Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle-Income Countries

Nicholas Moore, Douglas Glandon, Janice Tripney, Tomasz Kozakiewicz, Shannon Shisler, John Eyres, Rami Zalfou, Maria Daniela Anda Leon, Varant Kurkjian, Birte Snilstveit, and Ari Perdana
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<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tr>
<td>3ie</td>
<td>International Initiative for Impact Evaluation</td>
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<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>CI</td>
<td>confidence interval</td>
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<td>ESMAP</td>
<td>Energy Sector Management Assistance Program</td>
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<td>IED</td>
<td>Independent Evaluation Department</td>
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<td>LMIC</td>
<td>low- and middle-income country</td>
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<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>SMD</td>
<td>standardized mean difference</td>
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<tr>
<td>SRQ</td>
<td>systematic review question</td>
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Foreword

In 2015, the United Nations formalized electricity provision as an internationally recognized development objective through the creation of Sustainable Development Goal 7, which sought to ensure access to affordable, reliable, sustainable and modern energy for all. Developing countries have made major advances in providing electricity access in recent years. From 2000 to 2017, the proportion of the global population with electricity access increased from 78% to 89%.

While it is widely accepted that increased access to electricity has benefited households, especially low- and medium-income ones, a growing body of impact studies has shown that access to electricity programs in developing countries has brought mixed effects. Several challenges still prevent universal access to electricity: (i) high investment and operation costs, (ii) limited demand given market conditions, (iii) technical implementation and maintenance issues, and (iv) regulatory and political issues. Even with expanded access, other factors like quality of connection and equity may have limited the development impacts. Important evidence gaps remain for future studies to address. Understanding what works and doesn’t is important for policy planning and decision making.

The purpose of this systematic review report is to appraise and synthesize available, high-quality evidence on the effectiveness of electricity interventions on socioeconomic outcomes in low- and middle-income countries. This systematic review follows scientifically recognized review methods and has been peer-reviewed and quality assured according to internationally accepted standards. The Independent Evaluation Department (IED) jointly prepared this systematic review with the International Initiative for Impact Evaluation (3ie), a leading institution in rigorous and innovative review methodologies. This systematic review is a background paper to IED evaluation on ADB’s 2009 Energy Policy and Program, 2009-2018.

The systematic review finds that on average electrification interventions have small positive effects on a range of education, socioeconomic welfare, health, and environmental outcomes. These effects were associated with considerable heterogeneity across the studies, which highlights the need to have more impact evaluation studies of electricity projects, especially those looking at the effects on household welfare and the transmission mechanisms for these effects.

IED and 3ie believe that understanding and assessing the context-specific determinants of uptake and use of electricity infrastructure is key for yielding positive changes in social outcomes. Therefore, we hope to see more research in this area to provide better and more evidence-based policy decisions.

Marie Gaarder  
Executive Director  
International Initiative for Impact Evaluation

Marvin Taylor-Dormond  
Director General  
Independent Evaluation
Acknowledgments

This systematic review report was a joint product of the Independent Evaluation Department (IED) and the International Initiative for Impact Evaluation (3ie). The systematic review was prepared under the guidance of Marvin Taylor-Dormond, director general, and Walter Kolkma, director, IED, and Marie Gaarder, executive director, 3ie. Ari Perdana, evaluation specialist, led the IED team which comprised Myrna Fortu and Sergio Villena.

The 3ie team comprised Nicholas Moore, Douglas Glandon, John Eyres, Maria Daniela Anda Leon, Varant Kurkjian, Tomasz Kozakiewicz, Shannon Shisler, Birte Snilstveit, Janice Tripney, and Rami Zalfou. Support on research assistance was provided by 3ie’s consultant pool, consisting of Bertrand Bio Mama, Nilakshi Biswas, Jenny Chen, Joao Antonio dos Santos Lima, Hirut Gedamu, Danielle Guy, Meital Kupfer, Sanghwa Lee, Anika Muzib, Cristina Parilli Lozada, Zafeer Raval, Dislene Sossou, Tomoyo Suematsu, James Warburton, and Cameron Williams. The report was written following the systematic review protocol, which was prepared earlier by 3ie, and which drew on internationally recognized practice in the field of impact evaluation and systematic reviews. None of the 3ie team members had conflicts of interest, financial or otherwise, that may have influenced judgements made as part of this review.

The systematic review benefited greatly from the inputs and peer-review process from an advisory group comprising Chen Chen (World Resources Institute), Marc Jeuland (Duke University), Toshihiko Nakata (Tohoku University), Rabindra Nepal (University of Wollongong), Andrew Scott (Overseas Development Institute), and Govinda Timilsina (World Bank).

Preliminary findings of the systematic review were presented in a webinar, with additional team inputs from Manuel Barron (Universidad del Pacífico), Louise Grogan (University of Guelph), and Gunther Bensch and Jörg Peters (Leibniz Institute for Economic Research).

Several members of the Asian Development Bank (ADB) Energy Sector Group also commented on the preliminary findings: Sujata Gupta and Atsumatsa Sakai, senior energy specialist (East Asia Department); Diana Connett (Southeast Asia Department); and David Elzinga (Sustainable Development and Climate Change). Additional review and consultation were provided by David Raitzer (Economic Research and Regional Cooperation Department). Alfredo Bano-Leal, Sherine Ibrahim, Binh Nguyen, and Maya Vijayaraghavan provided internal IED comments.
Executive Summary

The Independent Evaluation Department, in collaboration with the International Initiative for Impact Evaluation (3ie), conducted a systematic review on the effects of access to electricity interventions on socioeconomic outcomes in low- and middle-income countries. The primary research question driving this review is “What are the effects of electricity access interventions on social outcomes for individuals, organizations, and communities?”

The evidence base of 126 studies, which corresponded to 89 independent impact evaluations, suggests that rigorous studies on the impact of electricity are still limited, while most studies have focused on supply-side interventions with different—and often implicit—causal pathways. Given the available evidence, the key findings of the systematic review are: (i) interventions in providing electricity access have brought on modestly positive effects on household socioeconomic outcomes; (ii) results vary considerably across studies; and (iii) understanding local, specific contexts matters for yielding positive changes in social outcomes.

The systematic review findings call for: (i) more funding for rigorous research to fill evidence gaps; (ii) adjustments to the expectations on the magnitude of outcomes of a project; and (iii) interventions targeting multiple constraints.

Finally, this review suggests that further development in these research areas is needed, with a focus on: (i) understanding the effect of demand-side interventions, (ii) conducting theory-based mixed-method evaluations, and (iii) measuring outcomes related to quality of life and social experience.

Background. While the proportion of the global population with electricity access increased from 78% to 89% between 2000 and 2017, an estimated 800 million people worldwide did not have any access to electricity in 2017. Access is still limited for low-income countries (especially in sub-Saharan Africa) and rural communities. At the same time, the quality of connections such as electricity capacity, availability, reliability, health and safety, and convenience are other factors that may affect the ability of an end user to use electricity when they need to.

Rationale. The rationale for this review is twofold. First, it intends to provide a comprehensive and up-to-date understanding of electricity access interventions, given the increasing importance of energy access in alleviating poverty. Second, the Independent Evaluation Department (IED) intends to make direct use of this review to inform the bank's wider sector investment from 2020 onwards.

Purpose. In particular, this systematic review forms part of the IED's sector-wide evaluation of the Asian Development Bank (ADB) support for the energy sector policy and program, which assesses ADB's 2009 energy policy and energy-related activities approved from 2009 to 2018. Currently, 43% of the bank's energy operations are focused on expanding access to electricity, mainly through power transmission and distribution projects and off-grid electricity projects. The results of this review will be used in conjunction with other evidence to allocate resources to ADB electricity access programs.

Method and Approach

Definition. A systematic review identifies, synthesizes, and assesses all available studies and/or evidence to generate a robust, empirically derived answer to a focused research question. Because such reviews look systematically across the evidence base to see what works and why, systematic reviews are more reliable for decision-making than single studies or looking at study results in an ad hoc way. A systematic review uses explicit and transparent procedures to identify all available research evidence. The method also applies clear inclusion and exclusion criteria, an explicit search strategy and systematic procedures for data extraction, and critical appraisal and analysis of included studies to ensure that systematic reviews are reliable and replicable.

Procedure. The first step for systematic review is to define the review scope using the population, intervention, comparator, outcomes, and study design (PICOS) approach, explained in Chapter 1.

Included publications. Electronic searches of academic databases produced a total of 68,590
records. Non-electronic searching and citation tracking produced a further 751 records for screening (resulting in 69,341). Multistage screening processes resulted in 126 studies being included in this systematic review. This corresponded to 89 independent impact evaluations.

**Location of studies.** Included studies span much of the globe but have been mostly conducted in South Asia (31) and sub-Saharan Africa (28), with a focus on India (17), Bangladesh (8), Kenya (6), and Ghana (5). Most studies were implemented in low-income countries rather than middle-income countries. In many cases, studies assessed the effects of levels of electricity availability, often rural grid connections, as opposed to a specific, discrete intervention. Over 90% of studies implemented a quasi-experimental design.

**Understanding the Evidence Base**

**Limited numbers of rigorous studies.** While studies have increased since 2013 (82% of studies included in this review were published in or after 2013), impact evaluation studies in energy—in which electricity is a subsector—account for less than 1% of all impact evaluation studies published from 2000 to 2015.

**Most studies focus on supply-side interventions.** Many interventions in the studies concerned levels of electricity availability, often rural grid connections. The most commonly evaluated intervention was changes in access to electricity, typically through on-grid access, although some studies considered changes to electricity quality or reliability. Of all the types of electrification interventions studied in the included papers, a majority focused on connections to the grid in rural or peri-urban areas. Few studies assessed demand-side interventions or cost.

**Studies address variety of outcomes, with different—and often implicit—causal pathways.** Evaluated outcomes and underlying theories of change vary across the literature. For instance, investigating how access to a solar panel that can power a light and charge a mobile phone affects child study time is very different from investigating the organization-level effects of a grid connection that enables a business or health facility to power refrigeration or temperature control systems or power other appliances, machines, and equipment. These variations, combined with limited theoretical narrative, add considerable complexity to this type of synthesis, and underscore the importance of carefully considering how to approach any meta-analysis.

**Synthesis of Results**

**Intermediate outcomes.** The intermediate outcome size observed in the treatment groups was 0.17 standard deviations higher than those in the comparison group (the effect size is statistically significant). Access to electricity interventions has led to increased use of electricity, as well as the ownership and use of electrical appliances, and to some extent improving reliability and making prices more affordable.

**Effects on education.** Electricity access interventions had a positive but small effect on the pooled education outcomes (0.05 standard deviations in the treatment group relative to the comparison group). Analysis indicated that electricity access resulted in a significant improvement for study time, especially at night. Small improvements were detected in years of schooling and school enrollments.

**Effects on household welfare.** Analysis from studies showed that new and/or improved access in electricity resulted in slightly higher levels of total household income by 0.06 standard deviations and a small reduction in household poverty incidence (positive welfare benefit of 0.08 standard deviations). There were some positive improvements of household assets and consumption, though not statistically significant as shown by large confidence intervals. Improved access to electricity also resulted in increased household income, with a bigger effect size reported in non-farm income. Farm employment increased only marginally.

**Effects on household time allocation.** Time allocated to paid work and consuming leisure (e.g., watching television) appeared to be positive overall. The estimates are relatively small and, in the case of leisure, imprecise because of large confidence intervals. No effects on unpaid work and rest were observed.
**Effects on business outcomes.** Some studies sought to measure other socioeconomic impacts like firm creation and performance. Improvement in business performance was found close to zero. The results from individual studies are mixed. Similarly, overall business productivity improved only marginally, with a large confidence interval. Most of it came from the improvements of agricultural activities, with no reported change across non-agricultural enterprises.

**Effects on female decision-making in the household.** Access to electricity led to marginal improvement in female empowerment at the household decision-making, by 0.03 standard deviations. From studies which reported relevant outcome variables, female household members are reported to have a bigger say over family planning, family care, and family economic management. Female members also reported having more independence or agency in their individual decision. However, none of the effect sizes for specific outcomes on female decision making was found to be statistically significant.

**Health outcomes.** Studies that reported some health outcomes saw a pooled effect size of 0.11. There were positive associations between access to electricity and the use of contraception and social benefit from lower fertility, access to health information (e.g., on vaccination), and positive health outcomes (e.g., increase in life expectancy, decrease in mortality rates, and fewer incidences of low birth weight). None of the specific health indicators were statistically significant.

**Environmental outcomes.** The review calculated the effect size on environmental outcomes from 17 studies, all of which concerned the use of traditional energy sources such as kerosene or wood fires. The overall benefit from lower use of traditional energy sources was associated with a positive effect of 0.1 standard deviations.

**Determinants of Household Access to Electricity**

**Positive factors.** While there was a large amount of heterogeneity in the results, qualitative review of the studies found common factors that increased the effectiveness of interventions. (i) Areas with better institutions, limited political and economic unrest, economic density, base levels of infrastructure, and access to established institutions are likely to be associated with larger changes in social outcomes.

(ii) Interventions are also more effective in areas with existing local networks to support delivery, the use of context-specific credit and payment tools, timely access to skills and expertise, and regular technical monitoring completed with communities.

(iii) Public subsidies for substitute products will negatively affect demand for electricity, while complementary products will positively affect demand for electricity.

(iv) Commercial connection fees and tariffs could not always be reconciled with the willingness and ability of target populations to pay for electricity services.

**Sociopolitical factors.** The review identified several contextual factors that shaped the effects of electricity. The main structural and cultural barriers impeding intervention effectiveness were political situation, economic performance, other interventions, and gender and cultural norms (Chapter 5).

**Factors influencing program effectiveness.** The thematic analysis sought to go beyond these categories to identify key design and implementation factors that influenced program effectiveness according to the studies. These factors included the costs of connecting to an electricity source, ongoing consumer business models, partnerships, the quality and type of implementation, and the reliability of supply (Chapter 5).

**Demand-side factors.** Fixing supply-side problems is not enough to make electrification programs popular among beneficiaries. Not all eligible consumers take up available opportunities to connect to modern energy services. Evidence suggests that beneficiary-related factors can also significantly affect the effectiveness of interventions. This review organized these barriers and enablers in three broad themes: (i) types of beneficiaries; (ii) consumer knowledge, understanding, and skills; and (iii) consumer attitudes, preferences, and beliefs (Chapter 5).
Summary of Key Findings

Positive but modest effects. Interventions in providing electricity access has brought on positive but modest effects on household socioeconomic outcomes. The systematic review finds that interventions aiming to provide new or improved access to electricity has led to increase in household connectivity and use of electricity and moderate effects in the ownership and use of household electrical appliances. The effects on education, socioeconomic welfare, health, and environment are positive but moderate.

Considerable heterogeneity across studies. Heterogenous results stem partly from observable study characteristics, such as study design, the type of outcome evaluated, the way variables were measured, location, method employed, or length of follow-up. However, most of the heterogeneity stems from factors beyond those captured by the analysis.

The importance of local, specific contexts. With a high degree of heterogeneity observed across studies, understanding and assessing how context determines or influences uptake and use of electricity infrastructure is key for yielding positive changes in social outcomes. Without appropriately considering these factors, beneficiaries may not take up electricity, use electricity at a much later date than anticipated, or consume sub-optimal levels of electricity for basic energy services, for short periods of time.

Implications for Future Policy and Interventions

Funding research to fill evidence gaps. A substantial gap exists in the evidence base because of the small number of impact evaluations; the wide variation in types of electrification interventions; and limited detail on intervention specifics, causal mechanisms, and costs. Funding for additional research on this topic—including process evaluations, health and environmental impacts, and qualitative research accompanying impact evaluations of specific electrification interventions—can help fill the gap.

Adjusting expectations on the magnitude of project outcomes. Governments and development partners should adjust the expectations on the magnitude of outcomes of an electricity project. The positive but modest effects on education and socioeconomic and environmental outcomes should not deter future investments in electricity access. Instead, they should provide a reality check on a plausible range in the magnitude of the potential impact of electrification interventions on these outcomes, and they should guide expectations about the results of an intervention.

Targeting multiple constraints for improved result. Evidence suggests that interventions targeting multiple constraints (e.g., electricity infrastructure and reliability, or reliability and affordability) yield better results than interventions targeting on a single constraint. Targeting multiple constraints also aligns with ADB’s Strategy 2030, which specifically calls for a transition in its program to more integrated solutions.

Areas for Future Research

Demand-side interventions. Studies should seek to understand the effect of demand-side interventions and the combinations of demand- and supply-side interventions. Of the studies that addressed demand, the majority focused on reducing cost barriers by testing voucher or subsidy interventions but did not address reliability, consumer preferences, social acceptance, regulatory constraints, and other factors affecting demand.

