

September 2019



# Lighting Global: Productive Use Leveraging Solar Energy (PULSE) Study Highlights

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# In a study conducted towards end of 2018, Dalberg & Lighting Global researched the productive use space, with a focus on agriculture

- **Global PULSE trends analysis:** to identify competitive dynamics for a range of PULSE products, focussing on appliances under 1kW
- **Detailed country/use case analysis:** to assess specific opportunities for PULSE use, with a focus on the business case for farmers
- **Market sizing:** to assess demand for PULSE products for three priority use segments across Sub-Saharan Africa up to 2030
- **Ecosystem mapping:** to identify the regulations, policies, and actors that can advance the market
- **Case studies:** on leading innovators in priority PULSE segments
- **PULSE supplier survey:** to understand what the industry is focusing on and how to move the sector forward

## Key findings (1/2)

- **PULSE appliances are increasingly available** in African markets, driven by early-stage firms and specialist distributors
- **Large international manufacturers are starting to take interest** in the off-grid market
- **The maturity of PULSE technologies varies** by type, geography and system capacity. Use cases often have little or no incumbency from alternatives
- **Solar-powered irrigation is most ready to scale**, with specialized cooling applications next, while agro-processing applications are still nascent and often not competitive with alternatives
- **The potential market is vast:** we estimate the total “addressable” market in sub-Saharan Africa for irrigation, cooling & refrigeration, and agro-processing combined to be **USD 11 billion** today
- However, **affordability remains a key barrier to growth:** we estimate the “serviceable” market (i.e., those farmers who can afford assuming some base access to credit) to be **USD 700 million** today. We estimate that this will increase to **USD 3 billion** by 2030, driven by rising incomes and declining product costs

## Key findings (2/2)

- **The business case for farmers is often not clear-cut**, especially outside of irrigation, due to high product costs, low utilization, and load volatility. Returns on investment are highly sensitive to utilization of the appliance, limited by production capacity as well as mobility
- **Aggregation is often the most viable solution**, however the PULSE sector faces traditional agricultural sector constraints, in addition to energy access barriers
- **Limited alignment with national development agendas** presents a missed opportunity. **Low awareness of PULSE benefits, unfavorable policies,** and inconsistent product quality & standards are also barriers
- There is a major role for development actors and policymakers to help unlock demand. Moving the sector forward will require **policy action, market development, concessional financing, and greater coordination** between energy and agriculture actors

# Agenda

- I **PULSE landscape**
- II Products & suppliers
- III Use case economics
- IV Challenges & opportunities

## How are we defining PULSE?

*“any agricultural, commercial, or industrial activities leveraging solar energy as a direct input to the production of goods or provision of services”*

# PULSE cuts across diverse agricultural, commercial, industrial, and social/public activities





























Non-Exhaustive list of activities

## AGRICULTURAL

## INDUSTRIAL

## COMMERCIAL

## SOCIAL/PUBLIC

<p><b>Irrigation</b></p> 	<p><b>Threshers</b></p> 	<p><b>Land preparation</b></p> 	<p><b>Clothing</b></p> 	<p><b>Hairdressing</b></p> 	<p><b>Cooking</b></p> 	<p><b>Education</b></p> 
<p><b>Mills</b></p> 	<p><b>Drying</b></p> 	<p><b>Chilling</b></p> 	<p><b>Carpentry</b></p> 	<p><b>Restaurant/ cafe</b></p> 	<p><b>Retail cooling</b></p> 	<p><b>Health devices</b></p> 
<p><b>Night fishing</b></p> 	<p><b>Cold storage</b></p> 	<p><b>Milking</b></p> 	<p><b>Construction</b></p> 	<p><b>Cinema</b></p> 	<p><b>Phone charging</b></p> 	<p><b>Vaccine storage</b></p> 
<p><b>Oil presses</b></p> 	<p><b>Egg Incubators</b></p> 	<p><b>Electric fences</b></p> 	<p><b>Electronic/ auto repair</b></p> 	<p><b>Transport</b></p> 	<p><b>Handcrafts</b></p> 	<p><b>ICT</b></p> 

Note: Utilizes IRENA terminology for Pico-grid (<1,000W), Nano-grid (<5,000W) and Micro & Mini-grids >5,000W)

