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LONDON

ELECTRICITY HUB OF BRITAIN

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Introduction

Michael Faraday's discovery of electro-magnetic induction (the foundation of electricity generation and electric motors) in September 1831[1] was celebrated a century later by various events in London.[2] These included an exhibition at the Royal Albert Hall, public lectures and a government dinner. Also in London, the British Association for the Advancement of Science (founded in 1831)[3] was holding its first annual meeting in the capital. More visible to the general public was the floodlighting of many public buildings as part of the International Illumination Congress that was holding its first meeting in England.[4] These special illuminations contrasted with the garish electric signs around Piccadilly Circus.

A special "Faraday Number" supplement published in ***The Times*** on 21 September 1931 included 37 articles that covered not only tributes to Faraday and his work but also the achievements of his successors in developing lighting, power, traction and radio. Some of the corporate advertising in the supplement stressed linkages with Faraday such as the Phillips headline: "Look Faraday! See what we have done with your coils". Others such as the General Electric Company emphasized size and the empire connection or the practical benefits like Berry's Electric "Magicoal fires".

For some historians September 1931 is a watershed in British history marked by the abandonment of the gold standard and the end of free trade.[5] The passing of so many of the pioneers of British electrification--Sebastian Z. De Ferranti (1864-1930), Emile Garcke (1856-1930), Thomas Edison (1847-1931) and Charles Parsons (1854-1931) also marked a turning point and the end of the "electric revolution".[6] By this time electrification had penetrated most parts of economic and social life. The process was, however, still incomplete and has continued to expand.

The gathering of so many people representing all branches of electricity highlighted the role of London as a transactional centre.[7] For convenience the multiplicity of transactions may be grouped into three interlocking sectors (**Figure 1**). Each sector includes a variety of interrelated activities. In the Science and Technology sector, various ideas generated in research establishments, universities and workshops were translated into products with commercial value. The Business sector covers all types of electricity supply

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[1] Michael Faraday (1791-1867) made his discovery at the Royal Institution. Brian Bowers, ***A History of Electric Light and Power*** (Stevenage: Peter Peregrinus/Science Museum, 1982), Chapter 2, "Michael Faraday", pp.12-24. The television series, "Shock and Awe: The Story of Electricity" (BBC Four, 2011) presented by Professor Jim Al-Khalili, explained the significance of Faraday's work in Episode 2 "The Age of Inventions".

[2] For the wider context of the celebrations, see: Frank A.J.L. James, "The Janus face of modernity: Michael Faraday in the twentieth century", ***British Journal for the History of Science***, Vol. 41(4), 2008, pp. 477-516. The events were well publicised in Britain and around the world. The BBC devoted its evening national programme on 21 September to the Queen's Hall meeting where the speakers included Sir William Bragg of the Royal Institution, the prime minister, Senator Marconi and various overseas guests. The rebroadcast to New Zealand, however, could not be heard by listeners due to atmospheric conditions and weak signals from the Chelmsford relay station. ***The Star*** (Christchurch) 22 September 1931, p.3. (Accessible online at Papers Past, www.natlib.govt.nz/newspapers)

[3] The London meeting was attended by 5,702 members, visitors and guests. See British Association for the Advancement of Science, ***Report of the Annual Meeting 1937 Nottingham*** (London: BAAS, 1937), pp.xiv-xv.

[4] "The International Illuminating Congress", ***Nature***, Vol.128, 1931, pp.588-589. Nearly 500 delegates were registered for the Congress which me in various centres including London.

[5] A.J.P. Taylor, ***England 1914-1945*** (Oxford: Oxford University Press, 1965. Reprinted with new introduction, London: Folio Society, 2000). See especially pp.251-261.

[6] Two major studies of electrification conclude in 1930. Se R.A.J. Hennessey, ***The Electric Revolution*** (Newcastle upon Tyne: Oriel Press, 1972) and Thomas P. Hughes, ***Networks of Power: Electrification in Western Society, 1880-1930*** (Baltimore: Johns Hopkins University Press, 1983).

[7] See Kenneth E. George, "Transactional forces and the metropolis", ***Ekistics***, Vol.49, 1982, pp.416-423. Transactional forces are often described as the Quaternary sector of the economy and involve the creation, analysis and dissemination of information. Some of the information generated forms the basis for decision-making in the traditional sectors: Primary (extractive), Secondary (manufacturing), and Tertiary (services). Activities in the Quaternary sector include research and development, business services, higher education, and government policymaking.

undertakings and the manufacture of equipment and electrical products as well as the associations that supported all operations. Almost all activities involved the State in some way—government-supported laboratories, legal frameworks covering contracts, patents, safety regulations and most importantly the granting of franchise areas.

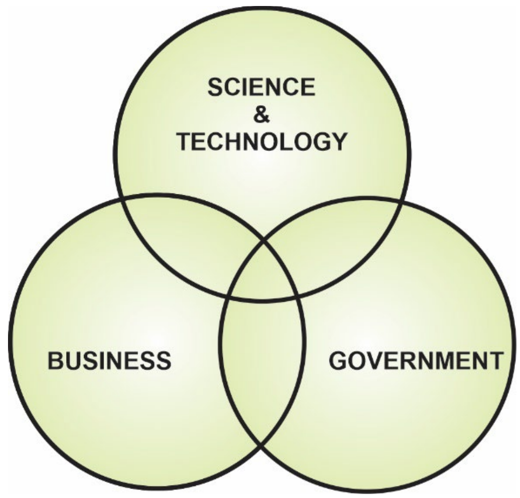

Figure 1 ELECTRICITY TRANSACTIONS AND SECTORS.

Most of the interaction between the sectors was in the form of information—the exchange of ideas, promotion of products and services, negotiation of contracts and the settling of disputes. The national transmission grid, at the peak of construction activity in 1931, was a clear example of the complex of transactions that were concentrated in London. Every stage of development had involved consultations: first around the legislation in 1926, then the appointment of the Central Electricity Board, followed by the preparation of the area schemes by the Electricity Commissioners and consulting engineers. Implementation of the schemes required further rounds of consultation—for arranging loans, planning substations at or near existing power stations, and negotiating contracts for the supply of equipment. As the transmission lines began to cross the countryside, objections by community groups had to settled by public inquiries and ultimately by decisions of the Minister of Transport.

Members of the Institution of Electrical Engineers were an integral part of most transactions affecting electricity supply. They formed the core of a technical elite that had evolved in the late 19th century.[8] Membership of the IEE extended across all sectors from the National Physical Laboratory to the management of electricity undertakings and government where three of the four Electricity Commissioners were members of the Institution. The IEE in Savoy Place served as meeting place and information centre with an extensive library and publication programme of journals and science abstracts. Publications and regional branches provided links with members across the British Isles and overseas.

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[8] See Sophie Forgan, "From modern Babylon to White City: Science, technology and urban change in London, 1870-1914", chapter 3 in Miriam R. Levin et al., ***Urban Modernity: Cultural Innovation in the Second Industrial Revolution*** (Cambridge, Mass: MIT Press, 2010). Parts of this chapter add a further perspective to the work of W.J. Reader, ***A History of the Institution of Electrical Engineers 1871-1971*** (London: Peter Peregrinus, 1987).

A few examples illustrate the interlocking roles of individual members of the IEE in 1931. John Kennedy[9] had prepared the way for the formation of the Electricity Board for Northern Ireland which subsequently appointed Kennedy & Donkin as consulting engineers. Sir James Devonshire[10] had been responsible for North Metropolitan Electric Power Co., was a director of the Underground Electric Railway Company of London Ltd (1919-1933) and a member of the Central Electricity Board (1927-1936). At least three Members of Parliament held memberships in the Institution and had various business ties. Percy Pybus[11] (MP Harwich 1929-) was appointed Minister of Transport and responsible for electricity supply in the new National Government. George Balfour[12] (MP Hampstead 1919-) was chairman and founder of Power Securities (1922--), one of the largest holding companies in British electricity supply, as well as founder of the large construction company Balfour & Beatty Ltd. He had been opposed to the 1919 and 1926 Electricity (Supply) Acts, claiming that private companies could accomplish similar ends. Sir Philip Dawson[13] (MP West Lewisham 1921--) was a consulting engineer especially for electric traction and, in contrast to Balfour, had supported the 1926 legislation.

Central London (**Figure 2**) was a complex area of offices, public buildings, retailing, entertainment and mixed residential land uses. The area included all the service infrastructure for the conduct of transactions. Among the many facilities were research laboratories, reference libraries, the Patents Office, specialized printing and publishing, financial services and international telecommunications.[14] The eastern part of the area was governed by the City of London while much of the western area was included in the City of Westminster (an amalgamation of parishes created in 1900). Buildings associated with electricity transactions were located in various parts of the area.

The largest concentration was in Kingsway (opened in 1905) and adjacent streets. British Electric Traction had been established on Norfolk Street, off the Strand, in 1897 and had moved to one of the first office blocks on Kingsway a decade later. The Institution of Electrical Engineers moved to Savoy Place in 1910, taking over a building previously used by the Royal Colleges of Surgeons and Physicians. By 1931 the head offices of the largest British electrical manufacturers had been established in Kingsway and the Electricity Commissioners had moved from Whitehall to Savoy Court (in 1925). The district was a major centre of communications with Marconi's Wireless Telegraphy Co. in the Strand and the BBC radio broadcasting studios at Savoy Hill.[15]

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[9] John M. Kennedy (1879-1954), son of Alexander Kennedy. Partner in Kennedy & Donkin 1912-1934 when he was appointed an Electricity Commissioner. Elected President of the IEE in 1935. Obituary in ***The Engineer*** Vol.198, 1954, pp.361-362.

[10] Sir James Devonshire (1863-1946), educated at City & Guilds College. After service with British Thomson-Houston was associated with British Electric Traction for the development of Metropolitan Tramways and Northmet from 1899 until 1946. He was briefly chairman of Edmundson's Electricity Corporation 1929-1930. N.C. Friswell, ***Northmet*** (2000) pp.209/240.

[11] Percy John Pybus (1880-1935) began working at the Phoenix Dynamo Co. Bradford in 1906 and later became managing director and chairman of the English Electric Company after Phoenix was amalgamated with Dick, Kerr & Co., Preston and Willans & Robinson, Rugby in 1918. He was probably the only electrical engineer to serve as a government minister.

[12] George Balfour (1972-1941) was a major figure in British electrification, in construction work for tramways, hydroelectric projects and ownership of major companies. See Leslie Hannah, "Balfour, George", in ***Dictionary of Business Biography Vol.1*** (London: Butterworths, 1984), pp.125-128.

[13] Sir Philip Dawson (1866-1938) was born in Paris and educated in Belgium. He was noted for his consulting work on electric railways in Britain and overseas. Elected to the London County Council in 1919, he entered national politics as MP for West Lewisham in 1921. He became a director of the Greater London & Counties Trust Ltd in the late 1920s and was also a director of Edmundson's Electricity Corporation and Johnson & Phillips Ltd in 1931. Obituary in ***The Engineer***, Vol.16, 1938, p.366.

[14] The major centres were the General Post Office at St Martins le Grand and the Eastern Telegraph Co. at 84 Moorgate, as well as the Marconi Wireless Telegraph Co. in the Strand. The Eastern Telegraph Co. and part of the Marconi Co. were later amalgamated as Cable & Wireless Ltd.

[15] The BBC rented space in the IEE building from 1923 to 1932 when all work was transferred to the newly completed Broadcasting House. See W.J. Reader, ***History of the IEE*** (1987), pp.110-111.

Table 1 CENTRAL LONDON: SELECTED SITES OF ELECTRICITY TRANSACTIONS 1931.

	FARADAY CENTENARY		
1	Dorchester Hotel	Park Lane	W1
2	Queen's Hall	Langham Place	W1
3	Royal Albert Hall	Kensington Gore	SW7
4	Royal Institution	Albemarle St	W1
	SCIENCE & TECHNOLOGY		
1	British Museum (Library)	Great Russell St	WC1
2	Faraday House (College)	Southampton Row	WC1
3	Imperial College	Imperial Institute Road	SW7
4	Institution of Civil Engineers	Great George St	SW1
5	Institution of Electrical Engineers	Savoy Place	WC2
6	Institution of Mechanical Engineers	Storey's Gate	SW1
7	King's College	Strand	WC2
8	Royal Society	Piccadilly	W1
9	Science Museum	Exhibition Road	SW7
10	University College	Gower Street	WC1
	BUSINESS		
	a) *Holding companies*		
1	British Electric Traction Co. Ltd	Kingsway	WC2
2	British Power & Light Corpn (1929) Ltd	Smith Place	EC2
3	County of London ES Co.	New Broad St	EC2
4	Edmundson's Electricity Corpn	Broad Sanctuary	SW1
5	Electric Supply Corporation Ltd	London Wall	EC2
6	Power Securities Corporation Ltd	Queen St	EC4
7	Whitehall Securities Ltd	Whitehall	SW1
	b) *Manufacturing companies*		
8	Associated Electrical Industries	Aldwych	WC2
9	English Electric Co.	Kingsway	WC2
10	Callender's Cable & Construction Co.	Temple Avenue	EC4
11	General Electric Co.	Kingsway	WC2
12	Marconi Wireless Telegraph Co.	Strand	WC2
	c) *Associations*		
13	British Electrical & Allied Mftrs Assn	Kingsway	WC2
14	Electrical Development Assn	Savoy St	WC2
15	Electric Power Engineers Assn	St George's Square	SW1
	GOVERNMENT		
1	Board of Trade	Great George St	SW1
2	Central Electricity Board	Charing Cross	WC2
3	Company Registration	Somerset House	WC2
4	Crown Agents for the Colonies	Millbank	SW1
5	Dept of Scientific & Industrial Research	Old Queen St	SW1
6	Electricity Commissioners	Savoy Court	WC2
7	General Post Office	St Martins le Grand	EC1
8	Ministry of Transport	Whitehall Gardens	SW1
9	Patents Office	Southampton Buildings	WC2
10	Public Works Loan Board	Old Jewry	EC2

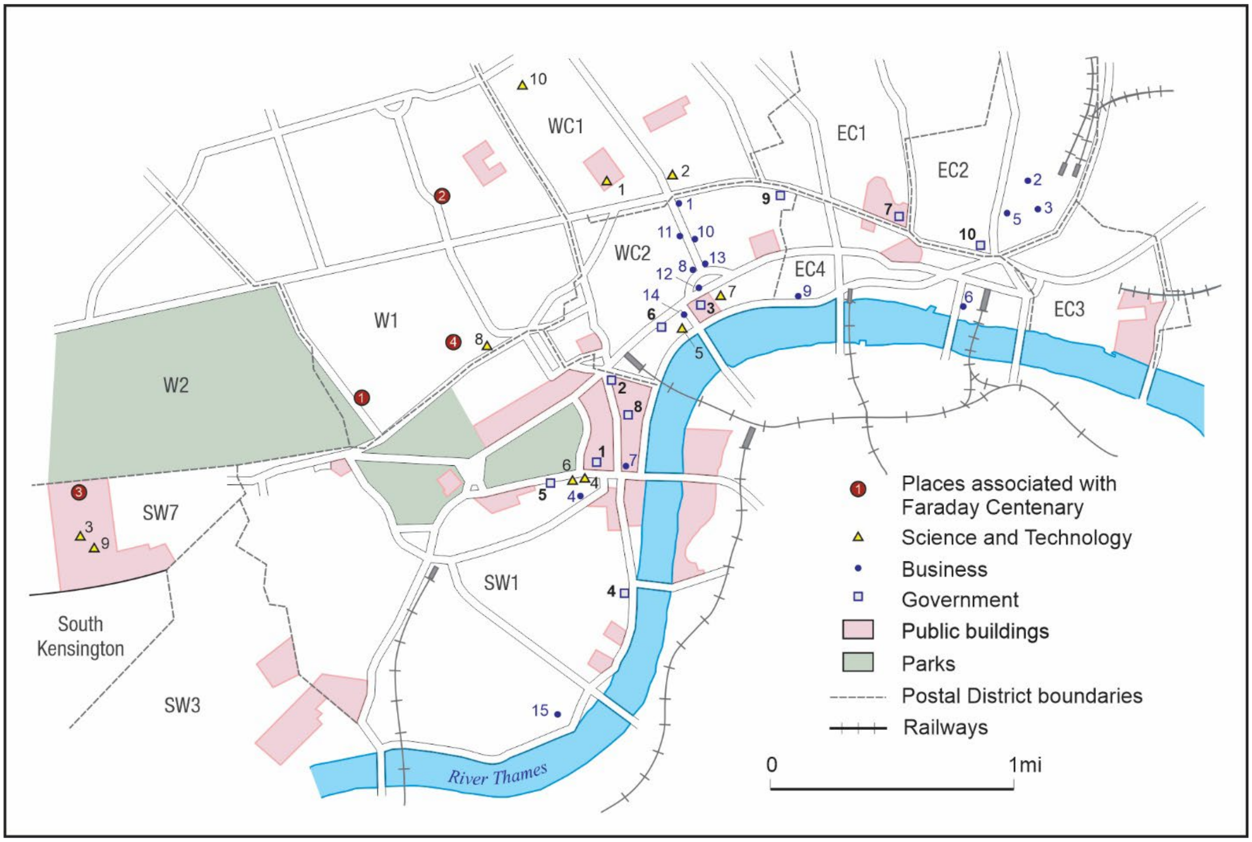

Figure 2 CENTRAL LONDON: SELECTED SITES OF ELECTRICITY TRANSACTIONS 1931.

