Coal switch

Halving Victoria's greenhouse emissions

A proposal by the Greenleap Strategic Institute and Beyond Zero Emissions

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Abstract

This document proposes a straight forward approach to cutting greenhouse emissions by virtually eliminating the use of thermal coal in Victoria. This is needed because coal is among the most greenhouse-damaging sources of energy. The proposal focuses on the stationary energy sector and is based around a three-year immediate-start program, which when implemented will yield a 50% reduction in the state's greenhouse gas emissions.

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Introduction

Beyond IPCC. A broad global consensus has emerged about the need to tackle climate change, with the IPCC reports most often cited as the authoritative case for change. However more recent reports and commentary suggest that the problem is far worse and the need for action far more urgent than the IPCC reports suggest. The proposal outlined is a response to the latest evidence based effects of climate change which show that IPCC recommendations do not go far enough toward highlighting the need for decarbonisation[1].

Urgency. Decarbonisation is absolutely necessary, and must be accomplished as quickly as possible. There is a high risk of an albedo flip[2] event triggered by the complete loss of the summer Arctic ice extent, now predicted by US Navy oceanographers to occur in the next five to seven years [1]. This has turned the climate crisis into a full-blown emergency [2]. Actual events including the dramatic ice sheet melting of recent times suggest that the IPCC reports were too conservative [3] and that the consequences of global warming could be far more severe and sudden than previously thought [4]. Recently Dr James Hansen[3],has asserted that to avoid dangerous climate tipping points, we need to stabilise the level of greenhouse gases in the atmosphere at between 300 and 350 parts per million CO_2[4], far below the levels of 450- 550 considered in the terms of reference in the Garnaut report [16].

Achievability. Existing renewable energy technology is available now, at scale, with proven reliability, capacity and scalability, and at a cost that is far lower than the real cost of fossil fuel generated energy[5]. Indeed, as the price of fossil fuel rises inexorably, the cost of wind and large scale solar thermal plant are being reduced dramatically as a result of increasing economies of scale and realised innovations in the technology [5].

Making a start. We can begin rolling out the amount of wind and solar recommended in this report with confidence that these are sound infrastructure investments, leading to significant industry growth. Thus we can begin the initial stages of the complete 10 year zero-emission transition right now, giving us time to plan the more complex elements of complete decarbonisation concurrently with the execution of this plan.

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1 The process of removing carbon (predominantly carbon dioxide) fron the atmosphere, thereby reducing its effect on climate change.

2 'albedo flip' refers to the sudden and substantial decrease in surface reflectivity. This in turn directly leads to an increase in surface temperature.

3 Dr Hansen of NASA's Goddard Institute of Space Sciences, one of the world's most eminent climate scientists, and his country's top climate modeller.

4 The concentration of carbon dioxide is already 387ppm with between 10-40ppm built in (NASA)

5 The real cost = the generation cost plus the cost of cleaning up harmful by-products of the generation process and ultimate disposal of the generation waste and spent equipment

Our predicament

Currently Victorians are among the highest per-capita emitters of greenhouse gases in the world [6], largely as a result of our reliance on lignite combustion for electricity[7]. This will be increasingly regarded as unacceptable by the international community and indeed by the electorate, particularly as the increasingly serious impacts of climate change are felt by ordinary Victorians.

Climate change effects are predicted to be very severe for Australia [8]. Victoria can expect particularly severe consequences as a result of (among other things) permanent reductions in rainfall and its effects on food and water security, the frequency and severity of forest fires and the visible degradation of our landscape [9]. Climate change is already contributing to global geo-political instability.

Victorians are increasingly drawing the connection between our disproportionately high greenhouse gas emissions and visible effects of climate change. In 2002 a survey by Taylor Nelson Sofres for the Climate Action Network, found that 77% of people thought coal-fired power stations should be phased out within twenty years [10]. This sentiment will only become stronger.

Outline

We propose an initial three-year program designed to meet the following primary criteria:

1. Reduce Victoria's total greenhouse gas emissions by 50% within 3 years;
2. Continue to provide domestic and business customers with energy security;
3. Retain a strong and growing economy.