Source: Dalberg analysis, 2018

# The market for agricultural PULSE products has significant potential for concentration and critical mass

## Why PULSE in agriculture?

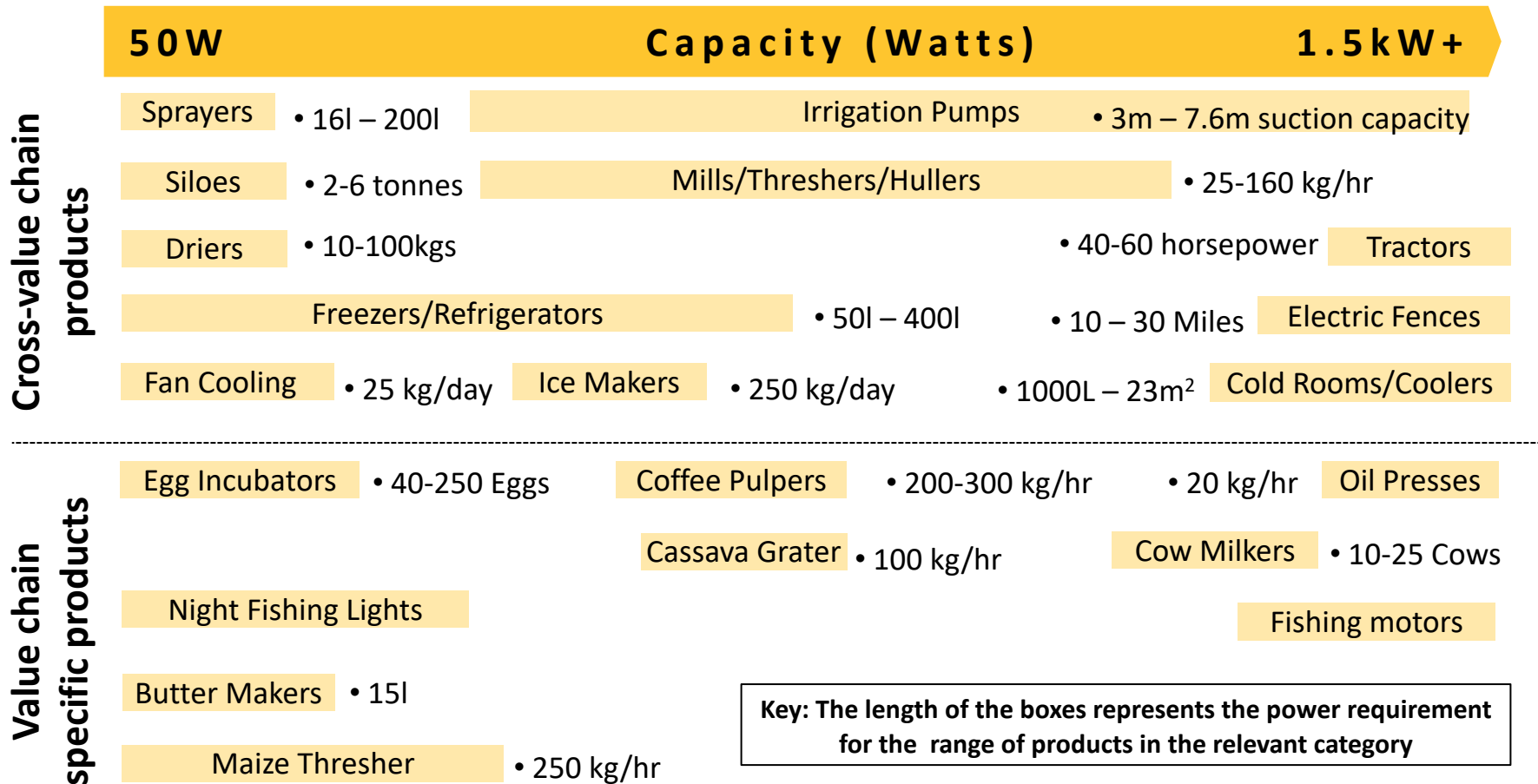
- 1 Agriculture is the **single most dominant sector in rural economies**, where majority of off-grid population are living
- 2 **Agricultural transformation** is high on government and donor agendas with a focus on value addition, agro-processing, mechanization, reducing post-harvest losses
- 3 PULSE in agriculture is **an important growth segment for off-grid solar providers** to expand market and deepen customer relationships
- 4 Agriculture has a **unique set of impact mechanisms**, creating multiplier effect on incomes, consumer spending, and growth in the real economy



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# PULSE appliances for agriculture are diverse: within each category, there is a range of technologies and associated capacities (1/2)



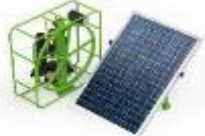
Source: GIZ, Photovoltaics for productive use Applications, 2016; World Bank, double dividend, 2017. The Fish Site, Photovoltaic applications in aquaculture: A Primer, 2014; Engineering for Change, A solar thermal aerator prototype could improve aquaculture in developing countries, 2017; Vikaspedia, Solar drying systems, 2017; Navgathi, Solar fishing boats, 2017

# PULSE appliances for agriculture are diverse: within each category, there is a range of technologies and associated capacities (2/2)

## Irrigation Pumps

### Surface water pumps

- Wattage: 75w – 1.5kW
- Head: 6-75m



### Submersible pumps

- Wattage: 0.45-2
- Head: 4-310m



## Cooling/Drying

### Chilling systems

- Wattage: 40-200W
- Capacity: Up to 45l of milk/day



### Refrigeration

- Wattage: 40-400W
- Capacity: 50-400l



### Freezing/ice making

- Wattage: 95W
- Capacity: 1.2kg/day



### Walk-in cooling units

- Wattage: 2kW+
- Capacity: 9 tonnes+



### Fan cooling

- Wattage: <50W
- Capacity: 25-100kg



## Agro-processing

### Flour Milling

- Wattage: 500-750W
- Capacity: 25 -160kg/hr



### Husking/Threshing/Hulling

- Wattage: 100-375W
- Rice Capacity: 35 -70kg/hr
- Maize Capacity: 250kg/hr



### Grating

- Wattage: 250W
- Capacity: 100kg/hr



### Oil & nut presses

- Wattage: 1.5kW
- Capacity: 20kg/h



# Despite growing activity and interest, few PULSE technologies at different capacities are ready for commercial scale in SSA

	Irrigation pumps	Cooling & refrigeration	Agro-processing
Large	> 5 Ha	> 10,000 L	> 10 MT/day
	<i>While technologies exist there are limited large scale applications in practice</i>	<i>Typically applied as walk-in cooling, technologies are available at an aggregated scale, but uptake remains low</i>	<i>The main examples that exist are mini-grid applications as like-for-like replacement of grid processing</i>
Medium	2 – 5 Ha	2000 – 10000 L	2 – 10 MT/day
	<i>The majority of supplier distributors are targeting this scale and uptake is reasonable depending on the geography</i>	<i>Fewer technologies in this category as providers are either looking at large aggregated systems or smaller individual systems</i>	<i>The main examples that exist are mini-grid applications as like-for-like replacement of grid processing</i>
Small	< 2Ha	200 – 2000 L	1 – 2 MT/day
	<i>Technologies are well developed and available but affordability and market development are barriers</i>	<i>Productive uses typical adapt refrigeration intended for small retail enterprise use, uptake is low</i>	<i>Incumbent technologies exist but the system size is prohibitive for standalone applications</i>
Very Small	< 1 Ha	< 200 L	< 1 MT/day
	<i>Recent product development has increased affordability, precedents are emerging in some markets and are starting to scale</i>	<i>Productive uses typical adapt refrigeration intended for household use and uptake is low</i>	<i>There are limited standalone technology choices and use cases are unproven</i>

