Integrated Electrification Pathways for Universal Access to Electricity: A Primer

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SUSTAINABLE ENERGY FOR ALL

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Introduction

At the current pace of electrification, the world is not on track to achieve the ambitions of Sustainable Development Goal 7 (SDG 7): to ensure access to affordable, reliable, sustainable and modern energy for all. According to the *Tracking SDG7: The Energy Progress Report 2019*, access to electricity is growing, but not fast enough: 150 million people gained access to electricity between 2016 and 2017, however that still leaves 840 million people without access, down from just under a billion in 2016 and 1.2 billion in 2010. And 573 million of those people – 1 out of 2 – are in Sub-Saharan Africa. While it is increasingly acknowledged that the energy access gap will be met with a mix of off-grid, mini-grid and on-grid electrification solutions, findings from Sustainable Energy for All's (SEforALL) *Energizing Finance report* series indicate that only around 1% of global finance for energy access flows to off-grid and mini-grid solutions.

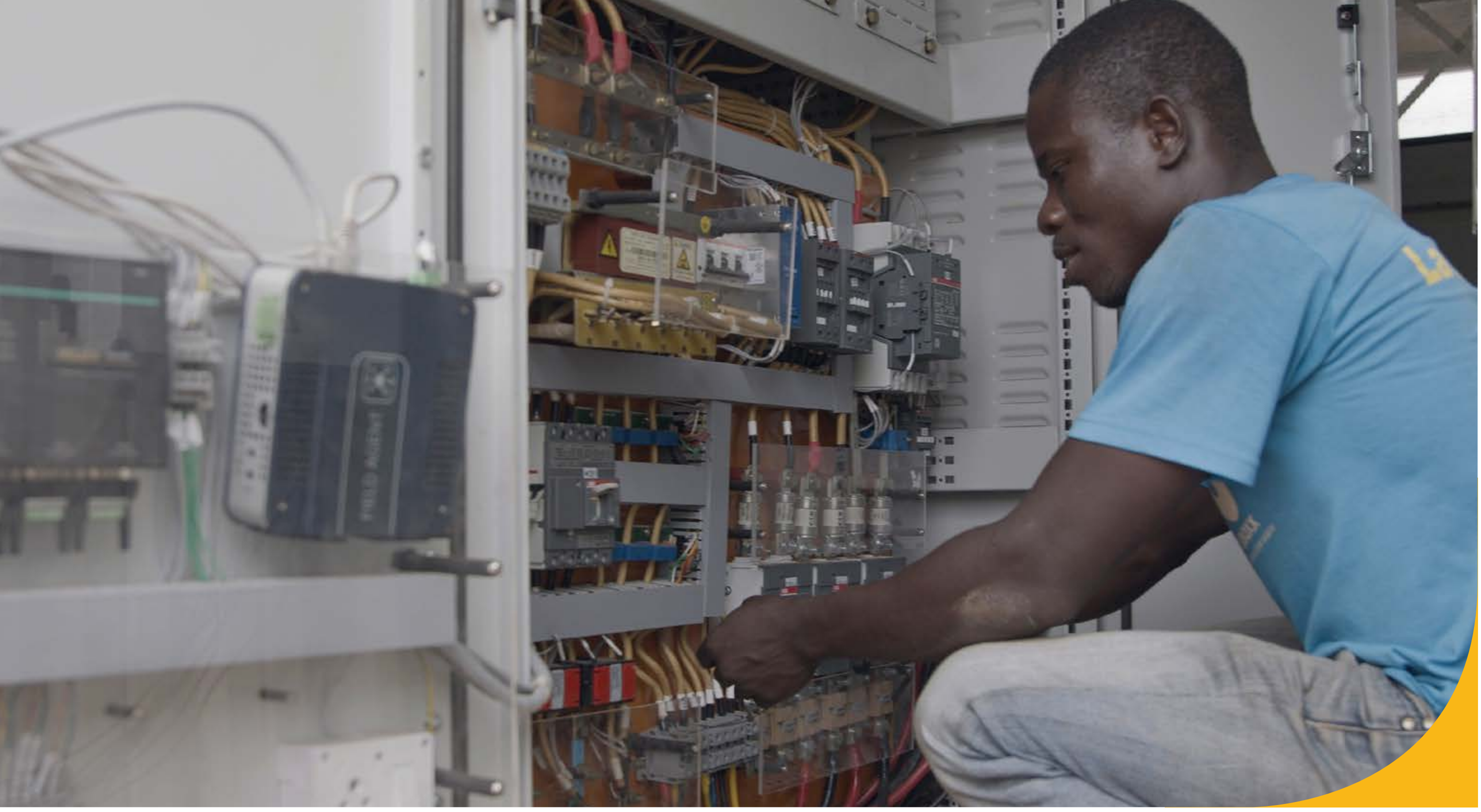
Uneven progress on universal electrification stands in stark contrast to continuing renewable energy technology developments and decreasing costs as well as to the increasingly attractive business case for decentralized solutions to meet the electricity needs of rural and remote communities. While many governments have embraced multiple technologies to electrify their citizens, centralized grid, mini-grid and off-grid solutions are often deployed independently of one another rather than designed as complementary solutions that form part of a cohesive vision for delivering universal access. A lack of clear electrification plans from governments and complementary policy and regulation to facilitate deployment of multiple energy access technologies has resulted in fragmented solutions and in many cases stagnated progress. This creates a major challenge in addressing the electricity access gap at scale.

