

Energy in a Changing Climate

How nuclear power would impact the Australian economy

Abstract

In late 2012, two government agencies produced models of Australia's future electricity generation mix out to 2050. DRET¹ released the Energy White Paper (2012) and CSIRO released eFuture. The EWP reflected current government policy and did not include nuclear power while the CSIRO web-based modelling tool had provision to include nuclear.

The features of these models, and the scenarios from which they are drawn, make it possible to assess their respective impacts on the economy out to 2050 and hence to determine the specific impact of excluding nuclear energy from the mix. The areas of national economic impact evaluated here are:

1. The cost of greenhouse gas abatement;
2. The cost of health damage from burning fossil fuels to generate electricity;
3. The cost of electricity generation and its impact on retail costs;
4. The jobs created in developing a nuclear power industry;
5. The capital costs involved and
6. The cost of delaying the introduction of nuclear power.

The analysis shows that nuclear energy will:

- Save \$130 billion in abatement cost.
- Save around \$20 billion in health damage from burning fossil fuels.
- Lower the generating cost of electricity by 20 per cent, reducing electricity bills.
- Create 29,000 direct and indirect jobs in the nuclear industry.
- Require no additional capital investment to include nuclear power to replace alternatives.

Further delaying nuclear beyond 2025 could cost over \$8 billion a year in abatement and health costs.

¹ Department of Resources, Energy and Tourism

Introduction

The Energy White Paper (2012) (EWP) [1] looked to reduce greenhouse gas emissions by reducing the current fossil fuel mix in electricity generation from 86 percent down to 42 per cent by 2050, but ignored nuclear power.

The CSIRO web-based modelling tool eFuture [2] provided for the inclusion of nuclear power and reduced the fossil fuel mix to 12 per cent by 2050.

This paper compares the proposed energy mix in the EWP and eFuture to facilitate an analysis of the potential impact on the Australian economy of including nuclear energy in the electricity mix. The advantage of using the EWP in the comparison is that it reflected government expectation for the future energy mix as well as providing estimates of capital costs of building that mix.

For consistency in the comparison, the same electricity cost and emissions intensity was used for each energy source in both the EWP and eFuture models. The source for these costs and intensities was the Bureau of Resources and Energy Economics (BREE) Australian Energy Technology Assessment (AETA 2012) [3].

Assessing the Economic Impact of Nuclear Power

Data from EWP (see Fig. 1) was compared with the eFuture modelling tool using the default scenario with nuclear permitted (see Fig. 2).

Using the total electrical energy in terawatt hours (TWh) generated by each technology as shown in the charts, the greenhouse gas emissions produced and the volume-weighted average (VWAP) LCOE² were calculated using the emissions rates and LCOEs set out in Chapter 3 and 4 of the BREE AETA 2012 report. These calculations were performed for the three year period from 2012 to 2015 and each five year period between 2015 and 2050.

