Target return and inflation

Input to the AER Inflation Review 2020

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Glossary

Abbreviation	Stands for
AER	Australian Energy Regulator
ARR	annual revenue requirement
capex	capital expenditure
NEL	National Electricity Law
NEO	National Electricity Objective
NER	National Electricity Rules
NGL	National Gas Law
NGO	National Gas Objective
NNRT	net nominal revenue after tax
NSP	network service provider
opex	operational and maintenance expenditure
PTRM	post-tax revenue model
RFM	roll forward model
SMAR	smoothed maximum allowable revenue

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Executive summary

1. We were asked by the Australian Energy Regulator (AER) to consider two questions:

   - Does the regulatory framework successfully deliver the current target—a real rate of return outcome?
   - Should the AER instead target a nominal or hybrid return?

2. The starting point for our analysis is the national electricity and gas objectives (NEO and NGO); these objectives guide the AER in regulating the revenue of electricity and gas network service providers (NSPs). The NEO and NGO provide for the promotion of efficient investment in, and operation of, network services in the long-term interests of consumers.

3. Investors in specific, long-lived, assets necessary to supply network services would expect to maintain the real value of their investment: ex ante, a service provider would therefore expect to achieve a real return and to be compensated for expected inflation; ex post, the service provider would expect to be compensated for actual inflation so that it achieves the expected real rate of return. Hence, the long-term interests of consumers requires that investors can expect real returns on capital ex ante and that these returns are able to be achieved ex post.

4. If the present value of regulated revenue is set to equal the present value of costs (including a return on capital), then consumers pay no more than is required to attract the investment needed to efficiently provide the service. Hence, regulation that seeks to set the present value of revenue equal to the present value of costs is in the long-term interests of consumers.

5. Consistent with these regulatory objectives, the AER targets a real rate of return on capital. It operationalises this objective by determining an allowed nominal rate of return. The real rate of return is achieved through deducting the AER's estimate of expected inflation from the allowed nominal cash rate of return, substituting outturn (lagged) inflation for expected inflation in the annual price adjustment process, and the revaluation of the service provider's asset base at the end of the period using outturn inflation.

6. The AER model is therefore consistent with the regulatory objective. We have tested this outcome through formal modelling (algebraic equations) and by spreadsheet modelling scenarios over multiple regulatory periods. The AER approach delivers the intended real rate of return regardless of whether outturn inflation is above or below the AER forecast of inflation.

7. There is a relatively small deviation from NPV=0 in the typical application of the AER model. For most NSPs, the revenue in the first year of a regulatory period locks in expected inflation for that year, rather than substituting in actual (lagged) inflation. Therefore, if expected inflation for that year is greater (less) than actual inflation, the NSP receives a higher (lower) return than expected. This effect persists through the regulatory period because each year's revenue is a function of the previous year and so, ultimately, all are a function of the first year.

8. Stakeholders have correctly identified that the current regulatory approach may result in negative cash returns to equity; negative cash returns to equity may occur with a low allowed nominal rate of return on equity and/or high leverage. If, in addition, outturn inflation is low

relative to expected inflation, then the return on capital may in amount be insufficient to meet the obligation to pay interest.

9. In its 2017 Final Position paper, the AER observed that the regulatory regime targets the total real return on capital, and not a real return on equity. Similarly, the Australian Competition Tribunal has referred to estimates of return on equity and debt as simply a means to the end of estimating the overall rate of return on capital.

10. We agree with the AER that NSPs are best placed to bear the risk of their financing decisions, rather than consumers, and that by targeting total real returns the benefit or detriment from financing decisions remain the concern of the service provider. However, we note that the sustained fall in inflation expectations mean that the parameter estimates determined recently by the AER imply a negative cashflow return on equity for a benchmark efficient entity. An assumption that the benchmark efficient entity would fund dividends (and growth) from depreciation cashflows—that is, spending less on replacement of real capital—would not be consistent with the efficient investment and efficient operation of an NSP, at least beyond the short-term. Borrowing to pay dividends may be justified by the higher increase in the RAB (than would be expected with a positive cash rate of return on equity) and consequential increase in revenue, though may alter the cash payment profile for consumers.

11. We suggest that the AER consider, during its 2020 Inflation Review, whether a projected negative cash return on equity might indicate an underlying inconsistency in one or more inputs into its estimate of WACC and expected inflation. Some possible aspects to explore might include:

- whether the estimate of expected inflation is too high and thus causes the negative cash rate of return on equity
- whether the nominal cost of equity might be under-estimated relative to the estimated expected inflation
- whether the assumed capital structure is efficient, given the relative rates of return to equity and debt.

12. In response to the prospect of varying real rates of return to equity, and the possibility of negative cash returns to equity, some stakeholders have suggested hybrid approaches. We explore two hybrid approaches:

- The first hybrid approach we explore would involve including interest on debt as an expense in setting the ARR; we show that this approach would make no difference to the cash rate of return on equity, and therefore would not address the concern raised by stakeholders.
- The second hybrid approach would decompose the expected revaluation gain into a revaluation gain for equity holders and an expense in setting the ARR. We show that this approach would effectively shift the regulatory regime from targeting a total real rate of return to targeting a real rate of return on equity; it would thereby intervene in the capital structure decision and thus result in a less efficient allocation of the risk of financing decisions.

13. From this analysis, our preliminary conclusions on the questions asked by the AER are as follows:

- The regulatory framework successfully delivers the current target—a real rate of return outcome.
- The AER should not instead target a nominal or hybrid return.

14. Our analysis leading to these conclusions suggests some aspects of the regulatory approach that the AER might consider exploring during its 2020 Inflation Review.

1. Introduction and scope

1.1 Introduction

15. This report was commissioned by the Australian Energy Regulator (AER) as an input into its Inflation Review 2020. The report considers two questions:

- Does the regulatory framework successfully deliver the current target—a real rate of return outcome?
- Should the AER instead target a nominal or hybrid return?

16. In preparing this report, we reviewed, amongst other things, the following information currently before the AER:

- The AER's 2020 discussion paper on the regulatory treatment of inflation (Australian Energy Regulator, 2020).
- The AER Inflation Review Final Position Paper published on 20 December 2017 (Australian Energy Regulator, 2017).
- Submissions received from stakeholders through 2019 seeking a review.[1]
- The AER's final decision and submissions received from stakeholders during the recent PTRM and RFM update.
- Submissions made to the Independent Pricing and Regulatory Tribunal New South Wales (IPART) in support of hybrid nominal and real returns.

17. We also draw from, and update, analysis we prepared for the AER as it undertook its 2017 Inflation Review (McWha, Murray, & van Zijl, 2017).

1.2 Scope

18. In addressing the questions asked by the AER, we structure our report into seven sections as follows:

- *Section one: introduction and scope*. This section introduces our report and outlines its scope.
- *Section two: regulatory objective and principles*: This section discusses the relevant regulatory objectives and principles established by the National Electricity Rules and National Gas Rules.,.
- *Section three: the AER model*: This section describes the AER approach to setting allowed revenue. It describes the building block approach and how this approach is represented in

[1] These submissions and comments are available at: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/review-of-expected-inflation-2017/updates

the AER's Post-Tax Revenue Model (PTRM) and Roll Forward Model (RFM). We specify a formal model to assess whether the building block model, and the variations proposed in submissions to the AER by stakeholders, achieve in concept, the regulatory objectives discussed in the preceding section.

- *Section four: assessing the AER approach*: In this section, we apply the formal model to the approach taken by the AER in its PTRM and RFM and price control mechanisms to assess how closely the current approach meets the regulatory objectives and principles, and the likely significance of any divergences. We illustrate this assessment with multi-period spreadsheet modelling of the AER approach.
- *Section five: construction of the estimated real rate of return:* In this section, we discuss the construction of the allowed real rate of return by the AER, using the formal model specified in section three to identify issues for consideration.
- *Section six: assessing the variations proposed by submitters:* In this section, we apply the formal model to the variations proposed by stakeholders and two hybrid approaches, and assess whether those variations would better meet the regulatory objectives and principles relative to the AER's current approach.
- *Section seven: conclusions:* In our final section we distil the analysis from the proceeding sections to answer the questions:
    - Does the regulatory framework successfully deliver the current target-a real rate of return outcome?
    - Should the AER instead target a nominal or hybrid return?

2. Regulatory objectives and principles

2.1 NER and NGR objectives and principles

19. The National Electricity and Gas Objectives (NEO and NGO) guide the AER in regulating the revenue of electricity and gas network service providers (NSPs). These objectives are:

> **NEO (National Electricity (South Australia) Act, 1996, s 7):**
>
> to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to— (a) price, quality, safety, reliability and security of supply of electricity; and (b) the reliability, safety and security of the national electricity system
>
> **NGO (National Gas (South Australia) Act, 2008, s. 23):**
>
> to promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas

2.2 Translating these principles and objectives into a target rate of return

20. A properly estimated rate of return will lead to NSPs charging prices for their services that promote efficient investment in, and efficient operation, and use of electricity and gas services for the long-term interests of consumers. That is, the required rate of return on capital, properly estimated, will serve the NEO or NGO (ActewAGL Distribution, 2017, para. 112).

21. Return on investment can be considered in either "nominal" or "real" terms. The nominal rate of return is the return, expressed as a percentage of assets, without adjusting for inflation. The real rate of return on an investment is the nominal return adjusted for inflation. A real rate of return is a measure of the income available to an investor after preserving the value of the original investment.

22. This concept of the real return as a measure of income, and the difficulty of correctly adjusting for inflation, can be traced in the economics literature to early 20th century economists, and in particular to J R Hicks. Hicks famously defined (Hicks, 1946, p. 172):

> a man's income as the maximum value which he can consume during a week, and still expect to be as well off at the end of the period as he was at the beginning.

23. Hicks outlined the difficulty of estimating real income ex ante, as it requires estimates of future interest rates and prices. However, if the required rate of return is to serve the NEO or NGO in promoting efficient investment, firms must expect efficient investment will be profitable, or they will not invest. As the Australian Competition Tribunal (ActewAGL Distribution, 2017, para. 156,

157) observed recently, a test for assessing the revenue allowance for a regulated service provider is that:

> It would require that a regulated entity be allowed a stream of revenues over the life of the asset that, at the time the investment is made, have a net present value, measured at the prevailing WACC, equal to the cost of the asset.
>
> The Tribunal considers that to be entirely conventional economic thinking in perfect accord with the Rules and is potentially a test that the AER could use, together with other criteria specified in the NGR, to establish its choice between approaches.

24. Regulators in other jurisdictions express similar views (HM Treasury Advisory Group, 1986, p. 19, as cited in Commerce Commission New Zealand, 2016):

> No commercial competitor would come into an industry if they did not expect to be able to recover the decline in the real values of their assets, as well as earn a normal profit (the opportunity cost of capital). They would measure their return on investment after recovery of funds sufficient to maintain the real value of the financial capital they had invested.

25. If the present value of revenue is equal to the present value of costs (including a return on capital), then consumers pay no more than is required to attract the investment needed to efficiently provide the service. Hence, regulation that seeks to set the present value of revenue equal to the present value of costs is in the long-term interests of consumers.

26. This principle, of setting the present value of revenue equal to the present value of costs, is referred to as the NPV = 0 principle. We apply this concept in assessing below the AER approach, and variations suggested by submitters.

3. The AER approach and method of assessment

3.1 The AER approach

3.1.1 The building block approach

27. The AER sets regulated revenue based on its estimate of the efficient costs that an NSP expects to incur in providing its electricity or gas network services. The forecast revenue is built up from the sum of five components (building blocks):

- return on capital, which compensates investors for the opportunity cost of funds invested in the NSP
- return of capital (depreciation), to return the initial investment to investors over time
- operating expenditure
- adjustments arising from incentive schemes and other adjustments
- corporate tax.

