Submission
No 247

INQUIRY INTO ELECTRICITY SUPPLY, DEMAND AND PRICES IN NEW SOUTH WALES

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Submission to the NSW Legislative Council Inquiry into Electricity Supply, Demand and Prices in New South Wales

Submission by: Barrie Hill, Dr Robert Barr AM and Robert Parker

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Introduction

Over the past two decades the utility of the Australian electricity sector has markedly deteriorated. A combination of privatisation of public assets, renewable subsidies, and poorly designed liberalised markets has led to the current situation. Costs to residential and industrial consumers have risen from world's lowest to close to world's highest with predictable impacts particularly on industry. The reasons for this situation have been well documented in submissions to this inquiry and many others. In summary they include failure of the market design concept to include payments for capacity, the impact of renewable subsidies on base-load utilisation, gaming, and generator/retailer market power. Much of the submission, review and discussion from all inquiries shows little or no understanding of the complexities of power system engineering, despite much repeated claims that such reviews are technology neutral or technology agnostic. The fact is that technology and well managed engineering detail design is crucially important to ensure system technical standards, reliable operation every minute, and lowest overall cost. Poor choices promoted for the existing and future electricity sector have already led to expensive mistakes that will bedevil many households and Australian prosperity as a nation for years to come.

This submission provides a strategy to address a deep-seated and serious issue the reasons for which are not generally articulated as the underlying causes are not well understood. That issue is the failure of any long term planning or provision for future base load generation investment.

The Electricity Sector Investment Dilemma

Managed electricity sector generation replacement is a policy issue currently left to the market which is completely unable (or prefers not) to collectively respond in any way that resembles the national interest. A classic Tragedy of the Commons issue. The investment problem is driven by the fact that the current liberalised market provides no reliable long-term guarantee for return on capital investment for new base load generation. An energy only market where the only chance for plant utilisation and financial return is settled every half hour gives no security or incentive to investors who may wish to provide capital for base load facilities. No bank, local or international will provide debt funding to support equity investment under these circumstances.

This situation is totally at odds with all acceptable organisation governance principles for both the public and private sector and if allowed to continue will lead to a worsening situation for the electricity sector and consumers. Interesting to note this week that engineers predicted the collapse of the Genoa road bridge ten years ago but widespread procrastination by opportunistic politicians prevented implementation of an appropriate solution.

Some commentators and renewable sector lobbyists have promoted the concept that base-load generation will no longer be required and is an impediment to the deployment of renewable energy. This concept maybe true if costs to electricity consumers are of no concern and reliability is of minor importance. However detailed engineering system analysis shows that coal, nuclear or gas base load power will continue to be required for the foreseeable future to underpin the reliable provision of electricity to current technical standards at acceptable cost. Generally unpredictable levels of solar and wind power will continue to require appropriate system quality management, transmission augmentation, and quick start backup response in the current grid always at greater overall system cost than base load power generation of any type.

Analysing The Investment Options

This submission takes information from a preliminary investment proposal document that provides the basis for future electricity generation investment in Australia and New South Wales. The study is based on detailed engineering system analysis with supporting economic analysis to achieve lowest cost and lowest emission outcomes for a fully reliable system that could support the National Energy Guarantee concept. The proposal does not promote large scale demand management as this is considered as an inappropriate band-aid response to inherent system failure in a modern industrial society.

All options that have been promoted by various institutions and individuals have been analysed and consolidated using load and generation data provided by the Australian Energy Market Operator for each period of 30 minutes over the year 2017. This represents 17,520 data sets analysed for the current system, winter/summer, day/night electricity load demand pattern utilising all feasible generation combinations supporting the Australian electricity sector. Only this level of analysis picks up the real intermittency issues with solar and wind generation options and allows an engineered response.

A system engineering model first matches the actual load demand at each data point with a feasible generation combination to ensure all demand is met at all times. When balance is achieved the final generation mix is costed, transmission, distribution and retail costs are added and a cost to the consumer is calculated. A minimum cost can be quickly achieved by optimising the final generation mix. The model mirrors the actual working of the Australian grid and current National Electricity Market to provide all relevant output values for decision makers. The model allows analysis of future options in a depth not seen in any other form of publicly available analysis to date. The majority of previous modelling efforts seem to fail to reflect system engineering reality by using averaging concepts for individual generation options which smooth over intermittency issues for many cases. Details of the model are available at www.epc.com.au

All costing data has been taken from actual capital and operating values currently seen in Australia. Information for the nuclear power option was provided by South Korean government agencies during an intensive study tour of that country believed to be the most efficient electricity provider in the world. The Korean costing information was revised by Australian consultants and contractors to ensure compatibility with labour rates and general civil engineering costs currently seen on local major projects.

The investment failure crisis can only be overcome by the provision of minimum 15 year power purchase agreements provided by government or alternately by direct investment in the electricity sector by government. These two financing options have markedly different financial outcomes for the same asset investment. Private investment organisations require a cost of capital return of at least 12% {typically 20% equity 80% debt) whereas public investment can be managed for 3% interest rates or less. This leads to system levelised costs for base load private and public investment as noted in Appendix 1. Inherent in both these possible options is the need for electricity supply from both to operate outside of the existing liberalised market to ensure full plant utilisation and secure investment return. In one sense both options constitute a payment for long term capacity at lower cost than currently seen in the national energy only market.

Outcomes from a small selection of possible generation outcomes are shown in Appendix 1. These cover the National Electricity Market as it currently operates with the progressive introduction of low emission technologies renewable solar and wind, and nuclear power. The cost of emission abatement is also calculated. While all load is met for each case further analysis is required to ensure grid system quality standards and stability is maintained for the higher level non synchronous renewable options. It is interesting to note from the illustrations of load and supply, the significant impact of behind the meter solar installations. These installations occasionally go part way to reducing peak loads and are clearly worth supporting with appropriate feed in tariffs although this is balanced with higher costs for partially utilised back up plants.

The analysis leads to the conclusion that if cost of supply is important, new base load investment should be undertaken directly by government in advance as ageing private generation assets are slated to be retired. This option is already being discussed for some generation capacity such as high efficiency coal and large scale pumped storage. The most likely plant retirement program is well understood and is not detailed in this submission. This strategy will likely stabilise the current market so that price increases driven by plant closures as seen in the past will not be repeated. In addition great care must be exercised to ensure the current market arrangements including renewable subsidies do not continue to prematurely disadvantage existing base-load generation technically and economically. This disadvantage arises by forcing under-utilisation and eventual closure driven by inappropriate financial conditions as was illustrated by the Northern and Hazelwood generation plant closures.

The Lowest Cost Lowest Emission Option

If emission reduction is accepted as a serious imperative then only nuclear power provides this outcome in a reliable cost-effective manner as this submission verifies and world experience demonstrates. The opportunity for a managed transition of retiring coal fired generation directly to nuclear power generation in NSW may already be too late. At least one new coal or gas fired power station will probably be required to replace Liddell in NSW before two new nuclear power units could be commissioned . There is currently no proposal to replace the Liddell generator with base load capacity illustrating the extent of the investment issue and the possibility of some market manipulation. This has prompted much uninformed speculative debate but no action.

THE IMPLEMENTATION PROGRAM

A review of the current base load power station retirement program for New South Wales and information gathered from South Korea indicates the following action proposal for this State. It is recommended that the New South Wales parliament initiate an investment program to build ten 1000 MWe nuclear power plants to be progressively commissioned over the 20 year period 2030 to 2050. The capital cost will be A$6.2B for each 1000 MWe unit, approximately A$65B in total for a full program including all other infrastructure support. The program will be completely cost neutral to the State of New South Wales for a generation sale price direct to consumers or through the NEM of 8 cents per kilowatt hour while supporting the full intent of the National Energy Guarantee as it is now proposed.

The generation units recommended for installation are the APR1000+ pressurised water reactors (PWR) designed and manufactured by South Korea. These units are an updated version of the OPR1000 unit which have a long history of development and world class reliable operation with over 10 units now in operation. Excellent local and export performance has seen recent 1400MWe versions of these units constructed on time and on budget; a factor of the utmost importance for investments of this nature. The larger units although more cost efficient are not suited to the current NSW grid but may be in the future. There is no other nuclear plant option currently available that provides the lowest overall risk profile or value for money at this time. Small modular reactor power plants hold out the promise of significant advantage for the future. These units could not be recommended for installation in Australia until significant operating experience has been gained in countries of origin.

The nuclear industry and electricity supply for South Korea is fully managed by government with minority public shareholding while manufacturing and construction capability is provided by the private sector. Electricity is provided to the nation as a service by the public sector to stimulate wealth creation throughout the entire economy. Unfortunately as electricity pricing in Australia now shows the supply of electricity as a tradable commodity is strangling this nation's wealth creation. In South Korea the unit electricity price to all consumers is US8c/ kWh. The 30% nuclear power contribution is provided at around US4c/ kWh. This performance model could easily be utilised in NSW with the benefit of sharing all financial aspects of the investment in the form of a public/ private arrangement.

It is recommended that the first two units for NSW be fully contracted from South Korean suppliers on a turnkey basis. That country is dedicated to supporting progressive local manufacture of future units. New South Wales already has most of the infrastructure and technical expertise necessary to achieve local construction for later units and the potential for export of manufactured components to other developing countries. The flow on economic benefit to the State over the 20 year period would likely exceed A$100B. The well managed Korean government program has seen economic benefits well beyond these proportions.

CONCLUSION

If the committee finds this summary submission of interest and relevant full details of a preliminary investment proposal can be provided at a later date. That study outlines all information required for an investment proposal as recommended by Federal Government Guidelines for Major Projects. The proposal covers every aspect from detailed investment justification to project risk management.

Information resulting from the South Korean study can also be made available although it is accepted that one intensive week of study by three senior engineers provided an introductory insight rather than a comprehensive review of the massive national electricity supply program that has been achieved by that country.

SUBMISSION CONTRIBUTORS

Mr. Barrie Hill was formerly Principal Consultant Mining and Energy for Jacobs Australia, Director of Engineering for the Australian Nuclear Science and Technology Organisation (ANSTO) and General Manager Queensland Magnesia. Mr. Hill has an extensive background in major project analysis and implementation, power station engineering including nuclear, and process plant development and operations. He is a Fellow of Engineers Australia and Member of the Institution of Mechanical Engineers.

Dr Robert Barr AM is a consulting engineer, director of his company Electric Power Consulting Pty Ltd and the current National President of the Electric Energy Society of Australia. Robert has over 42 years experience in the field of power systems and electricity distribution, is a Fellow of Engineers Australia and a member of Consult Australia. Robert is an Honorary Professorial Fellow at the University of Wollongong and was awarded the title of Australian National Professional Electrical Engineer of the year in 2012. Dr Barr became a Member of the Order of Australia in 2013.

Mr. Robert Parker is a civil engineer with over 35 years of experience in project management and the economic evaluation of projects. He is the former President and current committee member of the Australian Nuclear Association. He holds a Masters in Nuclear Science from the Australian National University. In 2015 Rob attended the International Congress on Advances On Nuclear Power Plants in Nice (ICAPP 2015)where he signed the Nice Declaration along with the national representatives of 38 other nuclear associations. This declaration advocates the use of nuclear energy to address man made climate change by ensuring that 80% of electricity comes from low-carbon sources by 2050.

