SUSTAINABLE ENERGY FOR ALL

Data Standards for Integrated Energy Planning

WORKSHOP REPORT

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SUMMARY

There is increasing recognition that integrated energy planning is key to achieving universal access, and that geospatial modelling provides a low-cost, dynamic and data-driven means of energy prioritization and planning. While this is an encouraging trend, the increasing use of geospatial least-cost modelling is also highlighting one of its key challenges: data gaps and data quality. As with any modelling exercise, geospatial models are only as good as the data and assumptions on which they are based. As more countries make use of geospatial tools to inform their universal energy access strategies, it is imperative that the data used in these tools are as accurate and consistent as possible.

The increasing use of geospatial least-cost modelling is also highlighting one of its key challenges: data gaps and data quality.

To address this issue, Sustainable Energy for All (SEforALL) hosted a workshop about data and integrated energy planning in July 2020. The workshop brought together experts in data and energy planning to explore how geospatial-based integrated energy planning can be made more accurate, consistent and practical through better data. Specifically, the workshop focused on identifying the data needs and quality of integrated energy planning, where data/quality gaps exist and how they can be filled. These issues were explored in the context of both electrification and clean cooking planning.

Key themes emerging from the workshop included:

- The importance of reflecting demand-side considerations in geospatial integrated energy planning: Energy planning has traditionally focused on the supply side, with attention paid to technologies such as the central grid. Demand-side considerations are often overlooked or simplified. To ensure that integrated energy planning is effective and meets the needs of people, it is imperative that demand is better reflected in planning (both for electrification and clean cooking). This should be done through investments in demand-side data such as detailed information on ability and willingness to pay, productive uses, electricity growth and demand heterogeneity.
- Data are not static: The inputs and data that inform energy planning are often thought of as being static, however in reality, many inputs are dynamic. For example, technology costs can evolve rapidly, due to learning curves and innovations, and can change significantly as economies of scale are leveraged. As planning exercises can span multiple years, if not decades, it is important to consider the dynamic nature of data and inputs.
- There is no single, ideal dataset or level of data quality needed for integrated energy planning: Data quality needs vary based on the intended use of the planning/modelling exercise. For this reason, it is important to identify which stakeholders a planning/modelling exercise is intended for before defining what data might be needed and at what level of granularity/accuracy. Furthermore, planners should be pragmatic and think about the optimal level of data quality in terms of the minimum data attributes or characteristics (e.g. granularity) that generate similar insights to those that might be gained with more 'perfect' data.

- Geospatial integrated planning/tools can play at least two important roles for the clean cooking sector: While the clean cooking sector has yet to make widespread use of geospatial integrated planning, such modelling/planning can help the sector by: (1) serving as a central framework around which different national and sub-national stakeholders can come together to explore linkages, evaluate trade-offs, compare costs/consequences and coordinate different clean cooking stakeholders and strategies; (2) facilitating operational-level or technology/fuel specific decision-making, such as identifying attractive markets or distribution strategies. Making use of geospatial integrated planning for these purposes will require substantial investments and improvements in cooking data and analysis, however these challenges should not deter from efforts to develop a geospatial integrated cooking framework. The development of such a framework can spur further investments in data.
- Adoption of electric cooking and its implications need to be better understood: As advances in electric cooking spur the convergence of electrification and clean cooking, it is important that planners and power suppliers (e.g. utilities, mini-grid developers, solar home system (SHS) providers) better understand the implications of greater electric cooking adoption on energy demand.
- Opportunities exist to fill data gaps and improve data quality at relatively low cost. Advances in remote sensing and analytics are making it easier to obtain planning data and information at increasing levels of granularity and across a wider set of geographies. This includes, for example, data about where people live and their built environment but also increasingly data about people's ability to pay and the economic potential of communities. Cell phone-based surveys and remote monitoring are other cost-effective ways of filling data gaps, especially as they relate to understanding consumer preferences and energy consumption. While these and other data collection tools and techniques have reduced the need for on-the-ground data collection, there is still value in carrying out on-the-ground surveys in certain circumstances, especially to better understand consumer behaviour needs and consumption or location of low voltage (LV) power lines, all of which are critical inputs to energy planning.

These themes and more are examined in greater detail throughout the rest of this report.

INTRODUCTION

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In July 2020, Sustainable Energy for All (SEforALL) hosted a workshop on improving and standardizing data used by governments and their partners for integrated energy planning. The workshop was held in the form of a series of virtual consultative meetings around the following topics:

- Electrification Planning: Data Needs and Gaps
- Electrification Planning: Data Quality
- Clean Cooking Planning: The Role and Value of Geospatial, Integrated Planning
- Clean Cooking Planning: Data Needs, Gaps, and Quality
- Coordinating Electrification and Clean Cooking Planning

This outcome document synthesizes the discussions that took place over the five meetings.

The workshop was undertaken in support of SEforALL's new Universal Integrated Energy Plans (UIEP) initiative, which aims to accelerate the adoption of 'best-in-class' integrated energy plans among high energy access-deficit countries. The workshop brought together 65 participants, representing 28 organizations involved in generating, analyzing or using data for energy planning purposes (see Annex B for a full list of participants) to share their diverse perspectives, experiences and insights regarding what core data sets and data quality are needed for integrated energy planning to be more accurate, consistent and practical. The workshop's outcomes are intended to inform the development of a set of best practices that SEforALL will work with governments and their development partners on so that they can adopt them in their integrated energy plans and be beneficial to the energy sector as a whole.

A. BACKGROUND

In order to achieve universal access to affordable, reliable, sustainable and modern energy for all by 2030 (Sustainable Development Goal (SDG) 7), comprehensive energy planning is key to guide the development of countries' energy systems. Integrated energy access planning can facilitate problem solving and make it possible to explore linkages, evaluate trade-offs and compare consequences, thereby helping countries to develop an effective energy access strategy that supports national sustainable development goals. When done right, integrated energy access planning is data-driven and takes into account least-cost supply and demand considerations, affordability, environmental and social protection, and the integration of renewable resources, all within a national context.

Thanks to advances in information technology, digital tools such as geographic information systems (GIS), satellite imagery and machine learning are making it easier to take a data- and evidence-based approach to integrated energy access planning. They are allowing for accelerated, relatively low-cost, and visually powerful modelling of optimal energy pathways that clearly define the role of utilities, mini-grid and off-grid solar companies (OGS) and clean cooking solution providers in achieving universal energy access. More specifically, such approaches and tools can be used by:

- Governments to aid planning, coordination and resource mobilization for universal energy access efforts
- Utilities to prioritize grid densification and/or extension to communities where it is most cost effective
- Mini-grid developers to find suitable sites more quickly and reliably
- OGS companies to identify desirable sales regions, cross-check customer information and better plan distribution channels
- Clean cooking solutions companies to identify desirable sales regions, identifying resource availability and household affordability to serve areas with new and improved cooking solutions
- Donor and investment communities to fund and finance solutions
- Local academia to play an important role for capacity building and to support knowledge transfer.