Commercial readiness:

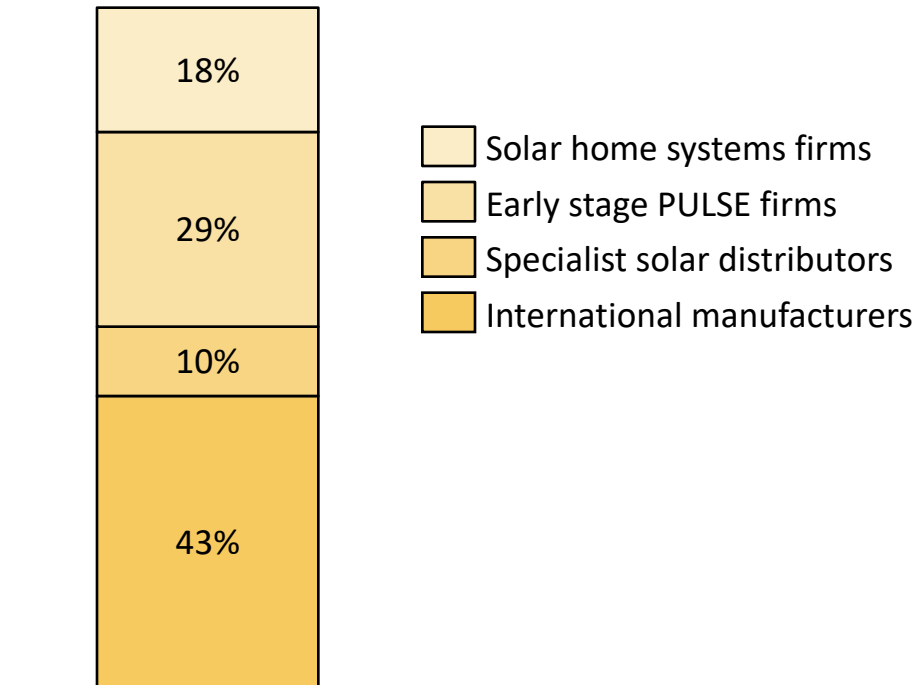
 High

 Mid

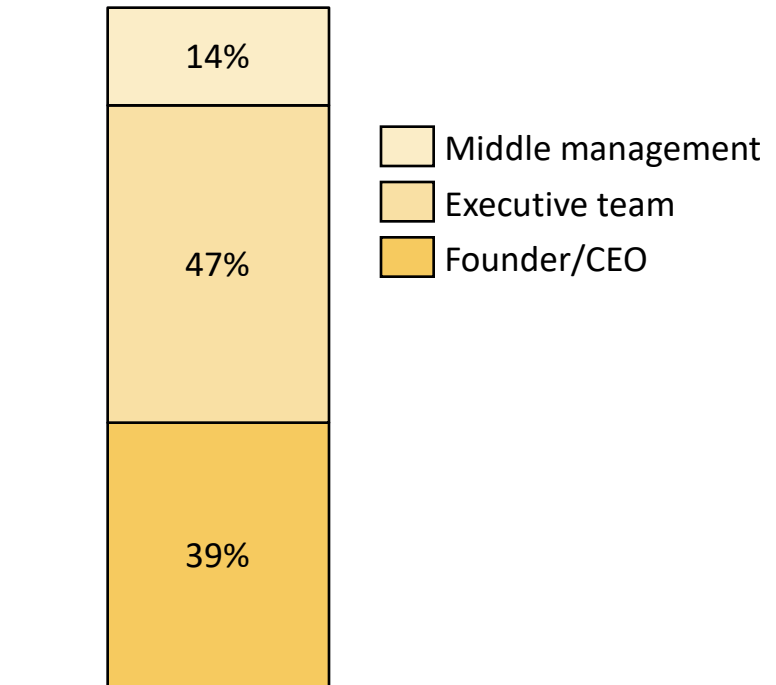
 Low

# We conducted a short survey of suppliers of productive use appliances

**Participant mix by company type (%)**, respondents = 49



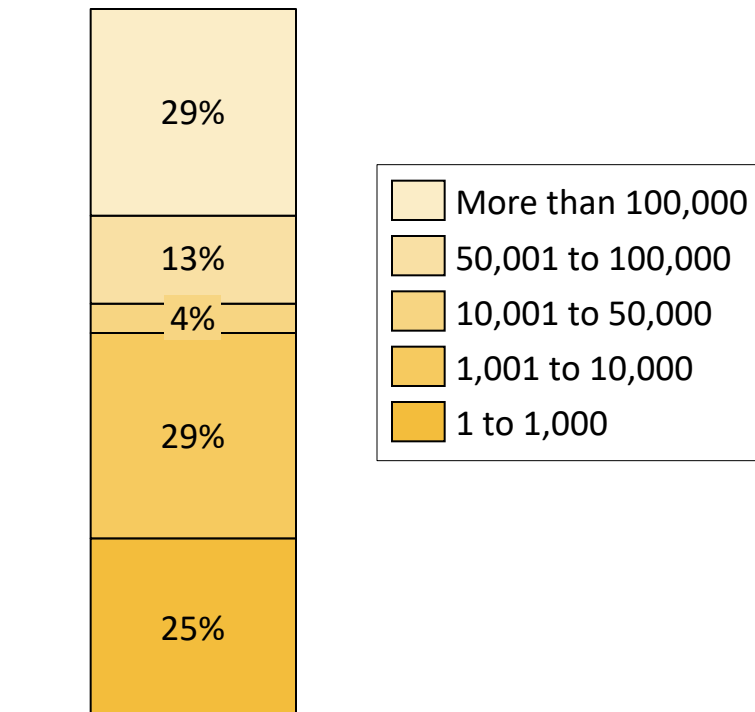
**Participant mix by respondent role within company (%)**, respondents = 49



