Energy and Economic Growth
Applied Research Programme

Does energy access promote economic growth?

EEG Energy Insight

A summary of an EEG webinar examining some of the evidence

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There is general acceptance in the development community that access to electricity is a driver of economic growth. However, while a relatively large body of evidence supports this, recent research has questioned the assumption.

EEG recently hosted a webinar to discuss the different findings and potential reasons behind them, with a specific focus on five studies. The session brought together a panel of five researchers who have all studied, or are studying, the link between energy and economic growth. Each provided an overview of their research and answered questions from the Chair and a live audience.

The panellists were: Dr Kenneth Lee, Director of the Energy Policy Institute at the University of Chicago's Air Quality Life Index (and previously Executive Director of the Energy Policy Institute at the University of Chicago, in India), Dr Maarten Voors, Associate Professor at the Development Economics Group, Wageningen University, Dr Dana Kassem, a Researcher at the Department of Economics, University of Mannheim, Dr Robyn Meeks, Assistant Professor at the Sanford School of Public Policy at Duke University, and Professor Clark Miller, a Professor in the School for the Future of Innovation in Society and Director of the Center for Energy & Society, Arizona State University.

This paper is a summary of the key areas of discussion. The main conclusions were that the messages from research on whether energy access promotes economic growth are unclear; different research methods tend to deliver different results; complementary factors, including access to electrical appliances and markets, and electricity reliability, play a significant role in determining whether electrification delivers benefits; and the impact of electricity access may take time to prove. It was also agreed there is a need for additional research, and some ideas are briefly covered in this paper.

The webinar was held as part of a series exploring the emerging body of evidence from the EEG research programme. A recording of the webinar can be found at www.energyeconomicgrowth.org/content/past-events.

Research included in the discussion

Five research studies were examined during the webinar, two of which are part of the EEG research programme, either fully or in part. Four of the researchers – Dr Kenneth Lee, Dr Maarten Voors, Dr Robyn Meeks and Professor Clark Miller – have worked, or are working on, papers or projects funded by EEG.

Dr Kenneth Lee discussed a widely cited paper he co-authored (Lee, Kenneth, Edward Miguel, and Catherine Wolfram. 2020. "Does Household Electrification Supercharge Economic Development?" *Journal of Economic Perspectives*). It is based on a field experiment where hundreds of randomly selected households in rural Kenya were connected to the national grid for the first time, with the aim of answering the research question: 'What is the direct effect of electricity access on household living standards?'.

The study is included in the EEG State of Knowledge paper Electrification and Economic Development: A Microeconomic Perspective, co-authored by Kenneth Lee.

Dr Maarten Voors shared insights from research being undertaken in Sierra Leone. The team is conducting an impact evaluation of the Rural Renewable Energy Project (RREP), a large-scale electrification project implemented by the Government of Sierra Leone in collaboration with the United Nations Office for Project Services (UNOPS) and funded by international donors, including the UK's Foreign, Commonwealth & Development Office (FCDO). It is providing electricity connections to rural communities in Sierra Leone through the installation of solar mini grids.

Dr Voors explained that the project enables electricity to be sold to households while clinics and schools receive access for free. The research team collected data before the mini grids were installed, and studied the impact of electrification on clinics and the wider community following the installations (and also plans to continue this research). A related study – Electricity access and resilience to COVID-19: Can electricity access help improve Sierra Leone's resilience to the COVID-19 crisis? – has been funded by EEG.

Dr Dana Kassem discussed her research paper on the impact of grid expansion on industrial development in Java, Indonesia (Does Electrification Cause Industrial Development? Grid Expansion and Firm Turnover in Indonesia, July 2021).

By collecting and digitising data on Java's electrification infrastructure and using data from the large and medium manufacturing census, Dr Kassem analysed how the

evolution of the electricity grid during the 1990s affected manufacturing activity.

Dr Robyn Meeks covered research on the rapid increase in the construction of micro hydro mini grids in rural Nepal over the past 15 years (approx.) and the impact on manufacturing and labour outcomes (Meeks, Robyn and Thompson, Hope F and Wang, Zhenxuan, Electrification to Grow Manufacturing? Evidence from Nepal, March 18, 2021, Duke Global Working Paper).

