Energy Peace Partners

Energy Access, Renewable Energy and Social Impact: A Literature Review

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1. Introduction

There is an explicit assumption prevalent in policy-making, public and private sector, and academic circles that energy access, electrification, and an increase in renewable energy infrastructure, consumption and connectivity, leads not only to economic and environmental benefits, but social benefits as well. The importance of energy access and electrification globally is enshrined in Sustainable Development Goal 7 which calls for a global commitment to action to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030. The goal encompasses three dimensions: universal access to energy, a higher share of renewable energy, and an improvement in energy efficiency. Beyond just this goal however, energy access ties into almost all the other Sustainable Development Goals (SDGs) by facilitating and enabling relevant development goals. Renewable energy in particular has been called out for its central importance to achieving many of the other SDGs (SDSN, 2019). Energy Peace Partner's (EPP) mission of supporting renewable energy as a building block for peace, fits neatly into the SDG framework, but the question of how to demonstrate, or 'prove' this linkage is vastly complex, as demonstrated by the findings of this literature review.

This literature review first delves into the state of knowledge on the social benefits of energy access – exploring what are the theories, and what is the evidence? It then digs deeper into peace benefits more specifically, before concluding by briefly touching on the renewable energy – conflict nexus. The review is by no means entirely comprehensive – the literature on the subject matter, particularly the evaluations, is quite extensive, and the review is intended as an ongoing project to be updated as we continue to build out our knowledge base.

2. What are the social benefits of energy access?

Despite the implicit and explicit idea that energy access and renewable energy can provide a myriad of benefits beyond purely economic or environmental, to date, there is not a lot of evidence as to how, why, and to what extent social impacts exist (Terrapon-Pfaff, Gröne, Dienst, & Ortiz, 2018). There is also a recognition that part of the reason for this dearth of evidence is that there is no 'standard' in place to evaluate and measure how, why, and to what extent energy access or renewable energy projects provide benefits. As the Monitoring and Evaluation in Energy for Development (M&EED) International Working Group stated in their seminal guide on measuring and evaluating energy for development projects, "We aren't sure what to measure and there are no recognized standards" (M&EED, 2006). More than 15 years later, this still seems to be the case. For example, a study undertaken by the Global Impact Investing Network (GIIN), analyzed the impact measurement approaches taken by 13 members of GIIN who invest in the clean energy sector. These investors, who are particularly focused on serving bottom-of-pyramid consumers in emerging markets, were found to have 'some commonality' in the types of metrics used to measure the social and environmental impact of clean energy investments, grouped around nine themes.[1] Yet, each investor took a different approach to measurement and what they measured (GIIN, 2014).

In conflict and fragile settings in particular, there is a dearth of evidence or analysis on how energy sector interventions both impact, and are impacted by, the context in which they exist. The United States Agency for International Development (USAID) for example has concluded that the energy-conflict-fragility dynamic is dependent on, "the specific political, economic, social, cultural, and historical context" of a country, potentially making a common framework for analysis of social (or other) benefits difficult (Morris, 2017).

Nonetheless, a handful of 'handbooks' or 'guides' to measuring impact in the energy for development, energy access, or renewable energy project sectors, have been developed.

The M&EED International Working Group established "A Guide to Monitoring and Evaluation for Energy Projects" in 2006, that outlines a general framework to implement M&E on a project. It also includes five specific thematic modules for M&E for: Decentralized Rural Electrification, Rural Electrification by Grid Extension, Regularization by Urban Electrification, Improved Biomass Stoves, and Institutional Support. Within each of these themes, it identifies the M&E process based on OECD standards of Input→Activity→Output→Outcome→Impact, providing some ideas for indicators and how to measure each of these components.

In 2017, Sustainable Energy for All (SEforAll) and Power for All commissioned the Overseas Development Institute (ODI) to develop a framework for measuring what they refer to as the "Energy Access Dividend" of decentralized energy access (ODI, 2017). They define the dividend as a function of the costs of connections, their affordability to different population groups, the development impacts of electricity use for various levels of access, and the timing of the access. They originally provided 13 potential indicators to include in calculating the dividend, 12 of which are household level indicators, and one an environmental indicator. These indicators were: value of savings on household lighting expenditure, use of savings, health status, hours spent studying, hours spent working to earn income, hours spent on domestic care, savings on costs of phone charging, access to mobile phone, time required for essential communications, hours spent on leisure – TV/radio, access to radio/TV, access to refrigerator, and reductions in climate change emissions.

In their three case studies (Bangladesh, Ethiopia, and Kenya), they use three indicators for which data is available to calculate this dividend, which is measured per indicator. For example in Bangladesh, under the SDG 7 target scenario (access for all by 2030), they calculate dividends for households in five tiers[2] of electricity access, across the indicators of: total hours of study, CO2 emission reduction, and black carbon emission reduction. Household dividends calculated for Tier 1 are summarized in the table below.

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[1] The nine categories of focus are: access to energy, job creation, environmental benefit, cost savings, enhanced opportunities for productivity and income generation, poverty level of end users, gender impact, and health benefits.

[2] The five tiers focus on the quality of electricity being accessed, ranging from Tier 1—with basic lighting or mobile charging for several hours per day—to Tier 5, which represents close to 24 hours of high power generation, served by an electrical utility.

Table 1: Household Energy Access Dividend in Bangladesh

Household Dividend **(Cumulative per household, over 9 year period)**	**Tier 1**
Total lighting and charging expenditure reduction ($)	217
Total hours of study (hours)	428
CO_2 emission reduction (kg)	514
Black carbon emission (kg CO_2e)	5,541

In 2018, the Inter-American Development Bank released a guide – "Measuring the benefits of energy access: a handbook for development practitioners" (Practitioners, Barnes, & Samad, 2018) – which aims to provide a practical approach to measuring the benefits of providing electricity and clean cooking energy to populations without access to modern energy. The handbook outlines both a framework for tracing pathways linking electricity or clean cooking adoption to development outcomes, and the two most commonly used approaches to measuring these benefits: consumer-surplus approach and regression-based techniques.

The benefits-pathway it outlines for electricity adoption runs through the purchase of appliances, which is considered the precursor to any benefit. For example, it links the purchase of a TV or radio to the outcome of greater access to information and knowledge. There are six over-arching themes in their development outcomes: information, education, business productivity, more efficient cooking, greater comfort, and more productive time use. The guide gives a comprehensive outline for regression-based techniques to derive the impact of electrification on outcome variables of interest, including model specification, control variables and even survey questions to collect data needed to estimate. It does warn that this technique is difficult and requires a lot of resources for data collection and analysis, and that monetary values may be derived but requires an additional step.

The guide outlines several under-measured benefits of energy access, these being: reduction in kerosene use, women's empowerment, benefits of public lighting, benefits of potable water.

In 2020, GOGLA (the Global Off-grid Lighting Association) released its 'Standardised Impact Metrics for the Off-Grid Solar Energy Sector' (GOGLA, 2020), and identified seven thematic areas in which to collect data. These are: energy access, economic activity, income generation, kerosene replacement and CO_2 reduction, light availability and quality, energy spending, and financial inclusion. For each of these themes, there are suggested indicators (in line with the IRIS standards), and formulas for calculating these indicators. GOGLA together with Altai Consulting, also developed a set of guidelines and best practices for conducting M & E around off-grid solar energy projects, including a step-by-step guide from research question to data collection design (GOGLA & Altai Consulting, 2018).

2.1 State of Evidence

There are several meta-analyses of the state of evidence for social and economic benefits of energy and renewable energy projects in non-conflict specific settings, which are helpful in giving an overview of social impact findings. However, according to these meta-analyses, approaches to evaluation vary widely, as do the outcomes being measured, and the findings obtained. While one study may find, for example, a positive effect of lighting on study-time and educational outcomes, another will find no effect.[3]

A 2010 analysis of rural-electrification projects in sub-Saharan Africa (Bernard, 2010) found that overall rates of connectivity remain low, despite the implementation of rural electrification projects, and that most studies show limited productive use of electricity – mainly for lighting, radio, and TV, rather than income generating or even domestic uses. Overall, the author finds a general lack of reliable evidence for impacts based on the following three reasons:

- Because energy is an enabler of other development outcomes, it is hard to aggregate into one cost-benefit ratio.
- Attribution needs to account for those with and without the intervention. Attribution is also hard because the causal chain may be affected by other external factors.
- Timing of measurement remains a problem. Many development outcomes are slow moving so evaluations that don't take a 'long-view' may miss these.

A 2013 systematic literature review of the impact on livelihoods of renewable energy access interventions in developing countries (IOB, 2013) focused on 66 studies looking at effects on access, income and expenditure, health, social variables, CO2 emissions, and the private sector. They conclude that the robust evidence on effectiveness is scarce, concentrated in a few countries and mostly focused on health outcomes – but they do find overall evidence that health outcomes improve. On income and expenditure, they find that early-adopters of RE technologies tend to be higher income strata of households who can afford it, who incur upfront costs but then longer-term higher income generation. The review also finds that market variables, such as independent household increase in income, and the consequential purchasing power by consumers, determine whether energy triggers productive activities or not.

A meta-study conducted in 2014 summarises the findings of evaluations of energy access projects as related to labour market, household welfare, health, and business (Bonan et al., 2014). The evaluations use differing regression estimations as well as experimental designs, and there are no consistent findings along any outcome dimension, with some studies finding effects and others not.

[3] GOGLA has developed an open-access 'impact matrix' which outlines the research and evaluations that have taken place related to energy access projects that have been undertaken between 2011 and 2020, and these number 134. The matrix is a useful reference tool giving an overview of which studies measure what and where.

A 2015 meta-study on the "double-dividends" of climate-change interventions (forest conservation and household energy transitions) considered 100 evaluations on the impacts of energy interventions, the majority of which were evaluating more efficient cook-stoves and rural electrification (EBA, 2015). They find most studies employ 'basic' evaluative techniques rather than 'rigorous', the latter of which calls for some kind of counter-factual analysis. Within these key findings, they believe there is 'robust' evidence that advanced energy services, mostly in relation to rural electrification, deliver health and income benefits.

A 2018 review of the impact analysed 30 small-scale sustainable energy projects in the Global South found the studies under review had five impact pathways linking energy access to human development goals: increase in economic activities and employment, empowerment of disadvantaged groups, improvement in health, development of human capacity, and increased awareness and dissemination of renewable energies (Terrapon-Pfaff et al., 2018). They did a deep-dive on three of these pathways with the following findings:

- On the contribution to environmental impacts by diffusion of sustainable energy solutions: In 77% of studies, additional members in the family or community or project area adopted the technology or practice, and in 65% of studies the technology or intervention was adopted outside of project areas.
- On the contribution to productive activities: the majority of projects couldn't claim an increase in income resulting from project implementation.
- On the contribution to the empowerment of women: 73% of projects did, in part, contribute to increased gender equality or empowerment.

