Rachel Carson Center
Perspectives

Energy (and) Colonialism, Energy (In)Dependence

Africa, Europe, Greenland, North America

Edited by

CLAPPERTON CHAKANETSA MAVHUNGA
HELMUTH TRISCHLER

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Introduction

What does history tell us about energy transitions? What do energy transitions tell us about the history, moreover, of colonialisms throughout the world—from Greenland, to North America, to Africa, to Europe, for example? In talking of transitions, is it a question of entirely leaving one form and adopting the next, or of overlapping, even mutually complementary energy forms?

The five essays assembled in this issue of *RCC Perspectives*, developed from a workshop organized by Helmuth Trischler and Martin Melosi in 2013 entitled "Energy Resources: Europe and Its Former Colonies," try to address these questions. It would seem, from all of them, that in telling the story of energy in colonial projects, we are also telling the story of colonialism as a search for new forms of energy. At their core, all colonial projects derive from the imperative to transform the potential energy stored in colonized (or colonizable) subjects into mechanical energy for the production of wealth. The marshaling of the manual labor makes possible the transformation of nature into the inputs and infrastructures of energy production.

Therefore, it is important to discuss the rationale and identify catalysts behind decisions to switch from one energy form to another. Until the development of solar energy, almost all energy forms have involved the modification of the environment—excavating ores and dumping them; building dams and displacing people and animals; flooding forests; and more recently, creating crop fields for biofuels that are grown in monocultures. A new energy form is introduced to address a deficit, its promise to quench all energy shortfalls always hugely dramatized. Whether it is vast reserves of coal, uranium, and natural gas, or "electricity too cheap to meter," the initial promise eventually runs its full course, and the quest for new, more dependable energy forms begins again.

Energy transitions are never just about economics, engineering, or science. Rather, the question is why the use of specific scientific or engineering techniques makes sense at a particular time and leads to specific energy outcomes. The transitions could be related to imperialist projects such as the partition of Africa or the Nazi expansion into Eastern Europe; to a specific political party coming to power riding on a popular wave of mega-developmentalism; or the belief that certain energy forms have detrimental effects on the environment and should not be pursued. We see these cleavages in contemporary debates, about whether nuclear is safe; coal clean or dirty; solar energy cheap and capable of supplying energy for entire nations; biofuels more harmful or beneficial in light of climate change; and whether climate change is caused by human actions (specifically in relation to energy use) or simply an act of God. Beyond the scientific facts lie other facts: political, spiritual, cultural, and so on, all serving as a motor to turn science into reality. In some ways the essays gathered in this volume place these intersections between energy transitions and colonialism in the foreground.

The first three essays are all concerned, in one way or another, with fossil fuels (coal) and colonialism. Clapperton Chakanetsa Mavhunga's paper examines the links between energy, industry, and transportation in colonial South-Central Africa's history from 1885 to the 1960s. He locates this technological convergence at the confluence of British, Belgian, and Portuguese imperialism, giving a truly transnational and transcontinental character to the development of energy systems in the sub-region. He shows that while it is fruitful to start the exploration of energy history from "large scale" colonial systems and from forms like coal, hydropower, and uranium, we risk missing another trajectory: that of ordinary people and the (formerly) colonized. In this case, the Europeans built their first industries and transportation systems upon energy systems that Africans had already devised and used for centuries: firewood and manual labor. Then came coal, gradually replacing firewood on railroads and industries, but never replacing human power.

Ihediwa Nkemjika Chimee's study of coal and British colonialism in Nigeria focuses on conditions under which energy infrastructures developed under colonial rule. The development of coal and coal-based industries, Chimee argues, must be seen in relation to the master-servant politics of British indirect rule, in which traditional authorities (chiefs) were used as instruments of the colonial government to forcibly displace Africans from their ancestral lands to make way for mining settlements and administrative buildings for colonial officials. Fewer cases illustrate energy colonialism more starkly than in the use of energy to justify the disenfranchisement of colonized Africans and the conversion of African chiefs into human tools to mobilize their subjects as cheap labor for the colonial enterprise.

Similarly, Christopher Jones's essay explores how the British engineered America's first fossil fuel transition from the late-eighteenth century onwards—from wood to coal. His is the story of the transcontinental, trans-spatial mobility of British coal practices. He argues that the history of energy transitions, often written from the perspective of individual nations, has been transnational. The imagining of a coal-fired American future, Jones says, must be seen from the perspective of Europeans settling in a world of energy abundance—dense forests and an endless supply of firewood, countless streams to power mills, and wide tracts of land to clear to support horses and oxen. Indeed, the heterogeneous group of Philadelphia merchants, scientists, industrialists, politicians, and citizens that began to agitate for the use of anthracite coal in the 1810s was fueled more by opportunity than energy scarcity. A coal-burning future, therefore, was not at all inevitable.

The final set of essays relates to *hydropower* in mountainous regions. Ingo Heidbrink's is a fascinating essay on the path to energy sovereignty in Greenland through hydropower. Greenland is a mountainous country that possesses about eight percent of the world's freshwater supply, which in theory gives the country hydropolitical leverage. However, all of this freshwater is permanently frozen; Greenland in fact has the lowest installed hydropower capacity in the world. What use is energy, then, if it is dormant? Heidebrink illustrates how the unusable nature of the water had by the 1940s forced Greenland to rely on oil imported from outside Greenland or on coal for heating, pushing Greenland into a colonial and paternal relationship with Denmark. Heidbrink's example contrasts with Marc Landry's essay on Germany's Kaprun project in post-war Austria, which was not just a transition from coal to hydropower but from natural to artificial reservoirs to power the turbines. The key difference is that, unlike Greenland's frozen waters, the waters of Austria's Hohe Tauern mountain range flow, and can be harnessed into hydroelectric power.

In a discussion so thoroughly dominated by engineering, innovation, science, economics, and studies of contemporary environmental issues, it is easy to assume that energy has no history, when in fact it remains a truth that history has no energy. That is, our accounts of the human existence and its interactions with the biotic and abiotic environment—to say nothing of the spiritual—are still devoid of attention to energy, just as studies of energy are still either shallowly historicized or downright ahistorical. Together, these essays provide a starting point for a larger conversation not only about colonialism or history, but also energy humanities.

Clapperton Chakanetsa Mavhunga

Energy, Industry, and Transport in South-Central Africa's History

In 1885, two events occurred that had significant implications for energy, industrial, and transportation infrastructure development in South-Central Africa. One was the European discovery of gold in the Witwatersrand highlands of Gauteng, South Africa. The other was Belgian monarch King Leopold II's occupation of Congo. A scramble to grab the lands in-between ensued, pitting the Portuguese, British, Germans, and Boers against each other. Through chartered companies, the Portuguese took Angola and Mozambique, the British seized Southern Rhodesia and Northern Rhodesia, and Leopold founded the Congo Free State.

Three chartered companies played a critical role in the energy-industry-transport connections discussed in this essay. Two had orchestrated the occupation and creation of colonies: British South Africa Company (BSACo) in the two Rhodesias, and Companhia de Moçambique in Sofala and Manica province. Both Rhodesias were landlocked. Southern Rhodesia had the region's largest known deposits of high-grade coking coal, in Hwange (Wankie). BSACo administered the territory through which the primary railway line passed, as well as Rhodesia Railways, the only rail service in the Congo, Northern Rhodesia, South Rhodesia, and Mozambique. Congo's Katanga province had limitless deposits of copper, and Sofala had the best and most convenient port facilities in Beira, jointly owned by BSACo and Companhia. Katanga needed Wankie's coal; BSACo and Companhia needed Katanga's copper business. In 1906, BSACo partnered with Belgian capitalists to found the *Union Minière du Haut Katanga*, which obtained a charter from King Leopold II to mine copper in Katanga province until 1990.

In return for the supply of Wankie coal, BSACo secured rights to ship Katanga's copper on its 1,600-mile railway line to Beira, in Companhia territory (Warthin 1928, 307; Birchard 1940, 432). Despite having shorter options via Benguela, the 1906 agreement bound Union Minière to the Beira route and Wankie coal throughout the colonial period (Katzenellenbogen 1974, 66; Lunn 1992). BSACo itself administered two landlocked colonies, and needed Companhia to find an outlet for its railway traffic to the sea and global markets; Companhia of course needed the rail shipping business (Hance and van Dongen 1957, 308).

Southern Rhodesia's significance to these energy-industry-transportation connections lies in the BSACo's role as the principal railway developer in South-Central Africa. Rhodesia Railways' headquarters was in Salisbury; its engineering workshop was in Bulawayo, where three railway lines (the Mafeking line, the Wankie-Zambia-Congo line, and Salisbury-Umtali-Beira line) converged. Prior to 1936, the Katanga-Beira network was under four different authorities, each controlling its own stretch: Mashonaland Railways (Elizabethville to Victoria Falls), Rhodesia Railways (Victoria Falls to Salisbury), and the Beira Railway (Salisbury to Umtali, Umtali to Beira). Thereafter, Rhodesia Railways Ltd. took over the entire Northern and Southern Rhodesia railway systems; in 1947, it became a state-owned company. Throughout the period, copper business and coal fuel were inseparable from the traffic connecting Katanga, the Rhodesias, and Beira (see Figure 1 for all references).

Figure 1: Map of South-Central Africa, showing the railway from Katanga, through Wankie colliery to Beira, and the many ships that used to dock there. Source: National Archives of Zimbabwe, *British South Africa Annual* 1925–26, 144.

