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SPECIAL ISSUE ARTICLE

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# Measuring progress in megawatt: Colonialism, development, and the "unseeing" electricity grid in East Africa

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**SPECIAL ISSUE**
Making power visible. Codifications, infrastructures, and representations of energy

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## Abstract

The electrification of East Africa followed an exceptionally uneven path. After about 50 years of relative neglect under colonial rule, the construction of hydroelectric dams moved electricity generation into the focus of late colonial development policy and became the major field of intervention for foreign donors after independence. The metrics of electricity attained a role as indicator and driver for economic growth, and therefore as a target figure in economic policy, one that was arguably not justified by their actual significance in the energy landscape of East Africa. This paper analyses both the global preconditions of this shift and its local repercussions. Rather than the physical visibility of electricity in the form of large dams and high-tension lines, the paper focuses on the processes that rendered electricity ontologically visible. It traces attempts by engineers, expert advisors, or development consultants to translate the complex information associated with the generation and consumption of electricity into calculable and comparable metrics. The paper scrutinises these commensuration processes in terms of the resources and knowledge they required, the frameworks of agency they opened, and the way they fed into wider discourses of development. It asks

how the metrics of electricity themselves became part of the colonial and postcolonial politics of calculation, as they increasingly came to be seen as a medium for conceiving national economies. This trend was reinforced by the ascent of development economics in the 1950s and its influence on the ontological foundations of international development cooperation and post-independence nation-building. Because of the calculability and capital-intensity of its production, electricity lent itself perfectly to an economic policy based on macroeconomic aggregates and abstract growth models. Conversely, the electricity bias of international development agencies and the national government rendered rural, non-commercial, and non-productive energy use largely invisible.

**KEYWORDS**
Africa, colonialism, commensuration, development, electricity

## 1 | INTRODUCTION

> The hydro complex has drama and style, and there is an air of the extravagance in its hugeness and grace which is awesome in a country trying to mobilize scarce resources for development. Though hydro supplies a basic necessity, it creates the aura of a country which no longer has to scrimp and save, but can spend with largesse. Its hugeness and its taming of a wild river bespeak a technological victory, and it imparts dignity to the people and the country who conceive it. … The thermal plant, in contrast, is another industrial installation at the edge of the city. It is no political eyecatcher.[1]

With unusually colourful metaphors for an academic article, political scientist Judith Tendler described in 1965 what she called the "mystique" of hydropower projects in developing countries. Few scholars of Africa would disagree that the symbolic qualities of big dams, most notably their iconic visual appearance, were key for mobilising political support among late and post-colonial African governments and international donors alike. Arguably, the same holds true for the scholarly attention these dams have attracted. For its larger part, the history of electricity in Africa has followed electricity's visible representations, most notably big dams and their often detrimental social and environmental impacts.[2] Beyond their role as emblems of state power, modernity, or development, big dams in Africa also need to be understood as results of rationalisation processes and the way that political decision-makers, development consultants, and economists conceived the continent's social and natural environments. Electricity (generation) and its associated metrics increasingly served as a prism through which they viewed the complex set of informal and formal economic activities in post-independence African countries. Progress, many economists claimed, could be measured in megawatts.

As a point of departure, we might contrast this picture with the quantitative knowledge about Tanzania's energy landscape that is available today. An energy flow chart for Tanzania, created by the Lawrence Livermore National

[1]Tendler (1965, pp. 250–251).
[2]Hoag (2013); Isaacman & Isaacman (2013); Öhman (2007); Tischler (2013). For an overview of earlier literature, see McCully (2001).

Library in 2011, shows an energy flow of 36 petajoules (PJ) for all electricity and heat generated from hydropower, natural gas, coal, and petroleum combined. Biomass, in contrast, accounts for a staggering 770 PJ of energy flows. Even in industry, biomass accounts for 150 of the 170 PJ consumed.[3] Despite the methodological constraints of such a study, the general picture seems clear. Both domestic and economic life in Tanzania is heavily reliant on biomass, such as wood and charcoal for cooking or other processing activities in households and small businesses. It can be safely assumed that this reliance was no less pronounced in the past.

This paper examines the discrepancy between this relative insignificance of electricity within Tanzania's energy landscape and the central position electricity assumed in discourses on development throughout the country's colonial and post-colonial history. In doing so, it takes inspiration from recent literature on planning in Africa to understand the ontological visibility of electricity as an outcome of commensuration processes on different levels.[4] The term ontological visibility hints to the premise that the discursive presence of electricity depends on the ontological categories employed for understanding it—for example, its conception as an economic entity. In the planning and implementation of electricity infrastructures, the ontological visibility of electricity precedes (and determines) its material manifestations. Long before the first poles are erected, electricity (or the potential to generate and consume it) needs to be rendered ontologically visible to an audience of investors, political decision-makers, regulators, and so on, for example through output calculations or demand projections. This is usually the task of engineers in a process that can be framed as commensuration. In sociology, commensuration is understood as the social process of transforming a heterogeneous set of information into a common metric. Commensuration allows for the comparison of different entities, serving as a basis for decision-making and a crucial vehicle of rationalisation.[5] The metrics of electricity generation and consumption can be conceived as products of commensuration, because the planning of electricity infrastructures relies on the aggregation of disparate information pertaining to generation and demand. They also can become media of commensuration, for example when used to assess or compare entire industries or national economies.

Using the example of British colonial East Africa and post-independence Tanzania, this paper reconstructs electricity-related commensuration processes undertaken by the engineers, expert advisors, and development consultants commissioned by colonial administrations, utility companies, development agencies, and post-independence national governments to forward their respective agendas. The paper scrutinises the effects of these commensuration processes: how did they change the ways of seeing local natural and social landscapes in terms of their potential to generate and consume electricity? How did the translations, conversions, inclusions, and exclusions inherent to commensuration influence the pace and scope with which electrification policy materialised on the ground, for example in the form of hydroelectric dams and high-tension transmission grids? And finally, how did the codification of electricity itself, in statistics, graphs, network diagrams, or maps, become a way to articulate entire economic sectors or national economies?

Commensuration is neither a mere technical process nor is it neutral. To become a vehicle of rationalisation, commensuration has to follow laws that are assumed to be universal, such as the laws of the market. Yet, as Timothy Mitchell has argued, these so-called laws do not operate universally, but instead are effects of a particular way of ordering the world that privileges human reason and takes the form of technocratic expertise.[6] The "rule of experts" is not merely founded on an understanding of the world through the application of "exterior intelligence," but on an "ongoing performance that asserts the mastery of reason, ideas and human agents over the natural and material worlds."[7] This way of ordering the world is, in turn, inextricably linked to the history of Western colonial domination. This paper therefore draws on a growing body of literature that examines electricity as a proxy for establishing Western epistemic hegemony in the Non-West, and therefore a key area of colonial and postcolonial "techno-politics."[8]

[3]Lawrence Livermore National Laboratory (2014).
[4]Cf. Shamir (2018).
[5]Espeland & Stevens (1998).
[6]Mitchell (2002, p. 1).
[7]Kohlbry (2013, p. 478).
[8]See, for example, Shamir (2013); Meiton (2019); Coleman (2017).

In contrast to most existing literature, this paper is interested not only in electricity's potency as part of wider techno-politics, but also in the factors that limited its potential for establishing the rule of experts. The first was the rather messy political economy of electricity in the British Empire. Commensuration is not only an abstract principle; as a practical task, it usually requires an enormous among of work, organisation, and resources, and is riddled with risks and uncertainties. The question of who pays for this work and who profits from it, as I argue, turned out to be a major barrier for the project of tapping into the Empire's hydroelectric potential and turning it into the novel energetic base of Britain's imperial economy. The second factor was the difficulty of making hydropower generation fit with Britain's wider development agenda for the colonies, a task that became considerably easier after the reform of colonial policy in the early 1940s.

With a focus on Tanzania, this paper furthermore asks how political independence and the transition to multilateral development aid in the 1960s changed the modes and results of commensuration processes related to electricity. The conception of the electricity industry as a *sector* within abstract models of national economies, for which development economists came to claim universal applicability in the 1950s, tied dam-building even closer to the "economic growth paradigm" as an undisputed policy goal.[9] Because of the calculability of their output in economic terms, the construction of single-purpose hydropower dams took on a specific appeal to development banks, international agencies, and some groups with the post-independence government, even if it compromised on other development goals like irrigation. By connecting power-system building with the development discourse, this paper seeks to contribute to a wider history of knowledge and development in the context of decolonisation and the Cold War.[10] By focusing on electricity's ontological visibility, it adds further nuances to the study of hydroelectric dams in Africa that supply industry while leaving nearby communities without connection to the grid.

The paper is organised into four sections. The first section examines different commensuration processes related to electricity to explain Britain's long and winding path towards utilisation of its Empire's potential for hydropower. The second section explores the ambivalent role electricity played in the "politics of calculation" in British colonial East Africa. The last two sections then focus on the two decades following independence. The third section examines how the conception of electricity as an economic sector and the rise of development economics from the 1950s onwards paved the way both for Tanzania's entry into the big dam era and, as the fourth section shows, the adoption of a paradigm of centralisation in the planning processes for a national electricity infrastructure. The paper is based on a wide array of sources, including archival material from Tanzania, Kenya, and Britain, published and unpublished reports and studies, contemporary academic studies, newspaper articles, and a small number of oral history interviews.

