



# DUE DILIGENCE GUIDELINES FOR MINI-GRID INVESTORS IN NIGERIA

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## 1 Introduction

When considering any type of investment, it is necessary to undertake a due diligence exercise. Due diligence is defined as “a comprehensive appraisal of a business undertaken by a prospective buyer, especially to establish its assets and liabilities and evaluate its commercial potential”. It usually entails having a third party validate the information provided by the company.

According to Chapman C.E<sup>1</sup>., the theory behind due diligence holds that performing this type of investigation contributes significantly to informed decision making by enhancing the amount and quality of information available to decision makers and by ensuring that this information is systematically used to deliberate in a reflective manner on the decision at hand and all its costs, benefits and risks. Due diligence service investigates the attractiveness of an investment in view to understand what would make a transaction successful.

The present Guidelines propose a methodology to assess mini-grids in Nigeria:

- More particularly, Section 2 explains how a proportionate due diligence on mini-grid developers, generally falling under the category of Small and Medium Enterprises (SMEs)<sup>2</sup>, could look like in Nigeria based on the established practice and information available; and
- Meanwhile, Section 3 includes explanations on the functioning of an excel tool accompanying these Guidelines that was developed to help assess the commercial and, to some extent the technical, viability of solar<sup>3</sup> mini-grid projects based on a simple benchmarking methodology.

### Box 1: Definition of a mini-grid

Any vertically integrated electricity supply system with its own power generation capacity supplying electricity to more than 1 customer connected via a low or medium voltage distribution grid and which can operate in isolation from the main grid.

2 types of mini-grids can be distinguished as follows:

- **Isolated mini-grid:** means any electricity supply system with its own power generation capacity supplying electricity to more than 1 customer and that is not connected to the main grid.
- **Interconnected mini-grid:** means any electricity supply system with its own power

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<sup>1</sup> Chapman, C. E. (2006). Conducting Due Diligence. Practising Law Institute, New York, NY.

<sup>2</sup> According to the Central Bank of Nigeria (CBN), SMEs are “entities with asset base of Naira 5 million and not more than Naira 500 million (excluding land and buildings) with labour force (employees) of between 11 and 200”.

<sup>3</sup> Solar (Photovoltaic) was retained as the technology of reference for these Guidelines due to its level of maturity in Nigeria, as compared to other renewable energy technologies such as hydro, wind or biomass.

generation system, but installed within an existing low-voltage distribution network which is part of the distribution grid generally owned by the respective Electricity Distribution Company (DisCo).

These Guidelines were developed by the Nigerian Energy Support Programme (NESP), co-funded by the European Union and the German Government, and the Renewable Energy and Energy Efficiency Project (REEEP), co-funded by USAID and Power Africa, with a view to help international and local financiers and capital investors assess solar mini-grid projects (and the companies behind them) in Nigeria with the hope that this will contribute to unlocking access to finance for these type of projects.

## 2 Due diligence on the developer

### 2.1 Due diligence on SMEs

Depending on the size of the organization being reviewed, due diligence exercises vary in complexity and scale. Nonetheless, [Findlaw](http://www.findlaw.com)<sup>4</sup>, an international legal advisory organization, has provided a thorough checklist of information and documents that should be reviewed, if and when they are available, to assess small businesses.

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<sup>4</sup> [www.smallbusiness.findlaw.com](http://www.smallbusiness.findlaw.com)

**Figure 1: Due diligence cycle**

It should be said that many of the items on this list may not apply for smaller less complex businesses or may be information that is not available in Nigeria. However, efforts should be made to obtain as much information as possible to make informed decisions.

### 2.1.1 Organization and good standing

- a) The Company's Certificate of Incorporation and Memorandum and Article of Association, and all amendments there to.
- b) The Company's bylaws, if available.
- c) The Company's minute book. *This is not a common practice in Nigeria and should be an optional request.*
- d) The Company's organisational chart.
- e) Company's list of shareholders and number of shares held by each shareholder, which is usually included with the Corporate Affairs Commission Certificate.
- f) Annual reports for the last 3 years.
- g) A list of all property owned or leased by the Company. *In Nigeria, this would be provided if the company is using the property as collateral.*
- h) A list of the Company's assumed names and copies of registrations.

### 2.1.2 Financial information

- a) The Company's audited financial statements for last 3 years, along with auditors reports
- b) The Company's credit report. *The practice of credit reports is not as structured in Nigeria as it is in developed countries. An effective way of handling this aspect is to hire private credit check companies.*
- c) A schedule of all indebtedness and contingent liabilities. *This is not a common practice in Nigeria and should be an optional request.*
- d) A schedule of inventory.
- e) A schedule of accounts receivable and accounts payable.
- f) Any analysis of fixed and variable expenses and gross margins. *This is not a common practice in Nigeria and should be an optional request.*
- g) A description of the Company's internal control procedures.

### 2.1.3 Physical assets: capital equipment and real estate

- a) A schedule of fixed assets the Company intends to use as collateral for the loan, the address of the properties and copies of the land documents.
- b) A schedule of sales and purchases of major capital equipment during last 3 years. *This is not a common practice in Nigeria and should be an optional request.*

### 2.1.4 Intellectual property

A schedule of domestic patents and patent applications, if the product is the original design/idea of the Company. In the case where it is an internationally patented design, the company should provide documents showing it is an authorised reseller.

### 2.1.5 Licenses and permits

- a) Copies of relevant federal and state government licenses, permits and consents.
- b) Any relevant correspondence or documents relating to any proceedings of any regulatory agency.

### 2.1.6 Environmental issues

Where necessary, studies/certificates indicating no negative impact on the environment of the Company's activities. *In Nigeria, these certificates are issued by the Federal Ministry of Environment, generally, for specific projects, not the overall business activities of a company. However, small projects, generally, are exempted from these certificates. If necessary, an independent expert could however be hired to do an overall assessment of the impact of the Company's activities on the environment.*

### 2.1.7 Taxes

- a) Provision of receipts of federal and or state taxes paid for the last 3 years.



- b) Any audit and revenue agency reports if available.
- c) Relevant tax settlement documents for the last 3 years

### 2.1.8 Material contracts

- a) All loan agreements, bank financing arrangements, line of credit or promissory notes to which the Company is party.
- b) All guaranties to which the Company is a party.
- c) Any distribution agreement, sales representative agreements and supply agreements
- d) All security agreements, mortgages, collateral pledges and similar agreements.

### 2.1.9 Insurance Coverage

Where possible, a schedule and copies of the Company's general liability, personal and real property, product liability and other insurance

### 2.1.10 Consultants

A schedule of all law firms, accounting firms and similar professionals engaged by the Company in the last 3 years.

### 2.1.11 Articles

Copies of all articles and press releases relating to the Company within the past 3 years.

## 2.2 Doing due diligence on SMEs in Nigeria

While all the information on the above list is important, in Nigeria, there may be difficulties in obtaining some of the above mentioned information, as data are not widely available. There are however several credit bureaus and credit service companies that can provide the credit reports and most other due diligence investigations needed to make a well-informed decision.

