# Addressing Conflict and Inequity through Energy Access in the Democratic Republic of the Congo

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**Abstract**
Socioeconomic and development outcomes have long been observed to improve with growth in access to sources of energy and electricity. In this article, the interplay of these dynamics in the context of fragile and conflict-affected states is discussed, with a case study focus on the Democratic Republic of the Congo. Specific examples in the DRC are further analyzed to highlight opportunities for the development and expansion of electricity infrastructure to disrupt conditions that contribute to the continuation of conflict. The article ends by presenting a framework of metrics and indicators to consider in deploying electricity access options with the objectives of improving socioeconomic, gender, and environmental outcomes.

## 1. Introduction

Energy use has long been associated with improvements in development and social outcomes. Strong positive correlations have been observed between energy use per capita and economic development measures such as GDP per capita and the Human Development Index (Lee et al. 2017). These relationships persist when energy use is defined solely as electricity use and the sample of countries under consideration is limited to developing nations (Stern et al. 2016).

Although such relationships suggest that energy and electricity have critical ties to development, they do not imply causality. Studies that have sought to identify the causal effects of electricity access at the microeconomic level – i.e. within households and communities – find impacts of electrification on such outcomes as income, female employment, study hours, and manufacturing output, although there is significant variation in the magnitude of these impacts (Lee et al. 2017). Meanwhile, recent experimental evidence from New York City has found that street lighting reduces the incidence of nighttime outdoor crimes (Chalfin et al. 2019).

In considering potential outcomes, it is important to consider other factors that inform how energy development occurs. For one, the electrical load that can be supported often varies depending on the source of electricity (e.g. the grid or a solar home system). Furthermore, access to electricity does not necessarily translate to reliable electricity or ensure quality – frequent outages, voltage sags, and other issues can affect the power delivered and subsequent outcomes. Energy development with a reliance on fossil fuels will also tend to exacerbate pollution and related health problems.

Electrification may additionally serve to preserve or exacerbate inequities: expanding grid access, which is typically associated with high capital costs, tends to favor wealthier communities. Inequities may also be reinforced when gender dynamics, and their intersections with energy use, are not considered. In many developing countries, women and children tend to be the primary actors engaged with fuel collection and household uses of energy.

Collectively considered, these dynamics suggest that initiatives promoting energy and electricity access must involve a broader spectrum of considerations than the simple physics of energy provision. Classic and controversial works of sociology and development, from *Seeing Like a State* (Scott 1998) to *Dead Aid* (Moyo 2009), have highlighted that international aid and socioeconomic programs do not indubitably translate to reductions in poverty or increases in economic growth within recipient countries. Within the sphere of technology adoption is the widely-cited example of cookstoves. Development actors have long sought to replace traditional cookstoves, which produce large amounts of indoor pollution and contribute substantially to mortality, with cleaner-burning stoves. However, scholars such as Emma Crewe (1997) have documented how initial cookstove improvements were largely promulgated by external actors and considered the expertise of engineers over the needs and expertise of end-users, in turn driving low take up rates.

This article considers how an intentional approach to provide electricity via clean, renewable sources and address social inequities may promote improved socioeconomic, gender, and environmental outcomes, particularly in fragile and conflict-affected states. We frame this around a case study in the Democratic Republic of the Congo (DRC) – one of the world's least electrified countries – where conditions of insecurity continue to persist after decades of conflict. Drawing from academic literature and reports, as well as experiences on the ground in North and South Kivu, we discuss the landscape of energy access, and opportunities within it. We propose metrics and indicators to inform social and technical considerations in expanding energy access, as well as to assist with identifying the impacts of electrification on the empowerment of women, conflict mitigation, and environmental conservation.

The rest of this paper is structured as follows: Section 2 outlines the nexus of electricity access and development outcomes in the context of fragile and conflict-affected states. Section 3 describes the current state of energy use and electricity access in the DRC. Section 4 delves into two cases in the DRC, providing examples of opportunities for renewably produced electricity to improve socioeconomic outcomes. Section 5 provides an overview of metrics and indicators to consider in deploying electricity access options in this context and Section 6 concludes with recommendations.

## 3. Electricity Access and Development Outcomes in Fragile and Conflict-Affected States

In fragile and conflict-affected situations, both energy-related infrastructure and socioeconomic conditions are poorly developed. As Morris (2017) states: "most fragile and conflict-affected situations have significantly worse development outcomes relating to energy." Analyzing electricity access in countries identified as funding priorities for the United Kingdom's Department for International Development (DFID), Morris highlights that "on average 43% of the populations in the 21 priority countries DFID considers as fragile and conflict-affected situations (FCAS) had access to electricity in 2014 (falling as low as 4% in South Sudan), whereas on average 58% of the populations in DFID's 7 non-FCAS priority countries had access to electricity" (Morris 2017; World Bank 2017a).[1]

The potential connections at the energy, development, and conflict nexus have been of increasing interest to actors in the aid community, as well as aid donors. In its 2013 Energy Sector Directions Paper, for example, the World Bank posits that "providing electricity may be especially important in fragile and conflict-affected states, where resumption of electricity supply can be important in restoring confidence in the government, strengthening security and reviving the economy" (World Bank 2013). Morris (2017) characterizes the energy sector as potentially "constitut[ing] a central economic dimension of the so-called 'conflict trap': a sub-optimal equilibrium whereby poor performance in the energy sector therefore not only results from violence, but may also be one factor that creates the structural conditions for a continuation of violence."

Humanitarian aid and peacekeeping experts also recognize the role that energy access, particularly to renewable energy, may have for increasing resiliency in peace and recovery efforts. Mozersky of Energy Peace Partners, highlights that "if you look at climate vulnerable areas, conflict risk maps and energy poverty, there's a very strong overlap on all three of these indexes" (Fleming 2018). Figure 1 below provides one illustration of this overlap, by comparing the 40 most vulnerable countries separately ranked on the Fragile States Index (FSI) and the Notre Dame Global Adaptation Initiative Country Index (ND-GAIN), to countries where 60% or less of the population had electricity access, as of 2014, per the World Bank's Global Electrification Database. The FSI and ND-GAIN indices respectively provide a measure of conflict risk and vulnerability to the effects of climate change.

[1] DFID, the Department for International Development, is a department of the United Kingdom government with the responsibility of administering overseas aid. FCAS is an acronym referring to Fragile and Conflict-Affected States. Morris lists the 21 DFID FCAS priority countries as: Afghanistan, Bangladesh, Myanmar (Burma), Democratic Republic of Congo, Ethiopia, Kenya, Liberia, Malawi, Nepal, Nigeria, Occupied Palestinian Territories, Pakistan, Rwanda, Sierra Leone, Somalia, South Sudan, Sudan, Tajikistan, Uganda, Yemen and Zimbabwe. However, the Occupied Palestinian Territories are excluded from the averages he calculates, due to a lack of data availability. Meanwhile, the 7 DFID non-FCAS priority countries are: Ghana, India, Kyrgyzstan, Mozambique, South Africa, Tanzania, and Zambia.

