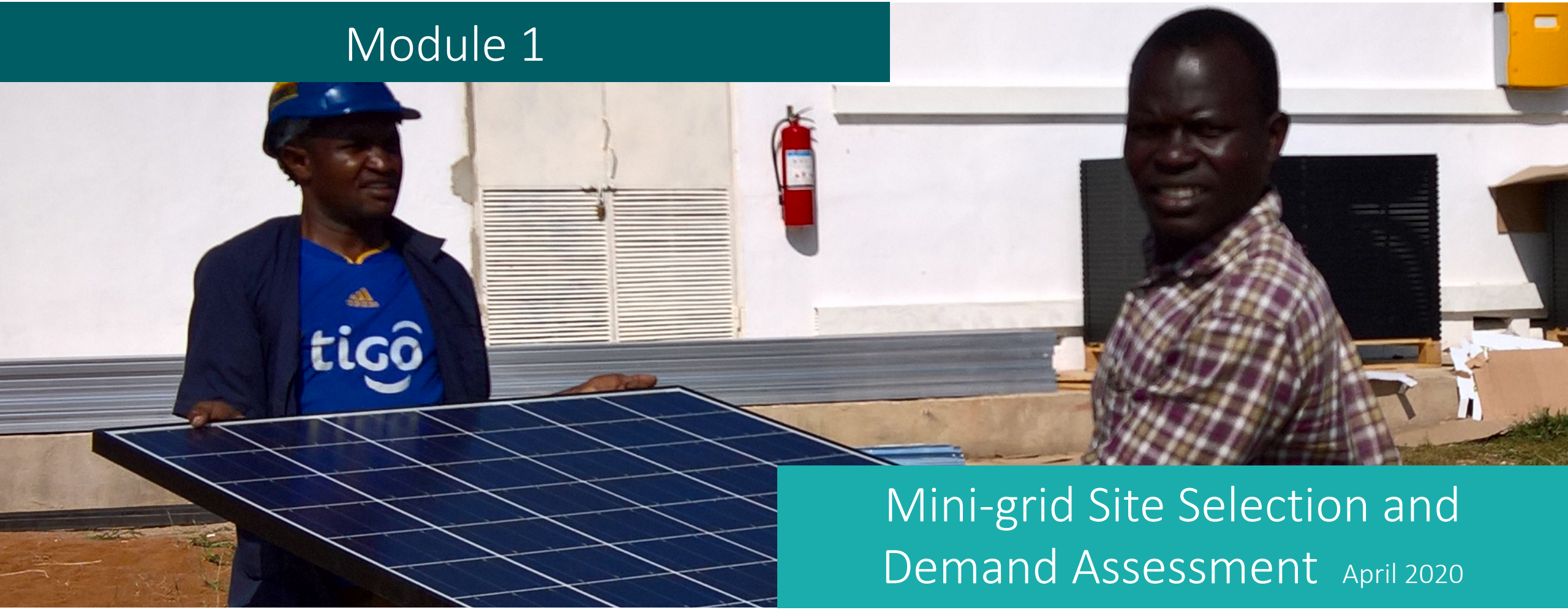
GREEN MINI-GRID HELP DESK

Module 1



Mini-grid Site Selection and Demand Assessment

April 2020

ENERGY4IMPACT
ACCELERATING ACCESS TO ENERGY

INENSUS

SUSTAINABLE ENERGY FUND for AFRICA

Module Overview

Introduction to the Module
- Learning objectives
- Module requirements
- Agenda

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
Introduction	Site Selection	Field Survey	Demand Assessment	Tools for site selection

End of Module
- Module recap
- Further reading

Objectives & Requirements

Learning Objectives

- Learn about the importance of site selection for mini-grid projects.
- Understand the main steps in site selection, the selection criteria used, and the data that needs to be collected.
- Learn how to carry out a field survey for demand assessment and the data that should be collected.
- Understand how demand data is analysed and what outputs are generated from this analysis.

Module Requirements

- This module is targeted at mini-grid developers and operators at all stages of development.
- They are expected to have a basic understanding of rural, off-grid energy markets and community dynamics in developing countries.
- No prior knowledge of site selection or demand assessment is required.

