

Fundamentals in Off-Grid Electrification – Impacts, SDGs and PBL



Funded by:



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Agenda

- **Off-grid Electrification Fundamentals**
- **Impacts Fundamentals and SDGs**
- **Project Based Learning (PBL)**

- Q&A
- Webinar feedback survey



Our speakers



▶ Leo Blyth

- Off-Grid Energy Access Consultant, supporting LEIA & EforA alongside Lighting Global & ESMAP / World Bank
- +20 years living/working in Africa as off-grid solar product designer, social entrepreneur, technical & strategic advisor



▶ Gill Davies

- Monitoring & Evaluation Manager for LEIA and other international energy access projects at Energy Saving Trust
- 15 years working in renewable energy sector, focusing on African and Asian off-grid contexts since 2010



▶ Emma Crichton

- Head of Engineering at Engineers Without Borders UK
- Civil engineer with six years experience in the Water industry in Scotland



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Off-grid Electrification Fundamentals

Leo Blyth



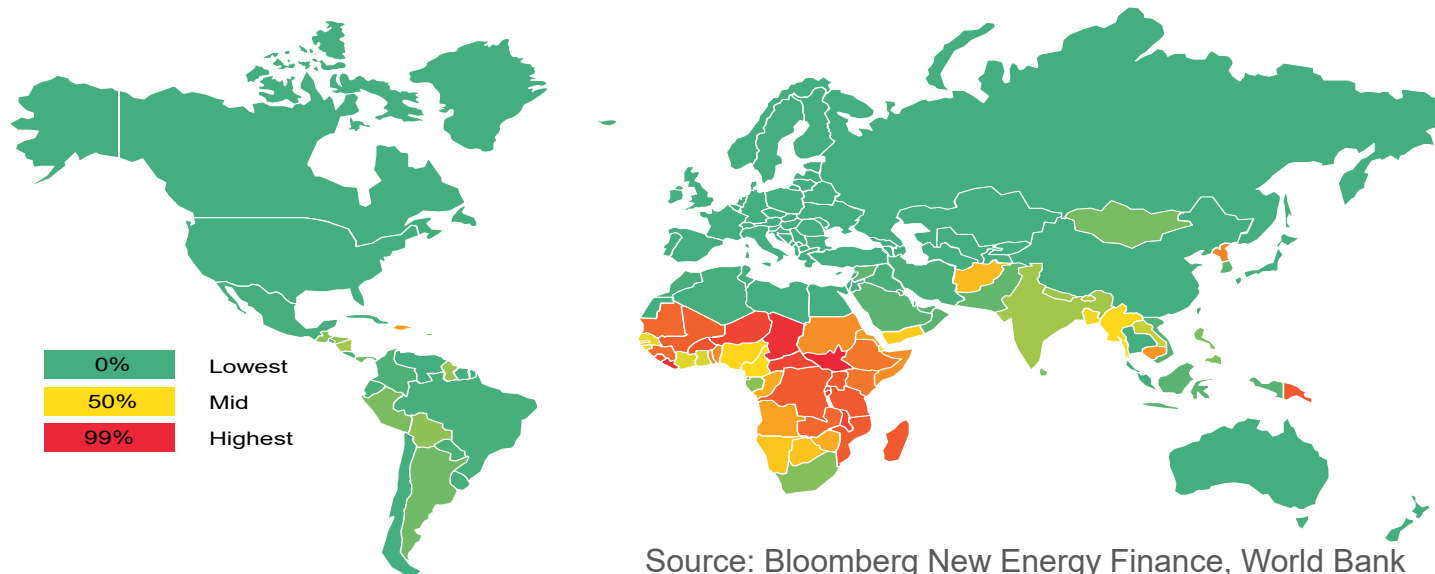
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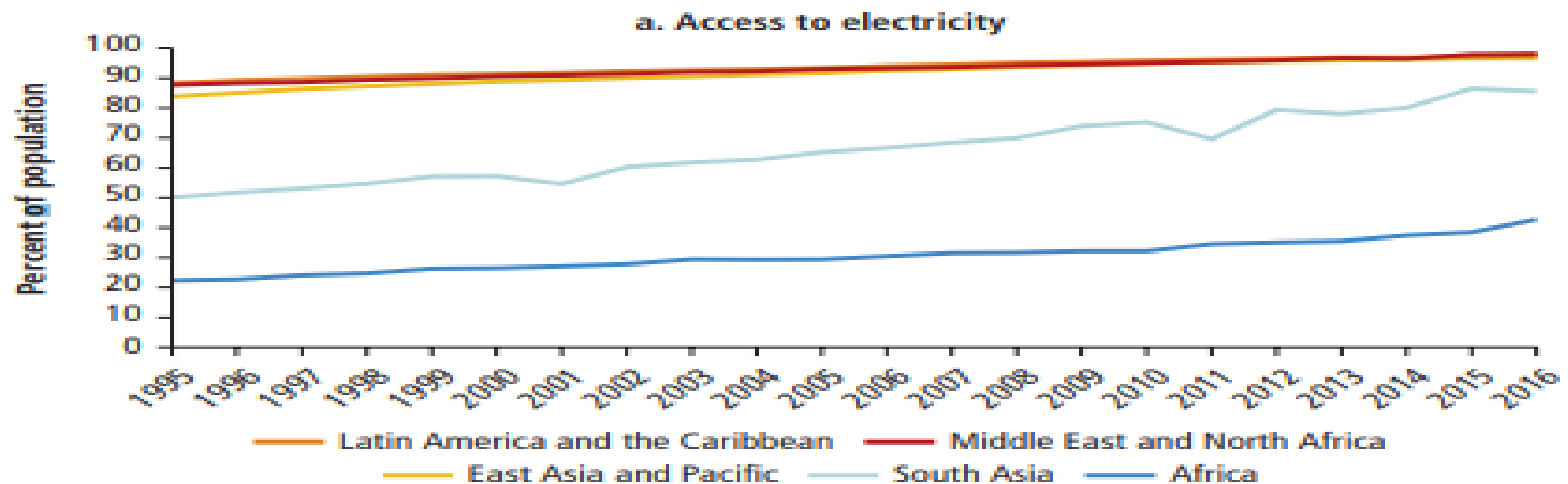
Approx. 25% of the global population lives in energy poverty

Share of population without grid access (% of total)



