Brief

Power to change the world

WGSI

Waterloo Global Science Initiative

PERIMETER PI INSTITUTE FOR THEORETICAL PHYSICS

UNIVERSITY OF WATERLOO

Contents

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Founded in 2009, Waterloo Global Science Initiative (WGSI) is a non-profit partnership between Perimeter Institute for Theoretical Physics and the University of Waterloo. WGSI's mandate is to promote dialogue around complex global issues and to catalyze the long-range thinking necessary to advance ideas, opportunities and strategies for a secure and sustainable future. The organization's core activities include its Summit Series, Blueprints, Fellowship for young leaders, and a range of impact activities programmed around each summit topic and its outcomes.

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Executive Summary

The world's population is now served by a vast global energy system, but there are significant gaps in provision. In 2016, more than a billion people still have no access to electricity. This is a situation that must be remedied as access to modern electricity services is the gateway to addressing many issues of inequality in health, education and economic opportunity.

Traditionally, communities have gained access to electricity through extension of existing power grids connected to large, centralized electricity generation plants. While there is some scope for further improving electricity access in this manner, large numbers of communities will remain unserved by following only this model. That might be because of their economic situation (they don't have the means to pay); their geographic location (they are too remote to make a grid connection economically or logistically feasible); or political (they are not influential enough to persuade the relevant authorities to build the required infrastructure).

In recent years a combination of new technologies, economic models and facilitating programmes has begun to change this situation. Innovations that harness plentiful, renewable sources of energy have allowed energy isolated communities to access technologies that range in scale from small solar lights that can replace kerosene lanterns and candles to smart mini-grids that can power entire villages. Thanks to such breakthroughs we are now in a position to provide the energy services that can bring a huge percentage of the world's population out of persistent poverty.

This potential revolution in energy access is not assured. Indicators suggest that, if things continue as they are, it will certainly not happen at a speed and scale required to achieve the United Nations Sustainable Development Goal 7: ensuring access to affordable, reliable, sustainable and modern energy for all by 2030. Meeting this goal requires purposeful co-ordination of a dedicated worldwide effort involving a range of institutions and individuals from the local to the global.

The partners engaging in this effort will need to be extremely diverse. They will include technologists who can increase the efficiency and affordability of new technologies and energy systems; public agencies that create an enabling environment to encourage decentralized energy distribution models and reduce the risks associated with private investments in new projects; entrepreneurs who can develop new models for distributing and selling energy services to customers in highly diverse contexts across the globe; the expert community to share knowledge and best practices across domains to train a generation of implementers and champions of new decentralized energy systems.

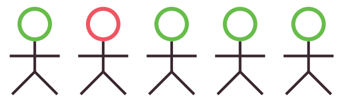
We do not know the full scope of what will be required to successfully implement SDG 7. If we are to improve the prospects of over a billion people in attaining access to electricity, we will need to understand, refine and develop current ideas, and create new partnerships that can catalyze breakthrough innovations and forge novel, creative alliances within the emerging decentralized energy space. This is the aim of the WGSI OpenAccess Energy Summit. In such a complex, interlinked yet diverse arena of global development, assembling and connecting the key players, including experts and future leaders, is a necessary first step towards delivering meaningful change.

Introduction

1.1 billion

people in the world without access to reliable, affordable energy

or approximately



1 in 5

Despite many decades of global efforts directed at mass electrification, we have failed to deliver modern electricity services to approximately one-third of the people on Earth. 1.1 billion people continue to live without access to electricity. A further billion have unreliable access.[1] According to the International Energy Agency's most optimistic scenario for future energy access, the number of people worldwide without electricity in the year 2030 is projected to remain above 1 billion. In Sub-Saharan Africa the problem is projected to get worse, not better. The fact that population growth is outstripping electrification means that by 2030 the number of people without electricity will have risen by 10% (16% in rural areas) from 2009 levels.[2] Clearly, our approach to opening up energy access has to change.

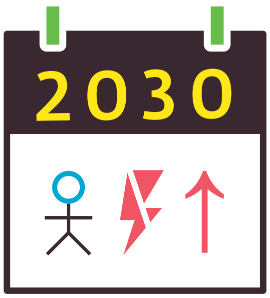
There is good reason for making a renewed effort. Access to electricity can open up economic and educational opportunities, eliminate the drudgery of hard manual labour and bring vast improvements in health care. These are only some of the reasons the UN has made ensuring access to affordable, reliable, sustainable and modern energy for all by 2030 one of its Sustainable Development Goals (Goal 7).[3]

Unfortunately, we are not on track to meet this goal. Although governments, NGOs, communities and researchers all over the world are trying to solve the problem of access to energy, the scale of the problem is far bigger than the pace and scale of current solutions.

This sobering scenario provides the rationale behind the Waterloo Global Science Initiative (WGSI) OpenAccess Energy Summit, to be held in April 2016. At a pre-Summit workshop held in October 2015, a group of assembled experts defined success in the following terms:

> *"The end goal is to improve well-being through the transformative change modern electricity services provide. We will identify and catalyze the strategies and actions necessary to sustainably provide the energy-isolated with reliable and affordable access to modern electricity services. This will be made possible by harnessing current and emerging science, technology and social innovations, and considering short, medium and long-term timeframes."*

1. IEA. (2014). World Energy Outlook 2015. International Energy Agency
2. IEA. (2014). Scenarios and projections. International Energy Agency
3. UN. (2015). Sustainable development goals. United Nations.



By 2030, in Sub-Saharan Africa,
the number of people without electricity will
increase 10%

WGSI's goal, then, is to create the necessary space for alignment of different organizations and disciplines to deliver effective solutions. Our organizational impact comes from fostering connections between individuals and stewarding the development of strategic partnerships to meet the global energy access challenge. Although an enormous amount of research has been carried out in the energy access space, questions and uncertainties about the best paths to progress remain, especially in the translation of research into action.

In any 'grand challenge' scenario, many efforts are unknowingly duplicated and valuable ideas are lost in the silos of disciplines. WGSI's expertise lies in convening facilitated conversations to advance breakthrough thinking, and the summit will address the global energy access challenge by bringing together a multidisciplinary, multinational, and multigenerational group of stakeholders for a four-day intensive event to develop an actionable framework for addressing this complex global issue.

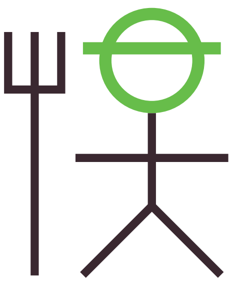
To prepare for the summit, WGSI is working to identify knowledge gaps and challenge assumptions in order to select a handful of specific challenges that WGSI has the capacity to address through its activities. The first move has been to create a specific focus for our efforts. Meeting SDG 7 is a multifaceted problem with many paths towards possible solutions. The problem space to be addressed at the summit must be narrowed down to areas where we think that we can make a real difference. Our focus is therefore on access to decentralized low-carbon electricity. This brief will not address access to improved fuels and clean cook stoves, a closely linked area that is the focus of a number of other initiatives.[4]

This document aims to provide a review of current global efforts across the electricity access landscape and serve as a foundation from which a team of experts will identify knowledge gaps, question assumptions about solution approaches and then formulate a plan for making meaningful progress in opening up electricity access.

4. Global Alliance for Clean Cookstoves. (2015). Our mission. Global Alliance for Clean Cookstoves.

2. Energy As Opportunity

Access to energy changes lives, communities and nations



In the developing world
agriculture accounts for:

29% of GDP | **65%** of the labour force

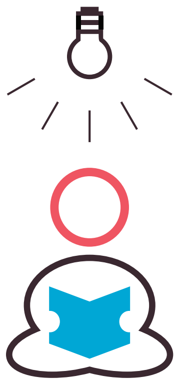
Energy matters. As United Nations Secretary General Ban Ki-Moon has remarked, "energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive."[5] It isn't hard to find examples that support his argument. African families who were able to switch from kerosene to solar powered electric lighting, for example, have found that the switch saved them an average of $70 USD per year. The most common uses of these savings? Education for their children, improvements to their agricultural business and better food.[6]

Agriculture presents a particularly impactful opportunity for immediate and significant improvements to life in the developing world. In these regions, agriculture accounts for 29% of GDP and 65% of the labor force. Lack of energy significantly impacts agricultural yields due to constraints on irrigation, equipment – both maintenance and operation – and the opportunity to add value to produce through post-harvest processing.[7] With access to modern energy services, rural areas can benefit from increased yields, a cold-chain infrastructure that reduces waste, and information technologies that manage agricultural supply chains and connect producers with markets.[8]

In business more generally, access to electricity can mean the difference between closing a shop at sundown, or keeping it – and the economic opportunities it creates – open into the evening. It means accessible power for the commercial and industrial equipment that can help pull entire communities out of persistent poverty. At home, being able to use electrical appliances can significantly save time and effort, allowing individuals the opportunity to earn income elsewhere and escape the trap of a subsistence lifestyle.[9]

When it comes to education, the impact of access to electricity is extremely significant. Today, only about 50% of students from families in the planet's lowest income quintile attend primary schools that are connected to the grid.[10] Schools without electricity access are unable to stay open for after-school programs once the sun goes down, or in conditions of extreme heat or cold. Without electricity, schools are also unable to utilize information and communications technologies (ICT) such as computers and the internet.

5. UN. (2012). Sustainable Energy for All: A Global Action Agenda – Pathways for Concerted Action Toward Sustainable Energy for All. United Nations
6. SolarAid. (2013). Impact report. SolarAid.
7. Utz, Veronika. (2011) Modern energy services for modern agriculture: A review for smallholder farming in developing countries. In Poverty-Orientated Basic Energy Services. Deutsche Gesellschaft für Internationale Zusammenarbeit.
8. Swaminathan, M.S. & Kesavan, P.C. (2015). Energy security and food provision in off-grid villages. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
9. Leopold, A., Stevens, L. & Gallagher, M. (2014). Poor people's energy outlook 2014. Practical Action.
10. González Diaz, J. (2015). Energy and ICT for educational inclusion in Latin America. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.



Today, only about

50% of students

from families in the planet's lowest income quintile attend primary schools that are connected to the grid

An immediate benefit of even basic ICT capabilities is better tracking of students' educational attainment over time and across communities and regions.[11] In the long-term, there are high hopes that the effective adoption of these technologies will significantly improve teaching and resources for education in the developing world, especially when it comes to science and mathematics, subjects that make a huge difference to future income.[12 13 14 15] Access to ICT will allow students to be able to conduct their own research, and teachers to build better lesson plans that draw upon knowledge beyond what is available in their often isolated communities. This is in large part due to the benefits of being able to access knowledge via the internet and other information networks. These can be reached through the mobile phones that are already commonly used throughout the developing world.

However, the educational benefits of electricity are not limited to the classroom. When students do not have electricity in the home, it reduces the time available to them to study and do homework. Early studies, including interviews with African teachers, have indicated that students in households where electric lighting is adopted tend to spend more time doing homework at night, have improved attendance records, and are more motivated in school.[6 16]

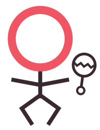
Electricity is also a driver of improved public safety. Street lighting and lighting in homes and community buildings improve safety at night, especially for women, who can become housebound after dark because of the increased risk of sexual assault. Lighting can also reduce the threat of attack by dangerous animals. Around-the-clock electricity for public buildings such as police and other emergency service stations (and their training institutions) creates access to these vital public safety services for longer hours and improves service quality.[9]

Then there is the radical improvement to community health that electricity brings. Startlingly, the World Health Organization estimates that globally, there are 4.3 million premature deaths per year that can be ascribed to the indoor air pollution resulting from use of traditional sources of

11. Hennessy, S., Ang'ondi, E., Onguko, B., Namalefe, S., Harrison, D., Naseem, A., & Wamakote, L. (2010). Developing the use of Information and Communication Technology to enhance teaching and learning in East African schools: Review of the Literature. Aga Khan University Nairobi Kenya.
12. Langdon, D., McKittrick, G., Beede, G., Khan, B. & Doms, M. (2011). STEM: Good jobs now and for the future. In US Department of Commerce Economics and Statistics Administration Issue Brief #03–11.
13. Elder et al. (2014), Connecting ICTs to Development: The IDRC Experience. Information Technologies & International Development, vol. 10, pp. pp. 83–85.
14. UNESCO. (2005). Towards knowledge societies. United Nations Educational, Scientific and Cultural Organization
15. Hooker, M. (2010). Concept Note: Building Leadership capacity for ICT Knowledge Societies in Africa. Global e-Schools and Communities Initiative
16. Keane, J. (2014). Pico-solar Electric Systems: The Earthscan Expert Guide to the Technology and Emerging Market. Routledge.

