

**EFFICIENCY
FOR
ACCESS**



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Off-Grid Electrification & Impact Fundamentals



energy[®]
saving
trust



Our speakers



Garick Lee

- Senior Energy Access Consultant for Energy Saving Trust & Technology Consultant for GOGLA
- 12 years working on energy access in developing countries and renewable energy
- MSc in Renewable Energy, BE, BCom
- Australian based in Vientiane, Laos

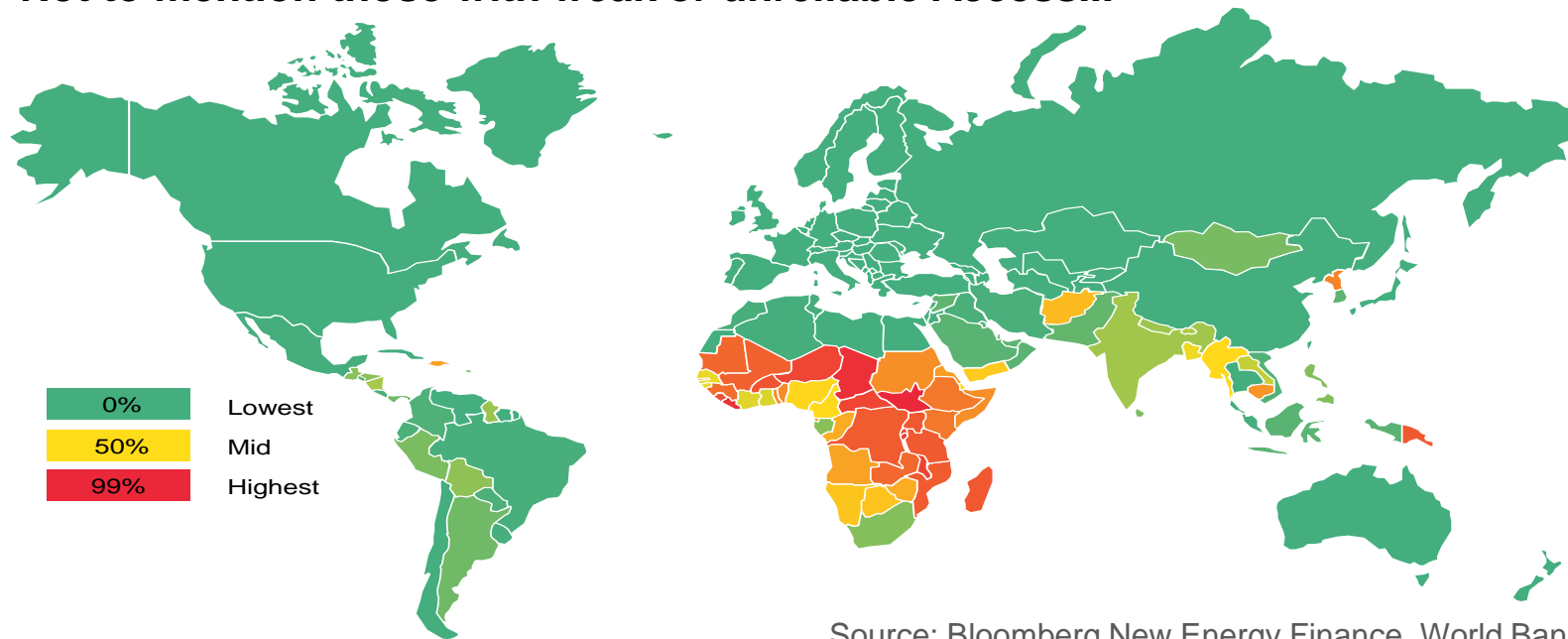


Leo Blyth

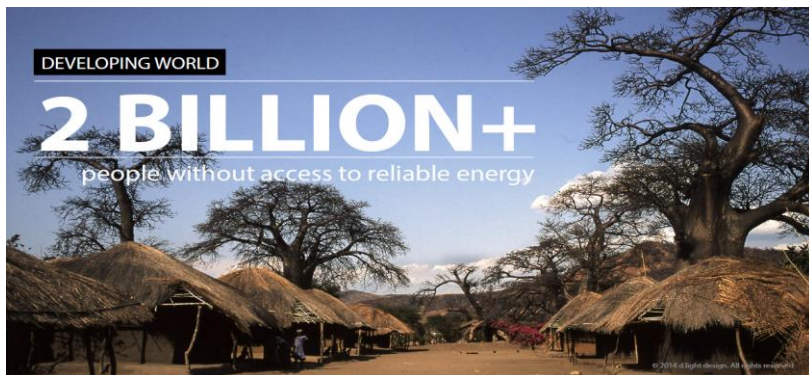
- Off-Grid Energy Access Consultant, supporting LEIA & EforA / EST & Lighting Global / the World Bank Group
- 20+ years living/working in Africa as off-grid solar product designer, social entrepreneur, technical & strategic advisor
- BSc with honors in Third World Development Studies
- British born, living in Washington DC, US

The crippling injustice: 25% of the global population lives in energy poverty

Share of population without grid access (% of total)
Not to mention those with weak or unreliable Access...



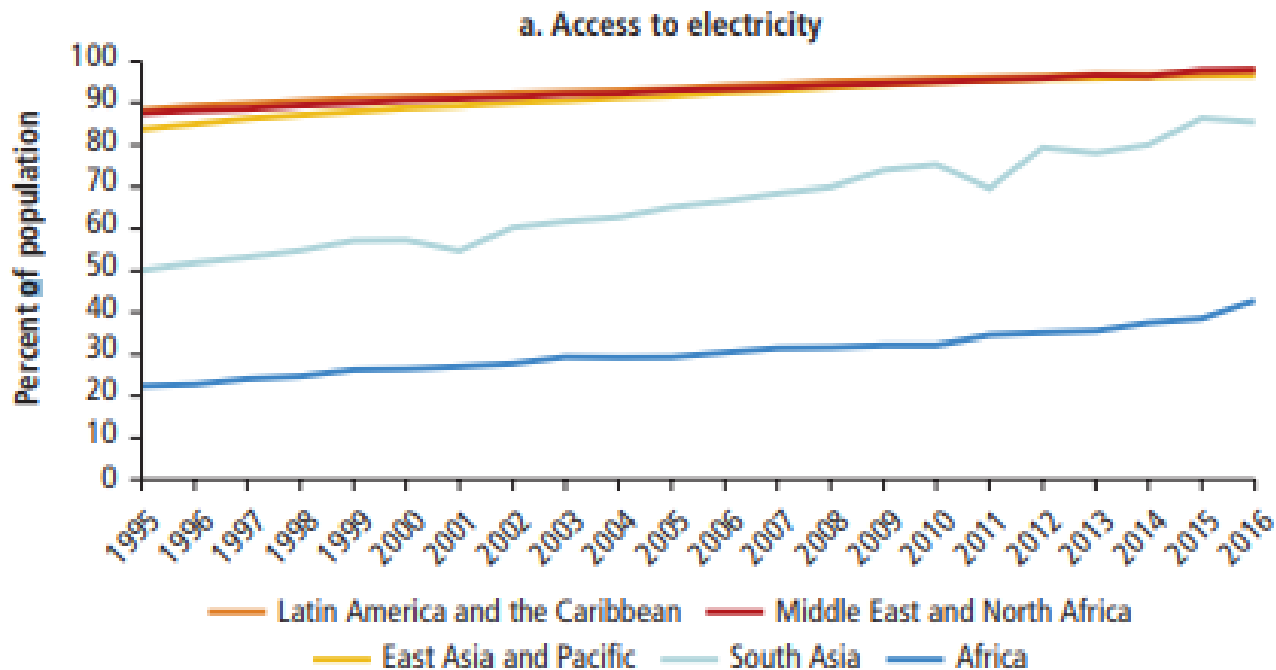
Source: Bloomberg New Energy Finance, World Bank



Energy Access - Sub Saharan Africa, the greatest challenge

- Sustainable Development Goal 7: “By 2030, ensure access to affordable, reliable, sustainable and modern energy for all.”
- In 2016 only around 40% of the population in Africa had **”access”** to electricity, far less than any other developing region.
- Around 80% of the population in South Asia had access to electricity.

Figure 1.1 Access to Electricity



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Technology & Innovation

Developing 'the right products/processes'
Accelerating Off-Grid Electricity access within homes & business

