Methodologies and Principles for Monitoring Access to Modern Energy

– Improving Access to Modern Electricity via on-grid Electricity Projects: Calculation and Attribution of Achievements to Different Stakeholders –

Discussion Paper

June 2015

Contact Persons:

Dr. Jens Drillisch - KfW
jens.drillisch@kfw.de

Dr. Carsten Hellpap- GIZ
carsten.hellpap@giz.de

Tim-Patrick Meyer – Consultant
tim.meyer@gmx.de

List of Content

List of Abbreviations

AC	Total annual electricity consumption [kWh/a]
AI	Access index
AQ	Additional annual electricity quantity [kWh/a]
CC	Competence Centre
CEPGL	Communauté Economique des Pays des Grands Lacs (Economic Community of the Great Lakes Countries)
CH	Number of households connected (before project implementation)
CP	Number of people connected (before project implementation)
DC	Development Cooperation
EL_t	Annual electricity losses before project implementation [kWh/a]
EL_{t+1}	Annual electricity losses after project implementation [kWh/a]
ER	Electrification rate
ES	Quantity of electricity saved annually [kWh/a]
EU	European Union
FC	Financial Cooperation
GL	Anticipated technical grid losses [%]
GTF	Global Tracking Framework
HC	Average annual household consumption [kWh/a]
HS	Average household size [people]
HT	Share of households in total electricity consumption [%]
IEA	International Energy Agency
IHC	Potential increase in the average annual household consumption [kWh/a]
kWh	Kilowatt hour
NC	New connections [number of people]
OAC	Operational assessment criteria
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
PN	Project number
PP	Programme proposal
P_T	Percentage of people with access Tier-T
RQ	Residual annual electricity quantity [kWh/a]
SDG	Sustainable Development Goal
SE4ALL	Sustainable Energy for All
SF	Share of the reporting donors financing in total donor financing
T	Value of the respective access Tier {0,1,2,3,4,5}
TC	Technical Cooperation
ToR	Terms of Reference
TP	Total population
UN	United Nations
UNSD	United Nations Statistics Division

List of Figures

1 Background and Scope of Paper[1]

Access to modern energy services is one of the decisive factors for development and the improvement of living conditions. Currently, more than 1.1bn people do not have access to modern electricity, access to clean cooking is even worse: Still 2.9bn people lack access to non-solid fuels for cooking. The UN-Initiative "Sustainable Energy for All (SE4All)" has given access to modern energy a boost and placed it high on the political agenda. Accordingly, "to ensure access to affordable, reliable, sustainable and modern energy for all" has been proposed to be one of the 17 Sustainable Development Goals (SDGs). The underlying goals coincide mostly with the three objectives of SE4All. As concerns energy access it is to ensure universal access to affordable, reliable and modern energy services by 2030.

Within the framework of SE4All, the World Bank and others developed the Global Tracking Framework (GTF). As concerns energy access, it is one of the great achievements of the GTF to have worked out a multi-tier definition of energy access allowing for a differentiated view on the classical binary perception of having or not having access (see Figure 1 for the case of access to household electricity supply).

Figure 1: Multi-tier Matrix Measuring Access to Household Electricity Supply

			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Attributes	1. Peak capacity	Power	-	V. Low Power Min 5 W	Low Power Min 70 W	Medium Power Min 200 W	High power Min 800 W	V.High Power Min 2 kW
		Daily capacity		Min 20 Wh	Min 274 Wh	Min 1.0 KWh	Min 3.4 KWh	Min 8.2 KWh
	2. Duration	Hours per day	-	Min 4 hrs		Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening	-	Min 2 hrs		Min 2 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability		-			Max 3 disruptions per day	Max 7 disruptions per week	Max 3 disruptions per week of total duration < 2 hours
	4. Quality		-			Voltage problems do not prevent the use of desired appliances		
	5. Affordability		-			Cost of a standard consumption package of 365 kWh per annum is less than 5% of household income		
	6. Legality		-			Bill is paid to the utility / pre-paid card seller / authorized representative		
	7. Health and Safety		-			Absence of past accidents and perception of high risk in the future		

Source: World Bank – GTF 2015.

As contribution to the SE4All-objective, several countries and donors have published their pledges: The European Union aims at contributing access for 500m people; Germany wants to help partner countries to provide 100m additional people with access. Accordingly, new programmes have to be planned and implemented.

During a first international workshop in March 2015, jointly organised by KfW and GIZ, a couple of questions that arise with the monitoring of concrete goals and objectives were discussed: How to calculate and measure the impact of different activities and projects, e.g. for those that

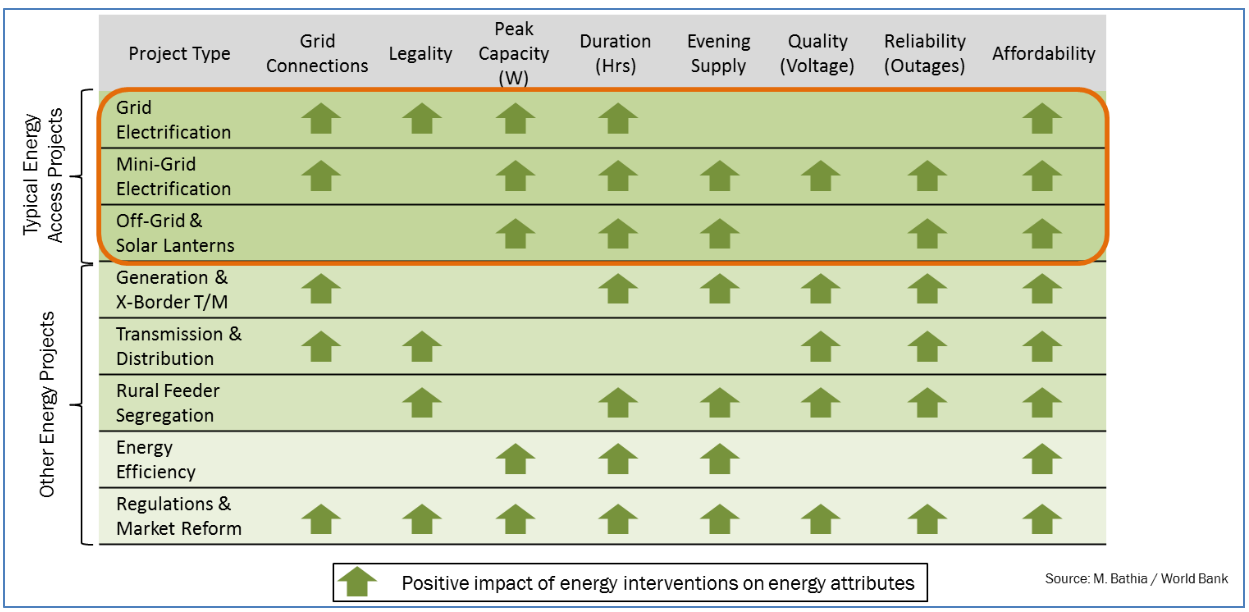
[1] This Discussion Paper is based on an internal study provided by Tim-Patrick Meyer, Consultant for Energy and Development, Frankfurt.

lead to more electricity in the network - such as electricity generation projects or transmission losses reduction programmes? Without doubt there is an energy access impact of such projects for those people that do have a connection but due to supply shortcomings never received electricity. But which number of new access should the project claim? As measurements on the ground in the planning phase of such a project are hardly feasible, there is a need for a calculation methodology.

Another question comprises the way joint financing is taken into account: How do you attribute access impacts to different donors and implementers? Early discussions among stakeholders revealed that double count should be avoided. As far as possible a harmonisation of calculation methodologies amongst donors and implementers should be aimed at.

The current discussion paper focuses on access to modern electricity via on-grid, non-classical access projects, such as generation and transmission projects and energy efficiency projects etc. (see Figure 2). It concentrates on counting the number of households & people. Quantifying the number of productive uses or social services (e.g., such as schools, hospitals, etc.) is important, but not included in this document. Neither is the issue of access to modern cooking services. [2]

Figure 2: Impact of Different Programmes to Improve Access to Modern Electricity



Source: M. Bathia / World Bank.

This discussion paper is providing a proposal of how to calculate access numbers and how to attribute those to different donors. It aims at helping donors in the monitoring of energy access programmes towards the achievement of political goals and objectives as the Sustainable Development Goal on Energy. Reported figures have to be credible and verifiable. Comments and suggestions for the applicability of the proposed methodologies are highly welcome. An Excel-based tool for calculation is available from the authors.

2 These topics will be included in following versions of the discussion paper.

2 Introduction

The following chapters describe the impact logic as well as the method used to calculate the impact of access to electricity for different project[3] types in the electricity sector. The current discussion paper focuses on grid-connected electricity projects. The respective projects can either be carried out directly or indirectly via the financial sector (e.g. credit lines). The measures can be concretely defined ahead of time or, as is the case with open programmes, roughly outlined when preparing the project.

In contrast to e.g. Solar-Home-System projects as “classical access project type” (see Figure 2) on-grid projects often do not directly provided first-time access to electricity. Instead, these are projects that provide indirect contributions and help create the necessary conditions. For instance, building a new power plant increases the availability of electricity / kilowatt hours, which is often the prerequisite for providing new connections and new household use. However, to increase the real number of households with access it may be necessary to expand the distribution grid and the actual physical household connection at the same time the power plant is being built.

When determining the impacts of access to energy, the aim is to capture both the contribution made by the project to providing completely new connections, i.e. raising people from Tier-0 to a higher Tier, as well as to improving the electricity supply of those households that already had access to electricity, i.e., raising people from Tier-1 to a higher Tier.