Traditional sources of fuel cause:

An estimated
4.3 million
premature deaths per year from indoor air pollution



1/2 of all premature deaths of
children under the age of 5

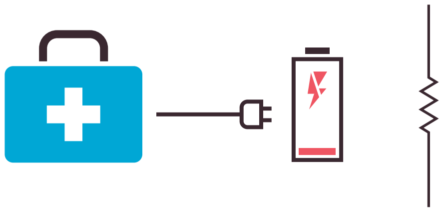
Approximately
300,000
deaths from fires every year

fuel.[17] This is more than for malaria, tuberculosis and AIDs combined,[18] and accounts for half of all premature deaths of children under the age of five.[19] While the primary driver of this risk is combustion of fuels for cooking, kerosene for indoor lighting plays a major role as well. On top of that, kerosene and firewood are strong drivers of fire risk, and WHO estimates that more than 300,000 people die as a result of fires every year, with fire-related deaths ranking among the top 15 causes of death for people aged 5–29 globally. This risk is elevated in the developing world, in large part due to the everyday use of these dangerous energy sources within the home.[9] It is unlikely that electricity provision in impoverished rural areas will completely obviate the need and desire for traditional fuels for cooking due to the high levels of energy required to cook using electricity, but the move to electric lighting could itself have a significant impact on these statistics and help bring greater awareness of their risks.

Unreliable or non-existent electricity is also a significant impediment to professional healthcare provision, affecting childbirth and emergency treatment and severely limiting night-time services. Almost a billion people worldwide are served by health facilities that are without reliable access to electricity. This includes 46% of India's health facilities, and 25% of facilities in Kenya, where blackouts are frequent.[9] Ineffective sterilization procedures, lack of lighting and other electrically powered equipment for critical operations and difficulty communicating with and attracting medical specialists from outside are only some of the significant consequences of poor electricity provision. At the systemic level, a lack of electrically-powered cold storage for blood and medicine is a major driver of the fact that so many vaccines delivered to developing countries are wasted shortly before they can be used.[20]

17. WHO. (2014). Burden of disease from household air pollution for 2012. World Health Organization Factsheet.
18. Subramanian, M. (2014). Deadly dinners. Nature, 509(7502), 548–551.
19. WHO. (2014). Household air pollution and health. World Health Organization Factsheet.

Health facilities without reliable access to electricity:



Serve almost
1 billion
people worldwide

Electricity access may also have more indirect cultural, economic or political benefits to individuals and communities. These may be harder to measure but nevertheless become powerful drivers of improved quality of life in the developing world.

One such benefit is to gender equality, which can be significantly enhanced by access to electrical appliances that reduce the time needed to perform the many household tasks that hamper women's freedom throughout the poorest regions of the world. Women have also become change-makers in a number of electrification initiatives, empowering their communities and themselves in the process.

Another indirect benefit is the greater economic opportunity provided by the services that access to electricity provides. These include access to ICT infrastructure, educational, training and other resources. When equipped with these new tools, local innovation and entrepreneurship opportunities may be enriched.

Finally, access to electricity may benefit the political enfranchisement of poor communities by better connecting them with the world around them and the avenues available for asserting their political rights.[21] With a reliable source of electricity, infrastructure for greater political connectivity and organizational capability can be enabled.

With the advantages of providing universal electricity access made clear, it is time to look at what kinds of changes are possible.

20. WHO (2011). Vaccination: Rattling the supply chain. Bulletin of the World Health Organization, 89:324–325.
21. Jacobson, Arne. (2007). Connective power: solar electrification and social change in Kenya. World Development 35, no. 1: 144–162.

3. The Pathways to Energy Access

As yet unexploited potential that will help meet the world's energy needs

This section examines the infrastructure and resources that can be leveraged to meet our global goals concerning energy access. There are three branches: delivery structures, energy sources and energy management technologies.

3.1 Delivery structures

It is possible to identify two obvious pathways for providing access to electricity for the 1.1 billion people worldwide that are currently without it. One is extending existing grids. The other is expanding the scope of decentralized infrastructure.

3.1.1 Grid extension

Traditional methods of generating baseload power and distributing it through a centralized grid system have played a vital part in unlocking high levels of economic development. These technologies are well understood by the energy sector, and are based on tried-and-tested technologies.[22] Extending existing infrastructure will be critically important to providing affordable, reliable and safe energy to those in rural areas and – perhaps more immediately – to the world's rapidly expanding urban populations.

Over half of the global population now lives in urban areas. By 2050, this proportion is expected to rise to approximately two thirds, in large part driven by significant migration of African and Asian populations away from rural areas and into cities.[23] The move toward urbanization can be a key driver of improved electricity access. Populations are moving closer to existing infrastructure, allowing greater numbers of people to be served with relatively smaller investment in transmission infrastructure required. However, there are problems to be resolved. Increasing demand places increasing burdens on an infrastructure that is already stretched to the breaking point in places. Blackouts and load shedding are commonplace all around the developing world, making it challenging to operate a reliable business or provide adequate community services.

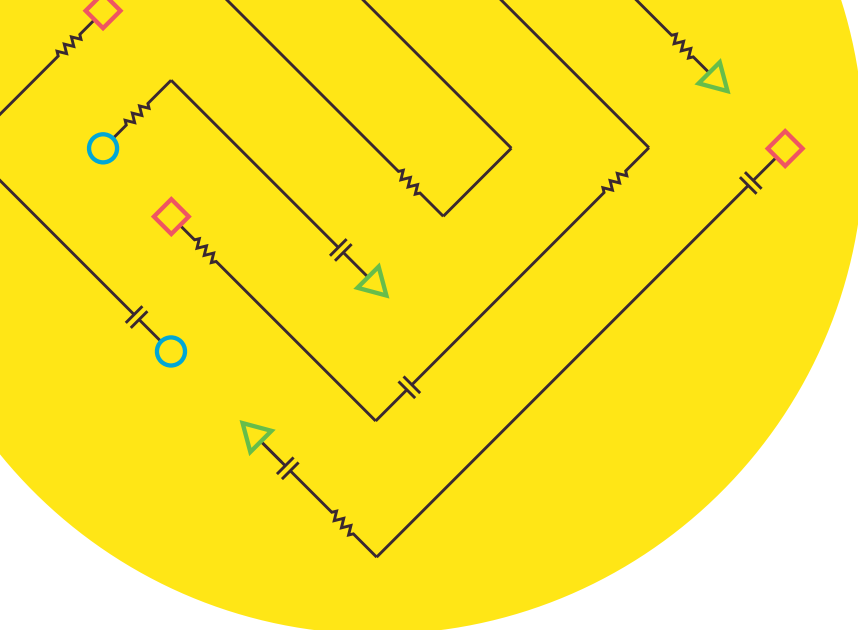
A number of questions need to be resolved before we can work out how best to achieve safe, reliable electricity access through grid extension. There are issues over whether those moving to cities from rural areas are able and willing to pay for provided electricity: anecdotal evidence suggests that theft of energy through unauthorized connections, a concomitant lack of safety, and inadequate regulation are already major problems facing efforts to provide electricity in the world's slums, shanty-towns and favelas.

There are also questions over how much of the current urbanization would be stemmed by improved energy access in rural areas. Is it possible that, if rural areas were to be electrified, with all of the attendant economic and other benefits that electrification brings, the flow of rural poor into urban and peri-urban areas would be slowed, city infrastructures would suffer less strain, and rural life would be enriched? That has certainly been argued and if true would add another significant indirect consequence to electrification efforts.[24]

3.1.2 Decentralized infrastructure

According to the International Energy Agency, grid extension will play a significant role in extending electricity access. However, in many locations decentralized options such as mini-grids and single-user-systems will be required. Decentralized infrastructure is crucial, largely because transmission costs will continue to make extending the grid to many rural areas far too costly for either private or publicly funded ventures.[25] The International Energy Agency currently predicts that 55% of the additional electricity required to

22. Caine, M. et al. (2014). Our high energy planet. The Breakthrough Institute.
23. UNFPA. (2015). Urbanization: An urbanizing world. United Nations Population Fund.
24. Holmes, J. & van Gevelt, T. (2015). Energy for development – the concept. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
25. IEA. (2010). Energy Poverty: How to Make Modern Energy Access Universal? International Energy Agency.



provide universal access by 2030 will most economically be delivered by decentralized (not-grid connected) systems.[2] These are, by their very nature, flexible – a huge advantage in the energy marketplace. Modern energy services can be provided at the household or village level at scales that match demand, providing the energy for basic services and serving as a useful stepping stone toward the domestic and commercial opportunities that energy access brings.

Decentralized energy technologies can be split into two categories: single-user systems and micro-grids, both of which can vary tremendously in their size, complexity and cost.

Single user systems deliver enough power for a single appliance, dwelling or small commercial operation. Increasingly solar-powered products are penetrating the single-user systems marketplace.

At the smallest scale, 'pico-products' such as solar powered lamps, deliver high quality electrical energy that aims to replace the basic services provided by kerosene lamps, and increasingly also offer mobile phone charging in the same unit, a service on which poor households currently spend significant portions of their scarce financial resources.[26]

Solar home systems are larger, but can be self or professionally installed. They typically cost about $200-$500 USD, which is paid in installments over one to three years, and generally comprise a small solar panel, battery, and necessary cables or other electrical output equipment. This can provide enough electricity to power a few appliances such as a fan, radio, television and even a small refrigerator or iron, as well as powering multiple lights and charging small devices. With careful design and construction, they can be made durable, and can be easily expanded. Though they tend to require some maintenance, in comparison to alternatives such as buying kerosene fuel or using mobile phone charging stations, these modern energy products are highly competitive in cost terms over their product life-cycle.[27]

Despite the relatively low purchasing power of the consumers who are the main market for pico-power systems, the emergence of innovative payment and end-use technologies at increasingly low costs has led to rapidly expanding uptake in this market.[28] Programs in Asia and East Africa in particular have flourished. This growth mirrors the rapid growth of the mobile phone market over the past decade, and the mobile payment revolution that has come with it in these areas of the world has itself benefitted the pico-power market. This trend is exemplified in the success of the Lighting Global program, which has already supported the sale of more than 10 million quality verified solar lighting products globally.[29]

While the market for single-user systems is beginning to flourish, creating a cluster of interconnected electricity consumers (often an entire village or small town) in a **micro-grid** can be even more beneficial to consumers. Micro-grids provide major advantages over single-user systems. They can be powered by a variety of sources, from non-renewable diesel-fueled generators to renewable options such as small scale hydro, biomass, solar and wind. The interconnection of multiple energy sources, usually coupled with some form of energy storage capacity, allows for more productive and efficient energy provision than single home systems are generally able to provide.[30] What's more, economies of scale

26. Alstone, P., Gershenson, D., & Kammen, D. M. (2015). Decentralized energy systems for clean electricity access. Nature Climate Change, 5(4), 305–314.
27. Kammen, D. (2015). Energy innovations for smart villages. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
28. Bardouille, P. et al. (2012). From gap to opportunity: Business models for scaling up energy access. International Finance Corporation.
29. Lighting Global. (2015). Program results as of December 2014. Lighting Global Initiative.
30. Alstone, P. et al. (2015). Off-grid power and connectivity: Pay-as-you-go financing and digital supply chains for pico-solar. Lighting Global market research report.