² Levelised Cost of Electricity

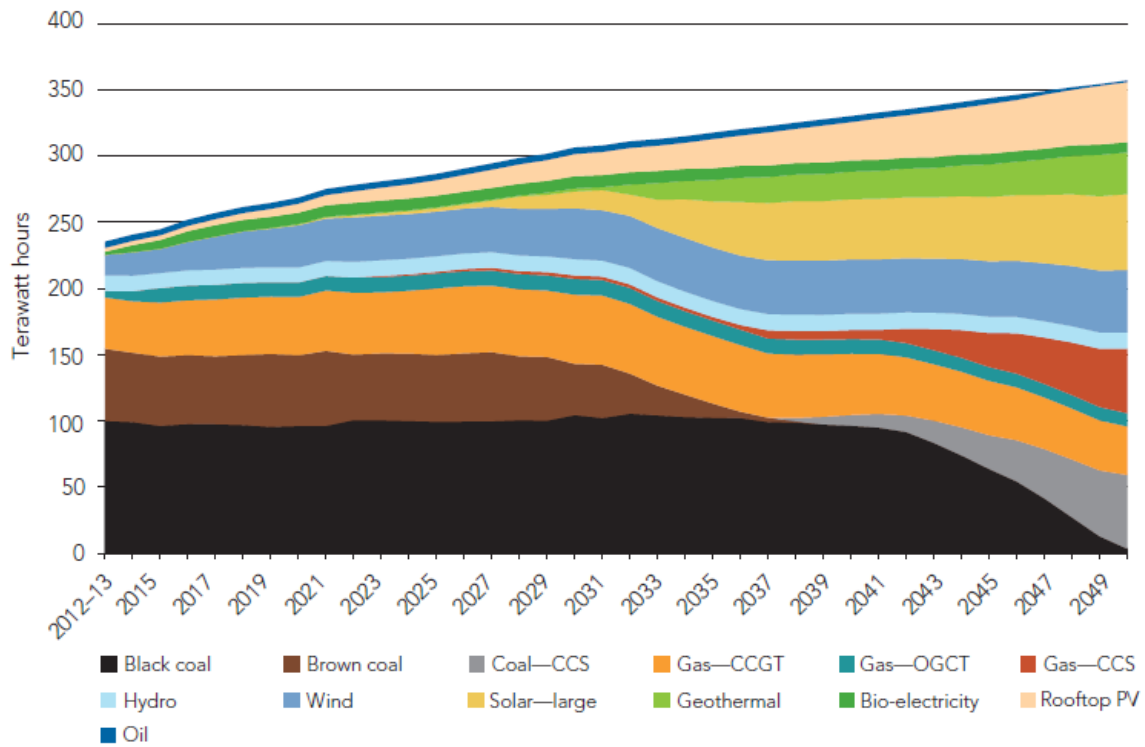
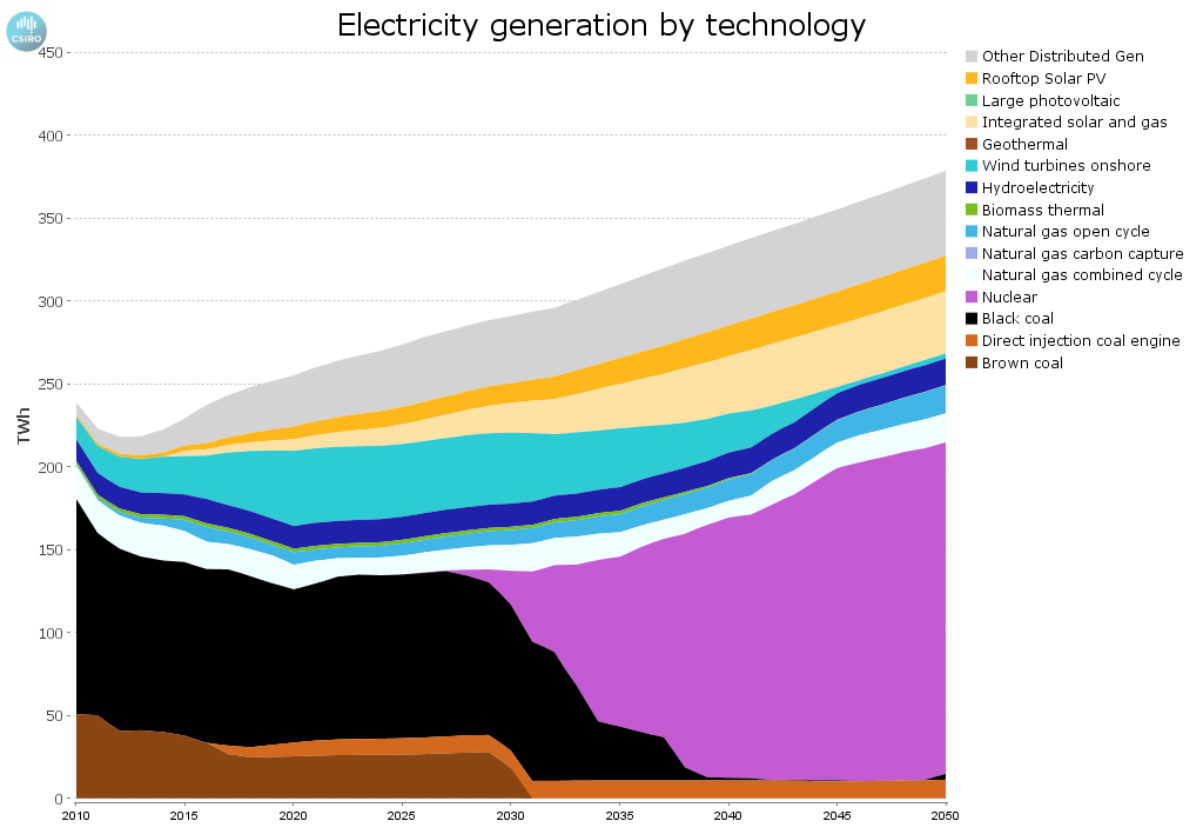