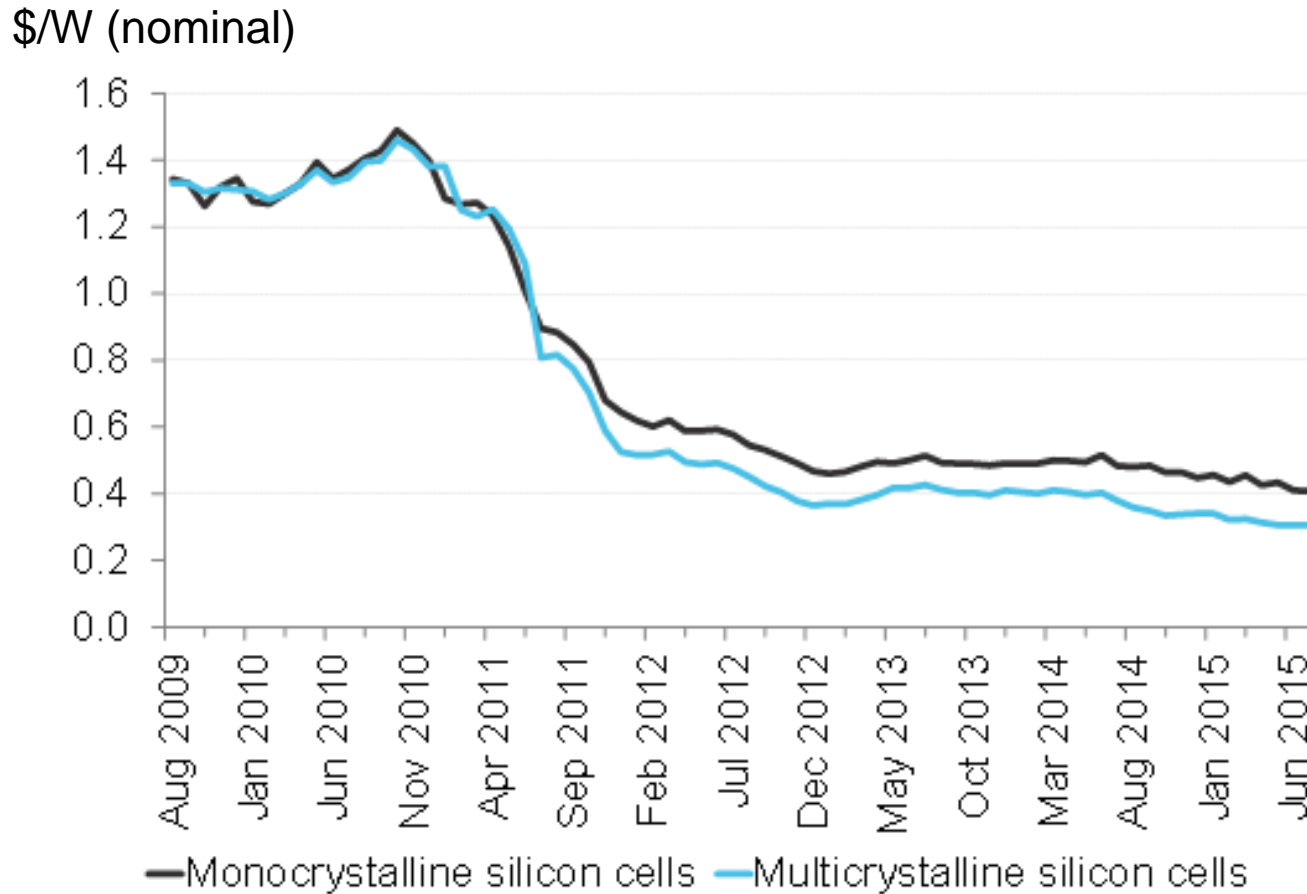


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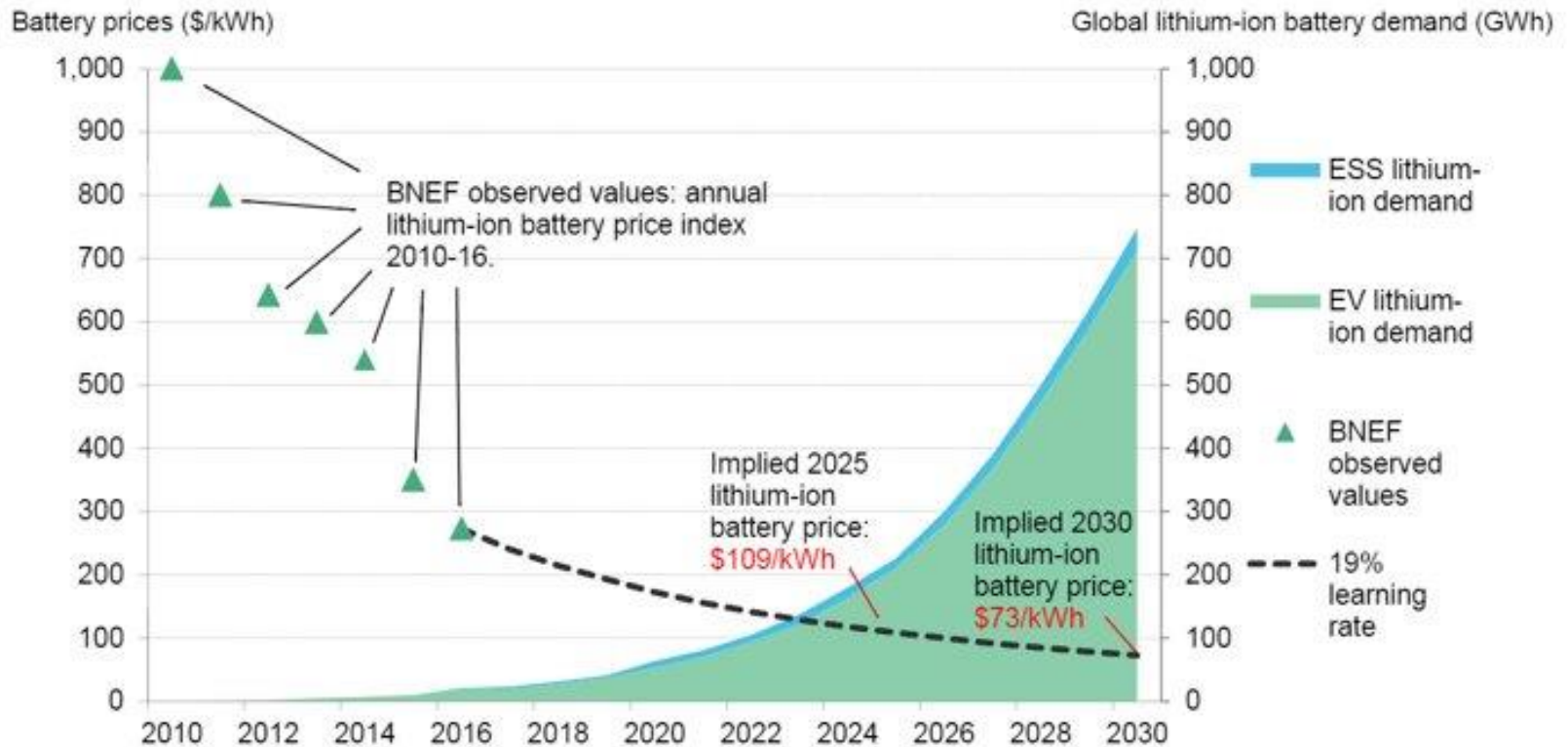
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Price of crystalline silicon cells, 2010 - 2015



Source: Bloomberg New Energy Finance
Solar Spot Survey

BNEF's Lithium-ion battery price forecast, 2010-30



Source: Bloomberg New Energy Finance

Enter the Dragon... Plug & Play Solar Home System Kits

A SHS electricity connection in a box



M-KOPA 600 package

- 24" Flat Screen Digital TV
- 30W Solar Panel
- 2 x Solar Lights with high and low setting
- Solar Rechargeable LED Torch
- Solar Rechargeable Radio
- ~\$60 deposit, \$30/month
- Total \$650 (\$550 to buy outright)

From Off/On to a continuum of Electricity Access

In the same way Mobile Phones offer leap-frogging Vs landlines...

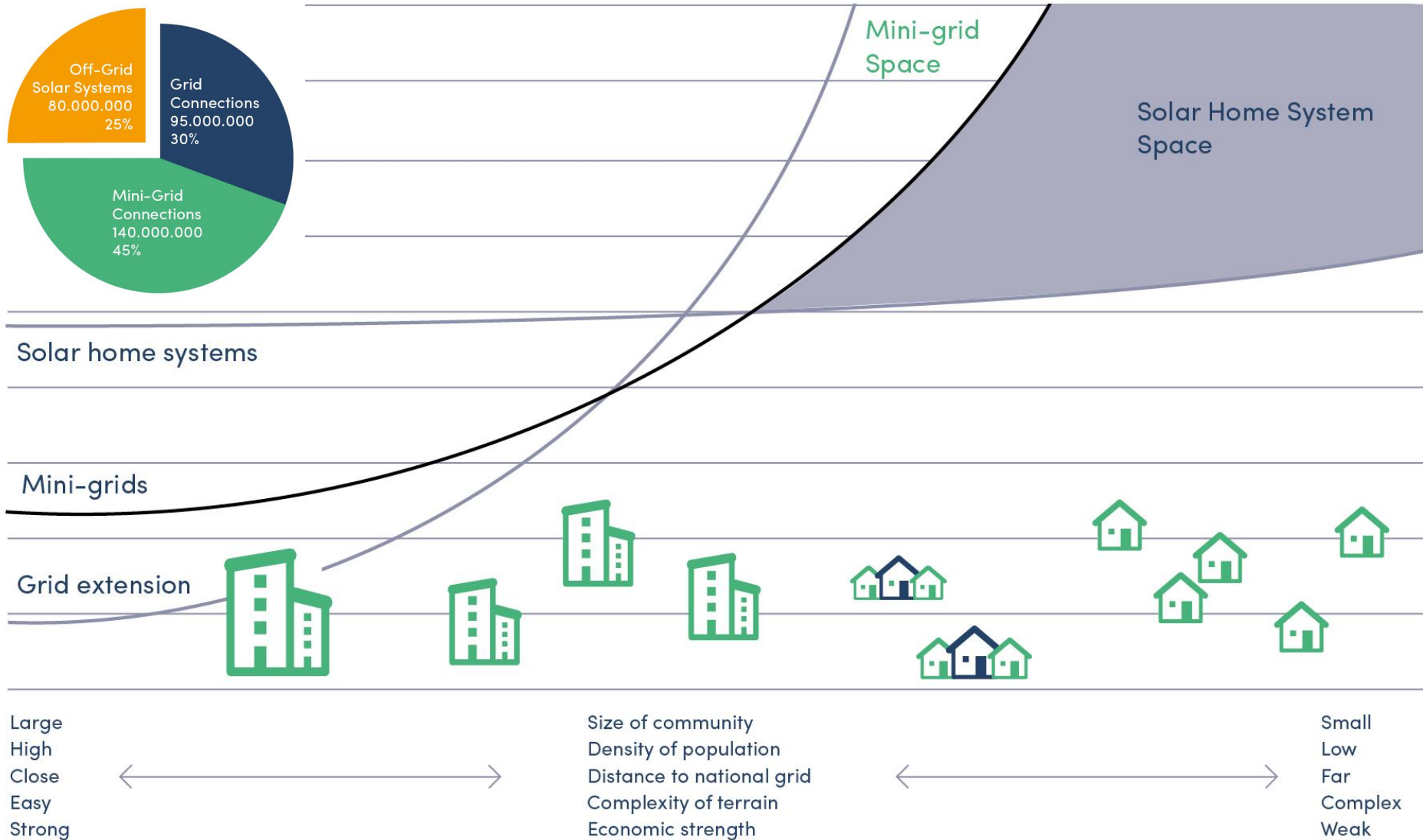
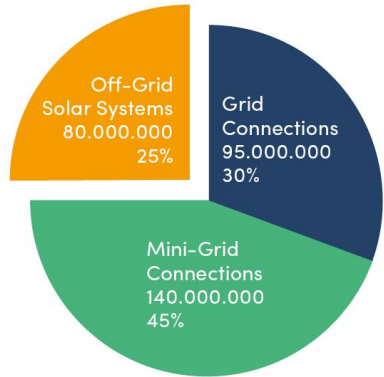
Off-Grid Solar Enables the unelectrified
To Climb an "Energy Access Ladder" or "Energy Stacking"