## 2 | THE COMMENSURATION OF THE "ALCHEMIST'S DREAM": HYDROPOWER AND THE BRITISH IMPERIAL ECONOMY

In the last two decades, a growing number of studies have engaged with the visual appearance of electricity infrastructures and electricity-related services in colonial and post-colonial contexts. In his study of colonial Delhi, Leo Coleman highlights the central position that the public display of electrical lighting occupied in imperial ritual.[11] As Brian Larkin has argued for British colonial Northern Nigeria, the significance of electricity infrastructures for indirect rule was beyond simply staging the representation of rule through visual spectacle. The everyday experiences and aesthetics of electricity were instrumental for provoking feelings of the colonial sublime, thereby "addressing and producing a particular sort of modern colonial subject."[12] Such perspectives draw on a Foucauldian understanding of power that is based not on repression, but on incorporation and internalising modes of rule.[13] Electricity forms part

[9]Cf. Schmelzer (2016).
[10]Speich (2008); Schmelzer (2016).
[11]Coleman (2017, Chs. 1, 2).
[12]Larkin (2008, p. 21).
[13]Larkin (2008, p. 33).

of a wider technological organisation of society as a means of subjugation, something that Mitchell has referred to as "techno-politics."[14]

If we follow Patrick Joyce, what distinguishes techno-politics in the colonial and postcolonial world from that in the "West" is precisely the aspect of visibility. In the West, technological regimes served as proxies of liberalism, because they are invisible (both physically and discursively) and therefore considered technical and outside the political process. In the colonies, however, technology was visibly and permanently foregrounded as evidence of European superiority.[15] Technological projects became a form of monumentalism that would later be appropriated by post-colonial political elites and for which large hydropower dams became iconic.[16] Large dams have been extensively studied in their representational and legitimising function both for late colonial regimes and post-independence authoritarian, developmentalist regimes.[17] Works in this tradition emphasise the significance of electricity as a technology that is laden with symbolic meaning. Yet, they tend to place much weight upon physical visibility—lavishly funded imperial rituals, well-staged opening ceremonies of dams, or awe-inspired testimonies by contemporary observers—and too little on the more mundane aspects of planning, financing, and operating electricity infrastructures.[18]

Beyond its deliberate staging, a more subtle but no less consequential dimension of electricity's techno-politics was its ontological visibility. Several recent works have traced how the codification of electricity in statistics, graphs, network diagrams, or maps reaffirmed the ontological reality of colonial and post-colonial states, economies, or geographies.[19] The first large electric system in British colonial Palestine, for example, "was central to the making of modern Palestine as a precisely defined geographical-political entity," as Fredrik Meiton argues.[20] Not coincidentally, these works are based on the study of regions where interconnected grids emerged relatively early compared to other parts of the former colonial world. They cannot therefore be used as an empirical basis for generalisations about the techno-politics of electricity in the British Empire, and even less for a simple instrumentalism. For several reasons, electricity infrastructures were no "tools of empire" (or of post-independence nation building) ready to be utilised for political representation by those in power.

First, electricity infrastructures were expensive to build. Their high capital intensity, unmatched by any other public utility, necessitated high upfront investments, while the potential revenues generated by them often remained to be proven.[21] Especially in the case of hydropower projects, the political ambitions attached to large dams were often at odds with their techno-financial feasibility. Not least for this reason, the political economy surrounding electrification was far messier than that of, for example, railroads and canals, as Sunila Kale argues in her comparative study of different governance models of electricity in colonial India. This diversity revealed a mixed understanding of state power itself and the colonial state as an engine of "development."[22] Apart from India, the Colonial Office's hands-off approach of providing concessions to private companies left Britain often with much less control over electrification in its colonies than it had hoped.[23]

Second, the forms of electricity's ontological visibility mentioned above were neither stable nor were they determined by an intrinsic logic. The codification of electricity was not simply the work of rendering visible the physical world associated with electricity generation and consumption by applying supposedly universal methods of measurement and calculation. It was an act of deliberately producing an ontological reality that could serve as a base for planning, financing, and managing electricity infrastructures.

[14]Mitchell (2002).
[15]Joyce (2003).
[16]Larkin (2008).
[17]See, for example, Brendel (2018).
[18]Cf. Tischler (2013, p. 21).
[19]Coleman (2017, Chs. 3, 4); Shamir (2013, Ch. 5); Meiton (2015; 2019).
[20]Meiton (2015, p. 978).
[21]The only exception was the steam railway in its formative years; cf. Hausman, Wilkins, & Hertner (2008, p. 19).
[22]Kale (2015, p. 456); see also Kale (2014).
[23]Shamir (2016). India was administered through the Indian Office.

The essential commensuration task in any electricity project is that of matching metrics for the projected supply and demand, both technically (generation capacity in kW or MW exceeds that of maximum demand at any time) and economically (revenues from selling a kilowatt-hour of electricity exceed the sum of capital and running costs for its generation). Arguably, this task was riddled with even more uncertainties in East Africa than in Europe or the US.[24] The difficulties began on the supply side. Especially for hydropower projects, the unknown topography and seasonal flow variations of African rivers made it notoriously difficult to calculate future electricity output. There is a large body of literature that describes how engineers and consultants in both colonial and postcolonial contexts struggled with the quantitative taming of rivers in East Africa.[25]

The difficulties of calculating the demand were by no means smaller, given fact that pre-existing industries and infrastructures that were known to absorb major loads were absent in East Africa. After all, the number of the—mostly European and Asian—urbanites who could afford the relatively high tariffs necessary to operate smaller systems remained in the lower tens of thousands during colonial rule. They accounted for the relatively predictable market for domestic electric lighting and later other electricity-related services like fanning or cooking, served by "a small-scale luxury industry, closely geared to non-African needs" that mostly relied on small thermal power plants.[26] Quite distinct from the conception of electric *lighting* was that of electric *power* as a motive force for motors or machines. This ontological differentiation was reflected, for example, in the title of the East African Power and Lighting Company (EAP&L), founded in 1922, and the fact that in the accounts of utilities, lighting and power customers were separated into different categories.[27] It is this category of electric *power* that this paper focuses on.

As opposed to urban (mostly European and Asian) demand for electric lighting, quantifying industrial demand for electric power was a much riskier bet on a colony's economic future in the 5–10 years it would take to build a major dam and its corresponding transmission infrastructure. The case of hydropower generation in colonial and postcolonial Africa is a prime example of the inherently interpretative and deeply political nature of commensuration and its long-term consequences once it materialised in large technical systems that tied up huge amounts of capital. When facing the formidable challenge of translating colonial economies into calculable and predicable loads, those who initiated projects for power generation relied on the development scenarios advanced by British colonial policy.

Soon after the turn of the century, that outlook seemed to be promising. The Empire's supply of electric power had turned into a question of geopolitical significance for British politicians. The idea of harnessing the rivers in the colonies for hydropower generation fed into sweeping visions of putting the Empire on a novel energetic base. The promises of hydropower generation fit perfectly into a concept of "constructive imperialism" that dated back to Joseph Chamberlain's tenure as colonial secretary from 1895 to 1903.[28] His idea of colonial development was extractive, geared towards utilising colonial resources to make the metropole economically self-sufficient. It was also transitive, with a clearly defined subject (Britain) and objects, such as the tin deposits in Malaya, or the agricultural potential of Uganda. This imagery revolved around electricity's physical function in the extraction of raw materials and their transformation into commodities—a fact that was reflected both in metaphors and in prevalent forms of codifying this potential. "There is power enough to gin all the cotton and saw all the wood in Uganda," Winston Churchill had mused in his travel report of 1907 about the energetic potentials of the Ripon Falls at the outflow of the Nile from Lake Victoria.[29] The first study to systematically compile information on the Empire's hydropower resources in 1922 tellingly used the unit of horsepower (hp) to quantify these potentials. Yet, aggregate figures on how much water was flowing "unutilised" into the ocean was of little value itself. Britain simply lacked "the practical and commercial information that would assist development of this important national resource," the report concluded.[30]

[24]Cf. Shamir (2018, p. 19).
[25]See, for example, Shamir (2018); Öhmann (2007); Hoag (2013); Showers (2011).
[26]For quote, see Wilson (1967, p. 25).
[27]S. H. King (1920, Jun. 1), Report on existing plant and future requirements [Report], T 161/1049, National Archives of the United Kingdom, London, UK (hereafter BNA); see also Shamir (2013, pp. 130–131).
[28]Norris (2013, p. 5).
[29]Churchill (1908, p. 74).
[30]Clerk & Gibson (1922, p. 49).