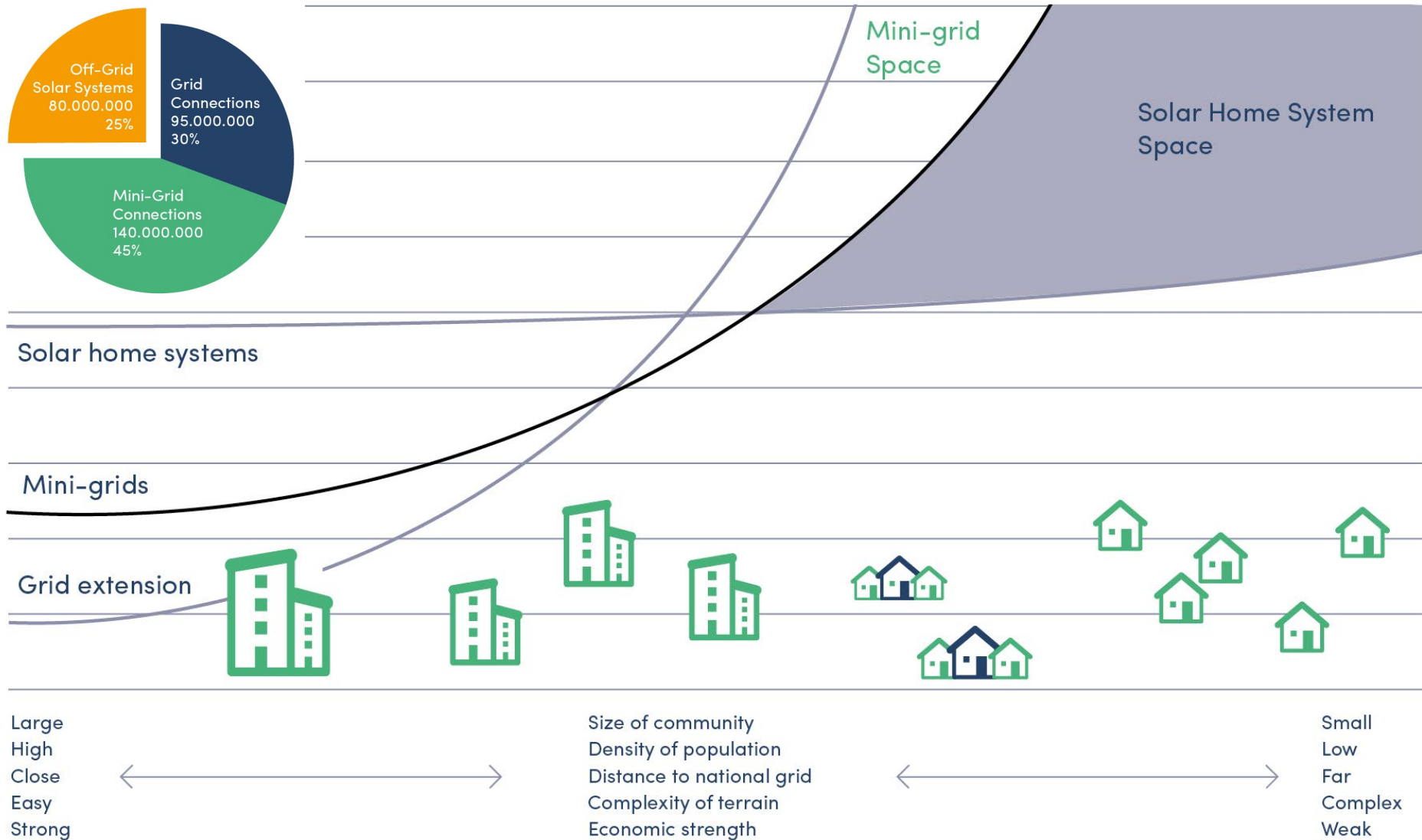
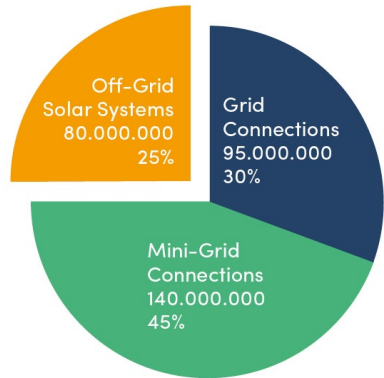
Source: Bloomberg New Energy Finance, World Bank

Figure 1.1 Access to Electricity



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)



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"

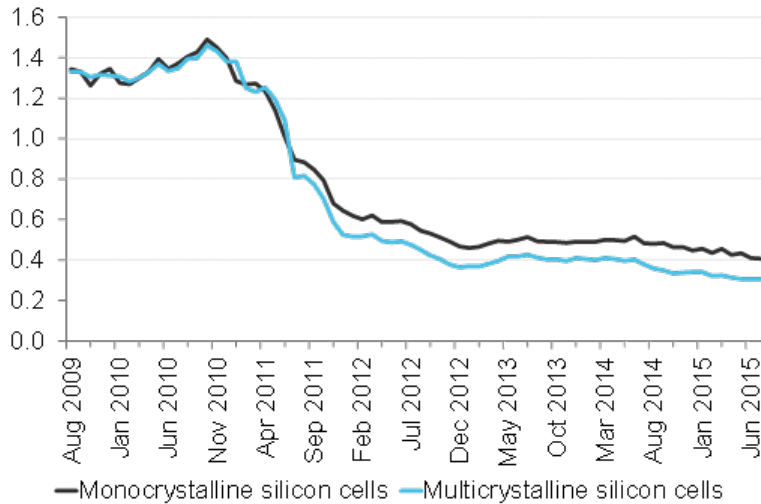
	Pico-powered Lighting Sys.	Solar Home System	Micro / Mini-Grid	Regional Grid
Scale (~Watts)	1 – 10	10 – 100's	100's – 1000's	$10^6 - 10^{11}$
Topology	DC Only	DC – some AC	Mostly AC	Nearly all AC
Loads				
SE4ALL Tiers	1	2 to 3	1 to 5	4 to 5
	US\$ 10-120	US\$ 140-1000	Highly variable	Highly variable