The mini-grid sector in Nigeria is at its early stages. The [Bank of Industry](#) (local development bank) was the first financier in Nigeria to have done due diligence on several mini-grid developers. In addition to this, REEEP supported 2 mini-grid developers to undergo a financial due diligence process to access finance by an international debt crowdfunding platform called [bettervest GmbH](#). The table below includes the list of criteria used by bettervest for their due diligence process.

**Table 1: bettervest's investment criteria checklist**

### Country Specific

Overall assessment of country risk: development index, corruption index, other useful and readily accessible indices

Exchange rate risk

Rule of law: e.g. to what extent can claims be successfully enforced

Legal risks (authorization difficulties). i.e. are official permits valid/reliable, do grandfathering policies exist?

Incorporation of exchange rate, inflation and GDP forecasts

Market data for the first 18 months

**Company Specific**

Creditworthiness (are there loans to be repaid by the company? If yes. How many and for what purposes)

Reputation screening: company

Reputation screening: board members, founders, CEO

Company verification (name, address, contact, tax identification number, commercial registration number, etc.)

Company structure (legal status, certified copy/scan of the certificate of incorporation)

List of shareholders and their respective capital disclosures

List of silent partners (or statement declaring there are no silent partners)

Statement that no obligations/liabilities exist other than those stated

Management board and powers of representation

Ownership structure

Business operations

Company figures; number of employees

Company figures: revenues, costs and profits of past 3 years (and possibly future forecasts)

Securities such as real estate, machinery, etc. (market value and load capacity)

Balance sheets

Profit and loss account

Economic development (commissions, business development, forecasts)

Sphere of business activity and probability of default

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Were invoices/bills paid on time?

Debt ratio

Experience in the line of business and references

CV's from founders, board members, CEO

Balance sheet and income statement assessments:

- e.g. high short term liabilities (relative to cash flow)
- e.g. shareholders loans correspond to/equivalent to equity capital
- e.g. large percentage of borrowed capital (relative to total capital)
- e.g. high, inexplicable costs
- e.g. arbitrarily high reserves
- e.g. sudden layoffs
- e.g. sudden increases of existing salaries
- e.g. sudden selling of essential assets

Other industry specific abnormalities in balance sheets and income statements

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Source: *bettervest GmbH*

The experience gained by REEEP has been used to inform the creation of a basic due diligence guideline of information and reports that should be, for sure, accessible to any potential investor. Below you will find a list of these reports, a short description of each and the approximate cost in Naira.

### 2.3 Nigeria due diligence required reports and checks:

- Audited financial statements:** The most important of all is having financial statements audited by an independent accountant firm (Approx. Naira 300k)<sup>5</sup>.
- Credit report:** Nigeria has 3 authorized credit bureaus (CreditRegistry, XDS Credit Bureau and CRC) that check for any outstanding debts or a history of defaulting on loans. Investors should have at least 2 of the 3 companies provide a report (Approx. Naira 65k – Naira 100k).
- Corporate search:** This is to make sure company registration and other legal documents are validated (Approx. Naira 30k – Naira 50k).
- Reputational check:** Necessary to know more about the company's reputation and that of the directors, it should be acknowledged that information of this kind is limited in Nigeria (Approx. Naira 10k – Naira 20k).

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<sup>5</sup> If possible, it is recommended that the investor hires its own auditor to undertake this activity.

- e) **Tax clearance Check:** This is to make sure they are up to date on tax obligations. (Approx. Naira 20K).
- f) **Professional License and Document Verification:** If a company is making any claims of professional qualification or membership to certain organizations in their prospectus these claims should be verified (Approx. Naira 20K).

Services mentioned in bullet points c) to f) are usually undertaken by credit service companies or law firms.

Depending on its complexity, a financial due diligence process will be between **Naira 200K – Naira 300K** in total.

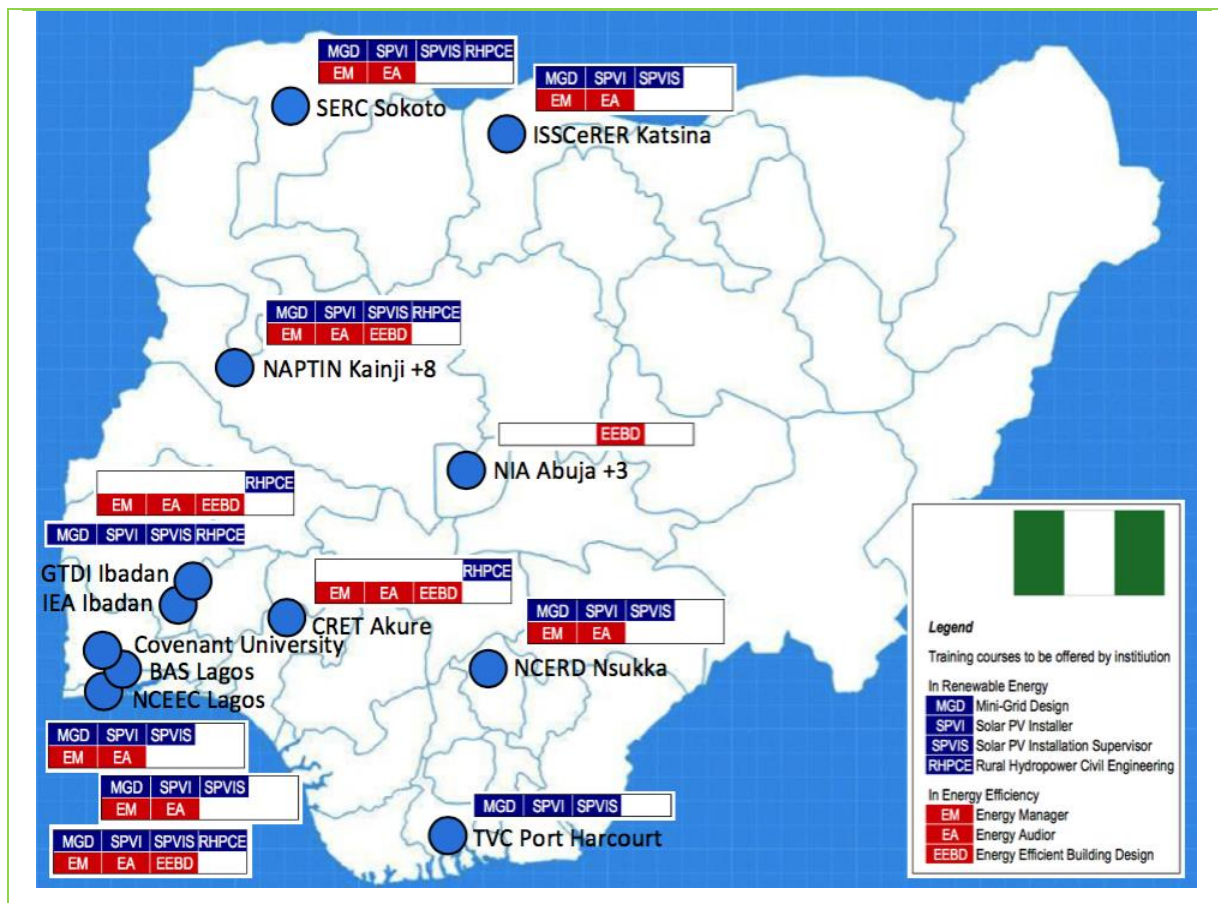
Finally, it is worth noting 2 aspects:

