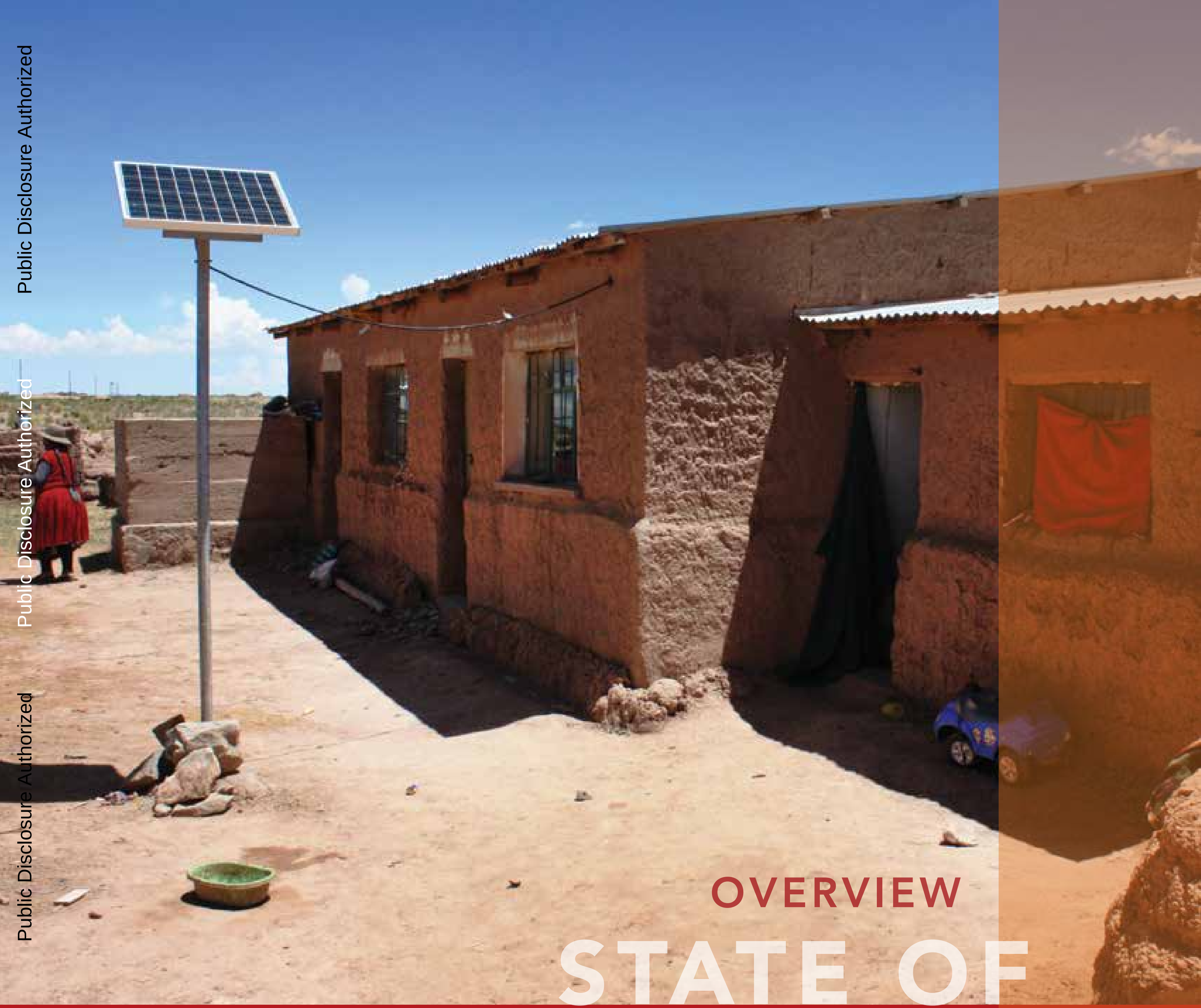

OVERVIEW

STATE OF ELECTRICITY ACCESS REPORT

2017

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OVERVIEW

STATE OF ELECTRICITY ACCESS REPORT 2017

WORLD BANK GROUP

ESMAP
Energy Sector Management Assistance Program

SUSTAINABLE ENERGY FOR ALL

ACKNOWLEDGMENTS

The development of the State of Electricity Access Report (SEAR) benefitted from advice of a Steering Committee led by the World Bank, Energy Sector Management Assistance Program (ESMAP). The membership of the Steering Group was as follows:

African Development Bank (AfDB)
Asian Development Bank (ADB)
Department for International Development—UK Government (DFID)
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Food and Agricultural Organization (FAO),
Inter-American Development Bank (IDB)
International Network on Gender and Sustainable Energy (ENERGIA)
Kreditanstalt für Wiederaufbau (KfW)
Practical Action
Renewable Energy Policy Network for the 21st Century (REN21)
Sustainable Energy for All (SEforAll)
United Nations Foundation (UNF)
World Bank (WB)
World Health Organization (WHO)

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Valuable support in preparation was provided by World Bank/ ESMAP staff and consultants: Mr. Venkata Ramana Putti, Ms. Barbara Ungari, Ms. Lara Born, Ms. Clara Alvarez, Ms. Xuege Lu, Ms. Natsuko Toba, Ms. Sunita Chikkatur Dubey, Ms. Srilata Kammila, and Ms. Connie Smyser.

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Case studies were coordinated by Ms. Dana Rysankova (ESMAP) and prepared by Mr. Sudarshan Kumar Saini, Mr. Ravindra Joshi, Ms. Sunita Dubey, Mr. Tim-Patrick Meyer, Mr. Jens Drillisch, Ms. Kathrin Kaestle, Mr. Robert van der Plas, Ms. Tomo Tanaka, Ms. Tripta Singh, Mr. Hung Tien Van, Ms. Jenny Tracy, and Mr. Kilian Reiche.

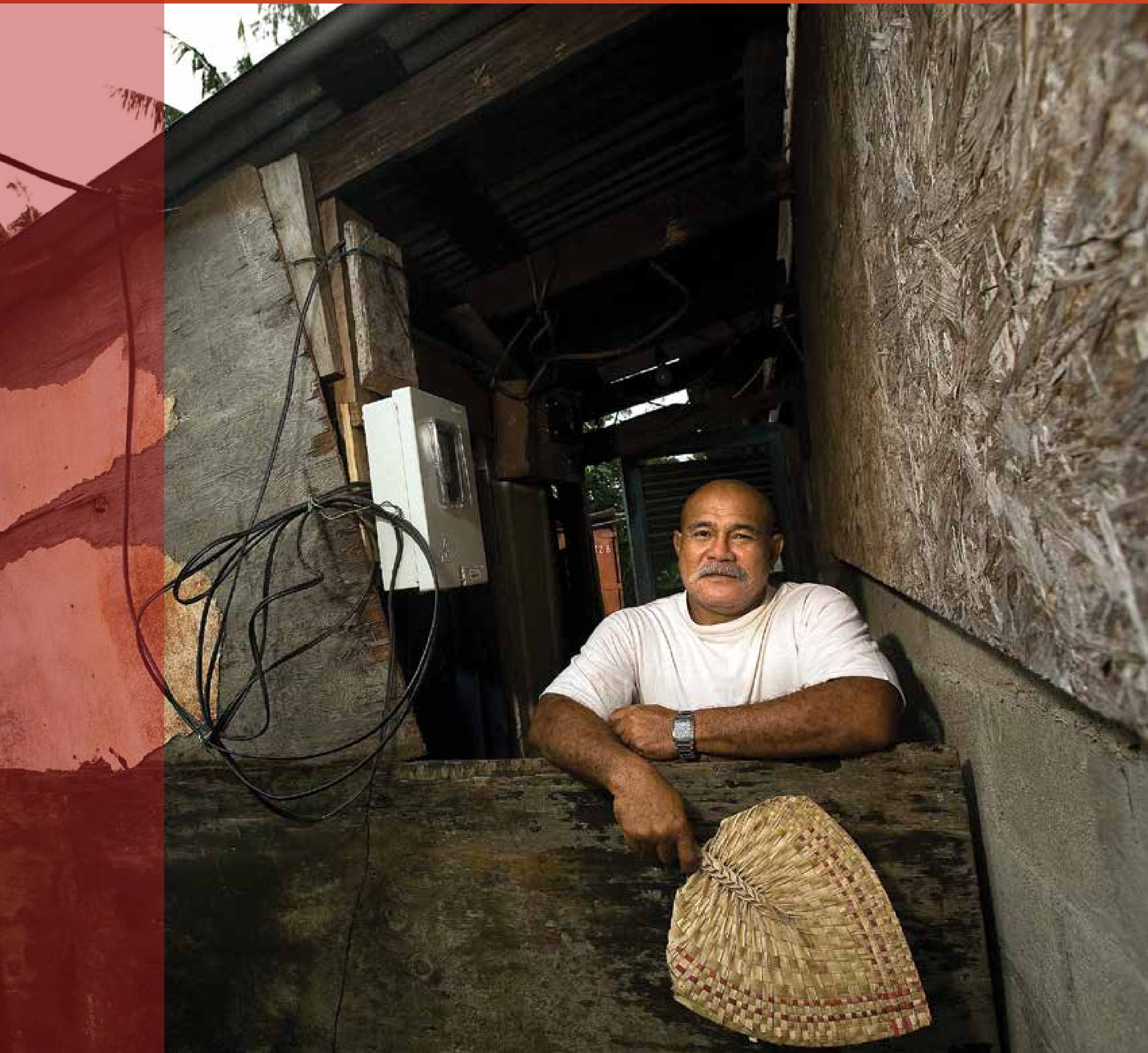
Impact evaluation reports were coordinated by Ms. Elisa Portale (ESMAP) and implemented by CIES International SRL (Bolivia); Infotrack Research and Consulting (Kenya); Sengsavang Rural Electrification (Laos); and field work and analysis were conducted by Mr. Hussain Samad and Mr. Voravate Tuntivate, the collaboration of Ms. Wendy Claribel Guerra Navarro, Ms. Lucia Spinelli, and Mr. Rome Chavapricha.

Review and Consultation: The World Bank's internal peer review process was led by Mr. Lucio Monari (Director of Energy and Extractives Global Practice, World Bank), with contributions from Mr. Simon Stolp, Mr. Ashok Sarkar, Mr. Jon Exel, Ms. Sudeshna Banerjee, and Ms. Yabei Zhang.

Substantive comments along the process were provided by Ms. Wendy Hughes, Mr. Malcolm Cosgrove-Davies, Ms. Vivien Foster, Mr. Richard Hosier, and Mr. Zubair Sadeque (World Bank); Ms. Naomi Paula Bruck, Mr. Russell Sturm, Mr. Leo Joseph Blyth, and Mr. Rahim Kanani (IFC); Ms. Jane Ebinger (SEforAll); Mr. Jens Drillisch (KfW); Ms. Monika Rammelt (GIZ); Mr. Alistar Wray (DFID); Ms. Yasemin Erboy Ruff (UNF); Ms. Rana Adib (REN21); Mr. Roberto Aiello, Mr. Arnaldo Viera, Mr. Javier Castillo, Ms. Alice Driver, Mr. Lauro Lage-Filho (IDB); and Mr. Giorgio Gualberti (AfDB).

Outreach: The communications process was coordinated by Ms. Susan Pleming and Ms. Anita Rozowska (World Bank). Four short video on SEAR were coordinated by Ms. Aarthi Sivaraman and Mr. Andy Shuai Liu. The online platform (http://esmap.org/sear) was developed by Ms. Aarthi Sivaraman and Ms. Barbara Ungari. The report was edited by Ms. Laura Wallace. Graphic design was by Naylor Design, Inc. with production support of Ms. Heather Austin (ESMAP).