… economies of scale mean (micro-grids) are generally less expensive per unit of energy delivered. They can support higher loads and load variance, and can provide the power for commercial purposes such as agro-processing as well as community based services such as water pumps and healthcare centres.

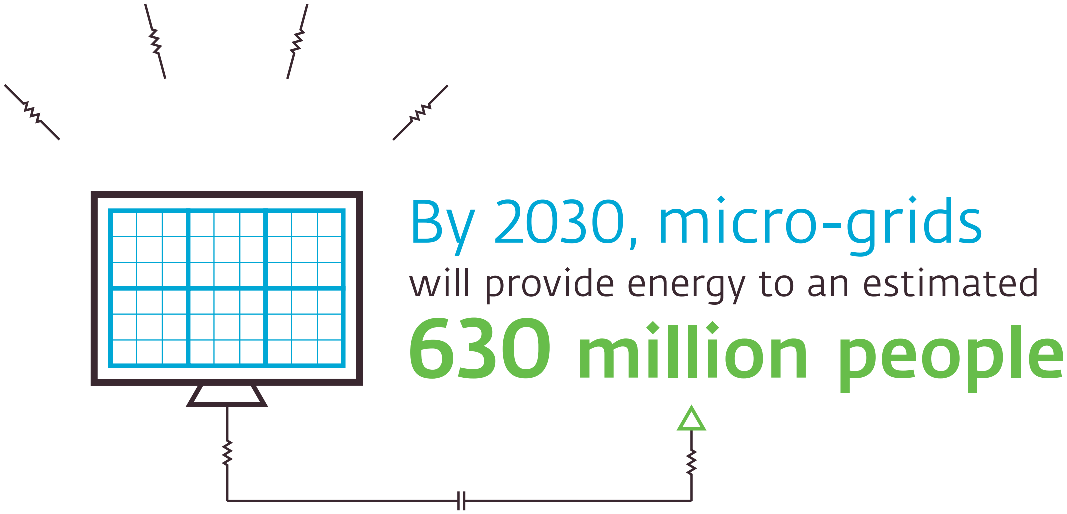
mean they are generally less expensive per unit of energy delivered. They can support higher loads and load variance, and can provide the power for commercial purposes such as agro-processing as well as community based services such as water pumps and healthcare centres.[31] However, they are more expensive, and an important enabler for micro-grid projects is the identification of possible private sector 'anchor clients'. A client wanting to invest in, say, mobile communications infrastructure installations might provide a sufficiently reliable guarantee of consistent demand and repayment for energy provided to make the investment worth the risk.[32]

A further advantage is that micro-grids can also be designed in ways that allow them to be scaled up efficiently at the pace of local demand and even be connected to the existing electricity grid if and when that becomes necessary or expedient.[31] In areas where grid connections are available but vulnerable to disruption (where extreme weather or natural disasters are more common) or prone to unreliability (throughout much of the developing world), micro-grids can also be used as a backup in order improve electricity provision resilience.[26]

This realization has taken hold in both the developing and developed world in response to perceived vulnerability of existing grid systems, a trend that is not limited to rural areas, or the poor. Communities and households in economically advantaged urban areas are pursuing micro-grids and solar home systems to replace or supplement existing grid connections. These systems are valued for a number of reasons. First, they are being used to test the usability of 'smart-grid' ICT solutions. These are expected to be important aspects of future energy systems that must cope with the more variable electricity generation capacity of renewable systems. They are also being constructed with the capacity for 'islandability' (they can be connected or disconnected from the existing grid).[33] A vision for so-called 'personalized energy services' is thus emerging, wherein electricity consumers (particularly in urban and industrial locations) become increasingly engaged in the generation and management of their energy through the use of advanced ICT and micro-grid systems.[34]

In short, micro-grids can be highly effective means of serving the variety of energy needs of energy isolated communities, as well as having the additional benefits of autonomy and flexibility which are increasingly in demand in both developing and developed world energy markets.[25] Small wonder, then, that estimates suggest they will be providing approximately 630 million people with energy by 2030.[35] This is not wishful thinking: as already noted, a range of decentralized energy service products and system sizes have been employed in various contexts depending on demand, consumer ability to pay, geography, and available financing. This market is rapidly expanding and has clearly moved past the pilot scale.[26] However, for all these projected successes, much needs to be done to accelerate progress to the point where micro-grids are available and useful to all those who would benefit from them.

31. LIGTT/LBNL (2014). 50 Breakthroughs: critical scientific and technological advances needed for sustainable global development. Report of Lawrence-Berkeley National Laboratory and the Institute for Globally Transformative Technologies.
32. Williams, N. J. et al. (2015). Enabling private sector investment in microgrid-based rural electrification in developing countries: A review. Renewable and Sustainable Energy Reviews, 52, 1268–1281.
33. NSERC. (N.D). About the Smart Grid Network. The Natural Sciences and Engineering Research Council of Canada.
34. Brown, M. (2015). Our Energy Future in 2035 Depends on New Technologies, Talents, Mindsets. Energized for the Future.
35. Gershenson, D., et al. (2015). Increasing private capital investment into energy access: the case for mini-grid pooling facilities. United Nations Environment Programme.



3.2 Electricity sources

According to the IEA, renewable energy sources will be the largest single source of electricity growth to 2020.[36] This projected growth is due to falling costs and the significant expansion of renewables exploitation in emerging economies and developing countries, where two-thirds of the growth will take place.

Much of that will involve the use of biomass, which is considered to be the largest current source of sustainable energy globally. Its attraction is partly due to its ability to produce heating, cooking and transport fuels in addition to electricity, as well as the fact that feedstocks are generally well-distributed, inexpensive and widely available.[37]

In terms of its ability to provide an energy source for electrification in energy isolated communities, biomass can be effective, as has been seen in a number of village-scale projects in rural India, where research into gasification technology has been proceeding for some time.[38] Biomass gasification offers a potentially powerful pathway to energy access, however more research and development is needed to enhance the efficiency of smaller gasification units and to ensure that these systems – especially if scaled up considerably – are operated sustainably given the complexity of the land-use issues associated with the derivation of feedstocks.

However, global concerns over greenhouse gas emissions, plus considerations about long-term sustainability, suggest that the exploitation of wind, hydroelectric and solar power is a preferable option where possible, especially as these are often in abundant supply in the areas under consideration.

Remarkably, wind and solar photovoltaics – operating at large and small scales – are likely to account for almost half of the total global power capacity increase to 2020. Rapid industrialization and development of infrastructure in unconnected areas means demand for small wind power, which is mostly decentralized, is already escalating.[39] Where there is a suitable water resource, small hydroelectric plants can also provide power to unconnected communities. In India, a couple of dozen micro-grid networks run on hydropower in the states of Karnataka and Uttarakhand. In Atlin, British Columbia, Canada, a small-scale hydroelectric project owned by the Taku River Tlingit First Nation is generating enough electricity to make the population consider connecting to external grids so that they can sell off their excess energy to clients like Yukon Energy.[40] China has made a significant investment in small hydropower systems, which now account for 27 per cent of the country's hydropower output.[41]

36. IEA (2015). Medium term renewable energy market report. International Energy Agency.
37. IEA. (2012). Technology Roadmap: Bioenergy for Heat and Power. International Energy Agency.
38. Buragohain, B., Mahanta, P., & Moholkar, V. S. (2010). Biomass gasification for decentralized power generation: the Indian perspective. Renewable and Sustainable Energy Reviews, 14(1), 73–92.
39. WWINDEA. (2015). Small Wind Market. World Wind Energy Association.
40. Yukon Energy. (2015) Pine Creek Hydro Project. Yukon Energy.
41. Ximei, L.et al. (2015). The Outlook for Small Hydropower in China. Power Magazine.
42. IEA. (2015). Snapshot of Global PV Markets 2014. International Energy Agency.

However, for low power appliances and applications, it is solar power that looks the best bet for overcoming energy disadvantage in the developing world. The installed global capacity of solar photovoltaic (PV) energy systems has increased exponentially for decades, rising from approximately 1.8 gigawatts in 2000 to 187 gigawatts by the end of 2014.[42] The cost of solar energy has declined rapidly over the past decade, nearing parity with traditional fossil fuel sources in some contexts, and falling below them in others – notably in some developing world contexts including East Africa.[43]

Though its intermittency means it needs to be used in conjunction with energy storage technologies, solar power has many advantages over other electricity production methods. It is clean and inexhaustible unlike climate-warming and high-polluting fossil fuels. It also has advantages over renewable options such as hydroelectric and wind power. These systems can only be located in limited geographic areas, and have variable site-specific costs that make large-scale implementation problematic for investors. The same is true for modern biomass energy production methods utilizing gasifiers and digesters, which rely on the close proximity of biomass feedstocks that can fluctuate in price and availability.

Across the globe, areas facing the most extreme energy poverty (in Africa and developing Asia) very often coincide with areas of high solar radiation, making them ideal locations for solar energy installations. Other benefits include the highly modular and configurable nature of PV systems, from small, durable panels for charging a single appliance, to large arrays capable of powering an entire village or town. In nascent and emerging rural markets where demand is difficult to estimate and may change significantly over time, these systems can be designed to allow scaling up or down without significant cost impediments. Finally, if locally created, the construction, operations and maintenance of PV systems can help boost regional economic development in one of the most important ways – through sustainable local employment.[26]

3.3 Energy management technologies

The explosion of mobile phone use in the developing world is more than a demonstration of the potentially rapid uptake of new technologies. It is also spurring the diffusion of renewable, decentralized energy technologies by providing access to mobile financing and energy system management services. Many energy access projects increasingly rely on these technologies to enhance service delivery and systems efficiency, reduce costs and make these systems more attractive to consumers, service providers and financiers.

43. Ondraczek, J. (2014) Are we there yet? Improving solar PV economics and power planning in developing countries: The case of Kenya. Renewable and Sustainable Energy Reviews 30: 604–615.

Photo credit: Julien Simery/UNESCO

There are already 90 active mobile phone subscriptions for every 100 people in the developing world. This recent trend in access to information technologies has sparked significant economic changes including the use of mobile banking systems which have become central to a number of financing strategies for renewable energy pico-power systems.[24] The high adoption rates for mobile phones indicate that there is willingness to pay for high-value technology-driven services such as mobile communication even in economically disadvantaged areas.[26]

Some examples where ICT solutions have been applied to pico-power and micro-grid systems include:

During generation: Monitoring and troubleshooting operations in real time, collecting and analyzing system data, optimizing and synchronizing multiple power sources in hybrid systems, managing storage to smooth intermittence of renewable energy supply, and regulating voltage, frequency and load levels (matching demand with supply).

During distribution: Minimizing technical and non-technical losses from theft and measurement errors.

During consumption: Synchronizing demand and supply (for example through the use of current limiters, power management administrators, and smart meters), billing and fee collection systems (including prepayment devices and mobile banking systems) and fraud prevention systems.[31]

The availability of mobile banking and prepayment services is particularly significant as it has helped confront one of the largest risks facing financiers and service providers – low consumer ability to pay. These services allow customers to prepay for the energy they use at the beginning of consumption cycles, providing a guarantee of payment for services delivered. ICT also allows for the remote management (including shutdown) of equipment and services by providers in the case of missed payments, providing a further level of security for providers and encouraging timely payment for services. Finally, since real time monitoring of demand, payment histories, and other information are recorded, credit records and a greater understanding of consumption dynamics can be established.[24] It is these credit histories in fact, that have enabled the first few solar home system companies to access commercial credit for the first time in the sector's history.