A second concentration was in the area between Victoria Street and St James's Park. Close to Parliament, the Institution of Civil Engineers had opened its headquarters in 1839 and consulting engineers had followed. The preparation of Electric Lighting Orders (1882-1919) had fostered close relationships with the Parliamentary agents also located in this area. The move of the Institution of Mechanical Engineers from Birmingham in 1877 further reinforced the engineering linkages. Edmundson's Electricity Corporation, one of the earliest holding companies, had established its head office at Broad Sanctuary by 1900. New small government departments also opened offices here--the Department of Scientific and Industrial Research in 1916 and the University Grants Committee in 1919. Other government establishments in 1931 included the Ministry of Transport in Whitehall Gardens, the Central Electricity Board in Trafalgar Buildings and the Crown Agents for the Colonies in Millbank. The latter organization was important in arranging contracts with consulting engineers and equipment suppliers, such as for the development of electricity supply in Suva, Fiji in the early 1920s.

Other clusters of establishments in 1931 included South Kensington and the City. South Kensington had Imperial College (1907) and the earlier institutions of the Royal College of Science, the School of Mines and the City & Guilds Engineering College. The City had the headquarters of several electricity holding companies and many special financial institutions such as the Public Works Loan Board which arranged capital borrowings for smaller electricity undertakings.

Associations were always attracted to Central London when they could afford the high rents for office space. The British Electrical and Allied Manufacturers Association was well endowed by members and had offices in Kingsway. In contrast the Electrical Development Association with more limited financial support had to settle in Savoy Street. Both locations were close to advertising agencies and the newspaper and magazine publishing industry in Fleet Street.[16] The Electric Power Engineers Association, then a small organization, took premises in St George's Square, Pimlico. When finances improved in 1932, the Electrical Association for Women moved from Kensington to 20 Regent Street which was much more accessible for members and closer to the centres of influence.[17]

I. Science and Technology

Learned societies established London's role in science and technology. The Royal Society for Improving Natural Knowledge, founded in 1660, began a long tradition of experimental work, publishing papers and providing scientific advice to governments. The Society for the Encouragement of Arts, Manufactures and Commerce, established in 1754, fostered work in many fields particularly agriculture and supported the development of more specialised societies. The Royal Institution was created in 1799 for the diffusion of knowledge and to facilitate the introduction of useful mechanical inventions and improvements. Public lectures on the application of science to the common purposes of life were a very important part of the work of the institution. Such lectures helped to prepare the elite for a long series of innovations which transformed society in the 19th century. Under the direction of Sir Humphrey Davy and then Michael Faraday, the institution prospered and facilitated many advances in science.[18]

London's first university colleges were created in the late 1820s and King's College and University College quickly became centres of research and education in science and engineering. Electrical technology emerged quickly from the early scientific discoveries. Charles Wheatstone (1802-1875), appointed to the chair of experimental physics at King's College in 1834, developed the electric telegraph with William Cooke (1806-1879). The first line between Camden Town and Euston Station on the London & Birmingham Railway was tested in July 1837.[19] Two years later the Great Western Railway installed a system between Paddington and West Drayton.

Telegraph systems, especially on railways, were expanded rapidly in the 1840s and their operation was enhanced by the work of Samuel Morse in the United States. Submarine cables linked England with France (1851) and Scotland with Ireland (1853).[20] London became the major centre of the world telegraph system as the cables reached out to India (1864) and North America (1866).[21] New Zealand, the most distant outpost of empire, was connected by cable across the Tasman Sea in 1876.[22]

London's commercial dominance was reinforced by the electric telegraph and the new communication technology was also reflected in manufacturing. The existing skills in making scientific instruments were extended to producing transmitting and receiving equipment. New products manufactured in London also included batteries, wires, insulators and submarine cables.

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[16] In 1930 there were four electrical weekly papers: ***Electrical Review***, ***Electrical Times***, ***Electrician*** and ***Electricity*** which were all published in the district. See ***Whitaker's Almanac*** 1931.

[17] ***The Woman Engineer***, Vol.III (13), December 1932, p.193. The EAW had previously occupied space from R.E. Crompton at 46 Kensington Court.

[18] O.J.R. Howarth ed., ***London and the Advancement of Science*** (London: British Association for the Advancement of Science, 1931), pp.38-51.

[19] Percy Dunsheath, ***A History of Electrical Power Engineering*** (Cambridge, Mass.: MIT Press, 1962), p.77.

[20] Dunsheath (1962), pp.211-212.

[21] Ben Marsden and Crosbie Smith, ***Engineering Empires: a cultural history of technology in nineteenth-century Britain*** (Basingstoke: Palgrave Macmillan, 2005. Chapter 5, "'The most gigantic electrical experiment': The Trials of Telegraphy", pp.176-225.

[22] Howard Robinson, ***A History of the Post Office in New Zealand***, Wellington: Government Printer, 1964), p.156.

Wireless telegraphy was also pioneered in London, developed by Guglielmo Marconi (1874-1937) and supported in the early years by the resources of the General Post Office.[23] By 1899 wireless transmission was established between Dover and Boulogne. Two years later the high-powered transmitter at Poldhu in Cornwall was in communication with St Johns, Newfoundland. With the protection of various patents and financial support from City interests such as Lloyd's marine insurance, the Marconi Wireless Telegraph Company expanded rapidly with installations around the world. By 1913 there were 50 civilian land stations in Britain and many vessels were equipped with wireless systems.[24] The Marconi company established its manufacturing base at Chelmsford.

While London was a major centre for the development of telegraphy, other electrical innovations were made elsewhere. Early electric generators were built by Zénobe Théophile Gramme (1826-1901) in Paris from 1870.[25] Siemens & Halske in Berlin were also making generators from this time and were pioneers in making electric motors for traction by the end of the decade. Arc lighting was developed in Paris by Paul Jablochkoff (1847-1894) and in the United States by Charles F. Brush (1847-1929).[26] Incandescent lighting emerged from the work of Thomas Alva Edison (1847-1931) and Joseph Wilson Swan (1828-1914) in Newcastle in the late 1870s. Edison had begun making telegraph instruments in 1869 and in 1876 established a research laboratory at Menlo Park, New Jersey, which produced a remarkable number of inventions including the carbon filament lamp, phonograph and telephone microphone.[27]

Electrical engineering which was evolving at a rapid pace in the late 1870s received some formal recognition in 1885 when University College London appointed J. Ambrose Fleming (1849-1945) as the first professor in this field. The consulting work of academics was very important in implementing the research knowledge gathered in laboratories. John Hopkinson (1849-1898) at King's College was not only active in scientific circles but also acted as an expert witness in patent cases and Parliamentary Committees. He made various improvements to the Edison dynamo as a company consultant in the early 1880s, worked on various electric traction projects with his brother Edward (1860-1922) and designed the DC system and power station for the central area of Manchester.[28]

London consulting electrical engineers, acting as individuals or in partnerships, were most significant from the 1880s to 1914. Their work involved designing power stations, distribution networks and electric tramway systems and railway electrification for local authorities and companies across the British Isles and overseas. They followed an earlier generation of civil and mechanical engineers in the Westminster district along the Victoria Street axis. The location close to Parliament was valuable in the application process for Electric Lighting Orders under the 1882 legislation. Among the major partnerships were: Bramwell & Harris; Kennedy & Donkin; Kincaid, Waller, Manville & Dawson; Medhurst, Page & Lloyd; and Preese, Cardew & Rider. Merz & McLellan, mostly based in Newcastle, opened a London office in 1901.

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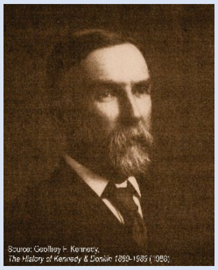
[23] Dunsheath (1962), p.269.
[24] ***The Year-Book of Wireless Telegraphy and Telephony 1913*** (London: St Catherine Press, 1913.
[25] Brian Bowers, ***A History of Electric Light and Power*** (Stevenage: Peter Peregrinus/Science Museum, 1982), p.90.
[26] The Brush company was taken over by the Thomson-Houston company in the 1880s and Thomson-Houston became part of General Electric in 1892. In Britain the Brush name as perpetuated by the Brush Electrical Engineering Co. Ltd, first in London and then in Loughborough. The British Thomson-Houston company retained its name partly to disguise the ownership by the American General Electric company.
[27] Bowers (1982), p.40.
[28] James Greig, ***John Hopkinson, electrical engineer*** (London: Science Museum, HMSO, 1970).



Sir Alexander Kennedy, FRS (1847-1928)

Mechanical and Electrical Engineer

Alexander Blackie William Kennedy was born in Stepney, London, son of the Rev. John Kennedy DD. He was educated at the City of London School and the School of Mines. Further training and experience were in marine engines, first in Millwall and then in Jarrow and from 1868 to 1871 in Leith where he was chief draughtsman at T.M. Tennant & Co. For the next few years he was a partner with Bennett & Kennedy, consulting marine engineers.[a]

In 1874 Kennedy was appointed Professor of Engineering at University College, London. One of his many innovations was an engineering laboratory (1878) one of the first to be established and later copied worldwide. As an academic he published several books and his research into the strength and elasticity of various materials was recognised by election as a Fellow of the Royal Society in 1887.

Seeing the potential of electricity as a new industry, Kennedy made a major career change. In 1889 he resigned from University College to become a consulting electrical engineer in Westminster. One of his first projects was for the newly formed Westminster Electric Supply Company where he designed the distribution system and three DC power stations.at Millbank, Eccleston Place and Davies Street. Later he designed the large AC station on the Regents Canal at Grove Road, St Marylebone. Other work included the power stations and electrical work for the Waterloo & City underground railway, the Great Western Railway's Paddington Station, and the Hammersmith & City line with a power station at Park Royal (1906).

Kennedy was influential far beyond London. His work for the British Aluminium Company, first at Foyers (1895) and then at Kinlochleven (1909) showed the potential of hydro-electric power. Among the many places where he designed local systems and power stations were Belfast, Glasgow, Edinburgh, Stirling, Kirkcaldy, Motherwell, Carlisle, Oldham, Manchester, Buxton, West Hartlepool, York, Rotherham, Grimsby, Ipswich, Croydon and Weymouth. In several of these projects he worked closely with the architect Stanley Peach to create power station designs that were highly acclaimed at the time.[b]

Kennedy's work in the various branches of engineering was recognised in many honours--President of the Institution of Mechanical Engineers 1894/95, a knighthood in 1905, and President of the Institution of Civil Engineers 1906/07. His experience and knowledge were important in his public service on many government committees before and during World War I. In retirement he was very active in the exploration of Petra, publishing a monograph on the subject in 1925 illustrated by his own professional photographs. Like many of that generation of electrical engineers, he was an active member of the Alpine Club.

Kennedy's legacy in electrical engineering extended long after his death through the consulting firm of Kennedy & Donkin. His younger son John Kennedy (1879-1954)[c] had joined the firm of Kennedy & Donkin in 1902 and remained as a partner until 1934 when he was appointed as an Electricity Commissioner, later becoming deputy chairman 1938-1947 and chairman in the last year of this organisation.

Kennedy & Donkin designed several of the grid schemes in the late 1920s and postwar power stations at Huncoat (Accrington), Chadderton (Oldham) and Westwood (Wigan). The district heating scheme in Pimlico using steam from the Battersea power station was designed by a member of the firm. Kennedy & Donkin was also active overseas, in Venezuela, the Owen Falls, Uganda and India.[d]

In 1998 Kennedy & Donkin became part of Parsons Brinckerhoff (a New York consulting firm established in 1885). Parsons Brinckerhoff (which had also acquired Merz & McClellan in 1995) later became part of WSP, a global company based in Montreal.

Notes

[a] Most of the biographical details presented here are summarised from obituaries: ***The Engineer***, Vol.148, 1928, pp.511-512; Institution of Civil Engineers, ***Minutes of Proceedings***, Vol.227, 1928-29, pp.269-275.
[b] Charles Stanley Peach, "Notes on the design and construction of buildings connected with the generation and supply of electricity known as Central Stations", ***Journal of the Royal Institute of British Architects*** Vol.11, 1904, pp.279-315.
[c] Sir John M. Kennedy OBE, Obituary, ***The Engineer*** Vol.198, 1954, pp.279-318. In addition to his work on the British Grid, he designed transmission systems for Northern Ireland and the Isle of Man. He served as President of the Institution of Electrical Engineers 1935-36 and received a knighthood in 1943.
[d] International work became increasingly dominant after 1948 when the nationalised industry took over much of the design work previously done by consultants. Kennedy & Donkin was the consultant for all the projects for the Electricity Board for Northern Ireland and its successor bodies from 1931 until privatisation in 1992. The projects of Kennedy & Donkin are described in detail in Geoffrey F. Kennedy, ***The History of Kennedy & Donkin 1889-1989*** (Liphook, Hampshire: Privately published), 237pp. Geoffrey Kennedy (1908-) son of John M. was the third-generation family member to serve as a partner, from 1933 to 1975. His son, John Alexander became a partner in 1972. During Geoffrey Kennedy's time with the firm, the staff grew from 30 to 900 and the offices were moved from Westminster to Woking and in 1983/84 to Godalming.

Learned societies and professional associations with their regular meetings and published proceedings were essential points in the exchange of knowledge and information. Engineering became a recognized profession by the time the Institution of Civil Engineers was formed in London in 1818. The Mechanical Engineers formed a separate Institution in 1847 (in Birmingham, moving to London in 1877). A more specialized electrical group began with the Society of Telegraph Engineers in 1871. "Electricians" were added to the Society's name in 1880 and a new title, the Institution of Electrical Engineers was confirmed in 1889. The growth in membership--from 110 in 1871 to 1,976 in 1891, to 6,327 in 1911 and 14,670 in 1931--reflected much of the development of the electricity supply industry.[29]

The British Association for the Advancement of Science formed in 1831 provided a wider forum for discussion and exchange, beginning with a meeting in York. Over the next century its annual meetings were held in provincial cities and occasionally overseas. (Four meetings were held in Canada, two in South Africa and one in Australia.) Many significant papers were read in the sessions of Section G, Engineering. The first London meeting in 1931 coincided with the Faraday Centenary.

London's role as a centre of education and training was recognized by the charter of the University of London granted in 1836. Degrees could now be awarded to students of King's College and the University College. A modified charter in 1855 allowed for external degrees, an important step in the development of provincial university colleges and for students overseas.[30] The University of London was an examining body until 1900 when teaching was added. Imperial College of Science and Technology in South Kensington was granted a Royal charter in July 1907 and became part of the University two decades later.

Technical education had various origins including the London Mechanics' Institution in 1824 (later renamed the Birkbeck Literary & Scientific Institution in 1866). The City and Guilds of London Institution formed in 1878, in response to an appeal for the promotion of technical education, established two important colleges and provided funds for some provincial cities. The Finsbury Technical College and the Central College in South Kensington quickly became important national centres for training in electrical engineering.

[29] W.J. Reader, ***History of the IEE, 1871-1971*** (1987), pp.304-305.
[30] External degrees in electrical engineering were allowed from 1907.

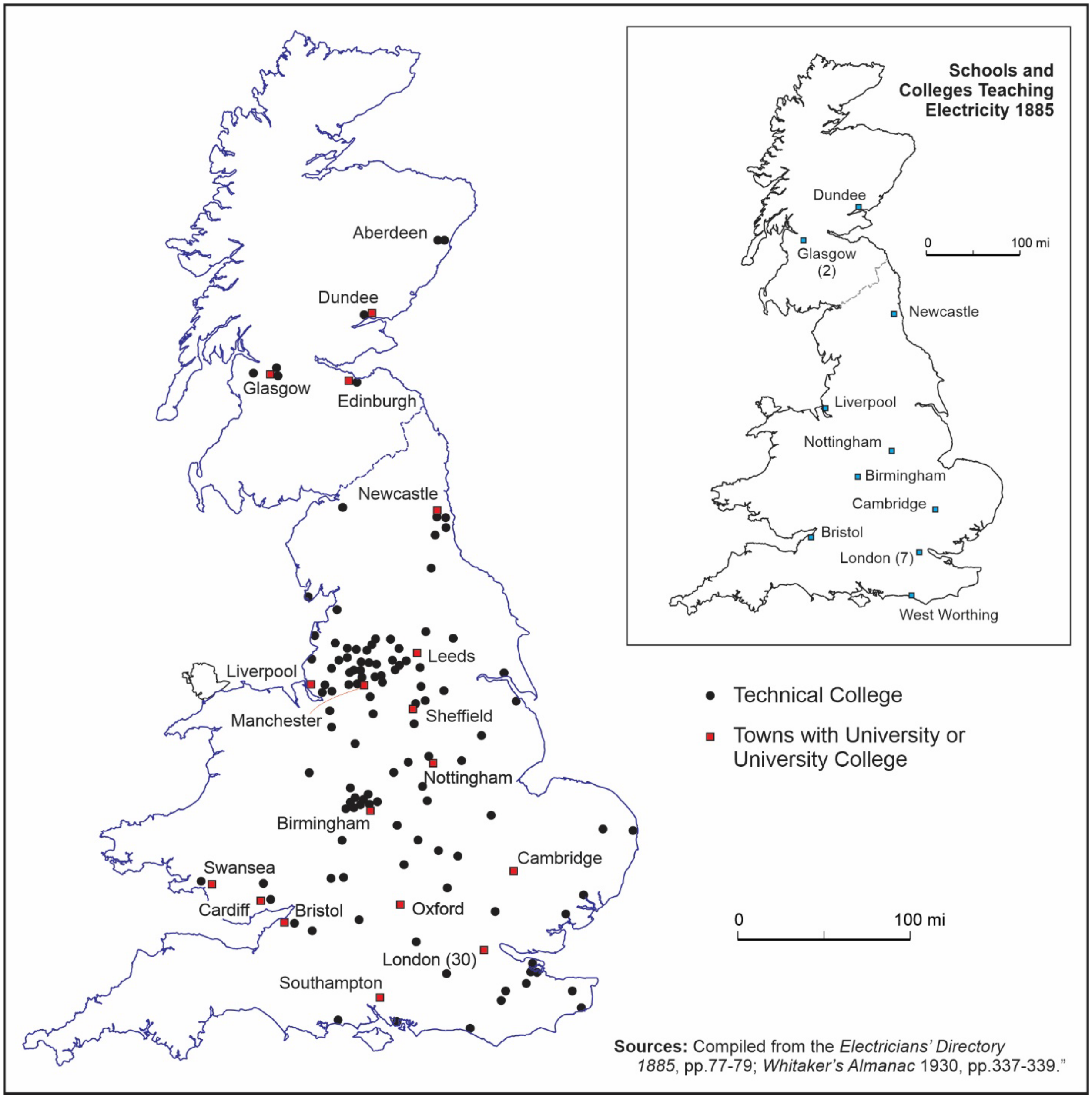


Figure 3 TECHNICAL COLLEGES 1930.