A meta-study conducted in 2019 by the Asian Development Bank reviewed 85 completed rigorous evaluations of energy interventions globally (Raitzer & Sibal, 2019). Across the studies, the authors found contradictory outcomes on the impact of electrification in the following areas: improved education for children, which may reinforce gender equality; female empowerment; the effect on labor outcomes; increased household income and consumption; improvements in air quality; and reduced fertility rates.

A 2020 systematic review of 126 studies corresponding to 89 impact evaluations on the effects of electricity access interventions on social outcomes (Moore et al., 2020), concluded that although these interventions seem to have led to modest positive effects on household socio-economic outcomes, the results vary considerably across the studies. Furthermore, they conclude that yielding positive social change requires understanding local, specific contexts. The overall findings on the intermediate outcomes was that access to electricity interventions led to an increased use of electricity, as well as ownership of electrical appliances in 'treatment groups,' as compared to controls. Results for the longer-term outcomes are summarised as follows:

- Access to electricity increased overall household welfare slightly – household incomes were slightly higher in 'treatment groups' than controls.
- Effects on time allocation seem to be inconclusive.
- Results from studies are mixed on business outcomes.
- There were marginal improvements in female empowerment in 'treatment groups' over control groups, at the level of household decision making.
- The results related to specific health outcomes were inconclusive.
- There was a positive overall effect on the environmental outcome: access to electricity resulted in less use of traditional energy sources such as kerosene.

After reviewing the studies, the authors found a number of factors to be critical in increasing the effectiveness of interventions. Interventions carried out in areas with better institutions and limited political and economic unrest, as well as base levels of infrastructure, tended to be more effective. They also found that interventions carried out in areas with existing local networks to support delivery, and context specific credit and payment tools, were more effective.

A 2021 systematic review of 107 peer-reviewed studies examined the household energy transitions in lower and middle income countries (Liao et al., 2021). While the authors recognize that systematic assessments on energy transitions remain limited, they identify multiple positive associations between energy adoption and household well-being. Specifically, the authors found positive benefits in education and income, with a greater likelihood of energy subsidies and country membership in energy organizations. In tandem with these findings, the authors prioritize the importance of understanding factors contributing to energy transitions, due to a range of barriers preventing households in lower and middle income countries from adopting clean energy.

Finally, a 2022 meta-analysis of existing literature discussing electrification effects on rural households found a genuine effect of rural electrification on household welfare (Ayana & Degaga, 2022). Specifically, the findings statistically support significant positive effects on education, employment, income, productive time uses and female empowerment.

The methods that have been used for evaluations of energy related interventions range from purely qualitative evaluations using interviews and focus groups; to non-experimental evaluations such as regression discontinuity designs, instrumental variables, propensity score methods and synthetic controls; and to experimental designs with simple randomized control trials, cluster or matched pair randomized control trials and encouragement designs. A good overview of the different methods is found in (Raitzer & Sibal, 2019).

Table 2: Summary of impacts on social and economic benefits

Authors	Assessments	Key Findings
Bernard (2010)	Rural electrification in Sub-Saharan Africa	Overall rates of connectivity remain low, despite implementation of rural electrification projects.
IOB (2013)	Renewable energy access in developing countries	Find evidence that health outcomes improve, but robust evidence on effectiveness is scarce for other variables.
Bonan et al. (2014)	Energy access in developing countries	No consistent findings along any outcome dimension.
EBA (2015)	Climate change interventions in developing countries	Find evidence that advanced energy services (rural electrification, e.g.) deliver health and income benefits.

Terrapon-Pfaff et al. (2018)	Small-scale renewable energy access in Global South	Environmental practices were sustained and adopted outside of target areas. Most projects contributed positively to the gender equality of women.
Raitzer & Sibal (2019)	Energy access in developing countries	Found contradictory outcomes on the impact of electrification on gender equality, improvements in quality of labor and education, and increases in household incomes.
Moore et al. (2020)	Electrification in developing countries	Find modest positive effects on household socio-economic outcomes, with great variability across the studies. Positive social change requires understanding local, specific contexts.
Liao et al. (2021)	Energy transitions in lower and middle income countries	Found positive benefits in education and income, with a greater likelihood of energy subsidies and country membership in energy organizations.
Ayana & Degaga (2022)	Rural electrification benefits	Findings statistically support positive effects on education, employment, income, productive time uses and female empowerment.

Evaluations as related to conflict and fragile settings are however very few and far between; as one review paper surmised, "the fact that there is hardly any high quality research attempting to apply a conflict-sensitive lens to the energy sector is both surprising and concerning" (Morris, 2017). Moreover, because the nature of conflict dynamics varies so widely between situations, it has been argued that variation in findings is to be expected, and that generalizations from context to context will be difficult (Morris, 2017).

2.1.1 One-number impact summaries

A few organizations have made attempts at 'one-figure' type impact summaries for their energy interventions, including 60 decibels with their 60dB impact index, and Solar Aid with their impact calculator.

One widely known and systemic measure of social impact is the social return on investment (SROI) methodology, which places a monetary value on social change associated with a project and compares this to the costs of inputs required to achieve it. In simple mathematical terms:

$$\text{SROI} = \frac{\textit{Net present value of benefits}}{\textit{Net present value of investment}}$$

For example, a SROI ratio of 3 means that for every one dollar invested in a renewable energy project, there is a social value of three dollars created. Both forecast and evaluative analyses are possible using this method.

SROI is increasingly used by non-profits and social enterprises, donors, investors, and corporations to assess and monitor performance. The benefit of adopting this methodology is that it is rigorous, involves stakeholders, and is a widely accepted measure of impact. The down-side is that it requires substantial upfront investment in deriving the social impact and quantifying this in monetary terms.

Two applications of this SROI analysis have been found in the renewable energy development space. In 2014, the Gold Standard Foundation (a key actor in developing standards, certification, and helping to monitor and finance greenhouse gas mitigation projects) commissioned a portfolio evaluation of outcomes beyond carbon mitigation in their projects. They wanted to measure and monetise the co-benefits of their project portfolio and did so through a SROI type analysis. They estimated these benefits along five dimensions: biodiversity, balance of payments, employment, livelihood, and health impacts (Gold Standard Foundation, 2014).

In 2019, Danske Commodities, conducted their annual social return on investment report for a rural electrification project they implement in Mali (Danske Commodities, 2019). They calculated an annual SROI for 2019 of 3.25, while over a ten-year period, they calculated this ratio to be 11.62.

3. Energy and Peace

The importance of providing energy access in conflict and fragile settings was emphasized by a World Bank study which concluded that 'resumption of electricity supply can be important in restoring confidence in the government, strengthening security and reviving the economy' (World bank 2013).

Can energy access, and renewable energy access in particular, actively contribute to peace benefits?

The immediate question to answer is of course what does ‘peace’ mean? There are two broadly accepted conceptions of peace: negative peace – referring to the absence of violence and conflict; and positive peace – referring to ‘a more lasting peace built on sustainable investments in economic development and institutions, as well as societal attitudes that foster peace.’[4]

This section first looks at the theory and evidence linking energy access and renewable energy projects to negative peace, before delving into the link to positive peace.

3.1 Energy and negative peace

The notion that increased access to energy and electrification may increase real or perceived security is quite widely assumed. These effects can occur at the individual, household, community or national level.

Several studies that looked at the impact of energy and electrification on individual perceptions of safety and security have found that as a result of electrification – in particular lighting – people’s feelings of personal safety have increased. An evaluation of two community renewable energy projects in Afghanistan found that one of the biggest impacts of energy access was an increase in perceived personal safety (Shoaib et al., 2016). An evaluation of the impact of solar home systems (SHS) in Senegal found that for households with SHS, there was a markedly reduced fear for safety, with members of these households leaving their houses at night more frequently than those without. Furthermore 30% fewer adults from SHS homes stated being afraid of their children playing outside after nightfall than their non-SHS counterparts (Bensch et al., 2012) .

The positive effect of electricity and lighting on women’s safety in particular has also been examined (Gillard, Oates, Kasaija, Sudmant, & Gouldson, 2019). In energy poor settings such as rural areas of under-developed countries, or displacement camps, women and girls are often burdened with the responsibility of essential household chores, such as collecting firewood or fetching water (Bradley & March, 2019). This leaves them vulnerable to physical and sexual violence as they often have to travel long distances, and are often doing so in the pre-dawn or post-sunset darkness.[5] Despite this theoretical link between increased electricity and lighting and women and girls’ safety, there is little empirical evidence to support or refute this link.

A 2019 study by Oxfam looked at the effects of lighting in or around sanitation facilities in humanitarian camps and the risk of gender based violence (GBV). The study found that while there was an overall reduction in fear of GBV once lighting was provided, it wasn’t consistently the case across genders or the three locations of the study - Uganda, Iraq, Nigeria (Oxfam, 2019). A 2017 study by UNHCR of Northern Uganda’s Rhino Camp refugee settlement found that the frequency of ‘something bad’ happening to a female survey respondent in an unlit location was more than six times higher than in a lit location (33% versus 5%), whereas it was the same frequency for male respondents (5% both lit and unlit) (UNHCR, 2017).

[4] Definition taken from positivepeace.org/what-is-positive-peace.

[5] Power Africa, “Exploring the Relationship Between Energy Access and Gender-Based Violence”, December 8th 2017. Accessed at https://powerafrica.medium.com/exploring-the-relationship-between-energy-access-and-gender-based-violence

At a community level, one meta-analysis of 13 impact evaluations of the effect of public lighting on crime rates found that across all the studies, on average, there was a 20% reduction in crime in 'experimental areas' (i.e. where public lighting was introduced), as compared to control areas (Welsh & Farrington, 2008). It has been argued that although several studies have focused on the links between public lighting and crime reduction, the valuation of the benefits of public lighting is difficult since there is no established way to assign value to reduction of crime in a community (IDB, 2018).

3.2 Energy and positive peace

Positive Peace is best explained and measured through the eight pillar framework developed by the Institute for Economics and Peace, whose component parts systemically interact to build societies attitudes, structures, and institutions that create sustainable peace. The eight pillars – in no particular ordering of importance – are: well-functioning government, free flow of information, low levels of corruption, high levels of human capital, sound business environment, acceptance of the rights of others, equitable distribution of resources, and good relations with neighbours.