Geospatial models are only as good as the data assumptions on which they are based.

An increasing number of policymakers are using geospatial integrated energy planning as a way of better understanding the technologies and spending required to achieve universal energy access. Countries such as Ethiopia, India, Kenya, Myanmar, Nepal and Togo are considering their electrification strategies with an eye to taking advantage of all available technologies and leveraging the private sector's expertise to meet SDG7.

While this is an encouraging trend, the increasing use of geospatial least-cost modelling is also highlighting one of its key challenges: data gaps and data quality. As with any modelling exercise, geospatial models are only as good as the data and assumptions on which they are based. For geospatial data, the level of granularity is of particular concern. Open access data are typically available at low spatial and/or temporal resolutions. More granular data are usually harder to attain and often come at a cost. For example, while data on high-voltage (HV) lines are publicly available, data on medium-voltage (MV) or low-voltage (LV) networks (e.g. distributed generation, lines, substations & transformers, connectivity, current loads) are often scattered and inconsistent, resulting in a higher need for assumptions and estimations. Furthermore, open access and crowd-sourced data are often unreliable, owing to difficulties in verifying the origin of datasets, how often they are updated or how representative they are. Important datasets such as energy demand, willingness and ability to pay, fuel supply chains, the location and energy needs of public institutions and productive uses are often unavailable or incomplete. Lastly, a key challenge is that many datasets are not regularly updated; as electrification is a dynamic task, having up-to-date information is critical for accurately monitoring progress in electrification. Together, these challenges are leading to uncertainty, inaccuracies and inconsistencies in analysis.

Another feature of current geospatial integrated energy access planning is that it is often focused on electrification, without much regard given to cooking. This is partly due to the dearth of nationally representative, verifiable data for cooking supply (e.g. fuel availability and supply chains) and demand (ability to pay, fuel preferences, willingness to adopt new cooking technologies and fuels) in energy-deficit countries. But as electrification rates rise, and technologies such as electric pressure cookers become increasingly viable, there may be a greater need for and benefit to coordinating clean cooking and electrification planning.

As more countries make use of geospatial tools to inform their universal energy access strategies and plans, it is imperative that the data used in these tools are as accurate and consistent as possible and that respective data management strategies are developed. This represents an opportunity for organizations involved in the production and use of data to collectively raise the bar and set the standard for integrated energy planning data.

B. WORKSHOP OBJECTIVES AND SCOPE

In response to the above-mentioned challenges, SEforALL conveyed a workshop in July 2020 on improving and standardizing data used by governments and their partners for integrated energy planning. The workshop's main objectives were to:

- Build consensus on the minimum data needs and quality for integrated energy planning, where data/quality gaps exist, and how they can be filled
- Enhance coordination among stakeholders involved in the production and use of data for integrated energy planning
- Discuss a set of principles that underpin data collection, use and dissemination, focusing on reliability, transparency and consistency
- Determine the feasibility and value of geospatial, integrated planning to advance clean cooking access.

These objectives were mainly geared towards national- and sub-national-level energy access planning, where the aim is to inform policymaking, but at times participants surfaced insights relevant to other forms of energy access planning, including off-grid area analysis, where the emphasis is on enabling organizational-level decision-making.

C. HOW THE WORKSHOP FITS INTO SEforALL'S WORK

The workshop was undertaken in support of SEforALL's new Universal Integrated Energy Plans (UIEP) initiative, which aims to accelerate the adoption of 'best-in-class' integrated energy plans among high energy access-deficit countries. The UIEP initiative involves four key activities:

SETTING THE STANDARD: Developing practical tools and knowledge products that help 'set the standard' for best-in-class integrated energy plans. These foundational activities will focus on, among other things:

- **Data:** Improving the availability, quality and consistency of data used in geospatial, integrated energy access planning. This will involve defining key data 'standards' and securing the buy-in of organizations involved in the development of integrated energy plans in the use of high-quality data
- **Governance:** Promoting good governance practices in the development of integrated energy plans (e.g. inclusive stakeholder consultations)
- **Cooking:** Developing a new paradigm for energy access planning that incorporates cooking into integrated electrification planning and explores how geospatial, integrated energy planning tools could advance the clean cooking agenda.

COUNTRY-LEVEL ADVISORY SUPPORT: Providing tailored advisory support to countries that have developed or are developing an integrated energy plan to help them better utilize their integrated energy plans and translate them into policies, finance and implementation.

FILLING THE GAP: Commissioning integrated energy plans in a select number of countries where an integrated energy plan may not exist or where it could be improved upon (e.g., expanding a plan to include clean cooking).

BUILDING DEMAND: Using high-level advocacy to secure political buy-in on integrated energy access planning and the role of distributed energy and a range of clean cooking solutions for meeting energy access goals and facilitating South-South learning.

The workshop's outcomes are intended to inform the development of a set of best practices that SEforALL will work with governments and their developments partners on so that they can adopt them in their integrated energy access plans and be beneficial to the energy sector as a whole.

KEY TAKEAWAYS AND EMERGING BEST PRACTICES

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This section summarizes the main takeaways from the discussions during the workshop. The takeaways are grouped into the following three sub-sections: (a) electrification planning, (b) clean cooking planning, and (c) coordinating electrification and clean cooking planning. Each sub-section begins with an overview of the key issues and questions that were discussed during the workshop for that particular theme and is followed by a synthesis of the most salient points and recommendations made by participants.

A ELECTRIFICATION PLANNING

I. SCOPE AND GUIDING QUESTIONS

The workshop's first two meetings focused on electrification planning. The main aims of these meetings were to: (i) build consensus around minimum data needs and quality standards, (ii) discuss opportunities to fill data gaps, and (iii) enhance coordination among stakeholders. To guide the discussion, participants were asked to consider and discuss the following questions:

- What modelling efforts are best-in-class, and to what extent has a lack of data availability and quality been a barrier?
- What outputs or insights are these models designed to generate?
- What are the most important data inputs for integrated energy planning, and how would you rank these inputs in order of importance?
- What data are available / partially available / not available?
- What characteristics define data quality?
- Where are the biggest gaps in terms of data availability and quality?
- What data quality should we be striving for to ensure that integrated electrification modelling/planning exercises generate accurate, consistent and practical results and outputs? Where are the biggest gains to be made (cost/value) on data improvements?