Micro hydro mini grids have played a large role in Nepal's electrification, with about 1,500 installed (Dr Meeks highlighted that some estimates suggest the country has the fourth highest number installed in any country in the world). With average system capacity of approx. 38kW, the micro hydro mini grids are powering activities such as sawing, milling and sewing and food processing facilities and mechanical workshops. Dr Meeks' team drew on data on the locations that were deemed appropriate and amenable for micro hydro mini grids and on the grids that were actually constructed. The team digitised data on manufacturing establishments, creating panel data sets for 2006, 2012 and 2018 to show the number of formal manufacturing firms employing 10 or more individuals.

Professor Clark Miller discussed his EEG-funded research project: Improving social and economic impact of energy infrastructure investments in Sierra Leone through enhancement of social value creation, capacity-building, and decision support. The project is based on an analytical approach that attempts to explain different economic outcomes arising from electrification. The project's results show that many low-income communities generate less value from the use of electricity than the electricity costs them. This undermines household financial security and lessens the prospects for economic growth.

Is there a link between energy access and economic growth? The messages from research are unclear

Energy projects are often developed on the assumption that once households and businesses are provided with access to electricity, they will automatically make use of the energy and will realise social and economic benefits, such as improvements in education, health, wellbeing, and employment opportunities.

A number of studies have provided evidence that electricity access delivers these kinds of positive outcomes. However, others have come to different, conflicting conclusions – including two of the studies discussed during the webinar – and question whether expanding access to electricity alone does in fact lead to meaningful economic growth and development.

In the study carried out in rural Kenya by Dr Kenneth Lee and his colleagues, households that received an electricity connection actually seemed no better off than those that weren't connected.

The team surveyed households after 18 months, collecting data on a range of different outcomes, such as employment and the assets people owned. Verbal and maths tests were also given to children in the households to measure differences in educational outcomes. When the team analysed the data, they found there were really no differences.

These results resonate with the findings from the study on the impact of electrification on rural health clinics and the wider community in Sierra Leone.

Dr Maarten Voors explained that there have been some promising signs in clinics and households, but no significant changes in terms of health or local economies.

In clinics, there has been some increased investment in cold storage (resulting in more vaccines and drugs being stored, which is particularly beneficial when considering COVID-19 health interventions). However, in terms of utilisation, there haven't been any changes in opening hours or additional services, meaning that electrification hasn't yet translated into an increase in the number of people being helped or treated. A range of other problems haven't been solved – for example, there is still a lack of support for nurses in terms of their salary and career prospects.

In the sites where mini grids have been built, more households have started to obtain electricity connections. Yet while households might have moved away from fossil fuels like charcoal and firewood for cooking, heating and lighting, electrification hasn't translated into improved incomes or food security, or reduced poverty. More businesses are also using electricity, but, in the short-term, it hasn't changed their inputs or outputs, turnover or profits.

Conversely, two pieces of research discussed during the webinar detected a more positive correlation between access to electricity and economic development.

In her study on the impact of grid expansion on industrial development in Java, Indonesia, Dr Dana Kassem found there was a positive effect on manufacturing. However, most of the increases in output induced by electrification were due to firm entry rather than improvements in the outputs of firms that previously existed. As locations

became electrified, they became more attractive for entrepreneurs to start their businesses there. It was noted that firms could have also emerged from the informal sector (having grown and then formalised, which benefits workers).

The creation of new firms resulted in more manufacturing outputs and more people working in the sector – but also a more competitive environment, which meant that unproductive firms that were able to survive before electrification were no longer able to do so. This translated into an increase in exit rates and higher average productivity in the market. In addition, newer firms were larger and employed more people.

Dr Robyn Meeks explained that in the study on rural electrification in Nepal, the micro hydro mini grids did lead to a statistically significant increase in formal manufacturing establishments, albeit the baseline numbers were low (so the overall presence of manufacturing firms remains quite low in these settings even after the micro hydro mini grids are constructed).