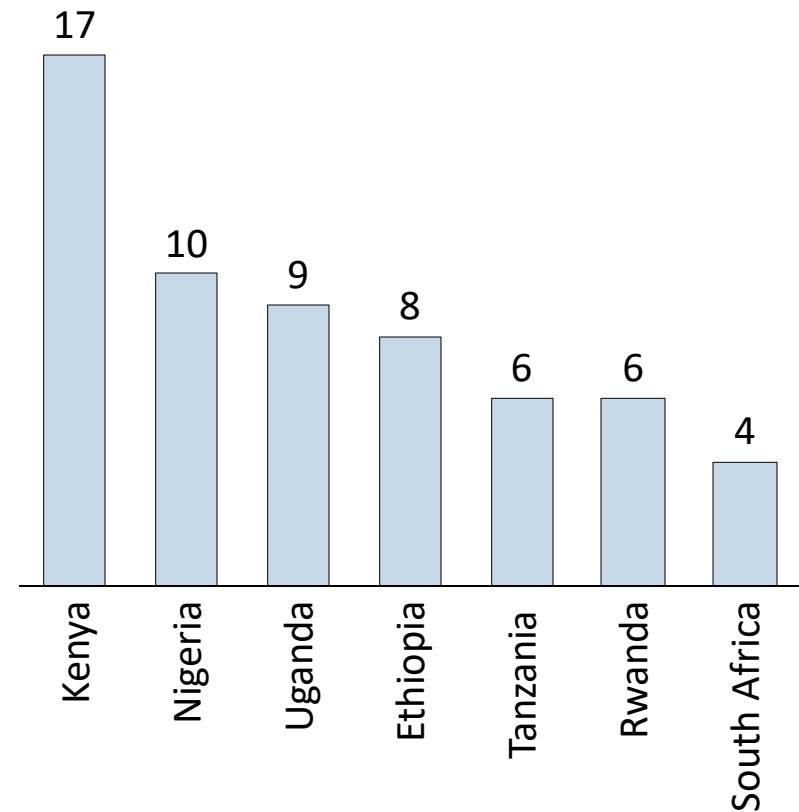
Source: IFC/Dalberg PULSE Survey 2018; Dalberg analysis

# Most firms have to date sold less than 10,000 PULSE units; Kenya, Nigeria, Uganda, and Ethiopia comprise highest share in African markets

**Company size by units sold**  
(%), respondents = 49



**African countries in firms' top 5 for sales**  
Number of firms, respondents = 49

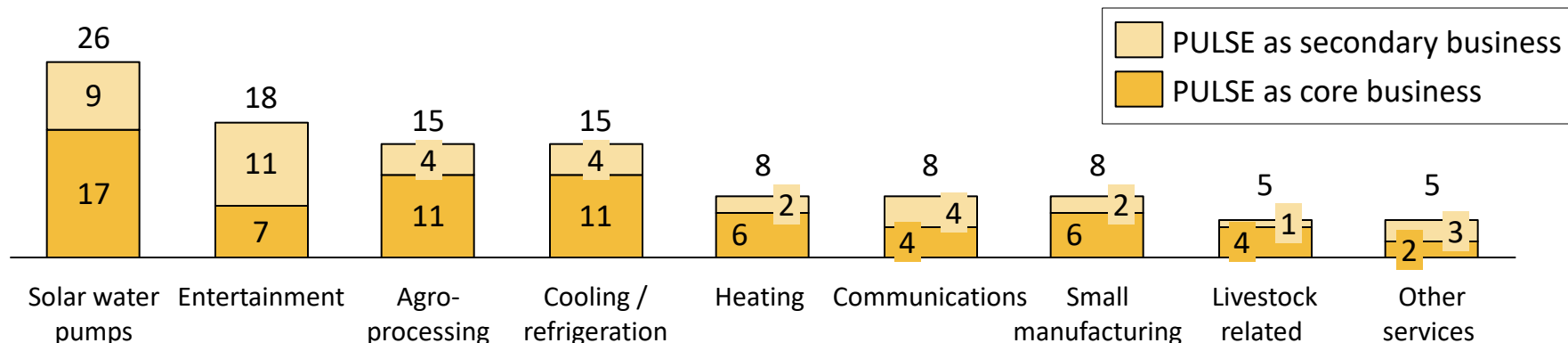


Source: IFC/Dalberg PULSE Survey 2018; Dalberg analysis

# As of today, PULSE suppliers are most focused on irrigation; in the future, PULSE suppliers are looking at processing and cooling