This essay argues that energy must be seen in interaction with transportation and industry in order for its role in South-Central Africa to be fully understood. All three—energy, industry, and transportation—are themselves always socialized and at the whim of human-engineered mobilities.

Energy-Industry-Transportation Connections in Deep Time

The colonial period was only one moment in a longer trajectory of industrialization in Zimbabwe. Many centuries before colonization, local Africans had already distinguished themselves in industrial pursuits such as mining, agriculture, hunting, and local and international trade (Chirikure 2010). From 1 AD onwards, various communities had utilized indigenous technologies to process gold, iron, and copper (Miller 2002; Summers 1969). Disused mines, smelting sites, collapsed furnaces, *tuyeres,* and remnant ores in places such as Karanda, Copper Queen, and Mupfure area near Chegutu all point to deep histories of metallurgy, which nineteenth century European travelers bore witness to and documented (Mauch 1971; Baines 1877; Selous 1893; Chirikure 2006). These combustion processes clearly show the role of forest hardwoods like the *mupani* in smelting.

Such industry did not exist in isolation from the outside world, but rather was deeply involved in and mutually shaped it. Thus in the ninth century, merchants from Arabia traveling in dhows were drawn to this industry, established coastal market settlements, and assimilated and intermarried with Africans to create Swahili communities. Until their displacement by Portuguese incursions into the interior around 1500, the Swahili acted as interlocutors between the hinterland and Arabic and Indian maritime commerce for five centuries (Mudenge 1988). Indeed, Arabian and Portuguese travelogues extensively document trade and industrial activity on the Zimbabwe plateau. They also clearly show the role of Africans as caravans or porters connecting sites of production in the interior and coastal markets like Inhambane, Sofala, and Delagoa Bay. From the east coast, commodities sailed off to India, Britain, Portugal, and Holland.

The exports were quite diverse. Apart from metals, a highly specialized ivory hunting industry supplied the maritime trade network (Mudenge 1988; Mavhunga 2014). Grain and other crops fed locals and incoming ship crews. VaShona metal workers of Nyanga in particular made significant innovations in water management and agrotechnology composed of furrows, ditches, and terraces, all intended to tame steep, fast-draining mountainsides into flat, water-holding crop-fields (Soper 2000). Nineteenth century travelers saw Barotse and vaTonga people along the Zambezi valley utilizing the alluvium and water that the river spilled into valley plains to produce an impressive array of crops (Livingston 1854, 1861; Holub 1881). Tobacco, cotton, sorghum, millet, and maize (a Portuguese introduction from the Americas) thrived, and animals like cattle, goats, and sheep were kept in tsetse fly-free areas (Mavhunga 2014). If we consider rivers like the Zambezi as energy-producing (through gradient, water currents, and floods, and as transport carrying water and alluvium deposited locally), then hydropower—as water for irrigation, as a transport for nutrients that gave energy to soils—had been already harnessed for a long time. The exact same thing could be said of the Nyanga terraces, designed to save water that might flow rapidly downward, and channeling it instead into agricultural value. The choice of where to settle depended on the fertility of the soils, the availability of water, and the presence of usable natural resources. Interestingly, when Europeans colonized the country, they chased away Africans and settled on their lands, then—through heavy taxation, pass laws, land dispossession, and force—pushed them onto the white settler farms where they continued to apply their indigenous knowledge and energy for the white man's enterprise.

The same is also true for mining. The writings of the first mineralogists that European companies dispatched to "the Northern Goldfields" of "Zambesia," for example, demonstrate beyond doubt that what was later called "exploration," "prospecting," and "discovery" of gold was a clear case of intellectual property theft. The writings of Thomas Baines, Karl Mauch, and Selous show clearly that "European prospecting" was merely a ploy of such mineralogists to get Africans to show them their mines, now derisively called "old native workings" and "slag," remnants of furnaces that used tons of hardwood to smelt and separate gold (and iron) from rocks mined from underground (Baines 1877). The archaeologist Roger Summers (1969) plotted the distribution of pre-European mining and metalworking on the Zimbabwe plateau on a map, confirming that virtually every deposit that European miners exploited in the twentieth century had been worked prior to colonization. Knowing that Africans could still continue engaging in what has nowadays come to be known as *kukorokoza* (small-scale mining and/or gold panning), the colonial government criminalized all unlicensed mining of any mineral. As a rule, no black person could be issued a license. Instead, Africans were, through heavy taxation, land dispossession, and draconian laws, forced to seek employment in the mines, where some of them extended their indigenous knowledge of mining and ironworking. Therefore, the "colonial moment" was more a junction of technological cultures than a rupture marking the end of the "pre-industrial" and the beginning of "industrial society," contrary to some Marxist scholars (Marks and Atmore 1980).

Colonial Transcontinental Connections

By displacing African modes of industry and taking away the means of African industrial production (mines, land), European presence and the capitalist mentality of large-scale manufacturing needed tools capable of mass production, of the kind that Africans never needed. This section is concerned with three key sites of colonial energy consumption.

The first is *the white commercial farm,* the destination of production equipment manufactured abroad. The windmills on most farms and game reserves in the Rhodesias came from Flint & Walling MFG. Co., from Kendallville, Indiana, USA. They were mostly used to pump water to dry-land paddocks and conservancies, and not for electricity. Most of the farm trucks came from the Dodge Brothers of Auburn Hills and the Ford Motor Corporation (both from Michigan). They were used not only for carrying farm supplies and produce to the market, but also as transport for farmworkers, along with the tractors. William Bain & Co. Ltd from Scotland was the principal supplier of haymakers. Tractors and farm machinery generally came from Ford, Deere & Company, or John Deere from Illinois, USA, and Massey-Harris Company, Limited, from Brantford, Canada.

The farm in Southern Rhodesia was easily the most cosmopolitan site of technological convergence, where the American "steel belt" met the best of Canadian and British manufacturing. But it is also a place where a new type of energy (petrol and diesel) was burnt to power machines, to do work that Africans had done using muscular, food-fueled exertion. Ships coming from the Arab world anchored and offloaded oil at the Beira port; from there the petroleum products were transported inland by rail (later on roads and through a pipeline for refining at Feruka), and distributed by road to petrol stations, where they were purchased by farmers who carried them to their own farms.

The second site is *the railroad*, stretching from the Congo via the two Rhodesias to the Mozambican port of Beira. The train engines that sustained the Rhodesia Railways system and carried Katanga's copper came mostly from the UK and the US. British suppliers of locomotives include: Robert Stephenson & Co. (Newcastle-upon-Tyne), Nasmyth, Wilson & Co. (Patricroft), Beyer, Peacock & Co. (Manchester), Kitson & Co. (Leeds), Neilson Reid (Queens Park), Dübs & Co. (Warrington, Lancashire), and North British (Glasgow), which supplied steam locomotives; and English Electric (Lancashire) and Brush Traction (Leicestershire), which delivered diesel locomotives. The American steam engine suppliers whose locomotives trolled the Rhodesian railways were HK Porter of Pittsburg, Baldwin of Philadelphia, and General Electric of Erie (all from Pennsylvania), while Davenport Locomotive Works (Davenport, IA) supplied locomotives powered by diesel. Until the introduction of diesel engines and of electric engines after 1945, imported locomotives in Rhodesia Railways' service were powered by coal from Wankie, and the visible high carbon footprint testifies to the idea of a railroad as a high energy consumption and pollution site. The railroad was also the site of energy consumption at another level: of

Africans as the human machines that colonial regimes and corporations used, by force at little or no wage, to build such infrastructures.

The third site is *the road.* An overwhelming number of the cars were American—for example, General Motors (Chevrolet and Buick), Ford, Plymouth, Chrysler, and Hudson Motor Car Company (the Terraplane), all from Michigan, as well as the Studebaker Corporation from Indiana. Those from British automakers Austin (London), Willys-Overland (Stockport), Vauxhall (Luton), and Morris (Oxford) were significantly fewer in number. Government statistics show that 1,722 private motorcars were registered in 1934. Of these, 1,407 were American and 308 of them were British-made ("More Motor Cars" 1936, 21). Like the farm, the road and service stations are interesting and original places to study as a venue for petrol and diesel consumption.

Energy-Industry Synergies

What kinds of energy transitions were required to host and fully utilize these incoming machines? Here I shall focus on the transitions and overlaps involving African labor, wood fuel, coal, and hydroelectric power, and the transportation systems involved. In the Belgian, British, and Portuguese territories, colonized subjects (Africans) were treated as animate forms of (mechanical) energy alongside oxen, donkeys, and horses. For example, by 1954, half a million Africans were employed in the mining and agriculture industries of Southern Rhodesia. Of these, half were foreigners, composed of one-quarter, one-sixth, and one-tenth of able-bodied African men from Nyasaland (now Malawi), Northern Rhodesia (Zambia), and Mozambique, respectively (Scott 1954, 29). Besides having their own means of transportation by walking, African men were transported from the Nyasaland, Mozambican, and Rhodesian countrysides to mines, farms, and factories using state- and company-owned automobiles (buses and trucks), barges, and trains. In turn they cut (with axes and machetes) and carted (using ox-drawn carts) the wood fuel that powered the first gold and iron furnaces, tobacco curing kilns, and pre-coal trains. They also mined the coal that replaced firewood, and from 1955 built the Kariba Dam, the hydroelectric power (HEP) dam and power station meant to supply unlimited power to industries that had until then depended on coal-fired power plants. A larger project beyond this essay investigates the effects of taking manual labor critical to communities in the African countryside to provide mechanical energy in the mines.