3 Introduction

3.1 Construction, rehabilitation and modernisation of power plants

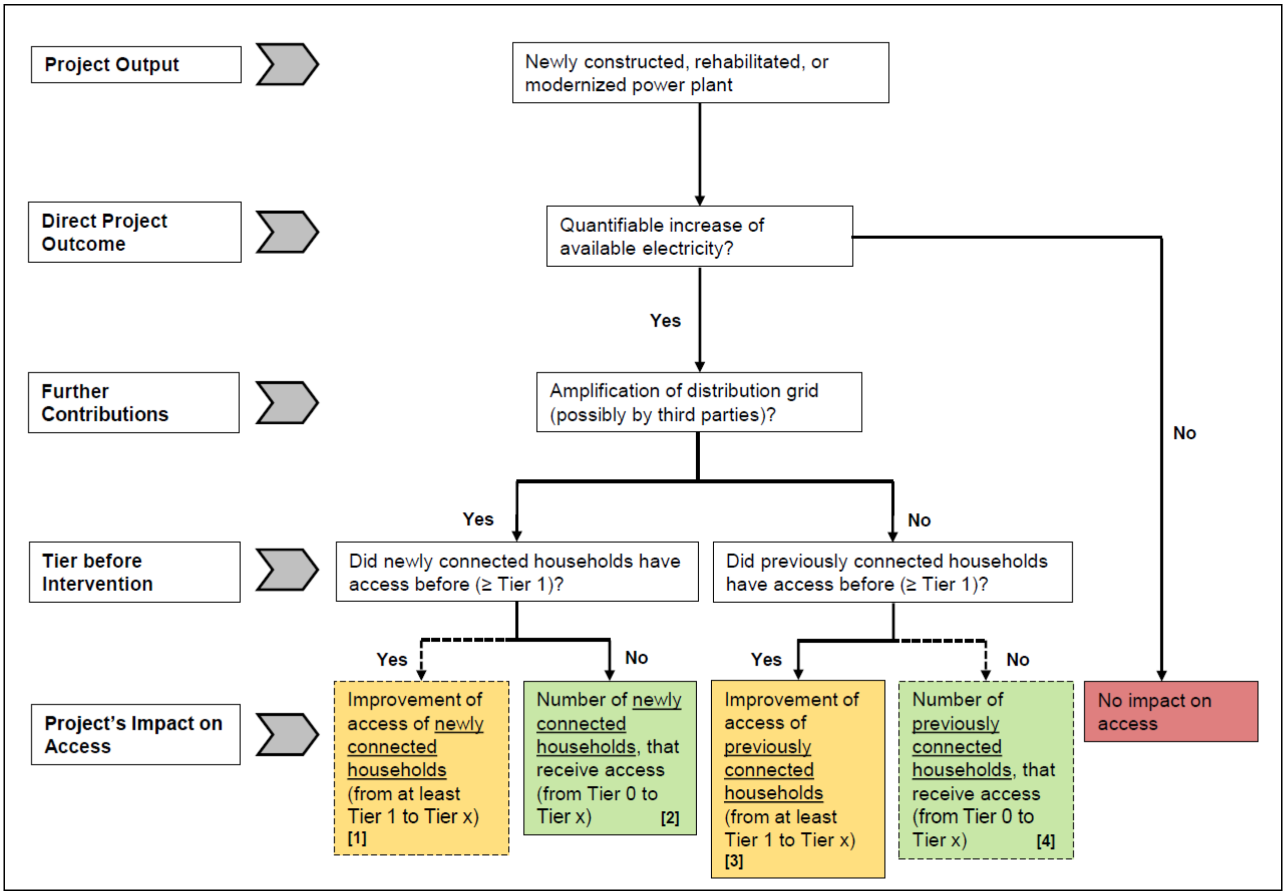
Figure 3 describes the method used to determine the impacts of access to energy to which a contribution can be made by building, rehabilitating and modernising power plants. The individual steps are then described in more detail.

The first step is to assess whether the measure results in an additional quantifiable amount of electricity because otherwise there is no impact of access to energy.

This is generally the case when a new, grid-connected power plant (regardless of the energy source: oil, coal, gas, renewable) is built. If, however, the aim is for a newly built power plant to completely or partially replace an old, existing power plant, the corresponding loss of electricity production must be deducted from the quantity of electricity produced in the new power plant.

3 Please note that in the following, the term “project” is used for describing different forms of interventions, such as programmes, etc. If not otherwise mentioned, the project is considered as the project of the donor that has to report on the access impact of this project, i.e., the “reporting donor’s project”.

Figure 3: Calculation of access impact for projects of construction, rehabilitation and modernisation of power plants



Source: T.-P. Meyer.

When rehabilitating grid-connected power plants, the goal is to maintain existing production capacities that would otherwise have to be decommissioned in the foreseeable future. Because power plants in need of rehabilitation often only generate part of the electricity they originally produced as a result of their condition, the rehabilitation measures generally increase annual electricity production. Rehabilitation can also often increase the installed capacity, which in turn may lead to higher electricity production. Modernisation measures that usually aim to improve a power plant's efficiency can therefore also bring about an increase in electricity production[4]. The increase in annual electricity production is the difference between the (estimated) annual production after rehabilitation and the annual production immediately before rehabilitation.

If an additional quantity of electricity is available, the next step is to determine whether the distribution grids are also being expanded and the number of household connections increased, since this is often the only way to use the additional quantity of electricity for the electrification of new households. For the purposes of this guideline, it was agreed to use a time period of two

4 In isolated cases, there are modernisation measures in power plants that do not lead to an increase in electricity production. One example can be an "Emission Reduction Programme" which aims to reduce dust contamination in coal-fired power plants by installing electrostatic filters.

years starting from initial operation of the power plant (or completion of the rehabilitation or modernisation measures). Expansion of the distribution grids does not have to be financed by the reporting donor, but can also be funded by third parties (other donors, government, etc.).

If the distribution grids are being expanded, it then needs to be determined whether the newly connected households previously had access to electricity. It is theoretically possible that some of the newly connected households already had at least access Tier-1 (see Figure 1) because they previously had an off-grid solution. In this case, it is possible that the access Tier of these households improved as a result of the connection to the electricity grid (min. Tier-1 increased to a higher Tier). This corresponds to path [1] in Figure 3. However, only those consumers that actually have access to electricity for the first time as a result of the electricity connection can be counted as newly created connections (increase from Tier-0 to a higher Tier). This corresponds to path [2]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as an improved supply) are also measured and quantified. If, however, the corresponding information is not available for this step or if an estimate indicates that only an extremely low number of households previously had access to electricity, it should simply be assumed that all newly connected households were previously without access (i.e. Tier-0). The respective path [2] is therefore represented by a solid line while path [1] is shown as a dotted line.

If the distribution grids are not being expanded, it then needs to be determined whether the connected households previously had access to electricity. If so (i.e. the households had at least access Tier-1), the project can play a role in improving the electricity supply of these households and increasing their access Tier. This corresponds to path [3] in Figure 3. It is also possible, however, that among the households that are already connected, some did not have access to electricity despite having an electricity connection. This is the case, e.g. if electricity is actually only available for less than four hours a day (or less than two hours in the evening) due to insufficient production or poor grid condition, meaning that this type of household would be classified as having access Tier-0 despite the grid connection. The additional electricity quantity resulting from the project can play a role in increasing these households from Tier-0 to a higher Tier access, therefore providing them with access to electricity. This corresponds to path [4]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step, it should simply be assumed that all newly connected households also previously had access (i.e. at least Tier-1). The respective path [3] is therefore represented by a solid line while path [4] is shown as a dotted line.

During preparatory projects to initiate a power plant project, e.g. preliminary surveys or potential studies for a geothermal power plant, the number of additionally connected users can only be estimated beforehand based on an assumed power plant output where the energy produced is then divided by the potential customers living in the catchment area. In the case of geothermal power plants, the actual output of a drilled hole can only be determined after the exploratory drilling is complete, and pressure, temperature and productivity tests have been conducted. It is correct that an impact of access to energy cannot be allocated to the measures needed to prepare construction of a power plant because the impact, which actually only occurs after construction, should be allocated to the completed power plant. This would otherwise result in overstated duplications of the impact of access to energy. It applies to all of the following calculations.

Calculating the number of newly created connections

The number of newly created connections (number of people) is calculated using the following formula that is to be applied to path [2] and path [4] in the diagram:

$$NZ = \frac{ZM \times (1 - NV) \times HN}{HV} \times HG$$

where:

NC = New connections [number of people]
AQ = Additional annual electricity quantity [kWh/a]
GL = Anticipated technical grid losses [%][5]
HT = Share of households in total electricity consumption [%]
HC = Average annual household consumption [kWh/a]
HS = Average household size [people][6]

The formula includes the following calculation steps:

First, the additional annual electricity quantity (AQ) is reduced by the technical grid losses (GL) because the lost electricity is not available to create connections. The resulting residual electricity quantity is multiplied by the total percentage of electricity consumed by households (HT) which yields the electricity quantity that can be consumed by households. Dividing the result by the average household consumption (HC) yields the number of households reached. This number still has to be multiplied by the average household size (HS) to determine the number of people reached.

The value for AQ is to be calculated for the project as part of the feasibility study. AQ is often an indicator of target achievement for this kind of project.

Depending on whether a project is being carried out in the national interconnected grid or in an isolated regional grid, the values at country Tier or the respective regional values are to be used for the remaining input parameters. If the latter are not available, they must be estimated using the figures at country Tier.

5 Important: only include technical losses! Non-technical losses (mainly electricity theft but also, e.g. accounting errors) are quantities of electricity that are not billed, but are still used.

6 Data sources (and calculation options) for the necessary input parameters for all formulae if not otherwise stated are listed in chapter 4.3 on page 33.

If the HT and HC parameters cannot be determined, the formula below can also be used to calculate the same results:

$$NZ = \frac{ZM \times (1 - NV) \times AP}{SG}$$

where:

CP = Number of people connected (before project implementation)
AC = Total annual electricity consumption [kWh/a]

Both formulae are based on the following assumptions:

- The additional electricity quantity does not change the distribution of electricity consumption by sector. The same percentage of electricity is available to households in the entire electricity grid both before and after the project implementation.
- Consumption of newly connected households corresponds to the average household consumption in the overall electricity grid. The newly connected households can thus be classified with the respective access Tier according to Figure 1. In reality, it is common for newly connected households to initially use less electricity than the average household. The selected approach therefore slightly underestimates the number of connected households calculated.