This work was funded by ESMAP. The authors gratefully acknowledge the financial and technical support provided by the Energy Sector Management Assistance Program (ESMAP). ESMAP is a global knowledge and technical assistance program administered by the World Bank. It provides analytical and advisory services to low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, European Commission, Finland, France, Germany, Iceland, Japan, Lithuania, the Netherlands, Norway, The Rockefeller Foundation, Sweden, Switzerland, and the United Kingdom, as well as the World Bank.



OVERVIEW

KEY MESSAGES

- Given current conditions, universal electricity access will not be met by 2030 unless urgent measures are taken. While nearly 1 billion people in Sub Saharan Africa alone may gain electricity access by 2040, due to population growth, an estimated 530 million people in the region will not have electricity access (IEA 2014).
- This energy shortfall must be rectified if the international community hopes to meet the 2030 Sustainable Development Goals, in light of the linkages between energy and other sustainable development challenges—notably, health, education, food security, gender equality, poverty reduction, and climate change.
- In many countries with low levels of electrification access, both grid and off-grid solutions are vital for achieving universal electricity access—but they must be supported by an enabling environment with the right policies, institutions, strategic planning, regulations, and incentives.
- Against a backdrop of climate change, plummeting costs for renewable energy technologies and adequate energy efficiency measures offer a tremendous opportunity for countries to be creative about electricity access expansion—with the emphasis on "clean energy."
- Emerging and innovative energy service delivery models offer unprecedented opportunities for private sector-driven off-grid electrification and accelerating universal electricity access—but only if countries can create the necessary environment for them to be replicated and scaled up.

INTRODUCTION

Without access to electricity, the pathway out of poverty is narrow and long. The current pace of progress is not moving fast enough: 1.06 billion people still do not have access to electricity, and 3.04 billion people still rely on solid fuels and kerosene for cooking and heating (IEA and World Bank 2017). Despite significant progress in recent decades, achieving universal access to modern energy services by 2030 will not be possible without stepped-up efforts by all stakeholders.

In September 2011, the Sustainable Energy for All (SEforAll) initiative was launched with a call for: (i) universal access to modern energy services; (ii) double the global rate of improvement in energy efficiency; and (iii) double the share of renewable energy in global energy production. This call is also one of the 17 UN Sustainable Development Goals (SDGs), which are part of the 2030 Agenda for Sustainable Development, adopted in September 2015. At root is a recognition that energy is a key factor for sustainable development and poverty alleviation, and that it plays an important role in all major development challenges that the world faces.

What can be done to get the international community on track to close the electricity access gap? This report—The State of Electricity Access Report (SEAR) 2017 begins with an examination of the critical role of energy toward the achievement of the SDGs, then provides a snapshot of the status of electricity access, based on the recent Global Tracking Framework Data (IEA and World Bank, 2017). It goes on to explore how countries can create a conducive environment for a transformative electricity access roll out, how clean energy fits into the picture, and how emerging and innovative service delivery models can accelerate progress on meeting the goals.

This report is supplemented by a package of other materials: (i) 10 Special Features that delve into topics ranging from electricity planning, human capital, gender, water, health, food, and agriculture—including in emergencies—to climate change, energy efficiency, and results-based financing (they are summarized at the end of this overview); (ii) 5 case studies; and (iii) 4 impact evaluation reports.

Its objective is to prompt governments, donors, the private sector, civil society organizations, and practitioners to develop interventions to close the electricity access gap by integrating lessons learned from countries that have expanded electricity access to their population, with insights drawn from emerging innovative business and delivery models. The SEAR is organized around five main questions:

- Why is electricity access critical for achieving the 2030 Agenda for Sustainable Development?
- What is the status of electricity access?
- What are the challenges and drivers of transformative electricity access?
- Why is it important to explore synergies between access, renewables, and energy efficiency?
- What are the emerging and innovative business and delivery models?

The key findings of the *SEAR Report 2017* are that urgent measures are needed to speed up access to modern energy services or there will still be several countries in 2030, mostly in Sub-Saharan Africa, with a significant percentage of the population going without. Both grid and off-grid approaches will be critical, but they will have to be supported by a conducive enabling environment of the right institutions, policies, strategic planning, regulations, and incentives. The good news is that lower costs for renewable energy technologies and adequate energy efficiency measures should make it possible for countries to be creative in meeting this challenge and put the emphasis on "clean energy"—that is, renewable energy and energy efficiency. There is also a growing role for the private sector to finance interventions, assuming the incentives are in place for investors to earn returns on their investments.

WHY IS ELECTRICITY ACCESS CRITICAL FOR ACHIEVING THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT?

For the international community, there is broad agreement that access to modern energy services is a necessary pre-requisite for alleviating poverty and boosting shared prosperity. Without energy, it is challenging, if not impossible, to promote economic growth, overcome poverty, expand employment, and support human development. Sustainable energy is the seventh goal of the 17 UN Sustainable Development Goals (SDGs), with a call to "ensure access to affordable, reliable, sustainable and modern energy for all." Its five targets indicate areas where policies can be designed—such as boosting the share of renewable energy in the global energy mix and doubling the global rate of improvement in energy efficiency (Box O.1).

Furthermore, energy can contribute to achieving the other 16 SDGs (Figure O.1). A review of all SDG targets indicates that energy is interconnected with 125 (74 percent) out of the 169 targets, making it crucial for all societies to recognize the key interlinkages of energy and the wider development agenda (Vera, 2016). Thus, planning for universal access to modern energy services should be an integral part of national planning efforts to achieve the SDGs. Studies of power outages indicate that lack of energy does lead to a loss of output at a firm level—for example, in 2013, the World Bank Enterprise Surveys showed that power outages in Tanzania cost businesses about 15 percent of annual sales—and greater availability of energy has been shown to lead to more income, jobs, and educational benefits at the individual household level. In addition, lack of access to modern energy (especially grid electricity) acts as a constraint on economic growth, while access to modern energy services can stimulate growth and employment opportunities.

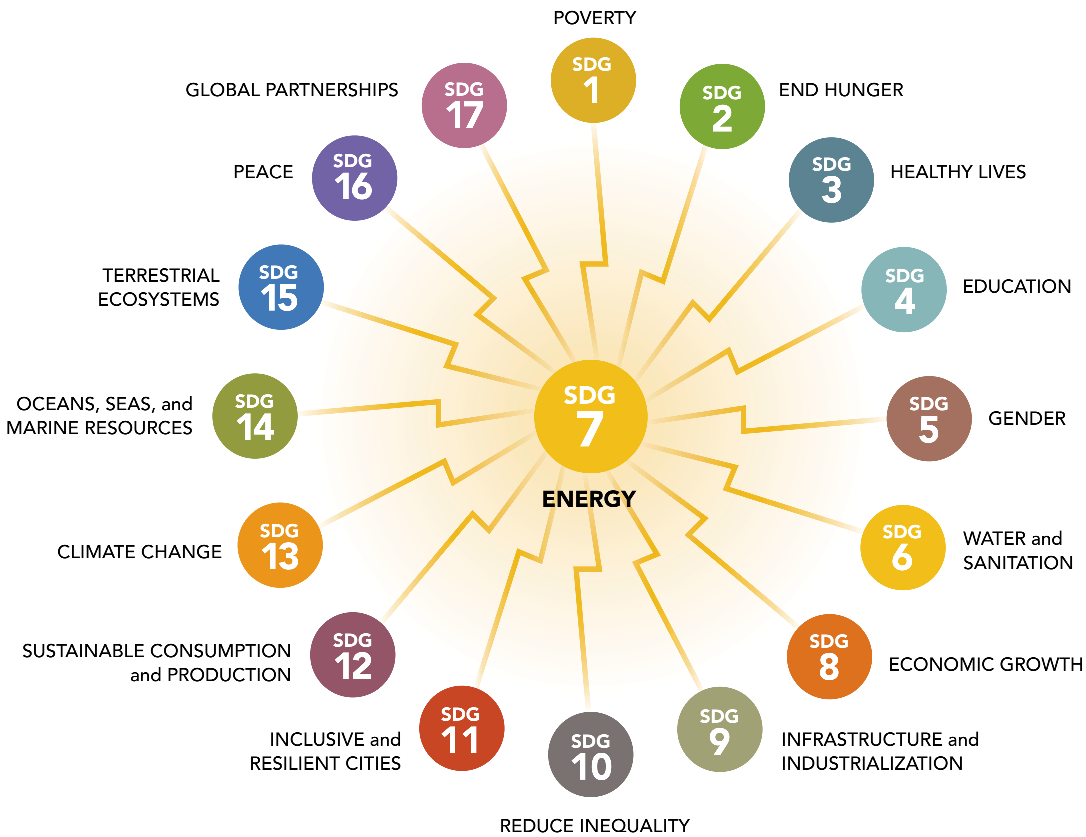
BOX O.1

Targets for Sustainable Development Goal 7

- By 2030, ensure universal access to affordable, reliable and modern energy services
- By 2030, increase substantially the share of renewable energy in the global energy mix
- By 2030, double the global rate of improvement in energy efficiency
- By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
- By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, Small Island Developing States, and land-locked developing countries, in accordance with their respective programs of support

Source: UN 2016.

FIGURE O.1 Energy is linked to all the remaining Sustainable Development Goals



Countries with the highest levels of poverty tend to have lower access to modern energy services—a problem that is most pronounced in Sub-Saharan Africa and South Asia, where a large share of the population depends on traditional biomass for cooking and heating and lacks access to electricity. Poor households lack the resources to purchase modern energy services (especially when there is a connection charge to obtain the modern energy source, as with electricity). At the same time, households lacking access to electricity and other modern energy sources have fewer opportunities for income generation (especially from agriculture). These households earn less, spend more time collecting biomass and less time on education, and pay more per unit for the limited amounts of modern energy that they can purchase (such as batteries for lighting and phone charging).

In addition, households using solid fuels and traditional cooking methods are subject to high levels of indoor air pollution, which is associated with high rates of mortality and morbidity, especially for women and children who have the greatest exposure to this pollution. Access to modern energy services, either through the form of advanced combustion cook-stoves using biomass, or through a switch to the use of LPG, can substantially reduce the long-term costs to the household from diseases associated with high levels of indoor air-pollution. Several studies estimating the benefits of electrification on households or small businesses suggest that electrification results in higher household income, with the magnitude varying considerably among countries. In Bhutan, non-farm income increased by 63 percent, while farm income was unaffected (Kumar and Rauniyar, 2011), and in India, non-farm income rose by 28 percent (Khandker et al., 2012). However, recent studies also show that the benefits of electrification can be overestimated if the endogeneity of a household is ignored—that is, electrification does not only affect income but income can also determine whether or not a household is electrified. For example, higher-income households are more willing to get a connection as soon as the grid arrives (particularly if the connection fees are not fully subsidized), and utilities prefer to provide electricity to higher-income communities (Bacon and Kojima 2016).

As for the environment, the link between energy and climate change is twofold. The energy system is a major contributor, as it generates greenhouse gas (GHG) emissions through energy production and use, while climate change can disrupt the world's energy system—as extreme weather events, sea level rise, water availability changes, and temperature increases affect supply and demand of energy. It is particularly challenging to estimate future impacts of the energy sector on climate change, as multiple factors are coming into play. Fortunately, the goal of achieving universal access to modern energy services in itself would result in a negligible increase of carbon dioxide (CO_2) emissions if the energy demand of the affected population is projected to remain low. However, as people emerge from poverty, demand for energy will increase, and power system planning will have to account for spillover effects.

