The Allen Consulting Group

Review of the Weighted Average Cost of Capital for the Purposes of Determining the Maximum Reserve Capacity Price

Supplementary report – the variable "*k*"

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Report to the Independent Market Operator

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Chapter 1

Introduction

1.1 Maximum Reserve Capacity Price

The methodology for calculating the Maximum Reserve Capacity Price is set out in Appendix 4 of the Market Rules. Essentially, the price is set to recover:

- a return on the value of assets (in this case, the cost of constructing an OCGT peaking plant and connecting it to the electricity transmission network) based on:
  - (double) the equipment price for the turbines (in American dollars, adjusted for US inflation and converted to Australian dollars)[1];
  - a 15 per cent margin for legal, approval and financing costs;
  - network connection and augmentation costs; and
  - the costs associated with constructing on-site fuel storage capacity equivalent to 24 hours fuel burn, and maintaining storage levels equivalent to 12 hours fuel burn;
- a return of the value of the OCGT peaking plant's capital costs over 15 years; and
- the fixed operating and maintenance costs of the peaking plant.

The methodology allows for all capital and fixed costs to be recovered through the Maximum Reserve Capacity Price — that is, all costs other than costs associated with actually generating electricity from the plant.

1.2 Scope of study

Within the formulae used to determine the Maximum Reserve Capacity Price, the variable "*k*" is established at a value that equates the net present value of 10 years worth of payments escalated at a rate of CPI-1 per cent with the payment stream from 10 years worth of unescalated payments.

Western Australia's Independent Market Operator (IMO) commissioned the Allen Consulting Group to advise on the methodology and model used to calculate the variable *"k"*. The IMO required that the Allen Consulting Group review the methodology and model currently used to calculate *"k",* and, in the event that these were considered incorrect or inappropriate, propose a new methodology and provide a new model as a Microsoft Excel spreadsheet.

This advice was developed as part of a broader study of the weighted average cost of capital (WACC) used to determine the Maximum Reserve Capacity Price, which is reported separately.

[1] It is understood that the doubling of the equipment price is to convert the equipment price into a plant cost, including construction and land acquisition costs.

Chapter 2

Objective in setting prices

2.1 Introduction

The determination of the Maximum Reserve Capacity Price is directly analogous to determining a regulated price for an infrastructure service.

Determination of prices for (regulated) infrastructure services is generally undertaken with the objective of determining prices that are sufficient to generate a stream of revenue equal to the cost incurred in providing the service.

Financial calculations applied in determining prices typically take the form of a net present value (NPV) analysis, where all cash flows are discounted into present value terms. The objective is to determine the prices that allows for a revenue stream consistent with a NPV of zero for the project, with a discount rate applied that is equal to the cost of capital for the relevant (notional) infrastructure project, typically expressed as the WACC.

The form of the discount rate depends upon whether cash flows are specified in nominal or real terms:

- if the cash flows are forecast in nominal (or 'money of day') terms, then a nominal WACC is employed; and
- if the cash flows are forecast in real (or 'constant price') terms, then a real WACC is employed.

Further, prices and regulated revenues may be expressed in nominal or real terms. As illustrated using a simple example in Table 2.1 for a notional 15-year project costing $100 in year 0, the revenue or "payment stream" may be specified as either:[2]

- a fixed nominal cash flow (that is, the annual "nominal price") that embodies a forecast of inflation (Column 1); or
- a fixed constant-dollar cash flow (Column 2) (that is, the annual "real price") (Column 2) that is escalated annually for inflation to derive the (nominal) price in any particular year (Column 3).

As shown in Table 2.1, for an asset costing $100, an investor would require an annual fixed nominal payment of $15.30 (in which case the investor bears the risk that the actual inflation rate differs from that forecast), or alternatively an annual fixed constant payment of $12.85 in real terms with annual escalation for realised inflation (in which case, the investor is substantially shielded from inflation risk). In both cases, the NPV of the initial cost and payment streams is zero when calculated with the appropriate nominal or real discount rate.

[2] The real WACC in Table 2.1 reflects that value provided to the Allen Consulting Group by the IMO. The nominal WACC has been calculated by the Allen Consulting Group using the Fisher equation, and an estimated long term inflation rate of 2.90 per cent, which was derived from annual inflation forecasts over a 10-year period from 2010/11 to 2018/19 provided by the IMO.

