Confidential Final Report to

Australian Geothermal Association

Preliminary Assessment of the Value of a new 275 kV Transmission line to connect Geothermal Resources to the NEM in South Australia

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Purpose of Report

- The purpose of this report is to investigate the potential economic benefits of accelerating the development of geothermal power delivery into the NEM through the early development of transmission lines from northern SA (the Cooper Basin, via the Arrowie Basin) into the NEM.
- The report is an independent study by MMA for AGEA undertaken with the cooperation of Geodynamics and Petratherm. The analysis considers the early development of 275 kV transmission lines from the Cooper Basin (Geodynamics project site), via the Arrowie Basin (Petratherm project site) to the NEM at Olympic Dam
- Specifically this report compares the economic benefits that arise from bringing forward transmission investment and a business-as –usual case under the proposed CPRS and RET scheme. The economic benefits are directly compared using the carbon pricing derived through the recent Treasury modelling of the CPRS.

Key Findings

- The primary finding of this report is that there would be significant benefits to the customers in both South Australia ($860m) and the NEM ($2,800m) as a whole (including South Australia) as a result of reduced power prices across all periods. These benefits arise from placing substantial downward pressure on electricity and REC prices in SA and across the NEM – displacing higher cost and intermittent forms of renewable generation such as wind.
- These customer (NEM - wide) benefits increase in the early phase, reaching a maximum of $1,400 million pa before the gains are eroded over time as prices scale back to equilibrium with new entry costs. The NPV over the analysis period of these benefits is $2,800 million on a NEM wide basis.
- The customer benefits in SA are also very significant and more resilient, reaching a maximum of $310m pa with an NPV over the analysis period of $860m.
- The customer (NEM – wide) benefits as calculated in this report are very large and would clearly justify, under existing NEM rules, the early development of transmission lines as regulated assets.

Approach to Modelling and Assessment of Benefits

- Detailed assumptions have been provided by Geodynamics and Petratherm Limited in a cooperative study with AGEA. For consistency, MMA has applied the same approach to modelling as in their recent report to Federal Department of Treasury on the CPRS and their report to AGEA on the long term costs of geothermal power generation.

- The benefits were determined by looking at an early development case and comparing it against a business as usual case with transmission development occurring but at a later date in the next decade and with geothermal development capacity constrained resulting in higher LRMC of geothermal generation through absence of economies of scale.
- Geothermal generator benefits were calculated by taking net revenue (revenue less operating costs less transmission costs to Olympic Dam) and comparing to the business as usual case.
- Customer benefits were calculated by comparing the difference in modelled pool price outcomes between the cases and applying those differences to the annual load volume to give total benefit. The changes in transmission costs between Davenport and Olympic Dam were included in the customer benefits.

Connections and scenarios

The particular focus of the study is the potential for connecting a 275 kV double circuit line from Innamincka near Moomba via Olympic Dam to Davenport near Port Augusta. The major concern of renewable energy generators exploring and developing potential projects in remote areas is that the main transmission system may not be extended in a timely manner to allow the projects to be funded and operate as planned. This matter of concern has been confirmed by the AEMC in its recent First Interim Report on Energy Market Frameworks in response to the challenges of the Carbon Pollution Reduction Scheme (CPRS) and the Expanded Renewable Energy target (ERET).

This report concerns itself with one particular example which is both an example of the potential problem and of particular concern to Petratherm and Geodynamics.

The concept that was evaluated was to examine building a double circuit 275 kV line from Innamincka to Paralana to Olympic Dam and reinforcing the system between Olympic Dam and Davenport as needed to support the forecast load and generation. A third single 275 kV circuit from Paralana to Olympic Dam was added when the required power transfer exceeded 400 MW to Olympic Dam.

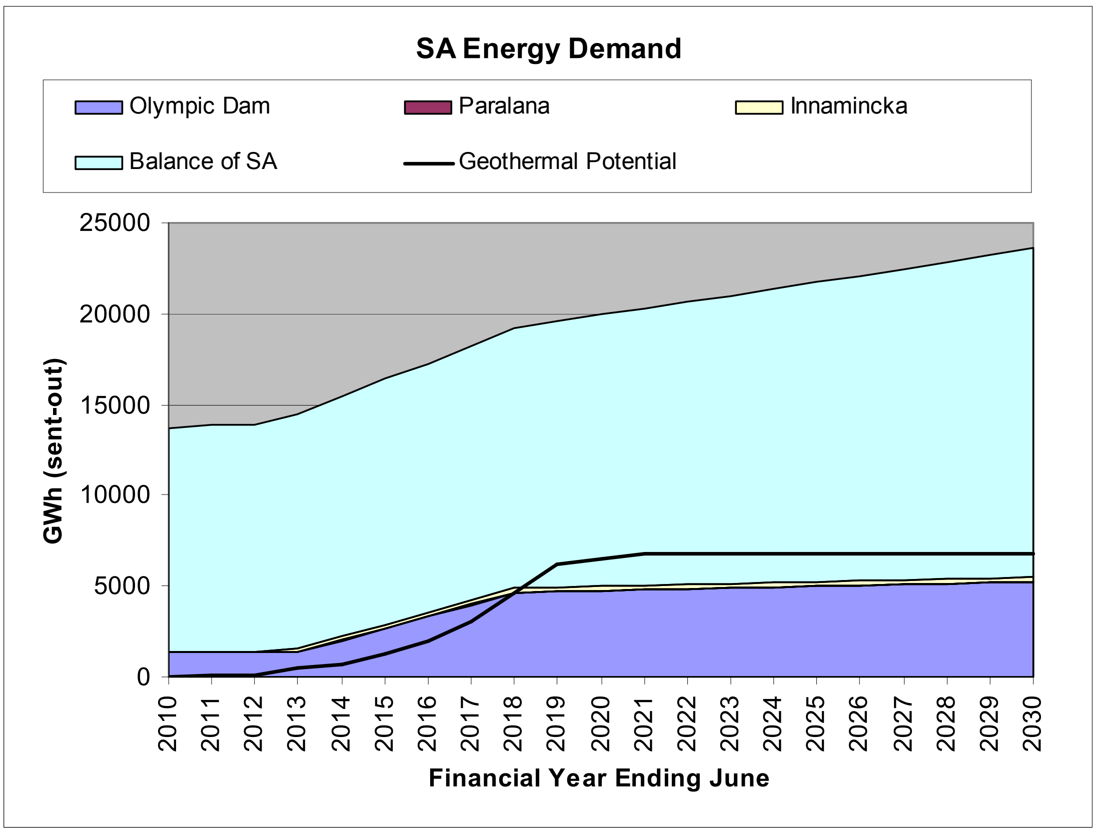
Three scenarios were analysed:

- A *Business as Usual* scenario where transmission connections are delayed and limited to a single circuit connection by 2017/18. In such a case, geothermal development to 2020 is limited to 235.5 MW at Innamincka and Paralana
- An *Early Transmission* scenario where a double circuit 275 kV line is built from Olympic Dam to Innamincka via Paralana from 2013/14 to connect up to 816 MW by 2020. Innamincka is connected by 2014/15. A third circuit from Olympic Dam to Paralana is added in 2017/18.
- A *Delayed Generation* scenario where the double circuit line is built but only 402 MW is developed by 2020. The third Olympic Dam to Paralana circuit does not proceed.

In the overall analysis, the *Delayed Generation* scenario was intended to represent the risk of the network development not achieving its full potential. It was assumed that if the double circuit line is committed, the geothermal generation reaches its 816 MW potential with an 80% probability for the purposes of weighting benefits.

The assumed demand profile was based on the 2008 demand forecast plus expansion at Olympic Dam as illustrated in Exec Figure 1. The potential geothermal generation exceeds the projected local loads at Innamincka, Paralana and Olympic Dam by 2018/19.

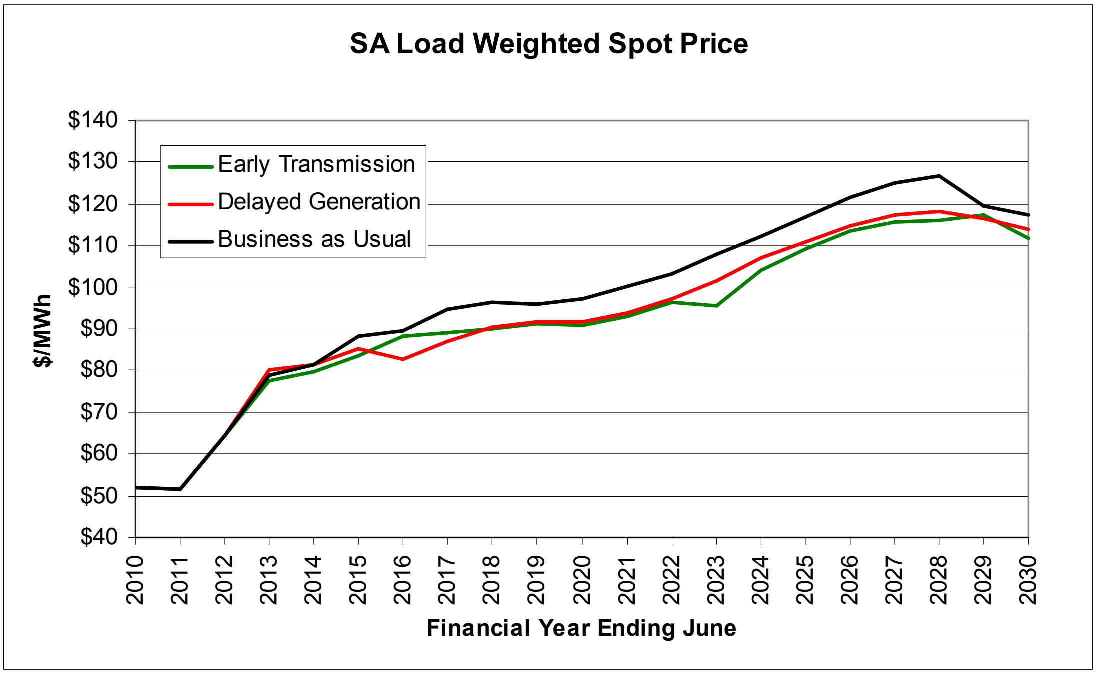
Exec Figure 1 Assumed South Australian Demand



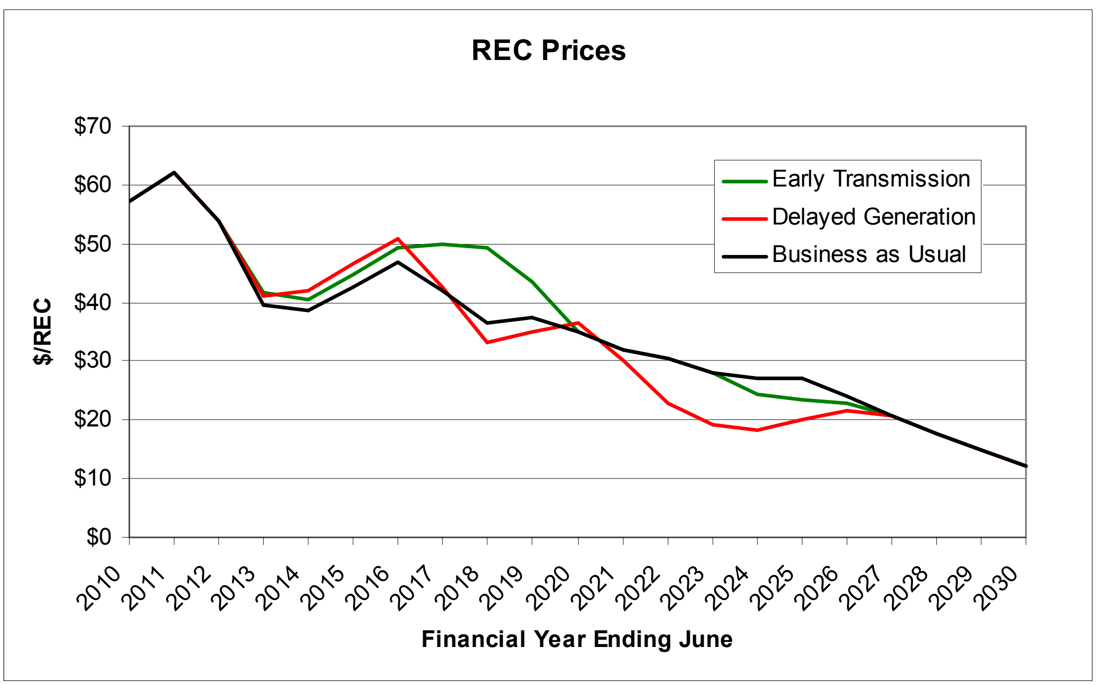
The overall effect of the proposed development is to reduce South Australian energy prices slightly as illustrated in Exec Figure 2 with some secondary effects on the Renewable Energy Certificate (REC) price as shown in Exec Figure 3. There are conflicting effects of the scenario conditions on the REC price in that the additional geothermal energy quantity would displace higher cost renewable energy and reduce REC price whereas the lower energy prices in the southern regions of the NEM would cause REC price to rise. There is also a third effect in that higher renewable energy in South Australia means less renewable energy elsewhere and slightly higher energy prices in other NEM regions. These higher energy prices elsewhere can compensate the effect on REC price of the lower price in SA.

When these factors are combined, we have found that South Australian geothermal generators would be expected to benefit from the proposed early transmission development if they can achieve the targeted levels of output. The net benefit to the geothermal generators after having paid for the transmission service to Olympic Dam is

Exec Figure 2 South Australia Load Weighted Energy Price

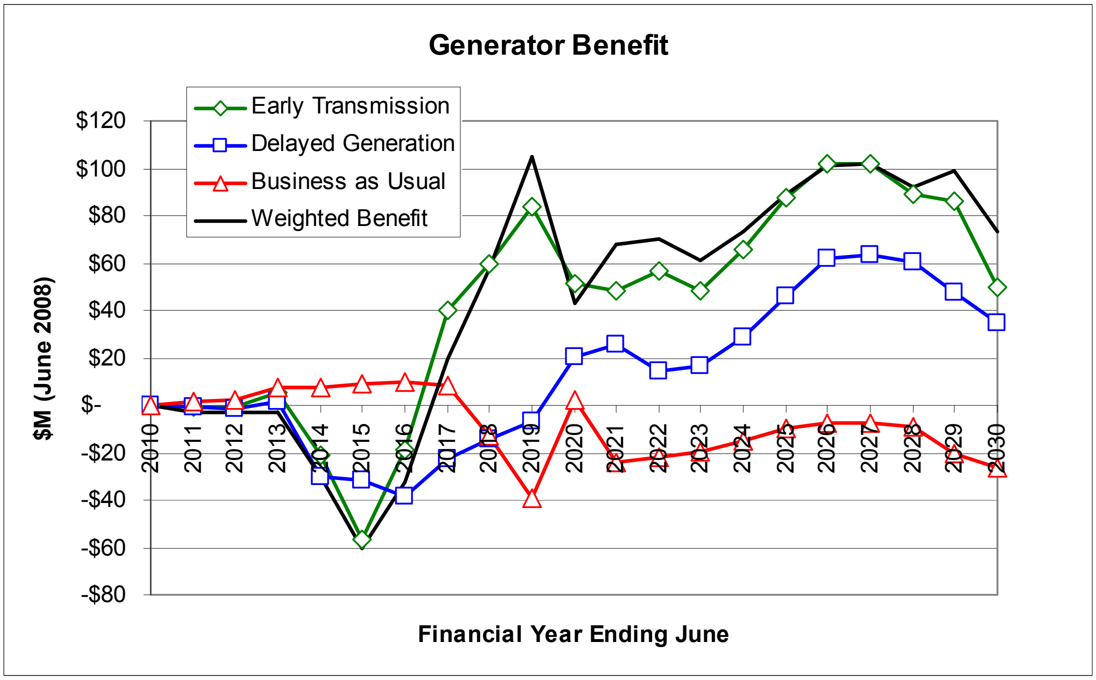


Exec Figure 3 REC Prices



shown in Exec Figure 4. After a few years when transmission costs outweigh generation benefits, the geothermal generators would benefit from the extension, even if they did not reach their full output potential as indicated by the Delayed Generation scenario.