This definition and measure of Positive Peace is known to be a statistically significant correlate of the absence of conflict and violence. It also provides a framework for assessing a country's, or community's resilience, that is its ability to plan, absorb, and respond to shocks (IEP, 2019a). Climate change related disasters are one such type of shock for which a country, or community, needs resilience. This Positive Peace framework also links directly to many of the Sustainable Development Goals, with research concluding that of the 169 targets outlined across all SDGs, 85% are relevant to more than two Positive Peace factors (IEP, 2019b).

Renewable energy can help build a state's resilience to climate change shocks, a fact increasingly recognised in the energy for development sector, as well as with investors in the renewable energy sector themselves (Cox et al., 2017).

Moreover, by the introduction of new technologies, innovations, employment opportunities and other down-stream economic opportunities, renewable energy projects could also help build resilience to other types of shocks (other than climate). For example, diversification of an economy away from reliance on producing or importing oil and gas, will make the economy more resilient to the booms and busts of the fossil fuel industry. The role of renewable energy in building resilience is being particularly emphasized in a post-Covid world where countries "build back better" (IRENA, 2020).

Sacchetto et. al make the case for investing in renewables in fragile states in particular, because not only is it cost-effective with a good return on investment, but because it contributes to building state capacity including in public service delivery, which is particularly important in post-conflict settings (Sacchetto et al., 2020).

As discussed above, Positive Peace provides a framework for analysing and measuring current resiliency, and a road map to build resilience in the future. Therefore, the following section examines the theoretical and empirical links between energy access and renewable energy in particular, as related to each of the eight positive peace pillars, done here in no particular order.

3.2.1 Well-functioning government

A well-functioning government is defined as one that engenders trust and participation, upholds the rule of law and delivers quality public services. This can be at a national, sub-national or local level, and can encompass a broad range of government and governance institutions.

Analyzing the link between political power and renewable energy, Burke and Stephens (Burke & Stephens, 2018) argue that renewable energy, by enabling decentralized energy systems and organizing distributed political power, allows for greater energy democracy and potentially democracy writ large. Vakulchuk et. al (Vakulchuk et al., 2020) in their review of renewable energy and geopolitics, argue that countries may democratize as the world shifts towards a renewable based energy economy for three main reasons. First, the decline in foreign earnings for petro-states may destabilize rulers as their populations rise up against them and usher in democracy; second, the decentralized nature of renewable energy will create more equal relationships between elites and non-elites, and third, renewable energy projects involve more democratic processes to manage, distribute and use energy, which will ultimately lead to democratic diffusion and stability.

Renewable energy also holds the potential to establish positive peace within geopolitical security risks (Su et. Al, 2021). After an empirical review of existing literature, Su et. al broadly determine that geopolitical risk has a positive effect on renewables–and vice versa. But by lessening the global dependency on fossil fuels, sources have observed that renewable energy may thus reduce associated geopolitical tensions. Importantly, the findings suggest that renewable energy can increase the interdependence of nations, promoting a lasting peace unattainable by traditional energy sources.

One evaluation of a community-level renewable energy project – a wind project on the Scottish island of Shapinsay – found that the project increased political efficacy and mobilization through increased co-operation and communication between the community and its local government (van der Waal, 2020).

Access to energy and renewable energy also has the potential to improve public service delivery, in particular health and education services, which are critical to any well-functioning state. A 2018 recent survey of conditions in health facilities in developing countries, found that only 41% of the 78 countries surveyed had health care facilities with reliable electricity. A 2017 UNESCO survey of electricity access in schools revealed that only an estimated 35% of primary schools in sub-Saharan Africa had access to electricity (Sustainable Energy for All, 2019) .

Off-grid renewable energy systems may provide a cost-effective and reliable option to electrify health care centers and schools, directly contributing to better public service delivery – and SDGs 3 and 4. For example, evaluations of World Bank programs in Bangladesh and Kenya found that health facilities with reliable electricity were open for longer (on average an hour more per day), and that electrified health centers attracted more qualified health workers (IEG, 2008). Better health services are particularly critical in light of the current Covid-19 pandemic.

3.2.2 High levels of Human Capital

Human Capital is the stock of intangible knowledge, social and other personal attributes such as health, that enable economic productivity.

The theoretical link between renewable energy and improving levels of human capital runs through two domains: health and education.

On the health front, increased energy access is thought to deliver benefits by, for example, the electrification of health centers leading to improved services, and household electrification allowing further access to health information, which in turn could lead to improved health and lower birth rates. The 2019 ADB meta-study found that in evaluations of impacts of electrification in Bangladesh, Colombia, Ghana, and Tanzania, there was reduced fertility from household electrification (Raitzer & Sibal, 2019).

Renewable energy has additional health benefits by potentially alleviating the need to use hazardous alternative energy sources such as charcoal for cooking, particularly harmful to health when used indoors. For example, in El Salvador an electrification program was found to reduce the incidence of respiratory infections by 6% in children under six, by reducing the overnight fine particulate matter ($PM_{2.5}$) concentration (Barron, & Torero, 2015).

Renewable energy has also been proven to be a highly promising form of rural electrification for health care centers (Moner-Girona et. al, 2021). A recent study of nearly 57,000 sub-Saharan African health care centers found that if all facilities were provided with PV systems, when considering only walking as a means of traveling, 298 million people would reduce their travel time by an average of 6 hours. Decentralized solar systems offer a reliable, quick, and cost-effective means to increase electricity access while providing critical social benefits.

On the education front, energy access in general is thought to increase educational outcomes such as literacy and school attendance. By enabling lighting at school, schools can offer lessons and learning in the evening, including for adults, they can introduce Information Communication Technology (ICT) into the class-room and they can enhance staff retention and teacher training (UNDESA, 2014).

Further, by enabling lighting at home, students are able to do homework and study in the evening, for example. An evaluation of two community renewable energy projects in Afghanistan found that at the household level, one of the biggest changes in welfare emanating from electrification was an improvement in learning conditions for children (Shoaib et al., 2016). In Kenya, an evaluation of the effects of solar lanterns found large effects on both study hours and grades (Hassan & Lucchino, 2016).

However, on the other hand, a randomized control trial evaluating the impact of an off-grid solar micro-grid project in India, across 1,281 rural households found little evidence of increased study time (or other socio-economic benefits such as business creation). But the authors argue that could be due to the small scale of the 'treatment': five hours of lighting and phone charging per day was offered to households at a subsidised cost (Aklin et al., 2017).

Enabling the use of electrified household appliances or machinery on the household farm may lead to a decreased need or desire to keep children at home to do manual labour and allow them to attend school. A meta-analysis of 85 impact evaluations conducted by the

Asian Development Bank found that across all studies where educational outcomes were measured, there was an average increase in school enrolments of 7%. However, one of the evaluations under study, in Honduras, found that electrification led to an increase in dropout rates among school boys (of 4.3%), and a negative effect on girls' years of schooling (reduced by an average of 34.7%), both caused by an increase in child employment after electrification (Jimenez, 2017).

3.2.3 Sound Business Environment

Sound Business Environment refers to the strength of economic conditions as well as the formal institutions that support the operation of the private sector to enable business competitiveness and economic productivity.

The theoretical link between energy access and boosting economic development suggests that with electrification will come an ability to reallocate time away from unproductive activities, such as household chores, towards more productive activities aimed at enhancing income generation (for example, manufacturing or agriculture)—thereby increasing employment opportunities and the potential to start businesses.

A meta-analysis of 30 small-scale sustainable energy projects in the global south (Terrapon-Pfaff et al., 2018) found some evidence for an improved business environment: in 50% of analysed projects, beneficiaries established new productive uses of energy; and in 27%, beneficiaries focused on improving current productive uses of energy. In 38% of analysed projects increased employment opportunities were generated.

But evidence is certainly mixed, especially across differing means of evaluating success. A study conducted across 16 states in India found that an increase in rural electricity connections generated large increases in manufacturing output, and increases in the number of small firms (Jimenez, 2017). Other studies, however, have found that controlling for other factors, electrification does not significantly affect firm performance in terms of profits, business income and employment growth (IEG, 2008).

3.2.4 An Equitable Distribution of Resources

Equitable distribution of resources includes equity in access to education, health, and equality in income distribution.

"Ensuring access to affordable, reliable, sustainable, and modern energy for all (SDG 7) is a key condition for reducing inequalities (SDG 10)."[6] The *Accelerating SDG 7* policy brief goes on to argue that the key to reducing income inequalities, gender inequalities, and inequalities in other dimensions such as rural/urban divides, is a reduction in the global energy disparity. Renewable energy is seen as a potentially catalyst in reducing energy inequalities, and in the longer term income inequalities as well.

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[6] UNDESA, "Energy and SDG 10 Reduced Inequalities", Policy Brief 6 – Accelerating SDG 7 Achievement. Pg. 2.

In many cases where some form of energy access is available, it is the poorest segment of society that ends up paying disproportionate shares of their income to energy. For example, an analysis of the U.S found that low-income households spend about 9% of their incomes on electricity, compared to just 3% for the average American. The study argues that by increasing access to affordable solar systems, this large income burden would be alleviated, contributing to a more equitable and just society (Sen, 2017). And it is a fact that the costs of renewable technologies continue to decrease: IRENA estimates that since 2010, solar PV module prices have fallen by almost 90%, while wind turbine prices by 55%.[7]

In many cases where some form of energy access is available, it is the poorest segment of society that ends up paying disproportionate shares of their income to energy. For example, an analysis of nine developing countries in Asia and Africa found that the percentage of household expenditure on energy sharply decreases as income rises. The authors emphasize that not only are lower-income households spending a higher percentage of their income on energy, but they are also relying heavily on biomass, rather than modern energy services (Bacon et al, 2010). Relieving this reliance on biomass, the declining prices of renewable technologies may contribute to a more equitable distribution of modern energy resources in developing countries. And it is a fact that the costs of renewable technologies continue to decrease: IRENA estimates that since 2010, solar PV module prices have fallen by almost 90%, while wind turbine prices by 55%.

What *kind* of energy access matters to inequality outcomes. A 2017 Oxfam study found that reliance on connecting to existing grids in sub-Saharan Africa favour wealthier communities, and can even exacerbate inequalities both within communities, and across them (Avila et al., 2017). This in turn can exacerbate conflict dynamics. A study of the Virunga Hydropower station in the eastern Democratic Republic of Congo (DRC) found evidence that the project 'illuminated' class differences within and between communities, as only the richer households could ultimately pay to connect (Marijnen & Schouten, 2019).