- These reports constitute only the raw data. Investors will need to use these data to analyse and make educated projections on the profitability of these projects.
- The checklist here is only for financial due diligence and should be complemented with a thorough evaluation of the company's technical capacity and capability regarding mini-grid project development.
  - In Nigeria, NESP and REEEP have developed a voluntary certification mechanism on mini-grid design. Investors may request the assessed company to submit the certificate on mini-grid design (See box below), any similar certificate(s) held by the company or its staff or proof that it received technical assistance on mini-grid development by any specialized body (local or international) as a basis to prove its knowledge on mini-grid development.
  - Meanwhile, in case the assessed company has already developed some mini-grid projects in Nigeria (or elsewhere), investors may want to receive a technical assessment from independent experts on the quality of the project (e.g. technology, installation, system sizing as compared to demand assessment/forecast, financial modelling – tariff strategy as well as revenue forecast as compared to real revenues upon start of operations -, bookkeeping, structure of project financing, funding sources, quality of the project's legal framework, alignment of project with existing regulatory framework, operational strategy incl. customer management relationship, replicability of business model and roll out strategy...).

### **Box 2: Mini-grid design certification mechanism**

Mini-grids are relatively new in Nigeria. Consequently, there is little practical experience to account for as yet. A few selected individual practitioners exist with commensurate experience. The qualification of mini-grid-designers however cannot be easily assessed.

### **Figure 2: Institutions offering the Mini-grid design (MGD) training**



Since 2016, mini-grid design is also taught in dedicated trainings for engineers. These last several weeks and are conducted by selected private and government training providers across the country in partnership with NESP and REEEP. There is confidence that the successful participation in these trainings by mini-grid developers will impart their relevant skills, especially as these courses are consistent with the standards evolved with the industry. Provider-issued certificates may lend themselves to be included as criterion. They may however not always be deemed credible, especially when not issued by a well-known institution.

### 3 Due diligence on the solar mini-grid project

#### 3.1 Introducing the excel tool

As previously said, as part of these Guidelines, an excel tool was prepared to help investors undertake financial (and to some extent technical) due diligence on specific solar mini-grid projects combining photovoltaic and lead-acid batteries<sup>6</sup>.

<sup>6</sup> The tool does not replace the developers' specific efforts and application of tools, including software (e.g. HOMER). It has limited suitability for assessing hybrid solar power plants combining photovoltaic, batteries and a fuel generator (generally used as back-up). The investment in a back-up generator and fuel costs will, however, most probably, be offset by an overall smaller investment in panels and most of all batteries. Whereas photovoltaic-related costs can still be compared with benchmarks, it fails to

Its purpose is to support investment (especially loan) decisions by providing answers to following questions:

- Is the assumed effective electricity demand realistic and realizable?
- Is the configuration compatible with the demand?
- To some extent, is the technology used of a reasonable quality?
- Are the cost items complete?
- Are price quotations reasonable?
- Is the cost structure acceptable?
- How much would be an acceptable electricity tariff based on capital cost considerations?
- How much do tariffs influence the cash flow and the loan repayment capacity?
- How much do financing alternatives influence the loan repayment capacity?

The investor will do the due diligence based on figures to be provided by the developer. These figures refer to customers and their electricity demand, as well as the equipment (incl. its configuration) required by the project and its costs (financial data) necessary to fulfil the forecasted demand.

The tool builds on standardized costs and some technical data to establish ratios, such as dividing them by the photovoltaic array's power ( $kW_p$ ) in order to arrive at comparable per- $kW_p$ -ratio or dividing them by the number of connections (i.e. a per customer ratio).

It compares these ratios with benchmarks or benchmark ranges, which were established based on the assessment of several existing and planned off-grid solar mini-grid projects in Nigeria, as well as data on existing mini-grids (incl. prices) published on the internet in 2017. It is recommended that the benchmarks are reviewed latest after 2 years (2019).

The benchmarks reflect a reasonable and commonly acceptable value or range. Values differing from benchmarks or outside the ranges might be realistic and acceptable, but deserve an explanation by the mini-grid developer for the deviation. This tool may also serve to assess whether the investor is sufficiently prepared thereby complementing the assessment of the developer's technical capacity/capability as specified at the end of Section 2.3. It shall also help to discuss and clarify particular issues so that the financier obtains more relevant information for decision-making.

Mini-grid financial models are generally very complex. This tool was kept intentionally as simple as possible to ensure that any investor, no matter its knowledge about mini-grids, could use it to do a preliminary assessment on a project. This however affects the accuracy of the tool. Since it is open source, investors will have the opportunity to build upon it with their own experiences in order to increase its accuracy.

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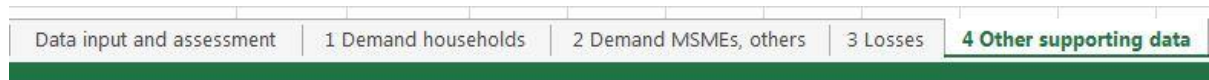
give a proper judgement about the proper size of the array and the battery bank. The tool cannot assess mini-grids powered by other generation technologies (i.e. hydro, wind, biomass).

### 3.2 Workbook design

The excel workbook consists of five worksheets.

“**Data input and assessment**” is the main worksheet. It can be used independently from the other four supporting worksheets by entering or overwriting data that the latter would generate otherwise.

**Figure 3: Image of excel workbook**




The four **supporting worksheets** present more detailed and comprehensible data for in depth analysis and assessment:


- “1 Demand households”
- “2 Demand MSMEs, others”
- “3 Losses”
- “4 Other supporting data”

*Sections 3.3 to 3.6 include a detailed explanation of each of the five worksheets.*

#### Box 3: Basic recommendations on handling the excel tool

Before entering data: Save the workbook with a **NEW FILENAME**.

For correcting inputs that may have affected functions use immediately this “undo” button  or the key strokes **CTRL + Z**, if necessary several times.

Look out for red triangle in top right corner of cells  for more information.

Provided detailed data are available it is recommended to fill in data according to the following sequence:

- “1 Demand households”
- “2 Demand MSMEs, others”
- “3 Losses”
- “Data input and assessment”
- “4 Other supporting data”

### 3.3 Demand assessment

The appropriate size and design of mini-grids depend on an adequate demand assessment. Customer segregation is recommended.

- “1 Demand households” presents the electricity demand per household as well as general data of the targeted community; while

- “2 Demand MSMEs, others” shows the projected demand of enterprises and others.