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

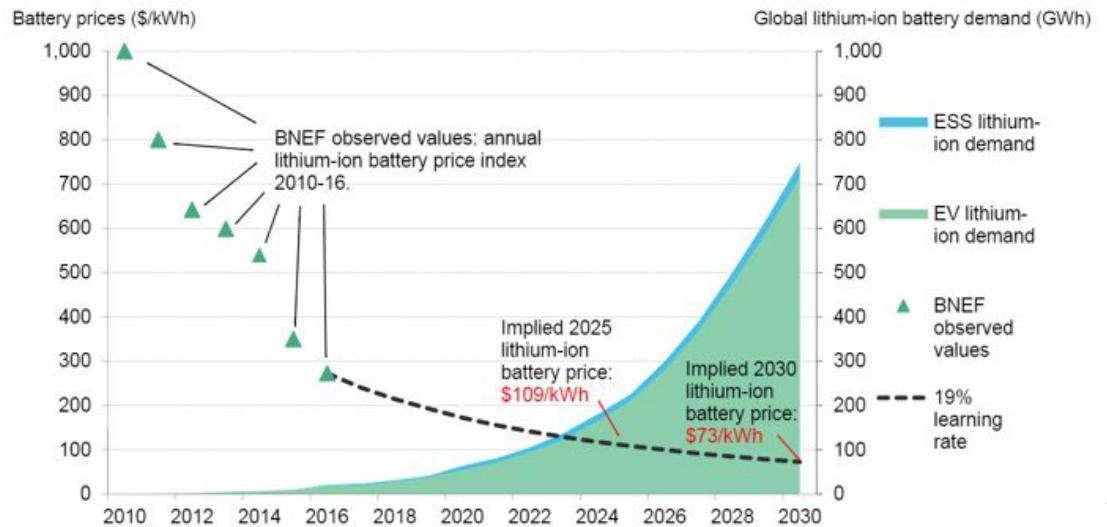
Price of crystalline silicon cells, 2010 – 2015

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

\$/W (nominal)



Source: Bloomberg New Energy Finance Solar Spot Survey



Plug & Play Solar Home System (SHS) Kits

Mass produced electricity connection in a box

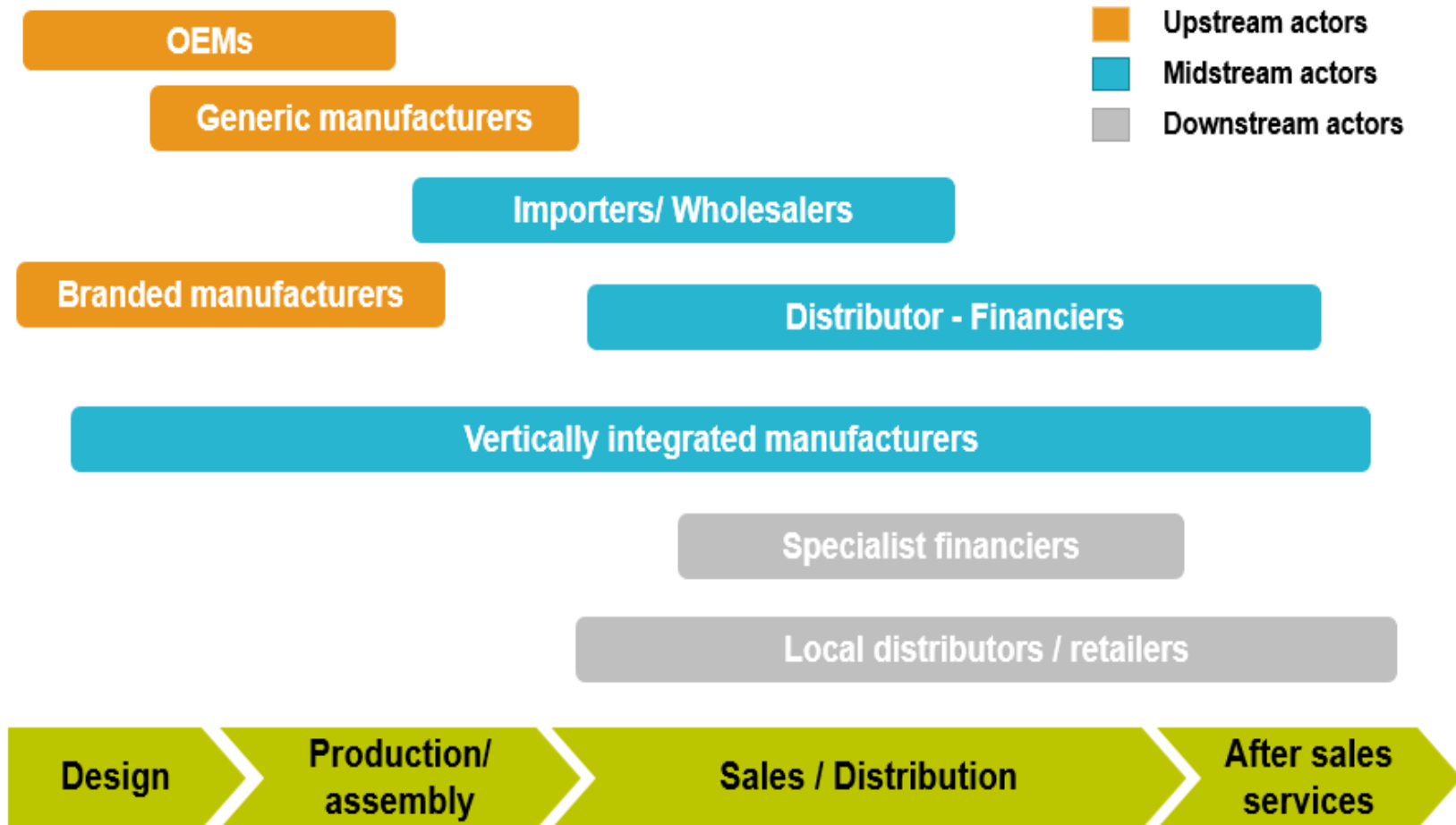


M-KOPA 600 package

- 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)

Off-Grid Appliance Supply Chain Actors / ecosystem

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



Top Off-Grid Electrification / Energy Access Resources

➤ International Energy Agency

- [Rate of Energy Access](#) – Africa & Global Energy Access Outlook
- [Energy Access](#) – SDG7 Data & Projections

➤ Sustainable Energy For All

- [Tracking Energy Access Towards SDG's – 2020](#)
- [State of Global Mini-Grid Market](#)

➤ Efficiency for Access / LEIA

- [The State of the Off-Grid Appliance Market - 2020](#)

➤ World Bank group Lighting Global Program

- [PULSE- Productive Use Leveraging Solar Energy, Market Potential](#)
- [Solar Off-Grid Market Trends 2020](#)

Power 4 All [Top Energy Access Trends - Distributed RE 2020](#)



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Impacts Fundamentals and Sustainable Development Goals

Gill Davies



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What does energy access mean to its end users?

