ERC0115 - Data for simple cycle costs for developing an index for the Market Price Cap

SKM REPORT ON SIMPLE CYCLE COST TRENDS

- Version 5
- 4 March 2011

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Sinclair Knight Merz
ABN 37 001 024 095
Level 11, 452 Flinders St
Melbourne VIC 3000 Australia
Tel: +61 3 8668 3000
Fax: +61 3 8668 3001
Web: www.skmconsulting.com

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1. Introduction

1.1. General

Sinclair Knight Merz (SKM) has been engaged by the Australian Energy Market Commission (AEMC) to provide data on the cost trends of Simple Cycle Gas Turbine (SCGT) powerplant that could have been developed in the National Electricity Market (NEM) in the period 1998 to 2010.

This is to inform the possible adoption of an index for the setting of the Market Price Cap in the National Electricity Rules (NER).

1.2. Background

The AEMC is currently considering a Rule change request submitted by the Reliability Panel that proposes (amongst other things) the indexation of the Market Price Cap and the Cumulative Price Threshold in accordance with the Stage 2 (intermediate) Producer Price Index (PPI).

The PPI was chosen as a proxy for movements in the costs of the new entrant SCGT plant which is generally assumed to be the marginal plant, and which is generally used as a guide in setting the Market Price Cap. This process is proposed to commence on 1 July 2012.

To help assess the value of the Stage 2 PPI for the above intended purpose, the AEMC is seeking to compare historic percentage price movements in this index against movements in the actual costs of SCGT plant.

AEMC expect this to be a qualitative evaluation rather than a strictly quantitative exercise as it is not expected that the chosen index will track SCGT costs exactly and there will be other factors that come into the final consideration such as desired levels of volatility etc. The purpose of this review is simply to provide a base from which to make a reasonable comparison between the different measures.

1.3. Method

Setting of the Market Price Cap includes consideration of the Long Run Marginal Cost of an efficient new entrant power plant designed to supply the market's highest demand segment[1]. Otherwise the Market Price Cap might obstruct the development of a generation plant necessary to meet a unit of demand growth that should be met according to the NEM's objectives.

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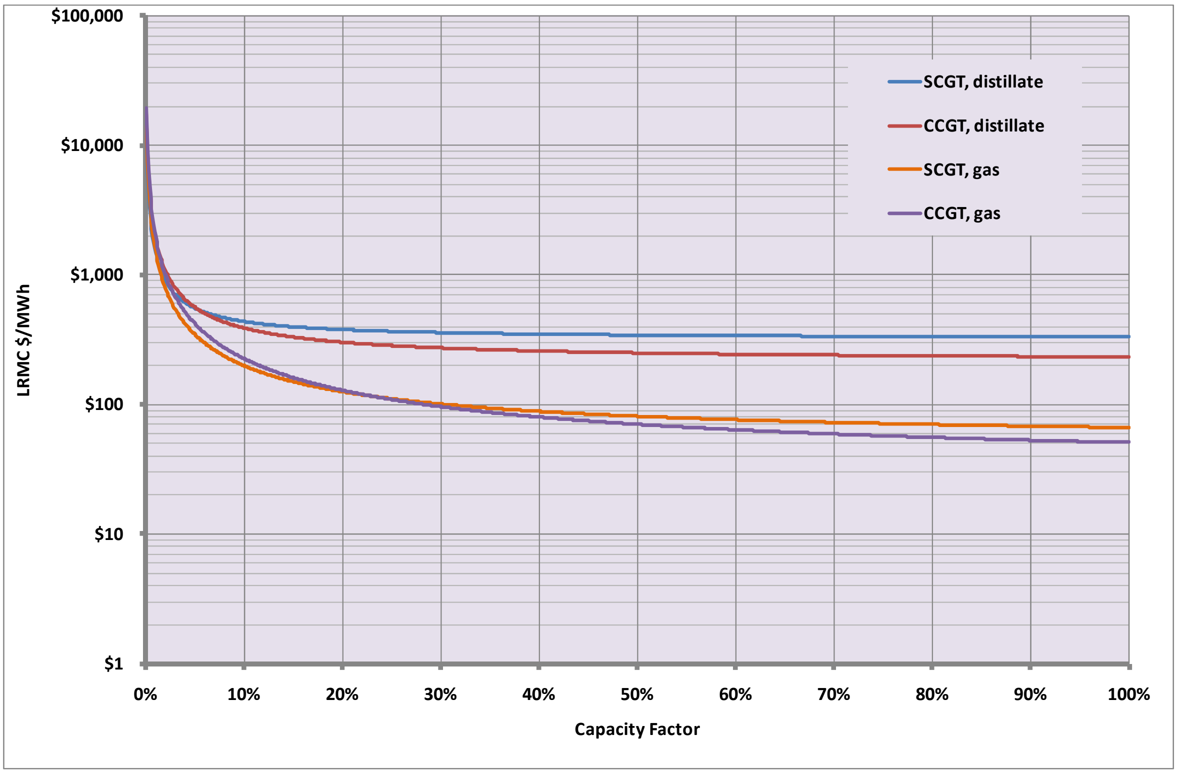
[1] The other elements that might be considered in the Market Price Cap are not within the scope of this review.

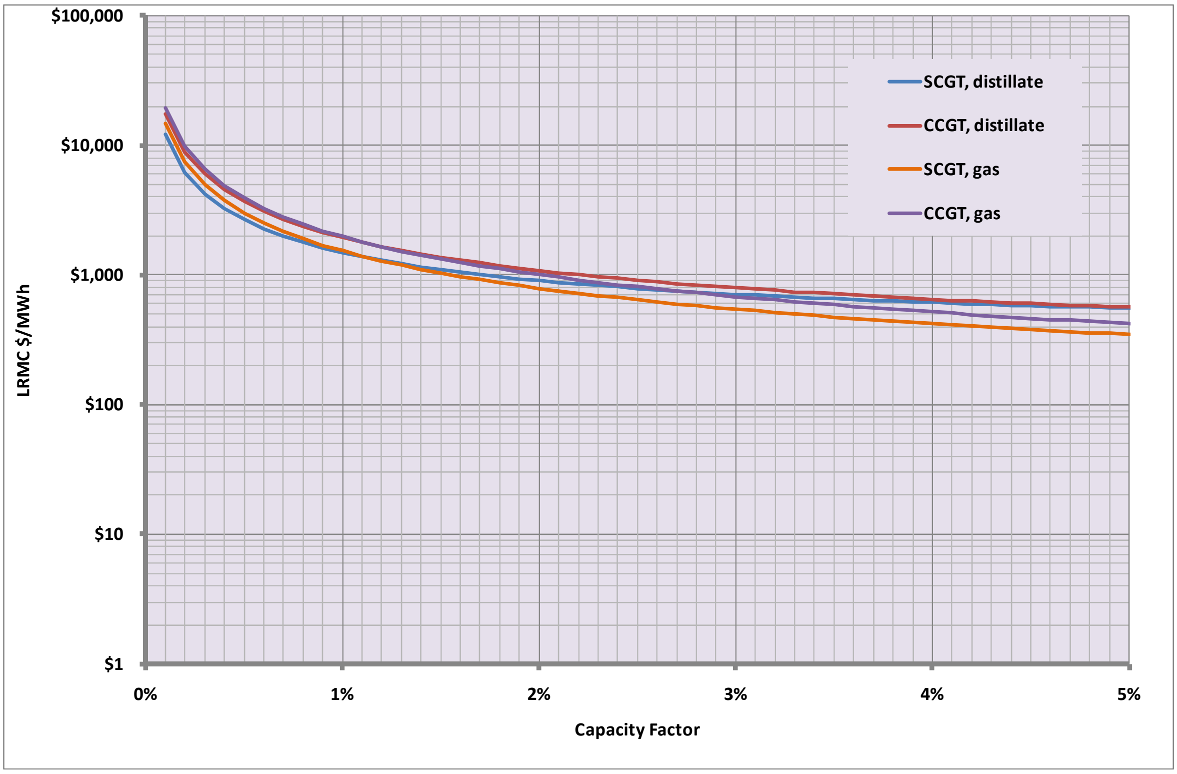
As shown in Figure 1 and Figure 2, at very low capacity factors, SCGT powerplants have a lower long run marginal cost than Combined Cycle Gas Turbines (CCGT)[2].