To allow the investor to fill in these worksheets, the developer has to provide its forecast on the consumers’ electricity demand and a profile stating how much electricity is demanded during day- and night-times. It is recommended that the investor asks the developer for proof that a demand assessment was undertaken to collect the data used to come-up with the demand forecast. The investor should ask for details regarding the methodology used to undertake the demand assessment.

### 3.3.1 “1 Demand households”

#### General socio-economic data on the targeted community

Some basic socio-economic data on the settlement or village, the location, its population and economic activity collected by the developer during the demand assessment shall help to understand better the potential household demand for electricity and the population’s willingness and capacity to pay as well as the general viability of the project and the risks involved. The developer should also indicate in this section other noteworthy facts, such as the project’s legal framework as well as the status of acquisition of the necessary regulatory approvals.

#### Box 4: General observations on project viability regarding demographics

As a rule of thumb, NESP has identified villages of 2,000 inhabitants or more with high population density rates<sup>7</sup> to be viable for mini-grid development. Demographics are generally positively linked to socio-economic development of communities. Communities of this size have revealed to have enough socio-economic activities to make mini-grids viable.

Project viability needs however to be assessed on a project by project basis and will also depend on the level of subsidy that the project plans to receive. Projects that are unviable for mini-grids may be viable for other technologies such as solar home systems.

In this section, the number of households and enterprises (Rows 12, 14, 15, 16) refers to all households and enterprises in the village and, therefore, it includes those not yet committed to receiving electricity from the mini-grid. These data are linked with the main worksheet “Data input and assessment”. Further data on economic activities can be derived from worksheet “2 Demand MSMEs, others”; which presents, inter alia, the fields of typical activity of local Micro, Small, Medium Enterprises (MSME).

#### Households

It contains information on the residential demand as well as general data (incl. socio-economic) on the village. Households are separated into four standard sub-groups:

<sup>7</sup> Benchmarks on population density have been included in the Excel tool, “Data input and assessment”, Section Distribution: Meters of distribution network per customer (less than 20), Number of customers per electric pole (more than 3)



- **Basic**
- **Advanced** (proposed indicator: fan, TV)
- **High** (refrigerator)
- **Very high** (e.g., air condition)

The consumption data for the household sub-groups are pre-set based on comparisons, observations and estimates. The data can be changed, for example, by in- or decreasing the number of items (Column C or 3), wattage (D or 5), average daily operation hours (F or 6) or adding another electric item (Others: rows 53, 56 and 59). The new data are entered into the uncoloured **cells** with borders.

The **number of households** for each sub-group has to be entered into the orange cells. Generally speaking and as a rule of thumb, it is most likely that customers with basic demand and advanced demand will be dominant.

The tool distinguishes between number of “potential” households (total) and number of **committed** households, those that signed a contract to receive electricity from the mini-grid.

Households with advanced demand are expected to consume about 200 kWh per year or about 40 kWh per capita; while the average demand for residential households is estimated at about 100 kWh per capita<sup>8</sup>.

For the assessment, the demand of all committed households is compared with the average national demand. The demand data are regarded acceptable if the local residential demand is up to 50% of the average national residential demand.

The figures on households in **orange** cells and data in **yellow** cells in this section are automatically transferred to the main worksheet “Data input and assessment”, Row 39, Columns B, C, D.

### 3.3.2 “2 Demand MSMEs, others”

The worksheet presents three tables for monthly data using the same format for

- **Commercial MSMEs;**
- **Productive MSMEs; and**
- **Public demand.**

For each of these categories and based on the developer’s survey data, details from up to nine prospective and committed customers with highest consumption could be included in cells A 38-46, A 58-66 and A 78-86 respectively.

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<sup>8</sup> OECD/IEA, [www.iea.org/statistics/topics/Electricity/Electricity Statistics](http://www.iea.org/statistics/topics/Electricity/Electricity%20Statistics)

Annual electricity consumption, residential (total) 2011: 13,568 (23,679) GWh or 57% or about 80 kWh per capita (about 400 kWh per household) for 2011, est. about 100 kWh per capita (about 500 kWh per household) for 2017

For the remaining identified customers that have a smaller consumption, aggregated and estimated figures shall suffice. The number of these customers shall be entered in cells A47, A67, A87 and their aggregated fuel consumption in cells D47, D67, D87. The number of businesses is generated in yellow cells A48, A68, A88 and automatically transferred to the main worksheet “Data input and assessment”, Section Demand households, cells C40, C41 and C42 respectively.

The projected electricity demand is based on the present fuel consumption (Column D or 4). The average monthly fuel consumption in litre is multiplied with the efficiency of the gen-set. On average, it is estimated that 1.5 kWh of electricity are produced per litre of petrol and 2,8 kWh are produced per litre of diesel fuel. If deemed helpful, a different efficiency ratio can be entered (Column E or 5), which we estimate at 0.8 – 1.2 for small and old petrol engines and up to 3.5 for larger (>40 kW) new diesel engines. The projected monthly kWh demand is presented in Column F or 6. The total kWh/day value (yellow cell at the bottom) is transferred to the main worksheet “Data input and assessment”, Section Demand households, cells D40, D41 and D42 respectively.

It is expected that the information included in the two tables “Additional financial data for consideration” and “Additional gen-set data for consideration” (Columns H-S, 7-17) helps investors to understand the operational energy cost situation of local MSMEs.

“Additional financial data for consideration” are not required for other applications. Few inputs allow assessing the likelihood that cost considerations may support or prevent entrepreneurs switching to mini-grid electricity depending on the:

- fuel price in the village, including transport cost (the price of petrol and diesel is similar<sup>9</sup>. The price may be differentiated according to customer sub-group in Column H or 7, Rows 36, 56, 76);
- individual monthly average expenditures for service, maintenance and repair of the gen-set (alternatively annual cost divided by 12); and
- envisaged electricity tariff. As a result, a different tariff may be set according to sub-group (Column K or 10, Rows 36, 56, and 76).

The result in Column L or 11 is the Naira amount mini-grid electricity may save each month (black) or may add (red), as compared to the customer producing its own electricity using its gen-set.

“Additional gen-set data for consideration” provide more information about the present gen-sets that the entrepreneurs and others use, in particular their size/capacity (kW, KVA), ownership, and how these tools were financed. The statements on operation hours might be opposed to the data on fuel consumption for consistency.

The data included in, “Additional financial data for consideration” and “Additional gen-set data for consideration” are not linked to any other worksheet and, thus, are not used for further processing in excel tool.

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<sup>9</sup> Mid 2017

**Box 5: General observations regarding local MSMEs using individual gen-sets**

Depending on the socio-economic profile of the village, a few MSMEs may account for a decisive share, sometimes more than 40%, of the electricity demand. Some MSMEs might find it less expensive to continue operating their old gen-set.

Generally speaking, mini-grid electricity tariffs will generally be above the operating costs of small diesel gen-sets. Additionally, MSMEs may need to invest in new equipment to power their machinery (e.g. replacement of combustion motor with an electric one) to make it compatible with the electricity supply from the mini-grid.

However, it is expected that most MSMEs accept higher expenses for electricity in exchange for more reliable electricity services and out of convenience (no need to put efforts into maintaining their gen-set anymore).