In recent years, many policymakers, industry executives, financiers and others in the international energy community have identified integrated approaches to energy policy planning as a means of leveraging all electrification solutions, be they via the centralized grid, mini-grid or off-grid solutions. Countries such as Ethiopia, India, Kenya, Myanmar, Nepal and Togo (among others) are considering their electrification strategies with an eye to taking advantage of all available technologies and leveraging the private sector's expertise to meet SDG 7. In many cases, an integrated approach is necessary to account for geography or population dispersion that makes centralized grid extension difficult or prohibitively costly. While some countries are pioneering an integrated approach, there is a lack of clarity among many others as to exactly what it means to develop an integrated pathway to universal electrification.

SEforALL seeks to bring clarity to a full-systems approach to electrification planning, especially its relationship to social and productive uses of electricity. This report defines "Integrated Electrification Pathways" (IEPs) that incorporate these important perspectives and lays out key steps to guide policymakers in creating strategies and developing policies and programs to support a comprehensive approach to electricity sector planning. By listening intently to policymakers, analyzing success stories, consulting experts and seeking feedback from a wide range of private sector stakeholders, SEforALL has compiled this Integrated Electrification Pathways for Universal Access to Electricity Primer to bring clarity to the sector and de-mystify integrated electrification.

What is an Integrated Electrification Pathway?

A set of inclusive planning approaches and policy measures that support using grid, mini-grid and off-grid technologies to provide electricity and the associated energy services necessary to meet human needs and contribute to sustainable development.



Key Features of Integrated Electrification Pathways

Beyond the definition on the previous page, it is useful to consider the four key features that characterize IEPs. While these are ideal features, it is unlikely that any IEP in use or currently in development successfully captures every aspect. However, each feature identified below has been used with success in countries or regions around the world and identifying these features at the beginning of any planning process can create an environment conducive to success.

1) IEPs place access to electricity in the context of sustainable development and human needs

A lack of access to electricity is strongly associated with poverty and reduced opportunity. However, socio-economic benefits arising from access will not be realized unless electrification provides reliable, affordable energy services that are targeted towards increasing incomes and improving health, education and other outcomes that enhance social wellbeing. Achieving these benefits requires an understanding of where both the needs and the potential for economic development are greatest. That understanding is gained through bottom-up consultations with consumers, local government agencies, civil society organizations, entrepreneurs, and investors, all of which can help identify electricity access priorities among households, community services and businesses. Consideration must also be given to the tier (see below) of access required since different needs may be more appropriately met with different technologies and delivery models.

Technological and business model innovation means there are now multiple pathways to providing electricity access. Decentralized solutions in particular can offer valuable electricity services to populations who may not otherwise gain access for years if not decades. Households may benefit from basic electricity services while schools, hospitals, industry and other activities require significantly greater levels of service. It is also now widely understood that while development and expansion of centralized electricity grids provide access to millions of additional people each year, grid connection in itself does not guarantee reliable electricity supply, with millions of grid-connected consumers lacking reliable and affordable access to electricity.

This nuanced supply-side picture has been captured well in the World Bank's Multi-Tier Framework for Measuring Energy Access (MTF), which describes access in terms of peak power capacity, duration of availability, reliability and other attributes. (See Figure 1)

Figure 1

Multi-tier Matrix for Measuring Access to Household Electricity Supply

ATRIBUTES			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
	1. Peak Capacity	Power capacity ratings (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
				Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
		OR Services		Lighting of 1,000 lmhr/day	Electrical lighting, air, circulation, television, and phone charging are possible			
	2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hrs	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2hrs

Adapted from the World Bank/ESMAP, Beyond Connections: Energy Access Redefined, 2015.

The MTF mapping of energy supply to energy services assists in understanding the types of services a given electricity access tier can provide. (See Figure 2)

Figure 2

Multi-tier Matrix for Measuring Access to Household Electricity Services

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Tier criteria		Task lighting AND phone charging	General lighting AND phone charging AND television AND fan (if needed)	Tier 2 AND any medium-power appliances	Tier 3 AND any high-power appliances	Tier 2 AND any very high-power appliances

IEPs result from an analysis of the development needs of unelectrified populations and consider the level of service that may be best suited to meet their needs, and in consideration of their ability to pay. This analysis is based on cross-sectoral consultation and the availability of appropriate technologies and delivery models.

2) IEPs consider all technological approaches and delivery models

Achieving universal electrification requires a complementary mix of approaches: the traditional approach of expanding centralized electricity grids and their associated transmission and distribution networks and other, decentralized solutions that encompass mini-grids, solar home systems, and solar lighting kits, usually delivered by the private sector and often leveraging innovative technology. In many cases, last-mile connections to the national grid can be costly and time consuming. Alternatively, a mix of technological approaches can be used to cost-effectively provide various levels of electricity access within shorter timeframes, as detailed in SEforALL and Power for All's *Why wait? Seizing the Energy Access Dividend* report. The IEA estimates that decentralized generation is now the least-cost option for increased electricity access in most circumstances, with mini-grids and solar home systems projected to account for up to three-quarters of the additional connections required for universal access in sub-Saharan Africa (although the exact proportion depends on the level of access provided)[1].

Investment in decentralized solutions not only provides electricity service to consumers today, but can help consumers move up the energy ladder in the future. Enabling access to electricity can bolster economic development, which can in turn increase consumers' ability to pay and make higher tiers of access more affordable. It is critical that IEPs lay out clear frameworks for interconnection where appropriate and serve as supplemental distributed generation if and when a central grid arrives, thereby guaranteeing long term return on investment and making clean, decentralized generation a no-regrets solution.

