OORJA

ACCESS - INCLUSION - IMPACT

PAY-PER-USE BUSINESS MODEL

FOR SCALING ACCESS TO PRODUCTIVE-USE APPLIANCES IN THE FARM SECTOR

ABSTRACT

Agriculture is one of the major economic drivers in South Asian and Sub-Saharan African countries. The majority of farmers living in these regions are poor smallholders who practice subsistence agriculture and lack access to energy, productive-use of energy (PUE) technologies, and capital resources. PUE technologies are energy-enabled products that enable their users to earn additional or new sources of income. There has been increasing interest in PUE for agriculture due to high customer demand, technological innovation, and high impact potential. While small-scale PUE products can be sold to consumers, the uptake of high-ticket PUE appliances over 1,000 W in capacity and costing US$2,000 and above – such as water pumps and agri-processing equipment – remains low because of the lack of appropriate financing solutions. In this article, we explore different end-user financing and business models for mainstreaming access to large-scale PUE to transform farmers' livelihoods. We compare the advantages and disadvantages of different models from the perspective of the end-user and the implementer. We focus on the nascent 'pay-per-use' business model, under which PUE assets are financed, owned, operated and maintained by the implementer and end-users pay for services according to their consumption, rather than acquiring ownership of assets. Oorja Development Solutions Limited (Oorja) is a private company that has pioneered the pay-per-use model for PUE in the agriculture sector. A case study of Oorja's work implementing pay-per-use irrigation, flour and spice milling and cooling services for horticultural produce in rural India is presented. The pay-per-use model was found to remove the upfront cost barrier for technology acquisition, provide quality and timely services throughout the agricultural cycle, and be scalable to reach under-served customer segments. The pay-per-use model has been successfully used by Oorja to mainstream access to agricultural PUE ranging from 2,000-5,000 W capacity and product cost of $3,000-16,000) among the rural poor, smallholders and women farmers. There is potential for pay-per-use business models to expand access to other large-scale PUE technologies that could transform farm livelihoods.

ABOUT THE AUTHOR:

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INTRODUCTION

Productive use of energy (PUE) appliances are a range of energy-enabled products that when used by customers, help them to generate additional or new sources of income. Evidence has shown that use of PUE products drives higher productivity, increased income and improved quality of life. Popular examples include solar fridges, egg incubators, solar water pumps, and electric sewing machines.

PUE products are usually available either as plug-in appliances (with power requirements typically less than 1,000 W) or as appliances integrated with an energy source, such as a solar panel and battery (for appliances with power consumption between 1,000 and 10,000 W). PUE is essential for supporting livelihoods in various sectors including agriculture, aquaculture, tailoring, weaving, food processing, poultry, pottery, carpentry, and many others.

South Asia and Sub-Saharan Africa are home to the largest rural populations in the world, and these rural communities are dependent on agriculture for their livelihood. The majority of farmers are small and marginal, meaning they have landholding less than 2 hectares, and they are also very likely to be economically and socially disadvantaged due to their low income, gender, caste, education level, or other factors. While small farms contribute to 90% of the world's agriculture production, many farmers themselves live in poverty deprived of essential services including energy, sanitation, education, and health. Agriculture in these regions is majorly dependent on rainfall which makes it highly vulnerable to extreme climate.

DEMAND FOR PRODUCTIVE-USE OF ENERGY IN AGRICULTURE

There is growing consumer demand for PUE appliances for use in agriculture and food production. Farmers require PUE appliances for use seasonally or cyclically in the agricultural production process, for example, tractors, tillers, sprayers, irrigation pumps, agri-processing mills, harvesters, threshers, etc. They may also have post-harvest energy needs, for instance, fridges, freezers, dryers, and other equipment for value addition, packaging, and branding of their produce. Agri PUE products such as water pumps, fridges and agri-processing equipment (e.g. mills and dryers) are increasingly affordable thanks to technological innovation, have a substantial market size, and a high potential to achieve impact in transforming livelihoods, tackling poverty, and mitigating climate change. This has created a recent drive from funders, implementers, and ecosystem enablers to promote PUE products in agriculture. The products with the highest demand and need are typically larger than 1,000 W, cost upwards of $2,000 per product and have complex logistical, financing, and after-sales service or maintenance needs. These factors have limited uptake of PUE products among the consumers most in need.