**3.4 “3 Losses”**

This is a tool to calculate into more detail the losses of the photovoltaic system. Technical losses are inevitable. Higher investments in more efficient electronic equipment reduce losses and would allow a smaller photovoltaic array dimension and battery bank capacity. A simple, rough and conservative calculation to estimate the annual electricity production for sale is:

- Annual irradiation x array name plate capacity x 55% = energy (electricity, kWh)<sup>10</sup>
- For example: 2,000 kWh/m<sup>2</sup> x 80 kW<sub>p</sub> x 55% = 88,000 kWh per year.

It is likely that a detailed calculation yields lower loss percentages, resp. higher production.

**Box 6: Remark on panel efficiency**

The panel efficiency, i.e. the percentage of irradiation that a panel converts into electricity, is rather irrelevant for the calculation here.

Low-performing panels convert 14% of the irradiation into electricity and require about 7 m<sup>2</sup> land per kW<sub>p</sub>. Meanwhile, high-performance panels convert 21% and require less than 5 m<sup>2</sup>.

A 100 kW<sub>p</sub> plant using efficient panels could save about 400 m<sup>2</sup> land, some 1,500,000 Naira (\$ 4,000) on mounting structures, transport, wiring, and labour. However, 100 kW<sub>p</sub> high-efficiency panels may cost at least 3,000,000 Naira (about \$8,000) more. Their specific price in \$/kW<sub>p</sub> is higher.

The optimization is the task of the developer.

The percentages in green fields (Column C) are **benchmarks** for comparison. The developer has to submit the **data** for the **loss percentages** in the orange cells. The **result** presented in the yellow boxes separates **loss percentages** for daylight and nighttime electricity.

<sup>10</sup> Alternatively: Annual irradiation of 1,000 kWh/m<sup>2</sup> collected with a 1-kW<sub>p</sub> array produces about 1.5 kWh per day/night for sale.

The loss for nighttime electricity is distinctly higher, as the electricity has to be stored in batteries first and discharged later. This chemical process produces useless heat, thus power is lost and sometimes also spent for cooling the power house.

The “Multiplier” takes account of irradiation variations throughout the year. It increases the necessary photovoltaic array area so that enough electricity can be generated during months with below average irradiation (rainy season).

Further explanations are presented in the worksheet and in comments embedded in some cells (red triangle in top right cell corner).

The loss percentages mentioned in E56 and F56 and the multiplier in E62 are then transferred to the main worksheet “Data input and assessment”, section Configuration, cells C59, C60, B64 respectively.

### 3.5 “4 Other supporting data”

Since most of the generation as well as metering equipment is generally imported, this worksheet provides relevant data for the assessment of transport costs of the equipment from Lagos port to the destination.

Just as a remark, in some cases, if the equipment that is being imported is light enough. It might be imported by Air Freight to Lagos or Abuja.

### 3.6 “Data input and assessment”

#### 3.6.1 General remarks on data entry

The developer must submit the data to be inputted into the **input data** fields which are coloured in orange or light red. It is recommended that some of the data, notably those included in the “Demand” and “Configuration” Sections, are entered using the supporting worksheets. It is however also possible to bypass the supporting worksheets.

**Output data** are generated via formulae and use the following colour/font code:

1. Key parameters
2. Data supported by benchmark, acceptable
3. Data suspiciously low (quality issue?) or high (expensive?)
4. Data very low or very high, need clarification (*check for mistyping*).
5. Additional information, comments for consideration

2,356
12
34
56
<i>italics</i>

More comments and information are visible when the cursor stays on cells with a red triangle in the top right corner. Further comments may appear close to the respective data depending on the data input.

**Assessment data** (above copied bullet points 2, 3 and 4) - indicated by the ratio's background colour - result from a comparison with benchmarks or benchmark ranges:

- **Green:** The ratio (or specific price) is within the benchmark range.
- **Yellow:** The ratio is below or above the benchmark range indicating perhaps (but not necessarily)
  - low quality products (if the value is below the benchmark);
  - a product, which might not be priced competitively (if the specific price is above the benchmark); or
  - a technically oversized product.
- **Red:** The ratio is distinctly below or above the benchmark. If it does not result from mistyping, it is recommended to investigate the reason for the deviation and ask the developer for explanations.

**Benchmarks or benchmark ranges** reflect specific costs (cost per capacity) for a 60-kW<sub>p</sub> to 100-kW<sub>p</sub> solar plant. Smaller plants have higher specific costs due to various fixed cost components. Generally speaking, the assessment of smaller plants is likely to show more yellow and red cells. A function at the bottom of the investment data input shows if the higher specific overall investment costs of smaller solar power stations appear acceptable.

It is worth to note that, it may well happen that some ratios are outside the benchmark range (cell colour yellow, red). However, the **overall result** is within it (green).

### 3.6.2 Contents

The worksheet is divided into 10 sections as follows:

**Table 2: Table of contents “Data input and assessment”**

Section	Contents
<b>1. Demand</b>	Electricity demand in location
<b>2. Configuration</b>	Size of photovoltaic array and battery capacity
<b>3. Investment</b>	
3.1. Site development	Costs in Naira, \$, cost assessment, benchmarks
3.2. Generation	Panels (array) and inverters, costs in Naira, \$, cost assessment, benchmarks
3.3. Storage	Batteries, related electronic equipment, costs in Naira, \$, cost assessment, benchmarks
3.4. Distribution	Poles, lines, and connections, costs in Naira, \$, cost assessment, benchmarks
3.5. Others	Project development costs in Naira, \$, cost assessment

<b>4. Investment summary</b>	Overall investment assessment, adjustment to size
<b>5. Capital cost</b>	Depreciation and cost of funds (expected Return on Investment, RoI) simulation
<b>6. Income projection</b>	Cash flow before debt service based on electricity tariff and operational cost simulation
<b>7. Financing</b>	Sources and cost of finance simulation
<b>8. Cash flow years 1 – 15</b>	Start-up simulation, inflation rate simulation, battery replacement simulation
<b>9. Govt subsidy policy</b>	Total national investment cost financing of solar mini-grids following Electricity Vision 30:30:30
<b>10. Benchmark baselines</b>	Information about benchmark adjustments for mini-grids below 100 kW <sub>p</sub>

### 3.6.3 Detailed explanations

Below is a detailed explanation per section. For proper understanding of the information contained in the table below, it is recommended that it is read with the Excel tool opened.

**Table 3: Detailed explanations “Data input and assessment”**

#### Demand (Rows 32 – 49)

All relevant data are transferred from worksheets “1 Demand households” and “2 Demand MSMEs, others”. Alternatively, **aggregate data** can also be entered directly in the respective cells here. *(The data transfer function will be lost; for re-installment press CTRL + Z several times until the formula re-appears.)*

The result is a key parameter, the **average daily electricity demand (kWh)**.

Some additional information for assessing the demand is offered. The potential resignation of large customers may be a threat to a stable income. Therefore, ideally, the share of the nine largest productive MSMEs should not exceed 30% of the total demand.