The greater control that ICT provides has already led to notable successes in managing these systems in the developing world. This includes a micro-grid project in Bhutan which was able to reduce brownouts caused by peaks in demand during cooking times by 92% through load-shedding devices that limited use of rice cookers and water boilers.[44]

44. Quetchenbach, T. G. et al. (2013). The GridShare solution: a smart grid approach to improve service provision on a renewable energy mini-grid in Bhutan. Environmental Research Letters, 8(1), 014018.

4. Learning by Example

Providing affordable, reliable global energy access is already under way

The range of underserved and underdeveloped energy markets spans the globe. Sub-Saharan Africa and developing Asia comprise the largest markets, but tens of millions still live in the dark in Latin America, and energy poverty is a major problem in island nations around the world. It is in fact, also still an issue in some isolated areas of the developed world. Islands and other remote communities also stand to gain from the emergence of affordable power from decentralized renewable energy systems. This is also true of energy consumers for whom a more resilient energy supply is highly valued, for example in regions where frequent natural disasters, storms or other factors threaten the reliability and/or quality of electrical power provision. However, there is already a wide variety of projects that shine light on potential solutions. This section provides an overview of a few of the energy provision programs already demonstrating the way forward.

4.1 East Africa

The continent of Africa faces some of the highest poverty rates in the world and therefore suffers from comparatively low rates of foreign and public investment in energy per capita. For this reason, a burgeoning private sector has seen a great opportunity to step in where the state has not or cannot, diffusing small, highly inexpensive pico-power devices and appliances at the household level. These energy products are aimed at replacing traditional sources of energy such as kerosene, which is comparably expensive per unit of energy delivered. Mobile phone charging is another energy service that is often grossly overpriced in Africa, costing an average of 20 cents per charge, which translates to over $40 USD per kWh. This is a far higher price than even the most expensive solar charging systems will demand.[35]

To date, East Africa has been ground zero for decentralized renewable energy adoption in Africa. Kenya in particular is an ideal market, with huge growth potential that has been demonstrated through a recent surge in mobile phone use, mobile money systems and successful energy access initiatives. Kenya also features the hub that is its capital city, Nairobi, which has advanced ICT networks and access to financiers and experts in decentralized solar power systems. Each of these can be leveraged in order to spur growth in energy access markets.[30]

As a result, Kenya has become one of the largest unsubsidized markets for solar home systems in the world and recently seen significant growth in 'pay-as-you-go' financing schemes for small-scale pico-power systems. These allow consumers with the least ability to pay for electricity to pay the small monthly fees they already pay for kerosene on solar lanterns or home systems. Kenya has also awarded its fist ever utility concession for a private company to generate and sell low carbon decentralized energy to consumers,[45] leading to a joint investment with Italian multi-national Enel Green Energy on a 12 million project to build over 100 mini-grids that will serve over 90,000 Kenyans.[46]

On top of this, Kenya has been the site of significant public-sector investments in community-scale micro-grid projects such as the UK-funded Energy for Development (e4D) concept – a five year, community-centric project aimed at developing community-scale renewable energy micro-grids.

The first e4D project, carried out in 2012, involved the creation of a PV-powered micro-grid in the remote village of Kitonyoni, Kenya. The project provides power for over 3,000 very poor inhabitants, including all of its major commercial and community service buildings. The entire 13.5 kW system

45. Powerhive (2015). Powerhive subsidiary becomes first private utility in Kenya's history to be licensed to sell electricity to the public. Powerhive News.
46. Powerhive (2015). Investment in renewable mini-grids marks major milestone for energy access & low-carbon development in East Africa. PR Newswire.

Photo credit: Natalya Savka

(including PV panels, battery storage systems and canopy) was assembled by e4D engineers, local contractors and villagers within a single week, and was designed to be highly replicable and scalable. The income generated through service fees and shared ownership supports its continued maintenance and operation, as well as recovers capital costs over time and provides micro-financing for other community projects. The canopy for the PV system doubles as a rain collector that enables water storage and commercial sale through a community co-operative. Furthermore, the community, commercial and household services provided by this system have led to a suite of spin-off benefits. Land prices have more than doubled. Ten new buildings and numerous businesses have been constructed in the neighbourhood, a development that has helped double local business income since the project's inception. A new maternity ward has also been donated, and health service availability has expanded rapidly, benefiting community wellness.[47] Since its completion, e4D has installed 5 additional projects in Cameroon, Kenya and Uganda. By the end of 2015 they are due to complete a 60 kWh system, which will be one of the largest decentralized solar mini-grids in Kenya.[48]

4.2 India

In developing Asia, the largest energy access challenge is found in India, home to 42% of the Asians without reliable electricity access. India has a relatively long history – since the 1990's – of initiating decentralized energy projects to support the economic development of remote village communities. Like Africa, the focus of many recent efforts has been on installing PV-powered systems, which have benefitted from lower maintenance and operational costs. India's energy access programs to date however, have favored larger community-level micro-grids (as opposed to smaller single-user systems) funded through public investment from governments and international development institutions. The many projects that have been carried out to date – some successful, some not – provide a number of useful lessons to guide future efforts.[49]

According to a 2014 report from UNEP's Global Network on Energy for Sustainable Development, recent projects have demonstrated the importance of community participation throughout the planning, construction and operation phases of these projects. This has come in the form of village energy committees or electricity cooperatives which provide various project management functions including maintenance and operations, training, revenue collection, and complaint redress. The level of engagement of local communities can differ considerably however, with dimensions such as social cohesion and community leadership likely playing a key role in long-term project sustainability.[49]

Another role played by community groups, often in collaboration with local government and NGOs, is the setting of tariffs. Tariff structure is important to ensuring that the capital and operational costs of the systems can be offset through revenue collection over time. On publicly-led projects, approximately 90% of capital costs are subsidized and some projects even subsidize operations and maintenance costs

47. Bahaj, A. (2015). Transforming rural communities through mini-grids. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
48. Sustainable Energy Research Group. (2015). Rural Electrification. Energy for Development.
49. Palit, D., & Sarangi, G. K. (2014). Renewable energy-based rural electrification: the mini-grid experience from India. UNEP Global Network on Energy for Sustainable Development.

… low cost and utility-style service delivery … has allowed Mera-Gao to provide electricity to over 500 Indian villages, which serves the lighting and mobile phone charging needs of over 65,000 people.

Photo credit: Natalya Savka

for up to five years. Once subsidies run out, revenues must be able to cover these costs in order for the system to remain in sustainable operation. The inability of past projects to secure sufficient revenue over time has become a major roadblock to securing financing for these projects. The emergence of smaller pay-as-you-go financing and utility-style schemes, where private interests own and operate the equipment while selling energy at a standard rate, have emerged and found some success in addressing this barrier. The success of such schemes is, however, highly dependent on the local context.

A successful example is that of Mera-Gao Power, which has worked in partnership with USAID to build and operate much smaller scale micro-grids. These projects, now supported by other agencies and investors, use solar panels coupled to a bank of inexpensive lead-acid batteries. They cost less than $1,000 USD per village and can be constructed within a single day. The low cost and utility-style service delivery of these systems has allowed Mera-Gao to provide electricity to over 500 Indian villages, which serves the lighting and mobile phone charging needs of over 65,000 people.[50]

4.3 Remote communities

Regions of geographic isolation can provide ideal locations for renewable energy micro-grid adoption. Without the ability to access grid-scale electricity, these populations are often consigned to purchasing diesel fuel to power generators at exorbitant prices. Fuel is generally delivered by truck, boat or even more expensively, by aircraft in the case of remote Northern Canadian communities which are locked in ice for much of the year.

Islands are often ideal for micro-grid utilization due to their geographic isolation. A successful example of an island that has transitioned away from diesel fuel towards locally generated renewable electricity is Kodiak Island, Alaska, USA. Kodiak is the second largest island in the United States, and home to over 15,000 inhabitants. Until relatively recently, 20% of Kodiak's electricity came from generators running on expensive imported diesel fuel. This created electricity prices a full 50% higher than the national average. A project to replace this capacity with wind power and flywheel storage (as well as some additional hydroelectric power) has made diesel electricity generation completely redundant. The resulting economic benefits have been significant, with electricity bills down enough to benefit businesses across the island.[51]

Another success story is the island of Samsø, 11 miles off the coast of Denmark, which now meets all its electricity needs through wind turbines on the island, and sells excess power to the national utility.[52] In South Korea, the state electricity utility has recognized that supplying energy to remote communities is uneconomic compared with enabling them to generate their own power. Sixty-four of South Korea's 180 island communities are now being supplied with the resources to create micro-grids powered by renewable energy sources.[53]

An example of a further remote community in the developed world with reliable and affordable energy access is the community of Tuntutuliak, Alaska, USA. Tuntutuliak is home to approximately 400 people, most of them Yup'ik Inuit, and has successfully installed a highly advanced micro-grid that is creating local economic benefits. The community utilizes state of the art wind power, smart-metering, and electric thermal storage technology to replace the biannual shipments of $7 USD/gallon diesel fuel that was crippling the local economy. The success of this project has encouraged two other neighboring communities to follow suit.[54]

Canada still has around 170 remote communities that rely exclusively on diesel, but some of its remote communities are beginning to operate micro-grids. NCC Development, formed by the chiefs of six First Nations communities, is working to reduce reliance on diesel fuel for remote First Nations by 50% by utilizing a combination of strategies including the construction of solar micro-grids, energy conservation, and load management.[55]

Such achievements demonstrate the potential for renewable micro-grids to bring economic benefits to many remote communities. Similar to their counterparts across the developing world, these communities often face both economic and political isolation as well as geographic remoteness. They stand to gain economically from the replacement of expensive fuel sources with clean renewable power generation but tend to suffer from a lack of resources to develop new energy systems.[56]

50. Kumar, R.V. (2015). Leapfrogging to Sustainable Power. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
51. RMI. (2015). An Alaskan Island Goes 100% Renewable. RMI Outlet.
52. Cardwell, D. (2015). Green-Energy Inspiration Off the Coast of Denmark. New York Times.
53. Ji-Yoon, K. (2015). Global sustainable energy starts on Korea's Islands. Korea Joong Ang Daily.
54. Guevara, L. (2015). Native Energy: Rural Electrification on Tribal Lands. RMI Outlet.
55. http://www.nccsolar.com/
56. Royer, J. (2013). Status of Remote/Off-Grid Communities in Canada. National Resources Canada.

5. Behind The Scenes

Unresolved questions over technologies, policies, business models and social issues

With these examples – and many more – already pointing the way forward, it seems there is a significant opportunity to accelerate progress towards global energy access. The greatest impediments are now political, bureaucratic, social and financial. This section provides an overview of the business models, financing initiatives and sustainability issues that must be navigated before success will be possible.

5.1 Who will pay?

Despite commitments from governments and international development finance institutions, the requirement for additional project financing is perhaps the greatest barrier currently facing energy access projects worldwide. Current funding levels from governments and international development institutions fall short of what is required to achieve universal energy access by 2030. Local public banks and multilateral agencies are also important sources of funding for individual projects, but cannot fill the large gaps in funding – as high as $134 billion USD per year – that exist at present.[57] This high estimate however is contrasted by others which calculate for a step-ladder approach, first attaining universal access at a lower level of power, such as using the solar-home-systems noted above, as an interim solution. These estimate somewhere around $70 billion USD by 2030 would be needed to achieve universal access.[58]

The problem extends not just to the question of how much investment is needed, but how best to allocate funding in order to incentivize additional growth. A variety of financing models exist, from wholly subsidized projects to public-private partnerships to for-profit initiatives. No single model will work best in every situation, and the broad range of project scales and contexts in the energy access space means that financing models should be matched to the needs of individual project types.[25]

5.1.1 Public funding and public-private partnerships

Aid organizations, international development institutions and governments provide the lion's share of funding to energy access infrastructure. These efforts are often carried out in collaboration with NGOs and local governments, and many successful programs capitalize upon links between these agencies and community groups, enabling project developers to assess local conditions and plan projects accordingly. The nature of donor funding often results in a focus on social impacts rather than long-term project sustainability and consistent revenue generation. This focus can lead to the failure of some projects that are not able to reach a level of sustainable project operation before donor funding expires.

