SMART VILLAGES

A pocket guide to rural energy & "smart villages"

SMART VILLAGES

New thinking for off-grid communities worldwide

The Smart Villages initiative is being funded by the Cambridge Malaysian Education and Development Trust (CMEDT) and the Malaysian Commonwealth Studies Centre (MCSC) and through a grant from the Templeton World Charity Foundation (TWCF). The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the Cambridge Malaysian Education and Development Trust or the Templeton World Charity Foundation.

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FAST FACT:

"Inefficient markets, policy barriers and under-investment meant that East Africans paid as much as 66 times more for their electricity than someone in the UK".[22]

1. THE PURPOSE OF THIS GUIDE

This guide helps policymakers, journalists, students, researchers and others concerned about rural villages in developing countries to have information about off-grid energy & smart villages at their fingertips.

2. WHAT IS THE SMART VILLAGES INITIATIVE?

The Smart Villages Initiative aims to provide policymakers, donors, and development agencies concerned with rural energy access with new insights on the real barriers to energy access in villages in developing countries—technological, financial and political—and how they can be overcome.

For remote off-grid villages, local solutions (home- or institution-based systems, and mini-grids) are often both more realistic and cheaper than national grid extension, though the national grid may eventually reach some, but not all, of these villages. Energy access initiatives should be designed to catalyse development and the creation of smart villages in which many of the benefits of life in modern societies are available to rural communities.

Together, energy and entrepreneurship underpin lasting development in smart villages.

3. CAN REMOTE VILLAGES HAVE THE SAME OPPORTUNITIES AS URBAN CENTRES?

Over 1 billion people—17% of the global population—lack access to electricity.

More than 3 billion people—38% of the global population—lack clean cooking facilities.

The vast majority—95%—of people without access to electricity and clean cooking facilities live in sub-Saharan Africa and developing areas of Asia. 80% live in rural areas.[1]

663 million people - 1 in 10 - lack access to safe water.

More people have a mobile phone than a toilet.

Globally, one in three schools lack access to safe water and adequate sanitation.

In low and middle-income countries, one-third of all healthcare facilities lack a safe water source.[2]

1 in 11 children is out of school. Almost 65 million adolescents between the ages of 12 to 15 years old were denied their right to an education in 2013, in addition to 59 million children of primary education that were out of school.[3]

Agricultural jobs make up over 52 percent of the workforce in Africa, and 59 percent in Oceania; agriculture can employ up to 75 percent of people in some places.

Behind these numbers lies an important question: Can rural residents have access to productive employment, clean water, healthcare, education, and communication—without leaving their villages?

Smart cities are on everyone's lips. More people now live in cities than in the countryside. And this trend continues: 96% of urbanisation between now and 2030 is anticipated to occur in developing countries.[4]

But this focus on cities is also worrying. Half the world's population do not live in cities. And that includes more than 70% of the world's poor. But must everyone migrate to a city for a better life?

We argue that "smart villages" can harness the transformative power of access to modern energy together with innovative application of technologies to use that energy to help to ensure that people in developing countries have options. Improving lives and livelihoods in villages and rural communities should be a starting point.

NAME: **Martin Saning'o Kariongi**

TITLE: **Director General, IOPA**

LOCATION: **Terrat, Tanzania**

Martin Saning'o Kariongi has been one of the driving forces behind IOPA, the Institute for Orkonerei Pastoralists Advancement, which started a radio station to help inform Maasai about land rights issues. To start the radio station, they needed electricity, however. With the electricity from jatropha-derived biofuel, the Maasai community was able to monetise the milk output of their traditional cattle by producing cheese and yogurt with the help of IOPA, a local social business run by and for pastoralists with support from international organisations in Sweden and the Netherlands.

Behind Terrat's dairy production is energy: a village mini-grid distributes electricity. This powers the modified shipping container housing their micro-dairy and cools and ages their award-winning cheese while being prepared for the market.

And where there is one enterprise there are usually others. Entrepreneurship is an essential element of a smart village. In Terrat, one sees a vibrant and thriving culture of entrepreneurship, from barber shops and hairdressers to furniture building, welding, and smartphone charging (often at the barbers' or hairdressers'). Energy powers all of these small businesses, which make life much more liveable for this remote community.

NAME: **Simon Bransfield-Garth**

TITLE: **CEO, Azuri**

LOCATION: **Cambridge, UK / East Africa**

As an entrepreneur in sub-Saharan Africa, Simon Bransfield-Garth and his colleagues at Azuri Technologies have faced their fair share of challenges. As he explains, "Any start-up is difficult, and doing stuff in Africa is difficult. In rural areas, there are few reliable postal services, modern roads, power, sanitation; education is variable; you can't routinely buy stuff. You have to build quite a lot from scratch. For example, most households don't have bank accounts. How do you go sell things on credit? But mobile money is more available in Africa. In Kenya, about one-third of GDP goes through mobile payments."

It is advances like mobile money—created by other entrepreneurs—that allow people in remote areas to access energy through PAYG solar home systems created by Azuri and other companies. He says Azuri was welcomed by rural villagers: "People were tremendously enthusiastic. They were using kerosene lamps. To be able to charge their phones, and not have horrible kerosene smoke is transformational"

In terms of scale, Azuri is right at the early stages: "we reach 50,000 households. Some would say that is scale, but with over 100 million homes without power, we regard the beginnings of scale as one million households." The barriers to scale thus far have been distribution and financing, particularly infrastructure finance. In spite of these challenges, Bransfield-Garth says they will reach one million households "definitely within the next five years."


© Azuri Technologies

4. WHAT MAKES A VILLAGE "SMART"?

But what is a smart village? Each community needs to define this for themselves—what may be "smart" in one place may be less important in another.

The basic building blocks of "smartness" include access to high-quality education, healthcare, information and communication technologies, finance, clean water and sanitation, and improved livelihoods, including entrepreneurial endeavours and value-addition by villagers themselves.

But underlying these building blocks lies one important element: energy.

Energy has the potential to be a catalyst for rural development. In many cases, the first energy-related priority in rural villages is access to light and phone charging. And while these are important developments, both for education and communication, a true smart village must go beyond these initial priorities.

Education: Both young people and older people need access to education. Schools need lights, and children and adults need light at home or elsewhere in the community to study and learn. Education is also enabled through computers and software, particularly if it is difficult to receive books, atlases, and encyclopedias. With energy and internet access and the right tools (computers, tablets, or smartphones), students and their parents can use the internet to access the world's knowledge base, continue their education remotely, and communicate.

A smart village, for example, will allow students (of whatever age) to access information about the wider world. We've seen examples of this, for example, in the work of Aleutia, a company that provides a "solar classroom in a box" in East and West Africa. In this solar classroom, students have access to computers pre-loaded with encyclopedias, maps, and other educational information. With an internet connection, they have opportunities to go beyond these materials.

Health: In health contexts, light is also essential, but weaker household lighting isn't sufficient. Refrigeration for vaccines, blood, or other medicines is also necessary to ensure that most basic health needs are met in a village.

But moving beyond basic needs, telemedicine can also allow more advanced and personalised healthcare. Remote communities can access experts from cities and towns, which can reduce the costs of healthcare and improve quality. Clean water and sanitation are of course essential for good health. Lighting can also improve security, which helps villagers' peace of mind.

Livelihoods: But even with these advances in education and healthcare, a village will not be self-sustaining and attractive to many of its own residents if it cannot improve the livelihoods of its inhabitants. And energy is essential for improving livelihoods.