Theory-based mixed-method evaluations. Mixed-method, theory-based studies provide an insight not only into the magnitude of effects but also why and how they arise, for whom, and in what contexts. Specifying such studies will provide practitioners with more nuanced insights that can support the formation of new policy and interventions.

Outcomes affecting quality of life and social experience. Studies have focused on educational and economic outcomes of electrification, with evidence pointing to modest effects. However, these are not the only—and may not even be the most important—effects of electrification. A few studies have measured other plausible outcomes, such as quality of life, but both the theoretical and empirical work in this area is limited.
1. The Independent Evaluation Department (IED), in collaboration with the International Initiative for Impact Evaluation (3ie), conducted a systematic review on the effects of access to electricity interventions on socioeconomic outcomes in low- and middle-income countries. The primary research question driving this review is “What are the effects of electricity access interventions on social outcomes for individuals, organizations, and communities?” The review was conducted using systematic methods and following internationally recognized methods as well as guidance from an advisory group comprising researchers and policy specialists in electricity access.

A. The Objective and Rationale of this Systematic Review

2. **Objective.** This systematic review has two objectives: (i) to map the existing evidence on the impacts of on- and off-grid access to electricity in low- and middle-income countries; and (ii) to synthesize evidence on the impacts of the on- and off-grid access to electricity programs, given the existing literature. The key systematic review questions (SRQs) that guided the whole review process are in Table 1.

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<tr>
<th>Question Number</th>
<th>Systematic Review Question</th>
<th>Focus</th>
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<tr>
<td>1</td>
<td>What are the effects of electricity access interventions on socioeconomic development outcomes for private individuals, organizations, and communities?</td>
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<td>2</td>
<td>To what extent do effects vary by population group and location?</td>
<td>Heterogeneity</td>
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<td>3</td>
<td>What factors relating to program design, implementation, or context are associated with better or worse outcomes along the causal chain?</td>
<td>Mechanism</td>
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<td>4</td>
<td>What is the cost-effectiveness of the interventions under review?</td>
<td>Cost</td>
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3. **Rationale.** The rationale for this review is twofold:

   (i) **Updating our understanding.** This systematic review intends to provide a comprehensive and up-to-date understanding of electricity access interventions, given the increasing importance of energy access in alleviating poverty. Access to energy, and electricity in particular, has become increasingly important as an expected mechanism to reduce poverty in low- and middle-income countries (LMICs). Thus, to address the global gap in access to electricity, developing partners, national governments and the private sector have increased investments in the sector. For example, investments in high-impact countries grew by $10.8 billion in 2015–2016 over 2013–2014 levels to an average of $30.2 billion per year. Aid to the energy sector among the Organisation for Economic Co-operation and Development (OECD) donors also increased over this period, reaching...

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an average of $29.8 billion between 2014–2016, with the Asian Development Bank (ADB) being the sixth largest donor to the sector.  

(ii) **Addressing evidence needs for ADB.** IED intends to make direct use of this review to inform ADB’s wider sector investment from 2020 onwards. In particular, this systematic review forms part of the IED’s Sector-wide Evaluation on ADB Support for the Energy Sector Policy and Program, which evaluates ADB’s 2009 energy policy and energy-related activities approved from 2009 to 2018. Currently, 43% of the bank’s energy operations focus on expanding access to electricity, mainly through power transmission and distribution projects and off-grid electricity projects. IED will use results of this review in conjunction with other evidence to inform ADB in allocating its electricity access programs.

B. **What is a Systematic Review and How to Use it?**

4. **Appraisal and synthesis of evidence.** Systematic reviews appraise and synthesize the available high-quality evidence on the effectiveness of social and economic development interventions in LMICs. In producing systematic reviews, 3ie follows scientifically recognized review methods and reviews are peer-reviewed and quality assured according to internationally accepted standards. Systematic reviews have gained increased popularity because both rigorous and innovative review methodologies are suited to inform policy and programming in the dynamic contexts and challenges of LMICs.

5. **Informing policy, practice, and future research.** Decision makers can use findings from systematic reviews to inform policy, practice, and future research. The structured approach to evidence gathering and synthesis mitigates the risks of making policy and practice decisions based on individual studies and can provide confidence to decision-makers that they have an unbiased summary of the evidence; the meta-analysis helps them understand both average effects and the variability of results across studies, thus informing their assumptions about the plausible magnitude of effect sizes for a given intervention as well as the extent to which it is context dependent. From a research perspective, systematic reviews improve the generalizability of findings from individual studies; highlight uncertainties, limitations, and evidence gaps where additional research is needed; inform priority-setting for research funding; and identify important topical focus areas for peer-reviewed publications.

6. **Linking data with decision-making.** Systematic reviews occupy a specific place in the broad spectrum of activities—or evidence architecture—needed to effectively link data to decision-making. As implied above, individual studies are essential building blocks for a systematic review; the fewer the number of studies addressing the same research question(s), the less potential value there is in reviewing them systematically. Similarly, systematic reviews comprise one building block in a range of evidence and considerations that inform policy and programmatic decisions. In some cases, decision-makers may use systematic reviews directly, particularly if the findings are strong, consistent, unambiguous, and sufficiently focused and nuanced to address current policy or programmatic questions. In other cases, and perhaps more commonly, systematic reviews serve as an input into a knowledge brokering process that distills academic research into pragmatic, tailored insights, whether in the form of policy briefs, guidelines, checklists, or other knowledge products (footnote 7). So, while reviews can be used as a data

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source to inform a direct policy decision, they can also be used as a source of ideas and information, which supports policy-making in a less direct way.  

7. Previous synthesis in the area. Several previous efforts sought to synthesize the evidence on the effects of electricity access interventions on social outcomes. This review attempts to build on these efforts by including more current research; build on our understanding of how effects might vary by outcome, intervention, and study characteristics; and complement these results by assessing the available qualitative evidence and experience-based evidence provided by the study. Among previous efforts, the more recent reviews are:

(i) A 2013 systematic review by The Netherlands Ministry of Foreign Affairs concludes that both improved cookstoves and electricity have a positive impact on household health environment, measured by the reduction in the indoor carbon monoxide and particulate matter levels. However, the impact on time savings is uncertain. Access to electricity has led to greater use of communication devices (television, radio, mobile phones, and the internet). In the short-term, improved cookstoves and electrification opened up new economic activities at the local level. However, the impacts on household income are modest, and many of the new initiatives do not last long, because of undefined and isolated markets, lack of purchasing power, and rural infrastructure.

(ii) Hamburger et al. reviewed 31 impact evaluations as part of a systematic review with a focus on geographic bias. The authors assessed the effects of household electricity access interventions on energy expenditure, household income and savings, business creation, and education in developing countries. They found that the geographical distribution of studies was narrow and found studies set in South Asia produced the highest number of positive impacts, followed by Latin America and the Caribbean and sub-Saharan Africa.

(iii) A systematic review for The World Bank's Independent Evaluation Group found that access to electricity had positive impacts on measures of household income and educational inputs, including school enrollment, study time, and years of schooling. The review found mixed effects on business income, health, and time allocation, and found that hours worked had increased for women but not for men. Finally, the review reported that the few studies evaluated outcomes related to health and women's empowerment.

(iv) Irwin et al. systematically reviewed studies that evaluated the health effects of electricity access interventions and found mixed results in changes in health status among adults and children. The authors suggested that reliability issues were a key barrier to program effectiveness.

(v) A 2019 study by ADB plotted the increased use of impact evaluation to understand the range of potential effects produced by the power sector, including electricity access interventions. The review does not attempt to synthesize results but maps the characteristics of studies and identifies key evidence gaps—improved electricity capacity and reliability, clean energy incentives, smart grids, renewable energy, energy efficiency, and fuel substitution—and highlights promising methods for future impact evaluations.

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C. Key Trends in Electricity Access, Reliability, and Use

8. **Electricity as a development objective.** While access to electricity was not a specific Millennium Development Goal, academic and development partner communities have acknowledged that its universal provision is a critical mechanism through which extreme poverty and hunger could be eradicated. In 2015, the United Nations formalized electricity provision as an internationally recognized development objective through the creation of Sustainable Development Goal 7, which sought to “Ensure access to affordable, reliable, sustainable and modern energy for all.”\(^\text{16}\) Achievement of this goal will be measured in part by the proportion of country populations with access to electricity, and investment as a percentage of gross domestic product into energy supply and efficiency projects.\(^\text{17}\)

9. **Key trends.** This subsection provides an overview of key trends in the sector in electricity access, reliability, and use, drawing on World Bank indicators. While binary access is a key to electricity and is a useful indicator of the extent to which people are able to make effective use of electricity for energy services, it is one of many attributes that should be considered when analyzing electrification.

10. **Access.** Major advances have been made in increasing access. Between 2000 and 2017, the proportion of the global population with electricity access increased from 78% to 89%. But an estimated 800 million people worldwide do not have any access to electricity in 2017, with more acute access issues for low-income countries (especially sub-Saharan Africa), rural communities, women, and children.\(^\text{18}\)

   (i) **Income status.** High-income country populations have had almost universal electricity access. Middle-income country populations were shown to have improved their access from 79% to 92% between 2000 and 2017 on average, although several LMICs such as Brazil and the People’s Republic of China (PRC) have achieved 100% access. Those living in low-income countries have relatively limited access, with electricity access for this group increasing from 15% to 41% in the same period, but some outliers, such as Afghanistan, Nepal, and Tajikistan, reported an access rate of at least 95% in 2017.

   (ii) **Geographical disparity.** Over 90% of population in Latin America, the Caribbean, North Africa, and the Middle East had access to electricity between 2000 and 2017. South Asian countries made drastic improvements in the same period, with the population proportion with access increasing from 57 to 93%. But in the case of sub-Saharan Africa, access improvements were more modest, increasing from 26 to 45% in the same period.

   (iii) **Rural and urban communities.** Urban access to electricity increased from 93% to 97% between 2000 and 2017 in LMICs and is considerably lower among rural communities, with the rate of access increasing from 61% to 77%.

   (iv) **Women and children.** It is suggested that women and children have different needs for energy than men and suffer the effects of limited access in different ways.\(^\text{19}\) For example, women are more likely to be the main cooks in low income countries, and as such, are likely to suffer more from health issues if electricity is not available; respiratory issues in children are particularly acute in this regard. Women suffering from limited electricity access may also develop coping strategies that affect activities elsewhere in the household and/or community, including fewer meals being cooked or restricted access to energy for other activities.

11. **Reliability.** Connection to an electricity source provides access in one sense but does not reflect other factors that may affect the ability of an end user to use electricity when they need to, such as electricity capacity, availability reliability, health and safety, and convenience, among others. The number

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of power outages in firms in a typical month can be used as an approximate measure of reliability, though
it may also be useful to factor in the duration of outages, which are strongly correlated with outage
frequency. Data from 2019 shows that power outages were more common in low-income countries
(an average of 11.1 outages per month) compared to middle-income countries (6.7 outages per month).
By region, power outages were most severe in South Asia (25.5 outages per month), largely driven by
Bangladesh and Pakistan. Other LMIC regions fare better, with Latin America and Caribbean countries
observing 1.9 outages per month, and sub-Saharan African countries observed 8.9 outages per month.
Fragile and conflict afflicted states also suffered from comparably higher outage rates in 2019 (14.2
outages per month), which reflects the context-dependent nature of electricity reliability.

12. **Consumption.** Providing access to a reliable source of electricity does not always increase
electricity use. Figure 1 shows that between 2000 and 2014, per capita electric power consumption
increased globally, with high income countries consuming higher levels, but consumption grew more in
low and middle-income (100%) and upper-middle income countries (121%). Over the same period,
consumption by region was highest in LMIC countries in Latin America and the Caribbean as well as the
Middle East and North Africa. Consumption growth was highest in South Asia (98%), followed by the
Middle East and North Africa (61%) and Latin America and the Caribbean (33%), while per capita
consumption growth decreased for sub-Saharan African countries by 5%.

![Figure 1: Overview of Electricity Use by Income Status and Region, Electric Power Consumption, 2000–2014](chart)

*Figure 1: Overview of Electricity Use by Income Status and Region, Electric Power Consumption, 2000–2014 (kWh per capita)*

Cari. = Caribbean, FCAS = Fragile and Conflict-Affected Situation, HIC = high-income countries, kWh = kilowatt-hour, LatAm = Latin America, MENA = Middle East and North Africa, SSA = Sub-Saharan Africa.
Source: 3ie analysis of World Energy Statistics and World Bank DataBank.

**D. Challenges for Expanding Electricity Access**

13. Despite the benefits of electricity access and notable improvements in access, many challenges
prevent populations from realizing those benefits. These challenges feature at the political economy,
supplier, and consumer levels.

14. **Reliability.** The benefits of electricity can only be achieved if consumers can access electricity when
they need it (paras. 11–12). Without adequate maintenance of electricity infrastructure, power outages

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20 Footnote 17, p. 31.
21 The data shows how consumption relates to country populations. It does not provide an overview of total power consumption
in a country.
and damage to infrastructure can occur. Reliability issues typically depend on in-country capabilities in installing and operating electricity networks (and other solutions) efficiently and effectively while protecting electricity infrastructure from external pressures. Key technical factors that could cause reliability issues include underestimating demand and/or not accounting for induced demand when expanding electricity infrastructure, insufficient safety and security procedures to deal with peak time demand, especially in the case of off-grid systems that are not able to draw on national infrastructure, and natural or human sabotage of power sources.

15. **Limited capacity in markets for expanding utilities.** In some cases, a constraint on access is limited local technical capacity to provide and maintain access interventions, either through limited human capital or access to required materials and supplies.

16. **Planning and coordination challenges.** Infrastructure projects require the coordination of multiple stakeholders, including private suppliers, target communities, local and national governments, and development partners. The need to engage with multiple parties (or the failure to consider all relevant parties) can result in ineffective planning, implementation delays, and poor delivery.

17. **High costs of investment and operation of electricity networks.** Expanding and operating national or localized electricity networks requires significant investment—for example, into the construction, connection, and maintenance of power generators, transmission networks, and local distribution networks. These investment costs are only justified if the network can recoup a sufficient level of revenue from consumers over the expected duration of operation. These costs are particularly high for remote and rural areas and some urban settlements in LMICs, because of low population density and often low levels of connection materials. The costs of investment and operation can also create challenges for suppliers seeking right level of finance when required to support such investments. Finally, expansion projects may result in issues of community severance or displacement and/or result in negative environmental impacts such as deforestation to accommodate a prospective power plant site, although current evidence on the net effect from electricity access projects is mixed.

18. **Weak institutions and regulators.** The effectiveness of governments and other related institutions is a key factor in facilitating the expansion and maintenance of electricity infrastructure. Effective governments can support electricity access interventions by creating and enforcing consumer and supplier regulation and responding to challenges caused by economic and political instability. In fact, challenging political and economic contexts of interventions often constrain the performance of reforms in improving the governance of electricity infrastructure.

19. **Costs of connection.** A key access challenge cited in the literature is affordability. Use of electricity is associated with several costs, depending on the nature of electricity access intervention and energy source. With on-grid electricity, buildings must be wired safely and connected to the grid, which involves administrative costs in applying and coordinating with local electricity suppliers. In some cases, the

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materials used to construct buildings do not facilitate a grid connection, which adds additional costs.\(^{29}\) These connection costs result in lower or delayed connection to higher tier energy sources and are made more acute if households or communities depend on seasonal income.\(^{30}\)

20. **Limited demand.** Limited demand for electricity affects (i) supplier decisions to invest in access expansion projects and (ii) beneficiaries’ ability to fully realize the benefits of improved access. Low demand is cited as a key barrier to investment in LMIC electricity access projects.\(^{31}\) This is true for some communities that are in proximate locations to on-grid infrastructure.\(^{32}\) Several studies find that willingness to pay for electricity is low in LMICs, and low consumer surplus, weak institutions, and poor community engagement exacerbate the issue.\(^{33}\) In some cases, household incomes cannot always cover the costs of gaining access to or consuming electricity. However, while costs are seen as a major determinant of demand, other factors include electricity reliability, consumer preferences, and social acceptance.\(^{34}\)

21. **Information failures.** Information failures about (i) the administrative and physical requirements of connecting to and paying for access and use of electricity, and (ii) the benefits associated with its use, may cause households, firms and public services to consume sub-optimal levels of electricity—for example by using electricity only for subsistence lighting or delaying connecting to an electricity source at all.\(^{35}\)

E. **Report Outline**

22. **The systematic review report is outlined as follows.** Chapter 2 explains the systematic review methodology. Chapter 3 presents the descriptive analysis of the studies included in this review. Synthesis results are in Chapter 4. In addition to quantitative analysis, this review conducted a qualitative analysis on the key barriers and enablers of electricity access, presented in Chapter 5. Finally, Chapter 6 summarizes the key findings and implications of this review and proposes some suggestions for policy and further research.\(^{36}\)

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CHAPTER 2

Methodology

23. This review complies with internationally recognized best practice for developing systematic reviews, theory-based evaluation, and evidence synthesis. This review sets out to synthesize quantitative causal impact evaluations and analyze effect size data (statistical meta-analysis) to provide estimates of the central tendency and heterogeneity of reported changes in outcomes of interest. To capture evidence on the context, implementation, and underlying mechanisms of electricity access interventions, the review implemented a thematic analysis to understand the type of barriers and enablers that could influence program effectiveness.