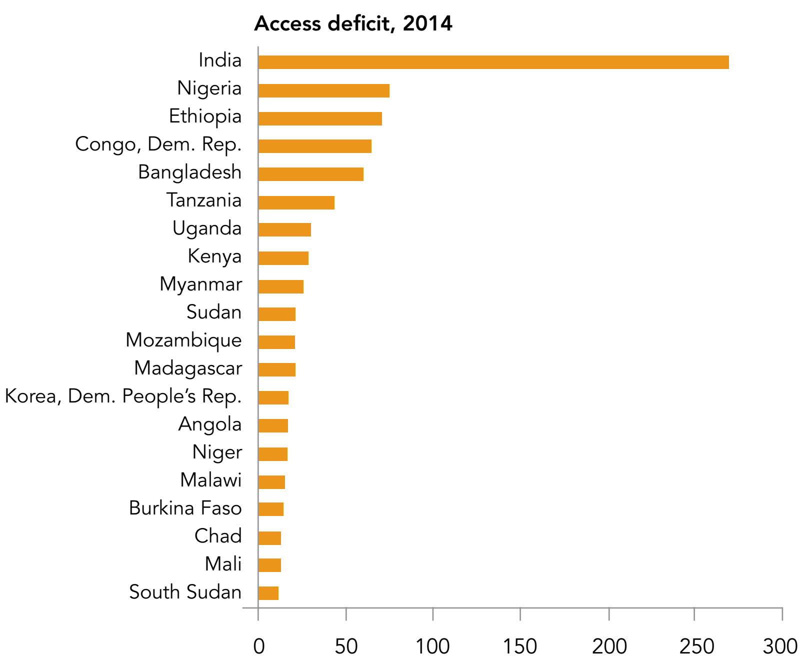
In sum, there are many opportunities for access to modern energy services to contribute to achieving the other SDGs if interventions are designed to operationalize the linkages between electricity access and other sustainable development challenges—such as health, education, food security, gender equality, poverty reduction, and climate change.

WHAT IS THE STATUS OF ELECTRICITY ACCESS?

In 2014, 1.06 billion people still lived without access to electricity—about 15 percent of the global population—and about 3.04 billion still relied on solid fuels and kerosene for cooking and heating (IEA and World Bank 2017). The electricity access deficit is overwhelmingly concentrated in Sub-Saharan Africa (62.5 percent of Sub-Saharan Africa population) and South Asia (20 percent), followed by East Asia and the Pacific (3.5 percent), and Latin America (3 percent) and the Middle East and North Africa (3 percent). In Sub-Saharan Africa, 609 million people (6 out of 10) do not have access to electricity, and in South Asia, 343 million people do not have access to electricity.

At the country level, India alone has a little less than one-third of the global deficit (270 million for electricity), followed by Nigeria and Ethiopia for electricity—and the 20 highest access-deficit countries for electricity account for 80 percent of the global deficit (Figure O.2).

FIGURE O.2 India has the world's largest electricity access deficit
(Top 20 countries for access deficit in electricity, 2014)



Source: IEA and World Bank 2017
Note: These countries account for more than 81 percent of the global access deficit.

Between 2000 and 2014, there were advances in electrification, with the global electricity deficit declining from 1.3 billion to 1.06 billion—and the global electrification rate rising from 77.7 percent to 85.5 percent. Progress with rural electrification is evident, with the global rural electrification rate increasing from 63 percent in 2000 to 73 percent in 2014. Urban areas across the world are already close to universal access at 97 percent. Although urban access rates have risen relatively little in the past 25 years, this level remains a major achievement when viewed against the rapid urbanization that has brought an additional 1.6 billion people into the world's cities during this period.

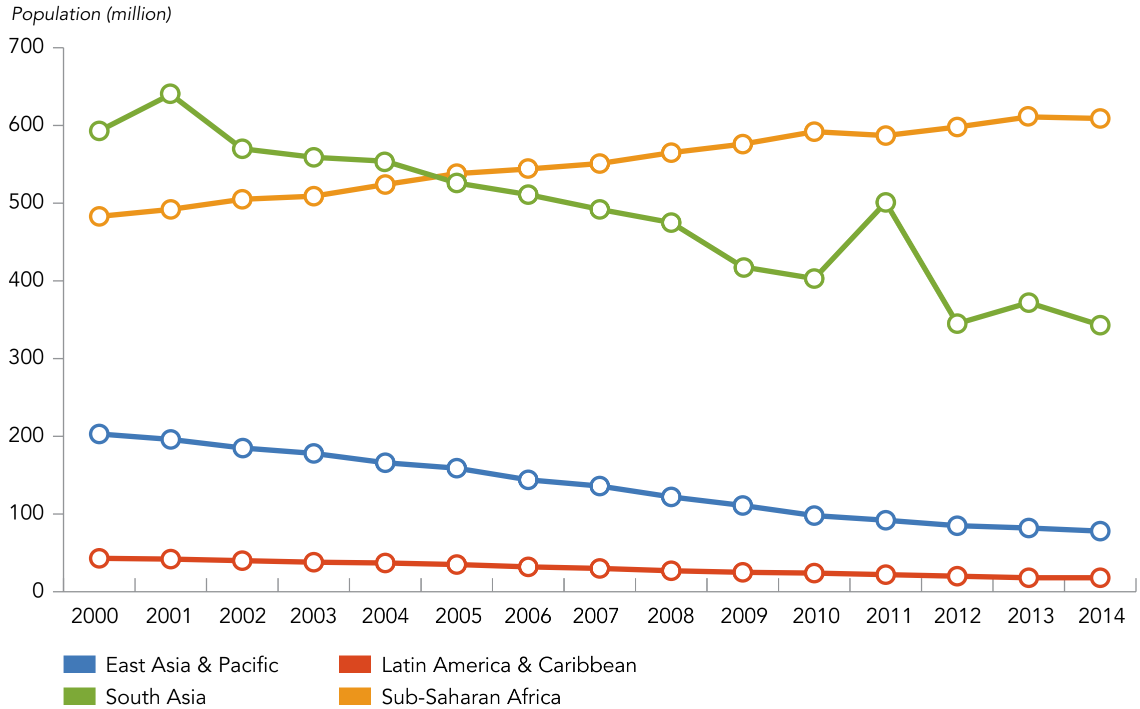
Among the regions, improvement in access to electricity in the period 2000–14 has been remarkable in South Asia (rising from 57 to 80 percent), in other regions growth during the same period has been moderate: for East Asia and Pacific (from 90 to 96 percent), Middle East and North Africa (from 91 to 97 percent), Latin America & Caribbean (from 92 to 97 percent) and Sub-Saharan Africa (from 26.5 to 37.5 percent). Trends in population lacking access to electricity are rising in Sub-Saharan Africa, where 609 million people still do not have access to electricity services. (Figure 0.3).

How much improvement will be needed to get the world back on track? Progress has fallen consistently short of the population growth rate since 2010, meaning that efforts in the remaining years will need to be stepped up to 0.9 percent for electricity (Figure O.4). At the regional level, Latin America, East Asia, and South Asia will be able to reach universal access by 2030, assuming conditions of constant growth in electricity, constant growth in population, and no major changes in political willingness and financial investments in increasing access. However, Sub-Saharan Africa is falling behind—currently growing at 5.4 percent annually against the needed 8.4 percent annually to reach universal access by 2030.

Although the access deficit in 2014 for electricity was overwhelmingly rural, the expected population growth of 1.5 billion by 2030 will be almost entirely urban, reflecting rural-urban migration. This implies that the number of rural households for which access needs to be created will stabilize and not be inflated by population growth. Although urban connections may be perceived as lower cost and therefore easier to implement than rural connections, the challenges presented by urban slums require regulatory and financial incentives to ensure that universal access is attained. A further challenge is presented by the recent spread of the "rapid growth of households" from developed countries to developing countries (Badger 2014, Bradbury, Peterson, and Liu 2014).

What is the anticipated price tag for closing the gap? A 2011 study by IEA on comparable estimates of current financing trends and future investment needs for achieving universal access to electricity provides a high-level estimate of investment needs of $45 billion a year, against actual investment flows at that time of an estimated $9 billion a year (IEA 2011).

FIGURE O.3 Sub-Saharan Africa is not keeping up with population growth for electricity access
(Trends in population lacking access to electricity, 2000–2014)

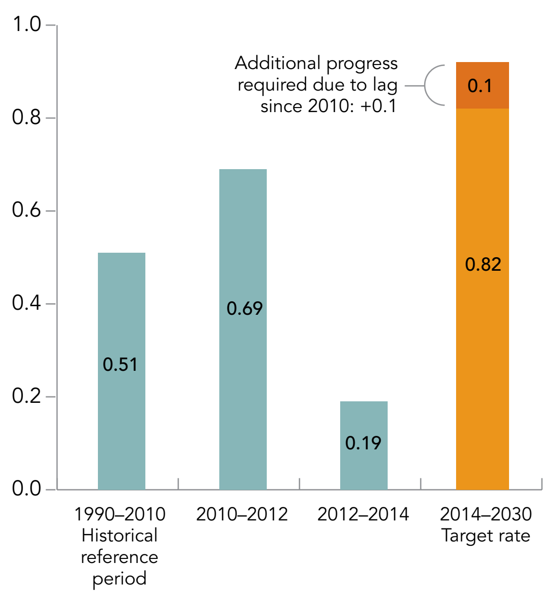


Source: Data from IEA and World Bank 2017

The World Bank's Access Investment Model provides detailed bottom-up estimates of the cost of reaching universal access in each of 15 countries with large electricity access deficits. These countries reflect differences in population and geography as well as local unit costs, and they can be used to give a global estimate of access investment needs (IEA and World Bank, 2015). The model, based on the Multi-Tier Framework, allows users to choose the tier of access that would be used to meet the universal access target, and illustrates how dramatically this affects the costs of electrification. Reaching universal access at Tier 1 (enough to light a few light bulbs and charge a mobile telephone) would require investments of $1.5 billion annually up to 2030. By contrast, reaching universal access at Tier 5 (full 24x7 grid power) would require investments of $50 billion annually.

In sum, universal electricity access will not be met by 2030, unless urgent measures are taken. While nearly 1 billion people in Sub Saharan Africa alone may gain electricity access by 2040, due to population growth, an estimated 530 million people in the region will not have access (IEA 2014). One tool that would help facilitate the effort would be a new way of measuring the electricity access target, beyond the traditional binary metrics—which can be misleading because they do not capture the multi-dimensionality of electricity access. The World Bank and ESMAP are working with partners to promote broader adoption of the Multi-tier Framework as the key monitoring platform for tracking progress toward SEforAll and SDG 7.

FIGURE O.4 Electricity access falls short of the pace to meet the 2030 target



Source: IEA and World Bank 2017

WHAT ARE THE CHALLENGES AND DRIVERS OF TRANSFORMATIVE ELECTRICITY ACCESS?

More than 70 countries have been working over the last four years to develop action plans, strategies, and projects to deliver on the goal of universal access to modern energy services. Their efforts have been supported by partnerships and initiatives from both the public and private sector that have emerged at the national, bilateral, and multilateral levels.

For electricity, meeting the demand created by increased access follows two main tracks: (i) grid-electrification providing connections to urban, peri-urban, and rural areas; and (ii) off-grid electrification through community level micro- or mini-grid systems, or isolated devices and systems at the household level. These two approaches have different capital requirements, serve different population densities, and use different technologies.

The expansion of national electricity grids, which is the "conventional" method for broadening access, involves adding power plants and extending high-voltage transmission lines and distribution networks into rural areas. In the past two decades more than 1.7 billion people have been added to national electricity networks worldwide, mostly in urban areas. Although progress has also been made in rural areas, the numbers are not rising as fast, because rural grid electrification programs involve connecting villages incrementally to the existing grid, with remote areas with small populations, high line losses, and low usage usually the last to be connected.

The biggest challenges to expanding grid-based electrification and access are the lack of sufficient generation capacity, poor transmission and distribution infrastructure, the high costs of supply to rural and remote areas, the inability of low income households to pay high connection charges, and the weak financial state of the utilities. The investment needs for a program to expand access to rural areas are large, while the possible receipts are likely to be insufficient to cover costs without financial support. A very substantial barrier to household access is the cost of connection. In Africa, unsubsidized connection costs often exceed the country's monthly income per person, and households have to pay these plus fees for inspection and application, security deposits, internal wiring, and equipment costs. These fees are usually charged upfront making it difficult for low income households to afford the service.