- **Figure 1 Gas turbine based life cycle costs at high capacity factors**



[2] Other technologies such as coal and renewable energy are not relevant to this discussion but in any case would have a higher cost at very low capacity factors.

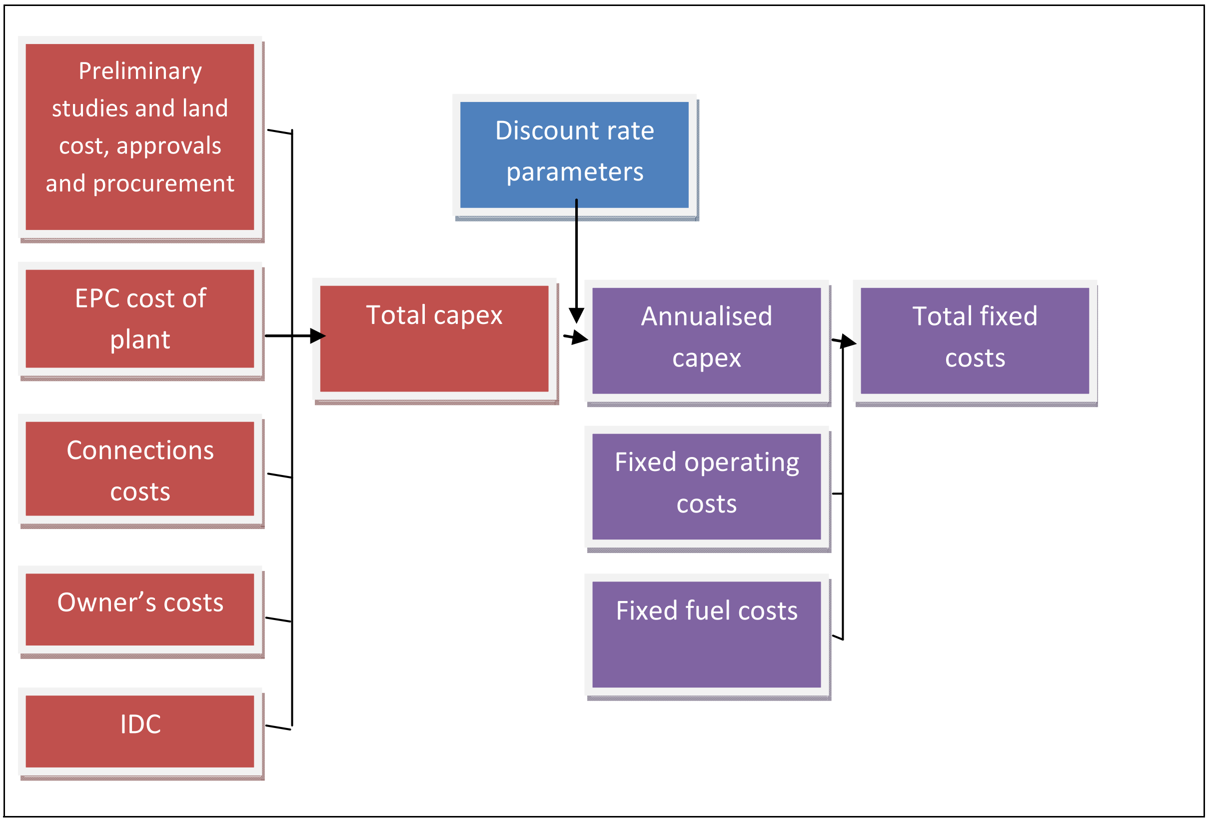
■ **Figure 2 Gas turbine based life cycle costs at low capacity factors**



At very low capacity factors the variable costs of a powerplant become immaterial, leaving the costs dominated by fixed costs. In this review, we consider the trend in fixed costs of a new entrant SCGT plant from 1998 to 2010 for comparison against other indices.

The elements of the calculation of fixed costs for a generic power plant are shown in Figure 3

Figure 3 Elements of fixed costs for power plant



In Figure 3, "EPC cost" is the capital cost that would be paid to the contractor who would deliver the main powerplant, "IDC" is Interest During Construction, representing the time value of the extent that the construction cashflows precede the plant's commercial operation date. Connection costs include the electricity and gas (if applicable) connection costs for the plant. Other connection costs could include water supplies, communications etc but for the plant types considered here these tend to be small. There may also be costs for infrastructure upgrades (such as reinforcing roads and bridges).

The total capital cost is made of the elements above or allowances (typically as percentages of the other elements) to cover these areas of the costs of delivering a project.

The annual payment amount equivalent to a total capital cost amount is given by:

$$PMT = \frac{d(1+d)^n}{(1+d)^n - 1} C$$

Where:

PMT = the annualised payment ($/year)

d = the discount rate;

n = the economic life of the asset;

C = the capital cost ($)

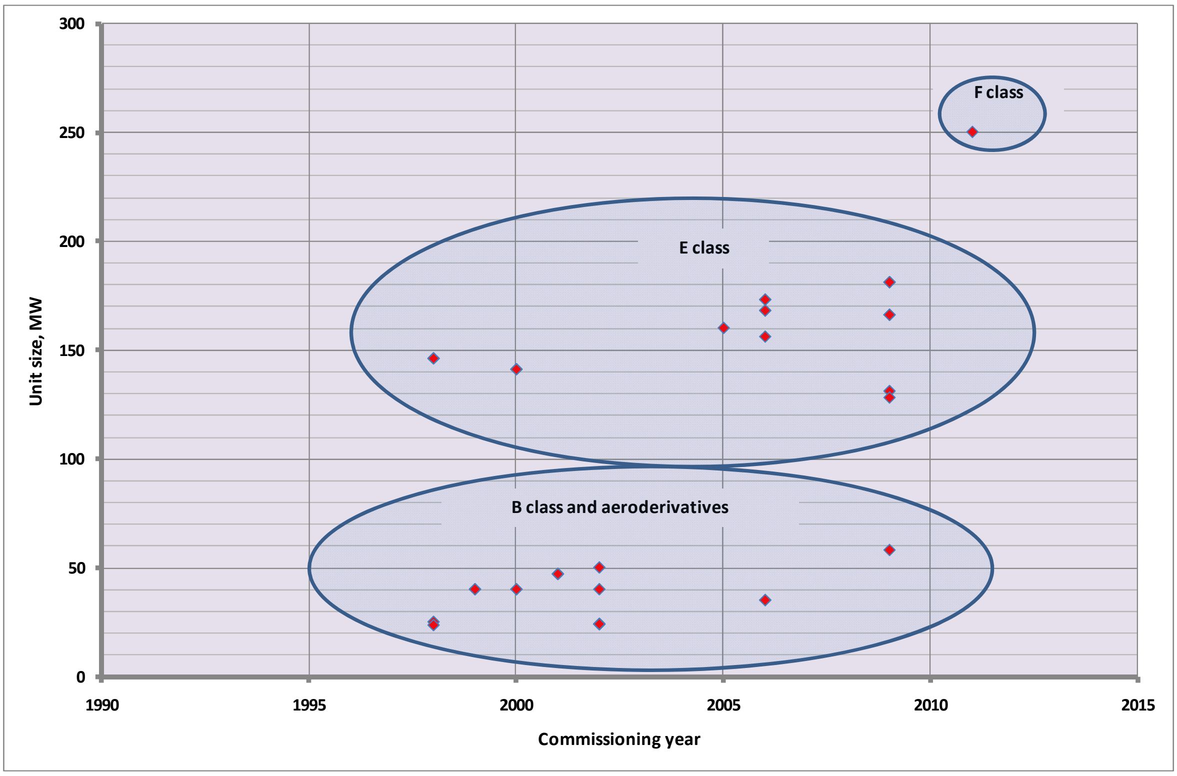
2. Parameters of a simple cycle new entrant

The SCGT plants that have been constructed in the NEM since 1998 can be categorised in three bands based on the gas turbine units deployed:

- Small gas turbines below 100MW. Based on aeroderivative gas turbines or "B" class gas turbines (such as Frame 6). Many of these are based on second-hand units;
- Most of the SCGT capacity is made up of "E" class industrial gas turbines between 100 and 200MW capacity/unit; and
- One plant (Mortlake) that uses "F" class industrial gas turbines in SCGT configuration.