28. Expressed in its simplest form, the building block approach to establishing the Annual Revenue Requirement (ARR) is as follows:

ARR = return on capital + depreciation + operational and maintenance expenditure + revenue adjustments + tax

where:

return on capital = weighted average cost of capital (WACC) x regulatory asset base (RAB)

29. Revenue is reset usually once every five years (with annual adjustments for inflation, as discussed further below). Setting revenue in advance provides NSPs with an incentive to lower costs below the regulatory estimate of efficient costs.

3.1.2 The PTRM and RFM models

30. Two key models used by the AER to calculate the building blocks are the Post Tax Revenue Model (PTRM) and the Roll Forward Model (RFM).

3.1.2.1 The RFM

31. The RFM is used to roll forward the Regulated Asset Base (RAB) from one year to the next, and from one regulatory period to the next. The closing RAB value for the last year of the regulatory period—immediately prior to the regulatory period that is subject to a revenue reset—becomes the Opening RAB value for the regulatory reset.

32. The general approach for calculating the closing RAB in any year within the RFM is:

Closing RAB for the previous year becomes opening RAB for the year in which the calculation is being made:

Plus any additions to the value of the RAB over the year, such as investment in new assets

Less any reductions in the value of the RAB over the year, such as depreciation and disposals

Plus indexation for actual inflation

Equals closing RAB for the year.

3.1.2.2 The PTRM

33. The PTRM calculates the allowed expected nominal revenue for an NSP; the model performs iterative calculations to derive the:

- Annual revenue requirement (unsmoothed)
- Annual expected revenue (smoothed)
- X factors that convert unsmoothed revenue to smoothed revenues over a given period.

3.1.3 The price control mechanism

34. The AER sets regulated prices for the first year of the next regulatory period based on the nominal revenue for the first year and forecast demand for the first year. For each subsequent year, revenue is determined annually by starting with the previous year's approved revenue and adjusting for inflation, less an X factor, and plus or minus any other miscellaneous adjustments.

3.1.4 AER presents its approach as targeting a real return

35. The AER presents its approach as targeting a real rate of return (Australian Energy Regulator, 2020, p. 21). This real rate of return is derived from the nominal rate of return and expected inflation. The AER considers that NSPs are compensated for this real rate of return plus actual inflation over the regulatory period.

3.2 A formal model for assessing the AER approach

36. In this section, we develop a formal algebraic model to assess whether the building block model and its implementation via the PTRM, the RFM and price control mechanisms achieve, in concept, the regulatory objectives discussed in section 2 above. In subsequent sections, we use this formal model to assess whether the variations proposed by stakeholders would better meet the regulatory objectives and principles relative to the AER's current approach.

37. Appendix A provides a list of symbols used in the equations that follow.

38. In the AER's building block model, the total allowed revenue for an NSP, for any year t in regulatory period j, comprises the annual revenue requirement (ARR) plus the revaluation gain ('allowance for inflation'), AI_t^j, from inflation indexation of the nominal opening RAB. The NSP receives the ARR as cash income in year t, and the revaluation gain as future cash flows. This

total allowed revenue equals the sum of the expected nominal return on capital (ENRC), depreciation (D), nominal opex (O), revenue adjustments (RA), and tax payable (Tax). This method for determining the total allowed revenue is shown in equation (1):

$$ARR_t^j + AI_t^j = ENRC_t^j + D_t^j + O_t^j + RA_t^j + Tax_t^j \quad (1)$$

That is

$$ARR_t^j - \left(O_t^j + RA_t^j + Tax_t^j\right) + AI_t^j = ENRC_t^j + D_t^j \quad (2)$$

39. The left-hand side of equation (2) is net nominal revenue after tax (NNRT), plus indexation of the RAB by e^j, the expected rate of inflation for period j. Hence:

$$NNRT_t^j + A_{t-1}^j e^j = A_{t-1}^J w_t^j + D_t^j$$

where w_t^j is the nominal WACC for period *j*.

40. Therefore:

$$NNRT_t^j = A_{t-1}^J (w_t^j - e^j) + D_t^j \quad (3)$$

and thus

$$NNRT_t^j + A_{t-1}^j e^j = A_{t-1}^J \left(w_t^j - e^j\right) + A_{t-1}^j e^j + D_t^j$$

41. That is, the building block model delivers the return on capital (comprising the cash component $A_{t-1}^J\left(w_t^j - e^j\right)$ and the revaluation gain $A_{t-1}^j e^j$) plus the return of capital, D_t^j.

42. In the PTRM handbook (and spreadsheets), depreciation and indexation of the RAB are combined into regulatory depreciation. As the impact on returns to equity from recognizing the indexation of assets is an area of particular interest to stakeholders (discussed in section 6) below, we separate depreciation and the allowance for inflation in our description of the model. Separating these elements allows us to represent the allowance for inflation as part of the return on capital, which assists in demonstrating whether the regulatory regime achieves the regulatory objective. This approach of separating depreciation from the allowance for inflation is presentational and the net adjustment adopted within the AER model achieves the same result.

43. The regulatory objective of maintaining real returns means that the present value of revenue must equal the present value of costs; that is, the net present value of the entity is zero. This result is explained below, and Appendix B provides a more detailed derivation.

44. The present value of the investment at the opening of year t in regulatory period j, V_{t-1}^j, is the sum of the cash flow for the current year, including capital expenditure, and the residual value of the entity at the end of the year. The sum of the cash flow, NNRT, is given by equation (3) above. The residual value of the entity at the end of the year is the closing asset value of the asset base (the opening value indexed for inflation) plus net capex, where net capex is nominal capex (C_t^j) less depreciation.

45. Hence the value of the investment is:

$$V_{t-1}^{j} = \frac{\left[A_{t-1}^{j}\left(w_t^{j} - e^{j}\right) + D_t^{j}\right] + \left[A_{t-1}^{j}\left(1 + e^{j}\right) - D_t^{j} + C_t^{j}\right]}{1 + w_t^{j}}$$

46. Rearranging and simplifying this equation we can see that the present value of the investment is equal to the opening investment in the asset base plus the present value of capex made at the end of the year:

$$V_{t-1}^{j} = A_{t-1}^{j} + C_t^{j}/(1 + w_t^{j})$$

47. Thus, for any year t during regulatory period j, in the AER's building block model the present value of the cash flow for the year and the residual value of the entity at the end of the year is equal to the initial outlay plus the present value of capex at the end of the year. Thus, for any year t, during the regulatory period j, the present value of the cash flow for the year and the residual value is equal to the present value of the outlays, that is, NPV = 0. It follows that, the principle NPV = 0 must also hold for the whole sequence of years to any future date.

4. Assessing the AER approach

4.1 Formal and applied modelling of the AER approach

4.1.1 We use two methods to assess the AER approach

48. In this section, we assess whether the AER's current approach achieves the expected result that the net present value of the investment is zero (allowing for an intended return on capital) and the NSP maintains the real value of its capital investment. We undertake two approaches to this assessment:

- Firstly, we apply the formal model specified in section 3.2 above to the structure of the AER's PTRM and RFM models and price control mechanism to assess whether the design achieves the intended outcome.
- Secondly, we undertake scenario modelling by applying the current versions of the AER PTRM and RFM models over 10 regulatory periods (50 years) to assess whether those models deliver the intended outcome.

49. In applying both approaches our focus is on the cost of capital.

4.1.2 Our focus is on the cost of capital

50. Recall from equation (3) above, that the net nominal revenue after tax of the NSP in year t of regulatory period j is:

$$NNRT_t^j = A_{t-1}^j(w_t^j - e^j) + D_t^j$$

51. In this formulation, the net nominal revenue after tax (NNRT) depends only on the opening asset base, the expected real rate of return, and depreciation. It does not depend on the allowed values of opex and the other building block allowances. Having determined NNRT, the annual revenue requirement (ARR) is determined by adding opex and the other building block allowances to NNRT. Ex ante an NSP would expect to earn sufficient revenue (ARR) to cover its opex, revenue adjustments, and tax, in addition to the NNRT: the NPV=0 principle still holds. The derivation of this result for the ARR is shown in Appendix E.

52. Appendix D provides further explanation as to why opex, revenue adjustments, and tax can be ignored when assessing the impact of inflation on NNRT. Of course, an NSP may experience actual opex (and tax) of a different amount than its opex (or tax) allowance. Expected real, non-capital, costs are specific to the firm, and can be affected by the choices of the firm or the regulator.

53. Structuring the model in this manner maintains the focus on the issues raised by submitters (discussed below), which concern how inflation impacts on capital costs and not the allowances for opex, revenue adjustments, and tax.

4.2 Applying the formal model to the AER approach

54. In the following analysis, we apply the formal model developed above to the approach taken by the AER in its:

- PTRM and RFM (these models are described in section 3.1.2 above)
- price control mechanisms (the price control mechanism is described in section 3.1.3 above).

4.2.1 Real returns in the design of the AER's RFM and PTRM

55. In the PTRM, the value of the opening asset base in year t of regulatory period j is the opening value of the asset base for that regulatory period plus real net capex since the start of the period (as above, net capex is capex less depreciation). Both the opening value of the asset base and net capex are adjusted for the expected inflation for the period. Using the symbols defined in Appendix A, we show in Appendix C that:

$$A_t^j = (A_0^j + RNC_1^j + \cdots + RNC_{t-1}^j + RNC_t^j)(1 + e^j)^t$$

56. The opening value of the asset base in regulatory period 1, A_0^1, is the closing value of the asset base at time 0. In the second, and subsequent, regulatory period(s) the opening value of the asset base, A_0^1, (j >1), is determined in the RFM by adjusting the opening value of the asset base from the previous period and the real net capex (RNC) of that period (capex less depreciation) by actual inflation. That is:

$$A_0^j = (A_0^{j-1} + RNC_1^{j-1} + RNC_2^{j-1} + RNC_3^{j-1} + RNC_4^{j-1} + RNC_5^{j-1})(1 + a_1^{j-1})(1 + a_2^{j-1})(1 + a_3^{j-1})(1 + a_4^{j-1})(1 + a_5^{j-1})$$

57. Thus, each regulatory period starts with an asset base that reflects the net capex made in the previous period and the actual inflation experienced during that previous period. That is, the opening asset base for all periods is the then current value of the asset base.

58. We show in Appendix C that:

$$NRT_t^j = [(A_0^j + RNC_1^j + \cdots + RNC_{t-1}^j)(1 + e^j)^{t-1}](w_t^j - e^j) + RD_t^j(1 + e^j)^t \qquad (4)$$

59. Equation (4) shows that in any given year t in regulatory period j, the NSP achieves the expected real return on its opening asset base (the term in square brackets), plus expected nominal depreciation.

60. Thus, the design of the PTRM and RFM models produce the intended building block result; that is, the allowed real rate of return on capital for any year t in regulatory period j is the nominal WACC set by the AER less its estimate of expected inflation $(w_t^j - e^j)$.[2]

4.3 Smoothing and annual adjustment

4.3.1 Smoothing

61. The annual revenue requirements (ARR) may vary substantially from year-to-year throughout a regulatory period depending on the value of the building blocks in each year. To mitigate the price shocks that would arise from such variability, the ARR series within a regulatory period is smoothed to a series of smoothed maximum allowable revenues (SMAR). The smoothing process is such that the present value of the ARR series is equal to the present value of the SMAR series. The smoothing process thus maintains the NPV = 0 principle.

62. The SMAR series assessed at time 0 in any regulatory period j reflects expected inflation and an X factor ('CPI-X' adjustment). Thus, the SMAR for year t in regulatory period j, assessed at time 0, is given by:

$$SMAR_{t,0}^j = SMAR_{t-1,0}^j(1 + e^j)(1 - X_{t,0})$$

where

$$SMAR_{1,0}^j = ARR_{1,0}^j$$

63. The X are initially set equal across the years of the regulatory period and can be interpreted as the annual change in real smoothed maximum allowable revenue. Derivation of the initial SMAR series is shown in Appendix F.