Plausibility check:

A plausibility check then has to be performed to compare the calculated number of electricity connections created to the number of people who are to be (in the case of ex-ante estimates) or were connected (in the case of ex-post measurements)[7] to the grid during activities to expand or consolidate the grid. A time period of two years starting from initial operation of the power plant (or completion of the rehabilitation or modernisation measures) is assumed. Only when the calculated value is less than (or equal to) the number of people connected within these two years can the full amount of the calculated value be reported. When the calculated figure of new connections is higher, however, than the number of newly connected people, only the latter figure can be reported as an impact of access to energy[8]. In this case, the entire additional electricity quantity would not be used to create connections, some would also be used to improve the electricity supply of consumers who are already connected.

The number of newly connected people per year can generally be obtained from the electricity supplier, the energy ministry or regulatory authority. Estimates or forecasts have to be used for

---

[7] As already mentioned, the expansion of the distribution grids does not have to be financed by the reporting donor’s funds, but can also be funded by third parties.

[8] The project's impact of access to energy cannot exceed the physical number of people connected to the grid for the first time.

ex-ante calculations of the impact of access to energy. Political targets to increase the number of connections (e.g. from master plans) must be viewed with scepticism because they are often not realistic. An approximate value can also be determined from other concrete electrification programmes of other donors. If there are no figures available through these channels, it is possible to assess the changes in electrification from 2000 to 2010 and estimate the average annual increase.[9] It is important that the resulting numbers are plausible. For example, figures cannot be calculated that would lead to more than 100% electrification (especially in countries that already have a high degree of electrification).

Taking into account the percentage of the reporting donor's financing:

It also needs to be kept in mind that the reporting donor often only contributes part of the funding, which is why the result is still multiplied by the share of the reporting donor financing in total donor financing (SF)[10]. It is important that this last calculation step is applied to the result after the plausibility check is complete because the plausibility check can reduce the calculated result.

Safety margin:

The result then has to be reduced by a safety margin (SM) of 20% that takes into account various potential inaccuracies and sources of error (see also chapter 4.1 on page 32).

After the plausibility check is conducted and the financing percentage and safety margin taken into account, the net result of the number of newly created connections is calculated: NC_n

Calculating the improvement in electricity supply

If the number of new connections calculated is greater than the number of people who are physically connected, the total additional electricity quantity of the project is not used to create new connections. There is thus a residual electricity quantity (RQ) that is used to improve the power supply of all connected households (also the newly connected ones). If no new connections are created, the total electricity quantity is then available to improve supply. The improvement can be quantified by calculating the potential increase in average household consumption using the formula below[11]. The households are thus increased to a higher access Tier according to Figure 1 if applicable. The formula is to be used for path [1] and path [3]:

9 The figures on changes in electrification can be found in the SE4ALL database of the World Bank: http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=sustainable-energy-for-all. Select "Access to electricity (% of total population)", the country and the years specified in this database.

10 It is important that the percentage of financing contributed by reporting donor to the total funding is not used (this also generally includes own contributions of the executing agencies and, if applicable, also loans from commercial banks), but only the percentage of donor funds accounted for by the reporting donor. The reason is that the investment can only be implemented with the aid of donors, and the overall impact is therefore distributed to the various donors.

11 The term "potential" is used here because many other factors affect the average consumption of households.

$$SHV = \frac{VM}{AH + \left(\frac{NZ_n}{HG}\right)}$$

where:

IHC = Potential increase in the average annual household consumption [kWh/a]
RQ = Residual annual electricity quantity [kWh/a]
CH = Number of households connected (before project implementation)
NC_n = New connections (net) [number of people]
HS = Average household size [people]

The formula includes the following calculation steps:

The residual annual electricity quantity (RQ) is divided by the total households connected after project implementation. The number of the households connected after project implementation corresponds to households already connected before project implementation (CH) plus the number of households connected for the first time during project implementation. The latter is calculated on the basis of the net result of the number of new connections (NC_n) divided by the average size of the household (HS). If no new connections were created previously, NC_n = 0.

However, the residual electricity quantity RQ must be calculated first using the following formula:

$$VM = (ZM \times (1 - NV) \times HN \times FA) - \left(\frac{\frac{NZ_n}{HG} \times HV}{(1 - SA)}\right)$$

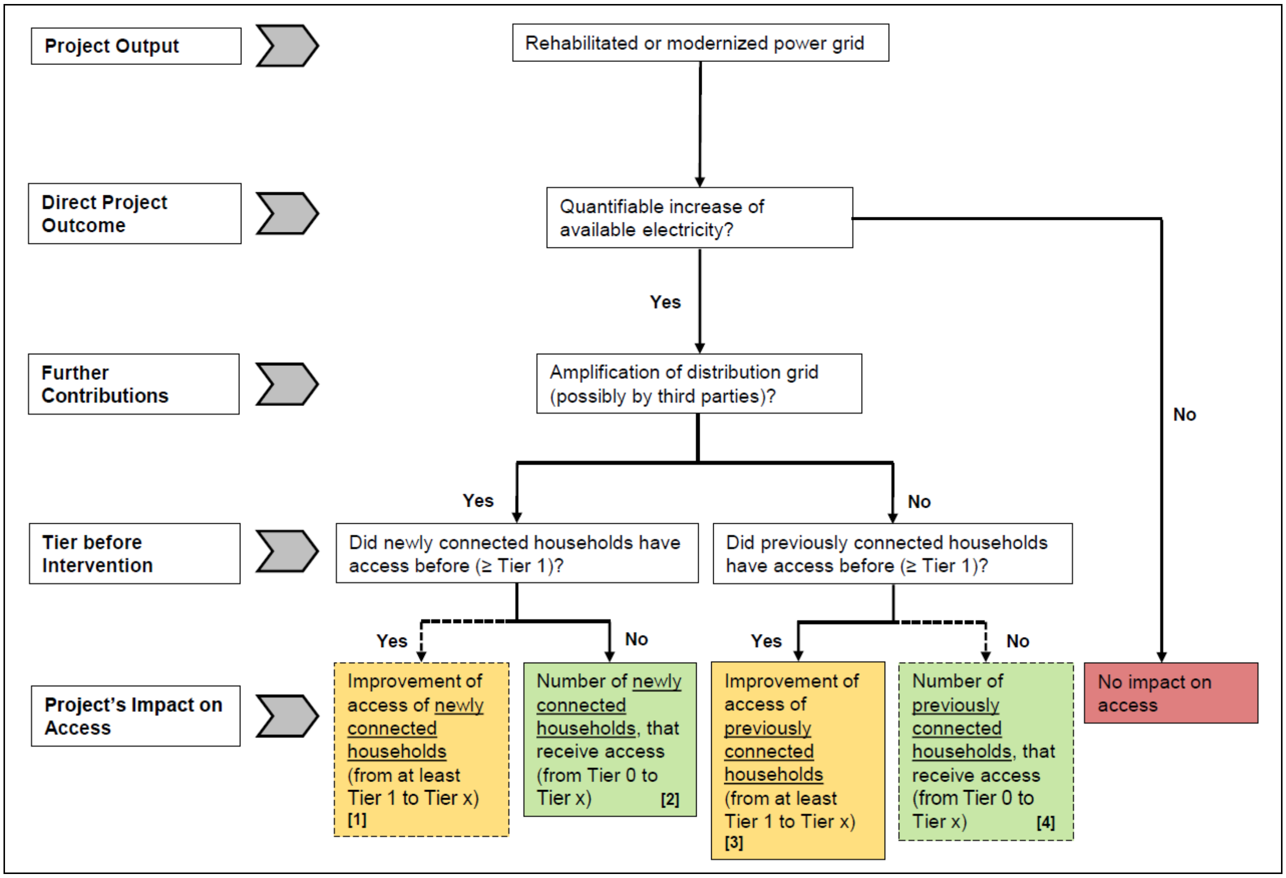
Even though this formula looks somewhat complicated, it is actually quite easy to understand: the original additional electricity quantity of the project (AQ) is first reduced by the grid losses (GL). The total percentage of electricity consumed by households (HT) is then multiplied by the share of the reporting donor financing in total donor financing (SF). The result represents the electricity quantity that is essentially available in the project to create connections and improve the electricity supply at household level and that can be allocated to the reporting donor. The electricity quantity that has already been "consumed" by creating new connections is subtracted from this number. The latter is calculated by first dividing the net result of the number of new connections (NC_n) by the average size of the household (HS). This yields the number of new connections expressed in households. If this figure is multiplied by the average annual household consumption, the result is the electricity quantity that is used to create new connections. This number then has to be divided by the deduction factor for the safety margin (1-SM).

3.2 Rehabilitation and modernisation of transmission and distribution grids

Figure 4 describes the method for determining the impacts of access to energy to which a contribution can be made by rehabilitating and modernising transmission and distribution grids.

The individual steps are then described in more detail. The method is essentially identical to the method used for power plant projects (see chapter 3.1).

Figure 4: Calculation of access impact for projects of rehabilitation and modernisation of transmission and distribution grids



Source: T.-P. Meyer

The first step is to assess whether the measure results in an additional quantifiable amount of electricity because otherwise there is no impact of access to energy.

When rehabilitating and modernising transmission and distribution grids, the goal is to maintain existing lines (and other components such as transformers, etc.) that would otherwise have to be decommissioned in the foreseeable future and to reduce technical grid losses. In some developing countries, the latter can be more than 5% in the transmission grid and more than 15% in the distribution grid, which is why reducing losses can considerably increase the quantity of electricity available.