Agenda

1. Introduction
   - Phases of a mini-grid project.
2. Site selection
   - Benefits of proper site selection
   - Clustering mini-grid sites
   - Stages in selection process
   - Key selection criteria
   - Population density vs. mini-grid size
3. Field survey
   - Planning
   - Structure
   - Implementation
   - Best practices
   - Challenges in data collection
4. Demand assessment
   - Definition
   - Outputs
   - Best practices
5. Tools for Site selection
   - Off-grid market assessment / mapping tools
   - Renewable resource assessment tools
   - Data collection tools

Phases of a Mini-grid Project

Focus of this module

Project Development

Early Stage

- Site selection:
  - Feasibility study
  - Renewable resource assessment
  - Demand assessment
- Technical design
- Preparing business and financial model

Late Stage

- Securing land and/or water rights
- ESIA
- Securing licenses
- Approval of regulated tariffs
- Establishing framework for community engagement / governance
- Procurement of equipment / tender for equipment supply

Implementation

- Installation and commissioning
- Securing PPA
- Setting up service contracts and payment systems for customers
- Drafting O&M and HSE manuals

Operation

- O&M
- Productive use stimulation
- Performance monitoring
- Revenue generation
- Planning for scale-up

Site Selection

Selecting the right site for a mini-grid depends on many factors.

Site selection factors

- Distance to the national distribution grid or other mini-grids, and any planned extensions of existing grids
- Population and settlement density
- Average income and purchasing power
- Existing economic activity
- Existing semi-industrials such as telecom towers
- Renewable resources available
- Accessibility and security
- Proximity to other sites for the purposes of clustering

4 stages in site selection

Stage 1: Desktop research

Stage 2: Site visit

Stage 3: Renewable resource assessment

Stage 4: Field survey & Demand assessment

Benefits of Proper Site Selection

Technology

- Ensure there is a **suitable energy resource** to provide reliable power
- **Size generation system** and **distribution network** to meet expected demand
- Determine existing mobile or internet connectivity (e.g. for remote monitoring or mobile payments)

Tariff structuring and Revenues

- Understand **ability and willingness to pay** for all customer segments.
- Set a tariff that:
  - Customers can **afford** and are **willing** to pay
  - Generates enough revenue to make the site **profitable**
- **Forecast repayment** of CAPEX and OPEX
- Identify opportunities for **KMM**, **PU** & **DSM** (see slide notes)

Project costs

- Benefit from **cost reductions** due to:
  - Optimal **system sizing** and **distribution**
  - Ability to **plan** for **connections** and **scaling in future**
  - **Bulk purchasing** & **economies of scale**
- Account and plan for the **arrival of the national grid**

Community Engagement

- **Make introductions** to the target communities
- **Build a good relationship** with the community, potential customers, and possible partners (e.g. vendors / maintenance)
- **Identify socio-economic needs** that can be addressed through electrification

Clustering Mini-grid Sites

Developing sites close to each other can have a positive impact on the viability of projects

- Cost sharing: personnel / management / maintenance / logistics / economies of scale shared between sites
- Economic benefits of electrification spread over a larger area, can develop larger economically-active markets
- Interconnected mini-grids can create wider, more resilient power networks, and can better integrate into the national grid when it arrives (ECCDSERG (2018)

Stages in Selection Process

Stages	Desktop Research	Site Visit	Renewable Resource Assessment	Field Survey & Demand Assessment
Main purpose/activities	• General scoping of the most promising sites • Baseline information of nearby electrified sites • Mapping view of the settlements • Usually based on secondary data • Information may not always be up to date	• Initial contact with the community and local authorities • Cross-checking/validating secondary data • Feasibility study: general appetite for a mini-grid, and electricity demand • Identifying suitable communication channels	• Detailed assessment of renewable resource availability and costs throughout the year • For solar PV projects, irradiation data is often readily available online and fairly accurate • On-ground studies required for other resources	• Detailed assessment of demographics, and general appetite for mini-grid power • Can be combined with the site visit stage in case of limited financial resources • Fundamental to estimating current electricity demand and forecasting demand
Common tools/data sources	National census, GIS data on un-electrified settlements, national rural electrification plans, renewable resource data, satellite imagery (e.g. Google Earth)	High resolution cameras, GIS tools, local area maps, high-level questionnaires to determine demand for electricity	Historical data (at least 5-10 years) on annual and seasonal resource availability	Data collection tools, local data enumerators

Key Selection Criteria (1)

Accessibility

- Proximity to other communities: More neighbouring villages gives access to a larger market for productive use opportunities.
- Types of roads: tarmac vs unpaved. Implications on equipment transportation and year-round accessibility.
- Terrain: flat vs mountainous. Implications on civil works and length of primary voltage lines.
- Security: for equipment and field personnel

Infrastructure

- Distance from existing national grid or mini-grid. GIZ (2014) suggested 50km minimum distance. More recent study of 16 mini-grids found the average distance to be about 23km IFC (2018).
- Plans for national grid extension in the area?
- Clear policies on what happens when the national grid arrives?
- Other infrastructure in area i.e. social institutions, roads, plans for infrastructure, govt. and NGO projects?

Key Selection Criteria (2)

Population Demographics

- Estimated population: population size per village and distance between villages. Implication on mini-grid configuration.
- Population density: Implication on distribution network.
- Population growth estimates: Implications on demand projections and system sizing.
- Average income plus assets per household or business: Good indicators of ability to pay for mini-grid power.