The special role of coal in Rhodesia's industrialization and as an industry in itself was such that an entire international transportation system was crafted around it. Coal also powered isolated thermal stations that supply individual industrial or municipal grids, for example Umniati (120 megawatts), Bulawayo (148 megawatts), Salisbury (153 megawatts), Shabani (31 megawatts), Umtali (16.5 megawatts), Gwanda (15 megawatts), Chipinga (0.4 megawatts), Wankie (18.5 megawatts), Chirundu (1.7 megawatts), Kamativi Mine (1.6 megawatts), and Gadzema (0.5 megawatts). Not only did Wankie have the best coal in Southern Africa; it also powered the entire region's transportation, mines, agricultural plant (especially tobacco curing barns), and industries barring South Africa.

Interestingly, even after the switch to coal was made, high costs, strikes, work stoppages, and the financial and infrastructural challenges of moving coal meant that the mines and smelters still deferred to wood fuel (Hance and van Dongen 1957, 329). Apart from illustrating the dependency of energy transmission on rail transportation, Wankie coal also shows an energy system vulnerable to traffic congestion, labor unrest, and inadequate haulage capacity. It is ironic that in the 1950s, the Southern and Northern Rhodesian governments went back to HEP after having abandoned it for coal-fired plants. For example, a plan to put generators in the path of the Mosi oa Tunya (Victoria Falls) waterfalls in 1906 had been abandoned in favor of coal-fired steam-driven power stations located at individual mines and industries. The transition to HEP matters because none of the countries discussed here have moved away from hydropower since they made that turn in the 1950s through the 1970s; in fact, the future of the subregion is hydro-bound.

Particularly striking are the techniques and technological developments adopted in energy use with each transition to a new energy source. From an engineering and technological perspective, I place the excavation equipment imported from overseas in the hands of the Africans who mined, moved, and burnt coal to smelt or power steam engines. Here, mobility calls attention to the movement of ore from underground, to the surface, to steam engines, to furnaces, to power plants. Even before mining, mobility enabled a systematic exploration of prospecting and surveying of a mine and the work that white and black people did, along with race, skill, and other considerations that determined their roles.

Conclusion

The *longue durée* approach to industry in South-Central Africa suggests a potentially fecund avenue into the place of energy in African history, one that has never before been attempted. It can potentially help us understand the energy factor so far silent in the accounts of indigenous mining and metallurgy, while explicating the environmental impacts of mining, smelting, agriculture, and other activities over time. It has been shown that energy is not merely coal, firewood, or electricity, but also embodied and human, inseparable from the transport functions of the body, and especially of the body at work, engaged in industry. The petrol- and electric-powered machine today elides a reality of human labor-intensive production before and typical of much of the colonial moment. In both mining and agriculture, the first colonial infrastructures were built upon preexisting African ones. The most significant shift was that whereas Africans had made their own tools and satisfied their own manpower-intensive modes of production, Europeans relied on machinery from the US, Canada, and Europe for transport, mining, and agriculture. These machines demanded the command of new, larger-scale sources of energy than previously envisaged, both in human and fuel form.

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Ihediwa Nkemjika Chimee

Coal and British Colonialism in Nigeria

The transition from coal to oil in Nigeria should be understood within its context under British colonial rule. In this paper, I explore one example of conditions under which energy infrastructures were developed in parts of the world that were under colonial rule. Specifically, I am interested in the degree to which the master-servant politics of British *indirect rule* (ruling the colonized through their traditional authorities and structures) related to the production of coal and coal-using industries in Nigeria.

The history of what eventually emerged as Nigeria started with the Niger Expedition of 1841 and the formation of the Royal Niger Company (RNC), a trading company that monopolized trade in both the interior and the coastal regions. The British monarchy had granted the company a charter to occupy territory of present-day Nigeria. The RNC therefore served as a medium through which British colonial and mercantile interests were protected until the revocation of the company's charter in 1900, and the subsequent creation of the Protectorate of Northern Nigeria (Falola and Heaton 2008, xiv).

After 1900, the British began to explore avenues through which the resources of the indigenous peoples could be exploited and maximized. To achieve this, they needed to create a structure for indirect rule—controlling Africans through their traditional authorities. The British reasoned that approaching the people through their local leaders would minimize opposition to British rule (Falola 1999, 70). In Northern Nigeria, they used the existing emirs and their traditional institutions. Indirect rule was also extended to the south, where commensurable offices did not exist, and new chieftainship lines were created. The measures were greeted with opposition, particularly in southeastern Nigeria (Falola 1999, 72).

The British converted traditional subsistence farming in many areas to promote the production of cash crops for export, and commissioned a number of railway projects to facilitate this traffic. The Lagos-Ibadan railway started in 1896 and finished in 1900. Between 1907 and 1909, extensions to the Ilorin, Kaduana, Zaria, and Kano lines were completed. Others followed—the line to Kano in 1913, and the Port-Harcourt, Enugu, and Maiduguri links in 1926 (Wright 1998, 18). Agriculture aside, mining development also spurred railroad development and coal demand. Coal mining in Enugu started in 1916, and the first attempt to mine coal in the Udi Hills yielded 7,000 tons. The coal was used locally to power trains, furnaces in the tin mines, and steamships. Generally speaking, foreign firms controlled the mining sector of Nigeria, making huge profits.

The development of mining depended on three key infrastructural developments. One was the creation and promotion of mining monopolies that enjoyed the protection of the colonial and British governments. The second was the setting up of a legal architecture criminalizing African initiatives, while coercing them to the mines, railroad construction, and agricultural sites to work for close to nothing (Afigbo 1972, 42–3). Examples of such legislation are the first Mineral Ordinance of Nigeria passed in 1902 and a series of amendments culminating in the Mineral Oils Ordinance of 1914 (Bower 1947, 2). The third infrastructure was the office of the warrant chief, who was expected to deliver his people as cheap and coerced labor to the colonial mining cartels.

Udi Division, Coal, and the British

From about 1885 to 1900, British interest in Nigeria deepened in an aggressive way. During this period, the Aro Confederacy constituted the main obstacle to British penetration into the Igbo and Ibibio hinterland (Ijoma 2010, 38–39). The 1902 Aro Expedition brought the Igbo group face-to-face with the British invaders, under the pretext that they wanted "to stop the slave trade" and to open the Igbo area to civilization and trade. Instead, they came with guns blazing (Nwabara 1977). Subsequently, these Igbo groups—the Ngwo, Eke Oghe, Ozalla, Owa, Nsude, etc.—would be renamed the Udi Division in 1908, named after the Udi Hills in the state of Enugu, where coal was discovered. The British proceeded to systematically expropriate African land for the development of mining settlements and administrative buildings for colonial officials.

From that moment onwards, warrant chiefs were installed to administer their own people on behalf of the British Crown. There were two outstanding warrant chiefs in the Udi Division: Ozo-Nebechi Okachi of Oghe, a prosperous trader and the first person there to be appointed a warrant chief in 1909; and Onyeama of Eke, a devious character and the last in the division to be appointed a warrant chief in 1910 (Onyeama

1982, 28). When coal was discovered in the Udi Hills, the status of these chiefs rose dramatically and antagonism towards them increased.

The single most important factor in the development of Enugu and its environs was the Crown ownership of land on which the town was built (Hair 1975). The chiefs in the Udi Division were made to each sign a “grant” surrendering their lands to the British, and were summarily given a paltry sum of 73 British pounds in compensation for any damage that government actions had caused (Onoh 1997, 9). Similar “agreements” were forced upon East Africa, particularly in Kenya, in 1917. People literally became squatters on their own ancestral lands.

The commencement of mining activities decisively shaped the economic relationship between the indigenous people and the British colonial authority. From the time of the discovery of coal in Udi Hills, the position and role of the warrant chief, whose domain fell within the precincts of the mine in particular and those within Udi Division, changed dramatically. They became a vital mechanism for recruiting and maintaining the stable labor force critical for digging coal from the tunnel, maintaining a reliable rail network to utilize the coal for its daily operations, and extracting ore and other products to the port for exportation. Some of the biggest consumers of coal were the Nigerian Marine (a quasi-military organization), the electric power station, and water works operated by the Public Works Department and the Gold Coast Railways (Nigeria Colliery Department 1938, 3–4). The insatiable demand for coal forced the colonial authorities to place the coal mines under the Nigerian Railway Department from 1917 to 1938, with a mandate to mine the coal and market it through European firms (Nigeria Coal Corporation n.d., 2).

Colonial Labor Workforce and the Coal Industry in Nigeria

In the early days of coal mining, contractors managed the production, and were paid for the amount of coal produced. These contractors in turn employed their own laborers who cut and carried the coal to the surface in head pans; they only paid for the product (Nigeria Coal Corporation n.d., 2). Chief Onyeama of Eke was the principal supplier of labor to the coal mines at Enugu, and for a number of years received a large subsidy from the colonial regime in recognition of his services (Lt. Governor to Secretary 1923). Ordinary people received nothing.