	Pico-powered Lighting Sys.	Solar Home System	Micro / Mini-Grid	Regional Grid
Scale (~Watts)	1 – 10	10 – 100's	100's – 1000's	$10^6 - 10^{11}$
Topology	DC Only	DC – some AC	Mostly AC	Nearly all AC
Loads				
SE4ALL Tiers	1	2 to 3	1 to 5	4 to 5
	US\$ 10-120	US\$ 140-1000	Highly variable	Highly variable

Reference: [Beyond Connections: Energy Access Redefined](#) & see Annex for overview

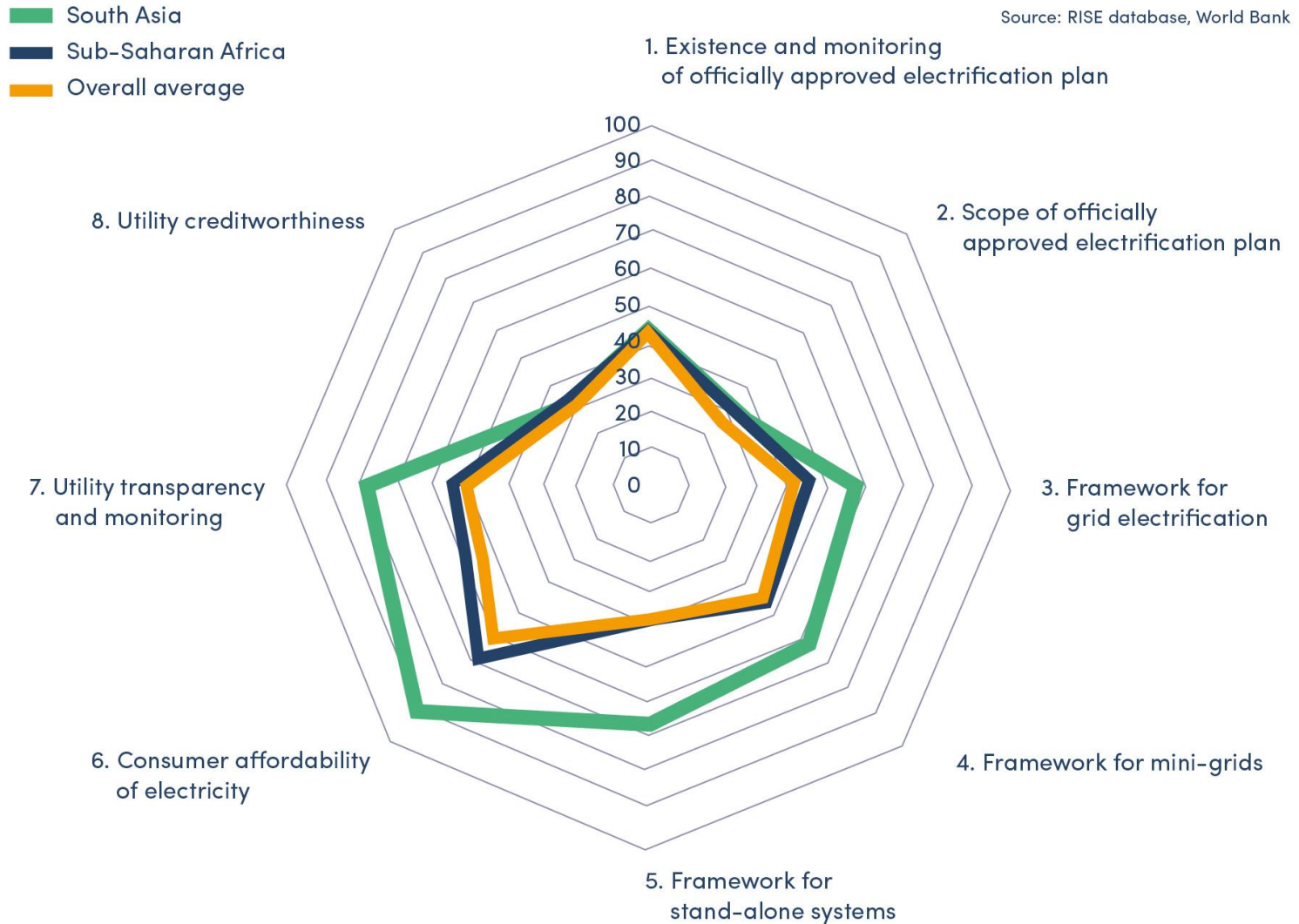
Off-Grid Solar is the Most Cost-Effective Solution for a Significant Proportion of People lacking Access

Unsubsidised electricity retail cost on site (euro/kWh)



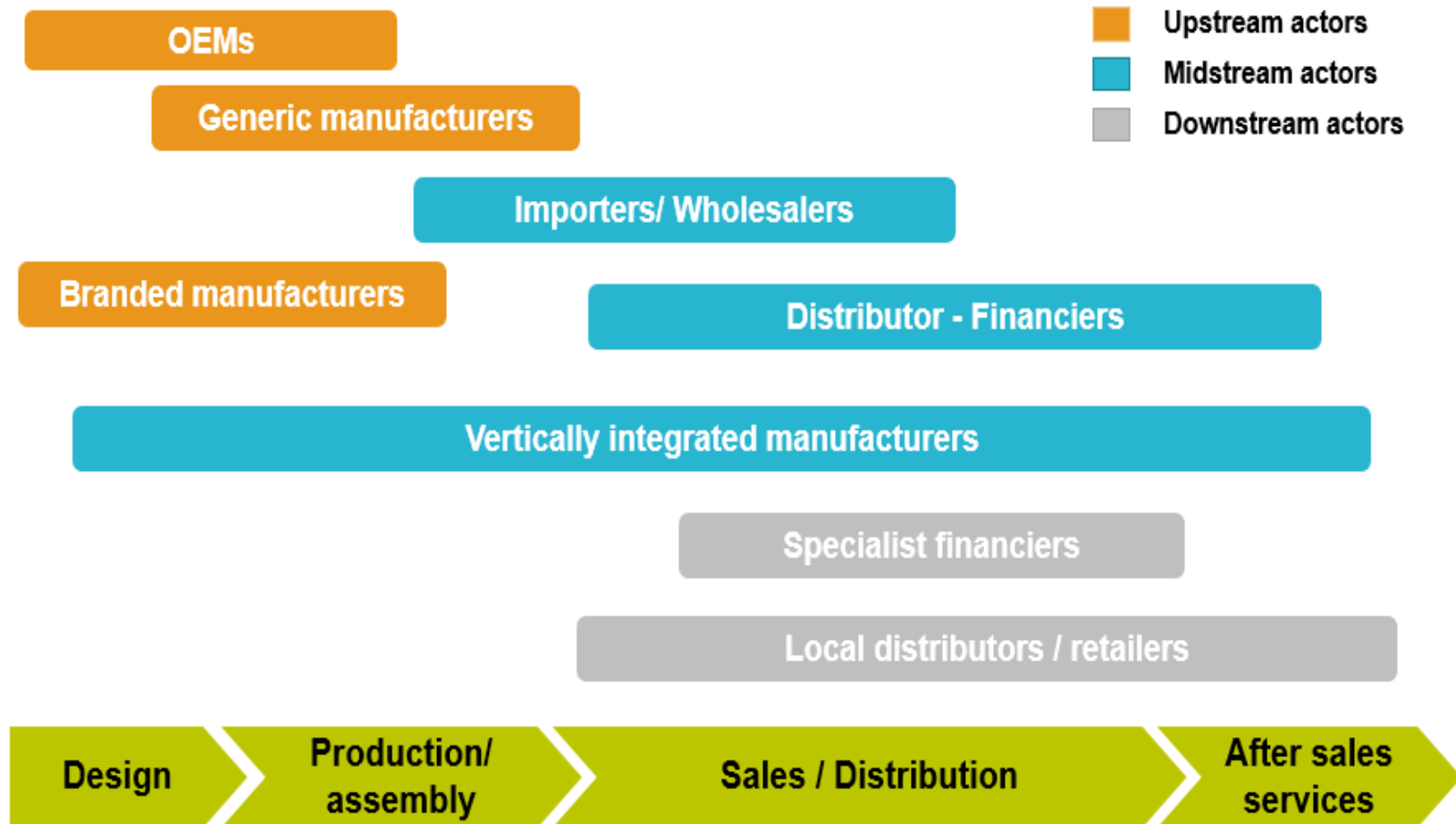
However, everyone has to work with the current Enabling Environment, or lack thereof....

Figure 9: Average indicator scores on energy access – Source: RISE Database, World Bank, 2016



Off-Grid Appliance Supply Chain Actors / ecosystem

It takes a Village to Raise One Child (or to bring one product to market...)