Economic Profile

- Larger energy consuming businesses vs smaller businesses. Implications on tariff structuring, energy requirements and diversity.
- Unique economic profiles per village and current spending on energy: Seasonality and implications on ability to pay for energy.
- Opportunities for value addition through electricity (as an enabler, catalyst, or differentiator).

Key Selection Criteria (3)

Energy Resources

- Is the resource (and ensuing technology) enough to meet current and anticipated community needs at an affordable rate, yet cover operational costs and capital costs?
- Renewable resource availability is limited to the site. Considering that renewable energy sources are not dispatchable and intermittent/seasonal nature, how does one produce reliable power all year round?

Access to Finance / Technology

- Presence of financial institutions with experience lending to base-of-pyramid customers at reasonable terms.
- Even better if they have experience providing loans for energy products.
- Common methods of money transactions, e.g. mobile money, using agents, etc. Helpful in determining suitable billing methods.
- Access to hardware / parts suppliers.

Population Density vs. Mini-grid Size

Number and size of mini-grids depends on how population is arranged

Type of site / customers	Mini-grid type	Approximate sizing
Densely populated towns or closely clustered villages	Single large mini-grid serving all customers	1MW or above
Dispersed villages	Multiple mini-grids of smaller capacity	40 to 200 kW
Dispersed villages with only lifeline[i] customers	Many DC nano-grids	Less than 10 kW

[i]Lifeline customers are those that only use electricity for lighting and maybe some low-power appliances. They will generally have no need for full-voltage AC.

Field Survey: Planning

Planning Phase

- Identify main outputs of the survey
- Identify and categorise target respondents
- Design survey questions
- Identify suitable survey/data entry tool(s)
- Identify/design analytical tool(s)

Key guiding questions

Why...
... do you need the survey?

Who...
... should be surveyed?

Where...
... are respondents located?

What...
... questions to ask?

How...
... many surveys to conduct?
... to gather the responses?
... to analyse the responses?

Field Survey: Structure

	Section	Example questions	What it tells you
	General information	• Name, age, phone number, GPS location, employment status, sector of occupation / business, household / business size	• Interviewee identification • Business sectors / value chains in the community / PU opportunities • Community geographic distribution
	Wealth, income & general expenses	• Construction materials of house, regular modes of transport used, monthly income, monthly expenses, airtime expenditure, bank account / financing / mobile money usage	• Wealth / disposable income (i.e. ability to pay) • Variation between population groups • Local transaction methods / financing
	Current energy sources & usage	• Energy sources (diesel, wood, kerosene, batteries, grid, solar home system) • Energy expenses & if financing was used	• Willingness to pay for energy • Potential competing energy sources • Economic benefit of a switch to electricity
	Electricity demand	• Appliances owned already (power & quantity) • Plans to buy appliances if mini-grid connected • Do they want to be connected to a mini-grid ? • Is there a need / desire for electricity / more power ?	• General appetite for mini-grid power • Indication of potential consumption & growth • Daily load profile (DSM opportunities)

Field Survey: Implementation

Implementation Phase

Demand Assessment

- **Determine sample size per target group**
  - Interview a representative sample of households, all businesses, local leadership and social institutions in the town. Some of this can be achieved through a focus group.
  - At least 95% confidence level with 5% error margin (University of Strathclyde, Practical Action, and Carbon Trust, 2018).
  - Calculate sample size here: https://www.surveymonkey.com/mp/sample-size-calculator/
- **Conduct field survey**
  - Train enumerators prior to conducting the survey on how questions should be asked and answered.
  - Enumerators should have a good understanding of the local language, environment and culture.
- **Collate and analyse data**
  - One database for all collected data.
- **Generate demand assessment report**
  - Detailed interpretation of data based on the outputs initially outlined in the planning phase.

Field Survey: Best Practices

- ✓ Create separate questionnaires for each respondent category (household, business, institution, etc.)
- ✓ Have prior knowledge of terrain, location and population distribution to estimate time and cost of conducting the survey.
- ✓ Interview the head of the household,and choose appropriate time (of the day and year) to conduct the survey, when they are more likely to be available, e.g. non-farming time.
- ✓ Ensure that the community members and local leaders are aware of, and give permission for, your activities prior to the field survey.
- ✓ Use experienced, well-trained enumerators who are fluent in the local language. Maintain frequent communication with them in the field and adjust for any bottlenecks
- ✓ Test the questionnaires in the field, including outputs and analysis before being used in the field surveys (both desktop and with enumerators).
- ✓ Collect GPS coordinates of respondents and take pictures to get an overview of community layout and terrain.
- ✓ Clean data and check for any missing data soon after collection, and re-interview individuals where inadequate information was provided.