24. This chapter summarizes the review’s methodology. First, we summarize the set of interventions considered in the review and then present a working theory of change that illustrates the set of expected causal pathways that result in improvements to outcomes of interest. We then describe the steps employed in the systematic review, which involved: (i) specification of our selection criteria; (ii) search strategy; (iii) data extraction; (iv) critical appraisal; and (v) synthesis methods.

A. Types of Electricity Interventions and the Theory of Change

25. Description of the interventions. Understanding the design choices for electricity access interventions is complex, and a number of frameworks attempt to map interventions in terms of their characteristics. For example, the Energy Sector Management Assistance Program (ESMAP) Multi-Tier Framework, developed in 2015, characterizes interventions across several dimensions including capacity, duration, reliability, and quality.\footnote{M. Bhatia and N. Angelou. 2015. Beyond connections: energy access redefined. Washington, DC: World Bank.} This review broadly defines electricity access interventions across three key dimensions: physical access, system policy and management, and incentives and consumer access, shown in Table 2 (footnote 13). Physical access and system policy and management concern supply-side interventions, whereas incentives and consumer access concern demand-side interventions.

26. Theory of change. The theory of change in Figure 2 integrates multiple program theories about improving access to electricity. This particular simple visual representation is adapted from two recent synthesis projects with a similar focus and scope. This model is loosely structured around the three intervention types in Table 2. Arrows point from theorized causes to effects, collectively showing a combination of theorized and empirical pathways that these three intervention types may follow in order to achieve to three main types of impacts: socioeconomic; health, safety and well-being; and environmental.\footnote{This report uses a simplified theory of change. An elaborated theory of change, with more detailed transmission mechanism, is presented in the technical paper (footnote 35).}
### Table 2: Overview of Electricity Access Interventions by Dimension

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Intervention Group</th>
<th>Intervention Subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical access</td>
<td>a) expanding coverage of the (on-grid) national (or regional) power transmission system to new areas and communities</td>
<td>(i) construction of new transmission lines</td>
</tr>
<tr>
<td></td>
<td>b) expansion of off-grid, decentralized power provision to new areas and communities, in the form of central grid, mini-grid, and stand-alone solutions</td>
<td>(ii) network densification measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i) financial incentives (for private enterprises)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) donation of equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) construction of off-grid systems</td>
</tr>
<tr>
<td>2. System management and policy</td>
<td>a) technical support</td>
<td>(i) supply-side management of on-grid system efficiency (for example, use of energy efficient equipment to increase generation and improve efficiency, and measures to reduce transmission and distribution losses at the point before the consumer meter)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) supply-side advance notification about on-grid service interruptions and service restoration times</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) supply-side post-installation maintenance and services (both on-grid and off-grid systems)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) supply-side improvement to quality of systems, installation and after-sales services (off-grid systems)</td>
</tr>
<tr>
<td></td>
<td>b) legal and regulatory frameworks and policies</td>
<td>(i) standards reform (for example, relating to design of micro-grid systems)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) improved standards for off-grid components and system designs (for example, subject to their being eligible for inclusion in subsidized programs)</td>
</tr>
<tr>
<td>3. Incentives and consumer access</td>
<td>a) financial resources that improve affordability</td>
<td>(i) tariff rationalization (for example, introduction of staged or time-use tariffs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) introduction or expansion of consumer credit schemes, loans or subsidies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) rental (fee-for-service) schemes</td>
</tr>
<tr>
<td></td>
<td>b) technical resources aimed at training and supporting consumers to maintain, repair and manage or construct off-grid systems</td>
<td>...</td>
</tr>
</tbody>
</table>

... = not available.

Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle-Income Countries

Figure 2: Electricity Access Program Theory of Change

27. Assumptions and expectations. The provision of new and/or improved electricity access interventions is assumed to enhance underlying electricity infrastructure. Technical, regulatory, and policy interventions are assumed to improve electricity system management and/or infrastructure. Interventions targeting consumer incentives and financial access may result in the introduction of new, or modification of existing, electricity products, services, processes or business models. These changes, either independently or jointly, are expected to provide new and/or improved opportunities for targeted populations to access electricity for desired energy services when they are needed. It is assumed that these interventions have been designed and implemented effectively and provide a well-maintained supply of electricity at an appropriate power capacity, that is affordable, and priced such that it is cheaper than existing traditional energy sources.

28. Intermediate outcomes. As a result of the improved electricity interventions, it is expected that targeted populations will either connect to or make use of an increasingly socially optimal level of electricity infrastructure for a range of key activities. This will include lighting, electrical appliance ownership and use (e.g., to access information and communication resources, provide temperature control) and household or firm production. Increased use may also produce demonstration and/or spill-over effects, where peers of electricity users are able to experience the potential benefits of electricity and then go on to invest in electricity infrastructure as a result. Adoption and use of electricity here assume that uptake is widespread and does not suffer from time lags.

29. From outcomes to impacts. This increased use is expected to bring the socioeconomic impacts listed in Table 2 and Figure 2. The realization of such impacts underpins the strategic rationale for providing new and/or improved electricity access. These changes are thought to arise through multiple assumed causal pathways, including the more productive allocation of labor and capital inputs present in households, firms and community and public services or producing intangibles changes related to a sense of safety, community, and wider well-being, and transitioning consumers towards cleaner energy sources, resulting in environmental benefits.

B. Selection, Screening, and Data Extraction

1. Selection criteria

30. Study inclusion and exclusion criteria. Table 3 summarizes the study’s inclusion and exclusion criteria in a population, interventions, comparators, outcomes and study designs (PICOS) framework. In addition to those criteria, the search included studies in any language published in 2000 or after, although search terms were in English only. No studies were excluded based on publication type (e.g., peer-reviewed articles, study reports in the grey literature, and doctoral theses). The review team also completed a targeted search for associated qualitative studies and process and economic evaluations. The team included studies that assessed some aspect of the implementation, uptake, or use of named interventions that were the focus of included studies. Appendix 1 lists the studies included in the review.

31. Excluded studies. The following interventions related to electricity access were outside the scope of the review:

(i) Energy efficient consumption. Interventions that seek to improve the energy efficiency or consumption of end users could arguably be included as an intervention that improves electricity access. Making existing electricity consumers more efficient may affect the ability of an electricity system to provide energy to others. However, for the purposes of this review, we have excluded interventions of this type, as the main focus is on providing new and/or improved access directly.

(ii) Specific-use solar-power technologies. Other interventions seek to provide solar-powered technologies with end uses ranging from lighting, basic appliance charging, and agriculture. These technologies are solar powered, and the interventions focus on enabling the end technology use rather than providing unconstrained energy access. As
a result, and because ADB’s portfolio focuses on higher-tiered electrification projects, we excluded these interventions from this review. However, we do acknowledge that lighting and charging enabled by low-tiered electricity solutions are an important subcomponent of electricity access.

Table 3: Population, Interventions, Comparators, Outcomes and Study Designs Summary of Review Criteria for Inclusion and Exclusion of Studies

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Inclusion and Exclusion Definitions</th>
</tr>
</thead>
</table>
| Population        | (i) Program beneficiaries in low- and middle-income are included.  
                    (ii) Program beneficiaries in high-income countries are excluded. |
| Intervention      | (i) Any intervention that seeks to provide new and/or improved electricity access to for either individuals, residential units (households, villages, municipalities), community-based organizations (schools, health clinics, community centers), or commercial enterprises (except those that build their own power transmission systems to access electricity for their own use alone).  
                    (ii) Interventions that seek to increase demand for electricity among any population group (demand-side). |
| Comparisons       | (i) Populations that receive ‘business as usual’ access, an intervention with a different type of access, or no intervention are included.  
                    (ii) Studies with no comparison are excluded. |
| Outcomes          | (i) The review will not exclude studies on the basis of recorded outcomes as long as they are realized by individuals, households, businesses or communities. |
| Study design      | (i) Randomized and non-randomized counterfactual studies. |


2. Screening

32. **Initial screening.** A systematic search of academic bibliographic databases and library catalogues was completed in November 2019 to identify qualifying studies. The list of databases is in Appendix 2. This strategy addressed potential publication bias issues by comprehensively searching unpublished literature and implementing additional searches for grey literature in specialist organizational websites, websites of bilateral and multilateral agencies, and repositories of impact evaluations in international development.

33. **Additional sources.** The team also considered additional sources: (i) other specialist databases (also in Appendix 2); (ii) websites of a set of specified organizations; (iii) backward and forward citation tracking; (iv) communication with researchers, through contacting researchers and experts recommended by the review’s advisory group, and publishing a call for information in a related blog post on the 3ie website and promoting it using social media; and (v) complementary wider research, including informally reported experience-based evidence to understand factors relating to intervention design, implementation, and context that may plausibly affect program effectiveness.

34. **Search strategy.** The team selected studies for data extraction using EPPI-Reviewer 4 software to: (i) prepare the records of studies included and remove known duplicate files; (ii) screen titles and abstracts; (iii) use machine learning aides to screen more relevant studies initially and enable the team move onto later stages in the review process while title and abstract screening was ongoing; and (iv) screen the full text of each study that met all the title and abstract inclusion criteria.39

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39 EPPI-Reviewer 4 is a software product that supports the management of and analysis in a systematic review. It manages references, stores PDF files and facilitate quantitative and qualitative coding and analysis. See J. Thomas et al. 2010. EPPI-Reviewer 4.0: Software for Research Synthesis. London: Social Science Research Unit, Institute of Education, University of London.
3. Data Extraction and Critical Appraisal

35. **Steps.** To extract effect size information and appraise the quality of studies included in the review, the team: (i) extracted quantitative data, identifying and linking multiple reports of the same study together before data extraction; (ii) extracted qualitative data using line-by-line coding to understand how interventions and context differ from one another, using a code-set developed with a semi-inductive approach; (iii) critically appraised the quantitative studies to consider the risk of bias and consistently assess the internal validity of social experiments and quasi-experiments; and (iv) critically appraised qualitative reports, using an adaptation of the nine-item framework developed by the Critical Appraisal Skills Program.

36. **Publication bias.** As with other reviews, this systematic review is vulnerable to publication bias, which results when the published literature systematically fails to represent the entire population of studies because of, for example, time lags, language use, small sample sizes, or outcome reporting biases, such as under or non-reporting of null effects.

C. Data Analysis

1. Calculating and synthesizing effect sizes

37. **Related question.** This step is related with SRQ 1 in Table 1 “what are the effects of electricity access interventions on socioeconomic development outcomes for private individuals, organizations and communities?” (para. 2). An effect size expresses the magnitude or strength of the relationship of interest. We extracted data from each individual study to calculate standardized effect sizes for cross-study comparison where possible and employed meta-analysis techniques to calculate overall effect sizes for using commonly understood formulas so that the results from different studies are presented on the same index and can be more easily compared. When included studies did not provide the data required to calculate effect sizes, we contacted the authors. When we did not get a response, we excluded the study from the meta-analysis but still included it in the descriptive and qualitative analysis. When a study provided multiple model specifications, our first choice was always to extract the author’s preferred model, if stated. If the author did not state their preferred model but presented a main model and then several robustness checks, then we assumed the main model was the preferred model. If the author did not state their preferred model and presented several models as the main models, we chose the effect size from the model with the most controls.

38. **Fixed and random effects models.** The choice of a computational model for meta-analysis depends on whether the studies are assumed to be functionally equivalent. If so, one may apply a fixed-effect model, which identifies the best estimate of a single "true" intervention effect, based on the assumption that the studies share a common mean and that differences in effect sizes stem from sampling error. In contrast, one would apply a random effects model, which identifies the average intervention effect across a distribution of effect sizes, if (i) the studies differed in important ways (e.g., subjects, interventions, or context) that may affect the results; and/or (ii) the review aims to generalize findings to a range of scenarios or populations. Both of those conditions are true for this systematic review, so this meta-analysis adopts the random effects model, thus providing evidence of whether electricity access resulted in general changes to socioeconomic welfare on average and indicating whether other factors beyond sampling differences influence effects.

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40. Possible bias includes: (i) identification strategy or mechanism of assignment into treatment and comparison groups; (ii) equivalence and comparability of treatment and comparison groups; (iii) unit of analysis and calculation of standard error; (iv) attrition bias; (v) motivation bias; (vi) the possibility of spillovers, cross-overs, and contamination; (vii) outcome measurement bias; (viii) selective analysis reporting; and (ix) other bias.


39. **Standardized mean difference.** To calculate standardized effect sizes, we used the standardized mean difference (SMD), which quantifies the size of an intervention effect in each study relative to the variability observed in that study. Specifically, we use Hedge’s, which is the SMD, with a correction for the bias induced by studies with small sample sizes. The SMD is interpreted as the change in the outcome of interest attributable to the intervention, measured in terms of standard deviations. For example, an SMD of 0.5 indicates that the intervention caused the outcome to increase by 0.5 standard deviations.

40. To assess whether electricity access interventions affect evaluated outcomes, we first pooled all standardized effect sizes together across the following five broad outcome domains: electricity access and use (intermediate outcomes), education, socioeconomic welfare, health, and environment.

41. **Variance or heterogeneity in effect sizes.** The pooled effect size ($g$) combines all effect size data in one outcome group to provide an overall measure of the central tendency, taking advantage of samples across multiple populations. This approach provides an indication of the underlying differences across studies that may influence $g$. In this case, we use the $I^2$ metric to define the potential presence of variance across effect sizes—or effect size heterogeneity—that does not stem from sampling differences. This metric is provided as a percentage and a common rule of thumb is that an $I^2$ of 0%–35% indicates a low level of heterogeneity, 35%–65% medium, and above 65% shows a high level of heterogeneity. While these estimates account for differences across outcome group, they do not consider other factors that may influence effect size variance, as discussed in the following section. We also test how sensitive these effects are to outliers by re-running the analysis with outlier effect sizes, defined as effects that are more than three standard deviations away from the unweighted mean.

2. **Assessing Heterogeneity and Underlying Causal Mechanisms**

42. **Related questions.** Assessing heterogeneity is the step to answer SRQ 2 (“to what extent do effects vary by population group and location”), while assessing the causal mechanism will answer SRQ 3 (“what factors relating to program design, implementation, or context are associated with better or worse outcomes along the causal chain?”) mentioned in Table 1. The approach presented in paras. 37-41 does not provide any understanding of other factors that may influence variance in effect sizes. Because the electricity access interventions considered in this review vary widely in their design and implementation features and context, the observed effect size heterogeneity is likely to be considerable. To address this, we implemented statistical models called meta-regressions, using quantitative effect size data and a framework analysis of associated qualitative evidence.

43. **Meta-regression analysis.** Meta-regression models are comparable to multiple linear regression models whereby the observed variation in an outcome variable is predicted by a set of explanatory moderator variables, or covariates. In this case, the outcome variable of interest is the SMD for each effect size. We selected covariates that concern outcome type, intervention, study, and region characteristics to understand what factors influence heterogeneity in this context. The regression coefficients derived from these models describe how the SMD changes with a unit increase in the explanatory covariates and whether these changes are statistically significant. In this way, meta-regressions address potential issues of confounding across the different selected covariates and provide more nuanced insight into the factors that influence heterogeneity. The analysis also estimates (i) the residual $I^2$ that remains after accounting for the moderators of interest and (ii) $R^2$, a more common diagnostic statistic used in regression analysis, which reflects the percentage of variance in effect size that is explained by the explanatory moderators in the meta-regression model. $R^2$ and $I^2$ are calculated separately and provide a signal of the explanatory power of the model only.