But renewable energy projects, particularly smaller scale, decentralized, and off-grid, can reduce inequalities. A recent (2020) empirical study on the link between renewable energy consumption and income inequality across 23 developed economies, found that in the time period between 1990 and 2014, there is evidence to suggest a link between increased renewable energy consumption and a decrease in income inequality (Topcu & Tugcu, 2020), although the direction of causality cannot be determined with certainty.

Renewable energy projects can help reduce income inequalities by providing employment opportunities either directly related to the project or in peripheral sectors. A 2013 analysis of the job potential from renewables in South Africa, for example, found that if an additional 62 terrawatt hours (TwH) were generated through renewable means, an additional 57,000 jobs would results, as compared to 43,000 new jobs if the energy were to come from fossil fuels (Petrie, 2013). Renewable energy projects can also facilitate business and livelihood opportunities which can help reduce income gaps, particularly for women. A meta-study of 38 energy access projects globally, for example, found a significant effect of electricity access on household poverty as well as household income (particularly non-farm income) (Moore et al., 2020).

[7] https://www.irena.org/costs

3.2.5 Low levels of Corruption

Corruption can lead to inefficiency in resource allocation, public distrust and a lack of funding for public goods and services, as well as civil unrest.

In their report outlining why renewable energy investments in fragile states should be prioritised, Sacchetto et.al (2020) argue that one of the benefits of renewable energy systems is their decentralized nature – particularly true for wind and solar – a characteristic which can reduce corruption inherent in large scale infrastructure projects (Sacchetto et al., 2020). Fossil fuel based power generation is generally reliant on concentrated power generation which in turn means that control of the grid is concentrated, predisposing these systems to corruption. Decentralised energy systems are more amenable to spreading control over power generation to a local level, which can create local economic benefits without corrupt influences (Stephens, 2019).

Another view-point argues that even in renewable energy, corruption and improper government action can exist, when there aren't necessary institutional controls in place. In many cases, the corruption or criminality are linked to the large investments in renewables and subsidy schemes that donors or governments are using to incentivize the uptake of renewables (Lyons, 2015). A study in Italy for example found that in the presence of weak institutions, wind renewable energy projects were increasingly hijacked by criminal activity because of the profitability linked to a government subsidy, and levels of corruption were high (Gennaioli & Tavoni, 2016).

There is a dearth of evaluative research that has been conducted on the link between renewable energy and corruption to provide conclusive evidence one way or another.

3.2.6 Acceptance of the Rights of Others

Acceptance of the Rights of Others includes formal laws guaranteeing basic human rights and freedoms as well as informal social and cultural norms that relate to the behaviours of people. It includes rights and empowerment for minority groups and non-discrimination.

Improved energy access and electrification is theorized to improve gender equality and lead to the empowerment of women, contributing to a more equal and cohesive society. Specifically, it has been claimed that women can become more independent, more involved in decision-making at household and community levels, and this empowerment leads ultimately to greater gender equality (ADB, 2018). One theory of change posits that energy projects such as solar lanterns enable ownership of resources and enhanced skills for women, in turn increasing their confidence and decision making power. For example, an evaluation by the ADB on enhancing energy-based livelihoods for women micro-entrepreneurs in India found that training on energy use, coupled with electricity access, can help to change the relative role of women in household decision-making, as well as their 'position' in community through a recognition of women's new skills (ADB, 2018).

Another causal mechanism suggests that electrification may give women the opportunity to use their time more productively and generate income or become employed. A meta-analysis of 85 impact evaluations of energy projects found that on average, across the reviewed studies, labour market participation increased by 25%, with women benefiting slightly more (Raitzer & Sibal, 2019). The meta-analysis identified several relevant studies: in Guatemala, a study found significant increases in female paid work time from rural electrification; a study in Nicaragua found a 23% increase in the propensity to work outside the home for females with electrification; and a study in South Africa found that electrification leads to a 9% increase in female employment rate.

3.2.7 Good Relations with Neighbours

Good Relations with Neighbours is defined as peaceful internal and external relations within and around a country. Internally, it refers to socially cohesive relationships between groups within a country.

It has been argued that access to electricity, through its impact on the use of communication devices such as phones, can increase social cohesion through increasing connectivity. A study of the impacts of mobile phone access and usage in 11 emerging economies found that 53% of surveyed adults said that mobile phones have had a positive effect on family cohesion (versus 20% saying negative effect), and that 47% stated a positive effect on civility (versus 25% saying negative effect).[8]

Renewable energy access has also been linked to fostering social cohesion through community energy project mechanisms. These projects are a form of community driven development, which have been seen as a valuable platform for promoting social cohesion and building social capital in fragile and post-conflict environments particularly, although impact evidence for such results where projects have been implemented is mixed (White et al., 2018).

Community renewable energy projects—power generated by localities rather than large energy providers such as village mini-grids—are argued to deliver a host of benefits where they are implemented, above and beyond climate protection and environmental benefits, including building community and social cohesion (Brummer, 2018). Unfortunately, there are few evaluations of whether these projects that have been implemented have actually resulted in increased social cohesion. One evaluation of a community wind project on the island of Shapinsay in Scotland found some increase in perceptions of community cohesion (van der Waal, 2020).

3.2.8 Free flow of information

Free flow of information relates not only to a free and independent press, but also to transparency within governance institutions and an environment in which access to information is made possible in a timely manner.

With access to electricity comes the ability to charge mobile phones and acquire other household appliances such as radio and televisions. Mobile phone charging increases phone usage and hence connectivity, potentially allows for increased access to internet, and the sharing of information. The ability to listen to radio or watch television can also increase access to information and news. An overview of the impact of off-grid solar across West and

[8] Pew Research Center, “Mobile Connectivity in Emerging Economies”, March 2019. Accessed at: https://www.pewresearch.org/internet/2019/03/07/mobile-connectivity-in-emerging-economies/

East Africa and South Asia found that in the African contexts in particular, access to electricity resulted in higher phone usage.[9]

An evaluation of the impact of off-grid solar home systems in Kenya found that households who received such a system reported an almost two-fold increase in weekly hours of radio compared to before acquiring the system. Furthermore, 75% of the households reported local news to be amongst the top four types of programming they listen to on the radio – a higher proportion than any other type of programming (Shell Foundation, 2020).[10] A meta-analysis of the studies of impacts of renewable energy access projects in developing countries found that access to TV and other media has a wide range of effects on social attitudes and behaviours, through the provision of information (IOB, 2013). For example, a 2008 independent evaluation of the World Bank Group found a positive association between watching television and decreased fertility in nine countries, due to better knowledge about contraception (World Bank, 2008).

It has also been argued that increased phone usage has also led to increases in cohesion across dispersed families and communities, and a broader sense of inclusion (Goodman, 2005).

4. Energy and Conflict

There is an abundance of literature and research on the nexus between energy and conflict, ranging from the geopolitics around energy supply and demand at a global level, to the direct linkage of energy access to conflict and social instability at a micro-level. Rather than getting into the intricacies of this more general topic, this section looks specifically at the state of knowledge on the link between renewable energy and conflict.

4.1 Renewable Energy and Conflict

To date there has been much less research on the links between renewable energy and conflict.

Why might a renewable energy-based world have a different effect on conflict dynamics than the current fossil-fuel based one? To start with, on a global scale, it is expected that a transition to renewables will lead to a geopolitical reshuffle, as fossil fuel exporters such as Saudi Arabia may face serious stagnation in their main economic life-line, leading to economic destabilization, and potentially political destabilization.

In a 2020 review of the links between renewables and conflict, Vakulchuk et al. highlight two camps; one that argues that a move to renewable energy will reduce conflict dynamics, the other that argues that renewables may renew or at least not diminish conflict dynamics. Arguments for ‘reduced conflict’ include the following: an expansion of renewable energy will lead to greater energy self-sufficiency; that because renewable resources are geographically more spread out and diverse, there are less reasons to start wars over controlling these, and that renewable energy will bring about a more equitable distribution

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[9] These results were self-reported as follows: 89% respondents in East Africa and 93% of respondents in West Africa. See GOGLA, “Powering Opportunity: Energizing Work, Enterprise and Quality of Life with Off-Grid Solar”, May 2020

[10] The report links access to information directly to SDG 16.

of energy and hence in the long-term a decrease in development gaps (Vakulchuk et al., 2020).

A broader argument linking renewable energy to conflict mitigation runs along the following lines. The effects of climate change can exacerbate conflict factors in fragile states that are climate vulnerable: a transition to renewable energy and away from fossil fuels will decrease climate pressure, and hence in the long-term potentially decrease climate change factors that exacerbate conflict (Edwards, n.d.). In other words, reduced greenhouse gas emissions due to increased renewable energy usage should reduce the risk of conflict that climate change effects would otherwise cause.

Yet another version of the 'reduced conflict' case argues that because renewable energy depends on flows and not on extraction of resources, at a state level there may be less incentive to engage in conflict for control. However, because RE infrastructure may increase competition for land, conflict may be driven to the more localised level and particularly involve non-state actors (Mansson, 2015). The Lake Turkana Wind Power Project in Kenya, Africa's largest windfarm, is highlighted as an example of this dynamic, which has pitted the project's investors and supporters against local communities, resulting in sometimes violent protests, and litigation.[11]

Arguments for 'increased conflict' on the other hand, believe that if the transition to renewables occurs under the same conditions of high energy consumption as currently exist, energy security vulnerabilities could still lead to increased conflict, and there is in fact a higher risk of cyber-conflict in trying to take control of RE systems. Furthermore, they argue that the dependence on critical materials to make some parts of RE systems (for example minerals for solar panels), may lead to conflict over control over these rare earth minerals, in the same way we fight for control over oil today (Vakulchuk et al., 2020). A 2018 report by the International Institute for Sustainable Development finds that a significant portion of minerals required for green technologies are located in states with high measures of fragility and corruption (IISD, 2018). For example, over 60% of the world's cobalt reserves – critical to battery production for electric cars and energy storage – is found in the DRC, which as of 2020 ranked 156th of 163 on the Positive Peace Index.

A more nuanced argument relating renewable energy projects and conflict claims that it can do so by exacerbating pre-existing fragilities, tensions, and cleavages. For example, an evaluative study of the Virunga Hydropower project in Eastern DRC found that the centralization of electricity supply through this project (as opposed to the decentralized charcoal based system of energy supply previously), actually increased rent-seeking by political elites and amplified social inequalities in the area. While the project was successful in producing social opportunity through job creation, providing long-term benefits to ex-combatants in an effort to sustain peace, and increased access to electricity around the park, many people in the communities where electricity was now available could not afford to connect (Marijnen & Schouten, 2019).