Table 2.1

NOMINAL AND REAL PAYMENT STREAMS FOR A NOTIONAL REGULATED PROJECT

Year	Constant nominal dollar payment stream	Constant current (real) dollar payment stream	CPI and escalation factor	Nominal dollar payment stream (Column 2 adjusted by Column 3)
	(1)	(2)	(3)	(4)
	Nominal WACC	**Real WACC**	**CPI**	**Nominal WACC**
	12.78%	**9.61%**	**2.90%**	**12.78%**
0	($100.00)	($100.00)		($100.00)
1	$15.3016	$12.8525	1.0290	$13.2252
2	$15.3016	$12.8525	1.0588	$13.6087
3	$15.3016	$12.8525	1.0895	$14.0034
4	$15.3016	$12.8525	1.1211	$14.4094
5	$15.3016	$12.8525	1.1536	$14.8273
6	$15.3016	$12.8525	1.1871	$15.2572
7	$15.3016	$12.8525	1.2215	$15.6997
8	$15.3016	$12.8525	1.2569	$16.1549
9	$15.3016	$12.8525	1.2934	$16.6234
10	$15.3016	$12.8525	1.3309	$17.1055
11	$15.3016	$12.8525	1.3695	$17.6015
12	$15.3016	$12.8525	1.4092	$18.1119
13	$15.3016	$12.8525	1.4501	$18.6371
14	$15.3016	$12.8525	1.4921	$19.1776
15	$15.3016	$12.8525	1.5354	$19.7337
NPV	**$0.00**	**$0.00**		**$0.00**

Source: Allen Consulting Group

Chapter 3

The variable "*k*" and the Maximum Reserve Capacity Price

3.1 Introduction

The variable *"k"* features in the calculation of the Maximum Reserve Capacity Price as follows:[3]

> PRICECAP[t] = **k** X (FIXED_O&M[t] + ANNUALISED_CAPCOST[t] / (CAP/SDF))
>
> Where:
>
> PRICECAP[t] is the Maximum Reserve Capacity Price to apply in a Reserve Capacity Auction held in calendar year t;
>
> ANNUALISED_CAPCOST[t] is the CAPCOST[t], expressed in Australian dollars in year t, annualised over a 15 year period, using a real pre-tax return to equity equal to the Commonwealth 10 Year Bond Rate (Real) plus a Margin for Equity of 15.1%, a real return to debt equal to the Commonwealth 10 Year Bond Rate (Nominal) plus a Margin for Debt of 1.5%, and a debt to equity ratio of 60:40;
>
> CAP is the capacity of an open cycle gas turbine, expressed in MW;
>
> SDF is the summer derating factor of a new open cycle gas turbine, and equals 1.18;
>
> CAPCOST[t] is the total capital cost, expressed in million Australian dollars in year t, assumed for an open cycle gas turbine power station of capacity CAP; and
>
> FIXED_O&M[t] is the fixed operating and maintenance costs for a typical open cycle gas turbine power station and any associated electricity transmission facilities, expressed in Australian dollars in year t, per MW per year.
>
> *k* is a factor set so that the net present value of 10 years worth of payments escalated on a CPI-1% basis is equivalent to the payment stream from 10 years worth of an unescalated payments.

3.2 Relevant cash flows

The annual capital cost of the investment in OCGT peaking plant (ANNUALISED_CAPCOST[t]) is determined as an annuity over 15 years, with the discount rate being specified as the real WACC. Note that as the real WACC is used to calculate the annuity, it is assumed implicitly that the plant receives the same real (or 'constant price') payment over its assumed 15 year economic life – only if the payment is escalated fully for inflation will capital costs be recovered (assuming the economic life is 15 years, the WACC is correct, etc.).

[3] Appendix 4 of the Market Rules.

Should a proposed OCGT peaking plant be successfully bid into a Reserve Capacity Auction, the price paid for capacity would be determined under a Long Term Special Price Arrangement by annual escalation of the initial bid price by a factor equal to the rate of change in the Consumer Price Index less one per cent (CPI – 1 per cent). That is, the starting payment will not be fully escalated for inflation. It follows that if the price cap applies and if "ANNUALISED_CAPCOST[t]" is used as the starting point for that price cap, then capital costs will not be recovered fully under that cap.[4]

Table 3.1 illustrates this proposition, showing that a payment stream (for the notional 15 year project with an initial cost of $100 — that is "CAPCOST[t]" is $100) based on an initial price that is escalated at CPI-1 per cent per annum would:

- under-recover if the initial price was set equivalent to the fixed constant dollar payment (Column 2) – which is the situation that exists under the Market Rules as described above; and
- over-recover, if the initial price was set equivalent to the fixed nominal dollar payment (Column 4) – which is the situation that would arise if "ANNUALISED_CAPCOST[t]" was calculated using a nominal rather than real WACC.

