Attachment 5.10

Application of REPEX model

20 January 2015

Ausgrid revised regulatory proposal attachment

Contents

1 Introduction

The AER has developed a predictive modelling approach called REPEX, which it uses to corroborate or reject DNSPs forecasts of replacement capital expenditure. In the case of the Ausgrid 2014-19 draft decision, it has also been used as a basis for substitution.

The model has been reviewed and a NNSW report was included in our initial proposal (Appendix C to Attachment 5.33 "*Report – REPEX Model Review*"). It identified several shortcomings of the model.

A report by Jacobs (*Review of AER Draft Decision REPEX*) also identified a range of concerns with the operation and assumptions embodied in the model.

The AER's draft decision placed 84% of Ausgrid's replacement expenditure program into the REPEX model. The model produced a range of results. The results the AER relied on in substituting their alternative expenditure forecast were 45% to 48% lower than Ausgrid's forecast. These were based on the model results using calibrated asset lives and either forecast unit costs (derived from Ausgrid's Proposal RIN data) or benchmarked unit costs.

The key issues with the use of the model to provide reasonable forecasts of replacement expenditure needs relate to the underlying assumption that past expenditure is a good predictor of future needs, that all replacement can be approximated by a simple proxy of asset age, and the validity of the approach to determining calibrated lives.

In addition, there are concerns with the correctness and validity of the data in the RIN – especially relating to the data definitions provided and required to be followed, the restrictive asset categories and the cross comparability between different DNSPs.

Nonetheless, predictive modelling is an appropriate method for validating bottom up forecasts to provide direction on the areas where unexpected variation has occurred so they can be examined in more detail. This is as relevant for a business to review its own forecasts as it is for a regulator. However, it is important to recognise the limitations of modelling, and apply it to asset categories that have characteristics that suit the modelling technique chosen.

2 Planning for the revised proposal

The planning for the initial proposal, which was submitted in May 2013, was completed in early 2013, with the substantive work being done during 2012. Since that time, another round of annual planning reviews has been completed. In parallel, we have made a range of improvements to our analytical techniques and applied them to the forecast for our revised proposal. This included reviews of all replacement programs and projects, whether they were in the Area Plans or the Replacement and Duty of Care Plan. It also includes an initial round of management challenge and refinement of each plan and the Board level review using the CASH modelling tool at the portfolio level.

As a result of these processes, we have identified some major projects that we have been able to defer without incurring a material change in risk, and improved targeting and timing of many of our lower level replacement and duty of care programs. These changes have been informed by some improvements to risk cost quantification techniques and cost benefit analysis for major projects.

The result is a better targeted, better justified replacement expenditure forecast that is 15% lower than our initial proposal.

In preparation for the revised proposal, we have applied the AER's REPEX model to the relevant parts of our revised replacement portfolio to assist in demonstrating that our proposed program is efficient and prudent, and in the long terms interests of our customers.

3 Ausgrid's approach

Ausgrid has approached this issue in its revised proposal by reviewing the asset categories that were modelled in REPEX in the draft decision to identify those where the characteristics of the asset class and the available data suit REPEX modelling and those that do not fit. We have tried wherever possible to include or exclude complete categories, so that the AER modelling can remain robust for those categories, and the need to re-run models is minimised.

Our approach followed the following steps.

1. The first step was to identify a series of characteristics of asset groupings that would mean that REPEX type modelling could be expected to produce meaningful results.

2. Match each RIN category that was used in the REPEX models to these criteria to determine whether they were strong or weak candidates for REPEX modelling

3. If necessary, split categories where the sub-categories within the category had significantly different characteristics and where material expenditures were involved.

4. Re-run the repex calibration and forecast unit cost modelling to determine the necessary parameters for the sub categories that needed to be modelled

5. Compare the 'calibrated – forecast' and 'calibrated – benchmark' results from the model to Ausgrid's revised forecast expenditure for those categories to determine the level of consistency.
6. For the categories of assets no longer included in the modelling, identify the key documents that contain the cost benefit analysis for those expenditures so that the reasonableness of the forecast expenditures can be assessed by other methods.

The following sections outline the results from each of these steps, and the final results.

4 Necessary characteristics

The characteristics identified in the Networks NSW report were:

A. *Reasonably homogenous assets within category*. Assets within the category should be similar in cost and key characteristics, including the unit of measure. If disparate elements are contained in a single category, results may be skewed. For example, a category that contained conductors measured in km and related termination equipment counted in units would be likely to present difficulty if the ratio between them changed. Typical replacement actions also need to be consistent. Replacing underground cable might involve simple excavation in open ground, the expense and complexity of bedrock tunnelling or submarine cable installation. Average unit costs are unlikely to be a good predictor for such disparate activities.

