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The political economy of electricity access

Lessons from Mozambique

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Introduction

This paper discusses the issue of electricity access as a key development challenge in the Global South. The development of energy services is a vital component of any social development policy strategy. Energy services such as heating, cooling, cooking and lighting meet basic needs to sustain life, and fulfil secondary socio-economic benefits such as recreation, educational attainment, economic productivity and poverty alleviation. Meeting energy service needs for the world's poorest people necessitates the use of different fuel sources and technologies under varying geographic, political and socio-economic conditions. For many in the developing world, energy services are met by the burning of solid carbon-based fuels such as charcoal, wood, peat or lignite (commonly referred to as brown coal). The use of such fuels is problematic due to the health and environmental costs of their production and use. Moving away from black-carbon intensive fuel sources towards cleaner burning gas and electric sources is of critical importance. As such, improving electricity access through the expansion of electricity transmission and distribution systems (so called electricity 'grids') and the connection of commercial and residential properties, has become an energy policy priority – driven by intergovernmental organisation and donor programmes to improve (primarily rural) electrification.

Although the expansion of electricity infrastructure across urban, rural and peri-urban spaces provides opportunities for improving the wellbeing and livelihoods of the world's poorest people, this process is not automatic. Electricity access is commonly measured in terms of the total number of grid-connected communities and/or households; however, the focus upon the technical infrastructure and the expansion of grid connection often belies problems experienced by households. Issues such as electricity pricing, supply intermittency, poor grid-connection reliability, as well as cultural and social practices of energy service use (such as preferences for specific cooking fuels for example) create a complex interwoven picture of energy use, demand and supply. Moreover, expansion of grid and electricity access is embedded in institutional and policy contexts that favour certain outcomes, geographies and social groups. Such problems of unequal access are exacerbated by domestic and regional disruption – i.e. civil unrest, political contestation and military conflict – and exogenous factors such as extreme weather events (exacerbated by anthropogenic climate change), global financial crises, changes in diplomatic relations, inward investment and potential 'enclaving' [1, 2]. Electricity access is therefore fundamentally an issue of *energy justice* [3]– one that is attendant to broader political, geographical and socio-cultural factors. This *Energy Insight* paper presents two aspects of the electricity access challenge. The first part outlines the difficulties and opportunities of expanding grid access to improve electricity service provision to the poorest people globally, and the second explores the complexity of the political and justice implications of electricity access provision, with reference to an in-depth case of Mozambique.

Part 1 – The electricity access challenge

Poverty alleviation for the lowest income developing nations is understood as a multi-dimensional problem that involves simultaneous progress across 17 Sustainable Development Goals (SDGs). The SDGs cover health, gender equality, jobs and livelihoods, environmental protection, and institutional governance. They are a comprehensive policy and planning tool for setting a global agenda to end poverty [4]. However, although there is a clear transnational political commitment to improving development outcomes through the mechanism of the SDGs, despite significant progress in the last decade, nearly 800 million people still live in extreme poverty – defined as those earning $1.90 per day or less [5]. The global challenge of multi-scalar and multi-sectoral poverty alleviation involves a complex array of policy and economic development options. At the core, however, is a need to improve *opportunities* for the poorest people, primarily by widening access to public services (including health and education) and basic infrastructure such as energy access [6], as well as their respective *capabilities* to meet their own needs [7-9].

With regards to energy, SDG7 emphasizes the need to "ensure access to affordable, reliable and modern energy for all by 2030" [4]. The SDG#7 is primarily interpreted by national policy institutions as a need to directly improve electricity and fuel access. Energy access is commonly posited as the mirror opposite of *energy poverty* – a condition of unstable and/or unaffordable access to electricity and clean fuels. SDG#7 presents a challenge to policy institutions, non-governmental, industry and third sector organisations. Achieving this goal requires the simultaneous development of both physical resources (including technological infrastructures, minerals and other extractive commodities, research and innovation, and ecosystem services) and social infrastructures (including political institutions, public services, cultural assets, capacity building and nurturing local capabilities, and transparent governance systems) [10, 11], such that social welfare is maximised through access to energy services, and not just the private profit of energy organisations. Social scientists commonly refer to these inter-related sets of social and physical components as 'socio-technical' systems [12, 13] that bring together a web of inter-connected human, physical, material and technological elements. *Electricity provision* and *access* are key examples of this socio-technical framing [14-16] – the provision of the service is not solely explained by the construction of the technical infrastructure, but rather in-relation to the broader patterning of energy services, contexts and cultures in which energy connects with the social life of users. Electricity access also underpins related commitments to reduce the risk of anthropogenic climate disruption from greenhouse gas emissions, and so the socio-technical system of energy services connects deeply with the broader ecological and geophysical systems that support human and non-human life and wellbeing on a global scale.

Energy access as a *policy priority* involves increasingly complex and interconnected international agreements on sustainable energy access and climate change. The global spotlight on rural electrification and sustainable energy transitions is mobilising billions of dollars in finance for technology transfer to the Global South, either to increase generation capacity or to extend grid infrastructures and domestic, or household connections [17, 18]. For instance, in 2013 investors mobilised US$13.1 billion globally in energy access, with 97% of that funding targeting electricity networks [17]. However, the deployment of significant financial resources to advance sustainable energy goals has often reproduced what could be termed *neoliberal* policy prescriptions. Public sector roles in energy services provision are, in many cases, limited to regulatory functions such as creating an 'enabling environment' for clean energy technologies to grow [19]. This represents a shift towards the development of the 'regulatory state' [20], characterised by processes of privatisation and deregulation which replaced the 'dirigiste state' of the past (whereby the state exerts a strong directive influence over investment) [21]. Thus *regulation*, rather than public ownership, planning or centralised administration, have become the key contextual factors influencing how low carbon energy transitions have come to be governed [22].

Despite the socio-technical nature of electricity services, analysts commonly frame sustainable energy provision as a matter for technical experts – a challenge of increasing transmission distances and maximising the number of consumer connections to centralised grid infrastructures. With a strong international focus on electricity grid extension, much existing development research has focused upon binary metrics, such as whether or not a household has an electricity connection [23]. Yet the energy access challenge is more complex. Clearly, the expansion of domestic connections does not automatically guarantee access to reliable and sustainable electricity. Moreover, even where the headline metric of grid access is increasing, this does not necessarily help policymakers to understand how expanding energy access relates with overall socio-economic development.