43 The analysis implemented the following model specification: $\hat{\theta}_k = \theta + \beta_1 x_{1k} + \cdots + \beta_n x_{nk} + \varepsilon_k + \tau_k$, where $\hat{\theta}_k$ is the predicted effect size for study $k$, $\beta_n$ is the coefficient estimate for covariate $n$ in study $k$, $\varepsilon_k$ is the sampling error, and $\tau_k$ is the error introduced as a result of the true effect size $\theta_k$ for study $k$ is only part of a wider distribution of true effect sizes.
44. **Further meta-regressions.** When the results of these regressions do not provide a clear interpretation, we implemented further meta-regressions for outcome domain subgroup levels. For example, in addition to implementing a meta-regression for the education domain, we may also implement separate models for the outcomes that comprise this domain, such as school enrollment, study time, or grade progression. We also explore effect size variance for each intervention subgroup, using effect size data across all outcome domains. In doing so, we attempt to identify key factors that may have influenced program effectiveness.

45. **Subgroup analysis.** To complement the analysis provided above, we also ran subgroup meta-analyses for outcomes that were determined to be theoretically similar, provided that there were at least two effect sizes that sought to measure the same outcome with comparable outcome measures.

46. **Framework analysis.** We also used framework analysis to identify which intervention and contextual characteristics could explain outcomes. This qualitative method is aptly suited for applied policy research and incorporates a hybrid approach of inductive and deductive theme development.

3. **Synthesizing Intervention Cost Evidence**

47. **Lack of sufficient data on cost.** Finally, to answer SRQ 4, “what is the cost-effectiveness of the interventions under review,” mentioned in Table 1, the team synthesized the evidence with regard to the cost of interventions. The research protocol called for standard approaches to synthesize economic appraisal evidence, depending on the available cost evidence. Evidence was to include unit and total costs to implementers and participants (and non-participants, as relevant), and cost-effectiveness ratios, to provide a set of standardized benchmarks to compare interventions. Because of an absence of sufficient data, we dropped this analysis from the systematic review.

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CHAPTER 3

Descriptive Results

48. This section presents the results of the literature search and a descriptive overview of the studies and interventions included in the review. It draws on metadata produced by the screening processes and descriptive information extracted from included study reports.

A. Search Results

49. **Title-abstract screening.** Electronic searches of academic databases produced 68,590 records. Non-electronic searches and citation tracking produced a further 751 records for screening, resulting in a total of 69,341. After removing 18,008 duplicate records, the team manually screened 51,332 study records against the eligibility criteria using title and abstract information only. At this stage, we excluded studies mainly because a study did not focus on a relevant intervention and/or was not an impact evaluation. Figure 3 below illustrates the search process.

![Figure 3: Overview of Search and Screening Process]

- **68,590** records identified through academic database searching
- **751** records identified through grey literature search and citation tracking
- **50,364** records excluded
- **396** additional duplicate records identified
- **51,332** records screened at title and abstract (after duplicates removed)
- **572** articles screened at full-text
- **126** included impact evaluation reports for quantitative synthesis
- Corresponding to 89 impact evaluations
- Additional research for 12 impact evaluations with qualitative component (mixed-methods)

LMIC = low- and middle-income country.
Source: 3ie calculation from 68,590 publication records.
Full-text review. After title-abstract screening, we assessed 572 records as potentially relevant and retrieved the records for full-text review. In total, 126 records met all the eligibility criteria and were included in the review (see Appendix 1 for the list of studies included). These records correspond to 89 unique studies.\footnote{While there are 85 unique main reports, two of them describe a series of evaluations conducted in different countries, using different datasets. In the context of this review, these are treated as different studies and have been coded individually as if the evaluations had come from separate reports. This means a total of 89 studies (reported in 126 papers) were included in the synthesis.} The discrepancy between the included records and number of studies stems from the fact that, in some cases, more than one publication reported the results of a single study. In total, 66 included study records were peer-reviewed journal articles (52%), with the remainder comprising a combination of grey literature and unpublished academic manuscripts. A majority of the records, 104 study reports (82%), were published in or after 2013 (Figure 4).

![Figure 4: Distribution of All Included Records by Publication Year](image)

Note: The number of 2020 studies reflect the additional studies suggested by the advisory group members after the search was completed in November 2019.
Source: 3ie analysis of 126 studies included in the review.

B. Characteristics of Included Studies

The PICOS review. The review team completed an analysis of study characteristics for all 89 included studies. Because of the design of some studies, the team was able to identify specific interventions in only 41 cases and coded intervention characteristics beyond the intervention type only for this subset.\footnote{This relates to intervention funding agency, off-grid energy source, scope of delivery (national, regional, or local), and geographical coverage (urban, rural, or both).} The key study features of unique impact evaluations included in the review, structured against the review population, intervention, comparator, outcomes, and study design (PICOS) are as follows.

1. Population

Geography. Included impact evaluations spanned five World Bank geographic regions (Figure 5). South Asia was the location for the largest number of studies (31 studies), closely followed by sub-Saharan Africa (28 studies).\footnote{World Bank geographic regions were used as they provide a common understanding of key regions across the world of interest.} This result largely stems from a high volume of studies in particular countries, including Bangladesh (eight studies), Ghana (five studies), India (17 studies), and Kenya (six studies) as shown in Figure 5. Conversely, the regions associated with the least number of studies were East Asia and the Pacific (nine studies) and the Middle East and North Africa (three studies).
Figure 5: Distribution of Included Impact Evaluations by Geography

Note: Two multi-country studies that did not disaggregate their analysis by country were removed from this chart to avoid overly distorting the result.
Source: 3ie analysis of 89 impact evaluations, associated with a total of 126 studies included in the review.

53. **Income.** Country income status was classified for the first year that data were collected in each evaluation. 48 This analysis shows that the highest proportion of studies were implemented in low income countries (50 studies), followed by lower-middle income (31 studies) and upper-middle income countries (6 studies). 49

54. **Study participants.** The majority of studies sampled rural areas (68 studies), mixed groups of men and women (75 studies), and both adults and children aged less than 18 years old (51 studies). Eleven research products studied only children and nine studied only women. Five studies did not provide any information to deduce gender and age of participants, but the unit of observation for four of them was manufacturing firms. Most studies present the breakdown of individual household members or the household head by socioeconomic status (63), education (56), age (54), and sex (46). Thirty-five do so for household size and 30 for housing conditions. A much smaller number disaggregate sample composition by ethnicity or race (13), religion (9), or disability (1).

2. **Intervention**

55. **Subject of evaluation.** Figure 6 below shows that the majority of studies sought to evaluate the provision of new and/or improved grid access (62 studies), followed by the provision of new and/or improved off-grid electricity access (22 studies), and financial resources to improve affordability (15 studies). Five studies sought to evaluate interventions that promoted technical support improvements, which includes two studies measuring the impacts of blackouts, and three studies evaluated legal or regulatory system reliability interventions. In three studies, the specific nature of the intervention forming the focus of the evaluation was not clear. One study evaluated the effect of an awareness raising demonstration program.

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48 As defined by the World Bank.
49 If the authors chose the date of publication or end line data collection for determining the classification of country income status, lower-middle income countries would have been the largest group.
Figure 6: Number of Included Studies by Intervention Type and Subject of Evaluation

Note: Multi-intervention was permitted.
Source: 3ie Analysis of 89 impact evaluations, associated with a total of 126 studies included in the review.

56. **Combined interventions.** Twenty-five studies were categorized under more than one dimension of electricity access. Most of them combined financial incentives with on-grid (eight) or off-grid (seven) physical access. In seven cases, grid expansion was coupled with various system reliability interventions, predominantly technical support. Six studies evaluated expansion of power using a mix of on- and off-grid. One of them was Samad and Zhang (2017), which evaluated different levels of electricity availability in the context of Rural Electrification and Renewable Energy Development Program in Bangladesh which also had a technical support and affordability component.50

3. **Outcomes**

57. **Outcomes of interest.** Of all the intermediate and final social outcomes, 67 were measured primarily at an individual or household level. Another nine were analyzed at the village or community level, four at the municipality level, and one at the province level. Manufacturing firms were the unit of observation for four studies, schools for two studies, and microenterprises and informal tailors for one study each. Overall, 45 studies reported effect size data on education outcomes, 32 studies reported on health outcomes, 73 studies reported socioeconomic welfare outcomes, and 25 studies reported environmental outcomes.

4. **Study Design**

58. **Evaluation design.** Included studies employed a range of designs. Of the 89 studies included for this review, eleven studies implemented randomized controlled trial designs, while the remainder employed quasi-experimental study designs.51 An overview of the designs shows that studies using statistical matching (36 studies) were most common (Table 4). Thirty studies implemented multiple methods to support their identification strategy. The most common combination was statistical matching and difference in difference (nine studies).

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51 Four studies have used a randomized encouragement design, which were classified as quasi-experimental instead of randomized control trial design.
Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle- Income Countries

Table 4: Overview of Study Evaluation Designs

<table>
<thead>
<tr>
<th>Methods Used</th>
<th>Number of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical matching</td>
<td>36</td>
</tr>
<tr>
<td>Instrumental variable estimation</td>
<td>32</td>
</tr>
<tr>
<td>Fixed effects estimation</td>
<td>23</td>
</tr>
<tr>
<td>Difference-in-difference</td>
<td>18</td>
</tr>
<tr>
<td>Randomized controlled trial</td>
<td>11</td>
</tr>
<tr>
<td>Regression discontinuity</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: 3ie analysis of 89 impact evaluations, associated with a total of 126 study reports. The total is higher than the number of analyzed impact evaluations because some studies employ multiple methods.

5. Other Study Level Characteristics

59. **Appraisal (risk of bias assessment).** Just over half (52%) of the studies received a rating of “medium to high” or “high” risk of bias in at least one critical appraisal category (footnote 40). There were specific areas of uncertainty or concern for both quasi-experimental and experimental studies. Potential spill-overs were noted as an issue for both study types because of the difficulty of neatly differentiating between those with and without access to electrification interventions (e.g., because of demonstration effects or the potential for sharing electricity), though the majority of authors acknowledged and sought to address or mitigate these concerns. For the quasi-experimental studies, the most common risks related to confounding (23% rated as "medium-high" or "high" risk) and selection bias at baseline (22% rated as "medium-high" or "high" risk). Medium-high or high risks were often related to the inadequate justification that the identification strategy would generate comparable treatment and comparison groups and high risks to the inability to account for potentially important covariates in the analysis. In over a quarter of the studies, insufficient detail in the research reports made it difficult to assess the risk of bias, resulting in an “unclear” rating for four of the assessment criteria.

60. **Time of outcome measurements.** The review team attempted to collect information on the time elapsed between the electrification intervention and the latest outcome measurement. While it was unclear for 27 studies, 36 study reports indicated an exposure length of between 1 and 10 years. A length of above 10 years was reported for 16 studies while the remaining 10 reported less than 12 months. The number of data collection points administered throughout the study was also captured. For a majority of studies (67 studies), only one or two outcome measurements were recorded.

61. **Funding agencies.** Study funding was provided by academic or research institutions (20 studies), international aid agencies (18), international financial institutions (17), government agencies (15), and foundations (4). However, it was not clear from the study reports reviewed what the study funding source was for the remaining 35 studies, or just under 40% of all included studies. Government agencies were the most common type of agency to fund named programs included in the review (28 studies). This was followed by international aid organisations (7 studies), private sector organisations (4), international financial institutions (3), and non-profit organisations (1). It was not clear for two studies.

62. **Independence.** A study was defined as independent by the review team when the evaluation team did not include any members of the team that delivered or funded the intervention under evaluation. In total, 83 studies (93%) were classed as independent, with three studies as partially or not independent; not enough information was provided in study reports to assess this for the remaining three studies. The team also assessed the independence of the data collection process, whereby data collection collected by the evaluation team or a third party was classed as independent. Eighty-three studies were classed as having an independent data collection process, another three as not independent but again, with an insufficient level of information made available to assess this in the case of the remaining three studies. Finally, the review assessed the presence of conflict of information statements and found that fifteen studies (17%) reported a conflict of interest statement, whether there was a conflict or not.
63. **Equity.** A majority of studies (38 studies) did not directly aim to address equity. Those that did mainly considered sex, place of residence, and socioeconomic status. The most common method employed to address equity considerations was to account for heterogenous effects using a subgroup analysis by sex (33 studies). About 20% of studies (21 studies) targeted a vulnerable population, predominantly in isolated rural areas. A subgroup of 14 studies analyzed equity dimensions other than sex—mostly age or education levels—of study participants. Other analyses of heterogeneity using interaction terms or quantile regressions are less common (eight studies) and have analyzed differential effects based on participants' income, consumption level, or sex. Three studies included a gender equality measure as an outcome and the same number employed an equity-sensitive method or theoretical framework for their analysis. Four studies (4.5%) referred to an ethical or institutional review board approval, which is markedly lower than the average in 3ie's international development evidence repository (25%).
CHAPTER 4

Synthesis of Results

64. This chapter presents the synthesis of results completed as part of the review. It was informed by data extracted from included studies, in addition to qualitative research and evidence from process evaluations that are linked to included studies. For each of the five broad outcome domains, we present the number of studies for which we were able to calculate effect sizes. The full results—standard mean difference, confidence intervals, and $I^2$ as measures of heterogeneity for all outcome variable—are in Appendix 3. The chapter ends with an exploratory analysis of the influence of intervention categories, study method, and publication bias.

A. Intermediate Outcomes

65. Causal pathways. There are several intermediate steps in the theorized causal pathways between implementing an electricity access program and realizing a change in a given social outcome. These intermediate outcomes concern program implementation, uptake, and/or a target population's response to an intervention. These outcomes may include, for instance, new household connections to electricity, changes in energy consumption, lighting use, or reliability of an electricity supply.

66. Included studies. We identified 35 studies reported in 44 study reports that evaluated the effect of an electricity access intervention on an intermediate outcome. We were able to calculate effect sizes of intermediate outcomes for all of these studies and grouped the outcomes into the following categories.

   (i) Electricity connectivity (10 studies). This outcome comprises the extent to which an intervention resulted in changes to a target population's connection to an electric supply. In all cases, outcomes evaluated reflect whether on-grid electricity access was achieved or whether electricity access was provided in some form.

   (ii) Electricity reliability (5 studies). Changes in the reliability of an electricity source were approximated using the hours of electricity available in a given period or the occurrence of reliability indicators, such as frequency of brown or blackouts.

   (iii) Electricity price (2 studies). Two studies based in India and Peru evaluated electricity price changes as a result of the implementation of an electricity access intervention.\(^{52}\) We considered the price level from the perspective of an end consumer and assumed that a price decrease was a socially improving outcome. This means a positive SMD in the meta-analysis reflects a decrease in the price of electricity.

   (iv) Lighting use (8 studies). Eight studies evaluated changes in lighting use as a result of an electricity access intervention. These changes were measured in the amount of time respondents in the studies reported using lighting.

   (v) Energy use (18 studies). Eighteen studies considered energy use across three main areas: electricity, batteries, and traditional energy sources such as wood, kerosene, or dung. We assumed a positive relationship between changes in an outcome and the SMD, except in the case of traditional fuel use, where we assumed a decrease in the effect was socially improving; a positive SMD in the meta-analysis reflects a decrease in traditional energy use.

Electrical appliance ownership and use (26 studies). As new and/or improved electricity access is provided to target populations, it may be the case that beneficiaries increase their ownership of electrical appliances to make more productive use of electricity. Seventeen studies evaluated changes in appliance ownership and use as a result of an electricity access intervention.

Effect sizes. Overall, electricity access interventions had a positive effect. The pooled SMD suggests that the intermediate outcome size observed in the treatment groups is 0.17 standard deviations higher than those in the comparison group (the effect size is statistically significant, with 95% confidence interval (CI): [0.08, 0.26]).53 The effect sizes of specific intermediate outcomes are in Figure 7. Electricity access interventions led to increased use of electricity, ownership and use of electrical appliances, and to some extent improved reliability and more affordable prices.54

Figure 7: Meta-Analysis Results on Intermediate Outcomes

Note: The effect sizes are measured in standardized mean differences; lines represent the 95% confidence interval.
Source: 3ie calculation.

Heterogeneity. The results varied highly between the studies, with $I^2 = 99\%$ for overall effect size, and $99\%–100\%$ for specific outcomes (Appendix 3). The high level of heterogeneity supports the need for moderator analysis. Using meta-regression analysis, we hypothesized that the heterogeneity may result from these observable characteristics of the studies: (i) intervention type; (ii) methodology used; (iii) year of publication; (iv) length of project intervention; (v) baseline levels of electricity access; and (vi) geographical location. The analysis shows that only one variable significantly influenced the pooled SMD for intermediate outcomes: studies where the intervention combines changes to both (i) policy or system management and (ii) affordability, while none of the other coefficients was significant. This implies that heterogeneity across studies might be explained by factors not captured by the study characteristics; some of which will be discussed in the qualitative analysis in Chapter 5.