Onyeama's efforts in supplying and forcefully recruiting the laborers for the Enugu Colliery owed much to the Ogwumili society, which the British officials derisively described as "a dreaded band of loyalists that committed all kinds of crime including a number of murders with impunity" (Chukwunze and Emebechi to Chief Secretary 1931). The Ogwumili submitted recruits or conscripts to contractors, who in turn supplied the Nigerian Railway with laborers. It had since been known that the warrant chiefs procured and delivered fellow Africans to colonial authorities as conscript labor, most of which were marshaled towards the construction of the railroad connecting Port Harcourt Harbor to the coal mines at Enugu, which was completed in 1916. How much these laborers were actually paid and how they were procured was of no interest to the colonial regime, as local people had been conscripted into the colonial workforce long before the discovery of coal (Lugard 1915, 10); they greeted ordinary people's complaints about the heavy-handedness of Chief Onyeama of Eke with indifference (Isichei 1976). Not surprisingly, in 1914, a number of towns within a 15-mile radius of what is now Enugu revolted against forced labor and conditions of work on the roads and railway lines, and the corruption and exactions of the warrant chiefs, court clerks, and Native Commissioners' messengers—British rule, generally (Isichei 1976, 134). The British colonial authority opened fire with machine guns and massacred the resisters in their thousands.

Pickaxes, shovels, and baskets were used to mine iron ore, which Africans were then forced to carry on their heads to the port of Onitsha on the Niger—almost a hundred miles. When the influenza epidemic arrived in 1918, it took a huge toll on miners, and the authorities (through their tools, the warrant chiefs) resorted to using even more force (Onjoku 2001, 172). While the workers were paid in peanuts (Nwabara 1977, 122; Ikechukwu 2012), Onyeama of Eke received an annual salary of between 400 to 500 British pounds (Isichei 1976, 204). In the logic of the colonial authorities, the chiefs were doing important work in keeping stable supplies of labor. When labor retainers meted out unjust treatment to workers, they knew they would simply get away with it. Workers were sacked midway into the work-month to compel them to default on their contracts and thereby forfeit their months' pay to their overlords. A miner could fall sick and not be granted sick leave; instead he was relieved of his job and had no recourse (Nebechi 2012). In November 1949, the continuing exploitation of mine laborers generated a serious impasse that led to the shutting down of production altogether. This colliery strike led to the fatal shooting of 21 unarmed miners by the colonial police force and the wounding of 51 others (Akpala 1965). This incident sparked general unrest in the country.

Such were the unethical labor practices and occupational conditions under which coal was produced in Nigeria between 1915 and 1950. The coal industry represents a classic example of colonial exploitation using traditional structures of administration, or indirect rule. Miners' relationship with their employer did not take any other shape from 1915 to 1950 than that of master-servant. Even when exploitation of the mineral sounded promising, the condition of the worker was never put into perspective. Coal production totaled 24,500 tons in 1916, 83,405 in 1917, and 148,214 in 1918—256,119 tons for the three-year period (Boyle 1918, 6). It continued to increase after the war, rising to 175,137 tons from 1922 to 1923—half of it going to the railways, a quarter to government departments, and the rest to private firms (General Manager's Report 1924, 832). The exponential profits made the colonial administration complacent about dealing with the occupational issues of workers.

The status of miners began to change from 1937, when the colliery was removed from the Railway Department's jurisdiction and established an independent government department. In 1941 the Workers' Council was reconstituted into a legal trade union and only after the colliery massacre did the British Colonial Office set up a council to attend to matters affecting government employees through regular roundtable negotiations (Colonial Office 1950, 6). The Nigerian Coal Corporation was created as a statutory body to manage Nigeria's coal resources; at last the workers could now approach this body and discuss their working conditions.

From 1950 to about 1958, the Nigerian coal industry enjoyed a monopoly on the fuels market. With the discovery of oil in the latter year, however, coal lost some vital sectors of its traditionally captive market. From this date to 1966, the share of coal production in the total energy production of Nigeria declined from 98 percent to 1.6 percent (Nwabueze 1971, 34). When the Nigerian Civil War broke out in 1967, coal production ground to a halt. Its three principal markets—the Railways, the Electricity Undertakings, and the Nigerian Ports Authority, consuming some 80 percent of the total output—also stopped the purchase of coal because of the war. After the war, the coal industry entered a precipitous decline as oil became the number one energy product in Nigeria. It remains so to date.

Conclusion

Colonial rule no doubt affected the economic development of Nigeria. From the inception of the coal mine in 1915 to about 1948, mine laborers in the coal fields suffered varied degrees of abuse including forced labor, underpayment, outright withholding of salaries on trumped up allegations, and even detention at the mines, particularly during the periods when private concessionaires were in charge of the colliery. The colonial regime was concerned with making profit through subjugating miners to degrading treatment and abuse. The warrant chiefs became a ready instrument with which the colonial authorities turned the local Agbaja people into servants and laborers. Using the pretext of legality, all royalties and revenues that accrued from the mines went into the colonial coffers. Coal was not a blessing to the majority of Africans, but a curse. Rather than enriching them, it impoverished their lives and limbs, denying them the possibility of an improved standard of living.

Suggested Reading

For a detailed understanding of the powers and functions of the NCC, see The Nigerian Coal Corporation Ordinance No. 29, of 1950, NCC Headquarters Enugu.

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Christopher Jones

The British Shaping of America's First Fossil Fuel Transition

When early Americans first came across outcrops of a shiny black rock in the mountains of eastern Pennsylvania at the end of the eighteenth century, they knew they had found coal. Though seemingly mundane, this simple fact merits further attention. It reveals that Americans were not encountering their world with a blank slate, but were deeply imprinted with ideas developed elsewhere. In particular, American knowledge of coal, like many other aspects of the young republic's culture, came from Britain. It was in America's former colonial power that many of the techniques were pioneered to bring coal out of the ground, prepare it for market, and burn it in homes and factories. Through the transfer of people, ideas, and written texts, Americans were well aware of the potentially revolutionary role of coal for the nation's political economy. Thus, when Americans initially found coal, they already had a clear picture of why it might be important to the nation's future.

American knowledge of British coal practices had at least two crucial implications for the timing and shape of the nation's first fossil fuel energy transition. First, British experiences dramatically accelerated the speed with which Americans sought to develop their coal reserves. When anthracite was first discovered, the nation was already blessed with abundant forests and falling streams. Another energy source was not needed. Yet because some Americans were hoping to replicate British economic success, they began experimenting with fossil fuels far earlier than they would have without this model. American use of anthracite was undertaken in a context of energy abundance, not scarcity. Second, Americans had ambivalent feelings about British industrial developments that shaped the patterns of the coal industry. While some saw coal as an opportunity to protect the young republic's independence and challenge the old European order, others looked with horror at the "dark and satanic mills" of British industrialization and feared that it would undermine the nation's republican ideals. These debates led to a series of policies concerning corporate rights and responsibilities that sought to balance economic growth with measures to encourage a virtuous citizenry.

The history of energy transitions is often written from the perspective of individual nations. This story suggests that attention to transnational contexts can help us better understand how, when, and why energy transitions occur.

Imagining a Coal-Fired Future

European settlers colonizing America arrived to a world of energy abundance. Dense forests offered what appeared to be an endless supply of firewood, countless streams were available to power mills, and wide tracts of land could be cleared to support horses and oxen. Whereas forests in the Old World were shrinking and most mill sites had already been claimed, Americans lived in a world of natural bounty. As a result, at the dawn of the nineteenth century, coal played a negligible role in American energy practices. The delivery of a few thousand tons of coal a year from Britain and Canada could meet the needs of a large city like Philadelphia and the whole nation imported only about 13,000 tons in 1810 (Powell 1978). With plentiful trees, rivers, and land, there was no pressing need for Americans to pioneer an energy transition.

And yet they did. Beginning in the 1790s, a heterogeneous group of Philadelphia merchants, scientists, industrialists, politicians, and citizens began to promote the use of anthracite coal, accelerating their efforts in the 1810s. Their imaginations were fueled by opportunity rather than scarcity. In part, they were inspired by looking northwest to the Lehigh, Schuylkill, and Wyoming valleys. Local citizens in these areas had identified outcrops of anthracite and had since begun using "stone coal," as it was often called, for several decades. But the view to the east was far more important for these early energy boosters. They knew that over the previous century Britain had entered a remarkable period of economic and industrial growth fueled by coal, iron, and steam engines. As Thomas Cooper, an American professor of chemistry, observed: "Every suggestion that brings forward the importance of coal to the public view is of moment: we know little of its value in Pennsylvania as yet. All, all the superior wealth, power and energy of Great Britain, is founded on her coal mining" (Cooper, quoted in Powell 1978, 1).

Cooper, along with Tench Coxe, Alexander Hamilton, and several others believed that the young nation should encourage the growth of manufacturing because it would generate profits, tax revenue, and a stronger military. In his influential 1790 report on American manufacturers, for example, Hamilton argued: "Every nation … ought to endeavor to possess within itself all the essentials of national supply" (Hamilton, quoted in Folsom and Lubar 1982, 90). Manufacturing was not simply a matter of economic gain; it was a matter of nation-building. And from observing British practices, Americans knew that coal was an important component of manufacturing because it could be used to power steam engines, produce iron, and provide heat for countless industrial operations.

