DOI: 10.32703/2415-7422-2023-13-2-376-398

UDC 553.45:621.22:621.311.2:622

Mohamad Khairul Anuar Mohd Rosli*
University of Science Malaysia
11700 Gelugor, Penang, Malaysia
E-mail: khairulanuarrosli@usm.my
https://orcid.org/0000-0001-7187-7529

Ahmad Kamal Ariffin Mohd Rus
University of Malaya
50603 Kuala Lumpur, Malaysia
E-mail: akamal@um.edu.my
https://orcid.org/0000-0002-2032-3064

Suffian Mansor
National University of Malaysia
43600 Bangi, Malaysia
E-mail: smansor@ukm.edu.my
https://orcid.org/0000-0003-0887-8312

*(correspondent-author)

The electrification of the tin mining in Kinta Valley: Role of Perak River Hydroelectric Power Company (1927–1940)

Abstract. *Electricity, first introduced in Colonial Malaya as early as the 1890s, and by the 1920s became the major source of power in the tin-mining industry. Surprisingly, despite its vital role in the economy, electricity has received little attention in Malaysian historiography. In the country's main tin-mining center, Kinta Valley, Perak, the Perak River Hydro-Electric Power Company with its head-office in London, played a significant role in supplying electricity for mine operator. Since early 1920s, British Government aimed to develop hydroelectric power by building dams on the Perak River. They viewed the Perak River as an important source of hydroelectric power for electrifying Colonial Malaya especially for tin mining-industry. Financial constraints forced the British Government, however, to hand over responsibilities to the PRHEPC. This article aims to identify how PRHEPC managed the development of electricity supply facilities and its significance to the tin miners in the Kinta Valley before 1940. The PRHEPC diversified its energy facilities development strategies to*

guarantee electricity supply to mine operators covering a wide area. Their ability to exploit the Perak River through the construction of a large-capacity hydroelectric station and the strategy to combine steam generation and grid supply systems allowed the PRHEPC to effectively supply electricity to a large number of mine operators in the Kinta Valley. The development was financially beneficial to the power companies because this capital-saving approach allowed them to generate electricity at a far lower price than the fossil fuel power stations for their consumers. Cheap energy allowed mine operators to minimize the cost of the tin mining operation, particularly the sector shifted from labour-intensive to a capital-intensive business strategy. To dominate the tin mining sector, the operators greatly invested in modernizing mining methods through utilization of machinery such as the high-cost dredges. It was therefore imperative for mine operators to obtain cheap energy to offset the cost of investments. This case study clearly displayed the development of the tin mining sector in Kinta Valley was not merely influenced by electricity use, but also its economical generation through hydroelectric.

Keywords: *tin mining; Perak River; hydroelectric; mining method; capital intensive*

Introduction.

Electricity was first developed as a basic public utility in Malaya in the 1890s a few years after its commercial use in Europe. British control over Malaya was the catalyst to the spread of Western science and technology, such as electrical engineering, incorporated into the development of basic public utility. Through their administration, the British made its obligation the provision of basic public utility. It was the practice of the Colonial Office in London to introduce any new technology in its colonies as a projection of its sense of power and prestige. These efforts were carried out through the shaping of British institutions and administrative policies that prioritised providing basic facilities. Aside from streamlining administration, the British viewed basic public utility as important in creating a conducive environment to attract foreign financiers to invest in the commercial economic sector. This viewpoint was articulated by Frank Swettenham (1906), "The Government cannot do the mining and the agriculture, but it can make it profitable for others to embark in such speculations by giving them every reasonable facility, and that we have tried to do". Therefore, immediately following his appointment as the first Resident-General of the Federated Malay States (FMS), which placed the four states of Perak, Selangor, Pahang, and Negeri Sembilan under one central administration in 1895, Swettenham stressed that his main role was, "to open up the country by great works: roads, railways, telegraphs, wharves" (Drake, 1979). In fact, William Hood Treacher, who replaced Swettenham in 1901 also underscored the same policy by stating that, "The general policy of the British Adviser…to assist the development…of the States by making roads whenever the necessity of them was apparent, by constructing railways, by works of drainage and irrigation" (Chan, 1967). The development of basic facilities was fully

carried out by the government through the establishment of specific departments such as Works, Railways, Irrigation and Drainage, and Post and Telegraph.

British colonial policies in Malaya prioritised the economic sector, especially tin mining that contributed largely to government coffers. To develop this sector, the government initially encouraged the influx of mainly Chinese labour. The emergence of electricity as a more efficient energy source meant efforts to develop it became important in basic facilities development policy to provide new energy source to mine operators. With this in mind, the government established the Electricity Board in 1921 before it was restructured and renamed the Electrical Department in 1927 to manage electricity supplies in the FMS. The establishment of these departments functioned as a development agent for the government, playing a key role in spurring economic growth. This situation illustrated that the British was responsible for creating modern infrastructure to develop the commercial economic sector, as acknowledged by a number of scholars. For instance, P. J. Drake (1979) states that the British government provided facilities for foreign investors to encourage the growth of private industry. P. P. Courtney (1972) stressed that the change in tin mining patterns was due to British policy and encouragement of foreign financiers. J. S. Sidhu (1980) opined that the British economic policy to modernise the tin mining sector included providing modern facilities to mine operators. Undoubtedly, the British played an important role in encouraging the growth of the tin mining sector as the backbone of FMS economy. In Kuala Lumpur, the main tin mining centre after Perak, the Electrical Department took the initiative and built a sub-station near the mining areas to facilitate electricity supply to the operators. In Perak, although the government did set up an electrical department, supply of electricity was managed by a private company, the Perak River Hydro-Electric Power Company (PRHEPC). The services of the PRHEPC challenged the earlier perception that the British government was fully responsible for the provision of basic facilities for economic development. The PRHEPC was responsible in ensuring the Kinta Valley, which functioned as the largest tin mining centre in Perak specifically and in Malaya generally, received ample supply of electricity. Although the British administration worked to develop electricity supply facilities, the cooperation with PRHEPC was necessary to guarantee the success of a high-impact project for the government.

The establishment of the PRHEPC was historically significant in the electricity industry of this country, especially in the framework of the colonial period. The services provided set a benchmark for the development of electricity supply, as it became the leader in hydro-based electricity industry. The PRHEPC was successful in managing the construction of the largest hydro-electric power station, specifically in Perak and generally in Malaya, with the capacity of generating up to 27,000 kW. Undeniably, a number of private companies had utilised the hydro method to generate electricity before PRHEPC. However, their generating capacity were low, and much generated electricity was limited to private use. For instance, the Raub Australian Gold Mining Company was the first company to apply the hydro method through the

building of a hydro-electric power station in Sempam River in the 1890s to facilitate gold-mining operation in Raub, Pahang (Richardson, 1939; Warnford-Lock, 1907). The Societe des Etains de Kinta, the French capitalist-owned tin-mining company also used electricity generated by the Rawang River in 1906 for prospecting work in Kampar (Ingham & Bradford, 1960). However, compared to its two precursors, the PRHEPC developed hydroelectricity to benefit consumers, especially tin mine operators in Kinta Valley. The role played by PRHEPC was significant, as the tin mining sector was the fundamental economic activity in Perak and in Malaya. Furthermore, the Kinta Valley served as the main tin mining centre that contributed a large amount of tin for the international market. Therefore, efficient energy supply such as electricity guaranteed the continuation and strengthening of the tin mining activity. This situation highlighted the significant role the PRHEPC played to drive forward the growth of the tin mining sector in Kinta Valley.