To make a village "smart" and sustainable, energy must also be used to improve incomes and livelihoods. "Productive uses of energy" are ways that individuals and communities can use energy to do precisely that.

What are productive uses of energy? Examples include:

- Milling and grinding agricultural products to add value and same time and money
- Refrigerating fish or dairy to preserve them for market
- Preventing post-harvest losses through temperature and humidity control
- Powering small businesses: shops that need cool drinks, mobile phone charging stations, barbers and hairdressers, radio stations, welders, and furniture makers
- Irrigation to increase agricultural yields

All of these uses of energy can allow people to continue to live in their villages—most likely with improved incomes—rather than moving to towns and cities.

For example, SNV Ghana has worked to design improved stoves used to smoke fish, adding to the villages' productivity and also decreasing the adverse health impact of smoke on the women entrepreneurs who are smoking the fish.

To achieve these productive uses of energy, more power is usually needed. Solar home systems can support some smaller businesses—shops, sewing, phone charging, and barbers and hairdressers. Typically, mini- or micro-grids become essential for other productive activities, like agricultural processing. Mini- and micro-grids still usually need subsidies from governments, donors, or investors.

But villages are not "smart" only because of energy, ICT, education, healthcare, clean water and livelihoods. Other factors come into play, including gender equality, people's satisfaction with their lives and ambitions, and opportunities for young people.

Villages can become "smart" in a self-sustaining, market-based fashion, given the appropriate enabling conditions. Technology and services can be provided entrepreneurially, with rural consumers paying for what they use. Donors are necessary on the ground level, but self-sustaining businesses are the ultimate goal.

5. OFF-GRID ENERGY: THE CURRENT STATE OF AFFAIRS[5]

Access to energy remains an enormous challenge. Imagine that 1 in 7 of your neighbours does not have access to energy, and that 2 in 7 are breathing in smoke and fumes every day because they use kerosene for light and wood for cooking.

TABLE: Access to energy around the world

Area of world	National electrification rate	Rural electrification rate
Sub-Saharan Africa	32%	17%
Southeast Asia	81%	69%
Rest of developing Asia	65%	53%
Latin America	95%	85%

Worldwide, 84.6% of people have access to electricity. However, in "low income" countries only 25.4% have access. 34.3% of countries classified as "least developed countries" (LDC) have access, while in "heavily indebted poor countries", 29.2% of people have access to electricity.

But even behind these numbers, many remote areas of Latin American and the Caribbean, East Asia and Pacific, and South Asia remain without electricity – particularly in mountains, forests, and on islands.

The figure for Pacific Island small states helps to reveal this: only 51.9% are electrified even though all of East Asia and the Pacific reaches the figure of 96.1%.

The definition of what it means to have “electrification” may vary, and it can be challenging to access accurate data. People may only have access to electricity for limited periods or may experience frequent blackouts. People living in remote areas such as the Amazon or difficult to reach mountainous areas may also be left behind.

Countries with the lowest rural electrification rates[6]

South Sudan	0%
Burkina Faso	1%
Chad	1%
Sierra Leone	1%
Burundi	2%
The Gambia	2%
Democratic Republic of Congo	2%
Mauritania	2%
Liberia	3%
Madagascar	4%
Malawi	4%
Niger	4%
Tanzania	4%

Countries in Asia with the lowest rural electrification rates

DPR Korea	11%	Indonesia	71%
Myanmar	18%	Nepal	72%
Cambodia	18%	Mongolia	73%
Bangladesh	51%	India	74%
Pakistan	61%		

Countries in Latin America and the Caribbean with the lowest rural electrification rates

Haiti	8%	Peru	75%
Nicaragua	54%	Panama	78%
Bolivia	65%	Honduras	80%
Argentina	66%	Guatemala	81%

NAME: **Fatima Oyiza Ademoh**

TITLE: **Project Manager, Ajima Farms and General Enterprises Nigeria Ltd**

LOCATION: **Nigeria**

Ademoh says the biogas digester is key to a sustainable system that can unlock productivity for the local economy. Kuje is a "food basket" that produces crops like yam, maize, and rice, and beef from cattle raised both by traditional grazing and more intensively on farms.


© Ajima Farms

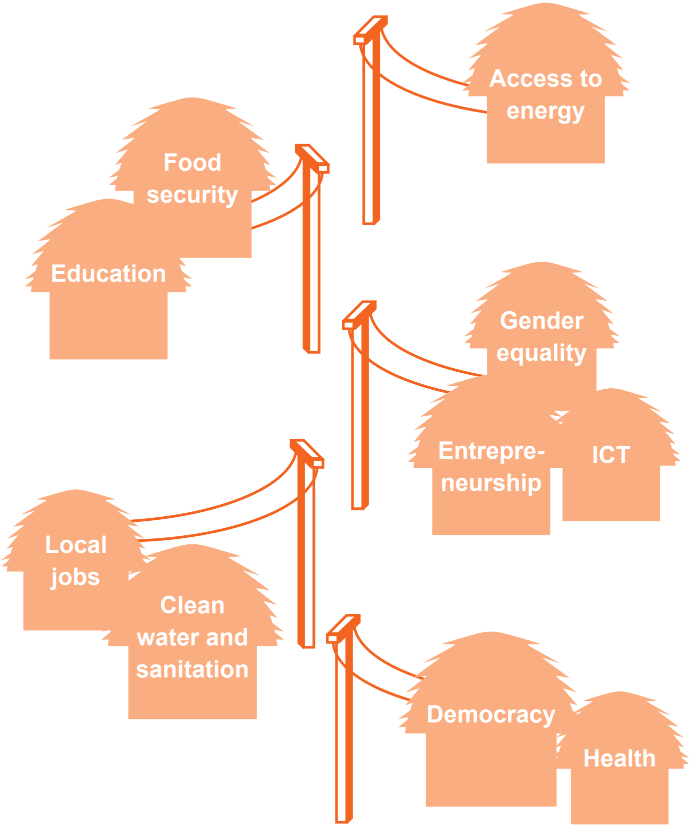
Cattle at Ajima Farms produce hundreds of tonnes of manure per month, waste that would normally be left in the fields producing methane, a greenhouse gas that is a potent contributor to global warming. The need to address the causes of climate change is a strong argument for turning that methane-producing agricultural waste to biogas. When biogas methane is burnt as cooking fuel or to power generators, it is regarded as adding no more CO^2 to the atmosphere than was consumed by plants at the beginning of the food/energy cycle that produced it.

Manure will be transported from the farm to the digester by van —a free service in exchange for a raw material that at this point seems to be in unlimited supply. “We have much more than we can deal with”, laughs Ademoh.

There’s an extra bonus to the system. The by-product of manure processed into biogas is natural fertilizer. “Our fertilizer will be less expensive and healthier than the chemical fertilizer local farmers are advised to use now”, says Ademoh.

That good fertilizer will help farmers be more productive—and electricity from the mini-grid will help them process and store their crops. Ademoh says the price of tomatoes, for example, crashes at the height of the harvest when the crop is plentiful. With refrigeration, farmers can store perishable goods like tomatoes longer and sell them at a better price over a longer period.

6. THE BUILDING BLOCKS OF A "SMART VILLAGE"



7. ACCESS TO ENERGY

What types of energy are available to rural villages?

Renewable energy sources are helping to make smart villages a reality. Many people in rural villages continue to "layer" energy—using fossil fuels and biomass alongside renewable sources. But, as costs of renewables like solar PV continue to decrease, renewable sources give people more options.