APPENDIX 1 - CASE STUDIES OF POTENTIAL BASE LOAD GENERATION REPLACEMENT OPTIONS

NOTES:

1. The full modeling inputs and results are shown for Scenario 1 to illustrate electricity transmission costing detail. Other scenarios use similar input methods and details but not all modeling outputs are provided in this Appendix - they are avail ble if requested.
2. The tables for each scenario list the costs of generation for all scenario results, namely:
    a. The System Levelised Cost Of Electricity (SLCOE) which includes the transmission costs specific to that scenario
    b. The final retail cost to consumers and
    c. The CO2 abatement cost over and above Scenario 1 the current NEM average emission level.
3. The hydro generator values have been varied in the scenarios to ensure the hydro generation output under each scenario remains at 8% of NEM demand.
4. The illustrations showing generation output for each scenario have been limited to a 20 day snapshot from the 1st July 2017 to 21st July 2017 - this is for visual clarity. The full year spectrum is available.
5. Pumped storage plays an increasingly import part in both renewable and nuclear scenarios. The nuclear scenarios make use of solar PV plus hydro plus pumped storage plus gas to meet the daily peak loads. This can be viewed at finer detail in the following image covering a seven day period.

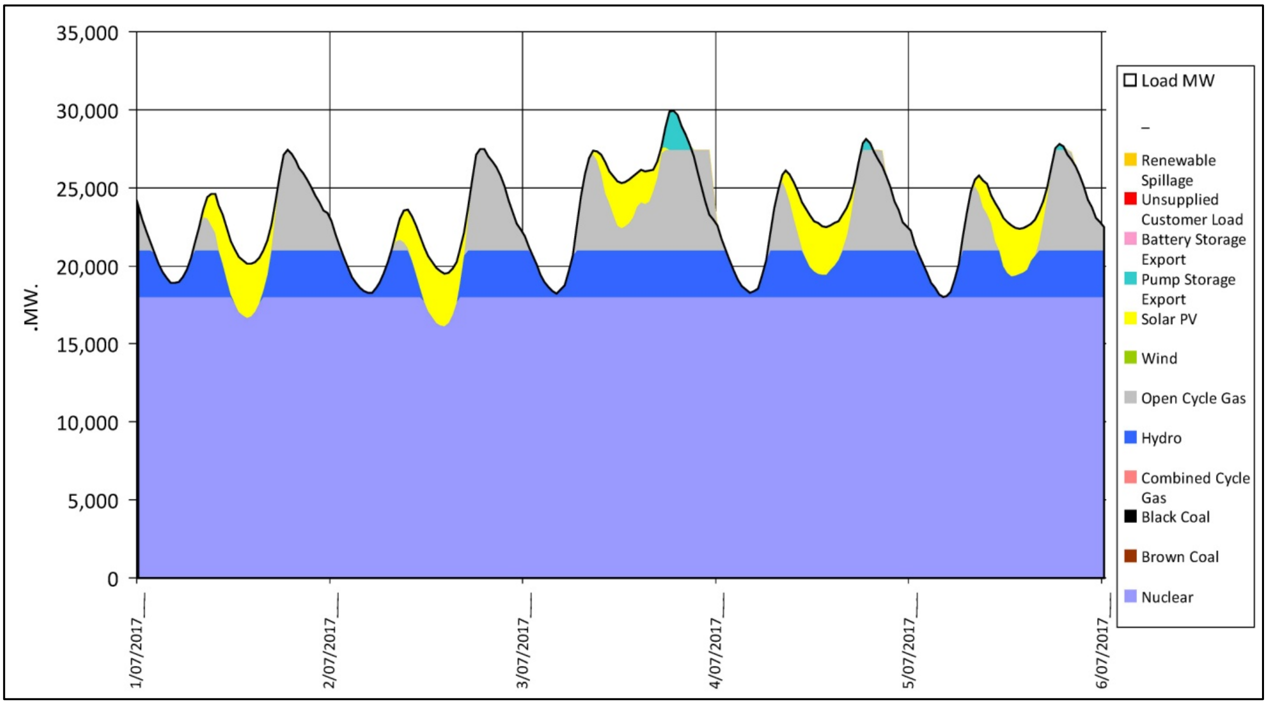
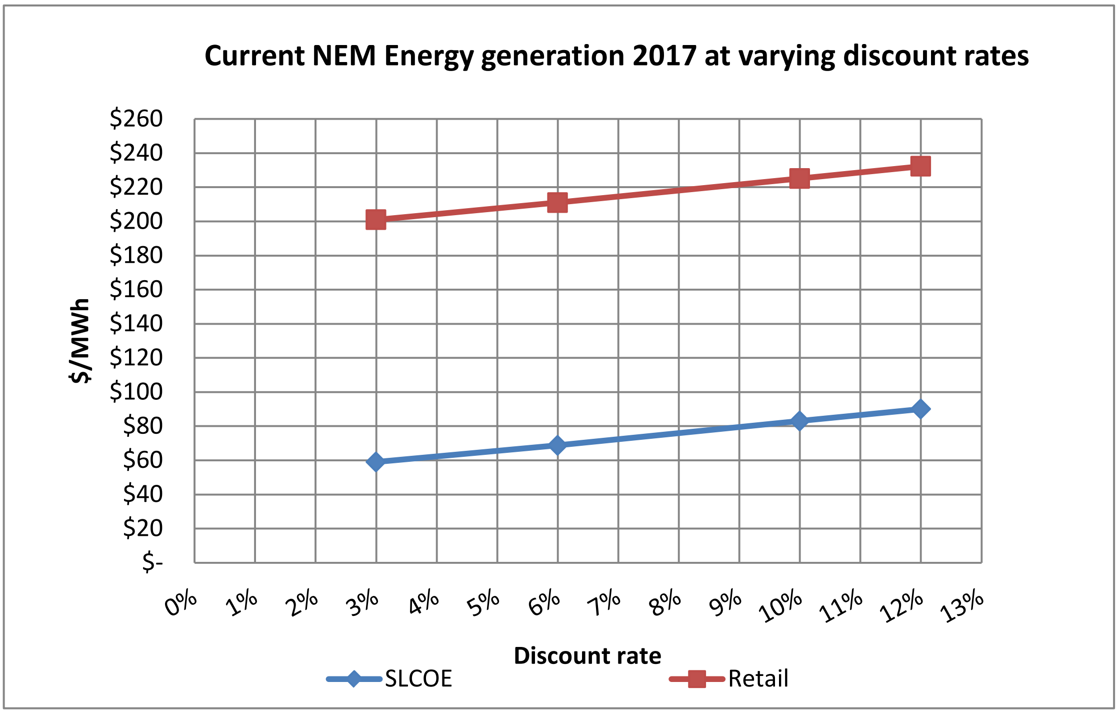


Figure 1 - Seven day snapshot of 82% nuclear power generation scenario meeting NEM Energy

6. The models use generator costs obtained from the AEMO "integrated System Plan" July 2018 and its supporting documents. Costs for existing coal power plants used in the model also use these latest values to replicate the current NEM generating costs.
7. **System Levelised Cost of Electricity** (SLCOE) being the final system cost which incorporates all the types of generation in the mix. The commonly quoted Levelised Cost of Electricity (LCOE) is frequently thought of as being a constant value. It is not. The LCOE varies according to how much time the output of a generator actually contributes to the system and of course, how much of its energy is either curtailed or wasted. The output from the model developed by Dr Robert Barr fully accounts for the varying LCOE of each generator and adds an allowance for additional transmission to produce a final system cost or SLCOE

Scenario 1 - Current NEM

	Carbon Intensity		0.83	Tonnes CO2/MWh	
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$ 55.00	$ 64.69	$ 78.83	$ 86.03
SLCOE	$/MWh	$ 59.01	$ 68.73	$ 83.00	$ 90.06
Domestic Retail	$/MWh	$201.00	$210.98	$225.11	$232.31
Abatement Cost	$/Tonne CO2	NA	NA	NA	NA



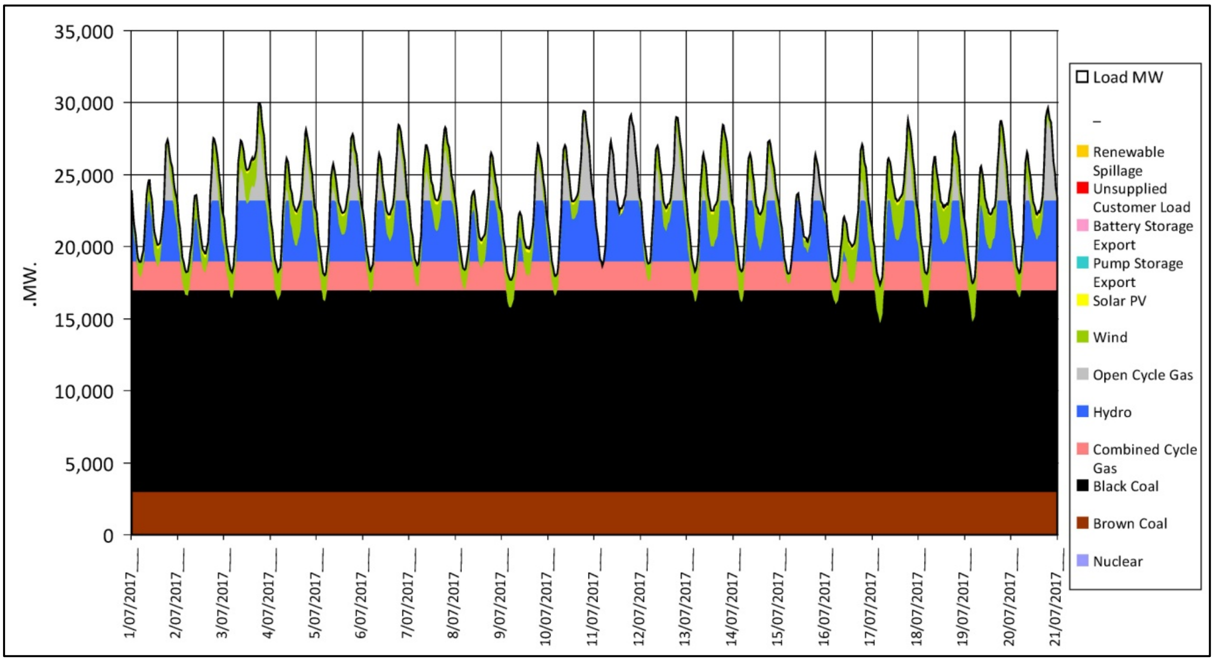


Figure 2 Base NEM Energy mix in 2017

GenTypeDesc	Installed MW	Storage Days
Nuclear	0	
Brown Coal Supercritical	3,000	
Black Coal Supercritical	14,000	
Combined Cycle Gas	2,000	
Hydro	4,200	
Open Cycle Gas	10,500	
Wind	3,500	
Solar PV	323	
Pump Storage	0	2
Battery Storage	100	0.06