Although electricity as supplied by PRHEPC contributed to the development of the tin mining sector, no exists to specific topic on it. In fact, studies on the development of electricity facilities are still lacking in Malaysian historiography. Muzaffar Tate is arguably one of the few researchers that produced a study on the development of electricity facilities in Peninsular Malaysia from its introduction in the 1890s to 1990 (Muzaffar, 1989; Muzaffar, 1991). His discussion focuses on the role of the government and its impact on governing the development of basic facilities during nationalisation. Although his discussion also focused on the setting up of the PRHEPC and the implemented development projects, a more detailed study is needed to fully comprehend the role, significance, and relationship between the services provided and the consumer aspect, especially the tin mining sector. Furthermore, Hellstrom (1935) and Rennie (1935), who also discussed PRHEPC, only focused on its main project, the construction of the hydro-electric power station. As their study was published a few years after the PRHEPC launched its electricity-generating power station operation, there was no information on the impact of its development on the consumer aspect. Clearly, existing literature do not comprehensively cover the issue, although providing electricity for the tin mining sector, centred in Kinta Valley, was the responsibility of the PRHEPC. In addition, electricity became the main source of energy used by mine operators by the 1920s.

As studies on the production of new energy technology such as electricity received little attention in Malaysian historiography, its impact on economic growth has not been analysed as much. This present article seeks to overcome one limitation of the economic literature by drawing attention not only to the evolution of energy development and electricity system, but, crucially, also to the adoption of electricity as a new energy source in tin mining sector, focusing on the role of the PRHEPC. This is in line with N. R. Jackson's (1963) recommendation to further research on the topic of change in the tin mining sector, as it was the core of economic history in Malaysia. According to Arthur W. King (1940), the transition from wood-fuel to coal and oil, to electricity, was among the largest change to occur in the tin mining sector. Therefore,

this article analyses how PRHEPC managed the development of electricity supply facilities to fulfil the demands of mine operators within a large area, and identifying its significance. This study uses the case study approach, in line with the structure of the electricity industry in the FMS prior to the 1940s, managed separately by the Electrical Department of each state. Interestingly, the situation in Perak differed from the others, as electricity supply services was led by the PRHEPC, responsible for supplying electricity to tin mining operators centred around Kinta Valley. Generally, more than 90 per cent of electricity use in Malaya focused around the tin mining sector (Kinloch, 1966). Perak, specifically the Kinta Valley, rapidly grew with tin mining, influencing electricity use. In 1938, 151,000 tonnes of tin were produced internationally, and 43,247 tonnes came from Malaya (Fermor, 1940). A large number of Malayan tin production was contributed by Perak, with 24,958 tonnes (Report on the Administration of the Mines Department and on the Mining Industries for the year 1939). Therefore, this case study approach, focusing on the Kinta Valley, allows for a more detailed analysis to identify the significance of electricity towards the growth of the tin mining sector, as well as measure the role of the PRHEPC as a private company within the framework of development of basic facilities, which was basically the responsibility of the government. The first part of this article looks at the theoretical relationship between electricity and economic growth. Next, the second part of the article identifies the establishment and background of the PRHEPC as the party responsible for managing the supply of electricity in Perak. Then the third part of the article focuses on the strategies employed by the PRHEPC to develop and manage generator infrastructure to ensure the effectiveness of supplying electricity to a large number of mine operators centred in Kinta Valley. The final part of this article will analyse the significant of electricity to mine operators. This article provides two important contributions to Malaysian historiography. Firstly, it provides further detail on the history of electricity services from the perspective of private ventures, such as PRHEPC which emerged as the main player in the electricity industry. Secondly, it fills in the gap in our history, on the relationship between electricity supply facilities with the tin mining sector, and the significance of PRHEPC services to the mine operators across Kinta Valley.

Methodology.

This study uses the historical method and qualitative research to reconstruct past events. Accordingly, this study requires the use of archival materials obtained from National Archives of Malaysia, which is located in Kuala Lumpur. The type of primary sources, we collected including the Annual Report and Account of the Electrical Department (1927–1938); Annual Report on The Social and Economic Progress of The People of Perak; Report on The Administration of The Mines Department and on The Mining Industries. In additional, we also use secondary sources, including dissertations, books, and journal. All information gathered was analysis using a narrative approach.

Results and Discussions.

The emergence of electricity as a more efficient, productive, and flexible source of energy had a tremendous impact on economic growth. The use of electricity as the driving power for motor and engines was proven to be more flexible than steam engines and allowed the reorganisation of work in factories and workshop. Work hitherto difficult or almost impossible for humans could be easily handled by electricity-generated machinery, and electricity was widely used to replace manpower and polluting traditional fuels. A few economic historians such as Wilkinson (1973), Wrigley (1988), and Allen (2009) viewed that energy-related innovation and improvement in energy supply and quality played a significant role in ensuring economic growth. They also viewed energy as a key component in explaining the Industrial Revolution. Furthermore, David I. Stern (1997) argued that energy is an essential factor of production and continuous supplies of energy are needed to maintain existing levels of economic activity as well as to grow and develop the economy. In general, these ideas originated from the theory forwarded by Robert Solow and Trevor Swan in 1956. This theory, known as the Solow Growth Model, states that economic growth is caused by three factors: labour, capital, and technology. Of the three factors, technology was seen as the most dominant. Although labour and capital were limited economic resources, the contribution from technology to growth is boundless. According to this Solow Growth Model, technological transformation has a significant influence on the economy, and growth could not effectively happen without advancements in technology (Solow, 1956; Solow, 1957).

Electricity was an example how technological advancement became the trigger for economic growth. One way to evaluate the role of electricity in economic growth is by studying historical success stories. Using the Solow Growth Model, from the lens of technology, this article reviews empirical evidence by analysing the link between electricity as supplied by the PRHEPC with the tin mining sector in Kinta Valley in a colonial setting. The formation of the PRHEPC was identified as bringing development in electricity supply, thus contributing to the growth of the tin mining sector. The effectiveness on electricity system-building by prioritising the hydro method and combining with steam, and implementing the grid supply, ensured the continuous rapid growth in mining in the Kinta Valley, even as they faced lack of labour and capital, especially among Chinese businessmen. The effects on infrastructure and supply quality were an essential factor of production and maintaining existing levels of mining activity, as well as growing and developing the economy.

The Establishment of the Perak River Hydro-Electric Power Company.

The PRHEPC involvement, until it emerged as the main plater of the electricity industry in Perak, began with the government's plan to implement a high-impact project through developing hydroelectricity. By the second decade of the 20th century, the British government took the initiative to improve electricity supply in Malaya.

Therefore, Frederick Bolton, an experienced hydro-electric engineer involved in multiple projects in Britain and South Africa, was appointed as Electrical Adviser to formulate a comprehensive development plan (High Commissioner Office, 1919). As an expert in this field, Bolton identified the potential of the Perak River as a source for hydro-electricity generation. With this in mind, a proposal was submitted to the government to implement the Perak River Hydro-Electric Scheme (PRHES) and exploit the Perak River (The Public Supply of Electricity Power and Light in Malaya: Interim Report, 1921). This implementation was able to meet the energy demands in the ever-growing tin mining sector in the Kinta Valley. However, financial troubles prevented the government from implementing the PRHES. In 1921, the FMS merely earned around $73,450,779, while its expenditure reached $101,426,220. In the following year, the FMS finances saw a further deficit, with an expenditure of $67,151,142 to an income of $59,818,670 (Rus, 2006). This problem emerged as a consequence of large-scale spending on development of basic facilities to boost growth in the export economy.