Electricity access can be problematised in multiple ways. First, is that where electricity grid access exists, it is often unreliable (especially in remote and rural locations). In many developing states, electricity access is commonly through irregular, patchy and informal (often illegal) connections [24]. On a technical level, there are further factors to consider, such as – is the connection to the central grid or an independent 'islanded' micro-grid? Are connections safe and well maintained? Are grid connections and electricity supply affordable? Is access dependent on one or more energy generation technologies? Is there sufficient skills capacity for repair and maintenance of electricity services? [25]. Second, for electrification programmes intended to connect new users nationally, these often do not significantly contribute either to the intensification of electricity consumption nor to the reduction of biomass (such as charcoal and fuelwood) use in households. This is because the domestic choice of energy source is dependent on factors such as fluctuating and uncertain prices and on household capability to invest in new energy-consuming appliances. Conversely, however, biomass sources and kerosene are often more expensive per unit of useful energy than higher-grade sources, suggesting that although electrification has proved challenging, it should (normatively) remain a key poverty alleviation strategy [26].

By relegating electricity access to a solely technical issue, the solution is often viewed at least by mainstream observers and decision-makers, as a process reliant on achieving economies of scale, and one that can be delivered and managed in a depoliticised and socially-neutral manner [27]. Critical geographers and social scientists studying energy, however, have increasingly come to question this view, pointing to the complexities of access and the socio-political dimensions of energy provision and energy infrastructures as key sites of contestation [28, 29]. On a simple level, electricity access can be understood in terms of the three "Rs"— rural electrification (*the process*), reform of the electricity sector (*the catalyst*), and renewable and other low carbon energy technologies (*the means*) [30]. Yet, in trying to improve access, across the world there has been significant growth in the development of centrally planned electricity transmission and distribution networks, with little attention paid by policy-makers, infrastructure development bodies, and planners to the broader social impacts, institutional configurations and local-regional development goals that drive particular socio-technical system changes. It is necessary therefore, to structure energy transitions and socio-technical system changes in context-specific ways – to incorporate 'bottom-up' assessment of the political, economic and social circumstances of regional, national or sub-national energy systems in which new technologies are to be applied [31].

Moreover, quantifying the impacts of energy access gains (or conversely the lost opportunities) to vulnerable populations remains highly challenging, so that calculating the costs and benefits of different electrification strategies remains difficult. Furthermore, many of the centralised grid systems emerging globally rely on fossil fuel-based sources of electricity, such as thermal coal, oil or gas. Energy networks are commonly subject to technological 'obduracy' and 'carbon lock-in' – or, how a combination of political, economic and technological path dependencies resulting from colonial histories, poverty, resource availability and technological capacity, steer energy system development down a carbon intensive pathway, which becomes increasingly difficult to reverse [32-34].

National governments are frequently motivated to expand centralised grid networks (either low-carbon or carbon-intensive) because domestic and commercial energy consumption is a key tool for economic growth of local and national economies. Some states are further motivated to invest in large energy-related infrastructures as a means forge visible connections with citizens (and voters) in their daily lives, at least at the level of political rhetoric [35, 36]. This issue of the political framing of energy infrastructure is significant. Of note is the problem of the so-called "securitisation framing" of energy access. Securitisation is a political discourse or policy frame in which decision-makers appeal to national-interest concerns of public safety in order to reduce individual rights and freedoms, and press forward with controversial policy measures unimpeded by democratic scrutiny. The energy security dilemma is one form of this securitisation frame – the perceived need to build new infrastructure to meet development needs means that land-use changes for grid infrastructure, renewable energy generation technologies and others (such as biomass, or new fossil fuel-powered systems) are implemented without access to information, opportunities for public scrutiny, access to public participation in decision-making or legal redress in the event of environmental justice disputes. Securitisation as a mechanism for infrastructure expansion is a growing problem across both high and low-income economies under conditions of rapid low-carbon transition [22, 37, 38].

From a development perspective, we are faced with multiple, seemingly incommensurable problems. The first, is the mass expansion of universal electrification (and supporting, yet often largely invisible infrastructures, including power grid lines and substations, pipelines, converters and outlets). The second, is the assurance of rights, justice, environmental protections and democratic accountability within the energy sector and its interaction with the wider political economy. The third, is avoidance of dangerous climate change by reducing the carbon footprint of multiple (and overlapping) socio-technical energy systems. Balancing these three policy priorities is an enormous challenge for international governance institutions, national and regional governments, local development agencies and civil society groups. This *Energy Insight* aims to contribute to debates on sustainable energy access across this 'trilemma' of the political economy of energy [39-41]. We do so through suggesting that historical-institutional and political-economic perspectives offer a set of tools to examine energy access and energy usage in particular places and contexts. These tools foster an analysis of structural conditions [42] while posing questions about who wins, who loses and why, as a result of particular policy frameworks and socio-technical systems [43]. As Castán Broto et al. [44] observed, "Not all transitions are just, and transitions themselves may generate further inequalities."

The benefits of electrification

Mass electrification and access to reliable energy services is an important goal for social and economic development and human wellbeing. As previously mentioned, electricity provision has tremendous social value, as well as offering secondary improvements to health and local environmental conditions [11, 45, 46]. For many people across the world, heating and lighting is provided by open flames – such as wick lamps or oil lamps, open fires and candles [47]. These are very low-efficiency heating and lighting sources. The greenhouse gas emissions associated with wood fuel and kerosene-based systems is significant. There are also considerable health impacts from the inhalation of black carbon and particulates produced by open flames. Providing electricity-based solutions to heating, cooking and lighting therefore has immediate health benefits from improved air quality, reduced risk of uncontrolled fires and associated injury and death, as well as potential domestic cost savings, thus improving household incomes.