Energy services can also be expanded using "off-grid" electrification, which involves much smaller grids than in grid electrification. One approach is "mini-grids"—isolated groups of generation, distribution, storage facilities within a confined geographical space. They are usually locally managed, have less than 10 MW of installed capacity, serve small household loads, and serve an area of up to 50 kilometers radius. Another approach is "micro-grids"—smaller units, typically operating with less than 100 kW of capacity, at lower voltage levels, and covering a radius of up to 8 kilometers.

Both of these can be powered by fossil fuels (diesel) or by renewables (hydro, solar PV, biomass combustion, and wind). Hybrid systems using renewable energy sources together with batteries or a diesel generator can be used to address the problems of intermittency. In very remote communities, energy services can be provided by off-grid units, such as PV solar home systems or pico-solar products. These can be deployed faster and more simply than a mini-grid.

What is holding up progress? The key hurdle appears to be creating an enabling environment for an electricity access roll out. While no single recipe exists, the evidence points to the need for the right policies, institutions, strategic planning, regulation, and incentives as vital prerequisites.

For rapid grid-based expansion, lessons from successful countries suggest the following main drivers: (i) there needs to be a sustained government commitment over a long period of time; (ii) there should be dedicated institutions to plan, implement, and expand electrification programs; (iii) there should be predictable financing mechanisms to support public sector programs and to attract private sector initiatives; and (iv) measures should be adopted to ensure the affordability of electricity services.

For developing off-grid schemes, mini-grids offer a means of supplying "grid-quality" power to communities quickly without having to wait many years for the grid-based distribution network to reach distant communities. However, there are challenges to be met in order to ensure that mini-grids are the least-cost solution and continue to provide affordable electricity services over the long-run, and that key risks are mitigated to offer viable business opportunities. High upfront investment requires anticipated load growth to materialize, or else there will be inadequate revenues to cover costs. Mini-grids tariffs are usually higher than grid-based tariffs (unless there is a significant subsidy to the mini-grid), which may limit the willingness-to-pay of households.

Where both grid and off-grid solutions are being developed, it is important to ensure complementarity of these solutions. For example, if the grid reaches the mini-grid service area, demand for mini-grid services would decline sharply and the investment in the stranded assets would become unrecoverable, in the absence of special policies to address this issue. Often, off-grid solutions are developed in geographic areas far from the grid to provide communities with electricity services sooner than the grid. Take the case of Cambodia, where, as a study by Tenenbaum et al. (2014) explains, there was a lack of policy on what to do when the grid reached the mini-grids. Eventually, the situation was resolved by the regulator issuing licenses to transform the mini-grids into distribution utilities—but it underscores the need for planning upfront for the eventual arrival of the grid to give investors more confidence to develop mini-grids in rural and remote areas. The study recommends four options for when the grid arrives:

- Small Power Distributor (SPD) Option where the Small Power Producer (SPP) operating a mini-grid converts to distributor that buys electricity at wholesale from the national grid and resells it at retail to its local customers.

- SPP Option where the mini-grid operator sells electricity to the operator of the national grid but no longer to its local customers.
- Buyout Option where the SPP sells its distribution grid to the national grid operator or other entity designated by the regulator and receives compensation for the sale of the assets.
- Combined SPP and SPD Option where the SPP converts to an SPD and also maintains a backup generator as a supply source to the main grid and retail customers.

As part of the planning process, it is essential to choose the right technology to provide the electricity, whether to urban or remote rural areas, in a cost-effective manner. That is where geographical information system (GIS) models—which enable the assessment of the cost of electricity provision and energy cost implications of competing technological systems in space and time—fit in (Howells et al., 2017). In addition, for electricity access programs to be transformative, special attention needs to be paid to productive uses of electricity services—defined as agricultural, commercial, and industrial activities that require electricity services as direct inputs to the production of goods or provision of services (EUEI PDF 2011; Short 2015; Contejean and Verin 2017). Rural and remote areas, which are often inhabited by low-income households and lack electricity supply, may not have opportunities to expand productive uses even if electricity is made available. In those cases, complementary initiatives—such as facilitation for micro-finance and vocational training—may be needed to both maximize the benefits of electricity programs and promote long-term sustainability.

In sum, while recognizing that each country will have to decide on its own pathways to universal access, sustainable government commitment will be essential, as occurred in Vietnam (Box O.2). Also vital will be making modern energy provision part of a broader vision of social and economic transformation. In many countries with low levels of electrification access, they will need both grid and off-grid solutions—supported by an enabling environment with the right policies, institutions, strategic planning, regulations, and incentives.

WHY IS IT IMPORTANT TO EXPLORE SYNERGIES BETWEEN ACCESS, RENEWABLES, AND ENERGY EFFICIENCY?

Meeting the global target for electricity access while achieving the Paris Agreement's goal of limiting global warming to below 2˚C will require a major shift toward "clean energy"—that is, renewable energy and energy efficiency. Supply from renewable energy technologies is now growing at an unprecedented rate, while the growth in the global economy is starting to decouple from energy-related carbon emissions, thanks to the adoption of energy efficient measures and technologies.

Since 2013, the world has added more renewable energy power capacity (an estimated 147 GW by end 2015) than conventional capacity, while investment in renewable power and fuel in developing countries in 2015 surpassed that in developed countries. Energy efficiency and technology reduced the growth of global final energy demand by almost two thirds (0.7 percent increase as opposed to the previous decade's average 2 percent). This growth has been driven by significant reductions in the costs of renewables. In 2014/2015 the median cost of producing baseload power from residential solar was $200/MWh—sharply down from $500/MWh in 2010—compared to about $100/MWh for conventional sources. Wind and solar PV costs were lower, and long-term contracts in some countries were in the range $60-80 for onshore wind, and $80-100 for utility scale solar PV.

As ***renewable energy*** continues to gather momentum, grid integration is emerging as a key issue to accommodate a higher share of renewables. One of the biggest challenges will be coping with the variability and intermittency of modern sources of renewable energy (such as solar and wind)— given that the current grid infrastructure in many countries was built on the basis of controllable energy sources and organized around the generation-transmission-distribution model. The good news is that renewable energy technologies are flexible, modular, and can be used in various configurations, ranging from those that are grid-connected to those that are off-grid.

Mini-grids are emerging as a key player for cost-effective and reliable electrification of rural areas (Figure O.6) . It is projected that one-third of total investments toward achieving universal access by 2030 will be targeted to mini-grids, with the vast majority (over 90 percent) coming from renewable energy generation. Hybridization of mini-grids is increasingly popular, especially in countries that have been powering exiting mini-grids with diesel. Moreover, improvements in storage systems will increase the use of renewables and decrease the share of diesel which would mainly supply evening peaks. Mini-grids can also contribute to the socioeconomic development of a region. Besides providing basic energy services (lighting and phone charging), they can fuel productive activities such as pumping, milling, and processing. A recent comparison of diesel and hybridized mini-grids at seven sites in Africa, Asia, and Latin America, showed potential savings ranging from 12 to 20 percent, depending on oil prices.

It is true that the huge potential for electricity access using mini-grids is hindered by numerous challenges—including inadequate policies and regulations, lack of proven business models for commercial roll-out (notably for pico-solar systems), and lack of access to long-term finance. But many countries are currently developing mini-grid policies to address these problems. India has released a draft national policy for mini and micro grids, which, if adopted, will create the proper framework and environment for developing 500MW capacity over the coming decade. Kenya's Energy Regulatory Commission has licensed Powerhive East Africa Ltd. to generate, distribute, and sell electricity—the first private company in Kenya's history to receive a utility concession. Powerhive will develop and operate solar mini grids of a total capacity of 1MW to power 100 villages.

BOX O.2

Vietnam's National Drive to Achieve Universal Electricity Access

Vietnam's experience demonstrates that where strong political commitment exists, the goal of universal access to electricity is achievable irrespective of the country's starting condition. This commitment, however, needs to go hand in hand with a willingness to learn from past mistakes and correct one's course when circumstances change.

In 1994, when Vietnam started its universal access drive, its electrification rate was only 14 percent, comparable to the access rates of the least electrified countries in Africa. By 1997, the rate had jumped to 61 percent, and by 2002, it was over 80 percent. Today, the Vietnamese population enjoys the full benefits of electricity, with an access rate over 99 percent.

Vietnam's secret to success was not betting on a particular electrification approach, but rather allowing the approaches to evolve over time. In the initial "take-off" phase (1994–97), the goal was to trigger fast access expansion by empowering communities and local authorities to build their own systems. During this phase, little attention was paid to service quality, costs, tariff levels and other regulatory aspects. It was a highly decentralized approach, with a very limited role for the national utility EVN, which was only selling electricity in bulk to these newly created mini-distribution entities. This was a period of extremely fast electrification, with the rate jumping from 14 percent to 61 percent in just three years—as well as record investments leveraged from users, communities and local governments.

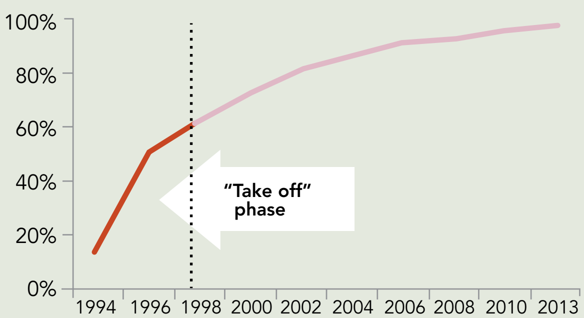
However, there was a trade-off between the pace and the sustainability of the electrification efforts. As it turned out, many new distribution networks were of low technical quality and suffered high losses, and the newly established entities did not have sufficient experience nor the financial strength to operate them. The subsequent phases, therefore, prioritized sustainability measures, with a heightened focus on ensuring service quality and both technical and financial viability. Gradually, the dispersed local electrification networks were consolidated into larger units and their operators corporatized; most of them were eventually absorbed by the national utility, EVN.

While many elements of Vietnam's electrification approach are unique to Vietnam, its key lessons are pertinent to all electrification efforts:

- Vietnam has achieved universal access to electricity largely due to the government's unwavering commitment to electrification, and its willingness to learn and when necessary change course.
- Fast progress and a record fund mobilization was possible by making electrification a national priority, engaging central, regional, and local government, along with rural communities.
- Fast progress is not just a matter of political commitment, it also requires a strong demand and a willingness to pay from the participating population—when rural income rose, electrification took off.
- The trade-off between speed and sustainability of electrification efforts needs to be carefully managed.
- Technical standards appropriate for rural areas should be developed and enforced right from the start of the national electrification program.
- Electrification goals should not happen at the expense of the national utility's financial viability.

Source: SEAR Case Study: Vietnam's national electrification program, forthcoming.