4.3.2 Annual price adjustment

64. At time 1, the SMAR for year 1 is typically kept at the value set at time 0, that is:

$$SMAR_{1,1}^j = ARR_{1,0}^j$$

65. However, the SMAR values for the later years in the regulatory period are adjusted for actual one-year lagged inflation (that is, at time 1, for the inflation experienced in year 1) in place of

2 While it is conventional to refer to $(w_t^j - e^j)$ as the real rate, the precise real rate, r_t^j, is given by $(1+ w_t^j) = (1 + r_t^j)((1 + e^j)$, and thus $r_t^j = (w_t^j - e^j)/(1 + e^j)$.

expected inflation. The X factor calculated at time 0 continues to be applied.[3] Similarly for the adjustments made at later times in the period.

4.3.2.1 First year effect

66. The effect of keeping the first year SMAR at the value set at time 0 is to lock into the outcome for the first year the expected inflation rather than actual inflation. This means that for most NSPs, there is a difference between the expected real revenue and the actual real revenue. If expected inflation for the first year is greater (less) than actual inflation, the NSP receives a higher (lower) return than expected. This effect persists throughout the regulatory period because each year's revenue is a function of the previous year and so ultimately all are a function of the first year.

67. The error in actual tariff revenue in year 1 equates to $[1 - (1 + a)/(1 + e)]$ times the allowed revenue for year 1. The error only applies to revenue from tariffs. Revaluation income in the RFM is not subject to this error, because in each year it is updated using actual inflation.

68. The error can be corrected by adjusting the SMAR for year one by $(1 + a)/(1 + e)$.

4.3.3 Annual price adjustment with trailing average cost of debt

69. The allowed cost of debt is updated each year as a trailing moving average over 10 years and the X factor is adjusted to reflect this approach. The X factor for year 2 is calculated from resetting the 'PV{ARR} = PV{SMAR}' equation. Similarly, the X factor is adjusted for years 3, 4 and 5.

70. As a result of these adjustments, the NPV=0 principle is maintained in each year in the estimation of the ARR series (updated for use of the trailing moving average cost of debt in WACC). The conversion each year to the SMAR series (to reflect experienced inflation) also maintains the NPV=0 principle as the 'CPI - X' adjustment equates aggregate present values.

71. The derivation of this result is set out in Appendix G.

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[3] For example, for the 2013-18 SA transmission determination, which did not include the debt cost update approach, the required annual revenue adjustment process treats the X factor as fixed: https://www.aer.gov.au/system/files/AER%20-%20transmission%20determination%20for%20ElectraNet%27s%202013-18%20regulatory%20control%20period%20-%2030%20April%202013.pdf, pages 3 – 4.

4.4 Multi-period spreadsheet modelling of the AER approach

72. To provide quantified illustrations of the findings discussed above, we set up scenario modelling of the AER PTRM and RFM models over 10 regulatory periods (50 years). We use the test models to assess whether the AER PTRM and RFM models achieve the intended outcomes of those models. Our test model links to the most recent versions of AER PTRM and RFM models.[4] We used a scenario control mechanism to run the linked AER models multiple times, with each run representing a different regulatory period. The inputs and outputs were stored along with the calculation process so the entire 50-year sequence is generated from the two AER models. This structure allowed specific changes, or components, of the AER models to be tested readily (the changes only affect one model and not 10).

73. The test models were populated with a single asset, where the opening asset value is $1000 (in real terms) with annual capital investments of $100 (in real terms). For simplicity all operating costs are set to zero. A fuller description of the modelling is set out in Appendix H.

74. Table 1 shows a summary of the results of the modelling. In the scenarios in which inflation outcomes are the same as inflation expectations, the NPV of the expected net revenue and the NPV of actual revenue are the same as expected; that is, the models achieve the NPV=0 result. In the scenarios where expected inflation is higher than outcome inflation, the NSP gains a small positive NPV benefit, and where inflation outturns are higher than expected the return to the NSP is slightly lower, as anticipated from the first year effect discussed above.

Table 1 Summary of NPV=0 scenario results showing the percentage deviation from the NPV=0 result.

No	Scenario name	Ex ante %NPV error	Ex post %NPV error
1	Flat 2.5% Inflation (for both outcome and expected)	0.0%	0.0%
2	Ave correct; but 10 year down/up	0.0%	0.0%
3	Forecast too high (3.5% - with outcome = 2.5%)	0.4%	1.0%
4	Forecast too low (1.5% - with outcome = 2.5%)	-0.5%	-1.0%
5	Forecast too high + Outcome descending each 5 yr	0.2%	1.5%
6	Forecast too high + Outcome ascending each 5 yr	0.7%	0.5%
7	Monte Carlo auto generation (approach 1)	-0.4	0.2%

4 *Electricity post-tax revenue model* (distribution) - *April 2019 amendment*; *Electricity roll forward model* (distribution) – *April 2020 amendment*. As the gas models are the same, at this stage it does not seem necessary to replicate the modelling also using the gas models.

8	Alternating (by Reg Period) Flat 3.5%/2.5% Outcome Inflation (2.5% expected)	0.8%	-0.2%
9	Alternating (by Reg Period) Flat 2.5%/5.5% Outcome Inflation (2.5% expected)	-0.8%	0.2%

5. Construction of the estimated real rate of return

5.1 AER's estimate of WACC and inflation

75. In the preceding sections, we reviewed the regulatory objective of targeting a real return. We showed that the allowed real return for any year t in regulatory period j is the nominal weighted average cost of capital (WACC) for year t, less the AER's estimate of inflation for period j; that is, $(w_t^j - e^j)$. In this section, we discuss the construction of the allowed real rate of return by the AER.

76. The WACC for year t, in period j, w_t^j, is the weighted average of the estimated nominal return on equity, k^j, and an estimate of the cost of debt. The cost of debt estimate is the 10-year trailing moving average of the nominal cost of debt over the period $(t-9, t)$.

77. The AER uses the Sharpe-Lintner-Mossin form of the capital asset pricing model (SLM-CAPM) to estimate a starting point and a range for the expected return on equity, and considers a range of material in arriving at a point estimate for the expected return.[5] The cost of equity is forward looking. It thus reflects estimates of the risk free rate (based on the rate observed shortly before the start of the regulatory period on Commonwealth Government Securities with a 10-year term), the market risk premium, and the equity beta (the measure of the extent to which returns to equity for an NSP vary with the aggregate market). The estimated cost of equity is the return that the AER expects is needed to attract funds to make efficient investments in network assets.

78. In 2013, the AER moved from an on-the-day approach to estimating the cost of debt to a trailing average methodology. The change, initially an option, was intended to reduce the risks facing suppliers by more closely matching the method of estimating the regulatory return on debt with debt raising practices. These non-inflation risks associated with estimating the cost of debt using an on-the-day approach are outside the scope of this report.

79. The use of a trailing average cost of debt reflects the AER assumption that the benchmark efficient entity issues debt with a 10-year term, and issues 10% of its debt portfolio each year (with a BBB+ rating).

80. The AER's estimate of inflation for period j, e^j, applies throughout period j and is the geometric average of 10 years of annual inflation forecasts from year 1 in period j.[6]

81. The method of estimating the nominal WACC and the AER's approach to estimating inflation are out of scope for this report and are taken as given. However, it should be noted that the SLM-CAPM does not address uncertain inflation, which results in the nominally risk-free asset

5 AER, *Rate of return instrument: Explanatory Statement*, December 2018.

6 AER, Final position, Regulatory treatment of inflation, December 2017, p. 114.

having a risky real rate of return. The CAPM with uncertain inflation is derived in Appendix I. The impact on the estimate of the return on equity compared with an estimate resulting from application of the SLM-CAPM depends on currently unavailable empirical estimates of the covariance between inflation and the return on equity and the covariance between inflation and the returns on the market portfolio.

5.2 Expected inflation, outturn inflation, and embedded inflation

5.2.1 Expected inflation, outturn inflation and the rate of return on equity

82. As discussed above, the regulatory regime provides for a real return, viz, the nominal WACC less the AER's estimate of expected inflation.

83. It is important to understand that, conceptually, the expression $(w_t^j - e^j)$ represents the real rate of return. The nominal rate, w_t^j, is a 10-year rate, so the inflation embedded in it is effectively expected inflation over the ten year period, annualised. This is why the AER uses a ten year geometric average to determine e and thus the real rate of return $\left(w_t^j - e^j\right)$.

84. Actual inflation (a) is the annual rate of inflation for a single year. This means that there is no reason to expect that e should be equal to a, even if the AER has perfect foresight, unless inflation is expected to be constant for 10 years.

85. The targeted real return is not impacted by any mismatch between the AER's expected inflation and outturn inflation. The total return on capital is the cash component of the return plus the revaluation gain. The ARR is set so as to achieve the cash component $A_{t-1}^j(w_t^j - e^j)$ and therefore if outturn inflation is at the expected level e^j, the realised nominal rate of return on capital is then w_t^j. However, if outturn inflation is a_t^j then the total rate of return on capital is given by:

$$(w_t^j - e^j) + a_t^j = w_t^j - (e^j - a_t^j)$$

which differs from $w_t^j$by $(e^j - a_t^j)$. However, the realised real return is:

$$[w_t^j - (e^j - a_t^j)] - a_t^j -= w_t^j - e^j$$

which is the targeted real return.

86. If there is a difference between the AER's expected inflation and the annual outturn inflation there will be a change in the return to equity. The cash component of the rate of return on capital is:

$$w_t^j - e^j = (1 - L)k^j + Ld_t^j - e^j$$

$$= (1 - L)[k^j - e^j/(1 - L)] + Ld_t^j$$

87. Thus, given that debt is compensated at the nominal rate, the cash rate of return on equity is:

$$k^j - e^j/(1-L)$$

88. Therefore, if outturn inflation is at the expected level e^j, the realised total rate of return on equity is:

$$k^j - e^j/(1-L) + A_t^j e^j / A_t^j (1-L) = k^j$$

89. However, if outturn inflation is a_t^j the rate of revaluation gain for equity is:

$$A_{t-1}^j \, a_t^j / \, A_t^j (1-L) = \; a_t^j/(1-L)$$

and the resulting total rate of return on equity is:

$$k^j - (e^j - \, a_t^j)/(1-L)$$

90. This total rate of return differs from k^j by $(e^j - \, a_t^j)/(1-L)$. Therefore, while the impact on nominal WACC is just the difference between the expected and outturn inflation rates, in the case of the nominal rate of return on equity the difference is magnified by leverage. The real rate of return on equity is:

$$k^j - (e^j - \, a_t^j)/(1-L) - \, a_t^j \; = k^j - (e^j - \, a_t^j L)/(1-L)$$

91. This real rate of return on equity differs from $k^j - e^j$ by $L(e^j - \, a_t^j)/(1-L)$. If leverage is less than 50%, this difference for the real return on equity is less than the difference for the nominal rate. However, if $L < 0.5$, this difference is less than the difference for the nominal rate but if leverage is $L > 0.5$ the difference is larger.

5.2.2 Expected inflation and embedded inflation

92. The market assessment of expected inflation at any point in time, like the WACC itself, is not observable. If the AER's estimate of expected inflation differs from the (unobservable) expectation of inflation, NPV=0 would still hold *ex ante* as the allowed ARR_t^j would adjust to compensate for the difference in the rates. However, *ex post* the difference results in different nominal and real rates of return on capital.

93. The AER acknowledges this possible result in its inflation discussion paper, noting that it is unlikely that its estimate of inflation is equal to the weighted average rate of inflation embedded in the WACC.[7] This result occurs because of possible differences between the AER's method of estimation of inflation and the aggregate market's assessment of inflation.

94. If the rate of inflation embedded in the WACC is i^j, and the outturn rate is a_t^j then an NSP's investment would have justified the nominal rate of return on capital $\left(w_t^j - \; i^j + a_t^j\right)$ and real rate $\left(w_t^j - \; i^j\right)$. However, application of the AER regulatory model, results in the rates of return

[7] AER, *Regulatory treatment of inflation: Discussion paper*, April 2017, pages 40-41.

being the rates $(w_t^j - e^j + a_t^j)$ and $(w_t^j - e^j)$ as shown at paragraph 85 above. The difference between the corresponding rates is in each case $(e^j - i^j)$.