Policies and industry strategies to improve energy security through mass electrification in urban, peri-urban and rural locations can provide a number of substantive advantages. First, improvement of electricity-based energy provision can raise living standards for the poorest people, in terms of amenities and services. For example, in many cases, increasing access to electricity reduces household expenditures for energy services (such as kerosene) by replacing them with direct access [48, 49]. Other energy services are of growing social significance. Mobile phones are becoming an important part of many local and regional development strategies. Phones are often presented in the popular media as non-essential luxury items, however, we argue that they should be understood as basic needs technologies across all levels of society. Access to mobile phones improves educational outcomes, mental health, political engagement and social capital available to the poorest people [50-54]. Additionally, phone access provides better integration of family networks and social support (particularly under conditions of forced or seasonal migration due to environmental stressors, civil unrest or market changes), improved communication with business services, supply chains and financial organisations (including participation in the marketplace through mobile banking and money transfer using smartphone apps and telephone banking). Access to Internet services through mobile phone data also improves access to educational materials, practical information to improve community adaptive capacity and the strength of social networks. Mobile phones and underlying electrical and terrestrial telecommunications infrastructure reduce communication costs and therefore allows individuals and firms to send and to obtain information quickly and cheaply on a variety of economic, social, and political topics. Reduced cost of mediated communication, in turn, leads to tangible economic benefits, improving agricultural and labour market efficiency, producer and consumer welfare, alongside with wider rural connectivity [55, 56]. However, the poorest people, particularly those who live off-grid usually in rural and peri-urban communities, spend significant amounts of time and personal financial resources charging mobile phone batteries; electricity access would ameliorate these constraints. Given the (variable but generally increasing) rate of uptake of mobile phone technologies across the developing world [57, 58], providing reliable electricity sources for this purpose alone would have beneficial development outcomes.

Second, improvements in the availability of electricity services increases the direct and indirect employment opportunities for supply-side energy services. These include electricity generation, technology installation, distribution and sale across the energy delivery chain, and the economic development effects on the demand side – such as improving productivity of rural industries (such as food processing) [30, 49]. As mentioned in relation to the twin commitments of improving electricity access and reducing global climate change risk, numerous innovations have emerged in the low-carbon energy innovation 'space'. These include micro-renewables, such as stand-alone solar water heaters and solar photovoltaics (PV), wind power and geothermal technologies, micro/mini-grids, alongside innovations such as agrivoltaics, which combine solar PV suspended above growing areas to provide shade for high-value crops [59]. There are also innovations with aquavoltaic systems, or so-called "floatovoltaic" technology – water-deployed solar photovoltaic systems combined with farming of aquatic organisms [60]. Accordingly, there is a rapid expansion of local markets for renewable electricity generation, technology installation, maintenance and consulting [61, 62].

Given these dynamics, enhancing electricity access is not solely a challenge for development organisations, it also represents opportunities for human-centred and bottom-up community energy provision [63], entrepreneurial activity, new forms of public-private partnerships, and models of community ownership for energy generation [64, 65]. As Alstone et al. [66] argue, the contemporary electricity technology landscape is permeated with rapidly developing (and rapidly spreading) *decentralised* network models and systems. Community energy provision is primarily brought about through the deployment of decentralised energy networks, which combine high-efficiency consumer and end-use appliances and low-cost renewable energy generation technologies including (but not limited to) low-cost photovoltaic cells [64, 65, 67]. As Alston et al. [66] continue, the growth in decentralised systems to improve rural and peri-urban electrification is a type of technological *evolution*, facilitated by the growth in information technology access, specifically through mobile phone network infrastructure and virtual financial services. They argue that decentralised electricity systems are *disruptive* in that they rapidly increase access to basic electricity services to improve quality of life, whilst simultaneously driving action towards low-carbon development – effectively bypassing the need for centralised and grid-connected fossil fuel-based systems.

Third, a shift from black-carbon based energy and fuel sources (e.g., lignite [brown coal], peat, dung or domestic charcoal) towards domestic electricity-powered lighting and gas or geothermal heating will greatly reduce the health risks [68], such as respiratory disorders, cancer and heart disease associated with prolonged exposure to black-carbon fuels [24, 68-71]. Moreover, a shift from centralised fossil fuel-based electricity production from coal (particularly lignite) will reduce the carbon emissions per unit of energy and thus mitigate climate change impacts from rapid economic development [72, 73]. It will also reduce the health risks associated with ambient air pollution, such as smog and ozone pollution that blights many of the world's most populous cities. There is a need therefore for the simultaneous mass electrification and rapid transition towards low-carbon/low-particulate pollutant energy-generation technologies.

Fourth, reliance upon black-carbon fuel sources for heating and lighting is associated with widespread local environmental degradation and poor environmental health, primarily from deforestation for fuelwood and charcoal. An estimated 2.7 billion people globally rely upon wood-based fuels for cooking [74]. There is a lack of reliable baseline data on global charcoal consumption, and as such, there is a risk that over-generalisation around the extent to which charcoal is causing forest damage is preventing an effective policy response [75]. However, case studies in different developing country contexts using different methods (including satellite image observational studies and ethnographic studies) do show deforestation occurring [76-78]. Mass charcoal production provides opportunities for income-generation [79], though it commonly damages biodiversity and ecosystem service provision, with resultant negative impacts upon agricultural capacity and human health and wellbeing [80, 81]. Over 80% of urban households in sub-Saharan Africa employ charcoal as a primary cooking fuel, and charcoal also provides a significant source of income for rural households in areas with access to peri-urban and urban markets; though charcoal use is of course not limited to rural communities [82-85]. As Zulu and Richardson [86] have observed, poorer households are more likely to participate in the production and sale of charcoal, primarily to provide an economic safety net by supplementing other sources of income. Policy responses to reduce household dependence on charcoal must therefore not only replace wood fuels in domestic settings but must also provide an alternative income stream for farmers and labourers.

Fifth, electrification has secondary social benefit outcomes beyond the direct economic benefits to households from reduced heating, lighting and fuel costs, or the alterative income generation streams. For example, improved heating and lighting, reduced time gathering wood fuels, and reduced time spent on seeking mobile phone charging, will improve opportunities (particularly for women and girls) to engage in recreation and education, thus improving wellbeing, health and social outcomes [87]. Studies of rural electrification find that the greater the likelihood of a household's access to an electric grid, the more time the household's children are likely to spend studying at home, offering indirect evidence of an improvement in levels of schooling [88, 89]. Other researchers have shown electrification to accelerate opportunities for women. Domestic electricity access helps to move women and girls into more economically productive activities, and Samad and Zhang [90] find that electrification measurably improves women's decision-making ability, mobility, financial autonomy, reproductive freedom, and social participation.