FIGURE O.5 Electrification Becomes a National Priority
(Vietnam Household Electrification Rate, %)

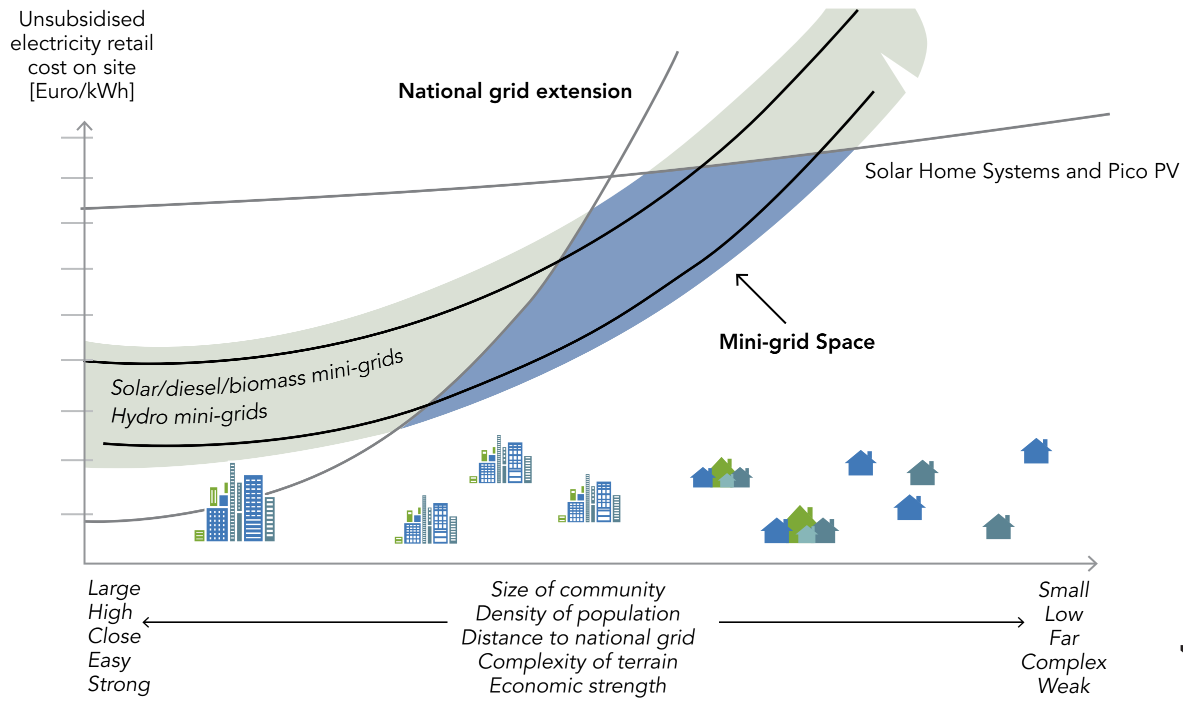


Further, with the rapidly decreasing costs of stand-alone/isolated renewable energy systems, renewable energy is no longer an expensive solution for electricity access. Solar lanterns, solar mobile phone chargers, and certain solar home systems can provide Tier 1–3 energy services (as per the Global Tracking Framework Tier Based System) for between 4 and 20 percent of the cost required for grid extension. Solar Aid, a private solar company, which has sold some 1.5 million solar lights (benefiting some 9 million people), estimates that $10 solar lights can help African families save an average of $60 annually, simply by not using kerosene for lighting purposes.

The stand-alone electricity product market is expanding rapidly, and Navigant Research estimates the market for pico-solar products will grow from $550 million in 2014 to $2.4 billion in 2024. Globally, some 20 million households are now powered by solar home systems and 0.8 million households are supplied by small scale wind systems, according to IRENA estimates. Pico solar PV systems—which typically provide less than 10 watts of power and are primarily used for lighting or powering electrical appliances (like radios or mobile phones)—have developed rapidly in recent years, due to the fall in price of solar modules, the use of highly efficient LED

FIGURE O.6 **A growing role for mini grids and renewables**

(Opportunities for grid extension, mini grids, and distributed renewable energy systems)



Source: EUEI PDF/REN21 (2014)

lighting systems, and the emergence of innovative business models.

So what are the biggest obstacles that countries face in introducing and scaling up the share of renewables in energy use? They range from the presence of large fossil fuel subsidies, the inadequate communication of the advantages of renewables, unclear government policies, a lack of good financial options, and insufficient community involvement. Fortunately, these obstacles can be ameliorated by the creation of a pro-renewables policy and long-term government commitment—sand within this framework, innovative business models are emerging and are leading off-grid electricity access developments.

Energy efficiency, once overlooked, is being seen increasingly as a tool in delivering modern and clean energy services. It reduces the costs of energy supply, therefore making access more affordable. For example, energy efficient light emitting diodes (LEDs) radically reduce the size and costs of the solar PV and batteries needed to provide service, making these technologies affordable for vast new market segments. By end-2015, at least 146 countries had enacted energy efficiency policies, while at least 128 countries had energy efficiency targets. There has also been a drop of more than 30 percent in the primary energy intensity between 1990 and 2014.

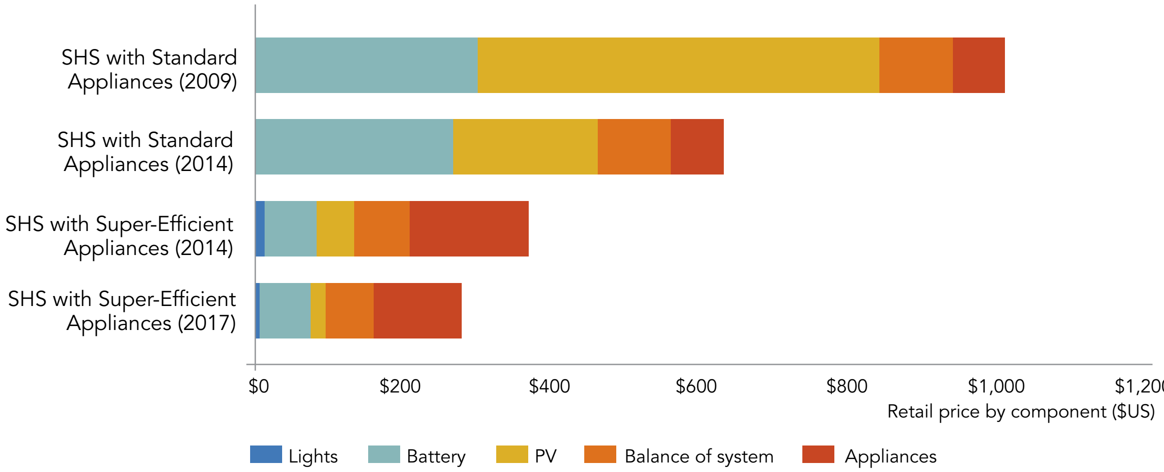
What is hindering energy efficiency from playing a bigger role? The barriers are many: (i) high tariffs and import duties on appliances and equipment used in those markets where access is to be increased; (ii) financial constraints that tend to favor products with the lowest initial cost, even though many products with superior energy performance have a lower lifecycle cost despite a higher upfront cost; (iii) a lack of overlap between professional communities engaged on electricity access and on energy efficiency; and (iv) a lack of focus on the overall energy sector, often because of concentration on solutions involving increased grid generation capacity.

Even so, there are many examples of smart practices and effective models for incorporating energy efficiency. Some high-impact programs have prioritized a broader view on developing electricity access markets looking to commercial and supply-chain management, policy reform, and consumer awareness. One relatively simple way to improve efficiency is through distribution transformers, which are an integral part of every grid. Transformers are a globally traded product, and at least 16 developed and developing economies (including Brazil, China, India, Mexico, and Vietnam) have either minimum energy performance standards or labels in place that regulate or facilitate the installation of highly-efficient transformers. These existing efforts make the establishment of new programs and policies far less burdensome for developing economies.

The success of off-grid technologies for providing energy solutions in recent years is largely attributable to the availability of energy efficient appliances. For instance,

FIGURE O.7 Solar home systems are increasingly offering more for less

(Retail purchase price for three solar home systems that provide identical levels of service)



Source: Phadke, A. et al. 2015.

in many countries the use of high efficient LED lamps has enabled the implementation of various modern lighting programs and initiatives in rural and electrified areas. As the Royal Swedish Academy of Sciences put it when announcing the 2014 Nobel Prize in Physics: "The LED lamp holds great promise for increasing the quality of life for over 1.5 billion people around the world who lack access to electricity grids. Due to low power requirements, it can be powered by cheap local solar power."

Energy efficient appliances have helped to reduce the energy investment costs required to kick-start electricity access programs. Shaving a single watt from an off-grid appliance's load results in lower initial solar package costs, improved service, or both (Van Buskirk 2015). Similarly, energy efficiency can make larger off-grid solar home systems more affordable. According to a recent analysis "the upfront cost of a typical off-grid energy system can be reduced by as much as 50 percent if super-efficient appliances and right-sized solar PV and batteries are used, while delivering equivalent or greater energy service." (Van Buskirk 2015). Thus, advances in energy-efficient devices now allow households to reap more benefits from the relatively small amounts of electricity available to them. Instead of illuminating a single light bulb, CFLS and LED lamps use provide more and better light and consumer less energy, leaving enough energy to power other electronic devices such as fans and low-wattage TVs and appliances (Figure O.7).

In sum, it is clear that clean energy will play a strong role in ensuring universal access to energy services. Plummeting costs for renewable energy technologies and adequate energy efficiency measures offer a tremendous opportunity for countries to think differently and be creative about electricity access expansion.

WHAT ARE THE EMERGING AND INNOVATIVE BUSINESS AND DELIVERY MODELS?

A major focus of the universal electricity access push these days is reaching people living in remote areas, but it is increasingly clear that the traditional approach to electricity grid extension will not suffice. Grid-based extension of electricity supply involves significant upfront investment by utilities, and the connection costs to remote areas—which demand less electricity—are high. Consumers cannot afford large upfront costs, so payback to the utilities can be achieved only over an extended period, or is simply not feasible. Until recently, support for non-grid electricity systems has been based on funding allocations from public programs, but this approach is not sustainable.

There are good prospects for private sector business applications to supply this market, but there are only a limited number of successful installations. Experience from such approaches to energy service delivery suggest that the best models have a number of common features (Table O.1): (i) consideration of the demands, interest, and restrictions of local customers, including the desire to pay with mobile payments systems; (ii) strong partnerships along the whole supply chain, from the government and utilities to private sector service providers; and (iii) adaptation of market dynamics to local conditions to support successful, sustainable clean energy solutions.

In Tanzania, E.ON has five small-scale rural electrification systems operating, with connections to 200–300 customers. The overall goal is to electrify 1 million people in 10 years, or about 250,000 households—which means that between now and entering the scale-up phase, it must develop the ability to standardize. In Nepal, Gham Power, a developer of solar micro-grids and commercial off-grid systems, has deployed over 600 projects, including large industries, small businesses, and hundreds of households.

These applications include three micro grids, with the intention to develop at least 100 such projects in the next few years. The three existing projects have been implemented in partnership with N-cell, the largest telecom company in Nepal, which participates both as an investor and as an off-taker (with a PPA) from the micro-grid system.

Pay as you go (PAYG) models have become increasingly attractive in many markets. This is based upon experience suggesting that, even under local conditions in remote markets, the key to a cost-effective stand-alone energy system business is a finance model that matches affordable pricing for the target consumers with an adequate return on investment for the supplier. PAYG solar companies seek to provide energy services at a price point that is less than, or equal to, consumers' current spending on kerosene, candles, batteries, and other low-quality energy services. Providers are incentivized to offer quality after sales service, since a user's ongoing payments are tied to the system continuing to function.

PAYG providers can take one of two approaches to financing the system to the consumer:

- An indefinite fee for service in which the consumer never owns the system itself, but rather merely pays for the ability to use it. Payments are typically made on the basis of when the consumer needs power and can afford it.
- The consumer eventually owns the system after paying off the principal of the system cost—and the consumer must make discrete payments, typically on a daily, weekly, or monthly basis (thereby resembling a typical financing arrangement).