Table 1 Generator Mix in Current NEM Energy output

Electric Power Consulting Pty Ltd
Power System Generation Mix Model Output

Scenario: Base as per NEM 10%   Version 1.6   Run Number 525

Generation Type	Installed MW	Net Available MW	Storage Days	% of Load Energy Suppied	Levelised Cost of Energy (LCOE) $/MWh	Contribution to System Levelised Cost of Energy (SLCOE) $/MWh	Carbon Intensity T/MWh	Contribution to System Carbon Intensity T/MWh
Battery Storage	100	100	0.06	0.0%		$0.16		
Solar PV	323	323		0.4%	$133.46	$0.54	0.034	0.00
Wind	3,500	3,500		5.2%	$109.55	$5.65	0.012	0.00
Open Cycle Gas	10,660	10,500		1.7%	$441.43	$7.61	0.606	0.01
Hydro	4,200	4,200		8.0%	$113.17	$9.10	0.024	0.00
Combined Cycle Gas	2,116	2,000		7.0%	$98.91	$6.90	0.415	0.03
Black Coal Supercritical	14,815	14,000		63.9%	$61.49	$39.27	0.9635	0.62
Brown Coal Supercritical	3,175	3,000		13.8%	$69.37	$9.59	1.228	0.17
Total	38,889	37,623 MW					Total.....	0.83

Energy storage decrease 0.0%

Total..... 100.0%

Subtotal Generation..... $78.83 /MWh

Extra Transmission... $4.04 /MWh

System Levelised Cost of Energy $82.86 /MWh

Base Transmission..... $42.25 /MWh

Delivered Cost of Energy for Transmission Customers $125.11 /MWh

Distribution... $100.00 /MWh

Delivered Cost of Energy for small LV Customers $225.11 /MWh

CO2 Emission Abatement Analysis

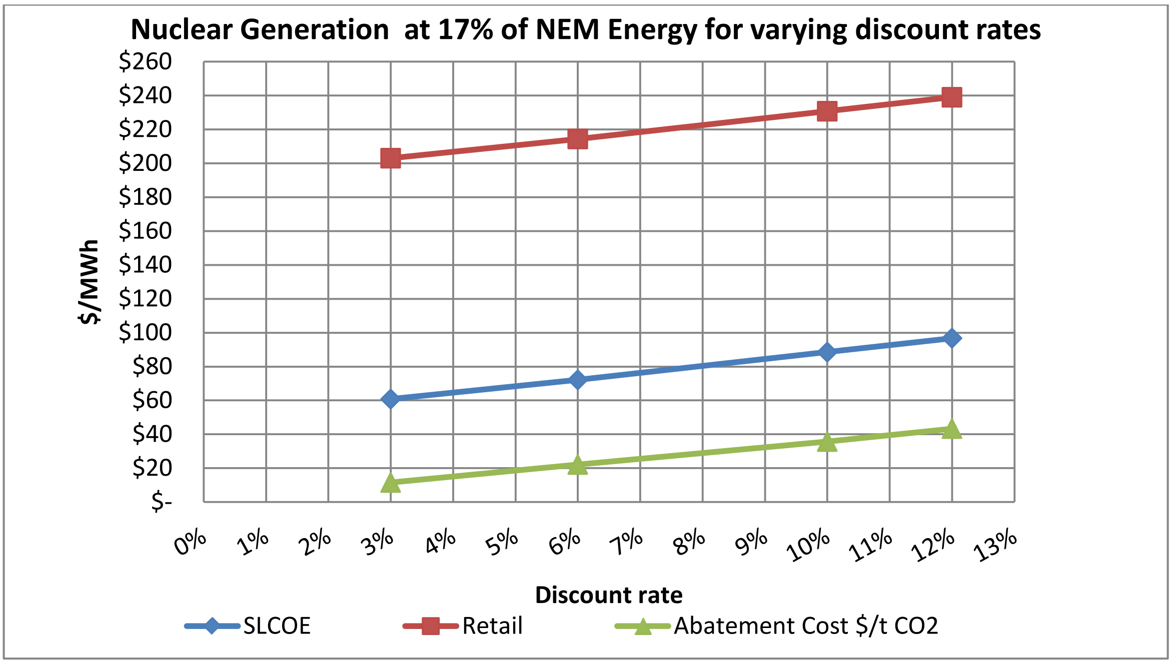
Reference Base level.... $68.73 /MWh 0.83 T/MWh

Cost of Abatement N/A /Tonne

Figure 3 - EPC model output for current NEM Energy mix 2017

SCENARIO 2 - NUCLEAR POWERED ELECTRICITY GENERATION - 17% OF NEM ENERGY

	Carbon Intensity		0.67	Tonnes CO2/MWh	
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$ 57.42	$ 68.78	$ 85.14	$ 93.38
SLCOE	$/MWh	$ 60.80	$ 72.16	$ 88.53	$ 96.77
Domestic Retail	$/MWh	$203.05	$214.40	$230.78	$239.02
Abatement Cost	$/Tonne CO2	$ 11.56	$ 22.18	$ 35.74	$ 43.38



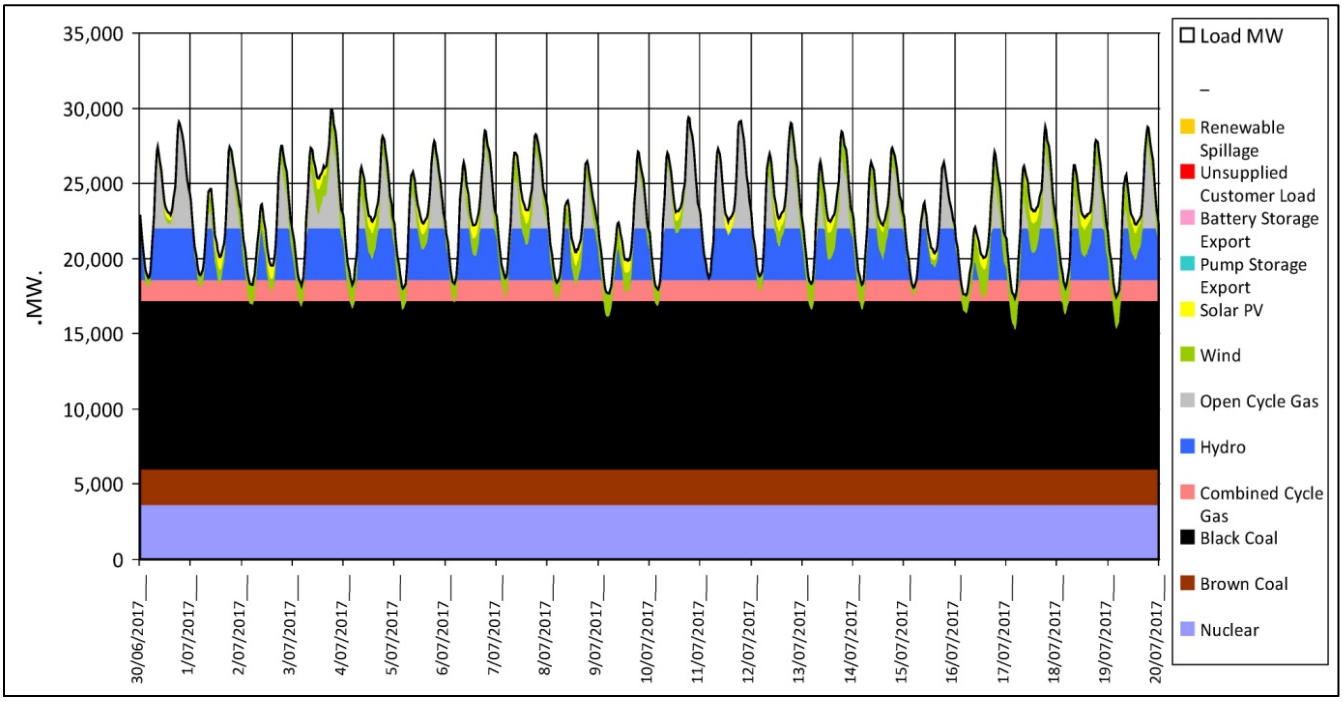


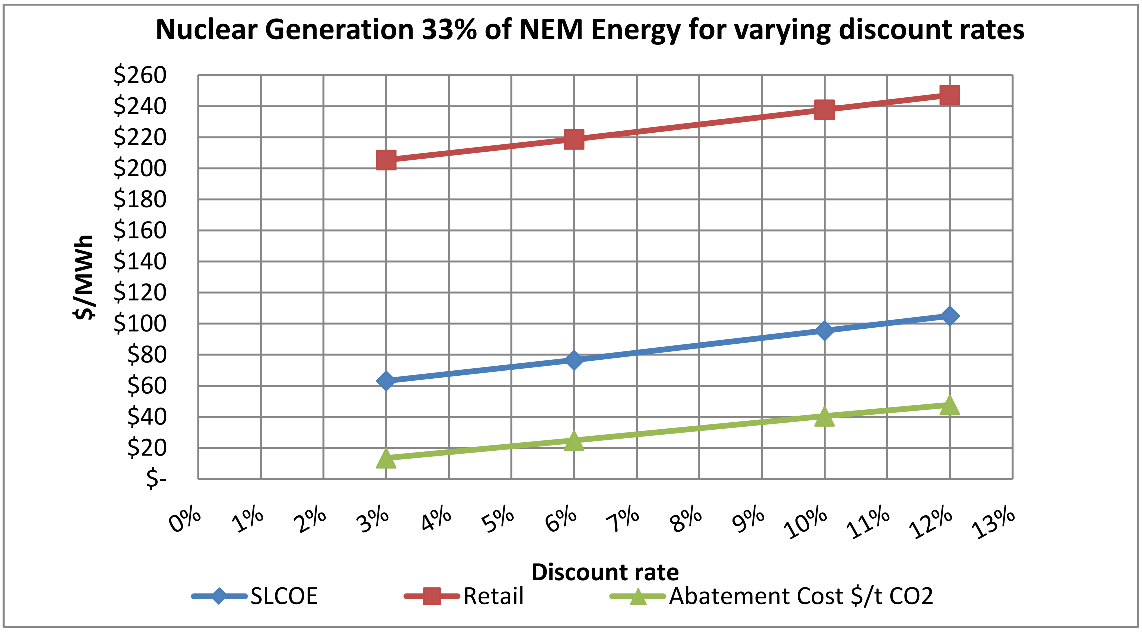
Figure 4 - Nuclear Power Generation 17% of NEM Energy

GenTypeDesc	Installed MW	Storage Days
Nuclear	3,600	
Brown Coal Supercritical	2,400	
Black Coal Supercritical	11,200	
Combined Cycle Gas	1,400	
Hydro	3,400	
Open Cycle Gas	9,690	
Wind	2,800	
Solar PV	1,000	
Pump Storage	1,500	2
Battery Storage	100	0.06

Table 2 Generator Mix for 17% Nuclear Energy on NEM

SCENARIO 3 - NUCLEAR POWERED ELECTRICITY GENERATION - 33% OF NEM ENERGY

	Carbon Intensity		0.51	Tonnes CO2/MWh	
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$ 59.94	$ 73.25	$ 92.28	$101.77
SLCOE	$/MWh	$ 63.25	$ 76.56	$ 95.59	$105.08
Domestic Retail	$/MWh	$205.50	$218.81	$237.84	$247.33
Abatement Cost	$/Tonne CO2	$ 13.47	$ 24.87	$ 40.45	$ 47.75



