Stephen Browning - ESI History Mk VII.

Googling Edison Holborn Viaduct and Ferranti Deptford finds all sorts of useful stuff.
Also the "CEGB story' booklet is up on an AboutBlyth site and Glyn England's musings from 1982 (view from my Window) are on a South Western historical electricity site.
Plus the main Electricity timeline document produced by the Electricity Council in 1987, Rob Cochrane's book Power to the People and various other sources.

Looking at the current difficult situation we appear to be in, I've been digging around how Electricity delivery has progressed in GB. I thought you find this interesting.....
There is a salutory lesson re excess capacity which really held us back until 1933, albeit at that time also with serious supply type diversity.

Much new Electricity Generation and Supply equipment was on show at the 1881 Paris Electrical Exposition and 1882 Crystal Palace Exhibition. Edison had by far the largest exhibit in Paris (including 'Jumbo' the 125hp monster generator). Edison and Swan displayed the new incandescent lamp. This engendered a number of projects which really kick started the Electricity revolution.

In 1882, Edison set up Holborn Viaduct power station (DC, using 'Jumbo'), positioned so as to use the Sewer (Sir Joseph Bazalgette) which crossed underneath the Viaduct and up to Newgate Street for the wires as he did not have a licence to dig up the streets. He ran cables up the side of a pub (Holborn Tavern) and overhead to the Telegraphs building of the General Post Office. But the head of the GPO Telegraphs and Edison had an professional animosity which had to be resolved first. Edison went back to New York, opened Pearl Street Generating station in September 1882, then other DC stations dotted across the Big Apple. Also started the New York Steam company to use the excess heat. Holborn Viaduct closed in 1884; limited expansion blamed on the 1882 Act preventing systems crossing area boundaries (see next page).

Lord Crawford went to the 1881 Paris exhibition and on his return suggested to his cousin Sir Coutts Lindsay that the new Incandescent light bulbs would work well in his Grosvenor Gallery in Bond Street. Coutts Lindsay installed a small generating unit. The neighbours were impressed with the new lighting and asked if he could add some more plant as they would take 'all the spare current'; thus he expanded the station in 1885. In 1886 he hired Sebastian Zian de Ferranti who realised a big solution was needed. He proposed giant Steam driven Alternators (10000HP) at Deptford, down the river to enable large volume cheap coal supply (Northumbrian by sea) and cooling. Then AC cables at the (unheard of) voltage of 10kV running along the huge viaduct of the London and Greenwich Railway to London Bridge and then Charing Cross. So, Lord Crawford and Sir Coutts Lindsay started the London Electricity Supply Corporation (LESCo).
Ferranti could only manufacture cable in 20' lengths so there were 8000 joints from Deptford to Charing Cross, only 15 of which faulted in 40 years of operation....

Up to the 1882 Electricity Act, a Private bill in Parliament was required to set up an Electricity undertaking. The new Act permitted the Board of Trade to licence Electricity Utilities and permitted the breaking up of streets and stringing of overhead lines for Electricity supply, with the consent of the Local Authorities. However, licences would only last 7 years and the Authorities could take over the supply company assets after 21 years (later increased to 42). They could also prevent companies from crossing authority boundaries. This hindered the development of Electricity in the UK.

Thus, LESCo had to apply to the Board of Trade for a multi-Authority block licence to dig the streets in Central London for distribution. However, there were a lot of competing requests for orders in each Area and customers could demand a supply and choose type (AC or DC,, voltage etc!!). The Board of Trade tried to restrict the number of suppliers in each Area but the inefficient small Area based station model prevailed. This restricted the supply area for the larger LESCo undertaking and the customers were initially reticent to select it. However, some common sense then prevailed, customers came back 'in droves' and Deptford grew rapidly. In 1892 the first Oil circuit breaker was installed to deal with breaking increased current levels and the station even had to be taken out of service in early 1906 for complete replanting.....) Note that the sending end voltage at Deptford had to be raised to 11kV to maintain 10kV in the West End of London. 11kV is still in use today as 'second level' distribution.

In 1889 Nicola Tesla, working for George Westinghouse, promoted Polyphase AC systems in the USA for distance transmission which needed High Voltage. A two phase 25Hz system was put in place to connect Niagara Generation to New York. Tesla then defined the principles of 3 phase AC Generation and Distribution. The last of Edison's New York Public DC supplies was 'spiked' in 1981.

In 1901 Charles Merz and William McLellan built the first 3 phase Generating Station at Neptune Bank, Newcastle, then the first Alternator with an electromagnetic rotor in 1903. In 1904 Merz and McLellan built Carville A, being the first Turbo-Alternator station of the modern type. Other developments, including Mertz-Price protection for Alternators was also developed for the Newcastle-upon-Tyne Electric Supply Co. By 1912 they had the largest integrated system in Europe.