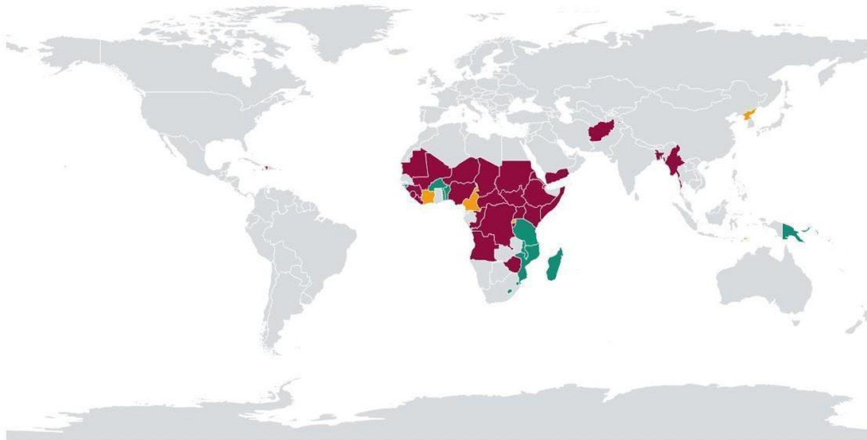

**Figure 1.** A high-level comparison of the overlap between countries classified as experiencing conflict risk, climate vulnerability, and energy poverty. Data are from the 2016 Fragile States Index, developed by the Fund for Peace, the 2015 ND-GAIN Country Index, from the University of Notre Dame, and the World Bank's Global Electrification Database from 2014. Thresholds used are the 40 most vulnerable countries listed on the FSI and ND-GAIN, and countries where 60% or less of the population has access to electricity, which is comprised of 47 countries.
Countries in maroon (n=27) appear on all three indices; countries in green (n=12) are vulnerable per ND-GAIN and % electricity access; countries in yellow (n=5) are vulnerable per the FSI and % electricity access; countries in blue (n=1) are vulnerable per the FSI and ND-GAIN.
Produced with David Mozersky of Energy Peace Partners and used with permission.

Effectively addressing electricity access – particularly in the developing and FCAS context – requires a consideration of several intersecting dimensions. For example, the provision of electricity is complicated by the challenges associated with building out the infrastructure for a centralized grid. In the context of high-intensity conflicts, such infrastructure may be particularly vulnerable to attack. For example, the high-intensity conflict in Syria saw damage to pipelines for oil and natural gas, as well as electricity transmission networks. According to the country's Minister of Electricity, "by early 2013, more than 30 of Syria's power stations were inactive and at least 40 percent of the country's high voltage lines had been attacked" (Gobat and Kostial 2016). In Somalia – with the exception of some cities in Somaliland and Puntland – the private sector now largely owns and operates the energy supply system, because of massive disruptions to, and ultimately the incapacitation of, public energy infrastructure (AfDB 2015). Although more research is needed at the intersection of energy, development, and conflict, Morris (2017) suggests that "a private sector-led approach focused on smaller-scale generation may in fact be more effective than alternatives in the face of violence."

Thus the scale of energy provision may be an important consideration in the FCAS context, and today's landscape and pace of technology innovation is such that alternative models to a centralized grid are possible. Decentralized (or distributed) electricity access options, including solar home systems, microgrids, and storage technologies, open up new opportunities by offering greater flexibility and the potential for more localized control, often at lower costs. These solutions may be grid-connected, off-grid, or take a hybrid approach, and they may be deployed as alternatives to, or enhancements of, the traditional grid.

Decentralized options thus have the capacity to improve economic and social outcomes, and if renewables-based, offer the additional benefit of environmental gains. However, the developing and conflict context recommends considering the potential future implications of any designs for electricity provision. Jones and Howarth (2012; cited in Morris 2017) have warned against "creating future dependencies that could make fragile states very vulnerable to high energy prices." Designing robust, renewables-based options can help to mitigate against the costs of scarcity associated with fossil fuel resources. Other considerations might include designing systems with adequate flexible modularity to adapt to future needs, or analyzing the compatibility of systems with future grid connections.

## 3. Conflict and Energy Access in the DRC

The DRC is a country long affected by conflict. Whilst 2003 marked the official end to the Second Congo War and the country's transition to recovery after a conflict described by some as "the most deadly...since WWII," armed groups continue to operate in the wake of the war, in particular beleaguering the country's eastern region (Coghlan et al. 2004). Fifteen years later, in 2018, the country remains one of six countries on very high alert for the FSI, alongside Central African Republic, Syria, Yemen, Somalia, and South Sudan (Fund for Peace 2018).

Conflict scholars note that the perpetuation of insecurity and violence in the DRC are reflective of the dynamics of a war economy. Jackson, for example, highlights that the current context of the Congo "represents a radical mutation of livelihood strategies responding to an economy profoundly destroyed by colonial and postcolonial neglect and greed, and more recently by... years of vicious war" (Jackson 2002). Vlassenroot (2002; cited in Laudati 2013, p. 42) has explained "the proliferation of Mayi-Mayi armed groups in the [country's eastern] region" by arguing that "individuals' decisions to join these groups must be understood as a 'viable employment option' in the face of wider social and economic inequalities created by the looting of Congo's resources" (Laudati 2013). Furthermore, there is evidence that for many armed combatants, "allegiance to particular [armed] groups may depend on which offers the greatest security and financial benefits, rather than ideology per se" (Laudati 2013).

Amidst this landscape of continued insecurity, several international actors have sought ways to facilitate peacebuilding and to support the country's recovery after years of war. These efforts have included infrastructure projects as vehicles for peace. In eastern Congo, for example, Bachmann and Schouten (2018) note that "a patchwork of feeder roads, bridges, government buildings and waterworks [have been] propelled by the UN and its peacebuilding partners."

Bachmann and Schouten (2018) argue that in moving these projects forward, peacebuilding organizations have yet to critically examine the dynamics that inform how or if such efforts contribute to stability or peace (see also: Jones and Howarth, 2012). Here, we seek to critically approach and consider how electricity infrastructure powered by renewable energy sources may contribute to changing socioeconomic conditions and insecurity by promoting the resiliency of communities and supporting stable livelihood opportunities. Before doing so, we examine the current state of energy and electricity access in the DRC.