This financial crisis hindered the government' plan to implement large-scale projects such as the PRHES, which required a lot of capital. At the same time, however, the development of the PRHES needed to be expedited to provide electricity supply to tin mine operators. To overcome this problem, the government worked to attract investment from private companies. After lobbying a number of investors in London, Bolton managed to capture the interest of Armstrong Whitworth to invest in PRHES. This joint venture with Armstrong was not really new, as his company was previously responsible for the building of the battleship H. M. S. Malaya for the FMS, launched on 18 March 1915 (Yusof, 2019). Armstrong Whitworth & Company was among the leading companies in engineering, providing their services in shipbuilding, locomotives, and airplanes. In addition, the company was also involved in a number of hydroelectric projects such as in Deer Lake, Newfoundland and Nymboida, New South Wales in the 1920s. This rich experience, as well as the guarantee by the company to complete the PRHES without FMS financial aid, convinced the government to grant a concession Muzaffar, 1989). With that, an agreement was signed between the Sultan of Perak, Sultan Iskandar Shah and Sir W.G. Armstrong Whitworth & Company on December 1925 (Perak River Hydro Electric Company: Title to Land, 1929). The PRHEPC was formed in 1926 as a developer for PRHES, responsible for managing the generation, transmission, and supply of electricity to consumers, especially tin mine operators in the Kinta Valley for 80 years. For domestic use, the PRHEPC was granted a concession to supply electricity in Kuala Kangsar District, the *mukims* of Durian Pipit, Temelong, and Lenggor in Upper Perak; Kinta District; the *mukims* of Chenderiang, Batang Padang, and Bidor in Batang Padang District; the *mukims* of Pulau Tiga, Kampung Gajah, and Panjang Ulu in Lower Perak (Perak River Hydro Electric Company: Title to Land, 1929).

Taking this vast responsibility, the PRHEPC took steps to strengthen administrative and implementation through network-building with a number of parties.

The formation of this organisational structure allowed the company to manage administrative affairs and development projects more efficiently and effectively. On administrative, the appointed company board members were experienced individuals, directly involved in the electricity industry. Among them were Lord Meston of Agra and Dunottar, the Manager of Calcutta Electric Supply Corporation Limited, while Col. B. C. Lockhart-Jarvis was the Director of Kensington and Notting Hill Electric Light Corporation Limited. For implementation, the PRHEPC appointed the Rendel, Palmer & Tritton Company as Consultant Engineers, with Preece, Cardew & Rider Company as Technical Advisors to help manage the development project (Perak Hydro-electric Scheme, 1927). Furthermore, the PRHEPC also cooperated with a consultant company from Sweden, the *Vattenbyggnadsbyrån*, among the pioneers in hydro-electric engineering in Europe. Through this cooperation, the PRHEPC benefited from access to the latest technology in building electricity supply, thus ensuring its efficiency. In addition, Armstrong also brought his skilled and experienced staff in hydroelectricity to be seconded in Perak to help implement the PRHES. For instance, Edwin Charles Steer, who worked with Armstrong Whitworth & Company since 1925 and involved in drawing up hydro-electric schemes in a number of areas in Great Britain, and the construction of a dam in Newfoundland, was appointed as Chief Assistant Engineer, later Resident Engineer, to manage PRHES in 1928 (Anonymous, 1958). Gordon Mabor Walker, who served as Assistant Engineer of Hydro-Electric Department, Manchester was appointed Assistant Engineer and Mechanical Engineer in PRHEPC (B. C. L .- J., 1957).

The Implementation of the Perak River Hydro-Electric Scheme.

Developing the river for hydro-electricity generation proved to be more economical, as it was fully dependent on natural water flows. In contrast, the use of fossil fuels such as coal, natural gas, or oil, could manipulate the electricity supply process, due to their limited availability and unrenewable nature. This situation made their price unstable, influencing costs of generating electricity and affecting both operators and consumers. Furthermore, other consumer sectors already compete for access to fuel supply. In the FMS, aside from the electricity industry, coal supply was largely allocated to railway transportation. Therefore, the energy industry players tirelessly worked to diversify their electricity generation methods, depending on renewable energy sources such as water. However, the suitability of water source should also be identified before exploitation, as providing hydroelectricity should not only focus on present needs, but also future interests, and its impact on the ecosystem. The Perak River was discovered to possess suitable characteristics to be developed as a main source of hydro-electricity generation, with a height of 105 feet from sea-level, which flowed as far as 170 miles (Perak Administration Report for the year 1931, 1932; Winstedt, 1927). In addition, the rapid water flow was able to produce high kinetic energy, thus usable to generate electricity in large quantities.

When the PRHEPC took over the PRHES scheme, the company began monitoring to identify strategies areas along the Perak River as the site for a hydro-electric power station. This step was important to ensure company operation, and the process of generating and supplying electricity remain smooth. According to Robert J. Michaels (2006), "Electricity can be produced and delivered economically only if highly specialized assets are in place…some generators must be close to consumer…Investment in generation and transmission is a long and costly process and once in place, the equipment cannot be cheaply redeployed to some other location or use". Through the monitoring, Chenderoh was selected as the site for a hydro-electric power station. Undeniably, other sites such as Kenering, Bersia and Temenggor could also be potentially exploited as a source of hydro-electricity generation. These areas were later developed by the National Electricity Board in the 1970s to generate hydroelectricity. However, the selection of Chenderoh by PRHEPC was due to its close geographic location to tin mines in Kinta Valley compared to the aforementioned sites, located far into Upper Perak. The distance between the hydro-electric power station and the consumers was the main factor considered, as it minimised expenditure on transmission lines, and reduced loss of electricity during supplying. Furthermore, Chenderoh also has a natural lake that could function as a catchment to prevent river overflow when the dam was finally complete.

Construction work on the hydro-electric power station began in 1927, involving a number of contractors such as Topham, Jones & Railton Limited (construction engineering), Glenfield & Kennedy Limited (water gates), Ransomes & Rapier Limited (sector & intake gates), The English Steel Corporation Limited (water turbine), and The English Electric Limited (alternators) (Hellstrom, 1935). The dam structure was built with the length of 231 feet on the right side of the riverbank, fortified with concrete and steel piles 60-feet deep. On the left side of the riverbank, dam construction covered a length of 120 feet, fortified with concrete and steel piles 30-feet deep. The dam wall, to stop water flow from the right side of the river, was built with a length of 245 feet, with a height of 193 feet, while on the left side of the river covered an area of 434 feet with a height of 193 feet. The sector gate section, located at the mid-part of the river, was built at a height of 177 feet (Hellstrom, 1935). Aside from the dam, other main sections of the hydro-electric power station include the powerhouse. The building had reinforced concrete, divided into three sections that placed the water-turbine to generate electricity via kinetic energy, produced through streamflow. Its height was between 145 and 174 feet, and also equipped with apparatuses such as turbine scroll-cases, generators, governors, travelling cranes, and so on (Hellstrom, 1935). The height of the dam and building was key to preventing river overflow during a flood. The station, with a generating capacity of 27,000kW was completed, and began its electricity supply operations to consumers on 27 July 1930 (Report on The Administration of The Mines Department and on The Mining Industries for the year 1930). The construction of the Chenderoh Hydro-Electric Power Station made it the largest station, specifically in Perak and generally in Malaya.

Merging Methods of Generation.