CHALLENGES TO SCALE

The cost of agri PUE is the major challenge barrier to scale, as the upfront capital investment for high ticket-size items such as water pumps is unaffordable to most consumers who earn less than $100-150 per month. Affordability is low, as most consumers do not have the ability either to invest cash upfront or pay on credit. Factoring in farmers' inability to pay means that a total market size of $11.3 billion for solar water pumps, agro-processing and cooling and refrigeration

in sub-Saharan Africa translates only into a $734 million serviceable market, according to IFC Lighting Global. So, what do consumers do instead? Smallholder farmers are forced to rent locally available equipment/machinery at a higher cost or simply forego the use of these appliances altogether, negatively impacting their profits. In addition, many regions of the Global South where these consumers live are energy-starved and depend on fossil fuel for on-farm energy use, which is both expensive and polluting. In contrast, clean energy PUE products are increasingly available and thus have high carbon emissions mitigation potential in replacing diesel, kerosene, and other fossil fuels. Clean energy sources to power PUE could be solar, hydro, wind, biomass, or hybrid solutions. Off-grid solar has fallen in price, is well established globally, and can power a broad range of appliances. Thus, productive use leveraging solar energy (PULSE) – the dominant sub-category of PUE – presents a strong case for investment.

The market opportunity for agri PUE is immense but tapping into it requires that we address affordability constraints. In this article, we explore the business and end-user financing models that have the potential to enable the uptake of high-impact PUE products by farmers to substantially increase their agricultural productivity, income, food security, nutrition, and quality of life. We centre the needs of under-served consumer segments that have been difficult to reach via direct sales methods. These include low-income users, smallholder farmers, women, Dalit communities, minorities, and other marginalised communities. These consumers require PUE products or services that are available near them, affordable, of good quality, reliable, with timely maintenance or after-sales service, and for multiple needs at the same time.

Oorja has made solar-powered irrigation services available to smallholder farmers through a pay-per-use business model. Groups of 15-20 farmers pay for irrigation at affordable tariffs up to 50% cheaper than diesel-based irrigation. A locally hired Operator is supported by a network of collections assistants and engineers.

In the next section, we focus on the 'pay-per-use' business model innovation pioneered by Oorja Development Solutions Limited (Oorja) in rural India. We present a case study of the successful use of this model in the providing access to solar water pumps, agri-processing mills and cooling for horticultural produce. We also present other examples of pay-per-use in different

geographies, discuss the potential for this business model to be scaled to millions of consumers and its potential applicability beyond the farm sector in supporting non-farm livelihoods.

BUSINESS AND END-USER FINANCING MODELS TO SUPPORT PUE UPTAKE

New and innovative business and end-user financing models are needed to support uptake of income-generating appliances among low-income agrarian communities. These models should cater to the needs of customer groups - centring their need for affordability, reliability and proximity - and should be relevant and applicable to the agricultural systems in the local context.

There are various established and innovative business models and end-user financing schemes being explored and implemented in the Global South in response to challenges faced in the water-energy-food nexus. These models have been applied to address issues specific to the agricultural sector such as access to irrigation, reduction in use of fossil fuels, reduced drudgery of women and farm labourers, improved farm productivity, climate mitigation and adaptation, and gender inclusion. Some of the business models and end-user financing mechanisms currently being used for providing access to large-scale PUE technologies to consumers are:

1. PAY-AS-YOU-GO (PAYG OR PAYGO)

In the Paygo model, consumers who do have the capacity to pay the high upfront cost of the PUE product pay 10%-20% of the total cost upfront initially. The remainder is paid in regular instalments, though in some cases these can be paid flexibly according to consumers' seasonal income. Ownership of the product is transferred to the consumer once the product is paid, usually over a period of 18-36 months. Many products, such as micro solar pumps of 500 to 1,000 W, can be locked remotely if the payments are not made on time. The payment is generally made through scratch cards or mobile payments (most prevalent in Africa) or cash. The Paygo model usually relies on the consumer obtaining a credit score, which can be difficult to prove especially for un/under-banked consumers. This model is well-established for small off-the-shelf PUE such as solar home systems and household appliances (Tiers 1 – 3 on the ESMAP energy access scale – see Table 1 below) but repayment risks are much higher for larger appliances (Tiers 4 & 5), which would require additional financing. The implementer may raise capital through venture funding, impact investment, donor funding or loans in order to finance the asset costs.