Drawing a comparison to Norway's successful hydropower projects, Douglas Spencer, a British company manager, claimed a few years later that no less than the fulfilment of an "alchemist's dream" for the British Empire was at stake.[31] These hydropower visions were further fuelled by a general anxiety that Britain, after winning the First World War, was losing out in the industrial competition with the United States and mainland Europe. While observers in Britain saw the end of coal as the global energy base looming, they were anxious that Britain was missing the boat in the transition to other energy sources. As the British Isles lacked significant hydropower potentials, British companies had gained little experience with this technology at home. The First World Power Conference in 1924 in London was an attempt for Britain to regain a lead in energy research as well as to take the commensuration of energy resources to a global level—naturally, under British guidance. If electricity was the "wonder worker of the day and generation" as the chairman of one session claimed, waterpower as an energy source received the bulk of scholarly attention at the conference.[32]

The push for the quantification of global energy resources coincided with a shift in colonial economic policy towards what Jacob Norris has termed "the first age of colonial development."[33] British colonial policy in Africa became more assertive in fulfilling its "Dual Mandate" to exploit the continent's resources for the benefit of both indigenous people and European colonisers.[34] Departing from its earlier predatory, if increasingly systematic, colonial policy, Britain developed a more comprehensive program of colonial development that would lead to the 1929 Colonial Development Act. Rather than prioritising welfare, however, the program focused almost exclusively on the development of infrastructures to increase the production of primary products for export. For East Africa, it included a £10 million loan guarantee over 10 years for the extension of railway networks, the expansion of harbours, road construction, and mechanical transport, as well as a £3 million loan for the Gezira Cotton Scheme in Sudan.[35]

Notably, electricity infrastructures were not included in the loan schemes for Africa. The enthusiasm for hydroelectric development among engineers and industrialists was initially met with reluctance from the Colonial Office. The bureaucrats had little faith in the actual economic potential of hydropower projects in the British colonies, and considered a central, coordinated strategy to quantify this potential with surveys, hydrological measurements, or market studies as premature. "First of all, find something for which we want the power," an official dryly commented on a request by Spencer to do so in 1921.[36] The Office's advisory network concentrated instead on areas that were considered essential for administering and economically developing—or rather exploiting—the colonies, such as health and sanitation, education, agriculture, nutrition, and labour or mineral resources.[37] Another request by Spencer in 1927 to include "electro-metallurgical and electro-chemical subjects" in the Colonial Office's extended advisory networks left colonial administrators puzzled about "what exactly they are going to discuss there."[38] Electricity was essentially a matter of trade policy, the Colonial Office argued, referring him to the Empire Marketing Board.

In several newspaper articles, Spencer criticised how, in the field of hydropower development, Britain applied the same laissez-faire policy of granting concessions to private companies that stemmed from a time when electricity was mainly used for small-scale systems for lighting.[39] By the mid-1920s, the only place where this model had resulted in sizeable dams was India, where the private Tata company had built three dams in 1915, 1919, and 1922 (with capacities of 72, 78, and 300 MW, respectively). In other places, hydropower projects were delayed by negotiations between the Colonial Office, the governments of the respective colonies, and private companies, on the division of expenses for the studies required to quantify potential supply and demand for hydroelectricity, and raising the capital for subsequent development. The privately financed Chenderoh dam in British Malaya (40 MW), for

[31]Spencer (1927).
[32]Smith (1924, p. 1417). The transactions include 26 papers on water power resources, two on oil resources, and nine on coal.
[33]Norris (2013, p. 7).
[34]Lugard (1922).
[35]Hodge & Hödl (2013, p. 10).
[36]Minutes (1921, Oct. 17), CO 323/885/55, BNA.
[37]Overview in Hodge (2007, pp. 9–10, 44).
[38]Minutes (1927, Jul. 26), CO 323/983/8, BNA. For expertise on hydropower, the Colonial Office usually commissioned the electrical engineering firm of Preece, Cardew, and Rider.
[39]Hoag (2013, p. 138).

example, built by Spencer's employer Armstrong-Whitworth, turned into a financial disaster that forced the government to intervene with its own funds in 1930.[40] In East Africa, only those dam projects for which potential demand was predictable and easy to quantify attracted investor support: for example, in the North of Tanganyika, where sisal plantations needed plenty of processing energy. In 1931, a subsidiary of EAP&L began the construction of a hydropower dam on the Pangani river (15 MW) with private capital from Britain, notably only after nearby sisal plantations gave assurances that they would replace their fuel engines or water turbines with engines run on electricity from the dam.[41]

In Uganda, the small European population grew increasingly frustrated with the absence of any public electricity supply by the mid-1930s, putting additional pressure on the colonial government to deliver on its—rather long-term—vision of harnessing the River Nile for large-scale hydropower generation.[42] Meanwhile, white settlers in Kenya demanded a substantial increase in EAP&L's limited generation capacity, which led to regular power cuts.[43] Financed by the Ugandan and Kenyan governments, the Colonial Office, and EAP&L, an engineering expedition was sent in 1934 to explore the hydroelectric potential of two Kenyan rivers and the River Nile in Uganda, and to provide the geological, hydrological, and commercial data necessary to commence hydropower development on these rivers. In his historic-ethnographic study of that mission, Shamir meticulously maps out the heterogenous field that engineers had to navigate in their quest to translate the specificities of the local natural and social environments into calculable variables.[44] The engineers' report would significantly determine how colonial administrators, utilities, and subsequent expert advisors came to "see" both rivers as potential sites of hydroelectricity production. For the River Nile, the report provided a list of three potential dam sites, including calculations of projected total output in kW and costs per kW of output.[45]

Identifying potential demand proved to be more difficult. The British development agenda for Uganda provided no scenario in the subsequent years in which substantial industrial demand would arise. A book on Uganda from 1935 (with a foreword by the governor) bluntly stated that "the Protectorate is unsuited to intensive industrial development" because of its landlocked position. Industrialisation, it added, would take away labour from the strategically important cotton sector.[46] Cotton, Uganda's major export crop, was grown by African smallholders. Large plantations as potential customers of electricity were almost entirely non-existent.[47] At times, initiatives to process agricultural goods in East Africa were even suppressed out of fear of generating competition for the industry in Britain. In Tanganyika, for example, a factory for binder twine had to close in 1936 after protests from rope-, twine-, and net-makers in Britain.[48] In the development plans for Uganda and Tanganyika of the late 1930s and early 1940s, electricity generation was barely mentioned.[49]

Moreover, the experts' methods for estimating demand were unsuited to quantifying the size of another potential market for electricity, the "native" consumers. Even though their reports contained numerical tables of houses and "small native shops" that might use electricity, the experts could not conceive of them becoming a sizeable load any time soon.[50] Not only the explorer-engineers but also the established power utilities struggled with rendering visible "Africans" and their potential demand for electricity. Except for a few senior "African" state servants who

[40]Tate (1989). In correspondence on hydropower development in Tanganyika, the project is cited as a warning example, cf. n.d. to S.H. Wilson [Letter] (1927, Nov. 12), CO 691/93/9, BNA.
[41]Crown Agents to Undersecretary of State [Letter] (1931, Aug. 6), CO 691/114/4, BNA. For negotations with sisal planters see correspondence in CO 691/101/4, BNA. The initial study was financed by a British industrialist, who claimed his money back after not receiving the concession.
[42]Governor W. J. Gowers to the Secretary of State for the Colonies [Letter] (1931, Nov. 12), CO 536/165/14, BNA.
[43]Hayes (1983, pp. 261–62); A.O. Cosgrove (1944, Mar. 7), Report on the East African Power & Lighting Co., Ltd. with particular reference to its failure to fulfil its obligations under the Kenya Electric Power Ordinance [Report], CO 533/533/4, BNA. Hereafter, this document will be referred to as Cosgrove (1944), Report.
[44]Shamir (2018).
[45]Shamir (2018).
[46]Thomas & Scott (1935, p. 352).
[47]King & Van Zwanenberg (1975, p. 125).
[48]Coulson (1982, pp. 101–111).
[49]Cf. Byerley (2005, p. 230).
[50]Shamir (2018, p. 17).

lived in government housing and could afford the high tariffs, utility managers considered the connection of African households to be generally irreconcilable with their technical and legal requirements and their business model. The list of issues was long: how to enter contractual relationships in an environment of legal uncertainty (for example, the absence of land titles), how to wire "native huts" according to safety regulations, how to design affordable tariffs, and who would cover the prohibitively high costs for electricity meters and grid connections?[51]

Regulatory frameworks for electricity provision in East Africa had been adopted from other colonies with only minor modifications, which made it almost impossible to make arrangements tailored to the needs of the (mostly rural) African customers—precisely because these regulations were abstracted from the racial and social heterogeneity of potential users in the colonies.[52] The only metrics used to differentiate between different customer groups were their levels of consumption and the distance of their houses from the grid. Somewhat ironically, a "non-discrimination" clause served as a legal basis for the exclusion of African customers because it stipulated that customers for whom these two metrics were similar could not be treated differently. When, in 1937, managers of EAP&L discussed the introduction of a "a special rate for natives" in Dar es Salaam, they realised that they could not deny the same rate to European or Asian customers with an equally low level of consumption. To offset the losses from charging lower rates to the latter, the company would need to "connect 100 native huts."[53] Apparently, this was too much for the utility. The proposal was not followed up. It was not until the mid-1950s that the EAP&L began its first, rather half-hearted experiments with specific "African tariffs," slot meters, and load limiters.[54]

