Electricity Generated in Australia, 1900-1955:

Historical data compiled for CSIRO

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GEORGE WILKENFELD AND ASSOCIATES Pty Ltd
ENERGY POLICY AND PLANNING CONSULTANTS
PO Box 460 Katoomba NSW 2780 Sydney Australia Tel (+61 2) 4728 1155
geosanna@ozemail.com.au

Contents

1. Overview and guide to spreadsheet

The aim of this project is to quantify electricity generation capacity and production in Australia over the period 1900 to 1955. The project was undertaken for CSIRO by George Wilkenfeld and Associates (GWA).

The main output of the project is a Microsoft Excel file enumerating the available data on electricity generation capacity (in MW) and electricity generation (in GWh), by fuel type and state, for each year over the period 1900 to 1955. This report should be read in conjunction with the final version of the file, [AUST Elec Data 1900-55 V6].

In this report, references to worksheets in the file are given as, for example [\CW Elec]: the worksheet that contains all data from Commonwealth yearbooks. State data worksheets are named in a similar way. All worksheets have a similar structure: data for 1899 at line 4, 1900 at line 5, down to 1955 at line 60 (starting at 1899 allows better anchoring of interpolations, where necessary).

To assist in checking the 1900-55 data, CSIRO provided data compiled by the Electricity Supply Association of Australia (ESAA) on electricity generation and on associated fuel use over the period 1955-1965 (no ESAA data were provided on MW generation capacity).[1] It was required that the 1900-55 data series be matched with the 1955-65 data series "in a way that indicates it is reasonably consistent."

The 1955-65 ESAA electricity generation data are in the file [HistoricalGeneration.xlsx] and the fuel consumption data in [HistoricalElectricityFuelCons.xlsx]. For purposes of comparison, [AUST Elec Data 1900-55 V6] is linked to the former but not the latter, since estimates of fuel consumption are outside the scope of the present project.[2]

CSIRO also supplied copies of Longfield, C.M. (1957) and Department of National Development (1958) – see References. However, it became apparent that these were tertiary data sources, and took their data from the Commonwealth yearbooks (secondary sources) that were accessed directly for the present project. (Reports of the electricity producers themselves are considered primary sources, and were used where available – mostly as compiled in Tait's Electrical Directory (TED) – see next section).

The sources of data in [AUST Elec Data 1900-55 V6] are indicated in the following ways:

- The source is named in the adjacent cell, e.g. "V1943-44,395" means that the data came from page 395 of the 1943-48 Yearbook of Victoria; or

- The source is named in the cell comment (there are so many comments that selecting "view all comments" makes the worksheets unreadable, so it is suggested that comments be read one by one); and/or

[1] The ESAA was founded in 1918 as a voluntary association of State regulatory bodies and the major generation, transmission and distribution organisations. There was a major reorganisation in 1991 to reflect the new market and privatisation arrangements (Brady 1996). In 2016 the ESAA ceased operating: the generation and retail companies constituted themselves into the Australian Energy Council (AEC) and the transmission and distribution companies into Energy Networks Australia (ENA).

[2] When opening [AUST Elec Data 1900-55 V6], do not update links, or there will be an error message.

- The colour coding of the cells (Table 1). Data taken direct from named external sources are in black text in unshaded cells. Calculated cells are generally standard factor HP to kW, kW to MW or kWh or GWh conversions. Estimated cells are best guesses by the author. Interpolated value cells contain equations used to generate a sequence between two other values.

Table 1 Indication of data sources

12345	Raw data
12345	Calculated
12345	Estimated
12345	Interpolated
12345	Transferred
12345	TED 1927
12345	TED 1929
12345	TED 1940
12345	TED 1948

If a data series starts after a black horizonal line it indicates that there are no earlier data, and if it finishes with a black line it indicates there are no later data – this generally applies to power stations that open or close within the 1900-1955 period, or to data sources that start or cease publication.

The spreadsheet [AUST Elec Data 1900-55 V6] also contains graphs of the key data. These are reproduced in Section 3 of the present report. The name of the corresponding tab in the worksheet is given under each diagram.

2. Sources, Assumptions and Findings

Sources

The main published sources of statistical information on electricity generation and supply in Australia covering the period 1900–1955 are indicated in Table 3. Most Commonwealth and State yearbooks are available online on the ABS website, and the rest are available at the National Library of Australia and at several state and university libraries.[3]

Although no details of the method by which electricity-related data was collected in the yearbooks has been found, a comparison of the different publications suggests that it was the responsibility of the State statisticians in the first place, and then complied by the Commonwealth office. In the early years "Establishments Furnishing Electric Light and Power" were reported alongside (and sometimes intermixed with) information about gas works.

The yearbooks variously report "electricity generated" or "power supplied and used", or (in the early years when pricing was on the basis of number of lights rather than on metering) "light supplied and use". In some cases it was necessary to estimate a loss factor and hence estimate energy generated from energy "sold" or "used". Fortunately, the reporting units have always been consistent: kWh or – later – multiples of kWh.

Reporting of capacity has been even less consistent. Some yearbooks report "horsepower of engines" but this does not necessarily mean the installed generating capacity: at various times it is the average load (presumably calculated over the year) and at other times the maximum load recorded. Sometimes an additional "reserve or idle horse-power capacity" is separately reported. Although this is not explained, it may be the *difference* between the average or maximum load and the installed capacity.

It is common for yearbooks to revise previously published values for earlier years on the grounds that the wrong definition of "power" was used by reporting entities, but an explanation of the earlier or indeed the revised method is rare. Where there is no extra information there is no alternative but to use the raw HP values (converted to kW or MW)[4]. However, as this uncertainty tends to be restricted to the period before the rate of plant installation and energy output accelerated in the 1920s, the effect of any error is small.

Aside from the yearbooks, data was obtained from the following sources:

- Tait's Electrical Directories (TED) of Australia and New Zealand, published at irregular intervals between 1913 and 1948. These list every town and municipality having an electricity supply, the details of the plant (generally HP for boilers and engines/turbines, and kW or MW for the generators). Plant are generally classified by combustion cycle (i.e. steam or internal combustion, IC) rather than by fuel type, except on rare occasions when reporting unusual configurations (e.g. wood-fired steam boilers in Kalgoorlie). Each volume has generation or sales data for three or four years only. The data series are therefore not continuous.

[3] Given the restrictions on travel due to Covid-19, the only library accessible to the author during this project was the State Library of NSW (SLNSW).
[4] I HP = 0.746 kW

- The official histories of the major electricity supply organisations in each State (see References).

- The National Library of Australia's *Trove* database of scanned newspapers. Over the period in question, these often reported at length on the annual general meetings of major electric companies and government agencies, and on events such as the opening or augmentation of power stations.

Definition Issues

In the 1900-1955 period there were three main categories of electricity generation:

1. "Electric light and power works" (as they are generally called in the yearbooks) – municipal, private or government-owned enterprises generating to supply their own customers and sometimes supplying in bulk to other electricity undertakings;

2. The tramway and railway commissioners in each State operated power stations primarily for their own traction needs, station lighting and, later, bulk supply sales to local government and private electricity undertakings along the rail routes. These power stations were sometimes included in "Electric light and power works" and sometimes not. For the period 1910-1930 the Commonwealth yearbooks reported electricity used by tramways for all States, but it is not clear how electricity generated by the tramway commissioner-owned power stations for other purposes was treated. The distinctions disappeared once all publicly owned power stations – rail/tram and general purpose – were acquired by State electricity authorities;

3. Factories and mines generating for their own use and, sometimes, also for commercial supply to the surrounding villages and towns.