The availability of cost-effective, low carbon electricity access solutions creates new opportunities for providing essential services and represents a new paradigm for electrification planning. However, this new paradigm must be incorporated into existing electrification plans to broaden their scope. The ESMAP Regulatory Indicators for Sustainable Energy (RISE) database shows that 35 of the 54 countries with the largest energy access deficits have official electrification plans in place, but the scope of those plans varies widely[2]. The good news is that many countries have requested assistance in creating or improving their plans.

3) IEPs rely on high-level commitment and support for an inclusive, coordinated planning process

Electrification plans developed with government sponsorship at the highest levels and with expert support from key stakeholders are more likely to succeed than those which have no such backing. Depending on the size of a country and the structure of its governance, such plans may be created at national or sub-national level, although alignment across all levels of government is essential to prevent the creation of a patchwork of conflicting policies. Moreover, IEPs should be developed in close consultation with ministries responsible for finance and national development planning, in addition to ministries whose objectives are enabled by access to electricity such as ministries responsible for health, agriculture, education and gender, to name

1. International Energy Agency, World Energy Outlook 2018.

2. Analysis from the RISE database found here: https://rise.esmap.org/scores

a few. Published plans with targets and time frames help provide a clear signal of intent and opportunity to international donors as well as to national and international investors and developers. Market surveys indicate that companies selling solar kits and solar home systems identify government electrification plans as a top energy policy priority for the clarity they offer on businesses' potential addressable markets[3].

It is essential to establish a structured engagement process between the government agencies involved in the electrification planning process and the various stakeholders (consumers, local government agencies, civil society organizations, entrepreneurs, and investors) that can ensure the appropriateness of policies to meet socio-economic development needs and attract necessary investment. Since governments and priorities can change, it is also desirable for planning bodies to create linkages with independent sector regulators, universities, research institutions and other expert organizations to foster continuity and build local institutional knowledge and capacity.

4) IEPs include supportive policy measures, facilitate investment and are market enabling (not market inhibiting)

Successful electrification strategies include fiscal, regulatory and other supportive policy measures that create an enabling environment for both service providers and consumers. Balancing the financial needs of service providers and the ability of consumers to pay for services requires a range of policies, depending on the type of service being supported and the target consumers. A strong enabling policy framework is essential for mobilizing and blending finance from a variety of sources, at various scales and across a variety of market segments.

While companies must be able to plan and complete projects and implement financially sustainable business plans, public sector service providers must also be able to attract investment. The latest RISE report indicates that only 37% of utilities in countries with low electrification rates meet basic creditworthiness criteria[4]. Their fiscal viability is often assured by government subsidies, which allow them to keep tariffs lower than the actual cost of electricity service provision. Policies that create a level playing field for both public and private sector energy service providers are the best means of ensuring the viability of a full suite of electricity access solutions and delivery models.

Maximizing the impact of electrification policies requires a focus on end use consumers and measures to support appropriate consumer finance can ensure that consumers are able to purchase and effectively use high quality, efficient products and services. Policies to educate and deliver technical support to consumers can enhance the economic impact of these measures.

A comprehensive integrated electrification plan does not mean that private developers should be restricted to doing business only in certain geographic areas, thereby inhibiting service delivery elsewhere. On the contrary, an IEP will provide incentives for the private sector to focus its activities within the framework of a comprehensive government strategy and long-term access targets. Governments should also provide clarity on their plans to extend central electricity grids in order to reduce uncertainty for the private sector and ultimately de-risk projects and long-term investment.

3. Power for All, Decentralized Renewables: from promise to progress, 2017.

4. Analysis from the RISE database found here: https://rise.esmap.org/scores

Planning Process for Integrated Electrification Pathways

Having identified the key features of IEPs, it is useful to consider how a planning process that captures these attributes can be developed and implemented, while acknowledging that the exact process and pathway will differ according to each individual country and sometimes sub-national context. Factors that influence the approach taken in each country are: existing electricity infrastructure, available energy resources, government institutional arrangements, socio-economic conditions and political economy. Electricity planning is often thought of in terms of models and data. However, the focus on socio-economic development needs, breadth of stakeholder engagement and links to supportive policy and appropriate finance are factors that distinguish the IEP approach. The steps to develop an IEP outlined below are indicative and informed by learning from good practice.

1) Establish a coordinating body empowered with high-level political buy-in and adequate long-term resources for implementation

Very often, overall responsibility for a country's electricity sector is the domain of an energy or

power ministry or similar government authority. Generation, transmission and distribution of electricity is typically managed by one or more public or private utilities acting under rules created by a sector regulator. Often, one or more separate government authorities focuses on rural electrification while other agencies deal with health, education and other social services. Ensuring that these government agencies work together on electrification planning across their institutional and sectoral boundaries is challenging enough, but the new paradigm of electricity access adds additional players and drives a need for even greater collaboration. The goal must be to incorporate the opportunities offered by these new approaches into the planning process to create an integrated approach.

One way to foster collaboration is through explicitly empowering a government body with the responsibility for providing electricity access through both centralized and decentralized approaches. This could be a new, separate body or an existing one with expanded authority and mandate. Placing such responsibility in the hands of a technology-neutral entity, for example, may create an opportunity to broaden its mission and drive a new operational model if the institutional capacity exists or can be built. That body would include technical experts, donors, investors and representatives of civil society, consumer groups and industry. It would consider access to electricity in the context of social and economic development needs, including how end users can affordably access the equipment and appliances necessary to ensure those needs are met.

