 kg. |
| **Weaving** | A processing step in the cotton value chain whereby yarn is interlaced to produce fabric. |
| **Winnowing** | A processing step in the rice and beans, pulses and oilseeds value chain where airflow (wind or fan) is used to separate lighter kernels from heavier kernels and to separate leftover husks and shells from the kernels. |

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# About Smart Power Myanmar

As part of The Rockefeller Foundation's global initiative to end energy poverty, Smart Power Myanmar works at the intersection of the public and private sectors to achieve one goal: accelerate electrification through catalysing new sources of investment, knowledge and know-how, to end energy poverty and promote economic opportunity in Myanmar. Smart Power Myanmar is a part of Pact, a global non-profit development organisation, and is managed by The Rockefeller Foundation.

Smart Power Myanmar focuses on three key areas which can accelerate Myanmar's rate of rural electrification:

1. Supporting the development of a sustainable mini-grid sector;
2. Mobilising finance for household connections at village level;
3. Supporting integrated electrification planning through data analytics and research.

In partnership with multilateral and bilateral donors (including The World Bank, JICA and The Rockefeller Foundation), private banks, off-grid developers, non-profit development organisations and communities across Myanmar, since launching in 2018 Smart Power Myanmar has:

- Directly financed nearly 2,000 connections and enabled another 40,000, impacting 224,000 people with connections to both on-grid and off-grid electricity;
- Facilitated 31,000 micro-finance loans for last-mile grid connections nationwide with our sister organisation, Pact Global Microfinance, totalling $13M in approximately 2,200 villages;
- Advised on more than $150M of other development finance initiatives, including:
  - Agence Française de Développement (AFD) Sovereign Loan Facility to support mini-grid investments in Myanmar ($61M)
  - Japan International Cooperation Agency (JICA) Two Step Loan Phase 3 for both mini-grid investments and community connections ($50M)
  - KfW innovative finance for leveraging mini-grid investment ($20M)
  - Italian Agency for Development Cooperation (AICS) funds for mini-grid project development and productive use support ($30M)
  - Designed local bank facilities mobilising more than $18M in support of mini-grids;
  - Created the $575,000 Energy Impact Fund, a revolving fund to help support community connections and productive uses in rural communities; and
  - Provided groundbreaking research, insights and business intelligence to assist government, developers and other investors in making informed decisions.

# About TFE Energy

TFE understands that access to affordable, clean energy will unlock the great potential of frontier markets. Working in collaboration with our partners, we continuously test and validate new data technologies in the field because we believe that they enable the high resolution insights needed to scale up decentralised energy in under-electrified places. This first-hand experience is brought into our advisory work with donor organisations, governments and private companies on decentralised energy policy, technology and delivery models. Our team consists of data technologists, community electrification experts and energy market, finance and policy analysts.

Sustainable Development Goal 7 enshrines the universal right to affordable, modern energy. We understand that this is only a first step; using this to catalyse local sustainable development requires consideration of what can most productively be done with this energy. Given the reliance of rural areas and developing economies on agriculture, energising agricultural value chains presents a clear opportunity. Leveraging our data technology and on-ground market expertise, we specifically examine the nexus between energy and agriculture in great detail, teasing out the crucial, crop, country and context specific characteristics of key value chains. Analysis of these allows us to define the practicalities, social impact, regulatory considerations and commercial viability of energy access interventions along value chains from off-grid community producers to on-grid urban exporters. This provides an invaluable guide to any organisation looking to prioritise their own investment into modernising agriculture and impactful energy access.



# Foreword

This publication is targeted to everyone interested in evidence-based investment and planning related to rural electrification and the agri-food value chain in Myanmar. Beyond Myanmar, we believe that it also contains insights that add to the growing global body of knowledge around the critical link between rural energy and agricultural value chains, and the potential for improving the way electrification can power businesses at scale.

Few people would disagree that energy plays a critical role in increasing productivity of enterprises and in improving livelihoods. For a country that once boasted one of the largest agricultural markets in the world, rural agriculture in Myanmar has tremendous potential to raise rural welfare through agricultural transformation. Productivity growth in agriculture – which predominates the livelihoods of the Myanmar's rural poor – could be several times more effective than growth in other sectors in reducing rural poverty. Developing energy intensive agricultural processes, such as large-scale irrigation or milling activities can help to significantly increase the commercial viability of electricity provision.

This publication, the latest from Smart Power Myanmar, was born from our conviction that as myriad players work towards connecting the remaining two-thirds of the country to reliable electricity, we all need to better understand how to bridge the gap between supplying electricity, and linking that power to existing and future value chains to maximise rural incomes and economic growth.

Thanks to the outstanding work of TFE's research team along with their partners at AFSIM, this study explores the opportunities for synergy between the goals of rural electrification and agricultural transformation in Myanmar, based on our hypothesis that leveraging complementary investments in agriculture and electricity can yield huge dividends in terms of poverty alleviation. Our approach for this study was to assess the energy requirements of the most important agricultural value chains and to develop/propose energy solutions and business models that can help deliver access and reliable supply of electricity to these value chains in a timely and cost-effective manner.

The greatest challenge to increasing electricity access in Myanmar is how to make electricity provision financially viable in low-demand rural households and micro-enterprises. Commercially attractive rural customers – in Myanmar this means current and potential rural agricultural processing enterprises – are key to reducing the barriers to accelerating grid and off-grid approaches to rural electrification.

Despite the billions being invested in electricity infrastructure in Myanmar through private capital, government financing, concessional loans and subsidies, few resources are being channeled towards the critical and complex nexus between sources of supply of electricity, and how that power is used productively in rural value chains and businesses. Donor funded programmes focusing on agriculture in Myanmar almost universally do not include energy as a component in programme design. Off-grid and grid extension programmes generally have not had access to quality on-the-ground research, data and analytical information to be able to make informed site selection and realistic demand prediction. Mini-grid developers often lack the resources and expertise to invest in rural development to grow demand, leading sometimes to underutilised plants that have greater potential. We believe that this study will go some way to help address this gap in knowledge and data, and that it will help provide a foundation for how electrification planning and financing should be best directed for maximum benefit for both on-grid and off-grid customers.

An understanding of how value chains can be strengthened is essential for investors, customers, government and long-term sustainability and revenue flows. Prior to the political upheaval of 1st February 2021 Myanmar was beginning to successfully attract investment interest and had secured multilateral financing for critical electrification infrastructure; on the other, national agriculture programmes, bilateral funding and development organisations were supporting a variety of agriculture programmes. However, there was little to no evidence that any programme or initiative was focusing strategically on how electrification and the productive use of electrification – incorporating the critical link with value chains – were related.

A brighter future for Myanmar's rural poor will require not only access to power, but access to power *within the context of complex rural value chains*. For Myanmar's rural poor to be able to step up and out of well-trodden cycles of poverty, electricity needs to be configured to power productivity, and for this to happen, tens of thousands of villages across the country will need the access and means to convert their micro-enterprises to improve the way produce is irrigated, processed, milled, stored and transported.

We hope that the findings from this report will encourage policy makers, financing institutions, private companies and technical support agencies from both the energy and the agricultural sectors to support a more informed and strategic approach towards the vital connection between electrification planning and the agri-food value chain. Ultimately, this can help Myanmar to move closer to meeting ambitious sustainable development goals.

Richard Harrison
*CEO, Smart Power Myanmar*

June 2021

# 1.0 Introduction

Access to energy is fundamental to social and economic development. However, as the tools and delivery models to supply this foundational enabler evolve, so too does the understanding that energy interventions are not sufficient in isolation. Successful interventions require consideration of what can most productively be done with this energy.

Color The appreciation of the positive impact that **productive uses of energy** can have
on community economies and the businesses of energy service companies (like private mini-grids) is evolving. What is becoming increasingly apparent, is that to realise the full value of these energy-enabled productive activities, they need to be well positioned in, and supported by **stable and resilient value chains**.