[4] In order to simplify the analysis, fixed annual operating and maintenance costs (FIXED_O&M[t]) have been excluded from the analysis — this does not impact on the value of the variable "*k*". However, we note that the manner in which the annual value of these costs is calculated differs from that adopted for capital costs. The Allen Consulting Group understands that the present value of FIXED_O&M costs based on the first 15 years of these costs is first calculated (the discount rate that is applied is unknown, but should be the WACC), and that the resultant present value is then divided by the number of years (15) and the size of the OCGT peaking plant (160 MW) to derive an annual cost. This approach may impact on a generator recovering all of its costs, and should be investigated further.

Table 3.1

PAYMENT STREAMS FOR A NOTIONAL REGULATED PROJECT WITH "CPI – 1" PER CENT PRICE ESCALATION

Year	"Unescalated" real payment stream	CPI – 1% escalated payment stream	"Unescalated" nominal payment stream	CPI – 1% Escalated payment stream
	(1)	(2)	(3)	(4)
	Real WACC	**Nominal WACC**	**Nominal WACC**	**Nominal WACC**
	9.61%	**12.78%**	**12.78%**	**12.78%**
		Escalation factor		**Escalation factor**
		CPI-1%		**CPI-1%**
1	$12.8525	$12.8525	$15.3016	$15.3016
2	$12.8525	$13.0967	$15.3016	$15.5923
3	$12.8525	$13.3455	$15.3016	$15.8885
4	$12.8525	$13.5990	$15.3016	$16.1903
5	$12.8525	$13.8574	$15.3016	$16.4979
6	$12.8525	$14.1207	$15.3016	$16.8114
7	$12.8525	$14.3889	$15.3016	$17.1307
8	$12.8525	$14.6623	$15.3016	$17.4562
9	$12.8525	$14.9409	$15.3016	$17.7878
10	$12.8525	$15.2247	$15.3016	$18.1258
11	$12.8525	$15.5140	$15.3016	$18.4701
12	$12.8525	$15.8087	$15.3016	$18.8210
13	$12.8525	$16.1090	$15.3016	$19.1786
14	$12.8525	$16.4151	$15.3016	$19.5430
15	$12.8525	$16.7269	$15.3016	$19.9142
NPV	**$100.0000**	**$92.3183**	**$100.0000**	**$109.9095**

Source: Allen Consulting Group

3.3 Determining the variable "*k*"

The objective in setting the Maximum Reserve Capacity Price should be to ensure that the present value of the payment stream under the Long Term Special Pricing Arrangement is such that the overall NPV of the notional OCGT project is zero.[5]

[5] More specifically, the "*k*" factor should ensure that the present value of revenue under the arrangement is equal to the present value of 10 years of payments set at "ANNUALISED_CAPCOST[t]". We note that the arrangement can only last for ten years, whereas "ANNUALISED_CAPCOST[t]" is calculated on the basis of a 15 year life, and that after the expiration of the arrangement, the maximum price that can be earned by the generator could be 85 per cent of "ANNUALISED_CAPCOST[t]". This raises some uncertainty as to whether the generator would recover all of its costs under the existing financial model inherent in the Market Rules, and suggests further investigation is warranted of whether the financial model (and hence the Market Rules) should be amended to better achieve the market objectives.

In the notional example set out in Table 3.1, this would require that the present value of the payment stream be $100 — the value of the initial capital investment. As also illustrated in Table 3.1, this does not occur where the escalation factor is set at CPI – 1 per cent if "ANNUALISED_CAPCOST[t]" is used as the starting price.

The logical role for the variable "*k*" is to scale-up the unescalated payment stream to equate the present values of the escalated and unescalated payment streams. The value of the variable *"k"* can be determined by solving for the value that achieves this equality, which is a value of 1.0832 for the illustrative notional project (Table 3.2).