For the present analysis, "public supply" is defined as categories 1 and 2 above. The data sources generally make a distinction with regard to category 3 generation that is exclusively for the use of a mine of factory, but are not always clear with regard to dual-purpose systems.

Method and Assumptions

Enterprises, distribution networks, ownership of power stations and supply areas changed and merged over time, so it is necessary to understand this process to properly interpret the published data.

By the 1940s, the metropolitan grids were increasingly integrated. This often led to double counting of energy that might be generated for bulk sale from one enterprise to another, which then sold it retail. The purchasing utilities, who might also have their own power stations, often lumped "power generated and purchased" together. To avoid double counting in these cases, it was necessary to trace the generation data for the main power stations separately, mainly with the aid of the TEDs or the annual reports of the organisation owning the power station at the time.

Given the discontinuities, gaps and uncertainties in the available data, the approach adopted was to start with the data in the yearbooks as the default, and overwrite them only where they were internally inconsistent or where more reliable information was available.

As the high-level State data did not disaggregate plant by fuel type, it was necessary to build this up from identified (named) power stations and in some cases to create "pools" of unidentified power stations of each fuel type. In general, the identified power stations were either hydro, or large thermal power stations using coal as the dominant fuel (usually with some fuel oil and coke or briquettes). Most of the unidentified power stations were IC plant using petroleum fuels.

There was no large-scale gas-fired generation in the period before 1955, but "gas producers" with "gas suction engines" were popular, especially in regional Queensland (Figure 14). Usually, the fuel for the producer was anthracite coal, but wood was also used in some areas. The gas produced (mainly hydrogen, methane and carbon monoxide) was supplied to one or more internal combustion gas engines coupled to generators. These were called "suction" engine because they regulated the production of gas. If the engine stopped, the back-pressure stopped the gas production process, so there was no dangerous build-up of pressure in the producer.[5] All suction gas plant were allocated to coal unless wood was specified as the gas producer fuel (see [\QLD details]).

Each TED entry gives the starting date for electricity supply in that town or district, the company or local government authority operating the system, whether they purchase or generate their own energy and, in the latter case, the type and output capacity of each main item of equipment (boilers, steam engines, turbines, IC engines and generators). As an example, the details for Queensland are tabulated in [\QLD details] and summarised in Table 2 and Figure 14. Where fuel is not stated it is assumed to be coal, although for stream plant it is possible that there was co-firing with wood or bagasse.

Table 2 Installed capacity of generating plant, regional Queensland

	Generation type 1927					**Generation type 1948**				
Fuel type	Steam	Suct-ion gas engine	Oil or diesel engine	Hydro	Total	Steam	Suct-ion gas engine	Oil or diesel engine	Hydro	Total
Fuel not stated	5945	2931			8876	23607	3519			27126
Wood		109			109		2577			2577
Petroleum			445		445			7167		7167
Hydro				24	24				7200	7200
Total	5945	3039.5	445	24	9454	23607	6096	7167	7200	44070
				Change from 1927		17662	3057	6722	7176	34616

All values kW. Source: TED 1927, 1948

Use of multiple fuels is not restricted to small regional power stations. Most large coal-fired power stations also used significant quantities of fuel oil, coke and other coal by-products (in the black-coal states) and brown coal briquettes (in Victoria). For the present study, all of the

[5] For an account of the process, see https://www.paxmanhistory.org.uk/suctngas.htm

generating capacity and output of large power stations has been allocated to the dominant fuel.[6]

The yearbooks generally report total installed capacity (MW) and total generation (GWh) but do not break these down by fuel type.[7] Therefore the following rules have been adopted:

- Calculate the total MW and GWh for the minor types and fuels: hydro, IC and non-coal-steam plant;
- Subtract these from the total MW and GWh for the state as a whole, and assume the residual is coal;
- Check the magnitude of the residual against the sum of the data for the major power stations – if there is significant disagreement, identify and resolve.

The two key values for each individual generator or power station are installed capacity (MW) and energy generated (GWh). In some cases only one of these quantities is available and the other needs to be inferred. This has been done using an assumed load factor (LF), based on the LF of other plant of the same type in that year.[8] The average LFs are illustrated in Figure 15. LFs vary both with the MW of plant installed and the GWh generated (which reflects electricity demand). LF falls in years where there are large additions to plant but energy demand has yet to catch up. For hydro plant, water availability is another variable. LF tends to rise in years following high rainfall, when storages are full, and drops in other years. The biomass and petroleum LFs in Figure 15 are based on limited actual data, hence the smooth curves, but the coal and hydro LFs are mostly based on actual data, where both MW and GWh values were available.

Findings

The capacity of generating plant installed for the provision of public electricity supply in Australia over the period 1900-1955 is illustrated in Figure 1 (by fuel type) and Figure 2 (by State). Until the first brown coal plant were built in Victoria in the early 1920s, generation was dominated by black coal in all States except Tasmania, where hydro capacity exceeded thermal as early as 1912. There were surges in plant installation in the depression years (a legacy of orders placed during the years of demand growth in the 1920s) and again after 1950, when plant ordered during and after the war could finally be delivered and installed.

The electricity generated for the provision of public electricity supply in Australia over the period 1900-1955 is illustrated in Figure 3 (by fuel type) and Figure 4 (by State). While growth in generation was constant, there were flat periods during the depression, due to constrained demand, and during the second world war, when the constraint was supply (plant and fuel availability) rather than demand. Figure 15 shows that overall load factors dipped during the depression, indicating under-utilised plant, and remained at a high plateau during the war years, before falling with the arrival of new generators.

[6] Power stations capable of using multiple fuels in roughly equal quantities were introduced in WA, but not until well after 1955.
[7] The CW yearbooks after 1937 report MW of generating capacity installed by state and by technology type (e.g. steam, IC, hydro) but not broken down by both. They did not report generation by fuel type up to 1955.
[8] LF is the ratio of actual to maximum theoretical output of a generator. A 1 kW generator operating uninterrupted for a year would produce 8,760 kWh. If it generates 3,000 kWh the LF is 3,000/8,760=34.2%

Figure 3 compares the total generation (GWh) estimated in the present report with the totals reported in the Commonwealth yearbooks. Agreement is reasonably close, with convergence by 1955. Figure 6 compares the installed capacity (MW) estimated in the present report with the totals reported in the Commonwealth yearbooks. Again, the agreement is reasonably good, but the reduction in capacity reported in the yearbook between 1946 and 1947 suggests an enumeration or classification issue, which undermines confidence in the yearbook data.

Consistency with 1955-65 data

Figure 5 illustrates the disjunction between the 1900-1955 generation data series and the 1955-65 series prepared for CSIRO by ESAA. While the general trend is consistent, the national ESAA total for 1955 is significantly lower than calculated for this project. This is because the ESAA collects data from its member organisations and companies, and not all public electricity suppliers were members of the ESAA over that period.[9]

The two data series are in good agreement for the States where public electricity supply was in the hands of a single state-wide authority by 1955: the State Electricity Commission of Victoria (Figure 8), the Electricity Trust of SA (Figure 10) and the Tasmanian Hydro-Electric Commission (Figure 12). The disagreements for the less centralised states (NSW, Queensland and WA) suggests that regional power producers were significantly under-represented in the ESAA data.