II. ROLE AND APPLICATION OF GEOSPATIAL ELECTRIFICATION PLANNING

Participants began the two meetings on electrification planning by discussing how geospatial electrification planning is being undertaken and what objectives these planning efforts are and should be facilitating. Participants generally agreed that geospatial electrification planning tools, such as the Open Source Spatial Electrification Toolkit (OnSSET), Network Planner, or the Reference Electrification Model (REM), are important for identifying the least-cost pathways for achieving universal electrification. This emphasis on least-cost optimization is especially important for government planners who are often tasked with allocating scarce public resources in the most efficient manner possible. But participants also stressed the importance of better reflecting demand-side considerations (such as ability and willingness to pay) into modelling efforts and the need to factor in national and local political economy considerations into planning processes.

While many inputs (e.g. quality and reliability of electricity supply, local preferences) can be translated into a geospatial electrification model in common terms such as cost, planners at different levels of government may have differing priorities that cannot always be translated into a comparable USD equivalent (e.g. the speed at which a technology can be deployed vs. how this technology fits with a national or international climate change plan). Furthermore, people's preferences may not always coincide with the least-cost solution. As such, some participants suggested that geospatial models should involve a multi-criteria analysis that goes beyond least-cost optimization, to facilitate collaboration between different aspects, such as the political, social, environmental, financial and technical aspects of planning and to help decision-makers understand the economic and non-economic trade-offs of different policy choices. Participants also stressed the fact that planning occurs over a long-term horizon (often a decade) and as such should be thought of as an ongoing process (not a static onetime event) and take into account the latent and future demand and aspirations of residential and non-residential customers, as well as technology development (e.g. price decline in batteries, novel smart metering technologies).

III. DATA NEEDS AND AVAILABILITY

After discussing the role and application of geospatial electrification planning, participants discussed what kind of inputs are necessary for geospatial electrification planning and the availability of data for those inputs.

KEY INPUTS

There was consensus that electrification planning inputs can generally be grouped into the following categories or steps in a geospatial electrification planning exercise:

- Identify unelectrified and undersupplied households and institutions: Data about the location and level of access to electricity of households, schools, health facilities, agricultural centres, and other productive uses and anchor loads.
- Calculate and characterize demand: Data about the ability/willingness to pay of unelectrified households, businesses and institutions and the expected electricity demand for different locations or settlements (including likely demand growth).
- Determine energy potential and options: Data about the available energy resources (e.g. global horizontal irradiation, hydropower potential and wind power density per area of interest) and the location and type of existing and expected grid infrastructure (voltage lines, transformers and power plants).
- Determine the optimal technology mix based on factors such as cost, speed of deployment, political/ consumer preferences: Data on other factors that enable analysis and optimization, including costs (e.g. capex and opex costs for different technologies and fuels and the cost of capital) and the built environment (e.g. topography, road infrastructure).

To help further identify the specific inputs and datasets that are important for geospatial energy planning, a detailed framework and list of key inputs were presented to participants; several additions and changes were made during the workshop to reflect the participants' views. A summary of the updated framework/list is reflected in Figure 1 below (for a more a detailed framework/list, please refer to Annex A).

Figure 1: List of Key Inputs to Geospatial Electrification Planning

Step	Category	Dataset	Availability	Additional Comments
STEP 1 Identify unelectrified households, institutions, etc.	Population	Population density & distribution (e.g. location, number and size of households/buildings)	Largely available	Several good sources exist that capture population density and distribution, with increasing levels of granularity (though not all are open access)
		Population growth and expected urban-rural migration	Limited	There is a risk that these data become outdated very quickly. Time series can be used to better understand patterns.
	Socio-economic	Productive uses (location of agricultural centres/value chains, telecom towers, C&I customers)	Partially available	Location of agricultural centres can be inferred from location of commercial centres and presence of commercial crop types in the country.
		Social services (location and type of schools, clinics)	Partially available	Ministries of Health and Education may have valuable datasets on location and energy status of institutions
	Access Status	Electrification status (in terms of tiers of access, including quality and reliability) for households, schools, clinics, etc.	Partially available	Often estimated through night-light datasets, supplemented by household surveys (esp. to measure quality and reliability, which may result in stacking of power solutions)
STEP 2 Calculate & characterize demand	Socio-economic	Ability and willingness to pay (the income level and/or energy expenditure in an area - $/km2)	Limited	Difficult to capture, and limited information is currently available around ability vs willingness to pay for electricity services
		Access to finance institutions	Limited	This is important information for mini-grid developers and off-grid SHS providers, supplementing information around creditworthiness
	Demand	Electricity demand (effective, latent and over time) for different locations or types of settlements and customers	Limited	
STEP 3 Determine energy potential & options	On-grid Infrastructure	High-voltage lines (existing & planned)	Largely available	Requires information on country-specific HV datasets as there are often discrepancies between global/continental HV datasets and country-specific ones
		Medium-voltage lines (existing & planned)	Partially available	Requires information on country-specific MV datasets as there are often discrepancies between global/continental MV datasets and country-specific ones
		Low-voltage lines (existing & planned)	Limited	
		Substation & transformers (existing & planned)	Limited	Datasets could be validated through a feedback loop from existing interventions (mini-grid)
		Power plants (existing & planned)	Largely available	
	Off-grid Infrastructure	Mini-grids (location)	Largely available	
		SHSs distribution network	Partially available	PAYG companies will have accurate records of customers' locations
	Energy Resources	Global Horizontal Irradiation (kWh/m2/year)	Fully available	
		Hydropower potential (power output (kW), head (m) and the discharge (m3/year)	Largely available	
		Wind speed or power density (m/sec over an area)	Fully available	

STEP 4 Determine optimal technology mix	Costs	Technology unit costs for SHSs, mini-grids, grid extension and densification, etc. (fixed and variable costs at different scales and time horizons)	Largely available	LCOE may be oversimplification; other costs need to be included (e.g. admin costs)
		Fuel prices ($/liter of diesel by location)	Partially available	National and local prices of fuel are critical, more so than global market prices
		Other costs (cost of capital, FX risk, import tariffs and duties, etc.)	Partially available	Will require information on specific national context
	Built Environment	Road network (existing & planned)	Largely available	Could be used as proxy for potential economic development, and access to supply chains
		Topography (incl. protected areas)	Largely available	Increasingly important for further downstream planning (e.g. mini-grid site selection)
		Cell coverage	Largely available	Data are available but not accessible in a GIS format

While discussing the inputs summarized above, participants stressed the following points:

- Many inputs / data variables are not static; they change over time and at different penetration levels. For example, technology costs will change over time and as economies of scale are leveraged. As such, planning must take into account the dynamic nature of inputs.
- As electrification planning decisions are made with time horizons ranging from 5 (SHS) to 40 (grid) years, it is important to look at latent or projected electricity demand (e.g. where electricity demand could grow or arise if access to electricity were made available). This is where time series or other historic data are useful in understanding how electricity demand may evolve/grow over time following access to electricity.
- Similarly, different customer segments (e.g. residential vs C&I) often have different electricity growth drivers (e.g. individual wealth vs GDP growth) and patterns, therefore it is important to factor these differences when forecasting electricity demand by consumer segment.
- Besides considering residential demand, it is important to capture larger loads, such as agricultural value chains, C&I customers and other productive uses, given that they can have a potentially large influence on a model's results and are a critical input for mini-grid and grid extension planning.
- It is important to articulate technology costs in their individual component costs and to capture and differentiate one-time costs vs re-occurring costs (O&M). This makes it easier to configure cost data based on the type of model or analysis that is being used. It is also important to capture other costs or factors that influence costs when building up the total cost of a particular technology (e.g. discount rates, technology efficiency, capacity factors, economies of scale).
- Besides technology LCOE there are other costs that can influence which technologies to deploy and at what scale (e.g. minimum quality standards, FX risks, or administrative costs such as bill collection). Participants also suggested the importance of using local component prices for more accurate representation of the national and local context.
- Where geospatial and other data (e.g. census) include highly disaggregated levels of personal or sensitive information, data privacy and protection concerns need to be addressed.