2. PAY-PER-USE

Consumers only pay for the services availed using the PUE products, based on their usage as per their need during the season or cropping cycle. Usage can be measured per unit of time, weight, quantity, etc., providing ease of use to end-users. Pay-per-use can easily substitute existing metered services, such as electricity, water or gas supply, and the risks of end-users failing to pay is greatly reduced by metering. Just like using Uber to pay only for a ride rather than renting/buying a vehicle, the pay-per-use model can transform any large PUE asset into a service. The upfront cost barrier is removed, as consumers do not have to invest in the high product or setup costs. Ownership of the assets is not transferred to the consumer at any point. However, this requires the implementer to have access to capital to finance the capital cost of PUE technologies. If a subsidy is required, this burden falls upon the implementer rather than the end-user. The costs of maintenance can be included in the usage charges. If users fail to pay or have less demand, the service can be offered to other nearby users. The pay-per-use model is suitable for providing services to an entire community rather than an individual and it can be applied to Tier 4 & 5 products that are essential for livelihoods. The

implementer typically raises patient capital through impact investment or donor funding in order to deploy larger assets which are more capital-intensive.

Table 1: Electricity access, appliances powered and business model typically used. Based on ESMAP Multi-Tier Framework for Energy Access.

		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
PEAK CAPACITY	POWER CAPACITY (IN W)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2,000 W
	Services	No electricity	Lighting, phone charging	Tier 1 + TVs, fans	Tier 2 + small appliances (sewing machine, entertainment systems)	Tier 3 + high power appliances (micro pumps, water heaters, irons, fridges)	Tier 4 + very high-power appliances (irrigation water pumps, pulverisers, rice hullers, cold rooms, freezers)
AVAILABILITY	Hrs/day	<4 hrs	Min 4 hrs		Min 8 hrs	Min 16 hrs	
PAYGO			Paygo: used for lower power capacity devices				
PAY-PER-USE						Pay-per-use: used for higher power capacity community-ased appliances requiring continuous use	

3. SUBSCRIPTION MODEL

The consumer pays a set subscription fee at a pre-defined set interval of time, usually monthly, quarterly or annually, irrespective of their usage during that period of time. It is similar to Payg and pay-per-use, in that the consumer can enjoy the benefits of the PUE product without owning it outright, but they pay a recurring subscription fee regardless of their usage. Many solar rooftop installation packages use this model, where users pay a fixed cost over a number of years, usually until they own the equipment outright. A pure subscription model can be continued for the full life of the product, with payments being used to pay for maintenance and equipment upgrades as part of the package. This provides the implementer with steady revenue streams and avoids the costs of equipment upgrades or repairs for the consumer.

4. RENTAL

Renting allows the use of physical assets without the consumer owning that asset. This is a traditional method of availing services for high-cost farming assets, where a local entrepreneur invests in a high-value asset and rents them out locally to users on a need basis. Rental models are highly flexible and consumers usually pay in cash and rent according to the use case, which

may be hourly, daily, weekly, monthly or over a longer rental period. However, they usually require contractual commitment by the consumer, as well as upfront warranty or insurance in case of damage to the asset. This model works for highvalue farm machinery such as tractors, harvesters and seeders. Rental models tend to become more expensive than ownership over a long period. At the end of the contract, the user may have the choice to purchase the asset – this more innovative model is known as 'rent-to-own'.

5. COOPERATIVE MODEL

A group of consumers finance the PUE appliance either through bank loans or upfront payments, or a combination of both. They may form a 'joint liability group' for the purposes of availing a bank loan either individually or through a group mechanism by mutually guaranteeing the loan, in case one member of the group defaults. The cooperative uses the PUE product and may charge usage fees which can be used to cover maintenance costs. Additional fees can be earned by supplying services to the nearest grid or other nearby users. This model relies on the banking sector's accessibility to smallholder farmers without extensive credit histories and sanctioning loans to low-income customers, which historically it is reluctant to as these consumers are considered high-risk debtors. It also relies on consumers being able to find the upfront capital and collateral value exceeding the principal of the loan and being able to service the high interest rates. Under this model, there is usually no financial or technical support for maintenance and repairs of the asset.

