# Does electrification create jobs? The evidence in low- and middle-income countries

Energy Insight

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## 1. Introduction

Universal access to 'affordable, reliable, sustainable and modern energy' is not only UN Sustainable Development Goal 7 (SDG7), but is also frequently seen as a foundation of economic and human development. Why and how does it lead to employment?

This Energy Insight examines three potential avenues of employment creation due to electrification in low- and middle-income countries: 1) job creation by grid-scale electricity generation technology; 2) job creation due to improved electricity supply where access already existed; and 3) new electricity access and job creation. We focus on these primary avenues for job creation in this Energy Insight brief, while recognising that there may be additional employment effects associated with automation, economic transformation and the production of input fuels and raw materials that are beyond the scope of this paper. We begin the analysis by providing an overview of common methods and concepts for estimating job impacts. We then examine each of the three potential avenues for job creation in turn, based on existing evidence and ongoing research within the applied Energy and Economic Growth (EEG) research programme.

The reviewed evidence suggests that renewable energy technologies enable greater direct, indirect, and induced employment opportunities than fossil fuel-fired electricity generation alternatives. This provides opportunities for significant *net* job creation, as well decarbonisation and health benefits. Where access to electricity already existed, there is the potential for additional job creation due to wider multiplier effects due to improvements in the cost, reliability, and overall quality of electricity supply. For new energy access, the evidence is more nuanced. While access to electricity has the potential to enable new employment opportunities and raise productivity, the displacement of traditional jobs and technologies implies a less clear-cut picture. It will be important for policymakers, donors, and investors to support people in the transition, so that long-term benefits are realised.

## 2. Methods and concepts for estimating the impact on jobs

The first step in any assessment to measure the potential job impact of electrification is identifying what to measure. Yet there is no consensus in the literature on methodology, scope, or unit of measurement. One reason for this is that job creation is rarely directly observable beyond the level of direct employees for a single project. Wider effects will need to be estimated. This hinges both upon the methodology and definition of the scope of measurement. Researchers have tended to use two broad methodologies: i) case studies and questionnaire surveys; and ii) modelling methodologies, particularly input-output modelling, computable general equilibrium (CGE) modelling, and econometric estimation approaches.

The first methodology typically focuses only on direct jobs associated with individual generation technologies (e.g. a solar photovoltaic installation) in a particular setting or based on nationally representative surveys. The benefit of this is that such studies tend to be more transparent and easier to understand than alternative approaches (see e.g. Lambert *et al.*, 2012). However, they suffer from limitations associated with any survey work, including representativeness and reliability.

The second methodology seeks to quantify the wider ripple effects on the economy based on modelling techniques.[1] It attempts to calculate three different effects (see also Blyth *et al*, 2014):

a) *direct effects* – jobs directly created as a result of an investment; this includes 'jobs created in the design, manufacturing, delivery, construction/installation, project management. and operation and maintenance (O&M) of the different components of the technology, or power plant' (Wei *et al.*, cited in Blyth *et al.*, 2014);
b) *indirect effects* – typically refers to the jobs created within the supply chain of a particular project, e.g. the raw materials and suppliers associated with a wind farm project; and
c) *induced effects* (also sometimes called *inferred effects*) – jobs created due to increased expenditure by direct and indirect workers.

[1] For a discussion of the benefits and limitations of each modelling technique, see e.g. Blyth *et al.*, 2014.

Studies also differ in their definition of scope: in particular, whether they examine *'gross'* or *'net'* job creation. Gross effects include only the positive impact on jobs from a particular investment. Net effects seek to take account of potential negative impacts of an investment, e.g. displaced coal jobs due to renewable energy expansion. Blyth *et al.* (*op. cit.*) find in their comprehensive literature survey that the majority of studies only estimate gross job creation. They also find that the net effect can be approximated based on the difference between, for example, a renewable energy and fossil fuel plant project. Thus, derived results tend to be similar to the smaller set of the literature that explicitly estimates net effects. However, the author of this Energy Insight brief cautions that wider effects of economic transformation due to electricity-induced lifestyle changes, industrialisation, and automation based on digital technologies almost certainly have additional longer-term employment impacts that would need to be modelled separately.