Figure 3 shows 17 schools and colleges "at which the science of electricity and its practical application are dealt with".[31] Seven of these were in London including the City and Guilds' colleges, University College, King's College, the Postal Telegraph School on Telegraph Street in the city and the School of Engineering at Crystal Palace, Sydenham. The three colleges in Scotland were notable early examples of training in electrical science.[32] Graduates from these colleges provided an important foundation for the development of public electricity supply after 1890.

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[31] ***The Electrician's Directory 1885***, pp.77-78.

[32] W.E. Farris, "Education and training of electrical engineers in Scotland" in David Dick, ed., ***A Scottish Electrical Enlightenment: Celebrating 100 Years of the Institute of Electrical Engineers in Scotland 1899-1999*** (Glasgow: IEE, 2000), pp.36-58.

The Technical Education Act 1889 was quickly adopted by the London County Council and other progressive municipal authorities.[33] By 1930 there were 29 polytechnics, colleges and technical institutions in Greater London. Nationally there at least another 130 similar institutions offering courses in technical and other subjects. Examining bodies included the City and Guilds and the University of London. A standard curriculum was adopted by a Higher National Certificate in Electrical Engineering in 1924.

Until World War I government interest in science and technology was fairly limited. The few direct activities such as the Royal Observatory at Greenwich and the Government Laboratory had practical applications for accurate navigation and measuring substances for customs and excise. While recognizing the need for national and international standards of measurement, the state preferred to award grants and charters to voluntary organisations. This was the case with the National Physical Laboratory established at Bushy Park, Teddington in 1901. The new laboratory was important for electrical measurements etc. consistent with international standards. Support for the NPL came from fees and a Treasury grant. The Laboratory was administered by the Royal Society until 1918.[34]

One of the long-lasting voluntary associations in 1931 was the British Standards Institution, first established as the Engineering Standards Committee of the Institution of Civil Engineers in 1901. Other groups such as the IEE joined in 1903. With a small office in Victoria Street, the Committee developed standards for various industrial products including recommending the 50Hz frequency for AC electricity supply. Charles le Maistre, an electrical engineer, was appointed as an assistant secretary in 1902 and became the first director of the independent British Engineering Standards Association in 1918 and the successor British Standards Institution until 1946. He was also general secretary of the International Electrotechnical Commission (formed in London in 1906) from 1908 to his death. Le Maistre was a powerful and largely unknown figure in the movements to standardise systems, and was "…the most significant standardisation entrepreneur of the first half of the twentieth century".[35]

The creation of the Department of Scientific and Industrial Research in 1916 reflected a major shift in government policy. Among the many demands for attention was the need to conserve coal. In 1918 a full-scale Fuel Research Station was opened in East Greenwich. Its work contributed to reducing coal consumption in power stations.

After the war the DSIR took over the operation of the National Physical Laboratory and promoted industrial research associations. The British Electrical and Allied Industries Research Association, formed in 1920, was an early example. By the mid-1930s the association had its own research facilities in Perivale.

Many other organisations with electrical interests began to develop specialized laboratories. The General Post Office concentrated its research on a new site at Dollis Hill. The Radio Research Board opened a research station at Slough during 1924. Private companies were also investing in research

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[33] Michael Argles, ***South Kensington to Robbins: An Account of English Technical and Scientific Education since 1851*** (London: Longmans, 1964).

[34] Sir Frank Heath, "Government and Scientific Research", Chapter V in O.J.R. Howarth, ed. ***London and the Advancement of Science*** (1937), pp.185-230. The staff of the NPL grew from 20 in 1902 to 200 in 1914 and reached 500 in 1935. See obituary of R.T. Glazebrook, ***The Engineer***, Vol.160, 1935, p.650.

[35] JoAnne Yates and Craig N. Murphy, ***Engineering Roles: Global Standard Setting since 1880*** (Baltimore: Johns Hopkins University Press, 2019) p.53. Charles le Maistre (1874-1953) was born in Jersey and educated at the Central Technical School, South Kensington. With all his national and international work, he was a clear example of the many transactional roles performed in London.

facilities such as the General Electric Company which opened a major complex at Wembley in 1923. Callender's Cables which had previously carried out all experimental work in the workshops at Erith began to develop a research laboratory in central London, eventually converting the former power station at Wood Lane for its work on high-voltage cables.[36]

London's dominance in electrical sciences was well established by the time of the Faraday Centenary celebrations. Growth continued with innovations in television, radar, computers, and other features of an evolving electronics age.[37] The role of government was enhanced in World War II and afterwards with new technologies such as nuclear energy.

II. Business

London had many advantages for a concentration of business activities associated with electricity: a large market (Greater London population 8.2 million in 1931); a world centre of financial services; national centrality in communications and transport, and all the features of a national and imperial capital.

Greater London had expanded on a grand scale since Faraday's time. The population had grown from 1.9 million in 1831 to 4.77 million in 1881 and then added another 3.45 million residents by 1931.

Major changes in accessibility enhanced the growth of London. Railway development, beginning with the London & Birmingham line opened in 1838, reduced travel times[38] and facilitated the flows of information by mail[39] and newspapers.[40] Road transport over long distances was revived by the motor vehicle and a national road network was defined by the Ministry of Transport in 1921 as a series of main highways radiating from London (A1-A6). Civil aviation, based at Croydon airport[41], was developing significantly. Telecommunications and radio broadcasting, all centred on London, added to the widening of the city's influence.

Business organization had been transformed by company legislation, new accounting practices and improved communications which allowed for much larger operations. Offices separated from warehouses or factories became increasingly common. Vickers Ltd, for example, moved its head office from Sheffield to a new block on Broadway, Westminster in 1911. Companies planning to cover the national market found that a London head office was most effective for their management. This was the case with the American retailer F.W. Woolworth which began in Liverpool in 1909 but quickly moved its head office to London, taking an office in Kingsway during 1913.[42] Marks & Spencer, based in Manchester from 1893 but recognizing the southward shift of its business, moved to London in 1924.[43]

Amalgamations of businesses into larger enterprises also added to the increasing centralisation in London. By 1921 banking in England and Wales was dominated by the big five companies, all with head

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[36] R.M. Morgan, ***Callender's 1882-1945*** (Prescot: BICC, 1982), pp.197-202.
[37] Peter Hall, Paschal Preston, ***The Carrier Wave: New Information Technology and the Geography of Innovation, 1846-2003*** (London: Unwin Hyman, 1988).
[38] Travel times between the two cities were reduced from 22 hours by stagecoach to 5.5 hours by rail. By 1931 railway timings had fallen to less than 3 hours.
[39] The Penny Post was established n 1840.
[40] W.H. Smith (established in 1792) added newsstands at railway stations from 1848 and later became the leading national distributor of newspapers.
[41] The modern terminal and an hotel were opened in 1928.
[42] Kathryn A. Morrison, ***Woolworths: 100 Years on the High Street*** (Swindon: Historic England, 2015), p.18.
[43] Asa Briggs, ***Marks & Spencer 1884-1984: a centenary history*** (London: Octopus Books, 1984), p.35.

offices in the City. Railway amalgamation (or grouping) in 1922 reduced the number of companies with the four survivors all centred in London Other major amalgamations such as Imperial Chemical Industries (1926) and Unilever (1929) chose London for their new headquarters.

The huge influx of visitors to the Great Exhibition of 1851 showed the benefits of large spaces for displays that could promote business. After the exhibition closed the buildings in Hyde Park were dismantled and rebuilt as the Crystal Palace (1854-1936) at Sydenham. More central localities were developed later at Islington (Royal Agricultural Hall 1862) and Kensington (Olympia 1886). Promoters of electricity saw the benefits of exhibitions as early as 1882 when the Crystal Palace was used to display lighting and other equipment.[44] Major exhibitions that gave electricity a prominent place included the Anglo-French Exhibition at White City (1908) and the British Empire Exhibition at Wembley (1924-1925). Regular displays at the Ideal Homes Exhibition (held at Olympia from 1908 and sponsored by the ***Daily Mail***) were used for general promotion of electricity as well as specific products. Even those far from London were reached by newspaper and magazine stories which advertised the latest trends and fashions.

Three themes are discussed in this section: corporate control and management, manufacturing and distribution of electrical products, and business associations.

Corporate Control and Management

London entrepreneurs were quick to see the possibilities of electric lighting. Early schemes envisaged a series of local franchises based on a particular technology with the patent rights held by the London company. The British Electric Light Company, registered in 1878, acquired the rights to the Gramme equipment. With Sir Charles Tilson Bright (1832-1888) a telegraph engineer as consultant, the company began work. Early projects involved the electrification of St Enoch station and hotel in Glasgow and lighting the Cannon Street station in London. The street lighting system being installed in Liverpool ran into technical difficulties and the company withdrew from the contract.[45]

The Anglo-American Brush Electric Lighting Co. was more ambitious. Registered in 1880 with a capital of £600,000, the company held the British rights to the US patents of C.F. Brush. In the 1882 applications for Electric Lighting Orders, the company and its regional affiliates applied for 47 ELOs covering places from Aberdeen to Folkestone. Only four ELOs were granted and these were later revoked by the Board of Trade for lack of activity. Although unsuccessful in the mid-1880s, the Brush company had a lasting influence in introducing Emile Garcke[46] to the electricity supply industry and in the formation of the Brush Electrical Engineering Co. in manufacturing.

In the late 1880s the House-to-House Electric Lighting Company developed plans for a series of regional companies to set up local electricity systems. The first application for an Electric Lighting Order, for Brompton & Kensington, was made in 1889 and for the following year 51 applications were deposited with the Board of Trade. The applications were made for towns from Aberdeen to Bournemouth and

[44] K.G. Beauchamp, ***Exhibiting Electricity*** (London: Institution of Electrical Engineers, 1997) covers all the London exhibitions.
[45] G. Woodward, "Electricity in Victorian Liverpool", ***Engineering Science and Education Journal***, Vol.1(4), 1992, pp.183-191.
[46] Emile Garcke (1856-1930) was born in Germany, came to Britain and was naturalised in 1880. By 1883 he was appointed secretary of the Anglo- American Brush group and later chairman and managing director of the Brush Electrical Engineering Co. In 1896 he established ***Garcke's Manual of Electrical Undertakings*** and registered the British Electric Traction Company which quickly became the largest tramway company in Britain. See Richard Roberts, "Garcke, Emile Oscar", in David J. Jeremy, ***Dictionary of Business Biography***, Vol.2 (London: Butterworth, 1985), pp.474-477.

included two places in Ireland, Cork and Londonderry. Only a few ELOs were granted but successful operations were developed in Brompton & Kensington, Leeds and Coatbridge.

Although these grand national schemes failed, some of the London electrical contractors saw opportunities for developing local systems in smaller centres where local authorities were unable and unwilling to invest in electricity. Edmundson's Electricity Corporation and the Electric Supply Corporation (representing Crompton interests) were formed in London during 1897. By 1910/11 Edmundson's had built 46 local systems and the Electric Supply Corporation owned 11. Drake & Gorham, another old-established London contractor, continued to specialise in country house lighting.[47]

A full-page advertisement in ***The Times*** "Faraday Number" for the Greater London and Counties Trust illustrated the scale of operations of a new entity. The text listed the "…Subsidiary and Associated Companies [that] generate and distribute electricity to a population of 4,500,000 over an area of 12,000 square miles, supplying electricity to 500 towns and villages shown on the map".[48] The Greater London and Counties Trust was not the largest of the holding companies. More secretive organisations had also been acquiring properties and taking up large new franchise areas.

Table 2 MAJOR LONDON-BASED ELECTRICITY HOLDING COMPANIES 1934-35.

	Sales million kWh	*Subsidiaries*	*Consumers*	*Generating Capacity kW*	*Power Stations*
Power Securities	783.5	31	304,106	450,772	20
County of London ES Co.	693.8	18	420,672	441,643	6
Edmundson's Electricity Corpn	425.3	45	257,409	206,245	24
British Power & Light	80.9	7	37,541	44,845	2
British Electric Traction Co.	48.9	13	56,128	13,070	8
Lincolnshire & Central ES Co.	32.1	5	21,644	9,446	4
General Electric Co. Ltd	27.5	11	30,620	7,529	11
Southern Areas Electricity Corpn	22.1	5	8,773	266	2
Electric Supply Corpn	20.1	8	11,714	1,556	3
*Johnson & Phillips**	13.0	3	7,950	1,260	1
Whitehall Securities	11.8	9	23,498	2,709	3
Totals	**2,159.0**	**155**	**1,180,210**	**1,233,341**	**84**

Source: Most details were compiled from Political and Economic Planning, ***Report on the Supply of Electricity in Great Britain*** (London: PEP, 1936). Generating capacity and power stations were added from Electricity Commissioners, ***Engineering and Financial Statistics 1935/36***.

*Not included in PEP Report.

[47] The company applied for a Special Order for Heathfield and Ringmer, Sussex on 4 February 1927 but withdrew the application on 22 March 1927. ***Seventh Annual Report of the Electricity Commissioners 1926-27*** (London: HMSO, 1927), p.171. The franchise was later granted to Johnson & Phillips in 1931. The report of the 30th Annual Meeting in ***The Times***, 31 October 1931, p.17, gave an extensive list of the current customers.

[48] ***The Times***, "Faraday Number", 21 September 1931, p.iv.

By 1936 when Political and Economic Planning[49] published its survey of the British electricity supply industry there were 11 holding companies based in London.[50] Collectively the 11 companies held a dominant position in the company sector, with 45.6 percent of sales, 62.0 percent of undertakings, 57.7 percent of consumers and 39.1 percent of generating capacity. **Table 2** provides details of the London-based companies.

Power Securities Corporation, inaugurated in 1922 was the largest holding company by value of sales and included many prosperous subsidiaries in London, the Midlands, Lancashire and Scotland. The company had been built up by George Balfour (1872-1941) first in central Scotland and then in the Midlands. Other areas were added in the 1920s including the Lancashire Electric Power Co. and the Grampian Electric Supply Co.

The County of London Electric Supply Co. was formed in 1892 as successor to one of the Anglo-American Brush companies and expanded from a strong base in the County of London into Essex and Kent after World War I. Its compact service area was supplied by a large generating station at Barking opened in 1925. The Bournemouth and Poole subsidiary had been associated with the company from the mid-1890s.

Edmundson's Electricity Corporation was incorporated in 1897, taking over the London branch of a Dublin gas installation business. By 1910 under the direction of F.E. Gripper[51] the company had established electricity undertakings from Inverness to Ilfracombe. After the takeover by Greater London & Counties Trust Ltd in 1928, the company was revitalized with American capital and expanded by new acquisitions.[52] **Figure 4** shows the extensive areas added in the southwest Midlands, South Wales, Wessex and East Anglia, as well as the scattered remnants of the old subsidiary Urban Electric Supply Co. in Berwick-on-Tweed, Hawick, Glossop, Grantham and Stamford.

British Power & Light Corporation formed in 1929 was one of a new group of holding companies, acquiring some of the last franchise areas available.[53] These included the Trent Valley-High Peak, South Somerset and West Hampshire, as well as the old-established North Wales Power Co.

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[49] ***Report on the Supply of Electricity in Great Britain*** (1936), 171pp. PEP (Political and Economic Planning) was an independent non-party working group of more than a hundred members including industrialists, distributors, officers of central and local government and university teachers. Notable early members included Max Nicholson (1904-2003), Julian Huxley (1887-1975) and Israel Sieff (1889-1972), a director of Marks & Spencer and chairman of PEP in the 1930s. ***Planning***, a fortnightly broadsheet, was issued from 1933 and many influential studies of administrative, economic, energy and social issues were published. PEP became the Policy Studies Institute in 1978 after merging with the Centre for the Study of Social Policy (formed in 1972). The Institute has been part of the University of Westminster since 1998.

[50] Other large independent companies included the Clyde Valley Electrical Power Co., North Eastern Electric Supply Co. (NESCO), Yorkshire Electric Power Co., Mersey Power Co., Northampton Electric Light & Power Co. and the North Metropolitan Electric Power Co. (Northmet).

[51] Francis Edward Gripper (1852-1927) served as managing director of Edmundson's from 1883 to 1927. Obituary, ***Journal of the Institution of Electrical Engineers***, Vol.66, 1927-28, p.1236.

