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# IMPACT ASSESSMENT FRAMEWORK

**JULY 2022**

FANS

**The Framework for fans is one of four Frameworks that aims to facilitate the reporting and shared measurement of impact evidence for a variety of stakeholders (e.g. distributors, developers, funders, appliance users and researchers). Ultimately, this project seeks to contribute to the creation of an industry-wide consensus for the assessment, reporting, and measurement of the impact of high-performing appliances.**

This Framework was developed by Rural Senses, SVT, CLASP, and Energy Saving Trust as part of the Low Energy Inclusive Appliances programme, Efficiency for Access' foundational initiative. Efficiency for Access is a catalyst for change, accelerating the growth of off-grid appliance markets to boost incomes, reduce carbon emissions, improve quality of life and support sustainable development.

We want to thank E Feng Loh and Joseph Thomas, Efficiency for Access Monitoring & Evaluation team for their support. Special thanks goes to Susie Wheeldon, Oliver Reynolds, and Sjef Ketelaars of GOGLA for both peer review as well as their ongoing support during the project. We would also like to thank the reviewers for their comments, including Chris Browne, Energy4Impact; Ben Hartley, Sustainable Energy for All; Rachita Misra, SELCO; Emiko Ubebe, Acumen, as their feedback has greatly improved this work. We also thank members of the GOGLA Impact Working Group for validating metrics related to televisions (TVs); as well as the Efficiency for Access Investor Network, and all the stakeholders and communities interviewed as part of this project. Their input has helped validate assumptions and metrics and made the Framework fit for purpose and relevant to those who intend to use it. We are very grateful to Sarah Hambly of Energy Saving Trust, Efficiency for Access co-Secretariat, for creating a communications plan for this work and her support in design and editing.

The framework was authored by Yau Ben-Or, Ramit Debnath, Richa Goyal, Stephanie Hirmer, Makena Ireri, Thalia Konaris, Sara Olsen, David Pritchard, and Josephine Tumwesige.

The Framework was developed using the best available evidence. **Nevertheless, users of the Framework should be aware of the limitations and caveats below.** Given these limitations as well as changes that will occur over time, it is likely that when reviewing and using the Framework users may find one or many of the following apply:

- some indicators are no longer important to stakeholders
- the calculation of the indicator is not accurate
- data needed to calculate the indicator are impossible to obtain
- new evidence suggests improvements to the indicators or the creation of new indicators

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# ABBREVIATIONS

*Please refer to the section, Framework at a Glance, for abbreviations for the variables used in the indicators. Refer to the tables for Input Variables and Standard Variables, as well as the list of IDs used for indicators.

| | |
|---|---|
| **EforA** | Efficiency for Access Coalition |
| **FAO** | Food and Agriculture Organization (United Nations) |
| **FTE** | Full-time equivalent |
| **GHG** | Greenhouse gas |
| **GOGLA** | Global association for the off-grid solar energy industry |
| **HPA** | High-performing appliance |
| **IAQ** | Indoor air quality |
| **IRENA** | International Renewable Energy Agency |
| **MCDA** | Multi-Criteria Decision Analysis |
| **NGOs** | Non-governmental organisations |
| **NREL** | National Renewable Energy Laboratory (United States) |
| **OPEX** | Operational expenditure per litre over the lifetime of a technology |
| **PAYGo** | Pay-as-you-go |
| **PAQ** | Perceived air quality |
| **PV** | Photovoltaic |
| **SDG** | Sustainable development goal |
| **SHS** | Solar home system |
| **SRH** | Slum rehabilitation housing |
| **SSA** | Sub-Saharan Africa |
| **TV** | Television |
| **WHO** | World Health Organization |

## DEFINITIONS

| | |
|---|---|
| **Confidence level** | The confidence level was assessed for each value for 'standard variables'. Three stars (***) indicate that a study is 'up to date' (i.e. conducted within five years of the assessment) and has, at the same time, a 'large sample size' (meaning that the data came from one study with 500+ samples or several studies with a total of 500+ samples). Two stars (**) indicate that studies are either 'up to date' or have a 'large sample size', and one star (*) indicates that the studies are not up to date and have a small sample size. |
| **Degree of urbanisation** | Description of territories or countries within three different categories of urbanisation as follows: (a) cities (densely populated areas); (b) towns and suburbs (intermediate density areas) and (c) rural areas (thinly populated areas).[1] |
| **End-user** | Those that use the appliances. |
| **Formula** | The specific data points necessary to calculate a given impact metric or indicator and how they should be combined to arrive at the impact indicators result. |
| **High-performing appliances** | High-quality and efficient off- and weak grid appliances that are intentionally designed for end-users living in an energy-constrained environment and advertised for use primarily with a PV module or a solar home system.[2] |
| **Indicator** | The means by which an impact can be gauged. |
| **Input variables** | Variables that the framework user needs to provide data for. |
| **Multi-criteria decision analysis** | A process used to help make a decision or choice by explicitly evaluating multiple criteria that may be in conflict with each other to choose the best option. |
| **Multi-criteria decision score** | Potential indicators were given a score of 0, 1, or 2 depending on how well they satisfied several criteria that are desired of impact indicators. See section below on Multi-Criteria Decision Analysis and Appendix 1. |
| **PAYGo** | The Pay-As-You-Go (PAYGo) business model is an innovative financial mechanism that enables off-grid customers to pay for high-quality solar products in a 'rent-to-own' system. The innovation that emerged to address the energy access challenge and to provide electricity generated from renewable energy sources at affordable prices, with payments facilitated by technologies and mobile phone credit.[3] |
| **Pipeline variables** | Variables that are of interest but where data is not yet available. While there is no set plan for these pipeline variables, we invite people to undertake research to close the existing data gap. |
| **Standard variables** | Variables provided within the Framework based on existing evidence. |
| **The Framework** | The Impact Assessment Framework for off- and weak-grid high performing appliances. The Framework describes metrics, indicators and formula that are to be used to assess the social, environmental and economic impacts of the four types of appliances. The Framework consists of Objective 1 from the original Efficiency for Access Request for Proposals: "Suggested metrics for industry use to report impact" (the 'impact metrics') and Objective 2: "Formula for impact indicators that the industry may be unable to report on but are nevertheless important to develop to provide a framework that could capture holistic impact" (the 'impact indicators'). |
| **User** | People who use the Framework. |
| **User-perceived value** | This term applies to the appliance users and refers to "the benefits, concerns, feelings and underlying drivers that vary in importance and act as the main motivators in the lives of the people—as perceived and defined by the [people] themselves at a given time".[4] |
| **Value** | The regard that something is held to deserve; the importance, worth, or usefulness of something. Specifically with respect to impact assessment, value or social value is the quantification of the relative importance that people place on the changes they experience in their lives. Some, but not all of this value is captured in market prices.[5] |
| **Variables** | A quantity which, during the calculation of a formula, is assumed to vary or be capable of varying in value.[6] |
| **Off- and weak-grid** | A place that is not connected to the main electricity grid, or a system that suffers from frequent brown / blackouts and voltage fluctuations / instabilities. |

1 Eurostat, Applying the Degree of Urbanisation. (2021) OECD. https://doi.org/10.1787/4bc1c502-en

2 Efficiency for Access, 'The State of the Off-Grid Appliance Market (2019) https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report

3 UNCC. 2021. Pay-As-You-Go Solar Technology: A Key to Unlocking Energy Access - Kenya and Peru. UNFCCC. https://unfccc.int/climate-action/momentum-for-change/activity-database/pay-as-you-go-solar-technology-a-key-to-unlocking-energy-access

4 Stephanie Hirmer and Peter Guthrie. 2017. The benefits of energy appliances in the off-grid energy sector based on seven off-grid initiatives in rural Uganda. Renewable and Sustainable Energy Reviews, 79, 924–934. https://doi.org/10.1016/j.rser.2017.05.152

5 Impact Management Project, Who. (2021) Impact Management Project. https://impactmanagementproject.com/impact-management/impact-management-norms/who/

6 Oxford Languages. N/A. https://languages.oup.com/google-dictionary-en/

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# Purpose and Context

**This report outlines the Impact Assessment Framework for fans used in off- and weak-grid settings. This Framework was developed by the Efficiency for Access Coalition team, Rural Senses and SVT between 2020 and 2022 in consultation with other stakeholders such as end-users, investors, donors, and companies. You can read more about the development process here. This Framework for fans is one of four standard Impact Assessment Framework for off- and weak-grid high-performing appliances. The other frameworks are for refrigerators, televisions (TVs) and solar water pumps.**

### Purpose of the Framework

The Framework aims to facilitate the shared measurement and reporting of the impacts of fans for a variety of stakeholders (e.g., distributors, developers, funders, appliance users and researchers) through the development of evidence-based social, environmental and economic impact indicators. Ultimately, this work seeks to contribute to the creation of an industry-wide consensus for the assessment, reporting and measurement of the impact of fans. For more information on how this and the other three frameworks (for refrigerators, TVs, and solar water pumps) were developed, you are encouraged to consult the methodology report.

This report harmonises existing evidence from a wide range of studies into an easy to use and robust set of impact indicators for fans. Some of the suggested indicators can be used now to report impacts, while others are not yet ready, mainly due to a data gap. Indicators that are not yet ready are nevertheless important to develop to provide a framework that captures a holistic set of impacts.

### Context

A holistic understanding of the impacts of high-performing appliancess is important because their use has been growing over the years. GOGLA's recent report recorded sales of 470,000 off-grid solar appliances between July and December 2020.[7] While recorded global sales were less than anticipated due to the impacts of COVID-19, the easing of some countries' lockdown restrictions in the second half of the year may have contributed to an increase in sales for this period. This is despite the additional constraints on cash flows, and shows the critical role of high-performing appliancesin providing homes and businesses with essential services. While fans only make up 2% of off-grid appliance sales, their importance in household and business applications is increasingly being recognised, with an increase in sales during the summer months of 49% (from 2019 to 2020).[8]

This is unsurprising. Research shows that with growing health risks from rising temperatures, especially in the Global South, devices like fans and air conditioners are essential to households to bridge the cooling gap. It is well established that extreme heat has adverse impacts on human health and functioning.[9] For example, increased risk of morbidity and mortality, cognitive impairment, low productivity and economic losses have been linked particularly to heat stress.[10,11,12]

A recent study by the International Institute of Applied Systems Analysis (IIASA) and the Yale University School of Forestry and Environmental Studies shows large gaps in access to essential space cooling, especially in India, South-East Asia and Sub-Saharan Africa. Between 1.8 to 4.1 billion people are at risk of heat-related health problems because of a lack of access to indoor cooling, with a median target of 3.7 billion people affected.[13] This number far exceeds the energy poverty gap indicated by the Sustainable Development Goal for energy access (SDG7).[14]

Solutions to ease immediate cooling risks include off-grid solar systems to power fans, refrigerators and last mile transport for vaccines in rural areas, as well as public cooling centres, sunlight-reflecting roofs, and house retrofits in cities.[15]

As government policymakers increase efforts to gather evidence for more proactive and integrated policy-making, businesses, governments and finance sectors collaborate to assess and act on the enormous commercial and economic opportunities that are arising from the need to provide sustainable cooling solutions for all. Manufacturers, industry associations and lenders are engaging and cooperating to develop products and financial solutions that will allow more low-income customers to gain access to cooling solutions. Additionally, all stakeholders are accelerating their innovation efforts and embracing a paradigm shift – they are thinking more holistically about how to deliver cooling affordably and sustainably.

The indicators listed in this report build on impact metrics released by GOGLA in partnership with Efficiency for Access providing more metrics to estimate the impacts created by off-grid high performing fans in a consistent, clear, and coherent manner. Therefore, they complete, and do not substitute the

7 GOGLA. 2019. Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data July - December 2019. https://www.gogla.org/sites/default/files/resource_docs/global_off_grid_solar_market_report_h22019.pdf

8 ibid

9 A. Mastrucci et al. (2019) 'Improving the SDG energy poverty targets: Residential cooling needs in the Global South', Energy and Buildings, 186, pp. 405–415. doi:10.1016/j.enbuild.2019.01.015

10 Baccini, M. et al. (2011) 'Impact of heat on mortality in 15 European cities: attributable deaths under different weather scenarios', Journal of Epidemiology & Community Health, 65(1), pp. 64–70. doi:10.1136/jech.2008.085639

11 A. Gasparrini et al. (2015) 'Mortality risk attributable to high and low ambient temperature: a multicountry observational study', The Lancet, 386(9991), pp. 369–375. doi:10.1016/S01406736(14)62114-0

12 J.G.C Laurent et al. (2018) 'Reduced cognitive function during a heat wave among residents of non-air-conditioned buildings: An observational study of young adults in the summer of 2016', PLOS Medicine, 15(7), p. e1002605. doi:10.1371/journal.pmed.1002605

13 ibid

14 SEforALL, 'New Chilling Prospects report shows lack of cooling access threatens health, prosperity and the climate', Sustainable Energy for All | SEforALL, Jul. 16, 2018. https://www.seforall.org/news/new-chilling-prospects-report-shows-lack-of-cooling-access-threatens-health-prosperity-and-the (accessed Aug. 04, 2021)

15 A. D'Aprile (2018) 'In a warming world, it is time to address the cooling access gap', Foresight, 18 July. Available at: https://www.climateforesight.eu/migrations-inequalities/in-a-warming-world-it-is-time-to-address-the-cooling-access-gap/ (Accessed: 4 August 2021)

indicators previously developed and published in the report by Efficiency for Access and GOGLA.[16] Some indicators appear in both reports (e.g., A-ENV). These are the indicators that apply to all four appliances and the repetition was left for completeness of the impact framework.