6. PAY BY PRODUCE

Payment using their harvested produce allows consumer access to PUE products without any upfront cost to them. The payments for the PUE appliances/products are aligned with the crop cycle of the consumers enabling low-income consumers to purchase or use PUE products. The implementer receives the payment by selling a portion of the consumer's produce in the market after the harvest. Any surplus from the sale of the produce is returned to the consumer. Here the implementer takes the risk of finding market for the produce and is exposed to commodity risk. Consumers may end up paying more for the PUE product as the payment period is longer (6-36 months). This end-user financing model can make the consumers dependent on the implementer to find a market for their produce. In the absence of upfront payment for the product, the implementing organisation is dependent on funding from investors for the upfront capital investment to provide solutions to the consumer.

Below, we compare these service-based delivery models from an individual consumer's perspective based on parameters such as the initial setup cost, ownership transfer, ease of use, accessibility, operations and maintenance cost, individual/community asset and exit barriers for the consumer.

PARAMETERS	PAY-PER-USE	PAYGO	SUBSCRIPTION	RENTAL	COOPERATIVE	PAY BY PRODUCE
Initial setup cost to user						
Ease of use						
Inclusivity						

Availability of maintenance and servicing						
Operations and maintenance cost to the user						
Exit barrier to the user						
Other industries where model has been applied	Taxi hire	Cloud data storage	Online content streaming	Housing	Dairy industry	Contract farming

Pay-as-you-go (Payg) models have been successful in mainstreaming access to household solar appliances and small agri appliances. However, as payments need to be recovered over a maximum period of 36 months, they are not suited for larger and more expensive PUE products. As there remains an upfront cost and payment contract with the Payg provider, they may not reach the most low-income customers. Other models such as rental and cooperative models struggle to cater to the complex after-sales service needs of PUE products, leading to dis-use of assets if customers cannot afford to repair them. After-sales services is a critical factor to ensure reliable and continuous accessibility to the productive use equipment for its full lifetime, especially for products less wellknown to local technicians, such as solar water pumps. Maintenance and servicing is effectively catered to only by the pay-per-use model, where the end-users are not responsible for the maintenance of the equipment and the implementer (service provider) is incentivised to ensure minimum downtime in order to continue generating revenues.

What if there is no implementer available to provide access to agri-energy services using one of the above delivery models? This is a frequent situation in which only a minority of consumers will be able to afford the upfront cost of PUE appliances. In some countries, governments may provide capital subsidy to enable individual consumers to gain access to large-scale PUE, helping reduce the investment required. These subsidies do not usually cover the full asset cost, leaving a significant portion to be financed by the consumer from their savings or a bank loan. There is often no scope for covering the costs of maintenance and repairs, unless the implementer provides an annual maintenance contract.

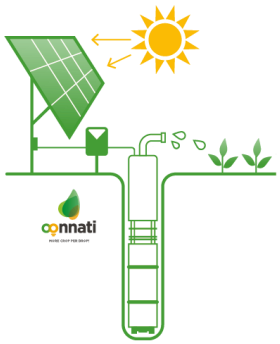
In the absence of a maintenance contract, it is highly likely the PUE product falls into dis-use long before its end of life. As an alternative to end-user financing and innovative business models, implementers themselves may obtain financing such as donor-led funding from nonprofit donors, impact investment capital, crowdfunding, bank loans and capital subsidy from governments.

THE PAY-PER-USE MODEL PIONEERED BY OORJA

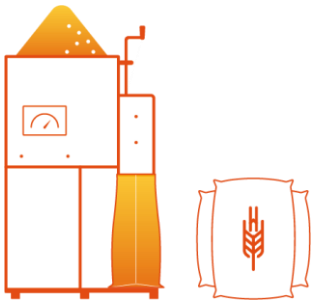
Oorja is a farming-as-a-service company that finances, installs, operates and maintains distributed solar energy systems for community use. It has focused on three PUE products: solar irrigation pumps, pulverisers for flour and spice milling, and cold storages. These PUE products are in high demand among consumers, stimulate higher farm income, rely on mature technologies, and require

significant investment. All are powered by solar photovoltaic technology, with significant carbon mitigation potential compared to fossil fuels.