### 3.2. The State of Energy in the DRC

Despite immense potential for hydropower, high-quality solar, and geothermal resources, as well as reserves of coal and natural gas, the DRC has one of the lowest rates of electrification in the world. Although exact numbers vary, due to differences in definitions of electricity access and difficulties with data quality, the DRC consistently remains one of the least electrified countries in the world. Per 2013 data, USAID reports the average electrification rate across the country to be 9%, with important disparities between urban areas – 19% – and rural areas – 1-2% (USAID 2017; ICF 2017).[2] In the country's Kasaï Occidental region, the rate is as low as 0.5%, whereas in the capital city of Kinshasa, the electrification rate is reportedly around 44%, but service from the grid is subject to regular disruption, blackouts, and low reliability (Climatescope 2017).

#### 3.2.1. Policy Infrastructure in the DRC's Energy Sector

The primary authority for the country's electricity sector is the national Ministry on Electricity and Hydraulic Resources (MHRE), which formulates and approves executive policies for the sector (ICF 2017; SEforAll Africa Hub and AfDB 2017). Supplementary support for policymaking is provided by the Ministry of Environment, Tourism and Nature Conservation (MECNT), Ministry of Hydrocarbons, and Ministry of Rural Development (ICF 2017).

Formalization of the country's electricity sector dates back to 1970, when Société Nationale d'Électricité (SNEL) was created as the general contractor for construction of the Inga 1 Hydropower Plant (Kadiayi 2013). Prior to 1970, concessions were made to private companies. In 1972, SNEL was established as a state-owned enterprise and given a mandate covering electricity generation, transmission, distribution, and trading of power (SNEL 2014; Kadiayi 2013). Around 2003, with the official end of the war, institutional reform processes were launched across all public sectors in the country (Kadiayi 2013). When these changes made their way to the energy sector in 2011, SNEL was transformed into a limited liability commercial company, and in 2014, the country's electricity sector was liberalized with the passage of the Electricity Law of 2014 (Kadiayi 2013; Climatescope 2017; ICF 2017). Perhaps one of the most important changes under the new law was to open the country up to independent power producers, effectively ending SNEL's longtime, de facto monopoly.

The Electricity Law of 2014 additionally provided for the creation of three new institutions – the Electricity Regulation Authority (ARE), the National Electrification Fund (FONEL), and the National Rural Electrification Agency (ANSER), though as of 2017, these agencies were not yet operational (ICF 2017). Moreover, it called for a "diversification of the energy mix, a focus on energy conservation and efficiency measures, and a 60% increase in the overall national electrification rate" (ICF 2017), and tasked two agencies within the MHRE, specifically the National Services of New Energy (SENEN) and the Technical Support Unit of Energy (CATE), with developing the country's renewable energy potential.

[2] According to the World Bank's Sustainable Energy for All database, as of 2016, 17.1% of the country's population had access to electricity (World Bank 2017a).

Furthermore, the law has transferred some power to the provincial level, allowing provinces to grant concessions for the generation, transmission, and distribution of electricity, when such activities occur within a single province. Concessions for generation are categorized and priced on the basis of the project's size (less than 1 MW, 1-5 MW, 5-50 MW, and greater than 50 MW) (ICF 2017). Matters are referred up if their impacts span provincial borders.

### 3.2.2. State of Physical Infrastructure in the DRC's Energy Sector

The total installed capacity of power plants in Congo is estimated at approximately 2,590 MW - about 2,442 MW of this is owned by SNEL, and approximately 135 MW by captive producers, most of which are associated with the mining industry (ICF 2017).[3] Considering a split of installed capacity by fuel type, approximately 2,472 MW (or 95%) are from hydropower sources, and approximately 34 MW (1.3%) from combustible fuels (ICF 2017). Although more than 94% of the country's installed capacity at present comes from hydropower, this only represents around 2.5% of the country's total hydroelectric potential (ICF 2017).

**Table 1.** Summary of major power plants in DRC. Source: IFC 2017.

| Unit Name | Rated Capacity |
|---|---|
| **Western Grid Network** | |
| Inga I | 351 MW |
| Inga II | 1424 MW |
| Zongo I | 75 MW |
| **Southern Grid Network** | |
| Nseke | 260 MW |
| Nzilo | 108 MW |
| Mwadingusha | 68 MW |
| Koni | 42 MW |
| **Isolated Hydroelectric Networks** | |
| Ruzizi I & II | 44 MW |
| Sanga | 11 MW |
| Tshopo | 18 MW |
| Kyimbi | 18 MW |

[3] As noted in ICF 2017, according to UNDP (2014), captive producers in the country include: SUCRIÈRE KWILU, NGONGO, PERENCO, MIBA, CFU, PLC, ONG, SNCC, SOKIMO, HYDROFORCE, HEDC and EDC.

| | |
|---|---|
| Mutwanga | 10 MW |
| Other IPPs | 135 MW |

Importantly, only 50% of nominal power is generally available to be dispatched at any point in time (ICF 2017). Power output tends to be low because the other half of installed hydropower capacity is typically considered to be out of service, due to age, underinvestment, and a persistent lack of necessary maintenance (Climatescope 2017; SEforAll Africa Hub and AfDB 2017; International Rivers u.d.). Investments in improving power output could help to stabilize the largely unreliable provision of electricity in the existing grid. However, without parallel investments in the transmission and distribution network, a larger power output is unlikely to improve electricity access, as the majority of the population is not connected to the grid.

At the distribution level, a few local concessionaires have emerged after the liberalization of the sector. For example, La Société Congolaise de Distribution d'Eau et d'Electricité (SOCODEE SA) has started to distribute electricity for the city of Goma and the territory of Nyiragongo (Singoma 2018). Though it is unclear what investments are being made to expand distribution infrastructure, it is likely that additional concessionaires will emerge over time.

Meanwhile, it is estimated that only 15% of the country is covered by accessible power transmission lines (CDC Group 2016). In several provinces, in particular Central and Northern Congo, the power grid is completely absent (ICF 2017). More specifically, the country does not have an interconnected national transmission grid network. Instead, there are three regional networks, operated by SNEL. These are Réseau Ouest (the West network), Réseau Est (the East network), and Réseau Sud (the South network). Although the lack of extensive transmission and distribution networks presents limitations to expanding electricity access, it also suggests opportunities for decentralized energy access options to play a larger role.

### 3.2.3. The Grand Inga Scheme

Though the country's transmission network is "fragmented into three regional grids," the western and southern grids are connected through the Inga-Kolwezi link, to support the transmission of power from the Inga hydro plants to Katanga's mining district (SEforAll Africa Hub and AfDB 2017). Additionally, the three regional networks are interconnected with the grids of neighboring countries – the Republic of Congo, Zambia, Rwanda, and Burundi – to facilitate power trading (ICF 2017).