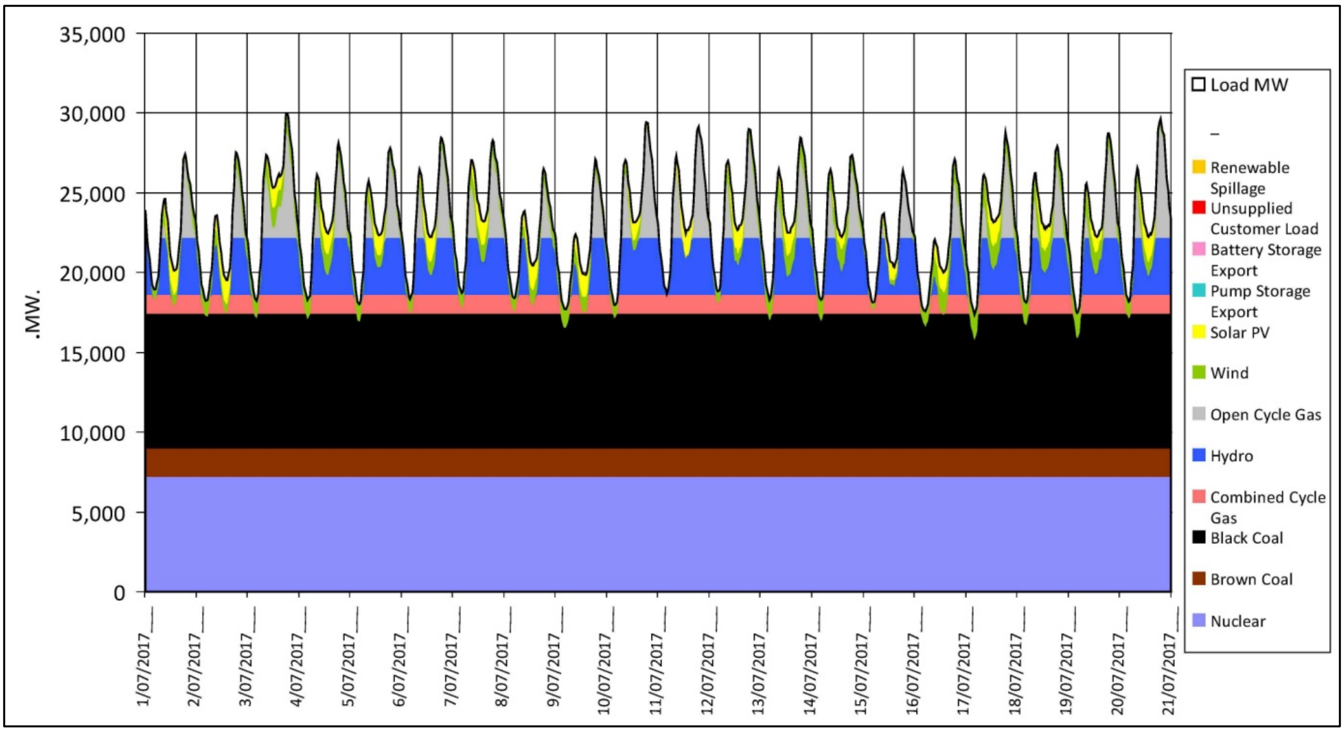


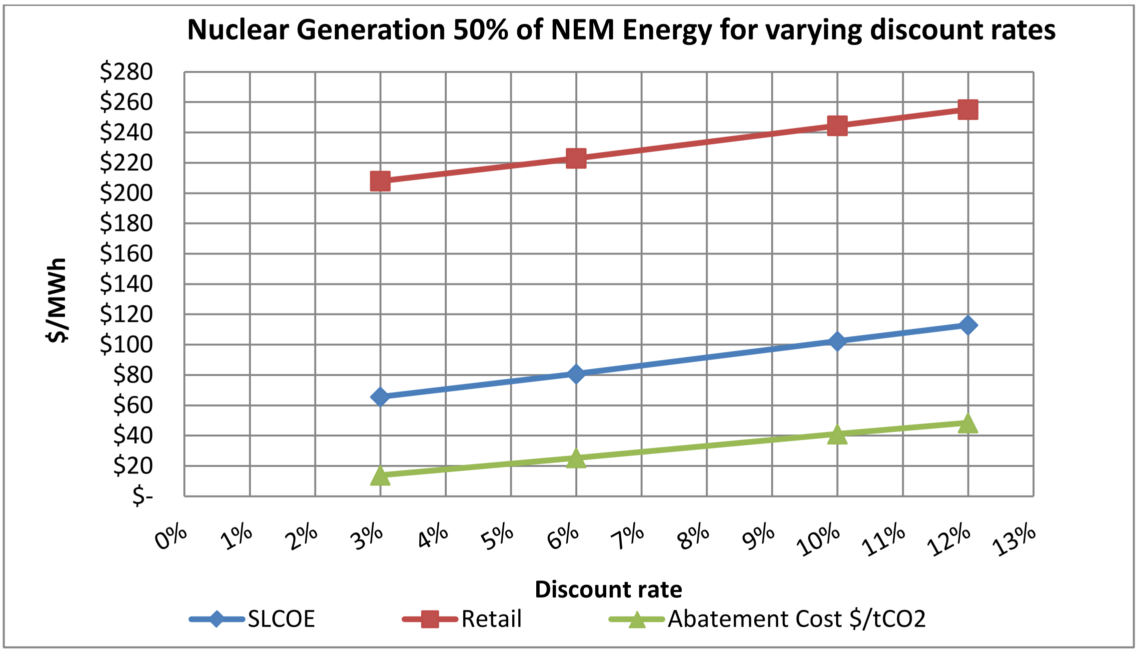
Figure 5 Nuclear Power Generation 33% of NEM Energy

GenTypeDesc	Installed MW	Storage Days
Nuclear	7,200	
Brown Coal Supercritical	1,800	
Black Coal Supercritical	8,400	
Combined Cycle Gas	1,200	
Hydro	3,600	
Open Cycle Gas	8,880	
Wind	2,100	
Solar PV	1,750	
Pump Storage	2,000	2
Battery Storage	100	0.06

Table 3 - Generator Mix for 33% Nuclear Energy on the NEM

SCENARIO 4 - NUCLEAR POWERED ELECTRICITY GENERATION - 50% OF NEM ENERGY

	Carbon Intensity		0.35	Tonnes CO2/MWh	
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$ 62.55	$ 78.00	$ 99.23	$109.91
SLCOE	$/MWh	$ 65.58	$ 80.72	$102.26	$112.93
Domestic Retail	$/MWh	$208.00	$223.00	$244.51	$255.18
Abatement Cost	$/Tonne CO2	$ 13.90	$ 25.39	$ 41.06	$ 48.41



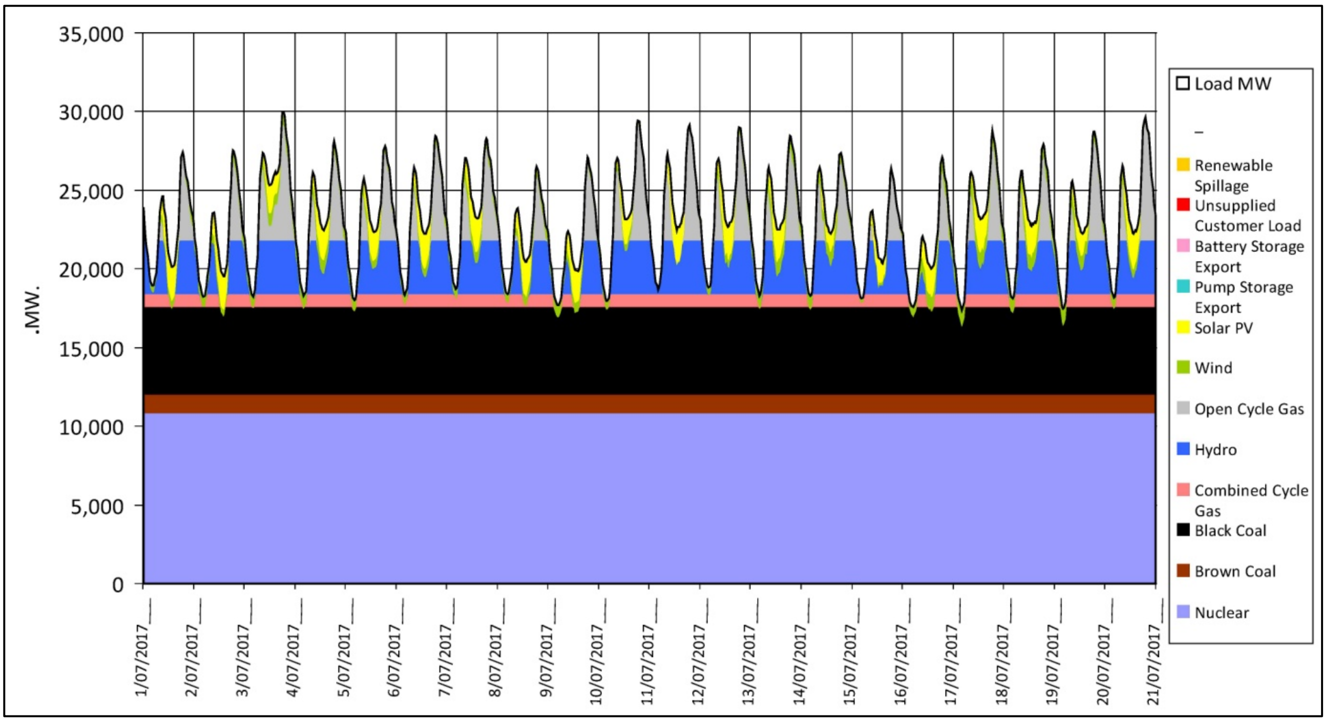


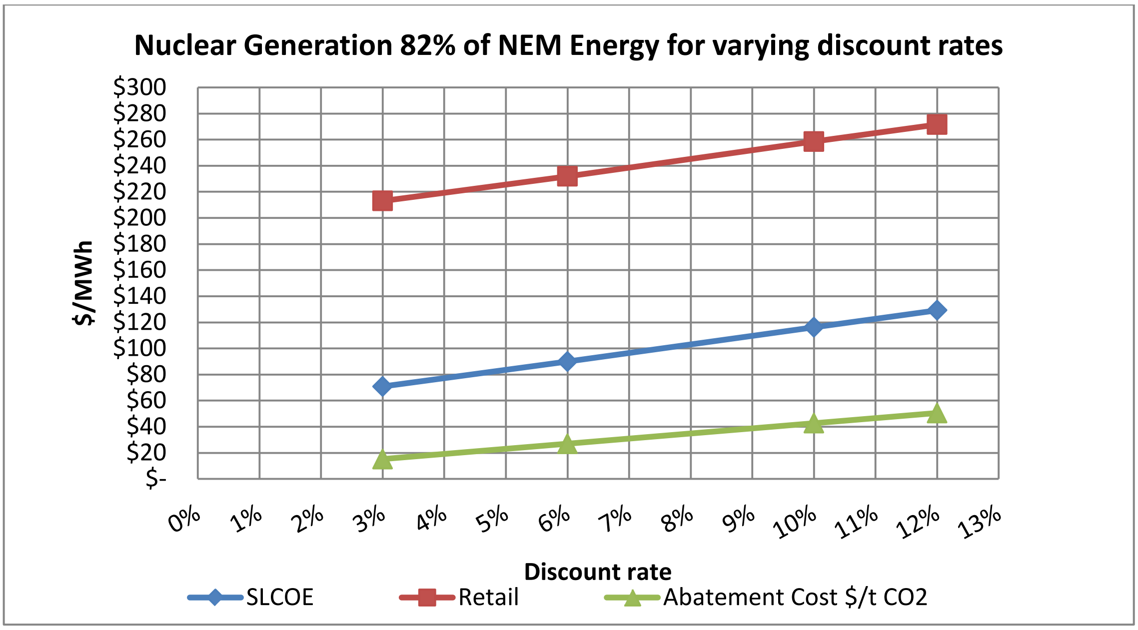
Figure 6 Nuclear Power Generation 50% of NEM Energy