In 1910/11 Ferranti as IEE President proposed full scale National Electrification with 100 stations at 250MW each to conserve Coal, improve efficiency and reduce costs.

In 1916 Charles Merz proposed the National Trunk Distribution systems. A Government review in 1918 identified the need for a more centralised system but the Act of 1919 did little to resolve the issues with multiple undertakings still dominating the field.

In 1921 Merz and McClellan opened North Tees Power Station, the first to use high temperature and pressure steam conditions . They then set up the first Grid system at 40Hz in the North East; largest single system in the World at that time but with no HV circuit breakers!!. They therefore commissioned Alphonse Reyrolle to come up with a suitable device.

But, by the early 1920's we had over 500 Electricity undertakings in the country with over 50 different combinations of AC/DC, voltage and frequency in the Capital alone. In fact you couldn't move across London and be sure you could take your appliances with you. Because of serious excess capacity (75%) and the resultant costs and charges, running five light bulbs cost a labouring wage and the GB demand was only about the same as that of Manhattan!!

The 1925 Weir committee (including Charles Merz) led to the 1926 Electricity Act which finally got the monster by the tail. A standard supply was defined - AC 3 phase 50Hz. Voltage levels were defined; 132kV grid with some 66kV sections plus distribution at 33kV then 11kV and finally 415V (Phase to Phase) to smaller premises (240V Phase to Neutral). The 122 most efficient major stations connected to it were to be operated in strict cost order, whoever owned them. Some 22kV, 6kV, 3.3kV and other voltages would be retained for local use in few places.

It is notable that Stanley Baldwin, as a Conservative Prime Minister, pushed through the 1926 act which is 'one of the most socialist pieces of legislation on the statute book'. The Act became law on 15 December 1926.

The Grid was built in 7 Area sections (around the main demand centres) with Emergency Interconnection; all in all 4000miles of 132kV circuits. A useful infrastructure project during the depression then the war. National then War Governments from 1931 to 1945; Ramsay Macdonald, Stanley Baldwin, Neville Chamberlain and Winston Churchill.

The Grid and the new Control structure was implemented in 1933, the level of excess plant plummeted, prices dropped dramatically and demand rocketed. From 750000 customers in 1920 to 9 million in 1937; the fasted growing system in the World.

And in 1937 on the October 29 night shift an enterprising National Control Engineer closed up all the Grid interconnectors (instructing stations at the end of each Interconnector line up and down to achieve Synchronism) and it held. By 1938 it ran solid across the country which of course helped considerably during the Second World War.

The (mainly municipal) utilities found the demand was now increasing at an alarming rate... For example, in 1937 Croydon had commissioned the No 7 30MW turbine at the A station, bringing the utility capacity up to @80MW. In 1939 the Corporation designed (and piled the site) for a brand new 300MW B station - 12 * 33MW boilers, would need 9 steaming for full load from the 6 * 52.5MW sets!!

Immediately after the war the municipals started building plant again but, especially by the time of Nationalisation in 1948, it was realised the units were too small. Croydon B was 'truncated' to 200MW which 'unbalanced' the already slow Coal to Bunker plant (station designed to look 'pretty') and thus it could never base load at full load.

Also, in 1952 the Clean Air Act was passed. From that time you start to see more 1,2 and 3 bar Electric fires being bought. The new Ring main wiring (30 amp circuits) was introduced in domestic premises to replace the old 15 Amp radially connected sockets.

Now there was a rapid move to 120MW then 250-350MW generators. It was also realised that the scale of overland coal transport needed for much larger stations near demand sources would be untenable. Thus 500MW then 660MW unit stations were designed near the fuel sources (Coal at the pits and Oil at the Refineries) with the 275kV then 400kV Supergrid going in for Bulk Power Transmission (Coal by Wire). In 1950 the Peak Demand estimate for 1970 was 30GW; that was actually surpassed in 1960.

The long established seabourne route from the Northumbrian coalfields to the Thames Estuary facilitated supply to large stations below Tower Bridge (including Kingsnorth dual fired adjacent to the Grain refineries and with a large Coal unloading jetty).

Up to the end of the 60's the older (Municipal) plant was still running hard to meet the Winter demands - Coal fired plant running Weekday base load and even the OCGTs being thrashed for 16 hours a day. However, after the 72/3 miners strike the margin situation eased and the older plant went to Two shift or Peak only manning. By the middle/late 70's most of the ancient ex Municipal stations (some which had started life 1890-1900) had shut down, along with those early post war municipal Coal stations which had been converted to Oil. The remainder of the municipal build (Coal fired) plant went in the early 80's.