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The Importance of Efficient and Affordable Appliances



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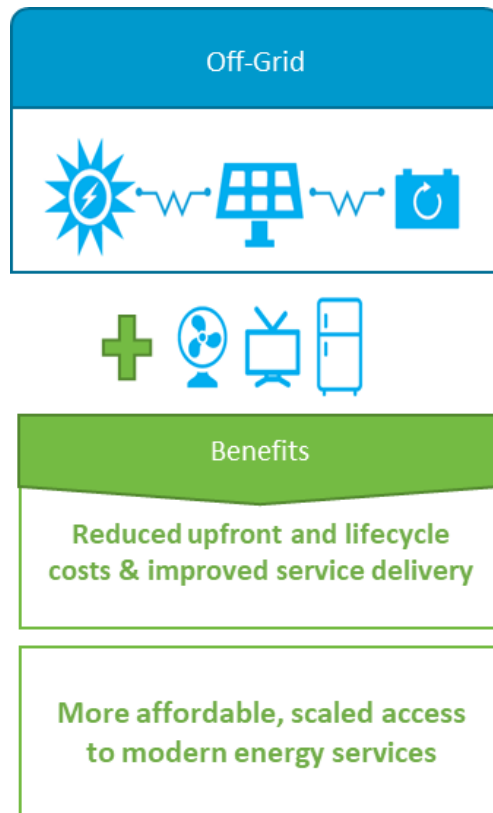
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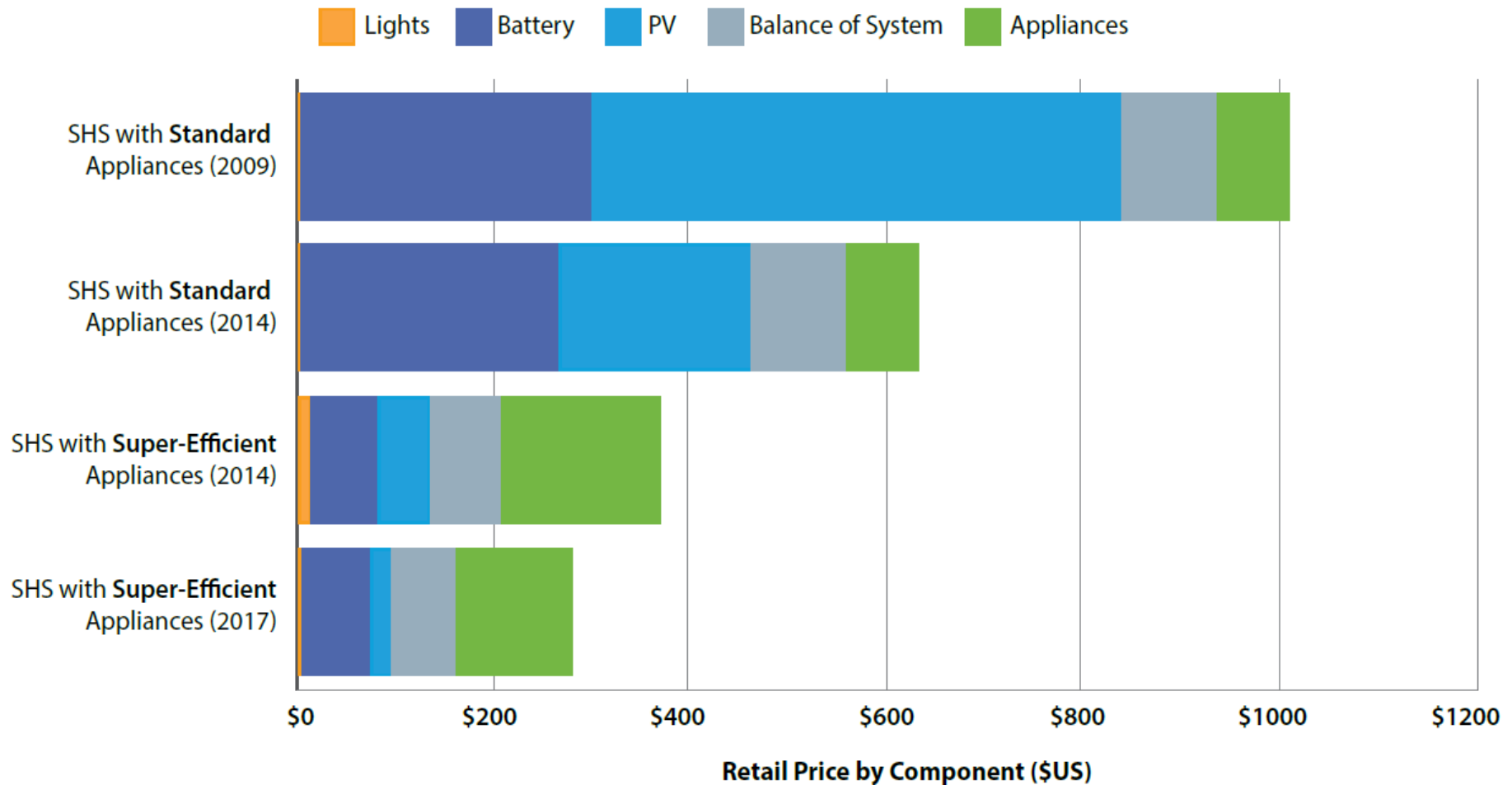


Theory of change

Appropriately-designed and highly energy-efficient appliances fundamentally improve the economics of energy access, maximising the value of every available watt and putting modern energy services within reach of millions worldwide.



Efficient Appliances Drive Cost & Performance Benefits for Off-Grid Energy Systems



Source: Phadke et al., 2015.

Poll #1

*A solar home system has a conventional refrigerator combined with a set of efficient appliances (a TV, fan, radio, 4 LED lights and a phone charger). The whole system requires a **700 Wp solar panel** and a **300 Ah battery** to run.*



*If we only change the refrigerator to an **appropriately designed, super-efficient refrigerator** what can we reduce the size of the solar panel and battery to, while maintaining the same level of energy service?*

Poll #1

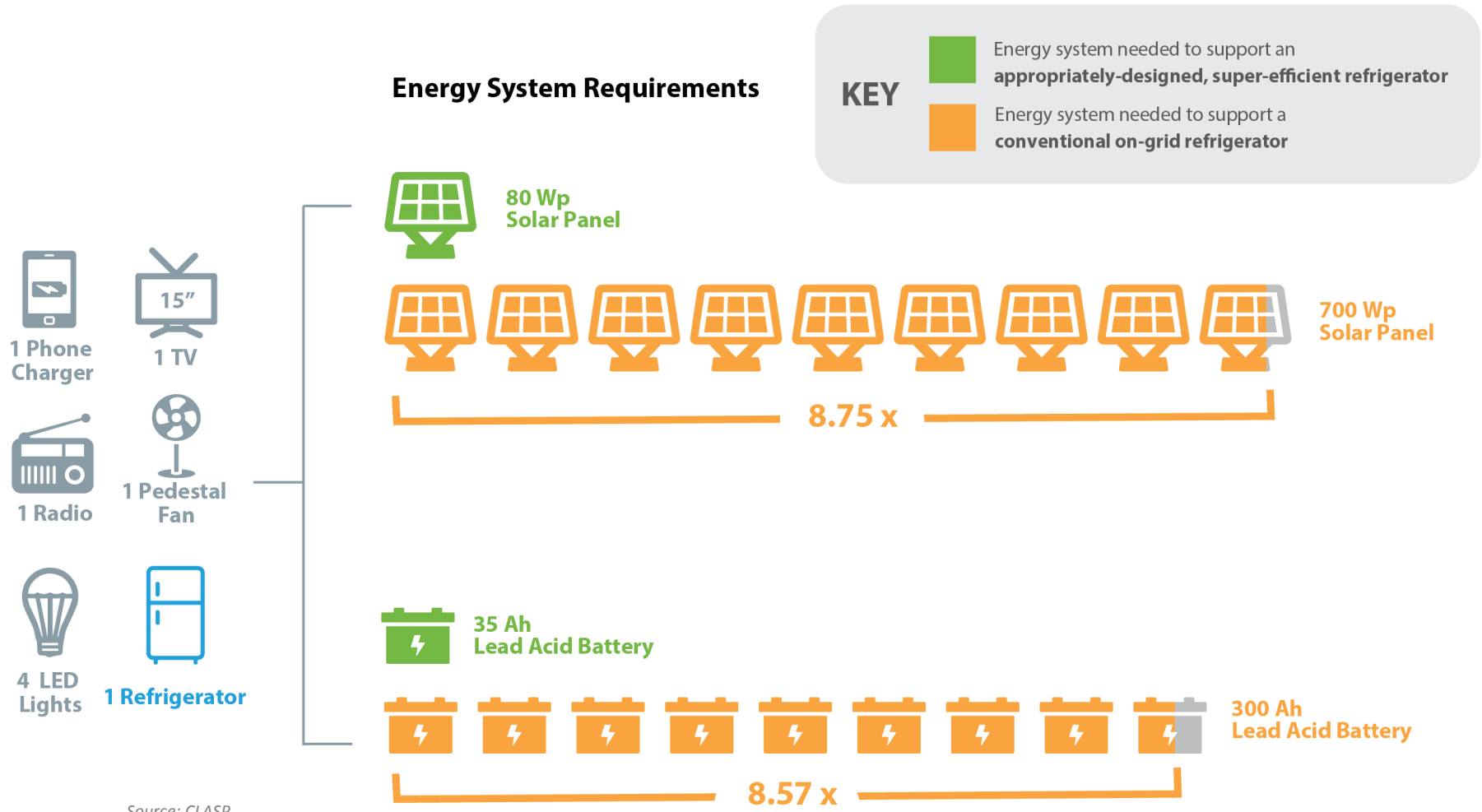
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*If we only change the refrigerator to an **appropriately designed, super-efficient refrigerator** what can we reduce the size of the solar panel and battery to, while maintaining the same level of energy service?*