DATA AVAILABILITY AND GAPS

Electrification planning is making use of an increasing array of datasets thanks to advances in remote sensing and a concerted effort to make data more publicly available. However, the participants highlighted several key data gaps that remain and that need filling in order to ensure that electrification planning efforts produce more accurate and reliable results.

- A key gap remains in data on electricity demand, especially for rural areas, small and medium-sized enterprises (SMEs) and other institutions. This includes measuring electricity demand both in a heterogenous way rather than in a homogenous (or aggregated) way, as well looking at electricity demand over time (i.e. taking into account latent and future demand growth).
- People's ability and willingness to pay for electricity is another area where there is a dearth of data. This has resulted in a reliance on proxies, such as asset ownership. Several high-quality datasets on ability to pay and creditworthiness exist, though in most instances they are not publicly available, and require a license to access.
- There is limited information available around both the quality and reliability of grid electricity, especially in rural areas. In grid-connected but undersupplied areas, customers face frequent brown- and blackouts and often resort to using back-up or stand-alone parallel power systems. Utilities (or other grid operators) may have (some of) this information on quality and reliability, though the participants agreed that making these data widely accessible remains a challenge.
- The location of low voltage (LV) lines is another gap that – once filled – could add significant value to planning exercises. Similarly, the location of transformers and substations is often not available at a national level for the majority of high energy-deficit countries.

Data ownership and licensing should also be taken into account. Often, data without clear licensing terms can be found, however, such data may not be available for use in models. Ideally, data are made available under an open-data license.

IV. DATA QUALITY

Building on the discussion around data needs and availability, the participants discussed data quality, including where it is important, where it remains a challenge and ways of improving both the availability and quality of data.

DEFINING DATA QUALITY

In addition to being available, data must also be of sufficient quality in order for integrated electrification planning to be accurate, consistent and practical. While there is no standard definition of data quality in the context of electrification planning, participants generally agreed that it pertains to the following characteristics:

- Granularity / spatial resolution: The amount of spatial detail in a given observation or area
- Timeliness / temporal resolution: How often data of the same area are collected
- Accuracy: The degree or closeness to which data / information match the real values in the real world
- Consistency: Refers to the absence of apparent contradictions in and across datasets
- Completeness: A dataset is "complete", if all the records are filled in for the area of interest (e.g. a good dataset for one county/district may not be useful or representative for national analysis).

Participants also cited several additional considerations that are related to and often cut across the characteristics mentioned above.

- The provenance and trustworthiness of the data. This typically refers to the trustworthiness of the data source, as well as the entities, systems and processes that influence the data.
- Interoperability — or the ability to exchange and make use of data/information across different data/ modelling platforms — was also cited as being important. Here, the format of data is critical to its interoperability.
- In addition to the quality of data, the quality of metadata should be equally considered. This information accompanies each dataset and provides information on e.g., origin, date of first publishing, format and license/use rights. The same quality characteristics apply both to data and metadata.

WHERE DATA QUALITY MATTERS MOST

After discussing what defines data quality, participants discussed how to think about the ideal level of data quality for planning purposes. Here, participants stressed the importance of being pragmatic and thinking about the ideal level of data quality in terms of the minimum data attributes or characteristics (e.g. granularity) that generate similar insights to those that might be gained with more ideal or perfect data. It was also pointed out that data quality needs will vary across different stakeholders, users and applications. The level of data accuracy, for example, required by a solution provider may be lower for certain inputs than that required by a government planner.

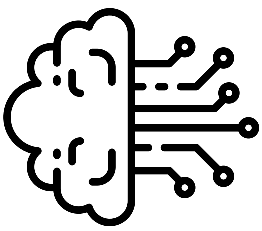
Participants identified several datasets where data quality (especially spatial and temporal resolution) is of particular importance:

- Population data: Knowing where people live, and by extension how densely populated areas are, is important to electrification planning given how closely linked technology costs (especially grid extension and mini-grids) are to population density. Thanks to satellite imagery and modelling techniques, such as the WorldPop dataset (which comes in 100x100m resolution) and Facebook's High-Resolution Settlement Layer (which comes in 30x30m resolution), high-resolution and frequently updated [modelled] population data do exist for many countries. This is important as census surveys, which have been the traditional source of population data for planners, are carried out very infrequently (usually every 10 years) and therefore are not always a reliable reflection of where people live.
- Electricity demand, including for productive uses: Several participants noted the importance of adequately estimating electricity demand and its evolution, including for productive uses. This is because of the notable sensitivity between anticipated demand levels and technology costs.
- Grid infrastructure: Similar to population data, it is important to have accurate data on the location and layout of grid infrastructure given how sensitive costing/planning is to the spatial relationship between the grid (especially MV and LV lines), the population or other demand centres.

IMPROVING DATA AVAILABILITY AND QUALITY

Participants highlighted a range of techniques or approaches to filling data gaps and improving data quality, with the below list providing specific opportunities relevant for electrification planning.