To meet these criteria, the program is based on the following straight-forward steps:

1. End all combustion of thermal coal (predominantly lignite) within three years;
2. Use natural gas as a transitional fuel, without any additional onshore gas processing infrastructure and minimising capital investment in the states soon to be redundant fossil fuels infrastructure;
3. Install turbine capacity to produce one third of Victoria's current electricity supply from wind power;
4. Install capacity to provide 10% of Victoria's electricity from Concentrated Solar Thermal power in order to make a significant beginning in the exploitation of Victoria's abundant solar resource which later will be expanded to power our new transport infrastructure.
5. Targetted Energy Efficiency, predominately around space and water heating freeing up inefficient and underutilised natural gas resource and a modest amount of end use electricity energy (10%) This program mimimises the need for expensive gas plant and also provides 55% of additional gas to power plants.

Victoria's Current Power Infrastructure

Currently Victoria's electricity predominantly comes from coal and natural gas as shown in the following table. Natural gas is also distributed directly to customers for onsite combustion. Both of these elements make up most of what is know as the stationary energy sector.

Table 1 shows that contrary to public perception, natural gas delivers more than half of the energy domestic and business customers in Victoria use. Conventional analysis looks at the amount of energy used at the supply side, but doesn't take into account the fact that not much of that energy necessarily makes it to consumers. Delivered energy is what is important in any benchmark of energy use. It can be misleading to just look at ABARE data that only quotes Primary Energy, without looking at the proportion of energy actually delivered.

Energy Source	Primary Energy (PJ/annum)	Delivered Energy (PJ/annum)	Efficiency (%)	Emission factor (kt/PJ delivered)	CO_2 emissions (Mt/annum)
Coal	705	165	25	380	62.7
Natural Gas to gas customers	220	187	85	75	14.0
Natural gas to electrical plants	38	15	40	160	2.4
Total	963	367	38	-	79.1

Table 1: Victoria's current energy distribution and CO_2 emissions

Sources: Energy in Australia 2008, ABARE [6]

The principal electricity generating facilities (systems greater than 100MW) in Victoria[7] are shown in the table below.

6 ABARE report [11], table 40

7 For a full list of power plants in Victoria see http://en.wikipedia.org/wiki/List_of_active_power_stations_in_Victoria%2C_Australia

Plant	Location	Capacity (GW)	Fuel / method
Hazelwood[8]	Latrobe Valley	1.5	Lignite
Loy Yang B[9]	Latrobe Valley	0.7	Lignite
Loy Yang A[10]	Latrobe Valley	2.2	Lignite
Yallourn[11]	Latrobe Valley	1.5	Lignite
Newport	Melbourne	0.5	Natural gas (steam turbine)
Anglesea	West Coast	0.15	Lignite
Jeeralang	Latrobe Valley	0.3	Natural gas (gas turbine)
Somerton	Central Vic	0.16	Natural gas (gas turbine)
Laverton	Melbourne	0.3	Natural gas (gas turbine)
Valley Power	Latrobe Valley	0.3	Natural gas (gas turbine)

Table 1. Victoria's primary power plants (> 100MW)

The Transition

There are five specific steps to the plan:

1. Fuel switching – eliminating coal and re-powering with gas;
2. Electricity and Natural gas end-use efficiency program;
3. Supply 33% of Victoria's electricity from wind;
4. Supply 10% of Victoria's electricity from Concentrated Solar Thermal;
5. Other non-emitting sources.

Step 1. Fuel switching – eliminating coal & re-powering with gas

The measure of the problem. The conventional measure of greenhouse gas emissions arising from energy generation is our 'emission intensity' in kilograms of carbon dioxide per kilowatt hour delivered. In Victoria our average emission intensity for mains electricity is currently 1.39kg/kWh[12]. By global standards this is *very* poor. It is poor because brown coal (lignite) is a low-grade fuel with a high water content.

8 Hazelwood: http://www.ipplc.com.au/

9 Loy Yang B: http://www.ipplc.com.au/

10 Loy Yang A: http://www.loyyangpower.com.au/

11 Yallourn: http://www.truenergy.com/Production/Yallourn/index.xhtml

12 See http://www.greenhouse.gov.au/

Conventional wisdom. It is broadly assumed that to improve the emission intensity of our current fleet of coal-fired power stations requires wholesale replacement of the plants. Obviously this would be a very costly and very time consuming undertaking. We challenge this basic assumption.