Challenges in Data Collection (1)

Challenge	Description	Mitigation
Question relevance	Asking questions that are relevant to energy consumption.	The following questions seem to best indicate potential energy use before a mini-grid connection: • Customer class (Home, Business, Home/Business, Public Premises) • Nature of business (if applicable) • Employment status • Current source of energy and uses • Current mode of transport • Appliances owned before mini-grid connection • Building construction materials • Mobile phone airtime spending See Williams, Nathan, et al. (2019).

Challenges in Data Collection (2)

Challenge	Description	Mitigation
Survey length	Longer surveys collect more data, but interviewees can become disengaged and costs increase.	1. Aim for survey to take less that 15-20 mins. 2. Follow best practices in Williams, Nathan, et al. (2019) and general survey literature for question selection / design. 3. Thoroughly test survey to understand which questions are / not useful. 4. Assess questions to determine if any are redundant questions (e.g. ”Occupation” & “Source of Income” are broadly the same thing).
Input error	Data is entered incorrectly to the survey, is illegible, or a paper-based survey is later entered incorrectly into a computer.	1. Use digital survey platforms, rather than surveys on paper. 2. Train enumerators on how questions should be answered in the survey. 3. Provide hints in the survey questions (many platforms allow this feature). E.g. “Enter phone number without spaces.” 4. Employ data validation: Restrict the types of data that can be entered in an answer. e.g. as question about phone numbers can be set to only accept numerical answers.

Challenges in Data Collection (3)

Challenge	Description	Mitigation
Misunderstood questions	Response does not answer the questions, and it is not understood by enumerator and/or interviewee.	1. Word questions so that they are not ambiguous. 2. Train enumerators so they understand the meaning of questions behind the wording. 3. Employ enumerators who are fluent in the local language. 4. Test survey and check responses to ensure questions are understood.
Individual identification	You are unable to match survey responses to individuals in the community.	1. Collect multiple pieces of identification from interviewees (e.g. first names & surnames, phone number, age, meter number – if applicable) so they can still be identified if any piece of info is entered incorrectly. 2. Aim to always interview the head of household / business. 3. If head is not available, ask interviewee for the name of the head of the household / business, and their relationship to them. This is vital if there are future surveys where the surveys need to be matched.

Challenges in Data Collection (4)

Challenge	Description	Mitigation
Understanding income / expenses	Responses to questions about income are inaccurate or biased.	1. Avoid asking direct questions about income / wealth (or do not solely rely on them). 2. Ask about proxies of wealth (e.g. housing construction material, modes of transport, airtime spending). 3. Consider providing a spectrum for questions about income e.g. USD 10-50 etc. 4. Break down questions into parts that a customer will know. E.g. a customer is unlikely to know their "monthly expenses on batteries" off-hand. Breakdown into "how often do you purchase dry cell batteries?" and "how much does one package of dry cell batteries cost"?. The monthly expenses can be calculated from there. 5. Seasonality in income and expenditure is quite significant particularly in rural agricultural communities.
Comparing between surveys	Data between surveys is not comparable, as different questions were asked.	1. Use the same surveys across different sites, so that data can be compared. 2. If there are some site-specific questions, incorporate a set of standard questions to be used in all surveys across different sites.

Demand Assessment: Definition

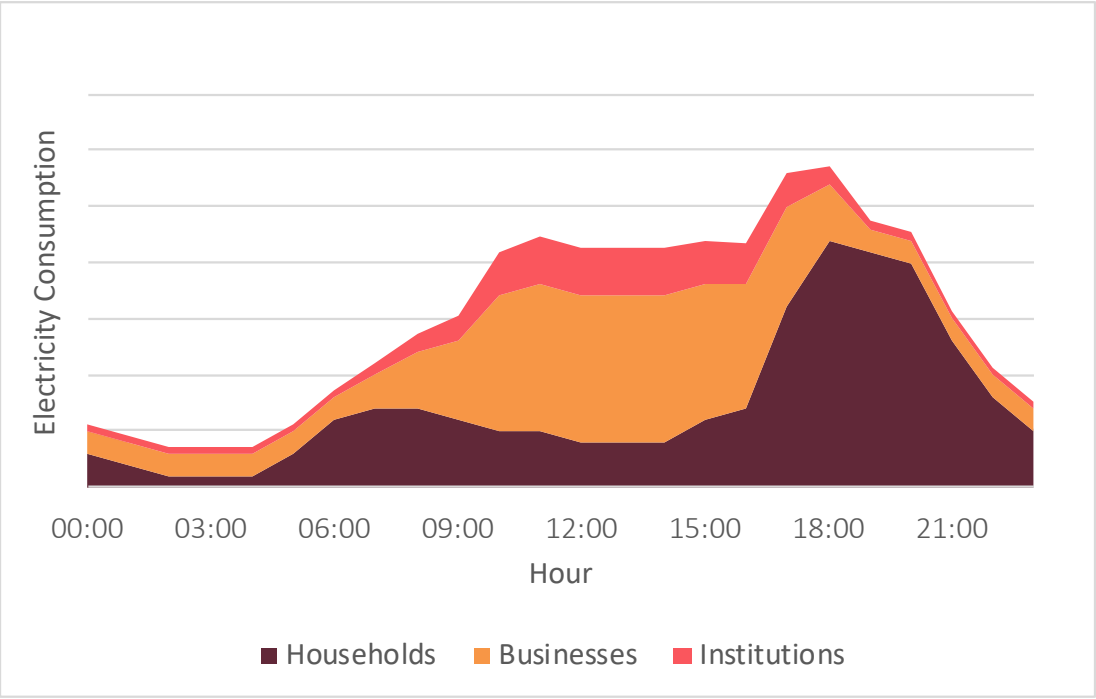
Demand assessment is an analysis of existing electricity demand and potential demand growth in a community before a mini-grid is built.