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[11] PRIO blog, "Renewable Energy as an Opportunity for Peace?", 2 April 2020. Accessed at https://www.sipri.org/commentary/blog/2020/renewable-energy-opportunity-peace

5. Conclusions

Energy access, and particularly clean energy access, has not only been called out as a crucial global development goal but also as a building block for many, if not all, the other goals set out in the 2030 agenda. Energy access, and restoration of energy access, has also been called out as particularly critical in the often-overlapping situations of energy poverty, conflict, and climate vulnerability. Renewable energy has the potential to mediate this tri-nexus, but only when renewable energy projects are conducted in a context-specific way.

There are many studies, both theoretical and empirical, that look at the social impact of energy access, above and beyond economic and environmental impacts, but also many conclusions and findings that arise from these studies. There is variation in project type, geography, time-period of intervention, as well as evaluation methodology, factors which all may contribute to these varied findings. There are few studies, however, of the impacts of energy access and renewable energy projects in particular in conflict and fragile settings.

The Positive Peace framework can provide a comprehensive methodology for analysing social benefits of renewable energy, and ultimately the peace benefits. In fact many of the outcome variables analysed in the hundreds of evaluations conducted so far are directly or indirectly linked to one or more of the eight pillars of Positive Peace, although they may not be discussed as such.

EPP will be able to look to the evidence base in developing its theory of change linking renewable energy interventions to the pillars of Positive Peace, and, will be able to leverage the existing manuals/guides for monitoring and evaluating energy for development interventions, in terms of developing the indicators and methodology for data collection, thus ensuring the use of 'best-practices'.

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Annex A: Summaries of Selected Literature

T. Ide et. Al, "Multi-method evidence for when and how climate-related disasters contribute to armed conflict risk", Global Environmental Change 62, 2020

Triangulating three methods – event coincidence analysis, qualitative comparative analysis and case studies – the authors find evidence to support the hypothesis that climate-related disasters increase the risk of armed conflict onset. Countries with large populations, political exclusion of ethnic groups and low human development are particularly vulnerable to this form of conflict onset. They find that for this group of vulnerable countries, almost one-third of all conflict onsets between 1980 and 2016 were preceded by a disaster within 7 days. Furthermore, the effect is found to be independent of the severity of the climate disaster.

The authors find that the mechanism linking climate disaster to increased risk of conflict onset is the improved opportunity structures for armed groups to escalate violence in ongoing conflicts in the aftermath of such disasters.

A. Eales et. Al, "Social Impacts of Mini-grids: Towards an Evaluation Methodology",

Authors' starting point is that although there is a general acceptance of the benefits of rural electrification through mini-grids, it is not often based on any evidence of these social benefit impacts. They provide an overview of the current knowledgebase on social impacts and methodologies used to assess these impacts.

Electrification can improve the quality of life by increasing levels of health, education, welfare and technology. UNDP finds that per capita electricity service is highly correlated with improvements in the HDI. Rural electrification in particular is crucial to development – found to increase youth literacy rates and enhance employment especially for women.

Authors recommend a three-pillared measurement framework to quantify the benefits of minigrids: social, economic and technical. They list indicators they consider relevant under each pillar.

E. Marijnen and P. Schouten, "Electrifying the green peace? Electrification, conservation and conflict in Eastern Congo", Conflict, Security and Development, 19:1, 2019
The authors look at the Virunga Hydro-power project in eastern DRC to analyse the political and social effects of electrification, and find that the centralization of electricity supply through this project (as opposed to decentralized charcoal based energy), increased electrification actually leads to rent-seeking by political elites, amplifying social inequalities in Congo. They call this project a form of 'techno politics'.
The Virunga Alliance (public-private partnership), was established to manage the seven hydro power stations, with three goals in mind; generate resources for the park to help with conservation efforts, contribute to sustainable development by providing electricity to rural communities allowing livelihood generation amongst other things, and peace-building – specifically, by luring young men away from engaging in violence to employment opportunities within the park and hydro stations.
VA theory of change:
Electricity → Creates jobs → alternative to joining rebel groups and fighting, especially for young men
Hydropower → Decreased use of charcoal → conservation and less environmental degradation
Hydropower → attracts business and investment → economic growth and development
Authors point of departure is that electricity and large technical systems more generally don't constitute a neutral background to society, but actively help shape in the constitution of society.
They find unexpected tensions that arise from the Virunga project:

- Illuminated and/or exacerbated class differences: most people in the communities around the park cannot afford to connect to the electricity – so there's an illumination of class difference, and sometimes these class differences also fall on pre-existing cleavages. Also electricity runs along the main road – those who are richer live closer to main road, and can also access electricity more easily. Those who are poorer live further – it's harder and more expensive to access.
- Privatizing a public good: because there is more supply than demand for electricity locally, the VA needs to sell of excess supply – and rich savvy businessmen have formed a conglomerate electricity distribution company to do that. They sell to Goma, to their inner circles and expats – so they become richer, and most of Goma's residents also remain without electricity.
- Empowering the predatory state: centralizing infrastructure goes hand in hand with the spread of illicit taxation and the predatory state. There's also been an increase in small business around Virunga which has amplified informal taxes and roadblocks.

C. Sacchetto et. Al. "Priorities for renewable energy investment in fragile states", International Growth Centre, November 2020
The authors provide arguments as to why investing in renewables in fragile states is not only cost-effective with a good RoI but also contributes to building state resilience.

They argue that conflict, poverty and poor governance all increase a state's vulnerability to climate change, and further that fragile countries have the lowest levels of access to electricity.
RE make sense because of the declining costs of RE, because it allows for increased and secure energy access, it allows for economic resilience, and leads to inclusion and empowerment, particularly for women.

1. Renewable energy makes economic sense: Re costs have fallen significantly, but fragile states aren't benefitting from these cost reductions.
2. Decentralised energy generation leads to increased energy access, and more secure energy access: centralised energy grids are more vulnerable to infrastructure attacks, and also more prone to corruption because power is more concentrated.
    a. Decentralization can lead to democratization of energy and allow more people to access. Can also lead to less reliance on importing fuels. Decentralized systems allow for diversification of energy supply, and are more modular and flexible and easer to build.
3. Innovative financing may be the key to unlocking energy investment in fragile settings
4. Inclusive energy distribution: can produce positive impacts from a gender perspective for example by decreasing burden on women to collect fire wood which makes them susceptible to attacks. Also allows economic empowerment if women have access to electricity and can make livelihoods
5. Investment in RE can be seen as building state capacity and public service delivery which is particularly important in post-conflict settings

M. Burke and J. Stephens, "Political Power and Renewable Energy Futures: A Critical Review", Energy Research and Social Science, 35, 2018
The authors examine evidence for the idea that RE – through the enablement od decentralized energy systems – enable and organize distributed political power, and vice versa. They conclude that RE offers a possibility, but not a certainty, for more democratic energy futures.
Although energy democracy is not explicitly defined, it involves the notion of reclaiming the energy sector (which is considered to be central sit eof political –economic struggle), away from centralized corporate utilities to shift power to workers, households, the community and public. It involves delivering tangible public benefits including decent and stable employment, and new public institutions, and ensuring fair access to energy.
The shift to renewable energy is seen not only as a technological or environmental change, but also a re-ordering of political and social relations. Energy – technological politics; energy sources or technologies based on concentrated sources such as fossil fuels tend to organize and enable concentrated forms of power and centralized or authoritarian politics, for example, oil.

Why would renewables allow for greater energy democracy, and maybe even democracy writ large?

1. RE enables citizens to take on new roles as producers and owners and therefore inspire new patterns of thinking which may increase interest in policy and decision making.
2. Ease of access to and ownership of modular end use technologies allows more people into the decision making space.

3. RE increases competition in energy markets creating space for new constituencies and alliances
4. RE enables greater diversity of local practices, increasing learning and inclusivity.
5. The complexity of operating RE infratsructures requires governance structures that engage with a wide spectrum of stakeholders.

IEG, "the Welfare Impact of Rural Electrification: A Reassessment of Costs and Benefits", IEG Impact Evaluation, World Bank, 2008
Examines the work on rural electrification projects to assess who benefits and under what conditions – looking at WB's projects in Bangladesh.
Key Findings:

- Widely recognized that the larger share of benefits from rural electrification is captured by the non-poor – but the gap closes as coverage expands. This pattern is due to two factors; which communities get connected, and which households can afford the connection.
    - In most countries, decisions on who gets connected are made on a "least-cost" basis, i.e. which are closest to grids or main roads, which also tend to be better off.
    - In most countries, increased coverage comes from extending the grid to other communities rather than getting more households within a community connected – the fee to connect is often too high for poor households even in a connected community, so inequalities exist or are exacerbated.

R. Vakulchuk et. Al., "Renewable Energy and Geopolitics: A Review", Renewable and Sustainable Energy Reviews 122, 2020
Authors look at and review the existing literature on the geopolitical consequences of renewable energy transition – as opposed to the current fossil-fuel status quo. They find two camps, one which argues that a move to RE will reduce conflict, and the other which argues that it may renew/or at least not reduce conflict.
RE → Reduced conflict arguments:

- Expansion of RE will lead to greater energy self sufficiency as it is more difficult to control, cut the supply or manipulate the price of RE. Due to geographically more even spread and decentralized technical nature, there's less reason to start wars to control it, and may even create more reasons to collaborate.
- More equitable energy distribution.

RE → No less conflict arguments:

- If transition to RE occurs under conditions of just as high energy consumption as present, then energy security vulnerabilities could still lead to increased conflict, for example disrupting power supply or geopolitical instability in energy producing countries.
- Dependence on critical materials for RE, for example to make solar panels, will mean accessing these minerals could lead to conflict, and dependence on countries that possess these materials, in the same way we rely on fossil fuel countries currently. Dependence on rare earth materials.
- Increasing risk of cyber-attacks with RE

There is agreement that the transition to RE will lead to a geo-political reshuffle, but disagreement on whether world will become more multi-polar, or just create new centres of polarity. Fossil fuel exporters may be biggest losers, as their key economic sector may stagnate, leading to economic destabilization and loss of geopolitical power. At the same time, countries that lead the transition will have a chance to come out on top – getting ahead of the curve on producing and exporting RE technologies and IP, leading to increased employment and revenues (according to IRENA). But may lead to trade wars?

Democratization of countries due to renewables:

- Decline in foreign earnings for petro-states may destabilize rulers as people rise up against them, and usher in democracy
- Decentralized nature of RE will create more equal relationship between elites and people
- Applying democratic peace theory then… as more countries become democratic, less chance of war
- RE involves more democratic processes to manage, distribute and use, and thus ultimately will lead to more stability.