Alternative. The burners in any existing coal-fired plants can be quickly and easily replaced or modified to be re-powered with natural gas. A plant thus modified would overall be more efficient than the unmodified coal plant. It would be slightly less efficient than a purpose-built gas-fired plant, but could be brought online much more quickly.

A new baseline. The emission intensity of a gas re-powered coal plant is in the order of 50% better than a coal-fired coal power plant. To simply replace coal with gas, based on a current coal-fired electricity generation of 46.4 TWh/annum[13], the emissions abatement of 33Mt of carbon dioxide is achieved[14] To put this into perspective, the plan to eliminate the incandescent light bulb in favour of the compact fluorescent Australia wide will only achieve a greenhouse gas abatement of 2 Mt[15].

Natural gas. The gas required to achieve gas re-powering is readily available and the gas infrastructure in the Latrobe valley is already in good proximity to the coal-fired plants. Current estimates of natural gas reserves from Bass Strait fields are about 8.0EJ[16]. This is capable of powering Victoria's power for about 23 years[17] at the peak requirement of this plan. However once the energy conservation measures and complete displacement of gas by renewables are factored in this resource would last much longer.

Stranded asset. Currently Victoria's reserves of lignite are considered a large economic asset. This assumption needs to be reviewed. Victoria's lignite should no longer be considered an asset. Economists consider this scenario one of a *stranded asset*. Herein lies the hardest pill to swallow for the industry. However, writing off the book value of Victoria's coal is a relatively small economic cost compared to the long-term costs of climate change. This has previously occurred with the Asbestos resource in Western Australia.

Research and precedents. Scenarios involving gas re-powering were presented as part of "Scenarios for a Clean Energy Future" report prepared for the US Department of Energy in November 2000[18]. Appendix E-7 of that document gives specific analysis. More recently there is support for gas re-powering in the report "Cofiring coal with other fuels", from the IEA Clean Coal Centre[19]. In particular section 13.9.5 describes the modes of re-powering coal-fired boilers[20].

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13 Annual Victorian electrical consumption of 45 TWh corresponds to 678PJ primary energy (ABARE figures for 2004-2005) and net system efficiency of 19%.

14 33Mt (megatonnes) of CO_2 emission abatement, based on 50% x 35 TWh x 1.39 kg/kWh

15 2Mt of emission abatement based on http://www.abc.net.au/news/newsitems/200702/s1851776.htm

16 8.0EJ = 8 million gigajoules. Source is ABARE Energy report [11] - 210bcm (table 2) * 38MJ/m^3 (table 52) = 8.0 x 10^{18}J

17 8.6 years comes from 8.0EJ/(678+251PJ/annum).

18 Scenarios for a Clean Energy Future report at http://www.ornl.gov/sci/eere/cef/

19 http://www.coalonline.org/site/coalonline/content/browser/81569/Cofiring-coal-with-other-fuels

Gas required. The natural gas resource used for the fuel switch will be around 100 PJ/annum[21] of the 258 PJ/annum currently used in Victoria's domestic and industrial / commerical sectors. 80% of this (80 PJ/annum) would be diverted from the domestic sector and 20% (20 PJ/annum) from the industrial/commercial sector through implementation of the first point in Step 5 of our proposal. An additional 81PJ of the spare 400PJ+ capacity will also be used in the 3rd (peak gas) year. This will then drop off at a rate of 1/7 per year over the following years 4-10. As we come off the peak year remaining supplies will be sent to NSW as part of their zero emissions renewables transition.

Other benefits. This fuel switch is a straightforward solution to the increasing pressures on Victoria's electricity supply around climate change, energy security and infrastructure (energy and housing). Essentially it is a rearrangement of resource allocation using almost entirely existing infrastructure, combined with energy efficiency measures in the domestic housing sector. It negates the need for large and costly infrastructure projects (such as building new fossil fuel power plants), whilst making enormous short term reductions in Victoria's Greenhouse gas emissions. It also has many other benefits including:

- Greater security and reliability of energy supply, particularly as a result of the reductions in peak demand which arise through efficiencies made at Step 2
- Improvements to Victoria's housing infrastructure, and the associated reduction in costs to working families in power bills;
- Health benefits (through eliminating dangerous localised particle pollution caused by lignite combustion and latrobe valley incidence of asbestos exposure related illness (7 times the national average));
- Eliminating the need for strip mining of lignite and the associated land degradation and other costs;
- Improvements in social equity as a result of far lower energy costs for families through energy efficient housing.