[52] By the time of the PEP survey, the Greater London & Counties Trust was in the process of dissolution as the American interests retreated. See Leslie Hannah, ***Electricity before Nationalisation: a study of the development of the electricity supply industry in Britain to 1948*** (London: Macmillan, 1979), p.232.

[53] The Edmond de Stein & Co. and Robert Benson & Co. banking companies were the leading supporters of British Power & Light. The chairman Henry Vernet was also deputy chairman of the Underground Electric Railways of London group and a former partner in Robert Benson & Co. George Victor Twiss MIEE was managing director. He had been a consulting engineer and worked on transmission systems in India, South Africa and New Zealand. See "Prospectus", ***The Times***, 13 May 1929.

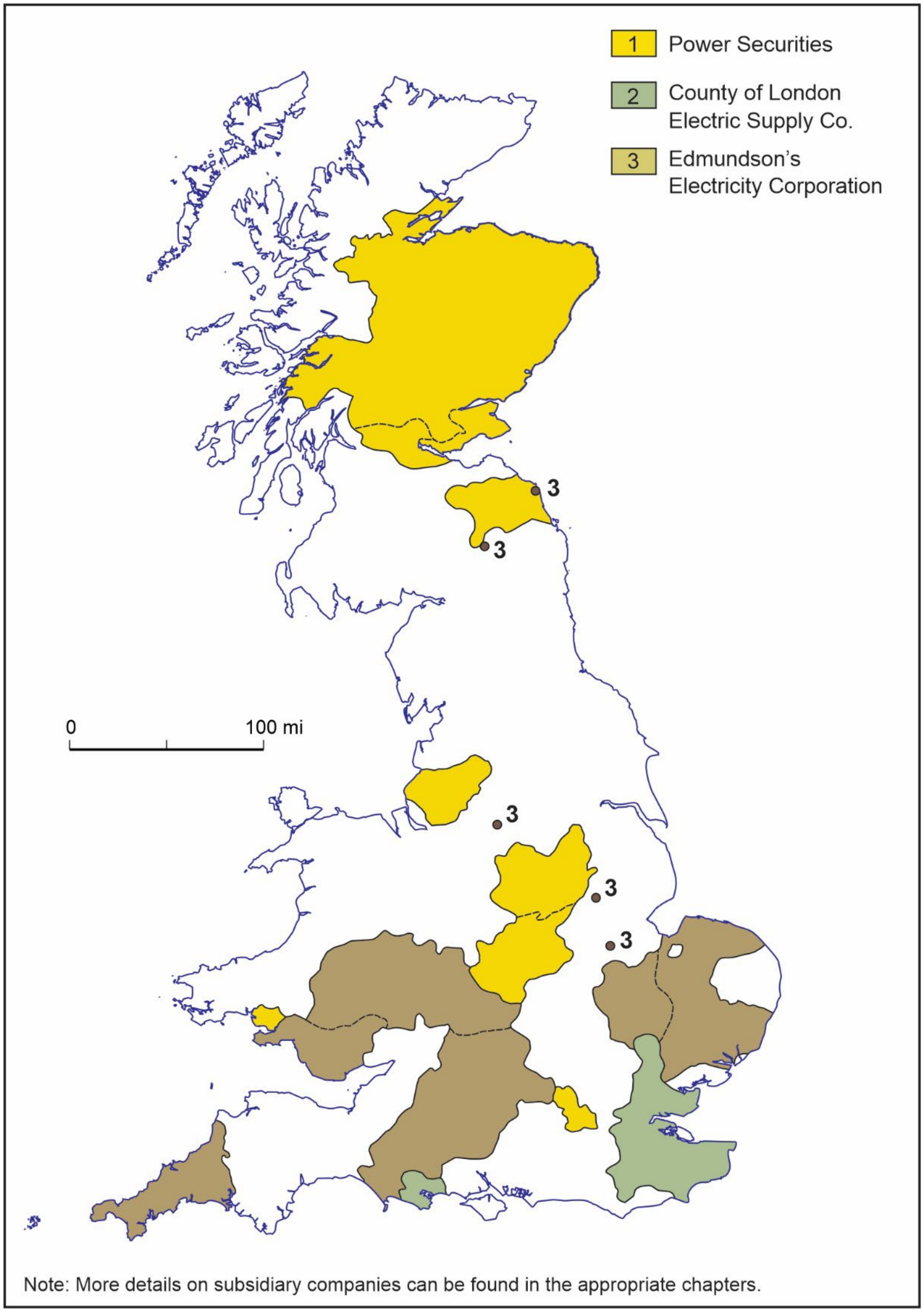

Figure 4 LONDON ELECTRICITY HOLDING COMPANIES I.

British Electric Traction Company established in 1896 by Emile Garcke had been a dominant force in British electric tramways.[54] By 1931 most of the tramway systems were being converted to motor bus operations or had been taken over by local authorities**. (Figure 5)** Earlier large-scale electricity supply projects had been sold off. These included the County of Durham companies sold to NESCO in 1905, the Northmet power and tramways companies transferred to the Underground Electric Railways of London Ltd in 1912/13, and the most recent sale of the Shropshire, Worcestershire and Staffordshire Electric Power Co, to Edmundson's in 1929. Some of the existing undertakings were remnants of old tramway operations such as Birkdale (Southport), Merthyr Tydfil, Isle of Sheppey and Weston-super-Mare. More recent acquisitions included the Lothians Power Co. and the Antrim Electric Supply Co. in Northern Ireland.

The General Electric Company was an old-established manufacturing business which added electricity supply in the late 1920s. New franchise areas acquired at this time included West Wales, the East Riding of Yorkshire, Cumberland and Wigtownshire.

Registered in 1897, the Electric Supply Corporation Ltd was associated with Crompton & Co, the pioneer electrical engineers and manufacturers. The pattern of holdings in 1934/35 shows remnants of earlier activity in St Andrews, Dumbarton, and Falmouth as well as small new developments in Sussex and the very distant Peterhead undertaking. Chelmsford undertaking was sold to the County of London Co. and Totnes to Torquay Corporation in 1935. The Hendon operation was sold to Northmet in 1937.

Lincolnshire & Central Electric Supply Co. was formed in 1931 to take over the new Lincolnshire franchises granted to Borlase Mathews. The company with offices in Northwood, Middlesex was owned by British & International Utilities Ltd (registered in 1930 by London banking and European electricity interests).[55] By 1934/35 the company had acquired old-established electricity suppliers in Altrincham, Windermere and Keswick. Thurso was added by 1936.

Southern Areas Electricity Corporation (formed in 1933) had scattered holdings with most of its sales coming from the Sussex E S Co. and Brentwood. There were minor operations in Salcombe, Seaton and Leominster.

Whitehall Securities Ltd with all its holdings in Devon and Somerset reflected a new emphasis by S. Pearson & Co. in the late 1920s when selling most of its operations in Chile to American interests.[56] Johnson & Phillips Ltd was an old-established cable and electrical equipment manufacturer which moved into distribution in the 1920s.[57] Three major franchise areas were acquired in Dunoon, County of Westmorland, and Ringmer in Sussex.

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[54] Roger Fulford, ***Five Decades of BET 1896-1946*** (London: BET, 1946). This is one of the few books that mentions the financial support of Foster & Braithwaite in the early development of the company. See also W.J. Reader, ***A House in the City: A study of the City and the Stock Exchange based on the records of Foster & Braithwaite 1825-1975*** (London: B.T. Batsford, 1979).

[55] William J. Hausman, Peter Hertner and Mira Wilkins, ***Global Electrification: Multinational Enterprise and International Finance in the history of Light and Power 1878-2007*** (New York: Cambridge University Press, 2008), p.193.

[56] ***Global Electrification*** (2008), p.185.

[57] Not listed in the PEP Report (1936). For details of the electricity supply companies, see: Collin Brooks, ***The History of Johnson and Phillips: a romance of seventy-five years*** (London: Company, 1950), Appendix 2.

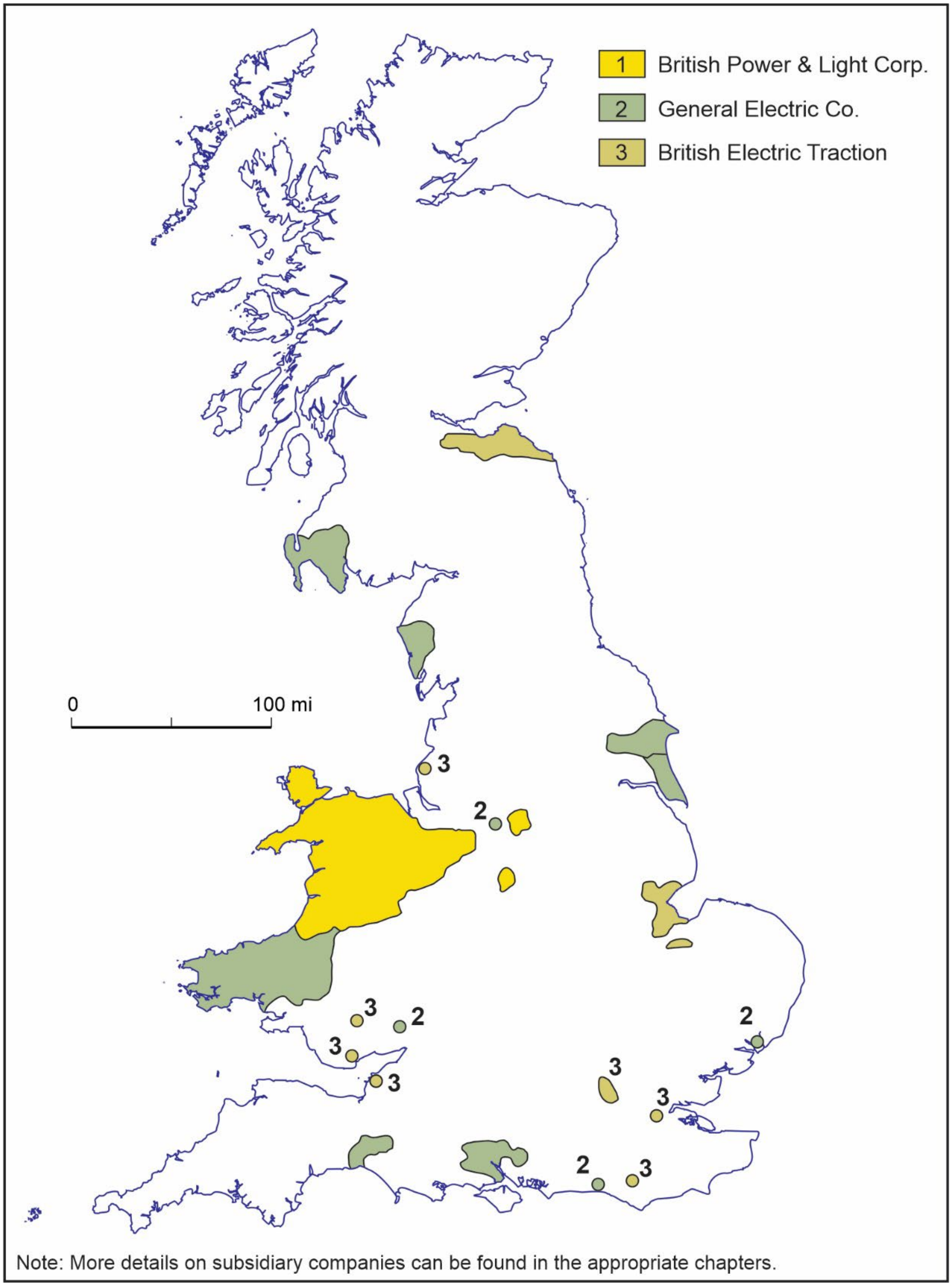

Figure 5 LONDON ELECTRICITY HOLDING COMPANIES II.

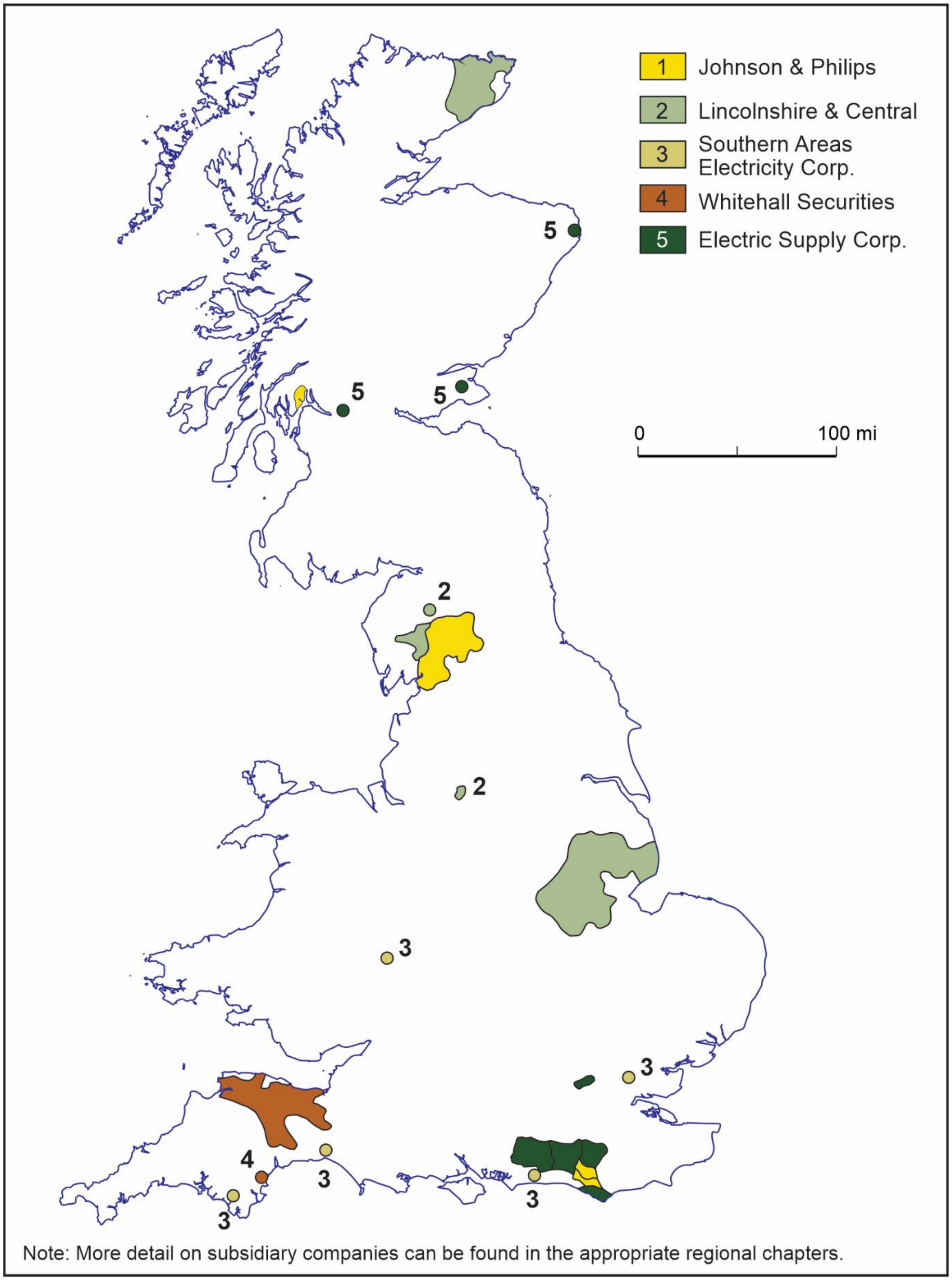

Figure 6 LONDON ELECTRICITY HOLDING COMPANIES III.

Robert Hammond (1850-1915)

London Electrical Entrepreneur

Born in Waltham Cross, Hertfordshire, son of a brewer, Hammond was educated at Nunhead Grammar School. He began work as a clerk with a London cloth merchant and then in 1870 moved into the iron ore trade. Hammond & Co. as it became had establishments in London, Middlesbrough and Bilbao. He took an early interest in electric lighting and by 1880 had installed arc lighting in a Middlesbrough iron works.[a]

In 1881 Hammond bought concessions from the Anglo-American Brush Electric Light Company. This covered parts of the North of England, Yorkshire, Hampshire, the Isle of Wight and Sussex. The Hammond Electric Light and Power Supply Company Ltd was formed in early 1882 and continued work already begun in several places including Chesterfield and Brighton and later extended to Eastbourne and Hastings. The non-statutory operations in the Sussex resorts were all successful and became the basis for later municipal systems. Technical problems with the Brush equipment affected the Hammond company which was voluntarily wound up in 1885.[b]

Hammond launched a new venture in 1888, the House-to-House Electric Light Supply Co. and was granted an Electric Lighting Order for the Brompton & Kensington district in 1889. A power station was built and supply to the district began. In the 1890 round of applications to the Board of Trade the company and its regional affiliates applied for 51 ELOs covering towns from Aberdeen to Bournemouth. Only a few ELOs were granted but successful operations were developed in Leeds[c] and Coatbridge.

As a consulting engineer Hammond designed a substantial number of electric lighting works mainly for local authorities. These included Ayr, Blackpool, Burton-on-Trent, Canterbury, Coventry, Dublin, Gloucester, Hackney, Hornsey, Mansfield, Middlesbrough, Morley, Newport (Mon), Pembroke Township (Dublin), St Helens, Tonbridge and Wakefield. Work overseas included projects in Madrid, Malaga and extensions at Bloemfontein. Hammond was also active in planning electric tramways in Gloucester, Exeter, Mountain Ash and Rhondda as well as Bloemfontein.[d] In 1902 his son Robert Whitehead Hammond became a partner assisting with projects including regional schemes in South Africa and London.[e]

Hammond presented a paper at the Johannesburg meeting of the British Association for the Advancement of Science (1905). Some of the features set out in “Electric Power Distribution for the Rand” were later taken up by the Victoria Falls and Power Co. He also worked with the London County Council on its plans for bulk supply (1906-7) and later, with H.F. Parshall, proposed another scheme for London. The 1908 Bill was passed by the House of Lords but rejected by the House of Commons.