One example of a unified approach is the Rural Electrification Authority of Zambia, which has responsibility for grid extension, mini-grids and solar home systems. Though an approach that unifies planning and execution of both grid-connected and decentralized electricity solutions is ideal, establishing a body focused solely on decentralized solutions can also be effective. An example of this is the Energy Revolution Task Force in Sierra Leone, which created a renewable energy association and a donor finance coordination group to engage with the Ministry of Energy and with energy planners. Another approach is to create an actual implementation body such as Bangladesh's Infrastructure Development Company Limited (IDCOL) which focuses on distributing solar home systems and mini-grids while the country's Rural Electrification Board focuses on grid extension.

Regardless of where such a coordination body is established, high-level political support and adequate long-term resources are essential to motivate engagement and send a signal about seriousness of purpose to stakeholders, including donors and investors. The goal should be to develop a plan for the services to be provided in specific locations, with associated targets and timeframes published to provide clear direction.

2) Solicit expert engagement to support plan development and build planning capacity

Developing a sound IEP depends on engaging experts with sufficient breadth of knowledge of the available technology options. Though there are some notable exceptions, governments are more likely to have internal expertise in centralized generation resources and associated transmission and distribution planning and less in decentralized solutions. If such expertise exists, it may not be in the same ministry or planning body as that which has responsibility for the central grid.

International financial and technical support from the World Bank and other development partners is indeed valuable, however additional sources of expertise and planning tools may be required. Because communities of best practice relating to the centralized grid, mini-grids, and solar home systems tend to be quite distinct, it is necessary to coordinate across them to make sure that their needs and system attributes are clearly identified and included in the planning process. This is additional to the development expertise necessary to ensure that IEPs consider the appropriate level of service to meet socio-economic development needs in various regions.

Coordination between donor organizations and other experts can be challenging and should be driven by government rather than external institutions. There are numerous examples of international consultants creating electrification plans without adequate documentation of methodologies or data sources. Establishing a university, research institution, or other expert organization as an institutional home for expert resources and data can help to bolster local capacity and ensure continuity of longer-term planning.

3) Work with experts and stakeholders to obtain relevant data for use in integrated modeling and to identify other planning tools

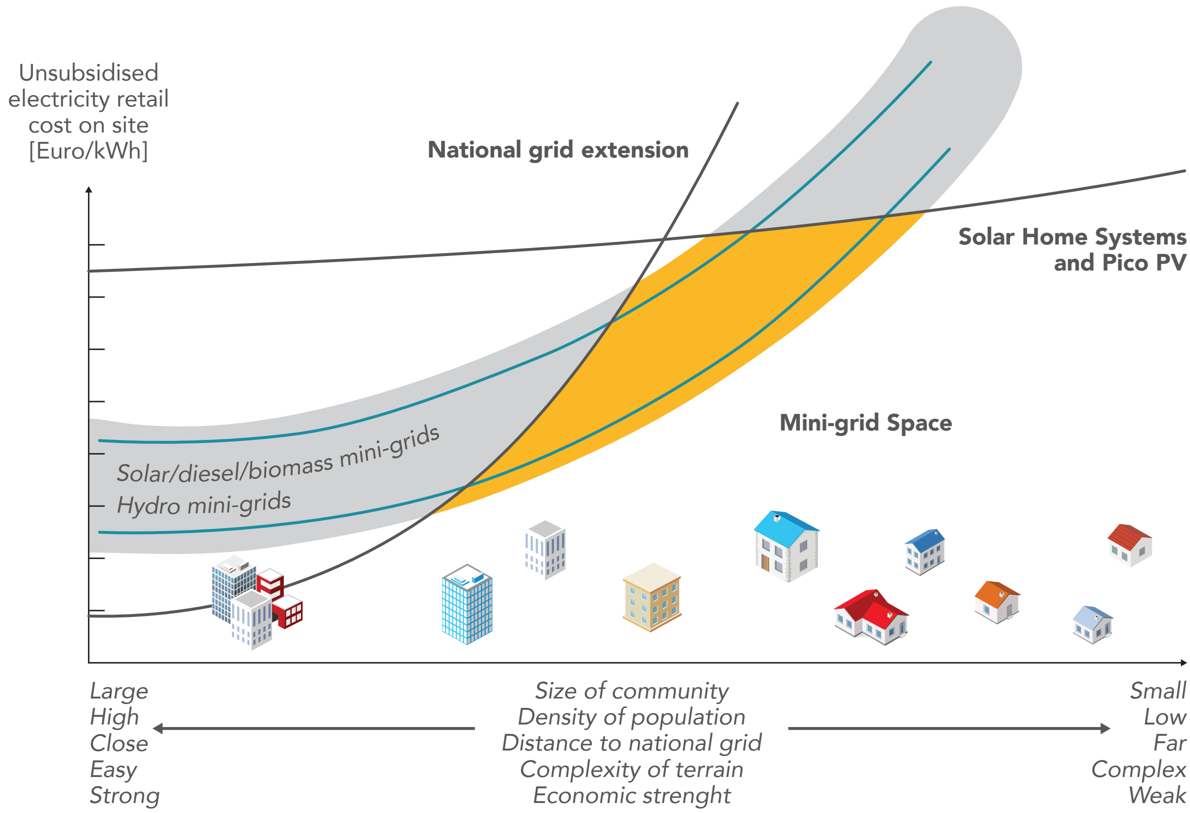
The planning process requires access to high quality data from multiple sources relating to population, the central electricity grid, renewable energy resources, and required service and load levels. This information can be used to create a geospatial database that can be used as an input for electricity sector models. Obtaining this information from multiple sources and placing it in a format appropriate for use in a particular model requires expert input. There have been several efforts to develop datasets and tools that consider integrated approaches and make them more accessible. Among these are the Open Source Spatial Electrification Tool (OnSSET), Network Planner, and the Reference Electrification Model, all of which have been used to explore electrification planning. For more information, see Further Resources below.