Table 3.2

PAYMENT STREAMS AND *k* FACTOR FOR A NOTIONAL REGULATED PROJECT WITH "CPI – 1" PRICE ESCALATION

Year	"Unescalated" real payment stream	CPI – 1% escalated payment stream	*k* factor adjusted escalated payment stream
Year	(1)	(2)	(3)
	Real WACC	**Nominal WACC**	**Nominal WACC**
	9.61%	**12.78%**	**12.78%**
		Escalation factor	**"*k*"**
		CPI-1%	**1.0832**
1	$12.8525	$12.8525	$13.9220
2	$12.8525	$13.0967	$14.1864
3	$12.8525	$13.3455	$14.4560
4	$12.8525	$13.5990	$14.7306
5	$12.8525	$13.8574	$15.0105
6	$12.8525	$14.1207	$15.2956
7	$12.8525	$14.3889	$15.5862
8	$12.8525	$14.6623	$15.8823
9	$12.8525	$14.9409	$16.1841
10	$12.8525	$15.2247	$16.4915
11	$12.8525	$15.5140	$16.8049
12	$12.8525	$15.8087	$17.1241
13	$12.8525	$16.1090	$17.4494
14	$12.8525	$16.4151	$17.7810
15	$12.8525	$16.7269	$18.1188
NPV	**$100.0000**	**$92.3183**	**$100.0000**

Source: Allen Consulting Group

As illustrated by Table 3.2, the effect of the variable *"k"* is to "un-do" the "– 1 per cent" component of the "CPI – 1 per cent" escalation factor by inflating the escalated payment stream to fully compensate the investor for inflation.

However, the payment stream that would be applied under the Long Term Special Price Arrangement is only for 10 years rather than the 15-year period over which the annuity is calculated. For the same notional project, the resultant payment streams, NPV and calculated *"k"* are shown in Table 3.3.

Table 3.3

PAYMENT STREAMS AND "*k*" FACTOR FOR A NOTIONAL REGULATED PROJECT WITH "CPI – 1" PRICE ESCALATION AND A PAYMENT STREAM LIMITED TO 10 YEARS

Year	"Unescalated" real payment stream	CPI – 1 escalated payment stream	k factor adjusted escalated payment stream
Year	(1)	(2)	(3)
	Real WACC	**Nominal WACC**	**Nominal WACC**
	9.61%	**12.78%**	**12.78%**
		Escalation factor	**"*k*"**
		CPI-1%	**1.0634**
1	$12.8525	$12.8525	$13.6669
2	$12.8525	$13.0967	$13.9266
3	$12.8525	$13.3455	$14.1912
4	$12.8525	$13.5990	$14.4608
5	$12.8525	$13.8574	$14.7355
6	$12.8525	$14.1207	$15.0154
7	$12.8525	$14.3889	$15.3007
8	$12.8525	$14.6623	$15.5914
9	$12.8525	$12.8525	$13.6669
10	$12.8525	$13.0967	$13.9266
NPV	**$75.1938**	**$70.7130**	**$75.1938**

Source: Allen Consulting Group

With the payment stream limited to 10 years, the calculated *"k"* and the nominal values of each annual payment, are lower than they would be if the payment stream were determined for the full 15-year period. This is because the longer the period over which the CPI-1 per cent escalation factor applies, the greater the divergence between the two payment streams.

3.4 Recommended method and model

As discussed above, the purpose of the variable *"k"* should be to equalise the present value of the stream of payments under the Long Term Special Price Arrangement with the present value of the future cash flows implied by the calculation of "ANNUALISED_CAPCOST[t]" (that is, a series of payments that start at "ANNUALISED_CAPCOST[t]" and then are fully escalated for inflation).

The preceding analysis represents the appropriate method and model for establishing *"k"*. A detailed spreadsheet model has been provided to the IMO that provides the basis for the preceding tables, and which also calculates *"k"* based on monthly, rather than annual, payments (consistent with the payment frequency under the Long Term Special Price Arrangement). The value of the variable *"k"* when calculated on a monthly basis is 1.0529 (to 4 decimal places)

Current methodology and model

The IMO's current methodology to calculate "*k*" is summarised in Box 3.1. The Allen Consulting Group has also been provided with an electronic copy of the Excel model used by the IMO to calculate "*k*" for the 2009/10 Capacity Year.

Box 3.1

IMO'S DERIVATION OF THE VARIABLE k

The net present value of the unescalated payments is defined by:

$$NPV_{unescalated} = \sum_{t=1}^{n} \frac{C}{(1+r_w)^t}$$

Where:

C is the constant monthly payment

r_w is a monthly real WACC derived by dividing the annual real WACC by 12; and

n is equal to 120

The net present value of escalated payments is defined by:

$$NPV_{escalated} = \sum_{t=1}^{n} \frac{C(1+r_e)^t}{(1+r_w)^t}$$

Where

r_e is the monthly escalation parameter equal to the annual "CPI-1 per cent" escalation factor divided by 12.