As a result of the failure to make it commensurable with the colonial development policy, the "alchemist's dream" vanished into thin air on its way from the British engineer's desk to the East African ground. In 1946, except for the Pangani dam in Tanganyika, which primarily served the "one-crop load" of sisal plantations, and two smaller dams serving Nairobi in Kenya (4.4 MW and 2 MW capacity), electricity provision in East Africa was entirely reliant on small-scale diesel generators and steam engines, which were comparatively cheap to build and easy to size, but expensive to operate. To cover the high operating costs, utilities charged tariffs that were too high to attract any energy-intensive industries or develop markets among African consumers. The discrepancy between the British hydropower mission and the political economy of electricity was particularly pronounced in Uganda. In 1938, more than 30 years after Churchill's visit to Lake Victoria, and 20 years after negotiations for a concession for developing the hydroelectric potential of the River Nile had started, electricity became commercially available there for the first time. It was generated by two small diesel generators operated by EAP&L in Kampala and Jinja, not far from the shore of Lake Victoria.[55]

## 3 | ELECTRICITY IN COLONIAL "POLITICS OF CALCULATION"

The case of East Africa adds to an increasingly heterogeneous picture of electricity's role in colonial techno-politics throughout the British Empire. Similar commensuration processes associated with the planning and operation of electricity infrastructures had varying political effects. Considering the low degree of centralised control, coordination, and financing by the British government (especially before World War II), it seems unsurprising that these effects varied considerably between different colonies.

These differences can be illustrated by comparing East Africa to the well-researched case of British Mandatory Palestine.[56] There, a wave of Jewish immigration in the mid-1920s had been accompanied by an inflow of private

[51]van der Straeten (2022).
[52]The Tanganyika Electricity Ordinance was based on the Palestine Electricity Ordinance, which was very favourable to private companies, as the attorney-general of Tanganyika complained. An adaptation of the Indian Electricity Act would have been much better, he claimed: CO 691/120/4, BNA.
[53]Don Small (1937, Sep. 3), Experimental Lighting in African Huts [Memorandum], 24387, National Archives of Tanzania, Dar es Salaam, Tanzania.
[54]Chief Electrical Engineer (1956, Sep. 19), Electrification of the African Areas [Memorandum], KZ/5/12, National Archives of Kenya, Nairobi, Kenya (hereafter KNA).
[55]Hayes (1983, p. 330).
[56]Norris (2013, p. 9).

capital, a large share of which went into the financing of "modern," capital-intensive, Jewish-owned agricultural and industrial enterprises.[57] The electricity demand of these enterprises drove the rapid expansion of grid-operated companies backed by Zionist capital and holding a concession granted by the British authorities. In the company's published statistics, the number of kilowatt-hours of consumption subsumed under the category of (industrial) power rose dramatically in the late 1920s, compared to that for lighting. Together with other reports and statistics, this data contributed to affirming an essentially novel ontological reality: With a nod to Mitchell's "politics of calculation," Shamir argues that expansion of the grid "established a material techno-statistical platform for the assembly of what gradually became known as the 'Jewish economy.'"[58] While the metrics of kilowatt-hours facilitated the commensuration of a Jewish economy, it rendered the less-capitalised (and therefore less electricity-intensive) Arab economy less visible ontologically. Ultimately, the Jewish politics of calculation would serve as a basis for an ethno-national politics of partition.[59]

The capital flowing into East Africa was less political. The figure that mattered most to the EAP&L shareholders in Britain was the annual dividend, putting their interests at odds with those of the European settler community, colonial administrators, and politicians—especially those who were in favour of an enhanced role of the state in colonial development. Especially in Kenya, tensions repeatedly ran high and led to several attempts to put EAP&L under municipal or state control.[60] In a report on the utility, put together with much zeal by Kenya's government electrical engineer in 1946, the metrics of electricity supply and consumption did not convey the story of a consolidating settler economy. Quite to the contrary, the engineer argued that EAP&L failed to fulfil its obligation under the colony's power ordinance and thereby undermined the colonial development agenda for Kenya. In several graphs and statistics, he meticulously demonstrated that EAP&L profits were not only higher than those of other utilities throughout the Empire, but also that they were mostly distributed to shareholders as dividends.[61] His report seemed to confirm earlier complaints by sisal growers that the company held a "monopoly without control."[62] In fact, EAP&L successfully defended its monopoly in Tanzania and Kenya until the end of colonial rule. There, even powerful settler organisations remained without influence on EAP&L, for example when it came to connecting settler farms that were too remote from the grid to make a connection financially viable.[63]

At the same time, the colonial electricity policy in Uganda underwent a remarkable turnaround that bears witness to the power of commensuration as a political strategy, if applied in a discursive environment that is particularly receptive to its outcome. This environment emerged from a reform of British colonial policy that began in the late 1930s. The economic turmoil of the 1930s had exposed the vulnerability of Britain's export-oriented colonial economic policy in times of falling commodity prices, leading to explosive social tensions and a breakdown of colonial legitimacy. To regain this legitimacy, Britain committed to a more inclusive policy of investing in and promoting the welfare of the African population, formalised in the Colonial Development and Welfare Act of 1940.[64] At the same time, the wartime exigencies revived belief in the state's ability to coordinate the exploitation and distribution of resources.

Shortly after end of the war, the colonial administration renewed its efforts to develop hydropower potentials in East Africa. It commissioned two experts from Britain to write a comprehensive joint civil and electrical engineering report for the purpose. The first, Charles Westlake, was a long serving utility manager in Britain and staunch supporter of the "British hydroelectric mission"; the second, E. V. Richards, was a civil engineer with experience from Tanganyika and India. What was intended as a joint report, however, turned into two reports after the hydraulic investigations and load estimations by Mr. Richards were disassociated from the study and its publication postponed.

[57]Shamir (2013, pp. 121–122).
[58]Shamir (2013, pp. 134–135).
[59]Shamir (2013, p. 137).
[60]Attempts to do so had taken place in 1911, 1936, and 1946; cf. Hayes (1983).
[61]Cosgrove (1944), Report. Regarding Cosgrove's zeal see Acting Governor to Secretary of State [Letter] (1944, Nov. 29) CO 533/533/3, BNA.
[62]Quote in Swift and Rutherford & Co to Stanley [Letter] (1943, Nov. 6), CO 533/533/4, BNA.
[63]Maddison (1956, Aug. 15) [Note], AE/17/53, KNA.
[64]Hodge & Hödl (2013, p. 14).

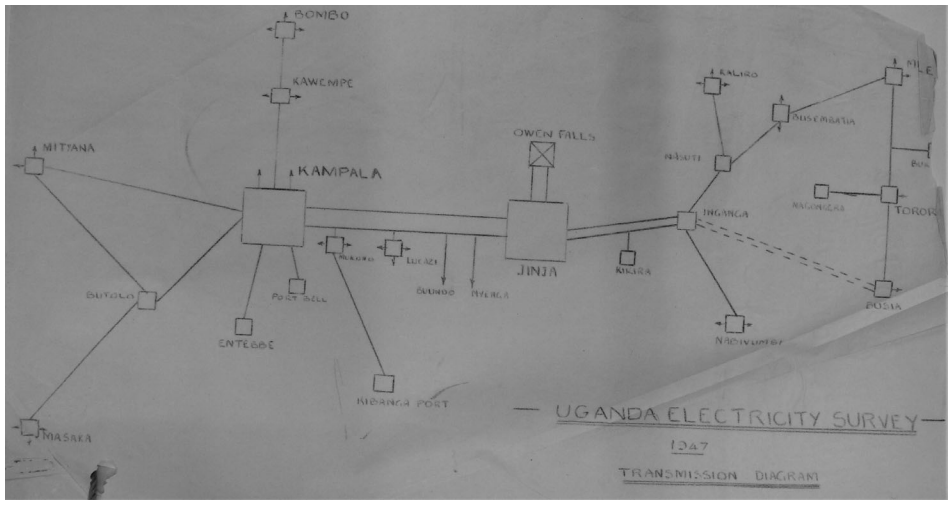


**FIGURE 1** The first design of the Ugandan grid was sketched by Charles Westlake in a hotel room in Kampala in 1947. (source: Charles Westlake (1947, Feb. 23), Uganda electricity survey 1947 [report], CO 852/844/1, BNA)

In September 1946, Westlake sent a preliminary version of his report to the Colonial Office. The "hurriedly written interim report" did not add much new information to what was known from earlier reports in the 1930s, but it differed in the way it organised and codified that information and used it to support its recommendations for action.[65] In February 1947, Westlake also sent a sketch of a grid connecting a prospective dam at Owen Falls with what he expected to become the main load centres in the colony (Figure 1). It conveyed a straightforward story of how cheap hydroelectricity would give rise to processing industries all around the colony, including a state-managed industrial complex centred upon Jinja Town next to the dam.[66] Westlake furthermore calculated that, if an arrangement could be made with Egypt further downstream to build the dam 1 m higher (thereby affecting the river's flow), the generation capacity of a dam at Owen Falls could be increased from the 75 MW calculated in 1935, to 150 MW.