Distribution and density of population are key inputs necessary to understand the type of service that may be most cost-effective, as indicated in the figure below. This shows schematically how higher populations with greater density and shorter distances to the grid are usually more easily served through grid extension, while mini-grids and solar home systems become more cost-effective as population size and density decrease and distance to the grid increases.

Factors such as complexity of terrain and lack of economic resources will modify this schematic view, with the latter helping to explain why there is still a large unelectrified urban population – access to the grid does not necessarily guarantee the means to pay for service. This underscores the point that least-cost planning is not the final objective, as the type and tier of electricity service most suited for particular areas and market segments must be prioritized over the relative cost of electricity. For example, a distant but highly productive load may help make the case for grid extension, despite the relatively higher cost. Conversely, solar home systems may be an interim solution for unelectrified urban populations who would benefit from lower tier electricity access. These considerations require consultation with appropriate stakeholders to ensure equity and a focus on maximizing development objectives.

Figure 3

Opportunities for grid-extension, mini-grid and distributed renewable energy systems



Adapted from the EUEI PDF, Mini-grid Policy Toolkit, 2014.

4) Develop supportive policy measures in consultation with community, civil society, and private sector stakeholders

Implementing an IEP involves creating a favorable environment for various electrification solutions. It is particularly important to ensure a legal and regulatory framework conducive to decentralized electricity investments, since these may be newer and less likely to have been considered in existing regulatory frameworks. It is critical to engage in a robust stakeholder consultation process, as noted in Step 1 of this planning process, to identify barriers that may be faced by technology and service providers.

Among the key policy and fiscal measures to be considered are:

- Lowering or removing import duties on mini-grid and solar home system components
- Ensuring the legal right for independent power production and sale
- Establishing fast, low-cost, and uniform licensing and permission for mini-grids
- Linking quality assurance standards to solar home system and mini-grid programs to guarantee performance and ensure customer satisfaction
- Implementing interconnection standards and compensation mechanisms for mini-grid operators to ensure payback if the main grid arrives

For mini-grids, specifically, it is also important to create tariff regulations tailored to cost recovery for the type and level of service provided. This is because, from a developer perspective, tariffs must be sufficient to cover operation, maintenance and investment costs, plus a margin. These costs will vary depending on the type and level of service provided. At the same time, tariffs must be consistent with consumers' ability to pay for agreed minimum levels of service. The gap between consumers' ability to pay and developers' cost recovery can, where appropriate, be addressed through grants or public financing (see Step 5, below).

Standardized and transparent tariff calculation methodologies consistent with overall cost and revenue assumptions will help to ensure market viability. It is worth noting that uniform national tariffs, though perhaps ideal from the standpoint of equity, are unlikely to be high enough to support rural electrification without subsidies or other government support. The cost of providing electricity to rural and off-grid consumers is often higher than it is for urban areas, depending on the tier of electricity service that is available and affordable to the consumer/household. Addressing affordability of electricity is a key concern to many governments and private sector alike, however the purchasing power of rural customers should not be underestimated; rural customers' ability to pay is often bolstered by the savings derived from no longer relying on kerosene, dry cells, or diesel generation. Consultation with community and civil society stakeholders can help to clarify this point.

The government or government-affiliated agencies have a role to play in ensuring the health of the off-grid market by establishing and monitoring minimum quality and efficiency standards for electrification technologies. This ensures that consumers have access to reliable electrification technologies and does not spoil the market for off-grid and mini-grid products or efficient appliances. Efficiency standards provide broad societal benefits by reducing net costs for consumers and ensuring that available electricity resources go further. Linking efficiency to equipment and appliance purchasing programs and consumer awareness campaigns is a good way to stimulate demand and facilitate uptake.

5) Take steps to mobilize finance and build the electrification ecosystem for both developers and consumers

An enabling policy and regulatory environment must also be conducive to investment in electrification projects and service delivery at all scales. In order to close the gap between consumers' ability to pay and the returns necessary for industry's financial viability, a portfolio of appropriate finance is needed, tailored to technology solutions and delivery models. Particular attention should be paid to building institutional and human capacity for the provision of local finance to the electricity sector. This not only enables the flow of local currency necessary to meet local working capital requirements, but drives a valuable cycle of building the investment capacity in local financial institutions that is needed for long term sustainability.

Stimulating demand for electricity is important both to generate cash flow for project developers and to encourage social and productive use of electricity. Demand stimulation can be achieved by providing loans and loan guarantees to technology providers to lower the cost of capital. Some countries have even experimented with innovative financing to rural electrification program "aggregators" (such as IDCOL in Bangladesh, or AEPC in Nepal) to facilitate affordable finance to consumers can enable them to purchase equipment and appliances, while bulk purchasing can lower costs, particularly for public facilities.