B. *Sufficient historical data to produce valid statistical results*. The model relies on statistical modelling to make predictions. If insufficient reliable historical data is available, the model may produce random results. This was recognised by in the draft decision and several categories from the RIN were excluded from the model (e.g. pole top structures).

C. *Characterised by large numbers of small, essentially like-for-like replacements*. Where the replacement projects are large and infrequent, annual results are not reliable. For example underground cable replacement often takes multiple years to complete. The units completed are typically reported in the final year, while the expenditure is recorded annually. This mismatch is critical, especially when only five years of historical data is available.

D. *Replacement activity driven primarily by deterioration of condition over time.* A fundamental assumption in the model is that time since installation is a reasonable proxy for how the need for expenditure changes over time. This holds true for many asset categories where the dominant driver is a form of 'wear out' mechanism. Some categories in our replacement program are clearly driven by non-age related mechanisms or risk issues. The model is not designed to forecast this type of expenditure requirement.

E. *Asset replacement plans relate to the key asset measure*. The bulk of the proposed replacement activity should be fundamentally related to the unit of measure for the asset class. For example, a program to deal with issues relating to safety of water crossings for overhead conductors has little relationship to the number of km of conductor installed or replaced over time. If the dominant features of a program are unrelated to the underlying measure, the model is likely to incorrectly estimate future needs.

5 Assessing the categories

There were 65 categories from the RIN against which Ausgrid's program was assessed in the draft decision. We assessed each of these against the five criteria above. The results are shown on the following pages.

Key

✓ - meets criteria

? - partially meets criteria, or has segments that do not meet the criteria, and segments that do

✘ - does not meet criteria

Replacement Category Assessment Matrix

RIN Category / Asset ID	Characteristic Assessment					Comments
	A Homogenous	B History	C Repeatable	D Time based	E Relevant	
POLES: STAKING OF A WOODEN POLE	✓	✓	✓	✓	✓	
POLES: < = 1 kV; WOOD	✓	✓	✓	✓	✓	
POLES: > 1 kV & < = 11 kV; WOOD	✓	✓	✓	✓	✓	
POLES: > 11 kV & < = 22 kV; WOOD	✓	✓	✓	✓	✓	
POLES: > 22 kV & < = 66 kV; WOOD	✓	✓	✓	✓	✓	
POLES: > 66 kV & < = 132 kV; WOOD	✓	✓	✓	✓	✓	
POLES: < = 1 kV; CONCRETE	✓	✓	✓	✓	✓	
POLES: > 1 kV & < = 11 kV; CONCRETE	✓	✓	✓	✓	✓	
POLES: > 22 kV & < = 66 kV; CONCRETE	✓	✓	✓	✓	✓	
POLES: > 66 kV & < = 132 kV; CONCRETE	✓	✓	✓	✓	✓	
POLES: < = 1 kV; STEEL	✓	✓	✓	✓	✓	
POLES: > 1 kV & < = 11 kV; STEEL	✓	✓	✓	✓	✓	
POLES: > 11 kV & < = 22 kV; STEEL	✓	✓	✓	✓	✓	
POLES: > 22 kV & < = 66 kV; STEEL	✓	✓	✓	✓	✓	
POLES: > 66 kV & < = 132 kV; STEEL	✓	✓	✓	✓	✓	