Improving access to energy along a value chain has a positive impact on the overall productivity of the value chain. This is particularly relevant in Myanmar where current levels of energy access are low and much of the economy is based on agriculture. Energy needs vary along these value chains, which stretch from deep rural off-grid farms, downstream into grid-connected urban areas and export markets. For example, energy for irrigation boosts agricultural yields, while energy-enabled processing (such as rice drying) improves product quality and reduces losses. It follows that there is significant value to be derived from well-designed investments into energy access that can support and strengthen agricultural value chains.

After years of insufficient investment into infrastructure, the agricultural economy of Myanmar is currently underperforming.

- With agriculture contributing 30% to GDP[1] and providing livelihoods for nearly 70% of the population, Myanmar's economy is closely tied to agricultural productivity.
- With vast tracts of fertile soil, abundant labour and the expansive waterways of the lower Mekong basin, Myanmar is endowed with significant agricultural
  resources. It is also strategically located between the two major export markets of India and China.
- However, Myanmar is not converting its competitive advantages into realised value.[2]
- The country consistently ranks poorly among its regional peers in terms of productivity and profitability of cultivated land.

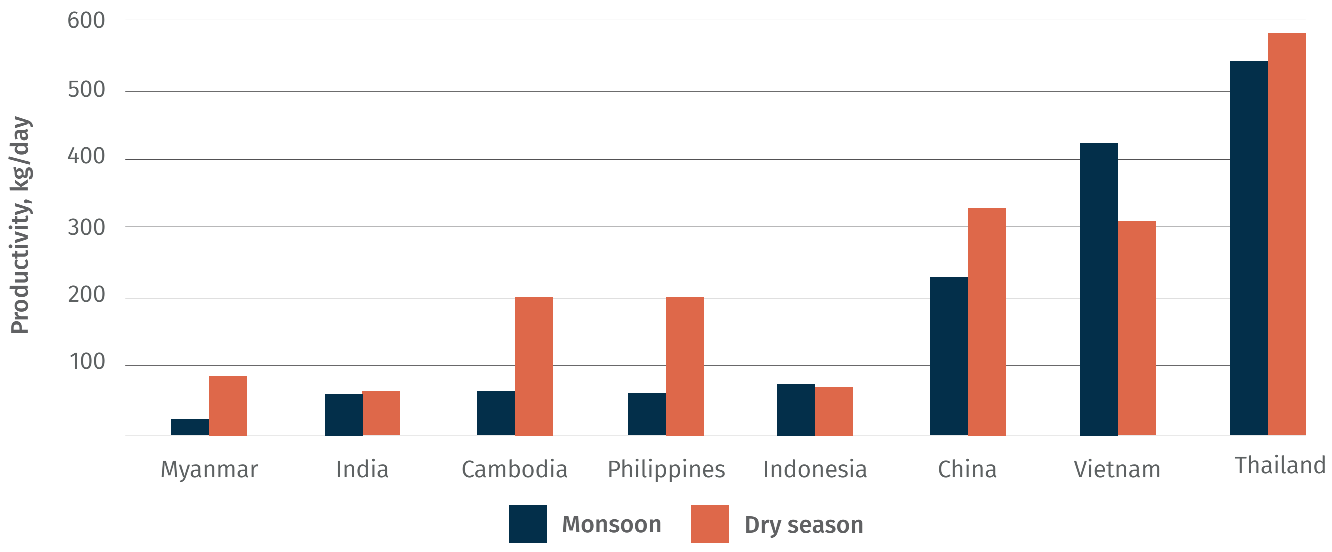
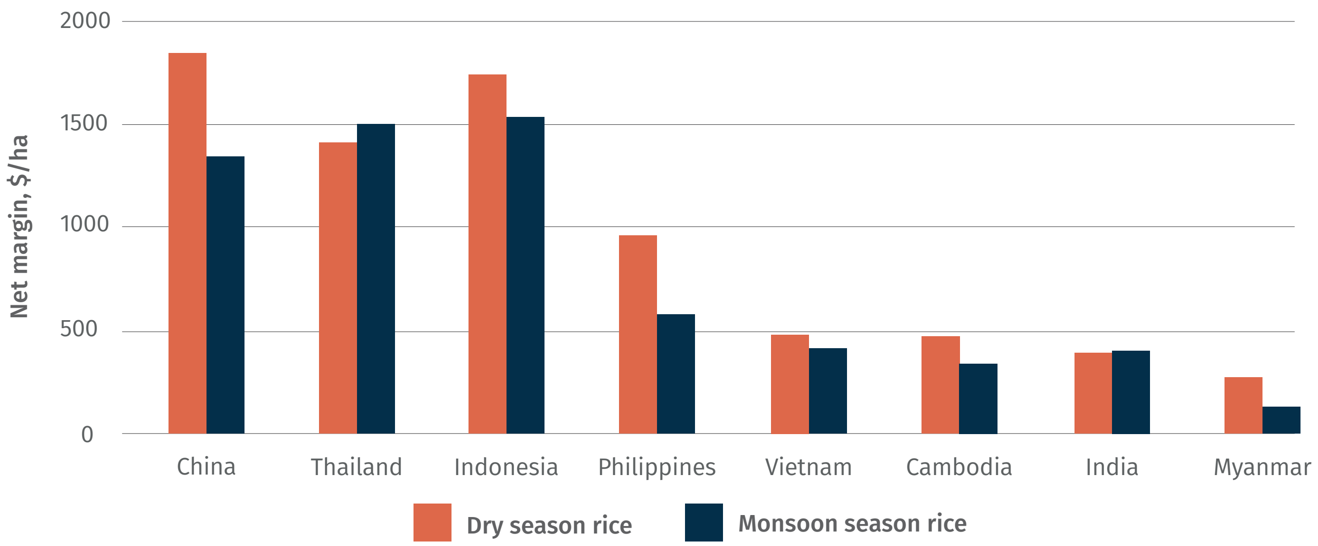



**Figure 1:** Rice productivity across seasons for regional peers

1 The World Bank, Myanmar Food and Agriculture System Project, 2020 (*link*)
2 The World Bank, Myanmar Farm Production Economics, 2016 (*link*)

- A key constraint is the low level of access to the energy required to produce more, and better quality, agricultural produce.
- At approximately 50%, Myanmar has the lowest electrification rate in Southeast Asia,[3] with farming areas having even lower rates of electrification. Even on-grid areas suffer from regular outages.

**Figure 2:** Profits from rice production compared to regional peers




The study is a deep dive into the agriculture/energy nexus in Myanmar. The most important areas of production for the major agricultural crops are identified and their value chains traced downstream. The flow of agricultural produce is tracked through communities and past nodes of agricultural aggregation to larger urban markets where economies of scale are leveraged and larger processors prepare output that is ready for wholesale or export markets. The study quantifies the value drivers and energy challenges at every node and describes how these affect the design of appropriate energy delivery models. The result is a guide to the opportunities to strategically invest in improving energy access along agricultural value chains in Myanmar. These investments can, in turn, increase the value captured by rural farmers, boost processor productivity, catalyse local economies and strengthen this nationally vital sector.

3 The World Bank, Press Release (*link*)





## 1.1 Deriving value from energy access

In most developing economies, energy generally becomes more expensive and less available the further one travels from central, urban areas. The effects of this are particularly evident in the value chains of sectors that span rural and urban economies. Agriculture in Myanmar is one such sector. Low levels of energy access in rural areas limits the ability of rural producers to process their crops. This drives energy enabled value addition further down the value chain and further away from agriculturally productive rural communities. Poor access to other supportive infrastructure (like roads) compounds this problem. Despite their critical role at the source of these key value chains, rural communities receive a fraction of the total value created between field and consumer. Instead, **value capture is concentrated in large commercial downstream processing or lost to market inefficiencies**. This, in turn, exacerbates the rural/urban divide and keeps rural communities in Myanmar locked in a cycle of poverty.