Lighting Global (a World Bank platform) has estimated that there are 32 PAYG companies in 30 countries, many of them in Africa. They use existing mobile payment systems or scratch cards for fee collection. Consumers benefit from increased affordability, increased confidence in the prod-

TABLE O.1 An Array of Emerging Delivery Models for Mini-Grids

COMPANY	OUTREACH	CURRENT TARGET	COUNTRIES	ENERGY SOURCE	SIZE RANGE	FOCUS/INNOVATION
E.ON	7 systems, 420 customers	1m people in 10 years	Tanzania	Solar, bio-diesel	6–12kW	Standardisation for scale; Establish track record for finance Cellphone payment
GHAM POWER	3 micro-grids	>100 micro-grids in 10 years	Nepal	Solar	1–10kW	PPA with N-cell (telecoms) for reduced risk revenue stream Rent-to-own agreements
HUSK POWER	15,000 households, several 100 businesses	75,000 households, 10,000 businesses, 125 agro units	India Tanzania	Biomass, Solar	15–250kW (biomass); 20kW (solar)	Accept >5 year payback Targeting 8–10 year loans Rural empowerment 3-year expansion plan Inclusive business model
INENSUS	Supports mini-grid development in Africa with related management systems and consultancy		Senegal	Solar, Wind	5–10kW	Low-cost smartcard meter Sale of "electricity blocks" "MicroPowerEconomy" delivery system—flexible tariffs & micro-credit
M-KOPA	340,000 homes (Mar 16)	+500 homes/day	Kenya, Tanzania, Uganda,	Solar	5–20W	PAYG business model Small SHS, LEDs & mobile phone charging services
POWERGEN (RENEWABLE ENERGY)	20+ mini-grids	50 mini-grids in 2016	Kenya & Tanzania, Zambia	Solar	1–6kW	Mini-grids compatible with central grid standards
POWERHIVE	4 sites, 1500 people (~300 connections)	100 villages	Kenya, Philippines (Africa/Asia expansion)	Solar	~20kW	Integrated tech system; Mobile money networks for pre-payment Dedicated software—predict revenue streams;
RUAHA POWER	1 pilot project (JV with Husk Power)	100 projects	Tanzania	Solar, biomass	300kW	Business model without subsidies Build Own Operate model Pre-payment meters
SPARKMETER	3 Earthspark mini-grids in Haiti	No fixed target	Asia, Africa, Latin America	Service for all types of mini-grids	0–500W	Metering with mobile payment system Cloud-based software "Gateway" usage dbase

uct, and access to maintenance services. For the supplier, PAYG lowers the transaction costs without the need for a significant rural financial infrastructure, and it reduces the cost and risk of doing business. M-KOPA Solar is an often-cited example of a firm with good experience of successful PAYG applications, having connected more than 330,000 homes in Kenya, Tanzania, and Uganda to solar power with over 500 new homes being added every day (Economist 2016).

Increasingly, operators in the off-grid market are dealing strategically with a set of factors that are opening space for business—notably, (i) thinking broader than energy; (ii) seeking a mix of public and private finance; (iii) combining investment with assistance; (iv) dealing with affordability issues in context; (v) engaging with consumers; and (vi) providing after-sales service.

The key challenge centers on the need for accessible financing models—which are starting to be launched in the form of new finance and investment companies that focus on mini-grids and solar home systems (SHSs). These firms, all established within the past few years, provide several means of financial support, including early-stage corporate investment, working capital, asset management, portfolio aggregation, and securitization. One way to offset the investment risk that arises in this sector has been to allocate short-term public funding. This allows project developers to offset upfront development costs. Recognizing the need for such early-stage support, a range of international development organizations is active in facilitating the establishment of new delivery models. However, such subsidies are difficult to access and other frameworks are being proposed that could be more effective, including performance based subsidies, and risk-adjusted subsidies for capital and operating expenditures.

In sum, emerging and innovative energy service delivery mechanisms are encouraging. Innovations in technologies and business models particularly present unprecedented new opportunities for private sector-driven off-grid electrification. If countries create the necessary environment for them to be replicated and scaled up, they could accelerate efforts to achieve universal access to modern energy services.

MOVING FORWARD

In developing countries, traditional grid supply will be the predominant approach for supplying urban households, whose number is likely to rise faster than population growth because of large rural-urban migration and the downward trend in household size. However, this approach will not be sufficient for meeting the goal of universal access to modern energy services by 2030. Developing countries will also need to use mini-grids and off-grid supply to provide access to the more remote households, whose global population is predicted to remain roughly constant during this period.

Mini-grids and off-grid solutions to energy supply are experiencing rapid falls in cost, because of technology improvements and scale economies in supplying growing markets. Even at the lower hydrocarbon prices of recent years, solar- and wind-based generation supply solutions are approaching parity with traditional hydrocarbon-based generation. The very high on-grid distribution costs associated with connecting remote households in areas of low population density will mean that few of these households will be able to afford grid-connection—unless there are subsidies available to cover a large fraction of these costs. Even schemes of spreading repayment of such charges over several years are unlikely to be financially viable without subsidies.

However, even with a cost superiority to on-grid supply, mini-grid and off-grid electricity will require state support through a number of channels: (i) a long-term commitment by the government to the goal of reaching universal access; (ii) the creation of institutions and regulations to facilitate the expansion of new forms of energy supply; and (iii) where needed, some financial support either to households so that they can afford access, or to firms to reduce the high initial costs of developing a new business model to deliver energy to previously unserved customers.

The bottom line is that substantial progress toward meeting the 2030 universal access to modern energy services goal can be expected in the coming years with the large number of different approaches that are now under way to supply off-grid electricity to supplement efforts in grid electricity expansion. But this will only occur if countries succeed in creating the enabling environment to de-risk and to attract the much-needed private sector investments.

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SEAR SPECIAL FEATURES

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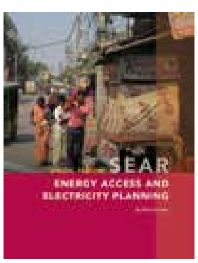
ENERGY ACCESS: BUILDING RESILIENCE IN ACUTE AND PROTRACTED CRISES	Andreas Thulstrup and Indira Joshi

SUMMARIES OF SEAR SPECIAL FEATURES



ENERGY ACCESS AND ELECTRICITY PLANNING

By **Mark Howells**, *Royal Institute of Technology,* **Hans Holger Rogner,** *International Institute for Applied Systems Analysis,* **Dimitris Mentis,** *Royal Institute of Technology,* and **Oliver Broad,** *University College London*

To lift people out of poverty, access to affordable, reliable, sustainable, and modern energy for all is critical. A central challenge is providing this access while avoiding past—and not creating new—pitfalls. In reality, this can occur only if there is a fundamental transformation of energy systems. The change needs to be comprehensive and consider the full set of "resource-to-energy-service" chains. That will necessitate greater energy efficiency and a bigger role for renewables, as well as other low carbon technologies in the global energy mix energy. Moreover, it must occur at a time when projected global electricity demand calls for installing some 6.7TW of new electricity generating capacity—worth an aggregate projected investment of $20 trillion from 2015 to 2040.

Clearly, a tall order, given that modern energy systems are highly complex and capital intensive. They are interwoven with many other sectors such as finance, natural resource systems, and the environment, as well as infrastructure. That means that countries will have to undertake comprehensive and systematic analyses and planning to identify and avoid (as far as possible) expensive stop-gap measures and long-term "lock-in" into inadequate and unsustainable infrastructures. In many instances, short-term pressure for immediate action will take precedence over long-term consideration for sustainability.

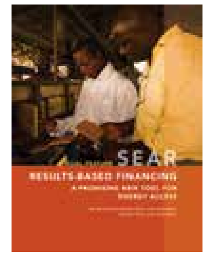
In practice, comprehensive energy planning at the national, regional, or local levels is further complicated because there is no one-size-fits-all energy system—and priorities vary sharply. On the one hand, in developing countries, access to affordable energy services can be a priority for rural areas. It fosters rural socioeconomic development and thus helps contain migration to the cities. On the other hand, with accelerating urbanization, low-income dwellers in large metropolitan areas may soon become the new energy poor. In contrast, the developed countries of Europe, North America, and Asia struggle with the replacement of aging plant and equipment. For electricity, the IEA estimates that some 40 percent of the existing capacity stock is scheduled for retirement by 2040. Thus, the timely replacement of old with (and the integration of) new renewable (and other low carbon) energy sources into the remaining infrastructure is a priority.

This Special Feature sheds light on how developing countries can carry out energy planning by reviewing available methodologies and tools. It includes the potential of integrating rural energy access and assess the potential uptake of bulk renewable energy technologies. It also probes how investment needs and cost-effectiveness are reflected in different analytic and planning tools, with a case study on Ethiopia –where current per capita electricity consumption is as low as about 50kWh, compared to 13,200kWh in the United States and 1,750kWh in neighboring Egypt. In addition, it examines the interaction of energy planning and scenario development and how these are applied to informed policy making.

Implementation informed by sound energy analysis and planning are essential to effectively bring electricity services to those currently without access. That analysis and planning needs to map out an energy system transformation, consistent with long-term sustainability and without making early access investment obsolete. Several enabling conditions are needed: support for adequate data collection, development of open accessible modelling tools, sustainable national capacity building to undertake analysis, and planning by local experts. Those local experts need to include stakeholders, especially technocrats from governmental institutions. But even deeper skills and knowledge management is needed. Planning is not a one-time affair, and a lasting sustainable impact calls for the establishment of centers of excellence, tertiary education, and networks of experts. Only then will planning processes become sustainable and be able to continue once the initial short-term assistance ends.

RESULTS-BASED FINANCING: A PROMISING NEW TOOL FOR ENERGY ACCESS

By Marco Hüls, *Deutsche Gesellschaft für Internationale Zusammenarbeit,* Marcel Raats, *Netherlands Enterprise Agency,* Josh Sebastian and Martijn Veen, *SNV Netherlands Development Organisation,* and John Ward, *Vivid Economics*



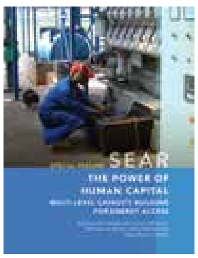
As donors search for ways to promote energy access in the developing world, a new tool being piloted in the sector is results-based financing (RBF). It typically offers incentive payments on the basis of results achieved to businesses that deliver pre-specified outputs—such as the number of new electricity connections or advanced cookstoves that are sold. By doing so, it tries to overcome market failures that constrain private sector delivery of modern energy services.

So far, the global community has had limited experience with the RBF in the energy sector, but a number of programs and initiatives are under way to explore how to pilot and mainstream RBF into their activities. This Special Feature focuses on how the RBF works in theory and in practice, with a special focus on a project to spur solar market development in Tanzania. This example comes from within the Energising Development (EnDev) program, a multi-donor energy access partnership program that is actively piloting RBF and that is currently financed by six countries (the Netherlands, Germany, Norway, the United Kingdom, Switzerland, and Sweden). The program promotes sustainable access to modern energy services that meet the needs of the poor—long-lasting, affordable, and appreciated by users. It is one of the first outcome-based and performance-based programs in the energy sector. By end-2016, it had reached 17.3 million people in households, almost 19,400 social institutions, and 36,600 small- and medium-sized enterprises.

Currently, EnDev together with its implementing partners, is carrying out 17 RBF projects in 14 countries. The portfolio is characterized by a balanced spread of implementers, RBF approaches, technologies, and geographies spread across Africa, Asia, and Latin America—with 5 projects that have a multi-country/regional character. It combines (i) risky but innovative projects with a strong focus on learning and (ii) models that have already been piloted and are very likely to perform well.

EnDev's experience suggests that the RBF facility can work best if it is flexibly embedded in a larger, more comprehensive and interacting package of market or sector development support. EnDev has also found that there is a substantial need to engage with all actors in the RBF chain—from financial institutions to private energy service providers. This helps strengthen their capacity to work with the RBF model, to develop business plans and planning, and to understand monitoring and verification requirements. And given that the centerpiece of RBF is that the private sector (including the financial sector) bears the full risk of dissemination of energy access solutions, it is critical to carefully think through pre-financing needs.