As an elder statesman Hammond acted as an expert witness in many Parliamentary reviews, was an arbitrator in various local cases of municipal power supply to tramway companies and served as honorary treasurer of the Institution of Electrical Engineers from 1902 until his death.

Hammond was always a very active promoter of electrification, publishing an early book ***The Electric Light in Our Homes*** (1894) and founding ***Lightning*** in 1891 (later renamed the ***Electrical Times***).

Other lasting achievements by Hammond included the formation of the Electrical Standardising, Testing and Training Institution in 1890. The testing laboratory for electrical instruments continued its work until 1938. Faraday House, the training part of the institution, was a private electrical engineering college that lasted until 1967. One of its innovations was the "sandwich system" in which students combined the theoretical learning of the lecture rooms and laboratories with practical experience in the workshops of affiliated companies. By 1928 some 2,000 students had joined the college and its graduates were employed in leading positions around the world.[f]

Although Hammond gave much energy and effort to all aspects of electrification he never made a fortune, leaving only £7,828 gross. [g]

Notes

[a] Brian Bowers, "Hammond, Robert (1850-1915) Consulting electrical engineer", in David J. Jeremy, ed., ***Dictionary of British Business Biography***, Vol.3 (London: Butterworth, 1985), pp. 21-23.
[b] I.C.R. Byatt, ***The British Electrical Industry 1875-1914*** (Oxford: Clarendon Press, 1979), pp.19-20.
[c] J.D. Poulter, ***An early history of Electricity Supply: The Story of the Electric Light in Victorian Leeds*** (London: Peter Peregrinus, 1986). The Leeds system opened in 1893 was taken over by the Corporation in 1898.
[d] Obituary, ***The Engineer***, Vol.120, 1915, p.156.
[e] Robert Whitehead Hammond (1876-1917) was born in Middlesbrough, educated at Eton and Faraday House. He designed the power station and destructor for the Rhondda Urban District Council. Serving in the South African War, he re-enlisted in 1914 and died in action three years later. See obituary in ***Grace's Guide to British Industrial History***.
[f] F.W. Lipscomb, ***The Wise Men of the Wires*** (London: Hutchinson, 1973), p.98.
[g] Bowers (1985), p.98.

Manufacturing and Distribution

Electrical engineering was one of the growth industries of the second industrial revolution. This sector of British manufacturing had employed only 2,600 in 1881; this grew to 245,300 by 1931.[58] Depending on the sources consulted, the London area in the early 1930s accounted for between 34 and 46 percent of all British employment in this grouping.[59] This high level of concentration reflected the significance of the large urban market for new products and the old-established industries of mechanical engineering, shipbuilding, manufacturing of telegraph cable and scientific instruments and the production of all types of consumer goods.[60]

Production of electrical equipment was conventionally divided into two classes. "Heavy" products were capital goods used in the generation, transmission and distribution of electricity. They included generators, transformers, switchgear, motors, cables and batteries/accumulators. Engines (steam and diesel) and turbines used as the prime movers in electricity generation were classified as mechanical engineering. By the 1930s many firms that had started in London had moved elsewhere in search of more space and lower working costs. Examples of such moves include Brush Electrical Engineering from Lambeth to Loughborough (1889), Ferranti from Charterhouse Square to Hollinwood, Oldham (1896), Siemens Dynamo from Woolwich to Stafford (1901), and British Thompson-Houston Co. from Bankside

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[58] C.H. Lee, ***British Regional Employment Statistics 1841-1971*** (Cambridge: Cambridge University Press, 1979.
[59] Douglas H. Smith, ***The Industries of Greater London*** (London: P.S. King, 1933); R.E. Catterall, "Electrical Engineering", Chapter 9 in Neil K. Buxton and Derek H. Aldcroft, eds. ***British industry between the wars: Instability and industrial development 1919-1939*** (London: Scolar Press, 1979), pp.241-275.
[60] J.E. Martin, ***Greater London: an industrial geography*** (London: G. Bell & Sons, 1966). The early chapters present a very effective review of the complexity of London industries.

to Rugby (1902). Some firms engaged in the heavy branches of electrical engineering remained in London. These included cable-making, transformers and turbines.

“Light” products included components and finished products such as lamps, lighting systems, wiring, telecommunications equipment, radios and other electronic apparatus, and domestic electrical appliances (cookers, heaters, fans, refrigerators, vacuum cleaners and washing machines). London was particularly well represented in this sector of electrical engineering.

The primacy of London in submarine telegraph cables and the later development of electric lighting and power attracted firms from outside. Siemens & Halske began a London agency in 1847, expanded into a full subsidiary as Siemens Brothers and opened a cable works at Woolwich in 1863.[61] Joseph Swan, recognizing the importance of the London market for incandescent lighting and after merging with Edison interests, moved the lamp factory from Newcastle on Tyne to Ponders End, Middlesex in the mid-1880s.

Local growth from wholesaling to manufacturing is illustrated by the history of the General Electric Company. In a full-page advertisement on the final page of ***The Times*** “Faraday Number”, the General Electric Company Limited claimed its rank as the “largest British Electrical Manufacturing Organisation in the British Empire”.[62] The company established in the early 1880s by German immigrants had begun as a wholesaler of engineering components. Electrical fittings were added in 1885 when Hugo Hirst[63] joined the business as a salesman. GEC was incorporated in 1889 and began to move into manufacturing, first with a factory in Manchester and then in 1893 adding lamp making in Hammersmith. By 1895 the company, managed from the head office in Queen Victoria Street[64], owned four factories—in Salford, Manchester and two in London. Wholesale branches had been established in Manchester, Glasgow, Birmingham, Newcastle and Dublin. Nearly 3,000 were employed.

After becoming a public company in 1900, GEC bought a 45-acre site at Witton on the northern outskirts of Birmingham. This became the largest production complex making dynamos, motors and switchgear. Further moves towards “everything electrical” came in 1914 with the formation of Pirelli-General and a cable-making works at Southampton. In 1918 the Erith works of Fraser & Chalmers was acquired, adding oil engines and steam turbines.

Figure 7 shows the extent of the company in 1931 when there were 30 branches in the British Isles and about 12 manufacturing plants. The company also had another 27 branches overseas in Australia, New Zealand, South Africa, India, China, Argentina, France and the Netherlands. Magnet House, Kingsway served as the grand headquarters of the company. Under various brand names the company made everything from lamps (Osram), electric kettles (Magnet), telephones (GEC), lifts (Express-SMS) to cables

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[61] J.D. Scott, ***Siemens Brothers 1858-1958: an essay in the history of industry*** (London: Weidenfeld & Nicolson, 1958).

[62] GEC was a little larger than Associated Electrical Industries (AEI) formed in 1929 after a merger of Metrovick (previously British Westinghouse) and British Thompson-Houston. English Electric had been established in 1919 combining the interests of Dick, Kerr & Co. (Preston) and Willans & Robinson (Rugby) and several other companies.

[63] Hugo Hirst (1863-1943) was born in Bavaria and moved to London in 1880. Unlike most electrical company leaders of the time, he was a salesman not an engineer or scientist, a factor that helped the growth of the firm. He was an early motorist, active in sports and prominent in fostering British business. Created a baronet in 1925 he was raised to the peerage as Lord Hirst of Witton in 1935***. The Times*** obituary, 25 January 1943, p.6.

[64] The telegraph address in 1906 was “Electricity London”.

and turbines (Fraser & Chalmers). Employment rose from 8,000 in 1912 to 15,000 in 1919 and 40,000 in 1938.[65]

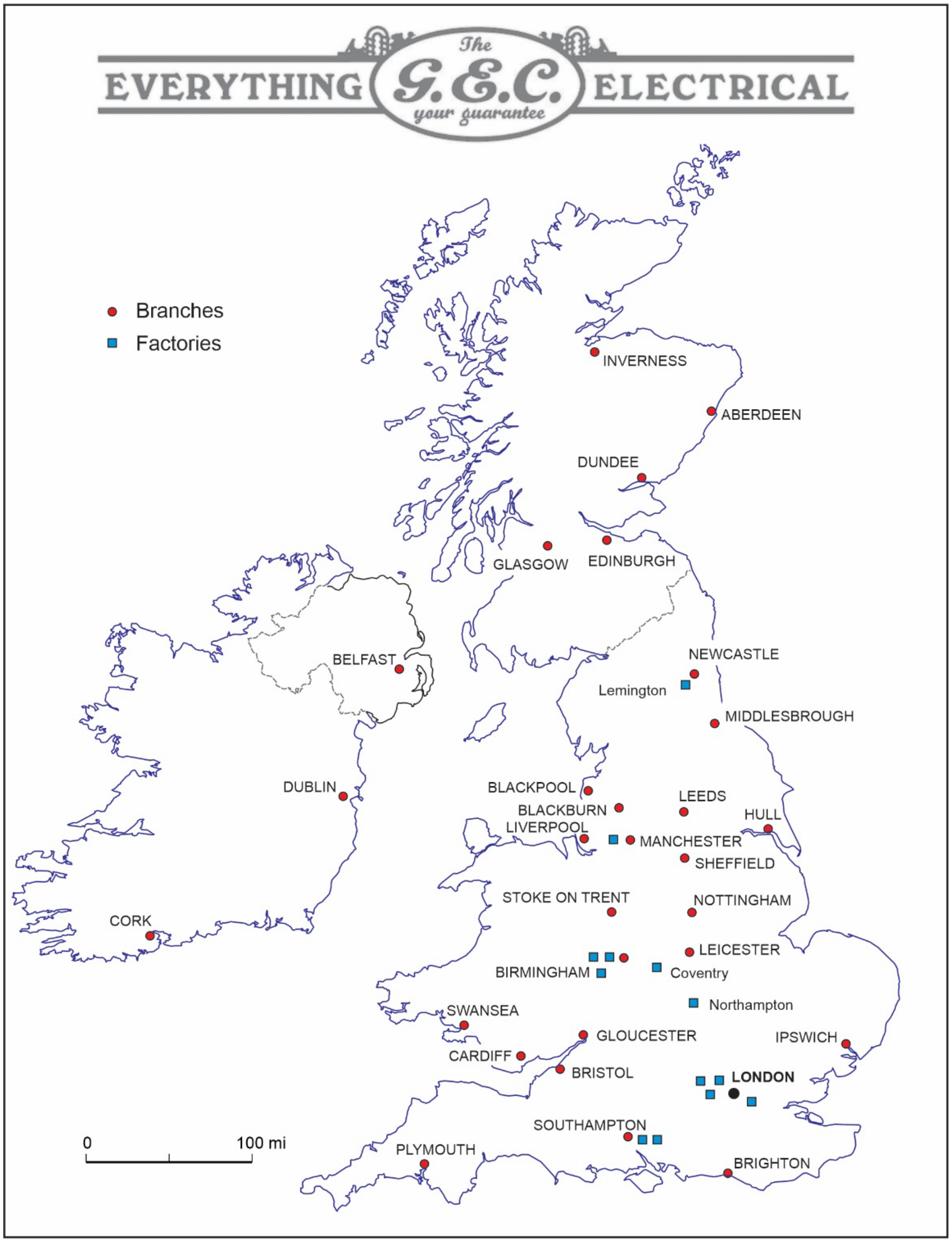

Figure 7 GENERAL ELECTRIC COMPANY BRANCHES AND FACTORIES c1931.

[65] Robert Jones and Oliver Marriott, ***Anatomy of a Merger: A history of GEC, AEI and English Electric*** (London: Pan Books, 1972). Especially chapter 4, "Lord Hirst of GEC"; ***Grace's Guide to British Industrial History***, a particularly rich website resource (www.gracesguide.co.uk) on companies, people and places.

Radio broadcasting which began in the early 1920s stimulated demand for new ranges of equipment and components, many of them produced by new companies. Captain S.R. Mallard began producing valves (vacuum tubes) in Hammersmith in 1920. The firm expanded rapidly, moving to Balham in 1923 and later to Mitcham in 1929. Under the ownership of N.V. Phillips, Eindhoven Mallard became part of a multinational enterprise, adding radio sets to the production line. A large branch plant in Blackburn, Lancashire was opened in 1938.

High tariffs imposed on imported products from 1931 encouraged overseas companies to set up British manufacturing plants. Hoover Ltd began making vacuum cleaners in Perivale (1933) where the location on an arterial road (Western Avenue) and an ornate styling for the factory also served as advertisement. Electrolux, a Swedish manufacturer of vacuum cleaners, built a factory in Luton at this time.

Although expansion of some firms took place in areas of high unemployment the general growth of electrical engineering continued to be dominated by South East England. New sectors that emerged during and after the war included radar, television, computers and a range of electronic devices for telecommunications. Employment in electrical engineering in Britain grew from 245,000 in 1931 to 557,000 in 1951, 757,000 in 1961 and 804,000 in 1971.[66]

Business Associations

London was the hub of most of the associations directly concerned with electricity supply or the manufacture of electrical products. They served the interests of their membership with information and exchange of news. They were also active in promotion, public relations and protection and by lobbying Parliament or government departments especially at critical times when their interests were threatened.

One characteristic of the British electricity supply industry from the late 1890s was a sharp political division between private companies and municipal enterprise. This divide "…was to dog the industry's future until it was finally resolved in 1948 by nationalisation".[67] Companies resented the early takeover by large municipalities as for example in Liverpool (1896), Sheffield (1898), Leeds (1898) and Birmingham (1900). At the same time municipal interests were against the creation of power companies with perpetual franchises and large potential service areas.

The Incorporated Municipal Electrical Association was formed in 1895 with J.H. Rider[68] providing most of the initiative. The first annual meeting was held in London the following year. Membership grew as the number of municipal undertakings expanded from 35 in 1894 to 379 in 1931. With the backing of organisations such as the Association of Municipal Corporations (1873-) the IMEA became a powerful lobby protecting its interests as well as serving as an information exchange.[69]

In response to the hostile municipal action against power company legislation the Incorporated Association of Electric Power Companies was formed in 1905. While few of the power companies were

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[66] Lee, ***British Regional Employment Statistics 1841-1971***.
[67] Hannah, ***Electricity before Nationalisation*** (1979), p.27.
[68] J.H. Rider (1864-1953) was then electrical engineer to the Borough of Bolton. He later moved to Plymouth and the London County Council Tramways. As a consulting engineer he also designed many power stations. Obituary ***The Engineer***, Vol.195, 1951, pp.635-636.
[69] The annual meetings of the IMEA were reported in some detail in ***The Engineer***.

profitable before World War I they all began to grow in sales and by extending their service areas. By the 1930s they had become a strong group.[70]

Both the IMEA and the IAPC were major players in the interwar struggle with the government to consolidate and rationalise the electricity supply industry. Other more local groups such as the London Electric Supply Company Association added strength to resisting reorganisation.

Industrial relations which became codified after World War I on the principles of "Whitleyism"[71] involved negotiations among many associations of employers and workers. National negotiations were generally settled in London and often involved the Ministry of Labour and the Trades Union Congress.

Matters relating to hours, wages and working conditions for manual workers in the electricity supply industry were the responsibility of the National Joint Industrial Council (NJIC) set up in 1919. The Council had 12 representatives from five major unions sitting with an equal number from the management side. For technical staff a National Joint Board ({NJB) covered the terms and conditions of employment. A later formation, the National Joint Council (NJC) looked after the interests of clerical and administrative staff.

The vulnerability of electricity supply to industrial action, especially at power stations, was evident in the General Strike of 1926.[72] Generally supplies were maintained and Whitleyism worked for another 50 years.

The Electrical Trades Union was one participant in the NJIC. Originally formed in Salford in 1889, the union headquarters were in Manchester from 1907 until 1929 when they were moved to Clapham. In 1931 the ETU had 31,000 members spread across electrical contracting and the supply industry. With rapid growth in membership from 70,000 in 1939, to 133,000 in 1945 and 243,000 in 1960, the ETU moved its head office to Hayes Court, Bromley in 1945 and then to Esher Place in 1964.[73]

Technical staff were represented by the Electrical Power Engineers' Association, formed in 1912/13 and reorganised in 1918. With 4,700 members in 1931, the EPEA had its headquarters in St George's Square, Pimlico. In 1964 when the Association had some 20,000 members it moved to new premises in Chertsey.[74]

The British Electrical and Allied Manufacturers Association was originally formed in 1902 as the National Electrical Manufacturers Association. Reformed under the new title in 1911 it became the premier trade association D.N. Dunlop (1868-1935)[75] who had previously worked for Westinghouse as a publicist in the United States and later in Britain was the prime mover of BEAMA. By 1922 it had its head office in

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[70] The IAPEC membership consisted of the following companies: Cleveland & Durham; Clyde Valley; Cornwall; County of Durham; Derbyshire & Nottinghamshire; Lancashire; Leicestershire & Warwickshire; North-Eastern (NESCO); Northmet; North Wales; Scottish Central; Staffs, Worcs & Warwicks; South Wales; West Kent; Yorkshire. Details from a full-page advertisement in ***The Times***, "Electricity Supply Number", 5 December 1933, p.xxi.