### Use of the Framework

The primary use cases of this Framework are:

- for organisations to assess the holistic impact they create by distributing fans
- to support funding decision making with regards to fans
- to inform mitigation strategies for the unintended negative impacts of fans
- to guide further research

To use the Framework to estimate the impact of fans and/or their distribution, users should follow these steps:

1. Choose the indicators you wish to use based on the type of impact you wish to estimate from the tables in Section 3 (or the spreadsheet).
2. Once you have identified the metrics in the summary table, please consult the associated detailed table in Section 4; you can identify them by their indicator ID. Please note that easy navigation is possible by using the spreadsheet version of the framework.
3. Consult the detailed table to check that the list of assumptions associated with that metric is valid in your specific use-case. Only use the provided metric if the assumptions are suitable for your use-case.
4. Calculate the impact by applying the input variables and standard variables:
    - **Input variables** are marked as 'input by user'. These are variables that the user needs to provide values for based on the impact being assessed.
    - **Standard variables** are 'plug and play' values based on existing evidence. It is important to check the detailed information about each standard variable as the most appropriate value may depend on the specific geography and degree of urbanisation of your product and customers. You can use the detailed information to ensure the value you choose matches the specific context of your product or service.
5. Where the value for the standard variable is given as a percentage (e.g., 3%) when used in the indicator formula it will need to be input in its decimal equivalent e.g. 0.003.
6. You can describe the impact using the phrasing of the impact statement and the results of your calculation.
For example, "950 kg of CO2 emissions were saved through the distribution of solar-powered fans during 2021".

### How to challenge the Framework

We invite users, researchers, sceptics, appliance users and others to challenge the framework and identify opportunities for improvement. For example, you may find:

- the framework uses indicators that are no longer important to stakeholders
- the calculation of the indicator is not accurate
- data needed is difficult to obtain
- new evidence suggests improvements to the indicators or the creation of new ones

**Please share with us evidence that could challenge or improve the metrics, variables, assumptions and data used in the framework by completing through this form.**


16 Efficiency for Access Coalition and GOGLA. 2020. Standardised Impact Metrics for High-Performing Appliances: Fans and TVs. https://www.gogla.org/sites/default/files/resource_docs/gogla_impact-metrics-appliances_paper2020_def-summary_0.pdf

# The Framework at a Glance

**IMPORTANT: For easy navigation, we recommend that you use the spreadsheet version of the Framework.**

The Framework consists of:

1. A table summarising the current indicators and formulae that were developed and make up the framework for fans.
2. A table of the agreed variables (standard variables) to be used in the metrics, as well as variables that require the Framework users' input (input variables).

The table below summarises the framework for fans. The tables show the ID for each of the indicators that are defined under the 'Indicator' column, which can be used to link to a more detailed table on each indicator. For each appliance, the ID starts with the letter of the appliance in this case F for fans. Where the ID starts with an 'A', the indicator applies to other appliances also, not just fans. This is followed by the indicator category: ENV for environmental, ECO for economic, and SOC for social. The formula to measure the impact, which can be positive or negative, is then given next. The variables are described in the tables that follow.

The Multi-Criteria Decision Analysis (MCDA) Score refers to the sum of the scores given to each indicator according to how well they each compare against desired characteristics, namely widely applicable, comparable, robust, relevant, time-bound/ timely, specific and dynamic. The maximum sum for the scores is 14. Please refer to the methodology report for more details.

The readiness level (or status) of the different indicators is indicated in the summary tables using a traffic light system. A green dot means that the indicator is ready to use, an orange dot means that parts of the indicator can be used and a red dot means that the indicator is not yet ready.

Indicators can have a positive, negative, or positive / negative impact. This is indicated using the following signs respectively +, –, + / –. Indicators are also elaborated individually; refer to the corresponding spreadsheets.

**Table 1: Fan framework**

| ID | INDICATOR | FORMULA | MCDA SCORE | STATUS | IMPACT |
|---|---|---|---|---|---|
| ENVIRONMENTAL | | | | | |
| **Emissions** | | | | | |
| A-ENV1 | **Tonnes of $CO_2$ emissions avoided** | (S × (1 – DL) × DR-GHG × PL × G) / 1000 | 13 | ● | ⊕ |
| **E-waste** | | | | | |
| A-ENV2a | **Annual tonnes of electric waste added** | S × WS / 1000 | 14 | ● | ⊖ |
| A-ENV2b | **Annual tonnes of electric waste avoided** | S × WS × WRP / 1000 | 12 | ● | ⊕ |
| ECONOMIC | | | | | |
| **Expenditure** | | | | | |
| A-ECO1 | **USD savings in fuel costs (solar-powered appliance replacing a non-solar-powered appliance)** | S × (1 – DL) × DR-GHG × PL × OPEXD | 12 | ● | ⊕ |
| **Job opportunity** | | | | | |
| A-ECO2 | **Number of new jobs created** | S × EF × EFa | 13 | ● | ⊕ |
| **Access and inclusion** | | | | | |
| A-SOC1 | **Number of people who gained access to an off-grid appliance for the first time** | S × (1 – DL) × (1 – DR-Access) | 12 | ● | ⊕ |
| A-SOC2 | **Number of customers currently accessing off-grid appliances through flexible financing** | SL-PAYGo × (1 – DL) × (1 – DR-Access) | 12 | ● | ± |
| A-SOC3 | **Number of people below the poverty line with access to an appliance** | S × (1 – DL) × (1 – DR-Access) × H × RPL | 11 | ● | ⊕ |
| **Ownership** | | | | | |
| A-SOC4 | **Affordability of monthly repayments** | (PAYGoMC / IMAC) × 100 | 14 | ● | ± |
| **Comfort** | | | | | |
| F-SOC1a | **Total hours of improved thermal comfort, cumulatively** | S × Ff × (PL – PTsp) × (1 – DL) × (1 – DR-Access) | 13 | ● | ⊕ |
| F-SOC1b | **Number of people who are experiencing improved thermal comfort** | SL × (1 – DL) × (1 – DR-Access) × H × PTC | 13 | ● | ⊕ |

| ID | INDICATOR | FORMULA | MCDA SCORE | STATUS | IMPACT |
|---|---|---|---|---|---|
| Health and wellbeing | | | | | |
| F-SOC2a | **Number of people who are experiencing improved indoor air quality** | SL × (1 – DL) × (1-DR-Access) × H × PIAQ | 13 | ● | ⊕ |
| F-SOC2b | **Number of people who perceived a reduction in carriers of vector-borne disease, e.g., mosquitos** | SL × (1 – DL ) × (1-DR-Access) × PDCV | 13 | ● | ⊕ |
| F-SOC2c | **Number of people who perceived improved health** | SL × (1 – DL ) × (1-DR-Access) × PIH | 13 | ● | ⊕ |

## Variables

Below is a summary of the variables that are used in the formulae used to calculate the indicator. These are separated into 'input variables', which need to be entered by the user of the Framework, and 'standard variables', which are provided with the Framework. The latter are based on existing evidence and end-user research conducted as part of this work.

### Input Variables

List of the variables where the user of the Framework needs to provide the value.

| VARIABLES | DEFINITION |
|---|---|
| **IMAC** | Average monthly income of the customer base (USD or equivalent) |
| **PAYGoMC** | Average monthly PAYGo commitment (USD or equivalent) |
| **SL-PAYGO** | Number of units sold through flexible financing currently in use (number of units) |
| **PL** | Estimated product lifespan (minimum of 1.5 × financing period, or 1.5 × warranty period in cash payments) (years) |
| **PTsp** | Average number of days per year in which temperature is above 26 °C (# of days/year). Data for different geographies is accessible here: Data for PTsp can be accessed here.[17] |
| **RPL** | Percentage of people who are under World Bank's International Poverty Line when gaining access to the appliance. The poverty line is determined as half of the median household income.[18] Regional values for the average (or median) household income by country can be found in the World Population Review.[19] |
| **S** | Number of units sold (cumulative, i.e. ever) (number of units) |
| **SL** | Number of units sold which are estimated to currently be in use (based on the products estimated lifespan being 1.5 × financing period, or 1.5 × warranty period in cash payments in number of units) |
| **WRP** | Proportional weight of each appliance that will be recycled (%) |
| **WS** | Weight of solar-powered appliance (kg) |

### Standard Variables

Standard variables are those for which a reasonably reliable estimate was found in the literature review and 'end-user' research conducted as part of this project. These values are included within the Framework. The values for some standard variables are given as ranges. Users should consult each specific variable sheet for information on local context (such as geography and degree of urbanisation)[20] to decide which value is most appropriate for their products, as well as the confidence rating[21] of each value. For more information, please consult the Standard Variables section.

17 Weather and Climate. N/A. https://weather-and-climate.com/

18 OECD. 2015. In It Together: Why Less Inequality Benefits All, OECD Publishing, Paris. https://doi.org/10.1787/9789264235120-en

19 World Population Review. N/A. https://worldpopulationreview.com/country-rankings/median-income-by-country

20 Degree of urbanisation describes territories or countries within three different categories of urbanisation as follows: (a) Cities (densely populated areas); (b) Towns and suburbs (intermediate density areas); (c) Rural areas (thinly populated areas) (Eurostat, 2021).

21 The confidence level was assessed for each value for 'standard variables'. Three stars (***) indicate that a study is 'up to date' (i.e. was conducted within five years of the assessment) and has, at the same time, a 'large sample size' (meaning that the data came from one study with over 500 samples or several studies with a total of over 500 samples). Two stars (**) indicate that studies are either 'up to date' or have a 'large sample size' and one star (*) indicates that the studies are not up to date and have small sample size.

Those variables marked as 'pipeline variables' are of interest, but relevant data are not yet available. While there is no set plan for these pipeline variables, we invite people to undertake research to close the existing data gap. Refer here for the corresponding sheet in the excel version of the Impact Assessment Framework for off- and weak-grid high-performing appliances.

| VARIABLES | DEFINITION | VALUE |
|---|---|---|
| **DL** | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | **3%** |
| **DR-Access** | Discount for repeat sales for estimating new access to solar powered appliance (including different companies) (%) | **5%** |
| **DR-GHG** | Ratio capturing sales replacing a diesel genset-powered appliance (%) | **3%** |
| **EF** | Employment factor (jobs / item sold) | **0.0082** |
| **EFa** | The proportion of employment factor relevant to each appliance | **25%** |
| **Ff** | Operation time fraction for a fan as hours per day (hours / day) | **4–8.5** |
| **G** | Average amount of greenhouse gases avoided per appliance, due to diesel displacement (kg / $CO_2$ / year) | **84** |
| **H** | Household size (number of people) | **5.5** |
| **OPEXD** | Annual operational fuel cost of a diesel-powered appliance (USD / year) | **34–58.17** |
| **PDCV** | Percentage of people who report using a fan to deter mosquitos (%) | **75%** |
| **PIAQ** | Percentage of people who associate their fan with improved indoor air quality (IAQ) (%) | **9%** |
| **PIH** | Percentage of people with access to the appliance who perceive that the appliance contributes to 'health and wellbeing' | **75%** |
| **PTC** | Percentage of people who associate their fan with improved thermal comfort (%) | **94%** |
| **TSP** | Indoor set temperature above which cooling using a fan is required (°C) | **26 °C** |

# Impact Indicators

## Here we give a detailed description of the evidence for the indicators and values proposed for fans.

The following tables provide an overview of the indicators and for each indicator:

- the formula and agreed values of the different variables
- a paragraph describing the different data sources used to reach the values, including insights from literature, end-user research and stakeholder input
- a discussion of data gaps and limitations, with special attention to limitations in terms of context (rural/urban, East Asia / East Africa)
- notes on indicators that were considered but not included in the final version

More detailed information about the values can be found in the respective tables for the variables.

