

# INPLASY

## The Impact of Mini-Grids on Rural Energy-Access Indicators in Developing Countries: A Systematic Review

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### ADMINISTRATIVE INFORMATION

**Support** - UCL ROS.

**Review Stage at time of this submission** - Completed but not published.

**Conflicts of interest** - None declared.

**INPLASY registration number:** INPLASY202510032

**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 9 January 2025 and was last updated on 26 January 2025.

### INTRODUCTION

**Review question / Objective** Access to modern, reliable, and affordable electricity remains limited in many rural areas of developing countries, where grid extension is often economically and technically challenging. Mini-grids are increasingly deployed as a decentralised electrification option, but evidence on user-experienced service quality remains uneven. Energy access is best assessed using multidimensional service indicators beyond simple connection status.

**Condition being studied** Rural energy access/service quality outcomes associated with mini-grid electricity systems in developing-country rural contexts, assessed via six energy-access indicators (electrification, availability, hours, affordability, reliability, consistency/power quality).

### METHODS

**Search strategy** Web of Science TS=(("mini-grid" OR "minigrid" OR "mini grid" OR "micro-grid" OR "microgrid" OR "micro grid" OR "off-grid" OR "Offgrid" OR "off grid" OR "decentralised energy" OR "decentralized generation" OR "distributed generation" OR "distributed generation" OR "standalone power system" OR "standalone power systems" OR "hybrid renewable energy system" OR "hybrid renewable energy systems" OR "rural electrification") AND ("electrification rate" OR "energy access" OR "electricity access" OR "energy availability" OR "days of availability" OR "electricity supply" OR "hours of electricity" OR "hours of supply" OR "affordable electricity" OR "electricity affordability" OR "tariff" OR "tariffs" OR "reliable electricity" OR "power reliability" OR "supply reliability" OR "energy consistency" OR "supply consistency" OR "energy performance" OR "power quality" OR "electricity service" OR

"energy service" OR "power supply" OR "power service" OR "electricity connection" OR "energy outcomes" OR "connection" OR "electricity usage") AND ("impact" OR "effect" OR "effects" OR "influence" OR "out-come" OR "outcomes" OR "evaluation" OR "assessment" OR "performance") AND ("empiri-cal" OR "case study" OR "case-study" OR "field data" OR "primary data" OR "cohort" OR "cohort study" OR "survey" OR "household survey" OR "interview" OR "mixed-method" OR "mixed methods" OR "observational") AND ("rural" OR "rural area" OR "rural areas" OR "remote community" OR "remote communities" OR "rural village" OR "rural villages" OR "off-grid village" OR "off-grid villages" OR "peri-urban area" OR "peri-urban areas") AND ("developing country" OR "developing countries" OR "low-income country" OR "low-income countries" OR "middle-income country" OR "middle-income countries" OR "low- and middle-income countries" OR "LMIC" OR "LMICs" OR "Sub-Saharan Africa" OR "South Asia" OR "global south" OR "emerging economy" OR "emerging economies") NOT ("solar home system" OR "solar home systems" OR "SHS" OR "simulation" OR "simulations" OR "urban" OR "urban area" OR "urban areas" OR "systematic review" OR "meta-analysis" OR "developed country" OR "developed countries" OR "high-income country" OR "high-income countries" OR "OECD" OR "Europe" OR "North America" OR "USA" OR "United States" OR "Canada" OR "Australia" OR "Japan" OR "South Korea" OR "UK" OR "New Zealand" OR "European Union" OR "EU")) and Article or Review Article (Document Types) and 2025 or 2024 or 2023 or 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2009 or 2008 or 2007 or 2005 (Publication Years) and English (Languages) SCOPUS TITLE-ABS-KEY (( "mini-grid" OR "mini-grids" OR "microgrid" OR "microgrids" OR "off-grid" OR "decentralised energy" OR "decentralized energy" OR "standalone power system" OR "standalone power systems" OR "hybrid renewable energy system" OR "hybrid renewable energy systems" OR "rural electrification" ) AND ( "electrification rate" OR "energy access" OR "electricity access" OR "energy availability" OR "days of availability" OR "electricity supply" OR "hours of electricity" OR "hours of supply" OR "affordable electricity" OR "electricity affordability" OR "tariff" OR "tariffs" OR "reliable electricity" OR "power reliability" OR "supply reliability" OR "energy consistency" OR "supply consistency" OR "energy performance" OR "power quality" OR "electricity service" OR "energy service" OR "power supply" OR "power service" OR "electricity connection" OR "energy outcomes" OR "connection" OR "electricity usage" ) AND