Renewable energy can be derived from the sun, wind, water, and biomass (among others) to provide electricity and heat for cooking. These innovations are transforming the way that energy can be distributed—often to the benefit of people who live "off-the-grid" and are most at risk of being left behind.

REN21 recently announced that 2015 was a record year for renewable energy installations. Renewable power generating capacity saw its largest increase ever, and distributed renewable energy advanced rapidly to close the gap between those who have access to energy and those who do not.

Technologies for rural energy

Most rural villages still rely primarily on biomass, such as wood, kerosene, or charcoal for their energy needs. But several technologies have become more affordable in recent years, including solar panels.

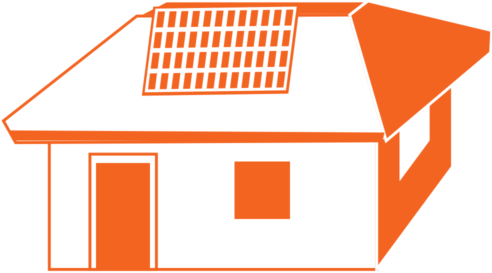
1. Solar panels
2. Biogas
3. Micro-hydro electric
4. Micro-wind electric
5. Improved cookstoves
6. LEDs
7. Low-energy motors
8. DC systems

The first four technologies in this list can generate energy in rural and often remote areas. They include technologies that power lighting, mobile phones, laptops, appliances, and small businesses and agricultural and fishing cooperatives. Other technologies produce heat, generally for cooking but sometimes for hot water. Some technologies, such as the production of a combustible biogas, may be used for both. Solar PV produces direct current (DC) energy, while the other technologies produce alternating current (AC).

Solar panels

Solar panels convert solar radiation to electricity. Companies and researchers around the world are working to make solar panels cheaper, more reliable, and more efficient. Solar panels have taken off in recent years, especially with the availability of solar home systems (SHS) and solar lights in many isolated, rural communities. Solar panels are also used for productive uses, such as solar drying and solar irrigation. Solar thermal systems can be used to heat water for agricultural uses or to sterilise medical instruments.

Power: .5 watts to several kilowatts. Application: Electricity; heating water



Biogas

Anaerobic digestion produces methane gas that can be combusted to produce heat, typically for cooking but also at larger scales to generate electricity. While there are many types of biogas digesters, this section focuses on a fixed-dome batch digester. Biogas technology captures the methane product of the anaerobic (i.e., the process occurs in the absence of oxygen) digestion (i.e. a series of processes that includes the chemical breakdown and fermentation of feedstock facilitated by bacteria) of an organic feedstock. The feedstock used for biogas digesters is often a combination of manure and starchy plants, mixed into slurry with water and fed into the inlet of the air and watertight chamber. As the anaerobic bacteria break down the organic matter, the gas rises to the top of the chamber where it exits by the gas outlet.[7]

To use the methane for cooking, it is generally directly combusted. Methane is cleaner burning than traditional biomass fuel because it produces much less soot and smoke during combustion.

Application: Cooking and electricity generation (e.g., with generator)

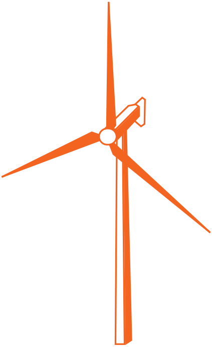
Micro-hydro

Also known as pico-hydro, micro-hydro utilises local streams to generate electricity by mechanically driving a generator. As the water resources that this technology relies upon is a shared resource, it is particularly important to have a high degree of community involvement for successful micro-hydro projects.

Power: 100 watts to 1MW. Application: Electricity

Micro-wind (electric turbine)

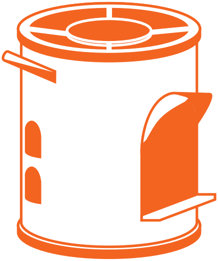
Wind turbines utilise the forces from wind to drive a mechanical rotor, which is generally connected to a generator and batteries. Wind turbines are sensitive to the



variability of wind resources—making properly siting the turbines a task that requires expertise.

Power: 200 watts to 50 kilowatts. Application: Electricity[8]

Improved cookstoves



Improved cookstoves are an important part of the energy picture. One important point is that they can decrease indoor air pollution, a leading cause of death in developing countries. However, there are challenges in terms of the acceptance of new types of cookstoves, standisation and reliable quality and dissemination among other factors.

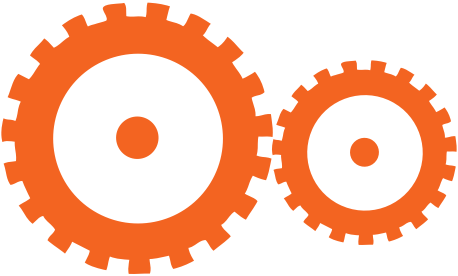
LEDs

LEDs (light-emitting diodes) are a semi-conductor source of light that have made rapid progress in recent years. They typically use 1 to 10 W of power and produce 5 to 10 times as much light per Watt of input power than a traditional incandescent light bulb.

They last around ten times as long as an incandescent light bulb and their price has dropped dramatically. They have consequently revolutionised lighting for both developed and developing countries.

Low-powered motors

Electric motors are key components of many devices, especially those that support rural productive uses of electricity (e.g., pumps, grinders, millers, cooling fans, or compressors). These motors tend to consume large amounts of energy, and therefore are a significant factor in determining the uses to which relatively small amounts of energy can be put. Sizes of motors in devices tend to be driven by cost rather than efficiency—but a change in this focus, coupled with research to further improve the efficiency of electric motors, could yield significant dividends for low-power productive use applications.