GenTypeDesc	Installed MW	Storage Days
Nuclear	10,800	
Brown Coal Supercritical	1,200	
Black Coal Supercritical	5,600	
Combined Cycle Gas	800	
Hydro	3,400	
Open Cycle Gas	8,000	
Wind	1,400	
Solar PV	2,500	
Pump Storage	3,000	2
Battery Storage	100	0.06

Table 4 - Generator Mix for 50% Nuclear Energy on the NEM

SCENARIO 5 - NUCLEAR POWERED ELECTRICITY GENERATION - 82% OF NEM ENERGY

	Carbon Intensity		0.05	Tonnes CO2/MWh
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$ 68.13	$ 86.97	$113.55	$126.59
SLCOE	$/MWh	$ 70.85	$ 89.96	$116.27	$129.31
Domestic Retail	$/MWh	$213.10	$231.94	$258.52	$271.56
Abatement Cost	$/Tonne CO2	$ 15.22	$ 26.96	$ 42.79	$ 50.49



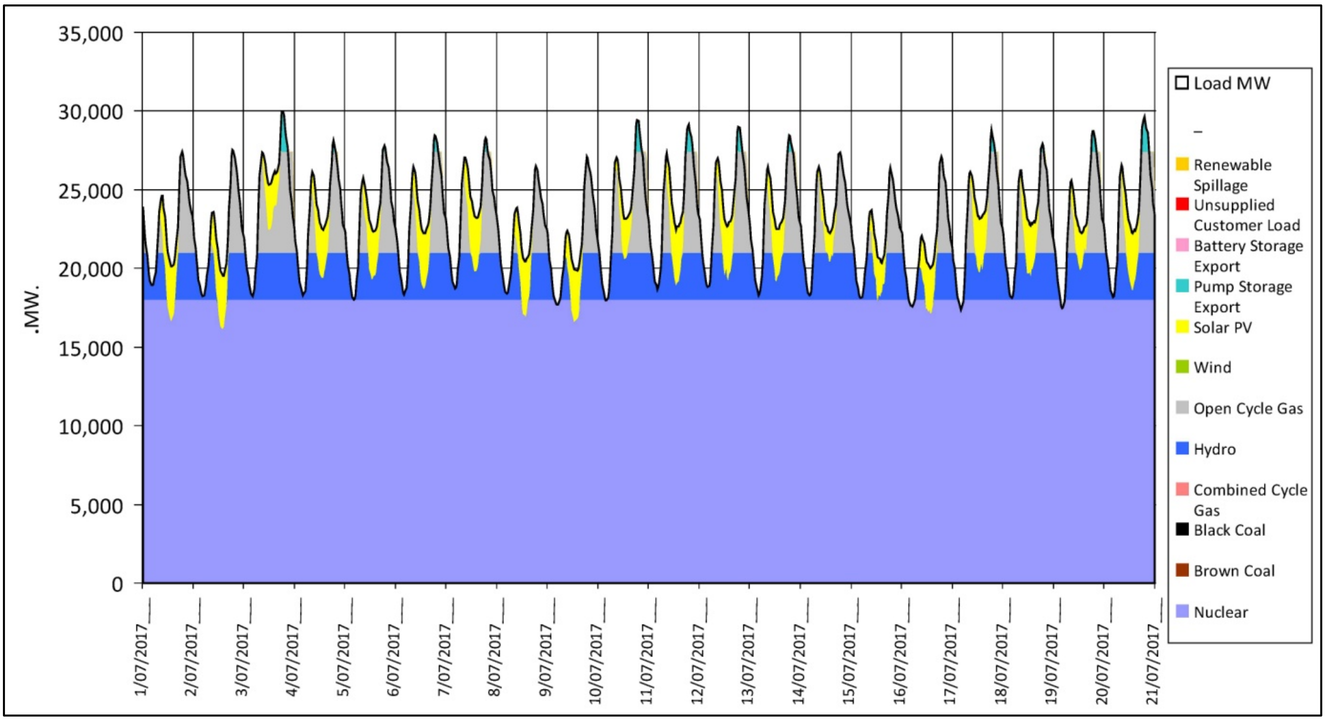


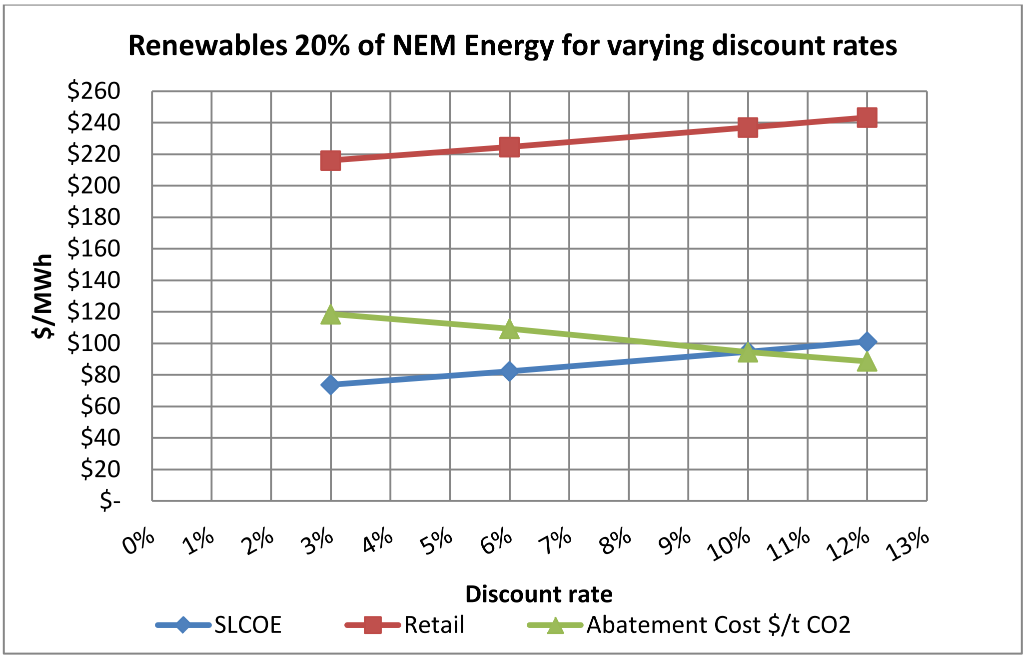
Figure 7 - Nuclear Power Generation 82% of NEM Energy

GenTypeDesc	Installed MW	Storage Days
Nuclear	18,000	
Brown Coal Supercritical	0	
Black Coal Supercritical	0	
Combined Cycle Gas	0	
Hydro	3,000	
Open Cycle Gas	6,450	
Wind		
Solar PV	4,000	
Pump Storage	5,000	2
Battery Storage	100	0.06

Table 5 - Generator mix for 82% Nuclear Energy on the NEM

Scenario 6 - Renewable Electricity Generation - 20% of NEM Energy

Carbon Intensity		0.7	Tonnes CO2/MWh		
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$ 66.37	$ 74.94	$ 87.36	$ 93.70
SLCOE	$/MWh	$ 73.76	$ 82.33	$ 94.75	$101.09
Domestic Retail	$/MWh	$216.01	$224.58	$237.00	$243.34
Abatement Cost	$/Tonne CO2	$118.55	$109.34	$ 94.48	$ 88.67