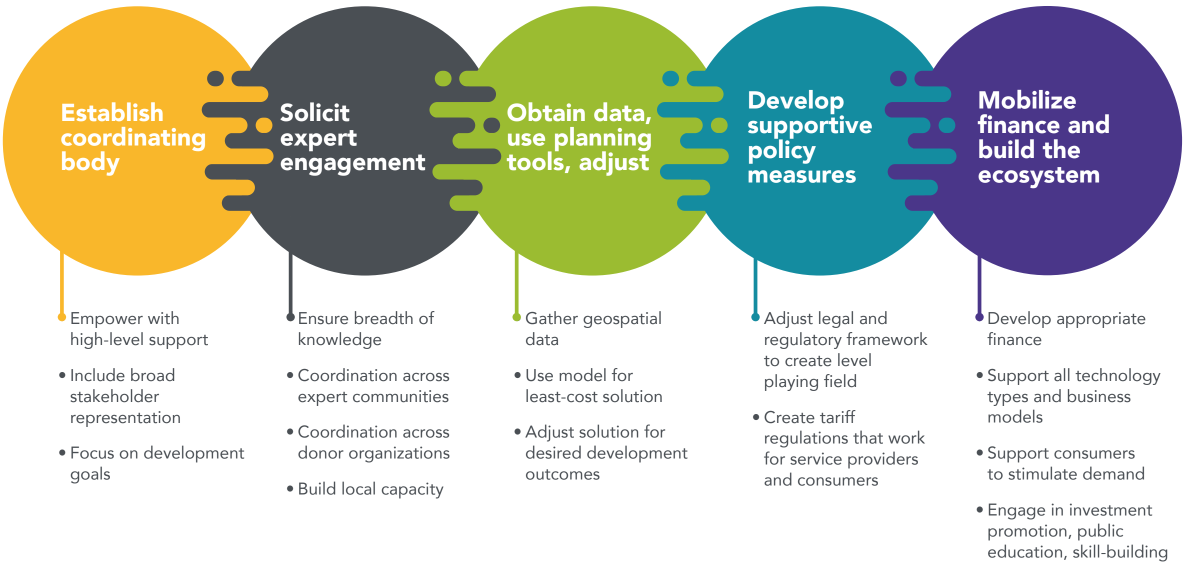
Other steps can be taken to bolster the electrification ecosystem; investment promotion campaigns can be conducted to communicate the enabling environment and crowd in private sector participation the market. Public education programs for consumers can raise awareness of the opportunities provided by electrification. Skill-building programs for workers can create opportunities for boosting local employment, from the technicians involved in project installation and maintenance to the micro and small enterprises that can grow through awareness of what access to affordable and reliable electricity means to their businesses.

Summary

An IEP is essentially a tool for inclusive development. IEPs build on traditional electricity planning and rural electrification approaches by explicitly considering new technologies and service delivery models while focusing on human needs and electricity access as an enabler of socio-economic development. They harness the views and expertise of stakeholders from across the electrification ecosystem to help shape an enabling environment for projects and service delivery at all scales. The IEP characteristics and planning steps identified here, along with examples and links to resources, can serve as a primer to those seeking to develop their own pathways in pursuit of the goal of ensuring access to affordable, reliable, sustainable and modern energy for all.

Figure 4

Process map



Further Resources

Electrification Planning Resources

https://undg.org/sdg_toolkit/open-source-spatial-electrification-tool-onsset/

https://qsel.columbia.edu/network-planner/

http://universalaccess.mit.edu/#/rem

http://electrification.energydata.info/presentation/

https://qsel.columbia.edu/assets/uploads/blog/2018/publications/geospatial-planning-framework-for-electrification-planning.pdf

http://universalaccess.mit.edu/#/cases

Howells, Mark, Han Holger Rogner, Dimitris Mentis, Oliver Broad. 2017. *State of Energy Access Report: Energy Access and Electricity Planning.* Washington: World Bank.
http://documents.worldbank.org/curated/en/628541494925426928/pdf/115065-BRI-P148200-PUBLIC-FINALSEARSFElectricityPlanningweb.pdf

Enabling Policy Environment Resources – General

Odarno, Lily, Anjana Agarwal, Amala Devi, Hisako Takahashi. 2017. *Strategies for Expanding Universal Access to Electricity Services for Development.* Washington: World Resources Institute.
https://www.wri.org/sites/default/files/Strategies_for_Expanding_Universal_Access_to_Electricity_Services_for_Development.pdf

Power for All. 2017. *Decentralized Renewables: From Promise to Progress.* San Francisco: Power for All.
https://www.powerforall.org/resources/reports/decentralized-renewables-promise-progress

Practical Action. 2016. *Poor People's Energy Outlook 2016: National Energy Access Planning from the Bottom Up.* Rugby, UK: Practical Action Publishing.
https://policy.practicalaction.org/policy-themes/energy/poor-peoples-energy-outlook/poor-people-s-energy-outlook-2016

Walters, Terri, Sean Esterly, Sadie Cox, Tim Reber, Neha Rai. 2015. *Policies to Spur Energy Access: Volume 1: Engaging the Private Sector in Expanding Access to Electricity.* Golden, Colorado: National Renewable Energy Laboratory.
https://www.nrel.gov/docs/fy15osti/64460-1.pdf

Enabling Policy Environment Resources – Mini-Grids

Agendbroad, Josh, Kelly Carlin, Stephen Doig, Claire Henly, Eric Wanless. 2017. *Energy Within Reach: Growing the Mini-Grid Market in Sub-Saharan Africa.* Boulder, Colorado: Rocky Mountain Institute.
https://www.rmi.org/insight/energy-within-reach/