The assessment analyses data from surveys of households, businesses, institutions and the village leadership

- Each potential customer can be analysed individually, by determining the electrical appliances already owned, appliances that would be bought once they are connected, and the willingness & ability to pay for electricity.
- Where lots of training data is available, other algorithms (e.g. machine learning / AI) can be used to predict the consumption directly from survey data.

Demand Assessment: Outputs

- Expected electricity demand
  - Total expected electricity consumption on the mini-grid at each hour of the day
  - Contribution from each customer group
  - Informs: system sizing, revenue potential, tariff structure & other demand side management (DSM) strategies
- Business operations & load profiles
  - Value chains in community, existing appliances / machinery / expertise
  - Consumption profile of each business over the day
  - Informs: productive use opportunities, DSM strategies
- Ability & willingness to pay
  - Potential customers who want electricity, can afford it, and their location
  - Informs: which customers to connect, distribution network design, setting a tariff, revenue potential



Example daily demand profile generated for a community during a demand assessment. *(Illustrative only, not real data)*

Demand Assessment: Best Practices (1)

Willingness to Pay (WtP)

Expressed WtP – The maximum amount a person says s/he is willing to pay for electricity. Based on perceived value of electricity.
Revealed WtP – The maximum amount a person could be willing to pay. Based on current expenditure on energy.

Ability to Pay (AtP)

A realistic estimation of how much a person can pay for electricity. Based on income and expenditure on energy.

Information to Capture

- ✓ **Expressed willingness to pay** based on realistic scenario of electricity provision, including tentative price
- ✓ **General economic activities** of the community and surrounding communities
- ✓ **Current sources of electricity/energy** vs. preferred alternative sources
- ✓ **Perceived value addition** from electricity access
- ✓ **Income**, income sources and seasonal variations of income
- ✓ **Monthly expenditure on energy**, including maintenance costs of auxiliary equipment
- ✓ **Initial cost of current energy sources**, including down payments for PAYGO/lease-to-own sources
- ✓ **Using proxies to estimate levels of income/wealth for households** e.g. expenditure on mobile airtime, land size, livestock size, housing structures, means of transport, etc.

Demand Assessment: Best Practices (2)

Current vs. Anticipated Demand

- Benchmarking typical electricity use by appliance:
  - Use commonly available kW sizes of appliances to estimate anticipated demand.
  - Realistic estimates of average hours of appliance use per day per customer category.

Typical Consumption per Category

- Households: 45 – 55 kWh p.a.
- Businesses: 240 – 260 kWh p.a.