**Improving energy access at the local level can help shift agricultural value addition upstream to both strengthen value chains, boost local incomes and drive rural socio-economic development.**

## 1.2 Productive uses of energy and the complexity of value chains

Better access to energy is not the only factor driving value addition further down the value chain and out of the reach of rural communities. There are plenty of publications,[4,5] and projects promoting productive uses of power as a tool to reduce rural poverty. However, these do not always recognise that unlocking the full value of **increased production or improved output quality are functions of factors wider than those at the single village level**.

1. Firstly, once local demand is met, the value of having more agricultural produce can only be realised via **access to external markets** where the surplus can be sold.
2. Secondly, the amount of money flowing around a village is limited. Overall spending on energy (or indeed other products or services) in a community can only increase if income from outside the community increases.[6]
3. Lastly, the dynamics that make an agricultural processing activity commercially viable are complex, crop specific and highly dependent on local and national enabling environments. For example, **the economic profile of an agricultural processor is highly sensitive to throughput**, in other words, the quantity and regularity of product being processed. To achieve viability, minimum thresholds of throughput are needed to compensate for the high costs of buying processing equipment. This will tend to favour processors at points of aggregation rather than at the source point of production in the villages, and low-cost equipment that can be used to process multiple types of crops with different seasonal profiles.

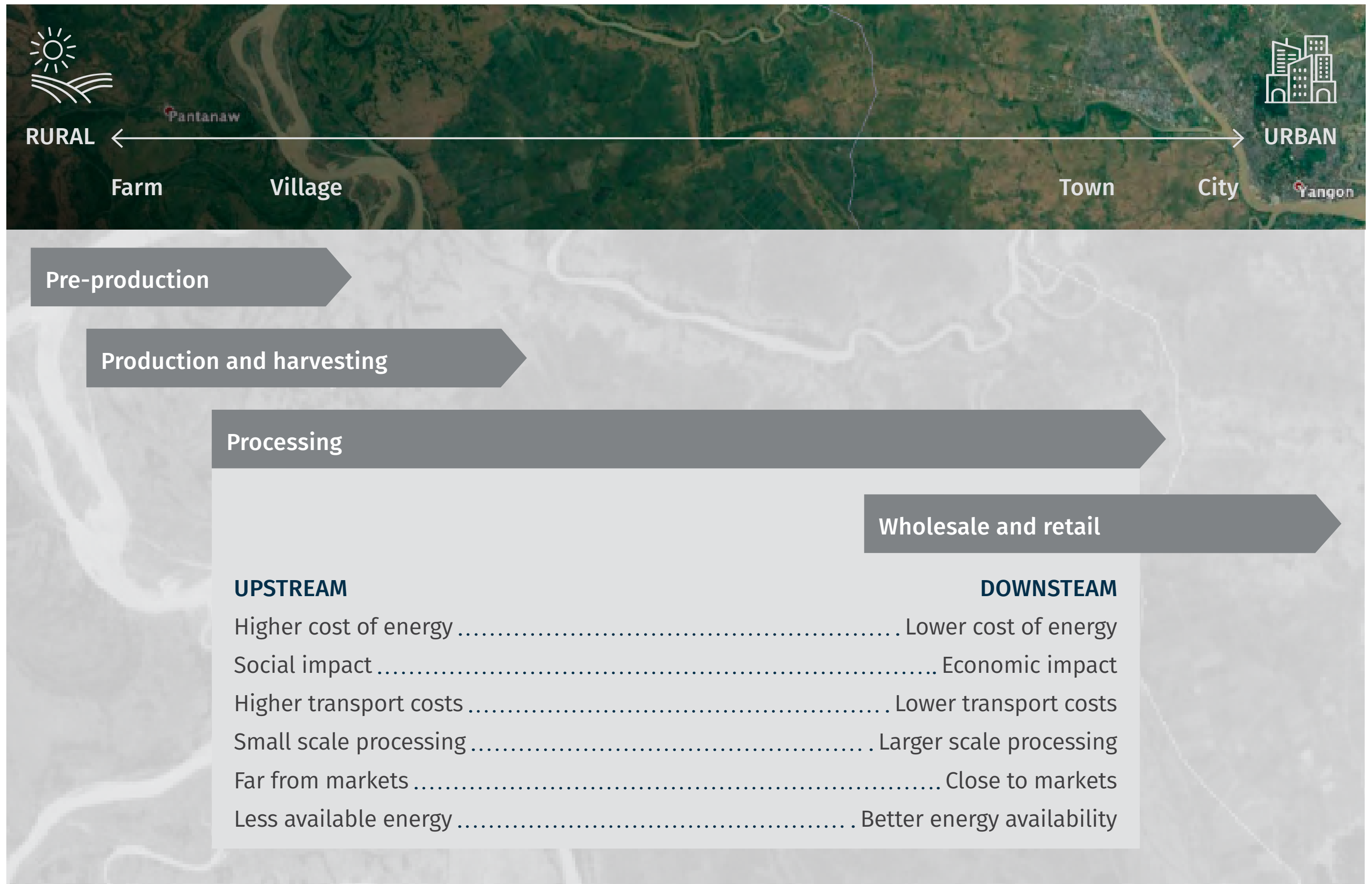
4 IIED, Remote but productive: Practical lessons from productive uses of energy in Tanzania, 2019 (*link*)
5 Cabraal, R.A., Barnes, D.F. & Agarwal, S.G., Productive Uses of Energy for Rural Development, 2005 (*link*)
6 It has been observed that mini-grid users often have a fixed amount of money to spend on energy. This also creates price elasticity and hence a sensitivity to tariffs. See: CrossBoundary and E4I's Innovation Insight: The Price Elasticity of Power (*link*)



1.0 Introduction

Energy, agriculture and their contextual dynamics can be visualised as a continuum ranging from upstream, off-grid producers on one end, to downstream on-grid consumers on the other. This provides a useful framework for evaluating the challenges, opportunities and likely impacts of an intervention focused on energy and agriculture, at different points along the value chain.

**Figure 3:** The agricultural value chain continuum from upstream rural producers to downstream consumers




Along the value chain steps investigated, **processing provides the most promising opportunity for energy access investment**. This is because processing activities add significant value to agricultural output and can generally be easily electrified. This is true for the electrification of typically manual upstream processes like rice threshing in the village as well as providing back-up power to large downstream processors like cotton spinning factories in areas where the grid is unreliable.

# 2.0 Key agricultural value chains in Myanmar

The historic prevalence of subsistence farming and policies centred around self-sufficiency in Myanmar, primarily for rice paddy, have focused government support on a small number of value chains at the expense of others. As a result, **the agricultural sector is not diverse and has had limited private sector involvement**. This has negatively affected competitiveness and the sector's potential as a driver of rural development. Recent initiatives by the World Bank and others have prioritised increasing diversification of agricultural practices, both to improve nutrition and boost agricultural livelihoods. Yet despite this shift toward greater diversification, **rice, beans and pulses continue to dominate agricultural production, collectively making up 67% of crop output and 75% of cultivated land in Myanmar in 2016**. These crops are core to economic activity in Myanmar and to national food security.

Evaluating which agricultural value chains are 'key' requires a robust assessment of several characteristics. These are structured along three central themes as indicated in the figure below.