- Advancements in GIS, remote sensing and artificial intelligence (AI) have widened the opportunities and options for filling data gaps in a cost-effective manner. For example, using satellite imagery and AI, Microsoft has generated high-quality building footprint maps for several African countries (e.g. Tanzania and Uganda). Predictive modelling can also be used to characterize energy demand by, for example, using past transaction records (e.g. SHS sales or electricity bills) to predict 'willingness to pay'. In a similar vein, GIS and other analytical tools can be used to find proxies when the ideal source of data does not exist. For example, road density and arable land can be used to estimate the economic health of a village or the potential for productive uses. Similarly, data on crop production can be used to estimate the adoption of pumped irrigation and milling requirements.
- Cell phone-based surveys were also identified as a low-cost option for collecting and validating data. One potential application for such surveys is in verifying grid reliability, especially in rural areas. Such data are usually not easily accessible (especially at scale) but can add a lot of value to electrification modelling, if made available.
- Participants generally agreed that on-the-ground data collection, which is often expensive and time consuming, should be reserved for certain 'high-value' inputs, such as understanding different consumer load profiles or the location of distribution lines. When it comes to grid infrastructure, a point was made that there is a cost-effective opportunity to digitize LV lines when utilities are extending wires, as this work already requires being on the ground. As demonstrated by the experiences of Kenya and Nigeria, this kind of effort does not have to be overly time consuming or expensive provided utilities are properly trained and equipped with the right hardware/software. On-the-ground surveys are also valuable in validating GIS or imputed data.
- Participants also discussed the importance of coordinating and collaborating with other sectors and stakeholders to unlock data. Ministries of Agriculture or Mines, for example, often have data that are of relevance to electrification planning. Similarly, utilities usually have data on the location and characteristics of grid infrastructure and energy consumption patterns, both of which are highly important to electrification planning. Accessing these data, however, can be difficult as utilities often need/require a clear directive from the government to share them (in case of publicly owned utilities). It also important to understand the priorities of utilities and align modelling/planning efforts around these priorities so that utilities have a vested interest in making data available.
- Building in feedback loops with past and ongoing interventions can also help fill data gaps. Through the use of meters on mini-grids, for example, it is possible to better understand forecasted vs actual electricity demand or see where there may be regional differences in electricity demand within a country. Similarly, as more grid infrastructure is digitized, it is important to feed that data into predictive modelling (e.g. GridFinder) in order to improve the accuracy of the models. This is important as it is unlikely that every country will be able to digitize its grid infrastructure.
- A number of commercial datasets with highly detailed resolution exist (e.g. Maxar/Digital Globe/Airbus/ LandScan). While very valuable, high resolution satellite imagery ("footprint data") remains difficult and costly to obtain, participants underscored the importance of trying to make commercial data more accessible to a broader community for planning purposes.



Advancements in GIS, remote sensing and artificial intelligence (AI) have widened the opportunities and options for filling data gaps in a cost-effective manner.

B COOKING PLANNING

I. SCOPE AND GUIDING QUESTIONS

The workshop's third and fourth meetings focused on integrated planning for clean cooking. The main aims of these meetings were to: (i) discuss the feasibility and value of geospatial planning for clean cooking, (ii) build consensus around minimum data needs and quality standards, (iii) discuss opportunities to fill data gaps, and (iv) enhance coordination among stakeholders. To guide the discussion, participants were asked to consider and discuss the following questions:

- What is the role/value of integrated planning to clean cooking and in what ways can geospatial, integrated energy planning advance the clean cooking agenda?
- What kind of planning approaches and tools do you see governments using to inform their national clean cooking strategies?
- How, if at all, have geospatial models been used to inform clean cooking strategies?
- What are the most important inputs for clean cooking planning? How would different stakeholders rank these inputs in order of importance?
- What data are available / partially available / not available?
- What are the ways to fill these data gaps?

II. ROLE AND APPLICATION OF GEOSPATIAL ELECTRIFICATION PLANNING

Participants began the two meetings on clean cooking by discussing how clean cooking planning is currently being undertaken, how and why it differs from electrification planning and what implications these differences have on the feasibility and potential role of geospatial integrated planning for clean cooking.

CONSIDERATIONS FOR GEOSPATIAL INTEGRATED COOKING PLANNING

As described in the previous section, many developing countries are making use of data and digital tools such as GIS, satellite imagery and machine learning to develop more informed, integrated and least-cost electrification plans that leverage all electrification solutions (e.g. centralized grid, mini-grids and off-grid). This same approach has yet to be widely adopted in the clean cooking sector. Despite considerable progress in clean cooking planning across Sub-Saharan Africa and Asia, few planning efforts for cooking take an integrated approach that goes beyond assessing individual fuels or technologies. Similarly, clean cooking planning seems to be lagging behind electrification planning in the use of GIS and similar tools in facilitating national-level decision-making.

Participants cited several unique challenges to cooking that help explain the differences between electrification and clean cooking planning to date and that need to be considered, if not addressed, when exploring the use of geospatial integrated planning for clean cooking moving forward.

- Complex cultural and consumer preferences: Culture and habits have a significant bearing on consumer behaviour as it relates to clean cooking. Different cooking fuels/technologies affect the way food is cooked but different electricity sources, if reliable and high quality, provide the same electricity; electrons are always electrons, but heat is not always heat. Furthermore, cooking needs are generally met, even if sub-optimally (with solid biomass, for example), as opposed to electricity needs that are often largely unmet when populations do not have access to modern forms of electricity. Therefore, the customer's decision-making process is fundamentally important to clean cooking because consumers need to be convinced to switch from one fuel to another. These complex cultural and consumer preferences are difficult to reflect and model in planning efforts.
- Fuel stacking: Stove and fuel 'stacking' are widely practiced in developing countries to meet different cooking requirements and to minimize risks from (often seasonal) variations in fuel prices, access and reliability of supply. This additional demand-side consideration complicates planning efforts and often poses a barrier to achieving the full benefits of clean cooking technologies.
- Impact of 'free' biomass on transitions to clean cooking solutions: In unelectrified areas, people often rely on the use of expensive traditional electricity sources (such as dry-cell batteries, diesel

or petrol fuel) that can be substituted by other sources of electricity (e.g. grids, mini-grids or SHSs). The incumbent fuel that many people use for cooking (solid biomass), on the other hand, comes at a small or zero monetary cost but at a large opportunity and human cost. Understanding and quantifying this opportunity cost poses several technical and methodological challenges that make it difficult to include in planning/modelling efforts.

- Relationship between fuels/technologies and services: One of the unique characteristics of cooking is that traditional cooking fuels and technologies are often used to generate additional non-cooking related services, such as home heating, which are valued by households and therefore impact consumer behaviour and choices. This value and cross-over between cooking fuels/technologies and different cooking and non-cooking services is not always recognized and reflected in planning efforts.
- Diversity of stakeholders: As opposed to the electricity sector, where there is typically considerable government interest and involvement in electrification planning and the expansion of electricity access (via the national grid), the cooking sector is often driven by a larger and more diverse set of stakeholders, especially private enterprises, who lack the mandate, interest or capacity to carry out the sort of holistic, geospatial, integrated planning that the electricity sector is known for.
- Lack of data: Cooking planning is hampered by a general lack of data but particularly related to: (i) non-commercial fuels (e.g. solid fuels, forestry); (ii) cooking for social services and commercial applications (e.g. SMEs); (iii) consumer-level behaviour and preferences; (iv) detailed and granular household-level cooking access and use/consumption. These data gaps need to be addressed in order to facilitate more robust planning in the clean cooking sector.