B. Education

Causal pathways. Access to electricity is often assumed to improve education outcomes and there are several potential and theorized causal pathways for how this may occur. New and/or improved lighting that would extend the effective school day and permit flexible home study was the main mechanism highlighted in included studies. However, other potential mechanisms exist—for example,
the increased use of electrical devices and digital working aids and the attraction and retention of high-quality teaching staff. These changes are expected to improve the education process and enable learners to invest more in education, both at school and at home. As a result, we expect that learner participation would increase—for example, in enrollment, grade progression, and years of schooling—which would ultimately produce positive learning outcomes, such as improved test scores or literacy rates.

70. **Included studies.** We identified 46 studies that measured education outcomes, of which 37 studies (published in 46 reports) provided sufficient information to calculate SMD. We were able to extract effect size information for the following educational outcome subgroups: school enrollment (12 studies); study time (17); grade progression (5); years of schooling (10); and learning outcomes (8).

71. **Effect sizes.** Electricity access interventions had a positive but small effect on the pooled education outcomes. The summary of meta-analysis results is in Figure 8. The pooled SMD is 0.05 standard deviations (95% CI: [0.03, 0.07]) in the treatment group relative to the comparison group for the educational outcomes included in the analysis. Further analysis indicates that electricity access significantly improved study time, especially at night, with small improvements in years of schooling and school enrollments. We do not detect meaningful and significant effects on grade progression and literacy rate.

![Figure 8: Meta-Analysis Results on Education Outcomes](image)

Note: The effect sizes are measured in standardized mean differences; lines represent the 95% confidence interval.

Source: 3ie calculation.

72. **Heterogeneity.** The pooled estimate is associated with a considerable level of heterogeneity ($I^2=75\%$ for the overall education outcome, and $50\%–75\%$ for specific outcomes). Interventions that expand access alone—both on- and off-grid—resulted in decreased effect size, while combining affordability with system and/or policy management components were associated with increased effect size. We also find a significant decrease in the pooled effect size for study populations based in Latin America and the Middle East and North Africa, for studies with high risk of bias, and for studies in countries with a high average nationwide level of electricity access.

C. **Socioeconomic Welfare**

73. **Causal pathways.** Electricity access is expected to produce transformative benefits across multiple areas of society, ranging from livelihood generation, increased productivity, improved socioeconomic well-being, and ultimately, reduced poverty. These benefits are expected to arise through a number of different mechanisms. New and/or improved access is expected to result in increased home and economic productivity and open up new economic opportunities, increasingly those that are not related to agriculture. Potential increases in household and firm wealth may produce positive externalities, for
example by increasing demand for local services and attracting residential and commercial migration, resulting in increased labor supply. Finally, access to electricity is expected to improve well-being, both through the improved set of opportunities described but also by improving the quality of social interaction and local safety.

74. Outcomes of interest. This subsection presents a synthesis of all outcomes relating to socioeconomic development. We were able to calculate standardized effect sizes for 59 studies found in 72 reports that assessed at least one socioeconomic outcome from the following domains: assets (7 studies); household wealth (38); labor supply (35); time allocation (25); business performance (10); safety (9); social cohesion and well-being (8); and female empowerment, which includes measures such as female agency and female involvement in family, family planning, and economic household decision making (8). The combined welfare effect size across different socioeconomic outcomes is 0.04 standard deviations (95% CI: [0.03, 0.06]). However, an analysis of different outcomes gives a wide variations of effect sizes.

75. Household welfare. In Figure 9, analysis from 38 studies shows that new and/or improved access in electricity resulted in slightly higher levels of total household income by 0.06 standard deviations (95% CI: [0.04, 0.07]), and a small reduction in household poverty incidence, which is translated to a positive welfare benefit of 0.08 standard deviations (95% CI: [0.03, 0.12]). There are observed positive improvements of household assets and consumption; however, the effects were not statistically significant, as shown by large confidence intervals. Improved access to electricity also resulted in increased household income, with a bigger effect size reported in non-farm income. Farm employment increased only marginally, although a breakdown between farm and non-farm income did not result in statistically significant effect sizes for both sources of employment.

Figure 9: Meta-Analysis Results on Household Welfare

Note: The effect sizes are measured in standardized mean differences; lines represent the 95% confidence interval.
Source: 3ie calculation.

76. Household time allocation. Based on 25 studies, time allocated to paid work and consuming leisure (e.g., watching television) appear to be positive overall (Figure 10). There are also observed benefits from reduced time to collect traditional fuel sources. However, these estimates are relatively small and, in the case of leisure, imprecise due to large confidence intervals. No effects on unpaid work and rest were observed.
Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle-Income Countries

Figure 10: Meta-Analysis Results on Household Time Allocation

![Figure 10: Meta-Analysis Results on Household Time Allocation](image)

Note: The effect sizes are measured in standardized mean differences; lines represent the 95% confidence interval. Source: 3ie calculation.

77. **Business outcomes.** Ten included studies sought to measure other socioeconomic impacts like firm creation and performance. Improvement in business performance is close to zero (Figure 11). The results from individual studies are mixed; for example, manufacturing firms in Myanmar that located their operations in areas of high electricity experienced increases in profits, while in India electricity access interventions did not have a significant effect on the number of business ownerships. Similarly, overall business productivity improved only marginally with large confidence intervals. Most of the improvement came from agricultural activities, with no change reported across non-agricultural enterprises.

Figure 11: Meta-Analysis Results on Business Outcomes

![Figure 11: Meta-Analysis Results on Business Outcomes](image)

Note: The effect sizes are measured in standardized mean differences; lines represent the 95% confidence interval. Source: 3ie calculation.

78. **Female decision-making in the household.** Access to electricity led to marginal improvement in female empowerment at the household decision-making by 0.03 standard deviations (95% CI: [0.01, 0.05]). From eight studies which reported relevant outcome variables, female household members are reported to have a bigger say over family planning, family care, and family economic management (Figure 12). Female members also reported having more independence or agency in their individual decisions.

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However, none of the effect sizes for specific outcomes on female decision making are statistically significant.

**Figure 12: Meta-Analysis Results on Female Decision-Making in the Family**

<table>
<thead>
<tr>
<th>Category</th>
<th>Effect Size</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.03</td>
<td>[-0.01, 0.22]</td>
</tr>
<tr>
<td>Family planning</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Family care</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Family economic</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Agency</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

Note: the effect sizes are measured in standardized mean differences; lines represent the 95% confidence interval.
Source: 3ie calculation.

79. **Heterogeneity.** The socioeconomic estimate is associated with a high level of heterogeneity ($I^2=91\%$). As above, we sought to account for this by implementing a meta-regression analysis. This model estimated that a combination of expansion and system policy or management components led to higher effect size. Surprisingly, we also estimated a weakly significant but negative relationship between the implementation of technical support and the overall effect size. Interventions targeting women also led to higher effect size. There is no statistical evidence that variables concerning methodology employed in the studies, publication year, duration of project intervention, levels of electricity access, and geographical location affected heterogeneity.

**D. Health Outcomes**

80. **Effect sizes.** The review included 21 studies that reported some health outcomes. In Figure 13, the pooled effect size is 0.11 (95% CI: [-0.01, 0.22]). On specific health outcomes, we find positive associations between access to electricity and the use of contraception and social benefit from lower fertility, access to health information (e.g., on vaccination), and positive health outcomes (e.g., increase in life expectancy, decrease in mortality rates, and fewer incidences of low birth weights). However, none of the specific health indicators are statistically significant. We also find no change in the measures of health symptoms.

81. **Heterogeneity.** The pooled estimate for health was associated with a high level of heterogeneity ($I^2=99\%$). This result can be explained in part by the results of the meta-regression results, which suggests that studies from Latin America, the Middle East and North Africa, and South Asia are associated with lower pooled effect size for the health outcomes. We also find that existing access to electricity access had a significant and positive effect on the variance in pooled effect size, and that studies with high risk of bias were associated with lower effect sizes.
Wide range of outcomes. While an earlier systematic review on electricity access noted the paucity of research in this area, we note an increasing number of studies investigating the health impacts of access to electricity (footnote 13). These studies focus on many different outcomes, and each study defines the outcomes of interest differently. This has led to a significant heterogeneity of the studies and wide confidence intervals of each outcome groups shown in Figure 13 and Appendix 3.

E. Environmental Outcomes

Challenges in conducting a meta-analysis. As with the studies on health outcomes, at this stage it is still difficult to implement a meta-analysis on the environmental outcomes. While there has been more interest in studying environmental outcomes of electricity interventions, researchers are interested in different specific outcomes. The review was able to calculate the effect size on environmental outcomes from 17 studies, all of which concerned the use of traditional energy sources such as kerosene or wood fire. The overall benefit from lower use of traditional energy sources was associated with a positive effect of 0.1 standard deviations (95% CI: [0.03, 0.16]). Only three studies, however, directly measured pollution outcomes at the household level, which was associated with a small positive welfare improvement, but was not statistically significant (Figure 14).
F. Further Exploratory Analysis

84. Intervention types. We extended the analysis by grouping all effect size information across all outcome domains by intervention type. In this case, we are interested in the factors that are important to consider for improving all outcomes with respect to each intervention of interest. Here we control for outcome domains and study characteristics. The effect sizes of different types of interventions by different outcome groups are in Table 5. Both off- and on-grid expansion brought positive and significant effects on the overall education, household welfare, and intermediate outcomes. Off-grid interventions have also brought positive and significant effects on health and environmental outcomes, while the effects of on-grid expansion, while positive, were not statistically significant. Interventions that provide technical support have shown small but statistically significant effects on education and household welfare outcomes. Meanwhile, interventions that aim to improve connection affordability led to positive and significant effects on all outcome groups except health. We did not find enough studies on legal or regulatory reforms and awareness creation to calculate the effect sizes.

Table 5: Meta-Analysis Results on the Outcomes of Different Interventions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Intervention Type</th>
<th>Intermediate Outcomes</th>
<th>Education</th>
<th>Household Welfare</th>
<th>Health</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid expansion</td>
<td>On-grid</td>
<td>0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.10</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Off-grid</td>
<td>0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.22&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>System reliability</td>
<td>Technical support</td>
<td>0.09</td>
<td>0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Legal or regulatory reforms</td>
<td>0.03</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Affordability</td>
<td>Financial resources</td>
<td>0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.24</td>
<td>0.14&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Awareness</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

... = not available.
Note: the effect sizes are measured in standard deviations.
<sup>a</sup>p-value < 0.01.
<sup>b</sup>p-value ≤ 0.05.
<sup>c</sup>p-value < 0.1.
Source: 3ie calculation.

85. Studies with multiple interventions. Of the 89 included studies, 25 (28%) were multi-component interventions that simultaneously targeted multiple constraints, most commonly the expansion of access (on-grid and/or off-grid) plus reliability (8) or affordability (15). Separate meta-regression analyses suggest that interventions targeting multiple constraints yield better results than interventions only targeting one of these constraints. For example, combining grid expansion with technical support would lead to higher household socioeconomic outcomes, and a mix of technical supports and financial incentives would result in higher education outcomes. However, the number of studies reporting multiple interventions is too limited for us to make a conclusion for the health and environmental outcomes.

86. Study method and bias. Meta-regression analyses suggest that there are no significant differences in effect sizes for experimental versus quasi-experimental designs for any of the outcome domains. However, we find smaller effect sizes for studies appraised as having high risk of bias for the education and health domains only, though sensitivity analysis indicated that this did not meaningfully change the findings. Another type of bias is publication bias, whereby studies, especially small number of observations and studies reporting null effects, are not published. We have attempted to partially mitigate this through an extensive grey literature search so that we are not limited to peer-reviewed publications. However, a range of other factors may have influenced our results and we suggest caution in interpreting this finding.

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Note: 3ie calculation.

56 Relative to low risk of bias studies. See footnote 40 for the list of possible sources of bias.
CHAPTER 5

Barriers and Enablers of Household Access to Electricity

87. This chapter presents the results of a thematic analysis of barriers to and facilitators or enablers of program effectiveness. In estimating the impacts of electrification in LMICs, we established that the studies in the review varied considerably. In the previous section, we explored the role of differences in outcomes, interventions, and study characteristics in explaining the lack of consensus across studies. The discussion in this chapter aims to partially explain the heterogeneity across studies that we observed in Chapter 4. We build on the evidence presented on overall and heterogeneous treatment effects to try to make sense of the complex factors that make the difference between successful and disappointing intervention implementation and results.

88. **Barriers and enablers.** The thematic synthesis of qualitative and informal data suggests that three different types of factors had some role in influencing program effectiveness: socio-political factors, intervention design, and demand-side factors. A summary of the barriers and enablers is in Table 6. The list of studies linked to each theme is in Appendix 4.

<table>
<thead>
<tr>
<th>Socio-Political Factors</th>
<th>Intervention Design and Implementation</th>
<th>Demand-Side Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political situation and structure</td>
<td>Connection charges</td>
<td>Types of beneficiary</td>
</tr>
<tr>
<td>Existing infrastructure and economic performance</td>
<td>Electricity business model or tariff</td>
<td>Consumer knowledge, understanding and skills</td>
</tr>
<tr>
<td>Gender stereotypes</td>
<td>Organizational partnership</td>
<td>Attitudes, preferences, and beliefs</td>
</tr>
<tr>
<td>Other interventions (substitute programs, complementary programs, electricity market; and sector subsidies)</td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implementation logistics</td>
<td></td>
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<td></td>
<td>Implementor resources</td>
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<td></td>
<td>Monitoring</td>
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</tr>
<tr>
<td></td>
<td>Reliability of supply</td>
<td></td>
</tr>
</tbody>
</table>

Source: 3ie analysis of 89 impact evaluations, associated with a total of 126 study reports.

89. **Summary.** Qualitative review of the studies finds these common factors increased the effectiveness of interventions and partially explained the heterogeneity across studies.

(i) Areas with better institutions, limited political and economic unrest, economic density, base levels of infrastructure, and access to established institutions are likely to be associated with larger changes in social outcomes.

(ii) Interventions are also more effective in the areas with existing local networks to support delivery, the use of context-specific credit and payment tools, timely access to skills and expertise, and regular technical monitoring completed in conjunction with communities were key enablers of effectiveness.

(iii) Public subsidies for substitute products will negatively affect demand for electricity, while subsidies for complementary products will positively affect demand.

(iv) Commercial connection fees and tariffs could not always be reconciled with the willingness and ability of target populations to pay for electricity services.
90. **Suggestive evidence.** The lack of robust evidence from formal research methods means we are not able to produce comprehensive findings about the multiple and interacting causal pathways in electrification interventions. Hence, the results we have on factors enabling or preventing positive effects of electrification are suggestive but not conclusive.

A. **Socio-Political Factors**

91. **Contexts.** While the importance of taking account of context in systematic reviews is now widely recognized, it is often challenging to do so because included primary studies provide an insufficient contextual detail. Our review found that the effects of electricity likely depend on several contextual factors, defined as the political, economic, and social conditions in which program implementation is embedded. Based on the thematic analysis, the main structural and cultural barriers likely to impede intervention effectiveness were the political situation, economic performance, other interventions, and gender and cultural norms. The remainder of this section provides a narrative overview of the factors identified in the review, which is derived from the studies listed in Appendix 4, Table A4.1.

92. **Political situation and structure.** The political situation or structures of a region or country can affect the market for energy supply and may constitute an important barrier to obtaining the desired outcomes for electrification programs. We found 17 studies contributing to political impact of electricity investments:

   (i) **Government mismanagement and inefficiencies.** Two studies suggest poor outcomes likely result from government mismanagement and inefficient investment. In one study with positive outcomes, authors described good management and coordination between the national government, local governments, and stakeholders.

   (ii) **Political unrest and instability.** Other studies explored themes such as political unrest, conflict, or instability in an area, which could impede the large-scale rollout of electricity and prevent repairs to damaged infrastructure, imposing a barrier to beneficiaries making use of energy services and obtaining desired social outcomes.

   (iii) **Government favoritism.** Favoritism can lead to government-controlled companies monopolizing electricity markets and electric grid investments being diverted towards districts that are favoured by a ruling party. On the other hand, newly elected government officials might reverse commitments made by their predecessors and favor alternative investments, causing delays or even cancellation to the planned provision of new and/or improved electricity access. Membership of an opposition political party could also impede household grid connection during village electrification.

93. **Existing infrastructure and economic performance.** Our analysis found 14 studies that revealed one of the factors influencing program effectiveness was regional and/or country and local economic performance during or before the study period. Grid electricity may improve outcomes where implementation has been in areas with: (i) better transport and links to neighboring commercial centres; (ii) existing industries that can benefit from cheaper sources of power; (iii) rising income levels during the study period, for example as a result of increased agricultural yields and income; and (iv) labor productivity that could be influenced by intangible factors such as social capital and entrepreneurial characteristics among the target population, cultural dimensions, and religion. Of the 14 studies, 3 specifically attempted to explain why business owners did not reap the benefits of improved energy supply. All three studies attributed this to saturated local markets and limited access to external sources of demand from regional or national markets.