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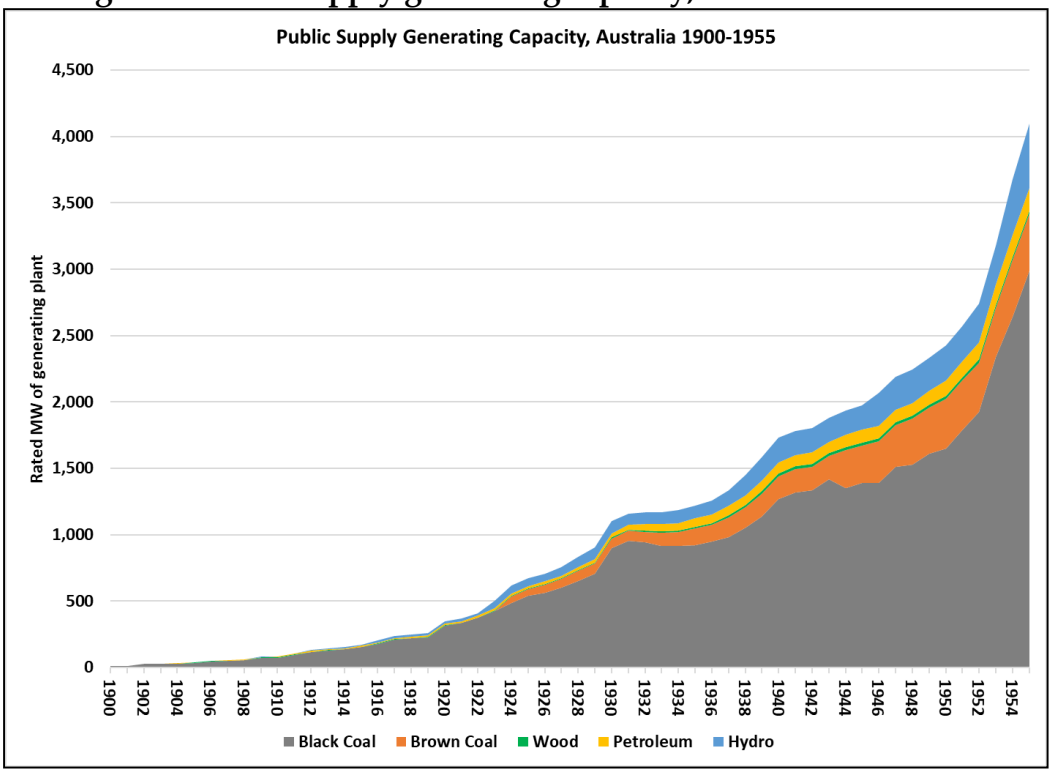
[9] This undercount has persisted into the present century – see George Wilkenfeld & Associates (2008).

Table 3 Sources of Statistical Information; Electricity Generation and Supply, 1900 – 1955

Publication	Coverage (within 1900-55 period)	Availability
Commonwealth Yearbook	1908 to 1955	1908 at SLNSW; 1909 – 1955 online
NSW yearbook	1904-05 to 1955	All online
Victoria yearbook	1902 to 1954-58	All online
Queensland yearbook	1901; 1937-55	1901 at SLNSW; 1937 onward online
SA yearbook	1913, then 1966	1913 at SLNSW; 1966 (online) has some data from 1946
WA yearbook	1900 to 1954-55	All online
Tasmania yearbook	From 1967	1967 at SLNSW; 1968 (online) has some pre-1955 data
Northern Territory	No data	First year book 1995 (online)
Tait's Electrical Directory (TED)	1913; 1920; 1925; 1927; 1929; 1934; 1936; 1939-40; 1948	GWA has 1927; 1929; 1939-40; 1948. SLNSW also has 1925, 1934, 1936
Australians: Historical Statistics, Fairfax, Syme & Weldon, 1987	Elec gen (GWh), Australia, 1919 – 1955 Installed cap (GW) 1927 - 1955	GWA has a copy – compiled from CW yearbooks. No state breakdowns