Exec Figure 4 Benefit for Geothermal generators



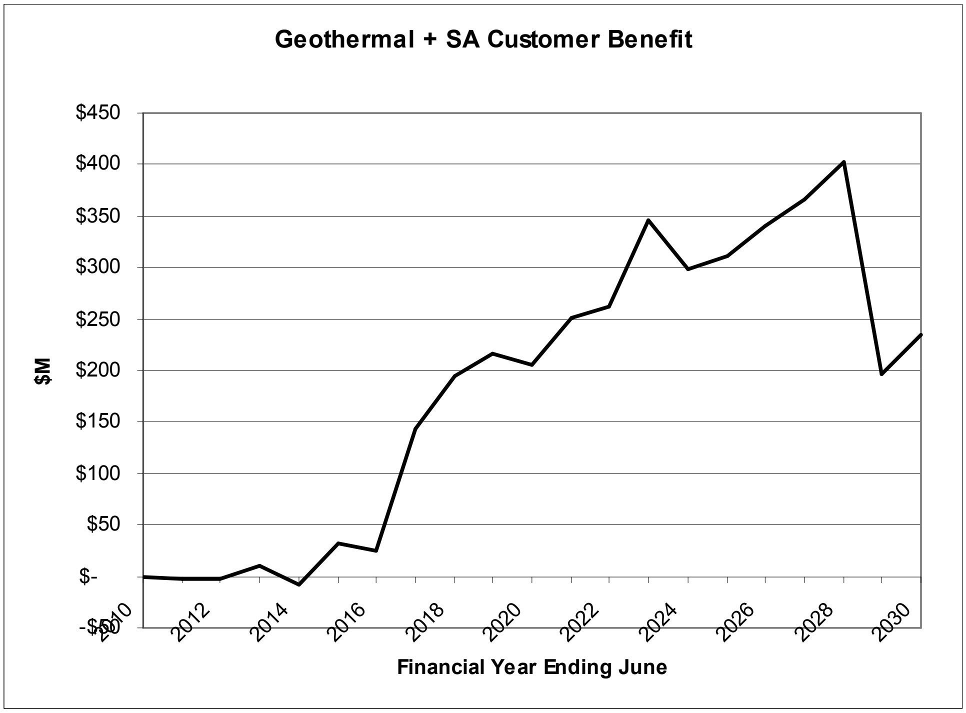
However the chart clearly shows that there is a potential barrier to entry due to the mismatch between costs and revenues in the early commercialisation phase.

However, the aggregate benefits to South Australian customers and geothermal generators as shown in Exec Figure 5 are substantial and enduring over the study period. Early benefits arise from lower REC prices, then subsequently from lower energy prices in the middle period with the long term benefits flowing to the geothermal generators from the profits on the geothermal generation itself plus $200 M per annum to SA customers through lower energy and slightly lower REC prices.

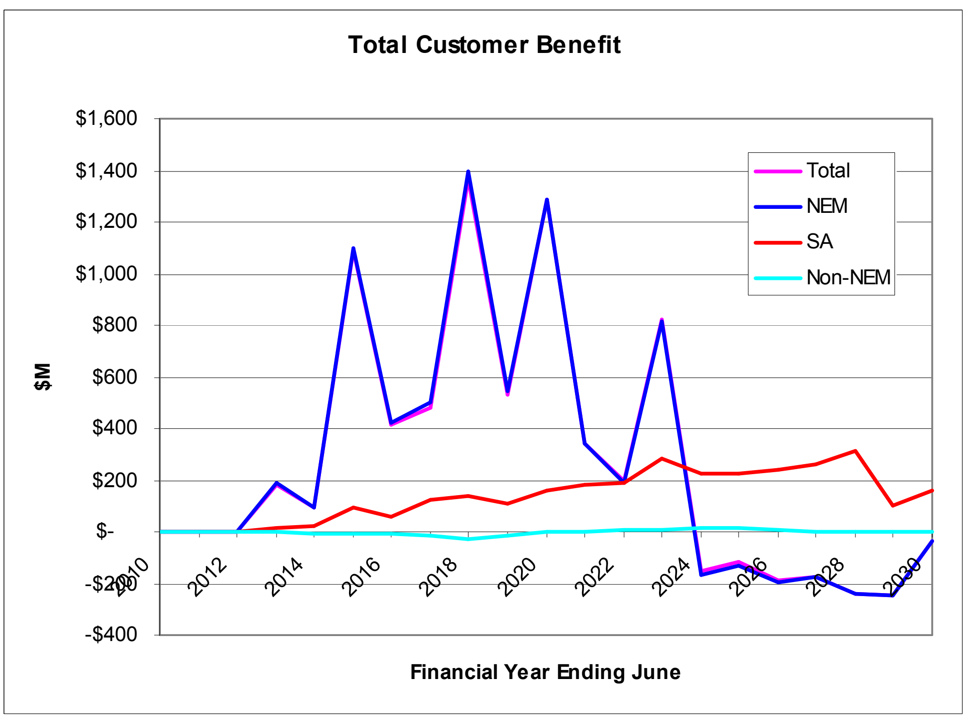
The overall benefits to the customers in SA, the NEM and non-NEM regions are shown in Exec Figure 6. There are some substantial benefits throughout the NEM in the early phase and these are progressively eroded. The benefits to the South Australian customers are more enduring due to the lower rate of growth and the benefit of the substantially increasing volume of geothermal generation which tends to hold back imports and bring the South Australian price down and closer to the Victorian price. The benefits to Non-NEM customers derived from the change in REC Price are quite small.

The analysis has shown that a double circuit 275 kV transmission line from Olympic Dam to Innamincka in association with full development of Olympic Dam would provide net economic benefits of some $1,068 M in present value terms in South Australia for South

Exec Figure 5 Benefit to South Australian Customers plus Geothermal Generators



Exec Figure 6 Total Customer Benefit (80% probability of achieving ET)



Australian customers and the geothermal industry. The net benefits to NEM customers was assessed as $2,802 M in present value terms at 9.3% real discount rate.

The net present value economic benefits over the whole NEM to all generators and customers is much smaller at $68 M due to the detriment to forms of generation other than geothermal power. However, there is a compelling case for South Australian market participants to ensure that such strategic investments that open up the renewable energy resources of the State are pursued in an effective and economic manner. The studies indicate that there is scope to optimise the timing and staging of the geothermal development to maximise overall market benefits and thereby improve the assessed value of $68 M.

A summary of the benefit components is shown in Exec Table 1. The Table includes either cost or revenue items for each scenario depending on the benefit component being assessed:

- The revenue and net benefit for the geothermal generators at Paralana and Innamincka are based on contracted revenue and REC price changes for each scenario;
- The total customer impact for South Australia, the NEM and all Australian customers are based on changes in wholesale load weighted prices and wholesale sent-out generated volumes. Note that secondary impacts due to changes in transmission marginal loss factors within regions were not assessed;
- The total customer impact for non-NEM customers was based on the change in REC price times sales volumes;
- The total system economic benefit was based on generation and fuel costs and capital costs for new facilities.
- The SA Benefit as shown includes only the SA customers and the geothermal generators. It does not include impacts on thermal generators in South Australia which would be unfavourable.

Exec Table 1 Summary of Present Value Analysis (9.3% real discount rate)

	NPV Comparison	Geothermal Generation Benefit	Customer Impact $M				SA Benefit	Total System Cost	
			Total	Non-NEM	NEM	SA			Transmission
Scenarios with Early Transmission	Early Transmission (80%)	$214.18	$202,907	$886	$202,021	$16,756	$1,139*	$70,592	$427
	Late Generation (20%)	$16.47	$202,099	$819	$201,279	$16,912	$784*	$70,146	$365
Base Case	Business as Usual	-$33.05	$205,523	$848	$204,675	$17,647	0	$70,570	$244
Weighted benefit of proposed transmission development		$207.69	$2,778	-$25	$2,802	$860	$1,068	$68	-$171

Notes: Refer to bullet points above table for definition of components of benefits

* these components are benefits relative to the Base Case which is zero. They are the sum of the SA customer benefits plus the geothermal generator benefits.

The analysis that has been conducted is only preliminary in that it only looks at one market scenario with varying success in geothermal development and only from the viewpoint of two proponents in the renewable energy market. The analysis has adopted some conservative features which may be partially offset by the more optimistic assumption that Olympic Dam expansion proceeds to completion by 2017/18. The full optionality of the proposed network development to assist other geothermal or solar thermal projects has not been considered and hence there may be some more value in the concept. Overall, MMA considers that this preliminary assessment is sufficient to provide a basis for easement and terminal station site planning so that feasible connection routes can be identified and a solid basis established for further exploring the costs and benefits.

1 INTRODUCTION

The Australian Geothermal Energy Association (AGEA) engaged McLennan Magasanik Associates (MMA) as an independent adviser to undertake a study of the impact of transmission constraints in optimising the choice of renewable generation in Australia. The particular focus of the study is the potential for connecting a 275 kV double circuit line from Moomba via Olympic Dam to Davenport near Port Augusta. The major concern of renewable energy generators exploring and developing potential projects in remote areas is that the main transmission system may not be extended in a timely manner to allow the projects to be funded and operate as planned. This matter of concern has been confirmed by the AEMC in its recent First Interim Report on Energy Market Frameworks in response to the challenges of the Carbon Pollution Reduction Scheme (CPRS) and the Expanded Renewable Energy target (ERET).

In the First Interim Report the AEMC says [1]:

> *"The new forms of generation are likely to be clustered in certain geographic areas that are remote from consumers and the existing transmission network. We consider that the existing model of bilateral negotiation for new connections will not cope efficiently with multiple connection applications to the same area nor will it be likely to manage efficiently the large expected volume of new connection applications. It is likely that this may result in unnecessary costs and delays."*

This report concerns itself with one particular example which is both an example of the potential problem and of particular concern to Petratherm and Geodynamics.

[1] AEMC 2008, Review of Energy Market Frameworks in light of Climate Change Policies, 1st Interim Report. December 2008, Sydney. (page vi)

2 OPTIONS AND SCENARIOS

2.1 Scope of work

The Australian government is in the process of introducing the expanded Renewable Energy Target (RET). Over the last few years, AGEA's members have been investing to prove geothermal technology, with the ultimate aim of developing a demonstration plant that will produce electricity in the NEM before 2015. Based on analysis by MMA and others, it is apparent that if the technology can be successfully developed, there is a huge market potential given the estimated lower cost of this form of generation relative to other forms of renewable generation. Apart from successfully demonstrating the technology, the main factor that could constrain uptake is the lack of a suitable transmission infrastructure and the inability of current regulations to optimise the transmission network to service new sources of generation. The latter issue was highlighted by The Garnaut Review in its final report, based on a review of market regulations by MMA.

This study was intended to provide a robust estimate of the cost of meeting the renewable energy target as affected by the current transmission arrangements with specific focus on transmission north of Port Augusta to the Cooper Basin. In the modelling undertaken by MMA for the Federal Treasury and the Department of Climate Change, it was assumed that action would be taken to optimise the transmission network. However, it was also assumed that entry of geothermal is delayed and its ramp up to 2020 constrained due to the uncertainty over the technology and the final form of the transmission network. This was considered a conservative approach to the modelling.

At this stage, MMA has assessed the benefits to the electricity market of revising the transmission arrangements to allow for early development of transmission north of Port Augusta to provide impetus for the development and connection of remote geothermal resources. The benefits of enhancing existing regulatory arrangements were estimated based on estimating the costs to the electricity market with and without changes to the transmission arrangements by simulating the impacts in the National Electricity Market (NEM). The costs assessed over the period to 2029/30 included:

- Thermal production costs as affected by inter-regional transmission losses
- Aggregate renewable energy costs
- The annualised capital and operating costs of the new transmission line

It was not practical with the model used to assess the impact of changes in intra-regional losses resulting from the changed pattern of power flows. Since we have changed the pattern of power flow with increased imports from Central Australia to Adelaide and reduced imports from Victoria, there are some countervailing effects that could increase or reduce losses overall. We expect that these loss changes would be about 200 GWh of extra losses worth about $20 M pa and therefore are of secondary impact. The losses on the transmission from Innamincka and Paralana to Olympic Dam of 480 GWh are offset by loss savings elsewhere of about 280 GWh. We have estimated the losses between Central Australia and Davenport by setting up a loss model between Davenport and Olympic Dam, so these effects were estimated in the modelling.

2.2 Factors not considered

The focus of the study concerns the inherent economies of scale in developing a new 275 kV double circuit line to open up resources north of Port Augusta. This line could also potentially support:

- Expansion at Olympic Dam by being integrated with augmentation of connections to that site
- Acquisition of solar thermal resources near the easement
- Support for Arckaringa coal to liquids project.

However these other options are likely to be in a later time frame than the immediate geothermal opportunity and more speculative and it was proposed that the focus be primarily on the geothermal related benefits with these other aspects only adding prospective benefits that would not be quantified. The conservative case was that none of these developments would occur prior to 2030 or if they were earlier they would not reduce the benefits of the 275 kV transmission line.

2.3 Potential Geothermal Expansion

MMA has previously surveyed geothermal developments for the Australian Geothermal Energy Association. From that survey, the potential power developments at Paralana and Geodynamics were reviewed. This information has been based on information from Geodynamics according to its latest (confidential) information as shown in Table 2-1. It is assumed that major transmission is available by 2013/14 from Paralana to Olympic Dam and from 2014/15 for Innamincka to Paralana. Any delay in the major transmission to Paralana or Innamincka would delay the development program accordingly. It is assumed that 30 MW of local load at 80% load factor is developed to facilitate the initial 50 MW capacity at Innamincka. This might be in the nature of data processing centre that could be remotely connected through communications facilities and which would not need long distance transmission capacity. Costs in Table 2-1 are shown in June 2008 dollars.

The Petratherm data were previously provided by calendar year. We have applied these data to the following financial year ending June for modelling purposes. It is assumed that Petratherm would find local load of up to 7 MW to facilitate the development prior to the major transmission line in 2013/14.

The long run marginal cost of power sent out from the power stations including transmission costs has been based on 25 years life for the geothermal assets at 9.3% pa real discount rate and for 50 years for transmission assets at 7.8% real discount rate. These

Table 2-1 Potential Geothermal Development in the north region of South Australia

Financial Year ending June	Geodynamics (Innamincka) Net sent-out capacity	Petratherm (Paralana) Net sent-out capacity
2011	0	7.125
2012	0	7.125
2013	50	7.125
2014	50	28.5
2015	100	57
2016	150	85.5
2017	250	114
2018	400	152
2019	550	190
2020	550	228
2021	550	266
Capacity Factor	95%	95%
Ultimate Capital Cost ($M)	$2,750	$1,300
Transmission Cost[2] ($M)	$553	$164
Generation LRMC ($/MWh)	$68	$72
Transmission Cost ($/MWhso)	$10	$7
Loss to Olympic Dam	15%	5%
LRMC to OD ($/MWh)	$91	$83

Note that capital and operating costs were confidential and an indicative range in shown this report.
Transmission stages:

- (light yellow) 2013/14 with double circuit Paralana to OD
- (light green) 2014/15 with double circuit Innamincka to Paralana
- (orange) 2014/15 with one extra circuit Davenport to Olympic Dam
- (teal) 2017/18 with third circuit Paralana to Olympic Dam

[2] These costs were derived from data from a Power Network Strategies report on geothermal connection costs as discussed below in section 2.5.

costs are only indicative and used for the economic analysis conducted in this report. They are subject to some uncertainty.