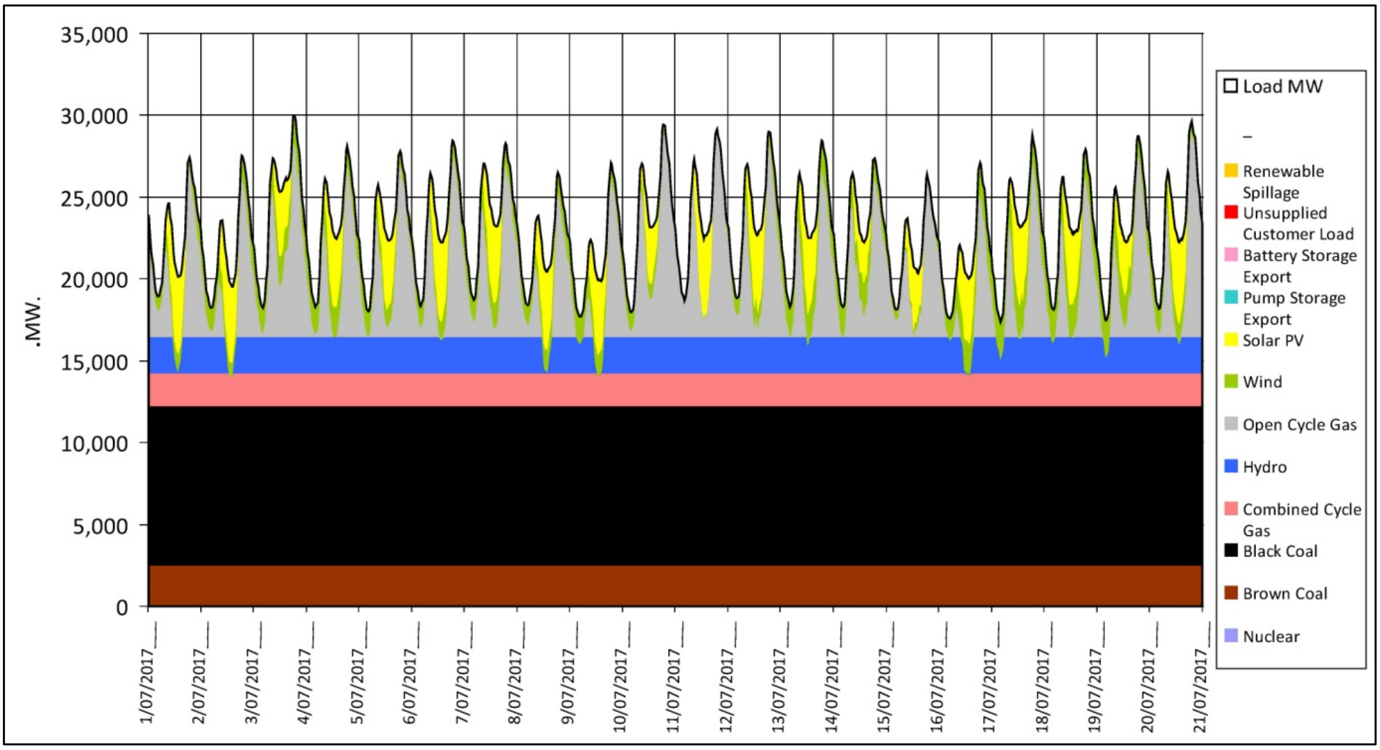


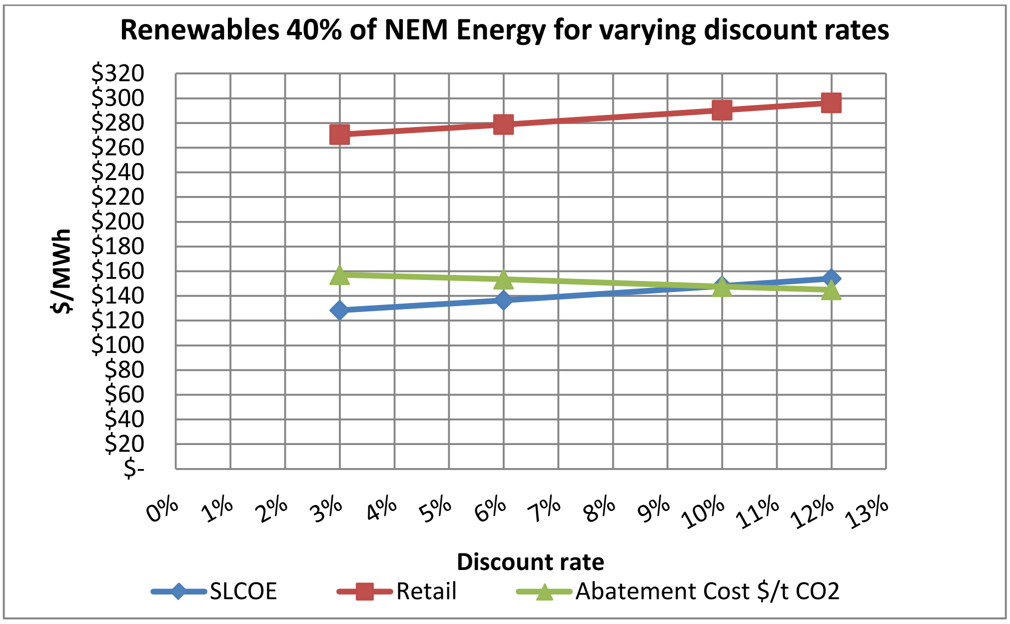
Figure 8 - Renewables generation 20% of NEM Energy

GenTypeDesc	Installed MW	Storage Days
Nuclear	0	
Brown Coal Supercritical	2,500	
Black Coal Supercritical	9,750	
Combined Cycle Gas	2,000	
Hydro	2,200	
Open Cycle Gas	13,800	
Wind	3,000	
Solar PV	5,500	
Pump Storage	1,500	2
Battery Storage	100	0.06

Table 6 - Generator Mix for 20% Renewable Energy on the NEM

SCENARIO 7 - RENEWABLE ELECTRICITY GENERATION - 40% OF NEM ENERGY

Carbon Intensity		0.37	Tonnes CO2/MWh		
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$102.76	$110.89	$122.49	$128.42
SLCOE	$/MWh	$128.36	$136.49	$148.09	$154.02
Domestic Retail	$/MWh	$270.61	$278.74	$290.34	$296.27
Abatement Cost	$/Tonne CO2	$157.15	$153.54	$147.50	$144.93



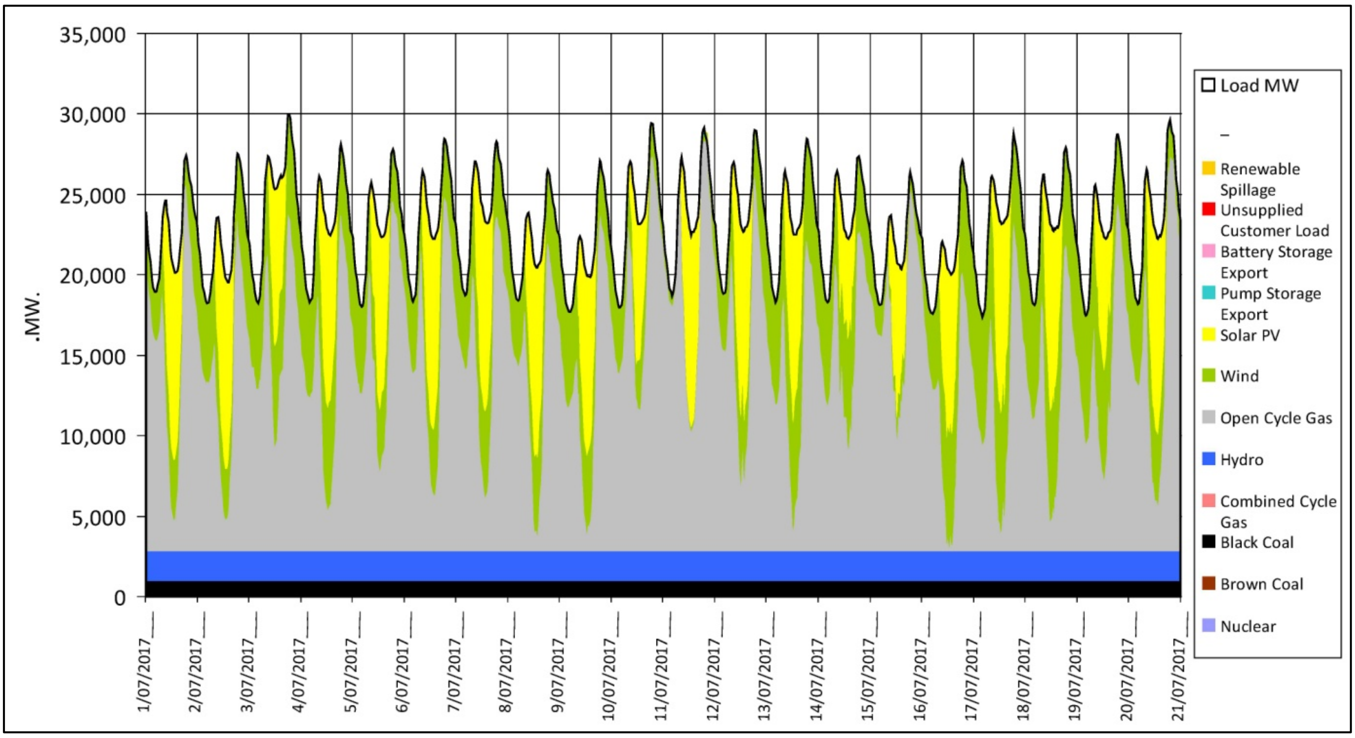


Figure 9 Renewables generation 40% of NEM Energy

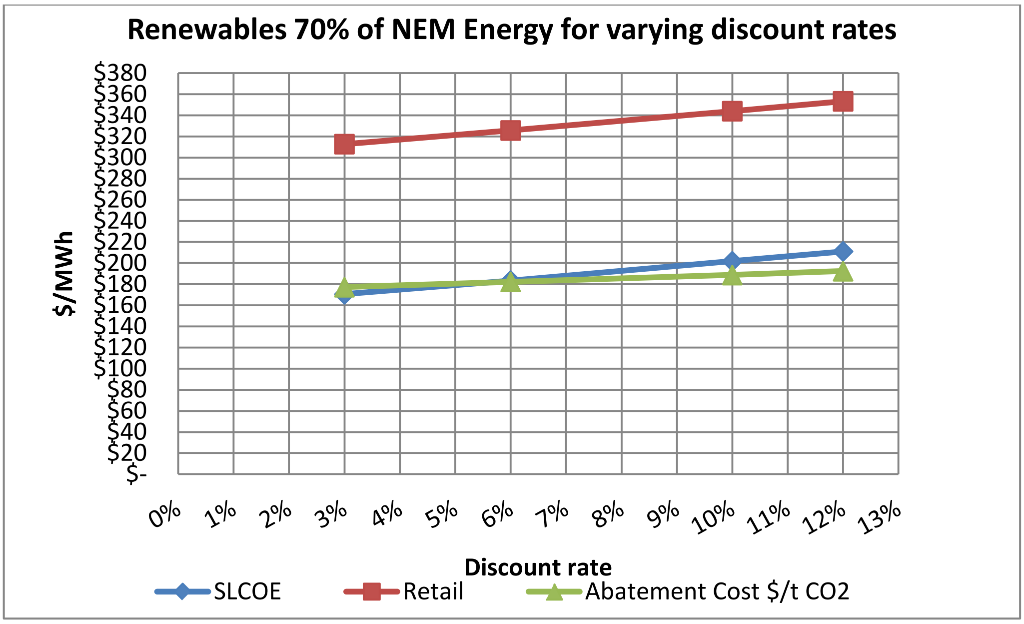
GenTypeDesc	Installed MW	Storage Days
Nuclear	0	
Brown Coal Supercritical	0	
Black Coal Supercritical	1,000	
Combined Cycle Gas	0	
Hydro	1,800	
Open Cycle Gas	25,500	
Wind	10,500	
Solar PV	13,500	
Pump Storage	2,750	2
Battery Storage	100	0.06

Table 7 - Generator Mix for 40% Renewable Energy on the NEM

SCENARIO 8 - RENEWABLE ELECTRICITY GENERATION - 70% OF NEM ENERGY

Carbon Intensity 0.2 Tonnes CO2/MWh

Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$110.71	$123.63	$141.94	$151.29
SLCOE	$/MWh	$170.57	$183.50	$201.81	$211.15
Domestic Retail	$/MWh	$312.82	$325.75	$344.06	$353.40
Abatement Cost	$/Tonne CO2	$177.25	$182.34	$188.76	$192.40