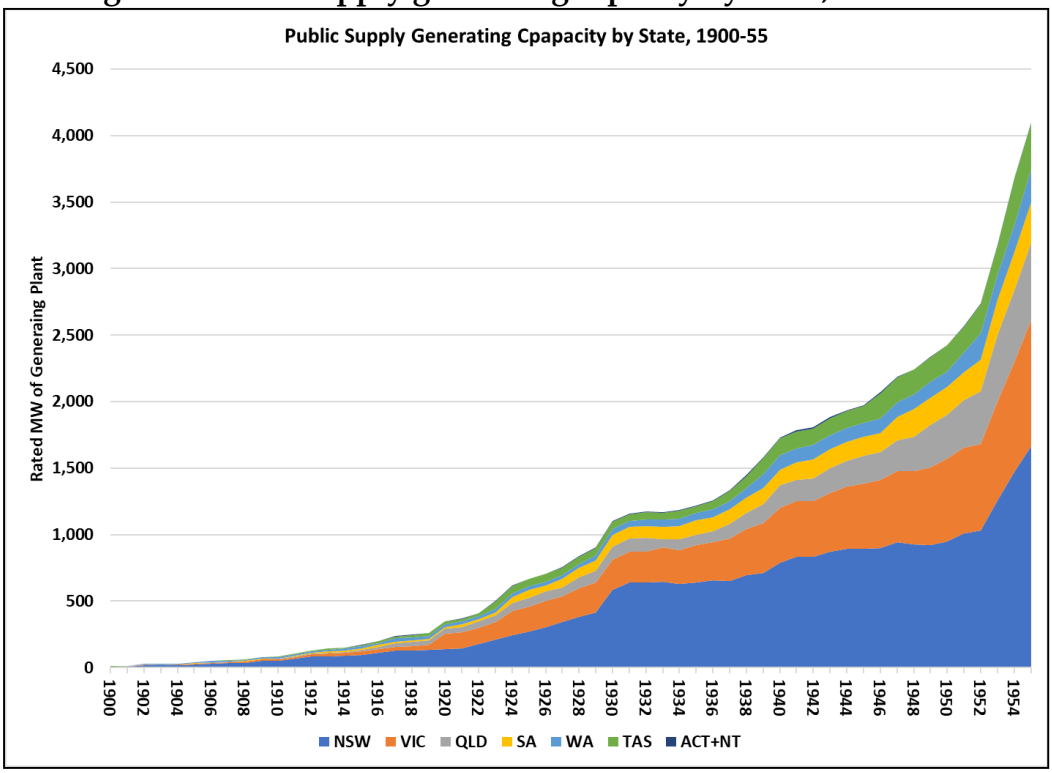
3. Diagrams

Figure 1 Public supply generating capacity, Australia 1900-1955



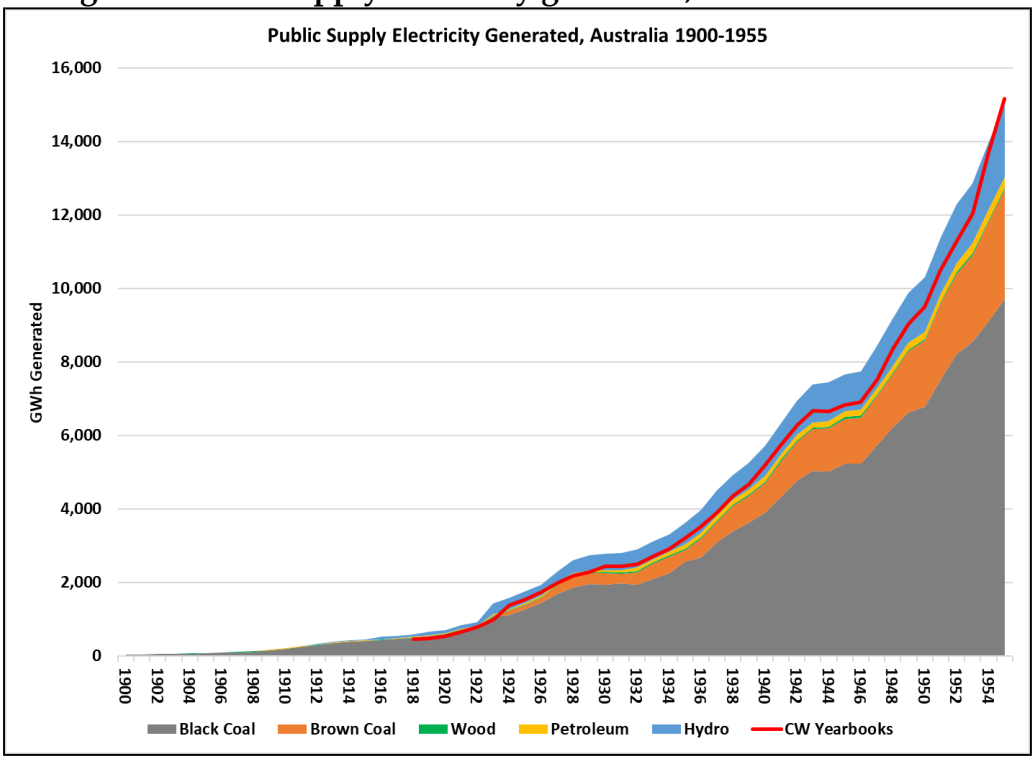
\Aust MW

Figure 2 Public supply generating capacity by State, 1900-1955



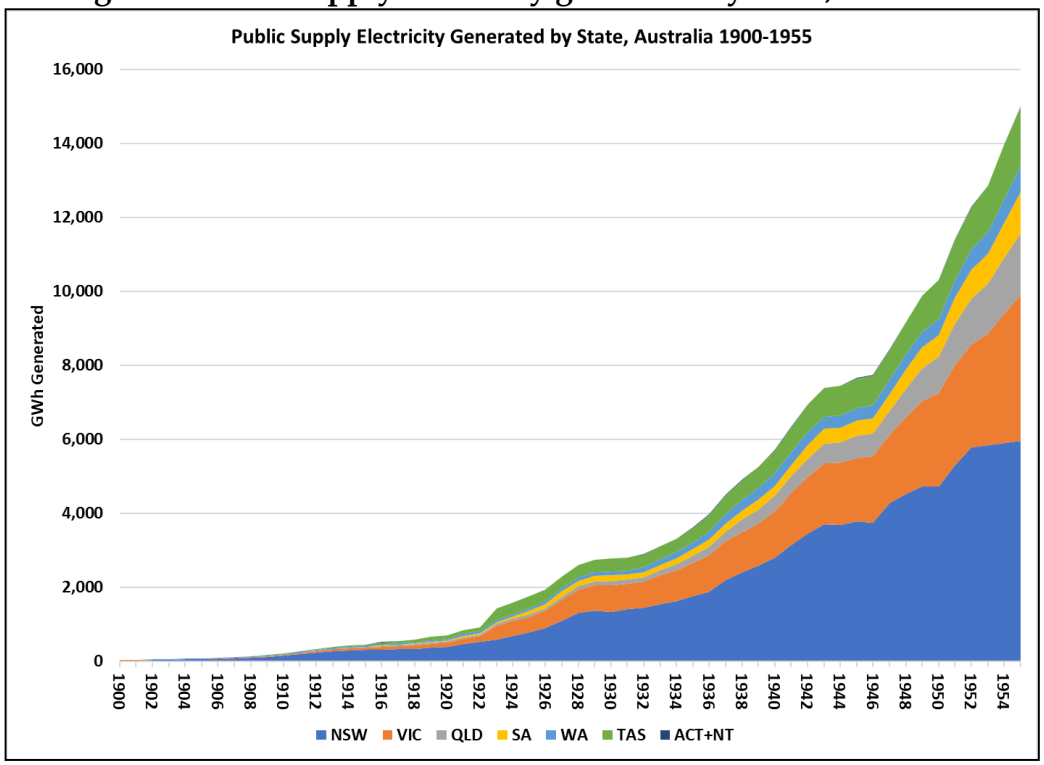
\State MW

Figure 3 Public supply electricity generated, Australia 1900-1955



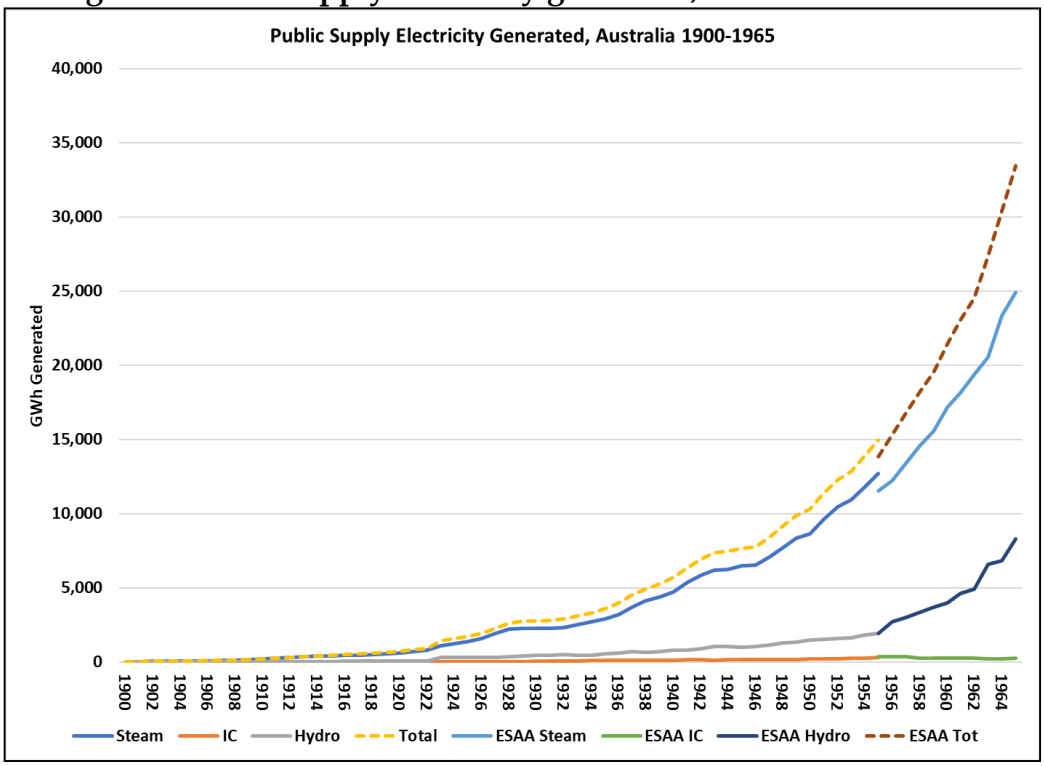
\Aust GWh

Figure 4 Public supply electricity generated by State, 1900-1955



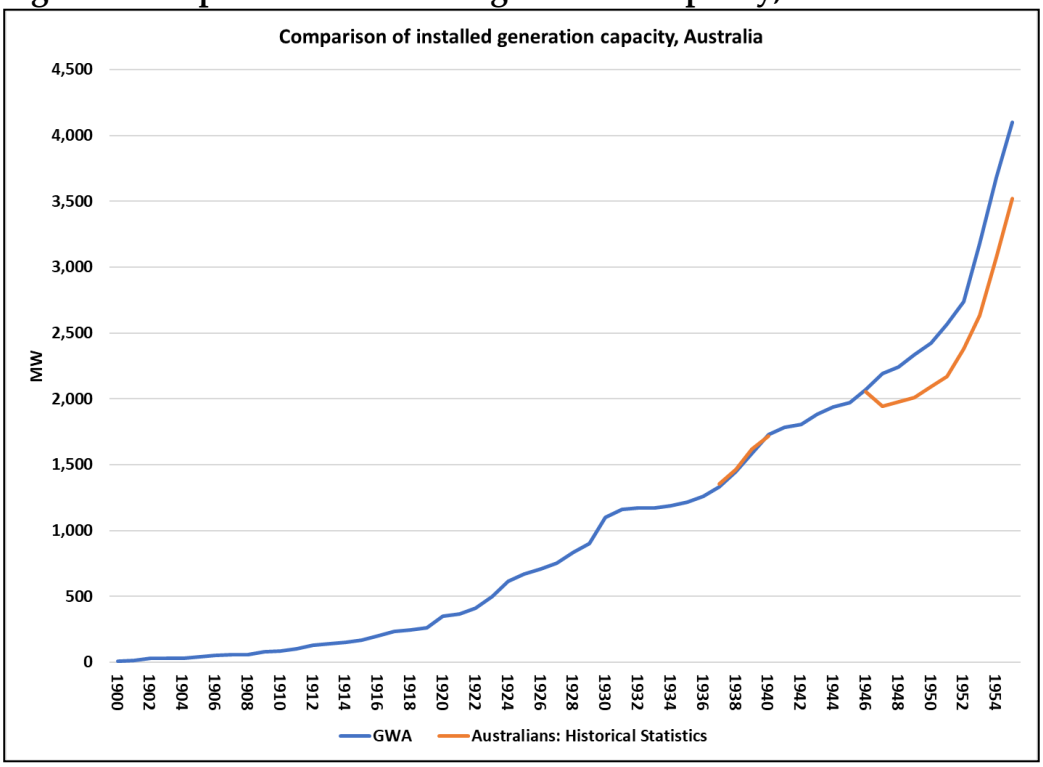
\State MWh

Figure 5 Public supply electricity generated, Australia 1900-1965



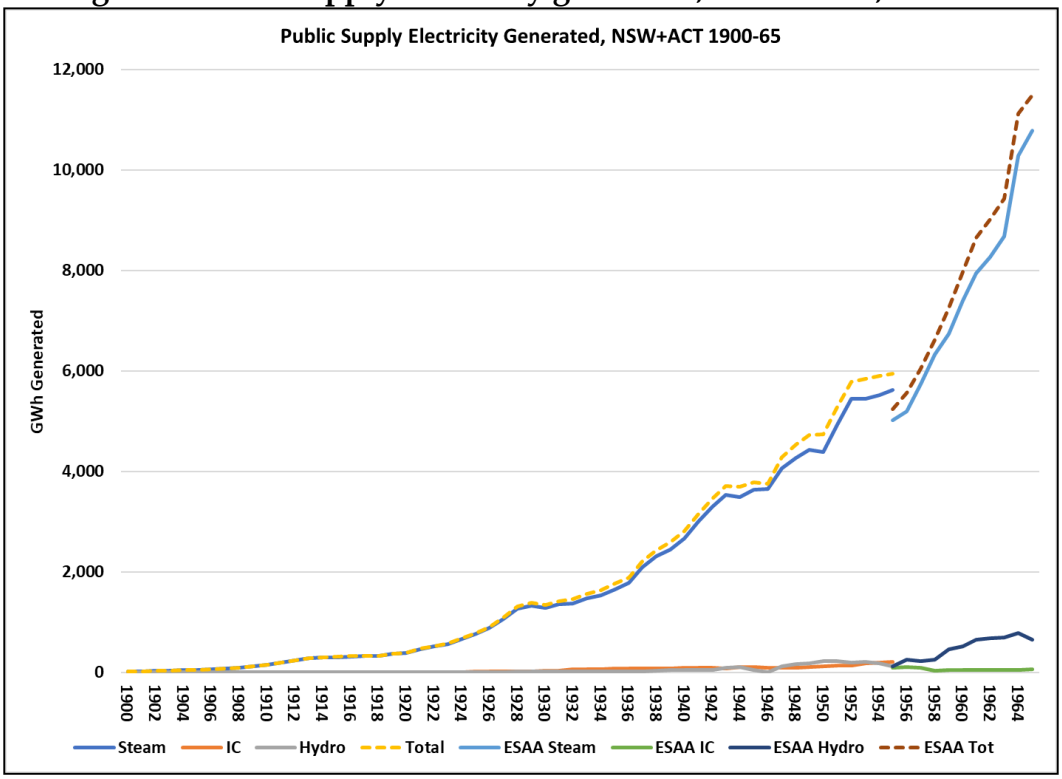
\Aust 1900-65

Figure 6 Comparison of installed generation capacity, Australia 1900-55



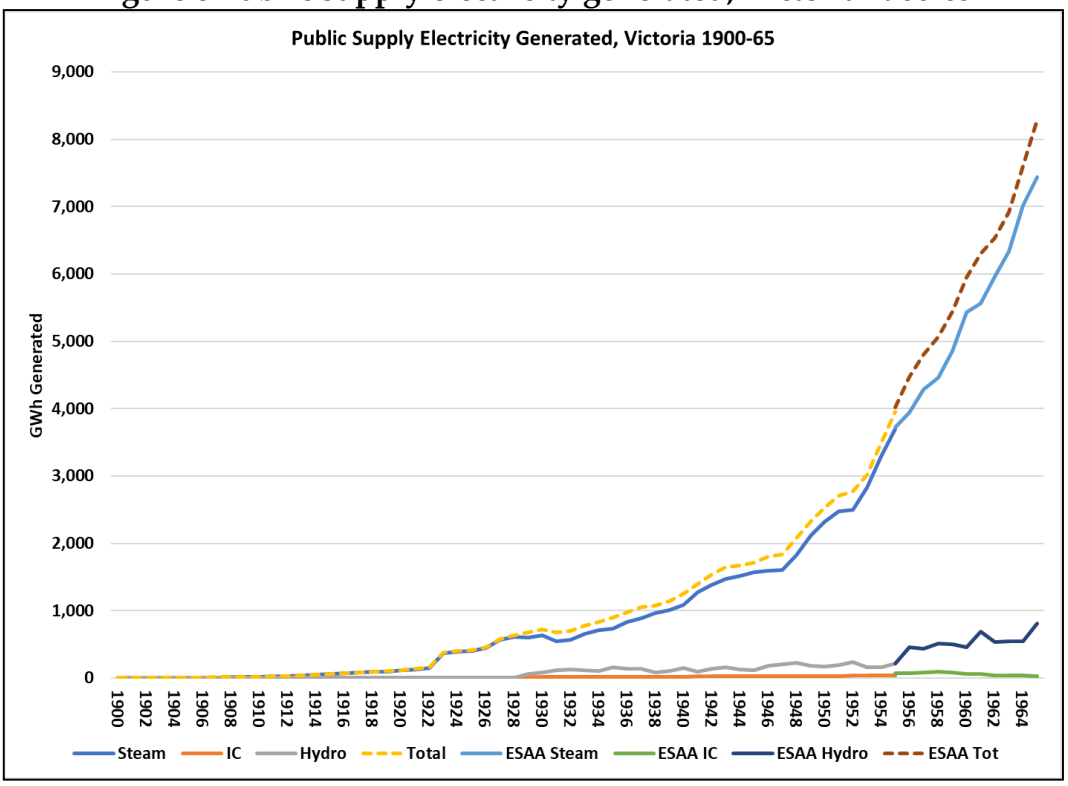