If an additional quantity of electricity is available, the next step is to determine whether the distribution grids are also being expanded and the number of household connections increased, since this is often the only way to use the additional quantity of electricity for the electrification of new households. For the purposes of this guideline, it is proposed to use a time period of two years starting from the completion of the rehabilitation or modernisation measures. Expansion of the distribution grids does not have to be financed by the reporting donor's funds, but can also be funded by third parties (other donors, government, etc.).

If the distribution grids are being expanded, it then needs to be determined whether the newly connected households previously had access to electricity. It is theoretically possible that some of the newly connected households already had at least access Tier-1 because they previously had an off-grid solution. In this case, it is possible that the access Tier of these households improved as a result of the connection to the electricity grid (min. Tier-1 increased to a higher Tier). This corresponds to path [1] in the Figure 4. However, only those consumers that actually have access to electricity for the first time as a result of the electricity connection can be counted as newly created connections (increase from Tier-0 to a higher Tier). This corresponds to path [2]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step or if an estimate indicates that only an extremely low number of households previously had access to electricity, it should simply be assumed that all newly connected households were previously without access (i.e. Tier-0). The respective path [2] is therefore represented by a solid line while path [1] is shown as a dotted line.

If the distribution grids are not being expanded, it then needs to be determined whether the connected households previously had access to electricity. If so (i.e. the households had at least access Tier-1), the project can play a role in improving the electricity supply of these households and increasing their access Tier. This corresponds to path [3] in Figure 4. It is also possible, however, that among the households that are already connected, some did not have access to electricity despite having an electricity connection. This is the case, e.g. if electricity is actually only available for less than four hours a day (or less than two hours in the evening) due to insufficient production or poor grid condition, meaning that this type of household would be classified as having access Tier-0 despite the grid connection. The additional electricity quantity resulting from the project can play a role in increasing these households from Tier-0 to a higher Tier access, therefore providing them with access to electricity. This corresponds to path [4]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step, it should simply be assumed that all the households which were already connected also previously had access (i.e. at least Tier-1). The respective path [3] is therefore represented by a solid line while path [4] is shown as a dotted line.

Calculating the number of newly created connections

The number of newly created connections (number of people) is calculated using the following formula that is to be applied to path [2] and path [4]:

$$NZ = \frac{(SV_t - SV_{t+1}) \times HN}{HV} \times HG$$

where:

NC = New connections [number of people]
EL_t = Annual electricity losses before project implementation [kWh/a]
EL_{t+1} = Annual electricity losses after project implementation [kWh/a]
HT = Share of households in total electricity consumption [%]
HC = Average annual household consumption [kWh/a][12]
HS = Average household size [people]

The formula includes the following calculation steps:

The annual electricity losses after project implementation (in kWh) are first subtracted from the (higher) annual electricity losses before project implementation. The additionally available electricity quantity calculated this way is multiplied by the percentage of electricity consumed by households (HT) which yields the quantity of electricity that can be consumed by households. Dividing the result by the average household consumption (HC) yields the number of households reached. This number still has to be multiplied by the average household size (HS) to determine the number of people reached.

The values for the electricity losses before and after project implementation are to be calculated for the project as part of the feasibility study. Loss reduction is often an indicator of target achievement for this kind of project.

Depending on whether a project is being carried out in the national interconnected grid or in an isolated regional grid, the values at country level or the respective regional values are to be used for the remaining input parameters. If the latter are not available, they must be estimated using the figures at country level.

If the HT and HC parameters cannot be determined, the formula below can also be used to calculate the same results:

$$NZ = \frac{(SV_t - SV_{t+1}) \times AP}{SG}$$

where:

CP = Number of people connected (before project implementation)
AC = Total annual electricity consumption [kWh/a]

12 Important: when calculating the average household consumption, use the total consumption at household Tier as a basis and divide by the number of households connected. If the total electricity consumption of the country/region (including industry, etc.) and/or the total number of households (including the households that are not connected) is used as a basis, the resulting values are incorrect.

Both formulae are based on the following assumptions:

- The additional electricity quantity does not change the distribution of electricity consumption by sector. The same percentage of electricity is available to households in the entire electricity grid both before and after the project implementation.
- Consumption of newly connected households corresponds to the average household consumption in the overall electricity grid. The newly connected households can thus be classified with the respective access Tier according to Figure 1. In reality, it is common for newly connected households to initially use less electricity than the average household. The selected approach therefore slightly underestimates the number of connected households calculated.

As in the case of projects for construction, rehabilitation and modernisation of power plants a plausibility check has to be made, the percentage of the reporting donor's financing share has to be taken into account and a safety margin has to be deducted (see chapter 3.1).

Calculating the improvement in electricity supply

If the number of new connections calculated is greater than the number of people who are physically connected, the total additional electricity quantity of the project is not used to create new connections. There is thus a residual electricity quantity (RQ) that is used to improve the power supply of all connected households (also the newly connected ones). If no new connections are created, the total electricity quantity is then available to improve supply. The improvement can be quantified by calculating the potential[13] increase in the average household consumption using the formula below. The households are thus increased to a higher access Tier according to Figure 1 if applicable. The formula is to be used for path [1] and path [3] in Figure 4:

$$SHV = \frac{VM}{AH + \left(\frac{NZ_n}{HG}\right)}$$

where:

IHC = Potential increase in the average annual household consumption [kWh/a]
RQ = Residual annual electricity quantity [kWh/a]
CH = Number of households connected (before project implementation)
NC_n = New connections (net) [number of people]
HS = Average household size [people]

The formula includes the following calculation steps:

13 The term "potential" is used here because many other factors affect the average consumption of households.

The residual annual electricity quantity (RQ) is divided by the total households connected after project implementation. The number of the households connected after project implementation corresponds to households already connected before project implementation (CH) plus the number of households connected for the first time during project implementation. The latter is calculated on the basis of the net result of the number of new connections (NC_n) divided by the average size of the household (HS). If no new connections were created previously, $NC_n = 0$.

However, the residual electricity quantity RQ must be calculated first using the following formula:

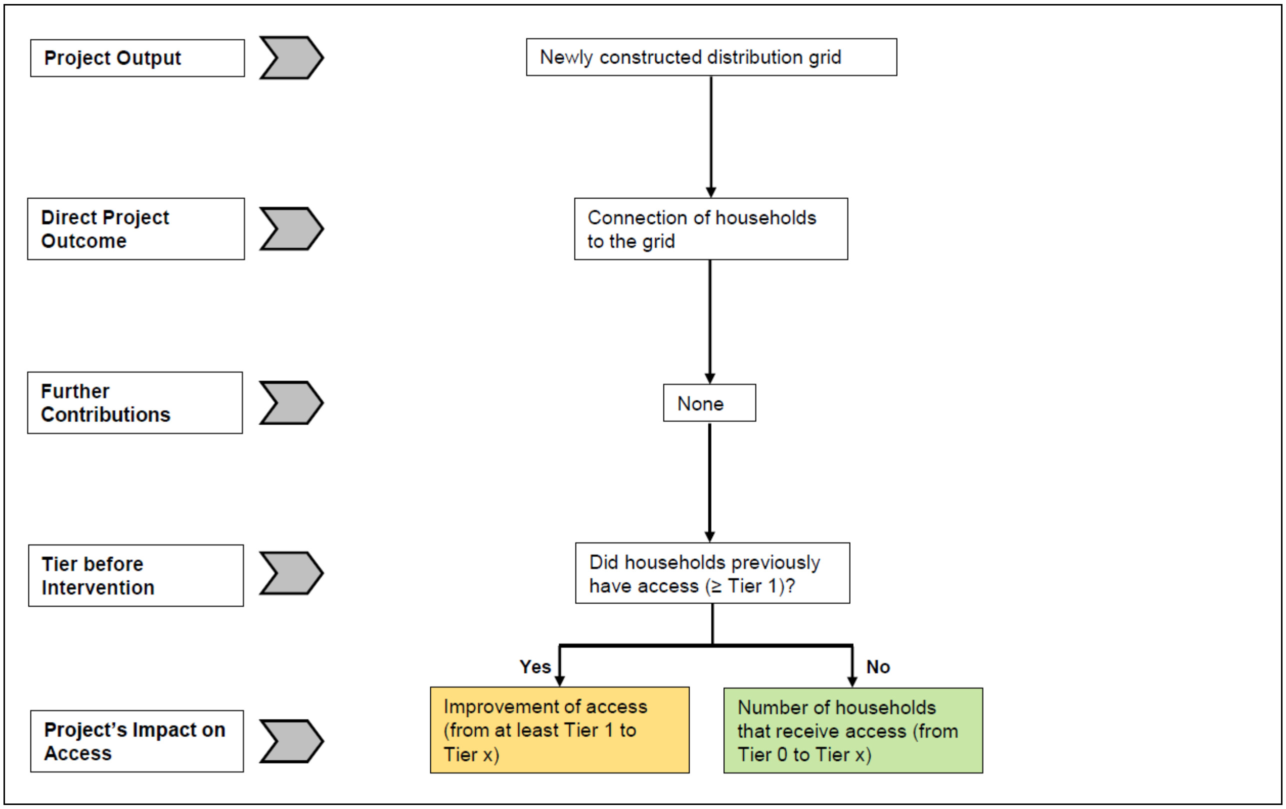
$$VM = (ZM \times HN \times FA) - \left(\frac{\frac{NZ_n}{HG} \times HV}{(1 - SA)} \right)$$

Even though this formula looks somewhat complicated, it is actually quite easy to understand: the original additional electricity quantity of the project (AQ) is first multiplied by the total percentage of electricity consumed by households (HT) and the share of the reporting donor's financing in total donor financing (SF). The result represents the electricity quantity that is essentially available in the project to create connections and improve the electricity supply at household Tier and that can be allocated to the reporting donor. The electricity quantity that has already been "consumed" by creating new connections is subtracted from this number. The latter is calculated by first dividing the net result of the number of new connections (NC_n) by the average size of the household (HS). This yields the number of new connections expressed in households. If this figure is multiplied by the average annual household consumption, the result is the electricity quantity that is used to create new connections. This number then has to be divided by the deduction factor for the safety margin (1-SM).