The estimated growth potential serves as a resilience indicator in case the demand assessment was too optimistic. It relates the not yet connected households and MSMEs to those who are connected. The indicator should be > 35%.

#### Configuration (Rows 50 – 80)

##### Photovoltaic plant configuration

The irradiation data are connected to “3 Losses”, but they can also be entered here. The data

provided by the developer can be verified (see map at the left side) according to the project's location. As a general rule, it is more efficient to produce electricity in the north (more irradiation), plants may be smaller, but specific investment costs per kW<sub>p</sub> might be higher (transport, management).

The daytime electricity demand results from the developer's demand survey. A percentage below 45% may justify an over-average battery investment.

Technical or system losses necessitate more electricity generation than electricity demand. The percentages for daytime losses are calculated in detail in worksheet "3 Losses" and automatically transferred to these cells. The data may also be entered here directly, thus bypassing "3 Losses". The automatic transfer function will be lost (*recovery with CTRL + Z*). Details shall be presented for losses below 30% for daytime and below 40% for nighttime electricity.

Battery operation increases electricity losses due to heat development when charging and discharging. Roughly, almost half of the sun-generated electricity is lost; the other half can be sold. It is the task of the developer to optimize the design. E.g., power lines with a small diameter increase losses, but are less expensive. Expenses for power lines (Row 155) below the benchmark may contradict low loss percentages. It seems almost impossible to realize losses below 25% for direct feed and below 35% for electricity from batteries.

The multiplier, a value of between 1.1 and 1.6 for Nigeria, serves to determine an array size that generates sufficient electricity during months with below average irradiation, more clouds.

If the annual average irradiation per m<sup>2</sup> is 6.0 kWh/day, it might be about 4.8 kWh/day during the rainy season. The multiplier would be  $6.0/4.8 = 1.25^{11}$ .

In the absence of exact data, 1.3 would be appropriate. It is minimum 1.1 irrespective of lower data input.

The photovoltaic array's power required is calculated based on demand data, losses and multiplier.

The photovoltaic array's **power proposed** by the developer should be in a range of about  $\pm 10\%$  of the calculated array power.

The electricity demand might frequently not be met if the plant power is too low.

In contrast, a large array might anticipate a future demand (see: Estimated growth potential **Rows 47, 48**). However, at the start, a substantial part of the investment will remain idle. The developer might better increase the investment when the additional electricity can be sold.

### Battery bank configuration

The battery bank configuration calculates the **nameplate energy** (kWh) resulting from

<sup>11</sup> For details, see <https://eosweb.larc.nasa.gov/sse/>.

multiplying the voltage (V) with the nameplate capacity (Ah) and the number of batteries. The capacity of a battery is lower, when the discharge takes place in a short time. The Ah-figure is lowest for C10-(discharge in 10 hours). *(See picture of battery label in Excel tool.)*

---

Two ratios are used for the assessment of the battery bank configuration.

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- Ratio 1 relates the battery nameplate energy to the panel capacity and recommends a ratio of 3.0 to 4.5 according to rule of thumb. A smaller ratio (less battery capacity) endangers the electricity supply after a number of consecutive cloudy days. A higher ratio hints to unnecessary investment in too much expensive battery power.
  - Ratio 2 returns the battery energy as a multiple of night demand and indicates how many nights electricity is available should the battery not be charged during the day. The useable energy is only about 60% of the nameplate capacity in order to prevent deep discharge that would result in premature battery degeneration, shorter lifetime, higher depreciation and cost.
-



## Investment (Rows 81-178)

The columns for the investment data follow a general pattern:

- Description of item
- Naira value, provided by the developer; all financial data inputs are in Naira. Quotations in foreign currency have to be transferred into Naira first using the exchange rate described below.
- USD/\$ value calculated by Excel based on the Naira/USD exchange rate (Cell B83). The exchange rate is the one that applies for the purchase of imported goods<sup>12</sup>.
- Assessment, a ratio, e.g. USD/kW<sub>p</sub>, is compared with a benchmark range, and presented in coloured cells:
  - green: acceptable,
  - yellow: outside,
  - red: questionable, explanation needed
- Comments: may appear for selected items and values. They do not influence the result.
- Benchmark or benchmark range that are considered reasonable; the benchmarks are presented in USD.
- Supporting picture
- Local component percentage, a rough estimate to establish the dependence on forex for further consideration (Column M)
- Local component value (Naira) (Column N)

## Site Development (Row 86)

**Land area** benchmark is about 15 m<sup>2</sup> per kW<sub>p</sub>: ~6-7 m<sup>2</sup> panel deliver 1 kW<sub>p</sub>; 100% are added for space between panels and land for the power house (~20-30 m<sup>2</sup>).

Large areas allow plant extension, however costs may be unnecessarily high.

The cost for **land use rights** differ considerably and are not standardized.

**Land development** includes land clearing, fencing, cost for a power house (including building permit) with a strong cement floor for the heavy batteries. An ecological design (green or sustainable architecture) with natural flow of air to cool the batteries might avoid the purchase and operation of an air conditioner (reducing internal energy losses and costs).

**Total site development** should not require much more than Naira 5 million for a 100 kW<sub>p</sub>

<sup>12</sup> A weakening exchange rate decreases local costs expressed in USD.

photovoltaic plant or \$150/kW<sub>p</sub>.

### Generation (Row 100)

It is assumed that the developer imports directly the **solar panels**, as this product is currently not manufactured in Nigeria. Provided the goods are sourced locally from importers, the price may be split by best guess into the assumed import price (cif: cost, insurance, freight to destination port) for the panels<sup>13</sup> and the other major components, namely customs clearance and land transport to location and unloading.

Custom clearance and port fees may vary substantially. The separation shall expose the reason in case of high panel costs.

Land transport cost from port to the plant location varies according to destination, accessibility and load. Panels for a 100-kW<sub>p</sub> plant might fit into a 20 ft. container and weigh about 9 ton gross (*see worksheet "4 Other supporting data"*). Land transport to off-road locations in the North could be more expensive; the higher irradiation there might compensate for this.

**Mounting structures** produced locally with steel might cost less but they need paint and suffer from corrosion in contrast to often-preferred aluminium profiles.

The quotations for **solar inverters** are separated into the product (cif) and costs for custom clearance and land transport (weight: less than 500 kg for a 100-kW<sub>p</sub> plant).

The panels generate direct current (DC). The solar inverters process DC into alternate current (AC) that is fed into the network. Irrespective of the solar inverters' potentially higher capacity than actually required (anticipating a future expansion), the investment is divided by the actual panel power (kW<sub>p</sub>) for the comparison with the benchmark. Costly inverters should provide efficiency rates of more than 96% (compare "3 Losses", Row 18).

The quotations for **other electronic equipment (BOS)** may vary in a wide range and depend on the particular technology for battery management and a potential gen-set connection. Higher expenses here might be balanced with lower expenses for electronic equipment accounted to the electricity storage management (Row 135).

The row for **other costs** allows separating and specifying other items related to electricity generation that do not fit and are not included in the above.