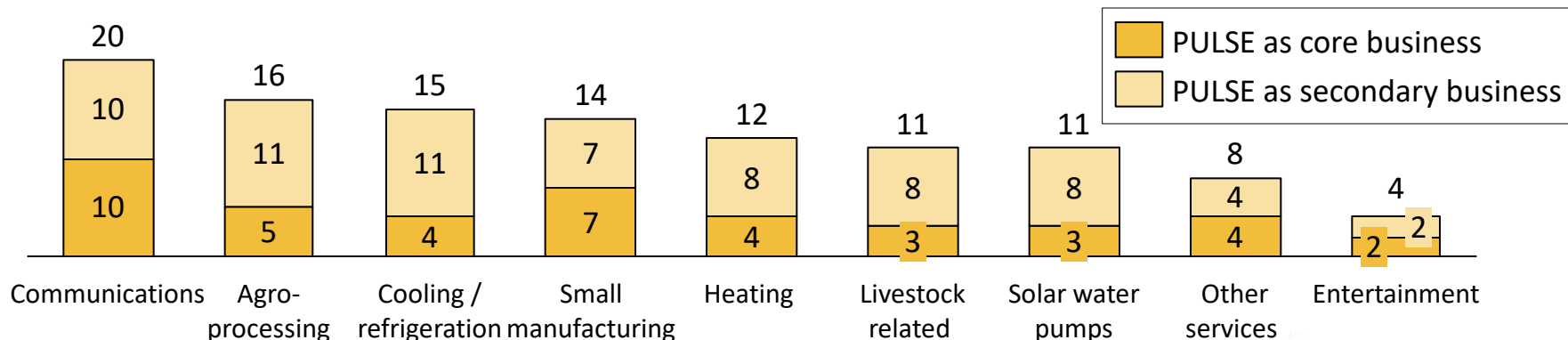
## Current PULSE products in portfolio

Number of firms, respondents = 49



## Planned PULSE products in portfolio

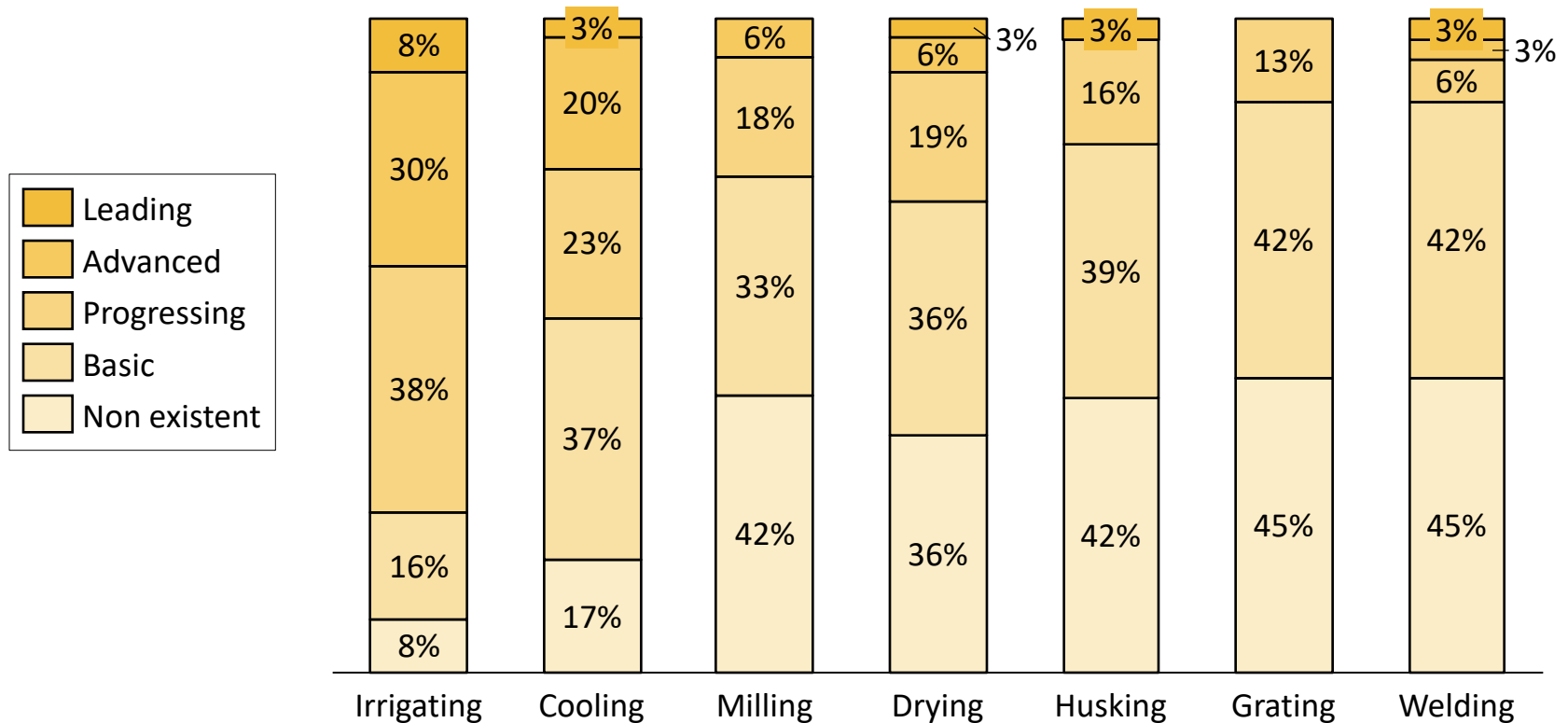
Number of firms, respondents = 49



# Solar irrigation solutions are perceived to be quite mature; agro-processing technology is perceived as very nascent across the board

Level of market / technology maturity for solar-powered solutions for agricultural uses

%, respondents = 49



Source: IFC/Dalberg PULSE Survey 2018; Dalberg analysis



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- III **Business case for farmers**
- IV Challenges & opportunities

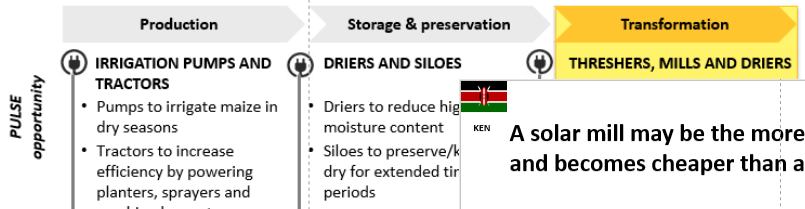
# The study looked at the business case for farmers with a value chain and product-based approach to assess commercial viability