In summary, the fuel switch will require a progressive three-year program to switch all existing coal-fuelled electricity generation to natural gas. This involves:

- Maximizing use of existing gas peaking plants from existing 15% capacity factor to 90+%
- Delivering 13TWh per year of gas following seasonal supply and demand curves of consumers and renewable power generation technology.
- Meet any deficit in capacity by re-powering Loy Yang A and B with gas and the bare minimum use of Hazelwood and Yallourn also repowered with gas

20 http://www.coalonline.org/catalogues/coalonline/81494/6092/html/6092_176.html

21 100 PJ/annum This increases available capacity over the winter period for the gas repowering.

- Re-powering with gas may require additonal short-run, high-capacity pipelines from Longford to the Latrobe Valley generators.

- Job impact – power station workers will be required in existing plants. A number of mine workers will be needed to undertake the huge task of rehabilitating the 3 main mines, and maintenance workers related to mining operations will be re-skilled into wind power maintenance roles or other related manufacturing and servicing industry. 10,000 jobs in this area will be created as part of the program, easily accommodating those involved in mine servicing. [22]

Step 2. Electricity and Gas End Use Energy Efficiency program

To save 5 TWh of electricity and 100PJ of gas consumption per year

55% of the natural gas required to achieve power plant re-powering(around 100 PJ/annum) will be diverted from the existing end use gas resource (around 250 PJ/annum). We also need to start mining efficiency with end use electricity eliminating demand growth. (ie if demand is growing at 500GWh pa then we must save 500GWh pa.) In the first 3 years we'll actually aim to go backwards and save growth in energy demand as well as an additional 5TWh (10%) an additional 80PJ will be brought onshore taking advantage of low plant utilisation at Otways and Longford outside of the winter heating season.

This will be achieved by:

- **Insulation program.** This is required to reduce energy needed for space heating and cooling in the domestic housing sector by at least 40% across the entire existing standing stock (averaging 70% – 90% per building upgraded). This program affects the domestic end use gas consumption (80PJ targetted saving) and the 5TWh electrical end use saving

- **Hot water service substitution program.** Conventional gas/electricity hot water services will be replaced by evacuated tube solar hot water services, boosted in winter months by very efficient (air source) heat pumps. The water storage tank will be located inside the building envelope for greater efficiency. The program should be 60% complete in year 3.

- **Heating systems substitution program.** Replacement of conventional gas and electric heaters with readily available ten-star high-efficiency DC inverter heat pumps with an energy conversion coefficient of five.

Because the energy efficiency of Victoria's current housing stock is so low by international standards, there are many low hanging fruit energy savings to take advantage of in this sector. The energy savings represent a net profit after 2**-10** years when set against the cost of the retrofit program.

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22 http://www.upi.com/International_Security/Energy/Briefing/2008/04/03/awea_announces_wind_leaders_in_us/1642/

The first part of the upgrade to Victoria's existing housing stock would be an incentive-driven **insulation program**. An example house upgrade would involve;

- Sub floor (bulk insulation and air cell foil – R3.0winter / R2.0 summer)
- Walls (Bulk insulation and air cell foil) –R3.0/3.0)
- Inaccessible walls and sub-floor -liquified expander extrusion foam via jet.
- Roof (bulk insulation R3.0-5.0 and triple layer foil silver bats R4.0/7.0)
- Draught proofing (significant infiltration losses mitigated) to 0.35 changes/hour
- Window upgrades (double glaze, curtain materials, pelmets) Mass market for double and triple glaze needs to develop to match US and European market.

The scheme (which could easily be privately or publicly financed) to retrofit existing housing stock would aim to pick up at least 50% of all stock with targeted end use space heating reductions (insulation).

All new housing stock would incorporate these standards as well as passive solar design and thermal mass storage, effective immediately. Given the recent release of large areas of land in new urban growth boundaries, for the construction of around 50,000 new houses, it is essential that we seize the opportunity to make these urgent changes to housing standards **before we** invest billions of dollars in this new housing stock that will be either an asset or a burden to Victoria for at least the next 90 to 100 years, .