The challenge to supply electricity to a large area with long-term guarantees to customers propelled the PRHEPC to take the initiative to diversify and merge methods of generation. Although the Chenderoh Hydro-Electric Power Station could generate large quantities of electricity, the generating process itself was unpredictable and dependent on the weather. Erratic rainfall distribution and droughts affected river-flow and quantity. The decision to merge methods of generation was the best approach to this challenge. The construction of a separate and alternatively operated power station gave the advantage to PRHEPC to reduce risk in electricity generation. This was supported by Matsunaga Yasuzeamon, "when you can't produce enough power because the volume of river is too low, you have to secure other means to augment the supply and compensate for the shortage" (Kikkawa, 2006). In October 1927, PRHEPC built a power station in Malim Nawar as a back-up to the Chenderoh Hydro-Electric Power Station, especially during the drought season (Annual Report and Accounts of the Electrical Department for the year 1927, 1928). In the event of disruption in transmission between Chenderoh Hydro-Electric Power Station and consumers in Kinta Valley, the Malim Nawar Power Station served to ensure electricity supply remained undisrupted (Report on The Administration of The Mines Department and on The Mining Industries for the year 1930). In addition, the Malim Nawar Power Station also expedited electricity supply to mine operators. This was because steam-type power stations took a relatively shorter time to complete compared to a hydro-electric one.

In October 1927, construction work on the Malim Nawar Power Station began, with the cooperation of a number of contractor companies such as the International Combustion Limited (boiler-plant and building), The English Electric Company Limited (turbo alternators), James Howden & Company (air-preheaters), Ledward & Beckett Limited, and S. Bullock Company (spray-pumps and piping) (Hellstrom, 1935). At the early stage, generation capacity was set at 5,000kW before the PRHEPC decided to increase capacity to 18,000 kW (Annual Report and Accounts of the Electrical Department for the year 1927, 1928.; Muzaffar, 1989). Construction took almost a year to complete, before official operations began in November 1928. Through the Malim Nawar Power Station, around 1,690,833 units of electricity were generated, and it increased to 5,927,728 units as soon as it merged with the Chenderoh Hydro-Electric Power Station (Perak River Hydro-Electric Power Company, 1931). The PRHEPC identified a strategic location to build a power station, southern Kinta Valley. The Chenderoh Hydro-Electric Power Station was located to the north. This location allowed the company to connect all tin mining areas located between the two stations. In other words, PRHEPC could supply electricity to all mine operators across Kinta Valley through connecting transmission lines along the area between the two stations.

Transmission Line Network.

The two high-capacity power stations were built in Chenderoh (27,000 kW) and Malim Nawar (18,000 kW) allowed PRHEPC to supply electricity to a large number of tin mining operators across the Kinta Valley. In other words, the operation of two stations was capable of producing electricity in large quantities, in line with the needs of the tin mining sector. For instance, the Chenderoh Hydro-electric Power Station was capable of generating around 26,399,230 units since operation began in 1930. Through the merging with the Malim Nawar Power Station, around 53,231,172 units of electricity was generated and supplied to tin mine operators (Report on The Administration of The Mines Department and on The Mining Industries for the year 1930). Therefore, the PRHEPC must manage the supply system efficiently so generated electricity can be fully utilised while preventing waste, as electricity could not be stored and must be directly supplied to consumers. To ensure the process of supplying electricity to consumers ran smoothly, the PRHEPC developed a supply network and grid distribution system, which connected the two power stations with the consumers. According to Robert J. Michaels, "Distribution lines must physically reach users, and transmission lines must cover the distance between distribution lines and generation" (Michaels, 2006). A transmission line of 66 kV was built, connecting the Chenderoh Hydro-Electric Power Station and the Malim Nawar Power Station. There were eight 22 kV sub-stations built along the line, in Temoh, Kampar, Petaling, Tanjong Toh Alang, Tronoh, Batu Gajah, Papan, and Menglembu, while two 66 kV sub-stations were built in Talang Pamaya and Selibin, connected to the 22 kV transmission lines. This distribution network allowed PRHEPC to supply electricity to every tin mine along the line.

Electrification on Kinta Valley.

In 1889, Kinta Valley emerged as the main tin mining centre in Perak, and generally in Malaya, replacing Latur. Since then, the Kinta Valley became the largest producer of tin. Between 1919 and 1923, Kinta Valley produced 398,478 *piculs* of tin from the total production in Perak of 492,961 *piculs* (Fermor, 1940). This followed the mass opening of tin-rich mines in Kinta Valley. Kinta Valley emerged as the district with vast areas of tin mines compared to the other six districts in Perak. By January 1939, there were 3,820 tin mines covering an area of 125,215 acres in Perak, and 2,811 mines in an area of 85,530 acres in Kinta Valley alone (Annual Report on the Social and Economic Progress of the People of Perak for the year 1938, 1939). This growth was further supported by supply of alternative energy and utilisation of more modern equipment such as dredges and gravel pumps. In general, use of alternative energy such as steam, hydraulics, and electricity, made tin extraction easier and more effective compared to human labour. One horsepower (h.p.) of alternative energy used to activate machinery could do the work of eight human labour (Ken, 1965). This meant

use of alternative energy such as electricity became more popular among tin miners to carry out their prospecting.

The introduction of electricity as a more effective energy source received encouraging demands from mine operators. In Kinta Valley, electricity supply by PRHEPC allowed a large number of tin mine operators to turn to them. According to Figure 1 below, it is clear that electricity became the energy source of choice for tin mine operators since 1930. This increasing trend was influenced by PRHEPC's success to manage the construction of a high-capacity power generator asset. As soon as the Malim Nawar Power Station began operation in 1928, the use of electricity continued to increase before it overtook alternative energy sources when the Chenderoh Hydro-Electric Power Station in 1930. From 47,963 h.p. of electricity used in 1934, around 39,622 h.p. was supplied by PRHEPC (Report on The Administration of The Mines Department and on The Mining Industries for the year 1934). By 1936, PRHEPC supplied 59,331 h.p. out of 80,828 h.p. electricity used in tin mines in Perak (Report on The Administration of The Mines Department and on The Mining Industries for the year 1936). The statistics proved the capability of PRHEPC to manage electricity supply to meet the demands of mine operators covering a large area, and its contributions in further developing the tin mining sector.