POTENTIAL ROLES AND USES CASES FOR GEOSPATIAL INTEGRATED COOKING PLANNING

After reflecting on the differences between electrification and cooking planning, participants discussed the potential role and value that geospatial integrated planning could play for the clean cooking sector. Participants generally agreed that geospatial integrated planning/tools can play at least two important roles for the clean cooking sector:

- Public Planning: Could serve as a central framework around which different national and sub-national stakeholders come together to explore linkages, evaluate trade-offs, compare costs/consequences and coordinate different clean cooking stakeholders and strategies. This is in contrast to electrification planning, which is generally about optimizing a mix of solutions/technologies on a least-cost basis.
- Market Intelligence: Could facilitate operational-level or technology/fuel-specific decision-making, such as identifying attractive markets or distribution strategies. This is especially relevant for newer or untested innovations or products.

Participants also discussed at least three use cases or key stakeholders for geospatial integrated planning/tools: (i) governments (national and sub-national), (ii) solution providers (fuel supply and manufacturing companies) and; (iii) financing institutions (investors, DFIs, etc.). Each of these stakeholders are likely to use geospatial integrated planning/tools to help address different needs, questions or 'pain points'. For example, government planners are often trying to understand:

- The baseline or magnitude of the cooking challenge (e.g. exactly who is cooking with what, where they are, how much are they spending)
- The landscape of solutions and resources available to them
- What is working and what is not; which solutions are low hanging fruits
- What investments are needed to scale up access to solutions and what additional reoccurring costs are there to ensure, for example, sustained use of cooking fuels/technologies (e.g. subsidies)
- Where those investments are needed
- The return on or benefits of their investments and how those differ from other investments (in other sectors for example). This includes impacts on job creation, health-related to household air pollution, climate change, gender equality and women's empowerment.

In this context, it is apparent that geospatial integrated planning/tools can help address many of these public sector-specific questions/needs. But, as emphasized by participants, it is important to identify and prioritize the specific questions/needs of stakeholders upfront and design planning tools with their particular use case in mind. It is also important to keep in mind that the data that inform these tools, and their required quality/attributes (e.g. spatial granularity), will vary based on the specific use case in mind. That said, several participants

acknowledged that the quality of data (e.g. level of spatial granularity) needed by different stakeholders is still an open question and deserves further consideration and discussion by the cooking sector.

Lastly, several participants noted the importance of acknowledging and understanding a country's political economy before undertaking clean cooking planning. As in the cases of Ghana and India, for example, politics and political drivers can often drive action on clean cooking and therefore dictate the kind of specific questions and/or data that planners may need to grapple with. This reinforces the need to make sure that cooking planning and modelling is more than just a least-cost optimization exercise and instead facilitates collaboration between the political, social and technical aspects of planning and helps decision-makers (including politicians) understand the economic and non-economic trade-offs of different political and policy choices.

III. DATA NEEDS AND KEY INPUTS

After discussing the role and application of geospatial clean cooking planning, participants moved on to discuss what kinds of inputs and datasets are necessary for geospatial clean cooking planning.

To facilitate the discussion, participants were presented with a proposed list of key inputs and datasets grouped into the following categories:

- Identify populations without clean cooking: Data about the location of households (women-led or not), SMEs, healthcare and education facilities and the level of access to cooking in each of those places.
- Calculate and characterize demand: Data about the ability/willingness to pay of households and institutions without clean cooking and the consumer needs and preferences for different cooking solutions, by cooking service.
- Determine clean cooking potential and options: Data about forest cover, annual deforestation, biomass sources and global horizontal irradiation and the current and expected fuels and technologies (ICS, LPG and other biofuels infrastructure).
- Analyze trade-offs and cost/benefits: Data that enable analysis, including cooking solution costs and performance, co-benefits (health, climate and gender equity), built environment (road and mobile network) and opportunity costs (such as time spent on gathering resources).

Several amendments were made to the list during the workshop to reflect the participants' views. A summary of the updated list is reflected in Figure 2 below (for a more a detailed framework/list, please refer to Annex A).

Figure 2: List of Key Inputs in Clean Cooking Planning

Step	Category	Dataset	Availability	Additional Comments
STEP 1 Identify populations without clean cooking	Population	Population density and distribution: Spatial quantification of the population (e.g. location, number and size of houses)	Largely available	Several good sources exist that capture population density and distribution, with increasing levels of granularity (though not all are open access)
		Population growth rate: Estimated annual growth rate of population (%)	Limited	There is a risk that these data become outdated very quickly. Time series can be used to better understand patterns
	Socio-economic	Social services: Location of type of educational and healthcare facilities	Partially available	Ministries of Health and Education may have valuable datasets on location and energy status of institutions
		Commercial cooking: Location of SMEs that have cooking needs	Limited	
		Women-led households: Proportion of households in which an adult female is the sole or main income provider and decision-maker (%)	Partially available	The World Bank and other sources provide these data
	Access Status	Access to cooking fuels and technologies: Proportion of population with access and sustained use of clean cooking technologies/ fuels (%)	Limited	Data from Multi-Tier framework can be used for measuring access to cooking solutions
		Electrification status: Proportion of population with access to electricity (different tiers of electricity services - %)	Partially available	Often estimated through night-light datasets, supplemented by household surveys (esp. to measure quality and reliability, which may result in stacking of power solutions)
STEP 2 Calculate & characterize demand	Socio-economic	Ability and willingness to pay: The income level and/or energy expenditure in an area ($/km2)	Limited	Difficult to capture, and limited information is currently available around ability vs willingness to pay for cooking fuels and solutions. Poverty maps could provide an indication of the income level and energy expenditure in an area.
		Consumer preference: Consumer needs and preferences for different cooking solutions, by cooking service	Limited	
		Access to finance institutions	Limited	
STEP 3 Determine clean cooking potential & options	Natural Resources	Forest cover: Extent of forest cover and mapping of protected areas Annual deforestation rate: Annual rate of land removal of a forest or stand of trees into farms, ranches, urban use or other non-forest uses per region (%)	Largely Available	
		Other biomass sources (non-forest such as e.g. livestock, waste, sugar cane): Current and potential agricultural activity as an indicator of agricultural residues	Partially Available	
		Global Horizontal Irradiation: Information about the Global Horizontal Irradiation (kWh/m2/year) over an area	Fully available	
	Fuel & Technologies	ICS infrastructure: ICS distribution infrastructure and retail points	Limited	
		LPG and other biofuel infrastructure: Surface transportation networks, pipeline networks and location of refill points	Limited	

