Expanding household electricity access

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Access to electricity is a critical ingredient in improving human well-being and raising living standards, but the existing evidence suggests that it is just one component of poverty reduction rather than a complete solution on its own.



A woman turning on a light in a house in India

Photo credit: Pradeep Gaurs, Shutterstock.com

Summary

Achieving universal energy access is a major global challenge and the focus of the United Nations' Sustainable Development Goal 7[1], . High rates of energy use are associated with higher wealth and standards of living[2], . However, as of 2022, around 685 million people lacked access to electricity[3]. Many of those without access to electricity rely on alternative fuels such as wood, coal, biomass, kerosene, or diesel for energy. These fuels can be cheap and accessible, but they also contribute to local air pollution, which has adverse health and environmental consequences. Electricity could reduce households' reliance on polluting alternative fuels. While many electric grids are still powered by coal, expanding electricity access could provide a path to future large-scale conversion to renewable energy sources. Improvements in renewable energy technologies may also allow regions without existing electricity infrastructure to "leapfrog" dirty energy sources.

Despite the association between energy use and higher standards of living, research measuring the causal impacts of electricity access lacks a clear consensus on how it affects household well-being. Fourteen studies (eight randomized evaluations and six quasi-experimental studies) measured electricity's impact on household well-being using a wide range of socioeconomic

indicators, such as income, health, education, and labor outcomes. Several non-randomized studies found large positive impacts of grid access across many of these metrics [8], [13], [20], but more recent randomized evaluations and quasi-experimental studies found minimal impacts of grid and off-grid solar access on household welfare. For example, four of the seven studies that measured household income and earnings found that electricity had no impact. Energy, including electricity, is a necessary component in raising living standards, given there are no examples of countries becoming wealthy without high energy consumption. However, the evidence suggests that household electricity access is only one critical ingredient for improving human well-being and not a panacea for poverty on its own.

The socioeconomic measures that researchers and policymakers typically use to measure the benefits of electricity for households do not fully capture the ways in which electricity is valuable and beneficial to people. Future research should measure households' revealed preferences, such as their demand for electricity at different prices, more consistently in order to shed more light on how much households value electricity and substitute between energy sources.

Supporting evidence

Randomized evaluations of subsidized grid connections found minimal impacts on household welfare in the short run. Expanding electrical grids is a costly and time-intensive process that depends on several political and economic factors, making randomizing grid rollouts logistically challenging. Two [4], [14], out of three [3], [4], [14], randomized evaluations of grid expansion efforts since 2009 found that increasing rural consumers' access to electrical grids did not impact household welfare. In Kenya, subsidized grid connections had no impact on households' consumption, health, student test scores, or value of owned assets [14], . Similarly, in Ethiopia, grid connection had no impact on households' levels of self-employment, time allocated to chores or leisure, children's study habits, or energy spending [4], . The one randomized evaluation that found large positive health impacts took place in El Salvador. Households that received a discount voucher to connect to the grid experienced lower overnight indoor air pollution and between 8–14 percent fewer instances of related respiratory infections among children than households that did not receive the vouchers after two years [3].

One possible reason why randomized evaluations of expanding electrical grids found few effects on well-being outside of immediate effects from switching to less-polluting fuel sources could be due to their focus on connecting individual households and studying outcomes over a short time frame (between one and four years). If the impacts of grid expansion depend on aggregate changes in electricity access or take time to develop, then small and short-run studies may miss impacts on labor, economic, and/or education outcomes. Further research could further uncover the importance of larger-scale and longer-term access.

A larger body of quasi-experimental studies has found that electricity generated welfare benefits for consumers in several contexts, especially in the long run and over large geographic areas. Existing economic conditions may drive benefits in these settings. Four quasi-experimental studies in Brazil, India, and South Africa found that access to an electric grid increased employment and the number of hours household members were able to work [8], [13], [20], [21], . Three studies in Brazil and India also found that electricity access increased households' incomes or consumption and expenditures (two common measures of household income) [13], [20], [21]. While these quasi-experimental studies provide some evidence of the benefits of grid electrification, they also have limitations that can make disentangling the causal effects of electrification on household welfare from other factors challenging. Several of these studies examined the impacts of large infrastructure expansions over a long time frame and their estimates may also capture economic changes other than the availability of the electrical grid which could drive their results.

Socioeconomic impacts generally occurred over many years through large infrastructure expansions connecting large geographic areas [8], [13], [20], [21], . In contrast, two studies [7], [9], of India's Rural Electrification Program found that the large-scale grid

expansion effort had no effects on employment, one of which [7] also found no effects on average household consumption, expenditures, or education in general. However, when these results were more closely analyzed by different types of villages, expenditures, firm growth, and industrial sector employment increased in large villages and villages with more economic activity, but not in small villages or villages not experiencing an economic boom. The different findings—and different methodologies—of studies covering larger populations over longer periods suggest that some of the benefits of electricity may materialize over time and that complementary economic conditions may drive the ultimate impacts of large-scale electrification, which may not be apparent in the short run.

Randomized evaluations of off-grid solar products found education or health benefits in some contexts but limited welfare benefits in others, possibly because they provided small amounts of energy. Five randomized evaluations of off-grid solar products studied either solar panels or solar-charged lamps owned by households, or privately operated microgrids connecting multiple households. In general, many off-grid solar products, including the ones tested in these studies, offer small amounts of power that could be used for lighting or small appliances like phone chargers.

Two studies in Kenya found that solar lamps distributed for free at schools had positive impacts on education, increasing students' math test scores in one case [12], and increasing homework completion rates, but having no effects on test scores, in the other [18], . One of the studies also found reduced symptoms of pollution-related eye and respiratory infections [18], . Another study in Rwanda found that solar kits with batteries and lights increased the time boys under age 12 spent studying, though there was no impact for girls or older boys [10].