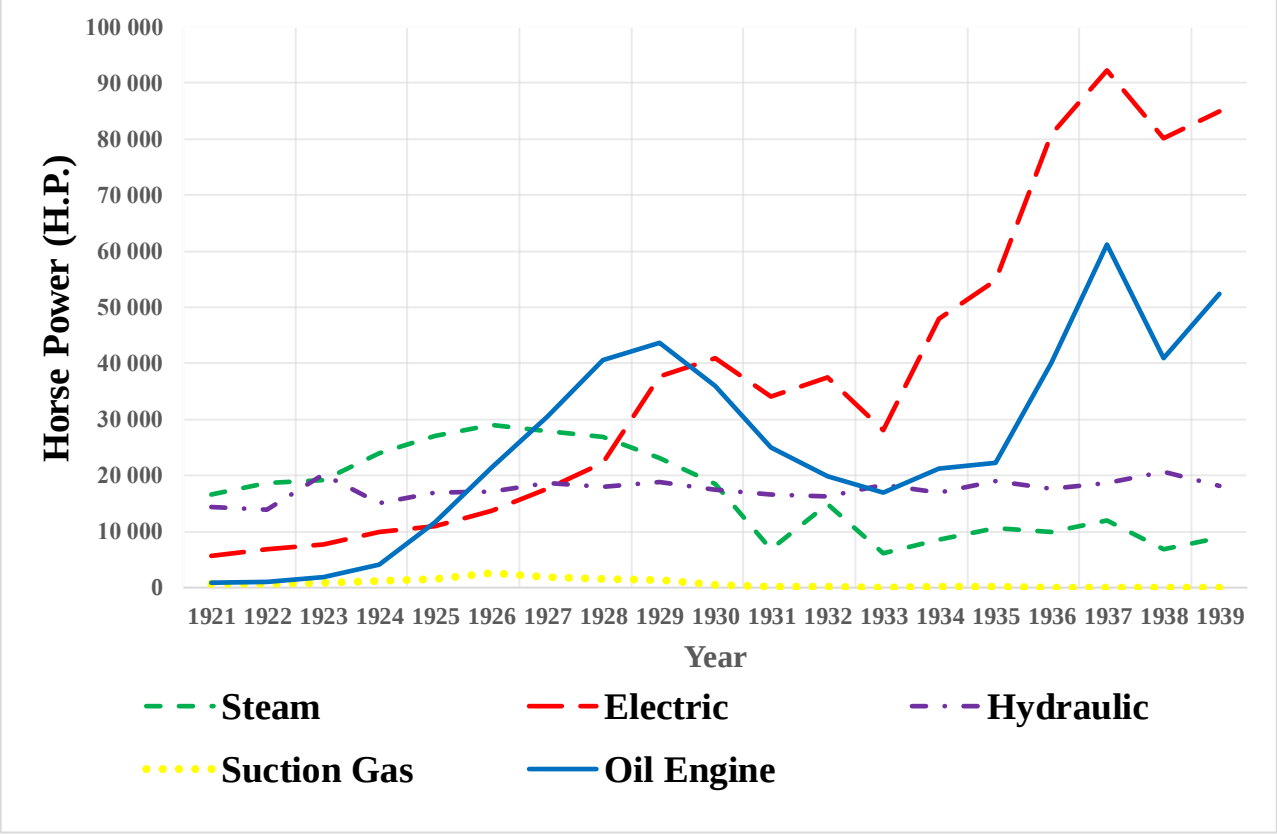

Figure 1. Energy Usage in the Tin Mining Sector in Perak, 1921–1938 (Source: Compiled from Federated Malay States: Report on The Administration of The Mines Department and on the Mining Industries, 1921–1938).

Supply of electricity as provided by PRHEPC was significant, as it was in line with conditions in the tin mining sector, which required a more stable and guaranteed source of energy. This was in line with Perak's, and Kinta Valley by extension, role as the largest producer of tin in Malaya for the international market. Between 1898 and 1938, no less than 27 per cent of the world's tin production came out of Malaya (Fermor, 1940). In the Malayan context, Perak contributed more than half of the total tin production. For instance, from the 63,974 tonnes of tin produced in Malaya in 1930, 39,825 tonnes were produced in Perak (Fermor, 1940). Therefore, it was important for mine operators to get a more consistent and suitable energy source for tin exploitation work to run smoothly. Before the introduction of electricity, mine operators turned to various energy sources. However, dependence of these energy sources was seen as risky and no longer suitable as the main power source to spur the export economic development, such as the rapidly growing tin mining sector.

Up to the early days of the 20th century, tin mining was still labour-intensive, especially Chinese labour. Throughout this period, mine operators had no problem obtaining labour, as the offers were high and sufficient for each demand. A large number of Chinese labours brought into Malaya worked in the tin mining sector. However, by the early decades of the 20th century, problems in supplying labour became more serious, as emigrants outpaced newly brought in labour. In addition, current and new labour diversified their services into other sectors, such as road construction, railway construction, and rickshaw-pulling, and this also affected labour supplies in the tin mining sector (Ken, 1965). At the same time, the growth of the rubber industry forced European businessmen to use Chinese labour as extra labour to support Indian labour in the plantations (Ken, 1965). Furthermore, health problems such as the spread of beriberi, of which labourers were especially vulnerable, and the low quality of life due to exposure to vices such as opium, meant labour was unstable and detrimental to mining operations. To overcome the problem of labour shortage, mine operators took the initiative to turn to alternative energy sources such as steam and hydraulics, produced through combustion. Undeniably, these energy sources did not require many labourers, as operators turned to labour-saving devices such as gravel pumps to excavate tin. However, even these energy sources proved unstable because of limited and unstable fuel availability, as they were also needed in other sectors such as trains and export commodities. Only two main coal mines supplied fuel to consumers, which were the Malayan Collieries Limited in Arang Batu, Selangor and Enggor Coal Syndicate in Enggor, Perak. However, the closure of the mine in Enggor in 1928 affected coal supplies (Report on The Administration of The Mines Department and on The Mining Industries for the year 1928). Meanwhile, mine operators such as in Tanjong Toh Alang, hitherto dependent on wood-fuel for energy production, also faced fuel shortage (Perak Administration Report for the year 1923, 1924).

Clearly, use of electricity as supplied by PRHEPC proved best for mine operators, as they were capable of supplying a stabler energy source. The diverse generating

methods operating through renewable and unrenewable energy sources allowed PRHEPC to reduce problems in supplying electricity to consumers. Although the Malim Nawar Power Station operated with coal, fuel shortage was no problem for the PRHEPC, as the majority of energy was generated by the Chenderoh Hydro-Electric Power Station. Electricity generation through renewable sources such as water from the Perak River and the high generating asset capacity guaranteed a stabler energy supply to fulfil current and long-term needs. PRHEPC's ability was unquestioned with the supply of electricity to its ever-increasing consumers. In 1932, around 35,778,199 units of electricity was provided by PRHEPC to mine operators in Kinta Valley (Annual Report on The Social and Economic Progress of The People of Perak for the year 1933, 1934). Supplied electricity units increased to 89,403,198 units in the following two years (Annual Report on The Social and Economic Progress of The People of Perak for the year 1934, 1935). By 1936, electricity use reached 202,099,958 units, further increasing to 247,097,397 units in the following year (Annual Report on The Social and Economic Progress of The People of Perak for the year 1937, 1938). The ability to generate electricity in large quantities also caused the government to shut down operations of power stations in Ipoh and Batu Gajah, and purchased electricity from PRHEPC to supply to the locals (Annual Report and Account of the Electrical Department for the year 1930, 1931; Annual Report and Account of the Electrical Department for the year 1932, 1933). Since 1929, purchase of electricity from PRHEPC continued to increase from 2,833,883 units to 4,794,694 units by 1939 (Annual Report and Account of the Electrical Department for the year 1929, 1930; Annual Report and Account of the Electrical Department for the year 1939, 1940). This indirectly explained the company's capability of ensuring continued energy supplies for consumer demands. Undeniably, electricity usage for the tin mining sector in Perak showed a decline between 1930 and 1933. However, this was not due to problems in supplying electricity, but a result of the economic recession and the collapse of tin prices, which forced mine operators to limit operations. Tin dumping led to the implementation of the International Tin Agreement in 1931 to restore market price by imposing tin production quotas among producing countries (Hoong, 1969). Later, as the tin market recuperated, tin production quotas were liberalised through the International Tin Agreement, renewed in 1933 (Hoong, 1969). Almost immediately, mine operators re-started their tin mining activities, thus increased electricity usage.