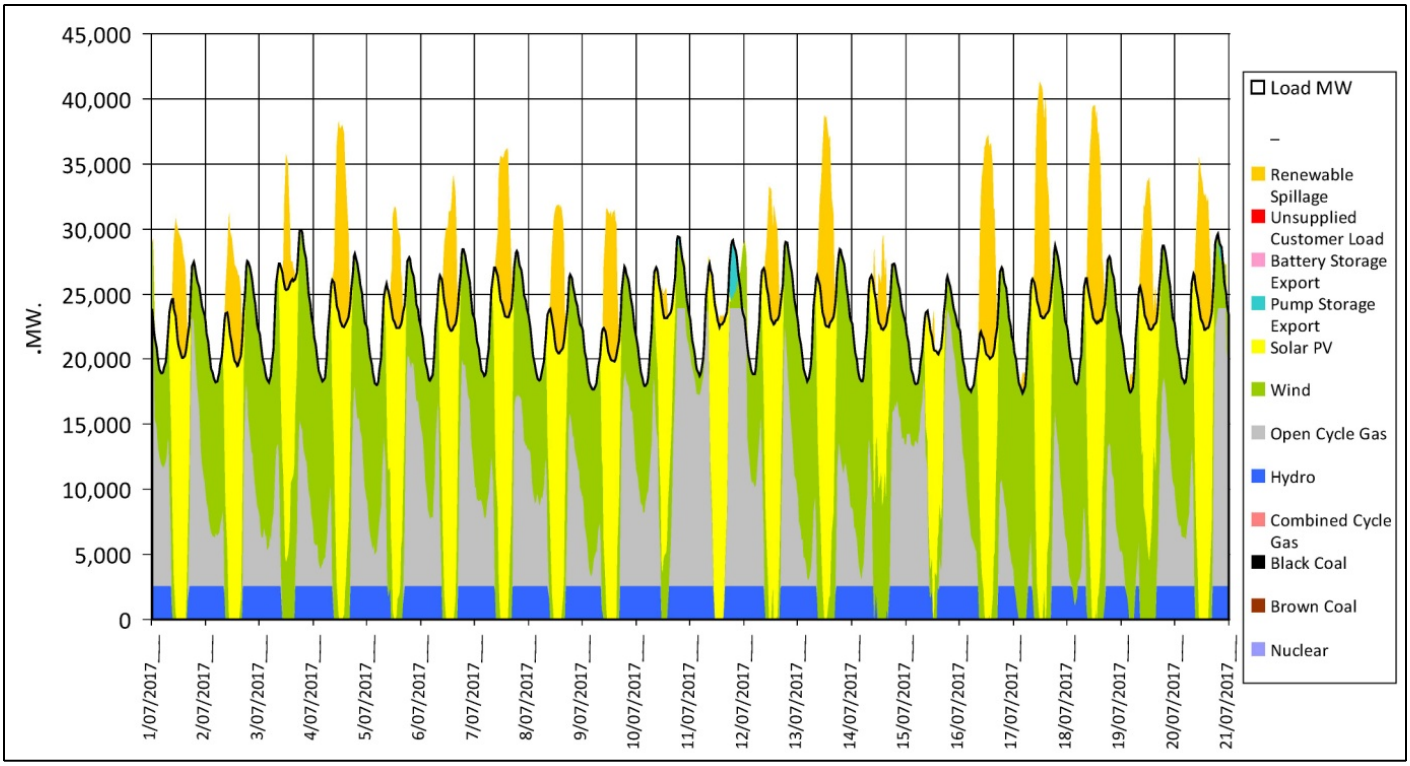


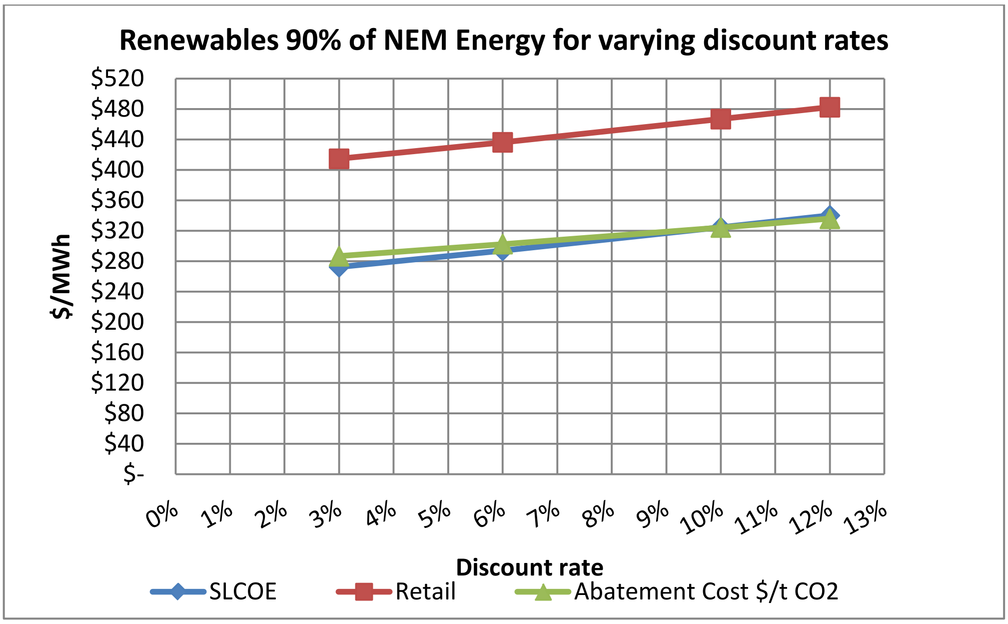
Figure 10 - Renewables Generation 70% of NEM Energy

GenTypeDesc	Installed MW	Storage Days
Nuclear	0	
Brown Coal Supercritical	0	
Black Coal Supercritical	0	
Combined Cycle Gas	0	
Hydro	2,600	
Open Cycle Gas	21,300	
Wind	25,000	
Solar PV	29,000	
Pump Storage	5,000	2
Battery Storage	100	0.06

Table 8 - Generator Mix for 70% Renewable Energy on the NEM

SCENARIO 9 - RENEWABLE ELECTRICITY GENERATION - 90% OF NEM ENERGY

Carbon Intensity		0.08	Tonnes CO2/MWh		
Parameter	Discount	3.00%	6%	10%	12.00%
Generation	$/MWh	$151.19	$172.81	$203.33	$218.92
SLCOE	$/MWh	$272.44	$294.06	$324.58	$340.18
Domestic Retail	$/MWh	$414.69	$436.31	$466.83	$482.43
Abatement Cost	$/Tonne CO2	$286.60	$302.58	$324.40	$335.86



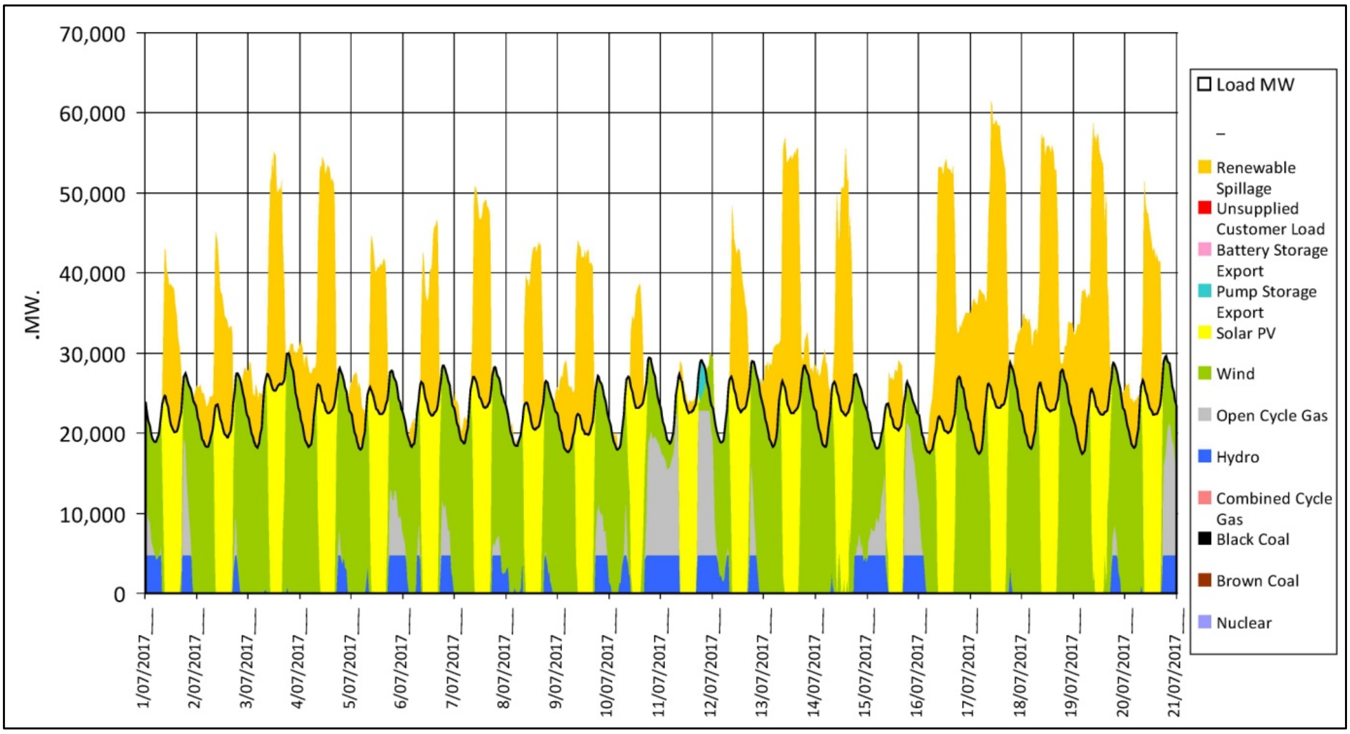


Figure 11 Renewables Generation 90% of NEM Energy

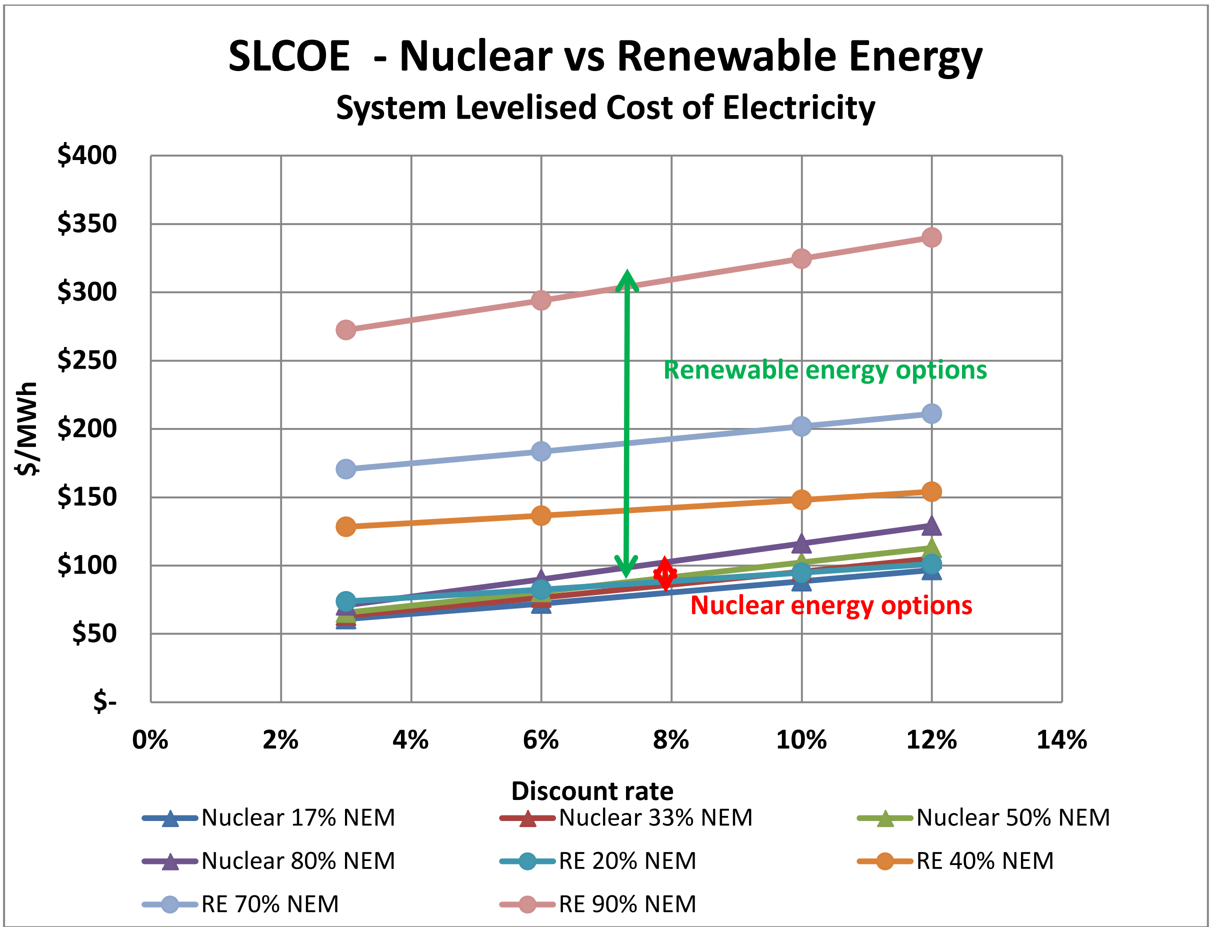
GenTypeDesc	Installed MW	Storage Days
Nuclear	0	
Brown Coal Supercritical	0	
Black Coal Supercritical	0	
Combined Cycle Gas	0	
Hydro	4,800	
Open Cycle Gas	18,000	
Wind	50,000	
Solar PV	55,000	
Pump Storage	5,000	2
Battery Storage	100	0.06