RIN Category / Asset ID	Characteristic Assessment					Comments
	A Homogenous	B History	C Repeatable	D Time based	E Relevant	
POLES: TOWERS	✓	✓	✓	✓	✓	This category was listed separately in our RIN, but the AER included it within poles. This category relates to tower refurbishment. Other elements of tower maintenance were placed under “Pole top structures” which were (correctly) excluded from the REPEX modelling
OVERHEAD CONDUCTORS: < = 1 kV	✓	✓	✓	✓	✓	
OVERHEAD CONDUCTORS: > 1 kV & < = 11 kV	✓	✓	✓	✓	✓	
OVERHEAD CONDUCTORS: > 11 kV & < = 22 kV ; SWER	✓	✓	✓	✓	✓	
OVERHEAD CONDUCTORS: > 11 kV & < = 22 kV ; SINGLE-PHASE	✓	✓	✓	✓	✓	
OVERHEAD CONDUCTORS: > 11 kV & < = 22 kV ; MULTIPLE-PHASE	✓	✓	✓	✓	✓	
OVERHEAD CONDUCTORS: > 22 kV & < = 66 kV	✓	✓	✓	✓	✓	
OVERHEAD CONDUCTORS: > 66 kV & < = 132 kV	✗	✗	✓	✗	✗	This category comprises replacement of overhead earth wires, refurbishment of access tracks & safety and regulatory compliance of water crossings. No expenditure for conductors themselves
UNDERGROUND CABLES: < = 1 kV	✗	?	✗	✗	✓	Comprises two programs relating to HDPE and CONSAC cable technologies. While age related, this is a particular technology issue related more to environment and design flaws. Solution costs vary significantly, and projects can be of long duration.
UNDERGROUND CABLES: > 1 kV & < = 11 kV	✗	?	✗	✗	✗	Expenditure in this category is almost entirely for the installation of 11kV underground cable as part of a larger replacement project. Typically a subtransmission cable or zone substation replacement driver that is solved (fully or partially) by transferring load at 11kV from one location to another. Projects are defined and justified in the Area Plans. Some expenditure related to pits and ducts for CBD cables (not the cables themselves). No relationship to the age, condition or length of 11kV cable involved.
UNDERGROUND CABLES: > 11 kV & < = 22 kV	✗	?	✗	✗	✗	
UNDERGROUND CABLES: > 22 kV & < = 33 kV	✗	?	✗	?	✓	These are major replacement programs assessed in detail within the Area Plan framework and part of strategic replacement strategies. Projects span multiple years and are not amenable to unit cost analysis. Replacement timing influenced by technology as much as
UNDERGROUND CABLES: > 33 kV & < = 66 kV	✗	?	✗	?	✓	

RIN Category / Asset ID	Characteristic Assessment					Comments
	A Homogenous	B History	C Repeatable	D Time based	E Relevant	
UNDERGROUND CABLES: > 66 kV & < = 132 kV	✗	?	✗	?	✓	age related deterioration.
SERVICE LINES: < = 11 kV ; RESIDENTIAL ; SIMPLE TYPE	✓	✓	✓	?	✓	Some elements of this program are technology and compliance risk related.
SERVICE LINES: < = 11 kV ; COMMERCIAL & INDUSTRIAL ; SIMPLE TYPE	✓	✓	✓	✓	✓	
TRANSFORMERS: POLE MOUNTED ; < = 22kV ; < = 60 kVA ; SINGLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: POLE MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; SINGLE PHASE	✓	✓	✓	✓	✓	Transformer replacement is reactive, rather than planned . They are replaced individually at end of life. Some replacements at larger sizes are a consequence of other major substation replacement programs. Re-use of these assets is sometimes possible.
TRANSFORMERS: POLE MOUNTED ; < = 22kV ; < = 60 kVA ; MULTIPLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: POLE MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; MULTIPLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: POLE MOUNTED ; > 22 kV ; < = 60 kVA	✓	✓	✓	✓	✓	
TRANSFORMERS: POLE MOUNTED ; > 22 kV ; > 60 kVA AND < = 600 kVA	✓	✓	✓	✓	✓	
TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; < = 60 kVA ; SINGLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; SINGLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; MULTIPLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; > 600 kVA ; MULTIPLE PHASE	✓	✓	✓	✓	✓	

RIN Category / Asset ID	Characteristic Assessment					Comments
	A Homogenous	B History	C Repeatable	D Time based	E Relevant	
TRANSFORMERS: KIOSK MOUNTED ; > 22 kV ; > 600 kVA	✓	✓	✓	✓	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; < 22 kV ; > 60 kVA AND < = 600 kVA ; MULTIPLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; < 22 kV ; > 600 kVA ; MULTIPLE PHASE	✓	✓	✓	✓	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > = 22 kV & < = 33 kV ; < = 15 MVA	✓	✓	?	?	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > = 22 kV & < = 33 kV ; > 15 MVA AND < = 40 MVA	✓	✓	?	?	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; < = 15 MVA	✓	✓	?	?	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; > 15 MVA AND < = 40 MVA	✓	✓	?	?	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; > 40 MVA	✓	✓	?	?	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 66 kV & < = 132 kV ; < = 100 MVA	✓	✓	?	?	✓	
TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 66 kV & < = 132 kV ; > 100 MVA	✓	✓	?	?	✓	