The upgrade to existing housing stock will be combined with a program of heating systems substitution, (again incentive-driven), to replace the more inefficient portion of Victoria's domestic heating systems with 10 star high efficiency DC inverter heat pumps. These are readily available in the Australian market and are sold world-wide in their millions by Panasonic and Toshiba. These heating systems have an energy coefficient of around five times, meaning that the end use electricity requirement for the same heat delivered is $1/5^{th}$ of a conventional resistive element based heater and this also makes them 1.5 times more efficient than an average gas furnace when powered by electricity generated from a gas plant.

Additional to the space heating upgrade there will be a program of **hot water service substitution**. Conventional gas/electricity hot water services will be replaced by evacuated tube solar hot water services, boosted in winter months by very efficient (air source) heat pumps. The water storage tank will be located inside the building envelope for greater efficiency.

The central purpose of this upgrade of Victoria's domestic housing stock is to free up enough natural gas from its current use for domestic heating, to be diverted to electricity generation and replace that portion of our electricity supply that would otherwise be provided by lignite (around 80PJ, with the remaining 20 PJ from industrial processes). After these programs, the upgraded stock will require 70-90% less heating, and the heating we do need will be provided by electrical systems rather than gas, which even after a relatively inefficient conversion to electricity in our refuelled coal power

plants, gives us at least a 1.5 times more efficient use of the our gas energy resource than direct heating.

As mentioned above the saving of 80 PJ from the domestic sector will be achieved by a combination of straightforward demand reduction and management measures to reduce the energy required to heat and cool Victoria's housing. These will include insulation and upgrading space and hot water heating systems. .

An important consequence of a large scale insulation program is that it substantially eliminates the six week winter heating peak and summer air-conditioning spikes. Demand peaks make it more difficult to ensure a secure and reliable electricity supply. These demand peaks are almost entirely the result of commerical and domestic space heating and cooling. Thus the program to upgrade Victoria's housing stock is ideally targeted to make the provision of secure and reliable electricity to Victoria's consumers far easier than it presently is and provides additional benefits

- Replace all standard electrical hot water services with heat pump-boosted solar hot water (mostly in rural areas). This also reduces transmission losses which in many cases are at greater than 20%;
- Reduction in the requirement for water to generate electricity – currently latrobe valley generators use the equivalent of 30% of Melbourne's water supply.
- With Seven times the national cancer rate in the Latrobe Valley, the operation of dirty and dangerous coal fired power stations has done no real service to the station workers or their community.

Step 3. Supply 33% of Victoria's electricity from wind generation

As mentioned previously, wind is the least expensive source of renewable energy. It is certain that a large proportion of our energy mix will come from wind. We must:

- Build the equivalent of seven 736 MW wind farms the same size as Horse Hollow wind farm operating since 2006 in Texas[23]
- Deliver 15 TWh of electricity on an annual basis varying with the seasonal supply and demand curves, which is proven in Spain[24]
- Each wind farm would consist of around 205 General Electric 3.6 MW or equivalent turbines
- 33% of annual supply – Spain recently reached a peak of 40% of power from wind ahead of all other sources. Spain is installing 4500MW of capacity in 2008, which is almost as much as we are proposing over 3 years.
- Project cost including turbines $10 billion

23 http://www.fplenergy.com/portfolio/pdf/horsehollow.pdf

24 http://news.yahoo.com/s/afp/20080325/sc_afp/spainenergyalternative

- Grid upgrade $2 Billion (based on recent HVDC upgrade for wind in Texas).

Step 4. "Big Solar" Solar thermal Energy

- Supply 10% of Victoria's electricity from Concentrated Solar Thermal power
- Install six 354 MW Concentrated Solar Thermal plants. These would be the equivalent size to the existing parabolic mirror plant that has been operating in California's Mohave Desert since 1991[25].
- Delivering 4.4 TWh per year of electricity matching future reduced summer demand peaks.
- Located in the state's north covering marginal farm land 5.5 km by 5.5 km
- The total cost today would be about $7 billion, however new technology being deployed by Australian Dr David Mills (Ausra Inc) in California will reduce this cost by up to 70% in the next three years through improved economies of scale.