Energy access

Customers report significant increases in the hours of light available. For example, before their purchase, two thirds of East African customers had less than 6 hours of light a day. Now, 53% have more than 10 hours



The SHS helps users to stay connected as they can charge their phones more often; many also access radio, TVs and fans



But what *impact* does that have on people's lives?

Quality of life

Nearly all SHS customers report quality of life improvements; 94% in East Africa, 97% in West Africa and 94% in South Asia

Safety

91% of customers in East Africa, 98% in West Africa and 90% in South Asia report feeling safer



Health

89% of customers in East Africa perceive health improvements in their household. This is also true for 86% in West Africa and 37% in South Asia



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Education

85% of households in East Africa, 91% in West Africa and 66% in South Asia report that children have more time to do their homework thanks to the light provided by the SHS



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Economic activity

34% of households in East Africa, 19% in West Africa and 12% in South Asia report that at least one member is undertaking additional economic activity due to the SHS



Additional economic activity translates into 21 FTEs per 100 SHS sold in East Africa, 8 in West Africa and 4 in South Asia

64% of customers in East Africa, 75% in West Africa and 25% in South Asia report they feel they have more money available since purchasing their SHS

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Climate

In East Africa, use of kerosene as a main source of light among customers shrunk from 39% to almost zero, reducing polluting emissions

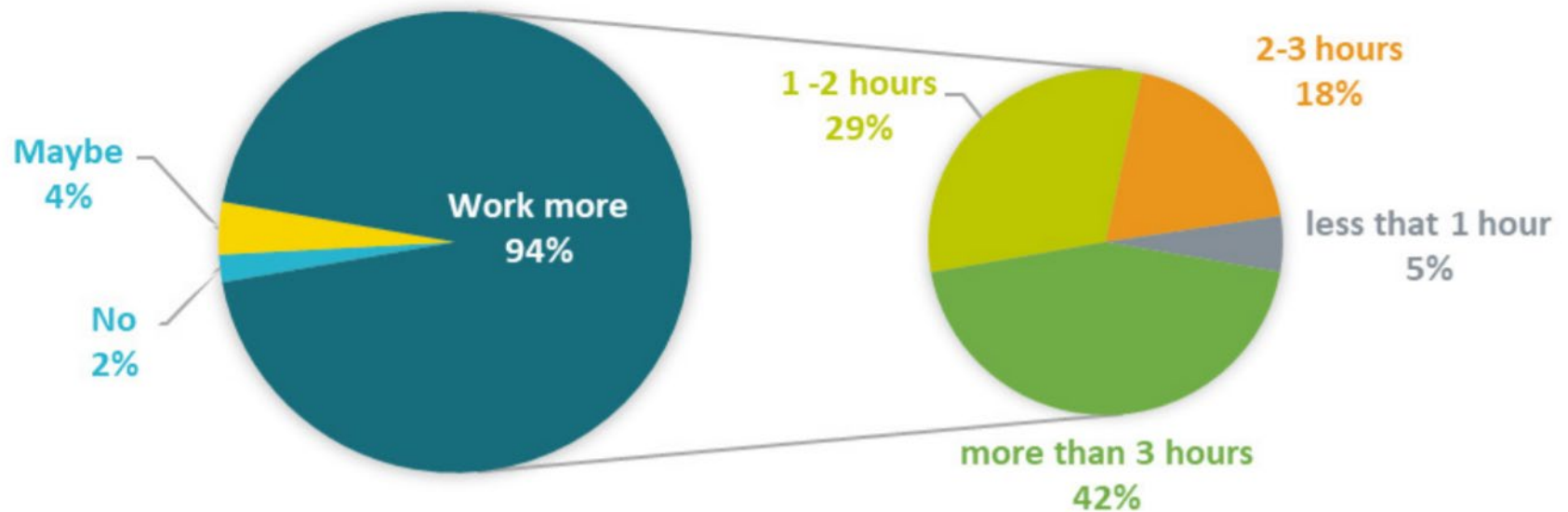


In West Africa, use of diesel generators as a main source of light decreased from 14% of customers to 4%

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Fans = extra productive time in hot climates

- Telephone surveys with 1600 off-grid fan customers in Bangladesh
- Research suggests that physical workers work one hour less on days that reach over 29 degrees Celsius – commonplace temperatures for nine months of the year in Bangladesh.