**Table 2: Environment**
A-ENV1: Tonnes of $CO_2$ emissions avoided

| METRIC | TONNES OF $CO_2$ EMISSIONS AVOIDED | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | A-ENV1 | | ● |
| | | | IMPACT |
| **Appliance name** | All | | ⊕ |
| **Unit of measurement** | Tonnes $CO_2e$ / year | | |
| **Definition** | $CO_2$ emissions saved during operation, for households or businesses replacing a diesel-powered appliance with a solar-powered appliance. | | |
| **Usefulness of metric** | Quantifying the benefit of replacing diesel-powered appliances with solar-powered appliances in terms of $CO_2$ emissions. | | |
| **Impact statement** | X tonnes of $CO_2$ emissions were saved through the distribution of [appliance name] since [start date of distribution]. | | |
| **Calculation** | (S × (1 – DL) × DR-GHG × PL × G) / 1000 | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e. ever) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-GHG | Ratio capturing sales replacing a diesel gen set-powered appliance (%) | 3% |
| | PL | Estimated product lifespan (minimum of 1.5 × financing period, or 1.5 × warranty period in cash payments) (years) | This variable is to be inserted by the user |
| | G | Average amount of greenhouse gases avoided per appliance, due to diesel displacement (kg $CO_2$/year) | 84 |
| **Assumptions** | • The operational $CO_2$ emissions of a solar appliance are assumed to be zero.<br>• Nonetheless, the US National Renewable Energy Laboratory (NREL) conducted a harmonisation study on all published lifecycle analyses of residential and utility-scale solar PV systems, harmonising the lifecycle emissions of PVs at 40g$CO_2e$ / kWh[22], with operational emissions estimated at 8.4 – 10.4g$CO_2e$/kWh. | | |
| **Supporting literature** | • The International Renewable Energy Agency (IRENA) estimates that accelerated deployment of solar PV alone can lead to significant emission reductions of 4.9 gigatonnes of carbon dioxide (Gt $CO_2$) in 2050.[23] | | |
| **Data gaps** | • Addressing more accurate usage pathways of appliances especially solar water pumps.<br>• In what percentage of the cases a solar-powered appliance is used in addition to the diesel-powered appliance.<br>• Identifying lifecycle emissions reduction, also considering production, transportation, maintenance and replacement of solar appliances.<br>• In the case of cooling (fan and refrigerator), addressing passive methods (e.g. building standards) as benchmark for emissions avoided. For example, if a building is a metal sheet building, and uses multiple fans to cool it, it will show higher level of 'emission avoided' and more efficiency achieved, although is actually an un-optimised solution. | | |

22 L.E. Stages, 2012. Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics. J. Ind. Ecol.

23 IRENA (2019), Future of Solar Photovoltaic: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation: paper), International Renewable Energy Agency, Abu Dhabi.

| METRIC | TONNES OF $CO_2$ EMISSIONS AVOIDED |
|---|---|
| **Usage notes** | • Impact insights from other Global South regions, especially Sub-Saharan Africa. Impact insights broken down by different appliance access use cases: gender access, actual access level (period) or extent of functionality<br>• Impact insights broken down into differences of geography, seasonality or differences in time-use. |

**Table 3: Environment**
A-ENV2a: Annual tonnes of electric waste added

| METRIC | ANNUAL TONNES OF ELECTRIC WASTE ADDED | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | A-ENV2a | | ● |
| | | | IMPACT |
| **Appliance name** | All | | ⊖ |
| **Unit of measurement** | Tonnes | | |
| **Definition** | Tonnes of electronic waste added annually due to the ownership and disposal of an off-grid appliance by households or businesses. | | |
| **Usefulness of metric** | Quantifying the electronic waste added to the environment when off-grid appliances are disposed of in the absence of a disposal plan. | | |
| **Impact statement** | Since [start date of distribution], X tonnes of electronic waste was added to the environment due to the distribution of off-grid appliances, in the absence of a recycling or reuse plan. | | |
| **Calculation** | S × WS / 1000 | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e. ever) (number of units) | This variable is to be inserted by the user |
| | WS | Weight of solar-powered appliance (kg) | This variable is to be inserted by the user |
| **Assumptions** | • It is assumed that the entire appliance, whether non-solar-powered or non-solar-powered, will be disposed of in full, without recycling or reuse.<br>• The indicator does not address the difference in environmental impact of different mass elements (all kgs are equal). | | |
| **Supporting literature** | • E-Waste is defined as: 'all types of electrical and electronic equipment that have been discarded'.[24] For our purposes, we include all parts in the appliance including all electrical components, as well as metal and plastic fractions, and excluding packaging and external power source.<br>• Appliances that include majority of mechanical components (such as water pump) are also considered an e-waste.[25]<br>• 'The expected quantity of e-waste going to landfill as a result of using solar appliances is 78 million tonnes by 2050'.[26] No appliance-specific data currently exist.<br>• A two-fold increase in the global sales of small-scale solar devices, including PV-based solar lanterns, solar water pumps, solar refrigerators and solar home systems was predicted between 2010 and 2022. Sales reached 130 million units between 2010 and 2017, and were expected to increase up to 250 million units in 2017 and 2022.[27] These sales were concentrated geographically in developing countries located in Sub-Saharan Africa, especially in East Africa, and to a lesser extent in South Asia and Latin America. | | |

24 Step. 2014. Solving the E-Waste Problem (Step) White Paper: One Global Definition of E-waste. https://www.step-initiative.org/files/_documents/whitepapers/StEP_WP_One%20Global%20Definition%20of%20E-waste_20140603_amended.pdf
25 C. Psomopoulos, D. Barkas and G. Ioannidis, 2018. The Recycling Potential of Submersible Sewage Pumps in the EU. Recycling. MDPI AG, 3(2), p. 14. doi: 10.3390/recycling3020014.
26 S. Weckend, A. Wade and G.A. Heath, 2016. End of life management: solar photovoltaic panels (No. NREL/TP-6A20-73852). National Renewable Energy Lab (NREL), Golden, CO (United States).
27 Lighting Global. 2018. Off-grid solar market trend report 2018 (No. 4; p. 24). International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Summary.pdf

| METRIC | ANNUAL TONNES OF ELECTRIC WASTE ADDED |
|---|---|
| **Supporting literature** | • Recent research put a spotlight on an 'emerging disposal problem' associated with the exponential rise in sales of small-scale and off-grid solar devices.[28] The World Bank estimated that of the 130 million off-grid solar devices sold, around 26 million off-grid solar devices went out of use in 2017.[29] Estimates show that solar e-waste represented less than 0.5% of the overall e-waste stream in 14 SSA countries in 2014. In 2014, an estimated 2,500t of off-grid solar products were put on the market of which 800t were in the waste stream. Solar e-waste disposal was expected to increase up to 10,000 tonnes by 2020 with Kenya leading the share with 3,800 tonnes, followed by Nigeria (530 tonnes) and Rwanda (350 tonnes).[30]<br>• The International Renewable Energy Agency estimated that by 2050, global cumulative solar e-waste volumes could reach 78 million metric tonnes.[31] |
| **Data gaps** | Addressing different components according to their environmental impact (e.g., battery vs cables). |
| **Usage notes** | WS includes only the appliance and inbuilt battery. It excludes packaging and external power source, but includes any other part of the appliance. |

**Table 4: Environment**
A-ENV2b: Annual tonnes of electric waste avoided

| METRIC | ANNUAL TONNES OF ELECTRIC WASTE AVOIDED | | |
|---|---|---|---|
| | | | **STATUS** |
| **ID** | A-ENV2b | | ● |
| | | | **IMPACT** |
| **Appliance name** | All | | ⊕ |
| **Unit of measurement** | Tonnes | | |
| **Definition** | Tonnes of electronic waste avoided annually due to the existence of a recycling plan. | | |
| **Usefulness of metric** | This metric rewards organisations that promote recycling and raise awareness of e-waste recycling. | | |
| **Impact statement** | Since [start date of distribution], X tonnes of electronic waste was avoided thanks to recycling plans. | | |
| **Calculation** | S × WS × WRP / 1000 | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e. ever) (number of units) | This variable is to be inserted by the user |
| | WS | Weight of solar-powered appliance (kg) | This variable is to be inserted by the user |
| | WRP | Proportional weight of each appliance that will be recycled (%) | This variable is to be inserted by the user |
| **Assumptions** | • It is assumed that the entire appliance, whether solar-powered or non-solar-powered, will be disposed of in full, in the absence of recycling or reuse plans.<br>• The indicator does not address the difference in the environmental impact of different mass elements (all kgs are equal). | | |
| **Supporting literature** | See A-ENV2a. | | |
| **Input from stakeholders** | Input from people / investors / donors. | | |
| **Data gaps** | • Solar appliance recycling potential in East Africa and Asia.<br>• Including the e-waste saved through using reused materials in the manufacturing process. | | |
| **Usage notes** | • WS includes only the appliance and inbuilt battery. It excludes packaging and external power source but includes any other part of the appliance.<br>• WRP is determined during the project / intervention depending on the recycling / reuse plan available.<br>• The above indicator could be improved or added in order to incorporate reduction in e-wastage. | | |

28 G. Bensch, J. Peters, and M. Sievert, 2017. The lighting transition in rural Africa – From kerosene to battery-powered LED and the emerging disposal problem. Energy for Sustainable Development, 39, 13-20. https://www.sciencedirect.com/science/article/pii/S0973082616310444

29 Lighting Global. 2018. Off-grid solar market trend report 2018 (No. 4; p. 24). International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Summary.pdf

30 F. Magalini, D Sinha Khetriwal, D. Rochat, J. Hulsmann, S. Munyambu, J. Oliech, I.C. Nnorom, and O. Mbera, 2016. Electronic Waste (E-waste) Impacts and Mitigation Options in the Off-grid Renewable Energy Sector (p. 62). UK Department for International Development (DFID).

31 IRENA. 2016. End-of-life management: Solar Photovoltaic Panels. International Renewable Energy Agency. https://irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels

**Table 5: Economic**
A-ECO1: USD savings in fuel costs

| METRIC | USD SAVINGS IN FUEL COSTS (SOLAR-POWERED APPLIANCE REPLACING A NON-SOLAR-POWERED APPLIANCE) | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | A-ECO1 | | ● |
| | | | IMPACT |
| **Appliance name** | All | | ⊕ |
| **Unit of measurement** | USD | | |
| **Definition** | Total USD saved in fuel-related operational costs for households or businesses replacing a diesel-powered appliance with a solar-powered appliance, throughout the solar-powered appliance's lifetime. | | |
| **Usefulness of metric** | The indicator provides an economic business case for solar appliances by highlighting the amount of operational costs that a household or business saves throughout its lifetime. | | |
| **Impact statement** | Since [start date of distribution], people saved x USD in operational costs due to moving from diesel-powered [appliance name] to a solar-powered appliance. | | |
| **Calculation** | S × (1 – DL) × DR-GHG × PL × OPEXD | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e. ever) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-GHG | Ratio capturing sales replacing a diesel genset-powered appliance (%) | 3% |
| | PL | Estimated product lifespan (minimum of 1.5 × financing period, or 1.5 × warranty period in cash payments) (years) | This variable is to be inserted by the user |
| | OPEXD | Annual operational fuel cost of a diesel-powered appliance (USD / year) | 34–58.17 |
| **Assumptions** | • The annual operational expenditure of a solar appliance is assumed to be zero.<br>• Only fuel cost reduction is accounted for i.e. costs such as seeds, fertiliser and labour are not considered. | | |
| **Supporting literature** | • The "Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh" report highlighted that, for those connected to the grid but facing significant financial constraints, a solar-powered, energy-efficient fan should mean financial savings and better value with the same level of electricity consumption.[32] | | |
| **Data gaps** | • Include other expenses that are not fuel.<br>• Magnitude of replacement market for solar appliances.<br>• The operational costs of solar appliances. | | |
| **Usage notes** | Values for OPEXD vary depending on the geography. To find the most suitable value please refer to the elaborated variable sheet (click on the variable name). | | |

**Table 6: Economic**
A-ECO2: Number of new jobs created

| METRIC | NUMBER OF NEW JOBS CREATED | |
|---|---|---|
| | | STATUS |
| **ID** | A-ECO2 | ● |
| | | IMPACT |
| **Appliance name** | All | ⊕ |
| **Unit of measurement** | Number of jobs | |
| **Definition** | Increase in job opportunities within the business (manufacturing, assembly, distribution). | |