Introducing the variable *"k"*, the equality between the unescalated and escalated payment streams is:

$$k \times \sum_{t=1}^{n} \frac{C}{(1+r_w)^t} = \sum_{t=1}^{n} \frac{C(1+r_e)^t}{(1+r_w)^t}$$

Normalising C, k is derived as:

$$k = \frac{\sum_{t=1}^{n} \frac{(1+r_e)^t}{(1+r_w)^t}}{\sum_{t=1}^{n} \frac{1}{(1+r_w)^t}}$$

The IMO indicates that the above equations consider an equal and consistent escalation of CPI through the investment period but, in practice, the IMO has used annual CPI forecasts.

Source: IMO 2007, Final Report: Maximum Reserve Capacity Price Review for the 2009/10 Reserve Capacity Year, IMO Report 19, January 2007, p.23.

The following observations are made on the IMO's existing methodology and model.

- There is an inconsistency in the current model:
  - the payment stream resulting from the annuity formula is assumed to be a fixed constant dollar payment stream (real WACC applied to the asset base) and so correctly discounted using a real WACC; but
  - the payment stream under the Long Term Special Price Arrangement is a nominal payment stream and the present value *should* be calculated using the nominal WACC, not the real WACC as occurs in the current model.
- There are errors in deriving the monthly real WACC and monthly CPI – 1 escalator, which should be calculated by taking into account compounding effects rather than simply dividing the annual figure by 12.
- The current model appears inconsistent with the Market Rules, in that payments under a Long Term Special Price Arrangement should be escalated *annually*, and only *after the first year* (that is, the first year of both escalated and unescalated payments should be the same — before being adjusted by "*k*") — the current model escalates payments monthly (including the first payment).
- Finally, the nominal WACC used to discount the payment stream under the Long Term Special Price Arrangement would be calculated using the Fischer equation and a forecast of inflation. This means that care is required to ensure there is consistency between this (single) forecast of inflation and that underpinning the "CPI-1 per cent" escalation under the Long Term Special Price Arrangement (where multiple single year inflation forecasts are currently used by the IMO).[6]

Recommended mathematical expression

Correction of the above inconsistencies and errors indicates the variable *"k"* should to be calculated by the expressions indicated in Box 3.2.

Box 3.2

ALLEN CONSULTING GROUP'S RECOMMENDED DERIVATION OF THE VARIABLE "*k*"

The present value of the unescalated payments is defined by:

$$PV_{unescalated} = \sum_{i=1}^{10}\sum_{j=1}^{12}\frac{C}{\left(1+r_{w_{real}}\right)^{12(i-1)+j}}$$

Where:

C is the unescalated payment;

r_{wreal} is the (effective monthly) real WACC;

i represents the year; and

j represents each month.

6 The Fisher equation is specified as: R = (1 + r) / (1 + i) – 1, where: R is the real risk free rate; r is the nominal risk free rate; and i is the rate of inflation. The Allen Consulting Group also notes that the IMO has previously based the "CPI" forecast under the Long Term Special Price Arrangement on forecast Gross Domestic Product increases, which are likely to differ significant from changes in the Consumer Price Index.

The present value of escalated payments is defined by:

$$PV_{escalated} = \sum_{i=1}^{10} \sum_{j=12}^{12} \frac{C\prod_{k=1}^{i}\left[1 + r(k)\right]}{\left(1 + r_{w_{nominal}}\right)^{12(i-1)+j}}$$

Where:

C is the unescalated payment;

$r_{wnominal}$ is the (effective monthly) nominal WACC;

r(k) represents the inflation rate (CPI-1%) for the previous year and r(1)=0;

i represents the year; and

j represents each month.

Given the present value of the two payment streams must be equivalent, the variable "k" can be defined as follows:

$$PV_{unescalated} = k \times PV_{escalated}$$

It follows that the variable "k" is defined as follows:

$$k = \frac{PV_{unescalated}}{PV_{escalated}}$$

Source: Allen Consulting Group

3.5 Other issues

The current method and model used to calculate the variable "*k*" has been reviewed by the Allen Consulting Group in the context of the existing Market Rules. Consequently, our recommended method and model for calculating the variable *"k"* is also framed within the context of the existing Market Rules.

Nevertheless, in undertaking this work, the Allen Consulting Group has also identified a number of aspects of the implied financial model in the Market Rules that underpins the calculation of the variable *"k"* which, if amended, may better facilitate the market objectives.

We comment further on these matters in our separate study of the weighted average cost of capital (WACC) used to determine the Maximum Reserve Capacity Price.