5.3 Inflation lag

95. The AER uses various lags of inflation in its measure of actual inflation. The AER undertook a Monte Carlo simulation of three different lag structures when it proposed amending the RFM in 2016:[8]

- the unlagged approach for all elements of the RFM (ignoring the 6-month implementation delay)
- the partially lagged approach which uses a one year lag for some elements and unlagged inflation for others
- the all lagged approach which uses a one year lag of inflation for all elements.

96. The Monte Carlo analysis shows that over a 50-year time horizon, with random inflation outcomes in each year, all three approaches had average NPV near zero, but the unlagged approach has the lowest absolute error (average squared NPV). In other words, while there was no evidence of systematic bias in any of the approaches, the volatility in the unlagged approach is lowest.

97. These results suggest that given a particular benchmark, the long-run average allowance for inflation will be the same; this in turn means that over time consumers will pay the same amount regardless of which approach is followed. However, the volatility can be reduced by matching the regulatory allowance for inflation as closely as possible to actual inflation.

98. Consumers and equity holders are on opposite sides of the volatility risk, where there is a mismatch in some cases equity holders receive too high a return and customers pay relatively too much. The reverse also occurs just as frequently in the simulation. The risk to both parties can be reduced by matching the allowance more closely to the cost (i.e. using unlagged inflation).

5.4 Annual update to the cost of debt

99. The allowed cost of debt is updated each year during the regulatory period as a trailing moving average over 10 years. For example, in the first year of regulatory period j, the cost of debt is the average of the cost of debt over the 10 years from the second year in regulatory period $(j - 2)$ to the first year in regulatory period j. In the second year of regulatory period j the cost of debt in the second year of regulatory period $(j - 2)$ is dropped from the calculation of the

8 AER, 2016, *Proposed amendment Electricity distribution network service providers Roll forward model (version 2) - Explanatory statement*, 31 August.

average cost of debt and the cost of debt in the second year of regulatory period j is added to the calculation.

100. The cost of debt in year t in regulatory period j is thus calculated as:

$$\frac{1}{10}\sum_{v=t-9}^{t} d_v$$

where d_v is the nominal cost of debt for year v in the interval $[t-9, t]$. With this approach, WACC varies from year to year even within a regulatory period.

101. Any change, Δd, in the allowed cost of debt simply results in a corresponding change in the allowed WACC by the amount $L\Delta d$. The cost of debt (interest) is paid at the nominal rate. Therefore, if one method of estimation of the cost results in a higher estimate than does a second method, the first method will result in a higher estimate of WACC than does the second method and, consequently, a higher allowed real return. However, there will not be a direct impact on the cash rate of return on equity, nor the total rate of return on equity.

102. The total cash rate of return for an NSP is $(w_t^j - e^j)$ where:

$$(w_t^j - e^j) = (1-L)\,k^j + Ld - e^j$$

$$= (1-L)[\,k^j - e^j/(1-L)] + Ld$$

103. Thus the cash rate of return on equity will differ from the rate k^j according to the value of e^j and L but any change in the cost of debt will simply result in a corresponding change in the nominal WACC.

104. The effect on the cost of debt from basing the estimate of WACC on a trailing moving average cost of debt can be analysed in terms of:

- contrast with WACC based on the cost of debt estimated at the beginning of the period),
- the year on year effect.

105. Paragraph 183 in Appendix H, shows that the expected impact on WACC, Δw, from estimating the cost of debt as a trailing moving average is given by:

$$\Delta w = L[\frac{1}{10}\sum_{v=t-9}^{v=t}(d_v - d^j)]$$

106. If the real cost of debt is assumed to be constant, then the impact on WACC can be stated in terms of a difference in expected inflation rates:

$$\Delta w = L\left[\frac{1}{10}\sum_{v=t-9}^{v=t}\left(i_v - i^j\right)\right]$$

107. That is, if historical inflation expectations are on average greater (less) than the expectation at the beginning of the period, then the impact is positive (negative) but is reduced by leverage.

108. Paragraph 187 shows that in terms of the year on year effect, the expected change in WACC from period t to $t+1$ is given by:

$$\Delta w \ = \ \mathrm{L}\left[\frac{1}{10}(d_{t+1} - d_{t-9})\right]$$

109. If the real cost of debt is assumed to be constant, then the impact on WACC is given by:

$$\Delta w = \mathrm{L}\left[\frac{1}{10}(i_{t+1} - i_{t-9})\right]$$

110. That is, if the inflation expectation for year $t+1$ is greater (less) than it was for year $t-9$ then the impact is positive (negative) but reduced by leverage.

6. Variations proposed by stakeholders

6.1 Stakeholders are concerned that return to equity is under compensated

111. Submitters have raised concerns that the combination of the AER approach to forecasting future inflation and the deduction of that expected inflation from the ARR means that investors will be under-compensated relative to the AER's allowed return on equity. SA Power Network provide the following example (SA Power Networks, 2019, p. 10):

> By way of example, the AER's allowed return on equity for SA Power Networks is currently 4.62%. Other things being equal, if actual inflation turns out to be 0.5% lower than the AER's 2.36% estimate, the actual regulatory return available to equity holders will be 3.37%.

112. SA Power Network say that the AER approach to inflation results in under-compensation for returns on equity even if outturn inflation is as expected. A similar argument is made by The Queensland Treasury Corporation. The Queensland Treasury Corporation observes that (Queensland Treasury Corporation, 2019, p. 3):

> The indexation return in the draft determinations is 6.12 per cent (ie, 2.45 per cent ÷ 0.4), which is 1.14 per cent higher than the allowed return on equity of 4.98 per cent. As a consequence, the return contribution from NPAT is negative 1.14 per cent per annum of opening equity in the PTRM.

113. Hence, these stakeholders are concerned that the AER is targeting too low a rate of return on equity, and that the adverse impacts from the low target rate will be compounded should outturn inflation exceed the AER expected inflation.

6.2 Impact of AER approach on returns to equity

6.2.1 Cash return, expected inflation, and leverage

114. As discussed above, the AER approach produces the intended total real return $A_{t-1}^{j}\left(w_t^j - e^j\right)$ ex post, irrespective of outturn inflation. In nominal terms, the approach returns $A_{t-1}^{j}\left(w_t^j - e^j + a_t^j\right)$; this nominal return divides up into $A_{t-1}^{j}\left(w_t^j - e^j\right)$ in cash and $A_{t-1}^{j} a_t^j$ as outturn revaluation gains.

115. As shown in paragraphs 86 and 87 above, the cash rate of return on equity is:

$$[k^j - e^j/(1-L)]$$

It is implicit in this result that for a given expected return on equity, the larger the AER estimate of expected inflation, e^j, and the larger the estimate of leverage, L, the smaller will be the cash component of the rate of return on equity. Indeed, it follows that if:

$$e^j > (1 - L)k^j$$

then the cash rate of return on equity is negative. That is, the NSP will generate a cash deficit (with insufficient funds to meet the interest due on debt) rather than a surplus, from which to fund dividends and growth.

116. This condition is feasible, and the likelihood of it occurring increases with higher leverage and a lower nominal rate of return on equity. For example, if $e^j = 2.0\%$, $L = 0.6$, $k^j = 4.5\%$ then the cash rate of return on equity is -0.5%. Assuming no mismatch between the expected and outturn rates of inflation, the revaluation gain rate on equity is $e^j/(1 - L) = 5\%$, thus giving the expected overall result of 4.5%. [=(-0.5 + 5.0)%].

117. The example confirms that if outturn inflation is at the expected level, the NSP will receive the expected total rate of return k^j. However, if outturn inflation, a_t^j, differs from the expected rate, the total rate of return on equity will differ from the expected rate by $(e^j - a_t^j)/(1 - L)$ (as shown in paragraphs 89 and 90). Thus, continuing with the example, if outturn inflation was 1.5%, the realised total return on equity would be 3.25% [=(4.5% -0.5/0.4)%]. However, if outturn inflation was 2.5%, the realised total return on equity would be 5.75% [=(4.5+0.5/0.4)%].

118. While the expected cash rate of return on equity may be negative, the total return on equity may also be negative. This condition could hold if the cash rate of return on equity is negative, that is, $e^j > (1 - L)k^j$, and outturn inflation is low, thus $e^j - a_t^j > (1 - L)k^j$. Where this applies, even the realised total rate of return on capital, $w_t^j - e^j + a_t^j$, is insufficient in amount to meet the obligation to pay interest.[9]

119. We discuss the implications of these results further below.

6.2.2 Illustration using AER parameters

120. To illustrate the effect of AER estimates of expected inflation and leverage on returns to equity, we apply the formulas derived above to a set of parameters from a recent AER determination.[10] Table 2 shows the WACC parameters used for this illustration.

Table 2 Parameter values for illustration

Parameter	Value
Cost of debt	4.87%
Cost of equity	4.56%

9 $e^j - a_t^j > (1 - L)k^j$, therefore $(1 - L)k^j + Ld_t^j - (e^j + a_t^j) < Ld_t^j$, that is, $w^j - e^j + a_t^j < Ld_t^j$

10 These parameters are taken from the rate of return set for SA Power Networks in the AER determination published on 5 June 2020. We have used the parameters from a recent AER decision so that the illustration is realistic and not to express any view in relation to the SA Power Networks' determination; the parameters in the illustration could be swapped for another recent decision.

121. Table 3 shows the expected and realised values for rate of return on equity and rate of return on capital under six scenarios in which:

- outturn inflation is 0.5% lower than expected (scenarios 1 and 4), equal to expected (scenarios 2 and 5), and 0.5% higher than expected (scenarios 3 and 6)
- leverage is set at 60% (scenarios 1 to 3) and then at 50% (scenarios 4 to 6); to highlight the effect of leverage on the results no changes are made to the inflation rates and the costs of equity and debt.

Table 3 Illustration using AER parameters

	Leverage 60%			Leverage 50%		
Scenario	**1**	**2**	**3**	**4**	**5**	**6**
	Leverage 60%			**Leverage 50%**		
Outturn inflation	1.77	2.27	2.77	1.77	2.27	2.77
Cash return on equity	-1.115	-1.115	-1.115	0.02	0.02	0.02
Expected revaluation gain equity	5.675	5.675	5.675	4.54	4.54	4.54
Expected return on equity	4.56	4.56	4.56	4.56	4.56	4.56
Expected return on capital	4.746	4.746	4.746	4.715	4.715	4.715
Expected real return on equity	2.29	2.29	2.29	2.29	2.29	2.29
Expected real return on capital	2.476	2.476	2.476	2.445	2.445	2.445
Realised revaluation gain equity	4.425	5.675	6.925	3.54	4.54	5.54

Realised return on equity	3.31	4.56	5.81	3.56	4.56	5.56
Realised real return on equity	1.54	2.29	3.04	1.79	2.29	2.79
Realised return on capital	4.246	4.746	5.246	4.215	4.715	5.215
Realised real return on capital	2.476	2.476	2.476	2.445	2.445	2.445

122. The results are as predicted from the preceding discussion:

- The real return on capital achieved by the NSP is the same as the expected real return on capital; that is, it is unaffected by variations in outturn inflation (scenarios 1 to 3 and scenarios 4 to 6).
- The realised real rate of return on equity varies in the same direction as inflation outturns: if outturn inflation is lower than expected inflation, then the realised real rate of return on equity will be lower than the expected real rate of return on equity (scenarios 1 and 4); similarly, if outturn inflation is higher than expected inflation, the realised real rate of return on equity will be higher than the expected real rate of return on equity (scenarios 3 and 6).
- If expected inflation is greater than the percentage of equity multiplied by the expected nominal rate of return on equity (that is, if $e^j > (1-L)k^j$, the cash return to equity will be negative (as in scenarios 1 to 3).