32 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

| METRIC | NUMBER OF NEW JOBS CREATED | | |
|---|---|---|---|
| **Usefulness of metric** | Enables demonstration of the contribution of the high-performing appliance supply chain to the local job market. | | |
| **Impact statement** | A total of x jobs have been created in local markets through the high-performing appliance supply chain. | | |
| **Calculation** | S × EF × EFA | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e. ever) (number of units) | This variable is to be inserted by the user |
| | EF | Employment factor (jobs / item sold) | 0.0082 |
| | EFA | Proportion of employment factor relevant to each appliance | 25% |
| **Assumptions** | The jobs are created within the geographical area being served. | | |
| **Supporting literature** | The values for EF and EFA are taken from the Power for All report, "Powering Jobs Census 2019".[33] Evidence from the same publication and others suggests that the off-grid solar value chain could generate up to 1.3 million full-time equivalent (FTE) jobs by 2022, excluding manufacturing.[34][35] For further details we recommend consulting the original report.[36] | | |
| **Data gaps** | Explore indirect jobs from upstream sectors and potential job displacement from traditional energy sectors. | | |
| **Usage notes** | • The above indicators would be applied to a specific geographical region that is the area of interest.<br>• The jobs being counted are those generated within that geographical region.<br>• The formula should not be used for appliances sold as a bundle with solar home system (SHS). | | |

**Table 7: Social / Health Impact**
A-SOC1: Number of people who gained access to an off-grid appliance for the first time

| METRIC | NUMBER OF PEOPLE WHO GAINED FIRST TIME ACCESS TO AN OFF-GRID APPLIANCE | | |
|---|---|---|---|
| | | | **STATUS** |
| **ID** | A-SOC1 | | ● |
| | | | **IMPACT** |
| **Appliance name** | All | | ⊕ |
| **Unit of measurement** | Number of people | | |
| **Definition** | Number of people engaging and benefiting from the off-grid market due to access to high-performing [appliance name]. | | |
| **Usefulness of metric** | Enables demonstration of the number of people who have benefited from clean energy using appliances. | | |
| **Impact statement** | High-performing appliances are enabling an estimated x people to access and use clean energy. This will allow them to build up assets which could help them to access more products and services in the future. | | |
| **Calculation** | S × (1 – DL) × (1 – DR-Access) × H | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e., ever) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | H | Household size (number of people) | 5.5 |
| | DR-Access | Discount for repeat sales for estimating new access to solar powered appliances (including different companies) (%) | 5% |
| **Assumptions** | That the majority of the customers are first-time owners and the appliance is not only allowing them to benefit from its functionality, but also enabling them to become more financially included. | | |

33 Power for All. 2019. Powering Jobs Census 2019: The Energy Access Workforce. https://www.powerforall.org/resources/reports/powering-jobs-census-2019-energy-access-workforce
34 Lighting Global. 2018. Off-grid solar market trend report 2018 (No. 4; p. 24). International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Summary.pdf
35 Power for All. 2019. Powering Jobs Census 2019: The Energy Access Workforce. https://www.powerforall.org/resources/reports/powering-jobs-census-2019-energy-access-workforce
36 ibid

| METRIC | NUMBER OF PEOPLE WHO GAINED FIRST TIME ACCESS TO AN OFF-GRID APPLIANCE |
|---|---|
| **Supporting literature** | • The "Powering Opportunity in South Asia" report found that 39% of respondents (the SHS owners) had their first experience of access to clean, modern power.[37]<br>• The "Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh" report noted that "...for many Bangladeshi customers, super-efficient off-grid fans create an opportunity to test solar technology for the first time. Super-efficient off-grid fans, therefore, have the potential to support a technological leap towards efficiency and wider use of solar".[38]<br>• "M-KOPA's 'Pay-As-You-Go' solar model has helped open up exciting new consumer markets. As off-grid energy connections increase, we are seeing millions of new consumers with greater financial stability and, for the first time, access to power."<br>• Efficiency for Access and 60 Decibels' study on Kenya, Rwanda, Uganda and Tanzania found that 80% of customers surveyed reported that it was their first time accessing a TV.[39]<br>• Another Efficiency for Access Coalition study focused on Kenya, Rwanda, Senegal, Tanzania, Uganda and Zambia found that 91% of the participants were accessing a solar water pump for the first time.[40] |
| **Data gaps** | • Explore the impacts of access on financial inclusion and further engagement in the appliance market (e.g., customer upgrades, use of PAYGo to purchase other products and services).<br>• Disaggregate this indicator for gender and income levels. |

**Table 8: Social / Health Impact**

A-SOC2: Number of people currently accessing off-grid appliances through flexible financing

| METRIC | NUMBER OF CUSTOMERS CURRENTLY ACCESSING OFF-GRID APPLIANCES THROUGH FLEXIBLE FINANCING | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | A-SOC2 | | ● |
| | | | IMPACT |
| **Appliance name** | All | | ± |
| **Unit of measurement** | Number of people | | |
| **Definition** | Number of people with current access to high-performing clean energy appliances through financing | | |
| **Usefulness of metric** | Enables demonstration of the number of people who have benefited from high-performing clean energy appliance financing through flexible financing. | | |
| **Impact statement** | PAYGo appliance financing is enabling an estimated x people access to high-performing clean energy appliances financing. This will allow them to build up a credit history which could help them to access more products and services in the future. | | |
| **Calculation** | SL-PAYGO × (1 – DL) × (1 – DR-Access) | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | SL-PAYGO | Number of units sold through flexible financing currently in use (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-Access | Discount for repeat sales for estimating new access to solar powered appliances (including different companies) (%) | 5% |
| **Assumptions** | • Currently most of the information about flexible financing comes from PAYGo systems and does not include other micro financing options.<br>• That the majority of PAYGo customers are unlikely to have a strong credit history and, as such, PAYGo financing is not only providing more affordable high performing appliances but enabling them to become more financially included.<br>• Most sales are PAYGo and therefore, the discount for loss is approximately equal to the discount for loss for all sold appliances. | | |

37 Altai Consulting & GOGLA. 2020. Powering Opportunity in South Asia: From Work to Well-being, the Important Role of Small Scale Solar. https://www.gogla.org/resources/powering-opportunity-in-south-asia-from-work-to-well-being-the-important-role-of-small

38 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

39 Efficiency for Access Coalition and 60_decibels. 2020. Use & Impact of Solar TVs: Lean Data Insights from Kenya, Rwanda, Tanzania, Uganda. https://efficiencyforaccess.org/publications/the-use-and-impacts-of-solar-tvs

40 Efficiency for Access Coalition and 60_decibels. 2021. Uses & Impacts of Solar Water Pumps. https://efficiencyforaccess.org/publications/uses-and-impacts-of-solar-water-pumps

| METRIC | NUMBER OF CUSTOMERS CURRENTLY ACCESSING OFF-GRID APPLIANCES THROUGH FLEXIBLE FINANCING |
|---|---|
| **Supporting literature** | • The "Powering Opportunity in South Asia" report found that 39% of respondents, the SHS owners, had their first experience of access to clean, modern power.[41]<br>• The "Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh" report noted that "..for many Bangladeshi customers, super-efficient off-grid fans create an opportunity to test solar technology for the first time. Super-efficient off-grid fans, therefore, have the potential to support a technological leap towards efficiency and wider use of solar.".[42] |
| **Data gaps** | • Explore the impacts of access on financial inclusion and further engagement in the appliance market (e.g., customer upgrades, use of PAYGo to purchase other products and services).<br>• Disaggregate this indicator for gender and income levels.<br>• Gather data about number of customers with access to flexible financing beyond PAYGo. |
| **Usage notes** | • This metric is simply equal to the number of people currently financing their appliance through PAYGo.<br>• The number does not include those who may have purchased a product previously through PAYGo financing and have already benefited from this level of financial inclusion. |

**Table 9: Social / Health Impact**

A-SOC3: Number of people below the poverty line with access to an appliance

| METRIC | NUMBER OF PEOPLE BELOW THE POVERTY LINE WITH ACCESS TO AN APPLIANCE | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | A-SOC3 | | ● |
| | | | IMPACT |
| **Appliance name** | All | | ⊕ |
| **Unit of measurement** | Number of people | | |
| **Definition** | Number of people that live under the World Bank's International Poverty Line for the specific region and have access to a high performing appliance. | | |
| **Usefulness of metric** | • Increasing the inclusivity of high-performing appliances among marginalised groups is essential for realising their positive impact.<br>• This metric rewards organisations that reach low-income end-users and allows them to monitor the progress of the sector as a whole. | | |
| **Impact statement** | X people under the poverty line gained access to high-performing [appliance name]. | | |
| **Calculation** | S × (1 – DL) × (1 – DR-Access) × H × RPL | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e., ever) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | H | Household size (number of people) | 5.5 |
| | DR-Access | Discount for repeat sales for estimating new access to solar powered appliances (including different companies) (%) | 5% |
| | RPL | Percentage of people that are under World Bank's International Poverty Line when gaining access to the appliance. The poverty line is determined as half of the median household income.[43] Regional values for the average (or median). Household income by country can be found in the World Population Review.[44] | This variable is to be inserted by the user |
| **Assumptions** | This formula does not include an increase in income post-purchase. | | |

41 ALTAI and GOGLA, Powering Opportunity in South Asia: From Work to Well-being, the Important Role of Small Scale Solar (2020) https://www.gogla.org/resources/powering-opportunity-in-southasia-from-work-to-well-being-the-important-role-of-small

42 Efficiency for Access, The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. (2020): https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

43 OECD. 2015. In It Together: Why Less Inequality Benefits All, OECD Publishing, Paris. https://doi.org/10.1787/9789264235120-en

44 World Population Review. N/A. https://worldpopulationreview.com/country-rankings/median-income-by-country

| METRIC | NUMBER OF PEOPLE BELOW THE POVERTY LINE WITH ACCESS TO AN APPLIANCE |
|---|---|
| **Supporting literature** | • In 2018, over 40% of the Sub-Saharan African population was under the World Bank's International Poverty Line. In East Asia, the same rates reached over 15% in 2014. The WHO dimension in the Impact Management Project recommends identifying how underserved the stakeholders of the intended impact are when measuring impact.[45]<br>• The Efficiency for Access and 60 Decibels' research (2020)[46] from Kenya, Rwanda, Uganda and Tanzania found that 30% of customers surveyed were living in poverty. |
| **Data gaps** | • Improve the mapping of income level at the day of purchase.<br>• Disaggregate this indicator for gender. |

**Table 10: Social / Health Impact**
A-SOC4: Affordability of monthly repayments

| METRIC | AFFORDABILITY OF MONTHLY REPAYMENTS | | |
|---|---|---|---|
| | | | **STATUS** |
| **ID** | A-SOC4 | | ● |
| | | | **IMPACT** |
| **Appliance name** | All | | ± |
| **Unit of measurement** | Percentage | | |
| **Definition** | The affordability of the monthly instalments. | | |
| **Usefulness of metric** | Enables understanding of the affordability of high-performing appliances for the end-user. | | |
| **Impact statement** | At [point in time] the average monthly payment for [appliance name] is x percent of the average monthly income of our target customers. | | |
| **Calculation** | (PAYGoMC / IMAC) × 100 | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | PAYGoMC | Average Monthly PAYGo commitment (USD or equivalent) | This variable is to be inserted by the user |
| | IMAC | Average monthly income of the customer base (USD or equivalent) | This variable is to be inserted by the user |
| **Assumptions** | That the majority of PAYGo customers struggle to meet the monthly PAYGo repayments. This implies that the access to the high-performing appliances presents an 'unreasonable burden' to the individual or household. | | |
| **Supporting literature** | • ALTAI and GOGLA's report [47] "Powering Opportunity in East Africa: Proving Off-Grid Solar is a Power Tool for Change"[48] found that 4% of respondents reported negative effects with the most common being feeling more stressed, likely related to repayments.<br>• For example, regarding to solar-powered TVs, Efficiency for Access & 60 Decibels' survey on the use and impact of the appliances found that 61% of the respondents reported that they have to make unacceptable sacrifices to make repayments. 2% had to cut back on consumption to make repayments.[49] | | |
| **Data gaps** | • More work on how to include changes in income post purchase in the case of productive use of energy (e.g., irrigation).<br>• Including the income increase post-purchase.<br>• Measure the default rates of appliances as a more accurate proxy for affordability.<br>• Disaggregate this indicator for gender. | | |