**Figure 4:** Dimensions for evaluating and prioritising electrification of agricultural value chains

| | |
|---|---|
| **Economic significance** | • Market size: annual crop value and production volumes<br>• Sector structure: number and size of producers and processors |
| **Degree of convergence** | • Intersection with other value chains<br>• Geographic proximity (to other VCs, markets, infrastructure)<br>• Similar or complementary seasonality |
| **Energy-driven value addition** | • Current and potential energy use<br>• Potential increases in productivity and/or value addition |

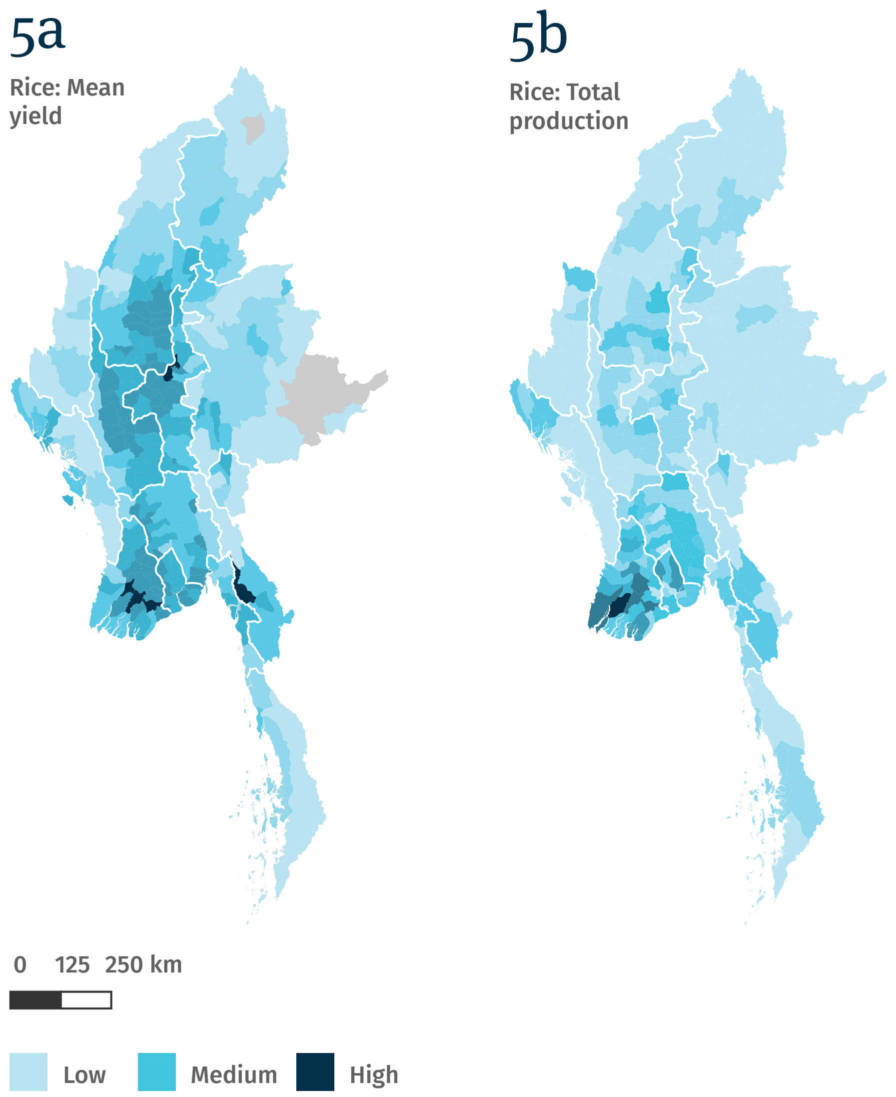
From this assessment, the value chains that were selected for deep dive analysis for the study were rice, cotton and BPO (beans, pulses and oilseeds).

# 2.1 Rice

## 2.1.1 Key takeaways

- Of the value chains investigated, rice is the most relevant for rural energy interventions. Taking up the most agricultural land (nearly three times more than the next largest) any successful intervention on the rice value chain would have wide applicability across the country.

**Figure 5:** Rice production and yield in Myanmar[7]




7 Production refers to the total production quantity of the relevant township (measured in tonnes).
Yield is calculated as total production divided by the total area of the township, which makes it a measure of agricultural productivity.





- However, the large scale of the sector also means that there is significant competition, and the profits are small.
- The lack of upstream processing means that rural rice-producing communities in Myanmar capture a significantly smaller proportion of economic value than those in neighbouring countries.
- High value addition, affordable machinery and the possibility of being powered by standalone, mini-grid or captive power systems make **threshing a high value, early-stage opportunity** for electrification.
- Irrigation increases yields and the potential number of crop cycles. However, pumping is primarily done in-field, and therefore is best suited to standalone energy systems like solar pumps.
- De-husking adds a lot of value to rice and is easy to electrify at a small or large scale, however because rice husk protects the grain during handling, transport and storage, it is important to consider where along the value chain is the best place for the dehusking process.

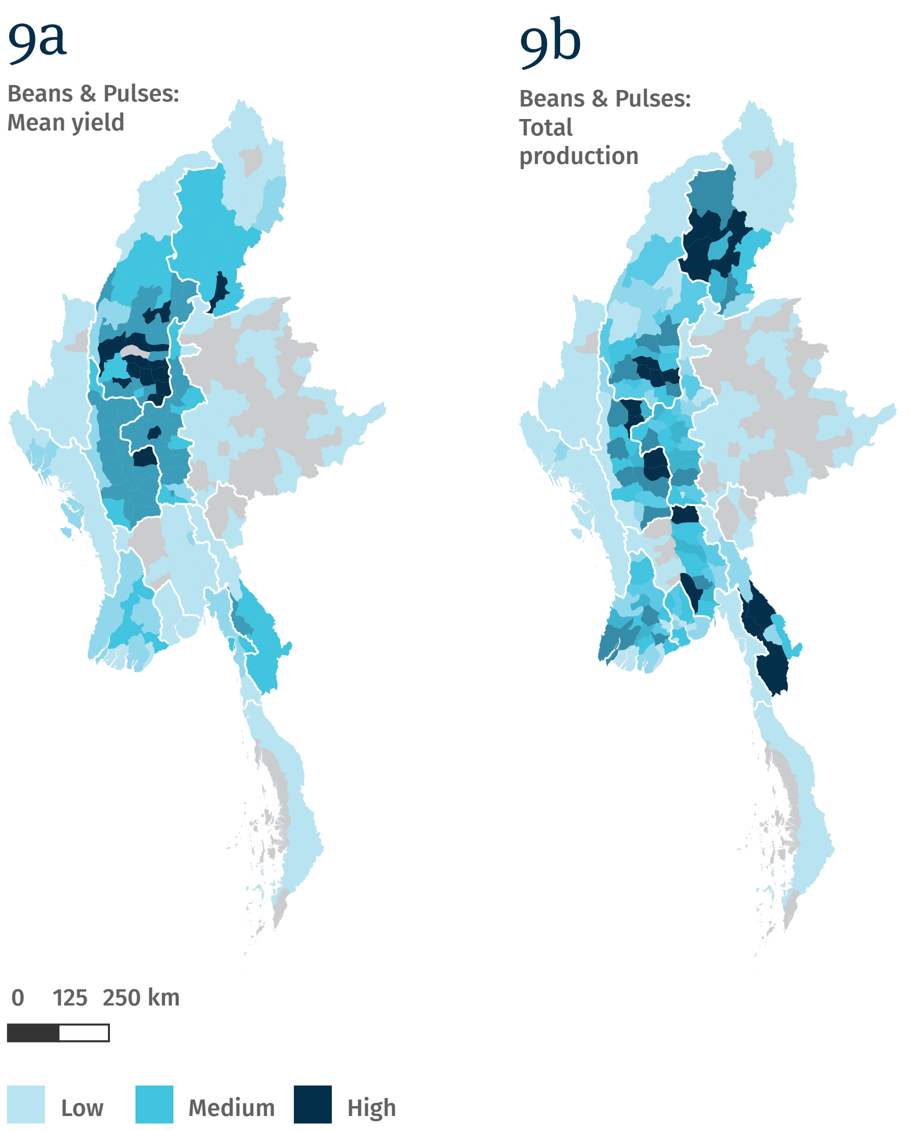
# 2.2 Beans, pulses and oilseeds

## 2.2.1 Key takeaways

- All equipment used by surveyed medium-scale processors except threshing machines are already powered by electricity.
- Various pieces of equipment including oil presses can be used to process several different crop types. This means that there is less machine downtime in between harvests of a specific crop and equipment can be used throughout the year.
- Grading and colour sorting machines are able to rapidly sort large amounts of produce into different quality grades. This, combined with their low power use, means they can add significant value per unit of energy consumed (kWh).