[71] See W.E. Swales, ***Forerunners of the North Western Electricity Board*** (Manchester: NWEB, 1963) p.83. All features of labour relations are considered by Hannah, ***Electricity before Nationalisation*** (1979) in Chapter 8.

[72] Frank Ledger and Howard Sallis, ***Crisis Management in the Power Industry*** (London: Routledge, 1995). Chapter 2, "1926: Electricity Supply and the General Strike", pp.11-22.

[73] John Lloyd, ***Light and Liberty: A History of the Electrical, Electronic, Telecommunication & Plumbing Union*** (London: Weidenfeld & Nicolson, 1990).

[74] Judy Slinn, ***Engineers in Power: 75 Years of the EPEA*** (London: Lawrence & Wishart, 1989).

[75] Daniel Nicol Dunlop was born in Scotland. He was a great publicist for electricity and had a "…personality of remarkable charm". He saw the World Power Conference "as a meeting place between scientists and engineers on the one hand, statesmen and engineers on the other". A correspondent writing to ***The Times***, 5 June 1935, p.10.

Kingsway close to the General Electric Company and other large manufacturers. The Association was a major supporter of the British Empire Exhibition at Wembley in 1924 and 1925. Dunlop was also the promoter of the First World Power conference also held at Wembley in July 1924. The conference welcomed 1,700 delegates from 48 countries and its proceedings gave impetus toward more effective management of the British electricity supply industry. Later world conference meetings were held in Berlin in 1930, Washington in 1936 and London in 1950.[76]

As a new technology, electricity had always needed promotion and publicity but any formal organisation had to wait until 1919 when the British Electrical Development Association was formed.[77] J.W. Beauchamp, the first director, explained the need for publicity in a paper presented at the World Power Conference in 1924.[78] Despite a reluctance by many undertakings to make voluntary contributions the EDA published extensively and was a major supporter of the Faraday centenary celebrations in 1931. From 1933 the Central Electricity Board began contributing to the EDA budget and expanded its promotion efforts.

In a new campaign the EDA introduced the "Wizard in the Wall" as propaganda for progress appearing in newspapers and posters in shops and showrooms:[79]

> *It is the sign of an age of cleanliness and leisure, of a brighter and briefer working day. It stands for electricity in the home.*

"The Wizard" had only a short life since it was never able to counter "Mr Therm" the long-lasting symbol of the Commercial Gas Association.[80]

After 1948 the Area Boards took over the more localized promotion work. The EDA was gradually absorbed by the Electricity Council in the 1960s.

While the EDA was always based in London and generally took a top->down approach, the Electrical Association for Women, established in 1924, developed along different lines.[81] Its strength and influence lay in local branches and an expanding membership. A Manchester branch supported by the wives of S.Z. Ferranti and H.C. Lamb was opened in 1926.[82] There were 16 branches in 1929 and nearly 60 in 1936. By 1956 the EAW had 160 branches and 14,000 members. The London office, first in Kensington and then in Regent Street, was the base for publication of ***Electrical Age for Women*** (later ***Electrical Age***). The EDA, recognizing the benefits of the EAW in promoting domestic uses of electricity, gave an annual subsidy.

Caroline Haslett as director gave much energy to the EAW from the beginning to her early death. Although only generally representing the middle-class segment of the electricity market, the EAW made many contributions to the Improvement of service and domestic appliances, raising safety standards

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[76] The World Power Conference later renamed World Energy Council remains based in London. See Ian Fells, ***World Energy 1923-1998: A commemoration of the World Energy Council on its 75th birthday*** (1998).

[77] Bill Luckin, ***Questions of Power: Electricity and environment in inter-war Britain*** (Manchester: Manchester University Press, 1990). Chapter 2, "Constructing the image".

[78] J.W. Beauchamp, "The place of publicity in the public service of electricity supply", ***Transactions of the World Power Conference London 1924*** (London: Lund Humphries, 1925), Vol.IV, pp.1657-1678.

[79] "The Wizard in the Wall". Full-page advertisement in ***The Times***, "Electricity Supply Number", 5 December 1933, p.xxviii.

[80] "Mr Therm" was designed by Eric Fraser, a graphic artist for the Gas Light and Coke Company in 1931. See: Stirling Everard, ***The History of the Gas Light and Coke Company 1812-1949*** (London: Ernest Benn Ltd, 1949. Reprinted by A & C Black for the London Gas Museum, 1992), pp.346-348. "Mr Therm" continued in use by the nationalised Gas Council until 1962.

[81] Bill Luckin, ***Questions of Power: Electricity and environment in inter-war Britain*** (1990). Chapter 3, "Targeting women".

[82] W.E. Swales, ***Forerunners of the North Western Electricity Board*** (1963) p.82.

and in local areas serving as an early consumer advocate. Its work completed, the EAW was voluntarily dissolved in 1986.[83]

III. Government / The State

There was little sense of the activity of state intervention during the Faraday Centenary celebrations of September 1931. ***The Times*** supplement contained only brief references to any role of government.[84] An absence of lengthy reports is understandable given the current financial crisis. The cabinet of the minority Labour government had failed to agree on proposals to reduce public expenditure to balance the budget. Ramsay Macdonald as prime minister had agreed to form a National Government on 24 August. Despite the difficulties the prime minister found time to deliver an address in Queen's Hall on the evening of 21 September. In paying tribute to Michael Faraday as a personal inspiration, Macdonald noted that "...Faraday was one of those enthusiastic men who lived with his heart and his imagination, who saw glory in the meanest of things and a mystery in the simplest of things".[85] Later in the week P.J. Pybus[86] as Minister of Transport in the new National Government, received 250 guests at a government dinner held at the Dorchester Hotel.[87] The Electricity Commissioners were represented at all the official gatherings during the Faraday event.[88]

Table 3 AUTHORISED ELECTRICITY UNDERTAKINGS 1889-1921.

	Companies	Local Authorities	Others	Total
United Kingdom				
1889	17	1	..	18
1895	52	39	..	91
1900	65	164	..	229
1921	232	331	..	563
Great Britain				
1922	212	315	7[1]	534
1926	238	356	2[2]	596
1931	279	379	8[3]	666

Notes:
[1] Persons
[2] Joint Electricity Authorities
[3] 3 JEAs, 5 Joint Boards
Sources:
1889 Author's estimate
1895/1900 Millward in Cambridge Urban History Vol.III (2000), Table 11.2, pp.326-327.
1921-1931 Annual Reports of the Electricity Commissioners.

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[83] The differences in the promotion work of the EDA and the EAW are explained in Elizabeth Sprenger and Pauline Webb, "Persuading the housewife to use electricity? An interpretation of material in the Electricity Council archives", ***BJHS: The British Journal for the History of Science*** Vol.26, 1993, pp.55-65.
[84] P.V. Hunter (Callender's Cables) wrote on the "National Grid", Lt-Col W.A. Vignoles (Electrical Development Association) on "Distribution of Electricity" and W.W. Lackie (an Electricity Commissioner) on "Power Stations of Today". ***The Times*** "Faraday Number", 21 September 1931, pp.xvi and xii.
[85] "Prime Minister's tribute to Michael Faraday", ***The Times*** 22 September 1931, p.14.
[86] Percy John Pybus (1880-1935) was unusual since he had trained as an electrical engineer and from 1921 had been managing director of English Electric and chairman from 1926. He may have been the only electrical engineer ever to serve in government. Elected as a Liberal MP for Harwich in 1929, he was Minister of Transport from 3 September 1931 until he resigned in February 1933.
[87] "Government dinner: Honour to Faraday", ***The Times*** 26 September 1931, p.8.
[88] ***Twelfth Annual Report of the Electricity Commissioners 1 April 1931-31 March 1932*** (London: HMSO, 1932), p.8.

Table 3 shows the growth of authorised undertakings from 1889 to the peak reached in 1931. Responsibility for the undertakings in Ireland was transferred to the new governments in Belfast and Dublin in early 1922. Numbers of undertakings continued to grow in the 1920s as franchises were granted for undeveloped areas and as previously non-statutory providers were "legitimised" by Electricity Special Orders. Examples include the East Anglian Electric Supply Co. (service began 1895) in 1926 and the Lynton & Lynmouth Electric Light Co. (service began 1890) in 1928. Consolidation of small companies and a few local authorities reduced the number of undertakings to 562 in 1948

Any discussion of the fragmented state of the electricity supply industry was avoided. In March 1931 there were 666 authorised electricity undertakings in Great Britain which owned 495 power stations. Public authorities (250 stations) generated 59.5 percent of the national electricity output while the company sector (245 stations) produced 40.5 percent.[89] This high degree of fragmentation was one of the unforeseen consequences of the franchise rules in the Electric Lighting Act 1882.

The electricity legislation administered by the Board of Trade offered an orderly structure of basic franchise areas and safety regulations. It was, however, inflexible and quickly outmoded by technical advances in generation and the development of long-distance AC transmission. Rules against amalgamations made consolidation of small supply areas into large units very difficult. The multiplicity of AC and DC systems, different frequencies and voltages also resulted in high costs and limited the potential benefits of large-scale operation. The power companies created by private Acts between 1899 and 1904 added another layer of complexity to electricity supply.

The Electricity (Supply) Act 1919 was part of the Reconstruction efforts[90] to address issues that had become critical during the war: wasteful use of coal, limited interconnection of power stations, inadequate power supply in many areas, and high costs of generation. Although "massacred in Parliament"[91] the legislation created a new body, the semi-independent Electricity Commissioners.

At first the state was not prepared to spend any funds on electricity supply, but this changed when rising unemployment in 1921 brought in some emergency measures. Under the Trade Facilities Act 1921, the Treasury Advisory Committee offered guaranteed low-interest loans for new works. New power stations at Brimsdown and Stourport and the enlargement of the hydro-electric capacity of North Wales Power were supported in this way.[92] The Unemployment Grants Committee also assisted some electricity schemes from 1920 to 1932 with grants amounting to £24.5million.[93]

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[89] ***Eleventh Annual Report of the Electricity Commissioners 1 April 1930-31 March 1931*** (London: HMSO, 1931), pp.10-11.

[90] Paul Berton Johnson, ***Land fit for heroes: the planning of British reconstruction 1916-1919*** (Chicago: University of Chicago Press, 1968).

[91] Johnson (1968), p.429. See also Leslie Hannah, ***Electricity before Nationalisation*** (1979), especially pp.67-74. George Balfour (1872-1941), MP for Hampstead, electrical engineer and chairman of many electricity companies, was particularly hostile to the Electricity Bill.

[92] Applications were listed in ***Annual Reports of the Electricity Commissioners*** with full details published in Parliamentary Papers.

[93] ***Final Report of the Unemployment Grants Committee 1920-1932***, Parliamentary Papers, Cmd 4354.

Sir John Snell (1869-1938)

Electrical Engineer and Administrator

Source: Pencil Portrait No.11; *The Engineer* 2 April 1937.

Among the many national developments accomplished by Snell were:

- facilitating the acquisition of the National Telephone Company by the state Post Office;
- reorganisation of electricity generation and the planning of the National Grid;
- standardisation of AC frequency at 50 cycles (Hz);
- encouragement of electricity undertakings to take long views, especially with reference to rural electrification.[a]

Born in Saltash, Cornwall, son of Commander John Snell RN, he was educated at Plymouth Grammar School and King's College, London. After completing his training Snell joined Crompton & Company and was responsible for laying the systems of mains for the Notting Hill Co. and in Stockholm.

Snell entered local government service n 1893, first with St Pancras Vestry where he designed and supervised the erection of the new King's Road power station. In August 1896 he was appointed Borough electrical engineer at Sunderland where he designed the new power station at Hylton Road. From 1899 with the additional role of Borough tramway engineer, he arranged the takeover of the horse tramway and developed the new electric system.

In 1906 he moved to London and as a consulting engineer worked for the London County Council on its metropolitans power scheme, designing a large power station at Barking with a capacity of 120,000kW.[b] He amalgamated his practice with Preece, Cardew and Rider in 1910. During the arbitration proceedings for the takeover of the National Telephone Co. He acted as the principal witness for the Crown, spending no fewer than thirteen days in the box. Although National Telephone claimed £21million for its property, it was awarded only £12.5million. For his services John Snell received the honour of a knighthood in 1914.[c] His last work as a consulting engineer was designing the East Harbour power station for Belfast Corporation.

During the war Snell served on many committees including the Board of Trade Electrical Trades Committee and was chairman of the Water Power Resources Committee. The final report of the latter committee was credited later for its role in Scottish hydro-electric development.[d]

In early 1920 Snell was appointed chairman of the Electricity Commissioners, a new body created by the Electricity (Supply) Act 1919. One of the early tasks was the formation of Joint Electricity Authorities as the key component in reorganising electricity generation. Without any compulsory powers or financial incentives to undertakings, it was an onerous duty of regional conferences, inquiries and voluminous correspondence. Throughout the conduct of these meetings [Sir John] "was always dignified, always fair and those to whom he had to announce an adverse decision never doubted his integrity or impartiality".[e]

In 1925 he was the chief technical advisor to the Weir Committee whose recommendations were largely embodied in the Electricity (Supply) Act 1926 that established a national transmission system and the Central Electricity Board. Plans for each grid scheme area were prepared by the Electricity Commissioners.

In this work Snell was assisted by E.W. Dickinson.[f] The nine regional schemes were all implemented by the Central Electricity Board and the final tower was erected in September 1933.

Work on the reorganisation of the distribution side of the industry began in the early 1930s. Snell was a member of the McGowan Committee which reported in 1936 but little progress was made before Snell retired in January 1938.

Snell's public service was extensive. He was president of the Incorporated Municipal Electrical Association 1902-03, president of the Institution of Electrical Engineers 1914-15, vice-president of the Institution of Civil Engineers 1926-1931 (only ill-health prevented his acceptance of the presidency) and president of the British Electrical and Allied Manufacturers Research Association 1928-29. His energy and influence were powerful forces in shaping the British electricity supply industry before nationalisation.[g]

Notes

[a] T.P. Wilmshurst,"Sir John Snell", Obituary Notice, ***Nature***, Vol.142, 1938, pp.384-385. Thomas Percival Wilmshurst (1869-1950) had begun his career with the pioneer Taunton Electric Lighting Co., moved to Exeter as manager and chief engineer in 1887, then Borough electrical engineer for Halifax, and then in Derby from 1898 to 1926. He served as an Electricity Commissioner from 1926 to 1935.

[b] The proposed Barking station with 12,000kW turbines was described in some detail in John F.C. Snell, ***Power House Design*** (London: Longmans Green, 1911), pp.17-21. A second edition was published in 1921. Snell had also published an earlier book, ***The Distribution of Electrical Energy*** (London: Simkin, 1907).

[c] Obituary, ***The Engineer***, Vol.166, 1938, p.71

[d] ***Power to the People: The built environment of Scotland's hydro-electric power*** (Edinburgh: Historic Scotland. 2016), p.11-13.

[e] Wilmshurst, Obituary, p.385.

[f] Ernest Winram Dickinson (1872-1946) had previously worked in Bolton under J.H. Rider and then with the London County Council tramways at Greenwich power station. He joined the Electricity Commissioners in 1926 and later became Rural Development Officer from 1930 to 1933 when he retired. (***Graces Guide-IEE history***)

[g] The Central Electricity Authority honoured Snell's work with the naming of a collier launched at Aberdeen in 1955. The vessel served the Shoreham power station and others in the lower Thames estuary. D. Ridley Chesterton and R.S. Fenton, ***Gas and Electricity Colliers*** (Kendal: World Ship Society, 1984), p.117.

The Electricity Commissioners

The Electricity Commissioners who were appointed early in 1920 had several functions: an administrative role in supervising electricity supply throughout Great Britain; a planning function to extend supply; and judicial powers over the building of power stations and the construction of overhead power lines. In 1931 there were four Commissioners: Sir John Snell (chairman), W.W. Lackie, T.P. Wilmshurst and Sir John Brooke. With a staff of 80, the Commissioners worked from offices in Savoy Court in the Strand. The expenses of the Commissioners were supported by a levy on the sales of all authorized undertakings.[94] This procedure allowed for independence from the Treasury.

The Electricity Commissioners worked under delegated legislation supervised by the Minister of Transport. Under the procedure of "special orders" the Commissioners' rulings were made as orders, confirmed by the Minister of Transport and then laid before both Houses of Parliament for 30 days and approved by resolution of both houses.[95] This procedure avoided the lengthy delays and sometimes uncertainties of the earlier Parliamentary process.[96]

[94] Electricity (Supply) Act 1919, Section 29.

[95] W. Ivor Jennings, ***Parliament*** (Cambridge: Cambridge University Press, 1939), p.472.

[96] Parliamentary procedures had resulted in some major developments with lasting consequences. These included the House of Lords amendments (1898-1900) which allowed the formation of power companies with perpetual rights and the rejection of the Administrative County of London Electric Power Bill of 1905.

One mandate of the Electricity Commissioners was to reorganize generation by forming Joint Electricity Authorities. A series of 15 Electricity Districts covering the main industrial areas were defined in 1920/21. Much effort was devoted to this work which required public inquiries, preparing draft schemes, and attempting to reconcile the sharp differences of opinion among local authorities and between local authorities and companies. The results were disappointing with only four JEAs established: North Wales & South Cheshire (first meeting 12 October 1923); London & Home Counties (4 November 1925); West Midlands (1 March 1926); and North West Midlands (17 June 1929).

Among the valuable lessons learned during this period of lengthy and often futile inquiries was the need for compulsory powers. It was also clear that the areas for integrated generation and transmission could be much larger than the early concept of the Electricity Districts. Another important requirement was a standardised frequency of 50Hz and therefore conversion of areas working at 25Hz, 40Hz or other frequencies. All these features were part of the confidential evidence submitted to the Weir Committee.