45 Impact Management Project. 2021. 'Who', Impact Management Project. https://impactmanagementproject.com/impact-management/impact-management-norms/who/
46 Efficiency for Access Coalition and 60_decibels. 2020. Use & Impact of Solar TVs: Lean Data Insights from Kenya, Rwanda, Tanzania, Uganda. https://efficiencyforaccess.org/publications/the-use-and-impacts-of-solar-tvs
47 ALTAI & GOGLA (2019). Powering Opportunity in East Africa:Proving Off-Grid Solar is a Power Tool for Change.
48 Altai Consulting and GOGLA. 2019a. Powering Opportunity in East Africa: Proving Off-Grid Solar is a Power Tool for Change. https://www.gogla.org/sites/default/files/resource_docs/powering_opportunity_in_east_africa.pdf
49 Efficiency for Access Coalition and 60_decibels. 2020. Use & Impact of Solar TVs: Lean Data Insights from Kenya, Rwanda, Tanzania, Uganda. https://efficiencyforaccess.org/publications/the-use-and-impacts-of-solar-tvs

| METRIC | AFFORDABILITY OF MONTHLY REPAYMENTS |
|---|---|
| **Usage notes** | • This metric is simply defining and measuring the affordability to a household, using the payment method which is based on the ratio of the payment for a particular commodity to a household's total resources.<br>• In case IMAC is not available, users can use national household surveys, or the FAO estimates available here, or other data services such as Fraym includes everything that is included in the monthly payment, including anything in the bundle.<br>• PAYGoMC includes everything that is included in the monthly payment, including anything in the bundle.<br>• IMAC is calculated as yearly income divided by 12 recognising that there is a seasonal effect in monthly incomes.<br>• In case and for PAYGo payments are not monthly, or not equal every month, PAYGoMC is calculated as the monthly equivalent. |

**Table 11: Social / Health Impact**
F-SOC1a: Total hours of improved thermal comfort, cumulatively

| METRIC | TOTAL HOURS OF IMPROVED THERMAL COMFORT, CUMULATIVELY | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | F-SOC1a | | ● |
| | | | IMPACT |
| **Appliance name** | Fan | | ⊕ |
| **Unit of measurement** | Hours | | |
| **Definition** | Cumulative hours a high performing fan is used to provide thermal comfort at home. | | |
| **Usefulness of metric** | Enables estimation of the functionality and usefulness of a fan providing thermal comfort. | | |
| **Impact statement** | Since [start date of distribution], the high performing fan industry has helped to improve thermal comfort for X hours. | | |
| **Calculation** | S × Ff × PL × PTsp × (1 – DL) × (1 – DR-Access) | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e., ever) (number of units) | This variable is to be inserted by the user |
| | Ff | Operating time fraction for a fan as hours per day (hours/day) | 4-8.5 |
| | PL | Estimated product lifespan (minimum of 1.5 × financing period, or 1.5 × warranty period in cash payments) (years) | This variable is to be inserted by the user |
| | PTsp | Average number of days per year in which temperature is above 26 °C (number of days / year). Data for different geographies is accessible here:[50] Data for PTsp can be accessed here.[51] | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-Access | Discount for repeat sales for estimating new access to solar powered appliances (including different companies) (%) | 5% |
| **Assumptions** | • The appliance is used in the home, and every household member benefits or has access to the appliance.<br>• Appliance access and use are assumed to be triggered upon reaching a certain threshold, an indoor set temperature (TSP). To a certain extent, seasonality or differences in time-use (acclimatisation variances by geography and local climate) are taken into consideration.<br>• Other factors that influence thermal comfort, such as, contextual [age, gender, individual health status], environmental [different qualities of building envelopes and construction, thermal insulation, internal and solar heat gains], behaviour [household occupants' behaviour] and appliance functionality [airflow, air speed, fan type, fan size and location], are not taken into account. | | |

50 R. Debnath, R. Bardhan, and M. Sunikka Blank, 2019a. Discomfort and distress in slum rehabilitation: Investigating a rebound phenomenon using a backcasting approach. Habitat International, 87, 75–90. https://doi.org/10.1016/j.habitatint.2019.03.010

51 Weather and Climate. N/A. https://weather-and-climate.com/

| METRIC | TOTAL HOURS OF IMPROVED THERMAL COMFORT, CUMULATIVELY |
|---|---|
| **Supporting literature** | • The Rural Senses (2021) survey of fan owners in India found that 67.8% ofrespondents associated fan use with comfort.[52]<br>• Efficiency for Access' (2020) survey of 1,600 off-grid fan customers in Bangladesh found that most of the customers bought fans for household use in a bedroom or living room area. 81% of respondents associated fan use with improvements in quality of life, with 66% noting that rooms are cooler. Furthermore, 92% of the respondents noticed that they felt less dehydrated and that they sweat less, both strong indicators of improvement in thermal comfort.[53]<br>• Another study from 2019 surveyed 1,224 households across four Slum Rehabilitation Housing (SRH) societies in Mumbai and found that 99% of the surveyed households' only method of regulating thermal comfort was the use of a fan.[54]<br>• In the investigation of thermal comfort and self-reported productivity in an office with ceiling fans in the tropics (Singapore), 91% of all respondents reported thermal satisfaction when the temperature set-point was 26 °C and fans were in use.[55]<br>• A survey on electrical appliance use and energy consumption in 60 Vietnamese households found that 100% of the respondents had fans and operated them for ~ 8.75 hours a day.[56] |
| **Data gaps** | None |
| **Usage notes** | • Data for PTsp can be accessed here.[57]<br>• It should be noted that all studies, with the exception of one, have been entirely conducted in Asia. Although some data from Uganda (East Africa) have been used to derive an average for default values (fan-use rate), the formula outcome will potentially be more accurate for Asian countries.<br>• The participants were disproportionately male. For instance, the study in Bangladesh reported that almost all respondents (97%) were male. Furthermore, they stated that the fans are used at home, rather than at their jobs, and it is known that it is the elderly, children and women who often work from home. |

**Table 12: Social / Health Impact**

F-SOC1b: Number of people who are experiencing improved thermal comfort

| METRIC | NUMBER OF PEOPLE WHO ARE EXPERIENCING IMPROVED THERMAL COMFORT | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | F-SOC1a | | ● |
| | | | IMPACT |
| **Appliance name** | Fan | | ⊕ |
| **Unit of measurement** | Hours | | |
| **Definition** | Cumulative hours a high performing fan is used to provide thermal comfort at home. | | |
| **Usefulness of metric** | Enables estimation of the functionality and usefulness of a fan providing thermal comfort. | | |
| **Impact statement** | Since [start date of distribution], the high performing fan industry has helped to improve thermal comfort for X hours. | | |
| **Calculation** | S × Ff × PL × PTsp × (1 – DL) × (1 – DR-Access) | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | S | Number of units sold (cumulative, i.e., ever) (number of units) | This variable is to be inserted by the user |
| | Ff | Operating time fraction for a fan as hours per day (hours/day) | 3% |
| | DR-Access | Discount for repeat sales for estimating new access to solar powered appliances (including different companies) (%) | 5% |
| | H | Household size (number of people) | 5.5 |
| | PTC | Percentage of people who associate their fan with improved thermal comfort (%) | 94% |

52 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished).

53 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

54 R. Debnath, R. Bardhan, and M. Sunikka Blank, 2019a. Discomfort and distress in slum rehabilitation: Investigating a rebound phenomenon using a backcasting approach. Habitat International, 87, 75–90. https://doi.org/10.1016/j.habitatint.2019.03.010

55 A. Lipczynska, S Schiavon, and L.T. Graham, 2018. Thermal Comfort and Self-Reported Productivity in an Office with Ceiling Fans in the Tropics. Building and Environment 135: 202–12. https://doi.org/10.1016/j.buildenv.2018.03.013

56 V.T. Le and A. Pitts, 2019. A Survey on Electrical Appliance Use and Energy Consumption in Vietnamese Households: Case Study of Tuy Hoa City. Energy and Buildings 197: 229–41. https://doi.org/10.1016/j.enbuild.2019.05.051

57 Weather and Climate. N/A. https://weather-and-climate.com/

| METRIC | TOTAL HOURS OF IMPROVED THERMAL COMFORT, CUMULATIVELY |
|---|---|
| **Assumptions** | • The appliance is used in the home, and every household member benefits or has access to the appliance.<br>• The appliance maintains its functionality over its lifetime.<br>• Other factors that influence thermal comfort, such as, contextual [age, gender, individual health status], environmental [different qualities of building envelopes and construction, thermal insulation, internal and solar heat gains], behaviour [household occupants' behaviour] and appliance functionality [airflow, air speed, fan type, fan size and location], are not taken into account. |
| **Supporting literature** | • The Rural Senses (2021) survey of fan end-users in India found that 67.8% of the respondents associated fan use with comfort.[58]<br>• Efficiency for Access' (2020) survey of 1,600 off-grid fan customers in Bangladesh found that most of the customers bought fans for household use in a bedroom or living room area. 81% of respondents associated fan use with improvements in quality of life, with 66% noting that rooms are cooler. Furthermore, 92% of the respondents noticed that they felt less dehydrated and that they sweat less, both strong indicators of improvement in thermal comfort.[59]<br>• The survey of 1,224 households across four Slum Rehabilitation Housing (SRH) societies in Mumbai found that 99% of the surveyed households only method of regulating thermal comfort was the use of a fan.[60]<br>• In the investigation of thermal comfort and self-reported productivity in an office with ceiling fans in the tropics (Singapore), 91% of all respondents reported thermal satisfaction when the temperature set-point was 26 °C and fans were in use.[61]<br>• The survey on electrical appliance use and energy consumption in 60 Vietnamese households found that 100% of the respondents had fans and operated them for ~ 8.75 hours a day.[62] |
| **Data gaps** | Better understanding of the accessibility of household members, especially women, to fans used at home. |
| **Usage notes** | • It should be noted that all studies, with the exception of one, have been entirely conducted in Asia. The formula outcome will potentially be more accurate for Asian countries.<br>• We take into account the end-user's perceived value of the appliance by quantifying the their subjective responses to derive the default value, PTC=95%. |

**Table 13: Social / Health Impact**

F-SOC2a: Number of people who are experiencing improved indoor air quality

| METRIC | NUMBER OF PEOPLE WHO ARE EXPERIENCING IMPROVED INDOOR AIR QUALITY | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | F-SOC2a | | ● |
| | | | IMPACT |
| **Appliance name** | Fan | | ⊕ |
| **Unit of measurement** | Number of people | | |
| **Definition** | Number of people who currently perceive that using a high-performing fan has improved air quality. | | |
| **Usefulness of metric** | Enables estimation of the functionality and usefulness of a fan to improve indoor air quality as perceived by the end-user. | | |
| **Impact statement** | X people with access to a high performing fan perceive an improvement in indoor air quality. | | |
| **Calculation** | SL × (1 – DL) × (1-DR-Access) H × PIAQ | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | SL | Number of units sold which are estimated to currently be in use (based on the products' estimated lifespan being 1.5 × financing period, or 1.5 × warranty period in cash payments) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-Access | Discount for repeat sales for estimating new access impact (%) | 5% |
| | H | Household size (number of people) | 5.5 |
| | PIAQ | Percentage of people that associate their fan with improved indoor air quality (IAQ) (%) | 9% |

58 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished).

59 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

60 R. Debnath, R. Bardhan, and M. Sunikka-Blank, 2019a. Discomfort and distress in slum rehabilitation: Investigating a rebound phenomenon using a backcasting approach. Habitat International, 87, 75–90. https://doi.org/10.1016/j.habitatint.2019.03.010

61 A. Lipczynska, S Schiavon, and L.T. Graham, 2018. Thermal Comfort and Self-Reported Productivity in an Office with Ceiling Fans in the Tropics. Building and Environment 135: 202–12. https://doi.org/10.1016/j.buildenv.2018.03.013

62 V.T. Le and A. Pitts, 2019. A Survey on Electrical Appliance Use and Energy Consumption in Vietnamese Households: Case Study of Tuy Hoa City. Energy and Buildings 197: 229–41. https://doi.org/10.1016/j.enbuild.2019.05.051

| METRIC | NUMBER OF PEOPLE WHO ARE EXPERIENCING IMPROVED INDOOR AIR QUALITY |
|---|---|
| **Assumptions** | • The appliance is used in the home, and every household member benefits or has access to the appliance.<br>• The appliance maintains its functionality over its lifetime.<br>• The appliance improves the air exchange rate and is used to supplement natural ventilation through open windows and doors.<br>• Contaminants are controlled, and the temperature and humidity are within acceptable ranges for the fan to have a positive impact. |
| **Supporting literature** | • The Rural Senses (2021) survey of fan end-users in India found that 47.8 % of the respondents associated fan use with improved air quality.[63]<br>• A study conducted in Peru has found that fans can be 70–80% effective in disinfecting air.[64]<br>• 81% respondents of the Efficiency for Access (2020) survey of fan end-users in Bangladesh associated fan use with improvements in quality of life. 7% was attributed to less dust, a strong indicator of improved air quality.[65]<br>• All the respondents in a study of human comfort and perceived air quality in warm and humid environments reported improved thermal comfort and Perceived Air Quality (PAQ) when using a fan.[66] |
| **Data gaps** | Air quality is affected by a number of factors and the actual impact of the fan on off-grid households' air quality should be investigated further and profiled using different household characteristics and fan specification that could contribute to this impact. |
| **Usage notes** | • The data are inconsistent and not conclusive.<br>• We take into account the end-user's perceived value of the appliance by quantifying their subjective responses to derive the default value, PIQ . Because the evidence is not sufficient, we take a very conservative value for PIQ_=7%. |

**Table 14: Social / Health Impact**

F-SOC2b: Number of people who perceived a reduction in carriers of vector-borne disease, e.g. mosquitos

| METRIC | NUMBER OF PEOPLE WHO PERCEIVED A REDUCTION IN CARRIERS OF VECTOR-BORNE DISEASE, E.G., MOSQUITOS | | |
|---|---|---|---|
| | | | STATUS |
| **ID** | F-SOC2b | | ● |
| | | | IMPACT |
| **Appliance name** | Fan | | ⊕ |
| **Unit of measurement** | Number of people | | |
| **Definition** | Number of people using a high-performing fan to benefit from fewer carriers of vector-borne disease (mosquitos). | | |
| **Usefulness of metric** | Enables estimation of the functionality and usefulness of a fan to fend off carriers of vector-borne disease as perceived by the end-users. | | |
| **Impact statement** | X people with access to a high performing fan perceive it is useful for fending off carriers of vector-borne disease. | | |
| **Calculation** | SL × (1 – DL) × (1-DR-Access) × PDCV | | |
| **Variables** | VARIABLES | DEFINITION | VALUE |
| | SL | Number of units sold which are estimated to currently be in use (based on the products' estimated lifespan being 1.5 × financing period, or 1.5 × warranty period in cash payments) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-Access | Discount for repeat sales for estimating new access impact (%) | 5% |
| | PDCV | Percentage of people that report using a fan to fend off mosquitos (%) | 75% |

63 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished).