Richards's report was published in January 1947. It was far more comprehensive and diligent in its analysis of potentials, more technical in its language, and conservative in its assumptions, concluding that "there is little prospect of any demand of power on a larger scale."[67] By that time, however, the maps and metrics provided by Westlake had been circulating for 4 months, supporting the position of a group within the colonial administration that was in favour of state-led hydropower development of the River Nile. Westlake's report garnered the support of the Colonial Office for a project that was "an act of faith" rather than a product of a realistic cost–benefit analysis, as the Financial Secretary to the Treasury commented.[68] In a radical departure from the laissez-faire policy that had persisted in Tanganyika and Kenya, the Legislative Council of Uganda followed Westlake's recommendation to nationalise the electricity supply in May 1947, acquire the existing assets from EAP&L, and set up a government-owned electricity utility that could push the ambitious project through.[69] With money borrowed short-term from the London capital market, the newly founded utility placed the first contracts for the construction of the dam in September 1949. When the dam began operation in 1954, it was not only the biggest hydropower project in British colonial Sub-Sahara Africa to date, but also the most expensive, with a price tag of £21 million.[70]

[65]Westlake to Monson [Letter] (1947, Mar. 19), CO 852/844/1, BNA.
[66]Charles Westlake to John Hathorn Hall [Letter], (1947, Feb. 23), CO 852/844/1, BNA.
[67]Richards (1947, p. 19).
[68]Cited in Wilson (1967, p. 2).
[69]Note (1947, Apr. 4), CO 852/844/1, BNA.
[70]Hoag (2013, pp. 135, 162).

Westlake's sketch of the future transmission grid had provided a visual representation of what the initiators of the Owen Falls project intended (and did not intend) it to become. Unlike Kenya, Uganda had no significant settler economy to be the potential beneficiary of cheap hydroelectricity. Despite Britain's reformed development agenda, the project was not designed as part of any immediate welfare policy. Westlake's original plans for the transmission grid made no provision for the connection of African households. If the African population were to benefit from the project, it would only be indirectly, through the jobs in the industries expected to emerge, and not as customers. "[W]ider social implications are not discussed," a 1948 memorandum on hydroelectric projects in the Empire that was circulated in the Colonial Office succinctly stated. The metrics that counted were the figures for generation capacity and the potential loads of the different dams.[71] In the first place, Owen Falls was an extension of the metropolitan economy into Uganda. The dam, as its initiators had hoped, would turn Uganda into an industrial powerhouse that received British capital as input and produced exportable commodities as an output that would mitigate the sterling crisis.[72]

After the completion of the dam, however, the projected industrial customers had failed to materialise, leaving the Ugandan utility to search for new markets for the excess capacity to generate the revenue needed to pay the interest on the investment capital. Somewhat ironically, it was the pressure from private investors, and not any political agenda, that caused the utility to assess the demand among rural African dwellers and develop the first rural electrification schemes in the whole of East Africa.[73]

If per-capita electricity consumption was "a useful indication of the general economic development of the country," as a British expert advisor claimed in a study on Tanganyika in 1954, the figure for East Africa remained dismal. At a mere 4 units (kWh) per head per annum, the average for Tanganyika was a small fraction of that of colonies like Malaya with 120 units.[74] The construction of two further hydropower projects on the Pangani river in Tanganyika shortly before and after political independence in 1961, however, remained closely linked to the political interests of the British metropole. The uncertain political future of Britain's colonies in East Africa had caused a mass exodus of private capital from the region. To show Britain's commitment to its former colonies beyond independence and maintain the strong foothold of its electro-technical industry in the region, the Colonial Office pressured British development banks to provide funding for the two dam projects, one at Hale Falls and the other at Nyumba ya Mungu further upstream, which almost exclusively benefitted the estate agriculture. Remarkably, these dams later came to be reinterpreted by Tanzania's post-independence leader Julius Nyerere as "evidence of the revolution which our country is deliberately and purposefully undergoing, … an example of the combination of brains, scientific knowledge, sweat, and discipline which will in practice transform our nation."[75]

## 4 | THE METRICS OF A CAPITAL TECHNOLOGY: THE SCIENTIFICATION OF ECONOMICS AND THE (HYDRO)ELECTRIC SALVATION PROMISE

1969 saw the publication of a study that codified electricity provision in East Africa in an unprecedented way. The study was aimed at overcoming the lack of "[c]omprehensive data on production, distribution, and consumption of energy," its author, German economist Hans Amann, claimed.[76] In fact, he had compiled and analysed an extensive amount of technical data on different aspects of energy use and provision in Tanzania, Kenya, and Uganda. It was the first time that a study systematically put this technical data in relation to macroeconomic indicators and thereby

[71]Hydro Electric Projects in the Colonial Empire [Memorandum] (undated enclosed in letter dated 1948, Aug. 26), CO 852/889/2, BNA. Hereafter, this document will be referred to as Hydro Electric Projects (1948), Memorandum.
[72]Hydro Electric Projects (1948), Memorandum.
[73]Wilson (1967); van der Straeten (2022).
[74]Egerton (1954, p. 11).
[75]"Mwalimu Opens Hydro-electric Plant" (1965), *News Review*, quoted in Hoag (2006, p. 249).
[76]Amann (1969, p. 34).

made energy provision legible as an economic sector. Despite the title suggesting a study on "Energy Supply," the bulk of it was dedicated to electricity, confirming Daniela Russ's argument that the energy economy had come to be "read" mainly through the flows of electricity.[77] Taking up one of the central tenets of development economics at the time, Amann claimed that "energy consumption per capita is widely accepted as an indicator of an economy's endowment with capital goods and advanced production methods, hence as a criterion of development."[78] Amann went further than Egerton, the colonial expert advisor, claiming that beyond electricity's role as a "gauging rod or mirror of economic growth," the electricity supply industries were a main *driver* of economic growth.[79]

Amann's study drew on the relatively young research field of development economics. The intellectual origins of this field can be traced back to the transformation of economics into a formalistic science based on mathematical models and macroeconomic aggregates. This transformation found its most visible expression in the ascent of the "Gross National Product" as a universal indicator for economic growth from the 1930s onward. Within the international institutional framework that consolidated after World War II, a homogenous set of shared terms, categories, and technical abstractions came to dominate the discursive framing of problems. At the same time, economists such as Colin Clark, Jean Fourastié, and Robert Solow utilised the newly available statistical data to devise models of economic growth that formed the base for the emerging discipline of development economics in the 1950s. These models explained economic growth in terms of the shifting weights between different economic sectors. Almost unanimously, development economists promoted industrialisation as the only cure for underdevelopment by increasing capital intensity, labour productivity, and technical progress.[80]

As an adequate economic policy to achieve this goal, most development economists proposed a balanced-growth approach of synchronising the growth of different sectors, rather than focusing investment upon a single sector. This position was met with a general scepticism within the World Bank and the UN economic commissions promoting large-scale "showcase" projects such as hydropower dams in the early 1950s.[81] In a widely received critique of balanced-growth theory, however, German-American economist Albert Hirschman argued in 1958 that economic development needed to be understood as a chain of disequilibria, in which one sector went ahead and others followed. Poor countries should focus their limited investment resources on a single sector characterised by strong "backward and forward linkage" to others. In this regard, the electricity sector ranked high on his list. Hirschman's theory of unbalanced growth provided the most powerful development narrative at the time, as it made the "high-modernist" appetites of post-independence governments and international funders for grandiose hydropower projects commensurable with a "rational" economic policy.[82] Not surprisingly, Amann's study on East Africa cited Hirschman extensively.

As Michel Callon has argued, the theories and market models devised by economists are more than external analyses; they shape the very socio-economic realities they are meant to represent.[83] The impact of the novel discourse in economics was not limited to offering a new interpretative framework for understanding economic growth—an inherent feature of capitalist societies predicated upon the accumulation of capital. In his history of the OECD, Mathias Schmelzer traces how the concept of economic growth turned into an undisputed core goal of a policy based on the hegemony of what he calls the "economic growth paradigm."[84] Economic growth became "engrained in statistical standards, international policy frameworks, … widely accepted norms" and, as will be shown in detail below, in increasingly technologically elaborate modes of commensuration, such as the cost–benefit analyses for power projects.[85]

[77]Cf. Russ (in press).
[78]Amann (1969, p. 21).
[79]Amann (1969, pp. 21–22).
[80]Speich (2008).
[81]van der Straeten (2022).
[82]Hirschman (1958). Notably, Judith Tendler, who praises the "mystique of hydropower" in the introductory quote of this article, was a colleague of Hirschman.
[83]Callon (2008).
[84]Schmelzer (2016, p. 10).
[85]Espeland & Stevens (1998, p. 318).
[86]Mitchell (2002, p. 81).