- Grading and sorting machines however, are expensive. This means that typically, only downstream processors, with their large-scale operations can afford them.
- Pressing seed directly into high value-density oil at the village scale avoids some of the downstream processes and can be an effective way to capture value upstream.

**Figure 6:** Beans and pulses production and yield in Myanmar



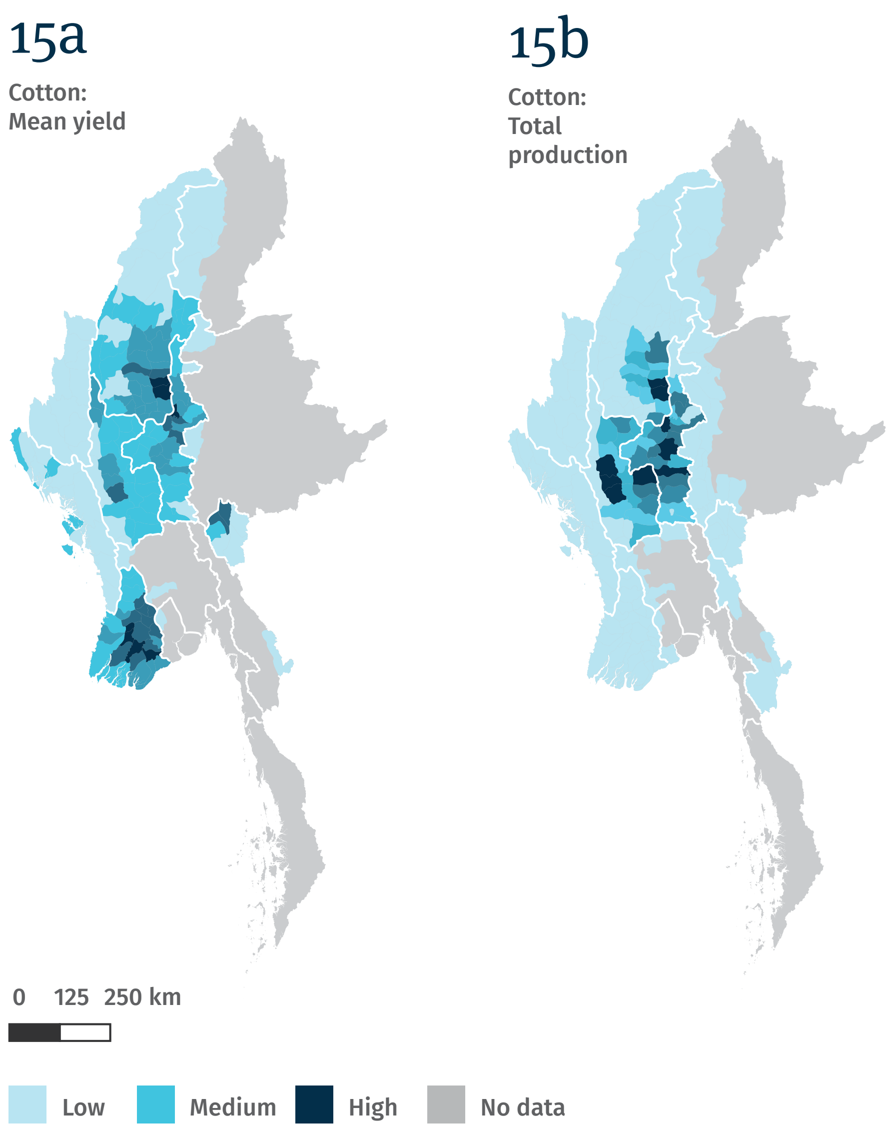

## 2.3 Cotton

### 2.3.1 Key takeaways

- Upstream processing (drying, ginning and cleaning) is done by both big and small processors but generally with inefficient machinery. This results in a low-quality product. Downstream processing is mainly done by largely government
- Yarn production can add significant value to cotton, but the machines are too expensive for many villagers to afford.

- Manufacturers use more imported yarn than locally produced yarn, as imported yarn is less expensive than local yarn if compared at the same level of quality.
- The costs of spinning machines (to make yarn) and power looms (to weave yarn into fabric) range from several thousand to tens of thousands of dollars. Without loans, small-scale processors find it difficult to buy this machinery. This and the downstream nature of the activity imply that these machines are better suited to more established, large-scale processors.

**Figure 7:** : Cotton production and yield in Myanmar





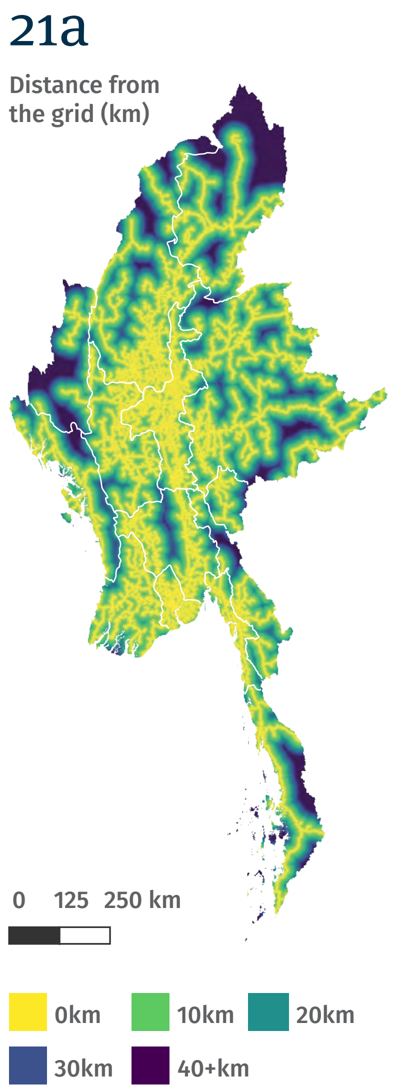


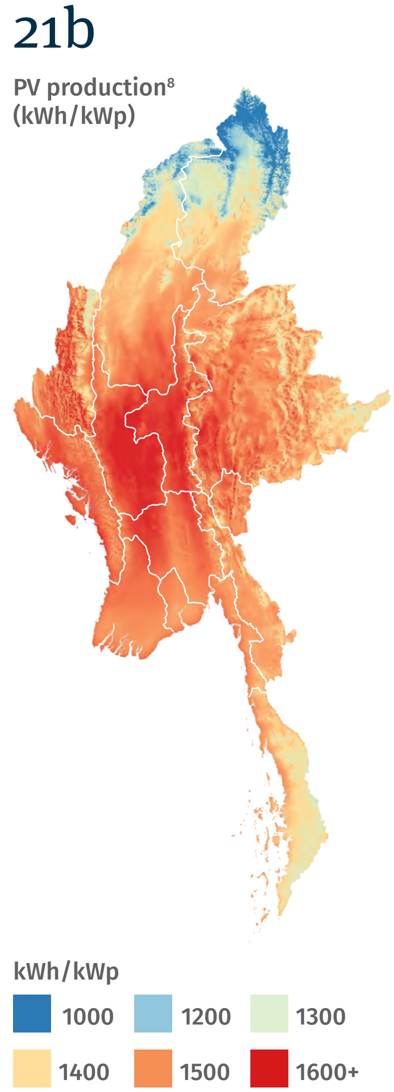

# 3.0 Tools for analysing energy use along value chains

During the course of the study, the energy challenges and opportunities along key value chains were identified and assessed through:

- Identifying and compiling local data sources and maps;
- Secondary desk-based research and a literature review;
- On-ground and telephone interviews with people across the value chain continuum, from farmers and industry associations to large processors and government departments;
- Geospatial analysis of night-light imagery (to locate grid infrastructure), local crop yield and productivity, road networks and layers relevant to generation technology including sunshine levels;
- Expert interviews with practitioners and support organisations.