3.3 Building new distribution grids

Figure 5 describes the method for determining the impacts of access to energy when new distribution grids are built.

Figure 5: Calculation of access impact for projects of new distribution grids



Source: T.-P. Meyer

The method used to determine the impact of access to energy is relatively easy for projects involving the construction of new distribution grids because the number of new households connected via the distribution grid should be known. The access Tier of these households before the project implementation is the only information that needs to be checked. This is likely to be access Tier-0 in most cases, whereby new connections to electricity are created through the project. It is, however, possible, that some households, for example, used battery-powered lamps before the project implementation and therefore already had access Tier-1. In these cases, the measure can lead to an improvement in electricity supply. The number of people for whom access is created or whose electricity supply is improved is determined by multiplying the respective number of households that benefit from the measure by the average size of the household.

It is assumed here that the consumption of the newly connected households corresponds to the average household consumption in the entire electricity grid and the necessary electricity quantity is provided by a corresponding increase in capacity or increased utilisation of the capacity of existing power plants[14]. The newly connected households can thus be classified with the respective access Tier according to Figure 1. In reality, it is common for newly connected

14 This assumption can be made because in a normal case distribution grids are only then built when enough electricity is available to supply the newly connected households.

households to initially use less electricity than the average household. The selected approach therefore slightly underestimates the number of connected households calculated.

As in the case of projects described above the percentage of the reporting donor's financing share has to be taken into account and a safety margin has to be deducted (see chapter 3.1). A plausibility check is not necessary as data are gathered in the course of project preparation.

3.4 Building new transmission lines

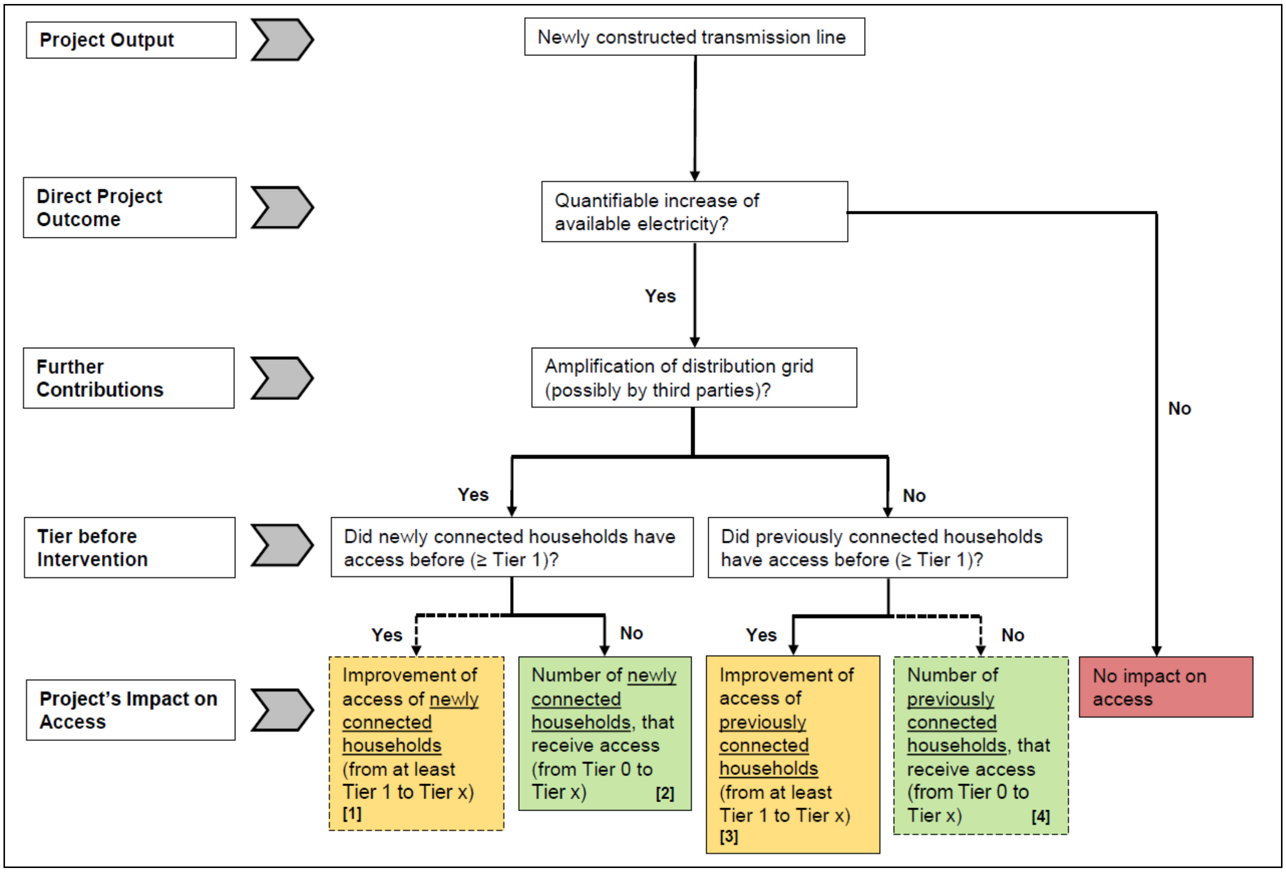
New transmission lines can be built for various reasons and therefore bring about different impacts of access to energy. A distinction is made here between the following three scenarios:

1) By replacing old transmission lines or relieving the strain on other lines, technical losses are reduced and the available quantity of electricity increases.
2) The transmission line connects a new power plant (that was built by a third party) to the interconnected grid (or an isolated grid), and thus makes the additional electricity quantity of the power plant available.
3) The transmission line connects a grid that was previously isolated to the interconnected grid resulting in more available electricity.[15]

In all three cases, the new transmission line contributes to increasing the available quantity of electricity. In the first case, the additional electricity quantity is a direct result of the project. In both other cases, an additional electricity quantity is made available to users as a result of the transmission line. The impact logic therefore basically follows the same logic as already described in chapters 3.1 and 3.2. The main difference is that in cases 2 and 3, the impact of access to energy can only be proportionally allocated to the reporting donor.

[15] It is assumed here that the electricity quantity in the interconnected grid increases overall because capacities are added or the capacity utilisation of existing power plants increased. The assumption can be made because normally then also previously isolated grids are connected.

Figure 6: Calculation of access impact for projects of new transmission lines



Source: T.-P. Meyer

Figure 6 describes first the basic method used to determine the impacts of access to energy to which a contribution can be made by building new transmission lines.

The first step is to assess whether the measure results in an additional quantifiable amount of electricity because otherwise there is no impact of access to energy. As already described above, a new transmission line can contribute in different ways.

If an additional quantity of electricity is available, the next step is to determine whether the distribution grids are also being expanded and the number of household connections increased, since this is often the only way to use the additional quantity of electricity for the electrification of new households. For the purposes of this guideline, it proposed to use a time period of two years starting from initial operation of the power plant (or completion of the rehabilitation or modernisation measures). Expansion of the distribution grids does not have to be financed by the reporting donor, but can also be funded by third parties (other donors, government, etc.).

If the distribution grids are being expanded, it then needs to be determined whether the newly connected households previously had access to electricity. It is theoretically possible that some of the newly connected households already had at least access Tier-1 because they previously had an off-grid solution. In this case, it is possible that the access Tier of these households improved as a result of the connection to the electricity grid (min. Tier-1 increased to a higher Tier). This corresponds to path [1] in the diagram. However, only those consumers that actually have access to electricity for the first time as a result of the electricity connection can be counted as newly created connections (increase from Tier-0 to a higher Tier). This corresponds to path [2] in the diagram. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step, it should simply be assumed that all newly connected households previously did not have access (i.e. Tier-0). The respective path [2] is therefore represented by a solid line in the diagram while path [1] is shown as a dotted line.

If the distribution grids are not being expanded, it then needs to be determined whether the connected households previously had access to electricity. If so (i.e. the households had at least access Tier-1), the project can play a role in improving the electricity supply of these households and increasing their access Tier. This corresponds to path [3] in Figure 6. It is also possible, however, that among the households that are already connected, some did not have access to electricity despite having an electricity connection. This is the case, e.g. if electricity is actually only available for less than four hours a day (or less than two hours in the evening) due to insufficient production or poor grid condition, meaning that this type of household would be classified as having access Tier-0 despite the grid connection. The additional electricity quantity resulting from the project can play a role in increasing these households from Tier-0 to a higher Tier access, therefore providing them with access to electricity. This corresponds to path [4]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step, it should simply be assumed that all newly connected households also previously had access (i.e. at least Tier-1). The respective path [3] is therefore represented by a solid line while path [4] is shown as a dotted line.

Calculating the number of newly created connections

The number of newly created connections (number of people) is calculated using the following formulae that are to be applied to path [2] and path [4]. The formula is slightly different depending on the case.

For case 1 (reduction of technical losses by replacing old transmission lines or relieving the strain on other lines), the following formula applies:

$$NZ = \frac{ZM \times HN}{HV} \times HG$$

where:

NC = New connections [number of people]
AQ = Additional annual electricity quantity [kWh/a]

HT = Share of households in total electricity consumption [%]
HC = Average annual household consumption [kWh/a][16]
HS = Average household size [people]

The formula includes the following calculation steps:

The additionally available annual electricity quantity (AQ) is multiplied by the percentage of Share of households in total electricity consumption (HT) which yields the quantity of electricity that can be consumed by households. Dividing the result by the average household consumption (HC) yields the number of households reached. This number still has to be multiplied by the average household size (HS) to determine the number of people reached.