123. Queensland Treasury Corporation has demonstrated the negative cash rate of return on equity result in terms of Net Profit After Tax (NPAT) (Queensland Treasury Corporation, 2019). For a given nominal rate of return on equity, if the expected inflation rate is at a level such that the cash return on equity is negative, NPAT will be negative:

$$NPAT_t^j = NNRT_t^j - D_t^j - A_{t-1}^j L d_t^j$$

$$= A_{t-1}^j (w_t^j - e^j) + D_t^j - D_t^j - A_{t-1}^j L d_t^j$$

$$= A_{t-1}^j [(1-L)k^j + Ld^j - e^j] - A_{t-1}^j L d_t^j$$

$$= A_{t-1}^j (1-L)[k^j - e^j/(1-L)]$$

Therefore:

$$NPAT_t^j < 0 \quad if \quad e^j > (1-L)k^j$$

124. Stakeholders therefore correctly identify that the current regulatory approach may result in negative cash returns to equity, and that this may occur with low allowed nominal rate of return on equity and/or high leverage. If, in addition, outturn inflation is low then total return on equity could be negative and thus even realised return on capital would be insufficient in amount to meet the obligation to pay interest.

6.3 Hybrid approaches

125. In response to the prospect of varying real rates of return to equity, and the possibility of negative cash returns to equity, some stakeholders have suggested hybrid approaches. In this section we explore two hybrid approaches.

6.3.1 Including interest on debt as an expense

126. The first hybrid approach we explore would involve including interest on debt as an expense in setting the ARR.

127. Given opex, revenue adjustments, and tax, the $NNRT_t^j$ determines the annual revenue requirement, ARR_t^j, as

$$NNRT_t^j = ARR_t^j - O_t^j - RA_t^j - Tax_t^j$$

128. Thus if interest was treated as a deduction from the ARR_t^j, this would be equivalent to setting the $NNRT_t^j$ net of interest, that is:

$$NNRT_t^j - LA_{t-1}^j d^j = ARR_t^j - O_t^j - RA_t^j - Tax_t^j - A_{t-1}^j L d_t^j$$

129. The cash component of the return on equity capital is thus:

$$\begin{aligned} NNRT_t^j - D_t^j - LA_{t-1}^j d^j &= A_{t-1}^j\left(w_t^j - e^j\right) - A_{t-1}^j L d_t^j \\ &= A_{t-1}^j\left[(1-L)k^j + L d_t^j - e^j\right] - A_{t-1}^j L d_t^j \\ &= A_{t-1}^j (1-L)[k^j - e^j/(1-L)] \end{aligned}$$

130. That is, the cash rate of return on equity remains at the same value as derived above, viz:

$$[k^j - e^j/(1-L)]$$

131. Given that the treatment of interest as a deduction from the ARR_t^j, rather than as a payment from the total return to an NSP, makes no difference to the cash rate of return on equity, this proposed hybrid approach does not address the stakeholder concern.

6.3.2 Decomposing the rate of return to equity

132. The second hybrid approach decomposes the expected revaluation gain $A_{t-1}^j e^j$ into two components: $A_{t-1}^j(1-L)e^j$ for equity holders as revaluation gain and $LA_{t-1}^j e^j$ treated as an expense in setting the ARR. Thus:

$$NNRT_t^j = A_{t-1}^j w_t^j - A_{t-1}^j(1-L)e^j + D_t^j$$

133. The cash component of the return on capital is thus:

$$A_{t-1}^j w_t^j - A_{t-1}^j(1-L)e^j = A_{t-1}^j\left[(1-L)k^j + Ld_t^j\right] - A_{t-1}^j(1-L)e^j$$

$$= A_{t-1}^j(1-L)(k^j - e^j) + A_{t-1}^j L d_t^j$$

that is, the cash rate of return on equity is $(k^j - e^j)$. The total expected rate of return on equity is:

$$\left(k^j - e^j\right) + A_{t-1}^j(1-L)e^j/[A_{t-1}^j(1-L)] = k^j$$

and the expected real return is $(k^j - e^j)$.

134. However, if the outturn rate of inflation is a^j, then the realised total rate of return on equity is $(k^j - e^j + a_t^j)$ and the realised total real rate of return on equity is $(k^j - e^j)$. Thus this hybrid approach effectively shifts the focus from a targeted total real rate of return to a targeted real rate of return on equity. The ARR_t^j increases by $LA_{t-1}^j e^j$ and there is a corresponding decrease in the revaluation increment to the RAB.

135. Given the results for the rates of return on equity, the expected total rate of return on capital is w_t^j and the expected real rate is $(w_t^j - e^j)$. However, if the outturn rate of inflation is a^j, then the realised total rate of return on capital is $[w_t^j - (1-L)(e^j - a_t^j)]$ and the real rate is $[w_t^j - e^j + L(e^j - a_t^j)]$.

136. Table 4 illustrates the impact of this hybrid approach relative to the current AER model. It adopts the same parameter values as in the earler example (see Table 2) but addresses only scenario 1: outturn inflation at 1.77%, that is, 0.5% lower than expected inflation of 2.27%.

Table 4 Illustration of returns from a hybrid approach

	Current approach	Hybrid approach
Cash return on equity	-1.115	2.29
Expected revaluation gain	5.675	2.27
Expected return on equity	4.56	4.56
Expected return on capital	4.746	4.746
Expected real return on equity	2.29	2.29
Expected real return on capital	2.476	2.476
Realised revaluation gain equity	4.425	1.77
Realised return on equity	3.31	4.06

Realised real return on equity	1.54	2.29
Realised return on capital	4.246	4.546
Realised real return on capital	2.476	2.776

137. The difference of 0.3% [$= (2.476 - 2.776)\% = L(e^j - a_t^j)$] between the real realised rates of return on capital reflects the impact of interest being paid at the expected rate of inflation. Under the current AER approach, equity holders bear the cost of the difference between actual and expected inflation on the debt component of capital. This results in a lower real realised rate of return on equity by 0.75% [$= (3.31 - 4.06)\% = L(e^j - a_t^j)/(1 - \mathrm{L})$].

6.4 Negative returns to equity, adopting a hybrid model and the NEO and NGO

138. In its 2017 Final Position paper, the AER observed that, under an approach that targets the initial real rate of return, debt related inflation effects can cause equity holders to not receive the initial real return on equity (Australian Energy Regulator, 2017, p. 88). The AER commented that:

> We consider that this effect was not an error or side effect; rather, it was well understood prior to the adoption of the current approach more than fifteen years ago. It reflects a deliberate policy decision on the appropriate level to assess returns for the benchmark entity-that is, at the service provider level (not the equity investor level).

139. The Australian Competition Tribunal has similarly observed that the regulatory regime targets a return on capital, not a component of the return on capital. The Tribunal referred to estimates of return on equity and debt as a means to the end of estimating the overall rate of return (ActewAGL Distribution, 2017, paras. 106, 110):

> there is a building block for return on capital. The return on capital implicitly - through the manner in which it is estimated - contains components for a return on equity and a return on debt. But the return on capital is not calculated separately for equity and debt. The return on capital (in dollar terms) is found by multiplying the rate of return (on capital) by the regulatory asset base (electricity) or the projected capital base (gas).
>
> ...
>
> The rate of return on capital has primacy. The use of the rates of return on equity and debt is a means to the end of estimating that overall rate of return, and to then determining the return on capital building block. From its total allowed revenue, the service provider must meet its debt obligations along with its opex, capex and other expenditures. The Rules are careful not to imply that there is a guaranteed return to the shareholders. They get what is left. If the

> service provider can operate more efficiently than expected - including no less in its debt management than its management of opex, for example - the shareholders may receive a higher rate of return than was expected in the forward-looking framework.

140. The AER observed that by targeting the overall rate of return, financing decisions remain the concern of the service provider, who bears the benefit or detriment of all such decisions (on the appropriate gearing level, whether to issue fixed or floating debt, whether to issue domestically or overseas, and so on) (Australian Energy Regulator, 2017, p. 88). The AER concluded that the current approach "appropriately assigns any risk arising from these financing decisions to the service provider, rather than consumers". It observed that when inflation causes the real return to equity holders to drop below the initial target, the real return to debt holders rises above the initial target-noting that this outcome is a consequence of the decision of the NSP to issue nominal debt.

141. We agree with the AER that NSPs are best placed to bear the risk of their financing decisions, rather than consumers. However, we note that the sustained fall in inflation expectations means that the parameter estimates determined recently by the AER imply a negative cashflow return on equity for a benchmark efficient entity. In turn, negative cashflows would mean the benchmark efficient entity would need to fund dividends from depreciation cashflows—that is, spending less on replacement of real capital or by borrowing. The former approach is not consistent with the efficient investment and efficient operation of an NSP, at least beyond the short-term.

142. We suggest that the AER consider, during its 2020 Inflation Review, whether a projected negative cash return on equity might indicate an underlying inconsistency in one or more inputs into its estimate of WACC and expected inflation. Some possible aspects to explore might include:

- Whether the estimate of expected inflation is too high relative to likely outturn inflation; as the example above illustrates, if outturn inflation is lower than expected, then the real rate of return on equity will be lower than expected.
- Whether the nominal cost of equity might be under-estimated relative to expected inflation; an adjustment to the nominal cost of equity would imply a higher real cost of capital.
- Whether the assumed capital structure is efficient, given the relative rates of return to equity and debt; that is, whether an efficient entity facing those estimated relative costs may adjust its capital structure.

143. Adopting a hybrid rate of return targeting real returns on equity would mitigate the risk that cash returns on equity are negative, by reducing the level of revaluation gains in favour of cash returns. However, it fundamentally changes the regime to one that focuses on the value of the entity to shareholders, not the overall value of the entity. Targeting the real rate of return on capital preserves the total value of the investment and provides an incentive to outperform the cost of debt allowance. Adopting a hybrid targets the real return on equity, preserving the value of the shareholders' investment. The overall value of the entity may change. Targeting a real

rate of return on equity intervenes in the debt structure and results in a less efficient allocation of the risk of financing decisions.

7. Conclusions

144. The long-term interests of consumers requires that investors can expect real returns on capital ex ante and that these returns are able to be achieved ex post. The AER targets a real rate of return on capital; its approach allows NSPs to achieve the targeted real return on capital ex post, and to be compensated for outturn inflation. The AER approach is therefore consistent with the regulatory objectives.

145. For most NSPs, the revenue in the first year of a regulatory period locks in expected inflation for that year, rather than substituting in actual (lagged) inflation. This means there is a relatively small deviation from NPV=0 in the typical application of the AER model.

146. Stakeholders have correctly identified that the current regulatory approach may result in negative cash returns to equity; negative cash returns to equity may occur with a low allowed nominal rate of return on equity and/or high leverage. If, in addition, outturn inflation is low relative to expected inflation, then the return on equity may in amount be insufficient to meet the obligation to pay interest.

147. We agree with the AER that NSPs are best placed to bear the risk of their financing decisions, rather than consumers, and that by targeting total real returns the benefit or detriment from financing decisions remain the concern of the service provider. However, we note that the sustained fall in inflation expectations means that the parameter estimates determined recently by the AER imply a negative cashflow return on equity for a benchmark efficient entity. We suggest that the AER consider, during its 2020 Inflation Review, whether a projected negative cash return on equity might indicate an underlying inconsistency in one or more inputs into its estimate of WACC and expected inflation.

148. In response to the prospect of varying real rates of return to equity, and the possibility of negative cash returns to equity, some stakeholders have suggested hybrid approaches:

- a hybrid approach in which interest on debt is included as an expense in setting the ARR would make no difference to the cash rate of return on equity, and therefore would not address the concern raised by stakeholders.
- a hybrid approach that decomposed the expected revaluation gain into a revaluation gain for equity holders and an expense in setting the ARR would effectively shift the regulatory regime from targeting a total real rate of return to targeting a real rate of return on equity; it would thereby intervene in the capital structure decision and thus result in a less efficient allocation of the risk of financing decisions.