**Figure 8:** Some examples of the geospatial data layers used in the value chain analysis

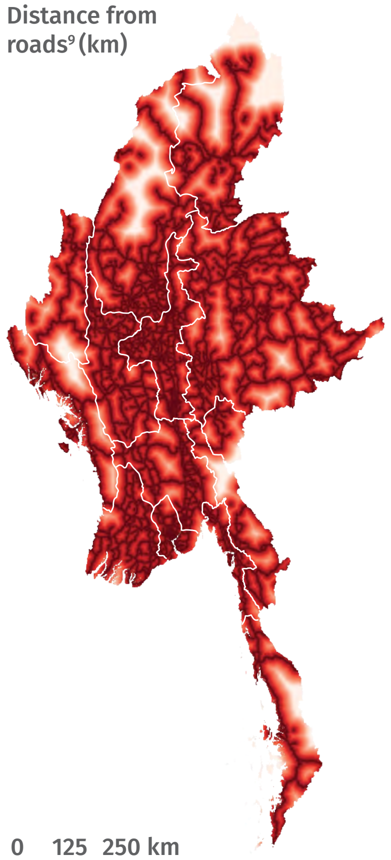



8 Global Solar Atlas (*link*)

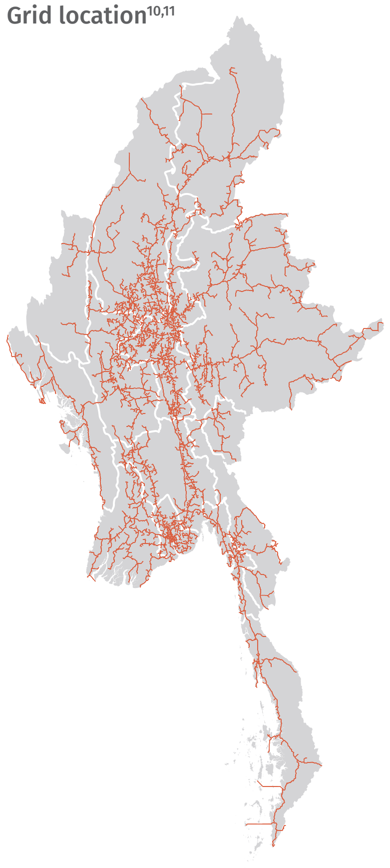
**21c**

Distance from roads[9] (km)




**21d**

Grid location[10,11]




9 OpenStreetMap (*link*)

10 This data, extracted using machine-learning based algorithms on night-light satellite imagery, NASA Visible Infrared Imaging Radiometer Suite (VIIRS) imagery and other spatial data, is available online in an interactive and zoomable map on the VIDA platform. (*link*)

11 Village Data Analytics (*link*)





# 3.1 Agricultural value addition derived from energy consumption

Agricultural value addition describes the increase in value of agricultural produce as it moves down the value chain and compares it to the energy used by each process. The outcome shows **the efficiency with which a value chain activity converts energy into economic value**. The technique can be used to design business plans, compare delivery models and find out which agricultural processes should be prioritised for electrification. It can be used to compare different value chains, activities along a single value chain or a single activity at different points or different scales along a single value chain.

An analysis of energy-derived value addition highlights the following insights:

- **The cost of downtime:** Keeping machines running by switching to an alternative energy source (like a captive solar energy system or back-up generator) is often valuable enough to justify the higher costs of that energy. **Cost justification** compares the increase in agricultural value resulting from agricultural processing against the cost incurred or tariff paid[12] for the energy to power the process. **Sufficient levels of value addition can offset high energy costs or tariffs**. This is especially relevant for off-grid mini-grids, where tariffs can be high.
- **Economies of scale:** If a processor has bigger machines and is processing greater volumes of agricultural input, the cost to process each kilogram decreases. Larger machines and processors tend to consume less energy for each unit of agricultural output than small ones. This means that their energy costs are lower for every kilogram processed.

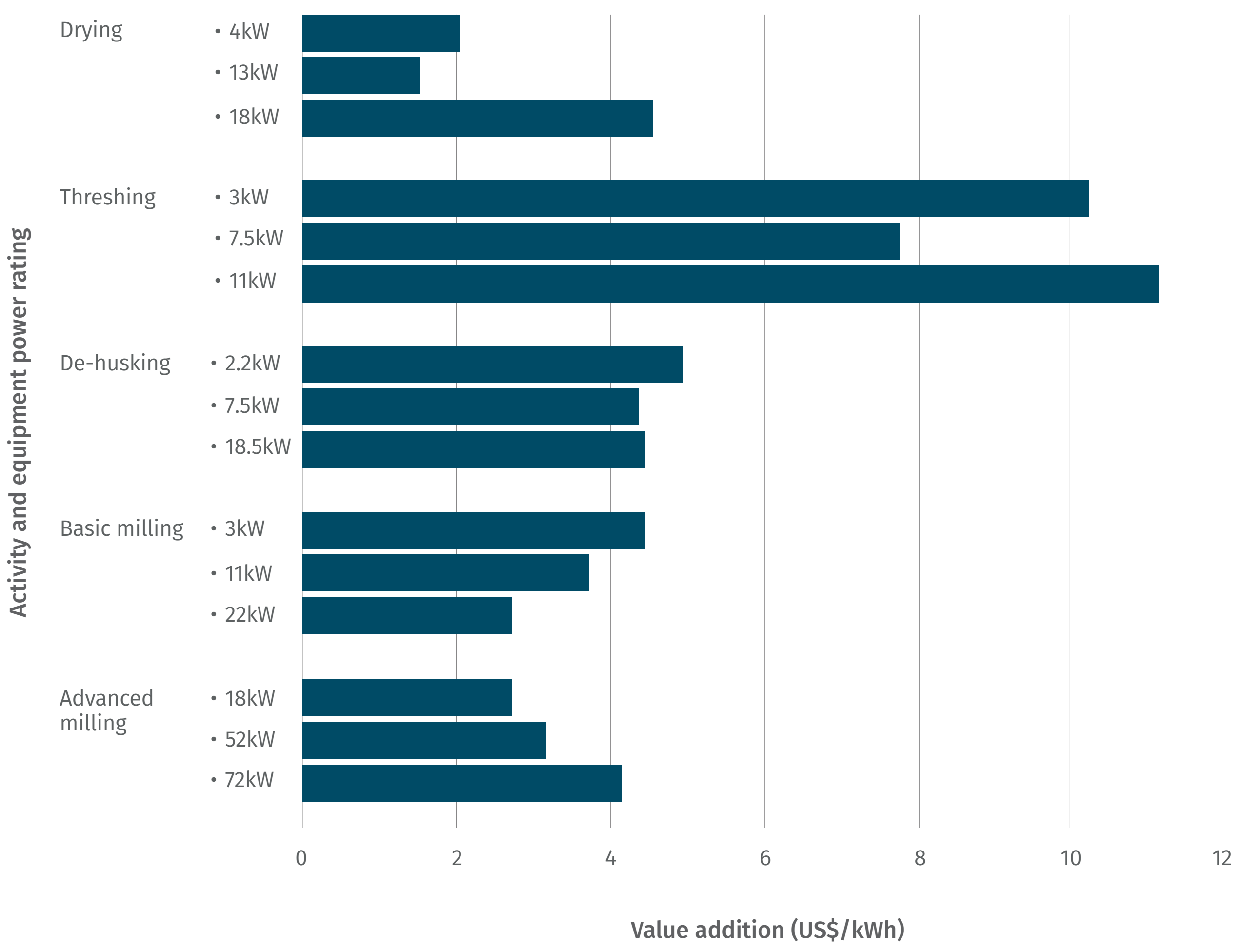
12 In cases where the agricultural processor takes ownership of the energy system (in the case of standalone systems and captive power systems), energy expenditure is a cost. For the mini-grid case, see footnote 13.