64 S. Zhu, J. Srebric, S.N. Rudnick, R.L. Vincent, and E.A. Nardell, 2014. Numerical Modeling of Indoor Environment with a Ceiling Fan and an Upper-Room Ultraviolet Germicidal Irradiation System. Building and Environment 72: 116–24. https://doi.org/10.1016/j.buildenv.2013.10.019

65 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

66 Y. Zhai, Y. Zhang, H. Zhang, W. Pasut, E. Arens, and Q. Meng, 2015. Human Comfort and Perceived Air Quality in Warm and Humid Environments with Ceiling Fans. Building and Environment 90: 178–85. https://doi.org/10.1016/j.buildenv.2015.04.003

| METRIC | NUMBER OF PEOPLE WHO PERCEIVED A REDUCTION IN CARRIERS OF VECTOR-BORNE DISEASE, E.G., MOSQUITOS |
|---|---|
| **Assumptions** | • The appliance is used in the home, and every household member benefits or has access to the appliance.<br>• The appliance maintains its functionality over its lifetime.<br>• The appliance can be used at the appropriate time for this function. |
| **Supporting literature** | • The Rural Senses (2021) survey of off-grid fan end-users in India found that 32.2 % of the participants associated fan use with protection from mosquitoes.[67]<br>• 39% of participants from Thailand reported using a fan to keep mosquitoes away from indoor spaces.[68]<br>• An investigation of the low utilisation of insecticide-bed treated nets among pregnant women in Ghana found that 28% of the participants reported using fans as a barrier to mosquito bites.[69]<br>• A study in Bangkok found that the most prevalent preventive behaviour among students for dengue haemorrhagic fever (DHF) was the use of an electric fan while sleeping (68.3%).[70]<br>• 81% of people surveyed in Bangladesh stated that super-efficient off-grid fans reduced the number of mosquitoes in their homes.[71] |
| **Data gaps** | More evidence regarding the efficacy of fans in reducing mosquito transmitted diseases. |
| **Usage notes** | • The data are not conclusive and are insufficient.<br>• We've taken into account the end-user's perceived value of the appliance by quantifying the their subjective responses to derive the default average value, PDCV. Because the evidence is not sufficient, we take a very conservative value for PDCV = 54%. |

**Table 15: Social / Health Impact**

F-SOC2c: Number of people who perceived improved health

| METRIC | NUMBER OF PEOPLE WHO PERCEIVED IMPROVED HEALTH | | |
|---|---|---|---|
| | | | **STATUS** |
| **ID** | F-SOC2c | | ● |
| | | | **IMPACT** |
| **Appliance name** | Fan | | ⊕ |
| **Unit of measurement** | Number of people | | |
| **Definition** | Number of people who perceive that the use of a high-performing fan contributes to improved health. | | |
| **Usefulness of metric** | Enables estimation of the number of people who perceive that the use of a high-performing fan contributes to improved health. | | |
| **Impact statement** | X people with access to a high-performing fan perceive it is improving health. | | |
| **Calculation** | SL × (1 – DL) × (1-DR-Access) × PIH | | |
| **Variables** | **VARIABLES** | **DEFINITION** | **VALUE** |
| | SL | Number of units sold which are estimated to currently be in use (based on the products' estimated lifespan being 1.5 × financing period, or 1.5 × warranty period in cash payments) (number of units) | This variable is to be inserted by the user |
| | DL | Discount for loss: products not working or not in use, excluding loss in supply chain (%) | 3% |
| | DR-Access | Discount for repeat sales for estimating new access impact (%) | 5% |
| | PIH | Percentage of people with access to the appliance who perceive that the appliance contributes to 'health and wellbeing' | 75% |
| **Assumptions** | • The appliance is used in the home, and every household member benefits or has access to the appliance.<br>• The appliance maintains its functionality over its lifetime.<br>• The appliance is used in a mixed method prevention and control strategy. For example, the fan is used to provide thermal comfort when using an insecticide treated mosquito net, or the fan is used to circulate mosquito coil smoke. | | |

67 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished).

68 V.A. Paz-Soldan, V. Plasai, A.M. Morrison, E.J. Rios-Lopez, S. Guedez-Gonzales, J.P. Grieco, K. Mundal, T. Chareonviriyaphap, and N.L. Achee, 2011. Initial Assessment of the Acceptability of a Push-Pull Aedes Aegypti Control Strategy in Iquitos, Peru and Kanchanaburi, Thailand. The American Journal of Tropical Medicine and Hygiene 84, no. 2 (4 February 2011): 208–17. https://doi.org/10.4269/ajtmh.2011.09-0615

69 Manu, G. et al. (2017) 'Low Utilization of Insecticide-Treated Bed Net among Pregnant Women in the Middle Belt of Ghana', Malaria Research and Treatment, 2017, pp. 1–7. doi:10.1155/2017/7481210

70 C. Chanyasanha, M.M. Han, and S. Teetipsatit, 2013. Dengue Hemorrhagic Fever Knowledge, Perception, and Preventive Behavior among Secondary School Students in Bangkok. 96: 11

71 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

| METRIC | NUMBER OF PEOPLE WHO PERCEIVED IMPROVED HEALTH |
|---|---|
| **Supporting literature** | • The Rural Senses (2021) off-grid end-user research in India found that 24.4% of the 90 users associated the use of a fan with a positive impact on family health.[72]<br>• 39% of participants from Thailand reported using a fan to keep mosquitoes away from indoor spaces.[73]<br>• An investigation of the low utilisation of insecticide-bed treated nets among pregnant women in Ghana found that 28% of the participants reported using fans as a barrier to mosquito bites.[74]<br>• A study in Bangkok found that the most prevalent preventive behaviour among students for dengue haemorrhagic fever (DHF) was the use of an electric fan while sleeping (68.3%).[75]<br>• 92% of respondents in Bangladesh reported a positive impact of super-efficient off-grid fans on the health of their families. Respondents noticed that they felt less dehydrated and that they sweated less, both strong indicators of overall health improvement and reduction in the risk of serious health conditions. In addition, 81% of surveyed end-users stated that super-efficient off-grid fans reduced the number of mosquitoes in their homes, an additional positive health indicator.[76] |
| **Data gaps** | More evidence regarding the impact of fans on health. |
| **Usage notes** | The data are insufficient to affirmatively attribute this impact to use of the high performing appliance. However, as more evidence becomes available, the perceived health improvements reported by end-users should not be ignored. |

72 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished).

73 V.A. Paz-Soldan, V. Plasai, A.M. Morrison, E.J. Rios-Lopez, S. Guedez-Gonzales, J.P. Grieco, K. Mundal, T. Chareonviriyaphap, and N.L. Achee, 2011. Initial Assessment of the Acceptability of a Push-Pull Aedes Aegypti Control Strategy in Iquitos, Peru and Kanchanaburi, Thailand. The American Journal of Tropical Medicine and Hygiene 84, no. 2 (4 February 2011): 208–17. https://doi.org/10.4269/ajtmh.2011.09-0615

74 G. Manu et al. (2017) 'Low Utilization of Insecticide-Treated Bed Net among Pregnant Women in the Middle Belt of Ghana', Malaria Research and Treatment, 2017, pp. 1–7. doi:10.1155/2017/7481210

75 C. Chanyasanha, M.M. Han, and S. Teetipsatit, 2013. Dengue Hemorrhagic Fever Knowledge, Perception, and Preventive Behavior among Secondary School Students in Bangkok. 96: 11

76 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

# Standard Variables – Elaborated

## This section provides a detailed description of the evidence for the values proposed for the standard variables.

The tables provide the values, geography and the degree of urbanisation for which the values are applicable; a summary of the evidence for the values; a score for the level of confidence users can have in the value based on the quality of the evidence; and limitations and potential biases with the evidence and hence values.

In the section of the table related to applicability, for each variable the 'degree of urbanisation' factor indicates which of three different categories of urbanisation the variable is appropriate for: (a) cities (densely populated areas), (b) towns and suburbs (intermediate density areas) and (c) rural areas (thinly populated areas).[77]

The confidence level was assessed for each value for 'standard variables'. Three stars (***) indicate that a study is 'up to date' (ie. conducted within five years of the assessment) and has, at the same time, a 'large sample size' (meaning that the data came from one study with over 500 samples or several studies with a total of over 500 samples). Two stars (**) indicate that studies are either 'up to date' or have a 'large sample size' and one star (*) indicates that the studies are not up to date and have small sample size.

**Table 16: DL: Discount for loss: products not working or not in use, excluding loss in supply chain (%)**

| DL | DISCOUNT FOR LOSS: PRODUCTS NOT WORKING OR NOT IN USE, EXCLUDING LOSS IN SUPPLY CHAIN (%) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Bangladesh | Rural | *** | 3% |
| **Assumption** | It is assumed that the off-grid use data are collected from a rural setting if it is not explicitly stated otherwise. | | | |
| **Supporting literature** | Efficiency for Access and GOGLA's study "The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh" found that from a sample of 1,614 people, only 2% of end-users described a negative experience (such as not enough power or the device not turning on).[78] | | | |
| **Limitations / biases** | 93% of the sample were male which means that one subset has more data than others. This may introduce participant biases. | | | |

**Table 17: DR-Access: Discount for repeat sales for estimating new access to solar-powered appliances**

| DR-ACCESS | DISCOUNT FOR REPEAT SALES FOR ESTIMATING NEW ACCESS TO SOLAR-POWERED APPLIANCES (INCLUDING DIFFERENT COMPANIES) (%) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Asia | N\|A | ** | 5% |
| **Supporting literature** | The value was derived following extensive consultation with GOGLA Impact Working group members / GOGLA member companies / Efficiency for Access network companies and relevant studies.[79,80] | | | |
| **Limitations / biases** | Self-reported data are often prone to response bias. There are limited secondary data to support this value. In addition, the data do not differentiate between fan types, appliances sold alone or sold as part of an SHS kit, nor identify different business models through which the appliance (kit) is sold. | | | |

77 Eurostat. 2021. Applying the Degree of Urbanisation. OECD. https://doi.org/10.1787/4bc1c502-en

78 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

79 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

80 Efficiency for Access Coalition and GOGLA. 2020. Standardised Impact Metrics for High-Performing Appliances: Fans and TVs. https://www.gogla.org/sites/default/files/resource_docs/gogla_impact-metrics-appliances_paper2020_def-summary_0.pdf

**Table 18: DR-GHG: Ratio capturing sales replacing a diesel genset-powered appliance (%)**

| DR-GHG | RATIO CAPTURING SALES REPLACING A DIESEL GENSET-POWERED APPLIANCE (%) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | N\|A | N\|A | ** | 3% |
| **Supporting literature** | According to the Efficiency for Access Off-Grid Appliance Working Group, repeat sales for fans account for approximately 3% of off-grid fan sales, and it is assumed this percentage represents diesel generator- powered fans. | | | |
| **Limitations / biases** | The assumption that all repeat sales relate to the replacement of diesel genset powered appliances, and not other technologies like batteries, is not supported by primary or secondary data. The variation of the coefficient established value across geographies is not studied. | | | |