The Tanzania pico-solar RBF scheme, implemented by SNV Netherlands Development Organisation, shows these lessons well. The RBF approach trials innovative mechanisms needed to spur last-mile distribution of clean energy solutions in the country. Of 41.5 million inhabitants, only 36 percent of the total population and 20 percent of those in rural areas have access to electricity, and a vast majority of the country is expected to remain off-grid for the coming decades. The Tanzania RBF enables companies to scale up operations and accelerate last-mile distribution of Lighting Global approved solar products in rural areas of Tanzania's Lake Zone. Initial results of this front-runner in EnDev's global portfolio of RBF initiatives look promising. Nevertheless, longer-term impacts, like its eventual effect on the market and the sustainability of the outcomes realized in Tanzania will be measurable only in the years after the RBF project has come to its close.



POWER OF HUMAN CAPITAL: MULTI-LEVEL CAPACITY BUILDING FOR ENERGY ACCESS

Emanuela Colombo and Lorenzo Mattarolo, *Politecnico di Milano,* Stefano Bologna and Diego Masera, *UNIDO*

Over the past decade, the debate on access to energy has tended to lean mostly on technology, finance, and policy as key drivers. Thanks to this approach, there has been some progress in expanding global energy access—although the goal of universal access is still far off and is likely to remain so for the next two decades. Scaling up the strategies for access to energy requires a different perspective and an innovative approach to capacity building.

In line with the ethical imperative of the 2030 Agenda for Sustainable Development of "no one left behind" and its focus on people, the cross-cutting role of human capital (individually and collectively, as communities and institutions) becomes crucial both as a catalyst and a booster. Indeed, without the proper human resources, it will be impossible to achieve a transformative change in energy access—one that is efficient, effective, equitable, empowering, and long lasting. That is why human capital is now recognized as a core dimension for any strategy designed to reduce energy poverty at the global and local levels.

The right skills and competencies are needed for the design, uptake, and sustainable management of technologies, business models, and the policy framework. At the same time, the introduction and adoption of new or improved energy technologies require new skills for installation, maintenance, and service. The innovative business models that form the basis of the new energy markets require that the various actors (including consumers, communities, policy makers, regulators, and financial institutions) understand their role and the key drivers. In strengthening the role of people throughout the entire energy supply chain—from production to users—capacity building and training activities become essential components of any successful project aimed at enhancing energy access. If properly designed, they develop the local expertise needed to replicate and scale-up successful initiatives, support ownership of stakeholders, and foster sustainability beyond the withdrawal of external partners.

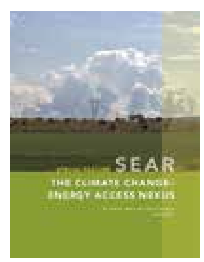
This Special Feature examines the power of human capital in expanding energy access. It begins with the concept of capacity building and its evolution, and then moves to how human capital contributes to energy access, highlighting objectives, principles, approaches, and lessons learned. The role of smart distributed generation and local prosumers is also discussed as an innovative example integrating capacity building within the new framework of a transformative approach to access to energy. The recent experiences of UNEP, IRENA, UNHCR, and GEF are discussed to provide insights and general principles. Four case studies by UNIDO in Cambodia, Kenya, Gambia, and Nigeria are also deeply analyzed.

The authors conclude that the complexity of today's energy sector calls for a change of perspective on capacity building based on a three-tiered integrated strategy, highlighting the who, what, and how: (i) a mix of target groups, skills, and stakeholders; (ii) a comprehensive life cycle approach along the energy supply chain, including socioeconomic analysis; and (iii) a set of diverse teaching strategies and tools to match the different targets' needs, expectations, and capacities.

This will facilitate the transformative change required to scale up access to energy, while promoting local ownership and empowerment, and convert energy into an enabler for access to other goods and services for economic and entrepreneurial development, ensuring long-term impact.

THE CLIMATE CHANGE–ENERGY ACCESS NEXUS

By Sameer Akbar and Gary Kleinman, *World Bank*

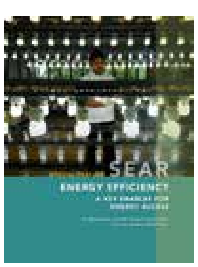


If the world is to have a reasonable chance of preventing global temperatures from increasing beyond 2°C above pre-industrial levels, net emissions of carbon dioxide (CO_2) and other long-lived greenhouse gases (GHGs) must approach zero in the second half of this century. This will have implications for virtually all aspects of the energy system, given the large and dominant role of energy-related emissions in our current carbon budget. At the same time, the effort under way to expand energy access through the Sustainable Energy for All (SEforAll) objectives—universal access to modern energy services, double the share of renewable energy in the global energy mix, and double the global rate of improvement in energy efficiency—will have significant consequences for existing energy systems, especially if all three objectives are to be achieved.

On the bright side, emerging linkages between the energy access and climate change agendas offer opportunities to simultaneously bring energy access solutions to scale, achieve mitigation objectives, and create more resilient and sustainable communities. And there are some signs of initiatives under way or being considered that try to seize these opportunities. For example, at the December 2015 climate change negotiations in Paris (under the auspices of the UN Framework Convention on Climate Change), an agreement was adopted that defines multiple objectives that, taken together, strengthen the global response to the threat of climate change. At the same time, it incorporates new terms and concepts, including "climate justice" and "the right to development" that link the global mitigation effort to the UN Sustainable Development Goals.

The Paris Agreement's structure—including "contributions" from all countries and a technology framework that addresses access and finance for those technologies that shift away from fossil-based infrastructure—is critical for improving resilience and the eventual reduction of GHGs in countries that still lack access to modern fuels. This point has been reinforced by recent World Bank research that shows that very poor, agriculture-focused countries typically do not consume a lot of energy. In fact, in 2011, the 900 million people (13 percent of the population) living in the 50 poorest countries emitted only 0.8 percent of global CO_2 emissions, yet they are among the most vulnerable to climate impacts.

Given the range of issues that tie energy access and environmental, climate, and sustainability concerns together, this Special Feature emphasizes that policy makers will need to deploy an optimal mix of mitigation, access, and financial strategies. For example, the principles of energy access require programs with strong government engagement that combine targeted subsidies and microcredit programs with local community engagement and support. At the same time, ensuring that mitigation concerns are included offers a point of engagement for climate finance by prioritizing renewable generation and landscape management aspects of these programs. Success in either of these challenges requires that communities be resilient in the face of climate impacts. This means that energy access programs must be robust to temperature and weather extremes. It also means that mitigation strategies must account for GHG emissions that are essential for achieving access objectives and include sequestration options that offset any residual emissions during a transition to carbon-free energy access for all.



ENERGY EFFICIENCY: A KEY ENABLER FOR ENERGY ACCESS

By Matt Jordan, CLASP, Jenny Corry,CLASP, and Ivan Jaques, *World Bank*

Energy itself does not meet the needs of energy-poor households, businesses, and communities. Rather, it is the services that energy enables—such as lighting, telecommunications, refrigeration, cooking, transportation, and mechanization—that transform lives and accomplish the goals of energy access. Yet billions of people today in developing countries (in both rural and urban areas) lack sufficient access to reliable, cost-effective modern energy services, which would help lift them out of poverty.

What can be done to improve this picture? A potent, too-often overlooked resource in global efforts to deliver modern energy services at least cost is energy efficiency. By reducing the energy supply investments required to provide energy services, greater efficiency optimizes the delivery and utility of energy service while mitigating the costs and harmful social and environmental impacts of energy supply. One estimate even suggests that universal access to modern energy services could be delivered using 50–85 percent less energy if currently available efficiency measures were utilized.

The benefits of energy efficiency are well-documented in residential, commercial, industrial, and transportation sectors in developed economies, and theory and limited experience from the field suggest that efficiency is a first-order energy access resource. Wherever energy supply investments are needed, energy efficiency should be considered to reduce the amount of investment needed. Wherever existing supply resources fall short, or are unduly expensive on the margins, energy efficiency measures should be explored to: (i) improve sectoral or system reliability and performance, and (ii) mitigate marginal fuel or tariff costs.

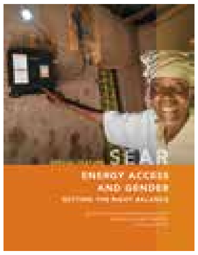
Unfortunately, energy efficiency is too rarely used as a resource in energy access efforts, and there are important gaps in the research and techno-economic analysis needed to support its use. The goal of this Special Feature is to highlight the role of energy efficiency as an energy access resource, along with providing an overview of opportunities where energy efficiency is supporting—and in many cases enabling—significant energy access impacts. Key recommendations for policymakers and energy access professionals include:

Make efficiency "first in the access loading order." The ideal approach is to first address generation, transmission, and demand-side inefficiencies, and then adjust supply to meet demand as needed.

Give efficiency a seat at the table. Energy access experts are not necessarily energy efficiency experts, and vice versa—and the public interest goals that draw individuals to these professional communities are not necessarily the same. Even so, these communities have a lot to learn from one another.

Educate and equip consumers. It is vital to educate consumers about the benefits of high-quality, energy-efficient appliances and devices—and equip them to act on that education through certification schemes, labels, and quality-assurance frameworks.

Redefine success. Defining success as "50,000 MW of generating capacity installed" will result in efforts to install 50,000 MW. Rather than setting project goals and metrics that imply access is solely a supply-side problem, define success as delivering energy service at least cost and set the appropriate metrics.



ENERGY ACCESS AND GENDER: GETTING THE BALANCE RIGHT

Soma Dutta, Annemarije Kooijman, and Elizabeth Cecelski, *ENERGIA, International Network on Gender and Sustainable Energy*

Why does gender matter in access to energy services? One focus of the gender, energy, and poverty narrative has been that since women play a significant role in energy systems as part of their subsistence and productive tasks, they are disproportionately affected by energy shortages. In recent years however, there is a growing awareness that energy, as a critical enabler to development, can also play a transformative role in the lives of men and women by enhancing their productivity and effectiveness at home and at work. For example, when women gain physical access to a connection and make use of energy services, the poverty reduction impacts are multiple, on health, income generation, and family. At the same time, there is evidence that going beyond their traditional role as "users" and "beneficiaries," women have started playing a role in expanding energy access—thereby becoming part of the solution to expand energy access for all.

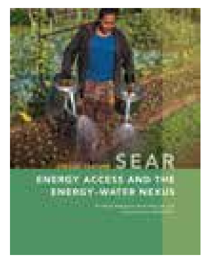
Men and women differ in the purposes for which they need and use energy and in their levels of access. Ensuring equitable development outcomes of energy interventions necessitates factoring in these differences. This Special Feature explores the linkages between gender, energy, and poverty and the empirical evidence on these linkages—with an emphasis on electricity and cooking energy. It also reviews global experience on what strategies and approaches have been employed to integrate a gender perspective in energy, what results have been achieved, and good practices and lessons learned. Unfortunately, most energy access projects and programs continue to deal with gender issues on a piecemeal basis. Thus, the key challenge now is to use both the lessons learned from the past and new evidence to increase energy access for both men and women.

In recent years, the linkages between energy access and gender have encouraged practitioners to incorporate gender-related actions into operations. Methodologies and good practices are emerging in three key areas: (i) "engendering" energy projects, programs, and policies through gender mainstreaming; (ii) empowering women to contribute directly toward expanding energy access as energy entrepreneurs; and (iii) financial inclusion, pricing, and subsidies.

In terms of gender mainstreaming, over the past decade, several organizations have taken this approach with energy programs and policies, for example, ENERGIA, Global Alliance for Clean Cookstoves, Asian Development Bank, and ECOWAS. Since 2007, ENERGIA has supported more than 35 medium/large scale energy access projects in Africa and Asia to mainstream gender. In addition, it is currently working with 3,750 women-led micro and small entrepreneurs in 7 countries, who have sold energy technologies to 1.8 million people. The AFREA Gender and Energy Program of ESMAP piloted gender activities in 6 countries (Senegal, Benin, Mali, Kenya, Tanzania, and Zambia). And the Global Alliance on Clean Cookstoves has been supporting its grantees under the Spark Fund3 to integrate and mainstream gender within their companies and operations.