ANSWER: A 80Wp panel with 35Ah battery

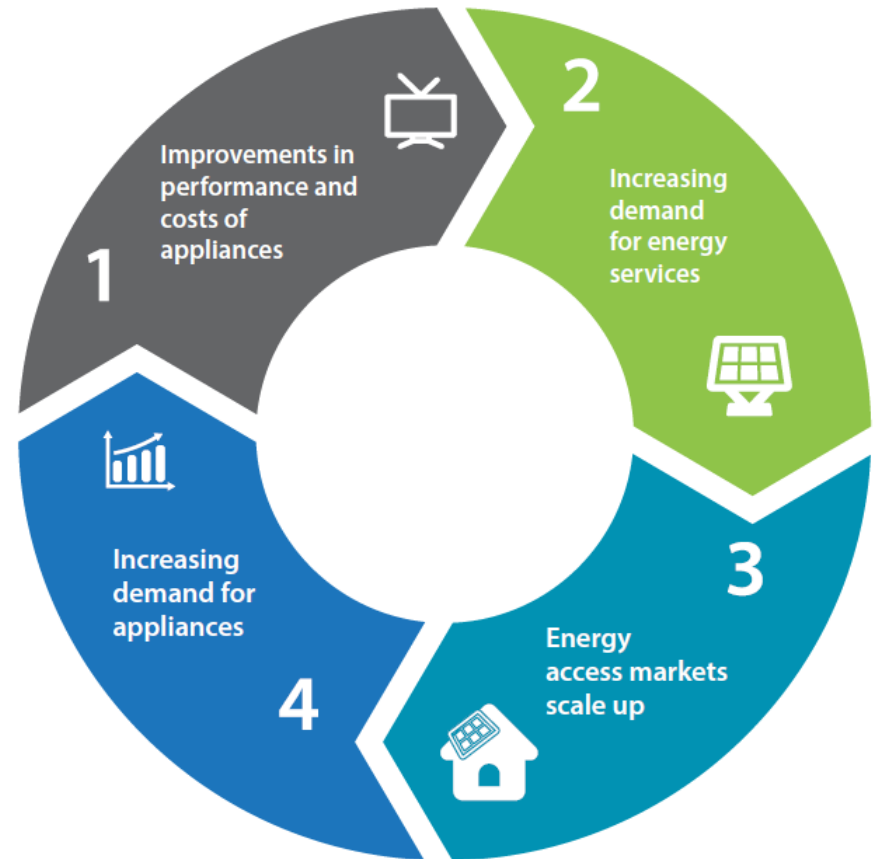
Appliance Efficiency Unlocks Greater Energy Access Outcomes



Source: CLASP

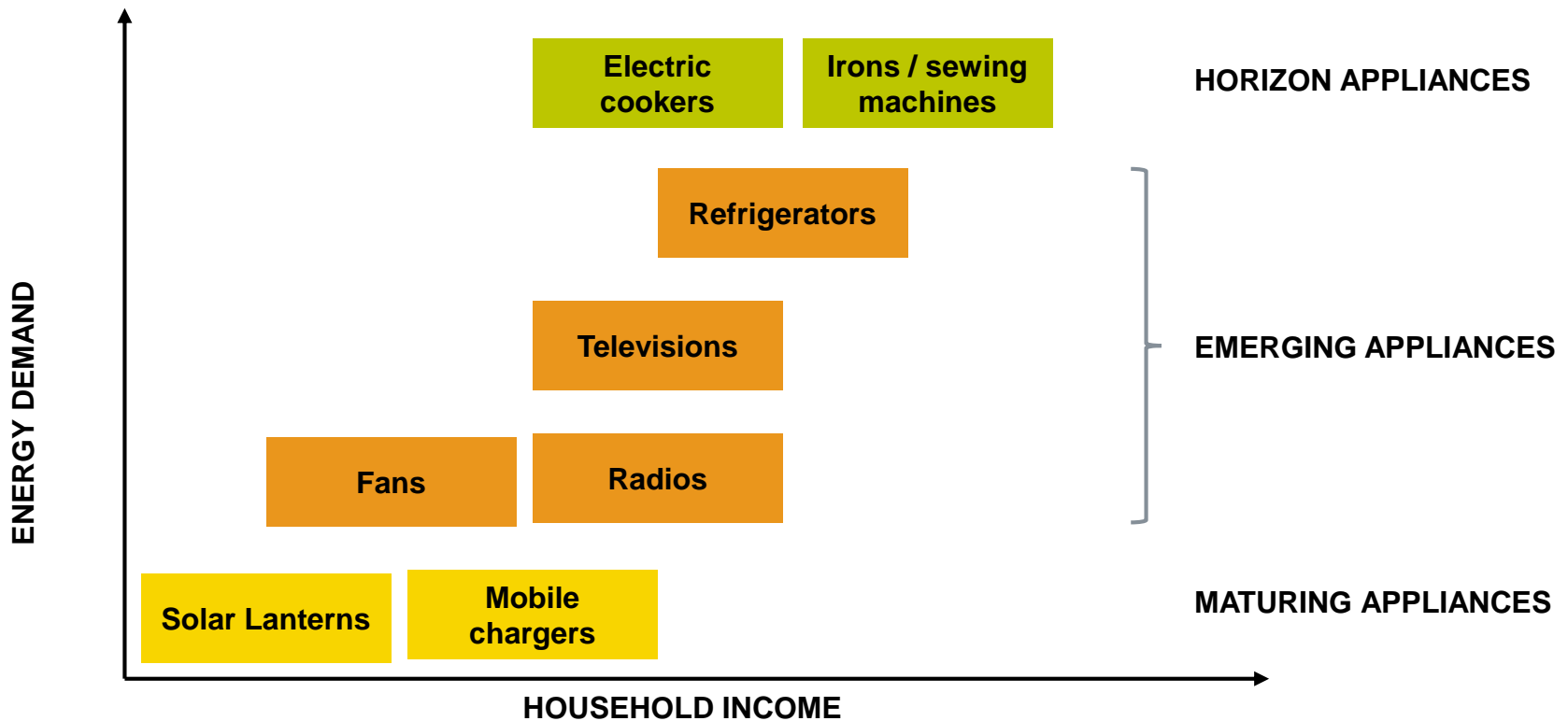
Efficient appliances create a virtuous cycle

- Create, sustain, and fulfill demand for energy
- Put modern energy services within reach of millions of under-served people
- Provide growth opportunities for entrepreneurs and energy service companies



There is a portfolio of appliances both on the market and at the horizon of innovation

ENERGY STACK OF OFF-GRID APPROPRIATE HOUSEHOLD APPLIANCES FOR BOP CUSTOMERS



Poll #2

*The efficiency of conventional refrigerators can potentially be improved by 60%. What is the potential contribution of **brushless DC variable speed compressors** to this efficiency increase?*



Poll #2

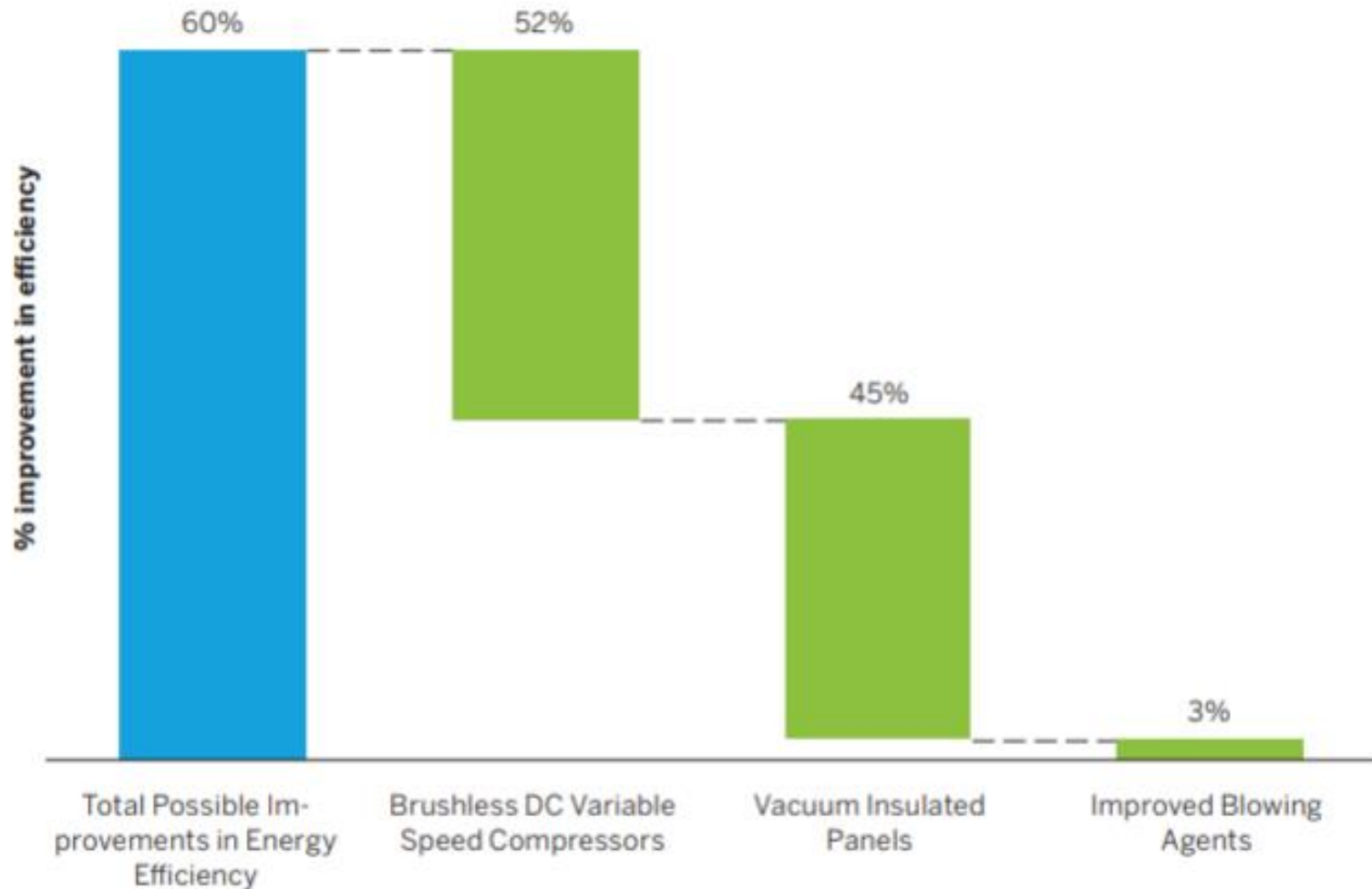
*The efficiency of conventional refrigerators can potentially be improved by 60%. What is the potential contribution of **brushless DC variable speed compressors** to this efficiency increase?*

Answer: 50%



Efficiency improvements: The case of refrigeration

FIGURE 10. ENERGY EFFICIENCY IMPROVEMENT OPTIONS FOR REFRIGERATORS^{1x}



Productive Use

Productive Use Leveraging Solar Energy (PULSE)

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

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

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

Irrigation Pumps

Surface water pumps

- Wattage: 75w – 1.5kW
- Head: 6-75m



Submersible pumps

- Wattage: 0.45-22kW
- 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





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The Impact of Access to Off-Grid Electricity and Energy Efficient Appliances



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By providing access to electricity services, appliances support a number of SDGs – especially for marginalized communities



How do Household Off-Grid Appliances Contribute to the UN Sustainable Development Goals?