Not everyone saw Britain as a desirable model, however. For many Americans, British society was characterized by great disparities in wealth, filthy urban slums, a degenerate working class, and a corrupt political system. Echoing a republican ideology made most famous by Thomas Jefferson, they favored policies that would support independent farmers and virtuous citizens. For this reason, Jefferson wrote bluntly: "For the general purposes of manufacture, let our work-shops remain in Europe" (1999 [1785], 171). If manufacturing was necessary, it should be located in the countryside at small mills. A nation of independent farmers with ample woodlots had little need for coal.

Though America's subsequent development as the world's foremost industrial power and consumer of fossil fuels may make it seem inevitable that citizens would have favored policies that promoted coal, this was hardly the case in the early nineteenth century. Americans already possessed abundant energy sources and a widespread aversion to replicating the evils of British factories. A transition to anthracite coal appeared anything but certain.

Canals for a Coal-Burning Nation

The breakthrough for coal boosters came with the development of canals in the two decades after 1815. Canals served two crucial functions. First, they provided the key technological breakthrough necessary to initiate a pattern of ever-increasing consumption. Mining anthracite was not a great challenge, as large quantities of coal were located near the surface and could be gathered with shovels, pickaxes, wagons, and brute strength. But shipping a bulky and heavy commodity long distances over rough roads and choppy waters was prohibitively expensive. As I have argued elsewhere, canals made it possible for the first time to ship anthracite cheaply and in abundant quantities; they created a landscape of intensification that stimulated and sustained an energy transition (Jones 2014; Jones 2010). Second, canals offered a point of compromise between advocates of manufacturing and supporters of republicanism. Whereas government policies to support manufacturing were fiercely contested, canals broadly appealed to early Americans because they could enable independent farmers to ship their harvest to markets. Explicitly invoking Jeffersonian ideals, the founders of the Erie Canal argued that "[Canals] constitute improvements peculiarly fit for a republic" (The State of New York 1816, 8).

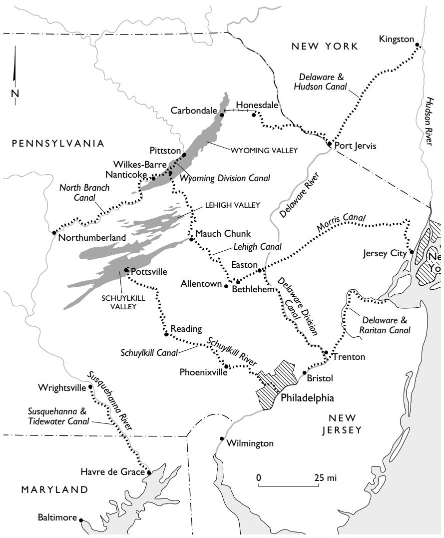

Figure 1: Canals important to the Anthracite Trade, 1834. Image courtesy of the author.

Coal boosters also recognized the potential value of canals. Josiah White, pioneer of the Lehigh Canal, made the case for the links between coal, canals, and economic growth explicit by drawing on Britain: "What would the value of all [British] labor be … without their canals? Canals are the foundation of their wealth. Canals give industry its essence—the collecting of raw materials and the sending of the products of the factory to market" (quoted in Hansell 1992, 56). Advocates of manufacturing and republicans may not have agreed about much, but building canals offered the potential of a common project.

Though republican dreams of agricultural conduits provided the stimulus for many canal developments, anthracite coal came to dominate the traffic of those built in Pennsylvania and New Jersey. The Schuylkill Canal epitomizes this rather unexpected development. When first proposed in 1815, the Schuylkill Canal was intended to capture the rich agricultural trade along the river, and local farmers purchased many of the shares of stock in the company. Coal was only an afterthought. Once it began operating, however, coal constituted more than three-quarters of the total shipments (Jones 1908). In conjunction with the Lehigh, Delaware & Hudson, Morris, and Delaware & Raritan canals, the Schuylkill channeled coal into cities such as Philadelphia and New York, thereby stimulating the growth of urban manufacturing. The modest gains of independent farmers were overshadowed by the advantages canals provided to urban industrialists. Canals, coal, and manufacturing grew together synergistically.

Constraining Corporate Power

In addition to debating *whether* to build canals, early Americans also discussed *how* such projects should be governed. They recognized that constructing canals might generate the undesirable concentrations of wealth and power that characterized British society. This led citizens and politicians to search for measures that would balance the need for large organizations to build and manage these systems with republican values. These deliberations were often manifested in restrictions to the corporate charters granted to canal companies that shaped the contours of America's first energy transition.

In the early nineteenth century, every corporate charter had to be approved by a separate act of a state legislature. Because canal companies were requesting extensive rights to raise capital, augment waterways, and charge tolls, politicians frequently insisted on limitations that augmented these privileges. When the Schuylkill Canal received its corporate charter in 1815, for example, the Pennsylvania Assembly sought to ensure that no single party obtained control of the canal. Each investor could buy a maximum of twenty shares, and the shares were divided between the counties along the path of the canal; each 50 US dollars share could be purchased with a down payment of only 5 US dollars, allowing many farmers to participate. This capitalization structure discouraged monopoly control.

Corporate charters could also be amended over time. The Schuylkill Navigation Company was initially authorized to raise 500,000 US dollars. By 1821, these funds had been spent and the company approached the Pennsylvania Assembly for the right to increase its capitalization. Because coal was now recognized to be an important article of trade, legislators insisted that in exchange for the right to raise more money, the company cede any right to operate coal mines. This provision encouraged a proliferation of independent mining operations in the Schuylkill Valley. But independent miners did not thrive everywhere. The operators of the Lehigh Canal refused to give up their right to mine coal in exchange for a higher capitalization. Instead, they took on large amounts of debt (a more expensive and risky financial strategy) so that they could control coal developments in the Lehigh Valley. These differences in corporate charters led to greater concentrations of power in the Lehigh Valley than in the Schuylkill Valley.

Public ownership was another option employed by Americans to avoid the pitfalls of powerful corporations. Because canals were often seen as profitable investments, some state legislatures formed organizations that would channel the gains into state coffers. For example, in 1824, the state of New Jersey chartered the Morris Canal to cross the mountainous northern part of the state. Similarly, in 1827 the state of Pennsylvania undertook the construction and operation of the Delaware Division canal. While the profits from these canals did not match initial expectations, they were still channeled into public budgets.

The attempts to craft a careful balance between corporate privilege and the broader public good produced tangible results. The first third of the nineteenth century saw the most widespread patterns of stock ownership in the antebellum era (Majewski 2006). The corporate checks on the Schuylkill and Lehigh canals limited their activities, helping support independent miners in the former case and slowing the growth of the latter. While these policies did not stop the rising use of anthracite coal, they altered the timing and contours of this energy transition.

Conclusion

America's turn to anthracite reveals two features of energy transitions worth considering further. First, it was an imitative transition based on the attempted emulation of British patterns. Many of the world's energy transitions have similarly been undertaken in times of abundance, not scarcity. They have been driven by the desire to replicate the accomplishments of others, such as economic growth, industrial power, and greater personal comfort. This suggests a greater role for trans-regional and trans-national history in energy studies, a useful departure for a field in which nation-specific studies predominate.

The widespread debate about the advisability of replicating British patterns is a second feature of this history worth noting. Many Americans in the early nineteenth century thought deeply about the connections between manufacturing and the nation's future. In many respects, they were far more attuned to the potential social consequences of energy transitions than we are today. They realized that such developments could generate concentrations of wealth and power that might undermine the nation's future. As a result, early Americans offer a model of integrated thinking about energy and society that today's citizens could benefit from replicating.

Suggested Readings

Further notes on historiography and evidence relevant to this paper can be found in: Christopher F. Jones, *Routes of Power: Energy and Modern America* (Cambridge, MA: Harvard University Press, 2014); and Christopher F. Jones, "A Landscape of Energy Abundance: Anthracite Coal Canals and the Roots of American Fossil Fuel Dependence, 1820–1860," *Environmental History* 15, no. 3 (2010).

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Ingo Heidbrink

Hydropower: The Unlikely Economic Base for the Complete Sovereignty of Greenland

About eight percent of Earth's freshwater is located in Greenland. Theoretically, this would mean that Greenland has some of the greatest potential for hydropower in the whole world. However, nearly all its freshwater is permanently frozen. In fact, Greenland is one of the countries with the lowest level of installed hydropower capacity, despite the abundance of (frozen) water. Hence, this resource—one that assured a means of agricultural, energy, and industrial development in Western Europe, the Americas, Africa, and Asia—is in fact continually dormant.

In the 1940s, there were only about 15,000 people living in small villages along the coasts of this remote Danish colony. For them, energy came from oil imported from outside Greenland, or from coal, which was used for heating. The few buildings with electricity depended on insular electricity generation based on diesel- or gas-driven engine-generator sets. A grid for the supply of electricity did not exist, and even in the larger villages, a centralized supply of electricity was unknown until the 1940s. The complete lack of electrical infrastructure was mainly a consequence of Danish colonial policy. Ever since it annexed Greenland as a colony, Denmark adopted a paternalistic no-contact policy towards the island. Consequently, 1940s Greenland looked very similar to the society that early Danish colonialists had encountered when they first came to the island. Hunting, fishing, and cryolite mining were the mainstays of the economy.