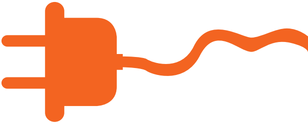


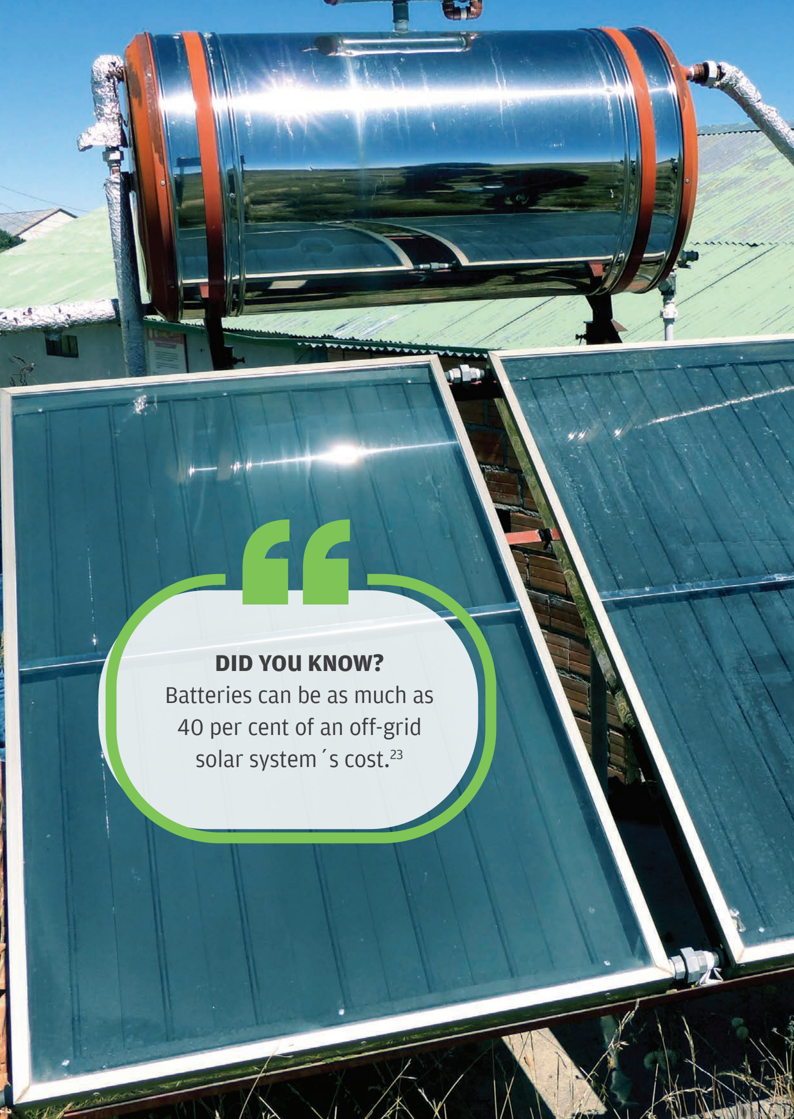
DC applicances and systems

Related to this, many off-the-shelf appliances are designed for use with alternating current (AC), the usual form of supplying electricity through centralised generation and long-distance grids for distribution to households, factories, and other buildings.

However, many of the electrical technologies upon which appliances are based require direct current (DC) electricity. Solar photovoltaic panels that provide electricity for off-grid settlements generate DC electricity already. Micro-grids and other technologies that integrate these DC electricity supplies with DC distribution and DC electrical appliances are likely to have energy efficiency and cost advantages over those which need to convert DC to AC. DC distribution systems, motors, and other appliances are therefore also particularly important areas of research for off-grid rural settings.

All energy technologies require the consideration of technical and socio-political issues[9]. As they require regular operational and maintenance support, developing supporting institutional arrangements is important as are training, education, and spare parts.





DID YOU KNOW?

Batteries can be as much as 40 per cent of an off-grid solar system´s cost.[23]

Off-grid energy: scale and impact

Improving the quality of life in remote, rural areas is frequently the first place energy interventions begin: light, mobile phone charging, and radios. Fortunately, a number of companies have developed “pico-solar lights”, small lights that can be recharged in the sun. These allow children to study in the evening, provide enhanced security, and allow families to buy less kerosene, which means less polluted air at home. Once consumers have used these small lights and trust their quality, they often then want to meet other energy needs, especially phone charging. All of these needs can be met by “solar home systems” (SHS), which can include anything from 1-2 light and phone charging to more complex systems that power radios, televisions, fans, and other small appliances.

While SHS improve conditions in individual homes, communities often find that they need more energy for so-called “productive uses”, such as agricultural processing, ice production in fishing communities, or irrigation. That is where micro- and mini-grids come into play. While they have a more significant upfront cost than a small solar home system, they can dramatically impact the income of a community, improving not only quality of life but livelihoods as well.

Homes: Solar home systems

The performance and affordability of solar home systems and pico-solar lights have made major advances over the last five years. In many countries, they now represent an attractive opportunity to provide households with a basic level of electricity.

These developments have resulted in what are termed “third generation” solar home systems that require one-third the amount of power of older systems to provide a given level of electricity services, resulting in cost reductions of 30–50%. Their weight has been reduced from 50 kg to 6 kg, making the devices more portable, and they are much easier to install.

In East Africa, commercial companies are offering “energy escalator” approaches—households can readily move to higher energy systems when they have paid off their current system and run more appliances, like TVs or refrigerators.

Looking ahead, as solar home systems become more powerful and affordable, and with improvements in energy efficiency and availability of DC equipment, a wider range of productive enterprises will become possible thanks to solar home systems. Until now, solar home systems have improved comfort and living standards but not necessarily livelihoods.[10]

Communities: Micro- and mini-grids

Micro- and mini-grids have a central power source—typically sun, water, wind or biogas—and a distribution network that provides electricity to a village or cluster of villages.

In contrast to pico-solar lights and solar home systems, mini-grids have made rather limited progress. In most cases, these systems have been made possible through subsidies.

Mini-grids tend to cost more than the revenues that they can generate through electricity sales. While there have been many pilots, there is as yet little evidence of significant scale up through commercial or semi-commercial schemes. To "balance the books" in future schemes, costs need to be reduced and/or revenues increased.

Future scientific and technical developments (particularly for solar panels and batteries) together with economies of scale should continue to reduce the cost of mini-grids.

On the revenue side, limits may be set on what can be charged, either by a government requirement to match grid-connected rates in urban areas or by the ability or willingness of villagers in poor rural communities to pay.

In order for villagers to pay more, new money must be brought into the village. Stimulating new productive enterprises and increases in the productivity of existing enterprises was identified in many workshops as a key to the long-term financial sustainability of mini-grids.[11]

NAME: **Avishek Malla**

TITLE: **Director of Engineering and Operations for SunFarmer Nepal, a subsidiary of SunFarmer International**

LOCATION: **Kathmandu, Nepal**

In 2015, Nepal was hit by a series of devastating crises. One earthquake was followed by another, and the year ended with a trade blockade with neighbouring India, depriving citizens of essential fuel and food. Avishek Malla, Director of Engineering and Operations at SunFarmer Nepal, says that even in the most testing of times, the only option is to keep thinking forwards.

A year earlier, Malla co-founded SunFarmer Nepal, a for-profit organisation providing solar energy to rural communities. He met Andy Moon, who co-founded SunFarmer, a non-profit based in the U.S. and Canada, whilst they worked together on a project for a hospital in a remote area in 2012. Moon wanted to build a company which could have more impact on local communities.

Malla had a very defined vision of what this company could be. Whilst in his previous job, he saw how energy subsidies were misused. The Nepalese engineer used to promote solar technology through donor programmes to remote, off-grid areas at the Alternative Energy Promotion Center (AEPC). "One of our major problems in government was that solar companies were not very ethical with the subsidies they were receiving for solar energy", he explains. "They were not maintaining the systems, which were financed by taxpayer and donor money. Subsidies are not long lasting, and we needed a sustainable model, which is why we ask customers to pay a nominal fee, with agreements for five or eight years, with the prerequisite that they maintain their systems".

"There are 2.2 million farmers in Nepal, paying US$2000 for a pump, and they could never in their lives imagine having a solar-powered pump. We started bringing in a bigger range of economical, smaller pumps, and we have created a market for that. The government has seen how international NGOs are supporting us and showing interest". To date, Sun Farmer Nepal has powered 1,884 kWh with their lease-to-own products in the agricultural sector, and a number of solar projects have been developed for farmers in Chitwan, a district full of crops such as maize and rice.

"We think a little bit differently", adds Malla. "We try to see where the needs are. However, it has to be profitable", he adds, acknowledging Sun Farmer Nepal's status as a for-profit subsidiary of Sun Farmer, a non-profit based in New York. "We wanted a sustainable business model, so we took a deliberate decision to be for profit. We want to keep providing energy security with investment returns".

The 7.8 magnitude earthquake in the summer of 2015, followed by a 7.3 earthquake, and the winter trade blockade from India, which provides 70% of Nepalese imports, provided an important space for Malla's team to work in. Disaster relief was a necessity in the mountainous, landlocked country. Today, over a year later, reconstruction work continues to rebuild infrastructure such as health facilities in an epicentre area, energy systems, and water pumps for drinking water systems. There are also projects on community irrigation. In all, 2,550 kWh has been powered in earthquake relief, and a 1.1kW system was built at the Bocha Health Post in Dolakha, which was near the epicenter of the earthquake that struck. "We're slowly rebuilding and taking a vital component at a time, like water, a fundamental need", says Malla. "We are also promoting the technology and the services we can give. We squeeze down our margins with attractive prices and support services. People are suffering".