For case 2 (connection of new power plants) and case 3 (connection of a previously isolated grid), the following formula is to be used:

$$NZ = \frac{ZM \times (1 - NV) \times HN}{HV} \times HG$$

In addition to the formula parameters above, the following also applies:

GL = Anticipated technical grid losses [%][17]

Here, the additional annual electricity quantity (AQ) first has to be reduced by the technical grid losses (GL) because the electricity lost as a result is not available for creating connections. This step is not necessary for case 1 because the additional electricity quantity here is precisely the result of reducing loss in the grid. The remaining calculation steps are identical to the formula for case 1: the residual electricity quantity after the technical losses have been deducted is multiplied by the percentage of electricity consumed by households (HT) which yields the quantity of electricity that can be consumed by households. Dividing the result by the average household consumption (HC) yields the number of households reached. This number still has to be multiplied by the average household size (HS) to determine the number of people reached.

16 Important: when calculating the average household consumption, use the total consumption at household level as a basis and divide by the number of households connected. If the total electricity consumption of the country/region (including industry, etc.) and/or the total number of households (including the households that are not connected) is used as a basis, the resulting values are incorrect.

17 Important: only include technical losses! Non-technical losses (mainly electricity theft but also, e.g. accounting errors) are quantities of electricity that are not billed, but still used.

The value for AQ is calculated differently depending on the case:

For case 1: the additional electricity quantity is calculated from the reduction of technical losses and is to be calculated for the project as part of the feasibility study. AQ is often an indicator of target achievement for this kind of project.

For case 2: the additional electricity quantity stems from a newly constructed power plant which is connected to the grid via a transmission line. The design of the line is directly dependent on the power plant's output and electricity production, which is why the respective figures would have to be taken from the feasibility study for the project.

For case 3: here, the additional electricity quantity originates from the interconnected grid to which a previously isolated grid is connected via the new transmission line. In this case as well, the design of the line depends on the planned electricity transmission, which is why figures on the additionally available electricity quantity (in the previously isolated grid) would also have to be taken from the feasibility study for the project.

Depending on whether a project is being carried out in the national interconnected grid or in an isolated regional grid, the values at country level or the respective regional values are to be used for the remaining input parameters. If the latter are not available, they must be estimated using the figures at country level.

If the variables HT and HC cannot be determined, the formulae below can also be used to calculate the same results:

For case 1:

$$NZ = \frac{ZM \times AP}{SG}$$

For cases 2 and 3:

$$NZ = \frac{ZM \times (1 - NV) \times AP}{SG}$$

where:

CP = Number of people connected (before project implementation)
AC = Total annual electricity consumption [kWh/a]

Both formulae are based on the following assumptions:

- The additional electricity quantity does not change the distribution of electricity consumption by sector. The same percentage of electricity is available to households in the entire electricity grid both before and after the project implementation.

- Consumption of newly connected households corresponds to the average household consumption in the overall electricity grid. The newly connected households can thus be classified with the respective access Tier according to Figure 1. In reality, it is common for newly connected households to initially use less electricity than the average household. The selected approach therefore slightly underestimates the number of connected households calculated.

Plausibility check:

As described above, a plausibility check has to be made for these kinds of projects and a safety margin has to be deducted as a final step (see chapter 3.1).

Taking into account the percentage of the reporting donor’s financing:

For cases 2 and 3, taking into account the percentage of reporting donor’s financing, it can also be determined which percentage of the overall impact of access to energy (to which third parties also contributed to increasing the electricity quantity) can be allocated to the reporting donor.

For case 2, the transmission line must be viewed as a "total package" together with the power plant it connects. The reporting donor’s financing for the transmission line therefore has to be divided by the total donor contributions for the power plant and line to calculate the percentage of the reporting donor’s financing. This is the only way to ensure that the impact of access to energy is correctly allocated to the reporting donor as a percentage.

For case 3, it is more difficult to determine the percentage of the reporting donor’s financing in the "total package" (from the transmission line and the increase in the quantity of electricity) because it is often not clear where the additional electricity quantity stems from. It is possible (depending on the country and the region) that the additional electricity quantity is provided without new investments by increasing the capacity utilisation of existing power plants. In view of this, it is proposed that - if no more detailed information on the origin and financing of the additional electricity quantity exists - only the percentage of the reporting donor’s financing of the transmission line is used. If, however, it is known that the additional electricity quantity is provided by a specific new power plant, the following method is to be used for case 2 (see previous paragraph).

Calculating the improvement in electricity supply

If the number of new connections calculated is greater than the number of people who are physically connected for the first time, the total additional electricity quantity of the project is not used to create new connections. There is thus a residual electricity quantity (RQ) that is used to improve the power supply of all connected households (also the newly connected ones). If no new connections are created, the total electricity quantity is then available to improve supply. The improvement can be quantified by calculating the potential[18] increase in the average household consumption using the formula below. The households are thus increased to a

[18] The word "potential" is used here because many other factors affect the average consumption of households.

higher access Tier according to Figure 1 if applicable. The formula is to be used for path [1] and path [3]:

$$SHV = \frac{VM}{AH + \left(\frac{NZ_n}{HG}\right)}$$

where:

IHC = Potential increase in the average annual household consumption [kWh/a]
RQ = Residual annual electricity quantity [kWh/a]
CH = Number of households connected (before project implementation)
NC_n = New connections (net) [number of people]
HS = Average household size [people]

The formula includes the following calculation steps:

The residual annual electricity quantity (RQ) is divided by the total households connected after project implementation. The number of the households connected after project implementation corresponds to households already connected before project implementation (CH) plus the number of households connected for the first time during project implementation. The latter is calculated on the basis of the net result of the number of new connections (NC_n) divided by the average size of the household (HS). If no new connections were created previously, NC_n = 0.

However, the residual electricity quantity RQ must be calculated first. The formula is slightly different depending on the case (see paragraph 1 of this section).

For case 1 (reduction of technical losses by replacing old transmission lines or relieving the strain on other lines), the following formula applies:

$$VM = (Z \times HN \times FA) - \left(\frac{\frac{NZ_n}{HG} \times HV}{(1 - SA)}\right)$$

For case 2 (connection of new power plants) and case 3 (connection of a previously isolated grid), the following formula is to be used:

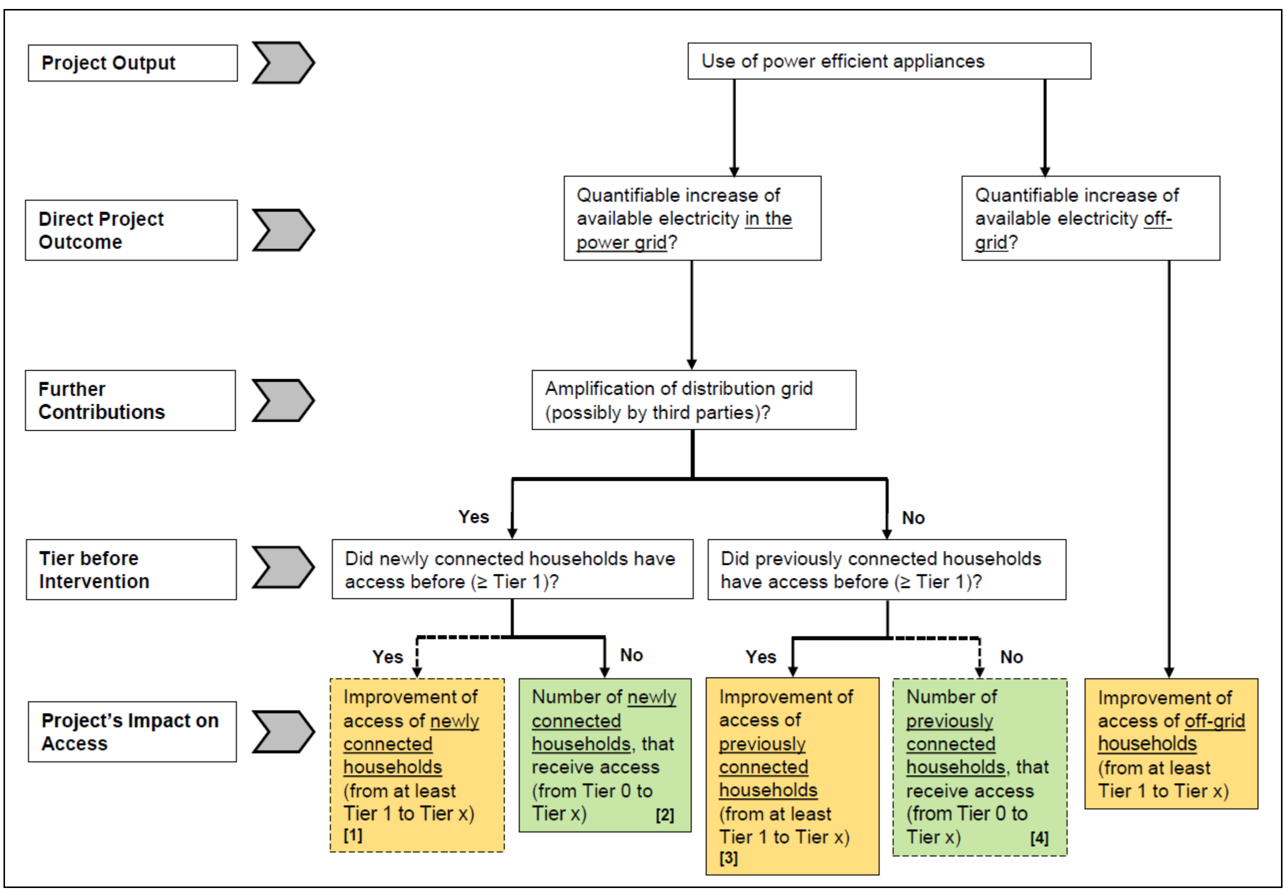
$$VM = (ZM \times (1 - NV) \times HN \times FA) - \left(\frac{\frac{NZ_n}{HG} \times HV}{(1 - SA)}\right)$$

Even though these formulae look somewhat complicated, they are actually quite easy to understand: the original additional electricity quantity of the project (AQ) is first multiplied by the total percentage of electricity consumed by households (HT) and the share of German DC-financing in total donor financing (SF). For case 2, the technical grid losses (GL) are also deducted. The result represents the electricity quantity that is essentially available in the project to create connections and improve the electricity supply at household level and that can be allocated to the reporting donor. The electricity quantity that has already been "consumed" by creating new connections is subtracted from this number. The latter is calculated by first dividing the net result of the number of new connections (NC_n) by the average size of the household (HS). This yields the number of new connections expressed in households. If this figure is multiplied by the average annual household consumption, the result is the electricity quantity that is used to create new connections. This number then has to be divided by the deduction factor for the safety margin (1-SM).