**Table 19: EF: Employment factor**

| EF | EMPLOYMENT FACTOR (JOBS / ITEM SOLD) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Jobs / item sold | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Nigeria | Nationwide | ** | 0.0188 |
| | East Africa | Nationwide | ** | 0.0082 |
| | India | Nationwide | ** | 0.0137 |
| **Assumption** | That fans are included in SHS packages and that the SHS system size can support a fan of a given size. | | | |
| **Supporting literature** | According to the "Power for All" report (2019), the employment factors for pico solar appliances and solar home systems in Nigeria, Kenya and India for 2017–2018 were 18.8 jobs, 8.2 jobs and 13.7 jobs per 1,000 items sold respectively. The information is based on a survey carried out across 150 companies in India, Kenya and Nigeria.[81] These companies were surveyed across the decentralised renewable energy (DRE) technology spectrum, and the survey covers the supply chain, from manufacturing and wholesale imports to sales, installation and operations. This included DRE companies working in off-grid, weak-grid or on-grid contexts.[82] | | | |
| **Limitations / biases** | The data are not segregated for each solar product, such as solar TV, fan, solar water pumps and refrigerators but rather given as an aggregated value for pico solar appliances and SHS systems. This may result in an overestimation of the actual contribution by each solar product. | | | |

**Table 20: EFA: Proportion of employment factor relevant to each appliance**

| EFA | PROPORTION OF EMPLOYMENT FACTOR RELEVANT TO EACH APPLIANCE | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Global | Nationwide | ** | 25% |
| **Supporting literature** | • Based on the "Power for All" report (page 44)[83]<br>• Discount ratios are assigned based on the average appliance-to-total-SHS-cost ratios from the VeraSol database. These values equate to 25% for fans. | | | |
| **Limitations / biases** | • The above figures relate to SHSs as a whole, and we make an assumption that in South Asia, the SHS packages include a fan.<br>• There is no specific reference to jobs created by the fan appliance market. | | | |
| **Data gaps** | Job creation along the off-grid appliance supply chain disaggregated by appliance. | | | |

81 Power for All. 2019. Powering Jobs Census 2019: The Energy Access Workforce. https://www.powerforall.org/resources/reports/powering-jobs-census-2019-energy-access-workforce
82 ibid
83 ibid

**Table 21: Ff: Operating time fraction for a fan as hours per day**

| FF | OPERATING TIME FRACTION FOR A FAN AS HOURS PER DAY (HOURS/DAY) | | | |
|---|---|---|---|---|
| **Unit** | Hours / day | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | East Africa | N\|A | ** | 4 |
| | South Asia | N\|A | * | 8.5 |
| **Supporting literature** | • A survey on electrical appliance use and energy consumption in 60 Vietnamese households found that 100% of the respondents had fans and operated them for ~ 8.75 hours a day.[84]<br>• The Rural Senses (2020) survey of off-grid fan users in India, found that on average people operate their fans for 12.1 hours a day.[85] A conservative value of 8.5 hours is used to account for the limitations of off- and weak-grid systems.<br>• In East Africa, research estimates that up to 60% of SHSs sold in the market over 2017 could have bundled DC fans, and about half would likely include DC-powered TVs.[86]<br>• The most common SHSs packages fall in Tier 1 and Tier 2, defined either by a minimum power capacity of 50W or 200Wh or by a service of electrical lighting, air circulation, television and phone charging are possible with a minimum availability of four hours per day. Therefore, it's assumed that the appliances can only operate for a maximum of four hours a day. | | | |
| **Limitations / biases** | • Most studies do not record the average operation of the appliance.<br>• In East Africa, it is assumed that the appliance use cannot exceed the system availability of four hours per day. | | | |

**Table 22: G: Average amount of greenhouse gases avoided per appliance, due to diesel displacement (kg $CO_2$ / year)**

| G | AVERAGE AMOUNT OF GREENHOUSE GASES AVOIDED PER APPLIANCE, DUE TO DIESEL DISPLACEMENT (KG $CO_2$ / YEAR) | | | |
|---|---|---|---|---|
| **Unit** | kg $CO_2e$ / year | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Internationally | N/A | *** | 84 |
| **Supporting literature** | Assuming that the solar equivalent appliance will have zero end-use emissions, the emissions of a single appliance equal:[87]<br>• (Required energy / 10^12) × Emissions Factor of a Diesel Generator; where the Required energy equals:<br>• (Delivered Energy × 3600 × 1 / Generator efficiency)<br>Assuming a generator efficiency of 25% and the following:<br>• run-time of 8 hours / day<br>• daily energy consumption of 0.33 kWh / day<br>• annual operation days of 240<br>Then the required annual Delivered Energy is 79 kWh / year, and the annual Required Energy is 0.001134 TJ / year.<br>As such, $CO_2e$ emissions saved due to use of a solar fan come to 84 kg$CO_2e$ / year.<br>Diesel Emission Factor: 74,100 kg$CO_2$ / TJ.[88] | | | |
| **Limitations / biases** | The above figures assume that a fan runs for eight hours daily for 240 days a year. However, this will vary depending on weather patterns in each region and the number of individuals who make use of the fan. | | | |
| **Data gaps** | Number of days per year and number of hours per week of fan use for different geographies of interest. | | | |

84 V.T. Le and A. Pitts, 2019. A Survey on Electrical Appliance Use and Energy Consumption in Vietnamese Households: Case Study of Tuy Hoa City. Energy and Buildings 197: 229–41. https://doi.org/10.1016/j.enbuild.2019.05.051

85 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished).

86 Lighting Global. 2018. Off-grid solar market trend report 2018 (No. 4; p. 24). International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Summary.pdf

87 ibid

88 ibid

**Table 23: H: Household size (number of people)**

| H | HOUSEHOLD SIZE (NUMBER OF PEOPLE) | | | |
|---|---|---|---|---|
| **Unit** | Number of people | | | |
| **Appliance** | All | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | South Asia | General | *** | 5.5 |
| | West Africa | Urban | *** | 6 |
| | West Africa | Rural | *** | 8 |
| | East Africa | Urban | *** | 5.3 |
| | East Africa | Rural | *** | 5.5 |
| **Supporting literature** | • Based on the interviews of 25,497 individuals in East Africa (61%), West Africa (16%) and South Asia (14%), the recorded average household size was 5.9.[89]<br>• A study in Bangladesh reported that the average household size of the sample was 5.3 people, with two-thirds of the household size falling into the range of three to six people.[90]<br>• One study from 2019 recorded an average household size of 5.7, while the other highlighted that "while the average household size was 7 across the research, urban households tend to be closer to 6 members while rural households are closer to 8 members".[91,92]<br>• Another report from the same authors stated that the average household size among pre-purchase interviewees was 6.9.[93]<br>• The United Nations (2107) reported an average household size of 4.8 in India and 6.8 in Pakistan.[94] | | | |
| **Limitations / biases** | Off-grid household data show larger household sizes than the national averages; this needs to be further investigated. | | | |

**Table 24: OPEXD: Annual operating fuel cost of a diesel-powered appliance (USD / year)**

| OPEXD | ANNUAL OPERATIONAL FUEL COST OF A DIESEL-POWERED APPLIANCE (USD / YEAR) | | | |
|---|---|---|---|---|
| **Unit** | USD / year | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | East Africa | Nationwide | ** | 34.82 |
| | India | Nationwide | ** | 58.17 |
| **Supporting literature** | According to articles published in 'Renewable Energy World', the average cost of 1 kWh generated by diesel generators is USD 0.25 and USD 0.318 for India and East Africa respectively. Therefore, the expenditure on fuel for powering a 46-inch, 75-watt fan for 8.5 hours every day in India = ((75 × 8.5 x 365) / 1000) x 0.25 = US $58.17 and in East Africa = ((75 × 8.5 × 365) / 1000) × 0.0.1318 = USD 34.82. The coefficient established value excludes the cost of the generator.[95,96] | | | |
| **Limitations / biases** | • The cost of fuel is volatile.<br>• The sizes, technology, air speeds and power consumption of fan appliances vary from one customer to another.<br>• An assumption is made that a 48-inch fan is the most common. | | | |

89 K. Harrison, S. Khan, T. Adams, and S. Dichter, 2020. Why off-grid energy matters. An Impact Performance Report. https://60decibels.com/user/pages/energy-report/60%20Decibels%20-%20Why%20Off-Grid%20Energy%20Matters.pdf

90 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

91 Altai Consulting and GOGLA. 2019a. Powering Opportunity in East Africa: Proving Off-Grid Solar is a Power Tool for Change. https://www.gogla.org/sites/default/files/resource_docs/powering_opportunity_in_east_africa.pdf

92 Altai Consulting and GOGLA. 2019b. Powering Opportunity in West Africa. Improving Lives, Powering Livelihoods with Off-Grid Solar. https://www.gogla.org/resources/powering-opportunity-in-west-africa-improving-lives-powering-livelihoods-with-off-grid

93 Altai Consulting and GOGLA. 2020a. Powering Opportunity in South Asia: From Work to Well-being, the Important Role of Small Scale Solar. https://www.gogla.org/resources/powering-opportunity-in-south-asia-from-work-to-well-being-the-important-role-of-small

94 United Nations. 2017. Household size and composition around the world. Data Booklet. https://www.un.org/en/development/desa/population/publications/pdf/ageing/household_size_and_composition_around_the_world_2017_data_booklet.pdf

95 A. Mburu, 2020. Solar + battery energy storage VS diesel in East Africa - Renewable Energy World. https://www.renewableenergyworld.com/solar/solar-battery-energy-storage-vs-diesel-in-east-africa/#gref

96 B. Trivedi, 2011. Solar Power Becomes Cheaper than Diesel in India - Renewable Energy World. https://www.renewableenergyworld.com/solar/solar-power-becomes-cheaper-than-diesel-in-india/#gref

**Table 25: PDCV: Percentage of people that report using a fan to deter mosquitoes**

| PDCV | PERCENTAGE OF PEOPLE THAT REPORT USING A FAN TO DETER MOSQUITOES (%) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | West Africa | General | * | 36.2% |
| | South & South-East Asia | General | ** | 75% |
| **Supporting literature** | • 39% participants from Thailand reported using a fan to keep mosquitoes away from indoor spaces.[97]<br>• A study in Bangkok found that the most prevalent preventive behaviour among students for dengue haemorrhagic fever (DHF) was using an electric fan while sleeping and 68.3% always slept with their fans on for this purpose.[98]<br>• 81% of people surveyed in Bangladesh stated that super-efficient off-grid fans reduced the number of mosquitoes in their houses.[99]<br>• 32.2% of surveyed people in India associated fan use with protection from mosquitos.[100]<br>• A qualitative study on the perceptions of the effect of small electric fans on comfort inside bed nets in southern Ghana found that 69.5% of the participants cited the perceived benefit of driving the mosquitoes away as a reason for using fans.[101]<br>• An investigation of the low utilisation of insecticide-bed treated nets among pregnant women in Ghana found that 28% of the participants reported using fans as a barrier to mosquito bites.[102] | | | |
| **Limitations / biases** | • The West Africa data are from two studies in Ghana that particularly focused on finding evidence to support net-fan systems. In other words, how the use of fans can increase the use of long-lasting insecticidal nets (LLINs). The result may not necessarily be representative of the region. The sample sizes in both studies are small, and a weighted average was used.<br>• In the case of South & South-East Asia, a weighted average of the four data points from research from Bangladesh, India and Thailand is used. The data points are a percentage of the study participants that used a fan or perceived that the use of the fan reduced the number of mosquitoes in their houses. In other words, it is not an objective fact but rather a subjective perception of the end-user. | | | |

**Table 26: PIAQ: Percentage of customers who associate their fan with improved indoor air quality (IAQ)**

| PIAQ | PERCENTAGE OF CUSTOMERS THAT ASSOCIATE THEIR FAN WITH IMPROVED INDOOR AIR QUALITY (IAQ) (%) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | South Asia | General | ** | 9% |
| **Supporting literature** | • A study conducted in Peru found that fans can be 70–80% effective in disinfecting air;[103]<br>81% respondents of another survey of fan end-users in Bangladesh associated fan use with improvements in quality of life. Of these 7% attributed the improvement in their quality of life to a reduction in dust within households and improved ventilation, both strong indicators of improved air quality.[104]<br>• 47.8% of off-grid fan users in India associated the use of a fan with improved air quality using the clean air label as an indicator.[105] | | | |

97 V.A. Paz-Soldan, V. Plasai, A.M. Morrison, E.J. Rios-Lopez, S. Guedez-Gonzales, J.P. Grieco, K. Mundal, T. Chareonviriyaphap, and N.L. Achee, 2011. Initial Assessment of the Acceptability of a Push-Pull Aedes Aegypti Control Strategy in Iquitos, Peru and Kanchanaburi, Thailand. The American Journal of Tropical Medicine and Hygiene 84, no. 2 (4 February 2011): 208–17. https://doi.org/10.4269/ajtmh.2011.09-0615