149. From this analysis, our preliminary conclusions on the questions asked by the AER are as follows:

- The regulatory framework successfully delivers the current target—a real rate of return outcome.
- The AER should not instead target a nominal or hybrid return.

150. Our analysis leading to these conclusions suggests some aspects of the regulatory approach that the AER might consider exploring during its 2020 Inflation Review.

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Appendix A Symbols used in equations

w_t^j = nominal WACC for year t in regulatory period j with the cost of debt estimated as a trailing moving average

w^j = nominal WACC for regulatory period j if the cost of debt is estimated at the beginning of the period

d_t^j = cost of debt foryear t in regulatory period j estimated as a trailing moving average

k^j = nominal cost of equity for regulatory period j

d_v = nominal cost of debt for year v in the interval $[t-9, t]$, concluding in regulatory period j

$(1 - L), L$ = proportions of equity and debt in the capital structure

e^j = expected inflation for regulatory period j

i_t^j = market assessment of inflation for year t in regulatory period j

i^j = market assessment of inflation for regulatory period j

i_v = market assessment of inflation for year v in the interval $[\mathrm{t} - 9, \mathrm{t}]$ concluding in regulatory period j

a_t^j = actual inflation for year t in regulatory period j

A_{t-1}^j = nominal opening RAB for year t in regulatory period j

D_t^j = nominal SL depreciation for year t in regulatory period j

RD_t^j = real SL depreciation for year t in regulatory period j

$taxD_t^j$ = depreciation for tax purposes for year t in regulatory period j

C_t^j = nominal capex for year t in regulatory period j

RC_t^j = real forecast capex for year t in regulatory period j

$NC_t^j = C_t^j - D_t^j$ = nominal net capex for year t in regulatory period j

$RNC_t^j = RC_t^j - RD_t^j$ = real net capex for year t in regulatory period j

RA_t^j = revenue adjustments for year t in regulatory period j

$NNRT_t^j$ = net nominal revenue after tax for year t in regulatory period j

O_t^j = nominal opex for year t in regulatory period j

RO_t^j = real opex for year t in regulatory period j

int_t^j = interest deduction for tax purposes for year t in regulatory period j

$TLCF_t^j$ = tax loss carried forward for application in year t

in regulatory period j

$$t = \frac{\gamma T}{1 - T(1 - \gamma)}$$

$\gamma =$ value of imputation credits

$T =$ corporate tax rate

$ARR_{t,v}^j$ = annual revenue requirement for year t, assessed at time v,

in regulatory period j

$SMAR_{t,v}^j$ = smoothed ARR for year t, assessed at time v, in regulatory period j after

"$CPI - X$" adjustment

Appendix B NPV must equal zero

151. In the AER's building block model, in any year t in regulatory period j, the annual revenue requirement (ARR) is the sum of the expected nominal return on capital (ENRC), regulatory depreciation (RegD), nominal opex (O), revenue adjustments (RA) and a net tax allowance (T). This is shown in equation (1):

$$ARR_t^j = ENRC_t^j + RegD_t^j + O_t^j + RA_t^j + Tax_t^j \quad (1)$$

152. Expanding regulatory depreciation into its component parts, equation (1) can be rearranged to show that the AER model achieves the NPV = 0 principle in concept:

$$ARR_t^j - O_t^j - RA_t^j - Tax_t^j = ENRC_t^j + D_t^j - AI_t^j \quad (2)$$

153. The left-hand side of this equation is net nominal revenue after tax (NNRT). That is:

$$NNRT_t^j = ARR_t^j - O_t^j - RA_t^j - Tax_t^j$$

154. It thus follows that NNRT is equal to the right hand side of equation (2), viz, expected nominal return on capital, less the allowance for inflation, plus depreciation (return of capital). That is:

$$NNRT_t^j = ENRC_t^j - AI_t^j + D_t^j$$

155. But expected real return on capital (ERRC) is equal to expected nominal return on capital less allowance for inflation, that is:

$$ERRC_t^j = ENRC_t^j - AI_t^j$$

and therefore:

$$NNRT_t^j = ERRC_t^j + D_t^j \quad (3)$$

That is, expected nominal net revenue after tax, is equal to the expected real return on capital plus the return of capital.

156. The ERRC for any year is the real rate of return on the opening value of the capital base. Thus, using the symbols defined inAppendix A, for any year t during regulatory period j, equation (3) can be stated as:

$$NNRT_t^j = A_{t-1}^j(w_t^j - e^j) + D_t^j$$

157. The present value of an NSP's investment at any time t in regulatory period j, V_{t-1}^j, is the sum of the cash flows for the next year and the residual value of the entity at the end of the year. The cash flow for the current year is the NNRT and the residual value is the closing value of the asset base plus net capex. Thus:

$$V_{t-1}^j = \{[A_{t-1}^j(w_t^j - e^j) + D_t^j] + [A_{t-1}^j(1 + e^j) - D_t^j + C_t^j]\}/(1 + w_t^j) \quad (4)$$

$$= [A_{t-1}^j(1 + w_t^j) + C_t^j]/(1 + w_t^j)$$

$$= A_{t-1}^j + C_t^j/(1 + w_t^j)$$

158. The right-hand side of this equation is the opening outlay plus the present value of capex made at the end of the year. Thus, for any year t during regulatory period j, the present value of the cash flow for the year and the residual value is equal to the present value of the outlays, that is, NPV = 0. It follows that NPV = 0 for the sequence of years to any horizon date T.

Appendix C PTRM and RFM achieve real return

Inputs to the models

159. Application of the models requires independent inputs of:

- the opening RAB, real capex and depreciation amounts for each regulatory period
- an estimate of the cost of equity for each period
- estimates of the cost of debt starting from 9 years prior to the opening date
- leverage
- the AER estimates of inflation for each regulatory period
- actual inflation rates starting from the opening date of period 1.

Asset base in the PTRM

160. The asset base in the PTRM is determined in regulatory period 1 as follows:

$$A_1^1 = A_0^1 + e^1 A_0^1 - D_1^1 + C_1^1 = A_0^1(1 + e^1) + NC_1^1$$

$$= A_0^1(1 + e^1) + RNC_1^1 (1 + e^1)$$

$$= (A_0^1 + RNC_1^1)(1 + e^1)$$

$$A_2^1 = A_1^1 + e^1 A_1^1 - D_2^1 + C_2^1 = A_1^1(1 + e^1) + NC_2^1$$

$$= A_1^1(1 + e^1) + RNC_2^1 (1 + e^1)^2$$

$$= (A_0^1 + RNC_1^1)(1 + e^1)^2 + RNC_2^1 (1 + e^1)^2$$

$$= (A_0^1 + RNC_1^1 + RNC_2^1)(1 + e^1)^2$$

$$A_3^1 = A_2^1(1 + e^1) + NC_3^1$$

$$= (A_0^1 + RNC_1 + RNC_2^1)(1 + e^1)^3 + RNC_3^1 (1 + e^1)^3$$

$$= (A_0^1 + RNC_1 + RNC_2^1 + RNC_3^1)(1 + e^1)^3$$

$$A_4^1 = A_3^1(1 + e^1) + NC_4^1$$

$$= (A_0^1 + RNC_1 + RNC_2^1 + RNC_3^1 + RNC_4^1)(1 + e^1)^4$$

$$A_5^1 = A_4^1(1 + e^1) + NC_5^1$$

$$= (A_0^1 + RNC_1 + RNC_2^1 + RNC_3^1 + RNC_4^1 + RNC_5^1)(1 + e^1)^5$$

161. For regulatory period 2, the asset base is determined:

$$A_1^2 = A_0^2(1+e^2) + NC_1^2 = (A_0^2 + RNC_1^2)(1+e^2)$$

$$A_2^2 = A_1^2(1+ e^2) + NC_2^2 = (A_1^2 + RNC_1^2 + RNC_2^2)(1+ e^2)^2$$

and so on to the end of the period:

$$A_5^2 = (A_0^2 + RNC_1^2 + RNC_2^2 + RNC_3^2 + RNC_4^2 + RNC_5^2)(1+ e^2)^5$$

162. Thus, for year t in regulatory period j:

$$A_t^j = (A_0^j + RNC_1^j + \cdots + RNC_{t-1}^j + RNC_t^j)(1+ e^j)^t$$

163. The opening asset base for regulatory period 1 is an exogenous input but the opening capital base for all later periods is determined by the RFM.

RFM

164. The opening value of the capital base for the second and subsequent regulatory periods is determined in the RFM by adjusting the opening value of the capital base for regulatory period 2, and net capex of the previous regulatory period, for actual inflation:

$$A_0^j = (A_0^{j-1} + RNC_1^{j-1} + RNC_2^{j-1} + RNC_3^{j-1} + RNC_4^{j-1}$$
$$+RNC_5^{j-1}(1+ a_1^{j-1}) \quad (1+ a_2^{j-1})(1+ a_3^{j-1})(1+ a_4^{j-1})(1+ a_5^{j-1})$$

NNRT in the PTRM

165. For regulatory period 1, the NNRT is determined in the PTRM as follows:

$$NNRT_1^1 = A_0^1 w_1^1 - A_0^1 e^1 + D_1^1 = A_0^1(w_1^1 - e^1) + RD_1^1(1+ e^1)$$

$$NNRT_2^1 = A_1^1(w_2^1 - e^1) + D_2^1$$
$$= [(A_0^1 + RNC_1^1)(1+ e^1)](w_2^1 - e^1) + RD_2^1(1+ e^1)^2$$

$$NNRT_3^1 = A_2^1(w_3^1 - e^1) + D_3^1$$
$$= [(A_0^1 + RNC_1^1 + RNC_2^1)(1+ e^1)^2](w_3^1 - e^1) + RD_3^1(1+ e^1)^3$$

$$NNRT_4^1 = A_3^1(w_4^1 - e^1) + D_4^1$$
$$= [(A_0^1 + RNC_1^1 + RNC_2^1 + RNC_3^1)(1+ e^1)^3](w_4^1 - e^1) + RD_4^1(1+ e^1)^4$$

$$NNRT_5^1 = A_4^1(w_5^1 - e^1) + D_5^1$$
$$= [(A_0^1 + RNC_1^1 + RNC_2^1 + RNC_3^1 + RNC_4^1)(1+ e^1)^4](w_5^1 - e^1) + RD_5^1(1+ e^1)^5$$

166. The same calculation is applied in the PTRM for later regulatory periods. Thus, for year t in regulatory period j:

$$NNRT_t^j = A_t^j(w_t^j - e_1) + D_t^j$$

$$= [(A_0^j + RNC_1^j + \cdots + RNC_{t-1}^j)\left(1 + e^j\right)^{t-1}]\left(w_t^j - e^j\right) + RD_t^j\left(1 + e^j\right)^t$$

167. The term in square brackets is the nominal opening capital base for year t in period j and thus the expression for $NNRT_t^j$ is the normal building block model with real return $(w_t^j - e^j)$ on the nominal opening capital base, plus nominal depreciation for the period.

Appendix D Extending the analysis to include opex and capex

168. Extending the analysis of NNRT to include opex and tax does not change the expected outcome. While NNRT is defined as:

$$NNRT_t^j = ARR_t^j - O_t^j - RA_t^j - Tax_t^j$$

169. In Appendix B we showed that for any year t in regulatory period j:

$$NNRT_t^j = A_{t-1}^j(w_t^j - e^j) + D_t^j$$

170. Hence, NNRT depends only on the opening asset base, the real rate of return and depreciation. It does not depend on the allowed values of opex and the other building block allowances. Ex ante the entity expects to earn sufficient revenue (ARR) to cover its opex, revenue adjustments, and tax: the NPV=0 principle still holds. The derivation of this result for the ARR is shown in Appendix Ebelow.