Country	PULSE use case	Value chain	Product	Incumbent break-even	Two-year ROI	Payback period
Kenya	Irrigation	Horticulture	Solar water pumps	Year 1	204% <sup>1</sup>	< 1 Year
	Agro-processing	Maize	Flour mill	Year 2	15%	21 months <sup>2</sup>
	Cooling/refrigeration	Dairy	Milk chillers	n/a	11%	22 months
Zimbabwe	Irrigation	Horticulture	Solar water pumps	Year 1	140%	< 1 Year
	Cooling/refrigeration	Dairy	Milk chillers	n/a	30%	19 months
	Agro-processing	Maize	Threshers	Year 2	29%	14 months <sup>1</sup>
Côte d'Ivoire	Agro-processing	Cassava	Grater	Year 3	-34%	37 months
	Agro-processing	Rice	Huller	Year 5	16%	21 months
	Cooling/refrigeration	Fisheries	Refrigeration	Year 4	101%	12 months

Key	Viability	Break even versus incumbent	Two-year ROI	Typical payback
	High	< Year 1	>100%	< 1 Year
	Medium	Year 1 - Year 2	<50%	< 2 Years
	Low	> Year 2	<0%	> 2 Years

# Use case identification and analysis exhibits

**PULSE products could boost yields, reduce losses, and provide alternative small-scale processing options in the maize sector**



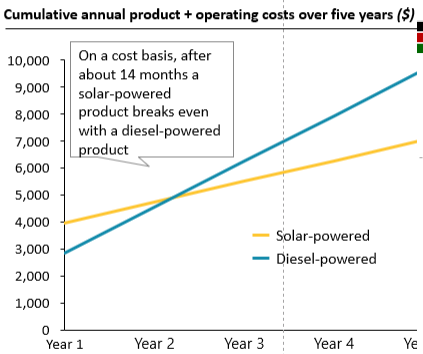
**PULSE opportunity**

**Power capacity of sample products**

- 0.45 - 22kW
- 30 - 45kW
- 100-200W

*\*solar-powered trucks are in testing, with benefits including powering air conditioning, refrigeration operations, and less in providing fuel savings. Source: Dalberg analysis & interviews, 2018; GIZ, Photo productive use applications, 2016*

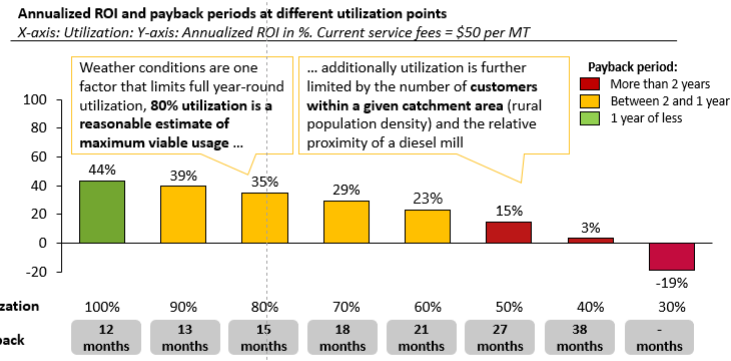
**A solar mill may be the more attractive option for remote customers, and becomes cheaper than a diesel mill after two years**



- Key assumptions**
- Product costs: \$ 3,250 (solar), 1,350 (diesel), with financing of 18% per year over 2Y, and after 20% is
  - Revenue/MT: \$50 (market price for milling services in Kenya)
  - Annual operating days: 292 for solar, 365 for diesel i.e. both the solar and diesel mill operate for 6h/d only operates at 40% effectiveness for 1k of the year (translating to 292 6h days or annual utilization of 80%)
  - Quantity milled: 88MT per year i.e. annual capacity of a solar mill based on 80% utilization (80% of ar

**The economics of solar vs. diesel**

**But seasonal capacity and customer catchment will limit utilization, should 60% (66MT) be achieved a solar mill can payback in 2 years**



**Higher service fees higher than \$50/MT might be paid due to added convenience of nearby mills; however the target population is extremely price sensitive**