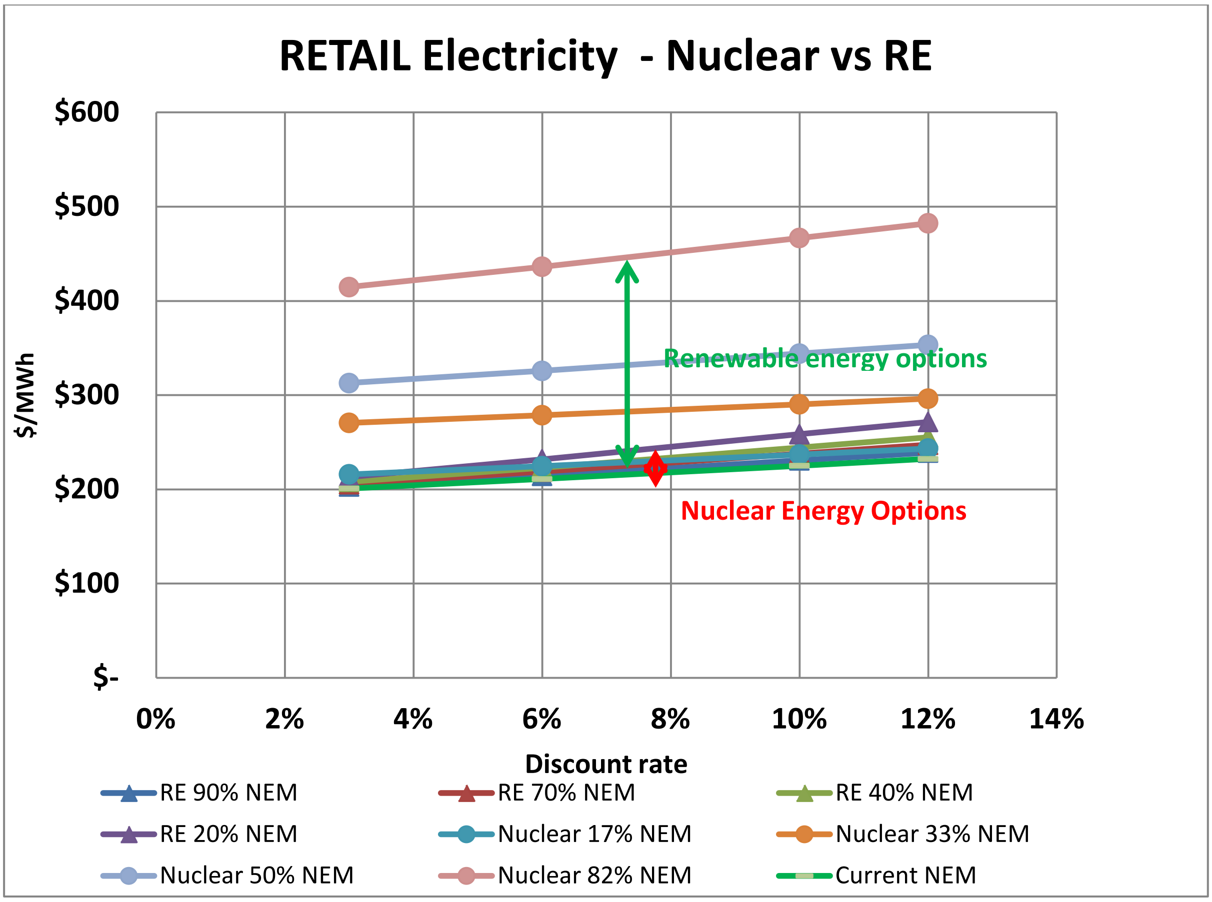
Table 9 - Generator Mix for 90% Renewable Energy on the NEM

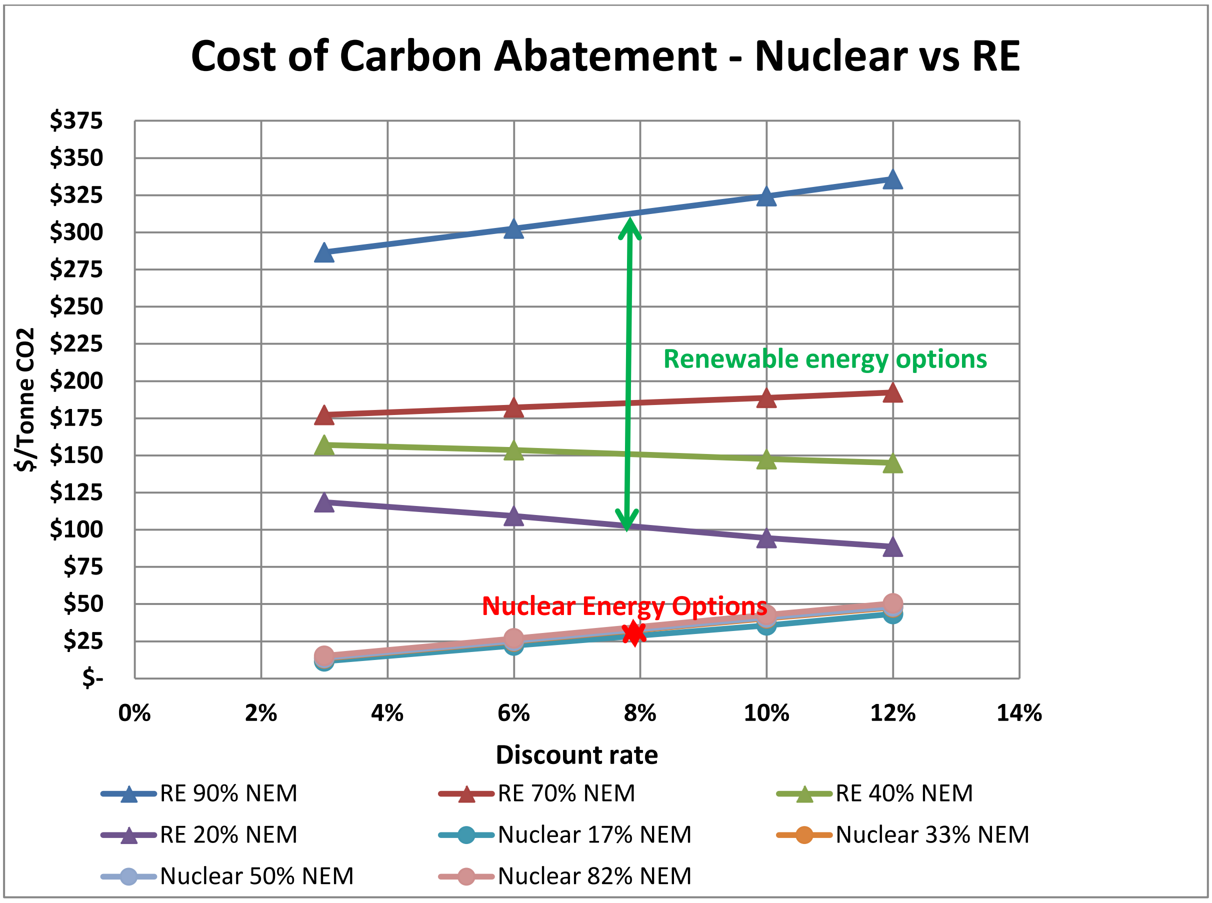
The Vital Statistics of Nuclear Generation vs. Renewables Generation on the NEM

The following three graphs show the comparison of:

1. **System Levelised Cost of Electricity** (SLCOE) being the final system cost which incorporates all the types of generation in the mix. The commonly quoted Levelised Cost of Electricity (LCOE) is frequently thought of as being a constant value. It is not. The LCOE varies according to how much time the output of a generator actually contributes to the system and of course, how much of its energy is either curtailed or wasted. The output from the model developed by Dr Robert Barr fully accounts for the varying LCOE of each generator and adds an allowance for additional transmission to produce a final system cost or SLCOE
2. **Retail Electricity**. This graph compares the final cost of the power at the wall for domestic and commercial customers on the NEM. A separate data base exist for Energy for large scale transmission customers such a aluminium smelters however in the interests of brevity this has not been included in this submission but is available for discussion.
3. **Carbon Abatement**. The three aims of our energy renewal are to achieve low cost, reliability and low carbon emissions. The final graph shows the vastly lower cost of carbon abatement (reduction) in terms of A$/tonne of carbon dioxide obtainable from nuclear energy compared to renewables. This performance is verified each day in France and Sweden.




RETAIL Electricity - Nuclear vs RE
$/MWh
$600
$500
$400
$300
$200
$100
$-
0%
2%
4%
6%
8%
10%
12%
14%
Discount rate
Renewable energy options
Nuclear Energy Options
RE 90% NEM
RE 70% NEM
RE 40% NEM
RE 20% NEM
Nuclear 17% NEM
Nuclear 33% NEM
Nuclear 50% NEM
Nuclear 82% NEM
Current NEM


Cost of Carbon Abatement - Nuclear vs RE
$/Tonne CO2
$375
$350
$325
$300
$275
$250
$225
$200
$175
$150
$125
$100
$75
$50
$25
$-
0%
2%
4%
6%
8%
10%
12%
14%
Discount rate
Renewable energy options
Nuclear Energy Options
RE 90% NEM
RE 70% NEM
RE 40% NEM
RE 20% NEM
Nuclear 17% NEM
Nuclear 33% NEM
Nuclear 50% NEM
Nuclear 82% NEM