3.5 Demand-side increase in electricity efficiency

Figure 7 describes the method used to determine the impacts of access to energy to which a contribution can be made by a demand-side increase in electricity efficiency. The method is essentially identical to the method used for power plant projects (see chapter 3.1).

Figure 7: Calculation of access impact for projects of demand-side energy efficiency



Source: T.-P. Meyer

Measures for a demand-side increase in energy efficiency increase the available quantity of electricity by reducing electricity consumption. If the efficiency measures are carried out for consumers without grid connections (i.e. outside of the electricity grid; e.g. for households with solar home systems), the reduction in consumption can also make it possible to use additional devices or extend the duration of use and thus contribute to increasing the access Tier of the consumers.

If the efficiency measures are carried out for consumers with grid connections (i.e. inside the electricity grid), the additionally available electricity quantity can be used to create access for new households or to improve the electricity supply of households that are already connected. The next step here is to determine whether the distribution grids are also being expanded and the number of household connections increased since this is often the only way to use the additional quantity of electricity for the electrification of new households. For the purposes of this guideline, it was agreed to use a time period of two years starting from the completion of the project measures. Expansion of the distribution grids does not have to be financed by reporting donor's funds, but can also be funded by third parties (other donors, government, etc.).

If the distribution grids are being expanded, it then needs to be determined whether the newly connected households previously had access to electricity. It is theoretically possible that some of the newly connected households already had at least access Tier-1 because they previously had an off-grid solution. In this case, it is possible that the access Tier of these households improved as a result of the connection to the electricity grid (min. Tier-1 increased to a higher Tier). This corresponds to path [1] in Figure 7. However, only those consumers that actually have access to electricity for the first time as a result of the electricity connection can be counted as newly created connections (increase from Tier-0 to a higher Tier). This corresponds to path [2]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step, it should simply be assumed that all newly connected households previously did not have access (i.e. Tier-0). The respective path [2] is therefore represented by a solid line while path [1] is shown as a dotted line.

If the distribution grids are not being expanded, it then needs to be determined whether the connected households previously had access to electricity. If so (i.e. the households had at least access Tier-1), the project can play a role in improving the electricity supply of these households and increasing their access Tier. This corresponds to path [3]. It is also possible, however, that among the already connected households, there are households that did not have access to electricity despite having an electricity connection. This is the case, e.g. if electricity is actually only available for less than four hours a day (or less than two hours in the evening) due to insufficient production or poor grid condition, meaning that this type of household would be classified as having access Tier-0 despite the grid connection. The additional electricity quantity resulting from the project can play a role in increasing these households from Tier-0 to a higher Tier, therefore providing them with access to electricity. This corresponds to path [4]. It is not unlikely that both cases ultimately exist, and it is important that the two impacts (new connections as well as improvements in supply) are also measured and quantified. If, however, the corresponding information is not available for this step, it should simply be assumed that all newly connected households also previously had access (i.e. at least Tier-1). The respective path [3] is therefore represented by a solid line while path [4] is shown as a dotted line.

Calculating the number of newly created connections

The number of newly created connections (number of people) is calculated using the following formula that is to be applied to path [2] and path [4] in the diagram:

$$NZ = \frac{EM \times HN}{HV} \times HG$$

where:

NC = New connections [number of people]
ES = Quantity of electricity saved annually [kWh/a]
HT = Share of households in total electricity consumption [%]
HC = Average annual household consumption [kWh/a][19]
HS = Average household size [people]
The formula includes the following calculation steps:

The quantity of electricity saved annually (AS) is multiplied by the percentage of Share of households in total electricity consumption (HT) which yields the quantity of electricity that can be consumed by households. Dividing the result by the average household consumption (HC) yields the number of households reached. This number still has to be multiplied by the average household size (HS) to determine the number of people reached.

The value for the quantity of electricity saved annually is to be calculated for the project as part of the feasibility study. Electricity saving is often an indicator of target achievement for this kind of project.

Depending on whether a project is being carried out in the national interconnected grid or in an isolated regional grid, the values at country level or the respective regional values are to be used for the remaining input parameters. If the latter are not available, they must be estimated using the figures at country level.

If the HT and HC parameters cannot be determined, the formula below can also be used to calculate the same results:

[19] Important: when calculating the average household consumption, use the total consumption at household level as a basis and divide by the number of households connected. If the total electricity consumption of the country/region (including industry, etc.) and/or the total number of households (including the households that are not connected) is used as a basis, the resulting values are incorrect.

$$NZ = \frac{EM \times AP}{SG}$$

where:

CP = Number of people connected (before project implementation)
AC = Total annual electricity consumption [kWh/a]

Both formulae are based on the following assumptions:

- The additional electricity quantity does not change the distribution of electricity consumption by sector. The same percentage of electricity is available to households in the entire electricity grid both before and after the project implementation.

- Consumption of newly connected households corresponds to the average household consumption in the overall electricity grid. The newly connected households can thus be classified with the respective access Tier according to Figure 1. In reality, it is common for newly connected households to initially use less electricity than the average household. The selected approach therefore slightly underestimates the number of connected households calculated.

As in the case of projects for construction, rehabilitation and modernisation of power plants a plausibility check has to be made, the percentage of the reporting donor’s financing share has to be taken into account and a safety margin has to be deducted (see chapter 3.1).

Calculating the improvement in electricity supply

If the number of new connections calculated is greater than the number of people who are physically connected, the total additional electricity quantity of the project is not used to create new connections. There is thus a residual electricity quantity (RQ) that is used to improve the power supply of all connected households (also the newly connected ones). If no new connections are created, the total electricity quantity is then available to improve supply. The improvement can be quantified by calculating the potential[20] increase in the average household consumption using the formula below. The households are thus increased to a higher access Tier according to Figure 1 if applicable. The formula is to be used for path [1], path [3] and path [5]:

$$SHV = \frac{VM}{AH + \left(\frac{NZn}{HG}\right)}$$

[20] The term "potential" is used here because many other factors affect the average consumption of households.

where:

IHC = Potential increase in the average annual household consumption [kWh/a]
RQ = Residual annual electricity quantity [kWh/a]
CH = Number of households connected (before project implementation)
NC_n = New connections (net) [number of people]
HS = Average household size [people]

The formula includes the following calculation steps:

The residual annual electricity quantity (RQ) is divided by the total households connected after project implementation. The number of the households connected after project implementation corresponds to households already connected before project implementation (CH) plus the number of households connected for the first time during project implementation. The latter is calculated on the basis of the net result of the number of new connections (NC_n) divided by the average size of the household (HS). If no new connections were created previously, NC_n = 0.

However, the residual electricity quantity RQ must be calculated first using the following formula:

$$VM = (ZM \times HN \times FA) - \left(\frac{\frac{NZ_n}{HG} \times HV}{(1-SA)} \right)$$

Even though this formula looks somewhat complicated, it is actually quite easy to understand: the original additional electricity quantity of the project (AQ) is first multiplied by the total percentage of electricity consumed by households (HT) and the share of the reporting donor's financing in total donor financing (SF). The result represents the electricity quantity that is essentially available in the project to create connections and improve the electricity supply at household level and that can be allocated to the reporting donor. The electricity quantity that has already been "consumed" by creating new connections is subtracted from this number. The latter is calculated by first dividing the net result of the number of new connections (NC_n) by the average size of the household (HS). This yields the number of new connections expressed in households. If this figure is multiplied by the average annual household consumption, the result is the electricity quantity that is used to create new connections. This number then has to be divided by the deduction factor for the safety margin (1-SM).

3.6 Combined forms of the project types above

There are often combined forms of the project types above, particularly in the case of credit lines. For example, some credit lines fund projects for renewable electricity production and measures to increase demand-side electricity efficiency. In these cases, the respective components for carrying out the calculations are to be considered separate projects. The respective impacts of access to energy can then be added together for the project as a whole.

To use this method, however, it must be known which percentage of the funds provided is reserved for which project approach in the overall project.

4 General Aspects

4.1 Safety margin for inaccuracies

As already mentioned in chapter **Error! Reference source not found.**, calculations of impacts of access to energy are based partially on estimated input parameters and therefore contain certain inaccuracies. The inaccuracies are generally greater for ex-ante estimates than for ex-post calculations. The sources of and reasons for these kinds of inaccuracies include:

- inaccurate forecasts of electricity yields, prevented losses or saved quantities of electricity;
- insufficient information about the exact percentage of total losses accounted for by technical losses;
- imprecise information or calculations on average household consumption;
- inaccurate household size because current figures are not available in many countries;
- input parameters for calculations that often stem from different years and sources and deviate from one another;
- different percentage of electricity consumed by households in the project region compared to the national level.

The sources of inaccuracies listed above can make the calculated result higher or lower and are likely to more or less cancel each other out over a number of projects.

However, there are also sources of error that generally lead to an overestimation of the impact of access to energy, e.g.:

- the assumption that the entire additional electricity quantity is initially used[21] by newly connected households in projects involving grid-connected electricity supply;
- uncertainty about the access level of the target group before a project starts.[22]

The impact of access to energy is generally underestimated, on the other hand, when it is assumed that the newly connected households consume the same on average as the households that are already connected. In reality, newly connected households usually use less electricity initially than the average household[23]. The selected approach therefore slightly underestimates the number of connected households calculated.

To adequately account for all of the uncertain factors and sources of error mentioned above, a safety margin of 20% is applied to all calculated results for the number of new connections for all projects that reduces the result accordingly.