These are shown in Figure 4.

Figure 4 Simple cycle gas turbine plants in the NEM, after 1990



The efficient new entrant is considered to be the larger sized gas turbines (more than 100MW unit size). This technology is subject to economies of scale and hence the larger units have a lower cost per MW than smaller units on a general basis. Thus, the "E" and "F class gas turbines larger than 100MW unit size are considered in the analysis.

The parameters of the current generation of "E" and "F" class gas turbines are shown in Table 1.

Table 1 Gas turbine parameters, clean-as-new[3]

	Net MW (ISO)	Net Heat Rate (ISO) GJ/MWh LHV
"E" Class		
Frame 9E	126.1	10.656
M701DA	144.1	10.350
SGT5-2000E	168	10.365
GT13E2	182.2	9.625
"F" Class		
Frame 9FA	256.2	9.728
Frame 9FB	284.2	9.512
SGT5-4000F	292	9.038
GT26	292.8	9.091
M701F4	312.1	9.161

[3] Data based on Gas Turbine World Handbook, 2010. Note ISO conditions refer to ambient and site conditions of 15°C, 60% RH, sea-level. "Clean-as-new" refers to the performance before making allowances for degradation. LHV refers to heat rate based on the Lower Heating Value of the fuel.

3. Simple cycle power plant cost structure

The cost structure of the EPC component of the capital cost has been analysed.

The estimated EPC capital cost for a SCGT plant in the NEM is presently approximately AUD650/kW. The indicative breakdown of this into components is shown in Table 2. The breakdown was derived using the PEACE[4] program.

- **Table 2 Indicative breakdown of EPC capex, SCGT plant**

	O/S equipment	Local equipment/ materials	Labour	Other	Total
Specialised equipment	60.0%	0.0%	0.0%	0.0%	60.0%
Other equipment	0.9%	0.9%	0.0%	0.0%	1.8%
Mechanical	0.6%	2.6%	4.7%	0.0%	7.9%
Electrical	0.5%	1.9%	4.8%	0.0%	7.2%
Civil, buildings	0.0%	1.2%	1.3%	0.0%	2.5%
Engineering& startups	0.0%	0.0%	2.1%	0.0%	2.1%
Contractor's o'heads, margins etc	0.0%	0.0%	0.0%	18.5%	18.5%
Totals	**62.0%**	**6.6%**	**12.9%**	**18.5%**	**100.0%**

For a SCGT plant, the cost is dominated by the imported cost of the main equipment – the gas turbine genset, control system and often the generator transformer also. A lesser proportion of approximately 20-30% is attributable to local equipment, local materials and commodities, and local labour (incl. management). The last category comprises the contractor's soft costs such as management, preliminaries, contingencies and profit.

The external infrastructure costs (electricity and gas connections, roads etc) vary considerably from site to site and also depend on how many units are planned for the site. A nominal amount of AUD40M would cover most 2x150=300MW plants, which would add $133/kW.

The other parameters (land, studies, procurement, owner's costs and IDC) are typically allowed as percentages of the above and hence won't influence the construction of an index. For completeness we allow 6% for pre-financial close costs, 11% for owner's costs and 3% for IDC.

The total capital cost on this basis would thus be (650+133)*1.06*1.11*1.03 =$944/kW.

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[4] Part of the GTPro suite of gas turbine powerplant analysis package by Thermoflow, Inc.

4. Data sources and cost trends

The cost trends of the gas turbines listed in Table 1 (or earlier versions of the same basic gas turbine model) from Gas Turbine World Handbook (various editions) are shown in Table 3. Note that separate Handbooks were not published in three of the years as shown.

- **Table 3 Gas turbine cost data from Gas Turbine World Handbook, USD/kW**

Current designation	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Frame 9E	\$182	\$183	\$199	\$207	\$210		\$165	\$150		\$188		\$231	\$260	\$245
M701DA	\$189	\$182	\$195	\$202	\$204		\$155	\$155		\$186		\$236	\$253	\$239
SGT5-2000E	\$180	\$180	\$188	\$190	\$194		\$155	\$150		\$180		\$225	\$243	\$230
GT13E2	\$208	\$205	\$205	\$209	\$213		\$166	\$155		\$186		\$236	\$241	\$231
Frame 9FA	\$186	\$188	\$190	\$194	\$199		\$160	\$152		\$177		\$224	\$228	\$212
Frame 9FB							\$170	\$148		\$177		\$229	\$238	\$230
SGT5-4000F	\$188	\$187	\$191	\$194	\$190		\$159	\$147		\$182		\$244	\$251	\$231
GT26	\$191	\$190	\$190	\$196	\$198		\$148	\$148		\$181		\$240	\$250	\$231
M701F	\$189	\$181	\$186	\$187	\$189		\$160	\$160		\$180		\$237	\$247	\$227
Avg E class	\$190	\$188	\$197	\$202	\$205		\$160	\$153		\$185		\$232	\$249	\$236
Avg F class	\$189	\$187	\$189	\$193	\$194		\$159	\$151		\$179		\$235	\$243	\$226
Avg E and F	\$189	\$187	\$193	\$197	\$200		\$160	\$152		\$182		\$234	\$246	\$231

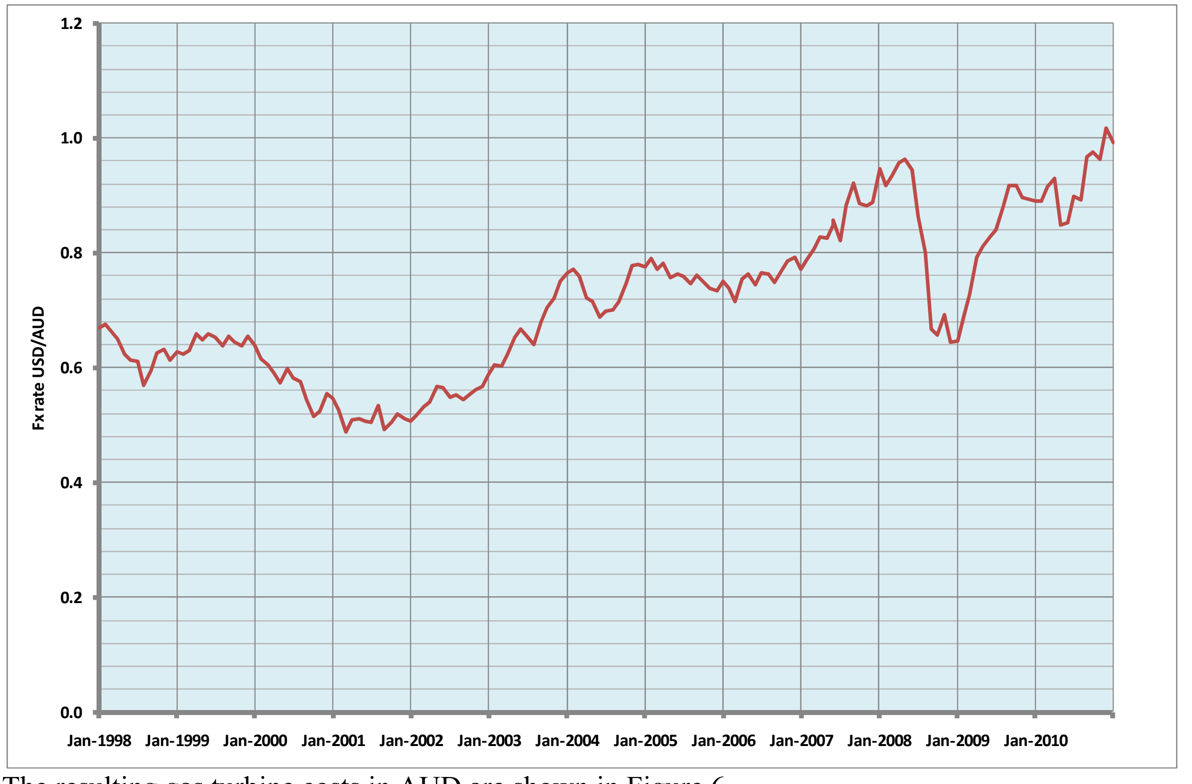
The Handbook prices are quoted in USD. The foreign exchange trends in the relevant years are shown in Table 4 and Figure 5.