Fig. 1 EWP Figure 3.8 Australia’s electricity generation mix to 2050 – AEMO medium demand scenario



Source: Copyright Commonwealth Scientific and Industrial Research Organisation 2012-.
 Chart based on user selected assumptions and generated by CSIRO's eFuture tool,
 Electricity Simulation Model #1953. Conditions of use, see www.efuture.csiro.au (Background).

Fig. 2 CSIRO eFuture default electricity generation mix with nuclear power

The Nuclear Build

The UK Government [4] set out a pathway to install up to 75 GW of nuclear power by 2050 to provide energy security and to decarbonise the UK economy to an 80 per cent reduction on 1990 emissions by 2050, a similar target to the one set by the Australian Government.

The UK consumes about 50 per cent more electricity than Australia. If we were to follow a similar nuclear pathway to the UK, we might expect to need 50 GW of installed nuclear capacity by 2050.

The eFuture model requires building approximately 25 GW of nuclear power stations by 2050 (see Fig. 3). Based on BREE capital costs in Table 3.10.1 of the AETA report, the first 1 GW unit (FOAK³) would cost \$4.2 billion and the other 24 units (NOAK⁴) would cost \$83 billion.

These costs will, of course, be offset by not building the geothermal and coal and gas CCS⁵ plants required for the EWP model.

The EWP 2012 report (section 6.1.2 on page 88) estimates the investment cost for the EWP model at \$195-225 billion out to 2050.

Using the eFuture nuclear model and applying BREE capital costs (except for distributed generation where CSIRO costs are used [5]), the estimated total investment cost will be \$175-235 billion out to 2050. This means no significant difference in total investment cost over the EWP estimate.

It is of interest to compare these investment costs with the recent assessment by the Australian Energy Market Operator (AEMO) for a 100 per cent renewable electricity supply [6] of \$219 to \$332 billion.

³ First of a kind

⁴ Nth of a kind

⁵ Carbon capture and storage

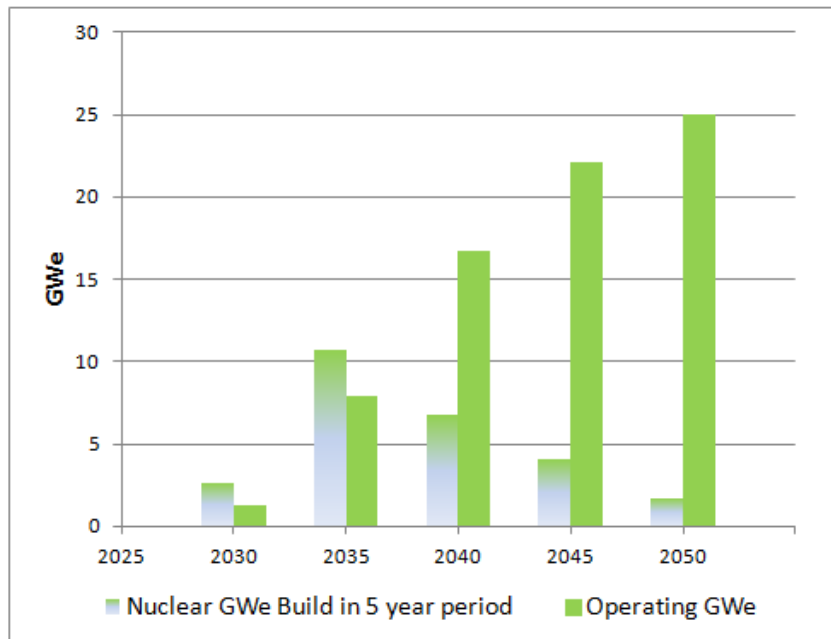


Fig. 3 Estimated Nuclear Build and Operating Capacity for the eFuture Model

Greenhouse Gas Abatement

The EWP in Section 1.2 sets out reductions in greenhouse gas emissions (GHG). Carbon pricing was introduced on 1 July 2012 to assist in achieving these emissions reduction commitments.