Oorja's target customers are smallholder farmers with less than one acre of land earning less than $100 per month with majority customers from disadvantaged communities (Scheduled Castes, Other Backward Classes etc) and women farmers. Oorja has pioneered an inclusive and innovative pay-per-use business model in which it sells irrigation, milling and cooling services to smallholder farmers and low-income consumers according to their consumption. The services are priced based on usage at fixed tariffs that are 20% to 50% cheaper than diesel-based pumping and milling. This removes the upfront technology acquisition cost barrier for high-cost PUE products, which include:



Solar water pumps, ranging from 3 or 5 HP capacity, costing $3,000 – $5,000 per system



Multipurpose pulverisers of 3 or 5 HP capacity, costing $500 – $1,000 per appliance (without solar PV)

Solar cold rooms of 2 to 5 MT capacity, costing $10,000 – $16,000 per system

Oorja's solar milling service makes multipurpose pulverisers accessible at the village level for flour and spice milling. The customer (right) has used the service for milling dried turmeric.

The company uses a careful site selection process involving user demand surveys and trust-building with the community before solar infrastructure setup. For the initial setup costs, Oorja relies on a blended finance funding model of both equity and grant capital. Oorja has delivered solar-powered irrigation, milling and cooling to 2,000 direct customers to date across Eastern Uttar Pradesh and Bihar, in India. Its customers have reduced their expenses on traditional fuels, and impact assessments have shown that they have been able to increase their crop yields and income by 15-29% in one year. Installation, maintenance, insurance and repairs are handled by the company and the charges are built into the usage tariffs, enabling the provision of high quality and reliable services with minimal downtime. This, in turn, has enabled a complete transition from diesel to solar power. In addition, users have reported a reduction in drudgery, time savings as services are provided on-farm, and greater convenience due to availability of multiple on-farm services at their location. This is consistent with studies that off-grid solar products and services increase climate resilience and improve agricultural productivity.

Oorja continuously works towards gender mainstreaming by adding more women farmers as customers, operators and train women to earn additional income. In the picture a group of women farmers are learning how to operate the solar pump and take flowmeter readings as part of a workshop.

Oorja's services were evaluated based on the same parameters as above from the perspective of service consumers.

PARAMETERS	OORJA	RATIONALE
Initial setup cost	None	Oorja finances the solar pumps, mills and cold storages. Users contribute only a very small one-time membership fee as evidence of buy-in.

Transfer of ownership to user	No	Oorja retains the ownership of the assets and ensures prompt maintenance and servicing and responsible disposal/recycling at the endof-life.
Ease of use	High	Services are easily available on a first-come-first-served basis to any user on-farm at a convenient location. Farmers pay for the services in cash and obtain the help of a local operator hired from within the community. Assets are fixed in place and do not require the user to carry heavy machinery into their field. Multiple integrated services are available to users.
Inclusivity	High	There is no upfront cost barrier for accessing the services. Any user wishing to avail the service can do so, irrespective of their landholding, socio-economic status, education level, or other factors. Gender inclusivity is promoted through hiring of female field staff, operator training and direct targeting of women as customers. Site selection is targeted at areas with a very high proportion of small-scale or landless farmers, low-income communities, minorities, Dalits and women farmers (disadvantaged groups in terms of the caste and gender hierarchy prevalent in India).
Availability of maintenance and servicing	Yes	Prompt maintenance, repairs and servicing are taken care of by the company within 1-3 days of reporting to ensure high uptime.
Operations and maintenance cost	None	The community-based assets are operated and maintained by Oorja to ensure minimum downtime and maximum utilisation. Users do not need any specialist or technical knowledge and incur no charges for maintenance and repairs.
Individual/community asset in the long run	Community	Solar assets are shared by groups of 15-30 consumers per system. In case one user no longer wishes to avail services, another user can replace them. Community use maximises asset utilisation and energy efficiency. In the case of solar water pumps, community use and keeping a price on water also helps promote judicious use of groundwater.
Exit barrier	Moderate	The alternatives available (such as diesel power) are costlier, less convenient and more time-consuming to fetch and operate, which discourages users from switching back to them. However, users can fall back upon diesel or the grid in periods of high demand.