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94. **Other interventions.** Eleven studies showed that delivering substitute or complementary interventions in the same locality might also affect program effectiveness on key outcomes of interest. Such interventions include:

(i) **Substitute programming.** Substitute energy programs delivered at the same time as the intervention, such as electricity market reforms which result in decreased electricity tariffs, as well as government subsidies for alternative fuels such as kerosene or bottled gas (e.g., to avoid voter backlash), can influence energy consumption patterns.

(ii) **Complementary programming.** Initiatives to expand access to electricity may not produce meaningful economic and non-economic impacts unless they are combined with complementary programs, such as those to facilitate household and non-residential purchases of electrical appliances or efforts to promote and raise awareness about the benefits of domestic and agricultural applications of electricity.

(iii) **Electricity markets.** The structure of energy market in a country may explain the presence or lack of positive effects on outcomes. Increased market competition or technology developments, for example, can reduce the cost of electrical appliances or the costs of hiring electricians to install or repair equipment or electrical appliances, affecting electricity access and consumption behavior.

(iv) **Sector subsidies.** Energy use subsidies may have undermined the financial performance of electricity access projects. Incentives to encourage energy use, especially in agriculture, may have surpassed the budget or ongoing operational costs of providing access. This suggests that large scale subsidies alone are not a sustainable mechanism to increase demand for energy services.

95. **Gender stereotypes and cultural barriers.** The benefits of electrification also depend on structural factors like social ideologies and gender norms which shape individuals' perceptions of appropriate role-related behaviors for females and males. A likely mechanism through which the effects of electrification are realized is that access to modern energy sources can reduce the hours devoted to unpaid physical labor, including the gathering of fuel sources, which mainly falls on women, allowing them to enter paid employment, perform labor market tasks more productively, and possibly earn larger incomes. This may improve women's bargaining power within the household and bring welfare gains across several other dimensions. However, some of the benefits are only realized by those women who are able to access jobs. In some contexts, it may be the case that social norms and gender discrimination prevent women from engaging in income earning activities or otherwise shape and constrain women's choices.

96. **Different effects for men and women.** There is evidence from eight studies that gender norms and cultural roles affect the labor supply effect of electrification differently for men and women. There is broad agreement that a likely mechanism for the impact of access to electricity is that it reduces the time women spend collecting cooking fuel such as firewood and increases the productivity of household tasks through improved technology, thereby freeing up women's time, which they may use for income generating activities either within or outside the home. However, while most suggest that this accounts for women benefiting more than men, two studies highlight that as household income increases, social norms may prevent women from performing jobs that are available. Redistribution of household chores may result in men dropping out of the workforce.

**B. Intervention Design and Implementation**

97. **Contexts.** While the quantitative analysis accounted for differences in broad intervention categories, the set of program design and implementation characteristics that make up the design choices of electricity access interventions is complex. The thematic analysis sought to go beyond these categories to identify key design and implementation factors that were thought to influence program effectiveness. These factors include the costs of connecting to an electricity source and ongoing consumer business models, partnerships, the quality and type of implementation, and the reliability of supply.
Appendix 4, Table A4.2 lists studies that describe the factors related to intervention design and implementation discussed in this section.

98. **Connection charges.** Connection costs are the costs associated with preparing a dwelling for receiving electricity and for the connection itself. We found 23 studies discussing connection charges as constraints faced by household. Nine studies pointed to specific financial barriers to connecting to an energy source, including high upfront costs to prepare and connect dwellings and increased average costs per connection, which limited connections to electricity. There is evidence from three studies that subsidizing the costs of connecting to an electricity source increases levels of connection to electricity sources. Other studies infer that schemes for free or discounted connections are likely to increase uptake.

99. **Electricity business models or tariffs.** Tariffs are key to incentivizing private investment in electricity infrastructure, especially for high-tier electricity access in rural areas. Tariffs could act as a barrier to effectiveness because of repayment challenges and wider acceptability issues. If tariff barriers are deemed too high, target populations may only make use of a limited number of energy services, such as basic lighting; default on payments; and may not fully substitute away from the use of traditional fuels. Four studies showed that high tariffs and restrictive or unsustainable business models were associated with increased levels of payment defaulting and/or limited the use of electricity to subsistence requirements, based on what would be required to perform basic functions such as lighting. This likely constrained the benefits of final socioeconomic outcomes—for example, limited use of labor-saving electrical appliances which could have permitted reallocating time to paid work away from home production. To remedy this issue, the programs mentioned in seven studies implemented flexible business models and innovative methods and fee structures, which they identified as key enablers, leading to higher electricity use. Examples include spreading tariff plans over a longer time period using credit instruments and the option to use pay-as-you-go or mobile payment systems.

100. **Organizational partnerships.** Interventions to improve access to electricity often involve more than one implementing organization and seek to engage target populations for specific reasons. These types of partnership activities and agreements may have influenced the effectiveness of electrification programs. Five studies acknowledged that partnerships forged with actors in the supply chain were beneficial in planning interventions and may have improved uptake and use. A smaller number suggested such partnerships could significantly influence final outcomes. They included involving (i) beneficiaries in planning, delivering, and monitoring interventions and (ii) local financiers and businesses with existing sales networks and strong access to potential electricity consumers. The delivery of new and improved access was often supported by several delivery partners such as country governments in the case of large infrastructure projects and multilateral organizations with specific capabilities. Two studies acknowledged that these partnerships facilitated implementation by supporting fund mobilization, appropriate equipment and technology, and guidance on execution.

101. **Location.** Studies frequently reported that geographical location and topography posed challenges to providing electrification and limited the extent to which companies will invest in ongoing maintenance repairs. There is evidence from four studies that utility companies prioritize urban centres and other areas of high population density because of their greater potential for business development, which has implications for energy services in rural areas which may be neglected or charged more for access.

102. **Intervention logistics.** The success of any infrastructure project is underpinned by sound logistical planning and preparation. Limited opportunities to effectively plan for implementation logistics or account for unexpected changes in context may cause delays to deployment and full implementation of electrification programs. Three studies reported challenges to implementation, including less-than-optimal stakeholder engagement during design, a lengthy applications process, supply shortages, and issues with procuring and managing contractors.
Implementer resources. Challenges in obtaining the optimal quantity and quality of resources to support implementation and on-going delivery is likely to affect program effectiveness. Post-implementation technical support, contractor performance, and local labor supply for community projects are common resource challenges faced by project implementors. Ten studies highlighted challenges related to financial, organizational, or technical resources that intervention agencies had access to, and their influence on implementation or ongoing delivery. Four other studies suggested this feature could significantly influence the success of electrification programs.

Implementation monitoring. Proper implementation and use are assessed in part through program monitoring—for example assessing consumer use and payment and technical performance. Without monitoring, it is expected that target populations cannot make socially optimal use of electricity for energy services when they need to. Five studies raised the issue of monitoring; two of them highlighted that the lack of robust monitoring and evaluation systems increases problems such as outages and theft, keeping electricity access levels low. There is evidence from three studies that periodic monitoring of the technical and management quality of installations and post-installation services can improve levels of consumption. This included monitoring visits to ensure proper functioning of off-grid technologies and ways of reducing theft (e.g., through applying contracts that households had to sign, declaring their intention not to sell or misuse the kit).

Reliability of supply. A common barrier across studies was the low reliability of power supply. Several studies reported that new or improved access increased the demand, which then resulted in service disruptions, and suggest a common cause is insufficient back-up capacity. In the event of reliability or scarcity issues, urban areas might receive preferential supply, which in turn creates critical access issues for rural areas. Seven studies point out that reliability issues can result in people stockpiling kerosene or alternative fuels, which has implications for outcomes such as household wealth and respiratory diseases; similarly, businesses may allocate capital resources towards back-up capacity, lowering profits.

C. Demand-Side Factors

Contexts. Fixing supply-side problems is not enough to make electrification programs popular among beneficiaries and close the gap from electrification uptake to continuous and sustained usage over time. Not all eligible households and non-household consumers take up available opportunities to connect to modern energy services, even when some or all of the costs are met through subsidization. Even a well-designed and properly functioning electrification program may not satisfy many beneficiaries, because they might be constrained by several individual and community level factors that do not allow them to fully benefit from it. There is evidence from 61 studies that beneficiary-related factors can also significantly affect the effectiveness of interventions (Appendix 4, Table A4.3). We organized this group of barriers and enablers in three broad themes.

Types of beneficiaries. Implementation and results may be influenced by the type of beneficiary taking up the intervention, as shown by 10 studies. Income constraints was one of the most frequently reported barriers that prevent by households and businesses from adopting and using grid or off-grid electricity services. In some contexts, wealthier households are likely to be better positioned to benefit from access to electricity, because they can purchase more electrical appliances or exploit new business opportunities opened up by access to modern energy sources. Since connecting to the grid often requires large up-front investments, seasonal variations in income (e.g., in agriculture and fishing) make it difficult for poor households and non-residential consumers to pay for larger expenses during certain months of the year.

Consumer knowledge, understanding, and skills. These barriers and facilitators can relate both to the intervention (grid or off-grid) and the processes and mechanics that underpin it:
(i) **Lack of knowledge and misperceptions.** Potential customers (residential and non-residential) may underestimate or have limited knowledge of the benefits of electricity, the capabilities and limitations of different energy sources that are currently available, or the application or connection processes. Barriers to connection include awareness of the long wait to get connected, perceptions of unfairness, confusion about how to apply, and a lack of awareness of project timelines.

(ii) **Understanding of costs.** Low connection rates have also been linked to low levels of understanding of initial costs, such as for wiring, versus usage costs. For example, beneficiaries might not understand the high associated costs of different appliances. Disappointment with the usage costs of electricity can lead to discontinued usage of appliances. Alternatively, there may be issues for the beneficiaries around complex billing or payment systems, where low levels of understanding may deter potential customers from signing up for an intervention in the first place.

(iii) **Technical knowledge and skills.** In some contexts, low human capital may mean that some beneficiaries do not have the technical knowledge and skills to operate, maintain, or repair equipment, which impacts key outcomes. For instance, lack of knowledge to solve technical problems can influence non-usage.

(iv) **Addressing human capital challenges.** Awareness meetings with community members and intensive training by implementers in operating equipment, preventive maintenance tasks, and procedures for participating in the program, are highlighted as an important means of addressed human capital challenges.

109. **Household income level.** The review found 29 studies that discussed consumer knowledge, understanding, and skills. There is evidence from 11 studies that household income level and purchasing power influence the uptake of electrification projects. Connecting to the grid often requires a large upfront investment (e.g., for building materials or off-grid technologies) and ongoing costs. Wealthier households tend to be closer to transmission lines, which could also explain why less well-off households are less likely to be connected. Other obstacles include low-quality housing and buildings which tend to have low roofs that cannot support the hooks and brackets needed to connect wires.

110. **Consumer attitudes, preferences, and beliefs.** The studies also contained a wealth of data on barriers and enablers related to consumer attitudes, preferences, and beliefs about electrification and change in general.

(i) **Attitudes.** Attitudes are likely to constitute an important barrier to obtaining the desired outcomes for electrification programs. In some contexts, there may be maximum values that consumers are willing to pay. They may perceive electricity as a luxury good rather than a productive investment and use energy services sparingly (e.g., for lighting but not for charging phones or powering radios). Dissatisfaction with the connection process may result in discontinued use. Attitudes toward adopting technological innovation may also play a role.

(ii) **Social influence and imitation.** Connection to electricity carries social status, so peer influence can also change consumer attitudes and behavior. In some contexts, neighbors strongly influence the individual decision to connect. Customers change their energy purchases and consumption based on that of their neighbors or community members. Learning from opinion leaders and wider social networks about the attributes of new technology may also influence household decisions to adopt.

(iii) **Preferences.** Beneficiaries might reject or discontinue use of more efficient household energy technologies because they prefer traditional fuels such as kerosene. In some contexts, electricity from a reliable grid is preferable in terms of service (it is traditionally perceived as superior). Expectations of the main grid’s imminent arrival in their area can lead consumers to be wary of investing in off-grid alternatives.

(iv) **Beliefs.** In some contexts, the levels of trust in governments and government agencies were much higher than levels of trust in local companies. Negative perceptions of the
private sector may hinder acceptance and uptake of initiatives led by private companies looking to invest in electrification.

111. **Neighborhood effects.** In total we found 29 studies that attributed project impacts, both positive and negative, to the consumer attitudes, preferences, and beliefs. There is evidence from three studies that neighbors with electricity strongly influence individual decisions to connect. A further four studies found spill-over effects that benefit neighbors without electricity (e.g., television, better lighting, or mobile charging can be easily shared). In one study, the external effect appears to come with a shift in consumption behavior, whereby households without electricity themselves shift their spending toward other goods, possibly in an attempt to maintain status.
CHAPTER 6

Key Findings and Implications

112. This chapter provides the key takeaways from the systematic review. First, we discuss the limitations that this review faced because of the available evidence base, then summarize the key findings, and conclude with recommendations for policy, programs, and further research.

A. Understanding the Evidence Base

113. This review provides the most up-to-date systematic review of the available evidence on electricity access impact evaluations, complemented with process evaluations and qualitative studies where possible. A descriptive analysis of the studies has helped us to understand the following limitations of the existing evidence base.

114. **Limited number of rigorous studies.** This systematic review is based on 126 articles (reviewed and non-reviewed), which corresponds to 89 impact evaluation studies—82 of which employed quasi-experimental methods—published from 2004 to 2020. While there have been more studies since 2013 (82% of studies included in this review were published in or after 2013), the number of impact evaluation studies in the energy sector in general—in which electricity is a subsector—accounts for less than 1% of all impact evaluation studies published from 2000 to 2015. At the same time, investments in the sector continue to increase, since access to electricity has become increasingly important as an expected mechanism for poverty reduction in the LMICs.

115. **Most studies focus on supply-side interventions.** Many interventions in the studies were levels of electricity availability, often rural grid connections. The most commonly evaluated intervention was changes in access to electricity, typically through on-grid access, although some did consider changes to electricity quality or reliability. Of all the types of electrification interventions studied in the included papers, a majority focused on connections to the grid in rural or peri-urban areas. Few studies assessed demand-side interventions or cost.

116. **Studies address several outcomes, with different—and often implicit—causal pathways.** The literature is varied in the outcomes evaluated and underlying theories of change. For instance, investigating how access to a solar panel that can power a light and charge a mobile phone affects child study time is very different from investigating the organization-level effects of a grid connection that enables a business or health facility to power refrigeration or temperature control systems or power other appliances, machines, and equipment. These variations, combined with limited theoretical narrative, add considerable complexity to this type of synthesis and underscore the importance of careful consideration of how to approach any meta-analysis.

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59 For example, investments in high-impact countries increased by $10.8 billion in 2015–2016 over 2013–2014 levels to an average of $30.2 billion per year (see footnote 3). Aid to the energy sector among The Organisation for Economic Co-operation and Development donors also increased over this period, reaching an average of $29.8 billion between 2014–2016, with ADB being the sixth largest donor to the sector.
B. Key Findings

117. Given the available evidence, this systematic review produces the following key findings.

118. **Positive but modest effects.** Interventions in providing electricity access has brought on positive but modest effects on household socioeconomic outcomes. The systematic review finds that interventions aiming to provide new or improved access to electricity has led to increase in household connectivity and use of electricity and moderate effects in the ownership and use of household electrical appliances. The effects on education, socioeconomic welfare, health, and environment are positive but moderate.\(^60\)

119. **Considerable heterogeneity across studies.** The results varied considerably among studies. This heterogeneity stems partly from observable characteristics of the studies, such as study design, the type of outcome evaluated, the way variables were measured, location, method employed, or length of follow up. However, we find that most of the heterogeneity results from factors beyond those captured by the analysis.

120. **The importance of local, specific contexts.** With the high degree of heterogeneity, understanding and assessing how context determines or influences uptake and use of electricity infrastructure is key for yielding positive changes in social outcomes. Without appropriately considering these factors, beneficiaries may not take up electricity, use electricity at a much later date than anticipated, or consume sub-optimal levels of electricity for basic energy services, for short periods.