- **Table 4 Foreign exchange rate trends[5]**

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
USD AUD	0.737	0.628	0.644	0.576	0.513	0.546	0.657	0.736	0.761	0.757	0.843	0.853	0.799	0.920

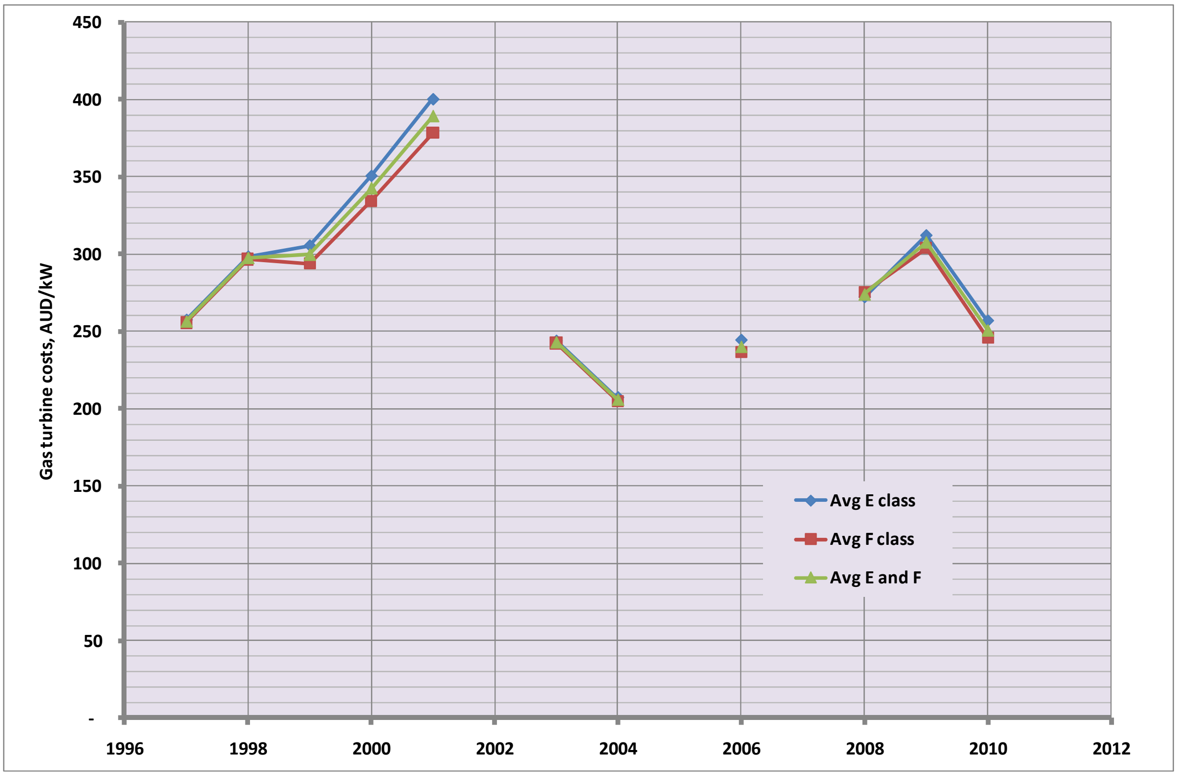
[5] Fx, CPI, interest rates applied are from Reserve Bank of Australia, monthly data averaged to annual unless noted otherwise

▪ **Figure 5 Foreign exchange rate trends**



The resulting gas turbine costs in AUD are shown in Figure 6.

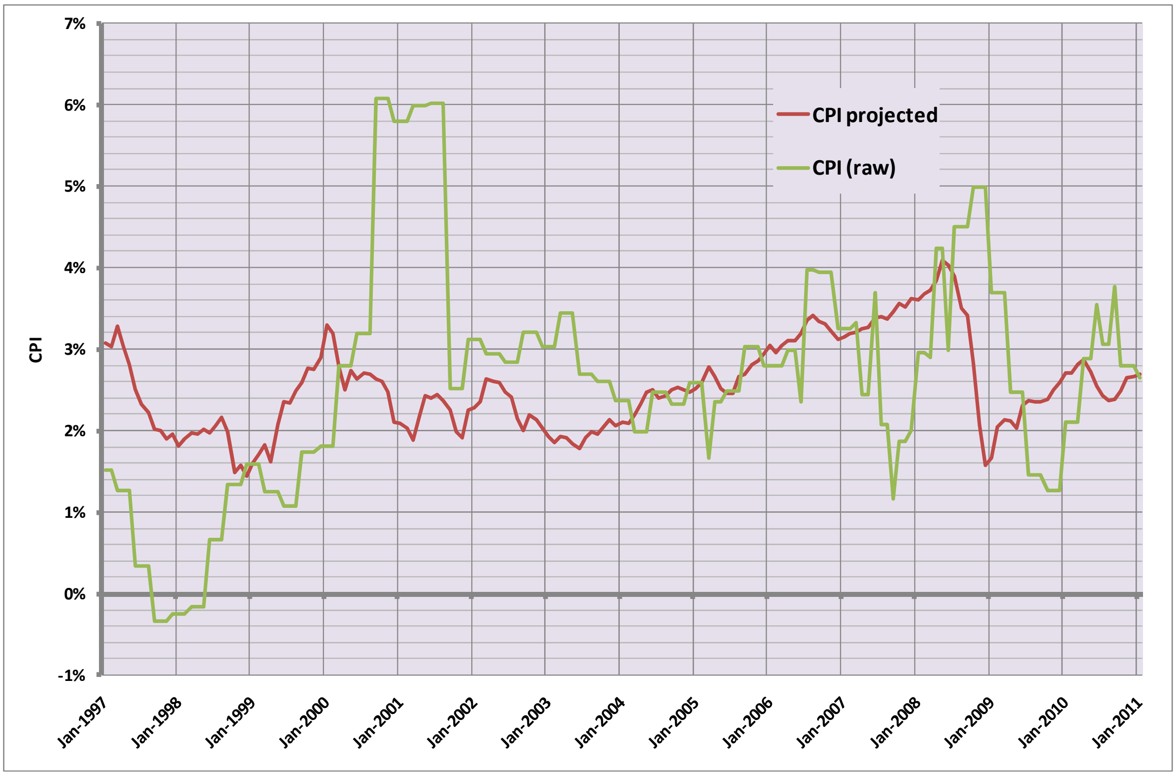
- **Figure 6 Gas turbine cost trends, based on Gas Turbine World Handbook, AUD/kW**



The trends in other parameters used in the analysis are given below:

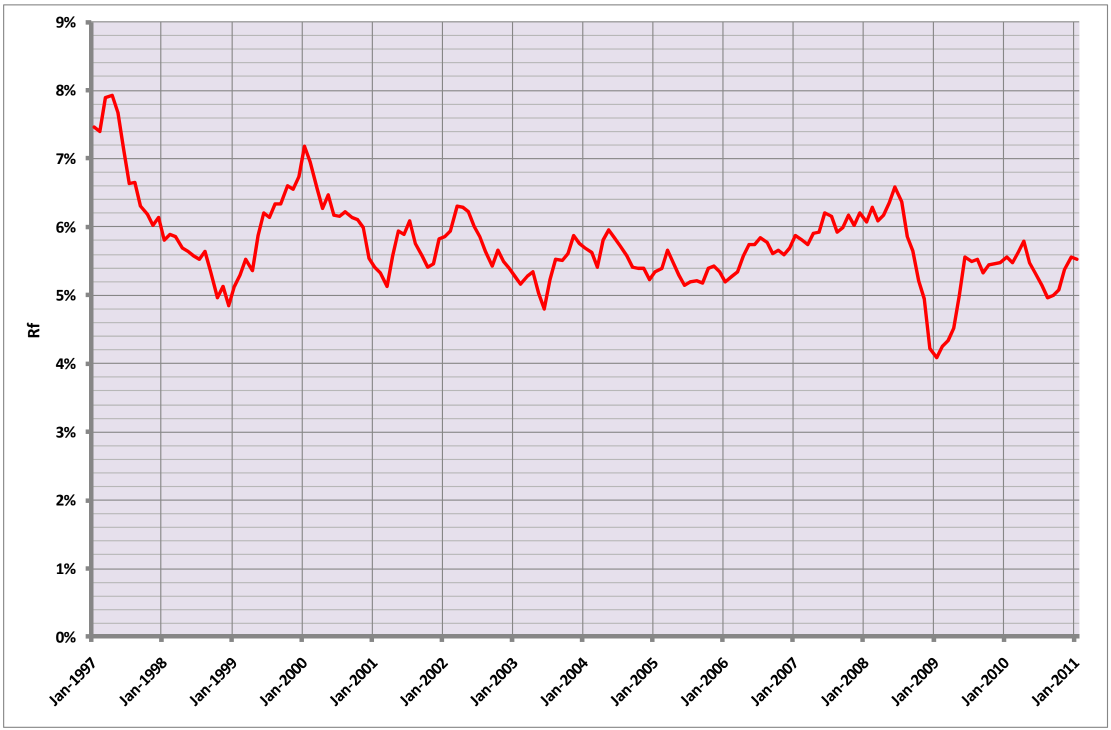
■ CPI	Figure 7
■ Risk free rate	Figure 8
■ BBB bond margin (relative to the Cwth Bond Rate)	Figure 9
■ Corporate tax rate	Figure 10

■ **Figure 7 CPI trends**



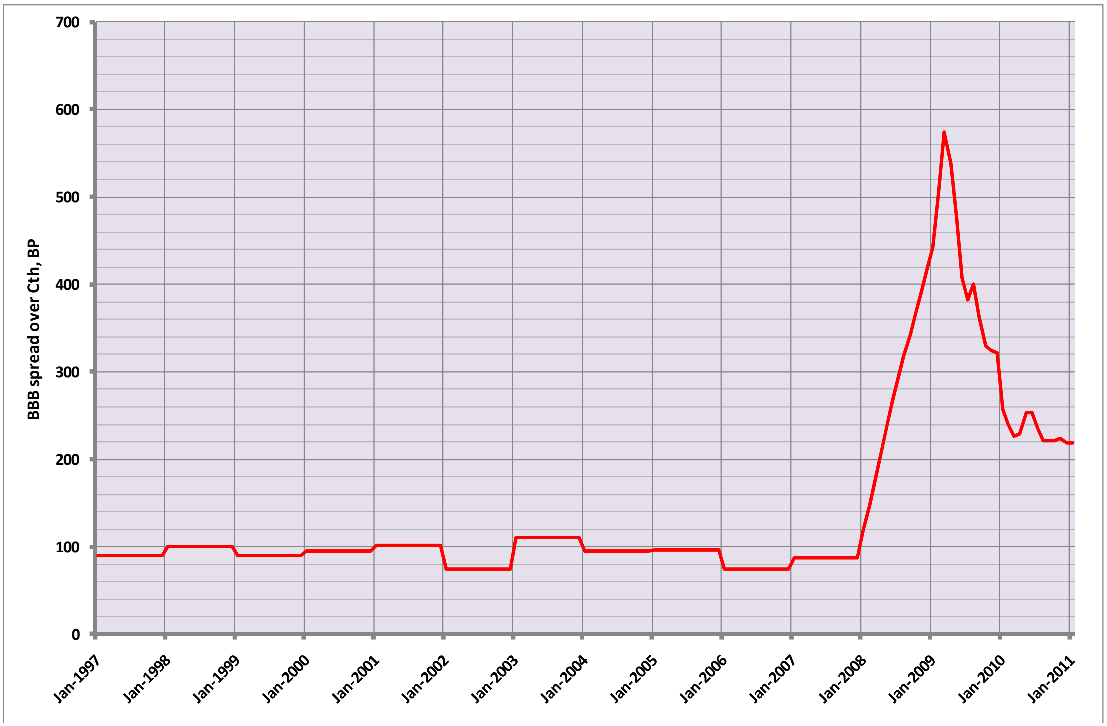
In this report the projected CPI determined from the Commonwealth 10 year bond rate and the indexed bond rate has been applied. Note the actual CPI index has been influenced by the introduction of GST in 2000.

- **Figure 8 Risk free rate trends**

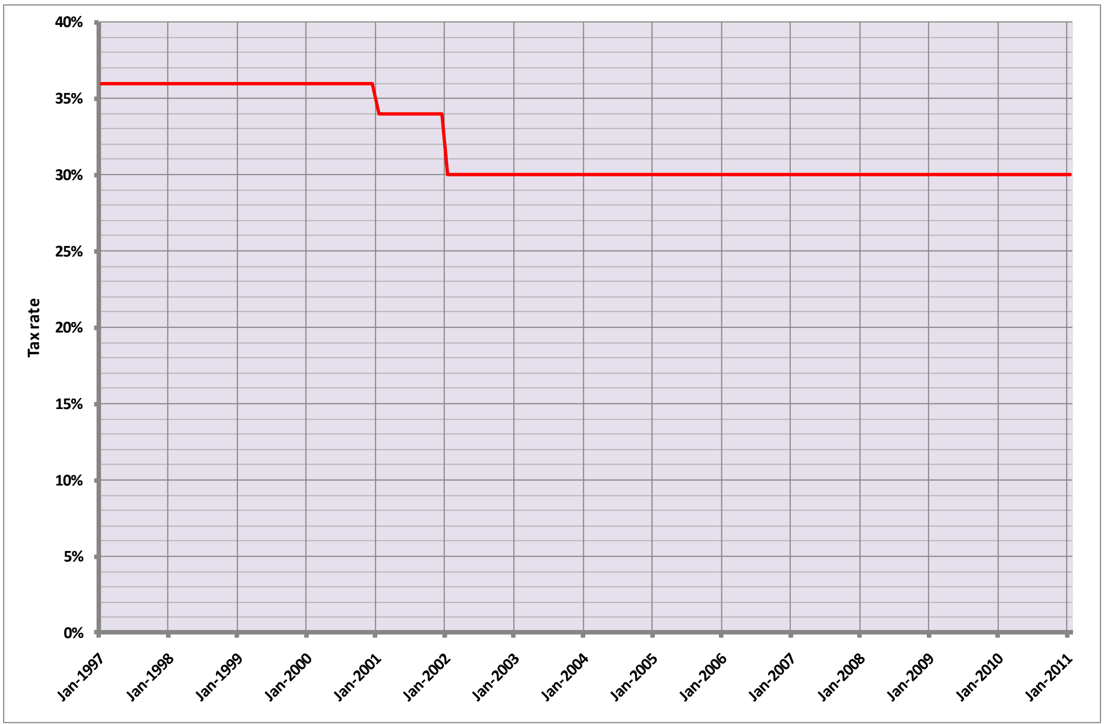


The risk free rate is based on the Commonwealth 10 year bond rate.

- **Figure 9 BBB bond rate relative to the risk-free rate (Basis Points above the Commonwealth bond rate)**



- **Figure 10 Tax rate changes**



Other parameters applied in calculating the discount rate and the amortisation factor are given in Table 5.