Source: Energy 4 Impact experience

Estimated Demand Growth Projections

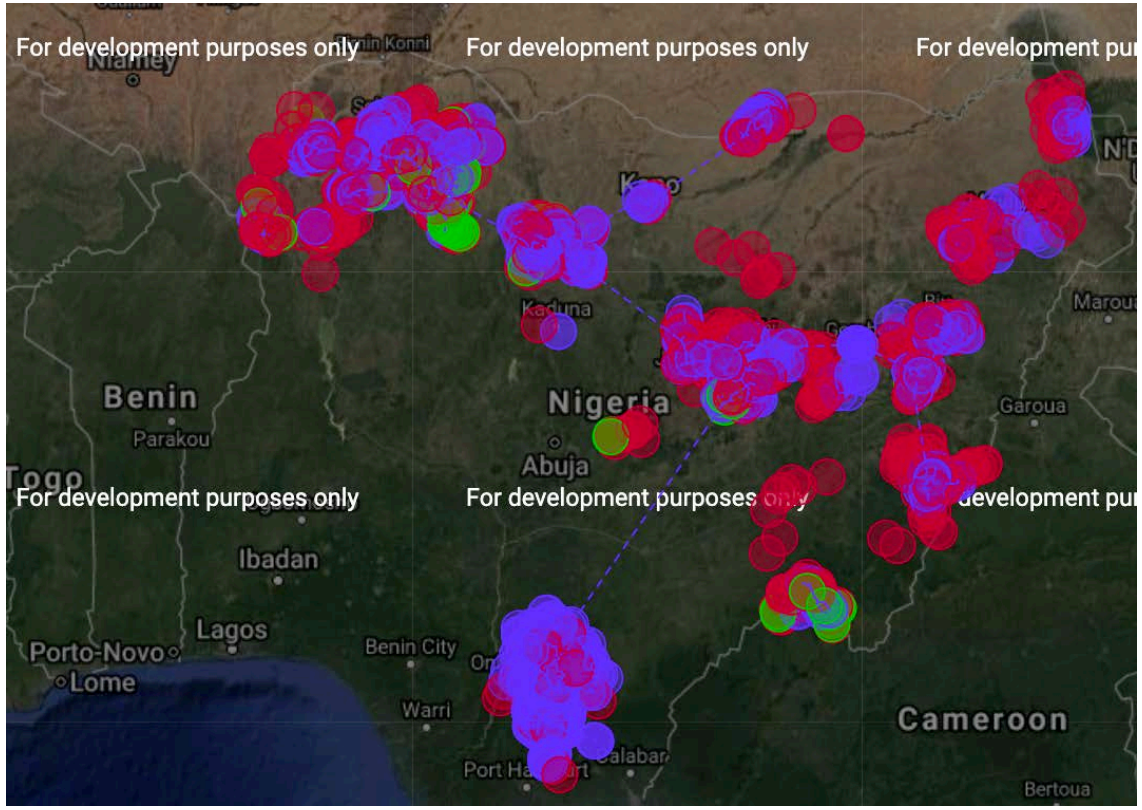
- Demand forecasting based on demand growth as a result of an increase in individual consumption and number of connections
- Be conservative in terms of demand projection. Use an "incremental step" approach in projecting growth – fast growth in the first year, then slower growth in the years that follow.

GPS Locations

- Mapping possible distribution network
- Determining possibility of PU zoning

Off-grid Market Assessment/Mapping Tools (1)

- Mainly used for decision making for off-grid electrification. Therefore useful for the preliminary research stage of site selection.
- Often display information in form of interactive maps.
- Often based on GIS mapping techniques, but some are non-GIS based e.g. use a scoring methodology.
- High level information usually provided e.g. areas not connected to the national grid, areas with planned grid extension, population and population density per location (incl. electrification rates), areas with potential for renewable energy utilisation.
- Some tools may provide further data e.g. socio-economic information per location (incl. major value chains), least cost options for electrification, existing infrastructure (grid, roads, etc.)



Network analysis from Network Planner (see next slides), showing sites in Nigeria.

Off-grid Market Assessment/Mapping Tools (2)

Tool	Description	Best used for
ArcGIS	General GIS / mapping tool	• Creating, using and analysing maps, and other geographic data • Complex mapping of a potential site & network planning
GeoSim	Decision support tool for planning rural electrification	• Spatial analysis, demand analysis, network planning, site selection, and system sizing
SWARM, Powerhive	Tool for site selection & demand analysis	• Identifying potential sites from satellite data (automatic) • Site analysis (financial, technical & geospatial) • Rank sites based on profit potential
RETScreen, Natural Resources Canada	Desktop tool	• Energy efficiency, renewable energy and cogeneration project feasibility analysis • Ongoing energy performance analysis
GIZ ProSolar Methodology	Report	• Solar mini-grid site selection handbook, GIZ (2014)

Follow the hyperlinks to view the resource.

Source: Clean Energy Solutions Centre (2015), Energy 4 Impact & INENSUS experience

Off-grid Market Assessment/Mapping Tools (3)

Tool	Description	Best used for
Network Planner	Planning tool for electrification at community up-to national level	• Exploring electrification options in rural communities • Compare long-term costs of installing solar, diesel or grid distribution networks • Perform sensitivity analysis on variables such as demand growth
DevelopmentMaps	Paid mapping services	• Mapping household / building locations using satellite imagery (must pay for service)
ECOWREX WRI	GIS mapping databases, some related to energy resources	• Understanding energy landscape in the country / region
Google Maps Bing Maps OpenStreetMap	General online mapping tools	• Overlaying maps onto satellite imagery, highlighting roads and major landmarks • Street View (Google Maps functionality) can be used to see what a site is like on-ground • Preliminary network planning