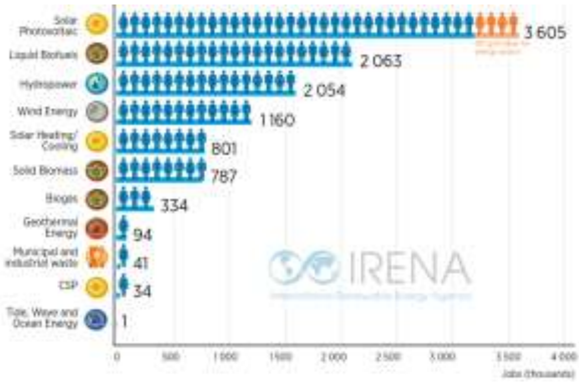
In addition, the literature distinguishes between different metrics of jobs creation. Two metrics tend to be used most frequently: 'jobs per megawatt (MW)' installed and 'person-year per MW' installed (the latter is also sometimes referred to as 'job-years per MW'). Typically, jobs per MW installed is used to indicate the number of permanent jobs in the O&M phase over the lifetime of a power plant, while person-year per MW describes temporary jobs in the construction phase (Lambert *et al.*, 2012). This makes it possible to distinguish between jobs at different stages. In order to assess total job creation, both measures can be combined by converting 'person-year per MW' jobs into 'jobs per MW' by dividing over the lifetime of a project. For example, 30 person-years per MW installed during the construction phase would equal one job per MW installed over the 30-year lifetime of a plant (*ibid.*). But as Blyth *et al* (2014) note, this is a crude measure, because different technologies require different levels of installed capacity to generate the same amount of electricity. One option is to correct for this by using the average expected capacity factor for different technologies to derive 'jobs per annual MW available' ('jobs/MWa'). Alternatively, this can be expressed in terms of electricity output, i.e. 'jobs per annual GWh'.[2] Yet another strand of literature uses the amount of money invested as the denominator (i.e. 'jobs/US$'). In particular, this makes it possible to express the effect of a stimulus package. However, such estimates are highly sensitive to how the investment is calculated, e.g. whether operating as well as capital costs are included, and how financing costs and discount rates are applied (see *ibid.*).

## 3. Job creation by grid-scale power technology

While the previous section highlighted the multitude of different approaches and measures for measuring job creation, there is one consensus across studies: grid-scale renewable energy projects create more jobs than fossil-fuelled electricity plants. Renewables tend to be more labour-intensive, particularly during the manufacturing, construction, and installation phase.

The renewable energy sector employed directly and indirectly 11 million people globally in 2018, compared with 8.6 million five years earlier (International Renewable Energy Agency (IRENA), 2019a). Nearly one-third of jobs are in the solar industry and 39% of all renewable energy jobs are in China. This is in part because China accounts for more than 60% of global solar cell and module capacities (*ibid.*).

### Figure 1: Jobs by technology worldwide, 2018




Source: IRENA, 2019a

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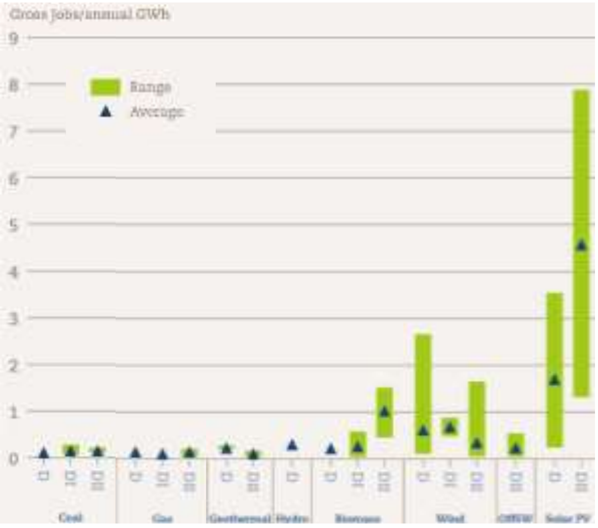
[22] 'Jobs per annual GWh' ≈ 'jobs/MWa' x $10^3 \div 8760$, where MWa is installed capacity adjusted for the capacity factor and averaged over a year. This is an approximation as actual GWh output will be project-specific and location-dependent.