Agenbroad, Josh, Kelly Carlin, Kendall Ernst, Stephen Doig. 2018. *Mini-Grids in the Money: Six Ways to Reduce Mini-Grid Costs by 60% for Rural Electrification.* Boulder, Colorado: Rocky Mountain Institute.
https://www.rmi.org/minigrids-money-reduce-costs/

Franz, Michael, Nico Peterschmidt, Michael Rohrer, Bozhil Kondev. 2014. *Mini-grid Policy Toolkit: Policy and Business Frameworks for Successful Mini-grid Roll-outs.* Eschborn, Germany: European Union Energy Initiative Partnership Dialogue Facility.
http://minigridpolicytoolkit.euei-pdf.org/

International Renewable Energy Agency. 2016. *Policies and Regulations for Private Sector Renewable Energy Mini-grids.* Abu Dhabi: IRENA.
https://www.irena.org/publications/2016/Sep/Policies-and-regulations-for-private-sector-renewable-energy-mini-grids

Enabling Policy Environment Resources – Solar Kits/Solar Home Systems

Global Off-Grid Lighting Association. 2018. *Providing Energy Access through Off-Grid Solar: Guidance for Governments.* Utrecht: Global Off-Grid Lighting Association.
https://www.gogla.org/sites/default/files/resource_docs/energy_access_through_off-grid_solar_-_guidance_for_govts.pdf

Productive Use Resources

Franco, Janina, V. Susan Bogach, Ines Perez Arroyo, Malte Lasa. 2017. *Promoting Productive Uses of Electricity in Rural Electrification Programs: Experience from Peru* (Live Wire Note 2017/80). Washington: World Bank.
http://documents.worldbank.org/curated/en/227571508913654470/pdf/120675-BRI-PUBLIC-24-10-2017-14-27-48-LWLJfinOKR.pdf

Johnstone, Kevin. 2019. *Off-grid Productivity: Powering Universal Energy Access* (IIED Briefing, January 2019). London: International Institute of Environment and Development.
https://pubs.iied.org/17492IIED/

McCall, Margaret, Scarlett Santana. 2018. *Closing the Circuit: Stimulating End-Use Demand for Rural Electrification.* Boulder, Colorado: Rocky Mountain Institute.
https://www.rmi.org/insight/closing-the-circuit/

Finance Resources

United Nations Development Programme, ETH Zürich. 2018. *Derisking Renewable Energy Investment: Off-grid Electrification.* New York and Zürich: UNDP and ETH Zürich.

https://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climateresilientdevelopment/derisking-renewable-energy-investment/drei--off-grid-electrification--2018-.html

Sustainable Energy for All. 2018. *Energizing Finance: Understanding the Landscape.* Vienna: Sustainable Energy for All.
https://www.seforall.org/sites/default/files/EF-2018-SEforALL.pdf

Bibliography

Agendbroad, Josh, Kelly Carlin, Stephen Doig, Claire Henly, Eric Wanless. 2017. *Energy Within Reach: Growing the Mini-Grid Market in Sub-Saharan Africa.* Boulder, Colorado: Rocky Mountain Institute.

Agenbroad, Josh, Kelly Carlin, Kendall Ernst, Stephen Doig. 2018. *Mini-Grids in the Money: Six Ways to Reduce Mini-Grid Costs by 60% for Rural Electrification.* Boulder, Colorado: Rocky Mountain Institute.

Dixit, Shantanu, Ashwin Chitnis, Bharath Jairaj, Sarah Martin, Davida Wood, Amrita Kundu. 2014. *10 Questions to Ask about Integrated Resource Planning.* Washington: World Resources Institute.

ESMAP. 2018. *Regulatory Indicators for Sustainable Energy.* Washington: World Bank.

Federal Ministry for Economic Cooperation and Development of Germany, Ministry of Foreign Affairs of the Netherlands, International Renewable Energy Agency, World Bank. 2018. *Policy Brief #24: Energy Sector Transformation: Decentralized Renewable Energy for Universal Energy Access* (Policy Briefs in Support of the First SDG 7 Review at the UN High-level Political Forum 2018). New York: United Nations.

Franco, Janina, V. Susan Bogach, Ines Perez Arroyo, Malte Lasa. 2017. *Promoting Productive Uses of Electricity in Rural Electrification Programs: Experience from Peru* (Live Wire Note 2017/80). Washington: World Bank.

Frankfurt School – UNEP Collaborating Centre for Climate and Sustainable Energy Finance. 2015. *Renewable Energy in Hybrid Mini-Grids and Isolated Grids: Economic Benefits and Business Cases.* Frankfurt: Frankfurt School of Finance and Management.

Franz, Michael, Nico Peterschmidt, Michael Rohrer, Bozhil Kondev. 2014. *Mini-grid Policy Toolkit: Policy and Business Frameworks for Successful Mini-grid Roll-outs.* Eschborn, Germany: European Union Energy Initiative Partnership Dialogue Facility.

Global Off-Grid Lighting Association. 2018. *Providing Energy Access through Off-Grid Solar: Guidance for Governments.* Utrecht: Global Off-Grid Lighting Association.

Graber, Sachiko, Patricia Mong, James Sherwood. 2018. *Under the Grid: Improving the Economics and Reliability of Rural Electricity Service with Undergrid Mini-Grids.* Boulder, Colorado: Rocky Mountain Institute.