M. Aklin et. Al., "Does basic energy access generate socioeconomic benefits? A field experiment with off-grid solar power in India", Science Advances 3, 2017

Randomized Control Trial conducted in India to examine the causal effect of off-grid solar power on electricity access and socio-economic indicators across 1281 rural households.

Key findings:

- Electrification rates in treatment group was significantly higher than in control group – up by 29 to 36 percentage points. But, daily consumption of electricity was not significantly different in treated and non-treated groups increasing only marginally.
- Found no evidence of socio-economic benefits: no effects on savings, household expenditures, business creation, time spent in productive work by women, use of lighting for study, reduction in violence for women.

P. da Silveira et. Al. "The power of light" socio-economic and environmental implications of a rural electrification program in Brazil", Environmental Research Letters 12, 2017

The authors assess the impact of a "Light for All" program that was launched in 2003 to bring electricity to the poorest regions of Brazil. They look at the socio-economic impacts, in particular the three components of the Human Development index; Health, Education and Income.

Their results find that the program had a positive effect on all three components, with the education results most impacted – although this result was achieved with complementary policies in place. They used a panel regression model alone to arrive at their conclusions; constructing a municipal level HDI but not controlling for anything other than a sum of money given to municipalities to manage the grant program. This seems to be a pretty clear methodological oversight – and probably don't want to rate this finding very highly based on this method.

T. Bernard, "Impact Analysis of Rural Electrification Projects in sub-Saharan Africa", The World Bank Research Observer, September 2010

Although slightly dated, this piece documents the *few* evaluations of electrification projects undertaken in sub-Saharan Africa. As of 2010, electrification rates were particularly low in the region, at only 40 percent, and electricity generation per capita was at 1/10th that in south and east asia. Rural electrification in the region was even lower, at 10 percent.

There was a lot of attention brought to the need for investing in infrastructure development here, and donors and the public sector in particular tried to intervene for three reasons: 1. Rural electrification is believed to help alleviate poverty through the enhancement of income and employment opportunities, as well as the development of human capital, and in the long-run the reduction of environmental pressures; 2. Typically the private sector's involvement in promoting rural electrification is low, so donors and govt's need to step in, and; 3. Rural electrification development responds to political incentives for governments – "governments consider it their duty to promote RE as a means to enrich economic and social cohesion across the territory." (p.g. 35)

The author distinguishes three phases over the period 1980-2010 with respect to rural electrification policies in sub-Saharan Africa. The first period involved many infrastructure for development projects, where RE was considered part of the solution to enhancing growth. In the late 80s and early 90s focus turned toward structural adjustment and away from RE, which was seen as contributing to a high debt burden of these countries and 'disappointing results' (although they were rarely evaluated). In particular low connection rates and low productive uses of electricity. The final period from the late 1990s and the adoption of the MDGs in 2000 focus again returned to the importance of energy as a necessary condition to fight poverty, enhance well-being and gender empowerment.

As of 2010, the author described the situation as follows:

- Low connectivity: even where electricity is provided, rural households remain largely unconnected – studies showing between 12 and 39 percent. Part of the explanation is connection costs which are very high, but also in the low perception of the benefits of electricty.
- Limited productive use: use of electricity is mainly for lighting and radio or TV, rather than productive uses, or even domestic uses.
    - 'electricity ladder hypothesis': households will switch to more efficient and clean fuels as they become available and their income increases. Little evidence that this is happening, and instead electricity is complementing other energy sources such as wood
- Lack of evidence for the impact of rural electrification projects: author finds three main reasons why there have been few attempts to measure this.
    - Energy acts as an enabler of development affecting lots of outcomes, which in turn are hard to aggregate to one cost-benefit ratio
    - RE programs affect final outcomes through long causal chains that may also be affected by the interaction of other external factors
    - Issue of what is the appropriate timing of measurement? Author states that potentially using intermediate indicators is a solution
    - Attribution problems: how much of the change is actually due to the project: simple before and after observations can show correlation but not causation. Comparing units "with" and "without" electricity also must account for initial conditions such as differences in poverty rates.
- Some methods used for IE:
    - Instrumental variables estimation: 2008 paper looking at rollout of universal electrification plan in South Africa. Uses community's land gradient as a predictor of electrification (which is not directly related to the DV of

employment rate of women). Found that thanks to electrification women are 13 percent more likely to participate in local labor market.

  - DiD estimators on matched samples: study on RE program in Vietnam, finding that electricity led to an increase in farm income but not other sources of income.
  - Randomized household-level encouragement: Ethiopia – looks at the effect of "smart subsidies" in take up of electricity connection in poor rural households, with vouchers randomly distributed in 10 villages.
  - Randomized phasing-in across communities: Kenya – looking at the impact of mini grids on electrification by randomly selecting which villages get electricity first, and then matched pairing those villages in first wave to those in second wave of electrification.

IRENA, "The socio-economic Benefits of Solar and Wind Energy: and econValue report", May 2014

IRENA proposes a framework for analysing socio-economic benefits of large scale renewable energy deployment, classifying them along four lines: macro-economic, distributional, energy-system related, and 'other'.

This report looks more deeply only at the macro-economic benefits and classifies these as; value added, gross domestic product, welfare and employment. However, descriptions of the other categories of benefits are as follows:

- Distributional; allocation of both positive and negative effects to different stakeholders within the energy sector. This can be among stakeholders within RE sector itself, within energy sector as a whole – RE v. traditional, through the economy from local to national to global, between different agents e.g. households v. government, and between different generations.
- Energy system related effects; additional costs and benefits of a system with RE as opposed to one without. E.g additional generation costs, grid costs v. benefits of reduced negative environmental externalities.
- Additional effects; catch-all for other stuff such as risk reduction, reduction of geopolitical and financial risks.

The report states that SE benefits can occur at many points along the value chain including project planning, manufacturing, installation, grid connection, operation and maintenance and decommissioning.

For the macro-economic benefits, IRENA talks about them as follows:

- Value added: value of G/S produced less value of consumption of intermediate inputs, and can be considered at micro-, meso-, or macro-level. Micro is more firm level, meso is industry level and macro is economy as a whole.
- GDP: "Research shows that the impact of RE deployment on GDP is overall positive despite limitations of existing approaches to assess it"(p.g 23)
- Welfare: focus on HDI
- Employment: is there a net gain or loss (displacing employment from fossil fuel industry)? Still debated. But argument is that decentralized nature of RE means more jobs. There are both direct and indirect jobs

Goes into detail about opportunities for value creation along the value chain.

Practical Action, "Ensuring refugee camps in Rwanda have Access to Sustainable Energy", 2020

PA together with partner organizations conducted a study on the situation of refugees living in camps in Rwanda, in terms of their access to electricity, in light of SDG 7 which explicitly references the needs of refugees and displaced people in its goal of providing sustainable, affordable and reliable access to energy for all.

Five key challenges to providing access to refugees and displaced people have been identified: 1. Energy is not a formal priority in humanitarian assistance; 2. Displaced people aren't included in national or international energy agendas; 3. Energy in displacement settings is under-funded; 4. Expertise and capacity to implement humanitarian energy solutions is limited, and 4; Data on humanitarian energy needs and solutions is limited.

The key findings of the report as related to energy access in these camps are as follows; access to electricity in refugee households is below the target set by Rwandan government, most households rely on firewood as primary source of cooking fuel, women spend three times more time on household chores than men, domestic energy needs are of highest priority and camp minigrids while providing high rates of electrification to services, rely on carbon-intensive sources of power. They conducted large scale surveys of households, enterprises and community facilities across three camps.

Renewable Energy for Refugees project: Three interventions targeting delivery of solar home systems in camps, increase access to improved cooking solutions, provide stand-alone streetlights for public spaces and provide solar electricity to camp institutions to reduce usage of diesel generators.

J. Terrapon-Pfaff et. Al., "Impact Pathways of small-scale energy projects in the global south – Findings from a systematic evaluation", Renewable and Sustainable Energy Reviews 95, 2018, p.g 84-94

The authors' premise is that despite the increased attention being focused on small-scale renewable energy projects in the developing world as a means to address energy poverty and thereby reduce poverty and support social and economic development, there is little systematic evidence on what actual impacts of these projects have been. They address this by providing a systematic analysis of three impact pathways (across 30 small-scale sustainable energy projects), through a method known as 'contribution analysis'. The overarching finding is that technological issues aren't the decisive factor in achieving development outcomes, but rather, that account must be taken of social, cultural, economic and environmental impacts.

The authors claim that along with the dearth of analysis of impact of small-scale energy interventions, the evaluations that do exist tend to only evaluate "what works" rather than also figuring out why and how – and that evaluations need to take a longer time horizon into consideration as human development is sticky and tends to change slowly.

They opt for change analysis as a method of evaluation as they claim that "the analysis tests the stablished theory against observed results while taking different sources of evidence and other influencing factors into account." They claim the aim with such analysis is not to establish impact but to increase the confidence that the intervention actually caused the impact.

Their 'contribution challenge' (step one of contribution analysis) is to figure out "how access to sustainable energy livelihoods can improve livelihoods and support sustainable development". They outline a number of impact pathways that have been previously suggested in studies and literature.

Small scale energy projects → increase of economic activities and employment

- → Empowerment of disadvantaged groups
- → Improvement of health
- → Development of human capacity
- → Increased awareness and dissemination of renewable energies

They focus on three impact pathways in their analysis of evidence, and for each of these they develop a theory of change

1. **Contribution to the dissemination of renewable energy solutions**

TOC:
Successful demonstration of small scale energy solutions → increased acceptance and local uptake → replication
Results:

- 87% of analysed projects were still providing energy to their beneficieries
- Of those still functioning 58% fully met energy needs
- Replications in project areas took place in 77% of cases, and outside project areas model implemented in 65% of cases analysed

Why results were achieved:

- Continuous engagement with implementing org and working with existing community structures helps with replication efforts

2. **Productive use of energy to increase income and livelihoods**

TOC:
Reduced time and labor efforts in household chores etc → increased time and labor efforts for other uses → new productive activities → employment, income increase
Enhanced skills and awareness of business opportunities → improvement of existing productive activities → employment, income increase
Results:

- 50% projects established new productive uses, 27% focused on improving current productive activities, 23% energy for consumption
- One third reported increased income
- 38% generated increased employment opportunities

Why results were achieved:

- Beneficieries need training on opportunities
- Financing options must be available for small scale entrepreneurs

3. **The contribution of energy projects to the empowerment of women**

TOC:
Ownership of resources, enhanced skills and awareness of women → increased influence and decision making power, gain in confidence → empowerment of women
Results:

- 73% projects contributed somewhat to "gender equality"

Why results were achieved:

- Explicit targeting of women with project activities

Main conclusions:

- Energy projects alone will not contribute to development outcomes. If you want any change to occur you need to plan for that in the planning stage for project implementation. For example, if you want there to be an increase in livelihood opportunities, you need to explore and understand the available opportunities, understand the skill levels of beneficieries and potentially provide technical and capacity training
- It is also equally important to provide support after project implementation phase – long time horizon.
- Before and after phase of project implementation phase are just as important

C. Gannaioli, M. Tavoni, "Clean or Dirty Energy: evidence of corruption in the renewable energy sector", Public Choice (2016) 166, p.g. 261-290

The authors look at the link between public policy around renewable energy infrastructure and projects, and the potential for corruption and criminal activity, focusing on wind energy in Italy. They find that in the presence of poor institutions, renewable energy projects and policies can still be hijacked by 'bad' influences.