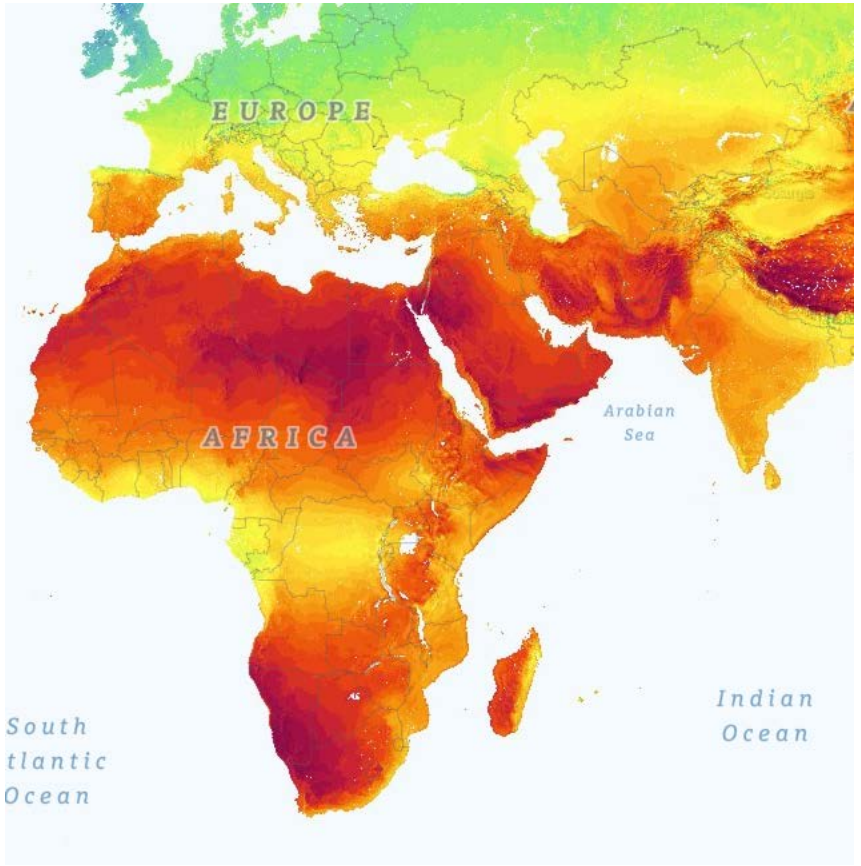
Follow the hyperlinks to view the resource.

Source: Clean Energy Solutions Centre (2015), Energy 4 Impact & INENSUS experience

Renewable Resource Assessment Tools (1)

- Helpful in renewable resource assessment stage of site selection.
- Provide information on daily and annual renewable energy resources available per location. Some tools, e.g. HOMER already have these tools as in-built features.
- Information can focus more generally on a country/region or can look more closely into different locations in a country/region.
- Some tools offer the option of making comparisons between different renewable resources.
- Most tools are online based and represent data in form of interactive maps.

Note: For renewable resources that are highly seasonal (e.g. such as biomass and hydro) it is necessary to perform an independent assessment at the site for at least a year to validate data acquired in the desktop assessment.



Example map from the Global Solar Atlas (see next slides), showing PV power output by location.

Renewable Resource Assessment Tools (2)

Tool	Renewable resource	Description
SWERA, NREL	Solar, wind	• Resource data sets and analysis tools from a number of international organisations (data not updated since 2011)
Global Solar Atlas, World Bank	Solar	• Online maps showing various global aspects of solar energy, e.g. irradiation, power output, optimum tilt angle, etc.
Global Wind Atlas, World Bank	Wind	• Online map of global wind resources • Wind resource data accounting for high-resolution effects (e.g. local variability)
POWER, NASA	Climate, wind & solar	• Prediction of Worldwide Energy Resources (POWER) • Over 200 satellite-derived meteorology and solar energy Analysis Ready Data • Provides data globally at a 0.5 x 0.5 degree resolution and updated nightly

Follow the hyperlinks to view the resource.

Source: Clean Energy Solutions Centre (2015), Energy 4 Impact & INENSUS experience

Renewable Resource Assessment Tools (3)

Tool	Renewable resource	Description
RE Explorer, USAID & NREL	Biomass, geothermal, hydro, solar, wave, wind	• Global renewable energy data, analytical tools, and technical assistance to developers, policymakers, and decision makers in developing countries
IRENA Global Atlas for Renewable Energy	Biomass, geothermal, hydro, solar, wave, wind	• Web platform that allows its users to find maps of renewable energy resources for locations across the world (global/regional/localised)

Follow the hyperlinks to view the resource.

Source: Clean Energy Solutions Centre (2015), Energy 4 Impact & INENSUS experience

Data Collection Tools

- Used during the field survey.
- Range from pre-designed online tools to custom offline/desktop tools. Can be available as free tools, or may require a monthly subscription.
- Choice of tool will depend on: remoteness of the location (mobile data connectivity), amount of data to be collected, devices used to input data, ease of setting up data for data processing, functionality required in survey, and budget.
- Some tools (e.g. Odyssey) come with analytical features which generate high-level findings of the field survey.
- **Choosing the right tool** is important because it can allow a developer to significantly reduce the time/cost/labour in data collection, while ensuring the data is as detailed and accurate as possible.