The energy escalator for off-grid villages in developing countries[12]

Technology	Generation capacity (kW)	Energy sources
Pico-power systems	0.001 – 0.01	Hydro, wind, solar
Stand-alone home systems	0.01 – 1	Hydro, wind, solar
Mini-grids	1 - 1000	Hydro, wind, solar, biomass; diesel; hybrid combinations
Regional grid connection	1000 - 1000000	Gas, hydro, wind, solar PV, biomass

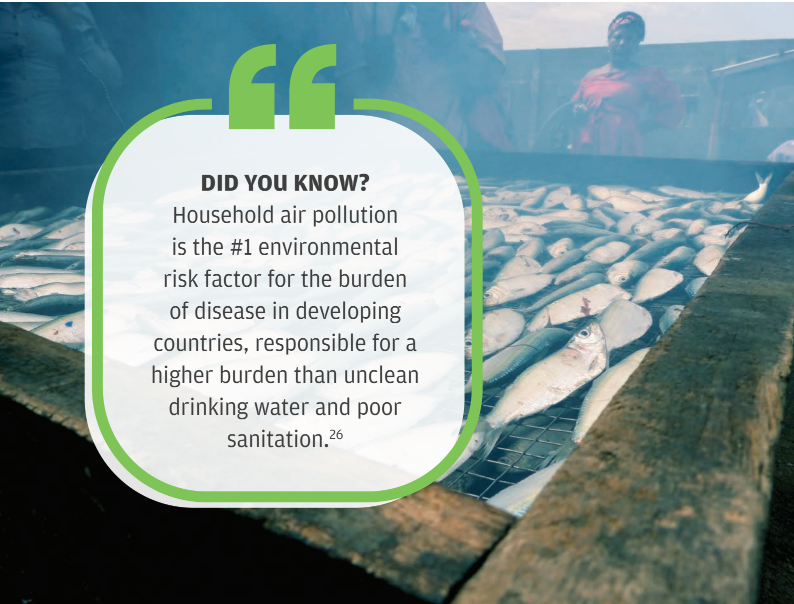
Source: Decentralized energy systems for clean electricity access, by Peter Alstone, Dimitry Gershenson & Daniel M. Kammen. Nature Climate Change 5, 305–314 (2015).

Services available	Estimated economic cost
Lighting, radio communication reception, two-way mobile communication	US$10-100
Same as above plus additional lighting and communication, television, fans, limited motive and heat power	US$75 – 1,000
Same as above plus enhanced motive and heat power, and ability to power community-based services	Medium-large capital cost, low marginal cost to end-user
Assuming high quality of connection, same as above up to a full range of electric power appliances, commercial and industrial applications	Medium-large capital cost, low marginal cost to end-user

What is occurring at the global policy level for energy access?

Governments, the private sector, development banks, and other finance bodies: all of these play a crucial role in improving access to energy throughout the developing world.

Let's begin with the global policy agenda—what role has it played in energy access to date? And what can be done to make policies—and financing—more effective at reaching those in the "last mile" who are at risk of being left behind?



DID YOU KNOW?

Household air pollution is the #1 environmental risk factor for the burden of disease in developing countries, responsible for a higher burden than unclean drinking water and poor sanitation.[26]

No one left behind: Sustainable Development Goals[13]

Heads of State and Government and High Representatives met at the United Nations Headquarters in New York in September 2015. Their 2030 Agenda for Sustainable Development set what they called “a supremely ambitious and transformational vision”, which recognised that eradicating poverty, including extreme poverty, is the greatest global challenge and a requirement for sustainable development. They pledged that *no one will be left behind*. This is a central principle of smart villages.

Given the adoption of the Sustainable Development Goals (SDGs), the most important timeline is from now until 2030, as described in the United Nations’ 2030 Agenda for Sustainable Development.[14] The SDGs both build upon and depart from the Millenium Development Goals, particularly given their universality. Countries in both the global north and south will need to make changes, not only so-called developing countries.

Features of smart villages appear repeatedly in the new 17 Sustainable Development Goals (SDGs) and 169 targets placing the concept firmly on the international agenda, recognising the catalytic impact of energy on development. The concept and establishment of “smart villages” provides a much-needed way of integrating all these interconnected goals.

The aim of the 2030 Agenda is to stimulate action over the next thirteen years. While Goal 7 specifically focuses on "Affordable and clean energy", all the SDGs are relevant for smart villages—and each SDG is linked to energy:

All the SDGs are relevant for smart villages

1. **Poverty**: Almost 50% of the world's population, and more than 70% of the world's poor, live in rural areas. Without rural development (which requires energy) they will either remain in poverty, or be forced to migrate to urban or peri-urban settings, where they will continue to be disadvantaged.

2. **Hunger**: Poor harvests can devastate a village. Villages are often the breadbaskets of their countries. Energy access and the resulting opportunity for economic engagement make rural communities better able to withstand shocks such as harvest failures. Energy also allows them to harness innovative technologies to enhance agricultural returns, e.g., through irrigation, access to the latest agricultural information, and post-harvest processing for value-addition.

3. **Health and well-being**: Provision of public health services at village level, including vaccines, safe childbirth, up-to-date health information and access to diagnostics, is only possible through availability of energy, for lighting, refrigeration and access to health-related ICT

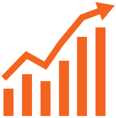
4. **Quality education**: Apart from the power of modern lighting to enable students to study after sunset, rural education can be improved with the use of ICT, giving rural students the same opportunities to access information skills as their peers in urban areas

5. **Improve gender equality**: Women are disproportionately affected by the lack of access to modern, clean energy, including indoor smoke pollution from cookstoves, and having to gather firewood daily. Energy access is not a cure all, but it can enable women to become entrepreneurs, to access education, and to help girls see their future opportunities.

6. **Clean water and sanitation**: Energy can help to purify water and provide better sanitation.

7. **Affordable and clean energy**: Achievement of this goal is critical for achievement of all of the SDGs. This is where Smart Villages have an important part to play in rural communities for the 1.1bn without electricity.

8. **Decent work and economic growth**: Rural communities can thrive when there is sufficient energy for "productive uses" such as adding value to agricultural products,



decreasing post-harvest losses, or starting small local businesses.

9. **Industry, innovation, and infrastructure**: Like cities, villages benefit from improved infrastructure and innovation in which energy is often a critical component, especially when sustainability and resilience are required.
10. **Reduced inequalities**: When a village is “smart”, villagers will all have opportunities to better their lives, and importantly will be able to access the same sorts of services (health, education, finance, etc.) as their peers in urban areas, reducing the urban-rural inequality divide.
11. **Sustainable cities and communities**: Smart villages can help to stem the flow of people to cities. But although much of the focus within this goal is on cities, it does refer to all types of human settlements. With almost half the world’s population not living in cities, there is also a need to make underserved villages and other rural communities safe, resilient, and sustainable. This cannot be achieved without access to energy.
12. **Responsible consumption and production**: A critical part of sustainable consumption and production is the ability to harness modern technologies and the availability of information.

This can be achieved at rural levels too, but only if energy is available. This also allows recycling to be carried out more meaningfully in a smart village

13. **Climate action**: Many energy technologies for off-grid villages are renewable or low-impact (e.g., hybrid diesel, solar, hydro, wind, clean cookstoves). And often they replace alternative technologies which have a higher climate change impact (e.g., kerosene lamps, inefficient cookstoves).