Overall, the analyses discussed here have implications for the ability of lower-income developing economies to promote and sustain increases in energy access, along with a range of associated benefits to this process. Given the extent of the energy access challenge, with an estimated 1.1 billion people currently lacking access to electricity [16], several authors argue for developmentalist and publicly-funded interventions, alongside nurturing opportunities for innovation and entrepreneurial approaches [19]. Yet, the picture remains complex; and apart from highlighting these direct and indirect benefits reached through increasing and improving energy access, geographers, STS (science and technology studies) scholars, and other critical social scientists have developed new lines of research on energy access in the global South. Such research has focused heavily upon energy poverty, justice and people's everyday lived experiences [44], low carbon energy transitions, along with social and cultural aspects of new lighting and cooking technologies [91].

Related to the emerging debates in which the concept of 'energy justice' figures prominently, Castán Broto [63] and Castán Broto et al. [44, 92] have recently explored the notion of 'energy sovereignty' over energy generation, transmission and distribution systems. In a developing and postcolonial context, this means learning to recognise how people themselves engage with the making of technologies of everyday life through hybrid forms of contextually generated innovation. Another stream of literature highlights the local and global infrastructures of production, transport and distribution of energy, along with practices of securing such activities and their spatial manifestations [93]. Such spatial justice issues concern problems of land-grabbing, displacement and social oppression linked to large-scale energy investments [2, 94]. This analysis seeks to uncover emerging spatial dimensions of power and politics, adding to our understanding of state-building and geopolitical relations, particularly in postcolonial contexts.

In the second part of this paper, we narrow the focus of electricity access within a geographically-bounded case study. Specifically, we explore these issues in the context of Sub-Saharan electricity access and development. This is followed by a discussion of a *critical case* of electricity access in

Mozambique: one of the Southern African region's largest hydropower-generating yet energy access-poor, countries. We outline and analyse some of the challenges involved in extending energy access in an equitable and sustainable manner, and then reflect upon the Mozambican case for broader energy-and-development policy and planning.

Part 2 – The political economy of electricity access: the case of Mozambique

Electricity access in sub-Saharan Africa

Although the benefits of electrification for global social and economic development are clear [95-97] in many states, notably in sub-Saharan Africa, most investments in the energy sector fail to meet the energy needs of the poorest people, even in countries where access to grid-connected energy services, unplanned service disruptions and power outages are commonly experienced. Moreover, supply of electricity is not always affordable, and many rural, off-grid and micro-grid systems only have sufficient capacity to provide a few hours of electricity services per day. Consequently, even for many of those who have gained access through a permanent grid connection, the absolute level of electricity consumption, and access to electricity services is low, and as the International Energy Agency argue, there is no universally accepted minimum threshold for what constitutes electricity access, particularly in establishing policy targets [18, 98, 99].

Fully two-thirds of total energy investment in Africa is dedicated to producing energy for export while roughly half of current electricity consumption is used for industry – primarily mining and refining, according the most recent *Africa Energy Outlook* [98]. Moreover, the needs and priorities of users, particularly those of the poor, have been widely overlooked in national energy planning, as the focus has largely been on locating strategic resources for global markets rather than providing energy services tailored to local needs and conditions, or offering a meaningful voice to users [17, 100]. It is necessary, therefore, to better understand and engage with the interests, power relations and policy networks that shape the prospects of realising climate and energy policy goals; acting as barriers in some cases and as vehicles for change in others [101].

Challenges around energy infrastructure and supply in the global South are often approached from what could be called a "top-down perspective," such that concerns with energy security and sovereignty compete with the demands of export markets and the need to facilitate global trade and resource flows. Such national-economy scale concerns often take precedence over household and community perspectives on energy access and use. This presents a serious challenge if ambitious targets to achieve 50% - 100% access to modern energy services by 2030 in Africa are to be achieved. Electricity infrastructure planning, construction, operation and maintenance remain technically challenging within countries that have geographically isolated and politically fractured regions [102]. The expansion of centralised electricity infrastructure is then coupled with complex long-term governance challenges, not least the effective mobilisation of funding from both internal sources (e.g. taxation-based public monetary and fiscal policy, public-private partnerships) and external sources (donors, loans, inward investment and venture capital) funding [103]. Furthermore, the management of complex financing programmes for energy system investment requires greater emphasis both upon the productive uses of energy, and upon effective processes of institutional governance to ensure that the vicious circle is broken between low incomes leading to poor access to modern energy services, which in turn places limitations on the ability to generate higher incomes. Breaking this cycle requires new thinking both in terms of the types of electricity technologies and resources deployed, and in terms of the range of actors involved in the management of such complex socio-technical systems [42, 96, 97].

While the diversification of energy resources, policies, investment models and governance practices would be beneficial for rapid socially sustainable energy transitions, the current dominant economic model across much of sub-Saharan Africa focuses on large-scale energy consumers whose activities are geared towards the growth of top-level economic indicators, such as GDP, in continuity with the colonial era. Conversely, a broad range of domestic and rural electricity benefits are construed as 'social welfare' or 'uneconomic' policy objectives [104]. In 20th Century Europe, electricity access was achieved through centralised power generation systems (usually situated in fossil fuel heartlands located close to industrial cities), and mass electricity transmission and distribution systems branching outwards from industrial centres to rural locations [105-107]. The centralised electrification model of 20th Century European rural development is increasingly challenged by decentralised and alternative energy transitions, incorporating new energy generation forms (including on- and offshore wind, hydro, solar and limited nuclear and biomass), and investment models including micro-renewables and community energy schemes [108-110]. Thus, the *normative ideal* of centralised power generation in Europe is now shifting towards one to dispersed and decentralised socio-technical energy systems [66, 111, 112]. However the rural electrification model still remains influential across the African continent, where mega-projects and centralised power systems are still heavily promoted [35]. The development of specific infrastructure models under certain governance arrangements is thus mutually reinforcing – political governance models that involve state owned/controlled infrastructure and energy resources will tend towards the construction of centralised systems of energy production, which in turn creates a system of centralised political authority through the control of access to energy services [102, 113].