Whilst recent estimates put the net import/export of electricity from DRC "to be nil," except for 50 MW from Zambia to supply mines in the Katanga region, the lack of extensive power transfers across borders is expected to change with the Congolese government's long-term plan to develop the Grand Inga scheme (ICF 2017). Once completed, the scheme is estimated to provide a total capacity of 39 GW, though various feasibility studies provide a potential range from 39 GW to 50 GW (Reuters 2014; ICF 2017). The Inga site is located approximately 225 km southwest from Kinshasa and approximately 50 km upstream from the mouth of the Congo River. Its hydropower potential comes from both the river's immense volume of water flow - second only to the Amazon River - and extensive elevation drops (ICF 2017). When or if completed, the Grand Inga project will be the largest hydroelectric power generating facility on Earth and is expected to help supply power regionally, through a network of high-voltage transmission lines.

The first phase of the Grand Inga scheme involves construction of Inga III, a dam with a projected capacity of 4,800 MW, and for which South Africa and the DRC have signed a treaty for joint development. As part of the agreement, 52% of Inga III's power output - roughly 2,500 MW - will be bought by South Africa. Of the remaining forty-eight percent, 27% will go to the DRC's mining industry, and SNEL will receive the remaining 21%, or 1000 MW, for its customer base (Reuters 2014). Despite the amount of expected power, most of the Congolese population will not benefit and the project is likely to contribute towards the disparity in electricity access between urban and rural/peri-urban customers: not only is the majority of the project's power slated for export and the mining sector, but the remainder is primarily expected to provide electricity to 7 million people in and around Kinshasa, where electrification rates are already higher than the rest of the country.

The inequitable distribution of benefits is only one of several critiques that have been raised in opposition to the Inga III project – many of which also apply to the Grand Inga scheme more broadly. Deshmukh et al. point out that the projected cost for just the Inga III project - $14-16.5 billion USD - "is more than 30% of DRC's 2015 annual GDP" and as such "may be a significant economic risk to the DRC and South Africa" (2018). Technical, social, and environmental concerns are also present. For one, precipitation over the Congo Basin has declined over the last three decades – sustained levels of lower rainfall will limit the dam's projected energy potential, which is a significant "determinant of its financial viability" (Deshmukh et al. 2018). Furthermore, assessments of Inga III by the World Bank and USAID reveal that the project will displace 10,000 people, pose "threats to endemic freshwater biodiversity and mangrove islands, and [reduce] carbon sequestration through reduced organic sediment flow to the ocean" (Deshmukh et al. 2018; World Bank 2014a, 2014b; USAID 2015). The latter speaks to the fact that whilst many consider hydropower as a way to produce energy with fewer greenhouse gas emissions, the potential savings are not as simple as calculating the amount of avoided emissions were the same amount of power to be produced via fossil fuels, namely when large hydropower projects are involved.

Deshmukh et al. further emphasize that Inga III faces risks from its dependency on the hydrology of the Congo River. Not only has rainfall declined, but the Congo Basin watershed spans six countries and watershed management can affect flow and sedimentation rates. Whilst changes in such rates can have ecosystem implications, they may also impact the performance of hydropower projects on the river. Thus, other development projects can pose a source of risk and uncertainty for performance of the Inga III project – these include "other hydropower projects on the tributaries of the Congo River and potential diversion of the Oubangui River, a major tributary of the Congo River, to relieve the loss of water in Lake Chad" (Deshmukh et al. 2018; USAID 2015).

### 3.2.4. Other Existing and Planned Electricity Expansion Projects

Since liberalization, a number of independent power companies have joined SNEL in providing electricity services in the DRC, particularly via hydropower (SEforAll Africa Hub and AfDB 2017). Although grids powered by solar photovoltaic panels are less common, this is expected to shift. With an average irradiation ranging from 3.5-5.5 kWh/$m^2$/day, the DRC has significant solar potential. At Manono in the province of Tanganyika, for example, a solar power plant provides the only large-scale source of electricity for the city, which has a population of roughly 20,000 people. Developed by the Belgian company Enerdeal in a deal with Forrest International Group, with SNEL being the ultimate client, the system consists of a 1 MW solar power plant with 3 MWh of air-conditioned, lead-acid storage. Recently completed, the plant is reported as powering street lights and households, as well as small and medium-sized enterprises, through several kilometers of medium and low voltage transmission lines (ICF 2017). The Manono project is currently the largest off-grid solar plant in the DRC and among the largest on the continent.

Meanwhile, through the Essor Access to Energy Project, DFID plans to support the development of several solar projects. The goal of the pilot initiative is to develop microgrids to supply power to five off-grid urban centers. Each solar project is expected to provide enough electricity for at least 100,000 inhabitants in a given city (Hunt 2018; ICF 2017).

#### 3.2.5. Energy Access in Rural Areas

Although there are several electrification initiatives in the DRC, biomass is nevertheless estimated to account for roughly 95% of primary energy consumption (SEforAll Africa Hub and AfDB 2017). This reflects the reality that 1) many urban homes continue to use charcoal, and to a lesser degree firewood, for cooking, and 2) in rural areas, biomass – both firewood and charcoal – tends to be the predominant source of energy.

At the same time, access to limited electricity is available in rural areas, generally in the form of solar lanterns, simple solar panel and battery systems, and/or small solar home systems. These are typically able to sustain low-load uses, such as lighting, cell-phone charging, and television use. In some communities, higher loads can be supported as diesel generator owners have built private businesses around the provision of power via informal, community-level grids. Small and medium enterprises in the commercial sector, and occasionally wealthier residential homes, pay fees to be connected to these grids.

These methods of energy access are associated with several environmental costs. The UNEP, for example, highlights that informal fuelwood and charcoal production and trade have led to massive deforestation and environmental degradation in the DRC (UNEP 2011). Meanwhile, the widespread use of diesel generators contributes not only to greenhouse gas emissions, but also to substantial toxic air contaminants that pose significant health risks. Although exact emissions depend on the type and quality of fuel used, as well as the quality of the diesel generator, more than 40 toxic air contaminants can be found in diesel exhaust, including benzene, arsenic, and formaldehyde (Awofeso 2011).

Although diesel generators pose health and environmental hazards, they continue to be used in parallel with solar panel and battery set-ups and small solar home systems because of the reliability of service offered and the ability to support higher loads, such as refrigerators. Diesel generator operators set defined periods of operation for their service, which provides a level of assurance to business owners supported by these local grids. Users of solar-related products, meanwhile, note dissatisfaction with the levels of limited service, which are often restricted to lighting and cell-phone charging. Additionally, many solar home systems are set up using informal expertise, which results in varying levels of system performance, frustrating experiences for users, and contributions to hazardous waste contamination in the absence of formal structures to collect defunct system components.