On the other hand, public utilities can and have taken it upon themselves to lead the way in providing decentralized rural electrification to energy poor communities. In Brazil, for example, the federal government has prioritized the provision of electricity to the roughly 8 million Brazilians who do not currently have it. Rather than leaving this task to entrepreneurs and NGOs, the government has provided significant financial incentives to utilities who extend their service – through decentralized generation based on diesel and solar sources – to remote Amazonian communities who would be extremely difficult to serve without such a commitment.[59]

Another avenue for project financing is through public-private partnerships. These models are attractive because they capitalize on the ability to attract both donor funding and private financing, thereby opening up additional sources of investment. The involvement of governments can also reduce regulatory risk, and financial risks can be transferred to governments in order to make the projects more attractive to private investors.[5]

57. Bazilian, M. et al. (2010). Understanding the scale of investment for universal energy access. Geopolitics of Energy 32, (10–11), 19–40.
58. Craine, S. et al. (2014). Clean Energy Services for all: Financing Universal Electrification. Sierra Club/Power for All white paper.
59. Zerriffi, H. (2010). Chapter 3: Distributed Rural Electrification in Brazil. In: Rural electrification: strategies for distributed generation. Springer Science & Business Media.

While grid extension, pico-power products and solar home systems have had notable success in attracting business interests, larger micro-grid projects tend to rely much more heavily on purely public funding. Experience from previous and existing micro-grid projects point to a number of barriers that face project developers in attracting investment. The financial sector is not familiar with business opportunities in this space, and there is a lack of capacity within financial institutions to assess the sector's business models and loan risk. What is more, commercial lending requirements are often poorly matched with the types of investments and the types of entrepreneurial activity involved. A 2015 UNEP-sponsored report on micro-grid project financing distilled the various problems into two primary types of barriers: **high risks** and **high transaction costs**.[35]

The expectation is that with more experience and successes, the business case for investing in these systems will become more solid as risks and transaction costs are reduced through experience.

The perception that micro-grid projects are **high risk** investments stems from a variety of issues. For starters, micro-grids are also often employed in 'difficult' regions. Low economic development (and therefore weak consumer purchasing power), high cost of capital, unstable political regimes and vague or unsupportive regulations can scare off many private financiers. Furthermore, micro-grid projects can be highly complex, and every project environment is different. Not enough experience has been gathered in order to create solid expectations about the types of risks that arise from each project type. The diverse range of risks facing these projects include those related to: the process of permitting; a lack of standardization in micro-grid system design; gaps in supply and demand assessments; links and conflicts with incumbent infrastructure; financial risks associated with difficulty and time required in securing loans; construction delays and cost overruns; currency exchange uncertainty; theft, tampering and corruption; uncertainty around payments (be they local customers or the utility if it connects to the mini-grid at a later date); political uncertainty around legality of independent power production when regime change occurs; uncertainty around monetization options around exiting a project; and poor organizational or operational structures within project development teams due to a lack of developers and operators with proven track records in this nascent sector.

High transaction costs stem from the complexities and time required to secure financing, need for in-depth studies into site identification, evaluation and due diligence, purchase of the system components itself, and the costs associated with engaging with communities.[25] High transaction costs are also a major issue for smaller systems for which the costs associated with managing small loans are disproportionately high compared to revenue creation potential.[26]

Micro-grids also require far more technical and project expertise than smaller systems, and high capital costs lead to longer payback periods, requiring a longer-term investment that is not attractive to private financiers.[31] All of these issues serve to elucidate some of the reasons why, despite the potential for unlocking massive economic opportunities, micro-grid projects that rely on renewable energy for power generation continue to be largely donor-funded. While attracting significantly more private investment should be a priority moving forward, publicly funded projects and public-private partnerships will continue to be important. The expectation is that with more experience and successes, the business case for investing in these systems will become more solid as risks and transaction costs are reduced.

5.1.2 Private business models

Private investment in energy access projects will be critical to address public funding shortfalls and to provide innovative project management, financing and technological solutions.[28] There is reason for optimism: despite the challenges of attracting private money, off-grid solar firms raised over $42 million USD in capital in the first month of 2015 alone, which is two thirds of what was raised in all of 2014.[60] This is a promising trend, as private-sector business models seek implementations that are sustainable over time (in order to maintain revenues) and scalable (in order to grow their business and increase revenues).

60. Lacey, S. (2015). Off-Grid Solar Firms Raised $42 Million in the First Month of 2015. Greentech Media.

The potential benefits of private sector involvement include:

- The ability of private sector actors to better quantify project benefits (and costs) and thus improve pricing and tariff collection
- More efficient operational control and management of attendant risks (i.e. design, procurement, construction, and operation/maintenance). Private enterprises can employ a variety of proprietary tools that may not be available to the public sector to manage systems, collect payments, monitor performance, and improve service quality over the long-term.
- A better use of limited capital, as it is evaluated according to economic value created rather than political influence, social measures of impact, or other non-economic factors.
- The sustainability of an approach that is driven by market dynamics rather than government subsidies.

A number of private sector business models have been developed for energy access projects. However, there are barriers facing private investment in the kinds of larger micro-grid projects that can provide more meaningful levels of power for energy-intensive and productive uses. The result is that many of these models have been developed for the pico-power and solar home system markets. Public financing is still expected to be required to support micro-grid development (as it is expected for centralized grid development).

One option is for a private enterprise to act like a utility which owns and operates the electricity production system themselves. These '**distributed energy service companies**' (DESCOs) charge ongoing fees for the services they provide. In order to be successful, these companies must be subsidized or achieve short payback times because of limits on financing available in developing countries. Strategies for achieving this include careful management of the ratio of investment to revenue per user, keeping operational costs low while dedicating significant revenues to cover them, incentivizing sales agents, building robust distribution networks, and remaining agnostic about the technologies they employ in order to ensure that no potential winning combinations of technologies and system types are discarded a priori.[61]

Many DESCO firms aim to alleviate the issue of weak consumer demand and ability to pay by offering small monthly payments for services are sometimes referred to '**pay-as-you-go**' (PAYG) models. The PAYG market is highly dynamic, with new approaches entering markets all the time, and companies switching strategies frequently in order to find a model that works.

Another model is **asset-for-purchase** (AFP), where the systems themselves are sold to users over the course of a set payment period. AFP models have shown significant consumer benefits including the ability to generate confidence in technologies through offering customers the ability to use products for a set period of time before owning it outright. Many AFP companies therefore offer to take back and provide a refund for any products which customers are unhappy with. Once ownership is transferred however, customers are able to leverage the asset to acquire additional system components, and their repayment history on the initial asset can be used to establish credit records that can lead to financing for other (non-energy) purchases or entrepreneurial undertakings.[28]

Business to business models also exist. In these schemes, hardware, software and service delivery support is sold to 'last mile' energy service providers such as DESCOs. The **Anchor-Business-Community-Domestic** (or ABCD) model is another variation, which has allowed private investment into much larger energy access projects. This is made possible through the identification of a so-called 'anchor-client' within an area of low energy access. The anchor client is a larger more reliable electricity customer that guarantees consistent payment for services. Common anchor clients include mobile towers, industrial mills, agricultural processors or large community buildings such as hospitals.[49]

Unfortunately, in many of the most impoverished regions of the globe, prospective anchor clients are few and far between except for the case of mobile phone towers which are providing the anchor load for up to one thousand micro-grids in India being developed by the Rockefeller Foundation's 'Smart Power for Rural Development' project.[62]

Many of these schemes leverage emerging ICT systems – piggybacking off of developments in the mobile phone and banking sectors – to track energy use, collect payments and provide after sales service. The application of large amounts of

61. Bardouille, P., & Muench, D. (2014). How a New Breed of Distributed Energy Services Companies can reach 500 mm energy-poor customers within a decade: A commercial solution to the energy access challenge. Working Paper.
62. https://www.rockefellerfoundation.org/our-work/initiatives/smart-power-for-rural-development/

data about consumer behavior to business planning gives PAYG firms important insights about the markets that they serve and gives them advantages over other players such as traditional utilities. The focus on tracking consumer behavior also enables high quality after-sales service, direct relationships with customers and remote monitoring of system performance.[28]

Tracking repayment histories and ensuring reliable revenue collection are critical initial steps to enhancing the amount of private investment that these enterprises can attract.[63] Fortunately, many firms claim repayment rates of over 90%, which is far better than commercial banks in the West can expect, and provide a foundation for further growth.[28] Other issues businesses must face include currency fluctuations when accessing capital from abroad, and the high relative transaction costs of financing, for example due to the fees charged by mobile network operators on the mobile money transactions that are central to many PAYG fee collection schemes.[24]

It is clear that perceptions of high investment risks are a problem. But if private, for-profit energy access businesses can successfully navigate the issues outlined above (and others not detailed), it may be possible to create standardized business models which will be essential to achieving universal energy access in the coming decades.[63]

Finally, a number of scholars have pointed to the potential benefits of 'pooling' micro-grid and other energy access projects into more diversified portfolios in order to seek financing from investors for whom project-scale risks are too high (or uncertain) to garner serious interest. Such a strategy may help in a variety of ways: it can centralize some fixed and transaction costs at the project level; significantly reduce investor risk through diversification; lead to the establishment of standards and common practices across projects; result in the collection and aggregation of larger sets of consumer and market data; and offer more streamlined risk analysis to investors.[35] The creation of these portfolios could also benefit the project types and scales that have fallen shortest in attracting investment: those attempting to utilize new technologies or micro-grid projects of a scale that falls between the ideal investment size of most funders. Bundling them together with more attractive investments may alleviate this problem.[28]

5.2 How can policy help?

For all their importance, financing and good technology alone cannot achieve everything necessary to opening up energy access. In this space, governments are key actors too. Energy is a critical public good, and setting – and maintaining – a positive government energy agenda is a critical part of the challenge.[22]

Many barriers to the success of energy access projects stem from policy or regulatory issues. They might, for instance, protect incumbent systems at the expense of investment in new, more appropriate or scaleable technologies and markets.[27] Public sector actions can spur investment by creating the necessary enabling environment for new, decentralized energy access projects to be successful. This may include the removal of policy and regulatory barriers, establishment of new policies and institutions, contributing financing support and actively encouraging collaboration across sectors including facilitation of private sector and civil society involvement.[25]

With pioneering projects, many required inputs, such as surveys of energy use or demand potential, are prohibitively expensive or are seen as public goods. Governments can act to provide these; doing so can be crucial to attracting private investment. Examples include the collection of information about markets and available resources, initiating consumer awareness campaigns that build public trust in new technologies and systems, and providing appropriate regulation to govern their use.[28]

Government action can also spur investment in an area where 'base of pyramid' customers provide a difficult business case. This might mean appropriate targeting of public sector investments in contexts where private money is not forthcoming due to perceived technical and financial risks, or supporting private sector investments with policies that act to open up markets. The creation of government programs that cover high up-front costs for consumers with weak purchasing power has historically been effective in encouraging private sector interest.[27]

That said, it is also important that public investments do not 'spoil' markets through over-investment in cases where a private sector-led approach may be more appropriate. Over-subsidizing, or giving away, technologies can stunt innovation and impede the market penetration of products that would otherwise be

63. Schmidt, T.S. (2015). Will private sector finance support off-grid energy? In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.

commercially viable. This balancing act must be targeted at closing the 'viability gap': the shortfall between potential revenues from customers and the necessary costs incurred by developers in ensuring the viability of energy access markets over time.[25] Past experience shows that without such interventions in markets, the distribution of public goods, including improved energy services, is often ineffective.[64] The existence of subsidies for incumbent systems such as fossil fuel use is an important case where revision of government action is needed. Phase-out of these policies has shown to be crucial to unlocking greater opportunities for decentralized clean energy, but must be undertaken in a manner that does not result in the deprivation of energy-poor individuals that rely on existing technologies for their welfare. Due to the extreme price sensitivity of poor households to changes in price of staple products, some scholars have suggested that short-term direct financial assistance to consumers can be more effective and politically palatable than subsidy removal.[27]

Governments and international institutions such as the UN also have a key role to play in evaluating energy needs and setting the appropriate context and expectations around what energy access targets should enable. Increasingly, international institutions and the energy access community have emphasized the importance of setting goals related to 'energy services' (i.e. providing the end-use services such as lighting, pumping water, etc.) rather than measuring the number of electricity connections in a country, or the total energy provision in kWh.