2.4 Analysis by Power Network Strategies

Petratherm had commissioned some network analysis by Power Network Strategies in September 2008. That report looked at connections between Innamincka, Paralana to Olympic Dam and Davenport. The analysis assumed that there was already 550 MW (500 MW average load) at Olympic Dam by the time the geothermal power is to be connected. The modelling assumed 400 MW from Innamincka and 250 MW from Paralana which is a little less than shown above in Table 2-1. The cost estimates for the key components are shown in Table 2-2.

Table 2-2 Transmission Connection Options (September 2008 costs)

Source	Maximum Power (MW)	Connection to	Transmission	MLF	Capital Cost ($M Sept 2008)
Innamincka	400 MW	575 km to Olympic Dam	Double circuit 275 kV	0.845	$404 M
Paralana	250 MW	375 km to Olympic Dam	Single circuit 275 kV	0.918	$192 M
Paralana	250 MW	365 km to Davenport	Single circuit 275 kV	0.892	$206 M

It may be possible for these options to support slightly higher generation levels shown in Table 2-1 if there is some local demand off-take and some additional stability control facilities, both voltage and system dynamic controls. We shall assume for the purposes of this study that these costs can provide a reasonable basis for estimating the transmission costs assuming that both projects proceed. Three circuits from Paralana to Olympic Dam if switched at Paralana could provide for additional power from Innamincka up to 550 MW with about $10 M for the additional switching. We have not priced the additional length of double circuit section that would be needed to align the transmission easements which were previously considered mutually exclusive.

The Power Network Strategies (PNS) analysis treated the geothermal projects as mostly mutually exclusive whereas this present study assumes that the full network development would need to support at least Innamincka and Paralana and possibly additional resources through further network development. The PNS study included two additional 275 kV circuits between Olympic Dam and Davenport. We propose double circuit construction for that new line to minimise costs. Based on the cost data in the PNS report, we estimate that double circuit development to cost about $133 M for 350 km. All up for the proposed connections the transmission cost is $729 M in September 2008 dollars and $721 in June 2008 dollars. Part of the double circuit line to Olympic Dam would be attributable to the Olympic Dam expansion, so we may assume that half is allocated to geothermal resources which gives a total network capital cost of $655 M. We would assume that the double circuit line from Davenport to Olympic Dam would be completed by 2017/18 with the third circuit from Paralana to Olympic Dam.

2.5 Innamincka to Davenport Transmission

Based on this analysis, the particular example of potentially delayed transmission network development which was the focus of this study is included in Table 2-1 and illustrated in Figure 2-1. The underlying map is extracted from the 2008 Statement of Opportunities. It shows the existing transmission network. To the NEMMCO map is added the new 132 kV line from Olympic Dam to Prominent Hill and a proposed 275 kV double circuit line from Innamincka to Paralana to Olympic Dam to Davenport and a single circuit 275 kV line from Paralana to Olympic Dam. The transmission lines could be built in a number of stages to progressively match capacity and cost to utilisation:

It may be staged as follows:

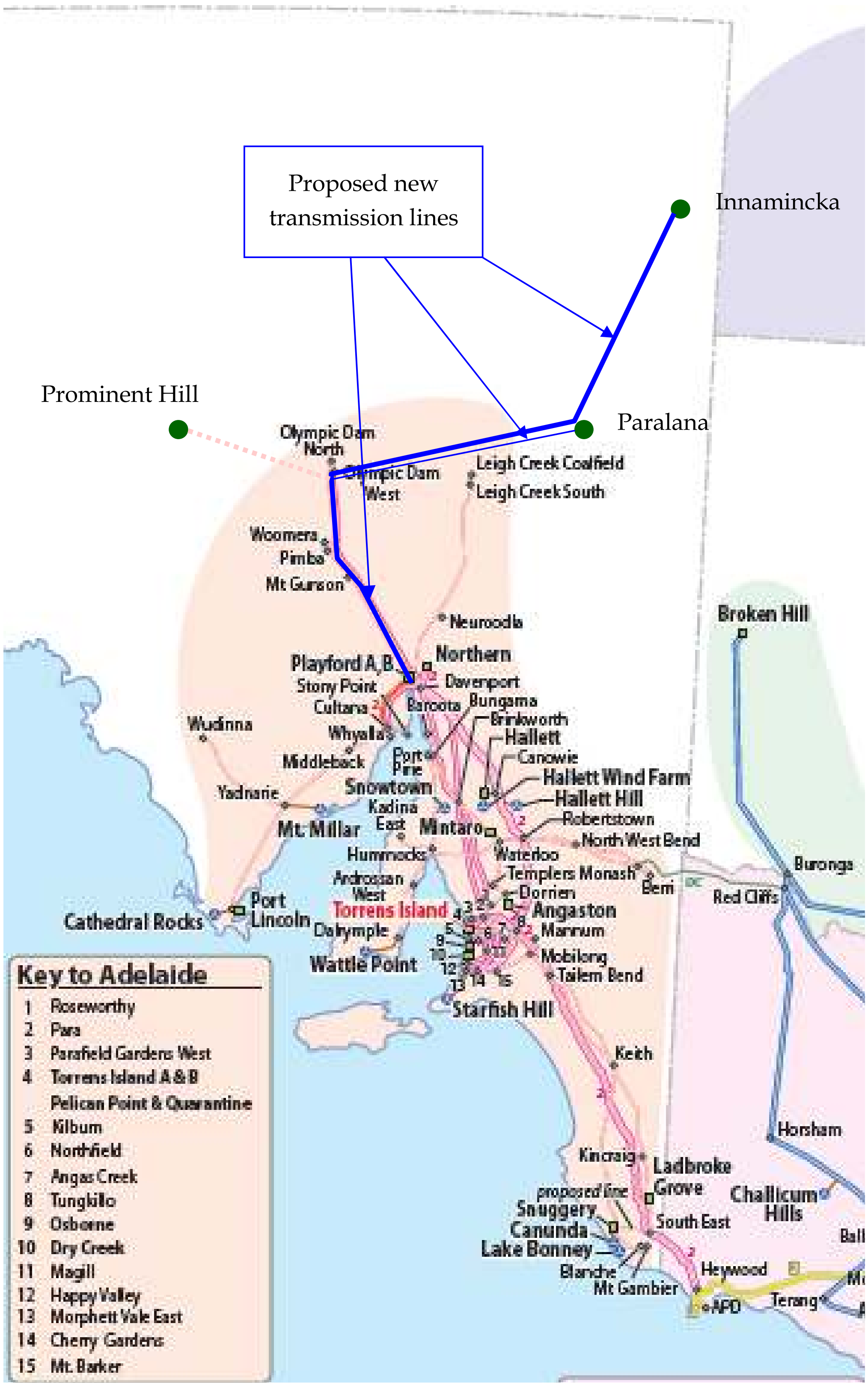
- Paralana to Olympic Dam single circuit line to meet initial load at Olympic Dam expansion from 125 MW with 21 MW of power from Paralana (2013/14).
- Innamincka to Paralana single circuit of double circuit line to provide extra supply from Moomba as geothermal capacity builds up at Innamincka (2014/15).
- Add second circuit from Paralana to Innamincka when the total generation is about to exceed 200 MW (2015/16)
- Add second circuit from Innamincka to Paralana when the Innamincka generation is about to exceed 200 MW or the combined export to exceed 250 MW (2016/17)
- Add a third circuit from Paralana to Olympic Dam and a double circuit from Davenport to Olympic Dam to provide for the full generating capacity of 816 MW and the full Olympic Dam load of 550 MW (2017/18)

This sequence was used to better match the transmission and generation capacity and produce a realistic construction profile. The Davenport to Olympic Dam line might be needed a year earlier than modelled, but we have not investigated that requirement.

There is also the possibility of early connection of Paralana to Leigh Creek and of later connection from Paralana to Broken Hill which may be beneficial under some scenarios of higher demand in South Australia and large scale renewable energy development in the Broken Hill region. However the value of the transmission line development for these options was not quantified.

The estimated capital costs associated with these stages would be as shown in Table 2-3, We have scaled the line costs by the length and allowed $36 M for terminal station costs (September 2008 dollars). The total transmission costs are $949 M in June 2008 dollars. We have allocated the cost of the Davenport-Olympic Dam transmission upgrade to customers on the basis that it would be part of the common system, serving northern

Figure 2-1 Connections in South Australia



Source: NEMMCo 2008 Statement of Opportunities and MMA analysis

Table 2-3 Capital Costs for Transmission Connections (June 2008 dollars)

Stage	From	To	Construction	Capital Cost $M
1	Olympic Dam	Paralana	Double circuit 275 kV line	$265.3
2	Paralana	Innamincka	Double circuit 275 kV line	$265.3
3	Olympic Dam	Davenport	Single circuit 275 kV line	$179.4
4	Paralana	Innamincka	Single circuit 275 kV line	$189.8
Total				$899.7
Notional Shares by Capacity		Regulated		$179.4
		Geodynamics		$552.9
		Petratherm		$167.4

loads and facilitating the surplus of surplus geothermal energy to remote customers. The transmission lines from Paralana and Innamincka into Olympic Dam have been allocated to the respective generators as connection assets. The capacity from Paralana to Olympic Dam is shared according to the 2020 capacity into Paralana. This split is for the purposes of estimating long-run marginal costs in the renewable energy market model.

We assume annual operating costs of 1% of capital costs.

2.6 Load Growth

An important part of the analysis depends on the load growth at Olympic Dam. Figure 2-2 shows the Electranet projection of non-diversified peak demand in the northern system. This would include loads at Davenport/Playford (32 MW), Leigh Creek (1.7 MW), Neuroolda (0.9 MW), Mt Gunson (0.43 MW), Woomera (negligible), and Olympic Dam (125 MW). The current level shown is 220 MW. It could be made up as shown in Table 2-4. The estimates for Prominent Hill, Woomera and Leigh Creek Mine are used to make up the total of 220 MW. On this basis the initial load out of the Olympic Dam connection as modelled in Strategist is assumed to include all nodes except Leigh Creek Town and Mine and Neuroolda. That gives an initial total of 177.43 which has been scaled by 95% for some notional diversification and rounded to 169 MW.

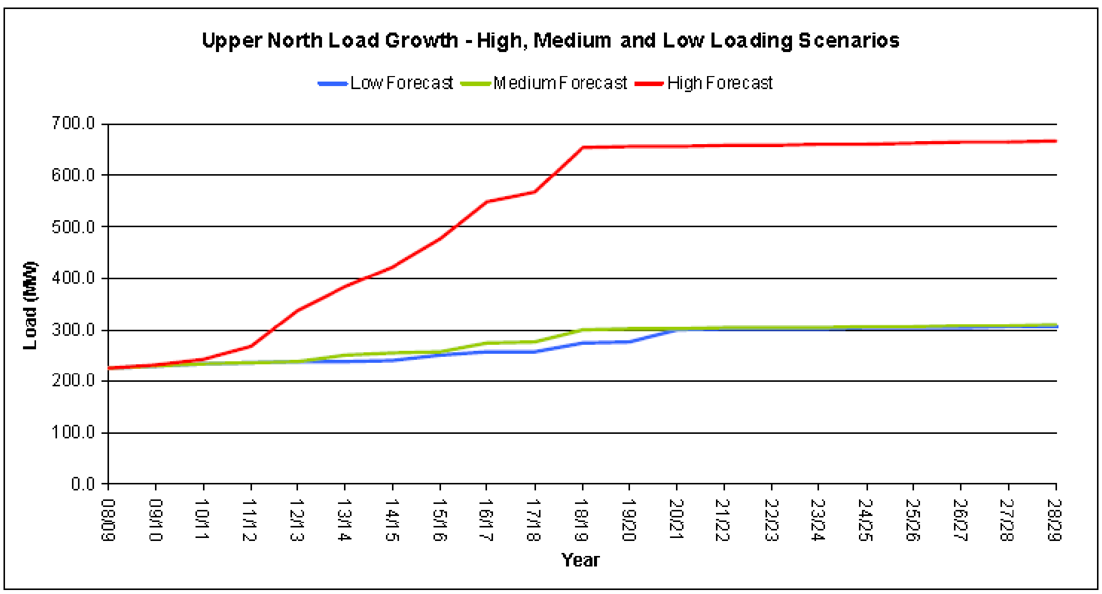
The ultimate increase in Figure 2-2 from the medium to the high is 350 MW (650 MW – 300 MW) which would be attributable to uncertainty in the Olympic Dam expansion.

We therefore assume 169 MW initially supplied out of Olympic Dam and nearby connections rising to 589 MW over the 5 year period from 2012/13 to 20 17/18 and then increasing at 1% pa. It is possible that there will be some local generation at Olympic Dam but the amount is uncertain. We have assumed that it does not significantly influence the

Table 2-4 Estimated make up of Northern Region load

Station	Peak MW
Olympic Dam	130
Prominent Hill	40
Mt Gunson	0.43
Neuroolda	0.9
Leigh Creek	8
Leigh Creek South	1.7
Playford/Davenport	31.7
Woomera	7
Total	219.73

Figure 2-2 Electranet Projection of Non-diversified peak demand in the Northern region of SA



Source: Electranet Annual Planning Review 2009, Figure 8.31, page 135

value of the geothermal energy. If there were a large amount of cogeneration at Olympic Dam, the loss factors would be less favourable for the geothermal plants.

Figure 2-3 shows the aggregate energy demand in South Australia and the median peak demand as modelled. The demand shown does not include inter-regional losses and losses on the Innamincka-Paralana- Davenport transmission links which were explicitly represented in the model. The zonal split of the energy demand is shown in Figure 2-4 together with the potential geothermal generation. The chart shows that the potential geothermal generation exceeds the demand north of Davenport and therefore would be able to replace some of the generation lost from Northern and Playford Power Stations