3.0 Tools for analysing energy use along value chains

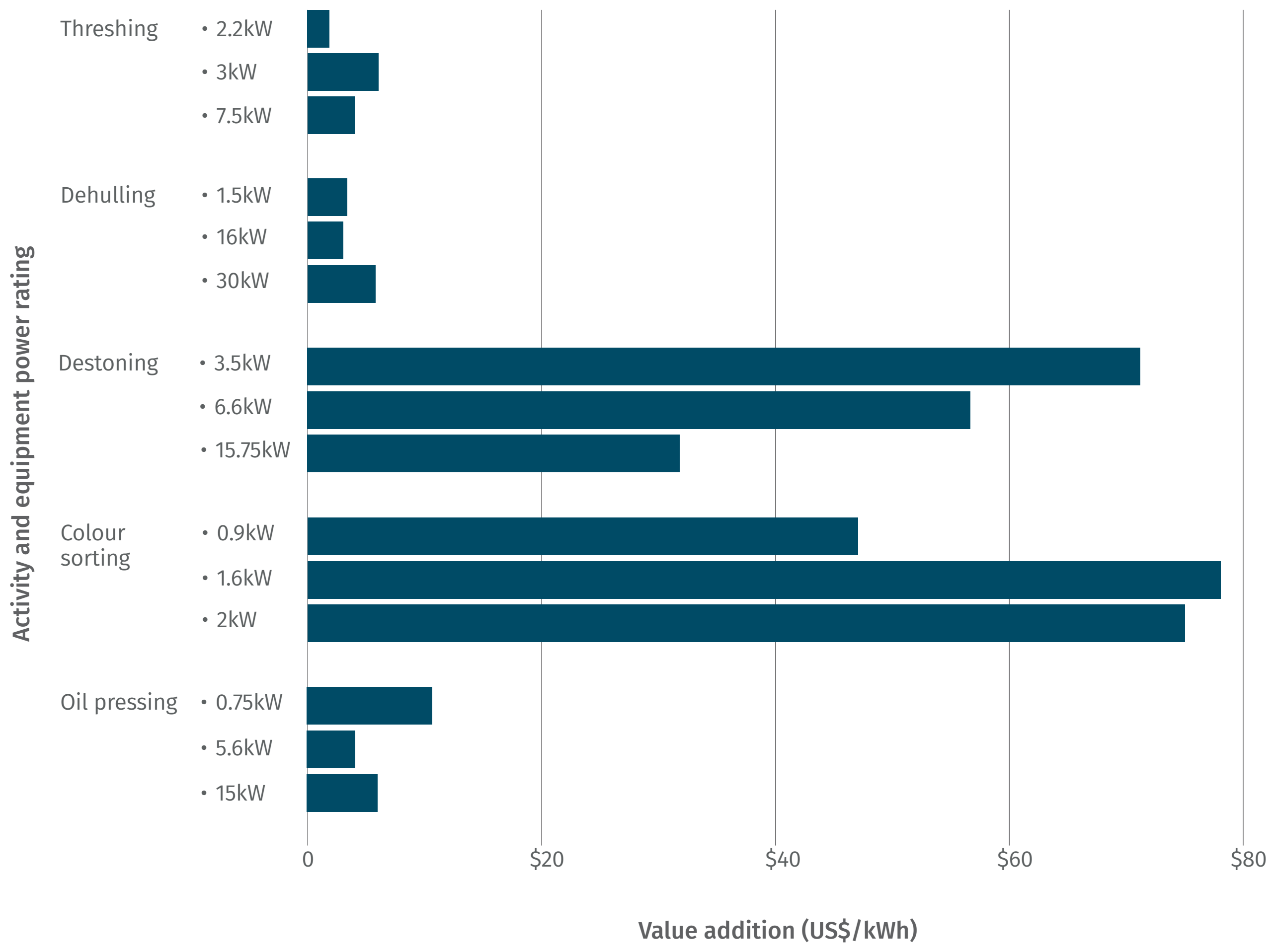
Figure 9 below shows the value addition per kWh of processes along the key value chains. **The greatest value addition per unit of energy consumed for rice processing comes from threshing which is an upstream activity. The greatest value addition for beans, pulses and oilseeds comes from colour sorting, a more downstream process. Spinning lint into yarn offers the greatest value addition per unit of energy on the cotton value chain.**

**Figure 9:** Process value addition as a function of energy consumed and equipment power rating

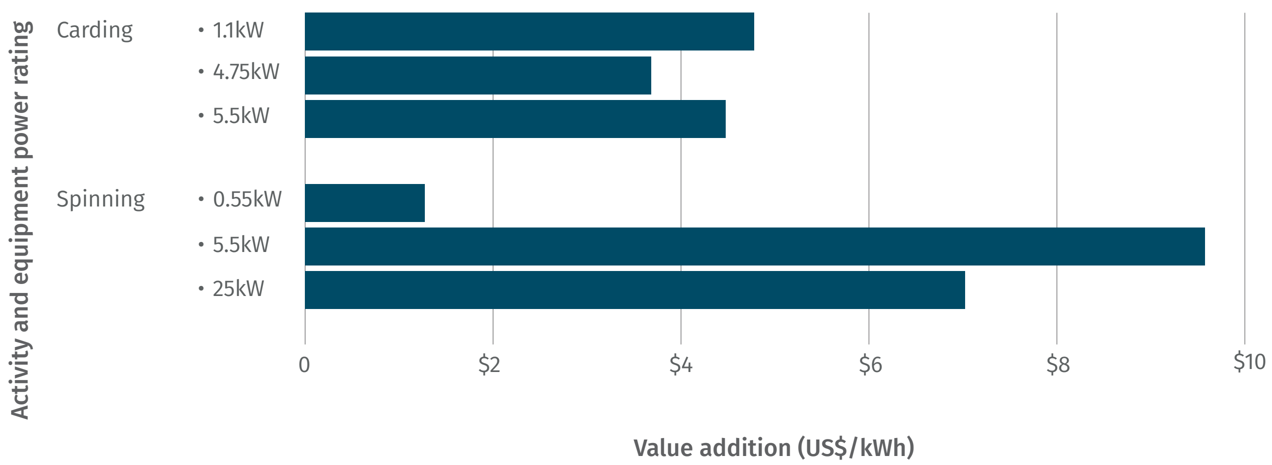
**20a:** Rice value addition per kWh




**20b:** BPO value addition per kWh




**20c:** Cotton value addition per kWh



## 3.2 Techno-economics of agricultural processing

Techno-economic analysis aims to assess and compare the feasibility of various interventions using a range of financial and operating variables. Major parameters for determining techno-economic viability are:

- **Capital expenditure (CAPEX)** includes the amount of money needed to buy equipment. High capital requirements make payback periods longer and as a result reduce profitability.
- **Operating expenditure (OPEX)** is defined as the ongoing costs of operating machinery and includes energy, labour, maintenance and other running costs.
  Operating costs are closely linked to machine uptime and therefore capacity utilisation, which, like CAPEX, affects payback periods and profitability
- **Capacity utilisation** is an indicator of how often a processing facility's total capacity is being used. Higher utilisation rates mean a machine is less idle, delivers more output and increases sales revenue. Utilisation is affected by seasonal variability and the availability of raw material inputs.
- **Levelised cost of energy (LCOE)** measures the average cost of energy, which may be generated from a range of sources, including national grid, mini-grid, diesel backup or other over a specified period of time. The cost of energy is an important consideration due to its influence on commercial viability metrics like profit.[13]
- **Processing scale** considers the range of scales and operating environments at which a processing activity is **practical** and **feasible**. Practicality evaluates the often-qualitative benefits and costs of conducting an activity at a given scale,[14] while feasibility is related to CAPEX, economies of scale and energy-derived value addition.