Even though the cryolite mine in Ivigtut was also the largest consumer of energy in Greenland, its needs were modest and diesel-powered. In fact, the whole energy supply of Greenland was based on imported fossil fuels. In the remote settlements, the use of electricity was often limited to battery-powered appliances. Greenland was a land barely touched by the electrification of the Western world. The majority of fuels, like train oil or blubber, were side products of the hunting industry. Although there is no solid data available, we can safely state that Greenland had one of the lowest amounts of energy per capita in the whole world. Things changed only gradually when in 1924 a coal mine commenced operations in Qutdligssat. With a total production of 570,000 tons of coal (other sources mention up to 600,000 tons) in the period between 1924 and 1972, the coal mine was an important element of domestic energy production, but it did not approach levels that would allow energy to be exported as a foundation of the economy (Taagholt and Bach 1985, 33; GEUS 2012).

When the US military established bases on Greenland during World War II (Hobbs 1941) the situation remained unchanged, as each of these military installations included its own power station that utilized imported fossil fuels for electricity production. At one of the Cold War installations of the US Army, there was even a modular nuclear power plant, clearly demonstrating that the use of hydropower seemed to be out of reach even for the military industrial complex of one of the global superpowers (Daugherty 1963). Of course, in the period after the end of World War II, all larger settlements were supplied with local electricity grids, but the power stations supplying them were based on diesel-driven generators, and thus still reliant on imported fuels.

In the 1980s Greenland's energy authority prepared a hydroelectricity development program as the first step towards ending the complete dependency on imported energy. This plan included the use of hydropower for the development of export-oriented industries (Taagholt and Bach 1985, 36). Although the program was designed to supply large sections of the island with electrical energy from hydropower stations, the only hydropower station that was realized before the year 2000 was the Buksefjord plant, which mainly supplies the Greenlandic capital Nuuk and was far too small to allow the export of electrical energy. With an installed capacity of 45 megawatts (30 megawatts up to 2008), the total capacity of the plant is still modest (Greenland Development Inc. 2012). In 2005, the 1.2 megawatts station at Tasiilaq was opened to supply the city's utilities. Three years later, Qorlortorsuaq station followed; its purpose was to supply the towns of Qaqortoq and Narsaq with a total capacity of 7.2 megawatts. Then, in 2009, the station in Sisimiut began supplying 15 megawatts of electricity from Lake Tasersuaq. In 2013 the completion of the hydropower station at Ilulissat was expected to add 22.5 megawatts. With a cumulative hydropower capacity of nearly 91 megawatts, Greenland was on target to supply the majority of its households with hydroelectric energy. Nonetheless, production is still low. A recent estimate of the energy needs of US military installations on the island concluded that Greenland is still dependent on the import of energy despite advances in the use of hydropower (King 2011).

Regardless, when it comes to domestic consumption of energy on Greenland, we can safely say that there has been a successful transition from imported fossil fuels to local hydropower. The two elements that do not fit into such an energy transition are either external, like the US military installations on the island, or related to ideas of an indirect export of energy in the context of gaining complete sovereignty.

The Question of Sovereignty

Greenland became a Danish colony via a gradual process dating back to the arrival of the Danish missionaries in 1723 (1767). Although other nations contested the Danish rights to the island, most notably when Norway claimed a portion of East Greenland in the early 1930s, Denmark established a colonial trading company (KGH) and subsequently a colonial administration that it financially subsidized (Blom 1973). This situation changed only for a short period during World War II when Denmark came under Nazi occupation and Greenland became a de facto sovereign nation. This status was possible only as the United States had two vital interests on the island that it sought to protect with military force and with a recognition of the sovereignty of the island. One was the cryolite deposit and mine in Ivigtut; the other was its geostrategic location with regards to the war. The US needed cryolite for manufacturing aluminum-based products (specifically aircraft), a fact that gave Greenlandic sovereignty an economic anchor.

It was a sovereignty that existed only as long as World War II continued; when the war ended, the de facto sovereignty also ended. All political powers were transferred back to Denmark. The global market for Greenlandic cryolite fueled by the war collapsed; in fact, the development of artificial cryolite synthesis made mineral cryolite redundant (Dixon and Scott 1947). The few other domestic industries like small-scale mining, fisheries, and fur production could not sustain an independent economy without colonial subsidies (Taagholt and Bach 1985). Nostalgia for independence from Denmark existed, but there was also a sense of belonging to Denmark, and without an economic base to back up sovereignty there was no alternative to returning to the status of a Danish colony. Even after new industries were developed, they were simply too small to support complete economic independence.

Thus the major issue was how to generate sufficient revenue within the colony to render the Danish subsidies academic. Colonies with rich deposits of sought-after and easily accessible resources like oil could aggressively attract direct foreign investment. Greenland does not have such high-value natural resources. The few operations in the context of gold mining or the extraction of lead and zinc are comparatively small in scale and, because of the Arctic environment, very cost intensive ("Greenland" 2010). Even if they can be continued or expanded, the royalties gained from these operations will by no means be large enough to replace the subsidies from Denmark and to sustain complete political sovereignty of the island. The same applies to non-extractive industries. A number of such industries have been set up since the change from home-rule government to self-rule government in 2009, yet their combined revenue is still far below the point of being able to support political sovereignty without external subsidies. If it is hoped that the process from colonial government via home-rule government (1979) to self-rule government (2009) will continue towards complete economic and political sovereignty of Greenland, the most important question is which industry can provide the financial base for a financially sustainable sovereignty. Although it appears somewhat unlikely that hydropower might become the most relevant base for Greenland's economic future, it seems to be the best option available for many people in Greenland.

Besides the generation of hydropower, there is the question of distribution of electricity. Direct export of electricity to other markets is simply impossible with the technology currently in place, as the distances between Greenland and these markets are excessively large. As direct export is not possible, the only available alternative seems to be indirect export of hydropower: that is, attracting foreign industries whose production processes are electricity-intensive, shipping in their complete raw materials, processing them with Greenlandic electricity, and then shipping the processed materials to the respective markets. The best-known model for such an indirect export of electrical energy up to now is the Icelandic aluminum industry, which produced in 2010 some 780,000 tons of aluminum, placing Iceland twelfth on the list of global aluminum producing nations (US Geological Survey 2011). This became possible only because of the abundance of hydropower in Iceland. But while such aluminum smelters were definitely an economic success story, the projects attracted strong environmental opposition (BBC 2012). In the aftermath, large aluminum-producing multinational companies like the mainly US-based ALCOA group began to look elsewhere for new production sites.

On paper, Greenland seemed to be an ideal location for such new aluminum smelter projects. In particular, the natural harbors, the relative proximity to European and American markets, and the theoretical abundance of hydropower made the island a prime target for aluminum smelter projects and hydropower. Furthermore, the Greenlandic self-rule government established in 2009 was looking for a source of revenue to replace the Danish subsidies, and the development of a large-scale aluminum industry seemed to offer such a solution. The remaining problems seemed to be technical, not least the construction of hydropower stations and the question of how to secure investors in the wake of the growing opposition that had greeted similar Icelandic adventures.

While the construction of small-scale hydropower stations for domestic energy production has helped to solve many of the technological problems of hydropower generation on Greenland, the question of upfront investments was still largely unanswered when the Greenland government and ALCOA started negotiations on the project. Both sides agreed that their respective interests substantially converged. However, assuming that the technological problems will be solved and the partners will find a solution regarding the upfront investments, is there really a common interest? For ALCOA the main objective is cheap energy for a new aluminum smelting operation, ideally in a region with a low level of resistance to the project. For the Greenlandic government, the most important aspect of the project is replacing the subsidy from Denmark with a domestic source of revenue and thus creating an economy that would be able to support and maintain complete sovereignty. In short, both sides are interested in the economic factor but for completely different, if pragmatic, reasons.

The Greenlandic self-rule government is based on a democratic and parliamentary structure, but the very limited source of revenue weakens its government. One large-scale hydropower project serves just one customer. One of the main arguments that proponents of the project advance is that Greenland gained its economic sovereignty during World War II mainly thanks to the cryolite mining activities of a single company. However, there are four differences between the historical mining operations and the proposed project. First, the mining was comparably smaller in scale and its upfront costs were marginal in comparison to the hydropower-aluminum smelter project. Second, cryolite was exportable to customers all around the globe and the whole operation was dependent not upon the operational decisions of a single multinational company, but on a wider network of buyers and their political and commercial obligations. Third, the Greenlandic authorities handled the mining operation themselves, a task that was made simple by the relatively low level of technology but that is completely impossible in the proposed combined hydropower-aluminum smelter project. Finally, cryolite mining provided an economic base for a de facto sovereignty only under conditions specific to World War II, whereas the large hydropower-aluminum smelter project guarantees a Greenlandic sovereignty entirely dependent upon one multinational company.

Is there no future for a Greenlandic sovereignty based on the utilization of the island's abundant potential for hydropower? It is hard to say. The main weakness of the proposed project is not the idea of basing economic sovereignty on hydropower per se, but that it focuses and depends entirely upon a single customer. As long as electricity cannot be transported over greater distances, a sovereignty based on hydropower will be impossible to attain. Therefore the question for Greenland is: If sovereignty is based on hydropower, is it really sovereignty?