The Control Framework comprised National, with 7 Area centres who actually instructed the large numbers of units. National Control was established behind the Bankside by 1938 but moved into the redundant lift shafts of the St Pauls Underground station on the Central Line during the war. It was then moved to temporary accommodation on Paternoster before going back to Bankside House and then to the purpose built centre with advanced facilities on Park Street (2 blocks behind where the Globe now stands) in 1971.

The Inter-Area transfer system allowed for a degree of Area based correction for forecast demand and generation errors. Strict National optimisation of On Load cost Merit Order was carried out at Peaks and Troughs with Transfers Interpolated in between.
To ensure that Generation is matched to required Demand at all times, without incurring excess costs for reserve provision, accurate prediction of demand is required at all forward timescales. More sophisticated models for analysis of demand against actual weather, then application of same with forecast weather to give forecast demand, were developed.

From the early 70's, Merit Order derivation (System Marginal Costing), Fuel planning and Generation planning down to day ahead used a heuristic computerised scheduler. For Fuel Allocation and Merit Order determination, annual simulations iterating with the Cost Optimised Fuel Allocation program were used. These Generation-Fuel simulations determined the right Merit order, with matching Fuel allocation, to use the fuel and generate in an optimal overall manner, allowing for scarcity of each source as well as individual source prices and transport costs. 500 individual fuel pit/coal type and refinery oil combinations, 2500 routes between sources and the 150 or so Power Stations.

CEGB System Operation System Control Development, National Control and the Computing centre worked on getting a better computerised scheduler into service, to optimise generation at every schedule point (not just Peaks and Troughs) and account for Start up costs and impact of dynamics.

The new mechanism first replaced the old scheduler in the Generation Planning and System-Fuel simulations, then was implemented in Control in 1985. It tightened up plant running to reduce Costs, Fuel burn and emissions. Saved a few billion.

Up to 1980 the CEGB had burnt Gas in two stations, West Thurrock and Hams Hall, overnight to help smooth the Gas flows. However, that ceased when the Gas Board tried to up the price to that of Oil. Also, at some point, the EU put an embargo on using gas for secondary Energy production, including of course Electricity Generation.

Then we get to Privatisation in 1989 and 1990. At the same time the EU (Leon Brittain as Competition Commissioner) raised the ban on using Gas for Electricity Generation which paved the way for high efficiency CCGTs on cheap Natural Gas.

In May 1993 National Control moved to its new centre in Wokingham with new Computer systems. New matching facilities were put in place in the remaining 4 Area Control centres. Then we progressed to National Central control based on two centres, with the operational functions split between them. Either centre can take on all vital Control activities, if needed, at a moment's notice.

From 1990 a lot of CCGT developments were started. Most of these used the sites of the last Municipal Power Stations (decommissioned by the mid 80's), which were ideal. The footprint of the CCGT stations was much smaller than the site area and Electrical (usually 132kV) and Cooling Water connections were in place. The Gas supply was usually adjacent on the site of an old Gasworks. In other cases CCGTs were built on riverside/seaside sites near the Gas National Transmission system and the Supergrid. Thus began the dash for gas which would increase the Gas demand by 50% and advance the demise of UK Continental Shelf production. However, in 1992 the Government cancelled the British Gas Lurgi Gasifier - HiCom Methanator project, designed to produce Synthetic Natural Gas from Coal, Biomass and Trash. This was intended to cover the eventual rundown of UK Continental Shelf Gas supply (now brought closer by the CCGTs), while maintaining diversity of primary fuel supply.

And then in 2001, with all customer demands now being metered (1994 - all premises over 100kW) or synthesised (1998 - profiling) to Half hours for wholesale Market reconciliation, Wholesale Trading and Matching Operation was put in place for Electricity. Multi party Bi-Lateral trading with the Operator making Unilateral adjustments for Major Generation-Demand mismatch (Market Timescales) then instructing the Generation fleet (and participating retail customer sites) explicitly at near real time. Unfortunately this will not achieve overall efficient operation.

With a fleet that is capable of producing 500+TWh but a demand of only 360TWh (Sent out)........
"There are an infinite number of ways of running an Electricity system badly!!"

Central management of the system, with hierarchical aggregation/dissemination of Distributed resources data and trading/instruction data to make participation manageable would facilitate a much better approach. The unbundling of the major ESI elements - Generation, Supply, Transmission, Distribution and System Operation gives a fragmented approach to cost-income application. To get the 'meaning of time' across to the Customer you need top to bottom (Generator to Customer) analysis. Hence the US Vertically Integrated Utilities are more successful at effectively engaging the retail customers. However, demographic differences dictate that a number of approaches are required.

Careful time series and time sequence modelling is needed to evaluate the best plant mix and control logistics for Energy - Electricity, Gas, Heat and Transport.
Please see my associated note on strategy and my Future Power Systems articles (Basics through to Brave New World) via the links at..... www.eleceffic.com