Prompted by the slow progress of the Electricity Commissioners and the backwardness of Britain in the electricity league tables revealed at the World Power Conference in London in July 1924, the prime minister appointed a small committee chaired by Lord Weir in January 1925. The other two members were Lord Forbes who (as Sir Archibald Williamson) had chaired the influential electricity committee of 1918 and Sir Hardman Lever, a former Financial Secretary to the Treasury. Sir John Snell was the technical adviser and Charles Merz provided critical evidence. The Weir report was completed by early May and made three key recommendations:

- Establish a national transmission system;
- Create a Central Electricity Board;
- Standardise all AC systems at 50Hz.[97]

The government accepted the recommendations which were all incorporated in a Bill that was introduced in Parliament in February 1926 and after much debate, often acrimonious, received Royal Assent in December.

While the Central Electricity Board was responsible under the Electricity (Supply) Act 1926 for building and operating the new national transmission system, the plans for each regional scheme were to be prepared by the Electricity Commissioners. The first of their plans, for central Scotland, had been developed while the legislation was in Parliament and was ready for submission to the CEB in April 1927. Eight other grid plan schemes were prepared by the end of 1930.

Plans for each regional scheme were published in two parts after adoption by the CEB.[98] The first part defined the area, listed all the authorised undertakings, selected power stations and transformer stations, as well as details of any frequency standardization. The second document, named "Supplementary Particulars" was much more detailed and included graphs of projected growth of generation to 1940/41 and tables of estimated capital costs and annual savings to the large undertakings because of the scheme. The consulting engineers who assisted the Commissioners in

[97] Ministry of Transport, ***Report of the Committee appointed to review the National Problem of the Supply of Electrical Energy*** (London: HMSO, 1927). The Weir Report was published after the Electricity (Supply) Act 1926 had come into force. An earlier version of the report is available at the National Archives (available online www.filestorenationalarchives.gov.uk)

[98] The scheme documents were published by HM Stationery Office.

preparing the plans also covered the fine details of transformer capacity and the size of generators in the power stations.

Once a regional scheme had been adopted by the CEB, the largely conceptual routes connecting power stations had to be surveyed on the ground and wayleaves had to be arranged with the property owners. When this work was completed the Electricity Commissioners had to grant consent to the actual construction of a section of line.[99] In the preparation of the initial plans and the final approval of each section, the Electricity Commissioners were already involved in the development of the national grid. Later changes to grid schemes and the building of new transmission lines all required the consent of the Electricity Commissioners and the making of Special Orders for confirmation by the Minister and approval by Parliament.

By 1931 the Electricity Commissioners had supervised an industry that had grown and changed over the previous decade. Generating capacity had been increased from 3.09million kW in 1922/23 to 7.19m kW in 1931/32, and there had been significant improvements in efficiency. Coal consumption had been reduced from 3.24lbs of coal per kWh generated to 1.78lbs and working costs had fallen from 1.05d per kWh to 0.23d. The number of consumers had risen from an estimated 1 million in 1921/22 to 4.6million in 1931/32 and per capita consumption had grown from 74 to 212 kWh.[100]

The limited coverage of Electric Lighting Orders of the early 1920s had been expanded by the approval of Electricity Special Orders. Most of southern and eastern England was now covered and further orders for northern England (primarily Westmorland), West Wales and the Scottish Highlands were in the process of approval. Experimental rural electrification schemes in the Bedford and Norwich area were designed to show what could be possible with limited expenditure.

With the new layer of organisation in the Central Electricity Board, a national transmission grid was under construction and would be largely completed by 1933. Standardisation of the AC frequency at 50 cycles (Hz) was replacing the 25 Hz and 40 Hz systems. The replacement of the earlier regional plans for Joint Electricity Authorities had been superseded by the national grid that was to prove a much more effective solution to the earlier problems of fragmented generation.

With plans for the grid schemes completed by the end of 1930, the Electricity Commissioners turned their attention to the problems of distribution. Various confidential reviews and discussions reached no obvious conclusions. A small committee of inquiry[101] was appointed in July 1935 and reported in May 1936.[102] After some delays the government published an "Outline of Proposals" in April 1937.[103] The proposals were met with strong opposition especially by small local authorities faced with abolition. With more pressing national issues of the time, reorganisation of distribution was set aside.

Although the Electricity Commissioners had failed to end the fragmented state of the electricity supply industry, their work had brought more order and efficiency during a period of major electrification. Experience gained from the work of the Commissioners and the operations of the Central Electricity

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[99] Details of the first consents to the Central Electricity Board for the construction of power lines were published in the ***Tenth Annual Report of the Electricity Commissioners 1929-1930***, Appendix K, pp.153-154.

[100] ***Twenty-third and Final Report of the Electricity Commissioners, 1 April 1947-31 July 1948*** (London: HMSO, 1950), p.6.

[101] The members were Sir Henry McGowan (1874-1961), industrialist, Chairman of Imperial Chemical Industries 1930-1950; Sir John Snell, chairman of the Electricity Commissioners; and John Morrison, a leading chartered accountant.

[102] Ministry of Transport, ***Report of the Committee on Electricity Distribution*** (London: HMSO, 1936), 103pp.

[103] Ministry of Transport, ***Electricity Distribution: Outline of Proposals*** (London: HMSO, 1951), 24pp.

Board was valuable in the smooth transition from fragmented local authority and company control to direct state ownership after nationalisation.

The phase of state intervention that began with the Electricity (Supply) Act 1919 came to an end with the Electricity Act 1947 and the state takeover of all electricity undertakings from 1 April 1948. Most functions of the Electricity Commissioners, notably consent for the building of new power stations and extension of existing stations, as well as approval of overhead transmission lines, were transferred to the Minister of Fuel and Power.[104]

The Central Electricity Board and National Grid

Reorganising electricity generation on a regional and national scale was the major accomplishment of state intervention between the wars. The government acted quickly following the Royal Assent to the Electricity (Supply) Act in December 1926. Sir Andrew Duncan[105] was appointed chairman of the new Central Electricity Board by the Minister of Transport in January 1927. The other seven members of the Board were appointed shortly afterwards. By the end of March Archibald Page[106] was chief engineer and the head office was established in Trafalgar Buildings, 1 Charing Cross.

As a new type of public service board, the CEB was not part of the civil service nor was it subject to the usual controls of the Treasury.[107] Capital for the transmission system was raised independently. These special features gave the Board flexibility in developing the project.

The main purpose of the National Grid was to provide interconnections between "selected" power stations. These were the most efficient and low-cost, with good access to cooling water and coal supply, and land available for further extensions. Economies of scale in generation would help to reduce wholesale prices of electricity and ultimately the prices paid by consumers. Large new stations, then under construction, such as Portishead, Ironbridge, Hams Hall, Clarence Dock (Liverpool) and Battersea, would be major contributors to the grid. Overhead lines at high voltage (132kv) would provide the interconnections between power stations, except in London where 66kv cables would provide the linkages. Transformer stations located at or near the selected stations would reduce the voltage to that of local distribution lines and mains. Much to the disappointment of many rural landowners where transmission lines crossed their property, electricity supply depended on the local distributors to make the necessary connections. This would often take years or even decades to accomplish.

[104] Electricity Act 1947, Section 58.
[105] Sir Andrew Duncan (1884-1952), Scottish industrialist who served on many government committees, including the Royal Commission on the Coal Industry of Nova Scotia 1925; chairman of CEB 1927-1934. Obituary ***The Engineer*** Vol.199, 1952, pp.474-475.
[106] Archibald Page (1875-1949), chief engineer Glasgow Corporation 1917; Clyde Valley Electrical Power Co. 1919; Electricity Commissioner 1920; chief engineer County of London Co. 1925; chief engineer CEB 1927-34; chairman 1935-1944.
[107] The organisation of the CEB is described in detail by Graeme Haldane. See Chapter 5 in W.A. Robson, ed., ***Public Enterprise: Developments in social ownership and control in Great Britain*** (London: Allen & Unwin, 1937).

Figure 8 ELECTRICITY GRID SYSTEM 1933-34.
Source: **Modern World Atlas** *(Edinburgh: John Bartholomew, c.1934), Map xiv, Great Britain, Electricity Grid System. (Author's Collection).*

The grid schemes were designed to be largely self-sufficient with only limited connections between them. Central England, for example, only had connections with the North West near Crewe, the South West near Gloucester, and the South East near Bedford. The single-circuit transmission lines which were the dominant type of linkage had a carrying capacity of about 50,000kW. This became a serious limitation during the war when large-scale inter-regional power transfers became necessary.

The Central Scotland Electricity Scheme, designed and built in three years, served as the prototype for all the other regional schemes built by the CEB. Work on the ground was supervised by a regional general manager and chief engineer. Design of the towers and transformer stations as well as the contracts for equipment and stations were generally handled by the head office. The first transmission tower was erected near Edinburgh on 14 July 1928 and the final tower (pylon) was raised near Fordingbridge, Hampshire on 5 September 1933. Some 26,000 steel lattice towers of various types were erected across the country.[108]

Major engineering works included the river crossings of the Clyde and Forth in Scotland and the Ribble, Humber and Thames in England. Negotiating wayleaves was a particular challenge in old urban centres such as Glasgow where the Dalmarnock-Yoker 132kv line had to be threaded through the built-up area. The Watford-Willesden line had to be fitted into the new residential development of Harrow Garden Village. Space for transformer stations had to be found near the selected stations, but sometimes several streets away as at Dalmarnock in Glasgow.

Figure 8 shows the layout of the national grid in 1934 when most construction had been completed. A few lines such as from Penrith to Egremont via Keswick were not built. Other sections such as the Severn crossing at Aust were revised by directing the line further upstream where construction costs were very much cheaper.

The CEB faced some strong opposition to some of its proposals especially in areas of high landscape amenity values. Some notable examples included the Keswick area, the South Downs near Eastbourne, and the New Forest.[109] Local inquiries were held by Ministry of Transport inspectors and some route modifications were made. One concession made to the opposition was the appointment in 1931 of the Council for the Preservation of Rural England as an official advisor to the Electricity Commissioners on the positioning of overhead lines to minimize their visual impact on the landscape.[110]

Table 4 provides some basic details of the nine electricity schemes contracted by the CEB from 1927. The delayed start of trading in South Scotland was due to the need to complete the five hydro-electric stations of the Galloway Scheme. In North East England trading began only in July 1938 when the whole regional system's frequency had ben converted from 40 Hz to 50 Hz.

Three firms of consulting engineers were responsible for much of the design work on the grid schemes:

Kennedy & Donkin: Central Scotland, South Scotland, North West England & North Wales, South West England & South Wales.

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[108] The completion of the grid was celebrated in a special 28-page "Electricity Number" in ***The Times***, 5 December 1933. Much of the promotion work was prepared by the Electrical Development Association.

[109] Bill Luckin, ***Questions of Power: Electricity and environment in inter-war Britain*** (Manchester: Manchester University Press, 1990). Chapter 6.

[110] CPRE, The Countryside Charity website (www.cpre.org.uk) "Our achievements and history: the early years."

Merz & McLellan: South East England, East England, North East England, Mid-East England.

Highfield & Roger Smith: Central England.

A grid system for the North of Scotland was built only from the late 1940s, after the formation of the North of Scotland Hydro-Electric Board.

Table 4 THE NATIONAL GRID ELECTRICITY SCHEME AREAS 1934.

Area Scheme	*Date adopted*	*Selected Stations*	*Approx.miles line: Primary*[1]	*Approx.miles line: Secondary*[2]	*Trading began*
Central Scotland	29.6.1927	10	347	11	1.1.1933
South East England	15.2.1928	30	507	350	1.1.1934
Central England	22.5.1928	20	415	31	1.4.1935
North West England & North Wales	12.10.1928	29	350	270	1.1.1934
Mid East England	19.3.1929	16	323	202	1.1.1933
North East England	22.1.1930	6	102	14	1.7.1938
East England[3]	31.3.1930	2	140	14	1.1.1934
South West England & South Wales	3.6.1930	14	651	110	1.1.1935
South Scotland[4]	31.7.1931	1	230	146	1.1.1937
TOTALS		**128**	**3,005**	**1,048**	

Notes:
[1] 132kv lines
[2] Mostly 33kv and 66kv lines.
[3] Combined with South East England for operating purposes.
[4] Combined with Central Scotland for operating purposes.
Sources: Compiled from Central Electricity Board Reports and ***The Engineer***.

Grid Control centres in Glasgow, Newcastle, Leeds, Manchester, Birmingham, Bristol and London (Bankside) were responsible for the detailed operation of the grid transmission system.

Further extension of the grid after 1934 included several new lines: *Galashiels->Carlisle, Hartshead->Neepsend (Sheffield), Ironbridge->Stoke-on-Trent, Leicester->Little Barford, Watford->Oxford->Gloucester->Ebbw Vale, Nursling (Southampton)->Melksham, Brighton->Portsmouth, Northfield->Hastings.* These extensions raised the total route mileage of the grid to 5,172 in 1947 (3,685 miles of 132kv lines and1,487 miles of lower-voltage lines).[111] By 1947 the number of selected stations had increased to 142 and 53 Special Agreement Stations had been added to the list of power stations directed by the CEB.[112]

The addition of the new layer of the CEB transmission system to the existing complex of undertakings that operated the electricity supply system led to increased centralisation and decision-making especially from London. Writing of his experience as a former Lord Mayor of Manchester in the early 1920s, Ernest Simon noted that for the Electricity Committee "…there is, broadly speaking, no control from Whitehall. There is no government audit and the committee {subject to the Council) can do what it likes with the profits". A footnote (perhaps added later): "Except the new control of the Electricity

[111] Central Electricity Board, ***Twentieth Annual Report 1 January1947-31 December 1947*** (London: CEB, 1948), p.12.
[112] The Electricity (Supply) Act 1935, 25 Geo 5, chapter 3, allowed the CEB to make other agreements with undertakings for generating supplies to the grid. This legislation also enabled the Board to supply electric railways directly without any extra charges from local distributors.

Commissioners mainly over capital expenditure, exercised to ensure efficient coordination of national electricity supply".[113] By the mid 1930s the position was rather different, for although the Corporation's Electricity Department continued to own and manage the two selected power stations at Barton and Stuart Street, the output was now directed by the CEB grid control office in East Didsbury while plans for future expansion were shaped by the strategies of the central offices in London.

The work of the Central Electricity Board introduced a new level of national planning and co-ordination in the operation of the electricity supply industry.[114] In the move from local to regional and national organisation the grid supported the growth of large (over 100,000kW capacity) power stations from 3 in 1925/26 to 16 in 1935/36 and 47 in 1948/49. Such growth helped to reduce costs, not only by greater efficiency but also by bringing savings in the reserve capacity for emergencies. Although the grid and power station system was essentially a producer and wholesaler, the lower costs helped to reduce the price of electricity to the final consumer. One result, as predicted by the Weir Committee in 1926, was a substantial increase in consumption which rose from 133kWh per person in 1925/26 to 374kWh in 1935/36 and 821kWh in 1947/48.[115]

Before the electricity grid the only widespread imprint of the state on the landscape was the work of the General Post Office. This included the standardised letter boxes and trunk telegraph/telephone lines that spanned the British Isles. A new element was added from the mid-1920s when the GPO introduced standardised telephone kiosks. Within a decade they were universal, not only in town streets but also villages and isolated mountain areas. London architects were important in the design of these additions to the landscape. Sir Giles Gilbert Scott designed the telephone kiosks[116] and Sir Reginald Blomfield advised on the standard designs for the transmission towers of the national grid.

The Central Electricity Board, conscious of the visual effect of thousands of steel lattice towers, appointed Blomfield as a consultant in October 1927.[117] Working closely with the primary designers of the towers at Milliken Brothers in Watford, Blomfield shaped the final prototypes which were erected near Edinburgh in July 1928. With the design finalised, specialised fabricators manufactured the steel parts, then galvanised and prepared them for shipment to the erection sites of the contractors. After the localised but heated opposition to building transmission lines, the grid towers quickly became an accepted part of life and landscape. Spender's poem "Pylons" published in 1933 gave recognition if not total acceptance. Two years later, a writer in the ***Architectural Review*** commented on "the improvement of the electricity grid which incidentally has given us, in the pylons, one of the finest additions to the landscape in modern times".[118] Universal use of the uniquely British term "pylon" for the grid tower was perhaps another popular mark of general acceptance.

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113 E.D. Simon, ***A city council from within*** (London: Longmans, Green, 1926), p.13.
114 See Rob Cochrane, ***Power to the People: the story of the National Grid*** (London: Newnes Books and CEB, 1985).
115 Hannah, ***Electricity before Nationalisation*** (1979), p.428.
116 Gavin Stamp, ***Telephone Boxes*** (London: Chatto & Windus, 1989). Sir Giles Gilbert Scott also designed the exterior features of Battersea power station for the London Power Co.
117 ***The Times***, 18 October 1927, p.16.
118 ***Architectural Review***, May 1935, p.197.