14. **Life below water**: Many island and coastal communities who act as custodians of marine ecosystems rely on fishing and tourism for their livelihoods—both of which require energy.

15. **Life on land**: Most villages rely on agriculture for their livelihoods, which access to energy can greatly improve. Furthermore, rural communities are typically the best custodians of their local ecosystem and biodiversity—energy can help them in this role by providing access to information and knowhow, as well as by making those communities more sustainable and resilient.

16. **Peace and justice**: Access to information via ICT can improve awareness, democratic participation by using such technologies as

electronic voting systems providing the ability to engage in national debate.

17. **Partnerships for the goals**: Villages cannot do it alone. They need energy to make their voices heard and to achieve sustainability or meaningful development.

Sustainable Energy for All (SE4ALL)[15]

In 2011, UN Secretary-General Ban Ki-Moon launched SE4ALL saying that "energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive."

How can governments, business, and civil society, working in partnership, make sustainable energy a reality for all by 2030?

This is a central question for SE4ALL, which has three primary goals:

- providing universal access to modern energy services
- doubling the global rate of improvement in energy efficiency
- doubling the share of renewable energy in the global energy mix[16]

SE4ALL views these three goals as mutually reinforcing, and states that "achieving the three objectives together will maximize development benefits and help stabilize climate change over the long run".[17]

It supports bringing modern energy technologies "to rural communities where extension of the conventional power grid is prohibitively expensive and impractical".

SE4ALL exists to provide a global vision, utilise the "convening power" of the UN and World Bank, mobilise stakeholders "around best practices and support the adoption of innovative solutions", and help to create the conditions that will "enable a massive scale-up of private investment in energy access and clean energy".[18]

Though 173 countries have renewable energy targets in place, and 146 countries had supportive policies by 2016, energy access remains a challenge.

Beyond the SDGs and SE4ALL, many programmes and projects exist for rural energy that are funded through the overseas development assistance (ODA) of individual countries and groupings of countries, such as the European Union—far too many to list in this short pocket guide. Moreover, the governments and civil society organisations of developing countries such as the Bill and Melinda Gates Foundation, USAID, and GIZ to name a few. They play a crucial role in setting their own priorities for development in line with the SDGs.

Top 10: OECD's Development Assistance Committee members (total amount devoted to overseas development assistance in 2015)[19]

European Union – $87.64 billion (EU Institutions $13.85 billion, EU member states $73.80 billion)

United States – $31.08 billion

United Kingdom – $18.70 billion

Germany – $17.78 billion

Japan – $9.32 billion

France – $9.23 billion

Sweden – $7.09 billion

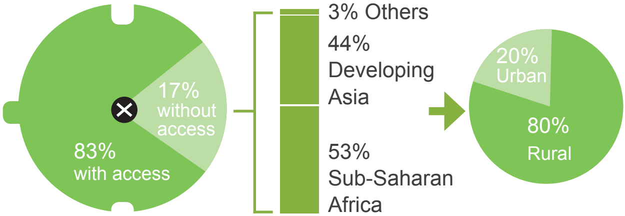
Netherlands – $5.81 billion

Canada – $4.29 billion

Norway – $4.28 billion

Italy – $3.84 billion

World electricity access and lack of access (2013)



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http://www.altenergy.org/renewables/renewables.html

NAME: **Moni Gupta**

TITLE: **Co-founder of Mobile Education for Smart Technology**

LOCATION: **India / Cambridge, UK**

Today, Moni Gupta is a PhD student in chemistry at the University of Cambridge. But she remembers her time as a child in India, where she had limited access to computers in school. So she sees herself in the students she interacts with through Mobile Education for Smart Technology, a non-profit organisation she co-founded. The project introduces village boys and girls to computers, in some cases for the very first time.

The group started in January 2015, when the Smart Villages Initiative challenged Cambridge graduate students to come up with a project that would contribute to rural development. Gupta says her mind went straight to the lack of computers in Indian schools, and she found others who wanted to focus on the same issue. That group formed the core of the project.

Next, Gupta recruited two partner organisations. The first, the Cambridge-based Madanyu, had developed the idea of using a tiny, open-source computer called Raspberry Pi as an educational tool. The simple computers are about the size of a deck of cards and connect easily to devices like monitors, keyboards, and cameras. For Gupta's group, Raspberry Pi units offered several advantages: they cost only US$40 to US$65 each; they were sturdy and needed little maintenance; and they ran open-source software that village schools could use for free. The workers at Madanyu trained Gupta and her colleagues in how to use the systems.

The other partner, Agastya, was based in India and ran a sprawling 170-acre campus in the southern Indian province of Andhra Pradesh. Agastya specialized in rural education, and offered to host the computer classes Gupta's team planned to run.

In September 2015, Gupta and four other team members arrived in Andhra Pradesh to conduct a two-week programme. They brought 37 Raspberry Pi units purchased with a grant of about US$4,000 from the Smart Villages Initiative. Half of the team taught classes at the Agastya campus, while the other members traveled to a nearby village and taught from a classroom in the


© Mobile Education for Smart Technology

local school. Then, during the second week, the team members focused on training local teachers, who led the classes themselves.

Although the Raspberry Pi computers were simple, students were able to explore a wide variety of tasks, including word processing, mapping, and writing code in the Python language. The students also got an introduction to scientific databases, in a project where they recorded and graphed the results of repeated bottle-rocket launches.

Because boys are often raised to be more outgoing than girls in the local culture, Gupta found that they often approached learning more aggressively, while the girls tended to stay quiet. Her team addressed this by organizing the students into groups that contained both genders, and setting up lessons that forced all the students to participate. “We tried to empower both at the same time and build confidence among the girls,” Gupta said.

8. What are the challenges and solutions for energy access in "smart villages"?

Financing and credit, policy and regulation, standardisation and quality standards: all of these are crucial for creating smart villages. Governments, small and medium enterprises, venture capitalists, angel investors, development banks, and other actors in the financial sector all play important roles.

Financing and ability to pay

One of the greatest challenges remains financing for energy and the communities' ability—and sometimes willingness—to pay. In the case of solar home systems (SHS), a decentralised energy option for lighting, phone charging, fans, and TV/radio, companies have made inroads. Consumers like the "pay as you go" (PAYG) concept and see that it is sometimes cheaper than paying for weekly kerosene.

Access to finance

Access to finance and credit remains one of the biggest challenges for off-grid energy, both for entrepreneurs creating off-grid energy businesses and for consumers.

The lack of access to financing is faced by businesses focusing on mini-grids, solar home systems, and improved cookstoves.

FAST FACT:
89 per cent of people in rural sub-Saharan Africa live without electricity, which is more than twice the proportion (46 per cent) in urban areas.[24]

Energy entrepreneurs

Energy entrepreneurs are not well-understood by banks, which find it difficult to calculate their viability and risk. These entrepreneurs rely on grants and angel investors to get off the ground and prove their business models work. For solar home systems, the amounts required get large very quickly as each installation costs US$250-500. In a PAYG model, capital investment needs to be covered by the company, too. Companies also need technical, marketing, organisational, and finance capabilities. A challenge for energy entrepreneurs is that they must also assess the credit worthiness of consumers—not an easy feat in remote rural villages.

Business models remain a crucial aspect for the success or failure of energy entrepreneurs' work. Often starting with a great idea and passion, many entrepreneurs find that their knowledge of market research, cultures, finance, or the red tape of regulation needs to be improved. This is where both governments and the private sector can play a crucial role in building small companies' capacity and helping them to grow.