However, randomized evaluations of solar microgrids in other contexts did not find impacts on other welfare measures. One randomized evaluation in India found that providing solar microgrids to groups of households in rural Uttar Pradesh did not impact households' labor, savings, consumption, or education [1], . Another study in Bihar similarly found that subsidized access to solar microgrids had no effects on household health, income, or students' math test scores, though researchers found positive but imprecise impacts on students' reading test scores [6]. These results suggest that students might use off-grid solar for lighting to help them study, but that it may not provide enough energy to be useful for other activities, and its use for lighting likely depends on the availability of other light sources and the reliability of the solar products.

For both grid and off-grid sources, households' demand for electricity was highly price-sensitive. Both of the randomized evaluations that found no impacts of grid access on households' average employment, education, consumption, or health identified high costs as a barrier that prevented many households from connecting to and making use of the grid when it was available [4], [14], . For example, in Kenya, only around 23 percent of households that received a 57 percent subsidy, and 6 percent of those that received a 29 percent subsidy connected to the grid [14], . Several studies also found low demand for solar products at market prices. In Cameroon [17], and Kenya [18], , only 29 and 31 percent of households purchased a solar light when offered at market price respectively. Studies in Cameroon [17], , India [5], , Kenya [18], , and Rwanda [11], , found that demand for off-grid solar products was significantly higher when offered at subsidized prices. For example, households in India were 13.3 percentage points more likely to connect to a solar microgrid at half-price relative to full price [5].

Low take-up and use could explain why many of these studies found that electricity access had few impacts across several welfare outcomes. Low-income households face financial constraints that may lead them to prefer to use money on things other than connecting to the grid or paying for electricity once connected. The evidence suggests that subsidizing the costs of connection may increase take-up. However, households in the grid subsidy evaluation in Kenya [14] used little electricity even when their grid connection was free. This suggests that prices of both connecting to and using electricity contributed to the minimal impacts of electrification in the short run. More evidence on how other factors, such as reliability and load size, impact households' demand for electricity is needed.

Studies measured the impacts of household electricity access on a wide range of socioeconomic outcomes that may not capture what households themselves value about electricity. Of the fourteen randomized evaluations and quasi-experimental studies that measured the impacts of grid and off-grid electricity access on households' well-being, seven measured outcomes related to household income or wages, six measured health outcomes, ten measured education outcomes, eleven measured labor or time use, three measured happiness or life satisfaction, seven measured household energy spending, and four measured total household spending. Of these, only three studies found positive impacts on income or earnings, two on health, five on education, four on labor, two on life satisfaction, four on energy spending, and one on overall spending (see **Table 1**). Based on these findings, it is not clear that researchers or policymakers should expect electricity access alone to improve all of these socioeconomic indicators. Even when electricity infrastructure is available, financial constraints may lead households to limit their electricity use in favor of other essential needs [15]. Traditional socioeconomic metrics may also miss the nuanced ways households may benefit from electricity when they can afford it. For policymakers seeking rapid improvements in specific welfare indicators, alternative interventions may offer more cost-effective solutions.

Future research should focus more consistently on measuring households' revealed preferences to capture how people value electricity and substitute between different energy sources. Households at the global energy frontier often combine and substitute between multiple energy sources to meet their needs, including grid, solar, diesel, kerosene, or solid fuels. Studies that only focus on one source of energy or only measure a handful of socioeconomic indicators may fail to capture the broader value of and spending on energy across different substitute energy sources, and what households do when electricity is unavailable, unreliable, or unaffordable.

For example, in one randomized evaluation in India, unconnected households were randomly offered solar microgrid connections during an ongoing expansion of the national grid. Participants' demand for the grid was higher than demand for off-grid electricity sources, particularly among richer households, but households were more likely to connect to a solar microgrid when it was subsidized and when the grid was not available or affordable. Modeling households' value for all sources of electricity, researchers found that households valued the choice between multiple sources of electricity more than any source alone. Researchers suggest that households preferred the greater energy load that the grid provided, especially since wealthier households were more likely to own appliances that require more energy to run [5], . These results suggest that households value having options, and substitute between sources of power depending on their needs. Other studies suggested that off-grid sources may be useful to supplement grids where connectivity is unreliable or where power outages are common [5], [2]. Future research on how households substitute between sources of electricity, and other energy alternatives, could provide more evidence on the value of electricity access more broadly compared to focusing on individual sources. Moreover, studying demand may give researchers and policymakers a better sense of how households value electricity relative to other goods, and may give more insight into benefits that households experience that may not be captured by socioeconomic indicators alone.

The evidence does not show that electricity access alone is enough to pull households out of poverty and suggests its ultimate impacts may depend on the local economic context, availability of other energy sources, and the time period over which outcomes are measured. Nonetheless, energy is a critical ingredient for improving households' living standards, and there are services that electricity can provide, such as cell phone charging and powering appliances, that other energy sources cannot. Researchers and policymakers should consider electricity access as one component of poverty reduction rather than a complete solution on its own. While not the focus of this insight, there is evidence that electricity access can be highly beneficial to firms, and may help spur wider economic growth that may benefit low-income households by increasing job opportunities or wages [16] , [19]. More research on households' demand and willingness to pay for electrical connections, substitution patterns between electricity sources, and the impact of factors like price and reliability on households' ability to take advantage of electricity is needed to help policymakers determine how to prioritize household electrification.

Additional Materials: Household Electricity Access Studies

Table 1: Socioeconomic Impacts of Household Electricity Access

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