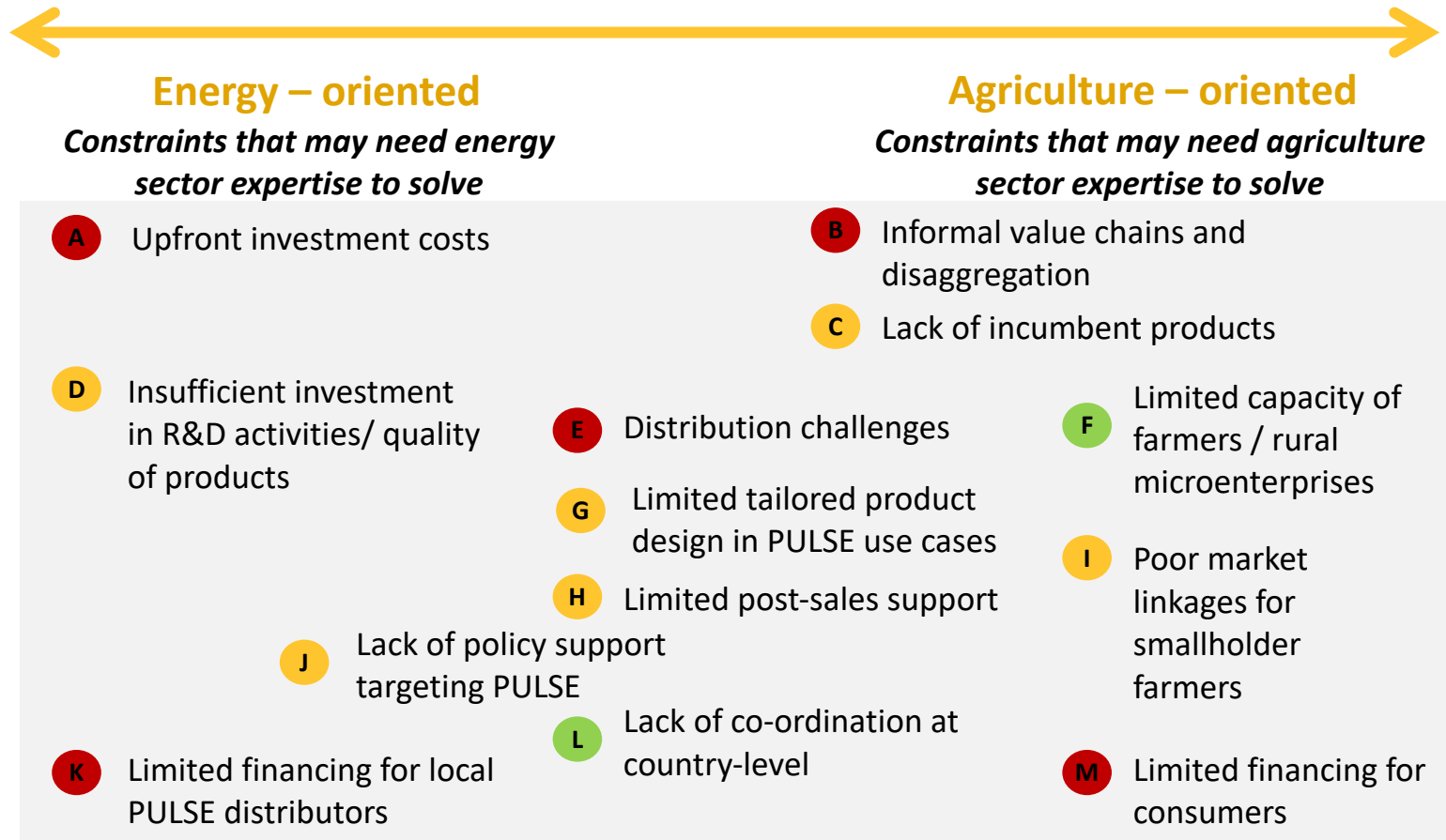
Note: 1. Milling is offered as a service. Households pay per kg for the crops milled. Analysis assumes financing costs of 18% per year. Annualized ROI based on a 5 year product life.  
Source: Dalberg analysis & interviews, 2018

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# There are diverse constraints to scaling PULSE, which will need a range of energy and agricultural interventions to unlock

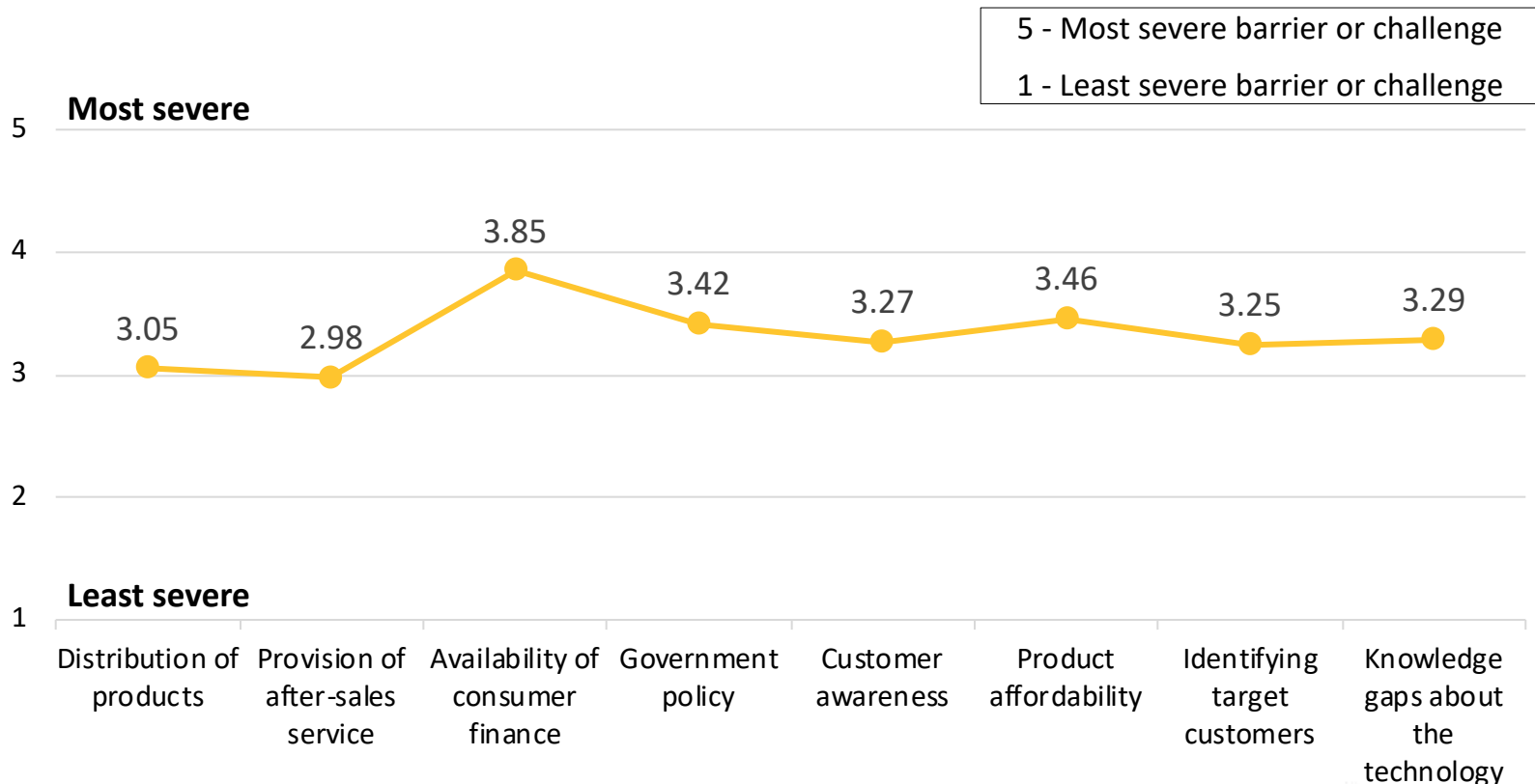


Severity of constraint: ■ High ■ Medium ■ Low

# Suppliers see financing and affordability as the biggest challenges to PULSE market growth, followed by, policy and customer awareness