A more nuanced understanding of the impacts of energy service delivery to permeate local, regional, national and international agendas is necessary. Simply using a have/have-not dichotomy misses many key aspects, particularly the quality of services as they relate to human health, community well-being and economic development.[9] A framework that has been created to better capture these dynamics is the Global Tracking Framework (GTF) created by the UN Sustainable Energy for All program, which was co-developed with the International Energy Agency to be the definitive global energy access measurement tool.

The GTF measures access across eight metrics; covering energy supplies and services; household and community energy services; employment-based metrics; and recognizes the benefits of decentralized systems in providing a variety of energy services.[64]

The use of more advanced energy access metrics, alongside greater integration of energy access agendas between local, regional, national and international agencies, can sharpen energy access efforts worldwide. Capacity-building together with co-ordination between the various public-sector levels can both benefit the efficacy of electrification projects and have wider benefits.

Goal-setting and co-ordination of macro-agendas at the international level is not a simple task. Some commentators have criticized the current UN approach – embodied in its SE4ALL initiative – for over-emphasizing climate and environmental goals over economic development metrics.[22]

5.3 Is current technology good enough?

The imperative for further innovation on technologies is a crucial aspect of a full-systems approach to achieving universal electricity access. Alongside innovation on financing and operational models, investments in research and development of next generation technologies can help to open up energy markets by lowering the cost of electricity and energy services. Concerted efforts are underway in university and national laboratories, and within private firms to deliver more affordable technological solutions and components, but must be accelerated. Key innovations can come from a variety of sources – sometimes unexpected – such as national defense departments which in countries such as the United States have already invested heavily in technologies for providing consistent power sources to positions in remote and difficult environments.[65] Taking advantage of the need for innovation on key energy system components that are required across a range of use cases in the developing and developed world may help to bring further innovation to the energy access space.

The untapped potential for renewable electricity generation in Africa (especially from solar power), provides a particularly compelling case for technological innovation on solar power systems targeted at the African market. These markets however feature consumers with the lowest ability to pay for energy services. A 2014 study by Lawrence Berkeley National Labs found that the overall monthly cost of electricity from renewable micro-grid sources utilizing existing technology averages $20 USD per month. This compares with suggested maximum monthly energy expenditure rates (10% of income) of $1.50 – $7.50 USD for 'low-income', 'subsistence' and

64. Sovacool, B.K. (2015). Public policy targets for energy access. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
65. Nathwani, J. et al. (2014). Sustainable Energy Pathways for Smart Urbanization and Off Grid Access: Options and Policies for Military Installations and Remote Communities. In Sustainable Cities and Military Installations (pp. 229–261). Springer Netherlands.

'extremely poor' households. Technological breakthroughs to lower the cost of these systems are therefore seen as crucially important for serving these markets sustainably.[66] The Berkeley study highlights five areas of technological innovation crucial to unlocking the potential of modern electricity services:

1. A suite of solar photovoltaic micro-grid components, to significantly reduce upfront costs
2. Appliances for household use (e.g., TVs, refrigerators) and income generation (e.g., irrigation pumps, saw and grinding mills, cold storage), which are significantly more affordable and energy efficient than those on the market today
3. New bulk storage technologies for micro-grids, which provide improved performance at a significantly lower cost
4. Affordable and easy-to-use grid management solutions (ICT) for decentralized renewable energy rural mini-grids
5. A 'utility-in-a-box' for making it simpler, cheaper and faster to set up and operate renewable energy micro-grids[31]

5.4 How do we make energy access innovations sustainable?

While adopting well-crafted policy and utilizing appropriate business models is crucial for delivering energy services to underserved markets, the long-term success of these initiatives also relies on other factors. Any successful energy infrastructure requires a fully-functioning after-sales service and long-term operational strategies to deal with changing demand, setting of tariffs, the repair and operations of energy systems, and the functional evolution of the system over time.[49]

The added value of ensuring long-term service sustainability is that it may encourage the development of local technical expertise, comprehensive education about the services being delivered and the full involvement of the community in decision-making processes. Thus, if carried out correctly, energy access infrastructure can result in local job creation, stronger local governance and increased trust and awareness about the benefits of these systems. Focusing on these aspects encourages community-level engagement with energy issues and may help to grow an emergent entrepreneurial middle class in impoverished areas through encouraging local economic development and skill acquisition.

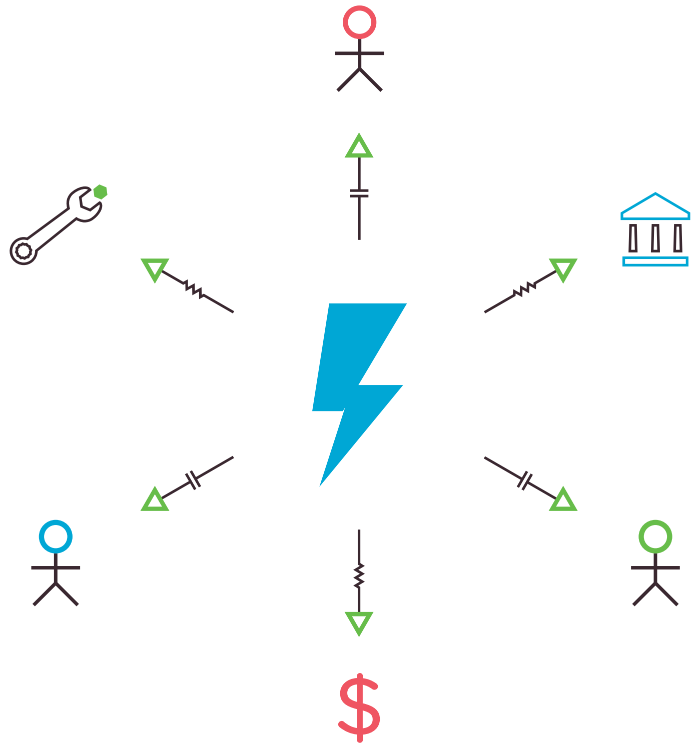
Ensuring the presence of sufficient numbers of well-qualified staff to operate micro-grids, provide sales and after-sales service for pico-power products, or perform other roles can be a major challenge – one that frequently threatens the success of energy access initiatives. Impoverished rural areas struggle to attract and retain qualified staff due to lower living standards and remoteness.[27] Providing training for locals (especially young people) is thus often important to ensuring local expertise over the long term. It can also provide a pathway to meaningful economic development through local employment in 'green jobs' such as sales agents, technicians, sub-distributors, and other roles.[28] Studies have suggested that experience in such roles often result in greater employability in other sectors as well, and that this can be a pathway towards economic freedom, especially for young people.[31] In particular, the acquisition of basic IT skills has been shown to enhance the economic prospects of rural populations.[67]

The importance of expertise also suggests that in the planning of energy access projects, technical and non-technical matters are closely interconnected and should be managed in concert. Technology should be chosen not only for its robustness but also for how it overlaps with the available knowledge and skill-sets of local people. What's more, training programs and local hiring practices have been shown to enhance trust amongst consumers and lead to a higher willingness to pay, providing a greater chance of long-term revenue generation and overall project or business sustainability.

In addition to ensuring proper training and local expertise, the organizational systems and structures of agencies and other groups that operate energy access infrastructure can be crucial to success of projects over time. Potentially economically viable projects and businesses can and have failed on account of overly centralized management structures by, for instance, focusing disproportionately on technical matters such as installation while lacking a clear delineation of the roles and responsibilities of stakeholders.[26]

Some evidence points to the value of 'participatory governance systems' at the local level which can support decision-making about projects over time and deal with unexpected challenges. They can also provide a clear local voice in discussions with other stakeholders such as external project developers, national or regional governments, business interests and non-profit groups. In Indian micro-grid cases this has shown

66. GIZ (2011) Modern energy services for modern agriculture: A review for smallholder farming in developing countries, GIZ – HERA – Poverty-orientated Basic Energy Services, Bonn and Eschborn, Germany.
67. Laidin, A.Z. (2015). Smart villages – the Malaysian approach. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.



to be particularly effective. Communities and external developers in India often form joint clusters of individuals acting in roles from plant operations to complaint redress to revenue collection. Many projects are implemented on the premise of community control of the system, with expertise lent through the involvement of external developers. It is noted that communities with stronger local governance systems are better suited to this community-driven approach.[49] However, different contexts may well give different results.

The same can be true in the area of tariff-setting. Rather than setting tariffs purely based on the cost of generation, tariff-setting committees in Indian micro-grid projects have taken other factors into account such as equity, income distribution, the availability of anchor clients, and government funding. Tariffs that are set based on this balance between affordability and cost of generation do not however exclusively emerge out of such committees; a number of private companies have also found success in setting energy service rates that reflect these twin imperatives.[49]

In addition, further awareness-raising and capacity building on the ground may inspire others to build and operate new energy access projects, resulting in greater investment, efficiencies of scale and a larger pool of skilled local labor.[68]

When designed and operated through effective organizational structures and local input, energy access programs have in many cases created economic (and other) benefits to the communities that they serve. Examples include micro-hydro projects in Nepal which have produced $8 USD of economic benefit per household per $1.40 USD invested; a project in Sri Lanka which allowed the community to invest three times the project cost in the market after the project was completed (showing significant private sector involvement was catalyzed); and the Solar Sister entrepreneur program in Sub-Saharan Africa which, according to the UN, generates more than $46 USD of economic benefits per dollar invested in the first year alone. These returns do not give immediate payback for the parties making the investment; they result from improved quality of life and economic opportunities for customers. So, although it is possible to create sustainable energy access, satisfying investors' short-term needs remains a challenge.[64] In many ways, this highlights that fact that electricity is still in many ways a public good, and extending access on the basis of increases in human welfare will require some degree of public investment.

68. Mnzava, A. (2015). Energy policies for off-grid villages in Tanzania. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.

5.5 What are the known unknowns?

There follows a preliminary list of unresolved questions, challenges and uncertainties that will, we hope, stimulate conversations in the lead-up to WGSI's OpenAccess Energy Summit as well as during the event itself

5.5.1 Technology

Breakthrough innovations: What kinds of breakthrough innovations could significantly reduce the cost structure of electricity provision in rural/remote areas? Can energy system research efforts be better aligned to deliver these innovations?

Scaling of energy systems: Can pico-power, home systems and community micro-grids be scaled up sufficiently to provide electricity on the scale seen in the developed world? Can/should integration with the grid be considered a necessary long-term goal for these systems and how can this be achieved efficiently?

Technological Integration: What innovations in fields outside of renewable energy delivery systems (in areas such as ICT, batteries and appliance efficiency) might be harnessed to enhance energy access efforts?

5.5.2 Financing

Business models: Are any clear winning strategies emerging? What makes these private projects work where others have failed or continue to rely on public funding? How can they be replicated on a larger scale?