The case of Mozambique

Mozambique's political and social history is deeply shaped by its colonial past. Mozambique lived for four centuries under Portuguese colonial rule, and the violent effects of colonial action remain significant – with the oppression of the slave trade and brutal civil political repression by Portuguese authorities remaining salient in Mozambican memories [114]. Mozambique's energy system, in its current form, is also shaped by this political and economic history. During the colonial period, deep divisions between the northern, the central Zambesi

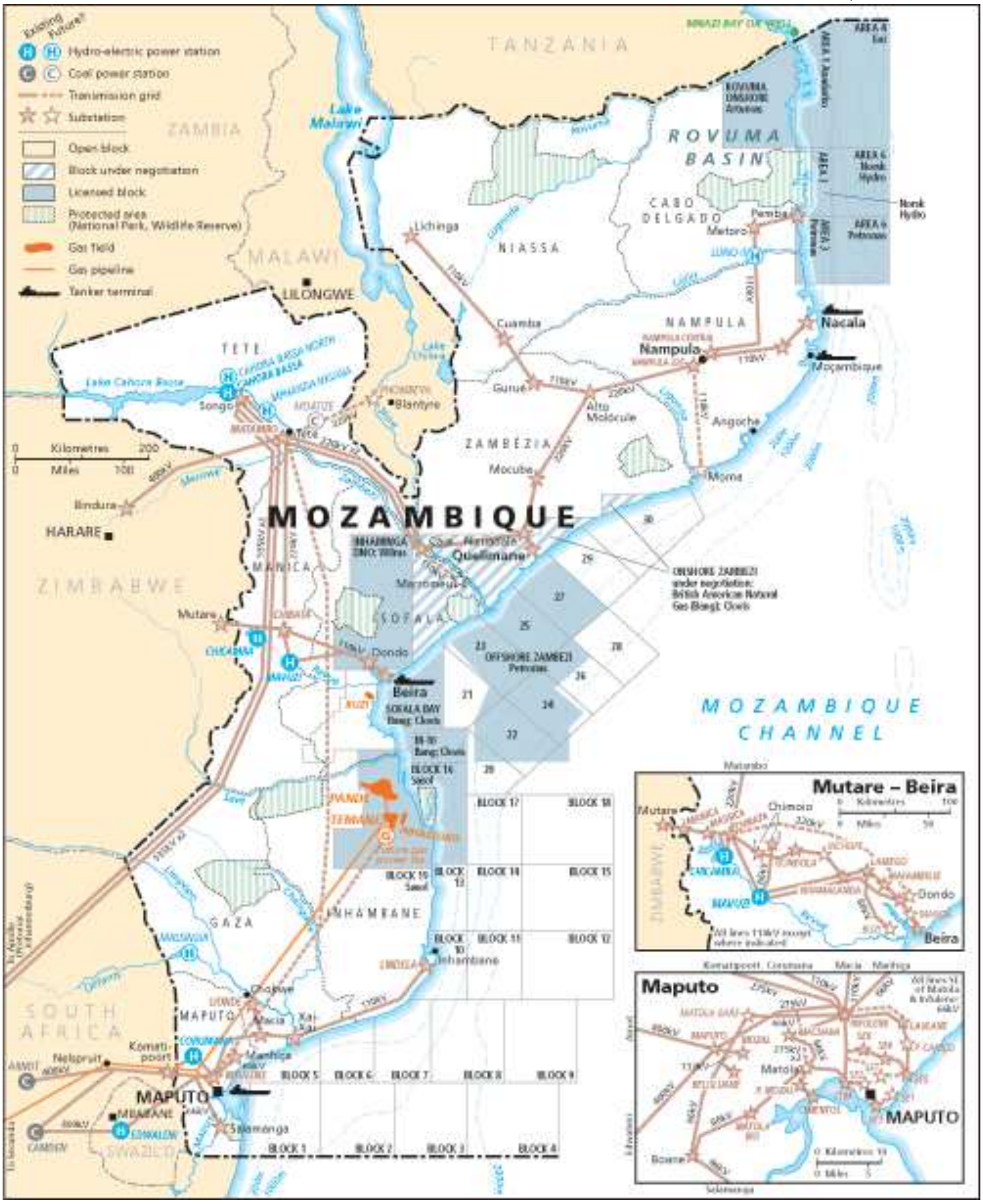

Figure 1 Figure 1 Map of Mozambique's electricity grid system. Source: https://www.geni.org/globalenergy/library/national_energy_grid/mozambique/mozambiquenationalelectricitygrid.shtml

valley, and the southern regions emerged. Under Portuguese rule in the 19th and early 20th centuries, the territory that was to become Mozambique was divided into separate concession areas and governed by charter companies, often British, until 1942 [115]. This is significant because geographical constraints to an integrated national development strategy also stem from the location of the capital in the far south, physically distant from the rest of the country. The development of infrastructure networks (e.g. railway corridors, roads and later power transmission lines), which linked regions of the country to their inland neighbours (South Africa, Zimbabwe, Malawi) rather than to interior regions [115, 116] followed this pattern.

The political fragmentation of the colonial territory was also reflected in the electricity network, which developed as three distinct systems: one in the south, around Lourenço Marques (the colonial designation of Maputo); another system in the centre, associated with the city of Beira; and a third system consisting of dispersed urban centres, but largely disconnected from each other [117] (see Figure 1). The coastal city of Beira is connected to the central grid, which extends through the central region to Zimbabwe, and draws on the Chicamba and Mavuzi dams built in 1950 and 1960, respectively, as opposed to Cahora Bassa, which supplies the south and far north.