171. Of course the entity may experience actual opex (and tax) of a different amount than its opex allowance. Expected real, non-equity costs are specific to the firm, and can be affected by the choices of the firm or the regulator. For example, the expected (post tax) return on equity will be greater (less) than the allowed regulatory return on capital if: [11]

- the regulatory allowance for tax is greater (less) than the expected actual cost of tax
- the allowed cost of debt is greater (less) than the actual cost of debt
- regulatory gearing is lower (higher) than actual gearing
- the allowed level of opex is greater (less) than the expected actual opex.

172. In addition, actual non-equity costs may be different than expected because of differences in factors not related to inflation (for example if actual volumes are different to forecast, or actual real opex is different to forecast).

173. Our focus is on inflation-related variances, and we consider the impact of inflation on nominal debt costs further below. In the following section, we consider the effects of the inflation adjustments in smoothing the allowed revenue and the annual price adjustment process.

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11 Houston, Greg, Hird, Tom and Nicola Tully, 2001, International comparison of utilities regulated post tax rates of return in: North America, the UK, and Australia, NERA.

Appendix E Derivation of ARR

174. Appendix B shows that for any year t in regulatory period j:

$$ARR_t^j - O_t^j - RA_t^j - Tax_t^j = NNRT_t^j$$

but tax payable is determined as:

$$Tax_t^j = t(ARR_t^j - O_t^j - RA_t^j - taxD_t^j - int_t^j - TLCF_t^j)$$

therefore:

$$ARR_t^j(1-t) - O_t^j(1-t) - RA_t^j(1-t) + t(taxD_t^j + int_t^j + TLCF_t^j) = NNRT_t^j$$

that is:

$$ARR_t^j = \frac{NNRT_t^j}{(1-t)} + O_t^j + RA_t^j - \frac{t}{(1-t)}\left(taxD_t^j + int_t^j + TLCF_t^j\right)$$

but:

$$t = \frac{\gamma T}{1-T(1-\gamma)}$$

therefore:

$$ARR_t^j = NNRT_t^j\frac{1-T(1-\gamma)}{(1-T)} + O_t^j + RA_t^j - \left(taxD_t^j + int_t^j + TLCF_t^j\right)\frac{\gamma T}{(1-T)}$$

Appendix F Initial derivation of SMAR

The set of annual revenue requirements, assessed at time 0, in regulatory period j, $\{ARR_{t,0}^{j}\}$ are converted by the '$CPI - X$' adjustment to a smoothed set, $\{SMAR_{t,0}^{j}\}$, with, in aggregate, the same present value. That is:

$$PV\{ARR_{1,0}^{j}, ARR_{2,0}^{j}, ARR_{3,0}^{j}, ARR_{4,0}^{j}, ARR_{5,0}^{j}\}$$

$$= PV\{SMAR_{1,0}^{j}, SMAR_{2,0}^{j}, SMAR_{3,0}^{j}, SMAR_{4,0}^{j}, SMAR_{5,0}^{j}\} \quad (5)$$

where:

$$SMAR_{1,0}^{j} = ARR_{1,0}^{j}$$

$$SMAR_{2,0}^{j} = SMAR_{1,0}^{j}(1 + e^{j})(1 - X_{2,0})$$

$$SMAR_{3,0}^{j} = SMAR_{2,0}^{j}(1 + e^{j})(1 - X_{3,0}) = SMAR_{1,0}^{j}(1 + e^{j})^{2}(1 - X_{2,0})^{2}$$

$$SMAR_{4,0}^{j} = SMAR_{3,0}^{j}(1 + e^{j})(1 - X_{4,0}) = SMAR_{1,0}^{j}(1 + e^{j})^{3}(1 - X_{2,0})^{3}$$

$$SMAR_{5,0}^{j} = SMAR_{4,0}^{j}(1 + e^{j})(1 - X_{5,0}) = SMAR_{1,0}^{j}(1 + e^{j})^{4}(1 - X_{2,0})^{4}$$

With use of the trailing average cost of debt, at time 0 in period j, only the WACC for year 1 of the period, w_{1}^{j}, is available. The set $\{NNRT_{t,0}^{j}\}$ is therefore calculated with $w_{t}^{j} = w_{1}^{j}$ for $t = 1, \ldots, 5$ and from which the corresponding set $\{ARR_{t,0}^{j}\}$ is calculated, as set out in **Error! Reference source not found.**. T hus equation (5) can be stated in full as:

$$\sum_{1}^{5} \frac{ARR_{t,0}^{j}}{(1+w_{1}^{j})^{t}} = \sum_{1}^{5} \frac{SMAR_{t,0}^{j}}{(1+w_{1}^{j})^{t}}$$

$$= \frac{SMAR_{1,0}^{j}}{1+w_{1}^{j}}\left\{1 + \frac{(1+e^{j})(1-X_{2,0})}{1+w_{1}^{j}} + \cdots + \left[\frac{(1+e^{j})(1-X_{2,0})}{1+w_{1}^{j}}\right]^{4}\right\}$$

$$= \frac{SMAR_{1,0}^{j}}{1+w_{1}^{j}} \frac{1-\left[\frac{(1+e^{j})(1-X_{2,0})}{1+w_{1}^{j}}\right]^{5}}{1-\frac{(1+e^{j})(1-X_{2,0})}{1+w_{1}^{j}}}$$

$$= SMAR_{1,0}^{j} \frac{1-\left[\frac{(1+e^{j})(1-X_{2,0})}{1+w_{1}^{j}}\right]^{5}}{(1+w_{1}^{j})-(1+e^{j})(1-X_{2,0})}$$

175. This equation can be solved iteratively for $X_{2,0}$ and thus the set $\{SMAR_{t}^{j}\}$ for the next 5 years can be determined with application of $SMAR_{1,0}^{j} = ARR_{1,0}^{j}$ in year 1.

Appendix G Derivation of SMAR with trailing average debt

176. If there is a change in debt costs, or the determination is reopened for cost pass through or contingent projects, then the smoothing process as explained in Appendix F is modified.

177. At time 1 in period j, the WACC for year 2 of the period, w_2^j, is available. The set $\{NNRT_{t,1}^j\}$ is therefore calculated with WACC set again at w_1^j for year 1 but w_2^j for years 2 to 5. The actual inflation rate for year 1 is also available at time 1 and is substituted for expected inflation in the SMAR for year 2. Thus, $ARR_{1,0}^j$remains the same but there will be a new set $\{ARR_{t,1}^j\}$ for years 2 to 5 and the set of forward smoothed annual revenue requirements is given by:

$$SMAR_{2,1}^j = SMAR_{1,0}^j(1+a_1^j)(1-X_{2,1})$$

$$SMAR_{3,1}^j = SMAR_{2,1}^j(1+e^j)(1-X_{3,0})$$

$$= SMAR_{1,0}^j(1+a_1^j)(1+e^j)(1-X_{2,1})(1-X_{3,0})$$

$$SMAR_{4,1}^j = SMAR_{3,1}^j(1+e^j)(1-X_{4,0})$$

$$= SMAR_{1,0}^j(1+a_1^j)(1+e^j)^2(1-X_{2,1})(1-X_{3,0})^2$$

$$SMAR_{5,1}^j = SMAR_{4,1}^j(1+e^j)(1-X_{5,0})$$

$$= SMAR_{1,0}^j(1+a_1^j)(1+e^j)^3(1-X_{2,1})(1-X_{3,0})^3$$

and thus equating present values gives:

$$\frac{ARR_{1,0}^j}{1+w_1^j} + \frac{ARR_{2,1}^j}{\left(1+w_1^j\right)\left(1+w_2^j\right)} + \cdots + \frac{ARR_{5,1}^j}{\left(1+w_1^j\right)\left(1+w_2^j\right)^4}$$

$$= \frac{SMAR_{1,0}^j}{1+w_1^j} + \frac{SMAR_{1,0}^j(1+a_1^j)(1-X_{2,1})}{(1+w_1^j)(1+w_2^j)}$$

$$+ \frac{SMAR_{1,0}^j(1+a_1^j)(1+e^j)^2(1-X_{2,1})(1-X_{3,0})^2}{(1+w_1^j)(1+w_2^j)^2} + \cdots$$

$$+ \frac{SMAR_{1,0}^j(1+a_1^j)(1+e^j)^3(1-X_{2,1})(1-X_{3,0})^3}{(1+w_1^j)(1+w_2^j)^4}$$

$$= \frac{SMAR_{1,0}^j}{1+w_1^j}\{1 + \frac{(1+a_1^j)(1-X_{2,1})}{1+w_2^j}$$

$$+ \frac{(1+a_1^j)(1+e^j)(1-X_{2,1})(1-X_{3,0})}{(1+w_2^j)^2}$$

$$+\frac{(1+a_1^j)(1+\ e^j)^2(1-\ X_{2,1})(1-\ X_{3,0})^2}{(1+\ w_2^j)^3}$$

$$+\frac{(1+a_1^j)(1+\ e^j)^3(1-\ X_{2,1})(1-\ X_{3,0})^3}{(1+\ w_2^j)^4}\}$$

178. This equation can be solved for $X_{2,1}$ and thus the set $\{SMAR_{t,1}^j\}$ for years 2 to 5 can be determined with application of $SMAR_{2,1}^j$ in year 2.

179. Similarly, the X factor is adjusted for years 3, 4 and 5.

180. The $NPV = 0$ principle is maintained in each year in the estimation of the ARR series (updated for use of the trailing moving average cost of debt in WACC) and the conversion each year to the SMAR series (to reflect experienced inflation) also maintains the $NPV = 0$ principle as the 'CPI – X' adjustment equates aggregate present values.

Appendix H Annual update to the cost of debt

181. The allowed cost of debt is updated each year during the regulatory period as a trailing moving average over 10 years.The impact of this approach on WACC and return on equity can be analysed in terms of (i) contrast with WACC based on the cost of debt set at the start of the regulatory period, and (ii) the year on year effect.

182. Firstly, the contrast with cost of debt for the regulatory period, that is, the cost of debt estimated at the beginning of the regulatory period along with the cost of equity. With nominal WACC based on a trailing average cost of debt an NSP's allowance for debt costs in year t of regulatory period j is given by:

$$L(\frac{1}{10}\sum_{v=t-9}^{v=t} d_v)$$

183. If instead nominal WACC were based on the cost of debt for period j, the allowance for debt costs would be given by:

$$Ld^j$$

Thus, Δw the impact on allowed WACC is given by:

$$\Delta w = L(\frac{1}{10}\sum_{v=t-9}^{v=t} d_v) - Ld^j$$

$$= L\frac{1}{10}\sum_{v=t-9}^{v=t} (d_v - d^j)$$

184. If the real cost of debt is assumed to be constant, then the impact on WACC can be stated in terms of difference in inflation rates:

$$\Delta w = L\,[\frac{1}{10}\sum_{v=t-9}^{v=t} (i_v - i^j)]$$

185. That is, if inflation expectations are on average greater (less) than the expectation at the beginning of the period, then the impact is positive (negative) but the impact is reduced by leverage.

186. Secondly, the year on year effect. An NSP's allowance for debt costs during year t of regulatory period j is given by:

$$L\left(\frac{1}{10}\sum_{v=t-9}^{v=t} d_v\right)$$

and in year $t+1$ during period j:

$$L\left(\frac{1}{10}\sum_{v=t-8}^{v=t+1} d_v\right)$$

187. Thus, Δw, the change in allowed WACC from period t to $t+1$ is:

$$\Delta w = L\left(\frac{1}{10}\sum_{v=t-8}^{v=t+1} d_v\right) - L(\frac{1}{10}\sum_{v=t-9}^{v=t} d_v)$$

$$= L[\frac{1}{10}(d_{t+1} - d_{t-9})]$$

188. If the real cost of debt is assumed to be constant, then the impact on WACC is given by:

$$\Delta w = L[\frac{1}{10}(i_{t+1} - i_{t-9})]$$

189. That is, if the inflation expectation for year $t+1$ is greater (less) than it was for year $t-9$ then the impact is positive (negative) but is reduced by leverage.