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Marc Landry

Catalyst for Transition: The Anschluss, Kaprun, and a Dual Energy Transition, 1938–1955

Austria's Hohe Tauern mountain range is special in many ways. The Tauern form the continuation of the main crest of the Alps as it passes from the western provinces of Austria. Comprising an area of some 6,000 square kilometers, the range is home to Austria's two highest mountains, the Grossglockner (3,797 meters) and the slightly smaller Grossvenediger (3,674 meters). The former represents the center of the Hohe Tauern National Park, the largest nature reserve in the Alps. Since 1935, the Grossglockner and the PasterzeKeesglacier, one of the largest glaciers in the eastern Alps, have been accessible to motorists via the Grossglockner High-Alpine Road. This spectacular drive winds through the Tauern, crossing the main crest at an altitude of 2,505 meters. The Hohe Tauern has also had a long tradition of tourism, with the classical spas of Mayrhofen and Badgastein in the northern part of the range attracting visitors to the Alps since the nineteenth century. The Tauern are well known in the geological community for the famous "window" that exposes the basement rocks of this part of the Alps at surface level.

The Hohe Tauern also occupy an extremely important position in both the Austrian and central European electricity supply. Since the 1950s, the range has been home to a series of high-altitude dams that store the summer floods of Alpine waterways for use during the winter, when Alpine streams dwindle considerably. The energy development of the Hohe Tauern has transformed the mountains into a source of auxiliary power for Austria's remaining hydropower plants, and the presence of these strategic reserves has been key in the creation of an electricity supply largely dependent on otherwise seasonal flows of water power. The sheer size of the Tauern dams has allowed them to assume a similar role in the Central European electricity supply as well. The Tauern energy has also been rich with symbolic significance for the postwar Austrian republic. In particular, the completion of the first large-scale hydroproject in the Tauern in the mid-1950s, the *Tauernwerke* Glockner-Kaprun, was hailed by many Austrians as an example of their postwar republic's political and economic recovery. Thanks to its four monumental concrete dams and shimmering blue reservoirs, Kaprun—as Austrians often refer to the facility in reference to the Tauern valley where the dams are located—holds a mythical status in Austrian society not unlike the dams of the Tennessee Valley Authority in the US.

Kaprun, however, was not a singularly Austrian achievement. Historians have demolished the "myth" of Kaprun by emphasizing that the project was launched and considerable progress was achieved during the National Socialist period, in part due to heavy use of forced laborers. Moreover, when a portion of Kaprun's generators came online, they fed electricity into the same grid that supplied power to Auschwitz. After the war, the second Austrian republic capitalized on the considerable work and investment performed during the *Anschluss*-period (and took advantage of new avenues of finance in the form of the Marshall Plan fund) and completed the Kaprun project. It has remained a cornerstone of the Austrian electricity supply ever since.

This essay approaches these developments from a slightly different angle. It considers how the Kaprun project launched by Germany drove two critical but neglected energy transitions (understood here as any change in the components of an energy system; see Smil 2010) in postwar Austria. In the most general sense, the Kaprun project represented a continuation of the hydroelectric energy transition that had been underway in west-central Europe—and Austria—since the 1890s. With several hundred megawatts in capacity, Kaprun would be one of the larger hydroplants in Europe. But energy experts also argued that projects like Kaprun would have an impact that went beyond the number of kilowatt hours they produced annually. High-altitude reservoirs, the argument went, would make all hydropower more economical and thus usher in a new era of hydropower exploitation. In the postwar period, the Austrian state picked up where the National Socialists had left off in pushing for the completion of the Kaprun dams. Thanks in no small part to the reserve power of the Hohe Tauern dams, the transition to hydroelectricity, which makes up over half of Austria's electricity supply, has made greater inroads in Austria than almost anywhere else on the globe.

Kaprun also embodied another, less obvious type of transition. In the Kaprun facility we can see an important shift in the purported source of hydropower. Up until the idea for Kaprun first emerged in the 1920s, when Europeans spoke of developing hydropower, they usually portrayed it as the harnessing of the energy of a specific watercourse. Along with the improvement of hydraulic technology came the use of energy from larger rivers such as the Rhine. In the Alps, hydraulic engineers began harnessing the power of waterfalls at the end of the nineteenth century and subsequently moved on to larger streams. At the turn of the twentieth century, high-lying lakes emerged as a uniquely montane source of hydropower. As the history of the Kaprun project shows, hydropower projects in the Alps eventually came to focus on activating the power of entire mountain ranges. From the very beginning, discussions of damming the Kaprun valley occurred in the context of exploiting the power of the whole Hohe Tauern range. Kaprun therefore marked a different way of harnessing water power, predicated upon the creation of a new type of hydropower landscape. As it happened, the transition owed much to the energy politics of Austria's northern neighbor.

Finally, a word about those politics. In a volume that explores the energy dimensions of the historical relationship between European imperial powers and their former colonies, an essay about Germany's impact on the postwar Austrian energy supply might seem misplaced. Although Austria is not often thought of as a former colony of Germany, several historians of the period have argued that the relationship did indeed resemble a colonial one in certain respects. Indeed, the historian of Austria's electricity supply from 1938–1945 concludes that by paving the way for an organized Austrian supply in the postwar period, German influence achieved something positive despite its "imperialistic economic conceptions" (Koller 1985, 206). In the case of the Kaprun, the Nazi leadership did indeed hold the power to harness the Tauern water power as it wished. Nevertheless, if the story here falls short of truly being one between former imperial power and colony, I hope that it might provide a fruitful basis for comparison.

Discovering the Tauern Power

German interest in the energy of the Hohe Tauern was not a product of the Anschluss era. In fact, over a decade before German annexation of Austria, the imperial gaze of several German electrical utilities "discovered" the water power of the Hohe Tauern and hoped to siphon off a fair portion of this energy to bolster their economic prospects. In the mid-1920s, Württembergische Elektrizitätswerke AG (WEAG), a smaller state utility company in the southern German province of Württemberg, developed a project to tap the energy of the Hohe Tauern with a series of dams in multiple valleys including the Kaprun. The WEAG plan called for concentrating a significant portion of the water draining off of the northern slope of the Tauern range in reservoirs located in two separate valleys. It recommended diverting water to these two valleys by piercing watersheds, crossing Austrian provincial borders, and covering considerable distance if necessary. Soon thereafter, the giant German General Electric Company (AEG)

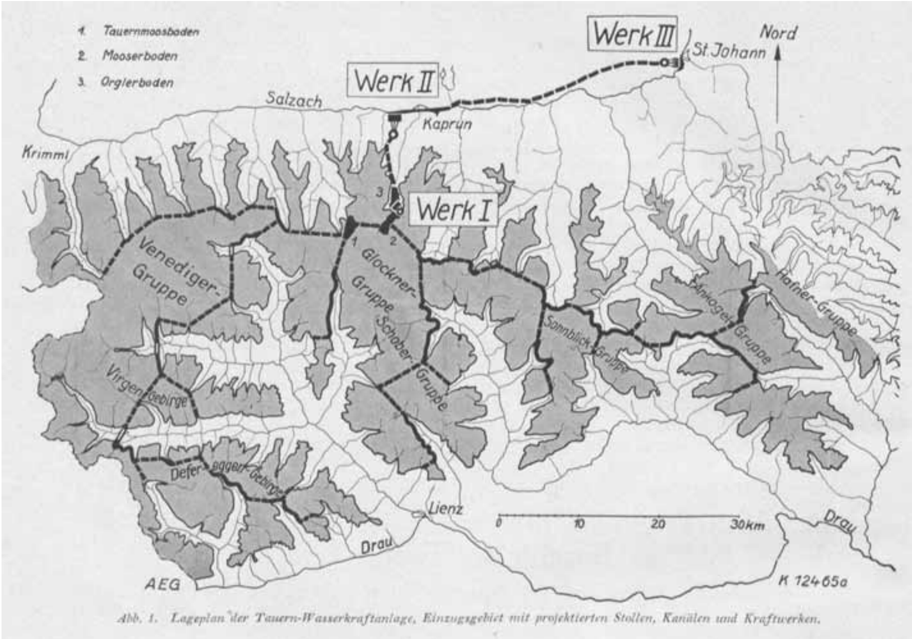

Abb. 1. Lageplan der Tauern-Wasserkraftanlage, Einzugsgebiet mit projektierten Stollen, Kanälen und Kraftwerken.

Figure 1: Map of the AEG "Tauern Hydropower Facility," 1929. Source: "Projekt einer Verwertung der Wasserkräfte im Bereich der Tauernkette," *Deutsche Wasserwirtschaft* 24, no. 2 (1929): 22.

also publicized its own plans for an even more ambitious "super" Tauern project (see Figure 1). Instead of constructing dams in multiple Tauern valleys, the AEG project envisioned centralizing as much Tauern water as possible in one single valley: Kaprun. Of all the Tauern valleys, Kaprun was the steepest, and therefore the most ideal for generating water power. To get the water to Kaprun, AEG foresaw building a network of high-altitude canals totaling 1,200 kilometers in length (*Hangkanäle*, see Figure 2). While AEG's designs boasted greater dimensions, both companies promised that their Tauern projects would generate enough electricity to satisfy all Austrian demands, and leave plenty of electricity left over for export to Germany.

For the time period, both Tauern plans represented something revolutionary. Up until that point, hydraulic engineers generally focused on developing the hydropower of singular waterways. The idea of concentrating the water of entire mountain ranges in high-altitude reservoirs (a practice that would become common in the Alps after the Second World War) was relatively new (Bätzing 2003). Rerouting water from valleys throughout a mountain range, moreover, promised to rob some areas of their water, with significant ecological and agricultural consequences.

Figure 2: Schematic depiction of the function of the slope canals. Source: "Das Tauernwerk," *Deutsche Wasserwirtschaft* 26, no. 1 (10 January 1931): 3.