RIN Category / Asset ID	Characteristic Assessment					Comments
	A Homogenous	B History	C Repeatable	D Time based	E Relevant	
TRANSFORMERS: DISTRIBUTION SUBSTATIONS - OTHER	✗	✗	✗	✗	✗	This category was placed outside the REPEX RIN categories in Ausgrid's RIN, but included within REPEX in the draft decision. It comprises mostly duty of care programs that do not arise primarily due to deterioration of condition related to time. This typically includes environmental, physical and electrical safety, and legal compliance issues. The remainder of the category is for replacement of assets that are not measurable in terms of the major asset units (earthing systems in substations, buildings, support structures and minor miscellaneous items) Highly variable, typically consequent on other issues rather than the deterioration of the assets themselves, no relevance to distribution transformer counts.
SWITCHGEAR: < = 11 kV ; FUSE	✓	✓	✓	✓	✓	
SWITCHGEAR: < = 11 kV ; SWITCH	✓	✓	✓	✓	✓	
SWITCHGEAR: < = 11 kV ; CIRCUIT BREAKER	✗	?	✗	✗	✗	This is a split category. LV circuit breaker replacements, HV circuit breaker replacements in distribution substations and replacement of individual oil circuit breakers in zone substations with Vacuum technology exhibit most of the characteristics. A large subset is the replacement of entire switchboards in zone substations. These projects are driven by switchboard condition as much as by the circuit breakers themselves. These are major replacement programs assessed in detail within the Area Plan framework and part of strategic replacement strategies. Projects span multiple years and are not amenable to unit cost analysis. Cost structures vary widely from brownfield replacements to semi brownfield requiring additional construction and changeover to completely new substations, and sometimes retirement of a substation without replacement at all.
SWITCHGEAR: > 11 kV & < = 22 kV ; SWITCH	✓	✓	✓	✓	✓	
SWITCHGEAR: > 11 kV & < = 22 kV ; CIRCUIT BREAKER	✓	✓	✓	✓	✓	
SWITCHGEAR: > 22 kV & < = 33 kV ; SWITCH	✓	✓	✓	✓	✓	

RIN Category / Asset ID	Characteristic Assessment					Comments
	A Homogenous	B History	C Repeatable	D Time based	E Relevant	
SWITCHGEAR: > 22 kV & < = 33 kV ; CIRCUIT BREAKER	✓	✓	✓	✓	✓	
SWITCHGEAR: > 33 kV & < = 66 kV ; SWITCH	✓	✓	✓	✓	✓	
SWITCHGEAR: > 33 kV & < = 66 kV ; CIRCUIT BREAKER	✓	✓	✓	✓	✓	
SWITCHGEAR: > 66 kV & < = 132 kV ; SWITCH	✓	✓	✓	✓	✓	
SWITCHGEAR: > 66 kV & < = 132 kV ; CIRCUIT BREAKER	✓	✓	✓	✓	✓	
SWITCHGEAR: > 11 kV & < ≈ 33 kV ; FUSE & FUSE SWITCH (not including enclosed type)	✓	✓	✓	✓	✓	
SWITCHGEAR: ZONE & SUBTRANSMISION SUBSTATIONS - OTHER	✗	✗	✗	✗	✗	This category was placed outside the REPEX RIN categories in Ausgrid's RIN, but included within REPEX in the draft decision. It comprises mostly duty of care programs that do not arise primarily due to deterioration of condition related to time. This typically includes environmental, physical and electrical safety, and legal compliance issues. The remainder of the category is for replacement of assets that are not measurable in terms of the major asset units (earthing systems in substations, buildings, support structures and minor miscellaneous items) mostly enabling expenditure allocated from major Area Plan replacement projects. Highly variable, typically consequent on other issues rather than the deterioration of the assets themselves, no relevance to switchgear counts.

On the basis of this assessment, the following categories have been identified as a poor fit to the required characteristics to make them good candidates for modelling using REPEX:

- OVERHEAD CONDUCTORS: > 66 kV & < = 132 kV
- UNDERGROUND CABLES: All five Asset IDs
- TRANSFORMERS: DISTRIBUTION SUBSTATIONS - OTHER
- SWITCHGEAR: ZONE & SUBTRANSMISION SUBSTATIONS – OTHER

In one case the category comprises a portion which would be a good match for the requirements of REPEX and a portion which would not:

- SWITCHGEAR: < = 11 kV ; CIRCUIT BREAKER

There are several cases where there would be concerns about the fitness of the data for REPEX modelling but on balance, the issues are not as significant as the cases above:

- SERVICE LINES: < = 11 kV ; RESIDENTIAL ; SIMPLE TYPE
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > = 22 kV & < = 33 kV ; < = 15 MVA
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > = 22 kV & < = 33 kV ; > 15 MVA AND < = 40 MVA
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; < = 15 MVA
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; > 15 MVA AND < = 40 MVA
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; > 40 MVA
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 66 kV & < = 132 kV ; < = 100 MVA
- TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 66 kV & < = 132 kV ; > 100 MVA

The remainder of the categories are a reasonable fit for modelling using REPEX.