## Most significant barriers / challenges to PULSE market entry and growth

Average ranking of barrier / challenge (1 to 5), respondents = 49

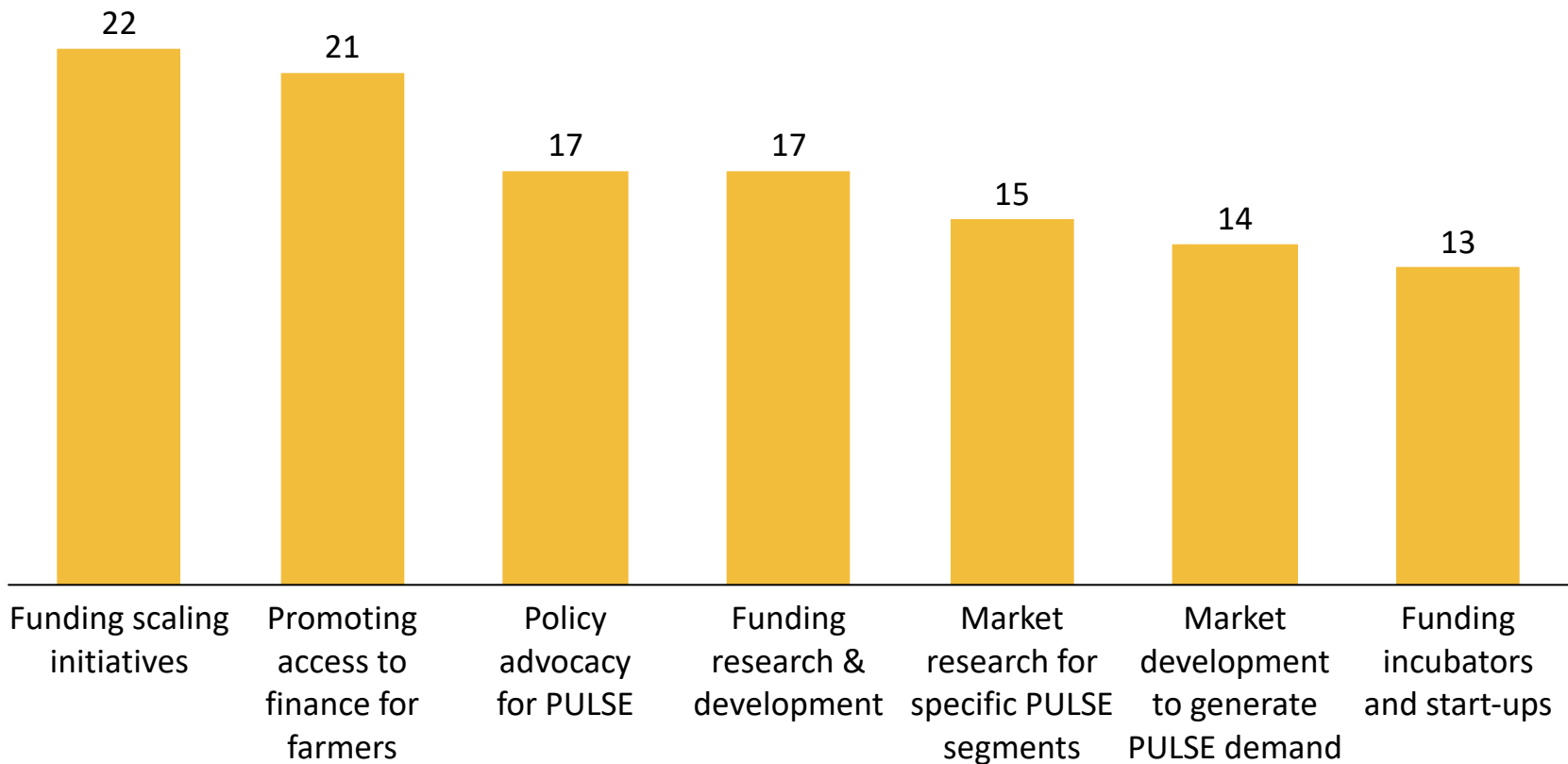


Source: IFC/Dalberg PULSE Survey 2018; Dalberg analysis

# PULSE suppliers seek funding to scale, advocate targeted policy change, and R&D to drive technology improvements

What areas of support should governments and multilateral organizations focus on?

Number, respondents = 49



Source: IFC/Dalberg PULSE Survey 2018; Dalberg analysis

# Development partners and policymakers have a major role to play in helping to build the market for PULSE products

- 1 **Better integrate PULSE into national policies**, notably in electrification and agricultural transformation strategies
- 2 Form **new partnerships across value chains**, building on existing capabilities of players involved in aggregation, rural finance, and adjacent product distribution
- 3 **Fund research & development** for more efficient DC appliances and product design tailored to specific use cases and markets
- 4 Structure concessional financing and patient capital, in particular for **consumer finance and working capital** for PULSE innovators and distributors
- 5 **Bring energy access and agricultural actors together** to continue to step out of any silos and develop fully integrated approaches