\MW Comparison

Figure 7 Public supply electricity generated, NSW+ACT, 1900-65



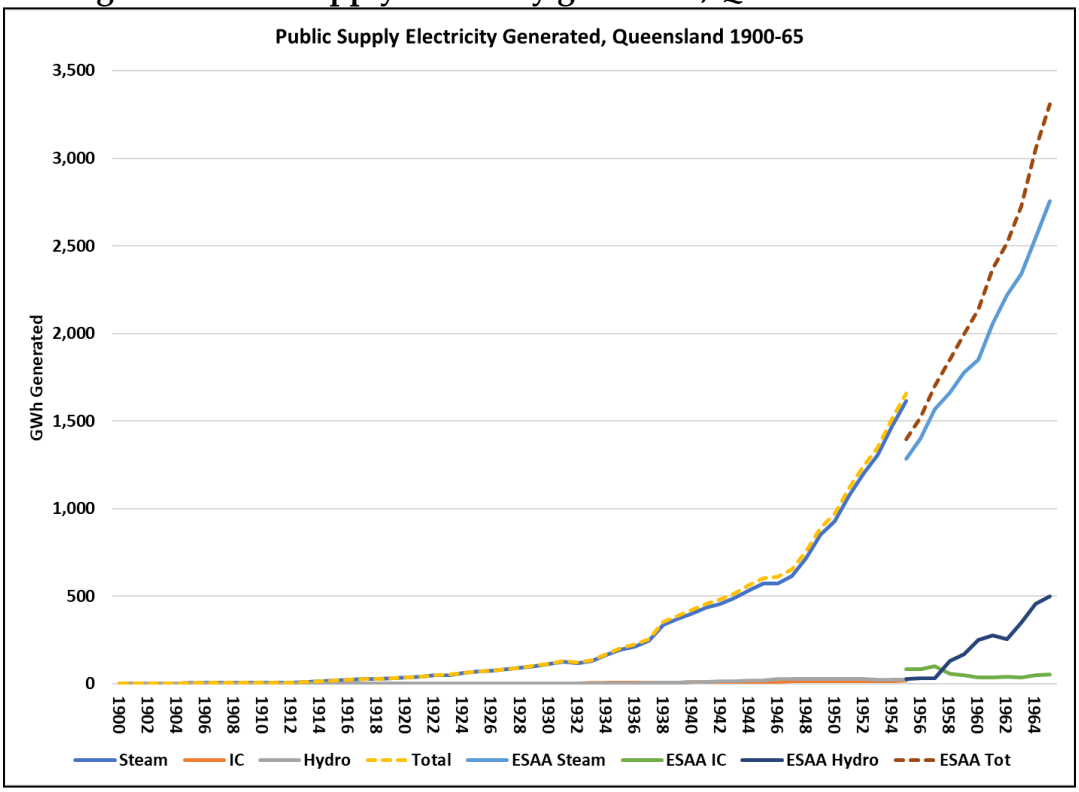
\NSW 1900-65

Figure 8 Public supply electricity generated, Victoria 1900-65



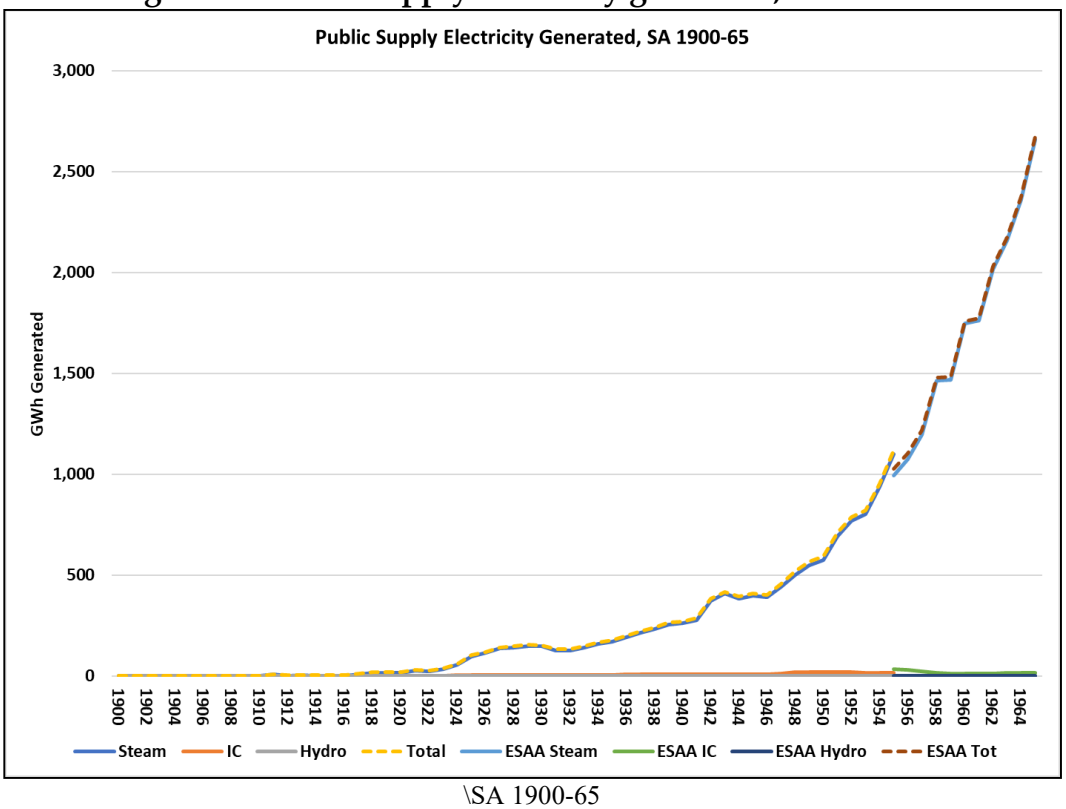
\VIC 1900-65

Figure 9 Public supply electricity generated, Queensland 1900-65



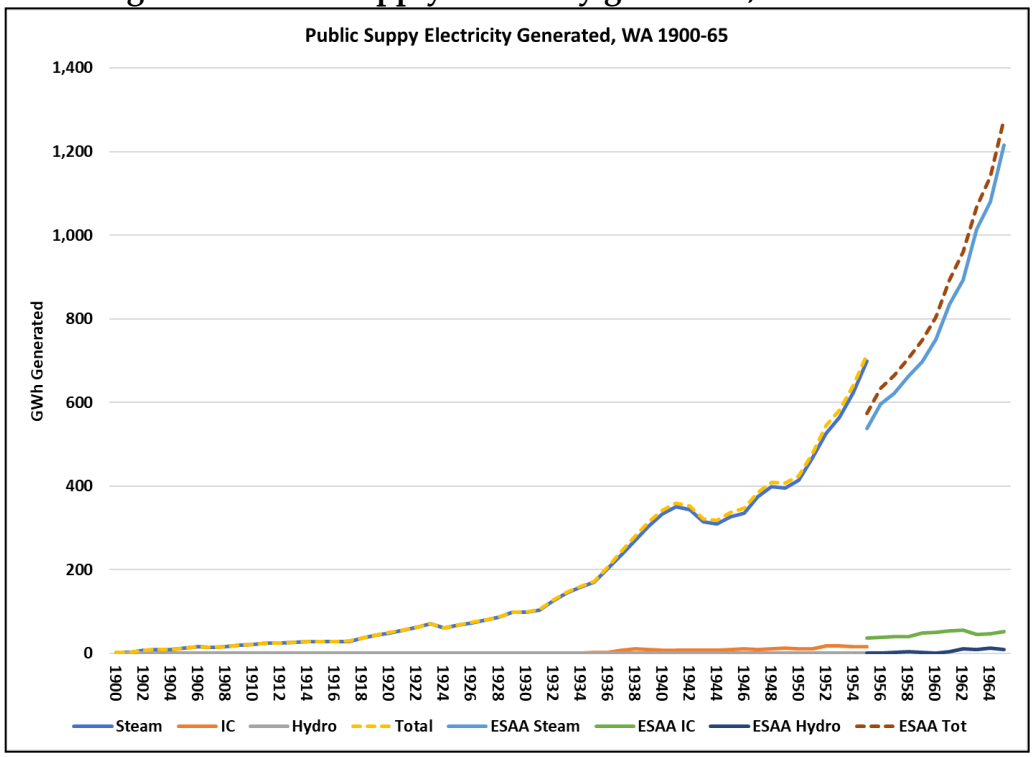
\QLD 1900-65

Figure 10 Public supply electricity generated, SA 1900-65



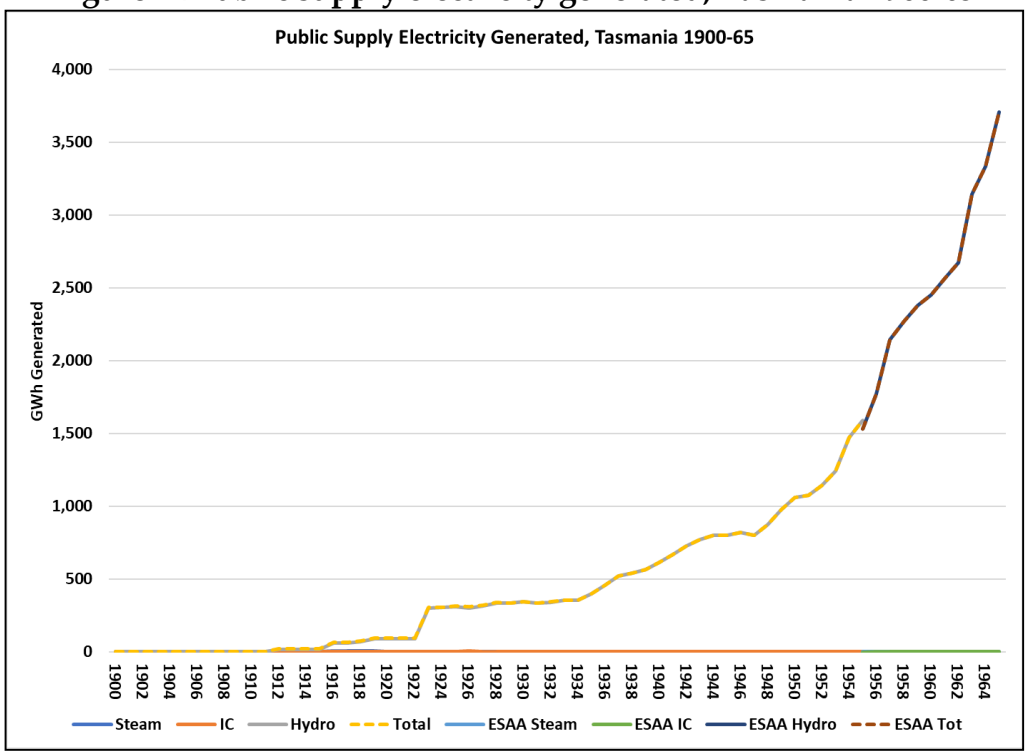
\SA 1900-65

Figure 11 Public supply electricity generated, WA 1900-65



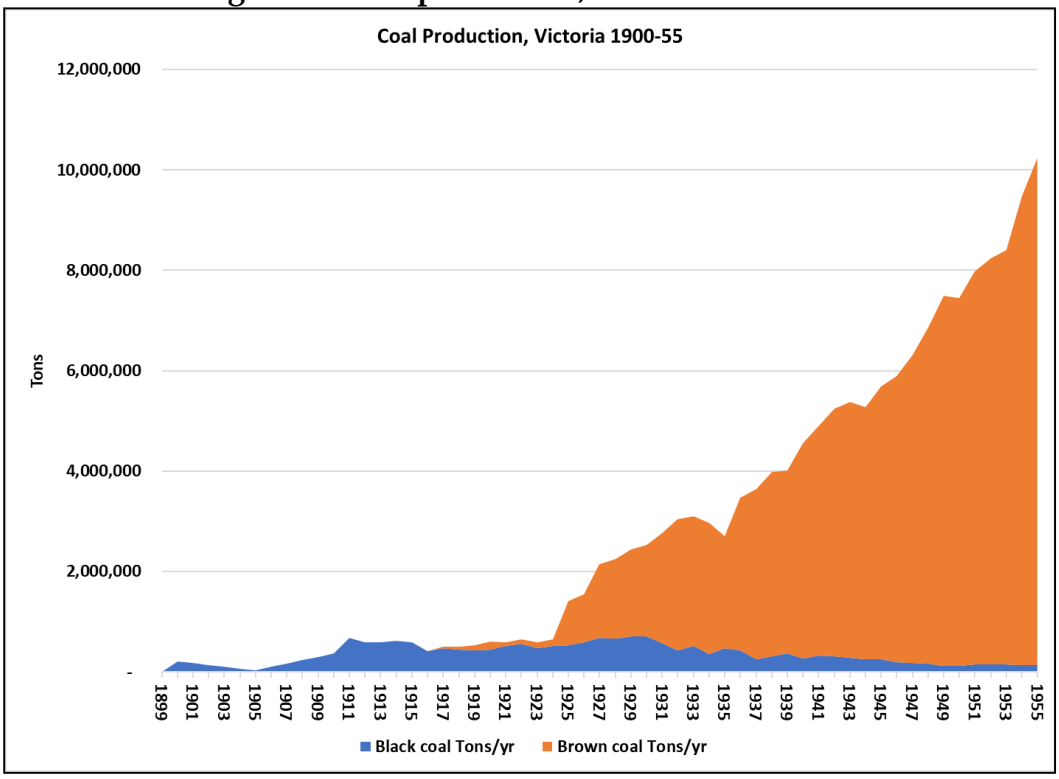
\WA 1900-65

Figure 12 Public supply electricity generated, Tasmania 1900-65



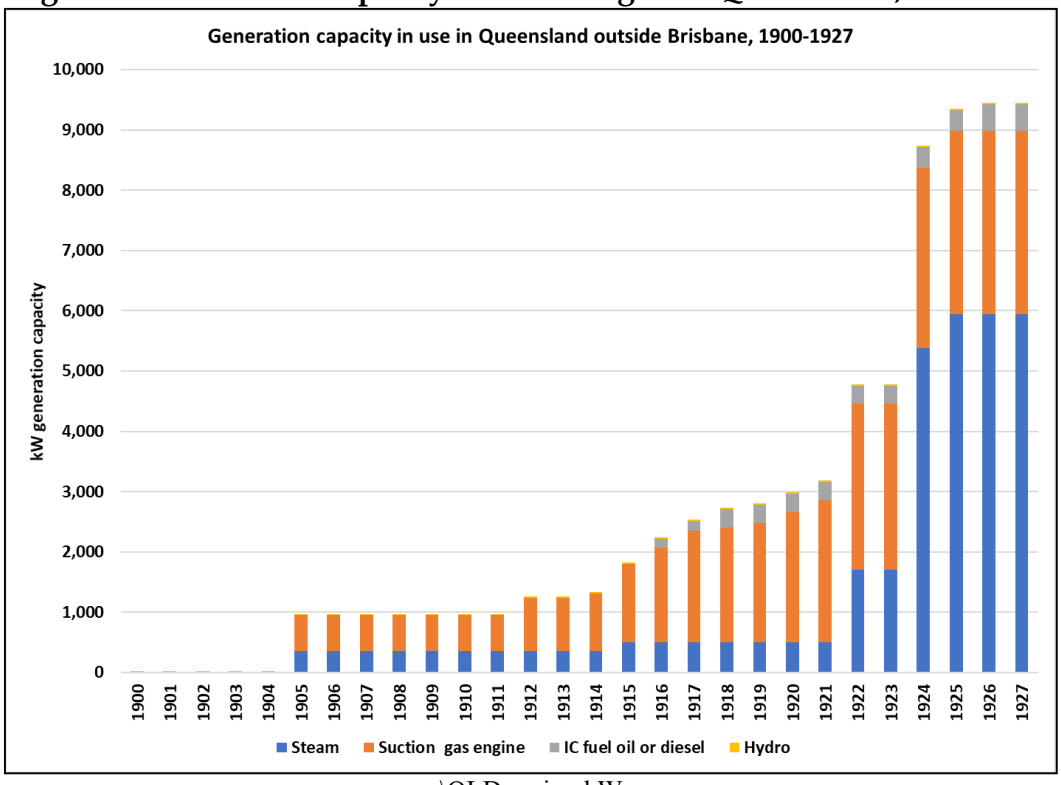
\TAS 1900-65

Figure 13 Coal production, Victoria 1900-1955