Figure 2-3 Aggregate South Australian Sent-out Peak Demand and Energy

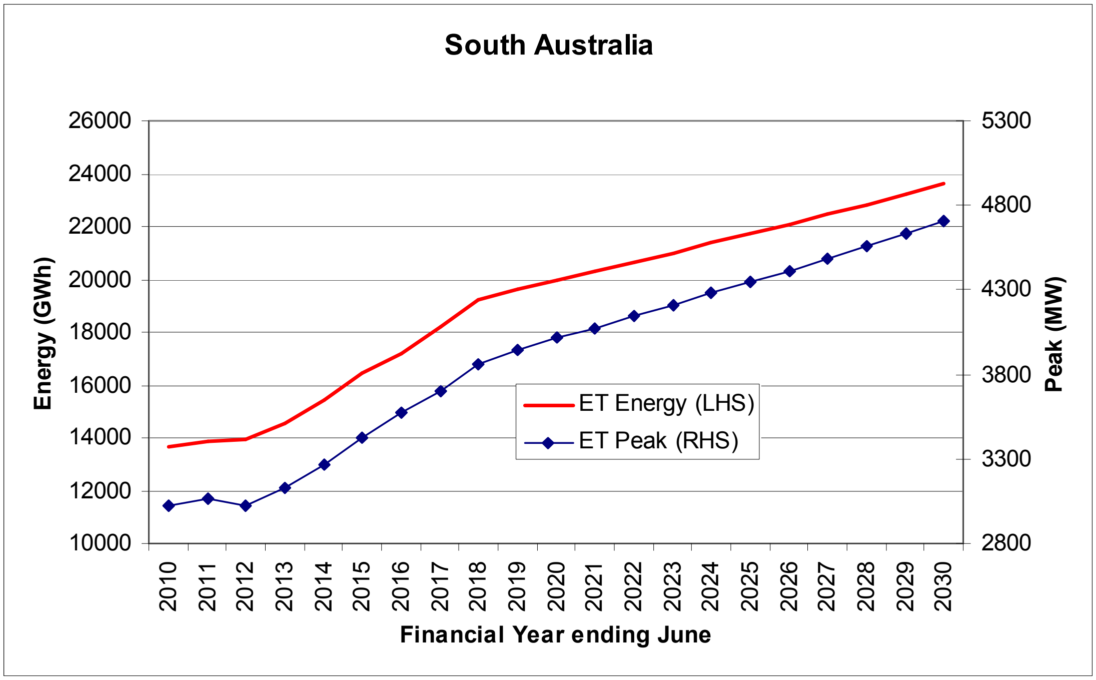
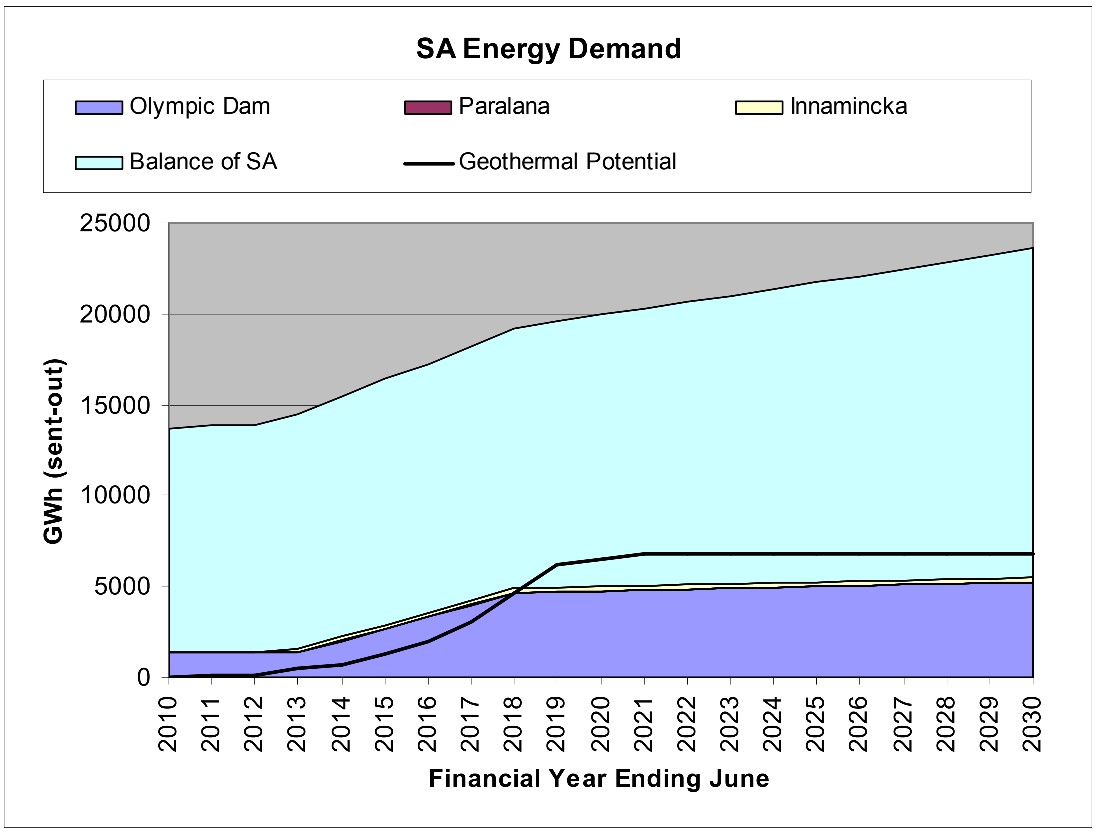


Figure 2-4 South Australian Energy Demand and Geothermal Potential



due to the impact of carbon pricing under the CPRS. The chart shows that the local loads at Innamincka and Paralana were assumed to be quite low compared to Olympic Dam and the remainder of South Australia.

2.7 Transmission Regulatory Scenarios

The study covered the period to 2030 so that a reasonable assessment could be made of the post 2020 impacts that depend on what happens prior to 2020.

The two scenarios considered were:

1. *Business as Usual Scenario (BAU)*: This scenario was based on the assumptions used in the modelling undertaken for Treasury for the CPRS White Paper, except that commitment to transmission north of Port Augusta will depend on a major sponsor ready to complete at least (say) 200 MW of plant. Following the development of the new transmission line north of Port Augusta, the minor players would be in catch-up mode. Hence, development of the transmission network to support the geothermal generation will be based on existing arrangements (which will affect the delivered cost of energy from geothermal resources relative to other renewable energy resources). This restriction will also apply to other renewable energy resources where relevant, such as wind on the Eyre Peninsula[3].

2. *Advanced geothermal development scenario*: This scenario will assume that a single circuit 275 kV circuit line would be added between Davenport near Port Augusta and Olympic Dam to provide for connection of remote geothermal resources between Olympic Dam and Innamincka. A double circuit 275kV line would be constructed from Olympic Dam to Paralana to Innamincka. This will bring forward the commercialisation of the geothermal generation to 2013/14 with production ramping up as soon as feasible. We have examined a staged development of the transmission line but since this add 20% to the project cost, it is not viable unless the second circuit is needed at least 9 years later than the first[4]. The benefits of bringing forward geothermal generation can then be compared to the cost of advancing the double circuit line to Olympic Dam.

   This second scenario was evaluated with two possible outcomes: a realisation of the expected response to an early commitment to the transmission line as well as a downside where the costs of geothermal are 10% higher than forecast and the development process is delayed. Only 402 MW of geothermal is built by 2020, less than half of the expected capacity of 816 MW. The overall benefits were assessed by a weighted combination of the favourable and down side outcomes, so as not to be too optimistic and to present a sober estimate of the risks in early transmission development. This provides an indicative basis for assessing the optimal timing. Further analysis would be required to provide the full valuation for a market benefits test, including load growth and supply uncertainties.

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[3] We think it will be beneficial to your case to demonstrate that other renewable technologies are also affected by the same issues.

[4] A 20% higher cost at 7.8% real discount rate requires a minimum delay of 9.22 years to have a lower net present value so that $0.8 + 0.4\ (1+7.8\%)^{-N} = 1$ solves as $N = \log(2)/\log(1+7.8\%) = 9.23$.

2.7.1 Scenario (1) – Business as Usual

Scenario (1) assumes the Business as Usual Scenario and that a critical mass of capacity is required to get the transmission line underway. A possible scenario is that both Petratherm and Geodynamics build 200 MW of combined capacity with a single circuit transmission line from Innamincka via Paralana to Olympic Dam by 2017/18. That would provide the basis for full testing of the first commercial stage which could then be doubled before any further transmission would be required. This would require a double circuit transmission reinforcement south of Olympic Dam by 2013/14 to reinforce the supply to Olympic Dam, given that the supply from geothermal resources would be uncertain and delayed. The development Plan for this scenario is shown in Table 2-5.

Without further renewable energy targets or a much higher carbon abatement target than the CPRS-5% it would be unlikely that further geothermal development would occur after 2020 as shown in Table 2-5.

2.7.2 Scenario (2) - Early Transmission Development

Scenario (2) could have different transmission development options depending on the rate of build-up of geothermal resources. Since the cost of staged development is about 20% higher than upfront development, a staged development has the same present value cost as an upfront development if the second stage is 9 years later at 9.3% real discount rate. Since the purpose of the study is to examine up to some 800 MW of geothermal plant by 2020, if the first stage is in 2012 then the second transmission stage would have to be required after 2021 for staged transmission to be viable. Therefore it is more economic to build the double circuit capacity at the initial stage since single circuit lines could not support 800 MW of geothermal capacity. A third single circuit between Paralana and Olympic Dam would be required by 2017/18 to support over 400 MW power transfer to Olympic Dam. We have assumed that a third 275kV circuit may not be needed between Davenport and Olympic Dam. System stability controls may be utilised to deal with the relatively high transmission impedance between Innamincka and Davenport if a third circuit between Olympic Dam and Davenport is not otherwise needed.

Accordingly the development plan is that shown in Table 2-6.

2.7.3 Geothermal Development Scenarios

With the early commitment to the double circuit 275 kV lines, it is possible that higher costs or technological difficulties mean that the ultimate generation target capacity is not achieved. To represent this range of risk, we have formulated a down-side scenario as shown in Table 2-7. A single circuit 275 kV line is constructed from Davenport to Olympic Dam and a double circuit 275 kV line is constructed from Paralana to Olympic Dam and then from Innamincka to Paralana. The third Paralana – Olympic Dam circuit is not needed as the geothermal power exported to Olympic Dam does not exceed 400 MW.

Table 2-5 Development Plan for Business as Usual

Financial Year ending June	Geodynamics (Innamincka)	Petratherm (Paralana)	Transmission
	Net sent-out capacity	Net sent-out capacity	
2011	0	7.125	
2012	0	7.125	
2013	50	7.125	
2014	50	7.125	Davenport-OD Dcct
2015	50	7.125	
2016	50	7.125	
2017	50	7.125	
2018	50	28.5	Paral-OD Scct
2019	100	57	Inn-Paral Scct
2020	150	85.5	
2021	150	85.5	
2022	150	85.5	
2023	150	85.5	
2024	150	85.5	
2025	150	85.5	
2026	150	85.5	
2027	150	85.5	
2028	150	85.5	
2029	150	85.5	
2030	150	85.5	
Capacity Factor	95%	95%	
Ultimate Capital Cost	$911	$495	
Transmission Cost ($M)	$223	$156	
Generation LRMC ($/MWhso)	$81	$84	
Transmission Cost ($/MWhso)	$16	$20	
Loss to Olympic Dam	9%	4%	
LRMC to OD ($/MWh)	$107	$107	

Table 2-6 Development Plan with Early Transmission Development

Financial Year ending June	Geodynamics (Innamincka)	Petratherm (Paralana)	Transmission
	Net sent-out capacity	Net sent-out capacity	
2011	0	7.125	
2012	0	7.125	
2013	50	7.125	
2014	50	28.5	Paral-OD Dcct, Davenport-OD Scct
2015	100	57	Inn-Paral Dcct
2016	150	85.5	
2017	250	114	
2018	400	152	Paral-OD Scct
2019	550	190	
2020	550	228	
2021	550	266	
2022	550	266	
2023	550	266	
2024	550	266	
2025	550	266	
2026	550	266	
2027	550	266	
2028	550	266	
2029	550	266	
2030	550	266	
Capacity Factor	95%	95%	
Ultimate Capital Cost	$2,750	$1,300	
Transmission Cost ($M)	$556	$164	
Generation LRMC ($/MWhso)	$68	$72	
Transmission Cost ($/MWhso)	$11	$7	
Loss to Olympic Dam	15%	5%	
LRMC to OD ($/MWh)	$93	$83	

Table 2-7 Development Plan with Early Transmission Development and Delayed Generation

Financial Year ending June	Geodynamics (Innamincka)	Petratherm (Paralana)	Transmission
	Net sent-out capacity	Net sent-out capacity	
2011	0	7.125	
2012	0	7.125	
2013	50	7.125	
2014	50	28.5	Paral-OD Dcct, Davenport-OD Scct
2015	50	28.5	Inn-Paral Dcct
2016	50	57	
2017	100	57	
2018	100	85.5	
2019	150	85.5	
2020	200	114	
2021	250	152	
2022	250	152	
2023	250	152	
2024	250	152	
2025	250	152	
2026	250	152	
2027	250	152	
2028	250	152	
2029	250	152	
2030	250	152	
Capacity Factor	95%	95%	
Ultimate Capital Cost	$1,407	$808	
Transmission Cost ($M)	$422	$109	
Generation LRMC ($/MWhso)	$76	$78	
Transmission Cost ($/MWhso)	$18	$8	
Loss to Olympic Dam	8%	4%	
LRMC to OD ($/MWh)	$102	$89	

2.8 Port Augusta to Adelaide

Figure 3-1 on page 18 shows that the total geothermal generation exceeds the total load north of Davenport. This means that some 690 MW less some 590 MW load or about 100 MW would be the peak export from Davenport south. In the event of constraints from Port Augusta to Adelaide there may be some displacement of generation at Playford Power Station. Some 100 MW flowing south could well match load on the Eyre Peninsula and Port Augusta most of the time so major constraints south of Port Augusta would be unlikely to be sustained.

2.9 Heywood Interconnection Upgrade

The increased volume of geothermal power associated with this development is not sufficient to require increase in the South Australian export limit, so we have not considered any cost changes in relation to deferment of any Heywood interconnection upgrades. There is some reduction in South Australian energy prices due to export constraints. However, it is expected that output at Torrens Island and Playford would be used to manage the risk of low energy prices in South Australia. In essence the geothermal power would displace thermal generation at Northern, Playford and Torrens island Power Stations. Assuming that there is no need to advance the Heywood Interconnection upgrade in association with the new 275 kV power line may be optimistic.

3 MODELLING ISSUES AND METHODS

3.1 Economic benefits

The sources of economic benefit would be:

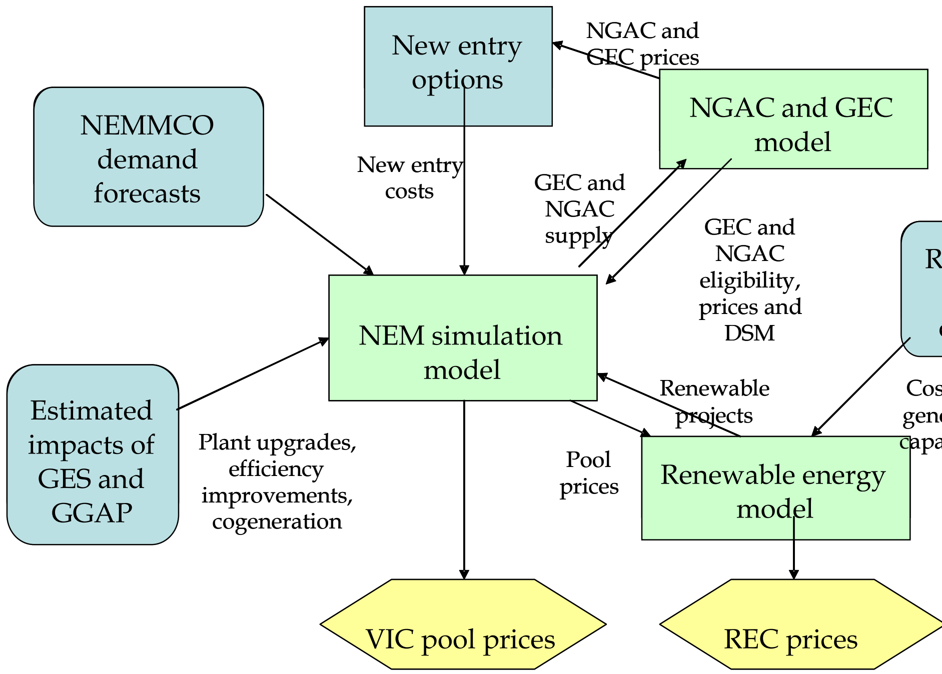
- Lower total cost of renewable energy resources in meeting the expanded RET
- Changes in the capital development plan for thermal resources
- Reducing loading on gas fired plants due to a greater portion of base load renewable energy
- Changes in transmission losses as reflected in changed production costs.

We evaluated how the expansion plans for thermal resources would vary between the two scenarios in terms of timing and optimal supply mix. For example, a higher proportion of geothermal power would result in less gas turbines needed to back-up wind power resources.

3.2 Modelling framework

The integrated modelling approach is iterative, as demonstrated in Figure 3-1. The modelling starts with the NEM simulation model, using NEMMCO demand forecasts, marginal costs and operating characteristics of existing generators, new entry cost assumptions, existing renewable energy projects, assumptions on GEC and NGAC prices, and estimated impacts of GES and GGAP.