Before electrification, approximately one in five villages in the sample had manufacturing establishments with 10 or more employees. The research team estimates that after electrification, it's risen to about one in three.

It is thought that smaller and informal firms could have also increased, but this was not captured by the data.

A shift in labour, from self-employment and agricultural work to working for salaries/wages was also witnessed, thought to be driven by manufacturing establishments of 10 or more employees, as well as smaller and informal enterprises.

There was also some evidence to suggest an increase in small non-agricultural and typically informal household enterprises – but these results are speculative.

The potential reasons behind the varying conclusions on whether electrification promotes economic growth is the focus of Professor Clark Miller's research. It attempts to understand and explain what's happening in different places and in different contexts by analysing whether or not energy use results in net positive value creation cycles for households and is, therefore, economically generative or extractive.

The factors that may be responsible for the different results were discussed in detail, with all panellists sharing their views and additional findings from research.

Different research methods – different results?

Different research methods – particularly observational studies/natural experiments and randomised control trials (RCTs) – have tended to deliver different results.

Observational studies/natural experiments

Some of the earlier research on the links between electricity access and economic growth relied on observational data from non-experimental, natural situations.

There is a relatively large body of evidence from these studies showing that access to electricity is a critical driver of economic development, and that once households have power, there are increases in consumption, income, labour supplies etc.

However, in an observational study or natural experiment, it is difficult to analyse the data in a way that accounts for all the possible factors that might be driving changes in economic development outcomes, and to isolate the effect of the power connection alone.

For example, an electrification programme might be combined with investment in road infrastructure, so improvements in livelihoods might be a result of both measures. It is difficult to account for unobserved factors that might be correlated with a household gaining access to power as well as the economic improvements that might occur in the household over time.

This raises questions over whether earlier literature had captured pure causal effects or had mistakenly captured correlations or associated relationships.

Dr Dana Kassem's study and the research undertaken by Dr Robyn Meeks and her colleagues were both observational/natural experiments.

Dr Kassem admitted that observation studies have their disadvantages relative to RCTs, which she called the "gold standard" in impact evaluations. Interpreting findings from observational studies as causal requires that we believe the assumptions of the research design, which is a matter of economic reasoning and empirical investigation.

While RCTs are superior in terms of causality, she pointed out that observational studies allow certain margins to be captured in a way that is not possible in randomised experiments (at least not without huge costs or impracticability). For example, an RCT to measure the impact of electrification on the industrial sector could be designed to experimentally vary a subsidised connection fee to a group of firms – but while this would give a

credible estimate of the effect of electrification on the firms themselves, it would not capture the effect on firm entry; the new firms could not be studied because they would not exist.

Randomised controlled trials and quasi-experimental methodologies

Some of the more recent literature on the links between electricity access and economic growth has deployed RCTs, or quasi-experimental methodologies that can isolate the effects of one specific variable alone.

They have tended to estimate much smaller effects from electrification – as was the case in the two studies covered by Dr Kenneth Lee and Dr Maarten Voors during the webinar.

The Kenya study Dr Lee discussed was an RCT. The sample of households was divided into treatment and control groups. As part of the study, randomly, the treatment group was offered different kinds of discounts to connect to the national grid and the control group was offered standard prices. The random variation in connection prices allowed the researchers to trace out a demand curve and experimental cost curves.

In the Sierra Leone study Dr Voors covered, quasi-experimental methods were used to study communities benefitting from RREP and comparison (non-beneficiary) communities. While the team didn't have any control over where the mini grids were constructed, they were able to track what was happening in clinics and comparison clinics in different places over time, and could do the same with randomly selected households within communities.

While different research methods seem to generate different findings, the panellists agreed that other factors are more likely to explain why the positive effects of electrification are seen in some contexts but not others.

Duration of research and results emerging over time

When discussing the different results, it was suggested that because some studies are collecting data within a relatively short timeframe, researchers might be seeing only a short-term picture, with the benefits of electrification potentially growing over time.

Some evidence suggests that the impact happens over the longer term, but in the short term, the gains are not that immediate. Therefore, where studies didn't see a significant impact from electrification, the benefits might materialise after a few more years.