Solar Water Pump End-User Case Study

➤ Malinda, a maize and watermelon farmer from Tanzania

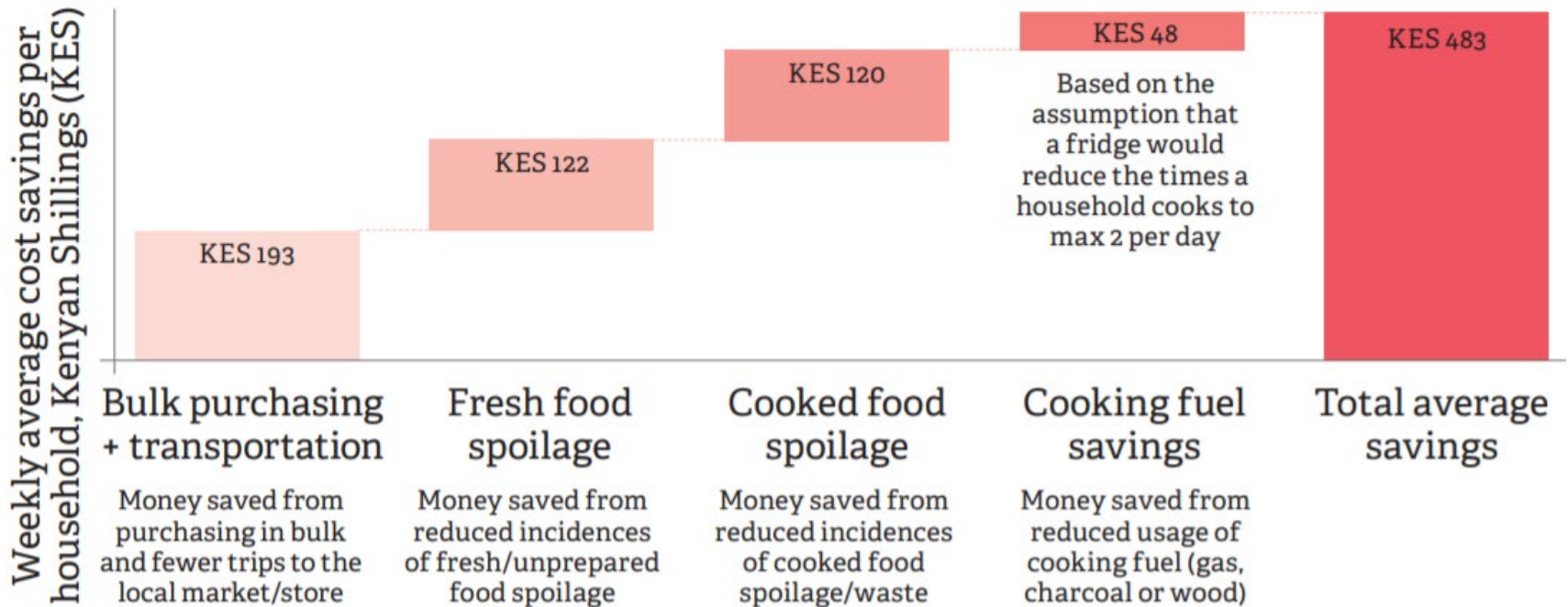
MALINDA CHANGWE

- Malinda has a 3 acre maize and watermelon farm and rears cattle and hens. He also supplements his farming income with fishing and another side business.
- Malinda bought his solar water pump to replace the fuel water pump he was previously using. His motivations for purchasing were primarily economic. Malinda used to spend about 26,250 Tanzanian shillings (US\$11.39) per week on water acquisition for his farm, he now spends nothing on this (not factoring in pump repayments).
- Since purchasing his solar water pump, he has continued to irrigate his 3 acres and experienced an increased income. He enjoys using his pump because he says it is durable, reduced his farm's expenditure and works very well.

"Because the solar water pump has no other expenses so I irrigate my farm so freely a factor which [has caused] my farm productivity to change. Now I get more products due to irrigation that I am doing so I get money for selling it, also I get enough food for my household."