Consumers

For consumers, the PAYG model has been very important—it has allowed them to access solar home systems. Consumers are able to pay in small, frequent amounts—

similar to the way they have been paying for kerosene. Depending on the system they choose, consumers usually have lights and may also have mobile phone charging, and a radio. Others are upgrading to systems that can support TVs, fans, and even refrigerators.

The need for more power

When we think of powering a whole village, and particularly businesses that add value to agricultural products, fishing cooperatives, or other types of “productive use” of energy, solar home systems cannot reach the levels of power necessary for many of these activities.

As in the case of Terrat, a village in Tanzania, a system for powering local businesses is crucial for the local economy. Mini- and micro-grids can be powered by biodiesel / biofuels, solar energy, hydroelectric energy, wind energy, etc., at times combined with diesel generators in hybrid systems.

But despite the many options for powering a decentralised grid, this is the point at which financing becomes truly challenging, as the upfront capital cost for a mini-grid or micro-grid tends to be too high to attract investors, and the pay-back period too long. As the prices of batteries and other elements continue to drop, mini- and micro-grids may become more affordable and profitable.

What can governments do to encourage energy access—a building block of smart villages?

This is the point at which financing, policy and regulation intersect, as national, regional, and local governments must prioritise the energy needs of rural residents as well as urban centres.

All levels of government take actions to help people in rural areas to improve their lives as this will not only help those in rural areas—it can also help to increase the quality of life in crowded urban areas as well as reducing the pressure from rural-urban migration.

- Develop and implement policies for off-grid rural electrification and improved cookstoves: take action.
- Make their countries business-friendly to small- and medium-enterprises (SMEs) in the energy sector: remove red tape.
- Be ambitious in rural communities. The basics of life are not enough.
- Better integrate national grid and off-grid planning to avoid undermining private investors who put their money into off-grid initiatives.

By finding ways to support solar home systems and mini- and micro-grids in far-flung communities, they will also support the education, health, and livelihoods of rural residents. But this needs to be part of a cross-cutting priority programme for development in rural areas, combining energy with education, healthcare, ICT, and infrastructure.

Rural or urban? This should be a choice, not an ultimatum.

Remoteness—out of sight, out of mind?

Remoteness remains a major challenge for communities that lack energy access. Whether in Amazonian forests, the mountains of Nepal, or the deserts of Kenya, the people most at risk of being "left behind" are often those in remote areas. And this remoteness is not necessarily a question of distance—it is frequently related to infrastructure, such as a lack of roads or poor roads. Climate and weather also plays a role, especially for mountain communities that may be difficult to reach during snowy or inclement periods.

Investment in infrastructure is one way to ensure that people are not being left behind—and indeed, have improved opportunities:

- Improved roads help communities to become less isolated.

- Energy for charging mobile phones helps people to stay in touch with information, including relevant updates (such as agricultural and weather information) via SMS and radio.

- More broadly, infrastructure for information technology will be important for villages, especially as new technologies make wifi more accessible, such as Microsoft's work on using television "white spaces"[20] for connectivity and on-going research on wifi from light, or "lifi".[21]

Capacity building

A lack of skills (technical and business) and institutional capacity are major challenges for creating energy access and ensuring that the access remains in the long-term.

- Training programmes should be put in place to fill the gaps: they may need to be ongoing activities rather than one-off events.

- Local people can install, operate, and maintain energy technologies—training is needed at all levels from local technicians, to engineers, product designers, and university researchers.

- Local entrepreneurs need advice and guidance in how to run successful businesses. This requires support from both the private sector and the government.

Quality control and counterfeit goods

Counterfeiting remains a problem, particularly for solar technologies. Counterfeit, unregulated solar panels or solar lanterns are on the market. Consumers buy them only to see them break after only a short time. The ease with which a counterfeiter can pretend to meet standards—or indeed, take advantage of the lack of standards—for solar panels and other technologies reduces consumer confidence and destroy potential markets. In each of these areas, governments need to become more active and improve consumer protection. This in turn supports SMEs in the energy sector who do not need to re-create consumer confidence from scratch.

Giveaways

Many examples exist where the free distribution of pico-solar lights and solar home systems had “spoilt the market”, undermining the business activities of local entrepreneurs and creating an entitlement mentality that jeopardises the prospects of future commercial initiatives. If people are given something for free, they tend not to value it, and it usually falls into disuse.

The ability and willingness of households to pay is often underestimated. The focus should be on the long-term sustainability of household energy initiatives—free handouts should be avoided.

NAME: **Ron Bills**

TITLE: **CEO, Envirofit**

LOCATION: **Across the developing world**

Ron Bills is Chief Executive Officer and Chairman of the Board for Envirofit, a global social enterprise that has revolutionized the way we think about energy access and development and, more importantly, household cooking. Envirofit stoves are designed to reduce indoor air pollution, a major environmental and health hazard that kills more people than HIV, malaria, and TB combined. Over the past 14 years, Envirofit has served more than 5 million people in East Africa, West Africa, Asia, and Latin America.

Envirofit started in 2004 with engine retrofit kits in Southeast Asia, changing from carburetors to direct injection, a switch that cut emissions by 70% and reduced the amount of fuel used by 35%. In fact, that's where Envirofit first got its name, as a portmanteau of "environment" and "retrofit." But Bills began to think about the ubiquitous cookstove, used by half the world's population who burn biomass for fuel on a daily basis—wood, charcoal, cow dung, and agricultural waste—and the indoor air pollution and health and environmental problems that result from it. There was a huge market opportunity here, he realized, that no one was focused on.

Soon a pilot program in India was designed to learn from many of the failures Bills had seen in the past. Too many products, he explains, are designed in a lab and then go straight to market.

But designers are "too close to the product" and often have fatal flaws because they don't anticipate particular consumer needs or habits. "We learned," Bills explains, "that we don't have the best ideas—our customers do. We have to listen to them." So, he and his team spent a great deal of time and money on understanding what customers need, and also what they like.

Bills says he is guided by this principle: "people want to be treated as customers, with dreams, desires, and aspirations, not as aid recipients." The growth and success of Envirofit—with 5 million customers served—is a testimonial to Bills's business acumen, earning him the recognition of 2016 Schwab Entrepreneur of the Year.

9. Energy and gender: How can energy access help rural women?

Energy access can help to transform the lives of women in remote, rural areas. When women have access to energy for cooking and for their livelihoods, frequently in agricultural work, they can gain time, earn money, access education, improve their health, and, perhaps most importantly, become empowered.

Time and drudgery

In many rural communities women are responsible for gathering firewood and cooking and basic subsistence tasks. Access to modern energy services can save 1 to 4 hours daily in cooking, fuel collection and food processing. Freeing up women's time from arduous tasks can allow them more time for educational, social, and income-generating activities.

Violence against women

Around 40% of women in sub-Saharan Africa, South Asia, the Middle East, and North Africa have experienced physical/sexual intimate partner violence. Increasing women's bargaining power through resource ownership and entrepreneurship can help protect women from spousal abuse. Electricity and energy provision can also restrict the area of vulnerability to sexual violence and assault by reducing the need for firewood collection (involving long journeys to remote areas) as well as by providing street lighting allowing for a greater sense of security.

Education

Women account for two-thirds of the world's 774 million illiterate adults. Electricity, particularly when associated with modern information and communication technologies, can substantially enhance the quality of education that can be provided in rural villages. Access to light also means increased time for studying and the potential to participate in adult evening classes. Girls who are no longer required to help their mothers with survival activities can attend school.