What are some of the universal strategies for engendering energy access? These include (i) recognizing unpaid work and making it visible; (ii) taking into account the differences in needs for energy services between men and women in designing energy interventions and providing targeted support to women's informal businesses that use energy; (iii) recognizing women-led energy enterprises as a central strategy for universal energy access and providing targeted support, at a large scale, to women energy entrepreneurs; (iv) targeting awareness of subsidies, measures for access to energy supply, and energy technologies and appliances, by gender and income; and (v) training and involvement of both women and men in the energy supply chain.

ENERGY ACCESS AND THE WATER–ENERGY NEXUS



By Diego Rodriguez, Anna Delgado, and Antonia Sohns, *World Bank*

The tradeoffs between energy and water have been gaining international attention in recent years as resource demand grows, climate change impacts manifest, and governments struggle to ensure reliable supply. Today, about 663 million people still lack access to improved sources of drinking water, and 2.4 billion people remain without access to improved sanitation. Water insecurity affects every continent. Additionally, 1.06 billion people lack access to electricity.

Water and energy resources are inextricably linked. Significant amounts of water are needed in almost all energy generation processes, including electricity generation and fossil fuel extraction and processing. Conversely, the water sector needs energy to extract, treat, and transport water. Energy and water are also both required to produce crops, including those used to generate energy through bio-fu-els. This relationship is what is known as the water-energy nexus, and it exists within the larger water-energy-food nexus. The impacts and tradeoffs of the energy-water nexus are being felt today:

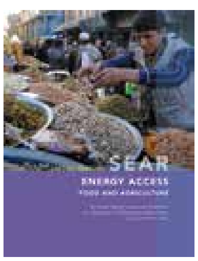
- In the United States, power plant operations are being affected by water variability, such as low water flows or high water temperatures.
- In Sri Lanka, China, and Brazil, recurring and prolonged droughts are threatening hydropower capacity.
- In the Middle East and North Africa, desalinating water is substantially increasing energy demand, and

pushing water utilities to explore ways to reduce energy demand or produce energy on site—in 2010, energy requirements for desalination in the United Arab Emirates were about 23.9 percent of total energy needs.

Such resource interdependencies could complicate possible solutions and make a compelling case to improve integrated water and energy planning. Yet energy planners and governments often make decisions without accounting for existing and future water constraints. Planners in both sectors often remain ill-informed about the drivers of these challenges, how to address them, and the merits of different technical, political, management, and governance options.

This Special Feature highlights that tackling energy and water challenges will necessitate addressing data gaps and developing indicators that reveal resource use and cascading effects across sectors. Integrated water and energy planning enhances sustainable development, national security, and economic stability—and it is especially needed in regions where climate change, urbanization, and population and economic growth are going to exacerbate water scarcity.

As policies are implemented to ensure that affordable, reliable, and sustainable energy is available to all, it is critical to consider the surface water and groundwater impacts that may result from them. There will be tradeoffs in all cases, but in analyzing and quantifying the impacts, the international community can ensure long-lived and sustainable successes.



ENERGY ACCESS: FOOD AND AGRICULTURE

By Olivier Dubois, Alessandro Flammini, Ana Kojakovic, Irini Maltsoglou, Manas Puri, and Luis Rincon, *FAO*

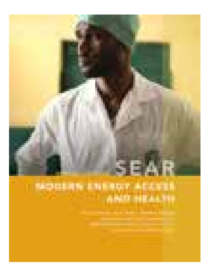
Over the past century, countries have been able to meet ever-increasing food demand partly due to the availability of cheap fossil fuels. The agri-food chain covers the production of farming products, their transport, processing, storage, distribution, and food preparation. Energy is needed at all steps of the agri-food chain, be it in direct (such as for production, processing and transport) or indirect (such as for manufacturing of inputs such as fertilizers, agro-chemicals and machinery) form.

In addition, the use of fossil fuels has resulted in food systems becoming a major source of greenhouse gas (GHG) emissions, with significant contributions to global climate change. A continued dependence on fossil fuel for food production would only increase agriculture's impact on climate, especially when considering that food production is forecast to increase by 60 percent in 2050 from 2006-2007 levels in order to feed the global population. On the other hand, climate change and changing climate patterns can cause severe droughts or floods and changes in water availability and soil quality, which may have significant impacts on agri-food systems. In some cases, these changes can also alter energy needs as such conditions may require more energy inputs. A lack of rainfall can lead to farmers resorting to the use of groundwater for irrigation, which requires energy for pumping; gradual land degradation can result in farmers using more chemical fertilizers, which in turn require more energy to be manufactured.

Against this backdrop, the global community has been looking for ways to develop food systems—"energy-smart food systems"—that can support food security and sustainable development. These systems improve access to modern energy services, rely more on low-carbon energy systems, use energy more efficiently, and are deployed through a water-energy-food nexus approach. They also take advantage of the fact that agri-food chains are not only a consumer of energy but also a producer of energy. Various energy-smart technologies and practices exist across the world. The challenge is to identify the context where they are most effecting and bring the most benefits, and then scale them up.

This Special Feature stresses that scaling up the uptake of sustainable energy solutions within the agri-food system, practices, and behaviors will entail aligning available solutions with local settings. Interventions require a people-centered "bottom-up" approach, and they need to be better tailored to local contexts. This means addressing the following questions: (i) For what purpose is energy required?; (ii) Which equipment and systems would be needed to produce energy?; (iii) Will the system be economically viable in the identified context?; and (iv) How can local capacity to run and maintain the systems be built?

Production of bioenergy from agricultural residues is one promising way in which access to energy can be increased in rural areas. But like other agricultural activities, bioenergy can compete for labor and natural resources and thus the benefits to be accrued have to be closely investigated to ensure food security is not hampered. In fact, some of these concerns can be addressed by well-designed policies and land management practices. What needs assessing is whether agriculture residues are available once other uses are accounted for (such as feed, fodder, and soil nutrients). If unused residues are available, this option can also allow mitigating climate change impacts by avoiding residues to be burnt in the field. All options need to be environmentally and financially sustainable. The overarching key principle is to ensure that the agrifood system and energy systems are integrated.



MODERN ENERGY ACCESS AND HEALTH

By Jem Porcaro, Sumi Mehta, Matthew Shupler, and Sarah Kissel, *UN Foundation,* and Michaela Pfeiffer, Carlos Francisco C. Dora, and Heather Adair-Rohani, *WHO*

Modern energy access is an important determinant of human health, as it plays a critical role in the capabilities of healthcare facilities and aids in the development of clean and safe household environments. In the developing world, thousands of healthcare facilities and hundreds of millions of households lack access to modern energy services. The situation will only get worse as the energy needs of communities and the health sectors in these countries are expected to increase dramatically in the years ahead. For example, the need for cold storage space for vaccines is expected to rise eightfold or more in coming decades, and the growing need to prevent or fight non-communicable diseases requires complex interventions that will drive additional energy requirements.

This Special Feature begins with a look at energy access and health implications, along with energy access and reliability gaps, at two levels: electrification of healthcare facilities and household energy. It then tackles the barriers to better energy access and reliability, and concludes with opportunities and options.

Its overall message is that addressing this unmet need in an efficient and timely matter will require decision-makers to better incorporate health considerations into energy policy, and vice-versa. At this point, there are many barriers for electrification of health facilities, including weak enabling environments, lack of awareness and information, insufficient human capacity and institutional support structures, affordability and lack of financing options, and weak local energy sector and service infrastructure. The barriers for household energy are also numerous and include user acceptability, gender norms, lack of financing options, and undervaluation of fuel and time saving.

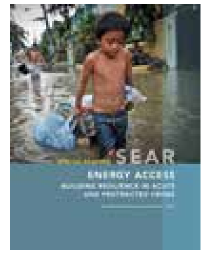
The international community's adoption of the UN's 17 Sustainable Development Goals (SDGs) opens a major opportunity for the health sector to improve access to, and the quality, of health services (especially for maternal, newborn, and child health services), by providing an opportunity to apply a nexus approach to energy and health—building on various linkages that energy and health have with sustainable development (including SDG 5 on gender equality, SDG 11 on sustainable urban environments, and SDG 13 on climate action).

A more comprehensive and systems-based approach, centered on a holistic evaluation of needs, is required, as opposed to a piecemeal approach that can lead to inefficiencies in design, unmet needs, and, often, early system failure. The most promising solutions range from decentralized renewable energy and hybrid solar PV/diesel, to grid extension, energy-efficient medical equipment, and a greater availability of clean energy sources and technologies at the household level (such as cleaner cookstoves and fuels).

Encouragingly, a growing number of organizations—including the WHO, Global Alliance for Clean Cookstoves, Sustainable Energy for All, and the UN Foundation—are working with governments to raise awareness about the inextricable link between energy and health. As these organizations move to identify and diminish research gaps, develop country-capacity for implementation, and overcome barriers associated with uptake and sustained energy use at the community and household level, they can simultaneously catalyze action needed to effectively and efficiently address multiple SDG goals.

ENERGY ACCESS: BUILDING RESILIENCE IN ACUTE AND PROTRACTED CRISES

By Andreas Thulstrup, and Indira Joshi, *FAO*



Energy constitutes a key component of the physical capital required by individuals and households to pursue sustainable livelihoods. Modern energy services are essential for ensuring the well-being of people, playing a key role in providing clean water, sanitation, health care, reliable and efficient lighting, heating, cooking, mechanical power, transport and telecommunications services to people. However, the importance of providing fuel and appropriate cooking technologies in emergency settings is often overlooked or inadequately prioritized by humanitarian and emergency response actors. While food may be provided—for example, through the World Food Programme food basket—the means to cook that food is not consistently provided, and when aid agencies do provide fuel, they often do not provide enough to cover needs. Lack of access to cooking fuel, as well as appropriate technologies for cooking and heating, has implications for a range of sectors and for the well-being and livelihoods of affected households.

The UN Food and Agriculture Organization (FAO) is addressing these challenges by engaging in the Safe Access to Fuel and Energy (SAFE) Humanitarian Working Group and implementing projects that address both the supply and demand for fuel in multi-hazard contexts. The inter-agency SAFE group works to facilitate a more coordinated, predictable, timely, and effective response to the fuel and energy needs of crisis-affected populations.

Within FAO, one of the organization's five strategic programs focuses on increasing the resilience of livelihoods to threat and crises. The program is implemented through cross-divisional and inter-disciplinary work that strengthens the linkages between humanitarian and development contexts. Under this framework, FAO's SAFE work contributes to reducing risks and vulnerability at the household and community levels, by improving access to sustainable energy. This work supports resilience building by contributing to the diversification of income and energy sources, reduction of environmental impacts, and improvement of food security and nutrition. FAO's work on energy access in emergencies also focuses mainly, but not exclusively, on protracted crises, and it adopts a holistic, multi-faceted approach that accounts for the mutually reinforcing linkages between energy and environment, nutrition, health, gender, protection, and livelihoods.

FAO adopts a multi-disciplinary approach to address the multi-sectoral challenges associated with energy in emergencies, involving three interlinked pillars:

- Ensuring a sustainable supply of energy through the establishment and promotion of agro-forestry, (which can provide fuel and food from the same land, communal woodlots and other modes of reforestation and afforestation), sustainable natural resource management, and use of agricultural residues and other alternative fuels (including renewables).

- Addressing energy demand—for example, through the promotion of fuel-saving cooking practices and fuel-efficient technologies for cooking and productive uses.
- Promoting sustainable livelihoods and diversifying livelihood activities to build resilience. The establishment and sustainable management of woodlots and agro-forestry can be promoted as a livelihood activity for both men and women.

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