They have two hypotheses:

1. all else equal, the windiest provinces are more likely to experience corruption
2. the introduction of the CV system leads to an increase in the extent of corruption, especially in high-wind provinces

In Italy in 1999 a market-based tradeable system of green certificates was introduced to require power producers and importers to have a minimum share of electricity generated by green energy sources (called the CV scheme). It was found that wind power increased in production significantly after this system came into effect and makes up about 4% of Italian electricity consumption.

Their theory of corruption is convoluted, and runs something like:

An entrepreneur needs to obtain a permit from a politician in order to build a wind farm. Paying a bribe increases the probability of obtaining such a permit. The ROI for the entrepreneur depends on the amount of wind in the area (which increases energy produced and hence revenues) and the public subsidies such as the CV scheme.

→ marginal return to bribing is increasing in the wind level so we should expect to see more bribing in high wind provinces (?), and the negative effect of windiness is higher in areas with lower quality institutions

→introduction of a market-based system with poor institutions will increase corruption in high wind areas.

A. Mansson, "A resource curse for renewables? Conflict and cooperation in the renewable energy sector", Energy Research and Social Science, 10, 2015

The author argues that because RE systems depend on exploiting flows rather than extracting stocks (such as in fossil fuel systems), states have less incentive t o engage in

conflict over resources. However, since RE systems may increase competition for land, this may increase the risk of local conflicts particularly those involving non-state actors. He further argues that since infrastructure for RE is generally smaller scale, they are less likely to be the direct targets of attack, but that because these systems rely on control systems to manage flows, they are more susceptible to cyber attacks.
The author distinguishes bioenergy and biofuels from other types of RE (wind, solar and hydropower), and analyses four stages in the supply chain where these systems may interact with conflict. The key conclusions are as follows:

1. Primary Resources:
    - Biofuels; more likely to interact with local as opposed to interstate conflicts, because resources are geographically spread but require large sections of land
    - Other RE; low risk of interstate and intrastate conflict because resources are abundant and geograohically widespread. The author claims that hydropower is an exception since it may increase tension between local actors and states with insufficient institutional capacity. (But how is this different than wind or solar farms?)
2. International trade:
    - Both bio and other RE pose low risk of conflict here, and in fact may incentivise cooperation
3. Conversion and Distribution:
    - Biofuels pose similar risk as current systems
    - Other RE, if small scale, than unlikely target for infrastructure attack, if large scale may be more susceptible to cyber attacks
4. End use:
    - Interaction is uncertain and depends on which energy end-use technologies are implemented.

The Gold Standard, "The Real Value of Robust Climate Action: Impact Investment far Greater than Previously Understood", A Net Balance Report for the Gold Standard Foundation, 2014

Gold Standard is a key financier of green-house mitigation projects, and commissioned a portfolio evaluation of outcomes in addition to carbon mitigation in their projects. GS designs their projects to deliver environmental and social outcomes such as improved human health, improvements to livelihoods and improved food security for communities.
They wanted to monetise the social benefits of their project portfolio – and they did so by SROI type analysis, although they did not calculate one final ratio but rather left valuations by outcome. The evaluation looked at four groups of projects – wind, cookstoves, reforestation and biodigesters. For each project type, they estimated the monetary value of social benefits along five dimensions; biodiversity, balance of payments, employment, livelihood and health impacts.

Danske Commodities, "Light over Mali", Annual Social Return on Investment Report 2019"

Danske Commodities brings electricity to off-grid areas of rural Mali. In 2019, DC conducted an SROI analysis on the solar projects it had undertaken that year, which were:

- Installing solar panels at five schools
- Installing five lamp posts in city centres
- Distributed 250 solar-powered homework lamps to children

A large part of their theory of change revolved around improved education and health outcomes, particularly the provision of adult basic education at local schools.

They calculate an SROI ratio for the 2019 year at 3.25, while over a ten year period this ratio is 11.62. The “input” in this case, was a donation of 200,000 Danish Krones (about $32k USD) to Light over Mali, to improve living conditions in seven villages, covering 15,000 Malians.

S. Karytsas et. Al, “Measurement methods of socioeconomic impacts of renewable energy projects”, IOP Conference Series: Earth and Environmental Science, 2020
An overview of the existing state of research, analysis and evidence for social impacts related to renewable energy projects. The authors note that most of the time the emphasis has been placed on environmental impacts, with little attention paid to social benefits. “…until now, no common framework on social impact measurement exists.” (for renewable energy projects).
The authors claim that social benefits can be classified into four categories: public perceptions; employment; health & safety, and; local infrastructure development. They go on to conclude that these benefits can result in increased social cohesion and stability as well as an overall increase in standard of living.
Authors review requirements for indicators, more or less SMART (specific, measurable, attainable, realistic and timely).

Global Impact Investing Network, “Impact Measurement in the Clean Energy Sector”, GIIN Network Insights
Overview of the impact measurement approaches taken by 13 members of GIIN who invest in the clean energy sector particularly companies serving Bottom-of-Pyramid consumers in emerging markets. 13 members include fund managers, foundations, development finance institutions and banks.
They find 12 commonly used metrics across this group, to measure the social and environmental impact of clean energy investments. However, each investor takes a different approach to measurement and what they measure.

The report finds that these investors invest in clean energy for BoP consumers “because they see significant opportunities to support sustainable energy solutions while improving livelihoods”. There are three main areas targeted for investment in clean energy in emerging markets: solar products for households and small business, such as solar lanterns, energy-efficient cookstoves and fuels, and micro-grids and mini-grids.
GIIN concludes that there are three key considerations when designing an impact measurement approach: 1. Measure what matters – every organization has different things that matter to them; 2. Most measurement is concerned with output (immediate tangible benefit), rather than outcome (longer term), although the latter is even more important. This is because there’s no clear way on how to measure outcomes, and usually requires more resources to track metrics over time; 3. Qualitative information is important as a complement to quantitative, in order to better understand causal links between outputs and outcomes.

What’s currently going on in the sector?

- Social impact is the key consideration of the 13 investors reviewed who invest in clean energy sector. They want to improve quality of life by allowing access to electricity
- Access to energy, job creation and environmental benefit are the primary metrics being used for clean energy investment
- Challenges:

- It's hard to contextualize the significance of impact if local conditions aren't taken into account
- Measurement is usually done by investee, with investor not really having much oversight to verify accuracy and reliability of data
- Current practice tends to be based on observable but unverifiable data – qualitative evidence and self-reported data.

Nine general categories of things being measured by these 13 orgs.

1. Access to energy : number of beneficieries and clean energy capacity of products sold
2. Job creation: number of people employed
3. Environmental benefit: Reduction of GHG emissions due to products sold
4. Investor leverage or demonstration effect:
5. Cost savings: HH cost savings resulting from shifts in spending on fuel
6. Enhanced opportunities for productivity and income generation: increased income resulting from income-generating opportunities
7. Poverty level of end users:
8. Gender impact: investment supports or empowers women/girls
9. Health benefits: reduced deaths and DALYs

Report goes through to detail how each metric is commonly measured.

I. B. Hatlelid and J. Aass, "The socio-economic Impact of Renewable Energy in Sub-Saharan Africa: A ripple effect analysis of the ASYV solar power plant in Rwanda", Master's Thesis in Economics and Business Administration, Norwegian School of Economics, 2016

The authors look at the ASYV solar power plant in Rwanda operated by a Norwegian company Scatec Solar to identify local socio-economic ripple effects arising from the companies procurement spending locally, and corresponding increased access to clean and reliable energy for local households and businesses.

They find that only a low share of the companies total value creation can be attributed to local suppliers in Rwanda, with a high dependency on imported products and foreign know-how. There is some expansion of employment locally.

They also find only modest impacts from electricity access in the short to medium term, and believe that limited market exchange and high electricity tariffs may explain this.

They use an input-output model design to arrive at their conclusions, with data collected both quant and qual in the field.

E. van der Waal, "Local impact of community renewable energy: A case study of an Orcadian community-led wind scheme", Energy Policy (138), 2020

The author studies the effects of community renewable energy projects on host communities using an evaluative method known as "change mapping", on a specific 900kW wind project on the Scottish island of Shapinsay. The findings of this study are that modest effects are seen on local economic development, social cohesion and knowledge and skill development.

The author condenses the local impacts that have been found through studies of CREs into 13 categories: local economic development; reduction of energy costs and fuel poverty; development of knowledge and skills; social cohesion; energy literacy; energy related behavioural change; local support for RE; impacts on liveability of the area; impacts on health and safety; impact on nature; political efficacy and mobilization; demographic effects and RE tourism.

Change mapping: describes how an intervention such as CRE contributes to a sequence of impacts through theories of change. Three steps involved: 1. Creating a community profile; 2. Creating a project profile, and 3; describing ToCs. This method is almost entirely qualitative.

For example, in the category of evidence for social cohesion – through interviews and fgd's the author found that the new community bus and electric car service was able to better connect less mobile elderly members to come together for a weekly lunch club.

A. Shoaib, S. Ariaratnam, "A Study of Socioeconomic Impacts of Renewable Energy Projects in Afghanistan", International Conference on Sustainable Design, Engineering and Construction, Procedia Engineering 145 (2016)

The authors study the socioeconomic impacts of two community RE projects in two towns in Afghanistan. They find that the two CRE projects led to modest improvements in economic conditions at both the town and household level, and that they improved the sustainability of energy supply to the two towns.

The authors conducted interviews in both towns, and assessed changes using a pre-designed questionnaire on social and economic benefits at both the household and community level. The number of respondents was 80 in one town and 60 in another, and the survey questionnaire was perception based.