In her Indonesia study, Dr Dana Kassem found that the impact of electrification grows very slowly over time, with the increase in manufacturing output being very slow. This also applied to the change in energy use at the firm level, with firms still generating some of their own electricity when the grid first arrived, which decreases over time.

Professor Clark Miller raised the question of how to create opportunities for the impact of electrification to happen over time without imposing high levels of costs on communities and undermining the potential for value creation and economic growth. He put forward the idea of access to electricity being payable only after economic growth has occurred.

Unlocking the productive benefits of electricity access

Crucially, economic and development outcomes are likely to depend not just on whether people have access to electricity, but also whether they have ways to use it productively.

Recently, there has been a shift in research focus, from trying to answer the question 'What are the impacts of electrification?' to 'How do we unlock the productive benefits of electrification?'

Electricity is an enabling technology, and research suggests its impact depends on other complementary factors. Delivering universal access to power without focusing on offering complementarities therefore might not return the expected benefits.

Households and businesses need ways to use power

To have a real impact and unlock the productive benefits of electrification, there is a need to ensure households, businesses and communities have the capabilities to use electricity and do more with the power that's being delivered. To be able to use energy and realise the benefits, consumers need knowledge, skills and opportunities – provided by markets or political systems.

The team behind the Kenya research examined why the connected households in the study seemed no better off than the unconnected households.

They concluded that providing households with access to electricity alone is not enough to drive economic development outcomes in a meaningful way. Electricity access is only useful if there are ways to use the power –

and there were not many ways for the Kenyans in the study to do that.

In many places, people were poor and couldn't buy appliances or had very little money available to pay for monthly electricity consumption. Many were working in agriculture, with limited ways to use power connections. All these factors might explain why the impact seen in the research timeframe was underwhelming.

Conversely, in Dr Dana Kassem's study, firms were already using electricity, but were producing their own power with generators, which is costly. Lack of access to the electricity grid was therefore a barrier to industrial firms. New firms were attracted to the electrified areas because they would have access to the grid instead of having to buy a generator.

Appliances and access to markets

Combining electricity connections with complementarities – such as access to electrical appliances or appliance subsidies, so that people have ways to use the power, or infrastructure investments to improve access to markets and commercial opportunities – can boost the benefits of electrification over the long term.

Despite her research findings, Dr Dana Kassem suggested that electrification alone might not be enough to "supercharge" industrialisation; if there are other non-energy barriers to entry – such as credit constraints or inadequate transportation infrastructure or other barriers to market access – then it's unlikely that electrification will transform the industrial sector.

Dr Maarten Voors is currently working on an EEG-funded randomised field experiment in Sierra Leone on the impact of access to productive appliances (Electrifying growth: Electricity access for productive use). It is testing if the development benefits of electricity are greater when rural entrepreneurs have increased access to productivity-enhancing technologies that require electricity.

Dr Voors suggested that access to energy-dependent appliances such as electrically driven pumps or electric rice drying technology could increase an agricultural worker's productivity, but this would still need to be combined with market access. Together, these factors could help to change the way local community economies are organised and to change businesses' and farmers' incomes.

Access to markets was also deemed important in the Nepal study that Dr Robyn Meeks discussed. The micro hydro mini grids were constructed in places that are very remote, but also in places close to where the historical grid is located. The researchers carried out analysis on heterogeneity and the impacts on manufacturing based on proximity to the historical grid, looking at the impacts for very remote micro hydro mini grids and those located more closely to the historical grid. They found the impacts of electrification were significantly less in the very remote areas.

Locations that are closer to the historical grid are closer to developed markets. The less remote places have greater access to supplies used in the manufacturing process and greater access to markets in terms of selling products they're producing.

All of this suggests that location and proximity to markets matters in terms of the impact of electrifying a certain location.

Project design, the social value of energy access and value extraction

Professor Clark Miller's approach is based on looking at how energy projects are designed, particularly in relation to the user's ability to use energy in ways that create value in their own lives, which he calls the social value of energy access.