**Total generation** investment is the addition of the components under this header. The sum is assessed and compared with an overall benchmark.

### Storage (Row 123)

It is assumed that the developer imports the major components. Provided the goods are

<sup>13</sup> For panel price indicators see: <https://www.enfsolar.com/>

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sourced locally, the price for the batteries and the other equipment may be split by best guess into the assumed cif price and the other cost items.

The benchmarks are only applicable for the two popular lead **battery** types:

- **Open wet or flooded lead acid (OPzS) batteries** offer a lifetime of more than 3,000 cycles or eight years provided discharge is limited to about 60%.
- **Closed gel type (OPzV) batteries** are almost maintenance free. They are more expensive measured by the specific cost (kWh/USD) despite a shorter lifetime of six to seven years.

Under a less reliable maintenance management (large distance to plant, weak supervision), wet batteries have a shorter lifetime and gel batteries are the better alternatives.

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A very low battery cif price might hint to a product not suitable for solar equipment and/or the material might be of inferior quality.

---

The expenses for **customs** clearance could be low if they are acknowledged as necessary equipment assigned for photovoltaic plants (renewable energy). The cost assessment for **transport** to the site has to take into account the weight (several tons, see “4 Other supporting data”, Row 30).

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**Electronic equipment** for battery management **includes inverters or converters** for altering the batteries’ direct current (DC) to 220-240 V alternate current (AC) for the mini-grid.

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The amount reportedly charged for customs clearance for electronic equipment varied in a wide range. As solar equipment, the import tariff should be below 10% of the cif-value. Transport to site might not constitute a significant expense. The in-/converters should weigh below 500 kg.

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The row for **other costs** allows separating and specifying tools related to electricity storage.

### Distribution (Row 144)

The **distance** from power house to settlement centre should be as short as possible to reduce costs for poles and cable and to limit electricity losses that increase with the length of the power line.

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The **length** of the **network** depends on the locations where the customers consume electricity. For each 20 meter distance, at least one customer should be connected, on average.

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The total **length** of the necessary **power lines** would be about twice the network length if 2 cables connect the poles plus 10% for sag and reserve.

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The **number of poles** should be as low as possible. The average distance from pole to pole should be more than 30 meter to keep costs low.

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The ratio customers per pole should exceed 3 for cost efficiency reasons. This ratio can be achieved in densely populated places.

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The developer has to procure concrete **poles**, organize transport and erection (labour). Trees may have to be cut. Using metal poles is not according to standards, although it may be the cheapest solution. Wooden poles may have a short lifetime unless they have been properly treated.

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The **power lines** or distribution lines (cables) are not further specified here.

The developer decides about system layout (single-phase, three-phase), cable specification, size, and supplier. Nowadays, for mini-grids, aluminium cables are cheaper than copper cables.

Popular single-phase 2 x 50 mm<sup>2</sup> cables may cost about USD 3 to USD 6 per meter and a much thicker three-phase cable more than USD 15 per meter, depending on diameter (or cutting surfaces) and other specifications. The power lines have to be attached to the poles (accessories: connectors, insulators; labour).

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The **customer connection** consists of the 10 to 20 meter service line from pole to house, a smart meter, a CUI unit, circuit breakers and in-house installation with switches and sockets.

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The row for **other costs** allows separating and specifying other items related to the distribution network.

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**Total distribution** network cost per customer decrease with higher population and enterprise density. Costs of more than USD 500 per customer should be scrutinized very thoroughly.

A high per customer investment for the network might be justified with high consumption, perhaps more than 1.5 kWh/day per connection and respective revenues.

### Others (Row 163)

These are non-tangible costs normally financed in advance with the investor's risk capital. They constitute a part of the total investment costs.

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**Project preparation** relates to the identification of the site, a demand survey as basis for an investment opportunity or (pre-) feasibility study and the project design.

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This category covers **costs of authorizations** e.g. land use rights and building permit (outside those for the site development (see Rows 93, 94), Environment Impact Assessment (EIA) Certificate and **others** (red tape).

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**Project management**, supervision, travel, wages for employees, etc. are the developer's overhead costs, normally financed with equity.

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The **total other costs**, the amount for the identification and management until the solar plant

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produces and sells electricity should ideally not surpass 15% of the total investment volume.

### Grand Total Investment (Row 172)

This row returns the total investment cost in Naira, USD and the specific investment cost USD/kW<sub>p</sub>.

For assessing the impact of foreign currency exchange rate fluctuations on the investment, the cost components were split into local costs and services payable in Naira and imported goods, in particular panels, batteries, electronic equipment, and 50% of power lines and customer connections (smart meter). The details are presented in Columns M and N.

It is expected that USD prices for some expensive components will continue to drop, namely photovoltaic panels, batteries, converters and some other electronic equipment. Their cost and their share in the total investment amount is exposed separately (Row 176).

The development of equipment prices in Naira or USD has a quite limited influence on the cash flow and Naira-loan repayment capacity. It is expected that during a 15-year period, the battery bank, in most cases probably around 10% of the total project volume, may have to be replaced once. The influence can be assessed in the section Cash Flow Simulation below (Rows 281 – 327)

### Investment Summary (Rows 179 – 204)

The investment summary presents an **overview of the cost blocks** (sections) in Naira and USD and the assessment (or comparison with benchmarks) of the investment costs for site development, generation, storage, distribution and overheads or management (other costs).

If the investment costs are more than 15% below the adjusted benchmark (yellow or red cells), it is recommended to review the sections with investment costs far below the benchmark for possible omissions or mistyping.

The overall investment for a 100 kW<sub>p</sub> plant with storage and distribution should not exceed USD 4,500/kW<sub>p</sub>. The specific investment costs (USD/kW<sub>p</sub>) increase with decreasing plant sizes. Higher specific investment costs may be acceptable for smaller plants, therefore the “adjusted” benchmark (see Section “Benchmark Baselines” below, Rows 353 - 364).

### Capital cost per kWh (Rows 205 – 221)

**Capital cost per kWh** take into account the technical depreciation plus the financiers’ expected Return on Investment (RoI). It is calculated based on the investment separately for site development, generation, storage and distribution to demonstrate the relative influence on the cost. The result indicates a kWh-price, which is necessary to cover the fixed costs (Row 219). **(For operational cost and total cost, see Section Income Projection below.)**

For their **income statements**, the investors will apply the highest depreciation rates possible. Their income statement would probably be negative for ten years, depending on inflation.

Any income tax holiday would probably not improve the return. Investors should have a profitable business to compensate the tax profits with tax losses from the operation of mini-grids, as high investment costs and low operating costs characterise photovoltaic electricity generation.