STEP 4 Analyze (trade-offs, costs/ benefits)	Fuel & Technologies	Cooking solution costs: Levelized cost of different cooking services per cooking technology/fuel	Limited	Important to not forget the localized cooking fuel prices for baseline fuels, such as wood, charcoal, and kerosene
	Co-benefits	Health: Public health benefits (or costs) associated with different cooking technologies/fuels	Limited	
		Climate: Climate benefits (or costs) associated with different cooking technologies/fuels	Limited	
		Gender Equity (including job creation livelihood)	Limited	
	Built Environment	Road Network: Existing & planned road infrastructure	Largely available	Could be used as proxy for economic development, and access to supply chains
		Mobile network coverage: Existing & planned mobile network coverage	Largely available	
	Opportunity Costs	Time spent on gathering of biomass fuels and other things such as water	Partially Available	

While discussing the inputs summarized above, participants stressed, once again, that the most important inputs to clean cooking planning will ultimately depend on and vary by the use case in question (public planning vs private sector). Setting that aside, participants emphasized the following, more generic points about the key inputs to clean cooking planning:

DEMAND AND CONSUMER BEHAVIOUR

- Given that many households make use of a 'stack' of fuel/stove combinations to meet their cooking needs, it is important to capture data about fuel use across fuels/technologies instead of only looking at a household's primary cooking fuel/technology (or some other proxy for access).
- Given the importance of cultural and personal preferences to how consumers choose and use different cooking solutions, it is imperative that clean cooking planning and modelling efforts rely on more than traditional inputs such as 'ability and willingness' to pay to characterize cooking demand. This includes factoring in how consumer habits and aspirations for certain fuels and technologies may change with changes in income and wealth. That said, participants acknowledged the difficulties of reflecting consumer habits and preferences in planning/modelling efforts given their inherent complexity.
- Similarly, given that households often use fuelwood for cooking as well as for heating and lighting their rooms, it is important that these 'co-benefits' are understood and factored into planning efforts, otherwise cooking plans may not reflect actual consumer behaviour.
- Given the widespread use and low cost of biomass in many countries, it is important to understand who is using these free fuels and where they are gaining access to them. This will help planners and solution providers target consumers with the most appropriate and cost-effective clean cooking technologies.
- The non-residential sector is an important consumer of cooking fuels. For example, in some countries it has been reported that 40–50 percent of cooking fuel is utilized for institutional cooking. It is important, therefore, to capture data on non-residential cooking in planning efforts.

SUPPLY

- When mapping out a country's various clean cooking resources/options (e.g. fuels and technologies), it is important to include data on livestock and sugar mills, as they are important to the feasibility of bio-digestors and ethanol production, respectively. Similarly, data on agriculture and farms are important to understanding the potential for creating pelletized/ briquettized biomass production.
- Data on market-enabling infrastructure (e.g. mobile network coverage) and the ease of doing business are important, particularly to the private sector, in understanding where and how feasible it might be to stimulate and expand certain market-led initiatives.

COST - [CO]-BENEFIT ANALYSIS

- The opportunity cost associated with the use of different fuels/technologies (namely solid biomass) is an important input that needs to be better reflected in planning, especially given that solid biomass often has little to no cost for households but involves a significant amount of time and effort for fuelwood collection and use. As such, participants suggested that planning and modelling efforts include, for example, the location of water sources and other natural resources. This can help determine the time spent by households (especially women and children) in collecting water and fuelwood and is also very important to capturing the gender-differentiated roles and impacts of clean cooking strategies.
- Another co-benefit that should be explored within clean cooking planning is job creation and the possibility of increasing local added value.
- Lastly, a point was made about the importance of reaching agreement across different stakeholders on the value of different costs and benefits and how to price different policy choices. This is important to building confidence in planning outputs and to facilitating dialogue across sectors and stakeholders. This is where it is important to involve and engage Ministries of Finance, for example, to help establish a standardized approach to cost-benefit analysis.

IV. DATA AVAILABILITY AND QUALITY

Building on the discussion about the key inputs necessary to facilitate geospatial integrated clean cooking planning, participants then discussed and identified the availability and quality of data for each input while brainstorming ways of filling data gaps. The following key data gaps were identified:

- On the demand side, there is a general lack of granular data on which cooking solutions are being used and where. Similarly, and perhaps more importantly, there is a dearth of data on fuel consumption and cooking patterns (e.g. the actual usage of both commercial and non-commercial fuels and stoves in households). Census data and the Multi-Tier Framework (MTF) surveys do contain some of these data, however they can easily become outdated and are often only statistically representative at the national or regional level, when more localized data are often needed. For example, information about fuel stacking might be representative at the district level, but likely not at the household level. This need for more localized data is partly driven by the need to capture cultural and/or regional differences in cooking practices within a country.
- More data on supply chains and distribution mapping within these supply chains would be beneficial (e.g. the number of operators and the preferential use of fuel. LPG, for example, can be used for co-generation, and for the industrial and agricultural productive use of energy and for cooking).
- Not all countries have easily accessible and local data on fuel prices, which are important for planning purposes and understanding consumer affordability. Mapping fuel prices geographically would go a long way to addressing this challenge. See 'Fueling Change: Building the Case for a Charcoal Price Index' for a call to action to improve charcoal price data.
- Further analysis is needed on the opportunity cost of time spent on cooking and collecting fuelwood and the value of this time (the implicit opportunity costs or shadow price). A methodology for determining opportunity costs should consider that time savings (associated improved access to modern cooking solutions) is not always monetized by households.
- Better data are needed on access to electricity and, in particular, data on power quality and reliability. This is of particular relevance to facilitating the coordination of electrification and cooking planning.

Remote monitoring was identified as a potentially effective way of collecting data on fuel usage. For example, remote monitoring devices are already beginning to be used to track LPG and could be used to monitor electric cooking.

- It was also noted that more data are needed around the use of biomass in commercial and institutional settings (e.g. schools, roadside stalls, SMEs).

A range of approaches to filling data gaps were identified:

- Remote monitoring was identified as a potentially effective way of collecting data on fuel usage. For example, remote monitoring devices are already beginning to be used to track LPG (as is the case in Nigeria) and could be used to monitor electric cooking. Another possibility to monitor stove uptake and fuel usage is via PayGo financing technology. Usage of traditional fuels can also be monitored via thermal sensors installed in people's homes however, this approach is challenging to scale up as the sensors need to be manually installed in households and the data often need to be collected manually. Here, the use of statistical sampling to create consumer profiles associated with various consumption patterns could be of use. These data could be further used as an input for predictive modelling and machine learning tools.
- When it comes to fuel prices, 'crowd-sourcing' using informants and engaging fuel distributors was also cited as a potential means of collecting localized data.
- Industry or commercial energy providers typically have a rich amount of consumption pattern data that, if unlocked, could be of tremendous value to cooking

planning. Industry's willingness to share data and a lack of data standardization, however, pose challenges.