Energy systems need to be able to translate electricity access into value. The approach Professor Miller uses tries to understand comparatively how social value creation occurs in different contexts. For example, it might occur differently in different kinds of places (dense urban areas, outlying towns, small cities, emerging grid areas and remote rural communities) and it might be productive, commercial or industrial. It might take the form of improved healthcare or education or the creation of small businesses or manufacturing in a new area. Or it could be more focused on improving people's capabilities to do things that result in wellbeing and opportunities to thrive.

Professor Miller believes that the technical design of an energy system should allow for people to be able to use energy in ways that generate value. He points out that design is not just about delivering electricity; it's about delivering real opportunities and real capabilities for value creation in a community.

He and his team aim to quantify some aspects of social value creation so that energy project designers can measure, in engineering terms, what can be accomplished from their projects. They are also working with utility companies, regulators and Sierra Leone's Ministry of Energy to try and understand how they might implement and integrate the idea of social value creation into project design.

Paying close attention to system design is also important for ensuring that energy systems create more value than they extract. All energy systems impose costs, risks, fees and burdens on users and communities, which can simultaneously extract value. This includes not only the costs of electricity but also the costs of backup energy supplies, appliances for productive energy use, and repairs of energy systems and appliances. This total cost of energy then needs to be compared to total tangible and intangible value created through energy use. Projects should be designed in a way that ensures the extractive element is below the level of social value creation – otherwise the net balance between value creation and value extraction becomes negative. This can erode wellbeing over time, especially in extremely low-income communities, or can result in the electricity never being used because it's too costly.

Professor Miller stressed there is a risk that communities could become saddled with expensive electricity systems that have not generated economic growth for them. Some communities have seen their lives and livelihoods detracted by how existing energy systems operate, with systems being a net burden, opposed to a net benefit with net positive social value.

He described a scenario of a major bank considering substantial investment in a major electrification project. While questions will be asked about the technology (where it is going to be installed, cost etc), remarkedly little attention will be paid to the human design side of the project.

Indeed, Professor Miller has seen project designers providing many pages of detailed techno-economic analysis of different sites and their suitability (for example, for micro hydro projects there would be information demonstrating there is sufficient water, and that the system wouldn't be impacted by seasonality etc), but only a few generic bullet points on the social and economic design, revealing little about the project's impact on social value. There wouldn't be any analysis of whether communities were going to be able to use the energy productively, or what it would take from a human standpoint to make that happen.

If there was a clear focus on ensuring that households, businesses and communities had the capabilities to use energy to create value – and this was made an integral part of project design – Professor Miller believes this would have a huge impact on the likelihood of a project delivering return on investment, and bankable future projects could be delivered in more areas.

He also stressed the importance of thinking about energy not just as a commodity, but as a system. He made the point that energy systems could be designed to create employment opportunities in the community through local reinvestment over time (for example, by investing revenues into local entrepreneurial activity). He suggested asking: Are the benefits of employment in the design of the energy project flowing to outsiders or to insiders?

Dr Kenneth Lee suggested that governments need to find ways for power to be useful and affordable for everyone. Some of the rural households in the Kenya study benefitted from electricity access more than others, potentially creating or exacerbating local inequality.

The team found some households were more entrepreneurial than others and there was suggestive evidence of some people benefitting sooner (for example, some were quick to realise that once they had a power connection, they could start a mobile phone charging business and earn income from it).

They found very suggestive evidence that people who were willing to pay more for a power connection (likely to be correlated with higher education levels or higher income levels) tended to be making more use out of the power connections in terms of things like accumulation of electrical appliances. There were even some suggestive differences on employment.

Delivering power connections without any additional interventions could therefore lead to issues of local inequality. For those designing universal access programmes, it is important to find ways to make power easily consumed, affordable and useful to everyone.

Reliability

The reliability of electricity services also has an important role to play in unlocking the benefits of electrification.

Professor Clark Miller suggested there should be a shift in focus/metrics, from supply side ('Do people have electricity?') to user side ('Do people have high-quality services being delivered to them?').

If households and businesses have high-quality, reliable connections, it can encourage them to increase their use of electricity, and to use it in different ways.