The transition to electricity as used by PRHEPC allowed mine operators to minimise expenditure on energy supply. According to the report by J. Laird, Senior Warden of Mines, the use of engines to generate energy- and labour-saving devices proved to reduce the operation costs borne by operators (Report on the Administration of the Mines Department and on the Mining Industries for the year 1930). In this regard, the implementation of the PRHES by PRHEPC could potentially supply electricity at a cheaper rate to mine operators (Perak Administration Report for the year 1925, 1926). Through services provided, operators no longer have to bear the costs on construction, generation, and maintenance of power stations, as they could directly receive electricity

from PRHEPC. In addition, hydro-based electricity generation via natural water flow from the Perak River allowed the company to reduce operating costs, thus provide electricity to all consumers at a lower rate. For instance, in 1935, the PRHEPC only spent around £26,878 to generate electricity (Perak River Hydro-Electric Power Co., "Directors' Report and Statement of Accounts for the year ended 31st July 1935, 1936). In that year, around 124,810,523 units were generated and supplied to tin mine operators in Kinta Valley, while a further 3,348,090 units were sold to the government to be supplied to consumers in Ipoh and Batu Gajah (Annual Report on The Social and Economic Progress of The People of Perak for the year 1935, 1936). In contrast, the government, through the Electricity Department, spent £38,734 to purchase fuel such as coal and oil to generate 53,297,401 units of electricity (Annual Report and Account of the Electrical Department for the year 1935, 1936).

Although tin mining areas in the Kinta Valley were vast and with many mining companies, the generation asset capability owned by PRHEPC provided operators with the opportunity to obtain electricity. For instance, the number of mine operators that engaged the services of PRHEPC showed an upward trend. In 1933, 39,663,579 units of electricity were supplied to PRHEPC to 66 consumers (Annual Report on the Social and Economic Progress of the People of Perak for the year 1933, 1934). This number increased to 110 consumers in the following year, with the sale of 89,403,198 units of electricity (Annual Report on the Social and Economic Progress of the People of Perak for the year 1934, 1935). By 1937, PRHEPC had 223 consumers, with a total 247,097,397 units of electricity sold (Annual Report on the Social and Economic Progress of the People of Perak for the year 1937, 1938). A large amount of mine operators in Kinta Valley that operated with dredges, such as the Jelapang Tin Dredging Limited, Kramat Tin Dredging Limited, Lower Perak Tin Dredging Limited, Malayan Tin Dredging Limited, and Southern Kinta Consolidated Limited, also depended on electricity supplied by PRHEPC (Ingham & Bradford, 1960).

Aside from new consumers, the capability of PRHEPC also drove a number of mine operators that initially managed their own electricity generation to switch to the company's services. This decision could further reduce to expenditure costs of these operators. For example, the Societe des Etains de Kinta ceased operations of their power station and signed a power purchase agreement with PRHEPC (Perak Hydro-Electric Company, 1929). Other large companies operating with dredges such as Anglo-Oriental and Osborne & Chappel also obtained electricity from PRHEPC (Perak Hydro-Electric Company, 1929). Dredges were more suitable for mine operators doing more effective tin excavation work. As tin ore yield from the surface up to a depth of less than 30 feet progressively decreases, operators were forced to dig deeper. The traditional mining method of using labour and equipment such as hoes and rattan baskets became more exhausting as they reached a depth of 30–50 feet. Although operators could turn to engine-generated power, it necessitated huge capital to purchase extra equipment such as pumping machineries, with the sodden mine surface (Hoong, 1969). Therefore, operators must improve their mining methods by using modern

machinery such as dredges, that could be used in watery mines. Although they invested heavily in dredges, mine operators could bear the cost by obtaining cheap electricity from PRHEPC.

At the same time, opencast mine operators, most of them Chinese, which operated with steam- and diesel engine-driven gravel pumps also transitioned to electricity and electric motors obtained from PRHEPC (Annual Report on the Social and Economic Progress of the People of Perak for the year 1933, 1934), as energy generated from steam, hydraulics, gas or oil methods require mine operators to manage their own power station. The fuel needed such as oil, coal, and wood were not always available, as other sectors such as the railways also compete for these resources. In addition, fuel prices were also unstable due to fickle market prices. This made it difficult for operators to ensure fuel supplies could meet the demands, not to mention to effects on expenditure. For Chinese operators, operation cost-reduction by turning to electricity and labour-saving devices such as gravel pumps and electric motors were in step with the changes in the mining sector. Up to the early 20th century, Chinese operators still possessed strong financial resources through sale of opium and gambling activities in the mines. According to Wong Li Ken, the revenue allowed Chinese operators to finance mining operations even as tin market price declined (Ken, 1965). However, the dissolution of opium monopolies by the government in November 1910 and gambling activities in December 1912 deprived them of a source of revenue (Voules, 1921; Ken, 1965). This made it difficult for operators to continue recruiting labour in large quantities. Furthermore, limited number of labourers led to a rise in wages. Lack of capital to manage energy supply themselves also led to increase in demands for cheaper electricity among these Chinese operators (Perak Administration Report for the year 1923, 1924). By using electricity also allowed Chinese operators to continue with their tin prospecting ventures (Perak Administration Report for the year 1926, 1927). Therefore, as soon as PRHEPC began their operations, a number of Chinese-owned mines such as Chan Tat Cho (Kampar & Chenderiang), Wong Peng Sam (Kampar), Choo Hoy (Temoh & Chenderiang) Wong Seong (Kampar), Loke Man Choke (Kampar), Leong Mong Chew (Kampar), Wan Fook (Kampar), Hah Liew Yee (Selibin), Chen Yoong Seong (Kampar), Leow Yee Thong (Kampar), Lai Weng Huin (Papan), Chong Foong (Pusing), Keat Hock Tong Mining Kongsi (Pusing), Yap Chin (Batu Gajah), Lim Boon Haw (Malim Nawar), and Tai Chee Show (Kampar), which operated opencast mines signed power purchase agreements with PRHEPC (Perak Hydro-Electric Company, 1929). For mine operators in Tanjong Toh Alang, fuel shortage such as wood could be overcome with the building of a sub-station in that area by PRHEPC, which provided electricity. Clearly, the facilities provided by PRHEPC helped Chinese operators to minimise their operation costs and at the same time ensured their survival in the tin mining sector.

Electricity and the Rise of Western Mining Company.

PRHEPC participation in the electricity industry indirectly changed the pattern of development in the tin mining sector. Through supplying of stable and cheap energy, PRHEPC helped European entrepreneurs to take control of the tin mining sector from the Chinese operators. Since the 19th century, both European and Chinese operators were involved in tin mining activities, specifically in Perak, and generally in Malaya. However, the influence of European operators, especially in tin production, were minimal compared to their Chinese counterparts. The period between 1820 and the early 20th century witnessed the domination of Chinese operators in the tin mining industry. Throughout this period, Chinese operators managed to contribute between 60 and 80 per cent of the annual tin production. This dominance was supported by their full control over manpower, i.e., Chinese labourers. In other words, the failure of European operators to control labour limited their involvement in the sector. Prior to the 20th century, Chinese labour was synonymous to tin mining, as tin ores located on the surface could be extracted with labour work and simple tools, such as hoes, rattan baskets, pans, and so on.