At the eve of independence in East Africa, the economy had come to denote "a distinct social sphere" that was created and advanced by science, statistics, and policy.[86] The rise of the economy as the *object* of politics furthermore shifted the framework of agency within that social sphere. According to Mitchell, it replaced democratic debate in development organisations and political institutions with "economic planning and knowhow," and concentrated power in the hands of economists or experts who were able to make their knowledge commensurable with the terms and metrics of economics.[87] The conceptual convergence of development and economic growth to a point where both were used almost synonymously conferred legitimacy specifically on those projects with measurable impacts on the key metric of economic growth: the GDP. Seemingly stripped of the political ambitions attached to it, reduced to bare growth indicators, and framed as something unequivocally desirable, development became what Neill Ferguson described as the "anti-politics machine" that turned complex political realities into "technical" problems awaiting solution by "development" agencies and experts.[88]

Within the context of late colonial rule and decolonisation in Africa, the appeal that development economics gained on different sides varied considerably. Its immediate influence on Britain's colonial policy remained relatively modest. When it came to the funding of training and research activities, the Colonial Office remained focused on social policy, reflecting the specific importance assigned to social anthropology in approaching the social and economic development of the territories it administered.[89] The economic initiatives undertaken by the Colonial Office, such as attempts to create national accounting frameworks for African economies, built upon existing projects that focused on social and cultural development.[90] Leading economists in Britain like Peter Bauer and Basil Yamey continued to conceive policy, market structures, institutions, and products primarily from the perspective of the British government's interest in managing its colonial territories.[91]

For international donors and the governments of newly independent states, however, development economics had a specific appeal and attained the status of a "salvation promise," as Daniel Speich has shown. After all, growth models came with the promise of achieving economic independence regardless of specific local conditions and historical legacy.[92] The conception of the economy as a "self-contained structure or mechanism whose internal parts are imagined to move in a dynamic and regular interaction" seemingly opened up an unprecedented capacity to act independently from external factors—most notably, the mercy of former colonial rulers.[93]

The development plan for Tanzania for the period from 1964 to 1969 provides an illustrative example.[94] Presented to the public by President Julius Nyerere in 1964, this plan was the first one that the new administration considered to be its own. Its conceptual representation of Tanzania's economy marked a departure from a tradition of British colonial economic planning that was essentially based on compiling individual projects from different ministries.[95] Taking inspiration from balanced-growth theory, this new plan discussed development potentials within the different economic sectors and the interplay between these sectors. It was "based on the observance of various equilibria in the economy which are regarded as essential for orderly and successful development," the responsible Minister A. Z. N. Swai claimed in the foreword.[96] Development goals were formulated on internationally standardised metrics, such as per-capita income and life expectancy.

The authors of the development plan recommended a two-pronged approach. On the one hand, Tanzania needed to industrialise to resolve what the authors considered an appalling structural imbalance, arising from its high reliance on agriculture. On the other hand, the agricultural sector itself needed to be modernised to increase its pro-

[87]Mitchell (2011, p. 124).
[88]Ferguson (1990).
[89]Tribe (2018, p. 103).
[90]For Tanganyika, see, for example, Peacock & Dosser (1958).
[91]Tribe (2018, p. 110).
[92]Speich (2008, pp. 184, 192).
[93]For quote, see Mitchell (2002, p. 82).
[94]United Republic of Tanganyika and Zanzibar (1964).
[95]Havnevik (1993, p. 37).
[96]United Republic of Tanganyika and Zanzibar (1964, p. 2).

ductivity. Generally, it was the agricultural sector for which government planners held their most ambitious visions of state-led transformation. Among them was the nascent idea of a "villagisation" program that would be famously cited as a prime example of a "high modernist" project by James Scott.[97] No less ambitious were the planners' ideas for a coordinated development of Tanganyika's river basins.[98] Notably, emphasis was put on the construction of dams for the purposes of flood control, irrigation, and irrigated cultivation, but less so on hydropower generation. The development plan did not attach specific significance to electricity and the proposed projects were comparatively modest in size. Bigger dam projects were only mentioned as long-term options.[99]

The idea of state-managed, multipurpose river-basin development was not new by any means. The Tennessee Valley Authority, a U.S. state agency that oversaw multiple dam projects and conducted various conservation, economic development, and social programs, had become the key reference for river-basin development since the 1930s.[100] Within the post-World War II framework for international development, many countries sought to replicate the TVA's highly complex and context-specific approach of developing a river basin, including dams and power stations, flood control facilities, navigation channels, reforestation, and erosion programs. When exported to the rest of the world, however, the original model of the TVA transformed significantly. Tanzania would be no exception. What had been designed as a comprehensive regional development program for the U.S. South turned into a project for the construction of large, single-purpose dams for hydropower generation. The electricity produced by these dams was transmitted through high-tension lines to the capital Dar es Salaam, thus almost entirely depriving the river basin and its inhabitants of the dams' benefits. This outcome was greatly at odds with the agenda of balancing agricultural and industrial development as it was laid down in the Tanzania's own development plan. In the following, I turn to the question of why the country's entry into the big dam era rendered the energy needs of those rural farmers invisible, although they were supposed to be the main beneficiaries of Nyerere's African socialist agenda.

This question cannot be answered without reference to the transition from bilateral relationships of colonial development policy to the multilateralism of international development aid, and the set of shared terms and concepts of development that the new and globally dispersed community of development consultants, managers, and politicians drew upon. The metrics of electricity production, as this section argues, came to mediate these concepts.

Decolonisation ended the bilateral relationship of British colonial development policy in Tanganyika, but it only did so rather gradually. Tanganyika's relatively peaceful path towards political independence earned it a reputation as a colonial "model student" and, somewhat ironically, unlocked the first substantial investments into the country's power sector by British development banks.[101] In 1965, however, diplomatic relations between the two countries broke off over Nyerere's support of the nationalist FRELIMO movement that fought in Mozambique against Portuguese colonial rule. The diplomatic rift reinforced the determination of the Nyerere government to break free from Tanzania's dependency on its former colonial ruler for funding and technical expertise. In practice, however, this was easier said than done. For example, at the newly founded national electricity utility TANESCO, many executive positions were still held by British expats in 1965, including the general manager who was replaced by an African Tanzanian as late as 1972.[102]

On the international level, Tanzania sought development assistance from all sides of the political divide to fund its ambitious development plan. During the 1960s, countries from both sides of the Iron Curtain competed for influence in the country by initiating and supporting various development projects. Socialist countries implemented projects for housing (German Democratic Republic) and railway construction (People's Republic of China).[103] The funding of electricity projects, in contrast, remained firmly in the hand of Western countries and soon turned into the single biggest field of intervention. After Tanzania nationalised its electricity industry from 1964 onward, private

[97]Scott (1998).
[98]United Republic of Tanganyika and Zanzibar (1964, p. 3).
[99]United Republic of Tanganyika and Zanzibar (1964, p. 52; Vol. 2, pp. 57–58).
[100]McCully (2001); Neufeld (2016).
[101]van der Straeten (2022).
[102]Öhman (2007, p. 197).
[103]Monson (2009); Myers (1994).

capital withdrew from the sector entirely, and international development funding became the only source of investment capital. In the mid-1960s, development agencies from several Western countries, including Norway, Sweden, the United States, Japan, and Canada, engaged in various projects for the construction of dams and transmission lines.[104] Accordingly, the number of involved parties in a single project increased dramatically. As late as September 1964, a British High Commissioner had noted with astonishment that the British company Balfour Beatty acted as "consultants, contractors, buying agents, and design experts for all TANESCO projects."[105] Only one year later, consultants, development agencies, and banks from all over the world entered into various forms of cooperation while pursuing their own agendas, often competing for funds and influence.

To collaborate in an environment in which few of these organisations had any prior working experience, they had to rely on a shared reference system that consisted primarily of abstracted terms and metrics. Within this communicative environment, transferable models and calculable outputs gained unprecedented authority, especially if they could be made commensurable with economic terms. Arguably, this novel reference system reconfigured the framework of agency for the different parties involved. It paved the way for a "rule of experts" in hydropower development—more specifically, those international consultants who were contracted to provide their expertise on the different aspects of hydropower development, including studies on the technical and economic feasibility of projects and, later, their environmental impacts.[106]

The development of the Rufiji Basin, which became the focal point of Western development agencies, offers a prime example of how the entry of these agencies into the former colonies changed the mediation of knowledge on local environments. The British colonial administration had already attempted to advance the commensuration of Tanzania's biggest river-basin statistical representations.[107] In partnership with the colonial government, the Food and Agriculture Organization of the UN (FAO) conducted an extensive survey of the basin between 1952 and 1961. Aiming for a quantitative overview of the entire basin's hydrology, geology, and topography, the FAO study team largely ignored qualitative, site-specific data and the observations of residents, British colonial officials, and surveyors. As Hoag and Öhman summarise, the "FAO's charts, graphs, and tables replaced colonial understandings of the basin's waterscape."[108] Despite the criticism it drew from experienced colonial advisors and administrators, the FAO reports offered the statistical environment that international development agencies needed. Specifically, the estimated potentials for hydropower generation at different sites and the corresponding investment costs caught the attention of the agencies, despite being based on scant hydrological data.[109]

The further development planning for the basin then became narrowly focused on hydropower generation, a possibility that had not even been mentioned in earlier studies. At the forefront were Norway and Sweden, two countries which tried to capitalise on their lack of a colonial past and were looking for new export markets for their respective hydropower industries.[110] In 1966, Sweden gave up its support for a dam project on the Wami River, which would have included an irrigation component, in favour of a single-purpose hydropower dam on the Great Ruaha River in the Rufiji Basin. This shift, although supported by TANESCO, sparked an outcry from the national government under Nyerere and the Tanzanian Water Authority, which championed irrigation and flood control to advance their goal of increasing agricultural productivity. Yet, the benefits arising from the latter were invisible to potential funders like the World Bank as long as they were not calculable in monetary terms, as John Fletcher, a Swedish development consultant and utility manager, pointed out. In an expert opinion that Swedish development agency SIDA had requested to solve the dispute, Fletcher wrote:

[104]van der Straeten (2022).
[105]Notes on a Safari to Tanga and Nyumbuya Mungu Dam by the High Commissioner and Mrs. Fowler, 10th to 13th September 1964, [Notes] (1964, Sep. 14), DO 185/35, BNA.
[106]Mitchell (2002).
[107]Regarding the concept of legibility, see Scott (1998).
[108]Hoag & Öhman (2008, p. 641).
[109]Hoag & Öhman (2008).
[110]Öhman (2007, pp. 163–165).