The carbon price in Figure 2.2.1 of the AETA report rises steadily from \$23 in 2012 to \$133 in 2050 for the Strong Growth, Low Pollution Core scenario. These prices were used to calculate the cost of GHG abatement in the electricity sector.

To achieve the reduction targets, Chart 5.2 in the Treasury modelling [7] shows that Australia will need to purchase almost half its abatement permits from overseas. This means that any additional reduction in domestic electricity emissions over and above those in the EWP will save the economy the cost of purchasing overseas permits.

GHG emissions from electricity generation are primarily caused by burning fossil fuels. Nuclear power has the ability to replace most of the fossil fuels that are still required within the EWP technology mix out to 2050. The assessed accumulated abatement cost out to 2050 for the EWP mix is \$290 billion. The eFuture model reduces the accumulated abatement cost to \$160 billion – an overseas abatement saving of \$130 billion out to 2050 (see Fig. 4) and achieves the Governments 80 per cent emissions reduction target.

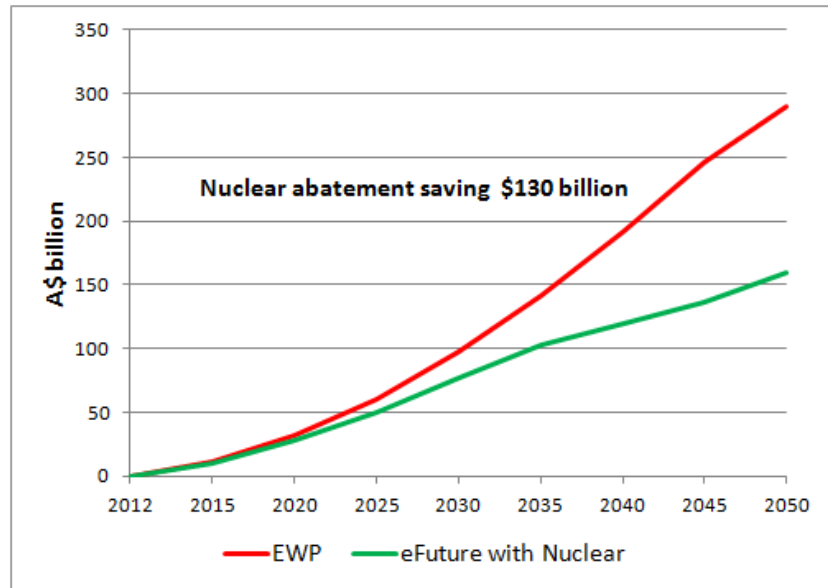


Fig. 4 Cumulative Abatement Cost from Electricity Sector

Health Cost Savings

Pollutants from burning fossil fuels can create health hazards (illness and death). The most common of such emissions from electricity generation are small particulates (such as PM_{10}^6), sulphur dioxide (SO_2) and nitrogen oxides (NO_x).

The ATSE report *The Hidden Costs of Electricity* (2009) [8] analysed externalities of power generation including costs attributable to health costs.

Health costs from ExternE [9] and the ATSE report were used in this analysis to assess the health cost impact of replacing more fossil fuels with nuclear power.

The ATSE report compared relative emission rates of PM_{10} , SO_2 and NO_x for fossil fuel power stations in Australia and Europe as well as relative population densities exposed to such emissions.

Calculations for all technologies using ExternE data shown in Figure 4 and 5 of the ATSE report, converted using the current exchange rate ($\text{€}1 = \text{\$}1.4$) and adjusted for Australian conditions as discussed above are shown in Fig. 5 expressed in $\text{\$/MWh}$.