In their comprehensive literature review, Blyth *et al.* (2014) review the direct (D), indirect (DI), and induced (DII) job creation of different energy technologies, as summarised in Figure 2. They conclude that, on average, fossil fuel generation technologies create 0.15 jobs/GWh and renewables 0.65 jobs/GWh.

### Figure 2: Gross job creation by technology




Source: Excerpt from Blyth *et al.*, 2015

This suggests that replacing fossil generation with renewables has a net positive job creation effect on average. Other studies come to similar conclusions and Chen (2017, cited in UN, 2018) finds that per dollar spending on renewable energy produces around 70% more jobs than spending on fossil fuels. Yet there is significant variation in estimated effects among studies, by technology and type (see Figure 2). Solar has a particularly high job creation potential. Moreover, as one would expect, induced jobs due to the wider effects of increased household expenditure tend to be larger than indirect jobs along the supply chain, which in turn are more numerous than direct jobs.

Part of the reason for high employment factors in renewables is the relative immaturity of technologies, which means they require a higher labour intensity. As technologies mature, employment factors tend to decline (see e.g. Aldieri *et al.*, 2019). Moreover, size matters – for example, larger wind project tend to be more labour-intensive than smaller ones (*ibid.*).

It is important also whether jobs are of shorter and longer duration, and where they are likely to occur. Analysis by Rutovitz *et al.* (2015), as summarised in Table 1, finds, for example, that a high proportion of short-term jobs are in manufacturing – particularly for wind, but also solar. Yet manufacturing is concentrated in a small number of countries, with China leading on solar, for example, while Denmark still accounts for a significant share of wind manufacturing (IRENA, 2019a). Most countries will have to create employment in other segments. This includes direct jobs in construction and installation, long-term jobs in O&M, as well as indirect and induced employment. As a result, actual employment factors vary greatly by country (see IRENA, 2013, and Rutovitz *et al.*, 2015).

### Table 1: Direct employment factors by stage

| | Manufacturing | Construction/ installation | O&M |
|---|---|---|---|
| | Person-year/MW | | Jobs/MW |
| Coal | 5.4 | 11.2 | 0.14 |
| Gas | 0.9 | 1.3 | 0.14 |
| Wind onshore | 4.7 | 3.2 | 0.3 |
| Wind offshore | 15.6 | 8.0 | 0.2 |
| Solar PV | 6.7 | 13.0 | 0.7 |

Source: Rutovitz *et al.*, 2015. Data for OECD countries

Construction, O&M, and other jobs offer the potential for significant local job creation. In its appraisal of the West Lunga Solar Project in Zambia, the World Bank (2017) estimated that 73% of construction and 98% of O&M jobs would be local. However, the European Union Energy Initiative (EUEI, 2017) notes that shortages of skilled staff in low- and middle-income countries are significant barriers for realising local employment potential. Employment conditions, remuneration, and social and gender equality promotion are also key to achieving the benefits of job creation. Supportive legislation, standards, 'local content', and other obligations may be instruments for attaining this (see e.g. UN, 2018).

Employment opportunities vary by gender. Women account for 32% of the renewable energy workforce on average globally, which is higher than the 22% share in the oil and gas sector (IRENA, 2019b). Moreover, studies have found significant gender segregation within electric utilities, with women commonly working in finance, human relations, legal, and accounting jobs – but less in science, technology, engineering, and mathematics jobs (Baldinger, 2020). Significant barriers to entry still exist for women, including social norms, hiring practices, lack of skills, lack of awareness of jobs, and lack of access to professional networks (*ibid.*). Several initiatives seek to increase the representation of women in the workforce. For example, the EEG programme-funded work by Schomer (ongoing) is collecting detailed data and developing platforms for networking, training, and mentorship in Ethiopia, India, Kenya, Pakistan, and Zambia. It is hoped that this will create gender benefits.

## 4. Job creation due to improved electricity supply where access already existed

Beyond employment effects due to individual technology choices, the previous section highlighted the potential for the creation of 'induced jobs'. As directly and indirectly employed workers in the energy industry spend their incomes, this has a multiplier effect for the wider economy that induces further job creation. These effects can be significant, as Figure 2 above illustrated. This effect is sometimes referred to as the 'Type 1' induced effect (IRENA, 2013).