Step 5 - Other Sources

- Existing gas-fuelled electricity generation 5 TWh per year
- Mortlake gas power project (factored in as last new fossil fuel plant built)
- Existing Hydro-electricity 1.1 TWh per year
- Additional 80PJ of gas brought onshore at Longford and Otways taking advantage of the low utilisation of gas infrastructureoutside the winter peak.
- Wind power generated electricity from Tasmania, transmitted via existing Basslink 5 TWh per year by installing 700 3.6MW GE or equivalent turbines in the island state. As per Hydro Tasmania plan to install 1520MW of wind predominately on the West Coast. 1000MW for export and 520MW for Tasmanian energy security[26]

25 An example of a large solar thermal plant is that run by FPL Energy in California. See http://www.fplenergy.com/portfolio/solar/facts.shtml

26 The Outlook for Tasmanian Electricity, James Brewer, Manager Customer Trading, 31 March 08

Energy Source	Primary Energy (PJ/annum)	Delivered Energy (PJ/annum)	Efficiency (%)	Emission factor (kt/PJ delivered)	CO_2 emissions (Mt/annum)
Coal	705	165	25	380	62.7
Natural Gas to gas customers	220	187	85	75	14.0
Natural gas to electrical plants	38	15	40	160	2.4
Total	963	367	38	-	79.1

Table 2: Victoria's primary energy today.

Sources: Energy in Australia 2008, ABARE [27]

Energy Source	Primary Energy (PJ/annum)	Delivered Energy (PJ/annum)	Efficiency (%)	Emission factor (kt/PJ delivered)	CO_2 emissions (Mt/annum)
Wind	57	57	100	0	0
Solar thermal	41	16	39	0	0
Coal	0	0	25	380	0
Natural Gas to gas customers	105	102	85	75	6.5
Natural gas to gas power plants	118	47	40	160	7.5
Natural gas to refueled coal power plants	117	41	34	188	7.4
Total	335	222	66	-	21.5

Table 2: Victoria's energy distribution and CO_2 emissions in Year 3

Sources: Energy in Australia 2008, ABARE [28]

27 ABARE report [11], table 40

28 ABARE report [11], table 40

Summary of sources of electricity generation at end of a three-year period

Currently Victoria's electricity consumption stands at 50 TWh per year.

The Electricity Energy efficiency program described above [1] will reduce this demand by 5 TWh per year and offset growth in demand.

This will stabilize total demand after the three year period at around 45 TWh per year. This will be met as follows:

Energy resource	**Energy** (TWh/year)
Wind	16
Natural gas from resource freed up from Natural Gas Energy Efficiency program	7
Existing gas fuelled electricity generation	5
Additional gas from longford	6
Concentrated Solar Thermal	4.4
Existing Hydro-Electricity	1.1
Wind energy /Hydro generated in Tasmania and transmitted to Victoria via Basslink	5
Total	**44.5**

Table 1. Energy Resource Contributions to Electricity Generated

Initiative	Billion dollars
Installation of wind capacity	10
Concentrated solar thermal	7
Transmission upgrade	2
Electricity/gas Efficiency Incentive program	10
Total	**29**

Table 2 Summary of costs

Conclusion

Victorians are currently among the highest, emitters of greenhouse gases in the world. Our emissions are higher than many industrialized countries with significantly higher populations including Austria, Hungary, Portugal, Sweden and Switzerland. Our high emissions are a result of our reliance on lignite (brown coal), which produces ninety percent of all of our power.

In the circumstances of the current climate emergency, this simply cannot continue. We are going to have to switch from lignite powered electricity generation to renewable sources. It is far better to do so now and have the opportunity to become a world leader in the clean energy transition, rather remain a world leader in greenhouse gas emissions.

The cost of around $29 billion is an appropriate level of investment to put Victoria on the path to a secure and clean energy future.

It should be remembered that there are huge costs; financial, social and environmental in continuing to generate our electricity from lignite. Coal power plants need to be maintained and replaced, and to continue pouring money into this nineteenth century technology in the current circumstances is a grossly inappropriate infrastructure investment decision.

On the other hand, there are huge economic, social and environmental benefits in making the switch to a secure and clean energy future, by replacing lignite power plants with energy infrastructure appropriate to the twenty-first century.

Ending combustion of lignitefor electricity generation in Victoria under this plan will result in an unprecedented 50% reduction in Victoria’s greenhouse gas emissions within three years, at essentially the same cost as phasing it out over a much longer period.

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Appendix 1. Emission Intensity Comparison

The emission intensity (kg CO_2 equivalent per kWh) of various forms of generation is shown in the graph below. The data is taken from
http://www.envict.org.au/file/Greenhouse_Brown_Coal_05.pdf