98 C. Chanyasanha, M.M. Han, and S. Teetipsati, 2013. Dengue Hemorrhagic Fever Knowledge, Perception, and Preventive Behavior among Secondary School Students in Bangkok. 96: 11

99 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

100 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished)

101 Jaeger et al. 2016. Perceptions on the Effect of Small Electric Fans on Comfort inside Bed Nets in Southern Ghana: A Qualitative Study. Malaria Journal 15, no. 1 (1 December 2016): 580. https://doi.org/10.1186/s12936-016-1614-x

102 G. Manu et al. (2017) 'Low Utilization of Insecticide-Treated Bed Net among Pregnant Women in the Middle Belt of Ghana', Malaria Research and Treatment, 2017, pp. 1–7. doi:10.1155/2017/7481210

103 S. Zhu, J. Srebric, S.N. Rudnick, R.L. Vincent, and E.A. Nardell, 2014. Numerical Modeling of Indoor Environment with a Ceiling Fan and an Upper-Room Ultraviolet Germicidal Irradiation System. Building and Environment 72: 116–24. https://doi.org/10.1016/j.buildenv.2013.10.019

104 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

105 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished)

| PIAQ | PERCENTAGE OF CUSTOMERS THAT ASSOCIATE THEIR FAN WITH IMPROVED INDOOR AIR QUALITY (IAQ) (%) |
|---|---|
| **Supporting literature** | • All 16 participants in the study of human comfort and perceived air quality in warm and humid environments reported improved thermal comfort and Perceived Air Quality (PAQ) when using a fan.[106] |
| **Limitations / biases** | Air quality is affected by several factors. The actual impact of the fan on off-grid households' air quality should be investigated further. It should be profiled using different household characteristics and fan specifications that could contribute to this impact. |
| **Data gaps** | Only two data points from Bangladesh and India were used because the other two studies did not provide a comparable data point. There is a lack of secondary data and other data points to support the coefficient. It should also be noted that the data points are a subjective perception of the end-user and are prone to response and participant biases. |

**Table 27: PIH: Percentage of people with access to the appliance who perceive that the appliance contributes to 'health and wellbeing'**

| PIH | PERCENTAGE OF PEOPLE WITH ACCESS TO THE APPLIANCE WHO PERCEIVE THE APPLIANCE CONTRIBUTES TO "HEALTH AND WELLBEING" | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Asia | N/A | ** | 75% |
| **Supporting literature** | • 39% of participants from Thailand reported using a fan to keep mosquitoes away from indoor spaces.[107]<br>• An investigation of the low utilisation of insecticide-bed treated nets among pregnant women in Ghana found that 28% of the participants reported using fans as a barrier to mosquito bites.[108]<br>• A study in Bangkok found that the most prevalent preventive behaviour among students for dengue haemorrhagic fever (DHF) was using an electric fan while sleeping (68.3%).[109]<br>• 81% ofpeople surveyed in Bangladesh stated that super-efficient off-grid fans reduced the number of mosquitoes in their houses.[110]<br>• 24.4 % of fan end-users in India associated fan use with preventative healthcare and 32.2 % of the participants associated fan use with protection from mosquitoes.[111] | | | |
| **Limitations / biases** | • A weighted average has been used due to the different data points and sampling sizes. This creates an error in generalisation.<br>• In addition, users' perceptions are prone to research design, participant selection and response biases. | | | |

**Table 28: PTC: Percentage of people who associate their fan with improved thermal comfort**

| PTC | PERCENTAGE OF PEOPLE THAT ASSOCIATE THEIR FAN WITH IMPROVED THERMAL COMFORT (%) | | | |
|---|---|---|---|---|
| **Unit** | % | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | South Asia | Rural & Urban | *** | 94% |
| **Supporting literature** | • The Rural Senses (2021) survey of fan end-users in India found that 67.8% of the respondents, respectively, associated fan use with thermal comfort.[112] | | | |

106 Y. Zhai, Y. Zhang, H. Zhang, W. Pasut, E. Arens, and Q. Meng, 2015. Human Comfort and Perceived Air Quality in Warm and Humid Environments with Ceiling Fans. Building and Environment 90: 178–85. https://doi.org/10.1016/j.buildenv.2015.04.003

107 V.A. Paz-Soldan, V. Plasai, A.M. Morrison, E.J. Rios-Lopez, S. Guedez-Gonzales, J.P. Grieco, K. Mundal, T. Chareonviriyaphap, and N.L. Achee, 2011. Initial Assessment of the Acceptability of a Push-Pull Aedes Aegypti Control Strategy in Iquitos, Peru and Kanchanaburi, Thailand. The American Journal of Tropical Medicine and Hygiene 84, no. 2 (4 February 2011): 208–17. https://doi.org/10.4269/ajtmh.2011.09-0615

108 G. Manu et al. (2017) 'Low Utilization of Insecticide-Treated Bed Net among Pregnant Women in the Middle Belt of Ghana', Malaria Research and Treatment, 2017, pp. 1–7. doi:10.1155/2017/7481210

109 C. Chanyasanha, M.M. Han, and S. Teetipsatit, 2013. Dengue Hemorrhagic Fever Knowledge, Perception, and Preventive Behavior among Secondary School Students in Bangkok. 96: 11

110 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

111 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished)

112 Rural Senses. 2021. Impact Assessment Framework End-User Research in Uganda & India (End-User research unpublished)

| PTC | PERCENTAGE OF PEOPLE THAT ASSOCIATE THEIR FAN WITH IMPROVED THERMAL COMFORT (%) |
|---|---|
| **Supporting literature** | • A survey of 1,614 off-grid fan customers in Bangladesh found that most of the customers bought fans for household use in a bedroom or living room area. 81% of respondents associated fan use with improvements in quality of life, with 66% noting that rooms are cooler. Furthermore, 92% of the respondents noticed that they felt less dehydrated and that they sweated less, both strong indicators of improvement in thermal comfort.[113]<br>• A survey of 1,224 households across four Slum Rehabilitation Housing (SRH) societies in Mumbai found that 99% of the surveyed households' only method of regulating thermal comfort was the use of a fan.[114]<br>• In the investigation of thermal comfort and self-reported productivity in an office with ceiling fans in the tropics (Singapore), 91% of all respondents reported thermal satisfaction when the temperature set-point was 26°C and fans were in use.[115]<br>• A survey on electrical appliance use and energy consumption in 60 Vietnamese households found that 100% of the respondents had fans and operated them for ~ 8.75 hours a day.[116] |
| **Limitations / biases** | The studies do not take into consideration other factors that can affect thermal comfort, such as house insulation, ventilation and human behaviour. Additionally, fan characteristics like the speed, air flow and coverage are not taken into consideration. |

**Table 29: TSP: Indoor set temperature above which cooling using a fan is required**

| TSP | INDOOR SET TEMPERATURE ABOVE WHICH COOLING USING A FAN IS REQUIRED (°C) | | | |
|---|---|---|---|---|
| **Unit** | °C | | | |
| **Appliance** | Fan | | | |
| **Applicability** | **GEOGRAPHY** | **DEGREE OF URBANISATION** | **CONFIDENCE** | **VALUE** |
| | Sub-Saharan Africa | General | ** | 26 |
| | South Asia | General | ** | 26 |
| **Supporting literature** | Two studies stated that at 26 °C, individuals in the Global South experience basic thermal comfort above which cooling is required.[117,118] | | | |
| **Limitations / biases** | An interplay of environmental, contextual and behavioural factors. Also, acclimatisation varies by geography and local climate and can affect the indoor set point. These factors are not taken into consideration. | | | |
| **Data gaps** | More data on the different environmental, contextual and behavioural factors and acclimatisation by geography need to be recorded. | | | |

113 Efficiency for Access Coalition. 2020b. The Socio-Economic Impact of Super-Efficient Off-Grid Fans in Bangladesh. https://efficiencyforaccess.org/publications/the-socio-economic-impact-of-super-efficient-fans-in-bangladesh

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116 V.T. Le, and A. Pitts, 2019. A Survey on Electrical Appliance Use and Energy Consumption in Vietnamese Households: Case Study of Tuy Hoa City. Energy and Buildings 197: 229–41. https://doi.org/10.1016/j.enbuild.2019.05.051

117 P. Dongmei, D. Shiming, L. Zhongping, and C. Ming-yin, 2013. Air-Conditioning for Sleeping Environments in Tropics and/or Sub-Tropics – A Review. Energy 51 (1 March 2013): 18–26. https://doi.org/10.1016/j.energy.2013.01.009

118 A. Mastrucci, E. Byers, S. Pachauri, and N.D. Rao, 2019. Improving the SDG Energy Poverty Targets: Residential Cooling Needs in the Global South. Energy and Buildings 186: 405–15. https://doi.org/10.1016/j.enbuild.2019.01.015

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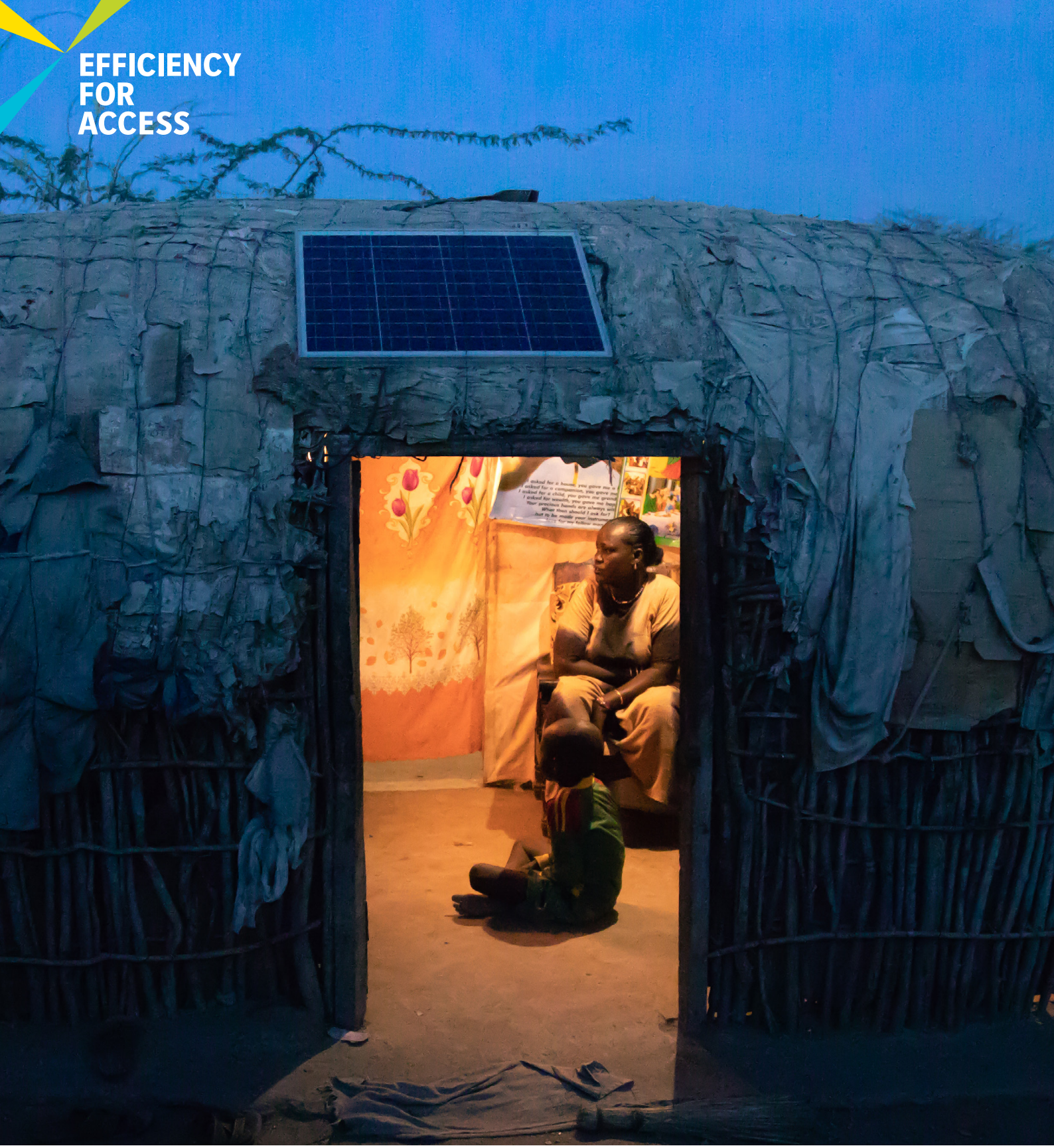

## CONTACT US


efficiencyforaccess.org
info@efficiencyforaccess.org
@EforA_Coalition