- In addition to engaging industry, participants stressed the importance of cooperating with development agencies, who also often have access to good data. The World Food Programme, for example, could be a potential source of data on cooking at schools.
- Phone surveys are a low-cost alternative to on-the-ground surveys that could be better utilized to collect household cooking data. When designing such surveys, or any survey for that matter, it is important to avoid survey bias. For example, when gathering data on consumer preferences, it is important that consumers understand not only what cooking solutions are available but what solutions might be on offer. It is also important to be aware of the limitations of surveys in terms of their ability to accurately represent cookstove usage.
- While not published by the World Bank, the MTF household surveys do collect geospatial information, which could be of use for planning purposes, if made available.

Despite several significant data gaps and the challenges in data gathering, several participants noted the importance of not letting these challenges deter efforts to develop a geospatial integrated cooking framework. As demonstrated by the evolution of electrification modelling, the development of even a rudimentary geospatial integrated cooking framework can spur further investment in data collection and quality, thereby improving the utility and functionality of the framework. Within this context, a recommendation was made to create a community of practice to help develop standardized data for geospatial clean cooking planning with a focus on the design of specific use case scenarios.

C COORDINATING ELECTRIFICATION AND CLEAN COOKING PLANNING

I. TRENDS IN THE CONVERGENCE OF ELECTRIFICATION AND COOKING: A LOOK AT THE ELECTRIC COOKING MARKET

Steady declines in the price of renewable and battery technology coupled with a range of innovations in off-grid technology and business models have led to significant improvements in electricity access in the last decade, both in the number of end users reached and the level of investment the sector has benefitted from. During this same time period, the price of charcoal (a traditional cooking fuel) has risen in many regions while electric cooking appliances have undergone various technological and cost improvements. This confluence of events presents an exciting opportunity to leverage the innovations and momentum of the electricity sector to expand clean cooking through the use of electricity.

One area where electric cooking shows promise is in urban and peri-urban areas, where people usually have access to electricity (via the national grid) and are paying for cooking fuels. But even in these on-grid settings, barriers exist. Blackouts, frequent load shedding, voltage instability and wiring failures can lead to unreliable and interrupted electricity supply, for example, resulting in customers reverting to their traditional cooking fuels. One way to potentially overcome this challenge is by using batteries, which can be trickle charged whenever power is available and provide power to cooking stoves or appliances when it is needed. The drawback of this approach is that it introduces an additional cost by way of the battery. Furthermore, progress continues to be made on the energy efficiency of electricity cooking devices, such as electric pressure cookers, which is improving their value proposition.

Opportunities for electric cooking in off-grid settings, through the use of mini-grids and SHSs, are only in the early stages of exploration as the commercial viability of both electric cooking and mini-grids is still unproven. For the mini-grids sector, the Modern Energy Cooking Services (MECS) programme is carrying out research on the potential of increasing revenue for mini-grid operators by including cooking as a driver of energy demand. One challenge that this faces is that rural households typically have a lower budget for energy services than urban households and even if they have the ability to pay, their willingness to pay is often low given that many households do not pay for their cooking fuel (as discussed in the previous section). Thus, there is a need for further business model innovations for electric cooking in the off-grid space.

II. OPPORTUNITIES FOR COORDINATING ELECTRIFICATION AND COOKING PLANNING

Following a presentation about the state of electric cooking, participants identified opportunities for coordinating cooking and electrification planning and the data and tools needed to facilitate the convergence of these two sectors.

OPPORTUNITIES AND CONSIDERATIONS

- Participants generally agreed that electric cooking should be considered as part of electrification planning, however cautioned that doing so may complicate electrification modelling and planning through the introduction of challenging issues such as fuel stacking. It was also noted that country- and region-specific characteristics – namely electricity prices – will ultimately determine if electric cooking is viable and scalable. For example, Ethiopia and Nepal are among a small handful of countries with interest in deploying e-cooking solutions, which is made possible due to their highly subsidized cost of grid electricity.
- While very new, the feasibility and benefits of coordinating cooking and electrification planning are become clearer. The MIT-Comillas Universal Energy Access Lab for example, has recently used its Reference Electrification Model (REM) to demonstrate a virtuous cycle of clean cooking and electricity costs. Using REM, MIT has shown that increasing electric cookstove penetrations can increase electricity consumption, lower electricity unit-costs through the realization of economies of scale, and improve the viability of electric cookstoves, continuing the cycle. In fact, the research shows that the viability of electric cookstoves can roughly double through coordinated planning versus planning clean cooking and electricity access independent of one another.
- When considering how to coordinate electrification and cooking planning, a point was made about the importance of capturing non-residential cooking demand (e.g. commercial and industrial) in addition to household cooking. In rural Nigeria, for example, there are industries with significant energy demands, around which rural populations and farmers exist. This represents an opportunity to integrate planning for household energy access with planning for economic growth.

DATA IMPLICATIONS AND NEEDS

- Many utilities may have excess capacity in their grid infrastructure (e.g. feeders, substations, transformers) to take on extra peak power, however how much 'head room' they really have is not always well known. Better data about this excess capacity, and grid infrastructure and networks more generally, would enable planners to investigate the feasibility of electric cooking and better understand the impact that increased use of electric cooking solutions might have on distribution grid infrastructure and grid reliability.
- Similarly, a better understanding of consumer behaviour and the elasticity of electric cooking adoption to different levels of electricity reliability and prices is needed. These kinds of data are important to utilities to help them understand how load duration curves might get shifted or affected by electric cooking (adding to the peak load vs flattening the load curve, see report made on a South African Case). In this context, it is important to consider the load duration curve at very local levels to understand the impact of electric cooking on power infrastructure, such as transformers.
- To help address some of these data challenges, MECS, in collaboration with several UK universities, is beginning to develop 24-hour domestic load profiles on a minute-by-minute basis. Two load profiles are being considered: a baseload with standard household electrical assets and an additional electric cooking load profile. The MECS team is working with both grid-connected communities and mini-grid developers to characterize household demand and create a classification of different profiles. Through its research, MECS has also evaluated the impact of power quality on electric cooking adoption and has noticed that in Ethiopia, for example, power quality is not a strong determinant on whether people cook with electricity. As mentioned above, additional research and data of this kind is crucial to integrating electrification and cooking planning.
- Unlike most other technologies for cooking, electric cooking has the potential to be metered. This allows for a low-cost way to monitor usage of devices and obtain consumption pattern data. These data could in turn be used to better understand the implications of a potential transition to electric cooking (e.g. for climate finance, impact investors, mini-grid developers, or utility operators).

ANNEX 4

A. SPREADSHEETS ON DATA AVAILABILITY AND QUALITY

A Google spreadsheet capturing the key inputs for both electrification planning and clean cooking planning can be found here: Data Availability & Quality Overview

Similar work was initiated by The World Bank Group, the Energy Sector Management Assistance Program (ESMAP), the KTH Royal Institute of Technology and the World Resources Institute under the Global Electrification Platform and can be found here: Geospatial Electrification Platform - Standards & Metadata

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