We therefore chose to remove the eight categories of Asset ID that were determined to be a poor fit with REPEX from the modelling. We elected to split the 11kV Circuit Breaker ID into its component parts and re-run the modelling for the suitable parts. The categories where the issues were less significant we chose to continue to model in REPEX, recognising that any high level model is at best a rough approximation to the actual values.

6 11kV circuit breakers

As noted, the category for 11kV circuit breakers includes two distinct populations. The large switchboard replacement projects are derived from the Area Plans. These are part of a broad strategic asset replacement program. In our RIN data, we provided separate data for LV (<1kV) circuit breakers from the 11kV circuit breakers, because we recognised these were two distinct populations. For this analysis we have also separated out the allocation of Area Plan project costs from the 11kV circuit breaker data and developed the necessary inputs for 1kV Circuit breakers excluding major substation replacements from the Area Plans.

Re-running the REPEX model to derive replacement volumes based on calibrated asset life and forecast unit cost values for these two subsets gives the following results:

Category / Asset ID	Units	Forecast Unit Cost	Benchmark Unit Cost
SWITCHGEAR: < = 1 kV ; CIRCUIT BREAKER	58	$162.29	$118.96
SWITCHGEAR: > 1 kV & < = 11 kV ; CIRCUIT BREAKER excl major substation replacements	485	$64.17	$47.04

Note that benchmark unit costs were not available for our additional Asset IDs. To provide reasonable inputs for the model, we scaled the derived forecast unit costs for the additional IDs by the ratio of the previous benchmark costs for the overall Asset ID and the previous forecast unit cost.

Since in the cases of each of the other Categories, we are excluding entire Asset IDs, there was no need to re-run the model to derive fresh data.

7 REPEX modelling

The re-arranged asset categories total $1,105 million of the total $2,707 million (corrected) replacement forecast from the initial proposal (41%). Using the forecast from the revised proposal, this value reduces to $914 million of a total $2,197 million (42%).

Re-aggregating the REPEX results from the draft decision for this collection of asset categories, and adding the data for the two new Asset IDs to cover the LV and 11kV circuit breakers produced the following results:

Replacement Life	Unit Cost	Model Outcome ($ million)
Calibrated	Forecast	954.7
Calibrated	Benchmark Average	869.1

A copy of the spreadsheet used to calculate these outcomes is attached as Appendix 1.

Conclusion

Based on this analysis, and the approach in the draft decision, the REPEX modelling suggests a “reasonable range” for the Ausgrid’s efficient repex for those categories that have been modelled is between $869 million and $955 million.

Since Ausgrid’s actual forecast of expenditure for these categories is $914 million, we consider that the REPX modelling has corroborated our view that this is a reasonable estimate of the expenditure required by a prudent and efficient operator for these categories.

8 Unmodelled repex

The unmodelled categories of replacement expenditure comprise:

- Underground cables
- Zone substation switchgear replacement projects
- Duty of Care program
- Miscellaneous Replacement programs
- Overhead conductors 66-132kV
- The components that were not modelled in the draft decision – SCADA, network control and protection, and Pole top structures.

The key documentation relating to each of these categories is identified below:

Underground cables - these projects are part of the strategic subtransmission cable replacement program. The reference documents that describe the program, its origins and justification are:

- The Area Plans, as revised by “*Area Plan Projects – 2014 Review of preferred strategies*”
- *Strategic Asset Prioritisation Sub-transmission Cables Rev 02*
- *Quantitative Risk Evaluation - Selected Replacement Projects 2015 – 19*
- *Subtransmission Cable Replacement Strategy – Peer Review, JacobsSKM April 2014*
- *ACAPS4030 LV Underground CONSAC Cables*

- *ACAPS4031 LV Underground HDPE Cables*
- *2014 review of replacement and duty of care*

Zone Substation switchgear replacement projects - these projects are part of the strategic 11kV switchgear replacement program. The reference documents that describe the program, its origins and justification are:

- The Area Plans, as revised by "*Area Plan Projects – 2014 Review of preferred strategies*"
- *Strategic Asset Prioritisation 11kV Switchgear Rev 2.1*
- *Quantitative Risk Evaluation - Selected Replacement Projects 2015 – 19*

Duty of Care program, miscellaneous replacement and overhead conductors 66-132kV and previously unmodelled categories – these programs are all part of the replacement and duty of care plan. The reference documents that describe these programs are:

- *2014 review of replacement and duty of care*
- *Relevant ACAPS documents identified in that review*

9 Review of unmodelled programs

The expenditures that were not able to be effectively assessed using the REPEX model fall into two categories – major projects arising from the Area Plans, and programs forming part of the Replacement and Duty of Care Plan.