⁶ Particulate matter 10 micrometres or less in diameter

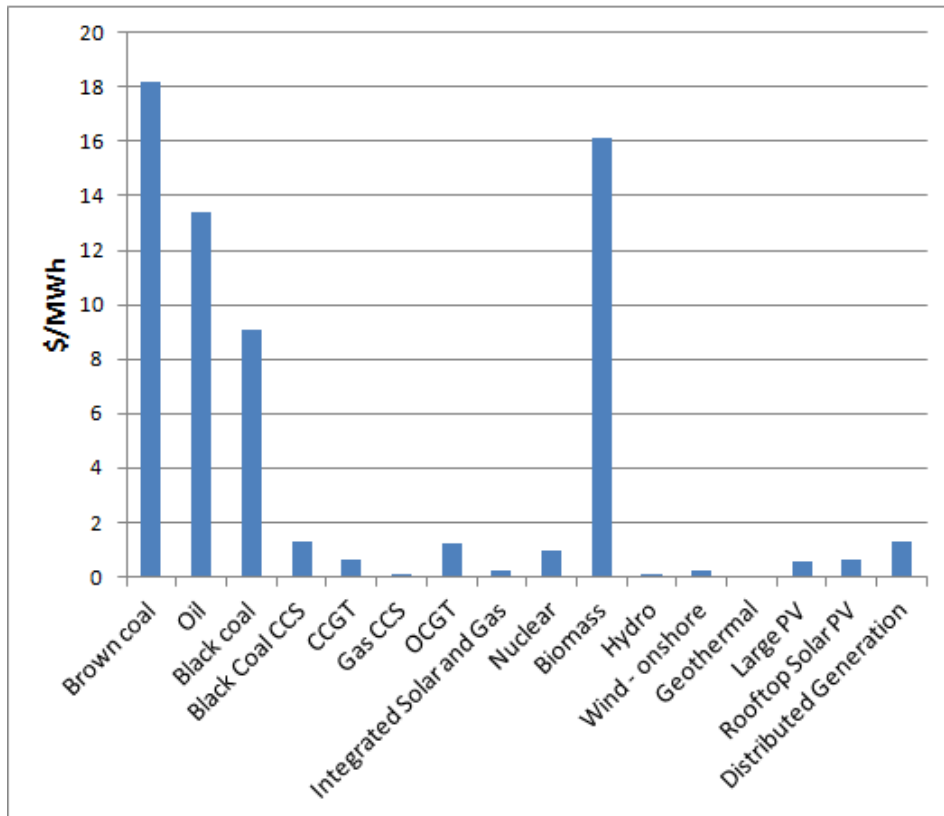


Fig. 5 Electricity Generation Health Costs by Technology

Using the health costs in Fig. 5, the total health cost out to 2050 of the EWP technology mix comes to \$60 billion. For the CSIRO nuclear model the total health cost is lower at \$41 billion. The difference represents a health cost saving to the economy – see Fig. 6.

85 per cent of the total health cost out to 2050 comes from black and brown coal so any uncertainties in the calculation of health costs from other technologies will have a small impact on the total health cost benefit.

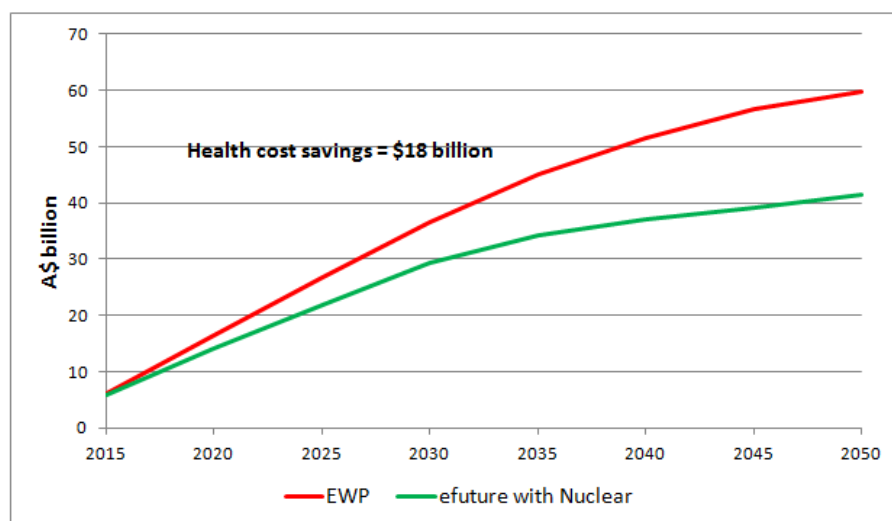


Fig. 6 Cumulative Health Cost from Electricity Generation.