After Portugal's Carnation Revolution of 1974 and the decolonisation of its African overseas colonies, the People's Republic of Mozambique formed in 1975, though after two years of independence, the country descended into a protracted civil war lasting from 1977 to 1992. During the conflict, the FRELIMO-led (*Frente de Libertação de Moçambique*) government sought to use energy infrastructures as part of the larger project of national unity and modernisation. The Cahora Bassa hydroelectric dam was to play a key role, but it would also require the integration and expansion of the very limited colonial-era electric grid. To this end, the government created a state-owned electricity utility, *Electricidade de Moçambique, E.P.* (EDM) in 1977, integrating some two-dozen dispersed colonial production and distribution units [117]. The government provided EDM with a 'social mandate' to support national social and economic development, but this was curtailed until the end of the civil war in 1992. From 1995, the post-war democratic restructuring of Mozambique saw the implementation of multi-party presidential and parliamentary elections – a process of democratisation that nonetheless has created a divide in civil authority between the ruling FRELIMO party, and the opposition party RENAMO across multiple political scales – affecting both national policy and local frameworks of governance [118]. The post-war period also saw the rebuilding of civil infrastructure. As such, EDM began to expand the domestic grid, with support from the donor community, regional partners and foreign investment (ibid). Since then, the grid has expanded substantially, connecting all provincial centres and all 128 districts (as of 2014) [119]. However, several important limitations remain. The existing network bypasses extensive rural areas, where the low density and low-income population makes it difficult and costly to connect people to the grid. The central and northern provinces depend largely on a single, ageing transmission line each, such that a single line failure is enough to cut electricity to a vast area [120]. The low rate of electricity access remains a key challenge for the country's economic development and social wellbeing.

Currently, Mozambique has one of the lowest rates of electricity access in the world, with roughly one-quarter of its 28.8 million inhabitants having access to electricity in 2018 [121]. It is an important case study because, similar to a number of African states, it enjoys abundant natural energy resources (natural gas, coal and hydropower, wind and solar potential) but continues to face entrenched energy poverty. Furthermore, the country has experienced a regime change from socialism to capitalism, followed by the privatisation of much of the means of production, along with protracted job scarcity and new socio-economic dynamics and challenges [115]. Concerns were raised in the post-war redevelopment and privatisation of state-owned firms and assets that such privatisation was tantamount to re-colonisation [122]. Energy access underpins many of these challenges, including rapid urban growth, gender and spatial inequality, and long-term environmental degradation. The Mozambican state has made electrification—both urban and rural—a major component of its development programs [123]. Despite the Mozambican government's modernising aspirations from the post-independence period to the introduction of multiparty democracy in the 1990s, through to recent efforts to attract global investors in the 2000s, a uniform energy provision infrastructure has failed to emerge. Policymakers and agencies have struggled to coordinate interventions around domestic cooking, electrification and mechanisation needs in agriculture into long-term, integrated energy planning model.

The country's electricity connection metrics include 20.17% of the population being grid-connected, where access in rural areas remains low at 5.7%, whilst urban areas continue to grow [121]. Besides the wide variance across the rural-urban continuum, electricity access rates also vary greatly by province and city. For instance: 95% of households have access to electricity in Maputo City, the capital of Mozambique, but this figure is 66% in Beira, historically Mozambique's second largest city [117].

EDM [121] attributes the low figures and divergence in access to electricity to the uneven distribution network, along with the historical exclusion of the private sector from investing in electricity projects, and low tariffs that are insufficient to fund new expenditure without subsidies, while remaining beyond reach for many Mozambican households, particularly the poorest. Nonetheless, the electrification rate has significantly increased over the past two decades, growing from 5% in 2001 to 27% in 2017, which has renewed optimism about the possibility of reaching 50% by 2023 and delivering universal energy nationally by 2030 [121].

The Mozambican government has endorsed the Sustainable Energy for All (SE4All) targets by 2030 and the Sustainable Development Goals (SDGs). It intends to achieve the SDG#7 through two strategies based on the characterisation of areas as either rural or urban, which has shaped the approaches for energy access adopted by state agencies and donors. First, there is a strategy of grid expansion in which the state-owned utility, EDM, extends transmission infrastructure to meet growing demand, particularly in cities and areas well-linked to commercial networks. Second is a strategy of decentralised generation, operating off the main grid, and shaped by a recognition of the limits of grid extension and by donor priorities for addressing clean energy and climate agendas. The latter is implemented by *Fundo the Energia* (FUNAE), a public institution established in 1997 with Danish assistance, to promote access to low-cost, sustainable and alternative sources of electricity in areas not served by the grid [121].

FUNAE promotes access to electricity through funding and implementing off-grid power production systems, specifically solar PV stand-alone systems and mini-grids, mini-hydropower and biomass [124]. However, less than 1% of households have benefited from off-grid connections, as FUNAE has mostly focused on electrifying schools, hospitals, administrative offices and pumping stations with solar panels [125]. What is more, many of the household connections have failed, due to operation and management issues [126]. Thus, there are difficulties in connecting through off-grid systems a considerable percentage of the 5.9 million households needed to achieve universal access to electricity networks [125]. Compounding these challenges, urban population growth has outstripped the pace at which households have been connected to the grid [96, 127]. Moreover, in early 2019, two major cyclones – Idai and Kenneth – caused significant damage to energy and other basic infrastructure in Mozambique's central and northern regions, the cost and governance challenges of rebuilding a resilient electricity network system in the affected areas require ongoing financial support and political scrutiny.

Some analysts emphasise the need to create the conditions for private sector participation to scale-up and accelerate the pace of off-grid connections [123, 126] in order to achieve electrification targets whilst simultaneously reducing the burden of infrastructure provision on public finances [126]. Fael [128] has suggested that private sector participation will require the creation of a regulating entity to control and inspect the tariffs applied by all operators to avoid oligopolistic/cartel practices. Infrastructures such as electricity networks are commonly subject to natural monopolism following privatisation, due to the high costs and lead times for construction, making it difficult for 'new players' to enter electricity supply markets without public finance assistance and governmental policy and planning support [129]. Strong regulatory practices are necessary to protect consumers' rights and interests regarding tariffs and network costs, the type and quality of service provided, including complains related to damage to their household electrical appliances due to power overload after a blackout or brownout.