> Money should be made to talk: each one of the parties should be made to weigh the money value of their wishes against the costs to be covered.—In this respect power seems to be superior. Opinions are divided as to the relative benefits in the future, but one thing is absolutely certain: plans for power are much more definite and much more accessible to assessments of costs and benefits, in a word much more tangible, than plans for flood control and irrigation; however important the latter may be in the future, they are at present, to say the least of it, slightly vague.—The important thing is that money should be permitted to talk and to dictate decisions.[111]

The calculability of electricity, combined with the unwavering belief in the advantages of capital-intensity, finally gave the decisive edge to the Great Ruaha dam project, compared to other options. A comparative report excluded possible revenues from irrigation or flood control, leading to the option of a dam on Wami River being dropped. When comparing the Great Ruaha dam to a diesel power plant in Dar es Salaam, the authors deliberately understated the capital costs for the dam, arguing that such a project would be better suited to attracting foreign credits.[112] With a number of calculations and statistics, the comparative study translated what was an inherently political question into a seemingly scientific truth. Based on the report, the World Bank decided in favour of the dam on Great Ruaha River, ignoring warnings about its environmental risks.

The decision for the hydropower dam bears witness to an unwavering faith in the authority of scientific methods, nourished by the mathematisation of economics, which had soon spilled over to other areas. In electricity-related commensuration processes, this faith was used to override any concerns about data quality. In earlier calculations, Fletcher had even used data from the river flowing nearby his Swedish office to extrapolate the long-term flow patterns of the Tanzanian rivers.[113] Ultimately, as experienced British senior officials that had remained in the Tanzanian administration correctly predicted, evaporation in the shallow reservoir led to a significant decrease in the dam's hydropower capacity.[114]

The Kidatu and Mtera hydropower plants in the Great Ruaha river basin substantially transformed the Tanzanian electricity infrastructure. By 1984, it increased the installed hydropower capacity in Tanzania from 50 MW to 200 MW. By 1990, hydropower contributed 95% of the country's total electricity generation.[115] The example of the Great Ruaha Power Project shows that Tanzania's entry into the big dam era was neither self-evident in economic terms, nor was it solely the result of the hubris of decision-makers in government or international donor organisations. It was much more about the modes of commensuration applied by international consultants and the role that electricity assumed in this process because of its calculability. Conversely, this perspective rendered other development goals, such as agricultural productivity increase or rural energy needs, largely invisible to international funders. The case of the Great Ruaha dam feeds into a wider story of the problem of generating reliable and representative data on African economies, and of how incomplete data shaped national and international discourses on development.[116]

## 5 | A SECTOR, NOT A SERVICE: BUILDING A NATIONAL INDUSTRY

The new terms and concepts associated with electricity provision were appropriated not only by foreign consultants but also by the African Tanzanian professionals who gradually replaced the expats that had been working in the responsible ministries, the utility, and research institutions. This new generation of foreign-educated managers and

[111]Cited in Öhman (2007, p. 186).
[112]Öhman (2007, pp. 183–184).
[113]Öhman (2007, pp. 267–268).
[114]Walsh (2012).
[115]Ghanadan (2008, p. 59); Öhman (2007, p. 17).
[116]See, for example, Jerven (2017).

engineers was to execute a process subsumed under the slogan of the Africanisation and nationalisation of the power sector. This process began in 1964, when the Nyerere government started acquiring all TANESCO shares and installed African Tanzanians with close relations to the ruling TANU party as chairmen. The new administration redefined TANESCO's corporate mission as the combination of three—at times contradictory—goals: Electricity supply was to serve as "an agent of development" and "a social service," while the utility was still to operate as an "economically viable organisation."[117]

To achieve these goals, the new administration restructured the power sector along the lines of the "traditional industry model." This model had been considered an international norm since at least World War II, when countries like Britain and France nationalised their power sectors. It promoted electricity supply in a state-owned, vertically integrated monopoly regulated by the government (and not an independent regulator).[118] The fact that information on power systems is less context specific than, for example, information on the fuel economy arguably contributed to the international circulation of standardised models.[119] Upon reorganising the power sector, the Tanzanian government followed a textbook version of the traditional industry model, earning it much praise from economists like Amann. Besides the construction of big dams as the dominant form of electricity generation, the reorganisation included the goal of centralising electricity provision on both a technical and an organisational level. Planners formulated a strategy of interconnecting the isolated grids into a "national grid" and introduced four unified national tariffs, as opposed to the prior system of local, cost-recovery tariffs.[120]

Analogously to the field of (development) economics, statistical aggregates on the national level dramatically gained significance in the planning processes for the power sector. During the 1970s, both international consultants and African Tanzanian academics relied on statistical methods to produce several forecasts of the country's future electricity demand.[121] The most influential of these studies was a long-term "Power Sector Master Plan," created by the Canadian consultancy firm Acres International and first published in 1978. For a grid system forecast up to the year 1995, the authors used a model that related the gross domestic product to the total energy generation and sales.[122] These studies consolidated a supply-driven, macro-level approach, which still characterises power system planning in Tanzania today.[123] As a national utility, TANESCO was planning its grid based on a country-wide master plan that was entirely detached from the distribution planning of individual branches.[124] The two levels of planning were characterised by entirely different of ways of seeing and therefore two different rationales for grid expansion. Planning on the national level followed a strict top-down approach, aimed at consolidating and interconnecting the isolated grids and electrifying smaller towns along their administrative hierarchy: first the regional capitals, then the district capitals. When it came to the connection of individual households, however, the local TANESCO offices continued to apply a commercial logic that excluded most potential customers in rural areas, even if they lived in proximity to the grid. While the number of officially electrified rural towns steadily increased, the number of rural households with connection to the grid only grew by an insignificant amount.

The representation of electricity through statistical aggregates created a skewed picture of Tanzania's energy-economic life: While rendering large industrial electric loads highly visible, the graphs and statistics made the non-commercial use of electricity largely invisible because the aggregate sum of domestic use remained comparatively

[117]Cited in Amann (1967, p. 5).
[118]Godinho & Eberhard (2018).
[119]Russ (in press).
[120]Amann (1969, pp. 127–128).
[121]van der Straeten (2022).
[122]Havnevik (1993, p. 271).
[123]Ghanadan (2008, p. 57); Showers (2011, p. 214).
[124]Interview with Maneno Katyega, former head of the research department TANESCO (2015, Mar. 17).
[125]Cf. Russ (in press).

low. The figures entirely misrepresented energy needs in rural areas and ignored the various forms of energy other than electricity that were used in small businesses and smallholder agriculture.[125]

Attempts to render rural energy needs visible on the national planning level proved to be short-lived. In 1972, economist Ernst Friedrich Schumacher published his famous book *Small is Beautiful*, inspiring a "basic needs approach" towards development.[126] In the footsteps of this movement, several international scholars and Tanzanian academics began investigating the availability and consumption of energy resources in rural areas, primarily charcoal, firewood, and kerosene. They also discussed solutions for the decentralised electrification of rural villages, such as wind, solar, and small hydropower.[127] In one of the most notable of these works, a study titled "The Poor Man's Energy Crisis," Professor Simon Nkokoni from the Institute of Development Studies at the University of Dar es Salaam complained that:

> The Energy Crisis has too often been seen in the context of the needs of industrialized, developed countries and urban centres of the third world [sic]. Hence, there is an over emphasis on ways and means to provide the urban residents with oil and electricity, usually from the grid .... While conventional, centralized energy systems will no doubt continue to play a crucial role in the socio-economic development process in the Third World Countries, many scholars of development have started to view seriously the energy crisis of the Third World from a different angle. Between 85% and 98% of people in Third World countries live in rural areas.[128]

International consultants involved in the planning of big dams did not fail to notice the challenge that this critical perspective presented to their projects (and the associated contracts). The text of a presentation delivered by the Norwegian consulting firm Norplan in 1983 mentions that "Tanzania has addressed the question of whether power supply should come from decentralized mini-schemes or centralized larger scale projects with transmission to the load centres." The consultants emphatically dismissed the argument, claiming that "to meet existing and forthcoming committed loads, centralized generation with transmission is the solution proposed in all studies."[129] Given the preferences of donors and the national government, it does not come as a surprise that international funding for rural energy provision remained insignificant well into the 2000s.