Cost of Electricity Generation

The rising carbon price necessarily leads to increases in the cost of electricity from those technologies that produce GHG emissions. Replacing more fossil fuel technologies with low emission technologies will reduce future increases in electricity prices. Nuclear power, with a carbon price, has one of the lowest LCOEs of any technology.

The rising carbon price increases the LCOE each year in the EWP mix to 2030 and flattens out from then on as fossil fuel use is reduced (see Fig. 7). In the eFuture nuclear mix, the LCOE increases to 2030 but falls significantly after 2035 as nuclear power progressively increases to be 54 per cent of total electricity by 2050. The VWAP LCOE for EWP in 2050 is expected to be \$157/MWh and the inclusion of nuclear power reduces this to \$126/MWh.

The LCOE numbers from BREE AETA do not include decommissioning for any technology. Nuclear decommissioning cost estimates from the US Nuclear Regulation Commission [10] and the OECD [11] suggest that decommissioning costs over the 60 year plant life will add only one per cent to the BREE estimated LCOE of \$96-108/MWh.

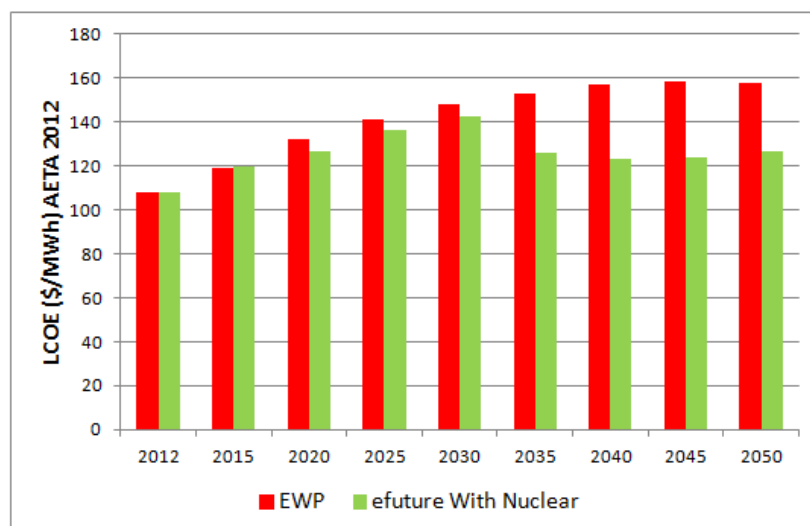


Fig. 7 Volume-weighted Average LCOE in Year Shown

Impact on Retail Electricity Prices

The Australian Energy Market Commission (AEMC) [12] estimates the national residential electricity price for 2012/13 at \$296/MWh. The wholesale cost (including carbon cost) made up 37.5 per cent of this retail price (\$111/MWh).

From the LCOE analysis above, the average LCOE in 2012/3 is \$108/MWh for both the EWP and eFuture models. This demonstrates that the VWAP LCOE is close to the AEMC estimated wholesale cost as expected.

If we assume that the ratio between the VWAP LCOE and retail price in 2015 stays roughly constant over time, then we can estimate retail electricity prices out to 2050 (see Fig. 8). The divergence of the LCOE in the two models after 2030 in Fig. 7 is reflected in the

diverging retail prices in Fig. 8. By 2045, the reduction in retail prices in the nuclear model is over 20 per cent.