In an experimental study that Dr Robyn Meeks is carrying out in central Asia and Kyrgyzstan, she has found that when reliability is improved, households increase electricity consumption and invest more in appliances.

If the quality of grid construction and the associated infrastructure – and the subsequent maintenance and repair programmes – are low, this can impact reliability, and thus utilisation.

There were reliability and grid construction quality issues in the Kenya study discussed by Dr Kenneth Lee. He explained that around 20% of the material that had been paid for and designed into the project wasn't delivered to site – meaning the end infrastructure was not as good as intended. When the team measured the reliability of the system, they found 19% of transformers were blacking out for many weeks at a time.

Dr Lee explained that Kenya has seen a phenomenal rate of electrification over the past decade (from 20-25% connected to 80% connected in six or seven years), and pointed out that it's often very easy to measure how many connections are in the field, but very difficult to measure how reliable the connections are and whether people are actually able to use the electricity. He suggested there should be a way for donors to hold governments accountable for delivering not just numbers of newly connected households but also high-quality connections that can actually be used.

Dr Maarten Voors suggested that planned maintenance of the solar mini grids installed in Sierra Leone should be just as important as the technical elements of the project.

In the Nepal study that Dr Robyn Meeks discussed, the lifespan of micro hydro mini grids varied; some were outliving the 20/30 years expected, but others weren't even coming close to that. She is currently examining how the functionality of infrastructure can be sustained over time, but stated it's a complex area.

Professor Clark Miller suggested there is little attention paid to the capability/capacity upgrades that are needed to transfer electricity access into value, but if there was, it would have a huge impact on return on investment.

Some of the other benefits of consumers receiving a high-quality, reliable service were also discussed during the webinar, such as customers being more willing to pay their electricity bills, which leads to increased revenues for utilities and more funds for maintenance (in turn making system reliability more likely, with a reduced chance of power outages).

Do the benefits of electrification always need to be related to economic growth?

During the webinar, the panellists debated whether, to be worthwhile, the benefits from electrification always need to promote economic growth and deliver improved outcomes in employment, health and education. Could improvements in people's quality of life and wellbeing – for example through having better lighting or the ability to charge a mobile phone or power a radio – potentially be just as valuable?

Dr Kenneth Miller pointed out that the electricity connections in Kenya cost the country's government over a thousand dollars per household, so there should be a focus on benefits, whether economic or non-economic. There needs to be tangible, visible or measurable benefits from investments.

Furthermore, it is in the best interests of governments, utilities and donors to ensure infrastructure investments return financial benefits. If the infrastructure generates revenue, this can help to fund maintenance so that the grid continues to work properly and reliably, and equipment and technology lasts for its expected lifespan. This is crucial if electrification is to have an impact on economic development.

Dr Maarten Voors raised the question of whether there should be a change from assessing increases in individual household incomes or changes in businesses to looking at structural transformation in local economies (for example, people moving out of low-paying jobs or moving from villages to towns).

Summary and ideas for further research

As governments seek to pursue universal access to electricity, it is important that we continue to question through research what action can be taken to ensure electricity access promotes economic growth.

Research has highlighted that the impact of electrification often depends on the context, and that there is lots of scope for different outcomes.

The one unanimous conclusion from the research is that access to electricity alone is not enough to drive positive development outcomes. With electricity being an enabling technology, households and businesses need the capability to use electricity if social and economic benefits are to be returned.

When energy projects are designed, it is therefore essential to know what potential consumers are going to do with the power that's delivered and what opportunities exist (or can be created) to enable them to unlock productive benefits.

Furthermore, energy systems are expensive to build, and are considerable investments (especially in the wake of the COVID-19 pandemic), and thus need to generate returns to encourage further investment and expansion, and to fund the maintenance and repair work that is essential for system longevity and reliability.

The researchers taking part in the webinar recommended further research on interactions between electricity access and different types of complementary inputs; the assessment of long-term changes following electrification/the temporality of growth; and ways to sustain the functionality of infrastructure to provide high-quality services – all of which would be of significant benefit to donors and policy makers.

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