Household refrigeration impacts in Kenya

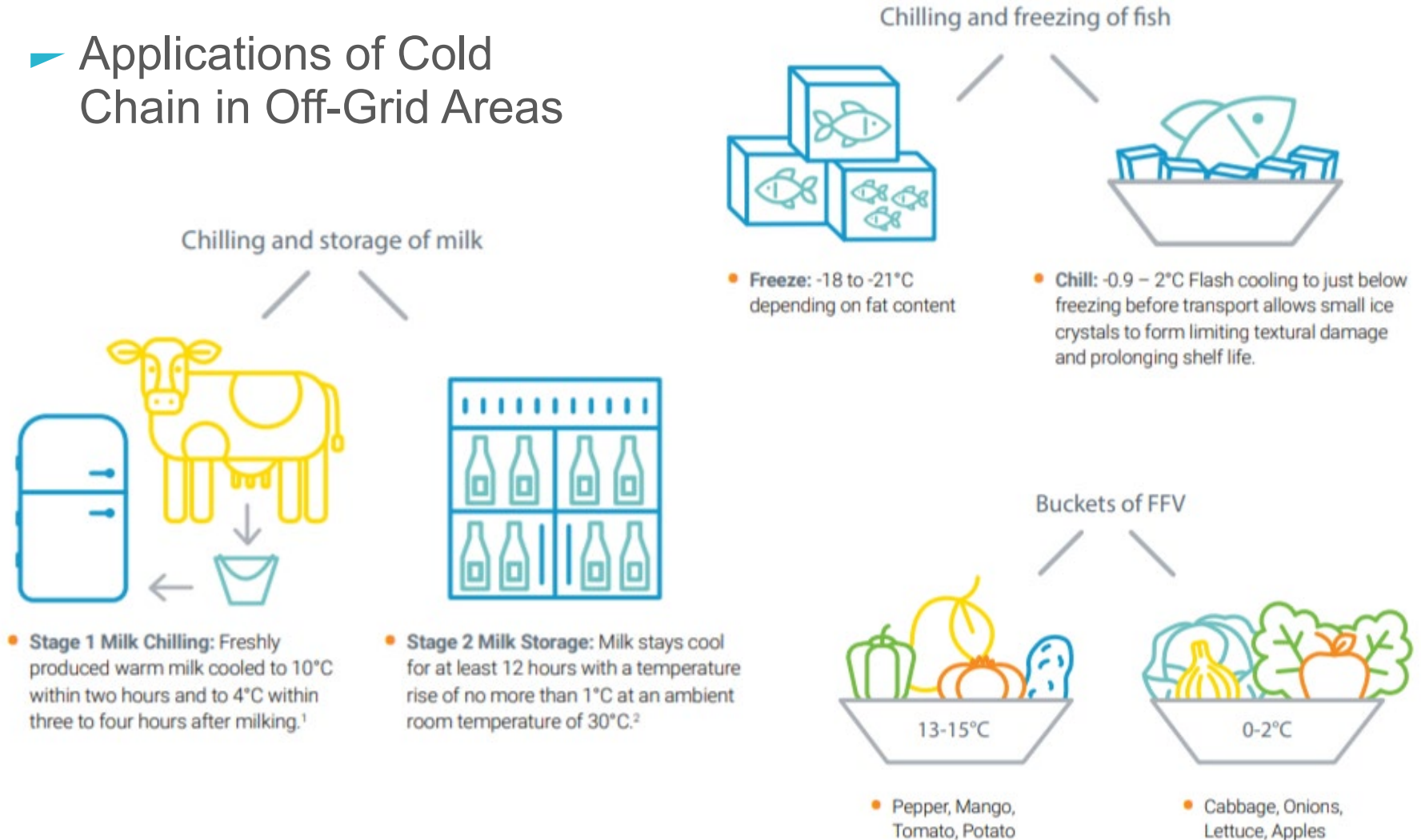


► Additional impacts

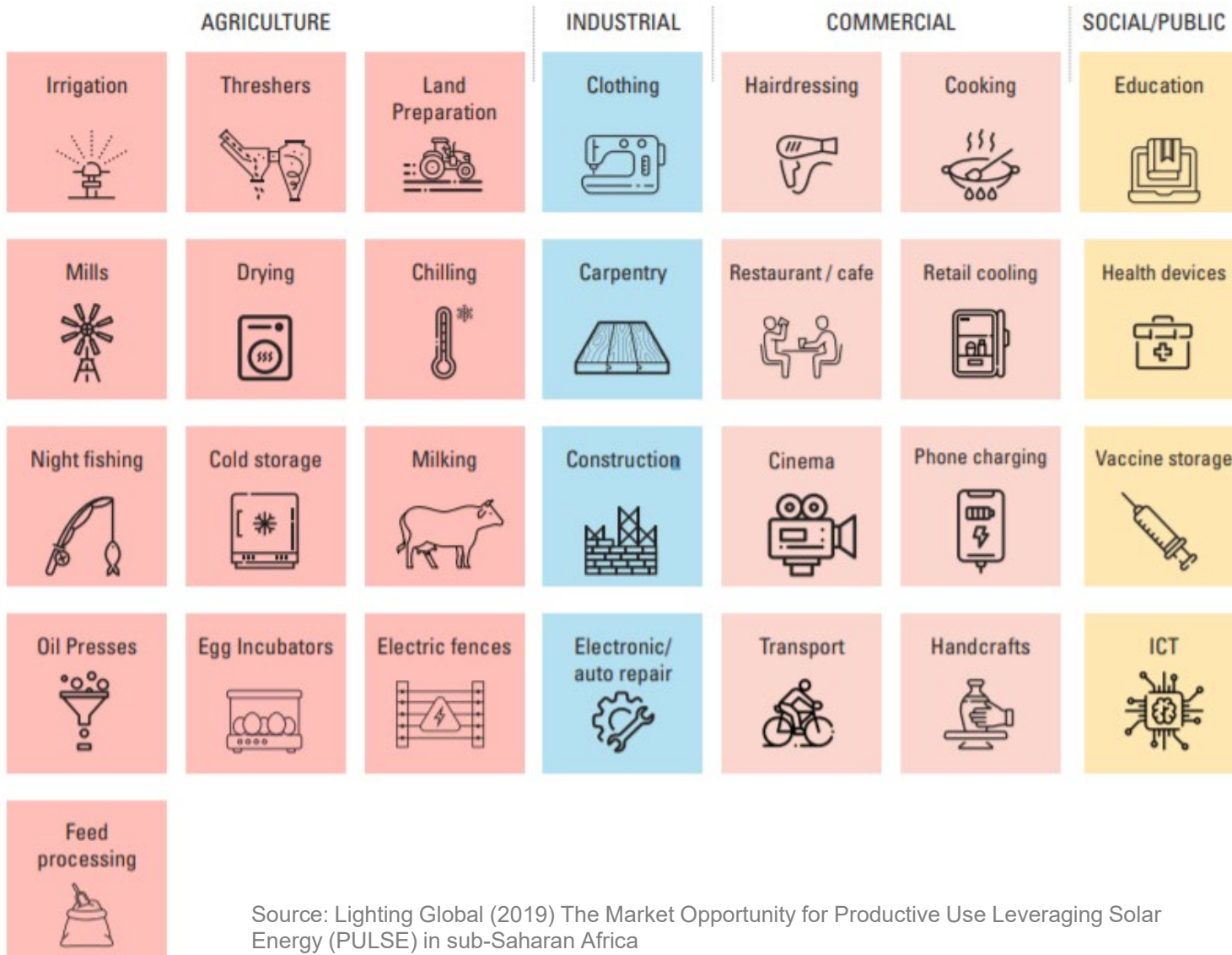
- 2 hours/week time savings, primarily for women
- Lower stress due to time savings and improved food 'safety'
- More varied diets, including fruit, veg, meat and fish
- Increased reliability from solar source and no electricity bills
- Increased conveniences

Cold Chain – Impacts from Whole Supply Chains

Applications of Cold Chain in Off-Grid Areas



Universe of productive uses relevant for off-grid markets in sub-Saharan Africa (non-exhaustive)



Source: Lighting Global (2019) The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in sub-Saharan Africa

Sustainable Development Goal (SDG) 7

- Affordable, reliable, sustainable and modern energy for all

Access to energy

Target 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

Renewable energy

Target 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

Energy efficiency

Target 7.3 By 2030, double the global rate of improvement in energy efficiency

Which other SDGs does energy access contribute to?



Quick Poll

► How many SDGs does energy access contribute to?

- GOAL 1: No Poverty
- GOAL 2: Zero Hunger
- GOAL 3: Good Health and Well-being
- GOAL 4: Quality Education
- GOAL 5: Gender Equality
- GOAL 6: Clean Water and Sanitation
- GOAL 7: Affordable and Clean Energy
- GOAL 8: Decent Work and Economic Growth
- GOAL 9: Industry, Innovation and Infrastructure
- GOAL 10: Reduced Inequality
- GOAL 11: Sustainable Cities and Communities
- GOAL 12: Responsible Consumption and Production
- GOAL 13: Climate Action
- GOAL 14: Life Below Water
- GOAL 15: Life on Land
- GOAL 16: Peace and Justice Strong Institutions
- GOAL 17: Partnerships to achieve the Goal

4 SDGs

6 SDGs

9 SDGs

12 SDGs

16 SDGs

Which other SDGs does energy access contribute to?

➤ When you consider energy appliances, almost all SDGs!



Example SDG Linkages in More Detail



Improve efficiency, reduce drudgery, and provide new farmers with new income-generating opportunities.



Reduce post-harvest loss and give small business new opportunities, such as cold beverage sales.



Extend potential working hours for households and businesses.



Improve the efficiency & quantity of food production, particularly for staple crops.



Improve crop yields and climate resilience.



Reduce food waste and post-harvest loss.



Reduce food insecurity by providing households with better nutrition.



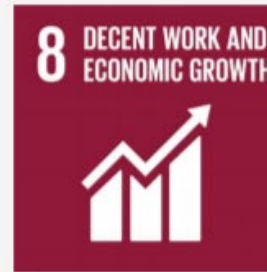
Reduce indoor air pollution and health risks caused by inefficient biomass stoves/open fires.