Job creation can go even further. For residential, commercial, and industrial customers with already existing access to electricity, changes in power provision may have additional effects in the near to medium term. First is the cost of electricity. If newly installed power plants have a lower cost than existing plants, this will contribute to reduced electricity retail prices (or will mitigate other potential upward price pressures), benefiting residential, commercial, and industrial users. As electricity is an input in the production of many goods and services, lower costs can stimulate economic activity and hence employment. This 'Type 2' induced effect in turn may increase households' disposable income, enhancing the multiplier effect (*ibid.*). While renewable energy sources have historically been more expensive than fossil-fuelled generation, their cost is declining rapidly such that they have become competitive in many locations even without subsidies (Bloomberg New Energy Finance, 2019).

A third potential induced employment effect may be due to the quality of electricity provision. Different utilities or distribution companies may offer different types of services, including the ease with which customers can be connected and payments be handled. In an EEG programme-funded study, Upadhyaya (ongoing) is examining in detail the quantity and quality of enterprises and jobs enabled by electricity in different areas of Nepal serviced by different distribution companies. KfW (2012) found significant economic and employment benefits from its overseas development assistance investments in enhanced power transmission and distribution grids. The creation of credit-worthy intermediaries may be another avenue for enabling investments to ensure sufficient electricity provision, such as those explored by entities including Africa GreenCo in Zambia.

Unreliable electricity supply is a particular challenge in many low- and middle-income countries. In his comprehensive EEG Energy Insight of the topic, Day (2020) summarises a broad range of evidence regarding the detrimental economic effects, including: deferral of activity; switching to less electricity-reliant processes; reduced firm performance; and job losses. In South Asia, almost 50% of business managers identify a lack of reliable electricity as a major constraint to their firm's operation and growth (Zhang, 2019, cited in Day, 2020), with economic losses due to power interruptions equating to 4–7% of GDP across the region (*ibid.*). Losses across sub-Saharan Africa are estimated to be 1–5% of GDP (Ouedraogo, 2017, cited in Day, 2020), and the probability of obtaining employment is at least 35% lower in sub-Saharan African communities with unreliable electricity supply (Mesah, 2018, cited in Day, 2020). Dzansi (2018) found that blackouts led to the contraction of Ghana's manufacturing sector and reduced household willingness to pay for electricity, which in turn weakened the utility's financial viability and thus created a vicious circle. EEG-funded research by Weldemariam *et al.* (ongoing) is examining the economic damage from poor power quality in Ethiopia. To mitigate unreliable electricity supply, the use of back-up generators has become widespread, with expenditure on such systems often as high as, or even exceeding, expenditure on the main grid (International Finance Corporation (IFC), 2019, cited in Day, 2020). With unreliable or costly electricity frequently a binding constraint to businesses and economic development (CDC, 2016), improved power supply has the potential to unlock activity and induce jobs.

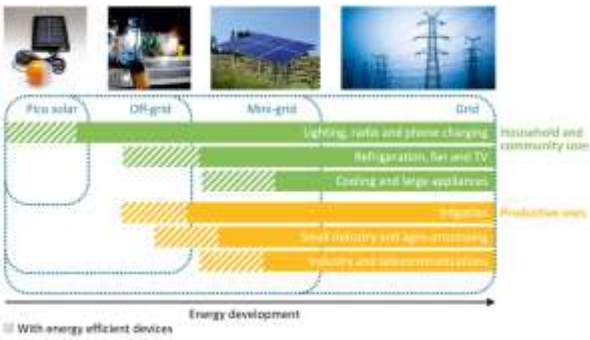
## 5. Electricity access and job creation

The preceding sections have focused on improvements to existing electricity supply networks and grid-scale generation technologies. However, electricity access is frequently still low in developing countries, particularly in rural areas. Access can be provided via grid extensions, mini- and micro-grids, home systems, clean cooking technologies, and energy technologies for productive uses (UN, 2018).

Measuring the employment effect from energy access is difficult due to data limitations, informality of jobs, diversity of actors and initiatives, and varying technologies and scales of deployment (*ibid.*). Job creation may depend also on structures for payment, business models, and any induced structural changes, including displacement of traditional agricultural jobs (*ibid.*).