13 In cases where the agricultural processor does not take ownership of the energy system (such as being a mini-grid customer), they will pay a retail tariff, which will be composed of LCOE plus the energy system operator's margin.

14 For example, practicality in the rice value chain recognises that threshing can be done at various scales and value chain nodes, but likely makes most sense upstream by reducing product weight and so transport requirements.





# 4.0 Delivering improved energy access

Identifying the energy challenges and opportunities along value chains is a critical step. Designing the best model to deliver the required energy however requires consideration of four critical questions:

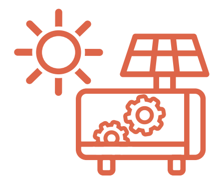
- **What is the source of finance** (e.g. commercial, concessionary, grant, CAPEX subsidy)?
- **Who owns the assets** (e.g. community, private, utility)?
- **Who is responsible for operations and maintenance** (e.g. capacity of local/national operators or location of technical staff)?
- **What is the revenue model** (e.g. tariff setting, how are payments collected)?

Answers to these questions will determine the fundamentals of the ideal energy delivery model in each unique case. There are also several practical considerations that can influence the viability of a delivery model. These practical considerations are outlined in the table below, alongside a list of possible energy systems. Some of these factors are the same nationwide and some vary from community to community. Most, however, directly or indirectly affect the commercial viability of projects. There is a lot of variation; a captive power system smoothing electricity supply for a yarn factory in a weak grid location for example, might have a return-on-investment profile attractive to commercial local finance and purely private sector ownership. A rural mini-grid powering a rice threshing machine on the other hand, might benefit from part community ownership, require subsidy or grant support for the necessary upfront capital, but yield greater social impact for example via localising value capture and improving rural livelihoods.

## 4.1 Energy systems

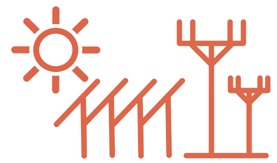
### Standalone systems

A dedicated energy source powering a single machine or piece of equipment (e.g. solar thresher), typically in off-grid rural settings such as on a farm.



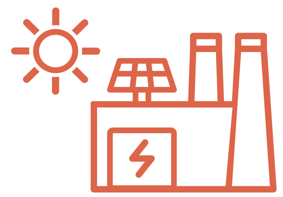
### Mini-grids

An energy service consisting of generation (e.g. solar PV, hydro, gasification) and low voltage distribution where electricity is consumed by multiple off-takers. Mini-grids can be isolated or interconnected with the main grid.



### Captive power systems

An energy system, typically in the form of rooftop solar, designed for a single user (off-taker). Captive power systems can be off-grid or grid-connected. If grid connected, the system is usually designed to provide energy when the grid is not available, either from energy stored in batteries or generated on-site, or both. These systems typically have the lowest levelised cost of energy, of the systems described above.



# 4.2 Considerations affecting delivery models of energy systems

### Policy & regulation

- Tariff structures
- Subsidies
- Institutional capacity
- Political support for sector
- Distributed renewable energy (DRE)-specific regulations (e.g. feed-in-tariffs)
- Regulatory clarity
- Grid encroachment policy
- Duties and taxes
- Sovereign risk and political stability
- National technical standards
- Quality assurance frameworks

### Finance and investment

- Currency risk
- Local finance sector capacity
- Access to project development capital
- Access to consumer finance
- In-country Development Finance Institution support
- De-risking mechanisms (e.g. first loss pools and aggregation platforms)
- Competing subsidies (e.g. fuel subsidies or subsidised national grid tariff)
- Ability to pay
- Mobile money penetration
- Revenue collection
- Experience of private sector operators

### Geography and site location

- Crop yield and production
- Area of land under irrigation
- Seasonal variation
- Number of yearly harvests
- Clustering with other villages and nodes of production
- Availability of supportive infrastructure (e.g. roads, health facilities etc.)
- Proximity to markets
- Quality of grid services
- Village density, size and rate of growth
- Labour availability
- Community socio-economic profile
- Environmental vulnerability
- Solar irradiation



4.0 Delivering improved energy access

# 5.0 Key findings and recommendations

## Key Finding - 1

Decentralised energy technologies have a higher LCOE than subsidised grid tariffs. They also deliver more reliable energy supply, meaning machines can keep running. The resulting **increased income can justify the higher LCOE from decentralised renewable energy systems**.

### Recommendation:

**To justify the higher LCOE from decentralised renewable energy systems, focus electrification efforts on agricultural processing activities that add significant value to the raw material.**

## Key Finding - 2

Interventions at different points of the value chain require different investments and deliver different types of outcomes. Focusing an energy intervention on small-scale upstream agricultural processing (e.g. threshing rice and pressing oilseeds) is well suited to mini-grids in off-grid areas where the addition of agricultural processing can stimulate energy demand directly and indirectly strengthen the local economy. This in turn enhances mini-grid commercial viability.

### Recommendation:

**Facilitate dialogue and better linkages between the agriculture and energy sectors. Leverage existing and emerging businesses (e.g. fintech providers) and distribution channels (e.g. mini-grid operators, agricultural extension workers) to extend the reach of financial services into rural areas so that farmers and processors can access processing equipment.**

## Key Finding - 3

Although upstream, off-grid projects will generally be more resource intensive (e.g. technical assistance and training) and require more grant and other development finance, they will also tend to yield greater social impact (e.g. improving rural livelihoods).

### Recommendation:

**Support local energy project developers with standardised designs, bulk procurement, data and GIS tools to identify high-value sites. Develop, establish and maintain an effective enabling environment for off-grid project developers and operators. This includes tailored finance, technical assistance and better clarity on tariffs, licensing and grid encroachment.**

## Key Finding - 4

Energy interventions focused on downstream medium- and large-scale processing (e.g. bean color sorting and cotton spinning) will be well suited to captive power systems like rooftop solar and/or battery storage to supplement grid supply during blackouts.

### Recommendation:

**Improve access to data on grid location and quality at agriculturally significant weak-grid locations in order to identify opportunities for captive power systems. On-ground surveys and sensor networks could help fill these gaps.**



5.0 Key findings and recommendations

## Key Finding - 5

Downstream projects will have higher value addition better economies of scale and lower LCOE than upstream off-grid interventions meaning that they can better compete with grid tariffs and fuel generators. The increase in processor uptime and hence revenue facilitated by reliable energy supply yields greater economic return per dollar invested.

### Recommendation:

**Enhance coordination between the public and private sectors to establish, develop and maintain an effective business enabling environment for DRE project developers. This might include developing support programs, updating regulation and tailoring finance for captive power solutions.**

## Key Finding - 6

The economic profile of downstream interventions Means that they suit scaled investment that can leverage commercial finance.

### Recommendation:

**Build the capacity of local lenders to develop financial products tailored to captive power solutions specifically. Develop national support mechanisms to de-risk investment into the sector (e.g. first loss pools).**

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