OTHER PAY-PER-USE AND PAY-AS-YOU-GO PIONEERS

APTECH AFRICA

Aptech Africa provides irrigation services to individual smallholder farmers in Uganda through three different delivery models. Customers are given the options to pay for solar powered pumps upfront, on a pay-as-you-go basis known as 'Pay-N-Pump', or on a lease-to-own basis over 30 months. At over $2,500, the upfront option has proven too expensive for rural farmers, most of whom have also been unwilling to commit to regular lease payments. The company's most popular option is 'Pay-NPump'. Farmers enter into a contract where they pre-pay using mobile money for monthly irrigation packages, thus paying for water only when they need it. The company also offers full maintenance to ensure the systems are up and running and agronomy training, which is included in the service fees.

Similar pay-as-you-go models over 18-36 months have also been implemented by Sunny Irrigation operating in Kenya, FuturePump and SunCulture in West and East Africa, focusing on low-cost small solar pumps typically less than 1 HP in capacity, suitable for a single small-scale grower.

AGSOL

Agsol provides efficient solar powered agro-processing machinery for cereal and grain milling in East African countries, covering the geographies of Kenya, Tanzania, Uganda and Zambia. Its energy-efficient solar milling technology is targeted at entrepreneurs in off-grid communities, who are offered financing using the pay-as-you-go model over two years. The entrepreneur then charges other users in the community for milling services. On average, its solar mills cost $3,500, which is payable in instalments by customers with ability to pay on credit. Poorer customers are able to rent the milling appliance from entrepreneurs, delivering social change and economic benefits to the entire community.

COLDHUBS

ColdHubs provides a solar-powered cooling-as-a-service solution at the farm gate and at marketplaces in Nigeria. The company builds walk-in cold rooms for 24/7 refrigerated storage of fruits, vegetables and other perishable food. ColdHubs offers users a flexible pay-as-you-store subscription model to a group of users (community model). Farmers pay a daily flat fee for each crate of food they store, reducing post harvest loss by 80%. In 2022, the company announced that it has started offering refrigerated transport services between its solar-powered cold rooms to complete the cold chain.

SOKOFRESH

SokoFresh offers farm level cold storage as a service and market linkage to small and medium scale farmers in Kenya. Farmers store food on a per-kg-per-day basis, without a large capital investment. The company specialises in high-value horticultural produce growers, such as mango and avocado farmer collectives. They have been able to increase farmers' income by up to 40%.

Table 2: Implementers working on providing large-scale PUE solutions in the agriculture sector in different regions and their business models.

COMPANY	OFFERINGS/ PRODUCT	UPFRONT COST OF PUE APPLIANCE	REGION	MODEL
KopaGas	LPG cooking cooking gas stoves	$150+	Tanzania	Payg

Smart Biogas	Bulk supplier of IoT system for biogas digesters for clean cooking provision	Not known	Global (implemented in Kenya, Uganda, Tanzania, India, Nepal)	Payg
Futurepump	Solar water pumping systems	$500-$700	Global (Africa, India, Nepal, Cambodia, Philippines, Papua New Guinea)	Payg
SunCulture	Solar water pumping systems	$300-$1,000	West Africa (Togo, Ivory Coast, Ghana) and Eastern/Southern Africa (Uganda, Kenya, Ethiopia, Zambia)	Payg
Sunny Irrigation	Solar water pumping systems	$430	Kenya	Payg
Aptech Africa	Solar water pumping systems	$2,600 (10 million UGX)	Uganda	Payg
Agsol	Solar milling appliances	$3,500	East Africa	Payg
Husk Power Systems	Biogas- and solar-powered mini grids providing AC electricity services to households, small businesses, community services and factories	Not known	India and Africa (Tanzania, Nigeria)	Payg
ColdHubs	Solar-powered post-harvest cold rooms and logistics		Nigeria	Pay-per-use
SokoFresh	Solar-powered post-harvest cold rooms		Kenya	Pay-per-use
Solar Freeze	Solar-powered post-harvest cold rooms and freezers for health centres, farmers and small businesses	Not known	Kenya	Pay-per-use

Most of the organisations above are selling micro or small-scale PUE products through the Payg model, sometimes with financing support from local financial institutions. They need to invest heavily on creating a local network of agents for sales and collection of payments. Customers with nonconsistent sources of incomes who struggle to pay on time often have their systems locked. If the livelihood of the customer is dependent on the product, this can have more negative impacts – for instance, preventing a customer from irrigating on time could result in reduced yield or crop failure.