In order to provide a level of top-down review for the programs, we used the approach from the draft decision of preparing applying historical trend analysis to identify any programs for which special causes needed additional explanation. These analyses are found in the 2014 Replacement and Duty of Care Review.

For the major projects forming part of the Area Plans, we considered the presence of the strategic prioritisation reports and the robust analysis of alternatives and opportunities in the Area Plans provided a high degree of confidence that the expenditures were prudent. In addition, we subjected the projects still in the planning stage to a newly developed quantitative risk evaluation approach, the results of which can be found in the document "*Quantitative Risk Evaluation - Selected Replacement Projects 2015-19".* Projects that we found could reasonably and cost effectively be deferred have been removed from the expenditure forecast for 2014-19. We did not consider it prudent to apply changes to projects that were already in-flight and substantially committed.

The results of this analysis are reflected in the replacement capital expenditure forecasts in our revised proposal.

10 APPENDIX 1 - APPLICATION OF REPEX MODEL

AUSGRID 2014 - Application of REPEX model

Calibrated life & forecast unit cost factors derived from AER model: AER Draft decision Ausgrid distribution determination - Ausgrid 2014 - Repex model (calibrated - forecast) - November 2.xlsm

Benchmarked Costs derived from AER model: AER Draft decision Ausgrid distribution determination - Ausgrid 2014 - Repex model (calibrated - benchmark average) - November 2.xlsm