However, changes in the tin mining sector, from a labour-intensive to a capital-intensive model, opened the gates for European operators to take control of the sector from the Chinese. The dearth of tin on the surface up to a depth of 30 feet required the operators to dig deeper to extract tin. In this situation, manpower was no longer suitable, and operators turned to modern equipment and machinery such as dredges. For Chinese operators, the lack of capital hindered them from purchasing cost-prohibitive dredges. As for the Europeans, their financial strength allowed them to utilise dredges and other labour-saving devices, thus monopolising tin production (Annual Report on the Social and Economic Progress of the People of Perak for the year 1935, 1936). The initiatives taken by these Europeans were further streamlined with the supply of far cheaper and more efficient electricity by PRHEPC. With that, the problem of labour shortage among European entrepreneurs were countered by cheap electricity from the company. Compared to labour, which was fully controlled by Chinese operators, electricity was not monopolised by any one operator. PRHEPC, as the body responsible for supplying electricity facilities, provided it to all consumers, without privilege to any one group. In addition, the huge generation capacity did not hamper any operator from obtaining electricity. Since 1929, no less than 60 per cent of tin produce were contributed by European operators, overtaking the Chinese. A large part of tin production as recorded by European operators were done through dredges. As mentioned earlier, most European-owned and dredge-operated tin mines obtained their electricity from PRHEPC. In 1936, through dredges, the Europeans could produce over 291,670 *piculs* of tin, and another 145,183 *piculs* through other means, compared to the Chinese that produced 286,141 *piculs* of tin (Annual Report on the Social and Economic Progress of the People of Perak for the year 1936, 1937). Although tin production saw an overall decline in 1938, European operators using dredges still dominated production. Through dredges, around 220,465 *piculs* of tin were produced, with another 116,338 *piculs* through other methods.

Meanwhile, the Chinese operators only managed to be produced 38 per cent of tin output, or 202,336 *piculs* (Annual Report on the Social and Economic Progress of the People of Perak for the year 1938, 1939).

Conclusions.

The establishment of the PRHEPC aimed to implement the PRHES, had a significant impact not only in its role to supply electricity to mine operators in Kinta Valley, but also ensured the continuation and development of the tin mining sector, through their supply of a more stable, consistent, and cheaper energy source. As a new company established to take over the scheme drawn up by the government, the PRHEPC proved their capability to realise this high0impact project. They did not merely focus on hydro-electricity development in the Perak River, but also took the initiative to diversify their generation methods to ensure the effectiveness in supplying electricity to their consumers. Clearly, their infrastructure development strategy, merging both hydro and steam generation, and the grid system, was suited to Kinta Valley's location as the main mining centre, with a large area, involving many prospecting companies. In other words, these constructed assets allowed the PRHEPC to supply electricity to a large number of mine operators to meet current and long-term demands effectively. This situation guaranteed each mine operator sufficient electricity supply, turning it into the main energy source for tin mining. Since its inception, the PRHEPC was responsible for driving the tin mining sector in Kinta Valley. The effort to develop electricity facilities was not limited to providing a newer and more efficient energy source, but also adapt to the changes in the sector. Labour and alternative energy sources such as steam were unreliable, involved a high cost, and were a constant problem for mine operators. Dependence of these energy sources also made mining methods limited and impractical. Therefore, the PRHEPC provided the best solution to mine operators to overcome these challenges. Their ability to supply electricity consistently and cheaply turned mine operators to their services. This was very beneficial to European entrepreneurs that used dredges to strengthen their operations, thus dominate the tin mining sector. Meanwhile, the transition to electricity among Chinese businessmen ensured their survival in the mining sector. Although faced with lack of labour and financial losses, electricity supply as provided by PRHEPC allowed Chinese businessmen to participate in tin mining activities, and to innovate mining methods. Evidently, the role played by PRHEPC through supplying electricity has a significant impact on ensuring the growth of the tin mining sector in Kinta Valley.

Funding.

This research received no funding.

Conflicts of interest.

The authors declare no conflict of interest.

References

Allen, R. C. (2009). *The British Industrial Revolution in Global Perspective*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511816680

Annual Report and Account of the Electrical Department for the year 1927. (1928). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report and Account of the Electrical Department for the year 1929. (1930). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report and Account of the Electrical Department for the year 1930. (1931). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report and Account of the Electrical Department for the year 1932. (1933). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report and Account of the Electrical Department for the year 1935. (1936). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report and Account of the Electrical Department for the year 1939. (1940). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report on The Social and Economic Progress of The People of Perak for the year 1933. (1934). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report on The Social and Economic Progress of The People of Perak for the year 1934. (1935). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report on The Social and Economic Progress of The People of Perak for the year 1935. (1936). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report on the Social and Economic Progress of the People of Perak for the year 1936. (1937). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report on The Social and Economic Progress of The People of Perak for the year 1937. (1938). Kuala Lumpur: The Federated Malay States Government Press.

Annual Report on the Social and Economic Progress of the People of Perak for the year 1938. (1939). Kuala Lumpur: The Federated Malay States Government Press.

Anonymous. (1958). Obituary: Edwin Charles Steer, 1893–1957. *Proceedings of the Institution of Civil Engineers*, *9*(2), 190–191. https://doi.org/10.1680/iicep.1958.2290

B. C. L.-J. (1957). Gordon Mabor Walker. *Journal of the Institutional of Electrical Engineers*, *3*(27), 173–174. https://digital-library.theiet.org/content/journals/10.1049/jiee-3.1957.0093

Chan, Ch. H. (1967). *The Development of British Malaya, 1896–1909.* Kuala Lumpur, New York: Oxford University Press.

Courtney, P. P. (1972). *A Geography of Trade and Development in Malaya*. London: G. Bell and Sons Limited.

Drake, P. J. (1979). The economic development of British Malaya to 1914: An essay in historiography with some questions for historians. *Journal of Southeast Asian Studies, 10*(2), 262–290. https://doi.org/10.1017/S0022463400014247

Fermor, L. L. (1940). *Report upon the Mining Industry of Malaya*. Kuala Lumpur: Government Press.

Hellstrom, B. M. (1935). The Perak River Hydro-Electric Power Scheme. *Minutes of the Proceedings of the Institution of Civil Engineers, 239*(1935), 253–312. https://doi.org/10.1680/imotp.1935.15278

High Commissioner Office. (1919). 2530. *High Commissioner Office.* Engagement of Mr. F. Bolton as Expert Adviser on Electric.

Hoong, Y. Y. (1969). *The Development of the Tin Mining Industry of Malaya*. Kuala Lumpur: Oxford University Press.

Ingham, F. T., & Bradford, E. F. (1960). *The Geology and Mineral Resources of the Kinta Valley, Perak.* Kuala Lumpur: The Government Press.

Jackson, N. R. (1963). Changing patterns of employment in Malayan tin mining. *Journal of Southeast Asian History, 4*(2), 141–153. https://doi.org/10.1017/S0217781100002830

Ken, W. L. (1965). *The Malayan Tin Industry to 1914*, Tucson: University of Arizona Press.

Kikkawa, T. (2006). The role of Matsunaga Yasuzeamon in the development of Japan's electric power industry. *Social Science Japan Journal, 9*(2), 203–219. https://doi.org/10.1093/ssjj/jyl032

King, A. W. (1940). Changes in the tin mining industry of Malaya. *Geography, 25*(3), 130–134. https://www.jstor.org/stable/40561301

Kinloch, R. F., (1966). The growth of electric power production in Malaya. *Annals of the Association of American Geographers, 56*(2), 220–235. https://doi.org/10.1111/j.1467-8306.1966.tb00555.x

Michaels, R. J. (2006, July 13). Vertical Integration and the Restructuring of the U.S. Electricity Industry. *Policy Analysis*, (572), 1–32. https://www.cato.org/sites/cato.org/files/pubs/pdf/pa572.pdf

Muzaffar, T. (1989). *Power Builds The Nation: The National Electricity Board of the States of Malaya and Its Predecessors (Vol. I: The Formative Years)*. Kuala Lumpur: The National Electricity Board of the States of Malaya.

Muzaffar, T. (1991). *Power Builds The Nation: The National Electricity Board of the States of Malaya and Its Predecessors (Vol. II: Transition and Fulfilment)*. Kuala Lumpur: Tenaga Nasional Berhad.