Table 5 Other parameters in capital amortisation

Parameter	Value	Notes/units
Market Risk Premium	6%	
Asset beta	0.61	SKM assumption
Gearing	60%	
Debt Margin	BBB + 50 BP	Extra margins are to allow for unrated status and transaction costs
Value of imputation	0	
Economic life	25	Years
Tax	Headline corporate rate	Simplified assumption. Tends to over-estimate the effective tax rate.

The parameters are combined (using the Capital Asset Pricing Model and the Monkhouse formula) to calculate the Weighted Average Cost of Capital (WACC). The WACC that is appropriate to apply as the discount rate in this calculation is the pre-tax real WACC. The trend in this parameter is shown in Figure 11. Annual averages as applied in the analysis are shown in Table 6.

The pre-tax real WACC is given by:

$$Kd = Rf + debt\ margin$$

$$Ke = Rf + \beta_a\, MRP$$

$$WACC_{posttax\ nominal} = \frac{gK_d(1-T)}{1} + \frac{(1-g)K_e(1-T)}{\left(1-T(1-\gamma)\right)}$$

$$WACC_{pretax\ nominal} = \frac{WACC_{posttax\ nominal}}{(1-T)}$$

$$WACC_{pretax\ real} = \frac{(1+WACC_{pretax\ nom})}{(1+CPI)} - 1$$

Where:

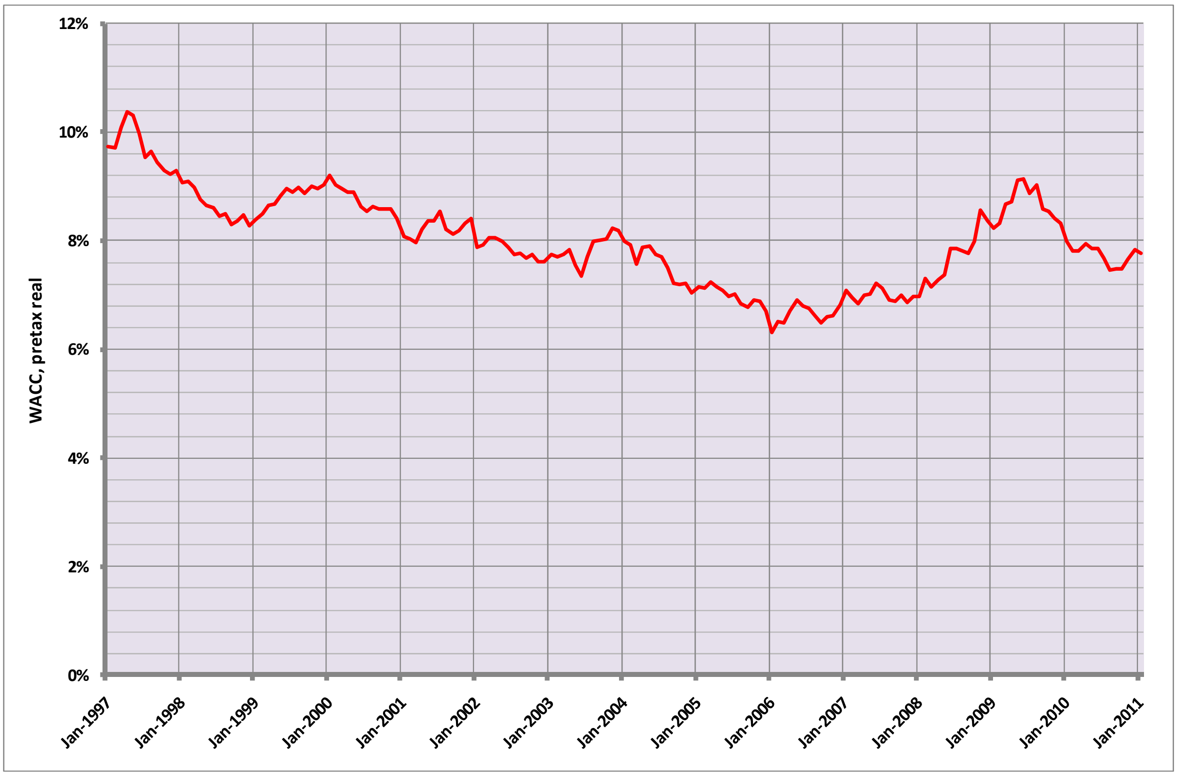
R_f = Risk free rate

β_a	=	Asset beta
MRP	=	Market Risk Premium
K_d	=	Cost of debt
K_e	=	Cost of equity (post tax nom)
g	=	Gearing
T	=	(Effective) tax rate
γ	=	Value of imputation

- **Table 6 Annual averages for the Weighted Average Cost of Capital (WACC)**

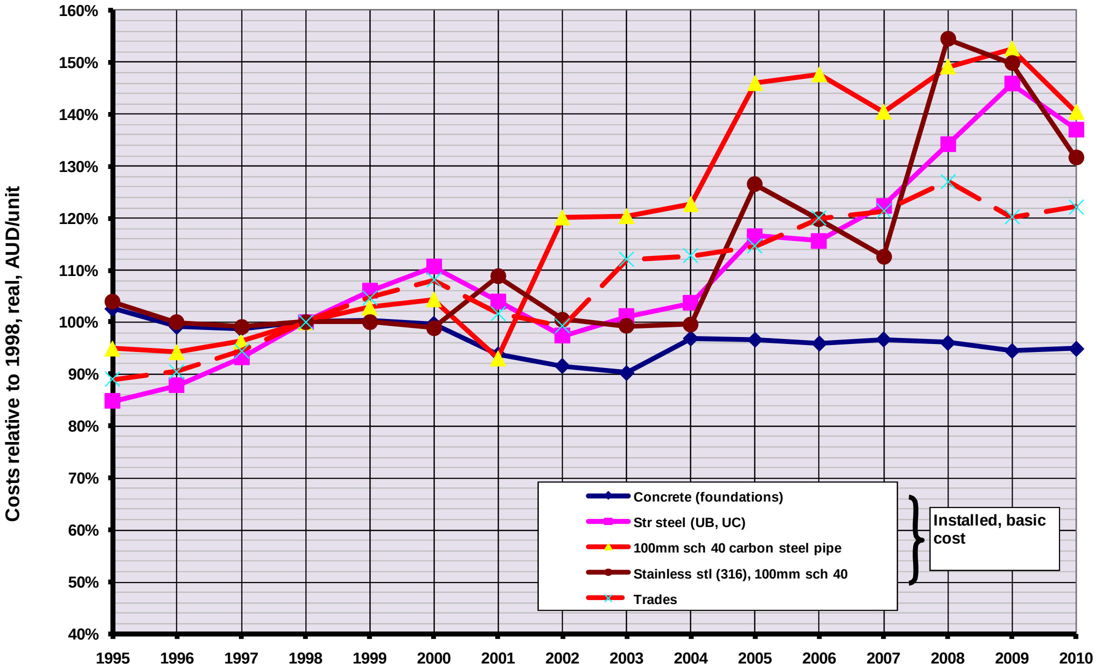
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
WACC	9.71%	8.63%	8.81%	8.74%	8.23%	7.83%	7.84%	7.57%	6.99%	6.63%	6.99%	7.69%	8.66%	7.74%

- **Figure 11 Trends in WACC**



Trends are also available for other cost elements of a powerplant. Those shown in Figure 12 have been derived from various editions of Rawlinson's "Australian Construction Cost Handbook".

▪ **Figure 12 Trends in local construction costs, real (base 1998 = 100)**



The indices can be used to calculate what the SCGT construction cost should have been in the period 1998 to 2010 using consistent data. The EPC capex is broken into overseas capex, local materials, labour and other costs and values calculated for each year as follows:

- The overseas capex component comes from the Gas Turbine World Handbook data with interpolation for the 3 missing years.
- Local materials costs are de-escalated using the average of the “concrete”, “structural steel”, “carbon steel” and “stainless steel” indices from Figure 12.
- Labour costs are de-escalated using the “Trades” data in Figure 12.
- “Other” cost elements (preliminaries, overheads, profit etc) are de-escalated using CPI.