			Calibrated Life					
Asset category	**Asset ID**	**Forecast Unit Cost**	**Mean**	**SD**	**Units**	**Cost**	**Benchmark Costs**	
POLES	POLES: STAKING OF A WOODEN POLE	12.5	12.6	3.5	6,899	$ 86,181	$ 7.50	$ 51,740.74
POLES	POLES: < = 1 kV; WOOD	6.7	60.2	7.8	27,285	$ 183,914	$ 4.40	$ 120,053.26
POLES	POLES: > 1 kV & < = 11 kV; WOOD	6.7	53.1	7.3	12,843	$ 86,569	$ 4.10	$ 52,656.28
POLES	POLES: > 11 kV & < = 22 kV; WOOD	7.5	57.3	7.6	26	$ 196	$ 0.50	$ 13.11
POLES	POLES: > 22 kV & < = 66 kV; WOOD	16.0	56.6	7.5	1,395	$ 22,310	$ 0.50	$ 697.66
POLES	POLES: > 66 kV & < = 132 kV; WOOD	16.0	60.4	7.8	197	$ 3,152	$ 0.50	$ 98.56
POLES	POLES: < = 1 kV; CONCRETE	11.9	48.1	6.9	35	$ 412	$ 9.60	$ 332.22
POLES	POLES: > 1 kV & < = 11 kV; CONCRETE	11.9	26.8	5.2	45	$ 531	$ 11.50	$ 512.92
POLES	POLES: > 22 kV & < = 66 kV; CONCRETE	98.3	44.2	6.6	85	$ 8,367	$ 20.20	$ 1,718.70
POLES	POLES: > 66 kV & < = 132 kV; CONCRETE	29.4	41.0	6.4	88	$ 2,575	$ 14.40	$ 1,260.39
POLES	POLES: < = 1 kV; STEEL	11.9	55.5	7.5	332	$ 3,947	$ 8.40	$ 2,785.05
POLES	POLES: > 1 kV & < = 11 kV; STEEL	11.9	48.4	7.0	5	$ 58	$ 8.50	$ 41.47
POLES	POLES: > 11 kV & < = 22 kV; STEEL	13.4	16.7	4.1	3	$ 35	$ 9.20	$ 23.89
POLES	POLES: > 22 kV & < = 66 kV; STEEL	29.4	11.5	3.4	65	$ 1,907	$ 19.80	$ 1,283.53
POLES	POLES: > 66 kV & < = 132 kV; STEEL	29.4	47.8	6.9	7	$ 215	$ 15.10	$ 110.25
POLES	POLES: TOWERS	176.3	67.2	8.2	33	$ 5,874	$ 176.30	$ 5,873.08
OVERHEAD CONDUCTORS	OVERHEAD CONDUCTORS: < = 1 kV	12.3	67.2	8.2	792	$ 9,711	$ 58.90	$ 46,672.10
OVERHEAD CONDUCTORS	OVERHEAD CONDUCTORS: > 1 kV & < = 11 kV	38.3	47.4	6.9	2,912	$ 111,655	$ 70.20	$ 204,430.62
OVERHEAD CONDUCTORS	OVERHEAD CONDUCTORS: > 11 kV & < = 22 kV ; SWER	36.2	87.9	9.4	0	$ 3	$ 36.20	$ 3.26
OVERHEAD CONDUCTORS	OVERHEAD CONDUCTORS: > 11 kV & < = 22 kV ; SINGLE-PHASE	73.2	40.6	6.4	19	$ 1,418	$ 73.20	$ 1,417.74
OVERHEAD CONDUCTORS	OVERHEAD CONDUCTORS: > 11 kV & < = 22 kV ; MULTIPLE-PHASE	62.5	75.6	8.7	0	$ 6	$ 62.50	$ 5.76
OVERHEAD CONDUCTORS	OVERHEAD CONDUCTORS: > 22 kV & < = 66 kV	106.2	54.8	7.4	265	$ 28,175	$ 228.50	$ 60,627.76
~~OVERHEAD CONDUCTORS~~	~~OVERHEAD CONDUCTORS: > 66 kV & < = 132 kV~~							
~~UNDERGROUND CABLES~~	~~UNDERGROUND CABLES: < = 1 kV~~							
~~UNDERGROUND CABLES~~	~~UNDERGROUND CABLES: > 1 kV & < = 11 kV~~							
~~UNDERGROUND CABLES~~	~~UNDERGROUND CABLES: > 11 kV & < = 22 kV~~							
~~UNDERGROUND CABLES~~	~~UNDERGROUND CABLES: > 22 kV & < = 33 kV~~							
~~UNDERGROUND CABLES~~	~~UNDERGROUND CABLES: > 33 kV & < = 66 kV~~							
~~UNDERGROUND CABLES~~	~~UNDERGROUND CABLES: > 66 kV & < = 132 kV~~							
SERVICE LINES	SERVICE LINES: < = 11 kV ; RESIDENTIAL ; SIMPLE TYPE	0.5	63.9	8.0	70,483	$ 36,489	$ 0.80	$ 56,386.53
SERVICE LINES	SERVICE LINES: < = 11 kV ; COMMERCIAL & INDUSTRIAL ; SIMPLE TYPE	1.1	76.3	8.7	1,691	$ 1,909	$ 0.80	$ 1,352.44
TRANSFORMERS	TRANSFORMERS: POLE MOUNTED ; < = 22kV ; < = 60 kVA ; SINGLE PHASE	34.9	80.0	8.9	21	$ 746	$ 5.70	$ 121.76
TRANSFORMERS	TRANSFORMERS: POLE MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; SINGLE PHASE	34.9	54.4	7.4	17	$ 591	$ 11.10	$ 187.84
TRANSFORMERS	TRANSFORMERS: POLE MOUNTED ; < = 22kV ; < = 60 kVA ; MULTIPLE PHASE	34.9	59.6	7.7	156	$ 5,446	$ 8.40	$ 1,310.13
TRANSFORMERS	TRANSFORMERS: POLE MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; MULTIPLE PHASE	34.9	58.5	7.6	484	$ 16,885	$ 17.90	$ 8,655.53
TRANSFORMERS	TRANSFORMERS: POLE MOUNTED ; > 22 kV ; < = 60 kVA	10.4	33.0	5.7	4	$ 44	$ 10.40	$ 44.61
TRANSFORMERS	TRANSFORMERS: POLE MOUNTED ; > 22 kV ; > 60 kVA AND < = 600 kVA	13.5	36.5	6.0	0	$ 5	$ 13.50	$ 4.58
TRANSFORMERS	TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; < = 60 kVA ; SINGLE PHASE	1.7	36.3	6.0	0	$ 0	$ 1.70	$ 0.01
TRANSFORMERS	TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; SINGLE PHASE	35.4	36.3	6.0	2	$ 75	$ 35.40	$ 75.15