The transition towards energy access can be defined via the Sustainable Energy for All initiative's multi-tier framework, in which Tier 0 implies no access, Tier 1 implies access to energy for a small light and for charging a phone, while Tier 5 comprises full access to modern energy (World Bank, 2015). Alternatively, the transition can be defined along technology options, as illustrated in Figure 3 below (International Energy Agency (IEA), 2017).

### Figure 3: Electricity access and technologies




Source: IEA, 2017

Lighting offers one example. Electric lighting (from pico-solar devices through to grid-connected lights) will provide direct formal jobs as well as informal jobs in manufacturing, retail, installation, and maintenance. Power for All (2019) found, through survey work in India, Kenya, and Nigeria, that pico-solar and small home systems could create between 5.0 (Nigeria) and 13.7 (India) direct formal jobs per 10,000 devices, with an additional 16.0 (Kenya) to 38.8 (Nigeria) direct informal jobs per 10,000 devices. These jobs are counted on a *gross* basis.

*Net* job creation from lighting – and energy access more broadly – is more complex. Dinkelman (2011, cited in Lee *et al.*, 2017) outlines that lighting extends the number of potential daily working hours, thereby increasing the potential supply of labour to the market. However, it also increases the productivity of home-based work, which might encourage individuals to increase their domestic work. Only if the first effect outweighs the second, will there be a *net* increase in employment rates. Dinkelman (*ibid.*) finds that in South Africa, rural electrification led to a nearly 10% increase in female employment. Home systems that can also provide mobile phone charging may have additional benefits as surveys have found that women that own a phone report have increased income and professional opportunities (Quak, 2018). Yet a range of other studies find that there may be no *net* effect on labour markets, or even a negative welfare effect (Lee *et al*, 2017). Practical Action (2015) found, through survey work in Kenya and India, that employment levels were similar, and increases in employment greater, among those who had *not* benefited from improved household electricity access compared to those who had, particularly for women. EEG-funded research by Miller (ongoing) adds to this body of research by assessing the social as well as economic outcomes of grid extension in Sierra Leone.

One consideration is that electrification will displace kerosene and candle lighting, with its associated jobs. Evidence from Nigeria suggests that there has been no discernible impact on overall jobs from kerosene displacement, vendors in Malawi and Kenya have reported no disruptive effects, and solar-lighting provides more jobs worldwide than fuel-based lighting (Milles, 2016). However, the simplicity of making electric tin lamps means that they have a lower employment factor than kerosene lamps, suggesting a potentially negative short-term effect (Mills, 2016).

Net effects are similarly complex when looking beyond lighting. Clean cooking may reduce household opportunities, particularly for women, who earn a living selling firewood (IEA, 2017). Energy for productive uses in agriculture may reduce job opportunities in the short term, despite potentially increasing the value of products and associated long-term economic gains. For example, in Vietnam, the introduction of electric grain driers cut the labour requirement per tonne of rice by 85% (Hodges *et al.*, 2011, cited in IEA, 2017). This reduced labour time has to be offset by individuals finding other productive employment, which takes time to materialise. It may also require individuals to attain new skills and competencies. However, most of the literature, and also survey work by Practical Action (2015), finds a possible overall positive relationship between electricity access for productive uses and increases in employment. EEG research by Peters (ongoing) focuses on micro enterprises in Rwanda, such as welders and agricultural businesses, to assess how access to electricity affects their ability to increase output, utilise more efficient technologies, and raise product quality, and the outcomes in terms of employment and income.

Financial terms and operating models will also play an important role in the potential impact of energy access technologies. Microfinance models for rural solar programmes in Bangladesh and the rise of 'pay-as-you-go' models in East Africa have been credited with enabling technology uptake and significant job creation (UN, 2018). Moreover, the longer-term productivity gains and employment benefits due to improved health, medical care, and sanitation are important reasons for striving towards universal access to energy (KfW, 2012).

Overall, the range of evidence of *net* job impact creation suggests that it is vital that policymakers support potentially displaced workers during the transition, promote skills development, mainstream gender, develop local supply chains, and strengthen labour market institutions, as well as labour standards (see also UN, 2018, and EUEI, 2017). Donors, as well as private investors, also have an important role to play, so that long-term benefits are realised for everyone. This will ensure not only that the quantity of jobs is maximised, but also the quality of those jobs.

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