A more formal movement to address energy service development in rural areas is currently being led by the MERH. Known as the Modern Villages Programme (PROVIM), its objective is to electrify 100 villages using hydro-powered green microgrids (SEforAll Africa Hub and AfDB 2017). More commonly, however, a lack of investment has posed a significant barrier to expanding electricity access at the extensive margin, thus sustaining the rural-urban divide in access. The traditional model of electricity provision often involves high, upfront capital costs such that connecting industrial communities or wealthier neighborhoods tends to be emphasized, to ensure financial profitability. However, the increasing technical advancements and falling costs associated with decentralized energy technologies, coupled with the geographical distribution of renewable energy resources in the DRC, can facilitate the expansion of new connections, such as to microgrids powered by distributed solar PV or mini and small hydropower projects.

Assessments of the DRC's renewable energy resources often focus on hydropower, given its estimated potential of 100,000 MW. Although the Inga site is estimated to account for approximately half of this total, *L'atlas des energies renouvelables de la RDC* shows that approximately 10,000 MW is "largely decentralized and offers the country the opportunity to develop other mini or small hydroelectric sites (between 1 and 10 MW), but also hydropower applications even better adapted to the local market structure (micro and pico hydropower that are below the megawatt)" (ICF 2017; UNDP 2014a). The *Atlas* also maps the distribution of other available renewable resources in the country, including solar (UNDP 2014a).

The activities and market expansion of the company BBOXX in the DRC exemplify the opportunities that exist. In 2018, BBOXX – which calls itself a next generation utility and offers pay-as-you-go energy solutions – signed a contract with the DRC government to "bring reliable, renewable electricity to 2.5 million citizens in the DRC by 2020" (BBOXX 2018). The first company to sign with the government to put its "Energie pour Tous" (Energy for All) initiative into action, it expects to provide smart solar home systems to power a light, radio and phone at approximately $15 per month, for households in remote, rural communities (BBOXX 2018). In the DRC, BBOXX has thus far largely operated in the urban environment of Goma, the provincial capital of North Kivu. In Goma, its products range from various solar home systems, including ones capable of powering television sets, to hybrid, distributed power systems which combine solar, storage, and diesel generators to provide a reliable source of electricity for customers with larger energy needs, including small businesses and schools.

## 4. Improving Outcomes in Fragile and Conflict-Affected Areas of the DRC with Electrification

As Morris (2017) highlights, energy development may be particularly important in fragile and conflict affected states, wherein "poor performance in the energy sector" may be "one factor that creates the structural conditions for a continuation of violence." The following sections highlight two contexts in which the development of electricity infrastructure may help to disrupt the conditions that support continued violence.

### 4.1. Electrification and the Mitigation of Participation in Conflict Activities in Virunga National Park

Virunga National Park, located in the Eastern part of the country in North Kivu province, is Africa's oldest national park (WWF 2017) and the continent's most biologically diverse area (Virunga National Park 2017a). It has been a UNESCO-designated World Heritage Site since 1979 and was founded primarily to protect the mountain gorillas (Virunga National Park 2017b). Over the years, the park has endured a series of challenges, including oil drilling interests (UNEP 2011). Although the multinational oil company Soco announced in 2014 that it would end its exploratory activities in the park, which included seismic testing in Lake Edward, activities in Uganda along the park's border pose additional pressures (WWF 2014; WWF 2015). In 2015, for example, the Ugandan government initiated an open and competitive bidding process for an oil exploration license in Ngaji block, which shares a direct border with Virunga Park and overlaps Lake Edward (WWF 2015). Although widespread outcry ultimately led bidding companies to overlook the Ngaji block, it remains on the government's list of blocks available for commercial exploration (Uganda Business News 2017).

Pressures are also attributed to communities living in and around the park, many of which were displaced upon the park's creation. Livelihood opportunities for these communities include illegal production of *ndobo* charcoal from the park, which involves access to the park mediated by armed groups such as the FDLR. At the peak of the crisis around illegal fuelwood harvesting in Virunga National Park, the equivalent of 89 hectares of forest were destroyed each day (UNEP 2011).

Seeking to facilitate additional economic opportunities for members of these communities, as well as to improve overall well-being and decrease participation in the numerous armed groups active within the park, the Virunga Foundation has implemented several community development projects. Four main sectors have been identified to help rebuild Eastern Congo's social infrastructure: 1) sustainable energy, 2) sustainable fisheries, 3) agro-industry, and 4) tourism (Virunga National Park 2017c). Park Director Emmanuel de Merode estimates that initiatives in these areas have created approximately 3000 jobs in the last 10 years. In particular, internal research and monitoring by the park has shown that 5-8% of the jobs created have been taken up by now-former combatants (Ramsay 2017).

Among the Foundation's development efforts are community electrification projects, powered by renewable energy. At present, electricity in the park is primarily supplied by small, off-grid hydroelectric plants (see Table 1, below). All hydropower facilities in the park are "run-of-the-river" – i.e. part of a river's flow is diverted into a canal, passed through turbines, then returned to the river body downstream. Compared to dam-and-reservoir based systems, run-of-the-river plants are cited as being less environmentally harmful (Baker 2017).

**Table 2.** Supply in the Virunga park comes primarily from small off-grid hydroelectric power plants.

| **Name** | **Location** | **Capacity** | **Status (Operation start date)** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Mutsora Hydroelectric Power Station | Mutwanga town on the Butahu river | 0.4 MW | Operational (Nov. 2013) |
| Matebe Hydroelectric Plant | Town of Rutshuru on the Rutshuru river | ˜13 MW | Operational (Dec. 2015) |
| Lubero Hydroelectric Power Station | Lubero on the Volcano river | 1.1 MW | Under construction (end of 2018) |

Note: Some contradictory sources mention a capacity of 9.4 MW for the Mutwanga power plant and of 12.8 MW for the Lubero power plant.
Sources: Mutsora Hydroelectric Power Station (World We Want Foundation 2017; Baker et al. 2017); Matebe Hydroelectric Plant (Virunga National Park 2015b), Lubero Hydroelectric Power Station (Virunga National Park 2017c; Radio Okapi 2016).

A 2017 study of the community impact associated with the Mutsora station, which powers a soap factory, households and public service institutions, suggests that positive impacts on the local community have been realized via improvements in public institutions and services, increases in household well-being, provision of services for small businesses, and transformation of the agricultural industry (Baker 2017). The station has directly increased the number of jobs in the community – through positions to operate the hydroelectric facility – and indirectly, by supporting the power needs of the soap factory and small businesses. In switching from a diesel generator to the hydro facility, the local hospital has additionally been able to decrease its intake patient power surcharge by two-thirds.