The discrepancy of the centralised approach from the official anti-urban African Socialist agenda of political and economic decentralisation and rural productivity increase was striking. By the mid-1970s, the Nyerere government had resettled millions of people into planned villages, shifted the capital to the small rural town of Dodoma, partitioned Dar es Salaam into three municipalities, and discouraged migration and investment into the former capital. At the same time, the reorganisation of the power sector bolstered Dar es Salaam's preeminent position within the national electricity system. The electricity generated by the big, new hydropower projects in the Great Ruaha river basin was transmitted directly to a substation in Dar es Salaam for redistribution, bypassing the rural areas on the way. The unification of tariffs shifted the focus of electrification further towards urban areas where distributions costs were lowest. Unable to raise tariffs to become more cost-recovery, TANESCO could operate in the rural upcountry areas only at a high loss, and maintained its focus on boosting access in urban areas. As a result, it was almost exclusively urban customers who benefitted from the introduction of cross-subsidised "lifeline tariffs," which made electricity consumption much more affordable for users who stayed below 100 kWh a month.[130] By 1992, a mere 14 out of 8,600 rural villages in the coun-

[126]Schumacher (1973).
[127]van der Straeten (2022).
[128]Nkokoni (1981, p. 23).
[129]Norplan (n.d. [ca. 1983]), Hydro-electricity in Tanzania's economy [Presentation manuscript], slide 11, retrieved from the archive of the Rufiji Basin Development Authority, Dar es Salaam, Tanzania.
[130]Ghanadan (2008).
[131]Kjellström, Katyega, Kadete, Noppen, & Mvungi (1992, p. 2).

try had been electrified.[131] In 2000, the percentage of households with grid electricity in Dar es Salaam had increased to 59%, compared to 30% in other urban areas and 1% in rural areas.[132] According to data from the World Bank, the proportion of the rural population with access to electricity was 18.8% in 2018.[133]

## 6 | CONCLUSION

Upon its completion in 1902, the Aswan Dam in Egypt was the largest masonry dam in the world. Through its sheer scale, Mitchell writes, it allowed people to imagine, for the first time "a world divided into human expertise on one side and nature on the other."[134] It was these symbolic qualities that paved the way for the rule of experts, based the primacy of human reason. Yet, in contrast to the Aswan Dam, which was built for irrigation purposes, it would take another 50 years before dams for hydropower generation of a similar scale were built in the British Empire.[135] With a focus on East Africa, the first section has framed Britain's long and winding path towards large-scale hydroelectricity generation in its colonies as a problem of commensuration.

Hydropower generation symbolically fit well within the transitive concept of colonial development, but its terms and metrics proved to less commensurable with those of Britain's actual development agenda than its promoters had hoped. While engineers lamented Britain's failure to utilise the energetic potential of the Empire's rivers in the 1920s, the Colonial Office initially remained reluctant to invest in the cost-intensive quantification of these potentials and coordination of its exploitation, and to include electricity in its centralised advisory networks. The challenges were not limited to the well-documented difficulties in exploring complex riverine natural (and social) environments, identifying dam sites, and translating their topographical and hydrological features into calculable outputs and costs. Equally difficult was the task of making colonial economies commensurate with the metrics of electricity demand. The expert advisors struggled with assessing how Britain's development plans for most colonies would translate into substantial loads in East Africa.

The potential market for electricity among the African population majority remained even more opaque. The scattered and mostly unplanned settlement structure of African households rendered them largely invisible to colonial planners. In the few documented cases of utilities trying to calculate the potential revenue from African customers, quantification did not work in their favour because regulatory frameworks and the utilities' business models offered little incentive to tap into this potential. The study of electrification in British colonial Africa through the prism of commensurability adds further nuances to works that frame the exclusion of Africans as something other than a direct result of identity politics or the racial bias of utility managers.[136] The techno-politics of electricity worked in a more subtle way, mostly under the guise of reasoned and non-discriminatory public and corporate policy. The racially exclusive nature of electrification in British colonial East Africa was less about actively preventing African customers from access than it was about, first, the failure to build electricity systems on a scale that would have rendered rural electrification techno-financially feasible, and, second, the absence of any subsidy policy for that purpose.

The role of electricity in the "calculative politics" of colonial rule was as diverse as its political economy throughout the Empire. In some colonies, the metrics and codifications of electricity were paramount to "affirming the ontological reality of a national economy, asserting authority over a definite territory, and gaining legitimacy."[137] In other territories, they could also lay bare the failure of the British concession model to achieve the goals set during the first age of development or to deliver on its promise of increasing welfare in the colonies after the reforms of the 1940s. This heterogeneity, even among Britain's territories in East Africa, became even more pronounced after World War

[132]Ghanadan (2008, p. 76).
[133]World Bank (2019).
[134]Mitchell (2002, p. 36).
[135]For a statistical overview of dam construction in Africa, see Showers (2011, pp. 200–205).
[136]Chikowero (2007); Hoag (2013).
[137]Shamir (2013, p. 135).

II. As the example of Owen Falls has shown, the metrics of hydroelectricity generation could unfold an unprecedented persuasive power as they fed into both the official rhetoric of restoring legitimacy by investing in welfare, and an internal debate among colonial administrators that conceived Uganda as extension of British industrial economy.

The general enthusiasm for hydroelectricity generation, often embedded in a wider concept of River Basin development, remained unbroken by the political turmoil brought by decolonisation and independence in the 1950s and 1960s. Post-independence governments fully accepted and continued colonial-era initiatives for dam construction, appropriating the symbolic qualities of large dams and aligning them with their own political agendas. At the same time, the establishment of the "economic growth paradigm," the increasing influence of development economics, and the transition to the multilateralism of development aid changed the modes and epistemic foundation of commensuration processes related to electricity. As was shown, these changes had deep and lasting consequences on the amount of international support that hydropower generation attracted and on the design of the dams that were subsequently built.

The conception of the economy as a self-contained mechanism and the unwavering belief in the potency of growth models in explaining its functional principles led to a kind of circular reasoning. The theory of unbalanced growth suggested that the expansion of electricity supply would create its own demand and justified almost any investment into the power sector. This alleged automatism made it easier to embed hydropower projects and their calculable outputs in a development discourse that became almost entirely focused on GDP growth. In turn, the "hegemony of growth" provided the necessary arguments for proponents of large-scale hydropower generation to promote industrial use within both the Tanzanian government and international agencies and to side-line calls for including irrigation components in the design of dam projects and for rural electrification.

Furthermore, the obsession with calculability led key decision-makers, for example at the World Bank, to privilege methodological consistency over data quality and override concerns of experts with more experiential knowledge. Within the multilateral frameworks of development aid, the activities of development experts and their circuits of communication became even more detached from conditions on the ground than those of colonial advisors had been.[138]

The convergence of electricity system-building with economic modelling also provided the ontological foundation for the nationalisation of electricity as a core element of post-independence nation-building. The macroeconomic aggregates that served as a basis for planning made non-commercial and rural uses of energy invisible. They paved the way for a centralised system that was geared towards large industrial customers and urban areas—a grid topology that provided a striking contrast with Nyerere's agenda of political decentralisation and rural productivity increase.

This perspective on electricity continued to shape energy policy beyond the period of state-led growth in Tanzania. In the early 1990s, the country began a process of market-oriented power sector reforms, following pressure from the international donor community. While these reforms tried to reverse the high influence of the state in the power sector, they arguably perpetuated the ontological legacy of the 1960s. The market reforms were based on an unwavering belief in the transferability of governance models in energy and were focused narrowly on economic performance indicators. The adoption of the "standard reform model" promoted by the World Bank became a condition for the provision of aid, loans, and other forms of development aid. By now, three decades of power sector reforms in East Africa have produced mixed results. Kenya, for example, is lauded for its successes in attracting international private investment, establishing independent regulation, and increasing electrification rates in recent years. In contrast, Tanzania has become an intensively studied case of a largely corrupted and incomplete reform process, despite some bright spots.[139]

One of these bright spots is the increasing emphasis on electricity provision in rural areas. This emphasis is not only reflected in changes on the institutional level, signified by the foundation of rural energy agencies across the region in the early 2000s, but also by the pluralisation of approaches towards electrification and indicators to

[138]There was, of course, some overlap between both groups; many former colonial advisors came to work for development agencies.
[139]Godinho & Eberhard (2018).

measure access to electricity. Researchers and development agencies have come to realise that the established practice of calculating electricity access rates according to the number of people living close to the distribution grid provided a skewed picture of actual service provision and have therefore proposed more use-centric measures.[140] Some approaches for rural electrification through mini-grids or stand-alone solar systems have reached considerable scale and found entry into national electrification strategies and regulatory frameworks.[141]

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[140]Bhatia & Angelou (2015).

[141]Cf. Tenenbaum, Greacen, Siyambalapitiya, & Knuckles (2014).

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