Expand access to quality medical care and reduce maternal and childhood mortality.



Reduce drudgery and save time, allowing women and girls to pursue other opportunities or an education.



Improve productivity and income-generating opportunities for farms and households.



Create a more informed and educated workforce and expand income-generating opportunities.



Improve the quality of working environments by expanding access to cooling technologies.

Energy Impacts and COVID-19 Spotlight

- Economic opportunities offered by appliances can help address household-level financial impacts of crisis
- Cold chain and solar water pumps can help food insecurity
- Televisions and computers can enable communications and distance learning
- Appropriate health equipment can help diagnose and treat COVID-19 patients
- [Listening in the time of COVID](#) interview series by 60 Decibels has so far interviewed 21,977 solar product customers in 19 countries
- Respondents were asked: “Are you using your energy product or service as normal during the COVID-19 pandemic?”
 - Nearly a third (**31%**) reported that their usage has increased
 - **41%** out of 600 energy appliance customers are using their appliance more than normal

Importance of inclusivity in energy access

- Not everyone will have equal access to energy sources and appliances
- And different people may benefit differently
- Remember to think about **inclusive design**
 - Affordability to reach the poorest
 - Gender considerations e.g. for different product types
 - Ease of use for people with disabilities



Energy Impacts and SDG resources

- Efficiency for Access / LEIA
 - [The Socio-Economic Impact of Super-Efficiency Off-Grid Fans](#) (2019)
 - [The Use and Impacts of Solar TVs](#)
 - [The Use and Benefits of Solar Water Pumps](#) (2019)
- CDC Group
 - [How innovation in off-grid refrigeration impacts lives in Kenya](#) (2019)
- GOGLA
 - [Powering Opportunity](#) (2020)
 - Impacts sections of [Global Off-Grid Solar Market Reports](#)
- 60 Decibels
 - [Why Off-Grid Energy Matters](#) (2020)
- ENERGIA (International Network on Gender & Sustainable Energy)
 - [Unlocking the Benefits of Productive Uses of Energy](#) (2019)
- Practical Action
 - [Poor People's Energy Outlook](#) (2019)



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Project Based Learning (PBL)

Emma Crichton



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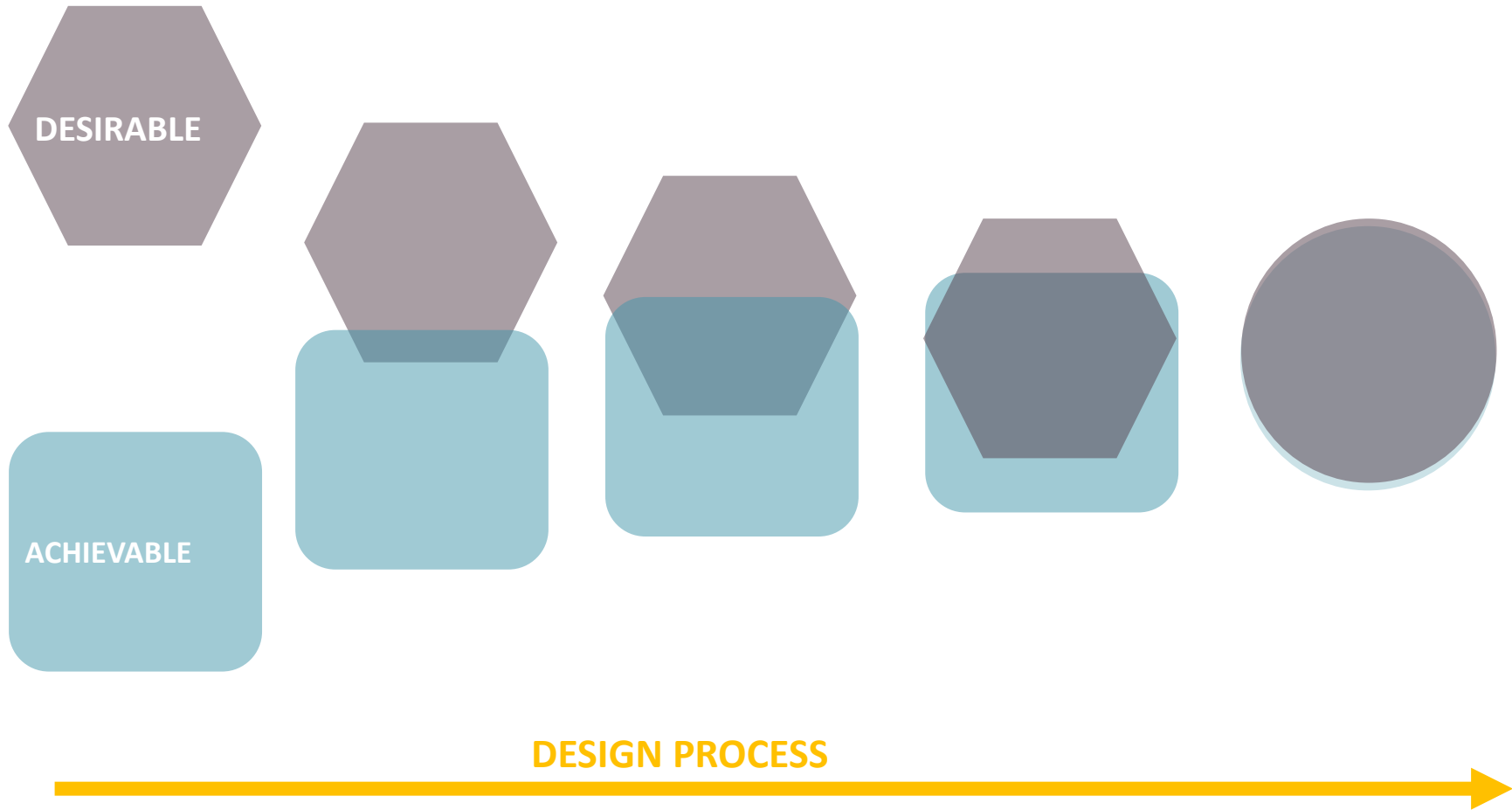
“[With the Efficiency for Access Design Challenge], it was amazing to bring an entrepreneurial experience to my studies.

Our project involved a lot of innovation, design-thinking, uncertainty... unlike structured academic projects, pushing us outside our comfort zone continuously.