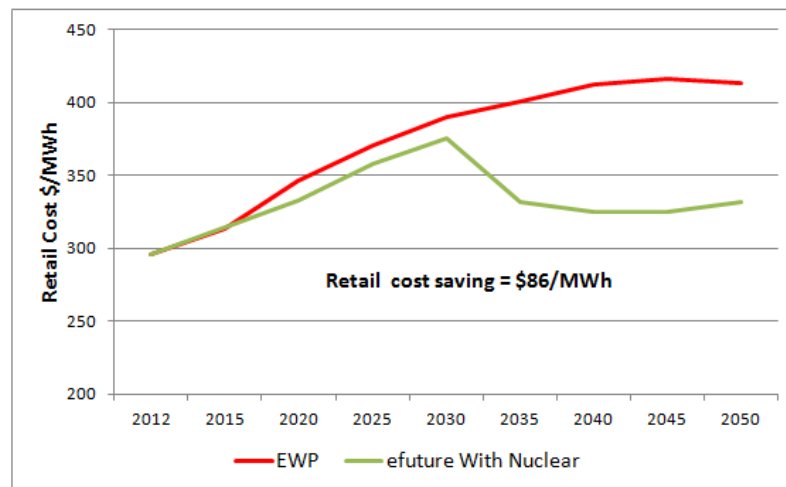


Fig. 8 Estimated Average Retail Electricity Prices in Period Shown

The impact on the economy of a 20 per cent reduction in retail electricity cost is difficult to assess. According to the Australian Bureau of Statistics [13], for household electricity users, the cost of electricity is about 2.5% of the total consumer price index (CPI) so the impact of a 20 per cent reduction is likely to be only a 0.5% reduction in the CPI.

The impact on industry, and on the economy as a whole, might be more difficult to assess. In a recent survey by the Australia Industry Group (AIG) evaluating the impact of the carbon “tax” on industry [14], the carbon price was estimated to have increased energy prices by an average 14.5 per cent.

The best way to minimise these price increases is to reduce the carbon intensity of energy generation through low-carbon energy sources like nuclear power.

Employment Opportunities from Nuclear Power

Consulting firm Brown and Pang published a paper on the nuclear workforce [15] reporting preliminary estimates of the workforce requirements, direct and indirect employment opportunities, education and skilling challenges under alternative nuclear power scenarios.

The mid-range scenario (25 GW by 2050) is very close to the suggested nuclear build in this paper so it is appropriate to use Brown and Pang data to show the anticipated number of direct and indirect employment opportunities.

Uranium mining, along with experts in nuclear science, research and regulatory bodies already provide over 2,000 nuclear power related jobs for the Australian economy. Indirect employment involved in power station operations and maintenance is expected to grow to 11,000 jobs by 2050 in the mid-range scenario. 18,000 direct jobs employed in construction and operation of the plants brings the total nuclear power related jobs to 29,000. Fig. 9 shows the anticipated growth in both direct and indirect nuclear jobs out to 2050.

According to Brown and Pang, if the nuclear build was extended to 50 GW then the total nuclear power related jobs could be 37,000.

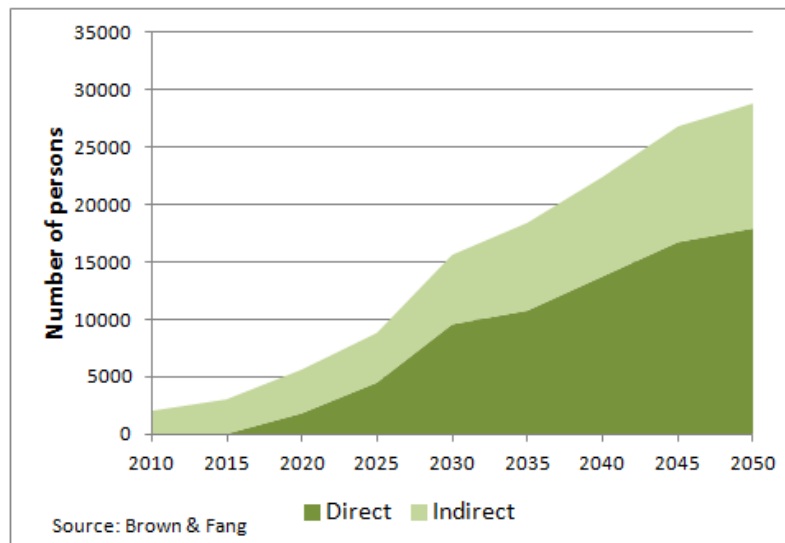


Fig. 9 Employment Opportunities in Building 25 GW of Nuclear Power Plants

Cost of Nuclear Delay

Delaying the start of the nuclear from 2025 to 2030 will have a significant impact on the potential savings in abatement and health costs. The abatement and health saving out to 2050 will reduce by \$40 billion. Annualised, this amounts to \$8 billion for every year that nuclear is delayed after 2025.

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Written by Martin Nicholson and presented at the ATSE *Nuclear energy for Australia?* Conference 26 July 2013

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