( "impact" OR "effect" OR "effects" OR "influence" OR "outcome" OR "outcomes" OR "evaluation" OR "assessment" OR "performance" ) AND ( "empirical" OR "case study" OR "case-study" OR "field data" OR "primary data" OR "cohort" OR "cohort study" OR "survey" OR "household survey" OR "interview" OR "mixed-method" OR "mixed methods" OR "observational" ) AND ( "rural" OR "rural area" OR "rural areas" OR "remote community" OR "remote communities" OR "rural village" OR "rural villages" OR "off-grid village" OR "off-grid villages" OR "peri-urban area" OR "peri-urban areas" ) AND ( "developing country" OR "developing countries" OR "low-income country" OR "low-income countries" OR "middle-income country" OR "middle-income countries" OR "low- and middle-income countries" OR "LMIC" OR "LMICs" OR "Sub-Saharan Africa" OR "South Asia" OR "global south" OR "emerging economy" OR "emerging economies" ) AND NOT ( "solar home system" OR "solar home systems" OR "SHS" OR "simulation" OR "simulations" OR "urban" OR "urban area" OR "urban areas" OR "systematic review" OR "meta-analysis" OR "developed country" OR "developed countries" OR "high-income country" OR "high-income countries" OR "OECD" OR "Europe" OR "North America" OR "USA" OR "United States" OR "Canada" OR "Australia" OR "Japan" OR "South Korea" OR "UK" OR "New Zealand" OR "European Union" OR "EU" ) ) AND PUBYEAR > 2004 AND PUBYEAR < 2026 AND ( LIM-IT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "re" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" )

**Participant or population** Rural communities in developing countries (developed-country contexts excluded).

**Intervention** Operational mini-grid/off-grid microgrid systems (deployed and operating).

**Comparator** Not Applicable.

**Study designs to be included** Empirical, field-based studies using primary or real operational/field data; simulation/optimisation-only studies excluded.

**Eligibility criteria** Studies are included if they:

- 1) Focus on rural settings in developing countries;
- 2) Evaluate an operational mini-grid/microgrid/off-grid system (not SHS-only, grid extension, or generator-only interventions);
- 3) Use empirical/field-based evidence or real operational data (not simulation/optimisation-only studies);

- 4) Report at least one of the six indicators (electrification rate, availability, hours, affordability, reliability, consistency/power quality);
- 5) Are peer-reviewed journal articles or peer-reviewed conference papers with full text available;
- 6) Are published 2005–2025;
- 7) Are written in English.

**Information sources** Scopus and Web of Science.

**Main outcome(s)** Six energy-access indicators: electrification rate; availability (days/week); hours of supply (hours/day); affordability; reliability; consistency (power quality).

**Additional outcome(s)** The extraction form also captured whether/how studies treated electricity access in relation to wider rural development outcomes, but the review synthesis is organised around the six service indicators.

**Data management** Search outputs were exported and compiled into a screening dataset; duplicates were removed using automated and manual checks. Data extraction used a structured form to capture bibliographic details, study design, context, mini-grid typology, and indicator definitions/metrics for the six energy-access indicators. Extracted evidence is organised into summary tables and appendices within the manuscript; data are contained within the review article and its supplementary/appendix materials.

**Quality assessment / Risk of bias analysis** Mixed-methods-compatible 10-criterion quality appraisal scored 0–2 per item (max 20). Studies not excluded for low scores; appraisal used to interpret confidence and highlight gaps.

**Strategy of data synthesis** Given substantial heterogeneity in study designs, contexts, and indicator definitions, the review uses a narrative synthesis structured around six pre-specified energy-access indicators: electrification rate, availability, hours of supply, affordability, reliability, and consistency (power quality). Evidence is summarised indicator-by-indicator, with cross-study comparability limitations explicitly noted. No meta-analysis is planned/performed; methodological quality is used to interpret confidence in reported findings rather than as an exclusion criterion.

**Subgroup analysis** No formal subgroup meta-analysis; heterogeneity explored qualitatively via geographic and technology variation sections/discussion.

**Sensitivity analysis** N/A.

**Language restriction** N/A.

**Country(ies) involved** United Kingdom.

**Keywords** mini-grids; rural electrification; energy access; service quality; affordability; reliability; power quality; systematic review; developing countries

#### **Dissemination plans**

The review will be disseminated through publication in a peer-reviewed journal (Energies submission) and related academic communications (e.g., presentations/seminars). Extracted evidence tables, PRISMA materials, and quality appraisal outputs are provided within the manuscript appendices and/or supplementary files to support transparency and reuse.

#### **Contributions of each author**

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