- 

All off-grid appliances expose households to new, time- and energy-saving products, which they may use to improve their productivity and incomes.
- 

Refrigerators, electric cookstoves, and solar water pumps free up time for women in the home, allowing them to pursue an education and income-generating activities.
- 

Off-grid refrigerators preserve food and reduce waste. **Solar water pumps** improve irrigation and extend the growing season.
- 

Solar water pumps increase access to clean water and reduce the risk of water-borne disease and illness.
- 







Refrigerators reduce the risk of food contamination. **Fans** improve comfort in the home. **Electric cookstoves** reduce indoor air pollution.
- 

All off-grid appliances accelerate access to clean, affordable energy and allow households to climb higher on the energy ladder.
- 

Televisions and IT devices provide access to educational content and news.
- 

All off-grid appliances promote sustained, inclusive and sustainable economic growth and full and productive employment for all.

TECHNOLOGIES

-  Lighting
-  Electric Cookstoves
-  Computers
-  Fans
-  Solar Water Pumps
-  Hair Clippers
-  Televisions
-  Refrigerators
-  Internet of Things

Powering Opportunity: A series of ground-breaking reports Establish the life changing impacts of Solar lighting & Home Systems

10 KEY FINDINGS

1
58% of households undertake more economic activities thanks to their solar home system

2
36%
of households generate additional income once they purchase an SHS



3
Households create an additional **\$35 per month on average**
Among households generating income


4
44%
of customers can spend more time at work
As they have more light hours and time due their SHS



7
89%
of customers report they use their phone more since using their SHS



5
 11% of customers started a new business

6
In 7% of households, owning an SHS enabled someone to get a new job 

8
 91% of customers report they feel safer with off-grid solar

9
91% report their health has improved since buying the SHS
Among households that used kerosene 

10
84% of customers say children have more time to their homework

Solar Water Pumps - Impacts in Use

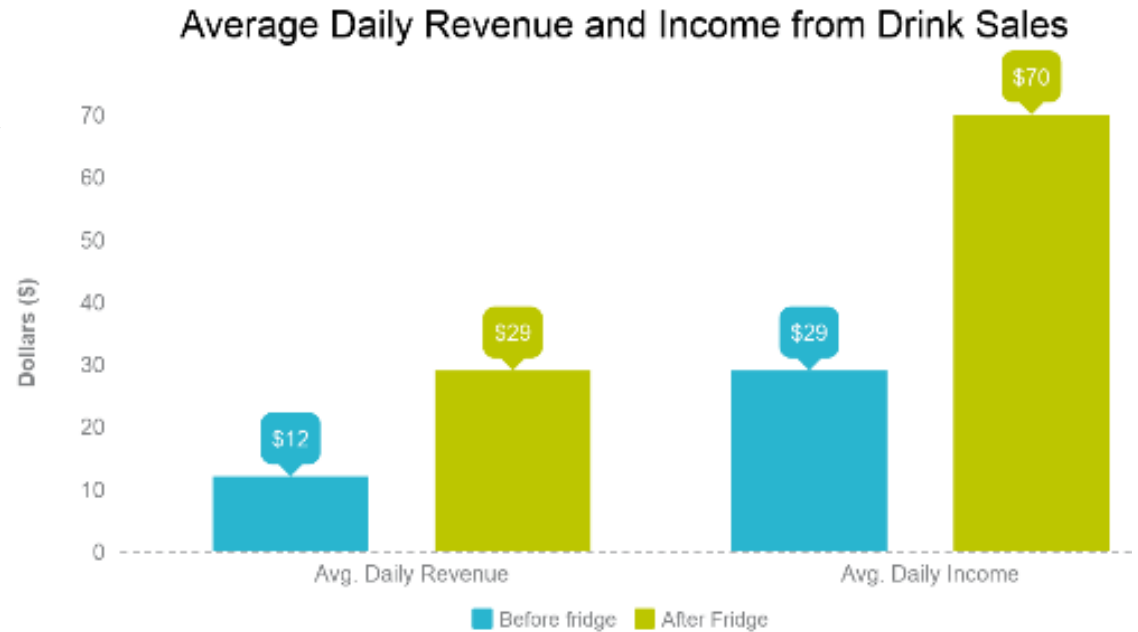
Customers report how their quality of life has changed. (n=324)

81% of customers reported positive quality of life impact.



Refrigerators – Impacts in Use

Data collected from 36 entrepreneurs in Uganda showed that average daily revenue from drinks increased from \$12 per day to \$29 per day, while average total daily income increased from \$29 to \$70.

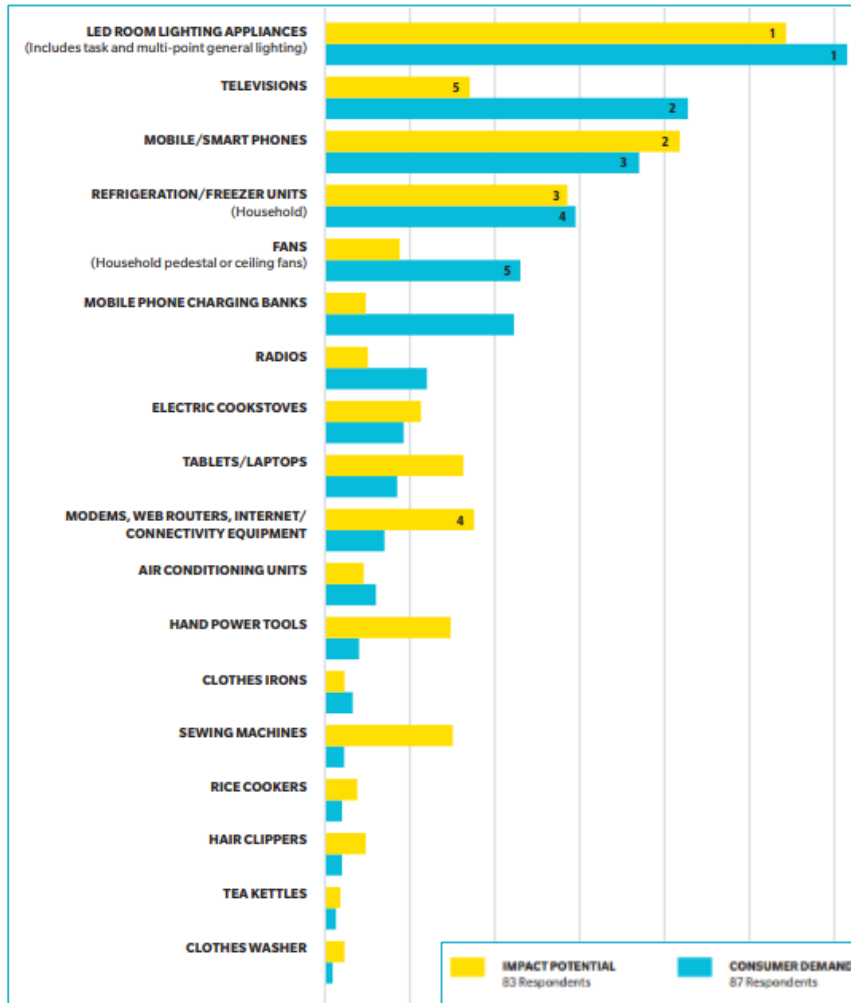


50%

Of entrepreneurs reported expending into a new business line, with fruit juice being the most common new product sold

Consumer demand is not driven by impact potential, as increasingly diverse and affordable products are available

2018 Household Use Appliance Demand & Impact



Entertainment, news, and sports are the top three purchase drivers for a television in East Africa

Almost 60% of the respondents bought the refrigerator to improve their business and attract more customers. Only 2% use them purely for convenience

Comfort is frequently cited as being the most important purchase driver for fans

Critical Importance of Gender in sustainable energy access

- Universal energy access targets are unlikely to be met unless energy policies are aligned to women's as well as men's energy needs, their assets, skills, limitations and capabilities, and existing gender norms.
- Involvement of women in energy-system supply chains is good for women and their families, and it is good for business
- Modern energy services for women's productive uses contribute to women's empowerment
- End-use appliances that deliver modern energy services to reduce drudgery and save time can transform gender roles and relations
- Improving the affordability, reliability, capacity and convenience of modern energy services can help achieve gender-equitable outcomes, and will be critical for universal energy access





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Thank you for your attention

You can type your questions in the question box



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Annexes

Beyond Connections: Energy Access Redefined

- Access to energy has been measured traditionally in binary terms—either having access or not. However, this method does not capture the multiple aspects of access—capacity, duration, quality and reliability, affordability, and safety—and its impact on socioeconomic development. This report outlines a new multi-tier framework (MTF) for defining and measuring energy access.
- The framework looks at the multiple dimensions of access in households, business, and community facilities. By providing more accurate, granular, and disaggregate data on the actual services received, the MTF is gearing up to become a powerful tool for tracking SDG7 and SE4All goals, and for informing policy and investment decisions. Information from the MTF can be used to prioritize investments and interventions, track progress, and capture the various modes of access delivery from grid to off-grid and to the range of cooking methods and fuels used. Finally, it could also help reflect the contributions of various programs, agencies, and national governments toward achieving the SE4All goals.