At present, only 10% of households in the areas around the park are connected to the local grid. Under the assumption that job creation numbers associated with the Mutsora station are generalizable across scale and other contexts, it is estimated that every MW of electricity that is produced and reliably supplied to the population around the park results in the creation of 800 to 1000 jobs through local business growth, when considering both directly-created jobs and indirectly-supported employment growth (Baker 2017). Although this does not consider the longevity or stability of those jobs, and is a rough estimate produced with a strict assumption, it highlights the opportunities that exist in this space.

Whilst hydropower remains the main source of electricity in the park, additional electrification via solar is expected in the future. In 2016, the GivePower Foundation (SolarCity – Tesla) supported a solar installation consisting of 200 solar panels, 7 Tesla Powerwalls, and 7 SolarEdge inverters (PV Tech 2016) to allow park rangers to run lights and radio (CleanTechnica 2016). Other partners on the project included Empowered by Light; Canadian Solar; the Leonardo Dicaprio Foundation; and Goal Zero.

### 4.2. Electrification and the Improvement of Socioeconomic Outcomes in Mining Communities

The second context this article considers are mining communities. In the DRC, wars in the mid-1990s led to the destruction of traditional economic bases in the eastern and southeastern regions of the country - namely agriculture and small trade. In this space, there was a resurgence of the mining industry, which became “one of the only viable ways to earn money” (World Bank 2015a). Today, mining remains important to the DRC, where large deposits of minerals such as coltan, cassiterite, tantalum, and gold can be found – minerals whose final uses in the worldwide economy range from fine jewelry to electronic and computer components. While wide-spread violence in mining communities and the minerals trade is well-documented, many people in the sector view mining as providing a much-needed source of income. In many regions, a large number of individuals are not originally from the area, but have instead travelled substantial distances seeking work at industrial or artisanal mine sites.

Whilst armed groups have been involved in many human rights violations in mining areas, studies also find that violence, including sexual violence, often occurs due to the actions of other members of the mining communities (World Bank 2015a, 2015b). Perks highlights that such “results suggest that simply disarming rebel groups will not end abuses in the mining sector, since civilian power structures are some of the most exploitative” (World Bank 2015b). A joint World Bank and Harvard Humanitarian Initiative (HHI) study, focused on artisanal and small-scale mining communities in North and South Kivu, found that for women and members of other disenfranchised populations, such as orphans and widows, the potential risks of working in mining communities included rape, sexual violence, and debt bondage (World Bank 2015). In addition to the hazards of being subjected to direct human rights abuses, these at-risk individuals also face systematic economic hardship and are often forced into marginal support roles of running restaurants and shops, transporting minerals, or engaging in transactional sex, with more profitable jobs reserved for men.

Even as entrepreneurs in mining communities today, women may not always realize economic profits. Female business-owners in mining communities may have to extend credit to customers unable to pay upfront for the costs of food. With transient populations, some of these debts may remain forever unpaid. In other cases, when miners who have taken on such debts are paid, they may “disappear” or spend the money on alcohol and women. Such dynamics can lead female-headed businesses to collapse or remain unprofitable. In an attempt to address this problem, some female entrepreneurs have sought to work with community social development initiatives associated with industrial mining companies to institute a system for receiving a portion of the pay for miners with existing debts.

In many mining communities, women are also limited from accessing venues to affect decision-making processes (World Bank 2015a). Such disempowerment can intersect with economic predation even within a household – for example, when women are able to make profits, their husbands may forcibly claim those funds to prioritize their own uses over those of the household. These interactions can lead to conflict and tension in the domestic household. Providing economic opportunities in tandem with household-level programming or savings plans may help to address some of these issues.

In other scenarios, women have formed their own informal associations. As one example, the World Bank-HHI study describes how one woman established a fund for sex workers and other vulnerable women (2015a). Individuals paid a fee of five dollars to enter into the association and the funds were subsequently available for members to use in order to cover healthcare bills and other expenses. The women in the association noted that the fund was a major component of their ability to access healthcare and weather financial downturns.

The World Bank and HHI study, carried out from 2012 to 2014, was among the first to extend the study of human rights abuses in the DRC to an analysis of the "gender dimensions of artisanal and small-scale mining (ASM) as a means to economic security for both men and women" (2015a). The report ends with several recommendations for improving gender dynamics within mining communities, including:

- Supporting steady employment;
- Helping women to access employment opportunities beyond transactional sex;
- Facilitating the development of grassroots, inclusive economic cooperatives;
- Providing technical assistance in modernizing practices associated with the artisanal and small-scale mining sector; and
- Improving healthcare and basic water and sanitation facilities.

#### 4.2.1. Zones of Opportunities For Energy Projects in Mining Communities

In the context of mining, conflict and gender dynamics as well as conversations with members of the community in which projects are expected to take place, should inform the priorities and forms of proposed electricity access projects.

For example, electrification projects may have the goal of improving community-level services, such as powering streetlights, providing electricity to medical facilities, schools, churches, and community centers, or providing power to support public internet access. On Idjwi Island, for example, a solar panel and battery system helps to support the operations of Pamoja Net, which offers pay-as-you-go internet access at roughly $3 a month, compared to equivalent access from mobile airtime priced at approximately $80 a month (Project First Light 2016). Whilst additional investments may be needed to help turn such access into supporting employment opportunities, other benefits can include enabling women to access social networks that provide economic and social support. Meanwhile, access to electricity can help to improve much-needed healthcare services. For example, whilst a small solar system can power a small vaccine bank in community health center, expanding the capacity of the system can support improved healthcare services, such as refrigeration to keep blood for transfusions.

Electrification can also support productive end-uses, increasing employment and business outcomes in the commercial sector. In mining communities, energy is already used to power milling machines, mobile phone charging, tailoring shops, hair salons, movie shops, bars/nightclubs, and 'public secretaries.' At present, most of the commercial activity that is electrified is supported by diesel generators. Many shops, salons, nightclubs, and restaurants have private generators, such as to power lights and fridges. Individual entrepreneurs in many communities also own large generators which are able to provide power to several businesses and households through an informal distribution network, for which lines are typically erected by the diesel generator owner-operator. Services are generally provided for a defined number of hours, set by the owner-operator, and businesses pay according to tiers of the level of service required, often determined by the type of business being connected and/or the number of appliances being used. As the costs of transporting diesel to these regions increase as areas become harder to access, renewably-generated electricity may help to improve profit margins, though the potential ramifications of displacing existing owner-operators must also be taken into account.