C. Implications for Policy and Future Interventions

121. **Funding rigorous research to fill evidence gaps.** A substantial gap exists in the evidence base because of the small number of impact evaluations; wide variation in types of electrification interventions; and limited detail on intervention specifics, causal mechanisms, and costs. Funding for additional research on this topic—including process evaluations, health and environmental impacts, and qualitative research accompanying impact evaluations of specific electrification interventions—can help fill this gap, especially if the funding comes with specific requirements for researchers to provide sufficiently complete and detailed information on each of the above points. Use of existing energy access frameworks could support characterizing intervention information in particular. The multi-tier framework proposed by the Energy Sector Management Assistance Program (ESMAP), for instance, categorizes types of household electricity supply into one of five tiers for each of several attributes (footnote 37).

122. **Adjusting expectations on the magnitude of project outcomes.** The positive but modest effects on education, socioeconomic and environmental outcomes should not deter future investments in electricity access. Instead, they should provide a reality check on a plausible range in the magnitude of the potential impact of electrification interventions on these outcomes, and guide the expectations about the results of an intervention. These effects were realized across a range of different contexts and settings and persisted after accounting for several study factors, including design, such as length of follow up, the type of outcome evaluated, or other factors such as local contexts and circumstances.

123. **Targeting multiple constraints for improved results.** Evidence suggests that interventions targeting multiple constraints (e.g., electricity infrastructure and reliability, or reliability and affordability) yield better results than interventions targeting one constraint. Similarly, interventions focusing exclusively on a single constraint, like expanding physical access to electricity (on-grid or off-grid), may produce smaller benefits than interventions targeting reliability, affordability, or a combination of the

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\(^{60}\) The effect size is large if the value is 0.5 standard deviations or higher; moderate if it is between 0.2 and 0.5 standard deviations, and low if lower than 0.2 standard deviations. See Cohen, J. 1992. A power primer. Psychological Bulletin. 112(1). pp. 155–159.
two, as observed in education. Though future research may identify other types of social outcomes with higher returns to electrification, in the short term it may be useful for policy makers and practitioners to consider not only the direct social effects of electricity access, but also the instrumental role electricity may play in multi-component interventions.

D. Areas for Further Research

124. **Demand-side interventions.** Studies should seek to understand the effect of demand-side interventions and combinations of demand- and supply-side interventions. Of the studies that addressed demand, the majority focused on reducing cost barriers by testing voucher or subsidy interventions, but did not address reliability, consumer preferences, social acceptance, regulatory constraints, and other factors affecting demand.

125. **Theory-based, mixed-method evaluations.** Increased adoption of theory-based approaches is likely to yield more nuanced results. For example, just under 15% of studies included a qualitative component and several studies did not sufficiently account for potential spillovers and contamination effects in their analyzes. Mixed-method, theory-based studies provide an insight not only into the magnitude of effects but also why and how they arise, for whom, and in what contexts. Specifying such studies will provide practitioners with more nuanced insights to support the formation of new policies and interventions (footnote 7).

126. **Outcomes affecting quality of life and social experience.** Studies have focused on educational and economic outcomes of electrification, with evidence base pointing to modest effects. Though additional research carefully accounting for intervention details and theories of change may yield clearer findings on differential effect sizes depending on beneficiary groups, intervention types, and various contextual factors, it seems unlikely that the effect sizes for these outcomes will increase dramatically. At the same time, it is important to consider that these are not the only—and may not even be the most important—effects of electrification. A few studies have measured other plausible outcomes, such as quality of life, but both the theoretical and empirical work in this area is limited.
Appendixes
APPENDIX 1: LIST OF REFERENCES

1. This section presents the list of references used to compile the systematic review. The reference list is divided into five categories:

   (i) **Included reports.** The main reports included in the review are used to represent related groups of linked reports.
   
   (ii) **Linked reports.** Multiple reports of the same study were identified and linked together before data extraction.
   
   (iii) **Additional linked reports.** Additional documents were sourced through a targeted search to help the review team answer systematic review question 3.
   
   (iv) **Other synthesis outputs.** These comprise previously published synthesis products on or related to electrification in low- and middle-income countries (LMICs).
   
   (v) **Additional references.** These studies or reference materials were used to develop the background or underlying systematic review protocol.

A. **Included Studies**


Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle-Income Countries


Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle-Income Countries


**B. Linked Studies**


Effects of Access to Electricity Interventions on Socioeconomic Outcomes in Low- and Middle-Income Countries


C. **Additional Linked Reports**


### D. Other Synthesis Outputs


G. Köhlin, S. Pattanayak, E. Sills, E. Mattsson, M. Ostwald, A. Salas, and D. Ternald. 2015. *In search of double dividends from climate change interventions evidence from forest conservation and household energy transitions.* Stockholm: Expertgruppen for Bistandsalays.


### E. Additional References


APPENDIX 2: SEARCH DATABASE

A. Electronic Searches of Bibliographic Databases and Library Catalogues

1. The following academic databases were searched as part of this review:

   (i) Cochrane Library;
   (ii) EBSCO Discovery: IDEAS RePeC;
   (iii) EBSCO Discovery: World Bank e-library;
   (iv) EBSCO: Agricola, Gender Studies, Greenfile;
   (v) EBSCO: Africa-wide;
   (vi) EBSCO: CAB Abstract;
   (vii) EBSCO: ERIC;
   (viii) IBSS (Proquest);
   (ix) Ovid: CAB Global Health;
   (x) Ovid: Econlit;
   (xi) Ovid: Medline;
   (xii) Ovid: PsycInfo;
   (xiii) Scopus; and
   (xiv) Web of Science.

B. Other Searches

2. The following set of additional specialist databases that were searched as part of this review:

   (i) 3ie RIEPS (Repository of Impact Evaluation Published Studies);
   (ii) Abdul Latif Jameel Poverty Action Lab (J-PAL);
   (iii) British Library for Development Studies (BLDS);
   (iv) The Campbell Collaboration Library;
   (v) Danida Research Portal (Ministry of Foreign Affairs of Denmark);
   (vi) Department for International Development (DFID) Research for Development (R4D) database;
   (vii) Eldis;
   (viii) International Labor Organization (ILO) Library;
   (ix) JOLIS library catalogue, International Monetary Fund, World Bank and International Finance Corporation;
   (x) OECD iLibrary;
   (xi) OpenGrey;
   (xii) Social Science Research Network (SSRN) eLibrary Database;
   (xiii) World Bank Independent Evaluation Group (IEG); and
### APPENDIX 3: FULL SYNTHESIS RESULTS TABLE

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<th>95% CI.U</th>
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<th>$I^2$ (%)</th>
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</tr>
<tr>
<td>Grade progression</td>
<td>-</td>
<td>0.02</td>
<td>(0.01)</td>
<td>0.05</td>
<td>c</td>
<td>70</td>
</tr>
<tr>
<td>Years of schooling</td>
<td>-</td>
<td>0.07</td>
<td>(0.05)</td>
<td>0.10</td>
<td>c</td>
<td>66</td>
</tr>
<tr>
<td>Literacy rate</td>
<td>-</td>
<td>0.03</td>
<td>(0.10)</td>
<td>0.16</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td><strong>Socioeconomic welfare</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH assets</td>
<td>-</td>
<td>0.06</td>
<td>(0.02)</td>
<td>0.13</td>
<td>a</td>
<td>87</td>
</tr>
<tr>
<td>Community assets</td>
<td>-</td>
<td>(0.01)</td>
<td>(0.26)</td>
<td>0.24</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>HH income</td>
<td>Total</td>
<td>0.06</td>
<td>(0.04)</td>
<td>0.07</td>
<td>c</td>
<td>80</td>
</tr>
<tr>
<td>HH income</td>
<td>Farm</td>
<td>0.04</td>
<td>(0.00)</td>
<td>0.08</td>
<td>b</td>
<td>62</td>
</tr>
<tr>
<td>HH income</td>
<td>Non-farm</td>
<td>0.06</td>
<td>(0.03)</td>
<td>0.09</td>
<td>c</td>
<td>49</td>
</tr>
<tr>
<td>HH income</td>
<td>Wages</td>
<td>0.05</td>
<td>(0.04)</td>
<td>0.13</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>HH consumption</td>
<td>-</td>
<td>0.11</td>
<td>(0.07)</td>
<td>0.29</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>HH saving</td>
<td>-</td>
<td>0.09</td>
<td>(0.69)</td>
<td>0.87</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>HH expenditure</td>
<td>All</td>
<td>0.05</td>
<td>(0.02)</td>
<td>0.11</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>HH expenditure</td>
<td>Education</td>
<td>0.04</td>
<td>(0.04)</td>
<td>0.13</td>
<td>42</td>
<td></td>
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<tr>
<td>HH expenditure</td>
<td>Electricity</td>
<td>(0.06)</td>
<td>(0.96)</td>
<td>0.84</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>HH expenditure</td>
<td>Other energy</td>
<td>0.00</td>
<td>(0.11)</td>
<td>0.11</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>HH expenditure</td>
<td>Food</td>
<td>0.07</td>
<td>(0.03)</td>
<td>0.12</td>
<td>b</td>
<td>88</td>
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<tr>
<td>HH expenditure</td>
<td>Lighting use</td>
<td>(0.15)</td>
<td>(1.74)</td>
<td>1.44</td>
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<td></td>
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<tr>
<td>HH expenditure</td>
<td>Health</td>
<td>0.01</td>
<td>(0.05)</td>
<td>0.07</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>HH expenditure</td>
<td>Other</td>
<td>0.15</td>
<td>(0.10)</td>
<td>0.39</td>
<td>99</td>
<td></td>
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<tr>
<td>Labor force participation</td>
<td>-</td>
<td>0.02</td>
<td>(0.00)</td>
<td>0.03</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>Total</td>
<td>0.02</td>
<td>(0.00)</td>
<td>0.04</td>
<td>b</td>
<td>80</td>
</tr>
<tr>
<td>Employment</td>
<td>Farm</td>
<td>(0.02)</td>
<td>(0.07)</td>
<td>0.02</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>Non-farm</td>
<td>0.07</td>
<td>(0.20)</td>
<td>0.33</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Business expansion (sales, revenue, profits)</td>
<td>-</td>
<td>0.01</td>
<td>(0.12)</td>
<td>0.13</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>All</td>
<td>0.04</td>
<td>(0.19)</td>
<td>0.26</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>Non-agriculture</td>
<td>0.00</td>
<td>(0.02)</td>
<td>0.01</td>
<td>b</td>
<td>0</td>
</tr>
<tr>
<td>Productivity</td>
<td>Agriculture</td>
<td>0.40</td>
<td>(0.07)</td>
<td>0.73</td>
<td>b</td>
<td>0</td>
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<tr>
<td>Time allocation</td>
<td>Paid work</td>
<td>0.05</td>
<td>(0.01)</td>
<td>0.09</td>
<td>b</td>
<td>78</td>
</tr>
<tr>
<td>Time allocation</td>
<td>Non-paid work</td>
<td>0.00</td>
<td>(0.07)</td>
<td>0.08</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Time allocation</td>
<td>Leisure (including media use)</td>
<td>0.07</td>
<td>(0.01)</td>
<td>0.16</td>
<td>a</td>
<td>95</td>
</tr>
<tr>
<td>Time allocation</td>
<td>Traditional fuel collection</td>
<td>0.07</td>
<td>(0.02)</td>
<td>0.13</td>
<td>b</td>
<td>77</td>
</tr>
<tr>
<td>Time allocation</td>
<td>Rest or sleeping</td>
<td>(0.01)</td>
<td>(0.05)</td>
<td>0.03</td>
<td>c</td>
<td>21</td>
</tr>
<tr>
<td>Women's empowerment</td>
<td>Overall</td>
<td>0.03</td>
<td>(0.01)</td>
<td>0.05</td>
<td>c</td>
<td>26</td>
</tr>
<tr>
<td>Women's empowerment</td>
<td>Decision making: family planning</td>
<td>0.03</td>
<td>(0.04)</td>
<td>0.10</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Women's empowerment</td>
<td>Decision making: family</td>
<td>0.04</td>
<td>(0.13)</td>
<td>0.21</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Women's empowerment</td>
<td>Decision making: family economic</td>
<td>0.02</td>
<td>(0.15)</td>
<td>0.20</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Women's empowerment</td>
<td>Agency</td>
<td>0.02</td>
<td>(0.02)</td>
<td>0.06</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>Overall</td>
<td>0.04</td>
<td>(0.03)</td>
<td>0.11</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 3: Full Synthesis Results Table

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Sub-Outcome</th>
<th>Effect size</th>
<th>95% CI.L</th>
<th>95% CI.U</th>
<th>Sig.</th>
<th>$I^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Public safety</td>
<td>0.05</td>
<td>(0.05)</td>
<td>0.14</td>
<td></td>
<td>71</td>
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<tr>
<td>Safety</td>
<td>Fire hazard</td>
<td>0.14</td>
<td>(1.56)</td>
<td>1.83</td>
<td></td>
<td>93</td>
</tr>
<tr>
<td>Poverty</td>
<td>Overall</td>
<td>0.08</td>
<td>0.03</td>
<td>0.12</td>
<td></td>
<td>85</td>
</tr>
</tbody>
</table>

### Health

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Sub-Outcome</th>
<th>Effect size</th>
<th>95% CI.L</th>
<th>95% CI.U</th>
<th>Sig.</th>
<th>$I^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy use</td>
<td>Traditional energy</td>
<td>0.10</td>
<td>0.03</td>
<td>0.16</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td>Fertility</td>
<td></td>
<td>0.22</td>
<td>(0.27)</td>
<td>0.71</td>
<td></td>
<td>99</td>
</tr>
<tr>
<td>Health information access</td>
<td></td>
<td>0.06</td>
<td>(0.55)</td>
<td>0.66</td>
<td></td>
<td>93</td>
</tr>
<tr>
<td>Health symptoms</td>
<td></td>
<td>(0.01)</td>
<td>(0.04)</td>
<td>0.02</td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>Health symptoms</td>
<td>Gastrointestinal</td>
<td>0.03</td>
<td>(0.06)</td>
<td>0.11</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>Health symptoms</td>
<td>Respiratory and air</td>
<td>0.01</td>
<td>(0.06)</td>
<td>0.09</td>
<td></td>
<td>76</td>
</tr>
<tr>
<td>Health outcomes</td>
<td></td>
<td>0.08</td>
<td>(0.17)</td>
<td>0.32</td>
<td></td>
<td>57</td>
</tr>
</tbody>
</table>

### Environment

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Sub-Outcome</th>
<th>Effect size</th>
<th>95% CI.L</th>
<th>95% CI.U</th>
<th>Sig.</th>
<th>$I^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy use</td>
<td>Traditional energy</td>
<td>0.10</td>
<td>0.03</td>
<td>0.16</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td>Pollution</td>
<td>All</td>
<td>0.02</td>
<td>(0.09)</td>
<td>0.14</td>
<td></td>
<td>88</td>
</tr>
<tr>
<td>Pollution</td>
<td>Indoor</td>
<td>0.00</td>
<td>(0.15)</td>
<td>0.15</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>Pollution</td>
<td>Outdoor</td>
<td>0.04</td>
<td>(0.59)</td>
<td>0.67</td>
<td></td>
<td>67</td>
</tr>
</tbody>
</table>

- = none, ( ) = negative, CI = confidence interval, CI.U = upper bound of the confidence interval, HH = household, Sig = significance.

Note: The effect sizes are measured in standard deviations. CI.L = lower bound of the 95% confidence interval; CI.U = upper bound of the 95% confidence interval.