21 As long as the number of new households actually connected is not exceeded.

22 The impact of access to energy is sometimes overestimated because it is often assumed that the newly connected households previously had access Tier-0.

23 This is due to the fact that they only buy devices that consume electricity little by little and are generally poorer.

4.2 Dealing with duplicate allocation

For the time being, duplicate allocation of access impact to different donors occurs. The following section identifies various causes of duplicate allocation and how it should be handled:

1) Development projects are often co-financed by various donors. It is still general practice that every donor, regardless of how much he contributes to financing, to take credit for the entire impact of access to energy. The aim is to eliminate the cause of duplicate allocation under the scope of all donors by taking into account the percentage of the reporting donor's financing as described above.

2) The assumption is that the entire additional electricity quantity is initially used by newly connected households in projects involving grid-connected electricity supply. While this may apply for calculations for individual projects even after the plausibility check is conducted, it may look different when considering multiple projects funded by different donors: the aggregated number of new connections calculated can exceed the number of new people physically connected in these cases. The different donors would have to split the impact of access to energy accordingly here to be correct. Because this kind of coordinated process does currently not exist among donors, this effect is taken into account by applying a safety margin to the calculated results (see chapter 4.1).

3) Impacts of access to energy are often not brought about solely by the interventions of individual donors. For example, creating access to electricity by building a new power plant requires the distribution grids (connection of households) to be expanded at the same time, an activity that is often carried out by other donors. The result is that both the donor who financed the power plant as well as the donor who financed the household connections take credit for the entire impact of access to energy. There is currently no way to generally determine impacts of access to energy because there is no close donor coordination. With this in mind, it is extremely important to make it clear that the impact of access to energy (in most cases) is not achieved solely through the reporting donor's project. Instead the reporting donor's project contributes to creating connections or improving electricity supply. impacts of access to energy are to be worded, for example, as follows:

   "The project has created a key prerequisite for enabling x million people to gain access to electricity for the first time. The average access level created for these people corresponds to level X of the Global Tracking Framework of the SE4ALL initiative. In addition, the reporting donor's project contributed to increasing the average electricity consumption of the X million households that already had access to electricity from X kWh to X kWh."

4.3 Data sources

A number of input numbers are needed for the calculations on creating new connections and improving the electricity supply described in chapter **Error! Reference source not found.**. This section shows which data sources the information necessary can be taken from.

It can generally be said that projects for which a PP was already created can provide some of the data necessary, particularly in the PP problem analysis and the sector analysis (part A). The project-specific (part B) and sector-related (part A) report (if it already exists) may also contain necessary data.

Current figures can usually also be obtained from the grid operator, the energy minister or the regulatory authority of the respective country. If this is not possible, or if no usable figures exist, the following data sources can be used. Please note that figures in different sources deviate in part from one another. To achieve a high level of consistency for the calculation results, as few different sources should be used as possible. The figures should also be from the same year if possible.

CH = Number of households connected (before project implementation)

No databases containing information on the number of connected households were identified. The estimated number of households connected, however, can be calculated by dividing the number of people connected (see CP) by the average household size (see HS).

CP = Number of people connected (before project implementation)

The number of people connected to the electricity grid in a country is easy to calculate by multiplying the electrification rate (ER) from the SE4ALL database of the World Bank24 by the number of the total population (TP)[25].

HT = Share of households in total electricity consumption [%]

The percentage of electricity consumed by households can be calculated on the basis of the IEA Energy Statistics: to do this, divide "Residential" by "Final Consumption" in the "Electricity" column of the respective country. The IEA Energy Statistics are available for OECD countries and non-OECD countries and accessible via the Energy CC.

For countries not included in the IEA Energy Statistics (this includes, e.g. some African countries), the percentage of electricity consumed by households can be calculated using the energy balances of the United Nations Statistics Division (http://unstats.un.org/UNSD/energy/balance/default.htm): to do this, divide the value for "Households" by "Final consumption" in the "Electricity" column in the energy balance of the

[24] It is important that the SE4ALL database is actually used here and not the general World Bank database. At the time this guideline was created, it also contained figures on electrification rate that were, however, incomplete and in some cases varied considerably from the figures in the SE4ALL database. The SE4ALL database can be found at the following link: http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=sustainable-energy-for-all. Select "Access to electricity (% of total population)" in the database. It should also be mentioned here that these figures may also contain off-grid solutions for electricity access, but they are usually hardly of consequence. If there is still a potentially resulting error, it is accounted for by the safety margin.

[25] Figures for the total population of all countries can be found at the following link of the United Nations Statistics Division: http://unstats.un.org/UNSD/Demographic/products/dyb/dybcensusdata.htm. Here, select the "Population by sex and urban/rural residence" dataset and use the respective total value that includes both men and women. If, contrary to expectations, no usable data can be found, the total population can also be found in the World Factbook: https://www.cia.gov/library/publications/the-world-factbook/. The current figures there, however, are often estimates, and some are different from the actual statistics.

respective country. Some of these results are slightly different from those in the IEA Energy Statistics, and the numbers are generally two years older. The UN electricity profiles should therefore only be used if there are no other sources for the respective country.

HS = Average household size [people]

The most reliable sources for current figures on average household sizes are the national statistics offices[26] of the respective countries. If the relevant figures cannot be obtained from them, the average household size can be calculated for many countries using the "Population Censuses' Datasets" of the "Demographic Yearbook" of the United Nations Statistics Division (UNSD). The total population can be found in the "Population by sex and urban/rural residence" dataset. Depending on the country, the number of households can be found in the "Households by type of household, age and sex of head of household or other reference member" and/or "Households by age and sex of reference person and by size of household" dataset.[27]

HC = Average annual household consumption [kWh/a]

The average annual household consumption can be calculated by dividing the total electricity consumption at household level ("Residential") from the IEA Energy Statistics (see HT) by the number of households connected (see CH). If the respective country is not included in the IEA Energy Statistics, the energy balances of the UN Statistics Division can also be used for the electricity consumption at household level (http://unstats.un.org/UNSD/energy/balance/default.htm).

It is important that only the household consumption and the number of households connected are actually used as a basis. If, on the other hand, the total electricity consumption (including industry, etc.) and/or the total number of households (including the households that are not connected) is used as a basis, the resulting values are incorrect.

GL = Anticipated technical grid losses [%]

The most accurate and current figures on the total losses and the technical and non-technical percentages can generally be obtained from the grid operator. These figures can also be obtained, if necessary, from the energy minister or the regulatory authority of the respective country. Here it is important to remember that technical losses take place during electricity transmission and distribution. In many countries, these grid levels are operated by different companies. Transmission losses (which are always technical) are generally between 2% and 6%. Technical losses at distribution grid level are between around 5% and 15%. This results in

26 also known as: Agency, Department, Office, Bureau, or Institute of Statistics.

27 For both datasets, it is important to make sure that the figure selected includes all households (both sexes, all age groups). It is important that both figures come from (at least almost) the same year. The datasets themselves can be selected at the following link: http://unstats.un.org/UNSD/Demographic/products/dyb/dybcensusdata.htm. If figures for a specific country are not included in the datasets mentioned, older figures from the "Compendium of Human Settlement Statistics 1995" of the United Nations Statistics Division (UNSD) can be used if necessary: http://unstats.un.org/unsd/demographic/sconcerns/housing/housing2.htm. These include average household sizes for many countries. However, these figures originate in part from the 1980s and may have changed significantly as a result of demographic change.

a total range of around 7% to 21% for total technical losses. Non-technical losses at distribution grid level (which usually involve theft) vary much more from below 1% to more than 30%.

If no figures can be obtained from the grid operators or government offices, the total losses (i.e. including non-technical losses) can at least be taken from various sources:

The total losses in transmission and distribution for most countries can be found in the World Bank database: http://databank.worldbank.org/data/home.aspx. Select "Electric power transmission and distribution losses (% of output)" in this database. The World Bank figures are based on the IEA Energy Statistics ("Losses" divided by "Production").

For some countries not included in the World Bank database and the IEA Energy Statistics, total losses can be calculated using the electricity profiles of the United Nations Statistics Division (http://unstats.un.org/UNSD/energy/balance/default.htm): divide "Losses in conversion and distrib." by the "Net production" in the electricity profile of the respective country. However, the figures available in this database deviate significantly in some cases from the figures of the IEA and World Bank. It generally has to be said that all of these sources publish figures that in some cases vary considerably from the real losses (for example, the losses in Mozambique are actually much higher than in the World Bank database or the electricity profiles of the UNSD).

The total losses are usually also mentioned in the OAC for electricity supply projects in Part A and/or Part B of the PP or in the reports, which means that this figure can often be taken from these documents for projects at a more advanced stage.

Now, however, the percentage of total losses accounted for by technical losses has to be estimated. They can vary considerably in developing and emerging countries. As a rough estimate, if no more exact information is available, it can be assumed that 75% of the total losses are of a technical nature[28].

AC = Total annual electricity consumption [kWh/a]

The total annual electricity consumption can be found for a number of countries in the IEA energy statistics under "Final Consumption" in the "Electricity" column of the respective country. The IEA energy statistics are available for OECD countries and non-OECD countries and accessible via the Energy CC.

An alternative source is the Key World Energy Statistics of the IEA. This is an annual publication that can be downloaded from the following link: http://www.iea.org/publications/freepublications/. The total annual electricity consumption can be found in the "Energy Indicators" section. The same figures are also available in the World Bank database: http://databank.worldbank.org/data/home.aspx. Select "Electric power consumption (kWh)" in this database. The figures of both of these sources are in some cases slightly different from the figures in the IEA energy statistics.

28 These errors are accounted for by the safety margin.

Figures for countries that are not available in the sources above (e.g. Afghanistan) can be found under "Consumption" in the electricity profiles of the United Nations Statistics Division (http://unstats.un.org/UNSD/energy/balance/default.htm). These figures, however, are not as current as the sources previously cited.