This section allows simulating the **major fixed electricity costs (per kWh)** using three parameters:

- **Depreciation for batteries** is separated. The lifetime of batteries is distinctly shorter compared to other equipment.
- The **technical depreciation for all other components** may be based on a lifetime of at least 20 years, i.e. 5% p.a.; even 30 years might be acceptable, as the equipment does almost not move (minimal wear and tear). Aging may affect the output by about -0.5% per year. A solar panel is not scrap when it produces 200 W after 35 years instead of 300 W when new. The scrap value of aluminium power lines remains substantial; the technical depreciation is low.
- **Expected Return on Investment (RoI)** p.a. is the compensation for providing funds, the income investors, shareholders, and creditors anticipate or demand. Commonly, sponsors expect a very low or even no return for their grants. Through special schemes, banks may charge single-digit interest rates for loans.

### Income Projection (Rows 222 – 248)

This worksheet does not produce a profit/loss statement. This section offers the simulation of income (electricity tariff) and expenses based on cash flows. Its purpose is to show a loan repayment capacity, i.e., if and how loan financing is possible.

Commonly, electricity tariffs vary according to access (time and capacity), consumption, and client. The **smart meters** allow setting the electricity tariffs individually. Preferential tariffs might prevent large customers, mostly productive MSMEs, continuing their gen-set operation.

Electricity from renewable resources, in particular solar electricity with minimum tear and wear and without direct costs related to consumption (no fuel costs) would ideally have to be paid with high fixed monthly access or subscription fees and low consumption fees<sup>14</sup>.

The following **tariff simulation parameters** are offered:

- Customer group;
- Fixed monthly connection/subscription charge, which is meant to recover part of the fixed capital costs; and

<sup>14</sup> It is acknowledged that opinions differ about the justification and necessity to implement a fixed fee that might burden most those with low consumption, i.e. the low income people. Thus, this section allows a tariff simulation with the highest possible level of flexibility by allowing different tariffs and fixed charges per customer category to expose the result for clients and developer.

- Tariffs for electricity consumption (Naira/kWh).

The following data are presented:

- average monthly bills according to customer groups;
- monthly bill for households with basic demand; and
- weighted average price or income per kWh.

When evaluating the kWh tariff, one should consider that the customers do not demand kWh; they want light, music, radio, TV, cold drinks, preserve food. Simple kWh price comparisons can be misleading.)

Some **expenses** are directly connected to gross revenues (stated as percentage); others are presented as fixed annual cost.

The rows “Other....” and “Miscellaneous...” offer cells for entering costs that are not specified elsewhere.

The **net cash flow** before loan service results. This amount may be used for loan service.

### Financing (Rows 249 – 280)

This section presents the **annual and monthly cash flow after loan service**. The simulation of various financing models shall assist decision-making. It may help to optimize the capital composition. It does not replace more detailed calculations that some parties may demand.

The following **variables** can be altered to simulate financing components and financing costs:

- additions to the investment amount (in Naira):
  - estimated amount for interest during construction;
  - start-up costs that are not included in the investment calculation above; and
  - others, contingencies, e.g., cost of loan agreement, etc.
- in % of total investment:
  - equity (developer, other parties);
  - government subsidy (may come with conditions such as limiting the tariff);
  - grant(s), the sum of various sources;
  - two different monthly instalment loans with fixed instalment amounts (mortgage); by system, the second loan finances the remainder; the amount for this loan can only be adjusted by changing one or more of the other components above.
  - different loan interest rates; the loan interest rates sum up the nominal rate, pro-rata fees and costs, and a surcharge for forex denominated loans considered to compensate for a weakening Naira;

- different tenors.

The **debt financing costs** are based on the assumption that the loan service starts 1 January together with the start of revenues for electricity.

The **net cash flow per year** (*month*) after loan service results from deducting the debt financing costs (Row 276) from the net cash flow per year (*month*) before loan service as stated above (Row 247).

### Cash Flow Simulation (Rows 282 – 327)

Loans are repaid from cash flows. This section adds more variables to determine the cash flow for up to 15 years. The result depends highly on the assumption made for the inflation rate. The cash flow simulation offers the following **variables**:

The start-up simulation takes account of a **capacity use below 100%** through years 1-3, i.e. the actual demand starts at a lower level. Many families might not have the money to buy immediately the appliances that they may have mentioned during the demand survey or even to pay for connections fees (if any).

The **battery replacement** can be simulated with assumptions on:

- the battery price development (USD-prices are expected to drop slightly);
- the battery scrap value (recyclable lead); and
- the battery replacement year.

The Naira/USD exchange rate development is not part of the projection for the replacement costs. It is assumed that the higher inflation rate compensates for a weakening of the Naira.

The **inflation rate** is pre-set to be the same for all years. It affects revenues and operational costs, but not financing costs. A change of the data in year 1 will change the data for all years. The inflation rate can be entered individually for each year. (To return to the pre-set function, use the key CTRL + Z.)

As a general remark, the Government aims at reducing the inflation rate. Therefore, the inflation rate can be entered individually for each year.

### Government Subsidy Policy (Rows 328 – 352)

This table informs, it requires no input. Inputs are an option for simulation.

The **Electricity Vision 30:30:30** presents forecasts until 2030 for the development of mini-grids. The table reflects the **nationally required** investment if solar mini-grids are implemented and **presents the necessary contributions of the various stakeholders** to achieve the Electricity Vision 30:30:30 goal.

It may help to assess the probability that investors, government, donors, and creditors make available the necessary funds.



For simulation purposes, the assumptions for the **investment costs per MW** can be changed. Under favourable conditions, the present investment amount is USD 4.5 million/MW (USD 4,500/kW). It is likely that this will be the investment amount under average conditions in 2020.

The potential for lower costs in future is debatable. Solar panels, electronic equipment, and batteries account for about one third of the investment. If their prices drop further by 50% (or even 75%), total cost will decrease less than 20% (30%) – only provided other costs remain constant<sup>15</sup>.

The **growth** indicates the additional investment for the entire four or five-year period on national level.

The table **Investment per average year** presents annual amounts that the different stakeholders have to provide each year if all solar mini-grids are financed following the same composition as presented in the above project.

The average annual investment until 2020 amounts to USD 197 million, but it is almost fivefold (USD 950 million) until 2025 and it more than triples again to USD 3,000 million per year until 2030. Special attention should be paid to the probability that the Government subsidy will be available to the extent exposed here.

The table **For simulation** offers the opportunity to change - independent from the actual project - the **percentage** contributed by private investors, Government subsidy and grants from other sources with debt adding up to 100%. Debt (potential bank financing) is the remaining percentage (or amount) after simulating the percentages for equity (H342), subsidy (H343), and grants (H344).

### Benchmark baselines (Rows 353 – 365)

This table provides information about the increasing cost efficiency with increasing plant power. The investment amount per kW<sub>p</sub> decreases with increasing array size.

The table presents benchmarks for 10-KW<sub>p</sub>, 50-kW<sub>p</sub> and 100-kW<sub>p</sub> photovoltaic power stations with storage and mini-grid, which were applied for the overall assessment (interpolation).

<sup>15</sup> Assumptions: total cost 100 (%), including electronic equipment accounting for 32 (%). If prices for electronic equipment drop 16 (50% of 32), total investment drops by 16% from 100 to 84. If prices for electronic equipment drop 24 (75% of 32), total investment drops by 24%.from 100 to 76.