The indexes for local materials and trades applied are shown in Table 7.

▪ **Table 7 Indexes for local materials and construction trades**

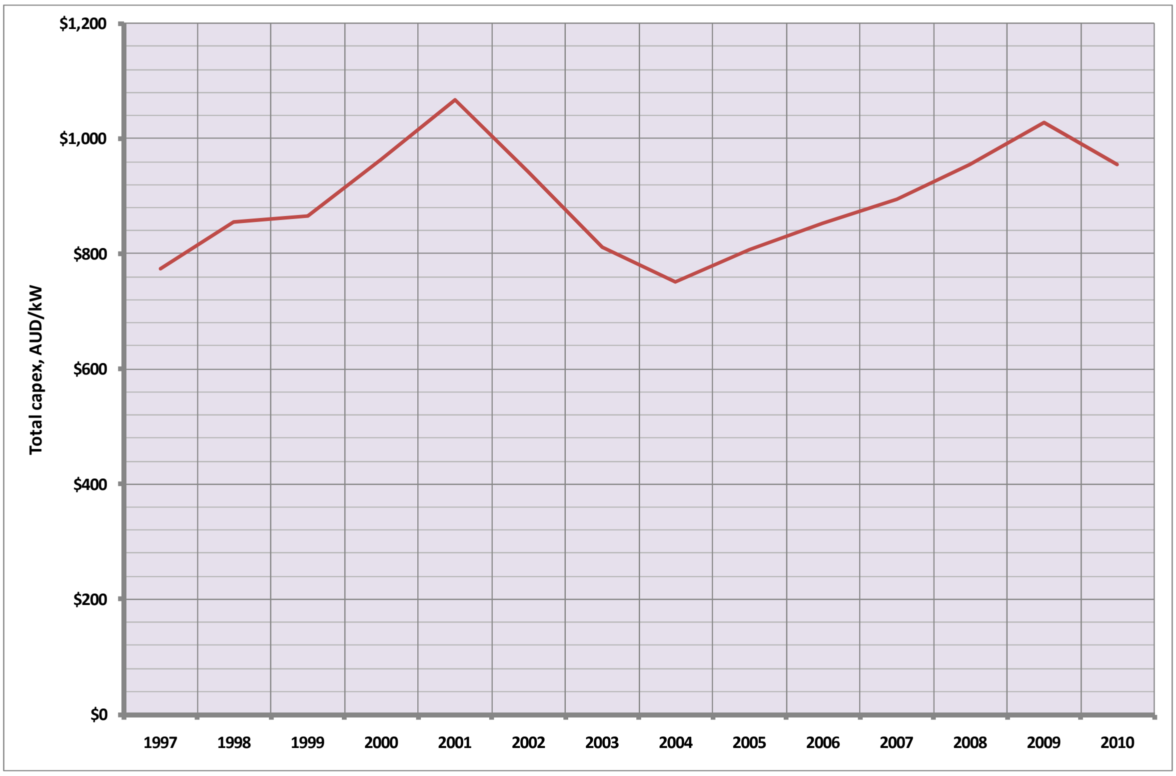
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Local materials	100	102	103	100	102	103	106	121	120	118	133	136	126
Trades	100	105	108	102	99	112	113	115	120	121	127	120	122

Table 8 and Figure 13 show the data calculated for the total capital costs in each year.

- **Table 8 Total SCGT capex, nominal AUD/kW**

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
O/S capex	$398	$461	$464	$531	$603	$490	$377	$319	$346	$372	$398	$425	$477	$409
Local matls	$24	$25	$25	$27	$27	$29	$29	$31	$37	$37	$38	$44	$46	$44
Labour	$43	$44	$47	$52	$57	$60	$58	$58	$67	$70	$73	$80	$82	$85
Other	$85	$86	$87	$91	$95	$98	$100	$103	$105	$109	$112	$117	$119	$122
EPC capex	$549	$616	$624	$700	$782	$676	$565	$511	$555	$589	$621	$665	$724	$660
Connect.	$93	$93	$95	$99	$103	$106	$109	$112	$115	$119	$122	$127	$129	$133
Prefin close	$38	$43	$43	$48	$53	$47	$40	$37	$40	$42	$45	$48	$51	$48
Owners	$71	$78	$79	$88	$97	$86	$74	$69	$74	$78	$82	$87	$94	$87
IDC	$23	$25	$25	$28	$31	$27	$24	$22	$24	$25	$26	$28	$30	$28
Total	$773	$854	$866	$963	$1067	$943	$812	$751	$807	$853	$895	$955	$1028	$956

- **Figure 13 Trends in SCGT capital costs, nominal AUD/kW**



5. Index

Using the discount rate above (Section 1.3 and Figure 11) to create an annualised equivalent to the total capex, and adding allowances for fixed annual operating costs (divided into labour and "other"), the total annualised costs are shown in Table 9.

■ **Table 9 Total annual costs of an SCGT plant, Nominal AUD/kW/year**

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Annual-ised capex	83	84	87	96	102	87	75	68	69	71	77	87	102	88
Fixed opex-labour	5	6	6	7	6	6	8	8	8	9	9	10	10	10
Fixed opex - other	7	7	7	7	8	8	8	8	9	9	9	10	10	10
Total	96	97	100	110	116	102	91	84	86	89	95	107	121	108

Reflecting these as an index, along with other comparator indices considered by AEMC, produces the indices shown in Table 10 and Figure 14.

■ **Table 10 Index of total annual SCGT fixed costs (base 1998 = 100)**

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Index	0.98	1.00	1.03	1.13	1.20	1.04	0.93	0.86	0.88	0.90	0.97	1.09	1.24	1.08
CPI	0.99	1.00	1.01	1.06	1.11	1.14	1.17	1.20	1.23	1.27	1.30	1.36	1.39	1.42
PPI (Stage 2)		1.00	1.003	1.07	1.11	1.12	1.13	1.14	1.20	1.28	1.33	1.44	1.41	1.42
Non-resid. constr		1.00	1.03	1.06	1.06	1.09	1.16	1.28	1.38	1.45	1.53	1.63	1.57	1.57

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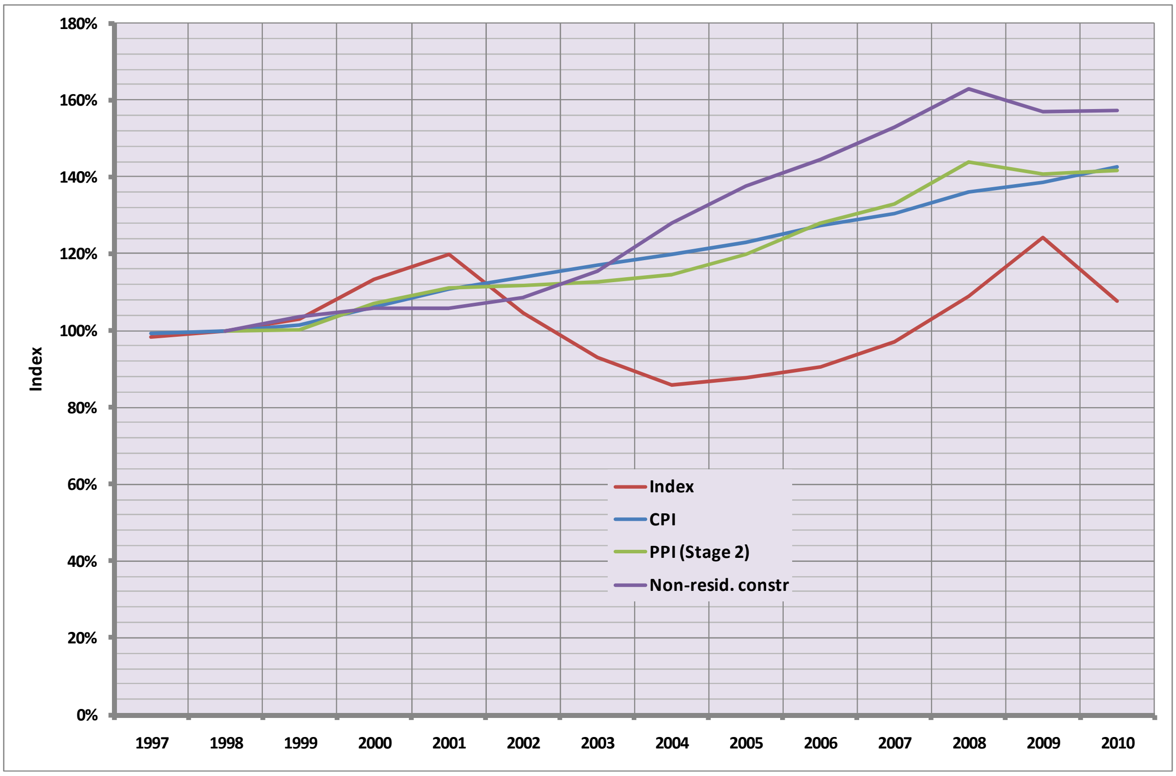
Figure 14 Index



It can be seen that there are periods where the alternative indices have the same trend "shape" as the SCGT fixed costs trends, however there are clearly periods where the indices diverge.