Appendix I Impact of inflation in estimation of expected return

190. Assuming that investors choose between portfolios on the basis of real returns, then in equilibrium:

$$\overline{r_j} = \overline{r_Z} + \beta_j'(\overline{r_M} - \overline{r_Z}) \quad (1)$$

where

$\overline{r_j}$ is the expected return on risky security J with real return r_j (and nominal return R_J)

$\overline{r_Z}$ is the expected return on the zero beta portfolio Z with real return r_z

$\overline{r_M}$ is the expected return on the market portfolio M with real return r_m

β_j' is the beta coefficient for real returns $= \sigma(r_J, r_m)/\sigma^2(r_m)$

191. The risk free asset, F, has zero risk in nominal terms but is risky in real terms. Therefore, from (1):

$$\overline{r_F} = \overline{r_Z} + \beta_F'(\overline{r_M} - \overline{r_Z}) \quad (2)$$

where $\overline{r_F}$ is the expected real return on the risk free asset F with real return r_F. Therefore

$$\overline{r_Z} = (\overline{r_F} - \beta_F'\overline{r_M})/(1 - \beta_F')$$

Substitution in (1) gives

$$\overline{r_j} = \overline{r_F} + [(\beta_j' - \beta_F')/(1 - \beta_F')](\overline{r_M} - \overline{r_F}) \quad (3)$$

192. Now $r_j = R_J - \pi$, $r_M = R_M - \pi$, $r_F = R_F - \pi$, where π is the uncertain rate of inflation, therefore

$$\beta_j' = \sigma(R_J - \pi, R_M - \pi)/\sigma^2(R_M - \pi)$$

$$= \left[\sigma\left(R_J, R_M\right) - \sigma\left(R_J, \pi\right) - \sigma(R_M, \pi) + \sigma^2(\pi)\right]/\sigma^2(R_M - \pi)$$

$$\beta_F' = \sigma(R_F - \pi, R_M - \pi)/\sigma^2(R_M - \pi)$$

$$= \left[-\sigma\left(R_J, \pi\right) + \sigma^2(\pi)\right]/\sigma^2(R_M - \pi)$$

Therefore

$$(\beta_j' - \beta_F')/(1 - \beta_F') = \left[\sigma\left(R_J, R_M\right) - \sigma\left(R_J, \pi\right)\right]/\left[\sigma^2(R_M) - \sigma(R_M, \pi)\right]$$

193. Substitution in (3) gives

$$\overline{R_J} - \overline{\pi} = (R_F - \overline{\pi}) - \{[\sigma\left(R_J, R_M\right) - \sigma\left(R_J, \pi\right)]/[\sigma^2(R_M) - \sigma(R_M, \pi)]\}[(\overline{R_M} - \overline{\pi}) - (R_F - \overline{\pi})]$$

Thus

$$\overline{R_J} = R_F - \{[\beta_J - \sigma(R_J, \pi)/\sigma^2(R_M)]/[1 - \sigma(R_M, \pi)/\sigma^2(R_M)]\}(\overline{R_M} - R_F] \quad (4)$$

194. This varies from the SLM form of the CAPM in respect of the coefficient on the market risk premium.

References

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Roll, R. (1977, March). Critique of the asset pricing theory's tests Part I: On past and potential testability of the theory,. *Journal of Financial Economics, 4*(2), 129-176.

Appendix J Multi-period modelling

Spreadsheet modelling

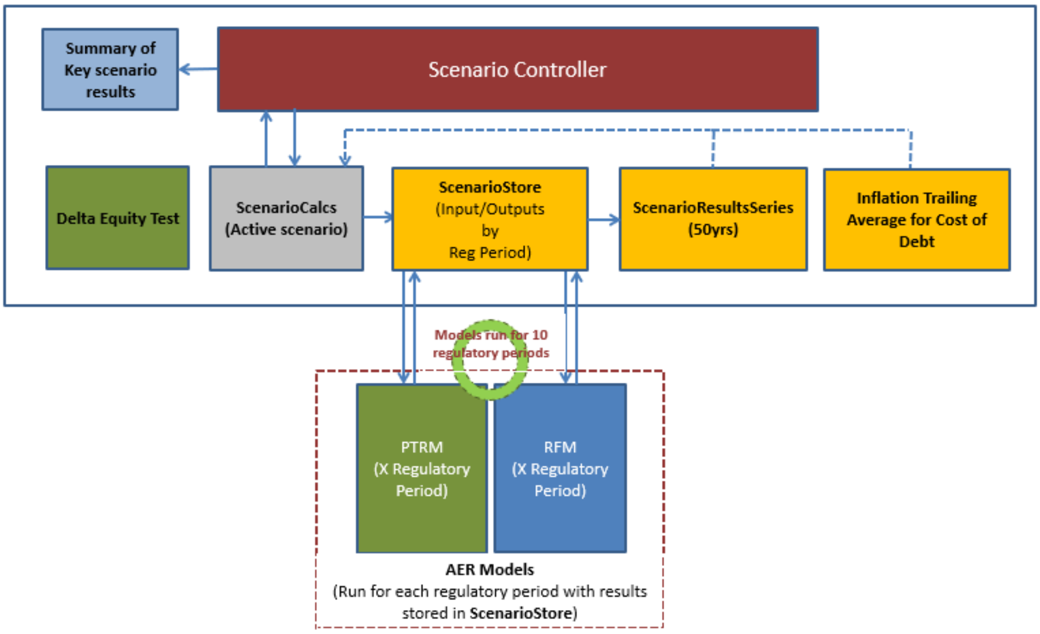
195. To provide quantified illustrations of the findings discussed in this report, we set up scenario modelling of the AER PTRM and RFM models over 10 regulatory periods (50 years). We use the test models to assess whether the AER PTRM and RFM models achieve the intended outcomes of those models—that is, whether they achieve NPV=0 allowing for a real return on capital.

196. This appendix provides a brief overview of this test modelling.

Approach

197. The test model links into the most recent versions of AER PTRM and RFM models.12 The model uses a scenario control mechanism so the linked AER models are run multiple times with each run representing a different regulatory period. The inputs and outputs are stored along with the calculation process so the entire 50-year sequence is generated from the two AER models. This structure allows specific changes, or components, of the AER models to be tested readily (the changes only affect one model and not 10).

Figure 1 Approach to multi-period modelling



[12] **Electricity post-tax revenue model** (distribution) - **April 2019 amendment**; **Electricity roll forward model** (distribution) – **April 2020 amendment.** As the gas models are the same, at this stage it does not seem necessary to replicate the modelling also using the gas models.

198. The test models were populated with a single asset, where the opening asset value is $1000 (in real terms) with annual capital investments of $100 (in real terms). For simplicity all operating costs are set to zero. There were three primary reasons for this approach:

- The approach avoided using data from an NSP and hence the impression of unduly focusing on one business.
- The approach is consistent with the existing long-term model used internally by the AER. Adopting a consistent set of assumptions for our modelling meant that initial differences in results could quickly be identified and the reasons for those differences traced and investigated.
- The "placeholder" data in the PTRM and RFM includes data that does not appear to inform an analysis of the issues being raised by stakeholders—this data includes capex that is immediately expensed, capital contributions, tax etc. To extend this data out for 5 regulatory periods would require additional assumptions in relation to forecast values etc, that would add complexity and complications without adding insight into the variables relevant to the Inflation Review.

199. The model explored the NPV of the expected net revenue and the outcome net revenue; that is, the NPV = 0 test

200. All results calculated in the model are derived from key outputs calculated in the RFM and the PTRM, including the annual revenue requirement (ARR), the X-factor, annual opening and closing RAB, and annual equity value.

201. The NPV =0 test for the 50-year modelling applies a calculation for the SMAR where the SMAR for each regulatory period is calculated from a constant X-factor that is generated from the PTRM (i.e. the default case). The model calculates the SMAR externally from the PTRM such that SMAR1 = ARR1, SMAR2 = SMAR1*(1-X)*(1+a), and so on for each year in the active regulatory period. We also calculated the PV for the unadjusted ARR from each PTRM run for comparison.

Modelling scenarios

202. The modelling results have been calculated for 9 inflation scenarios which are based on the AER's "Long Term Simulation linked to PTRMS and RFMs" (LTAS) model. The following table summarises the both the forecast inflation profile and the outcome inflation profile for each scenario.

Table 5 Description of inflation scenarios

No	Scenario name	Description
1	Flat 2.5% Inflation (for both outturn and expected)	Year 0 Inflation. 2.5% Forecast Inflation 2.5% for all years Outturn Inflation 2.5% for all years
2	Ave correct; but 10 year down/up	Year 0 Inflation. 2.5%. Forecast Inflation 2.5% for all years Outturn Inflation decreases from 4% in year 1 to 1% in year 5 (for all regulatory periods)

3	Forecast too high (3.5% - with outturn = 2.5%)	Year 0 Inflation. 2.5%. Forecast Inflation 3.5% for all years Outturn Inflation 2.5% for all years
4	Forecast too low (1.5% - with outturn = 2.5%)	Year 0 Inflation. 2.5%. Forecast Inflation 1.5% for all years Outturn Inflation 2.5% for all years
5	Forecast too high + Outturn descending each 5 yr	Year 0 Inflation. 1.0%. Forecast Inflation 3.5% for all years Outturn Inflation 4.0% descending to 1.0%
6	Forecast too high + Outturn ascending each 5 yr	Year 0 Inflation. 1.0%. Forecast Inflation 3.5% for all years Outturn Inflation 1.0% increasing to 4.0%
7	Monte Carlo auto generation (approach 1)	Year 0 Inflation. 2.75%. Forecast Inflation Monte Carlo auto generation approach 1 from AER LTAS model Outturn Inflation Monte Carlo auto generation approach 1 from AER LTAS model
8	Alternating (by Reg Period) Flat 3.5%/2.5% Outturn Inflation (2.5% expected)	Year 0 Inflation. 3.5%. Forecast Inflation 2.5% for all years -- First Regulatory Period Outturn Inflation 3.5% for all years -- First Regulatory Period Forecast Inflation 2.5% for all years -- Second Regulatory Period Outturn Inflation 1.5% for all years – Second Regulatory Period With pattern repeating across future regulatory periods
9	Alternating (by Reg Period) Flat 2.5%/5.5% Outturn Inflation (2.5% expected)	Year 0 Inflation. 1.5%. Forecast Inflation 2.5% for all years -- First Regulatory Period Outturn Inflation 1.5% for all years -- First Regulatory Period Forecast Inflation 2.5% for all years -- Second Regulatory Period Outturn Inflation 3.5% for all years -- Second Regulatory Period With pattern repeating across future regulatory periods

NPV=0 test

203. The NPV = 0 test results have been calculated for the first regulatory period (ex-ante and ex-post) and for 10 regulatory periods cashflows (ex-ante and ex-post). Table 6 below provides a brief description of each NPV = 0 test:

Table 6 Summary of NPV=0 test scenarios

NPV=0 test	**Description**
First regulatory period	
Ex-Ante NPV = 0 test for PTRM cashflows	Based on 5 year cashflow and annual the ARR NPV = 0 test for PTRM cashflow in nominal terms NPV = 0 test for PTRM cashflow in real terms
Ex-Post NPV = 0 test for Annual Pricing cashflows	Based on 5 year cashflow and annual SMAR (Constant X factor, outcome information), closing RAB (year 5) is RFM adjusted with outcomes NPV = 0 test for Annual Pricing in nominal terms NPV = 0 test for Annual Pricing in nominal terms
Multiple regulatory periods (10 periods or 50 years)	
Ex-Ante NPV = 0 test for PTRM long-run cashflows	Based on long run (50 year) cashflow and annual ARR NPV = 0 test for PTRM cashflow in nominal terms NPV = 0 test for PTRM cashflow in real terms
Ex-Post NPV = 0 test for Annual Pricing adjustments, long-run cashflows	Based on long run (50 year) cashflow, annual SMAR (Constant X factor, outcome information) NPV = 0 test for Annual Pricing in nominal terms NPV = 0 test for Annual Pricing in nominal terms

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