Summary

With a population of 8.2 million in 1931, Greater London accounted for 18.3 percent of the total population of Great Britain. This proportion had risen from 10.6 percent in 1831 and 16.0 percent in 1881. Other measures show varying levels of national dominance. The Port of London handled 34.5 percent of the value of national overseas trade (an average for 1926-30).[119] London morning newspaper circulation accounted for 83.3 percent of all morning newspapers sold in Britain (1946-47).[120]

Given these levels of dominance, it was inevitable that London would have a powerful role in the process of electrification. The potential market for all types of electrical equipment, from lamps to transformers, cables and generators, made London a magnet for early investment. Public electricity supply in London began to take off in the late 1880s after a decade of experimentation and private generation. By 1900 there were 29 electricity undertakings in Greater London and their sales accounted for 45.7 percent of all electricity sold in Great Britain.[121] In 1935-36 there were 62 undertakings and the London share of sales was 30.5 percent of the national total.[122]

London's dominance in electricity was much more than the size of the market. The transactions approach **(Figure 1)** helps to catch some of the complex interlocking relationships between science and technology, business and government that were at the heart of London's role in the national supply industry. Although other large cities such as Birmingham, Manchester and Glasgow shared some of the same elements as London, they were always overshadowed by the power of the capital.

The influence of London organisations covered many fields and extended across the British Isles and beyond.[123] Technical education, especially in electricity, was supported by the City & Guilds Institution and quickly diffused elsewhere with most local colleges following a curriculum set by London institutions. Electrification in Britain was fostered by London firms of consulting engineers and electrical contractors some of which evolved into holding companies. Holding companies based outside London had largely disappeared by 1931.[124]

Promotion of electricity usage by London associations also required the provision of equipment and supplies to market areas. General Electric responded with the establishment of branch offices and warehouses supported by commercial travellers. General Electric Ltd had 30 branches in 1931, from Inverness to Plymouth, including three in Ireland. Callender's Cables and Construction, a much more specialised business, had established 25 branch offices between 1901 and 1930.[125]

Government, although highly centralised in London, had a powerful outreach after the establishment of the Electricity Commissioners in 1920. The Commissioners not only controlled the granting of new franchise areas but, with their powers of consent influenced the location of power stations and the

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[119] L. Dudley Stamp and Stanley H. Beaver, ***The British Isles: A Geographic and Economic Survey*** (London: Longmans Green, 4th ed. 1954), p.653.
[120] Viscount Camrose, ***British Newspapers and their Controllers*** (London: Cassell & Co., 1947, pp.13-14.
[121] Calculated from tables published in ***Garcke's Manual 1900-1901***.
[122] Calculated from data published by the Electricity Commissioners in the ***Engineering and Financial Statistics 1935/36***.
[123] Overseas interests of British companies and banks are a separate study, partly covered by William J. Hausman, Peter Hertner and Mira Wilkins, ***Global Electrification: Multinational Enterprise and International Finance in the history of Light and Power 1878-2007*** (New York: Cambridge University Press, 2008).
[124] Christie Brothers & Co. (based in Chelmsford) and the Yorkshire Electric Power Co. (Leeds) were the only examples in the PEP survey (1936). Earlier examples, all absorbed by larger companies, included Northern Counties Electric Supply Co. (Newcastle), Western Electric Distributing Co. (Stroud) and East Anglian Electric Supply Co. (Stowmarket).
[125] R.M. Morgan, ***Callender's 1882-1945*** (Prescott: BICC plc, 1982), p.8.

siting of overhead power lines. Comprehensive statistics published by the Commissioners provided a detailed basis for planning as well as fostering improvements in efficiency. The Central Electricity Board which constructed and operated the national transmission grid added new elements of standardisation and direction from London.

The success of London agencies in British electrification depended on people with ideas, energy and skills of advocacy and administration. Some such as George Balfour, Emile Garcke and Caroline Haslett were well known. Others were less visible. Thomas Octavius Callender (1855-1938) was not only the manufacturer of cables but also director of many electricity supply companies. Andrew Wilson Tait (1876-1930)[126] served as chairman of many companies including Ferranti Ltd (1905-1928), British Aluminium Co. (1914-1928) and the Metropolitan Electric Supply Co. (1920s). Interlocking directorships such as these were common in the electricity supply industry. Charles le Maistre at the British Standards Institution promoted the adoption of standard fittings both at home and internationally.

London influence was sometimes challenged by provincial developments. The formation of the Northern Society of Electrical Engineers in Manchester (1893) was potentially a move against the dominance of the IEE in London. A new policy allowing the creation of Local Branches (1899) countered this threat and branches were formed in Dublin, Glasgow, Manchester, Newcastle-upon-Tyne and Cape Town during 1900.[127]

Although London consulting engineers practiced all over the British Isles, many urban systems were planned by local engineers. Early examples include the public supply companies in Liverpool (1883)[128], Glasgow (1889), and Birmingham 1890). Merz & McLellan, established in Newcastle-upon-Tyne in 1899, quickly emerged as a very progressive firm with innovative design work on Tyneside supply.[129] By 1904 the company had the confidence to tackle the fragmented London situation with a bulk supply scheme. Although the Administrative County of London & District Electric Power Bill was defeated in Parliament, the detailed plans gave much publicity to the firm which later acted as consultants to the London County Council (1913-15). Merz & McLellan designed the Barking power station for the County of London Company and the transmission grid system for southern and southeastern England. Many electrical engineers from the firm went on to major appointments in the public and private sectors.

Local authorities were often opposed to moves from London. In 1882 many places refused to give consent to the proposed development of the Anglo-American Brush Co., and in 1890-91 there were similar refusals of the schemes of the House-to-House Electric Supply Co. Most of the Power Company Bills proposed between 1898 and 1904 faced heavy Parliamentary opposition by groups of local authorities. In the early 1920s the proposals for creating Joint Electricity Authorities were often thwarted by local authority opposition. Later moves proposed by the McGowan Report to amalgamate smaller electricity undertakings were similarly rejected at the local level.

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[126] John R. Edwards, "Tait, Andrew Wilson (1876-1930), Accountant and Industrialist", ***Oxford Dictionary of National Biography*** (available online). Tait joined the newly formed Touche & Co. in 1900 and quickly became one of the outstanding accountants of his time. He was also active in the formation of the British Electrical and Allied Manufacturers' Association in 1911 and the Federation of British industries in 1916.

[127] Reader, ***History of the IEE 1871-1971*** (1987), p.61.

[128] G. Woodward, "Electricity in Victorian Liverpool", ***Engineering Science and Education Journal***, Vol.1(4), 1992, pp.183-191. The Liverpool Electric Supply Co. was established in 1883 by Arthur Bromley Holmes and J.C. Vaudrey. Vaudrey moved to Birmingham in 1890 to take the city electricity franchise.

[129] John Rowland, ***Progress in Power: The contribution of Charles Merz and his associates to sixty years of electrical development 1899-1959*** (London: Newman Neame, 1960), pp.41-47.

Home-rule movements in Ireland and Scotland were the most effective in ending London dominance. The Electric Lighting (Scotland) Act 1890 gave the new Secretary of Scotland a role in approving the submission of Electric Lighting Orders to Parliament. More autonomy was granted by the formation of the North of Scotland Hydro-Electric Board in 1943. Full autonomy came in 1955 when all powers related to electricity supply in Scotland were transferred from London to Edinburgh. The Government of Ireland Act 1920 allowed for the transfer of powers to the new capitals in Belfast and Dublin in early 1922. The Irish Free State with the Shannon hydro-electric scheme abandoned all British connections, making contracts instead with Siemens for the construction work, equipment and building of a transmission line. From 1925 Ireland's electrification took a wholly independent path. Northern Ireland continued to use British equipment and consulting engineers with Kennedy & Donkin as the dominant firm from 1931 to the 1990s.

Planning and national direction of electricity supply became increasingly centralised in London after the 1926 legislation as the Central Electricity Board built the transmission grid and the regional grid control centres came into operation. In October 1937 the seven regional grids were linked together as an experiment and began working as a national grid a year later.[130] This development together with the continued work of the Electricity Commissioners facilitated the moves towards nationalisation of the whole supply industry in Britain. By 1 April 1948 the London offices of the British Electricity Authority had achieved full control.

The Faraday centenary of 1931 was an opportunity to celebrate the development of electricity in Britain. From the beginning London had a powerful position with the electric telegraph and then with lighting and traction. The early start and the size of the urban region made London the dominant market.

London's early dominance in the manufacture of electrical equipment was quickly challenged by new firms especially in Lancashire and the West Midlands. By 1890 W.T. Glover & Co. was producing a range of cables at the Salford Electrical Wire Works and the British Insulated Wire Works Co. had established a factory at Prescot. Mather & Platt's Salford Iron Works had added an electrical department in 1883 and had just completed work on the pioneer electric tube line, the City and South London Railway. The importance of Greater Manchester in electrical engineering was reinforced by the location of the British Westinghouse works at Trafford Park, opened in 1902. Development in the West Midlands included Elwell-Parker, later the Electric Construction Co. in Wolverhampton; it had made equipment for the South Staffordshire electric tramway system and the Liverpool Overhead Railway both of which opened in 1893. In Birmingham the many small workshops making electrical parts and fittings were joined by the Witton Works complex of General Electric from 1900. Many London electrical engineering firms were now on the move, taking up new factory sites in Bedford, Peterborough, Rugby and Stafford.

Despite the fragmented organisation, statistics from the London & Home Counties Joint Electricity Authority[131] show that the area which accounted for 20.2 percent of the population of Great Britain had 28.1 percent of national generating capacity and 25.5 percent of national electricity sales.[132] This market

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[130] See Rob Cochrane, ***Power to the People: the story of the National Grid*** (London: Newnes Books, 1985 pp.28-29.

[131] The London & Home Counties JEA had been formed in 1925 after five years of negotiation and new legislation. Its area was larger than Greater London including places such as St Albans, Tilbury, Dartford, Guildford and Slough and with an estimated population of slightly over nine million.

[132] Calculated from Electricity Commissioners, ***Engineering and Financial Statistics*** and statistics published in "Electricity consumption in London and the Home Counties," ***The Engineer*** Vol.12, 1936, p.173.

dominance was also reinforced by the subtle relationships and transactions between science, business and government that influenced all parts of the country.

Aside from the main Faraday events in September 1931, the London Power Company staged a formal ceremony on St George's Day, laying a stone commemorating Faraday's great discovery in the foundations of the Battersea power station.[133] The stone was placed "as a landmark in the development of larger London's light and power and to serve as another memorial to the scientific heritage derived from famous Englishmen."[134] The striking design of the building (opened in June 1933 with much publicity) quickly became a symbol of modernity widely used in promoting electricity. In operation the new power station not only served the office buildings, department stores, cinemas, theatres and hotels of central London but also the expanding suburbs of Outer London with their new housing areas[135] and industrial estates[136] which were all lit and powered by electricity. Generation at Battersea ended in 1983 and after three decades of neglect the former "Cathedral of Power" and surrounding area have been redeveloped for multiple uses by a UK/Malaysia partnership.[137]

Note on Sources

Two books provide a detailed sense of the vitality and dynamism of London:

> Stephen Inwood, ***City of Cities: the birth of Modern London*** (London: Macmillan, 2005, 535pp.) covers development from the 1880s to 1914; and Jerry White, ***London in the Twentieth Century*** (London: Penguin, 2002), 526pp.
>
> The choice of 1931 as the focal point for this chapter was partly inspired by Howarth's ***London and the Advancement of Science*** (1931) which gave a comprehensive view of organisations of the time. An appreciation of contemporary manufacturing came from Douglas Smith, ***The Industries of Greater London*** (1933) while the role of government was partly derived from Leslie Hannah, ***Electricity before Nationalisation*** (1979).

These initial sources were supplemented by further material described in the footnotes. The annual reports of the Electricity Commissioners were particularly helpful, not only with the broader context but also in presenting the fine details of special orders, loan sanctions, and consents for new power stations and overhead lines. Many primary sources such as the PEP ***Report on the Supply of Electricity in Great Britain*** (1936) used in compiling **Table 2**, required much additional research to discover more background on the holding companies. The Times Digital Archive was particularly helpful for reports on company meetings and advertisements of prospectuses when new capital issues were being announced.

Examining London from the perspective of the transactions/relationships involved in the development and organisation of electricity supply has suggested many possibilities for further research. They include:

- More detail on early graduates of the City & Guilds College in Finsbury and Faraday College. Both institutions are mentioned in many biographies and may well have contributed to the "Electrical Elite" identified by Sophie Forgan (see Note 8).

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[133] The opening address was made by radio telephone from Ottawa where Lord Bessborough, a former director of the London Power Company, had just been installed as Governor General of Canada. ***The Times*** 24 April 1931, p.8.

[134] Rob Cochrane***, Landmark of London: The story of Battersea Power Station*** (London: Central Electricity Generating Board, South Eastern Division, 1986), p.16.

[135] Alan A. Jackson, ***Semi-detached London: Suburban development, life and transport 1900-1939*** (London: Allen & Unwin, 1973).

[136] Peter Scott, ***Triumph of the South: A regional economic history of early twentieth-century Britain*** (Aldershot: Ashgate, 2007).

[137] Details of the redevelopment are presented on the website www.batterseapowerstation.co.uk .

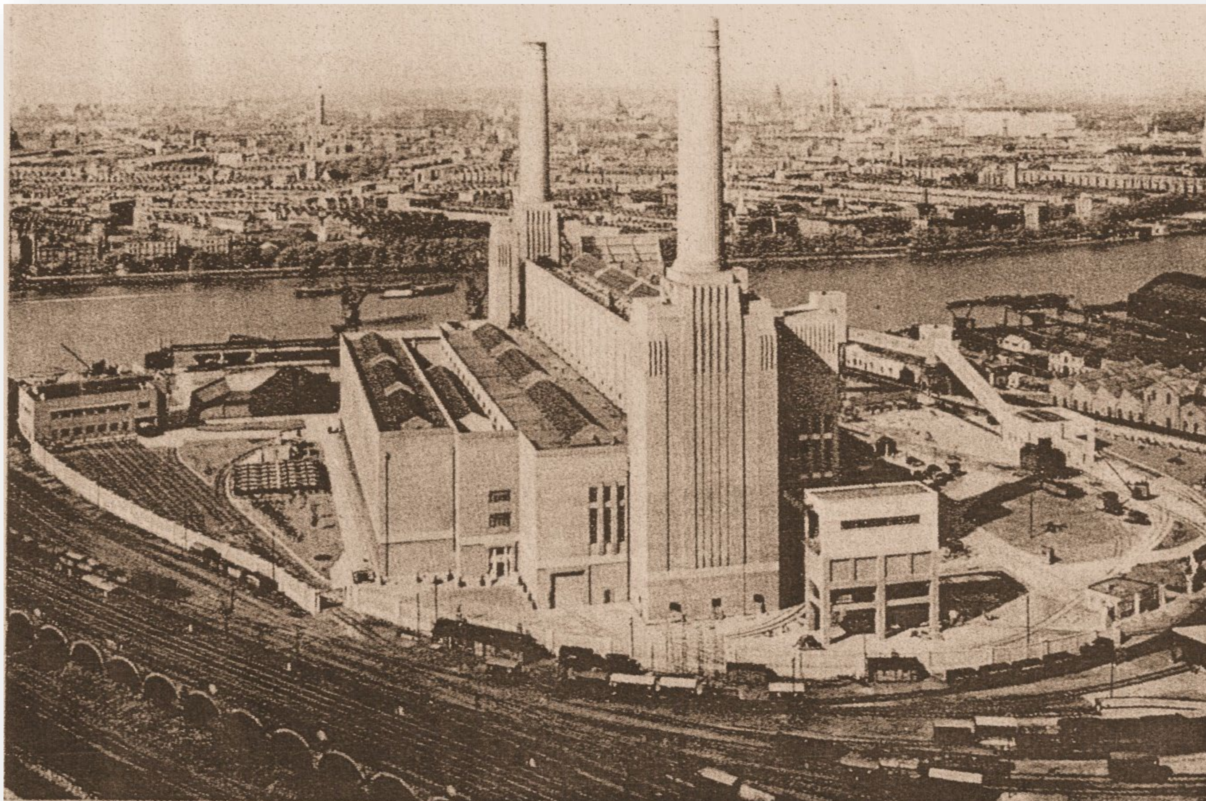
- How dominant were the London consulting engineers in national electrification?
- Electrical contractors were always an important segment of the industry but tend to be discounted. Edmundson's certainly deserves serious attention as both a contractor and a large holding company.
- Manufacturing, especially the radio and allied industries from which later electronic applications evolved, has much scope for further research.
- The role of the City financial institutions in raising capital for public supply undertakings (company and local authority and for manufacturing companies would benefit from further research.
- A cursory look at advertising history suggests that a closer look at the work of the Electrical Development Association would increase understanding of promotion efforts.
- While the state role has been studied in much detail, there is scope for examining the work of Parliamentary agents in the mechanisms of application for and approval of Electric Lighting Orders and Special Orders after 1920.

Garcke's Manual of Electrical Undertakings is the obvious starting point with its rich details of management personnel and company directors. Many new relationships await discovery in these volumes.

Grace's Guide to British Industrial History (www.gracesguide.co.uk) is another rich resource with many details of companies, people and places, and items such as ***Who's Who in Engineering*** 1922 and 1939.

The Institution of Engineering and Technology (IET) has a very extensive library and archive. Its website has many useful pointers including the digitized ***Women Engineer***. The obituaries published by the IEE (the predecessor of the IET) are particularly valuable.

Many new interconnections and relationships are possible by linking sources. Figure 2 would have been enhanced by also using ***Garcke's Manual*** for 1931 and the appropriate ***Kelly's London Post Office Directory*** with its detailed street-by-street listings. The micro-geography of the specialised electrical consultants and companies in the Victoria Street and Kingsway clusters could well reveal some interesting patterns and linkages.



London Power Company: Battersea Power Station, 1933

Later extensions doubled the size of the building and added two chimney stacks.
Source: Author's Collection.