Even in well-known mining regions, agriculture remains a predominant productive activity. A number of agricultural products are grown not only for immediate use, but also exported locally, such as palm oil, for which production is particularly extensive but not mechanized. In many cases, the most direct use of energy in agricultural production and processing is for milling, but these machines typically run directly on diesel fuel. Meanwhile, chickens are among the most common livestock animals and their production can be promoted with electricity-supported incubators.

As preferences for energy use, and ownership/management of electricity-supported enterprises can differ along gender lines, impacts of electrification can also accrue differentially by gender. For example, in some mining areas, fishing/aquaculture is a growing industry, where the use of refrigeration can help with preserving catches. At present, women – the ones predominantly selling fish – are forced by the lack of existing refrigeration to systematically reduce their prices at the end of the day.

Given that significant heterogeneity in access typically exists within a community, understanding the level of existing access compared to desired electricity access can be fundamentally important for managing expectations of associated outcomes. For example, whilst some individuals in a community may not have any form of electricity available in their household, others may already have lower-level, solar-powered solutions. Thus, an energy access project focused on providing lighting and cell-phone charging might be of interest to those individuals, but fail to attract a broader sweep of customers unless the costs and quality of service were improvements upon existing options. Additionally, it is unlikely that such access would influence such outcomes as employment.

## 5. Design and Deployment Considerations

Small-scale hydropower development in Virunga Park has shown some correlations with local economic development in the conflict-plagued, resource-rich province of North Kivu. However, electrification rates and socio-economic development in the eastern region of the Congo in particular remains nearly non-existent. Moreover, the contrast between hydropower development in Virunga Park and the Grand Inga Scheme highlights that improved energy access may act to mitigate the negative impacts of conflict or the perpetuation of conflict itself, but it may also further entrench existing inequities. That is, the development and deployment of new energy access systems should not only consider current options for access and the potential implications of disrupting the existing energy landscape, but also take into account cultural and gender-related dynamics, as well as the existing state of infrastructure and economic environment, which may mediate expected impacts.

The broader recommendation is that an accurate understanding of the specific context for deployment is key and failing to take these steps during project development can threaten the viability of, or reduce the intended impacts of, a project. One way to better understand the relationships between energy provision and the incidence of conflict is to take an informed approach to the design and deployment of a given system, and to monitor relevant metrics and indicators. When designing electricity access systems in fragile and conflict-affected states, relevant domains include: 1) technical considerations; 2) types of financing schemes; and 3) social dynamics.

Existing work in the energy access space, particularly with microgrids, has largely focused on technical and economic performance and thus provides a useful foundation to draw on. Evaluations of prior projects suggest that these aspects are important in determining the efficacy and sustainability of such systems. For example, understanding and moderating community expectations as to the level of service to be provided, balanced with cost considerations, may assist with the appropriate design and consequent sustainability of a given system. As with many technologies, a mismatch between consumer desires and the capacity of the technology to meet such desires, can create frictions. This may mean that one system of energy provision is rejected or soon displaced in favor of another, or that people are unwilling to pay at levels needed to financially sustain a given system. In one instance, attempts to provide electricity via solar microgrids in rural India were hindered by low demand, largely due to beliefs that expansion of the main grid and subsidized connections would soon arrive (Fowlie et al. 2016). Additionally, theft and non-payment are often correlated with perceptions of unreliable electricity services (Fowlie et al. 2016).

Overall, the existing literature emphasizes a few key aspects to consider in microgrid deployment, including: 1) engaging the local community throughout the life of the project, from design to deployment; 2) understanding the political context and engaging with relevant government bodies; 3) promoting income-generating loads; 4) ensuring system reliability; 5) providing for timely construction and timely repairs; 6) accounting for proper operation and maintenance; and 7) having transparency in billing, including a refusal to tolerate theft and/or non-payment (Schnitzer et al. 2014, Sovacool 2012, and ESMAP 2000). Systems should also be sized not only according to existing levels of consumption, but also with accommodations made for anticipated increases in demand. Additionally, appropriate knowledge of the community in which a system is to be deployed, and careful consideration of the financing structure in relation to local market structures, can be fundamentally important. For example, financing schemes based on existing structures may facilitate adoption of new systems, due to prior familiarity. Furthermore, pricing will be key to understanding the accessibility of energy access options among different demographics, and will thus situate the context in which impacts are realized. Thus, defining project objectives, clearly conveying the benefits and conditions of the project to community members, and having project members from the community, who can lend a deep understanding of the local regulatory and cultural context, can contribute substantially to a project's success. Project sustainability can also benefit from strong local engagement, including the training and promotion of local expertise.

An additional approach to energy development should include an explicit consideration of social factors, particularly in fragile and conflict-affected contexts where conflict sensitivity is key to prevent unintended consequences. In Table 3, below, we include examples of potentially relevant social metrics. Indicators such as the number of informal social associations and local governance structures can help to expose social hierarchies and reveal who typically has access to economic opportunities and grievance mechanisms. An analysis of these dynamics are important for understanding the contexts in which energy access may or may not affect gender and conflict relations. An understanding of social dynamics can also lend insights into areas where social tensions may occur in the context of energy development – in India, the same microgrid company experienced financial difficulties because operators, hired from within the communities, had strong social ties that superseded their obligations as employees to collect payments or report thefts from illegal connections (Fowlie et al. 2016).

**Table 3.** Metrics to inform design choices.

| |
|---|
| *Technical* |
| Coincident load based on existing electricity access options |
| Peak load based on existing electricity access options |
| Non-electricity fuel use for cooking |
| Timing of peak electricity use with existing options |
| Availability of resources for renewables-based electricity generation (e.g. solar or hydropower potential, etc.) |
| Flexibility of design to accommodate expected increases in electricity demand (compared to existing use), for immediate, short, and long timescales |
| Availability of – or measures to provide training for – local expertise in operation, maintenance, and repairs |
| Desired level of reliability (for example, availability of backup diesel generators during periods of maintenance or insufficient storage) |
| Availability of – measure to provide for – associated waste management for old or defective system components, including batteries |
| *Financial* |
| Payment systems for existing electricity/energy access options |

| |
|---|
| Costs for existing electricity/energy access options |
| Income or poverty measures for the community, by occupational categories and gender |
| Accessible lending opportunities |
| Non-community funding sources (e.g. international aid, private sector donations, etc.) |
| *Social* |
| Desired goal of electrification project (community, commercial, household) |
| Gender dynamics (e.g. differences in desired uses of energy; cultural dynamics that may influence access to resources) |
| Community governance structure and power hierarchies |
| Participants in community governance |
| Availability and types of grievance mechanisms/procedures |

In addition to design choices, measuring a suite of metrics/indicators before deployment and at different periods after deployment (for example, from one month to a year after) can help to provide a measure of the impacts associated with electrification. Table 4, below, provides a selection of indicators to measure the technical performance of a system and to understand associated economic, social, and environmental impacts. Depending on the defined goal of electrification – such as whether community, commercial, or household electrification is of interest – certain indicators or the associated magnitude of impact, may be more or less relevant. Additionally, the level of access provided, the quality and reliability of service, the fuel mix, costs for access, and available financing options – that is, aspects of the design itself – are likely to mediate expected impacts.