At the household level the biggest changes in social welfare were in relation to increased perceptions of personal security, entertainment options increased, and learning conditions for kids improved. Very few respondents perceived improvements in doing housework in terms of efficiency or hours, or for hygiene and health.

In terms of economic changes at the household level, highest perceived improvements were in expenses for energy , while income was not perceived to have increased substantially by many respondents.

At a community level, 50% of all respondents found that the community improved as a result of CRE while 37% found it did not. Biggest improvements were perceived to be in healthcare and education services. The majority of respondents did not perceive there to be job creation or business improvement due to CRE.

D. Raitzer et. Al., "Impact Evaluation of Energy Interventions: A Review of the Evidence", Asian Development Bank, April 2019

The authors review the current status of impact evaluations in the energy sector, with regards to social and economic impacts that are often assumed occur with energy projects in the development sector. They argue that impact evaluations are becoming increasingly more relevant in the sector as energy investment is becoming more oriented toward

environmental and social objectives, but that doing an IE in the sector may require creative approaches. In particular they call out methods such as synthetic controls, regression discontinuity designs and encouragement designs.
On the roll of RCTs, they argue that although large energy infrastructure can't generally be randomly assigned, encouragement designs can randomly vary incentives for using energy.

The authors review 85 completed methodologically rigorous impact evaluations, which fall into four broad categories: the impact of electrification (mostly focused on rural grids), the impact of energy efficiency programs (for example introducing energy efficient appliances), the impact of electricity sector reforms (for example privatization, unbundling), and 'others' (very specific studies).

Most of the studies have looked at outcomes which can be grouped into five categories, summarised below.

- Energy consumption and expenditure:
    - Mixed results on reduction or increase of electricity consumption.
- Labor/time use:
    - Electrification can lead to substantial changes in time use – especially for women and children; grid electricity and solar home systems were found to lead to increased study time for school children.
    - Average across studies is that electricity leads to an increase in labor market participation of 25%, with women tending to benefit more
- Income
    - Can lead to increased household income, consumption and expenditure – but evidence is mixed.
- Education
    - Electrification can improve educational outcomes: average increase of about 7% on school enrollments across studies, increased school attendance. But some studies found a negative effect on boys enrolment as electricity access increased child labor demand (Hondurus).
    - Educational outcomes can reinforce gender equality, as estimated effects are bigger for girls than boys over a range of educational outcomes
- Health
    - Can improve quality of indoor air and human health
    - Can reduce fertility – more time spent watching TV
- Gender Equality
    - Can impact female empowerment – through increasing female paid work time (Guatemala), changing relative role of women in hh decision making (Nepal).

The most commonly used methodologies for IE in the energy sector were identified as (Table 2 p.g 17 gives great overview of what these mean):

- Experimental Designs: Simple RCTs, Cluster or matched pair RCTs and Encouragement Designs
- Non-experimental designs: Regression Discontinuity designs, Instrumental Variables, Propensity score method, Diff-in-diff models, synthetic controls.

Monitoring and Evaluation in Energy for Development International Working Group, "A Guide to Monitoring and Evaluation for Energy Projects", 2006
This guide (a step-by-step) was developed in order to help project implementers build project specific M & E frameworks and procedures. They emphasise the fact that there is not a recognized standard on what to measure.

M & E for energy projects face extra challenges above and beyond other types of interventions, as;

- Causal chain linking energy access to improvements in peoples lives is often long, as energy access is needed for a range of beneficial outputs like production of food, clothing etc.
- M & E needs to be able to measure improvements in more than one area
- M & E must have long time horizons because often improvements only manifest years down the line
- Positive effects of energy access often require other inputs, so M & E schemes need a way to figure out attribution.

The guide outline a 10-step process for define project M & E scheme:

1. Identify project stakeholder M & E needs: for example donors, local authorities, users
2. Make a diagram of your project: input → activities → output → outcome → impact
3. Assign project results to links in causal chain: project M & E matrix
4. Choose indicators and data collection methods
5. Address transversal issues: e.g. gender equality and environmental sustainability
6. Write up draft M & E scheme
7. Validate scheme with project stakeholders
8. Integrate stakeholder comments into scheme
9. Execute M & E as part of project
10. Conclusion, follow up on recs

The guide presents five thematic modules with M & E guides: Decentralized rural electrification; rural electrification by grid extention; regularization by urban electrification; improved biomass stoves; institutional support.

They also explicitly advocate for the inclusion of gender goals in energy projects, because: gender equality is MDG 3; men and women have different energy needs; introducing new forms of energy may have different and unintended impacts on men and women and may exacerbate subordinate position of women.

Liao, C., Erbaugh, J., Kelly, C., Agrawal, A. (2021). Clean energy transitions and human well-being outcomes in Lower and Middle Income Countries: A systematic review. *Renewable and Sustainable Energy Reviews. July.*
This 2021 systematic review of 107 peer-reviewed studies examines the household energy transitions in lower and middle income countries. The authors consider factors with potential causal impacts, identifying associations between adoption of clean energy and household well-being. To narrow the overwhelming number of articles, the authors defined a clean energy transition as "a change from using a biomass or fossil fuel energy source to a

lower carbon-emitting alternative for one or more energy end uses". They primarily focus on local and household research, in contrast to a macro-level approach. The focus of the literature review is to "synthesize existing research on the drivers, types, and outcomes of clean energy transitions for households in L&MICs". To benefit our literature review, here are the key summaries of the authors' findings regarding the impacts of clean energy transitions on household well-being.

The review examines studies measuring the clean energy impact on five well-being outcomes: education, environment, health, income, and business productivity. In total, 21 studies quantified the effects of a clean energy transition.

- Health was the most common impact examined, and though most of the studies were indirectly measured, about half found significant positive associations on health, while the remaining concluded with mixed results.
- Income was the second most studied outcome variable—with most of the studies reporting positive relationships.
- Studies analyzing the impact of education found positive results when measuring the impact on years of education. The study analyzing the probability of sending a child to school found no statistically significant association.

The authors also analyzed adoption studies, which discussed factors associated with clean energy adoption.

- Higher levels of engagement with local energy organizations is associated with clean energy adoption.
- The analysis found a strong association with availability of clean energy credit and subsidies in facilitating clean energy adoption.

Overall, the review acknowledges a dearth of studies combining the analysis of clean energy adoptions and impacts, and prioritizes reducing barriers to clean energy adoption, particularly in rural and remote communities.

Ayana, O., Degaga, J. (2022). Effects of rural electrification on household welfare: a meta-regression analysis. International Review of Economics. 69, 209-261.

This meta-regression-analysis seeks to "objectively summarize the effect-size estimates from primary studies, identifying the degree of publication bias and underlying genuine effects" within a review of empirical literature (57 studies were used in the final analysis).

The authors analyzed the impacts of rural electrification on education, employment, and income. After accounting for publication bias, the results are as follows:

- **Education**: With the exceptions of three studies, 19 significantly viable studies found that that rural electrification has positive effect on educational outcomes
- **Employment**: 10 out of 16 studies report statistically significant effect of rural electrification on rural employments
- **Income**: From 29 studies, only 53.2% of estimates are significantly significant, with most of the remaining studies revealing a positive but statistically insignificant effect. Overall, the authors determine that electrification has a positive effect on rural income.
- **Productive Time Use**: Out of 22 studies, with 193 estimates, 12 studies report statistically significant effect of rural electrification on time uses. Although the final

weighted mean portrays a statistically significant positive association of electrification, there is no strong effect on time use.

- **Women Empowerment:** With 66 estimates from 11 studies the authors again find a statistically significant, but practically low weighted mean. However, once publication bias was accounted for, the regression results "consistently reveal the existence of positive and statistically significant genuine effect of rural electrification".

Su, C., Khan, K., Umar, M., Zhang, W. (2021) Does renewable energy redefine geopolitical risks? Energy Policy. November.

This empirical review of existing literature broadly discusses the impacts of renewable energy growth on geopolitical risk. There are several prominent conclusions provided by the authors, which emphasize a positive association between the advent of renewable technology adoption and geopolitics. First, by lessening the global dependency on fossil fuels, sources have observed that renewable energy may reduce geopolitical tensions associated with fossil fuel production, transportation, and consumption prices. The sources suggest that an increased interdependence among countries will lead to a positive impact on geopolitical stability. Additionally, the authors suggest that environmental incentives for transitioning to renewable energy is more useful for international peace, which may help reduce geopolitical risk because it does not lead to "resource curses, greater diversification and energy security in the producing countries".

However, the full sample outcome shows no causality between geopolitical risks and renewable energy. With both positive and negative impacts stemming from geopolitical risk to renewable energy, the authors conclude that geopolitical risk "has a crucial role to play in renewable energy development". In terms of energy supply and security, the renewable energy transition is quite useful, but the energy transition is ultimately driven by the higher energy security—and geopolitical stability is critical for development.

Moner-Girona, M., Kakoulaki, G., Falchetta, G. (2021). Achieving universal electrification of rural healthcare facilities in sub-Saharan Africa with decentralized renewable energy technologies. *Joule. 5,* 2687-2714. https://doi.org/10.1016/j.joule.2021.09.010

Driven by the advent of the COVID-19 pandemic, this study analyzed the effectiveness of renewable systems in electrifying rural health-care centers. More specifically, the authors studied costs and benefits of providing electricity through decentralized photovoltaic systems to nearly 57,000 sub-Saharan African health-care centers.

The authors found that if all facilities were provided with PV systems, 281 million people would reduce their travel time to a health facility with electricity access—by an average of 50 min. Even more drastically, when considering only walking as a means of traveling, 298 million people would reduce their travel time by an average of 6 hours.

A review of existing analyses found that as costs for solar technologies continue to decrease, the installed PV capacity in Africa has increased from 273.5 MWp in 2010 to 11 GWp in 2020. The authors thus suggest decentralized PV systems to be a medium-term solution for non-electrified health centers. To estimate the aggregate electrification costs for the healthcare facilities, the authors estimated the optimized PV capacity, the optimized battery capacity, and the associated costs for each; the estimated PV upfront cost varies regionally from EUR 4,500 to EUR 11,000. In total, the cost for implementation would be EUR 484 million, with few significant resource or technical barriers to using solar PV technologies.

There are several limitations to the precision of this study: (1) the authors utilized the Global Human Settlement Layer (GHSL) gridded population to estimate regional trends, but adoption of different population products may lead to different results; (2) there is limited data available on electricity grid lines, and the use of night-time lights to estimate electrification could miss facilities closed at night or/and not having outside lights. Despite these limitations, the overwhelming data suggests that decentralized solar systems offer a reliable, quick, and cost-effective means to increase electricity access while providing critical social benefits.