Figure 3-1 Interactions between models



MMA has developed an extensive renewable energy database that contains key costs and operating characteristics for existing, committed, and proposed renewable energy projects in Australia. MMA's renewable energy model uses this database to determine the least cost combination of renewable energy projects to meet the various renewable energy targets in each year. Generators in all of the eastern states are eligible to contribute towards either the MRET, VRET or NRET scheme, but not more than one. This profile of potential eligible renewable energy projects is incorporated into MMA's energy market modelling and thus has potential to displace thermal generation.

Outputs from the electricity market simulation are fed into the REMMA model which in turn provides improved input assumptions for the electricity market simulation. Iteration continues until a stable solution is reached.

3.3 Renewable energy schemes

There are currently three environmental schemes aimed at promoting additional renewable energy generation in Australia: the Commonwealth Government's Mandatory Renewable Energy Target (MRET) scheme, the Victorian State Government's VRET scheme and the NSW State Government's NRET scheme. The NRET scheme has been abandoned by the NSW State Government due the implementation of the expanded RET. The VRET will be superseded by the expanded MRET scheme.

3.4 MRET scheme

In 2001, the Australian Government introduced a Mandatory Renewable Energy Target (MRET) scheme that aims to increase the uptake of renewable energy in Australia's electricity supply. It is a key element of the Government response to climate change and greenhouse gas emission abatement. The majority of electricity retailers and wholesale electricity buyers on liable grids exceeding 100 megawatts (MW) are liable under the scheme. Under the current MRET scheme, the maximum annual target of 95 000 GWh is reached in 2010 and remains at that level until the scheme expires in 2020. In 2007, the Government expanded its MRET in a bid to ensure 20% of the electricity supply. This increases the MRET to 45,000GWh to be achieved in 2020. The Government seeks to bring both the national MRET and existing state-based targets into a single national scheme and phase out the renewable energy target between 2020 and 2030 as emission trading matures.

The Commonwealth Government's policy to achieve 2% additional renewable energy by 2010 has been implemented as a 9,500 GWh target with a maximum penalty for non-performance of $40/MWh. This penalty is not indexed to CPI. The penalty is also not tax deductible, meaning that under current company tax rates a liable party would be indifferent between paying the penalty or purchasing certificates at a price of $57/MWh.

This penalty would effectively provide a cap on the premium available for renewable energy. Whilst a ramp-up target schedule has been developed for each calendar year by the Government as shown in Table 3-1, a credits banking regime will stimulate earlier development of such projects.

The next two sections outline the current understanding of the state based renewable energy schemes. For the purposes of this modelling these schemes were replaced by the expanded MRET scheme from 2010 calendar year.

3.5 VRET scheme

The Victorian State Government's Victorian Renewable Energy Target (VRET) requires electricity retailers to purchase a minimum 10% renewable energy by 2016. Eligible renewable energy sources include hydro, wind, biomass, geothermal and solar (excluding solar hot water) and must be located in Victoria. The VRET scheme is implemented through a 3,274 GWh additional renewable energy target with a maximum penalty for non-performance of $43/MWh (in 2007 dollars). Unlike the MRET scheme, this penalty is indexed to CPI. The penalty is not tax deductible and is therefore equivalent to an after tax value of $61.40/MWh, which will act as a cap on the price of Victorian renewable certificates.

In the absence of an expanded National Renewable Energy Target, VRET will continue until 2030, and a target schedule has been developed for each calendar year as shown in Table 3-1, where it is super-imposed on the MRET target of 9,500 GWh per annum from 2010 onwards. Banking of certificates is allowed, however generators are only eligible to create Victorian renewable certificates for 15 years so incentives to enter the market early

Table 3-1 Renewable energy targets

Calendar Year	Expanded Renewable Energy Target including VRET (GWh)	Existing Renewable Energy Target + Victorian Renewable Energy Target (GWh)
2002		1,100
2003		1,800
2004		2,600
2005		3,400
2006		4,500
2007		5,600
2008		6,993
2009	8678	8,678
2010	12,500	10,463
2011	14,400	10,848
2012	16,300	11,233
2013	18,200	11,618
2014	20100	12,004
2015	22000	12,389
2016	26600	12,774
2017	31200	12,774
2018	35800	12,774
2019	40400	12,774
2020	45000	12,774
2021	45000	11,374
2022	45000	10,074
2023	45000	8,681
2024	45000	7,196
2025	45000	5,711
2026	45000	1,926
2027	45000	1,541
2028	45000	1,156
2029	45000	770
2030	45000	385
2031 +	0	0

will be diminished. The target ramps down after 2022 to reflect the fact that renewable energy projects developed to meet the initial target will no longer be eligible to create certificates after that period. The modelling has assumed that this scheme is fully replaced by the Expanded RET.

3.6 REMMA

MMA has developed a specialised Excel model of RET which is linked to our NEM and other electricity market models so that we can assess the relationship between energy prices and REC prices. This model was adapted for this study to make specific provision for the Petratherm and Geodynamics development plans associated with the proposed power line development and each of the supply scenarios.

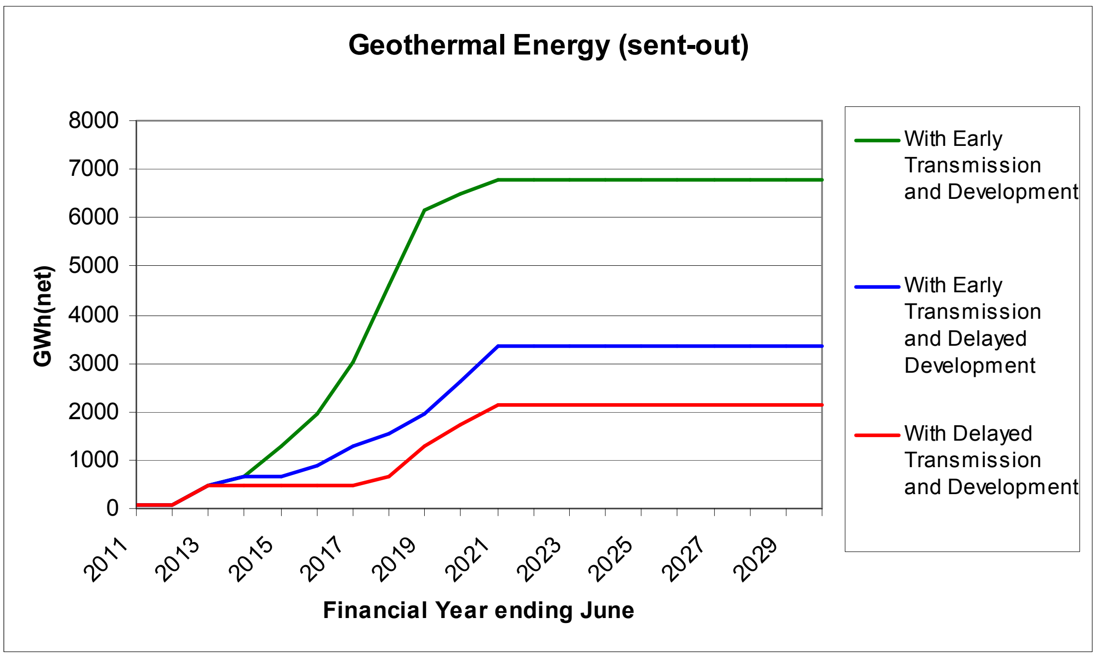
3.7 Modelling of Geothermal resources

Since the geothermal development plans are quite variable among the scenarios and the pattern of capital investment is variable, we elected to fix the Petratherm and Geodynamics projects in the renewable energy database and treat them as committed projects that do not set the market price for renewable energy certificates.

3.8 Build up of Geothermal Power

The build-up of geothermal energy potential among the three scenarios is summarised in Figure 3-2. The chart shows the sent-out generation is aggregate at Paralana and Innamincka.

Figure 3-2 Build up of geothermal energy supplied from Paralana and Innamincka



3.9 Process

The modelling process involved:

1. Rebuild the REMMA model to fix the Paralana and Innamincka development options as committed projects according to each of the three scenarios

2. Establish an initial renewable energy market solution based on previous energy prices

3. Set up Olympic Dam, Paralana and Innamincka as local regions and the Olympic Dam - Davenport-Torrens Island transmission as an equivalent interconnector

4. Insert the Paralana and Innamincka projects as equivalent power stations in the NEM Model at their respective nodes

5. Set up the local loads at Innamincka and Paralana consistent with the proposed pilot developments as shown in Figure 2-4.
6. Insert the new renewable development plan into the NEM and adjust the thermal expansion plan accordingly. Some additional wind was permitted in South Australia relative to earlier analysis by MMA because the total geothermal capacity was less than previously allowed (816 MW by 2020 versus 1300 MW previously)
7. Iterate the REMMA and NEM models to convergence for each scenario
8. Evaluate the system costs among the three development plans and confirm the benefits of early development.
9. Evaluate the customer impacts at the National, NEM and SA regional level in terms of the total wholesale cost of energy and RECs.

3.10 Limitations

There are some second order factors which were not considered in the modelling. For example, major changes in the flow of power across interconnections would alter intra-regional transmission marginal loss factors. This create some secondary effects in the relative customer benefits among the regions as some MLFs would rise at some transmission supply points and fall at other locations. This factor has not been evaluated. The only loss effects that are considered in the modelling are due to changes in inter-regional losses which influence relative regional energy prices.

Another example is that the interaction between the REC price the renewable energy distribution and energy prices was not fully iterated to convergence as this is a time consuming process. Generally one or two iterations were undertaken and once a consistent energy price path was determined, the resulting REC prices was then assessed. Any residual errors are expected to be minor as the energy price is primarily determined by the carbon price with inter-regional power flows as a secondary factor. Since the geothermal development largely influences the inter-regional power flows, this aspect of the solution was fairly stable from iteration to iteration once the thermal plant program was adjusted according to energy prices and new entry costs.

4 RESULTS

4.1 Uncertainties

The analysis of the potential benefits of the establishment of a double circuit 275 kV transmission line from Innamincka to Olympic Dam has some conservative and optimistic features. The analysis is optimistic to the extent that it assumes that Olympic Dam proceeds to full-scale operation by 2017/18. To the extent that the Olympic Dam expansion is delayed, the benefits of the development would be reduced. However, given that the lead-time for major expansion of Olympic Dam would have similar lead-time to the development of the transmission line once easements and primary planning approvals have been obtained, it should be possible to align the exposure to transmission costs and the receipt of energy benefits. There is a reasonable prospect of load growth at existing and future mining sites that could be supplied out of a hub at Olympic Dam. Therefore, the geothermal power might well be delivered to other sites if Olympic Dam does not reach its full potential in the period to 2020.

The analysis is conservative to the extent that we have not fully explored the ultimate value of the transmission line for connecting local loads associated with resource development or other renewable energy sources. With relatively modest additional investment for switching and voltage control plant, the transfer capacities may be increased to allow connection of other facilities. It may also be feasible to connect between Paralana and Broken Hill, which would also increase the capability of the network for delivery of energy from other renewable energy sources. Depending on other developments, a higher voltage and higher capacity network might be even more beneficial.

A full feasibility study would involve further analysis to optimise the transmission system design and commitment timing with regard to the evolving generation opportunities. However, the present analysis shows that there is economic potential for network development to connect the remote sources of geothermal power.

Having regard to these uncertainties, the current analysis indicates that network development associated with prospective geothermal development is likely to be viable and that easement and terminal station site planning should proceed to provide for prospective future needs.

4.2 Overview

The analysis of the results of the market modelling has considered the following aspects:

- The economic benefit to the geothermal generators assuming that they pay for all the transmission lines and connections to Olympic Dam;

- The change in benefits to customers in SA, the balance of the NEM and outside the NEM due to changes in renewable energy prices for the early transmission with down-side risk versus business as usual with limited development for geothermal plant;
- The changes in the annualised transmission costs assuming that they are recovered using a tariff linked to CPI, that is constant in real terms; and
- The change in the total system production costs including the alternative transmission costs for the early transmission with down-side risk versus business as usual with limited development for geothermal plant. This includes both the thermal and the renewable energy generation costs including the capital to new projects.

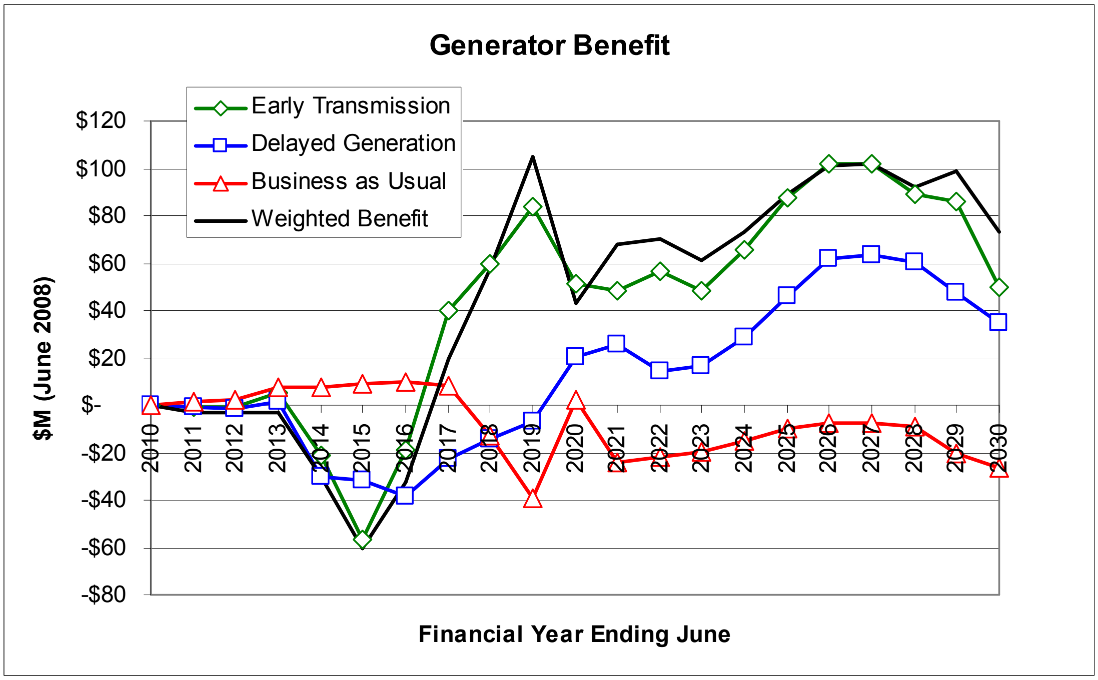
4.3 Benefits to Geothermal Generators

Assuming that the geothermal generators are required to pay for the transmission costs to Olympic Dam, which is a conservative assumption from their viewpoint, the annual benefits for the three cases are shown in Figure 4-1. These costs do not include the cost of augmentation between Olympic Dam and Davenport, as these costs would be more likely attributed to customers. It may be noted that:

- There are significant geothermal generator benefits in both the *Early Transmission* and the *Delayed Generation* cases given the target generation levels are met in both cases.
- *Business as usual* with small-scale incremental development and a minimum capacity connection is likely to leave the geothermal industry in a marginally non-viable position with on-going economic losses, although they may make some small profit in accounting terms. It may be difficult to recover the cost of a single circuit line to Olympic Dam due to unfavourable economies of scale. Such a development should only be undertaken initially if there is a strong prospective of further development from that position.
- The development of the double circuit line to Olympic Dam creates some negative annual benefits in the period from 2013/14 to 2015/16 with the *Early Transmission* development. This arises because the value of the available geothermal energy does not offset the annual cost of the double circuit transmission line.
- From 2016/17 the value of the *Early Transmission* line investment becomes apparent with annual value rising from $60 M per annum to $100 M per annum after 2025. Assuming that the projected costs of geothermal energy and the generation performance are achieved, and the load growth is delivered, the geothermal generators should be able to recover the cost of the transmission to Olympic Dam.
- Even if only half of the planned geothermal capacity is achieved as per the *Delayed Generation* scenario, the transmission line can still recover its costs from the value delivered to the geothermal generators.