Perak Administration Report for the year 1923. (1924). Kuala Lumpur: Federated Malay States Government Printing Office.

Perak Administration Report for the year 1925. (1926). Kuala Lumpur: Federated Malay States Government Printing Office.

Perak Administration Report for the year 1926. (1927). Kuala Lumpur: Federated Malay States Government Printing Office.

Perak Administration Report for the year 1931. (1932). Kuala Lumpur: Federated Malay States Government Printing Office.

Perak Hydro-Electric Company. (1929). CO 717/64/62367. Colonial Office: Federated Malay States Original Correspondence.

Perak Hydro-electric Scheme. (1927). CO 717/56/29074. Colonial Office: Federated Malay States Original Correspondence.

Perak River Hydro Electric Company: Title to Land. (1929). CO 717/65/62367/C. Colonial Office: Federated Malay States Original Correspondence.

Perak River Hydro-Electric Power Co. (1936). CO 717/51556. *Directors' Report and Statement of Accounts for the year ended 31st July 1935*. Colonial Office: Federated Malay States Original Correspondence.

Perak River Hydro-Electric Power Company. (1931). CO 717/79/82367. Colonial Office: Federated Malay States Original Correspondence.

Rennie, W. J. H. (1935). The construction of the Chenderoh water-power plant of the Perak river hydro-electric power scheme. *Minutes of the Proceeding of the Institution of Civil Engineering, 239*(1935), 313–355. https://doi.org/10.1680/imotp.1935.15279

Report on The Administration of The Mines Department and on The Mining Industries for the year 1928. (1929). Kuala Lumpur: The Federated Malay States Government Press.

Report on The Administration of The Mines Department and on The Mining Industries for the year 1930. (1931). Kuala Lumpur: The Federated Malay States Government Press.

Report on The Administration of The Mines Department and on The Mining Industries for the year 1934. (1935). Kuala Lumpur: The Federated Malay States Government Press.

Report on The Administration of The Mines Department and on The Mining Industries for the year 1936. (1937). Kuala Lumpur: The Federated Malay States Government Press.

Report on The Administration of The Mines Department and on The Mining Industries for the year 1939. (1940). Kuala Lumpur: The Federated Malay States Government Press.

Richardson, J. A. (1939). *The geology and mineral resources of the neighbourhood of Raub, Pahang, Federated Malay States, with an account of the geology of the raub australian gold mine*. Singapore: Geological Survey Department.

Rus, A. K. A. M. (2006). *Perkembangan Majlis Mesyuarat Persekutuan, 1909–1927 [The Development of Federal Council, 1909–1927]* (Unpublished Doctoral dissertation). Kuala Lumpur: Universiti Malaya [in Malay].

Sidhu, J. S. (1980). *Administration in the Federated Malay States, 1896–1920*. Kuala Lumpur, New York: Oxford University Press.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513

Solow, R. M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics, 39*(3), 312–320. https://doi.org/10.2307/1926047

Stern, D. I. (1997). Limits to substitutional and irreversibility in production and consumption: A neoclassical interpretation of ecological economics. *Ecological Economics, 21*(3), 197–215. https://doi.org/10.1016/S0921-8009(96)00103-6

Swettenham, F. (1906). *British Malaya: An Account of the origin and progress of British influence in Malaya*, London: John Lane The Bodley Head. https://doi.org/10.4324/9780429459047

The public supply of electricity power and light in Malaya: Interim Report. (1921, July 26). C. O. 576/23. Colonial Office: Federated Malay States, Minutes of Meeting and Proceedings of the Federal Council.

Voules, A. B. (1921). *The Laws of the Federated Malay States, 1877–1920, Vol. 2.* London: Hazell, Watson & Viney.

Warnford-Lock, C. G. (1907). *Mining in Malaya for gold and tin.* London: Crowther and Goodman.

Wilkinson, R. G. (1973). *Poverty and progress: An ecological model of economic development.* London: Methuen.

Winstedt, R. O. (1927). The Great Flood, 1926. *Journal of Malaysian Branch of Royal Asiatic Society, 5*(2), 295–309. https://www.jstor.org/stable/24249117

Wrigley, E. A. (1988). *Continuity, Chance and Change: The Character of the Industrial Revolution in England*. Cambridge: Cambridge University Press.

Yusof, T. A. (2019, March 18). HMS Malaya: Federated Malay States paid for ship. *New Straits Times*. Retrieved from https://www.nst.com.my/news/nation/2019/03/470285/hms-malaya-federated-malay-states-paid-ship

Мохамад Хайрул Ануар Мохд Рослі
Університет науки Малайзії, Малайзія

Ахмад Камал Ариффін Мохд Рус
Університет Малайя, Малайзія

Суффіан Мансор
Насціональний університет Малайзії, Малайзія

Електрифікація шахтової промисловості в долині Кінта: Роль компанії "Гідроелектроенергетична компанія "Річка Перак" (1927–1940)

Анотація. *Електрику почали впроваджувати в колоніальній Малайзії вже з 1890-х років, а до 1920-х вона стала основним джерелом енергії в гірничій промисловості з видобутку олова. Дивно, що, незважаючи на її важливу роль у економіці, електроенергетика отримала мало уваги в історіографії Малайзії. У головному центрі гірництва олова країни, у долині Кінта в Пераку, компанія "Гідроелектроенергетична компанія "Річка Перак" зі штаб-квартирою в Лондоні відігравала значну роль у постачанні електроенергії гірничим операторам. З початку 1920-х років британський уряд планував розвивати гідроенергетику, будуючи греблі на річці Перак. Вони вважали річку Перак важливим джерелом гідроенергії для електрифікації колоніальної Малайзії, особливо для гірничої промисловості. Фінансові обмеження, однак, змусили британський уряд передати відповідальність компанії "Гідроелектроенергетична компанія "Річка Перак". Ця стаття спрямована на визначення того, як "Гідроелектроенергетична компанія "Річка Перак" керувала розвитком електропостачання та його значення для гірників у долині Кінта до 1940 року. "Гідроелектроенергетична компанія "Річка Перак" диверсифікувала стратегії розвитку енергетичних об'єктів, щоб гарантувати постачання електроенергії гірничим операторам на великій території. Їх здатність експлуатувати річку Перак через будівництво гідроелектростанції великої потужності та стратегія поєднання систем генерації пари і мережевих систем дозволили "Гідроелектроенергетична компанія "Річка Перак" ефективно забезпечувати електроенергією велику кількість гірничих операторів у долині Кінта. Розвиток був фінансово вигідним для енергетичних компаній, оскільки цей капіталозберігаючий підхід дозволив їм генерувати електроенергію за значно нижчою ціною, ніж станції на кам'яному вугіллі для їхніх споживачів. Дешева енергія дозволила гірничим операторам мінімізувати витрати на видобуток олова, особливо коли сектор перейшов від праце-інтенсивної до капіталомісткої стратегії бізнесу. Для домінування в гірничому секторі оператори вкладали значні інвестиції в модернізацію методів видобутку за допомогою використання машин, таких як високовартісні екскаватори. Тому було надзвичайно важливо для гірничих операторів отримувати дешеву енергію для компенсації витрат на інвестиції. Цей кейс показав, що розвиток гірничого сектору в долині Кінта був важливим не лише використанням електрики, але й її економічним виробництвом за допомогою гідроелектрики.*

Ключові слова: *видобуток олова; річка Перак; гідроелектрика; методи гірничого видобутку; капіталомісткі*

Received 19.09.2023
Received in revised form 22.11.2023
Accepted 29.11.2023