More generally, electrification activities are not inherently inclusive in providing potential benefits, due to differences in costs, sociopolitical factors, and governance approaches. For one, electricity by itself does little. Rather, the benefits of electricity depend substantially on whether complementary inputs are available or readily accessible – these may include inputs that directly consume electricity, such as electrical appliances, or more indirect inputs, such as roads, which can facilitate the transport of goods for or resulting from end uses of electricity (Lee et al. 2017).

Thus, if a project seeks to support commercial activities, expected impacts should be informed by the availability and accessibility of complements to productive activities supported by electrification. For instance, if electricity-using appliances are not presently available, a measure of households' ability to pay for such appliances, and to access them if located in remote regions would be relevant. Additionally, the costs of transporting such appliances should be taken into account. The lack of a well-functioning transportation network may inhibit the export and sale of locally-produced items in more distant, and larger markets: a common concern for remote communities is the lack of adequate roads to transport goods to and from urban centers. An additional consideration is that potential applications of electricity can differ along gender lines, both within the household and commercially. For instance, women more often tend to benefit from appliances that reduce time spent on household tasks. Finally, whilst renewables-based energy access systems can provide a cleaner source of energy than existing diesel generators, providers of these new entrants should acknowledge and examine the potential implications of displacing local entrepreneurs who currently manage diesel-powered distribution networks in these communities.

With respect to assessment, such indicators can be measured and reported qualitatively, through a simple analysis of results from baseline and endline surveys. However, such reporting does not account for potential confounders. For example, if regional stabilization were to occur at the same time, then measured improvements in economic outcomes may be due to, or magnified by, those dynamics. A more robust approach can be to take an econometric approach and control for potential confounders.

**Table 4.** Selected indicators to measure performance and economic, social, and environmental impacts of electrification, including covariates to understand potential factors influencing impact – to be measured at baseline and endline.

| Metric | Unit of Analysis |
|---|---|
| *Technical Performance* | |
| Capacity utilization factor | Percent |
| Compatibility with future capacity expansion | Ordinal scale |
| Compatibility with existing infrastructure | Ordinal scale |
| Dependence on weather and climate conditions | Ordinal scale |

| | |
|---|---|
| Demand growth | Demand in kWh by community |
| *Economic* | |
| Livelihoods supported by electricity access | Number of individuals employed in electricity-using activities (by gender) |
| Time spent working | Number of hours per day (by gender) |
| Average levels of job incomes or business profits | Average income or profits by job and gender |
| Job seasonality | Distribution of jobs by season |
| Quality of transportation network | Varies<br>Potential indicators include: amount of time to reach the nearest market or city; cost to reach nearest market or city; a measure of quality based on satellite images |
| Costs and in-store availability of electricity-using appliances | US dollars or Congolese francs; number of appliances available for purchase, by type, within a defined radius of accessibility |
| *Social* | |
| Electricity access | Number of households |
| Status quo lighting (no longer in use) | Number of status quo lighting sources |
| Household change in available hours of light and electricity access | Number of hours per day per household |

| | |
|---|---|
| Household change in available light output | Number of lumens per household |
| Educational outcomes | Number of children in school, number of hours spent studying, test scores, etc. |
| Savings on energy-related expenditure, per household | US dollars or Congolese francs per household per defined time period |
| Public acceptance/perceptions of energy/electricity system performance | Ordinal scale |
| Perceptions of quality of life | Ordinal scale |
| Expressions of self-empowerment (for example, "I feel more in control of my future") | Ordinal scale |
| Reduction in morbidity and deaths | Number of days experiencing sickness in the past four weeks; number of deaths per year |
| Crime rate | Number of crimes in the past four weeks |
| Crimes against women | Number of crimes in the past four weeks |
| *Environmental* | |
| CO2 emissions | Tonnes of carbon per year |
| Air quality | SO2 equivalents, particulate matter |
| Renewable fraction of fuel sources | Percent of fuel used |
| Deforestation | Number of acres per year |

| | |
|---|---|
| Collection of non-functional or outdated system parts (e.g. solar panels, batteries) | Availability of collection mechanisms |

## 6. Recommendations and Conclusions

Scholars of the Democratic Republic of the Congo have characterized the landscape of conflict in the country as reflective of a "conflict economy." Thus, whilst the role of conflict minerals in sustaining conflict is of concern, these scholars note that simply breaking the link between minerals and armed groups is unlikely to substantially change the state of matters in the country. At the same time, infrastructure is often seen as a way to improve stability and to promote development outcomes in fragile and conflict-affected states. Electricity, in particular, is touted as an important input for economic activities and growth. In a country where joining an armed group is often seen as a viable livelihood choice, electrification that supports productive end uses may be a way to support economic activities that increase the opportunity costs of joining an armed group. Additionally, electrification can help to increase the resilience of communities affected by conflict. Existing electrification activities in Virunga National Park qualitatively demonstrate the potential for electricity to improve economic outcomes in rural communities.

An increasing body of literature assesses the microeconomic impacts of electrification in developing countries. Whilst most point to overall improvements in wellbeing, the magnitude of impact varies. The interest of academics in better estimating and understanding the benefits of electrification on development outcomes provides opportunities for developers and academics to collaborate in project design, deployment, and assessment, to better understand the conditions under which electrification can promote positive socioeconomic changes, including outcomes relevant for gender equity and environmental benefits.

Importantly, for energy access projects to accurately address local needs, such projects should be developed in partnership with local communities, organizations, and businesses. In seeking to improve upon the existing state of electrification, developers must also consider the potential implications of displacing locally-generated solutions, such as local owner-operators of informal, diesel-powered distribution grids. Furthermore, an understanding of gender-related dynamics can provide insights into designing a system that accounts for, and more equitably supports, gender-related differences in desired uses of electricity.

Given that the DRC suffers from one of the lowest rates of electrification in the world, the opportunities for improvements are immense. The country also has substantial resources to support renewables-based electrification. An expansion of renewables-based energy access options in the Democratic Republic of the Congo thus provides a distinct opportunity in which an intentional approach towards providing clean energy access and simultaneously addressing gender, social, and environmental inequities, can lead to significant improvements in outcomes for a country too long affected by violent conflict.

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