Subsidies: In what situations can public financing for micro-grid projects result in dependency and lack of project sustainability over the long term? Does equity matter: If the grid is subsidized, is it equitable that those on low incomes getting off-grid electrification pay full rates? How do we design subsidy structures that don't destroy markets or create perverse incentives? What impacts would phase-outs of fossil fuel subsidies have on the financing of renewable energy access projects?

Project standardization: To what degree is standardization of pilot projects (in terms of size, technologies, financing schemes, etc.) useful to generating interest from investors through lower perceptions of risk? Given the differences between projects is this a wise strategy over the long term, or should different contexts inspire a greater desire to find unique local solutions? Is there scope to create a menu of components of a system, together with operating protocols, so they can be selected in combinations to fit a local context?

5.5.3 Policy

Working with the private sector: To what degree should the role of governments and public institutions be to encourage private investment and business models to establish electrification efforts? In what contexts does electricity need to be seen as a public good – that is, a basic requirement for living? Does government have an obligation to provide adequate access to modern electricity services?

Goal-setting: What is the minimum target level of energy provision per household or community? How dependent is that on context and how should the target evolve over time as demand changes? How should the minimum acceptable kWh be determined and communicated in the policy realm? Should it be explicitly tied to the well-being of the community in a proportional scale, so that it is not a raw kWh metric?

5.5.4 Social Factors

Urbanization: What are the causal links between electricity access and migration to cities? Would rural electrification efforts slow urbanization? Given the growth of cities, should we prioritize efforts to provide safe, reliable grid-based electricity to the increasingly large number of people who live in 'informal' urban and peri-urban dwellings?

Perception of decentralized electricity: Politicians and customers sometimes see decentralized energy from smaller generation sources as 'second class energy' and crave grid connections. How do we make decentralization politically and socially attractive?

Training and expertise: Do the benefits of local training and expertise (local employment, skill development for those working in the sector and for new recipients of energy on how to use it to earn money, community participation, etc.) outweigh the costs (ex. time needed to train, expense of training, lack of capable applicants)?

6. Conclusion

Meeting the challenge and taking the chance

According to Deepak Nayyar, the esteemed Professor of Economics at Jawaharlal Nehru University, "The bottom billion must be seen as agents, or participants, in a process who can shape their destinies, rather than as patients, or passive recipients of the benefits from development programs designed by benevolent governments or institutions."[69]

While we would argue that the 'bottom billion' is not a monolithic block, and that opening up energy access for all its groups will require differentiated approaches, we certainly agree with Nayyar that providing global access to energy will not result from imposition of external 'solutions'. While energy for all is a goal laid out by global bodies – and a highly desirable one – its achievement will result from partnership.

What's more, it is important to recognize that energy provision will have pervasive social effects – not all of them positive. Delivering new energy systems to areas with a history of traditional methods of cooking, lighting and commercial activity will undoubtedly change the social and economic makeup of these communities. Some of these social considerations will challenge energy access project developers and the communities in which they are carried out. What happens to intra-community equity if not everybody can afford to get access through the micro-grid or pico-power solution? Will energy provision reinforce existing social stratification? Will access to mass communication disrupt local business and social relationships? Another major hurdle is generating trust in new technologies in areas where traditional energy sources have a close connection with cultural practices, and where traditional community values and mistrust of interventions from the developed world can be deeply ingrained.

Because of the large amount of data collected about customers through use of ICT, privacy concerns have been noted in some focus groups of new customers.[28] Illegal electrical connections set up by untrained individuals are a serious concern due to safety issues.[70] Awareness-raising about technologies, their benefits and proper use has been an important tactic to overcome some of the growing pains of their introduction into developing world markets. Such campaigns can, however, be expensive and often may be best left to the public sector rather than corporations.[35]

For all the challenges, renewable decentralized energy systems offer significant opportunities. A key area of opportunity is employment, as Nayyar points out. "For people who do not have the income to meet their basic needs, often in villages that have no energy access, employment opportunities are the only sustainable means of reducing and eradicating poverty," he says. "Moreover, employment creation and entrepreneurial activity mobilize the most abundant yet under-utilized resource in poor countries – the people for development."[68]

Early results and estimates regarding the employment creation potential of decentralized renewable energy are highly encouraging. According to the International Renewable Energy Agency (IRENA), nearly 4.5 million direct jobs can be

69. Nayyar, D. (2015). A better future for the bottom billion. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.
70. Ssali, M.J. (2015). How electricity changed our lives. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.

Photo credit: UNHCR / S.Ostermann

generated by 2030 in the decentralized renewable electricity sector.[71] An estimated 15,000 jobs have already been created in the West African off-grid lighting sector alone, which is nearly equivalent to the number of people employed throughout the region as kerosene distributors.[72]

Achieving wide access to reliable energy can have a significant impact on social welfare. This includes addressing issues of gender inequality and freeing large sections of the local population from the drudgery and inconvenience of tasks such as water collection and agricultural processing.

Women, children and young adults have the most to gain from the adoption of these systems. There is also evidence that decentralized electrification projects can benefit project effectiveness and also provide significant economic and social opportunities to the women involved. An example is the Barefoot Women Solar Engineers Association of Sierra Leone, which was formed on the basis of providing electricity to the most inaccessible regions of the country through involving those who stand to benefit most from the technologies – women – as agents of change. The program provides training to women in how to promote, set up and operate solar energy technologies. The foundation of the program is to foster the independence of women and girls through compassion, dignity and respect. It has been successful in not only improving their lives but also driving forward the adoption of these systems across the country, resulting in plans for a significant scale-up of the program beyond 2015, with the goal of electrifying villages in all 14 of the country's electoral districts.[73]

For young people eager to start their own businesses, electricity is a crucial asset benefitting their ability to find economic freedom and climb out of poverty. Many young people in rural areas migrate to urban areas to seek opportunity; however the potential for new electricity access programs to provide direct employment and further economic opportunities with their rural villages promises to make staying home a more attractive proposition. Those who do still want to leave can benefit from advance information about life and opportunities in urban environments. Electrified villages can also provide the amenities that young people crave, from television to nightlife to opportunities for self-employment.[69] Enlivening local life and providing opportunities for energy impoverished individuals to not only benefit from but also help create their new electrified communities must be central to energy access projects, wherever they might be carried out.

For all these reasons and more, it is important to hold a wide-ranging consultation to identify the best suite of solutions for opening up energy access to all. It is also important that the right people are involved in that conversation. At the April 2016 OpenAccess Energy Summit, WGSI will assemble individuals with appropriate expertise. Through a moderated discussion based on this briefing document, participants will share their perspectives with the assembled group and make recommendations regarding the best way forward.

71. IRENA (2013), Renewable Energy and Jobs, International Renewable Energy Agency, Abu Dhabi.
72. Mills, Evan (2014). Light and Livelihood: A Bright Outlook for Employment in the Transition from Fuel-based Lighting to Electrical Alternatives. UNEP/GEF en.lighten initiative. Paris.
73. Thorpe, C.A. (2015). Improving life for women and girls in Sierra Leone. In Heap, R.B (Ed) Smart Villages: New Thinking for Off-Grid Communities Worldwide. Smart Villages Initiative.

7. Appendix: WGSI's OpenAccess Energy Summit

April 24–27, 2016 – Waterloo, Ontario, Canada

7.1 Summit structure

WGSI Summits bring together a multidisciplinary, multinational and multigenerational group of approximately 40 people for four days of intensive working sessions. Half the assembled group are young leaders under the age of 30, the remainder are a mix of established experts and experienced advisors.

To begin, the Summit contributors share their experiences and develop a common understanding of the problem. From there, through discussions moderated by a professional facilitator, contributors turn their focus to the knowledge gaps and key areas of focus identified in this Brief.

At the end of the Summit, the contributors present a **Communiqué**; this provides a vision of the future and establishes key recommendations to make that future a reality. In the months following the Summit, this vision is fleshed out into a **Blueprint** that collates relevant research and case studies, and provides a roadmap to implementation.

7.2 Key players at the summit

7.2.1 Government – particularly energy policy and planning departments (local, national and global)

Electricity distribution , alongside healthcare and education, has traditionally been dominated by public-sector institutions. However, with innovations in small-scale power generation and private investment in decentralised markets, the landscape here is changing. Governments now have a wealth of choices over how to engage with electricity provision issues, some of which involve removing regulatory roadblocks, disincentives related to taxation and outdated legal frameworks in the energy sector in order to enable private sector actors to become involved. There are also opportunities to partner with NGOs and private sector financiers.

The shift from provider to enabler will not necessarily be easy for large bureaucratic public-sector institutions. However, the prospect of the economic growth, job creation and social stability that can come with energy access provision gives strong motivation to work with other actors and find ways to accelerate progress on energy access through expansion of decentralised systems. With energy access also embedded in the new UN Sustainable Development Goals, governments have a further incentive to address the issue. The Summit will provide an opportunity for a variety of government representatives to engage with private sector experts in energy access from different regions of the world, together pioneering a multi-actor approach to energy planning and provision that benefits from a global perspective and experience of many different contexts.

7.2.2 Academic community

Lab-based scientists and engineers will be necessary contributors to the design of decentralized renewable energy systems that fit the context of their use, and can provide hardware and software development support for the energy generation and distribution schemes of the future. Scholars in the social sciences and humanities can contribute through critiquing the suitability of plans, policies and legal frameworks, providing and disseminating case study examples and assessing the economic, social and cultural impacts of energy access projects. Both sets of scholars are likely to benefit through creative opportunities, access to new funding sources and a widened sphere of influence. During the Summit, these scholars will provide their expert knowledge of various energy access issues and projects, look to outline a programme of "grand challenge" projects and begin to frame and define the crucial areas of research that will be important to supporting the achievement of universal access to electricity.

7.2.3 On-the-ground implementers

Individuals and communities with experience implementing decentralized renewable energy systems in energy isolated communities are well-positioned to identify best practices and partner with other institutions to expand the reach of energy access projects worldwide. This will result in employment opportunities, increased economic and educational opportunities and enhanced lifestyles – including better health. Those attending the summit can kick-start the process of identifying necessary training initiatives, establishing a sound basis for recruitment and pinpointing organisations that can lead recruitment of locally-based workers to help with engineering, design, marketing, fundraising, community relations etc.

7.2.4 Transnational companies

The involvement of large, established businesses will be a huge asset to the drive for energy access. Whether already directly involved in energy or not, their ability to harness existing networks of expertise, supply chain infrastructure, and financial and human resources will accelerate progress toward universal energy access. The payback for these companies will be in customer goodwill, increased consumer wealth and spending and a wider customer base. Transnational companies will become more engaged when they come to understand that the provision of electricity to base-of-pyramid consumers can be a pathway to growth in emerging markets and can help drive demands for their products and services. At the Summit, representatives will help identify solutions that make sense for businesses already in operation in energy-isolated regions, and identify new business opportunities that energy access will open up.