Both traditional business & social enterprise models

- ▶ Commercial business models seek the highest sustainable and viable rate of return on investment – seeking to make money, and in many cases ‘social / environmental impact’
- ▶ **Incumbent OGSSA Business models :**
 - *White Goods “wholesale” model*
 - *Consumer Electronics “retail” model*
- ▶ **Emerging OGSSS & OGSSA business models are designed:**
 - *Vertically-integrated, energy service provider*
 - *Banker*
 - *Value chain specialist*

Description of Players across the Off-grid Appliances Supply Chain

White Goods “wholesale” model: Wholesale of equipment suited to institutional, community or high-end commercial enterprise customers. Split between international product suppliers and local distributors (some of which have networks and many are individual). No creation of last-mile commercial distribution channels

Consumer Electronics “retail” model: The primary modus operandi remains broadly unchanged, with OEMs or manufacturing brands retaining control over large parts of their value chains, including product design (in most cases), branding, quality control (including certification) warranty, support, and licensing of the product. Recent years, however, have seen new business models and areas of specialization emerge as the industry matures. These shifts largely pertain to the PAYGO segment, and are expected to significantly change players’ modes of engagement in the value chain going forward

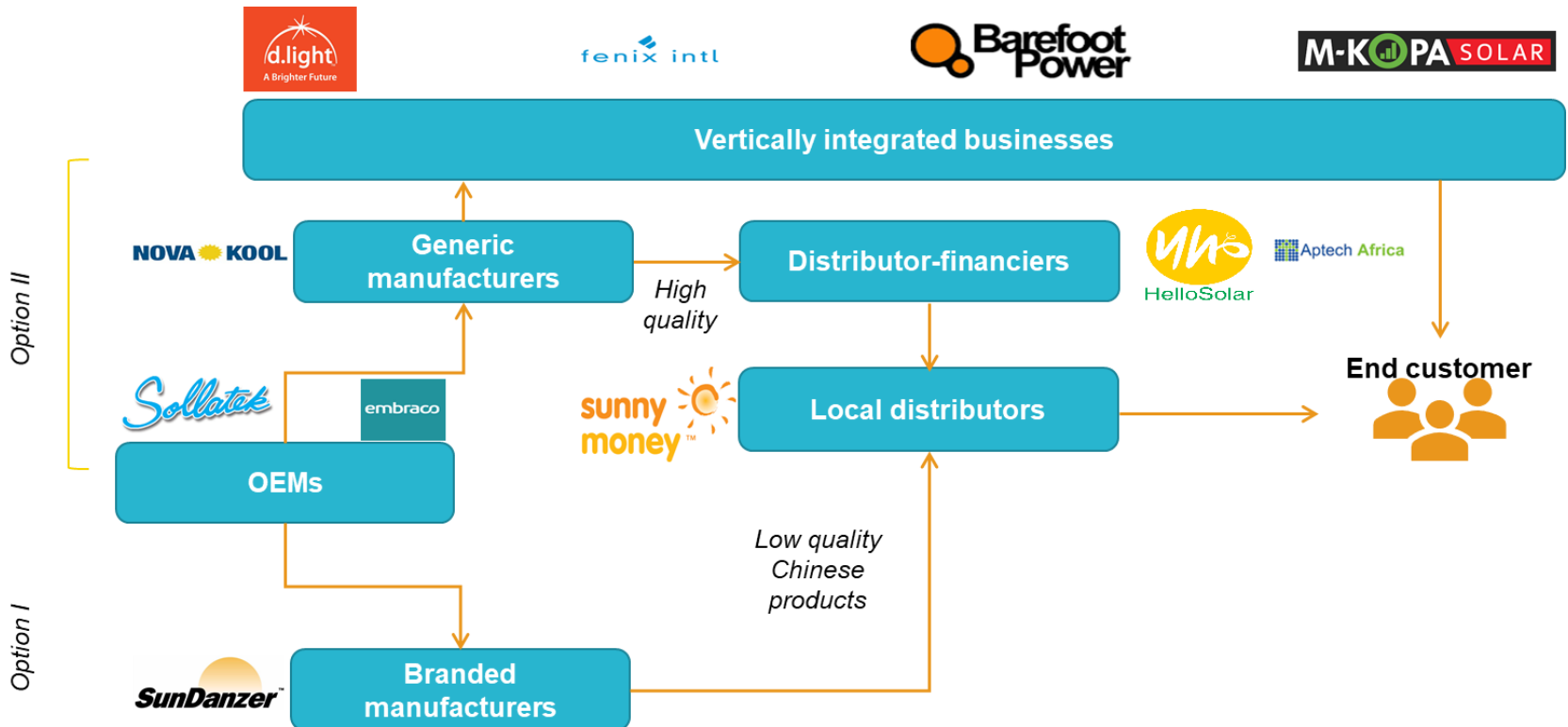
Vertically-integrated, energy service provider: This typology is similar to many business models today in which the company acts as a utility provider and controls most aspects of the value chain, from product design to payment collection. Examples include both companies that have entered the PAYGO space directly as well as established pico players moving into the PAYGO SHS space. During the nascent stages of the PAYGO industry, most new entrants chose to invest heavily in all parts of the value chain to compensate for the lack of suitable partners and to control the customer experience as they innovated to find an optimal business model. Pico players moving into this segment leveraged their product design expertise and existing distribution channels. Going forward, in maturing markets, companies may shift away from vertical integration as the emergence of suitable partners allows them the opportunity to save costs. In new markets, however, where OGS devices are less ubiquitous, companies may still need to establish their own networks to acquire and sustain customers.

Banker: In this typology, a company focuses on the customer-facing functions of the value chain, including sales, credit assessment, payment recoupment and after-sales service. PEG Africa and SolarHome exemplify this typology, procuring products from established OGS players and then investing in infrastructure to support customer acquisition and management. Going forward, the market may see increasing emergence of such models driven both by existing, vertically-integrated players shifting focus to the downstream value chain, and new entrants drawn into the market by the excitement surrounding PAYGO and looking to shorten their time to market by procuring existing products.

Value chain specialist: Companies operating in this typology typically focus on one part of the value-chain (usually upstream) and are horizontally integrated. Examples include Angaza, which specializes in PAYGO technology for a range of energy products, and Renewit, which focuses on product design and manufacturing of solar products ranging from lanterns to solar kiosks. The range of products integrated in this model may extend beyond OGS and solar. For example, Mobisol is licensing its hardware-agnostic software to enable up-selling of other consumer electronics and products sold with consumer financing.²³² Going forward, this model would be most attractive to players that are looking to leverage an existing capability (such as software design or manufacturing ecosystems) to enter the OGS market.