There are only a handful of implementers using the nascent pay-per-use model. In contrast to Payg, customers pay only according to their usage of the service and are not bound by repayment terms, neither do they need to acquire ownership of the asset. This model is more suited to large-scale PUE costing more than $2,000 per system, and is effectively the only model that has been able to unlock access to high-value appliances such as solar water pumps, cold rooms and agro-processing mills.

Within the agriculture sector, there is potential for pay-per-use models to increase farmers' access to PUE and non-energy appliances and machinery, such as for:

- Irrigation for crops: pumps, sprinklers, drip irrigation
- Water pumping for cleaning, cooking, drinking water and other household uses
- Drying or smoking equipment for fruit, tea and fish
- Electrical appliances for egg incubators
- Cold storage for produce and dairy preservation or medicine for livestock
- Waste-to-energy biofuel equipment for cooking, heating, and organic fertilisers
- Agri-processing for cereals, tubers and other produce
- Farm mechanisation: tractors, threshers, harvesters, etc.
- Input application: sprayers, etc.

There is also potential to apply pay-per-use models to non-farm PUE applications such as sewing machines, lathe machines, power looms, and other livelihood appliances. For instance, Selco India and its non-profit arm Selco Foundation have taken an ecosystem approach towards PUE, demonstrating 60+ livelihood interventions ranging from 60 Wp for a sewing machine to 7500 Wp, in the areas of textile, agriculture, animal husbandry, food processing, cottage industries, retails shops, pottery and many others. Rather than relying on end-user financing from bank loans, instead, the pay-per-use business model could be used to mainstream many more of these livelihoodenhancing products.

CONCLUSION

Cost is the biggest barrier to uptake of productive use of energy (PUE) products, which can transform livelihoods in the agriculture sector, combat energy poverty and mitigate climate change. Implementers of PUE solutions have focused on service-based delivery models, including pay-asyou-go, pay-per-use, subscription, rental and cooperative models. For high-ticket PUE products costing over $2,000 and with capacity above 1,000 W, such as water pumps and agri-processing mills, the inability of smallholder farmers to pay even on credit has limited uptake and the serviceable market size. Pay-as-you-go models have been successful in mainstreaming access to household solar appliances and small agri appliances, such as micro solar pumps, however they are not suited for larger products and fail to reach the most low-income customers. Other models struggle to cater to the complex after-sales service needs of PUE products, leading to dis-use of assets if customers cannot afford to repair them. Pay-per-use is a nascent business model that has emerged due to the need for financing of large PUE products, especially in the agricultural sector.

Oorja has made pay-per-use community solar-powered cooling service available to smallholder farmers and traders. The system is available at the market or the farm gate and users can store their horticulture produce on per-crate-per-day basis. In the picture is a locally hired Operator inside a cold storage unit. She is responsible for weighing and sorting of produce, payment collection and handle customer complaints/queries.

Its advantages are that it removes the upfront cost barrier for technology adoption, includes the costs of maintenance and servicing, and can be applied to a wide range of PUE products. Oorja has pioneered this model in the agri-energy sector and successfully applied it to solar water pumps, mills and solar cold storages in rural India. The advantages of the pay-per-use model were found to make it applicable to other farm, non-farm, energy and non-energy related machinery and appliances, such as food processing (rice hulling and polishing, oil expelling, cassava grating, crop drying, corn shelling, coffee pulping, meat grinding, etc), animal food processing (milling of poultry feed, pelletising), renting of farm equipment (tractors, harvesters, etc), clean cooking, powering small cottage industries (sewing machines, etc) and many other applications. Oorja's pay-per-use model has the potential to be replicated and scaled up globally to enable end-users to increase their agricultural productivity, reduce carbon emissions, become energy independent, alleviate poverty and build climate resilience.

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