Thus the overall impression is that there is a reasonable prospect that early development of a transmission network north of Olympic Dam could increase market benefits. The potential difficulty would be addressing the early commercialisation phase when

Figure 4-1 Annual Generator Benefit



the costs of the connection could not be carried by the geothermal generators without additional equity injection. This is a significant barrier to entry.

4.4 Total Customer Benefits

The total customer benefits to SA customers, the balance of NEM and outside the NEM was also modelled and depicted in Figure 4-2. The customer benefit was based on the regional load weighted wholesale prices multiplied by the sent-out consumption in each region. The transmission costs between Davenport and Olympic Dam were also included. It did not take into account any variation in the transmission loss factors at each major transmission load node and is therefore only indicative. The impact on REC prices was also included by estimating the renewable power percentage.

The total benefits initially increase over time as the early geothermal energy reduces prices in the NEM, particularly the southern regions of the NEM. These customer benefits would be eventually eroded as market prices come back into equilibrium with new entry costs. This is indicated with a reduction in customer benefits after 2021. The results are very sensitive to the modelling of new entry among the three scenarios, as small changes in prices can produce relatively large changes in benefit.

Almost all of the early customer benefit is realized within the NEM region, with negligible amounts of non-NEM customer benefit, being based on REC price changes only. The non-NEM customer benefit is based on the proportion of RECs that are not purchased in the NEM wholesale market. The South Australian customer benefit grows steadily from the year in which the first transmission link comes in (2013/2014), reaching a weighted benefit of $860 M over the 20 year period. It should be noted that the customer benefit

Figure 4-2 Total Customer Benefit (80% probability of achieving ET)

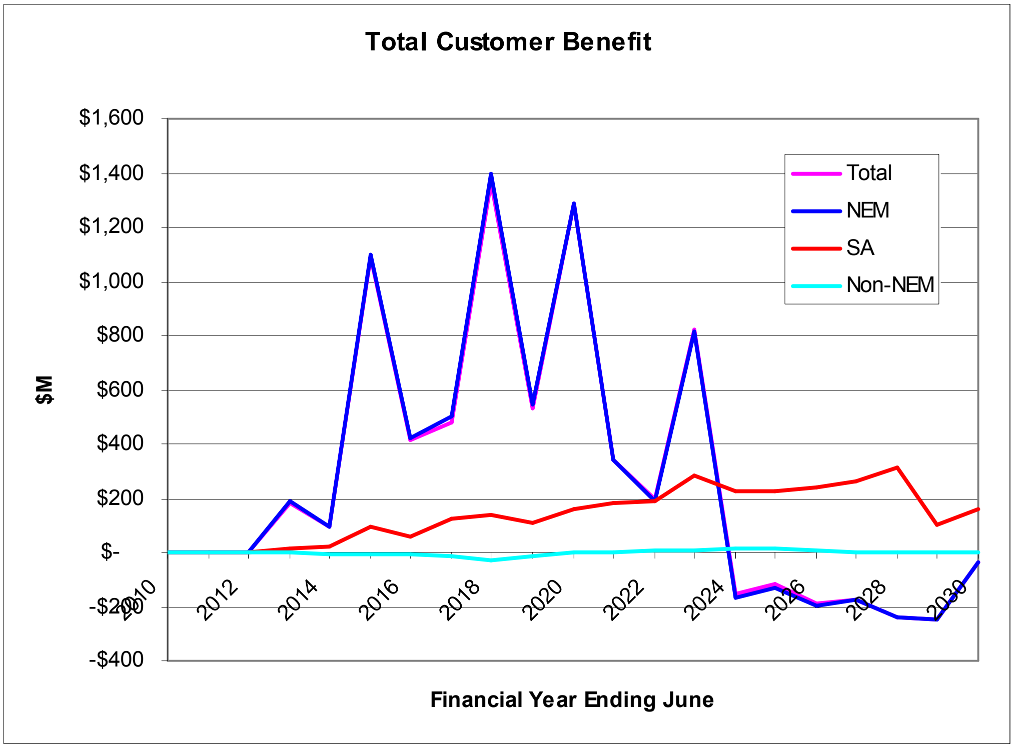
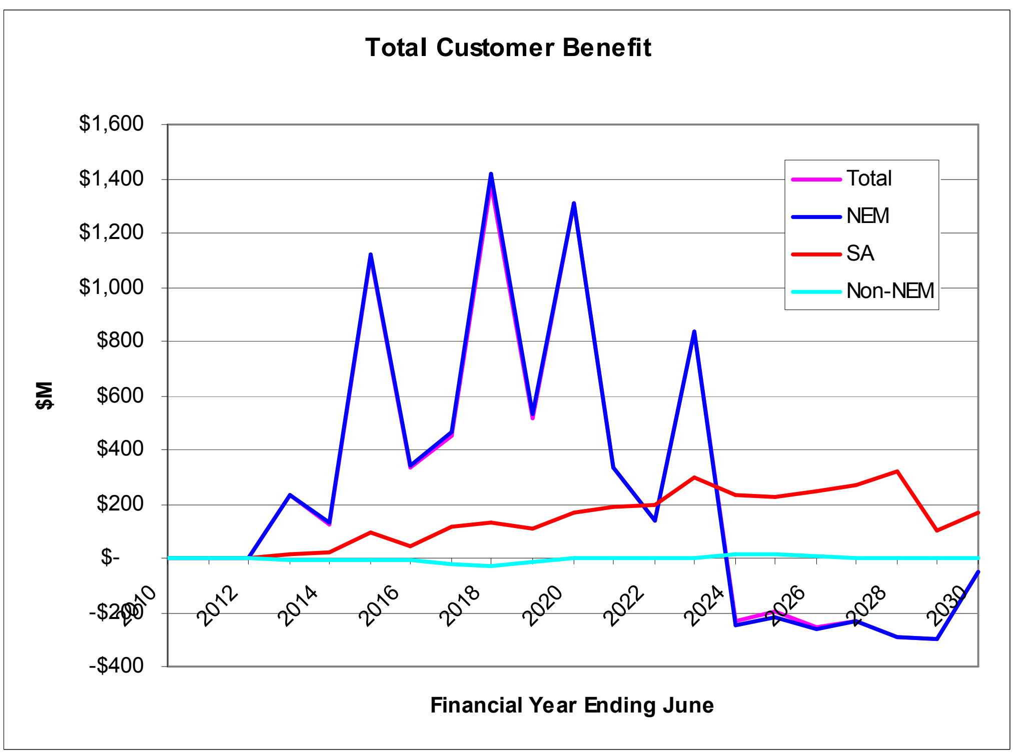


Figure 4-3 Total Customer Benefit (90% probability of achieving ET)



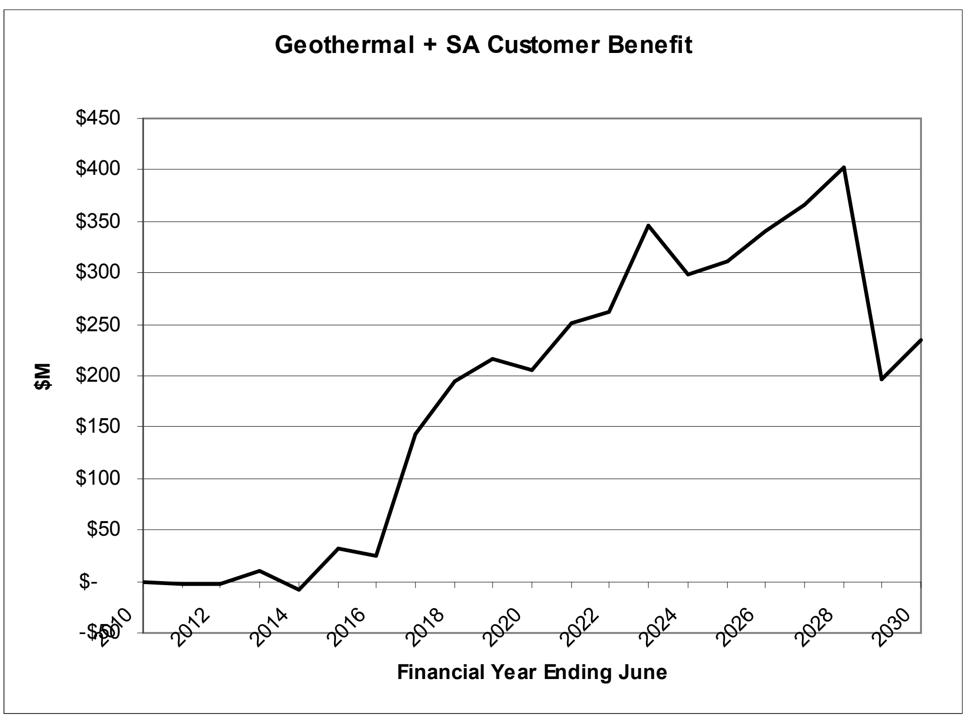
calculation is based on the assumption of an 80 percent probability of achieving the *Early Transmission* timing and a 20% probability of achieving the *Delayed Generation timing.* When the downside risks of early transmission is reduced (say a 90%/10% weighting), the total customer benefit could be further improved (see Figure 4-3).

4.5 Total South Australian Benefit

Since the split between generator benefit and customer benefit is subject to the impact of the level of competition and the response of other generators to the larger scale development of renewable energy, it is subject to some uncertainty. However, due to the effect of the interconnection between Victoria and South Australia influencing the South Australian energy price relative to the Victorian energy price, it is clear that additional renewable energy in South Australia would tend to reduce energy prices in South Australia and reduce REC prices to the extent that higher cost wind resources are displaced in the renewable energy market.

Combining the geothermal generation benefit and the SA customer benefit eliminates some of this competitive effect and provides a guide to the net impact on South Australians as a group of the proposed early transmission development. This benefit excludes any costs or benefits to other thermal or renewable energy generators in South Australia. This is illustrated in Figure 4-4 for the 80%/20% weighting of the transmission development scenarios. There is a reasonably consistent pattern of benefit to customers and geothermal generators

Figure 4-4 Benefit to South Australian Customers plus Geothermal Generators



for this proposed extension of the transmission system of up to $300 M per year. The early benefits are primarily with the customers and the later benefits are shared between the generators and customers with customers receiving $200 M per annum. The year to year volatility arises because small price changes can produce significant changes in annual value. Some of this value would be smoothed in practice due to contracting energy supplies. The modelling assumes that customers pay 10% above spot energy prices as a contracting premium.

This analysis indicates that there is likely to be a long-term local economic benefit in South Australia from the proposed network extension.

4.6 REC Price and Non-NEM Customer Benefit

The Non-NEM Customer Benefit was assessed solely from the change in REC Price among the Scenarios as shown in Figure 4-5. There are some changes to the REC Price which arise from the variations in the energy price. The higher energy prices that result from delayed geothermal generation leads to a lower REC prices which provides some cost offset from a customer's viewpoint. Similarly, the lower energy prices that result from earlier geothermal generation can result in higher REC prices to the extent that the combination of energy and REC price is needed to match the long run marginal cost of the next new entrant. The geothermal generators would receive the combination of energy and REC price and are not so much concerned about the relative proportion of the components.

However the Non-NEM Customer Benefit is dependent on the REC Price effect as such customers do not receive any benefits from changes in NEM energy prices. The net result is shown in Figure 4-6. Overall, we would expect a slight net benefit of the additional renewable energy to the market as a whole. However, the results show a small loss of $25 M in present value. We consider this to be within the modelling uncertainty and therefore conclude that there is no significant long-term benefit to Non-NEM customers.

There are conflicting effects of the scenario conditions on the REC price in that the additional geothermal energy quantity would displace higher cost renewable energy and reduce REC price whereas the lower energy prices in the southern regions of the NEM would cause REC price to rise. There is also a third effect in that higher renewable energy in South Australia means less renewable energy elsewhere and slightly higher energy prices in other NEM regions. This was observed in NSW in the *Early Transmission* scenario after 2025. These higher energy prices elsewhere can compensate the effect on REC price of the lower price in SA.

Figure 4-5 REC Price

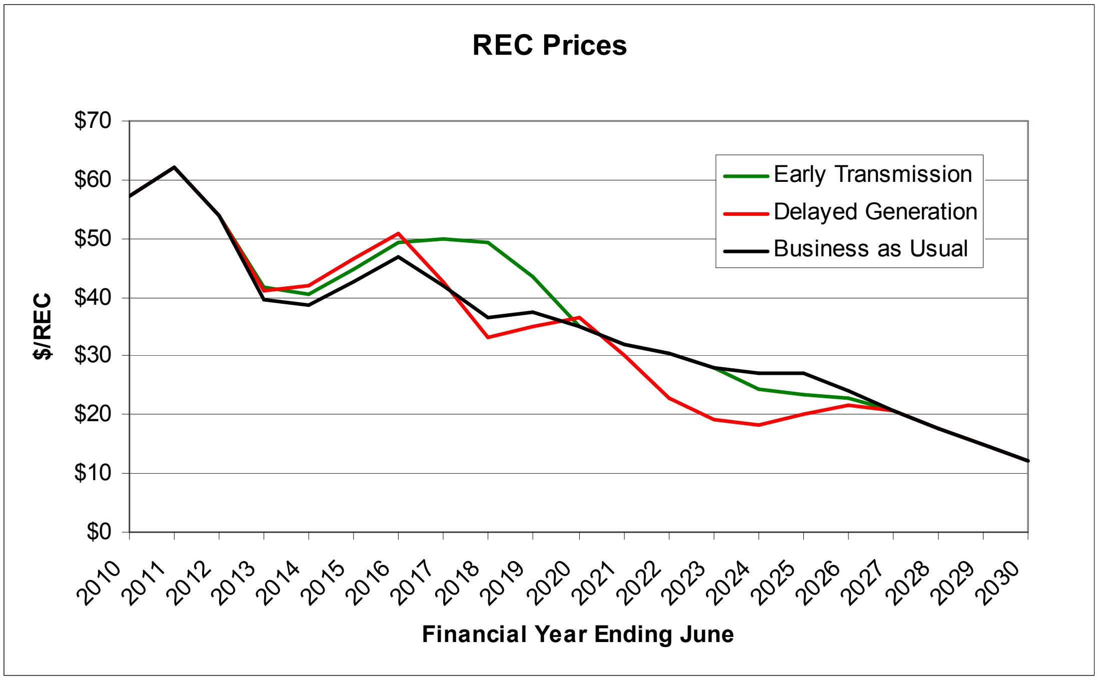
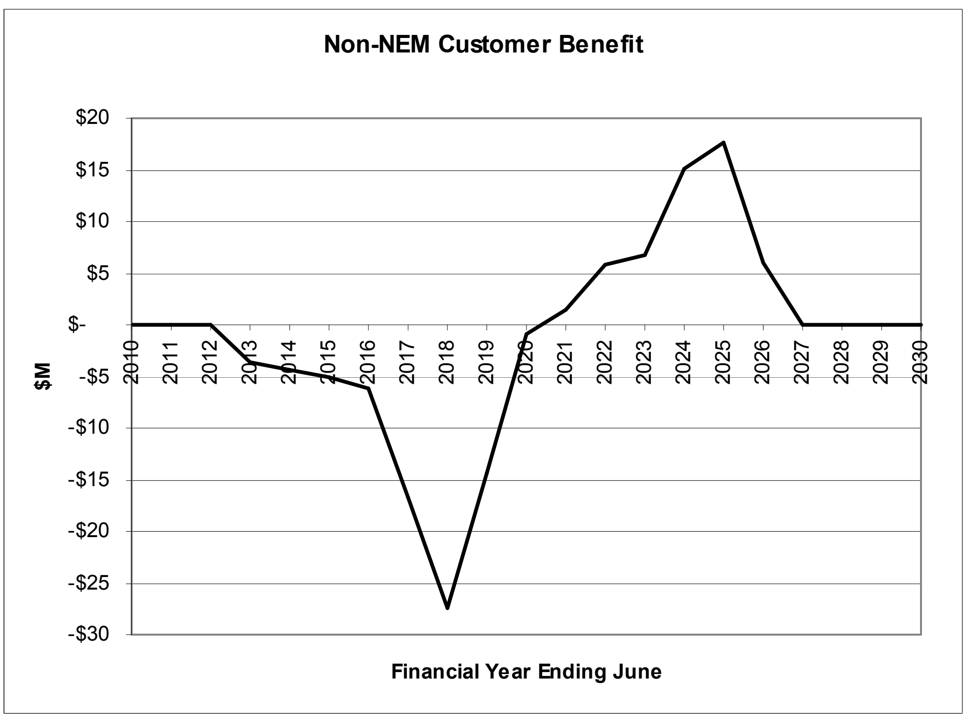


Figure 4-6 Non-NEM Customer Benefit



4.7 Annual Transmission Cost

The cost of transmission lines for the three modelled cases are depicted in Figure 4-7

The transmission cost is highest for the *Early Transmission* scenario and lowest for the *Business as Usual* scenario as one would expect. In *Early Transmission* scenario, a double circuit is installed to Innamincka but only a single circuit line is added between Olympic Dam and Davenport. The capital cost of the transmission lines is discussed in details in Section 2.5. The transmission costs are annualized using a life of 50 years and WACC of 7.8%. The timing of the transmission upgrade is summarized in Table 4-1. Note that the transmission cost for *Business as Usual* is quite similar to the *Delayed Generation* scenario and the *Early Transmission* scenario. This arises because the *Business as Usual* scenario requires a double circuit line from Davenport to Olympic Dam to supply the Olympic Dam load in the absence of reliance on large-scale geothermal power. Thus the network extension to Innamincka is considered to reduce the need for capacity to deliver power to Olympic Dam from further south. Note also that the addition of the single circuit from Paralana to Olympic Dam is not required in the *Delayed Generation* scenario, so this alleviates the risk of over development of the transmission network. That additional circuit can be delayed until the success in building the generation capacity is more certain.