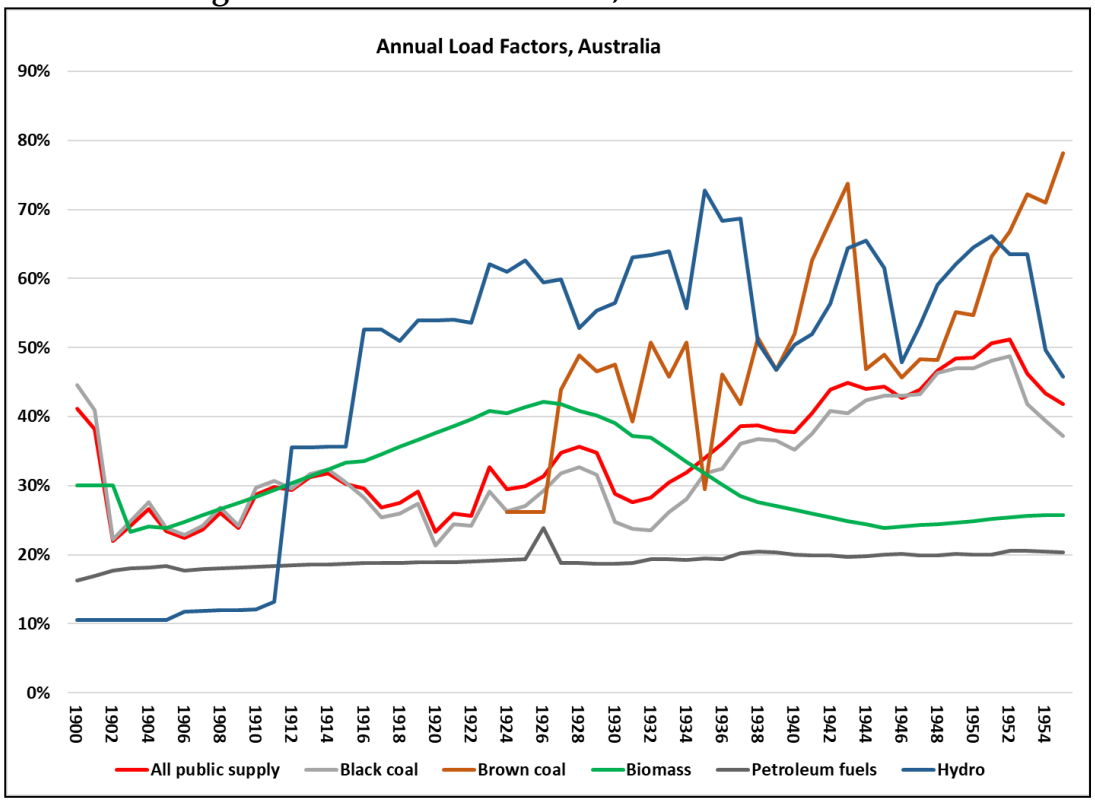
\V-tons

Figure 14 Generation capacity in use in regional Queensland, 1900-1927



\QLD region kW

Figure 15 Annual load factors, Australia 1900-1955



/Load factor

4. References

Australian Bureau of Statistics (formerly Commonwealth Bureau of Census and Statistics): *Official Year Book of the Commonwealth of Australia* (series), from 1901-1907

Anderson, G.F. (1955) *Fifty years of electricity supply; the story of Sydney's Electricity Undertaking*, Sydney County Council, Sydney 1955

Brady, F, ed. (1996*) Contribution on Australia* prepared for the Australian National Committee of CIGRE, for A Dictionary on Electricity

Department of National Development (1958) *The Supply and usage of energy in Australia*, Commonwealth of Australia, Canberra 1959