While many of the technological components of these new Tauern projects—dams, diversions, tunnels—had been tried elsewhere, undertakings of this kind in the unforgiving high Alps were relatively scarce. In particular, many engineers viewed the slope canals that formed the centerpiece of the AEG plan as an untested technique at best, and lunacy at worst. The planners at AEG defended their plan's dimensions, arguing that the Tauern power was so unique and lucrative that anything less than a gigantic project would be an unforgivable waste of precious natural resources (*Raubbau*).

Both of these bold plans must be understood in the context of the German electricity supply of the mid-1920s. At the time there was an urgency to develop Alpine water power (or white coal, as it was often called) on a grand scale. Demand for electricity was robust after the immediate aftermath of the First World War, and German utilities anticipated a continuation of this trend. To meet this expected growth in demand many German utilities were on the lookout for cheap new sources of electricity, and the water-rich Austrian Alps emerged as one of the most accessible sources of bulk hydropower. Advocates for incorporating more Austrian white coal into the German electricity supply also argued that it would bolster the national economy by freeing up German coal for more strategic uses.

At the same time, a consensus was also emerging that harnessing this energy economically required taking advantage of the mountain environment to store water behind large, high-altitude dams. Such reservoirs, proponents argued, would create auxiliary hydropower reserves that could counter hydroelectricity's greatest flaw: its seasonal fluctuations. Feeding stored hydropower into electricity grids would make existing hydroplants more efficient, and allow the development of marginally economic hydropower in the future. In short, a majority of electricity supply experts viewed storage works like Kaprun as the key to completing a transition to white coal in central Europe.

Although the AEG super project initially won the favor of the provincial governor of Salzburg, where the Kaprun dams were to be constructed, the utility did not manage to make much headway. By 1930, the worsening economic crisis diminished AEG's interest in the costly project. Ultimately, the ascent of National Socialism in Germany poisoned political relations with Austria and made AEG activity there impossible. But the push for an energy transition in the Hohe Tauern did not disappear for long.

Nazi Germany Sets the Hydropower Transition in Stone

Nazi Germany initiated the decisive steps towards realizing an energy transition in the Hohe Tauern. In March 1938, German forces invaded and occupied Austria. Soon thereafter, Austria was incorporated into the greater German empire as a province called the *Ostmark* (Eastern March). With the Anschluss completed, the Nazi state made a priority of developing the hydropower of the Hohe Tauern. Though Nazi energy planners remained unsure which Tauern project would get the nod, they nevertheless resolved that whatever the ultimate decision, the first dams would be erected in the Kaprun valley. No less a personage than Hermann Göring took an interest in the Tauern project, and the field marshal wielded the spade at the project's groundbreaking ceremony in May 1938. To finance the expensive undertaking, the Nazi government created the Alpen-Elektrowerke (AEW), a Reich-owned corporation charged with developing much of Austria's white coal. In the fall of 1938, AEW's engineers drew up detailed project designs, opting for a decentralized development of the Tauern power, similar to the original WEAG plan (see Fig. 3). The following spring, one of the Nazi Germany's energy czars confirmed AEW's choice in the face of a renewed campaign for a super Kaprun project. By employing forced labor, the AEW managed to bring part of the Kaprun plant online before the war's end, but the high dams remained to be built. Nevertheless, the decisions made during the Anschluss period set a decentralized development of the Tauern power in the future more or less in stone.

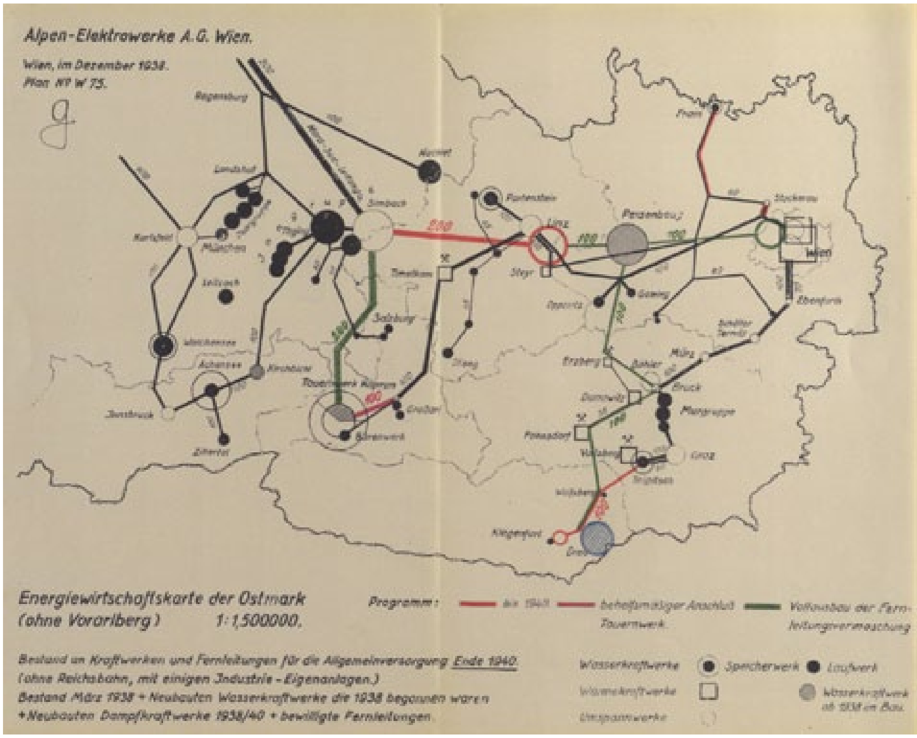

Figure 3:
AEW Energy supply map of the "Ostmark", December 1938.The map shows that the Kaprun power was to be fed into a north-south high-voltage transmission line to eastern Germany. Source: Salzburger Landesarchiv

Nazi Germany's drive to further the hydroelectric transition in the Tauern region stemmed from the belief that this best served the needs of an economy gearing up for war. German state economists believed that Tauern dams possessed enormous significance for the future German electricity supply and viewed their construction as a necessary component of a four year plan for Austria. Developing the Tauern energy would enable the substitution of hydroelectricity for coal in the German electricity supply. Conserving coal was deemed crucial, as the energy source could power a range of strategic uses. Most importantly, coal was indispensable in the production of the synthetic fuels so desperately required by the German war economy. Burning coal to generate electricity wasted much of the thermal and mineral value of the fossil fuel. The more Austrian hydropower that could be made available in the German electricity supply, the more that coal would be available for strategic purposes. It was this value that made the harnessing of Austrian white coal the most important concern for the German energy establishment in the months before the invasion of Poland.

Given the National Socialist penchant for technological gigantism, it is somewhat ironic that the Kaprun project begun during the National Socialist period represented the first step in what was viewed at the time as the more moderate plan to develop the power of an entire mountain range. The main proponents of decentralization were the AEW engineers who finalized the project plans. They found the super Tauern project to be technologically and economically unfeasible. AEW's head engineer also favored the decentralized project because he believed it could be completed in the foreseeable future. Nevertheless, AEW found itself compelled to defend their decentralized project against a renewed battle for the "super" variant.

Ultimately, a National Socialist energy czar appointed by Göring put paid to the "super" project. His concerns about the defense implications of concentrating all of the Tauern power in one valley, and the agricultural consequences of diverting so much water there, led him to opt for decentralization. This decision, taken in the spring of 1939, had irrevocable consequences for the postwar Austrian energy supply. For the different projects required vastly different dimensions and measurements for key components of the project. Once generators, turbines, and penstocks, for instance, had been ordered to fit the decentralized scheme, a return to the "super" variant could only accomplished at considerable extra time and cost. In opting for a decentralized development of the Tauern power in the interests of national security, Nazi Germany set a dual energy transition for postwar Austria in stone.

Suggested Readings

For an excellent synthesis of historical scholarship on Kaprun, see Georg Rigele, "Das Tauernkraftwerk Glockner-Kaprun—Neue Forschungsergebnisse und offene Fragen," *Blätter für Technikgeschichte* 59 (1997): 55–94. On forced labor see Margit Reiter, "Das Tauernkraftwerk Kaprun," in *NS-Zwangsarbeit in der Elektrizitätswirtschaft der "Ostmark", 1938-1945, ed.* Oliver Rathkolb and Florian Freund (Vienna: Böhlau, 2002), 127–98. Helmut Maier estimates 400 deaths among the nearly 4,000 forced laborers at Kaprun. See "Systems Connected: IG Auschwitz, Kaprun, and the Building of European Power Grids up to 1945," in *Networking Europe: Transnational Infrastructures and the Shaping of Europe, 1850-2000*, ed. Erik van der Vleuten and Arne Kaijser (Sagamore Beach, MA: Science History Publications, 2006), 129–58.

For a more detailed analysis of the Marshall Plan's impact on Kaprun see Georg Rigele, "Der Marshall-Plan und Österreichs Alpen-Wasserkräfte: Kaprun," in *"80 Dollar": 50 Jahre ERP-Fonds und Marshall-Plan in Österreich, 1948–1998,* eds. Günter Bischof and Dieter Stiefel, 183–216. Vienna: Ueberreuter, 1999.

Norbert Schausberger places the Anschluss in a historiographic tradition that interprets German foreign policy since the First World War as an attempt to secure world power status. See *Der Griff nach Österreich: Der "Anschluß,"* (Vienna: Jugend und Volk, 1988).

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