Access to grid-connected electricity remains aspirational to many households in Mozambique. As such, promises of electricity provision are often mobilised as a tool for political campaigns to attract voters, including in the recent national, provincial and local elections of October 2019. Yet, the majority of Mozambicans continue to rely on charcoal and biomass to meet their energy needs. In urban centres, charcoal is the major energy source for cooking, whilst fuelwood remains the primary fuel in rural areas [117, 130]. Growing demand for both fuel types drives high wood extraction rates over increasing areas of forest [130]. CO_2 emissions per capita remain comparatively low amongst Southern African states, at an estimated 0.2 metric tons per capita (2016) growing at an average annual rate of 5.52 % [131]. However, the transition to a low carbon economy is gaining policy and public attention in Mozambique. By most accounts, Mozambique's energy system is in transition: renewables are shifting the expectations of energy access, particularly in rural areas [132]. As growing deforestation pushes the supply of charcoal and fuelwood further from major cities, raising costs and secondary environmental impacts, there are growing calls to use domestic fossil fuel resources (including the newly-discovered natural gas deposits in the northern Rovuma basin, on the border with Tanzania) for the social benefit or *public good* of citizens [133]. The ambivalence and contradictory implications of an emerging energy transition are yet to be fully addressed, including long-term environmental degradation from a fossil-fuel-based transition pathway.

Mozambique's colonial history influences its evolving energy system

Mozambique's electricity generation is heavily dependent upon hydropower. Hydroelectricity is the primary energy source, accounting for about 77% of all electricity generated [120]. Alongside production from other smaller dams, with a combined capacity of 565 MW [127], the Cahora Bassa dam (2,075 MW) sits at the heart of the national energy system, supplying 25% of electricity supplied by EDM. The bulk of the electricity load (1500 MW) is then exported to South Africa under a long-term Power Purchase Agreement (PPA) between *Hidroeléctrica de Cahora Bassa* (HCB) and South Africa's electricity utility (Eskom), in force through 2029 [121]. Mozambique has registered a deficit, however, between demand and supply as the PPA restricts its capacity to increase the supply to attend the growing national and regional demand of electricity access. This has required EDM to purchase electricity from other energy sources that have emerged since the early 2000s. These include gas-fired power plants run by private firms, known as Independent Power Producers (IPPs). The tariffs from these new plants are higher than for HCB-supplied power, while they exceed the amount that can be recovered from current electricity tariffs [119]. This use of IPPs has exacerbated EDM's finances and constrained its ability to raise funds for grid extension and maintenance.

From a governance perspective, the Mozambican government has recently approved a new mandate for the energy regulatory authority, ARENE, to operate from 2018, with enlarged powers over tariff setting, concession granting and compliance controls [125]. The government's announcement notes that ARENE's main activity is to regulate electricity subsectors, including those resulting from any source of RETs, liquid fuels, biofuels, and the distribution and commercialisation of natural gas. Accordingly, ARENE could potentially play a role in bridging previously separate grid-connected and off-grid approaches, along with fostering links between electrification and fuel provision in multiple contexts. Shifts in Mozambique's political economy of energy have been ongoing since the early 2000s, when the government opened its economy to large-scale foreign investments, especially in extractive resources. In harnessing investment in these resources, including coal and offshore gas, the government aims to reduce long-term aid dependence while developing untapped markets [134, 135]. Yet, these developments risk entrenching carbon-intensive resources in Mozambique's energy mix.

Notwithstanding these trends, two major policy initiatives towards electrification include the Government of Mozambique's (GoM) regulatory and structural reform of its electricity sector to improve poverty alleviation, known as the Energy Reform and Access Programme (ERAP). The second is the Roadmap for a Green Economy (GER) since 2012, primarily aimed at rational natural resource utilisation (particularly energy) to preserve ecosystems for meeting The Sustainable Development Goals. The Mozambican state leveraged funding and support from the African Development Bank to generate what it describes as a "high-level" policy strategy. The roadmap establishes a series of ambitious development targets, namely, to become an inclusive middle-income country by 2030, whilst simultaneously increasing ecosystem service protections. The GER policy led to the Green Economy Action Plan (GEAP), which the Council of Ministers approved in October 2013. GEAP was lauded as an inclusive and pluralistic model of policy development – including the participation of multiple governmental institutions, alongside regional and local authorities, civil society and private sector stakeholders, and operating in concert with regional-to-national scale public consultation. Thus there is considerable evidence of a participatory-deliberative 'turn' [136, 137] in energy policy – whereby the legitimacy of policy outcomes is derived from the opportunity of affected stakeholders, including so-called 'lay publics', to have direct input into the decision-making process.

The GEAP intended to shape the government's 5-year plan and to provide the basis for greening the National Development Strategy currently under development. The plan is based on three pillars: sustainable infrastructure, efficient and sustainable use of natural resources and strengthening resilience and adaptability. These pillars include 15 sub-sectors and a total of 119 green growth policy options were identified through the technical review and the consultative process by the GoM. The aim of the former programme has been to increase efficiency of the electricity distribution services, as well as expand access mainly in the urban and peri-urban areas [138].

Although both policies focus on energy system development as economic growth and policy alleviation measures, reviews of government policy programmes show slow progress on the ground. In Mozambique, electricity access has been challenged by complicated governance factors. External evaluation of energy governance institutions deems them to be operationally inefficient and plagued by poor institutional reform [138-140]. As such, The World Bank Doing Business indicator for 'getting electricity' suggests that the process for connecting businesses and consumers to electricity grids is very slow even when they are in full reach of grid capacity [119].

Broader governance challenges

Aside from the electricity grid access, affordability and reliability, Mozambique faces multiple broader governance challenges. Additional factors concern the country's political economy of energy and wider networks in which the country's energy production and consumption currently circulate. The policy focus upon grid expansion has prioritised energy-generation 'mega-projects' such as hydro-dams, which have stimulated rapid GDP ,growth, but created few jobs and few local linkages [141]. Megaprojects are significant because, in both higher and lower-income economies, they provide some of the most enduring technical achievements created within society, and also some of the most costly or damaging mistakes [142]. Altshuler and Luberoff [143] argue that the neo-liberalisation of infrastructure management has encouraged governments to court major investors into infrastructure development through processes of privatisation of utilities, fiscal and regulatory inducements; effectively politicising infrastructure development (and simultaneously privatising public works – shifting away from direct public investment towards public-private partnerships). This has led to a 'scaling-up' of infrastructure development leading to a turn towards 'grand scale' or 'mega-project' development. Megaprojects have become a form of symbolic urban revitalisation through economic growth, and since the 1990s became an increasingly common feature of economic development across the world.