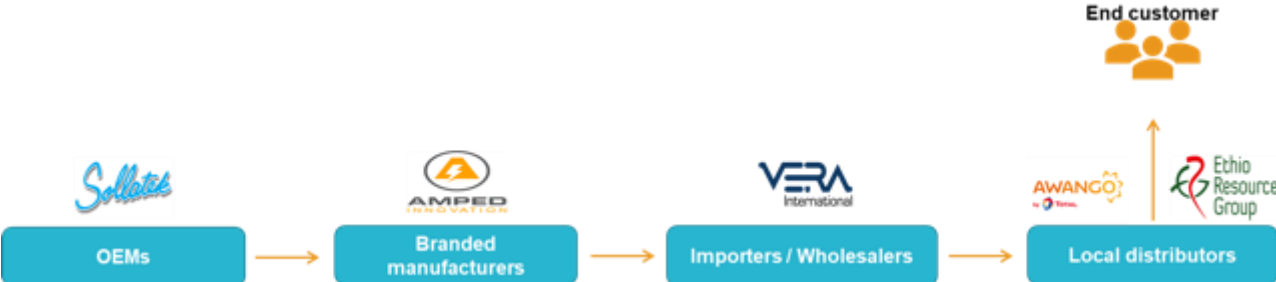
Mature “Energy Access” Business Model

High Potential Markets



Retail “Energy Access” Business Model

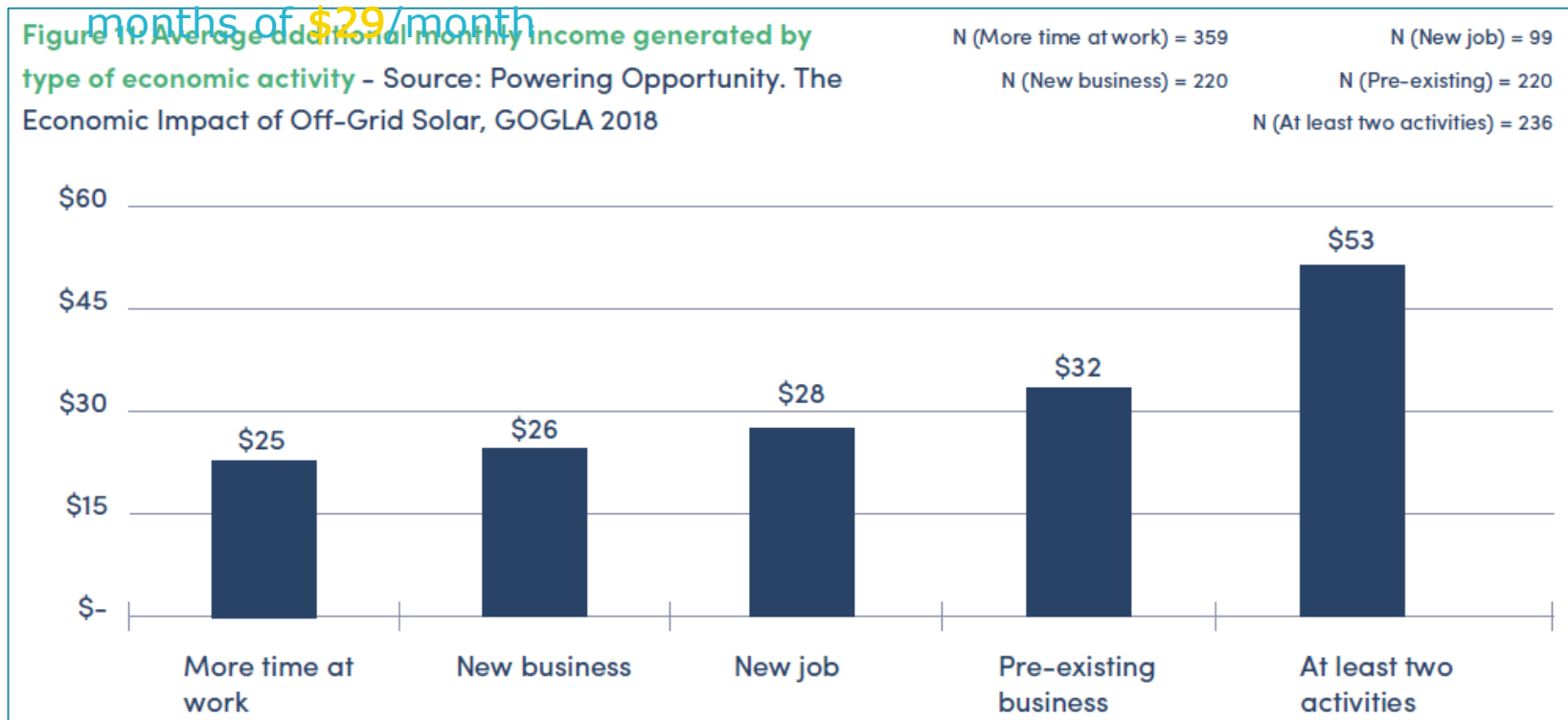
Nascent Markets







Increased Incomes

- ❖ Nearly **60%** of households report undertaking more economic activities thanks to off-grid solar
- ❖ Within 3 months, **36%** of solar home system owners had increased their income per month – by **\$35** on average
- ❖ **24%** of households were using their SHS in a business or income generating activity
- ❖ **89%** of these households see averaged increased revenues in 3

months of **\$29/month**



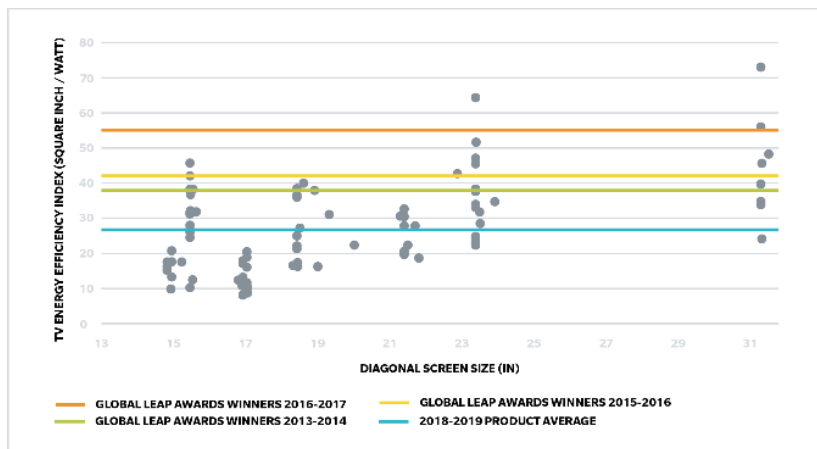
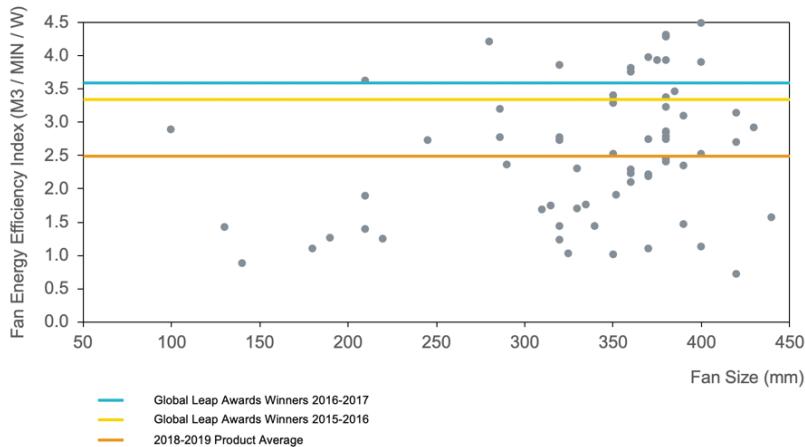
Additional income per business - share of GDP*

		Share of business	Average income generated	% of monthly GDP per capita
	Phone charging for a fee	34%	\$12.8	19%
	Shop or stall	20%	\$36.4	62%
	Bar or restaurant	11%	\$46.4	69%
	Showing TV for a fee	3%	\$43.5	57%

*GDP used is the average GDP of all countries included in the study: Kenya, Mozambique, Rwanda, Tanzania, Uganda

There is rapid evolution in off-grid appliance energy efficiency ratings, costs, and product diversity

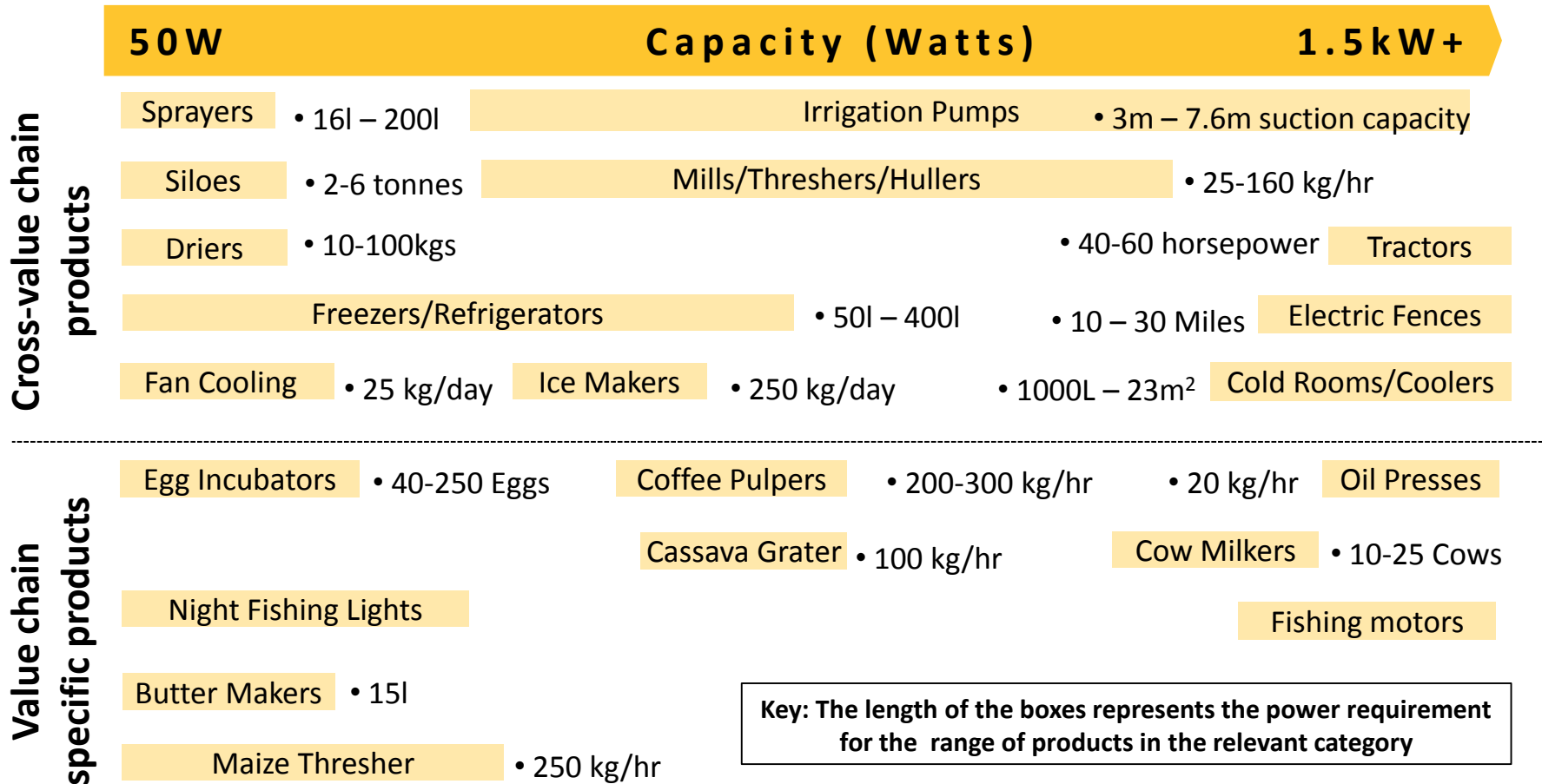
Fan and TV energy efficiency over time based on Global Leap Awards data



Increasingly diverse product eco-system with product variety, improved efficiencies, and falling product prices for some categories

- Number of off-grid appliance enterprise and products growing quickly – 3-5 branded manufacturers for each product in 2013 grew to 11 TV, 8 TV, 7 off-grid fan quality product mfg by 2017 in Global LEAP across dozens of products
- Efficiency rising (45% improvement in TV efficiency from 2014-2017), but very big disparity between average off-grid appliance and best in class (1.5-3x)
- Still big potential for efficiency improved, e.g., 50% for average TV with improved insulation, materials, motors
- Prices falling (23% decline in TV prices from 2015 to 2018, will be 30%+ by 2023)

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

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 exists 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

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% ¹	< 1 Year
	Agro-processing	Maize	Flour mill	Year 2	15%	21 months ²
	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 ¹
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