Howells, Mark, Han Holger Rogner, Dimitris Mentis, Oliver Broad. 2017. *State of Energy Access Report: Energy Access and Electricity Planning.* Washington: World Bank.

International Energy Agency. 2017. *Energy Access Outlook 2017.* Paris: OECD/IEA.

International Energy Agency. 2018. *World Energy Outlook 2018.* Paris: OECD/IEA.

International Energy Agency, United Nations Development Programme, International Renewable Energy Agency. 2018. *Policy Brief #1: Achieving Universal Access to Electricity* (Policy Briefs in Support of the First SDG 7 Review at the UN High-level Political Forum 2018). New York: United Nations.

International Renewable Energy Agency. 2016. *Policies and Regulations for Private Sector Renewable Energy Mini-grids.* Abu Dhabi: IRENA.

International Renewable Energy Agency. 2018. *Global Energy Transformation: A roadmap to 2050.* Abu Dhabi: IRENA.

International Renewable Energy Agency. 2018. *Off-grid Renewable Energy Solutions: Global and Regional Status and Trends.* Abu Dhabi: IRENA.

International Renewable Energy Agency. 2018. *Policies and Regulations for Renewable Energy Mini-grids.* Abu Dhabi: IRENA.

International Renewable Energy Agency. 2018. *Renewable Capacity Statistics.* Abu Dhabi: IRENA.

Johnstone, Kevin. 2019. *Off-grid Productivity: Powering Universal Energy Access* (IIED Briefing, January 2019). London: International Institute of Environment and Development.

McCall, Margaret, Scarlett Santana. 2018. *Closing the Circuit: Stimulating End-Use Demand for Rural Electrification.* Boulder, Colorado: Rocky Mountain Institute.

Mentis, Dimitrios, Mark Howells, Holger Rogner, Alexandros Korkovelos, Christopher Arderne, Eduardo Zepeda, Shahid Siyal, Costantinos Taliotis, Morgan Bazilian, Ad de Roo, Yann Tanvez, Alexandre Oudalov, Ernst Scholtz. 2017. *Lighting the World: The First Application of an Open Source Spatial Electrification Tool (OnSSET) on Sub-Saharan Africa.* Environmental Research Letters 12

Mills, Evan. 2017. *Global Kerosene Subsidies: An Obstacle to Energy Efficiency and Development* (World Development). Amsterdam: Elsevier.

Odarno, Lily, Sarah Martin, Catalina Angel. 2015. *10 Questions to Ask about Distributed Generation.* Washington: World Resources Institute.

Odarno, Lily, Anjana Agarwal, Amala Devi, Hisako Takahashi. 2017. *Strategies for Expanding Universal Access to Electricity Services for Development.* Washington: World Resources Institute.

Oxford Policy Management Institute. 2018. *Key principles for improving the effectiveness of strategic energy planning in developing and emerging economies.* Vienna: Sustainable Energy for All.

Power for All. 2016. *Decentralized Renewables: The Fast Track to Universal Energy Access.* San Francisco: Power for All.

Power for All. 2017. *Decentralized Renewables: From Promise to Progress.* San Francisco: Power for All.

Practical Action. 2014. *Poor People's Energy Outlook 2014: Key Messages on Energy for Poverty Alleviation.* Rugby, UK: Practical Action Publishing.

Practical Action. 2016. *Poor People's Energy Outlook 2016: National Energy Access Planning from the Bottom Up.* Rugby, UK: Practical Action Publishing.

Practical Action. 2018. *Poor People's Energy Outlook 2016: Achieving Inclusive Energy Access at Scale.* Rugby, UK: Practical Action Publishing.

Sanyal, Sanjoy, Jeffrey Prins, Feli Visco, Ariel Pinchot. 2016. *Stimulating Pay-As-You-Go Energy Access in Kenya and Tanzania: The Role of Development Finance.* Washington: World Resources Institute.

Scott, Andrew. 2015. *Building Electricity Supplies in Africa for Growth and Universal Access.* (Background paper for Power, People, Planet: Seizing Africa's Energy and Climate Opportunities). London: New Climate Economy.

Shirley, Rebekah G, Clayton Piatt, Brooke Maushund, Joon Hun Seong, Kelly Jiang, Kristina Skierka, Dan Kammen. 2017. *Policy Priorities for Catalyzing DRE Markets: Practical Lessons from the Most Successful Markets.* Manuscript Under Review.

Sustainable Energy for All, Power for All, and Overseas Development Institute. 2017. *Why Wait? Seizing the Energy Access Dividend.* Washington: Sustainable Energy for All, Power for All and Overseas Development Institute.

Sustainable Energy for All. 2018. *Energizing Finance: Understanding the Landscape.* Vienna: Sustainable Energy for All.

United Nations Development Programme, ETH Zürich. 2018. *Derisking Renewable Energy Investment: Off-grid Electrification.* New York and Zürich: UNDP and ETH Zürich.

Walters, Terri, Sean Esterly, Sadie Cox, Tim Reber, Neha Rai. 2015. *Policies to Spur Energy Access: Volume 1: Engaging the Private Sector in Expanding Access to Electricity.* Golden, Colorado: National Renewable Energy Laboratory.

World Bank. 2008. *Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs.* Washington: World Bank.

World Bank. 2015. *Beyond Connections: Energy Access Redefined.* Washington: World Bank.

World Bank. 2017. *State of Electricity Access Report 2017.* Washington: World Bank.

World Bank. 2018. *Tracking SDG 7: The Energy Progress Report 2018.* Washington: World Bank.

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