Gender roles and women's empowerment

By allowing more time for leisure activities women's mobility and participation in the community can be enabled. Energy access can also heighten gender awareness through television with women becoming more aware of gender equality issues by seeing images of empowered women and a vision of gender equality.

Health

Provision of clean energy provides benefits to women's health. Women and girls spend more time cooking over smoky traditional stoves than their male counterparts: use of clean cook-stoves and fuels minimises indoor air pollution and the associated ill-health and mortality of women. In addition, energy provision can improve the safety and working of health clinics, which can keep vaccines cold and provide light to help the safe delivery of babies at night. The reduction of arduous work can also reduce risks of injury and exhaustion.

Entrepreneurship

Access to energy can enable women to set up new, or expand existing, income generating activities. As a result women can gain an income outside the household (although they may not maintain control over this resource), enhance their social/political status, expand their ability to take a greater role in decision-making in the household, and participate in community life. Becoming entrepreneurs can also increase women's self-worth and confidence as well as challenging traditional repressive gender norms of labour. In terms of income, women's micro-enterprises such as knitting and beer brewing can benefit from extended working hours through access to lighting. The availability of mechanical and heat process technology can also contribute to the start-up and efficiency/productivity of these small-scale industries.

NAME: **Paras Loomba**

TITLE: **Founder, Global Himalayan Expedition**

LOCATION: **Himalayas**

When asked about his inspiration to work in remote areas, Paras Loomba said, "I was watching a documentary when I saw a world famous explorer, Robert Swan". He learned that Swan led a group of young entrepreneurs every year to Antarctica to raise awareness about climate change. But there was a catch: he has to raise US$20,000 to join this expedition. At first, it seemed insurmountable, but he managed to raise the funds. He went on the expedition and returned inspired. But upon his return, he also asked himself "what should I do with my life?"

Fast forward to June 2013: he decided to make a solo trip to Ladakh, situated at 12000 feet in the Himalayas, and trekked to some of the remotest villages in the valley. He thought about leading a similar expedition to this very remote area—especially when he realized the need for basic education and energy: "it touched me. I needed to follow my dream," said Loomba. He called Robert Swan and asked him to inaugurate his first expedition in Himalayas.

As part of his first expedition in 2013, Paras created an "Education Base", which would serve 500 students from 70 remote Himalayan villages with little or no infrastructure, such as water or light.

These students would learn how to implement hands-on clean energy and water projects for their villages.

But the next year, he had a new idea for a way to generate income both for the villages and for Global Himalayan Expedition (GHE): impact tourism. He believed that an expedition could create an innovative way of bringing energy and income to the remote Himalayan villages.

In 2014, he carried out a survey of 10 villages, looking for an energy solution that would be best suited for their needs. A direct current (DC) solar micro grid was eventually chosen because DC will be non – fatal and will not provide electric shock to people. In addition, there were customized LED lights working on DC. In this process, he learned that the government actually had no plans for energy in these small villages, many of which are up to 2,000 years old and require a trek from 1-10 days with 17,000-18,000 feet mountain passes. When India gained independence, the Prime Minister promised water and light for everyone. But "65 years later, there was no sign of what we heard".

In 2015, GHE electrified nine villages in three months as well as a pilot village. The biggest difference for the villages?: the income level increased. Trekkers used to camp outside homes, but now, as part of impact tourism, they are welcomed into villagers' homes and pay US$11 per night for a room and a meal. Two of the nine

villages that have been electrified were chosen as pilots for income generation. Handicrafts are also an area of potential income generation—but getting them to the market remains a challenge.

Other villages have started to get in touch, requesting that GHE comes to their villages. "You want the community to value it; they should ask for it". He added, "if you do anything good, it spreads; if you do anything bad, it also spreads". Ultimately, he says, "you need to take a leap of faith if you want to be a game changer."

FURTHER RESOURCES

Smart Villages' "Energy Entrepreneurs" series: http://e4sv.org/stories/energy-entrepreneurs/

Smart Villages' publications on energy across the global south: http://e4sv.org/resources/

Sustainable Energy for All: http://se4all.org/

International Renewable Energy Agency (IRENA): http://www.irena.org

Practical Action: http://practicalaction.org/

Energia: http://www.energia.org

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Global Alliance for Clean Cookstoves: http://cleancookstoves.org/

Energy4Impact: http://www.energy4impact.org

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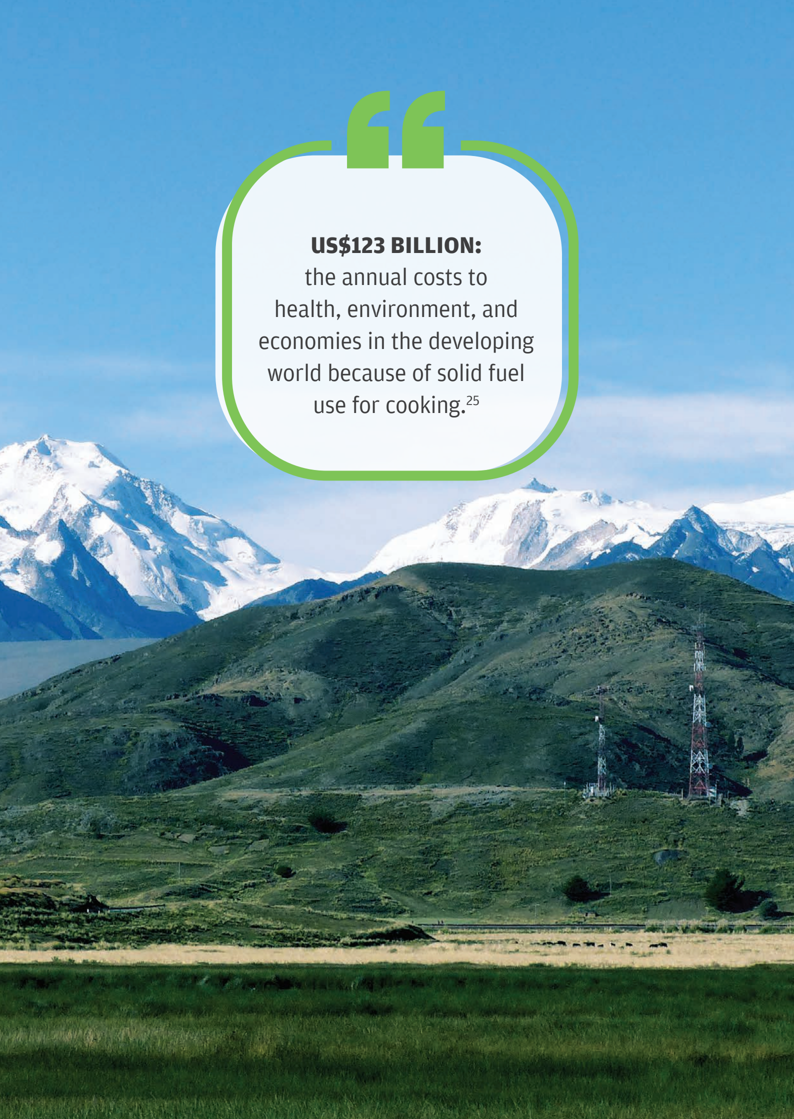
US$123 BILLION:
the annual costs to health, environment, and economies in the developing world because of solid fuel use for cooking.[25]



Women and girls smoke fish on a Sunday. A fish smoking project with improved cookstoves has been established by SNV in a coastal fishing community.

SMART VILLAGES
New thinking for off-grid communities worldwide