Figure 4-7 Annual Transmission Cost

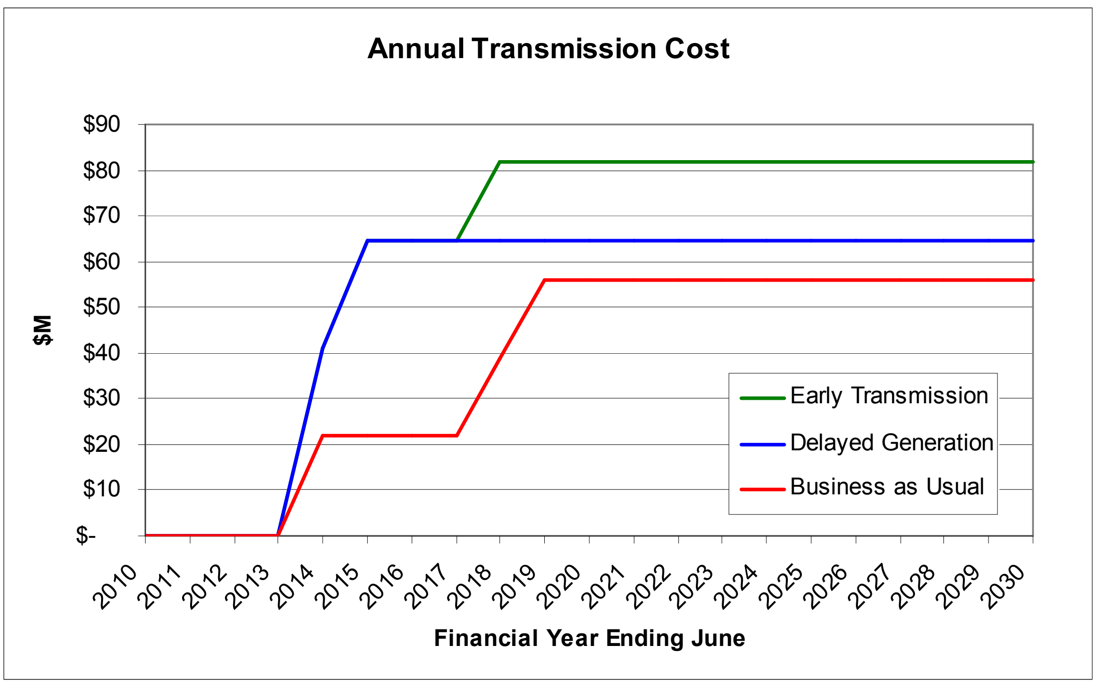


Table 4-1 Timing of Transmission Services

Timing of Transmission				Business as Usual		Early Transmission	
		Early Transmission		Delayed Transmission		Delayed Generation	
From	**To**	**Type**	**Year**	**Type**	**Year**	**Type**	**Year**
Innamincka	Paralana	Dcct	2015	Scct	2019	Scct	2015
Paralana	Olympic Dam	Dcct	2014	Scct	2018	Scct	2014
Olympic Dam	Davenport	Scct	2014	Dcct	2014	Scct	2014
Paralana	Olympic Dam	Scct	2018			Scct	3000

4.8 Total System Cost

The Total System Cost is defined as the combination of thermal energy market cost plus the total cost of the renewable energy market including the additional transmission lines and connections. The renewable energy market cost does not include the capital cost of committed and existing projects, apart from Innamincka and Paralana. In the renewable energy market cost (excluding Innamincka and Paralana, Figure 4-8), *Early Transmission* and *Business as Usual* have the lowest and highest system cost respectively. This is what one would expect since cheaper geothermal resources are available in *Early Transmission* scenario to replace the more expensive renewable options.

Figure 4-8 Total Renewable Energy Market Cost (excl. Innamincka and Paralana)

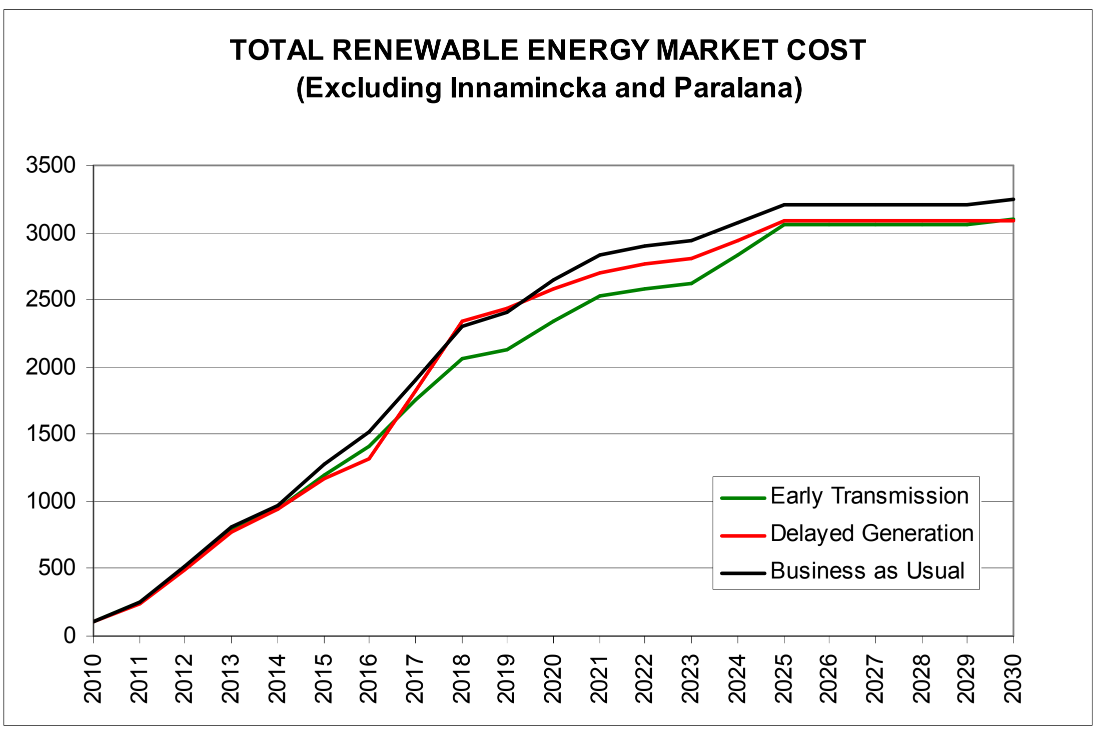


Figure 4-9 shows the total renewable energy market cost between the three cases (taking into account Paralana and Innamincka). There is significant variation in the cost between the three scenarios in absolute terms. The relative difference is small because the renewable energy market is so large under the new scheme. The generation cost saving

Figure 4-9 Total Renewable Energy Market Cost

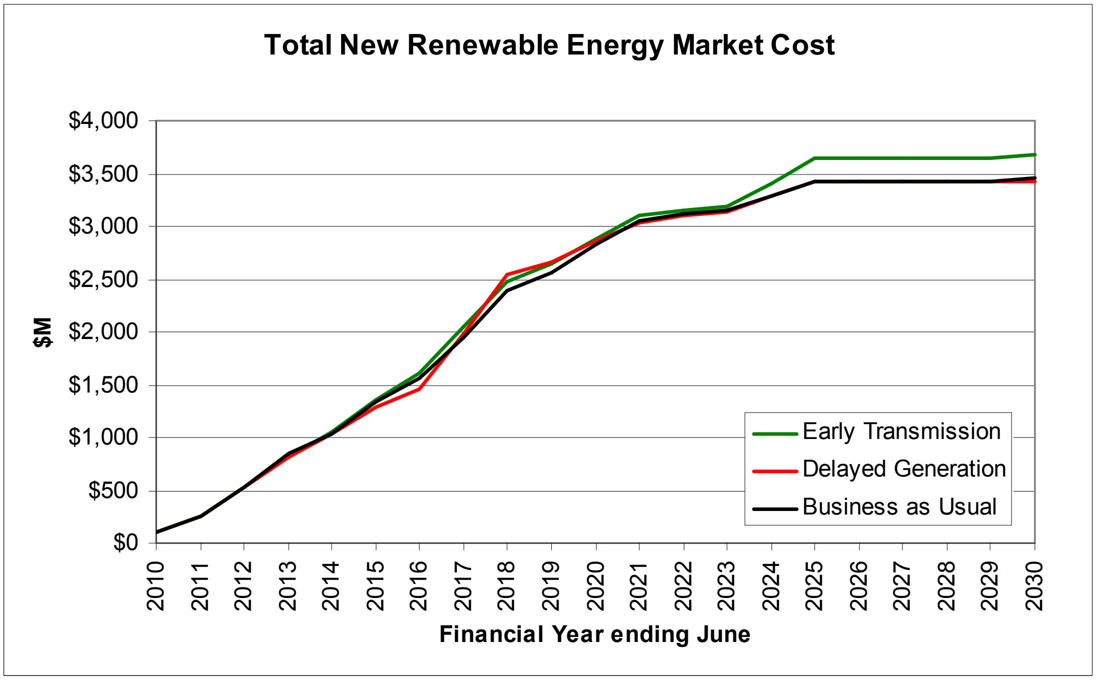
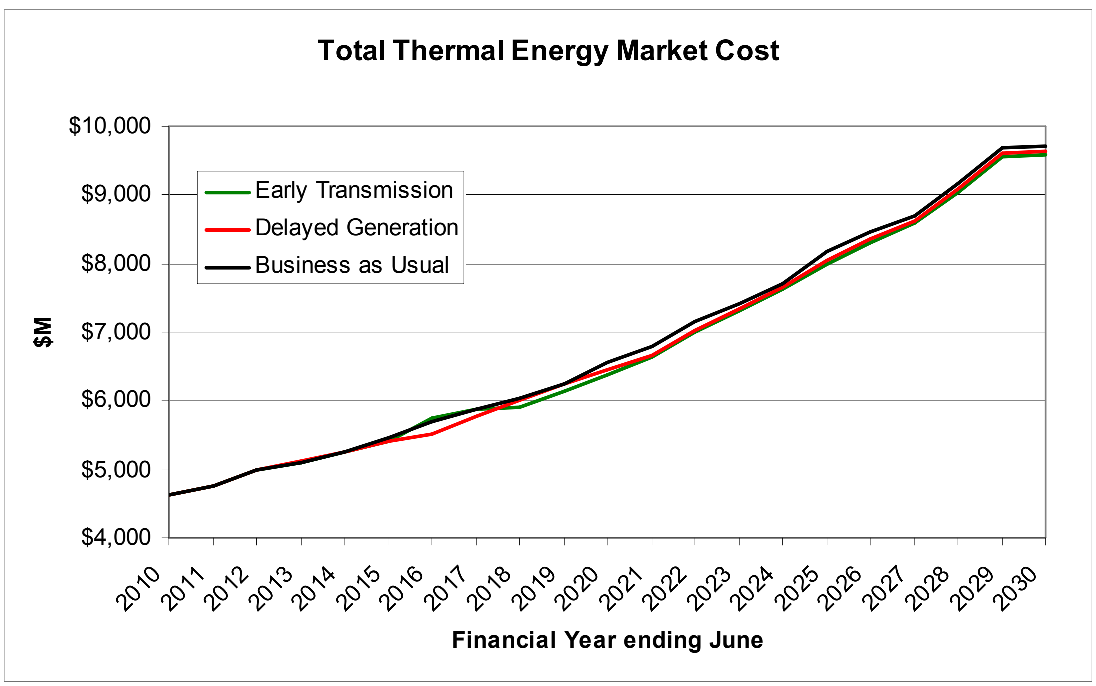


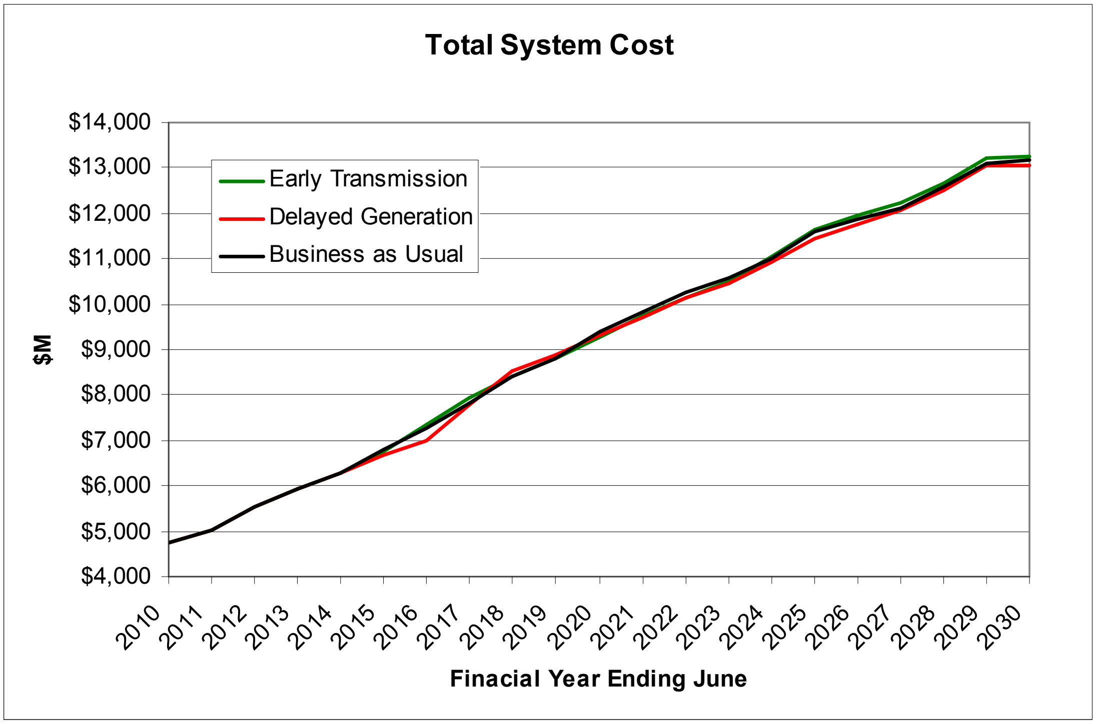
Figure 4-10 Total Thermal System Cost



in the *Early Transmission* scenario is offset by the higher transmission cost associated with building the double circuit transmission lines between Innamincka and Olympic Dam.