Edwards, C. (1969) *Brown Power; a jubilee history of the State Electricity Commission of Victoria*, SECV, Melbourne 1969

Egeberg, H.F. (1958) *The development of electricity supply in Queensland* (internet)

George Wilkenfeld & Associates (2008) *National Greenhouse Gas Inventory: 2007 Electricity Sector Emissions*, Prepared for the Department of Climate Change, Canberra, November 2008

Linn, R. (1996) *ETSA; the story of electricity in South Australia*, ETSA Corporation, Adelaide 1996

Longfield, C.M (1947) *The past, present and future of Australian power supplies*, The Economic Society of Australia and New Zealand, University of Melbourne, 1947

Saddler, H (1987) *Minerals and Energy*, in Australians: Historical Statistics, Fairfax Syme and Weldon Associates, Sydney 1987

Simmers, J.M (2003) *The Coming of the Light to Suburban Brisbane* (internet)

Tait's Electrical Directory (TED) of Australia and New Zealand (1927, 1929, 1939-40, 1948) Tait Publishing Co Pty Ltd, Melbourne and Sydney

Wilkenfeld, G. (1989) *The Electrification of the Sydney Energy System, 1881-1986*; unpublished PhD thesis, Macquarie University, Sydney 1989

Wilkenfeld, G. and Spearritt, P (2004) *Electrifying Sydney: 100 years of EnergyAustralia*, EnergyAustralia, Sydney 2004

Yearbooks of New South Wales, Victoria, Queensland, South Australia, Western Australia and Tasmania; published at various times by State statisticians and by ABS (see Table 3).

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