In Mozambique, in broad terms, the logic of neoliberal restructuring [122] has worked against distributive intentions: foreign companies are lured to large-scale, export-oriented projects, rather than connecting the poor to the grid, while the ongoing financialisation of the energy sector makes it complicated for national energy companies, such as EDM, and local communities to exert influence. These problems of governance are then exacerbated by the high levels of debt accumulating from energy megaproject development [144]. Energy megaprojects take decades to develop and build, involve agreement and cooperation from multiple public and private interests, and impact upon millions of people either directly or indirectly [145]. The broader social benefits from profit-sharing, infrastructure provision and regional development are commonly stressed by energy megaproject proponents to 'sell' the idea of a disruptive megaproject to public authorities. It is the potential mass profits and the supposed benefits that these bring in terms of employment and reducing 'economic friction' [145] that "justifies" the investment risk; megaprojects are therefore appealing to policy-makers for political and symbolic as well as practical reasons [146]. However, megaprojects such as major hydro-schemes commonly fail to achieve their stated objectives, often impose heavy cost overruns, project delays and unintended consequences, and these can only be absorbed with great pain and difficulty, often with little public support [145-147].

Moreover, there has been a lack of connection between EDM's planning for grid expansion and municipal planning around which areas are, in turn, growing and expanding. This has affected EDM's capacity to supply electricity, including the quality of electricity supplied to both old and new customers [148]. Officials in Frelimo have been, until recently, committed to this model of centralised provision of services, in order to promote security of energy supply, and specifically the supply of electricity [35]. Yet, the revelation in late 2016 of undisclosed government loans and debt have caused economic turmoil, which in turn has affected the provision of social services [149-151]. There has been resurgent conflict between the ruling party and Renamo, which resulted in armed clashes in 2013 through 2017. This political-economic contestation and insecurity has affected the central government's push to expand energy provision and access to energy by local populations affected by the conflict.

Apart from these challenges, we still have insufficient knowledge concerning the practices of acquiring and using energy at the household level in Mozambique. It is clear that shifts in the political economy of energy production have yet to fully transform energy provision and everyday energy practices in Mozambican households and businesses. For instance, fuel supply chains remain disconnected from the electricity generation and distribution systems and the extraction of resources such as coal or natural gas [85]. The consumption of biomass is of concern to authorities because of rapid deforestation, particularly within the hinterland of major cities. Though there is a paucity of qualitative and quantitative evidence, Castán Broto's research on climate compatible planning in the "Chamanculo C" neighbourhood of Maputo [152] found that residents have limited expectations of municipal or national intervention in the provision of urban infrastructure, including roads, sanitation, waste collection and electricity. Maputo has the highest electrification rates in the country, but many of the outer *bairros* (neighbourhoods) are characterised by the ubiquitous presence of charcoal for cooking and heating water. More recently, Castán Broto [63] has observed that the persistence of charcoal use in Maputo's periphery is due to the fact that it enables a measure of local control, or 'sovereignty' over energy resources.

Baptista [29] offers an account of the shift to a prepaid electricity meters in Maputo, implemented by EDM since 2004 to, among many reasons, facilitate access among consumers, reduce households' non-payment of electricity bills and discourage illegal connections to the grid. Using ethnographic research to examining everyday practices in local communities, Baptista found that the prepaid system has given households greater control over their own electricity consumption and allows urban dwellers to more easily gauge and understand what they consume, whilst reducing unexpected high, cumulative or incorrect billings by EDM, and thus avoid debt. Pre-payment has extended access to residents facing energy vulnerabilities, despite the structural inequalities in Maputo's provision of services [29]. On the other hand, the electricity tariffs that are above most household incomes have limited their continuous use of electricity services, and have forced households to adjust their electricity consumption to the financial resources available by combining charcoal use with limited use of electricity [29, 63]. These conditions resonate with the concepts of energy justice [153], scalar justice [154], and just transitions [43], which have argued that we must consider the multi-faceted entanglements of electric power and political power when discussing generational and spatial justice within energy production and consumption.

Conclusions

Mozambique is a major centre of hydropower production and has extensive coal and natural reserves, making it a potentially energy-resource rich nation. Yet, while energy resources in the country are abundant, Mozambican citizens has thus far received little direct benefit, especially those of lower-income status or in rural and peri-urban areas. Demographic growth, new energy consumption patterns, growing risks of extreme weather and climate disruption events, and institutional accountability deficits are all exacerbating what is experienced on the ground as an energy crisis [148]. Our focus on urban and peri-urban energy represents something of a shift away from the priority given to rural electrification within the objective of nationwide access to electricity.

As discussed above, increased electricity access can support economic development and the eradication of extreme poverty by supporting citizens in securing sustainable, cleaner and safer energy sources to power multiple productive activities, mediated communication, education, social network growth and entertainment. However, this movement is neither linear nor guaranteed, given wider political-economic frameworks and the institutional opportunities, constraints and conflicts that we have outlined in this paper. We must better understand and enlarge our analytical frameworks to account for the contextual factors that have shaped the growth and stagnation of electricity network development and its effects on everyday practices and uses of energy.

It is also important to explore scenarios of future development, and how they might be achieved (or resisted), in order to enact practical and sustainable grid access benefits to the poorest in the country. What is needed is further decision-support related research, in which policy responses can be tailored to future access goals, which account for broader socioeconomic and governance challenges and the ways in which social and political dynamics may reshape new energy systems. Currently, there is a gap between seeking to fulfil national SDGs (including SDG#7 on universal energy access by 2030) and the needs of poor households [125]. Fostering local ownership of community-based systems, capacity-building approaches and stakeholder empowerment are approaches with untapped potential. The case of Mozambique also points to the importance of examining social and material practices of acquiring and using energy, in some cases produced by new technologies such as solar PV and gas-fired cooking, and the ways in which people interact with them. Furthermore, we must better understand the historical and geographic scope of electricity sector reform in regions beyond the capital, Maputo, and move beyond static understandings of grid extension.

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