Tool	Description
KoBo Toolbox	Free & fee-paying online survey tool, with mobile app
Odyssey	End-to-end RE project development tool, including a survey tool and mobile app
Quick Tap Survey	Fee-paying online survey tool and mobile app
Survey Monkey	Fee-paying online survey tool and mobile app
Google Forms	Free custom forms and surveys. Limited functionality.
Microsoft Office (Word, Excel and Access)	Printed surveys, spreadsheet or database data storage

Follow the hyperlinks to view the resource.

Module Recap

- Site selection is the first stage in the development of a mini-grid project. It is important to know at a high level which sites are potentially viable and then start engaging with the local communities.
- Sites are selected based on accessibility, infrastructure, population demographics, economic profile, energy resources, and access to finance or technology.
- Demand assessment is the second stage in mini-grid development. Field surveys are used to collect data for the demand assessment. They should be designed to collect general information on customers, including their wealth, income, expenses, type of business and energy usage.
- The field data is used to calculate expected electricity demand and demand profiles. It also provides information on local value chains and which potential customers want and can afford electricity. Data from the demand assessment is used to develop the technical system design and business / financial model.

Further Reading

Blodgett, C., Dauenhauer, P., Louie, H., Kickham, L., (2017). *Accuracy of energy-use surveys in predicting rural mini-grid user consumption.* Energy for Sustainable Development. https://www.sciencedirect.com/science/article/pii/S0973082617304350

Booth, S., Li, X., Baring-Gould, I., Kollanyi, D., Bharadwaj, A., & Weston, P. (2018). Energy 4 Impact and NREL. *Productive Use of Energy in African Micro-Grids: Technical and Business Considerations.* https://www.energy4impact.org/file/2039/download?token=8ardN8he

Clean Energy Solutions Centre (2015). *Tools to Facilitate Mini-grid Practitioners.* https://cleanenergysolutions.org/sites/default/files/documents/mini-grid-tools.pdf

EEP. (2018). *Opportunities and Challenges in the Mini-Grid Sector in Africa: Lessons Learnt from the EEP Portfolio.* EEP. Retrieved from https://eepafrica.org/wp-content/uploads/EEP_MiniGrids_Study_DigitalVersion.pdf

ESMAP. (2016). *Assessing and Mapping Renewable Energy Resources.* ESMAP. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/24913/Assessing0and00ble0energy0resources.pdf?sequence=1&isAllowed=y

GIZ. (2014). *Where shall we put it? Solar mini-grid site selection handbook.* GIZ. Retrieved from https://renewableenergy.go.ke/asset_uplds/files/Site%20Selection%20Handbook%20150dpi%20for%20email%20+%20web(1).pdf

GIZ. (2016). *What Size Shall it Be? A Guide to Mini-Grid Sizing and Demand Forecasting.* GIZ. Retrieved from https://energypedia.info/images/0/0f/Mini-Grid_Sizing_Guidebook.pdf

Further Reading

IFC. (2018). *Benchmarking Mini-Grid DESCOs 2017 Update.* https://www.ifc.org/wps/wcm/connect/87b7df8f-94da-43ed-b168-3099b1edff45/IFC+Mini-grid+DESCO+Benchmarking+2017+Update.pdf?MOD=AJPERES

IFC. (2015). *Utility-Scale Solar Photovoltaic Power Plants: A Project Developer's Guide.* Washington: IFC. https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_utility-scale+solar+photovoltaic+power+plants

NRECA International. (n.d.). Module 5: Methodology for Evaluating Feasibility of Rural Electrification Projects. In N. International, *Guides for Electric Cooperative Development and Rural Electrification* (pp. 81-116). Airlington, Virginia: NRECA International. Retrieved February 2019, from http://www.nrecainternational.coop/wp-content/uploads/2016/11/GuidesforDevelopment.pdf

University of Strathclyde, Practical Action, and Carbon Trust. (2018). *Social Impact of Mini-Grids: Monitoring, Evaluation and Learning Tools and Guidelines for Practitioners and Researchers.* Energy Access Practitioner Network. Retrieved January 2019, from http://energyaccess.org/wp-content/uploads/2018/11/Monitoring-and-Evaluating-the-Social-Impact-of-Mini-grids.pdf

USAID. (2018). *What Are The Technical Components Of A Mini-grid?* https://www.usaid.gov/energy/mini-grids/technical-design/components

Williams, Nathan, Booth, Samuel S, and Baring-Gould, Edward I (2019). NREL. *Survey Use in Micro-Grid Load Prediction, Project Development, and Operations: Review and Best Practices*. https://www.nrel.gov/docs/fy19osti/72339.pdf