7.2.5 Education and training sector

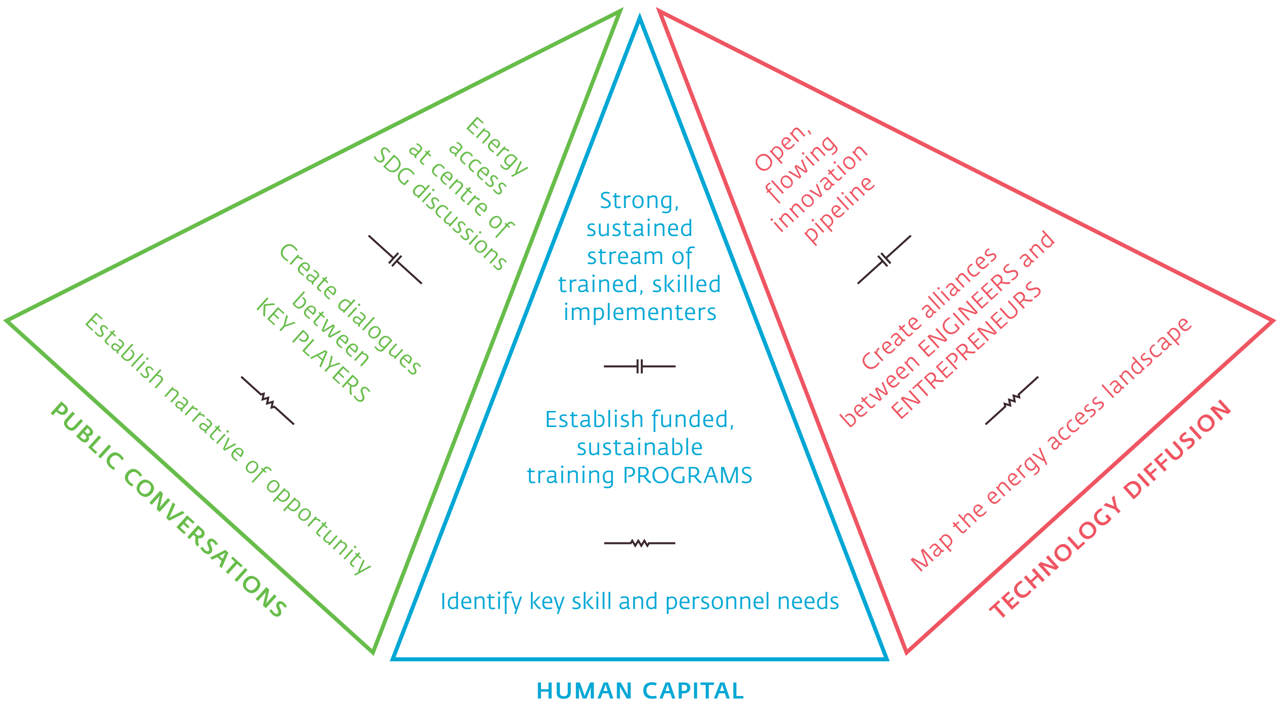
Achieving global-scale access to electricity will be impossible without a program to build capacity, in terms of trained human capital such as engineers, fundraisers, technicians, designers and community leaders. The problem is simply too big for solutions to be delivered by the energy access community as it stands today. Properly financed and government-supported programs will improve the education sector's outcomes and achievements, and provide the next generation of energy access entrepreneurs with the skills they need to build successful enterprises in this space. With accelerated training and education oriented towards solving energy isolation issues, there is hope that effective energy access schemes can scale fast enough to achieve universal access by 2030. This group's role at the Summit will include identifying likely early-adopter institutions and mapping out the strategic relationships that will facilitate the creation of useful training resources.

7.2.6 Financial sector (public and private)

Many energy access projects are hampered by the difficulty of raising funding. Building greater awareness of and confidence in these projects within the private finance sector could do a great deal to ameliorate this situation. Reducing financial risks for investors through policy intervention and public-private partnerships, identifying and communicating the kinds of profit-making opportunities that exist for business interests, providing training for financial personnel who make decisions on small loans, and education about the role of energy access in opening up economic growth are just a few of the activities that could lead private financiers into new and profitable opportunities in this space. While at the Summit, representatives from the finance sector will help develop meaningful criteria to encourage the sector's involvement in energy access initiatives and discuss with government sector representatives what partnership opportunities.

7.2.7 Media

Public conversation around issues of energy isolation needs to change. It is often framed in terms that suggest any extension of energy access will be an expensive public-funded effort, but there are more accurate and more appealing narratives. Energy access is an issue of economic opportunities, potential for improvements in well-being including provision of healthcare and education, empowerment of communities, and equitable distribution of the resources fundamental to modern life. The conversation about energy access can be enhanced through the dissemination of informed opinion in the media. An improved public perception of energy access issues will help motivate governments and transnational companies to become more deeply involved in accelerating progress and can inspire the next generation of bright young minds to unleash their enthusiasm and effort on the issue of universal energy access. This process will begin at the Summit, where journalists will participate in discussions and make useful contacts among the various sectors addressing energy access provision. Summit participants will also learn the value of working with the media to enhance the global reach of their work.



7.3 Project goals

The graphic above lays out our goals as we move forward through the energy access landscape. We envisage three programs running in parallel. One will reframe policy conversations, establishing and promoting a narrative where energy access is an economic, social, cultural, health and environmental opportunity. The second builds human capital through education, training and research. The third creates pathways by which new technologies are created and distributed.

Having established the general framework, we now provide more detail on our long, medium and short-term objectives.

7.3.1 Long-term

Aside from the obvious goal of creating energy access for every community, WGSI's long term aim is to have helped catalyze a steady flow of trained on-the-ground solution providers, a dynamic suite of resources such as case studies of success to inform further developments, and an engaged academic community of energy access champions dedicated to achieving further success and the continued identification and removal of remaining roadblocks to energy access.
On top of that, the aim is to have changed public and policy conversations about energy access into positive, solution-focused discussions of what needs to be achieved.

7.3.2 Medium-term

Create catalogue of energy access solutions
It makes sense to ensure that current and future knowledge is shared as widely as possible. An online, searchable, smart database of projects, hardware, software, financial information and construction experience will make implementing energy access solutions ever easier.

Establish network of scholars
The research communities of scientists, technology developers and the in the social sciences and humanities are ideally placed to act as informal consultants on energy access issues and to drive the development of new projects and resources. This will be even more effective as a resource if the scholars are themselves able to keep up with each others' work and hold conversations and create projects that cross disciplinary boundaries. Creating a professional network of energy access researchers will facilitate conversations and innovation within a framework where benefits and insights can be propagated across the community.

Establish a pipeline for trained implementers
If energy access programs are to thrive, it is not enough to develop suitably qualified personnel on an ad hoc basis. It will be important to set up stable, well-funded resourced training institutes and establish a program of courses and curricula. Widely available educational programming that can be tailored to meet the rapidly growing intellectual and skill development needs of the energy access community will be vital assets moving forward.

7.3.3 Short-term

Open conversations with business and financiers
The community of people who can help finance energy access projects are arguably the most important group to establish as key players in this space. A variety of business models is emerging, all of which must be considered when deciding how best to kick start any particular project. The input, support and understanding of financiers from the earliest stages will be vital to success

Engage with government bodies seeking energy access solutions
It is clear that economic advantage comes with energy access, and many governments overseeing areas where energy isolation is common are keen to find solutions. They are also in a position to smooth the path of implementation.

Change/inspire public conversation about energy isolation
Energy isolation is frequently spoken of in simplistic terms. There is a need for nuanced public conversations about the breadth of available solutions, positive stories about communities empowering themselves, and narratives concerning the economic success and restoration of equality that can come from gaining access to energy.

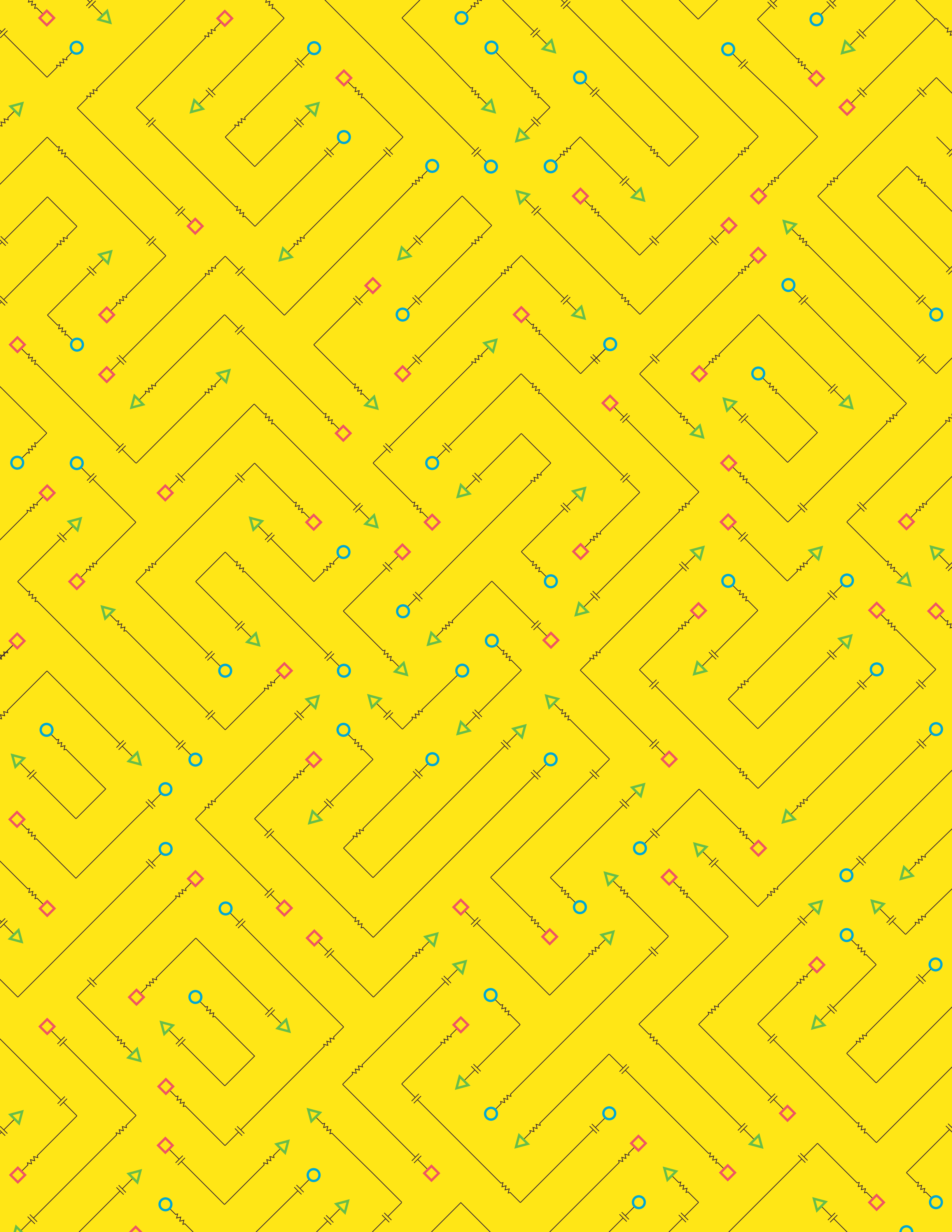
Create a forum where stakeholders can identify and discuss roadblocks to energy access
The implementation of energy access ideas has encountered a number of hurdles that often derail a project. These can range from import tariffs on hardware to regulations that forbid small generators from selling power to others within their community. For progress to be made, these issues need to be identified and workarounds or solutions found.

Create collaborative network that encompasses government / finance / technology / engineers / humanities / business / energy-isolated community leaders
There are many different stakeholder groups involved in solving the problem of energy isolation – civil society, businesses, government at multiple levels and NGOs, for example. It is vital that lines of communication are open between them, that they agree on common goals, and find ways they can collaborate towards achieving them. WGSI can facilitate this by establishing a collaborative network. It may be important to begin this process by mapping existing relationships, values, and resources.

Establish a set of criteria that will facilitate successful design, funding and implementation of sustainable energy access initiatives
Instead of each energy access project reinventing the wheel, it should be possible to establish a catalogue of hardware/ software solutions, funding models, checks and balances and recommended pathways for implementation – perhaps as a web-resource – that will help kick start the process.

Identify and support harvesting of low-hanging fruit
It is likely that a number of projects around the world are some way along the path to implementing energy access solutions, but perhaps facing particular problems that WGSI's resources are able to overcome. Targeted calls for information about ongoing projects may not only provide benefit for those projects, but also provide WGSI with valuable case study and direct real-world project experience.

Photo credit: Patrick Bentley/SolarAid



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