In the end, it was incredibly rewarding. For me, this made the experience very enjoyable and incredibly valuable.”

Joris Simaitis, student at University College London

The purpose of the design process in a project



Project-based learning: Value for students

Benefits of this teaching method

- Increased student engagement
- Employability
- Improved academic performance
- Increased creativity
- Improved student experience



Achieving SDG 7 is not easy...

Complex, real-world problems need a new approach

- Specify what you want to achieve, not how to achieve it.

Principles for projects in the 21st century:

- 1 Debate, define, revise and pursue the purpose
- 2 Think holistic
- 3 Follow a systematic procedure
- 4 Be creative
- 5 Take account of the people*
- 6 Manage the project and the relationships

Preparing you for your future

Globally responsible engineers

“The only thing we really know about the future is that it’s going to be unpredictable. We need to educate engineers who can cope with that unpredictability. They need to be able to work with technical uncertainty and in a changing political context. They need to be able to communicate effectively at the right levels to move things forward in a positive manner to support global development.

That means different conversations, different perspectives and solutions that are better for everyone. It’s only when we’re all working together that the best ideas happen.”

Laura Leyland, UK academic, Birmingham City University

Preparing you for your future

Project-based learning allows you to practice

- Engineering is responsible for changing the way people live.
- Education should prepare young people for life, work and citizenship.
- But by overcoming a challenge, we often learn the most.
- Become both problem identifiers and problem solvers, and this supports your transition to be a self-motivated individual, ready for industry.



Meaningful, useful projects

“Retire from your job but never from meaningful projects. If you want to live a long life, you need eustress, that is, a deep sense of meaning and contribution to worthy projects and causes.”

Stephen Covey, author



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Q&A



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Short feedback survey



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Additional Slides:

**The Role for Efficient and
Affordable Appliances**



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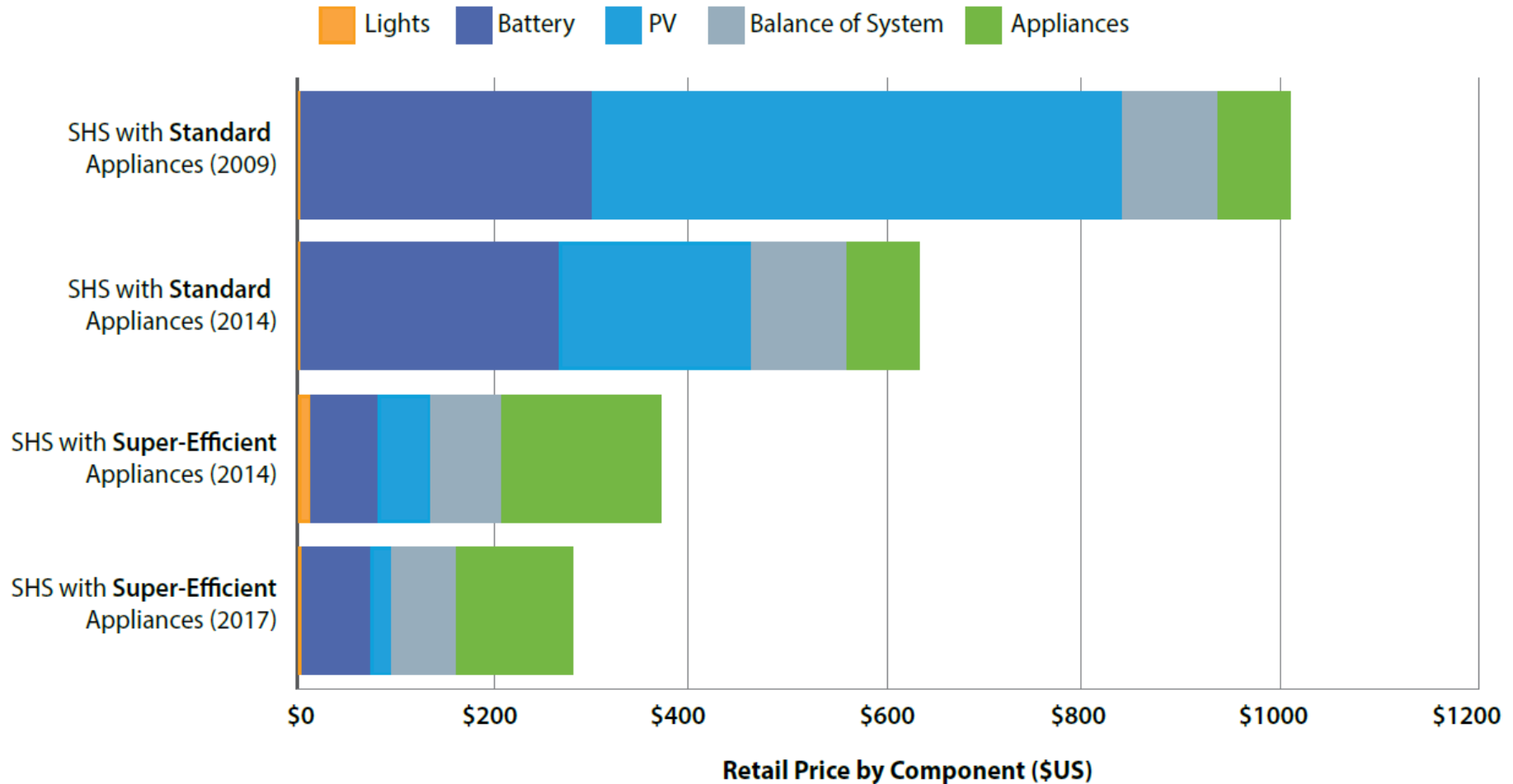
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Efficient appliances create a virtuous cycle

- 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



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











Source: Phadke et al., 2015.

Appliance Efficiency Unlocks Greater Energy Access Outcomes

Energy System Requirements

KEY

-  Energy system needed to support an **appropriately-designed, super-efficient refrigerator**
-  Energy system needed to support a **conventional on-grid refrigerator**

-  1 Phone Charger
-  1 15" TV
-  1 Radio
-  1 Pedestal Fan
-  4 LED Lights
-  1 Refrigerator

 80 Wp Solar Panel

          700 Wp Solar Panel

8.75 x

 35 Ah Lead Acid Battery

          300 Ah Lead Acid Battery

8.57 x

Source: CLASP

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



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