- $p$-value $\leq 0.01$
- $p$-value $\leq 0.05$
- $p$-value $\leq 0.1$

### Table A4.1: Summary of Socio-political Barriers and Enablers

<table>
<thead>
<tr>
<th>Theme and Number of Studies</th>
<th>Countries and Regions</th>
<th>Evidence Examples</th>
<th>Correspondence between Themes and Study Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political situation (13)</td>
<td>Argentina, Colombia, Honduras, India, Nicaragua, People’s Republic of China, Senegal, South Africa, sub-Saharan Africa (aggregated data), Viet Nam</td>
<td>“It is important to consider the political economy in Bihar when researching whether consumers will be interested in or satisfied with cheaper alternatives. Our finding is that micro grids are not perfect substitutes for grid electricity. If politicians promise to deliver grid electricity during political campaigns, non-grid alternatives may not be politically feasible, and constituents may not accept them.” Rains and Abrahams (2018). p. 295.</td>
<td>Of the 17 studies that contribute to this theme, three (numbers 1, 12, and 20 in the list of studies below) consider how government involvement in the electricity sector influences socioeconomic impacts. Of these, two studies (1 and 12) suggest poor outcomes likely resulted from inefficient investment and mismanagement by the government. In the third study with positive outcomes (20), authors described good management and coordination between the national government, local governments, and stakeholders.</td>
</tr>
<tr>
<td>Local or regional economic performance (14)</td>
<td>Argentina, Benin, Bhutan, Honduras, India, Kenya, Senegal, South Africa, Tanzania, Viet Nam</td>
<td>“Impact of large-scale investments in India’s RGGVY grid electrification program is crucially tied to local economic conditions, and higher in villages that simultaneously benefited from a boom in the price of a local commodity (guar plant).” Fetter and Usmani (2020). p.4.</td>
<td>Of the 14 studies that attempt to explain why business owners did not reap the benefits of improved energy supply, three studies (numbers 4, 24, and 25) attributed this to saturated local markets and limited access to external sources of demand from regional or national markets.</td>
</tr>
<tr>
<td>Other interventions (11)</td>
<td>Bhutan, India, Iran, Peru, Rwanda, Senegal, Viet Nam</td>
<td>“India’s kerosene subsidies reduce the opportunity cost of using kerosene, possibly explaining the lack of positive effects derived from setting up solar microgrids in villages. In settings with non-electrified rural communities and more expensive kerosene due to lack of subsidies (for example, many sub-Saharan African countries), the intervention could have performed better.” Aklin (2017). p. 4.</td>
<td>Evidence from two studies (numbers 10 and 23) highlights the influence of complementary interventions initiated by governments during implementation of the electrification program (e.g., resettling initiatives, road developments that remote villages closer to road points, and connection subsidies). Both studies suggest that they facilitated connections to the grid by optimizing cost per connection.</td>
</tr>
<tr>
<td>Gender stereotypes and cultural barriers (8)</td>
<td>Bangladesh, India, Nicaragua, South Africa</td>
<td>“In India, female members of a household are predominantly responsible for collecting cooking fuel such as firewood. Access to modern technology via electricity therefore frees up women’s time, which they may use for income generation.”</td>
<td>There is evidence from eight studies (numbers 8, 11, 17, 21, 28, 29, 30, and 33 below) that gender norms or roles affect the labor supply effect of electrification differently for men and women. There is broad agreement that a likely mechanism for the impact of access to electricity on women’s labor supply is the opportunity cost of time spent on work under the electric light.</td>
</tr>
</tbody>
</table>

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*Note: The above table is an extract from a larger document and is intended to summarize the main points regarding socio-political barriers and enablers to household access to electricity. The table includes evidence examples and the correspondence between themes and study outcomes as described in the main text.*
Appendix 4: Summary of Barriers and Enablers of Household Access to Electricity

<table>
<thead>
<tr>
<th>Theme and Number of Studies</th>
<th>Countries and Regions</th>
<th>Evidence Examples</th>
<th>Correspondence between Themes and Study Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>generating activities either within or outside the home.&quot;</td>
<td>Rathi et al. (2018). p.357.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>is that it reduces the time women spend collecting cooking fuel such as firewood and increases the productivity of household tasks through improved technology, thereby freeing up women’s time, which they may use for income generating activities either within or outside the home. However, while most suggest that this accounts for women benefiting more than men, two studies (8 and 33) highlight that as household income increases, social norms may prevent women from performing jobs that are available. Redistribution of household chores may result in men dropping out of the workforce.</td>
<td></td>
</tr>
</tbody>
</table>

List of studies

1. Aklin (2017)
2. Allcott (2016)
11. Dinkelman (2011)
13. Fetter (2020)
17. Grogan (2013)
19. Izadi (2016)
23. Lenz (2017)
30. Samad (2019)
32. Squires (2015)
33. Van de Walle (2017)

Source: Compiled by International Initiative for Impact Evaluation.
### Table A4.2: Summary of Intervention Design and Implementation Barriers and Enablers

<table>
<thead>
<tr>
<th>Theme and Number of Studies</th>
<th>Countries and Regions</th>
<th>Evidence Example</th>
<th>Correspondence between Themes and Study Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affordability: connection charges (23)</td>
<td>Bangladesh, Benin, Bhutan, Brazil, El Salvador, Ethiopia, India, Kenya, Nepal, Nicaragua, People's Republic of China, Rwanda, Tanzania, Viet Nam</td>
<td>“The program reached its limits in connecting areas closer to the grid and the average cost per connection increased, creating a challenge to take electricity to isolated areas far from the existing grid. In this context, less expensive technological alternatives should be considered when utilities pressure for high tariffs to compensate this situation. Capital costs to electrify most isolated communities can be twice as high than new grid connections. Observing the connections made by year, it can be noted that fewer new connections were made as time passed.” Bezerra et al. (2017). p 4.</td>
<td>Nine studies (numbers 8, 9, 13, 14, 17, 35, 41, 42, and 46 in the list below) found specific financial barriers to connecting to an energy source, including high upfront costs to prepare and connect dwellings and increased average costs per connection, which limited connections to electricity. There is evidence from three studies (8, 13, and 41) that subsidizing the costs of connecting to an electricity source increases levels of connection to electricity sources. Other studies infer that schemes for free or discounted connections are likely to increase uptake.</td>
</tr>
<tr>
<td>Affordability: electricity business models or tariffs (14)</td>
<td>Bangladesh, Benin, Burkina Faso, El Salvador, Guatemala, Kenya, Nepal, Peru, Rwanda, Senegal, Uganda, Viet Nam</td>
<td>“After first Solar Home Systems (SHS) were marketed in mid-2009, Yeelen Ba, the local company supplying SHS, experienced slow and low uptake of their panels. One contributing factor relates to the business model of renting without the option to purchase, which is not appreciated by many. Some do not understand that they must pay a fee each month for something of which they will never acquire ownership. Even those who understand this novel concept would often prefer to buy their panel.” Bensch et al. (2015). p 76.</td>
<td>Four studies (numbers 3, 10, 11, and 48) found that high tariffs and restrictive or unsustainable business models were associated with increased levels of payment defaulting and/or limited the use of electricity to subsistence requirements such as basic functions like lighting. This likely constrained the benefits of final socioeconomic outcomes—for example, limited use of labor-saving electrical appliances, which could have permitted a reallocation of time to paid work away from home production. In seven studies (4, 6, 19, 20, 28, 31, and 37), programs implemented flexible business models and innovative methods and fee structures to remedy this issue and identified them as a key enabler for higher electricity use. Examples include spreading tariff plans over a longer time period using credit instruments and the option to use pay-as-you-go or mobile payment systems.</td>
</tr>
<tr>
<td>Organizational partnerships (27)</td>
<td>Argentina, Bangladesh, Bhutan, Brazil, India, Indonesia, Kenya, Myanmar, People's Republic of China, Peru, Rwanda, Senegal, Tanzania, Uganda, Viet Nam</td>
<td>“ACCIONA Microenergia Peru (AMP) seems to have achieved a balance between financial viability and a focus on low-income customers. Working in coordination with the Peruvian government and having obtained the first rural electric concession based exclusively on solar PV systems, AMP has reduced the likelihood of an</td>
<td>Partnerships forged with actors in the supply chain were acknowledged in five studies (6, 17, 19, 37, and 42) to be beneficial in planning interventions and may have improved uptake and use. A smaller number suggested this feature could be a major influence on final outcomes. This included involving beneficiaries in the planning, delivery and monitoring of interventions, but also local financiers and</td>
</tr>
</tbody>
</table>
### Appendix 4: Summary of Barriers and Enablers of Household Access to Electricity

<table>
<thead>
<tr>
<th>Theme and Number of Studies</th>
<th>Countries and Regions</th>
<th>Evidence Example</th>
<th>Correspondence between Themes and Study Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evidence Example</strong></td>
<td>unexpected power grid expansion that would eat into its customer base before it recoups its investment in equipment. This coordination reduced the risk to the fee-for-service model and gives it financial viability.”</td>
<td>Arráiz (2015). p 20.</td>
<td>businesses with existing sales networks and strong access to potential electricity consumers.</td>
</tr>
<tr>
<td><strong>Intervention location</strong></td>
<td>Argentina, Bangladesh, Bhutan, Brazil, Colombia, India, Indonesia, Iran, Kenya, Myanmar, Nicaragua, Peru, Rwanda, South Africa, Africa (aggregated data), Tanzania, Viet Nam</td>
<td>“Impacts of electrification on poor households were markedly different in backward states that suffer from low levels of development and income, and inferior quality of infrastructure. Poor households in backward states experienced limited welfare improvements from electrification, or lower increases in monthly expenditures than those in non-backward states, possibly reflecting the limited economic opportunities and facilities in such states.”</td>
<td>Bhattacharyya et al. (2017). p 27.</td>
</tr>
<tr>
<td><strong>Intervention logistics</strong></td>
<td>Kenya, Rwanda, Tanzania</td>
<td>“Low demand may be partly attributable to the lengthy and bureaucratic process of obtaining an electricity connection. In the experiment of expanding electric grid infrastructure in rural Kenya, households waited 188 days on average after submitting their paperwork before they began receiving electricity. The delays were mainly caused by time lags in project design and contracting, as well as in the installation of meters.”</td>
<td>Lee et al. (2019). p. 24.</td>
</tr>
<tr>
<td><strong>Implementer resources - quality and/or quantity of</strong></td>
<td>Bhutan, El Salvador, Ethiopia, India, Kenya, Nepal, Rwanda, Senegal, Tanzania</td>
<td>“After one year of operation, one of the technicians in the mini-grid project had started his own business near the trading centre selling</td>
<td>Ten studies (6, 7, 8, 10, 17, 28, 39, 45, 58, and 59) highlighted challenges related to financial, organizational or technical resources that intervention agencies had access</td>
</tr>
</tbody>
</table>

---

The delivery of new and improved access was often supported by several delivery partners. These included country governments in the case of large infrastructure projects, and also multilateral organizations with specific capabilities. These partnerships were acknowledged to facilitate implementation in two studies (6 and 17) through support with fund mobilization, appropriate equipment and technology, and guidance on execution. Their influence was implicit in other studies.

There is evidence from four studies (1, 6, 43, and 54) that utility companies prioritize urban centers and other areas of high population density because of their greater potential for business development, which has implications for energy services in rural areas which may be neglected or charged more for access.
<table>
<thead>
<tr>
<th>Theme and Number of Studies</th>
<th>Countries and Regions</th>
<th>Evidence Example</th>
<th>Correspondence between Themes and Study Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation monitoring (5)</td>
<td>Bangladesh, India, Kenya, Rwanda, Uganda</td>
<td>&quot;Monitoring visits among recipients of the Pico-PV systems each two months was conducted to ensure the proper functioning of the systems and remind users of their commitment not to sell the systems. In line with expectations, a few Pico-PV kits disappeared, but the number of non-compliant treatment households remained manageable. 87% of the kits were still in use in the treatment group at the time of the follow-up.&quot; Grimm et al. (2017).</td>
<td>Of the five studies contributing to this theme, two (41 and 50) highlighted that the lack of robust monitoring and evaluation systems exacerbates problems such as outages and theft, keeping electricity access levels low. There is evidence from three studies (19, 28, and 37) that periodically monitoring the technical and management quality of installations and post-installation services can improve levels of consumption. This included monitoring visits to ensure proper functioning of off-grid technologies and ways of reducing theft (e.g., through applying contracts that households had to sign, declaring their intention not to sell or misuse the kit).</td>
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| Reliability of supply (27) | Argentina, Bangladesh, Benin, Burkina Faso, Colombia, Ghana, India, Indonesia, Kenya, Myanmar, Nepal, Nigeria, People’s Republic of China, Rwanda, Viet Nam | “Roughly 60% of schools that have installed other energy sources report having done so after they were connected to the electricity grid. The fact that grid electricity is not always reliable provides one potential rationale for why we find limited impacts of electrification on secondary schooling outcomes.” Berkouwer et al. (2018). p 11. | A common barrier across studies was low reliability of power supply. Several studies reported that new or improved access caused increased demand that resulted in service disruptions, and commonly suggested insufficient back-up capacity as a cause. In the event of reliability or scarcity issues, urban areas might receive preferential supply, which in turn creates critical access issues for rural areas. Several studies (2, 7, 34, 35, 49, 53, and 57) point out that reliability issues can result in people stockpiling kerosene or alternative fuels, which has implications for outcomes such as household wealth and respiratory diseases; similarly, businesses may allocate capital resources towards back-up capacity, lowering profits. In cases where independent authorities established and monitored universal standards for electricity supply quality, study authors suggested this had a positive effect on the reliability of electricity supply. In one study (number 6), consumption management of a mini-grid was achieved.
## Theme and Number of Studies

<table>
<thead>
<tr>
<th>Countries and Regions</th>
<th>Evidence Example</th>
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### List of studies

1. Aklin (2017)
2. Akpandjar (2017)
5. Arvate (2018)
7. Banerjee (2011)
15. Bhattacharyya (2017)
22. Ding (2018)
23. Fetter (2020)
24. Fetzer (2016)
25. Fujii (2018)
27. Grimm (2015)
32. Groth (2019)
33. Izadi (2016)
34. Karumba (2018)
37. Khandker (2014)
41. Lee (2019)
42. Lenz (2017)
43. Litzow (2019)
44. Nigussie (2015)
45. Numminen (2018)
46. Peters (2011)
47. Poczter (2017)
49. Rao (2013)
50. Rains (2018)
52. Rathi (2018)
53. Salmon (2016)
54. Samad (2017)
55. Samad (2019)
57. Smith (2016)
58. Thomas (2018)
59. Urpelainen (2017)
60. van de Walle (2017)

Source: Compiled by International Initiative for Impact Evaluation.
Table A4.3: Summary of Demand-Side Barriers and Enablers

<table>
<thead>
<tr>
<th>Theme and Number of Studies</th>
<th>Countries</th>
<th>Evidence Example</th>
<th>Correspondence between Themes and Study Outcomes</th>
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<tbody>
<tr>
<td>Beneficiary knowledge, understanding and skills (9)</td>
<td>Bangladesh, Benin, Burkina Faso, India, Peru, Rwanda, Tanzania, Uganda</td>
<td>“One explanation for why those that connect to the grid have on average lower profits than comparable firms in the non-access region may be a lack of familiarity with electricity-using production technologies, and an associated inability to assess the level of output needed to make profits using these technologies. Even when this level is known, the manufacturer may overestimate the product’s market potential in relation to the total cost curve.” Peters et al. (2011). p 781.</td>
<td>Of the 10 studies contributing to this theme, two (25 and 37) studied the impacts of electrification on economic outcomes. Both suggested that the negative findings observed for firm profits were influenced by deficiencies in human capital.</td>
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<td>Beneficiary attitudes, preferences and beliefs (29)</td>
<td>Bangladesh, Bhutan, Burkina Faso, Colombia, El Salvador, Ethiopia, Ghana, India, Indonesia, Kenya, Laos, Myanmar, Nepal, Nicaragua, Nigeria, Peru, Rwanda, Senegal, Tanzania, Uganda</td>
<td>“Community leaders described situations in which jealous neighbors created obstacles to others connecting to the grid; for example, some household owners who could not afford electricity would not allow lines to pass by their homes and property to connect adjacent households.” Chaplin et al. (2017). p. 30.</td>
<td>There is evidence from three studies (11, 14, and 18) that neighbors with electricity strongly influence an individual’s decision to connect. A further four studies (24, 27, 41, and 45) found there are spillover effects that benefit neighbors without electricity (e.g., television, better lighting, or mobile charging can be easily shared). In one study (number 45), the external effect appears to come with a shift in consumption behavior, whereby households without electricity themselves shift their spending toward other goods, possibly associated with an attempt to maintain status.</td>
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<td>Type of beneficiary (27)</td>
<td>Bangladesh, Benin, Bhutan, Brazil, Burkina Faso, Cambodia, El Salvador, Ghana, India, Indonesia, Kenya, Nepal, Nigeria, Peru, Rwanda, Tanzania</td>
<td>“Electrification efforts made by the Luz para Todos (LpT) program seem to have achieved more success in municipalities that had a low electricity access rate but a relatively high Human Development Index, implying that the drive to bring electricity to the countryside brought the most benefits to municipalities that were already doing relatively well in other development-relevant measures. Municipalities that previously had both low electrification rates and a low level of socioeconomic development appear to have fallen further behind.” Bezerra et al. (2017). p 9.</td>
<td>There is evidence from 11 studies (1, 3, 4, 5, 11, 13, 18, 30, 34, 39, and 41) that household income level and purchasing power influence the uptake of electrification projects. Connecting to the grid often requires a large upfront investment (e.g., for building materials or off-grid technologies) and ongoing costs. Wealthier households tend to be closer to transmission lines, which could also explain why less well-off households are less likely to be connected. Other obstacles include low-quality housing and buildings which tend to have low roofs that cannot support the hooks and brackets needed to connect wires (18). One study (11) found that having an existing informal grid connection increased the likelihood of households connecting.</td>
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### List of studies

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