The difference has at times been quite wide.

Some of the elements of the shape of the SCGT cost curve are from known events. For example in the lead-in to 2000 the gas turbine costs escalated rapidly due to a high rate of construction in USA. This reversed in the "dot-com" crash although this effect was damped by the drop in the Australian dollar in this period. This factor is not particularly related to Australian based indices.

In the second half of the last decade the costs of SCGT plant costs matched the trend in non-residential construction cost rises that have been widely reported. These were triggered by strong global demand for all heavy engineering materials and construction elements.

At the very end of the decade the SCGT costs have been influenced by the falling demand outside Australia caused by the Global Financial Crisis.

The extent to which the individual parameters making up the index vary, and the extent to which these drive changes in the index have been considered. Variations in the overseas market price of the prime equipment (principally the gas turbine generator component) dominate the variations in the index noted. Variations in the exchange rate and WACC are also important but less so than the overseas market price. Variations in the other parameters are of minor significance.

Of the comparator indices, the PPI (Stage 2) index has a higher correlation coefficient and covariance with the SCGT index than the CPI or non-residential construction indices however this evaluation is based on only 11 data points.

Figure 15 shows the influence of the main components making up the variation in the index separately. For each component the parameter is fixed in turn at the 1998 base value. The resulting line on the chart thus shows how the Index would have varied had that parameter not been a varying factor in the analysis.

Figure 15 Components of the variation of the index

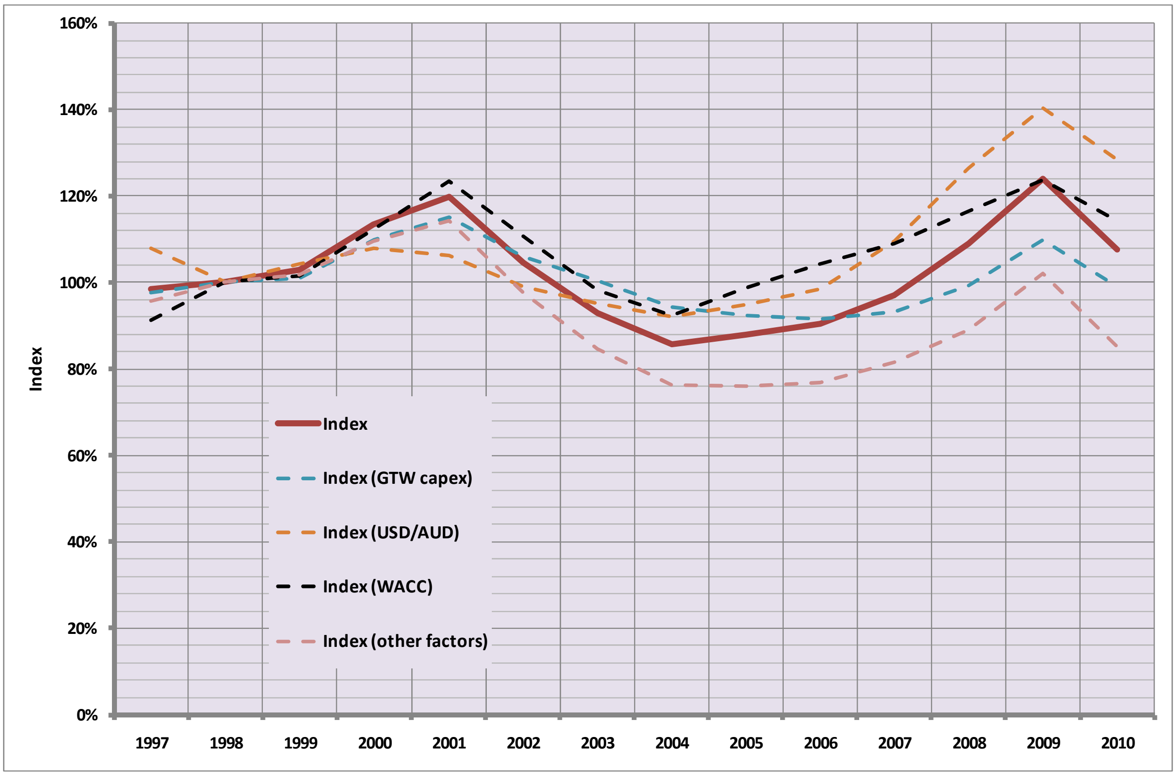
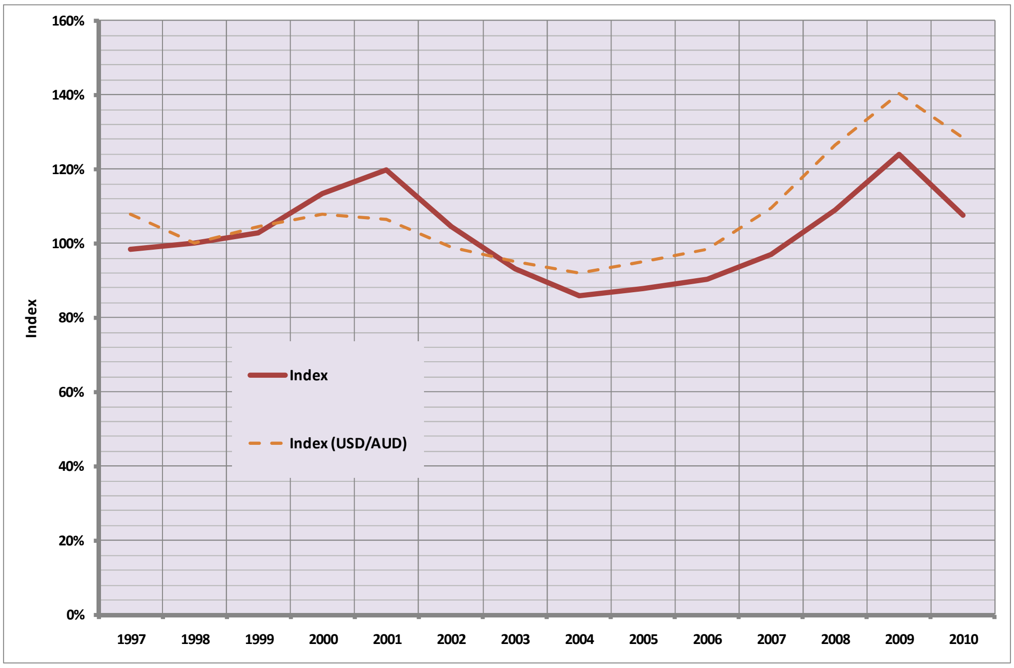


Figure 16 and Figure 17 show the extent to which the Index has been affected by changes in the exchange rate (Figure 16) and both the exchange rate and discount rate together (Figure 17) as opposed to the other factors.

■ **Figure 16 Impact on the Index if the USD/AUD rate was constant**



■ **Figure 17 Impact on the Index if the USD/AUD rate and the WACC were constant**