The realisation of the economic benefits comes about more through the interactions with the thermal generation market. The Total Thermal System Cost is shown in Figure 4-10. It may be noted that the Early Transmission scenario has significantly lower thermal system

Figure 4-11 Total System Cost

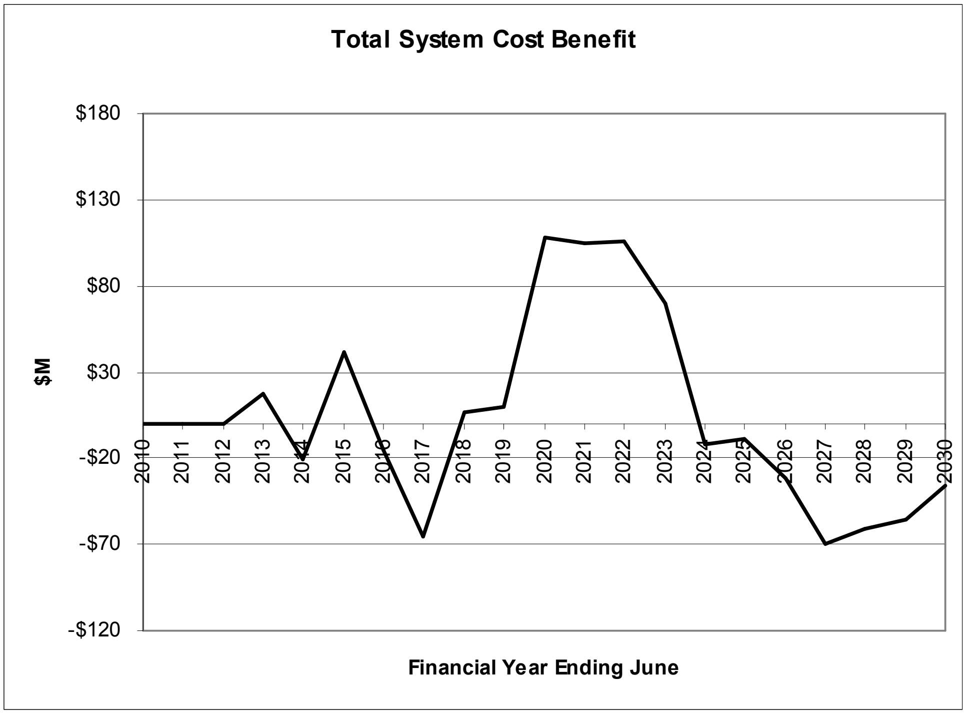


costs in the middle and later period of the analysis. If the geothermal generation is delayed, then this benefit is lost as some new thermal generation capacity needs to be advanced and generation levels increased.

The *Early Transmission* scenario has lower total thermal system cost in comparison to *Delayed Generation and Business As Usual cases*. This is due to the reduced loading on gas fired plants in SA when a greater portion of base load is supplied by the cheaper renewable energy generation, hence reduces the thermal system cost. The total system cost for the three cases are depicted in Figure 4-11. It may be noticed that there are some variations in relative cost over time. To the extent that the full utilisation of the double circuit line from Olympic Dam to Innamincka can be exploited there is the prospective of reduced economic costs overall. However, due to the long distance and relatively high cost, it will be necessary to optimise the overall development to ensure that these economic benefits are captured during and as a result of the development program. Benefits can be achieved during the development program providing there is a sufficient level of confidence for the lower cost sources of generation to be developed in a timely manner and the higher cost resources to be delayed from development.

The Weighted System Cost Benefit is shown more clearly in Figure 4-12. The net benefit is defined by combining the *Early Transmission and Delayed Generation* scenarios, with a probability of 80% in achieving Early Transmission outcome and a 20% probability for the double circuit transmission line to proceed with *Delayed Generation* as the resulting

Figure 4-12 Weighted Total System Cost Benefit (with 20% downside risk)



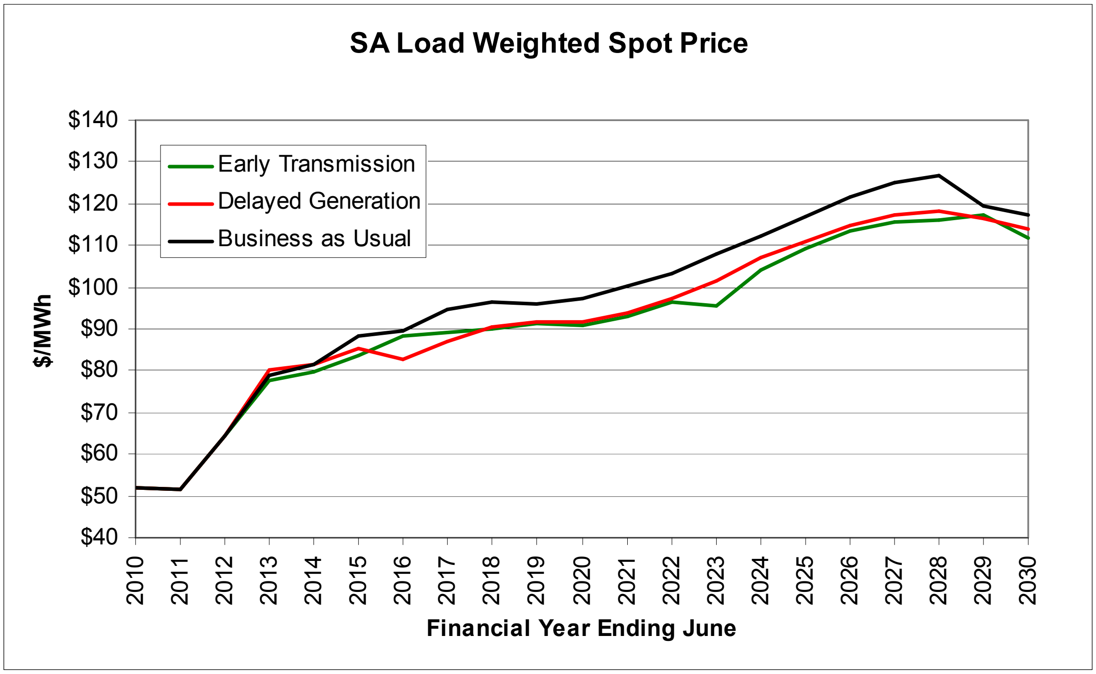
outcome. The System Cost benefit is maximised after the transmission line is completed and the geothermal generation approaches the capacity of the transmission line. Eventually the system cost benefit will be eroded as the renewable energy mix achieves its lower cost potential and the thermal system has adjusted to the distribution of renewable energy production. Having regard to the inherent difficulty in making these calculations without extensive refinement of the individual scenarios to keep all factors internally consistent, these results should be regarded as indicative in magnitude. The present value of the Total System Cost Benefit is $68 M over this period.

The Downside scenario has a lower Total System Cost than the Early Transmission scenario, which was not expected. We would take this to indicate that there is further opportunity to optimise the overall transmission and generation development program to minimise total market costs. This points to the issue that when planning large power development programs, one cannot assume that the most rapid development is the most economic or profitable, despite apparent economies of scale. Therefore, MMA recommends that Geodynamics, Petratherm, and other geothermal developers will need to coordinate their activities and related network planning to obtain the best outcome for themselves and the customers.

4.9 Effect on South Australian Energy Prices

Figure 4-13 shows the load weighted South Australian energy price, which was used to assess the customer benefits. The chart shows that the extra geothermal generation is expected to lower SA energy prices significantly primarily through reducing imports and

Figure 4-13 South Australia Load Weighted Energy Price

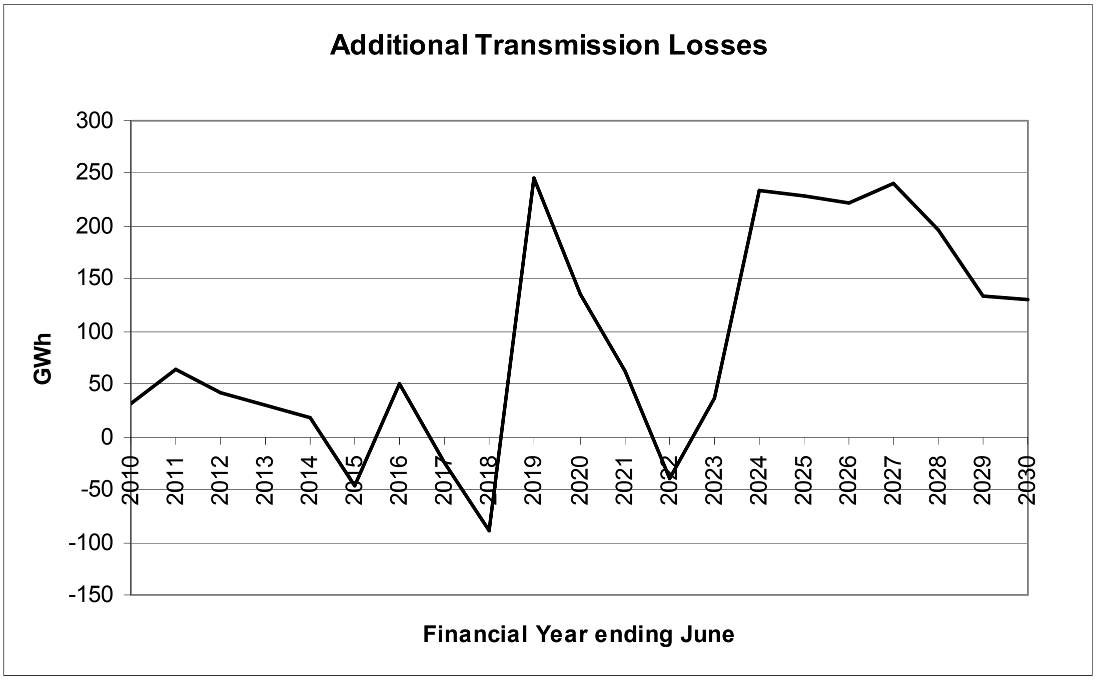


increasing exports from South Australia. In the *Business as Usual* scenario, an additional CCGT is built in South Australia to compensate for the lower level of renewable energy from geothermal sources. Additional thermal capacity would be needed in principle to compensate for the greater amount of variable wind powered generation that replaces the lost geothermal energy.

4.10 Effect on Transmission Losses

The analysis also examined the inter-regional transmission losses in the Strategist NEM model including the losses on the network from Innamincka all the way down to Torrens Island. The losses were based on quadratic loss functions for these connections within South Australia, the key interconnectors as well as some intra-regional links within Queensland. The overall result showed that network losses would increase by about 200 GWh net for a net 5600 GWh supplied from Innamincka and Paralana. This is about 3.6% of the generation delivered from the geothermal sites and 4.1% of the power delivered to Olympic Dam. There are some loss savings from the redistribution of inter-regional power flows that offset the losses of some 480 GWh on the lines to Olympic Dam at the full output. Thus, there are some offsetting benefits arising from reducing transmission losses elsewhere in the NEM.

Figure 4-14 Additional Transmission Losses (Weighted)



4.11 Overall Assessment

Table 4-2 shows the net benefits in the various categories in present value terms over the study period to 2030 at 9.3% real discount rate.

The Table includes either cost or revenue items for each scenario depending on the benefit component being assessed:

- The revenue and net benefit for the geothermal generators at Paralana and Innamincka are based on contracted revenue and REC price changes for each scenario;
- The total customer impact for South Australia, the NEM and all Australian customers are based on changes in wholesale load weighted prices and wholesale sent-out generated volumes. Note that secondary impacts due to changes in transmission marginal loss factors within regions were not assessed;
- The total customer impact for non-NEM customers was based on the change in REC price times sales volumes;
- The total system economic benefit was based on generation and fuel costs and capital costs for new facilities.
- The SA Benefit as shown includes only the SA customers and the geothermal generators. It does not include impacts on thermal generators in South Australia which would be unfavourable.

The weighted benefit is shown assuming a 20% probability of the geothermal generation being delayed and only reaching half its potential capacity by 2020. Whilst the overall total system costs are not significantly different, there are some significant customer benefits and geothermal generator benefits in South Australia. The Non-NEM benefit is regarded as negligible.

Table 4-2 Net Benefits in Present value Terms

	NPV Comparison	Geothermal Generation Benefit	Customer Impact $M				SA Benefit	Total System Cost	
			Total	Non-NEM	NEM	SA			Transmission
Scenarios with Early Transmission	Early Transmission	$214.18	$202,907	$886	$202,021	$16,756	$1,139*	$70,592	$427
	Late Generation	$16.47	$202,099	$819	$201,279	$16,912	$784*	$70,146	$365
Base Case	Business as Usual	-$33.05	$205,523	$848	$204,675	$17,647	0	$70,570	$244
Weighted benefit of proposed transmission development		$207.69	$2,778	-$25	$2,802	$860	$1,068	$68	-$171

Notes: Refer to bullet points above table for definition of components of benefits

* these components are benefits relative to the Base Case which is zero. They are the sum of the SA customer benefits plus the geothermal generator benefits.

These results confirm that a double circuit 275 kV transmission line extension from Olympic dam to Innamincka via Paralana in conjunction with reinforcement of the Davenport to Olympic Dam transmission 275/132 kV system would enable geothermal energy to be connected to the NEM with the prospect of net economic benefits. Whilst there is a risk that the full geothermal potential may not be developed following completion of the double circuit line, it is likely that the network extension would provide other benefits for regional loads and other forms of renewable energy. As long as the geothermal capacity reaches some 400 MW there would remain net economic benefits from the transmission development. The studies to date indicate that there is scope to optimise the timing and staging of the geothermal development to maximise overall market benefits.

5 CONCLUSIONS

The analysis has shown that a double circuit 275 kV transmission line from Olympic Dam to Innamincka in association with full development of Olympic Dam would provide net economic benefits of some $1,068 M in present value terms in South Australia for South Australian customers and the geothermal industry. The net benefits to NEM customers was assessed as $2,802 M in present value terms, including the South Australian customer benefit.

The net present value economic benefits over the whole NEM to all generators and customers is much smaller at $68 M due to the detriment to forms of generation other than geothermal power. However, there is a compelling case for South Australian market participants to ensure that such strategic investments that open up the renewable energy resources of the State are pursued in an effective and economic manner. The studies indicate that there is scope to optimise the timing and staging of the geothermal development to maximise overall market benefits and thereby improve the assessed value of $68 M.

The analysis that has been conducted is only preliminary in that it only looks at one market scenario with varying success in geothermal development and only from the viewpoint of two proponents in the renewable energy market. The analysis has adopted some conservative features which may be partially offset by the more optimistic assumption that Olympic Dam expansion proceeds to completion by 2017/18. The full optionality of the proposed network development to assist other geothermal or solar thermal projects has not been considered and hence there may be some more value in the concept. Overall, MMA considers that this preliminary assessment is sufficient to provide a basis for easement and terminal station site planning so that feasible connection routes can be identified and a solid basis established for further exploring the costs and benefits.