TRANSFORMERS	TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; > 60 kVA AND < = 600 kVA ; MULTIPLE PHASE	35.4	55.4	7.4	248	$ 8,778	$ 37.70	$ 9,353.33
TRANSFORMERS	TRANSFORMERS: KIOSK MOUNTED ; < = 22kV ; > 600 kVA ; MULTIPLE PHASE	40.5	38.2	6.2	83	$ 3,345	$ 74.50	$ 6,157.79
TRANSFORMERS	TRANSFORMERS: KIOSK MOUNTED ; > 22 kV ; > 600 kVA	35.4	36.3	6.0	0	$ 0	$ 35.40	$ 0.00
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; < 22 kV ; > 60 kVA AND < = 600 kVA ; MULTIPLE PHASE	208.0	68.8	8.3	135	$ 27,976	$ 48.70	$ 6,550.38
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; < 22 kV ; > 600 kVA ; MULTIPLE PHASE	208.0	62.4	7.9	60	$ 12,446	$ 65.70	$ 3,931.31
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > = 22 kV & < = 33 kV ; < = 15 MVA	371.5	62.0	7.9	13	$ 4,852	$ 371.50	$ 4,852.34
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > = 22 kV & < = 33 kV ; > 15 MVA AND < = 40 MVA	706.2	48.2	6.9	39	$ 27,590	$ 706.20	$ 27,590.74
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; < = 15 MVA	1041.6	65.8	8.1	0	$ 478	$ 1,041.60	$ 477.76
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; > 15 MVA AND < = 40 MVA	1166.4	41.9	6.5	6	$ 6,782	$ 1,417.40	$ 8,241.87
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 33 kV & < = 66 kV ; > 40 MVA	10076.3	36.1	6.0	1	$ 8,784	$ 108.10	$ 94.24
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 66 kV & < = 132 kV ; < = 100 MVA	571.5	49.6	7.0	21	$ 11,748	$ 2,880.10	$ 59,203.72
TRANSFORMERS	TRANSFORMERS: GROUND OUTDOOR / INDOOR CHAMBER MOUNTED ; > 66 kV & < = 132 kV ; > 100 MVA	2608.6	49.6	7.0	5	$ 13,771	$ 2,608.60	$ 13,771.25
~~TRANSFORMERS~~	~~TRANSFORMERS: DISTRIBUTION SUBSTATIONS~~							
SWITCHGEAR	SWITCHGEAR: < = 11 kV ; FUSE	1.8	134.3	11.6	0	$ 0	$ 1.80	$ 0.00
SWITCHGEAR	SWITCHGEAR: < = 11 kV ; SWITCH	32.9	71.0	8.4	772	$ 25,374	$ 17.60	$ 13,579.58
~~SWITCHGEAR~~	~~SWITCHGEAR: < = 11 kV ; CIRCUIT BREAKER~~	142.7	64.2		671		105	
SWITCHGEAR	SWITCHGEAR: > 11 kV & < = 22 kV ; SWITCH	17.8	76.9	8.8	0	$ 0	$ 17.80	$ 0.04
SWITCHGEAR	SWITCHGEAR: > 11 kV & < = 22 kV ; CIRCUIT BREAKER	46.6	41.8	6.5	0	$ 0	$ 46.60	$ 0.02
SWITCHGEAR	SWITCHGEAR: > 22 kV & < = 33 kV ; SWITCH	135.7	59.1	7.7	418	$ 56,653	$ 49.50	$ 20,668.26
SWITCHGEAR	SWITCHGEAR: > 22 kV & < = 33 kV ; CIRCUIT BREAKER	206.0	51.8	7.2	206	$ 42,418	$ 119.00	$ 24,499.37
SWITCHGEAR	SWITCHGEAR: > 33 kV & < = 66 kV ; SWITCH	0.0	99.4	10.0	0	$ 0	$ 48.70	$ 0.13
SWITCHGEAR	SWITCHGEAR: > 33 kV & < = 66 kV ; CIRCUIT BREAKER	223.5	37.8	6.1	7	$ 1,632	$ 103.20	$ 753.36
SWITCHGEAR	SWITCHGEAR: > 66 kV & < = 132 kV ; SWITCH	180.9	57.4	7.6	155	$ 28,105	$ 72.70	$ 11,293.05
SWITCHGEAR	SWITCHGEAR: > 66 kV & < = 132 kV ; CIRCUIT BREAKER	655.5	49.8	7.1	12	$ 7,652	$ 127.30	$ 1,485.96
SWITCHGEAR	SWITCHGEAR: > 11 kV & < ≈ 33 kV ; FUSE & FUSE SWITCH (not including enclosed type)	135.7	18.6	4.3	47	$ 6,364	$ 135.70	$ 6,364.47
~~SWITCHGEAR~~	~~SWITCHGEAR: ZONE & SUBTRANSMISION SUBSTATIONS~~							
SWITCHGEAR	SWITCHGEAR: < = 1 kV ; CIRCUIT BREAKER	$ 162.29	83	9.14	58	$ 9,413	$ 118.96	$ 6,900
SWITCHGEAR	SWITCHGEAR: > 1 kV & < = 11 kV ; CIRCUIT BREAKER excl major substation replacements	$ 64.17			485	$ 31,118	$ 47.04	$ 22,809

SUBTOTALS						
		SRP	**RRP**	**C-F**		**C-B**
POLES		$ 408,046	$ 243,811	$ 406,243		$ 239,201
OVERHEAD CONDUCTORS		$ 141,850	$ 194,086	$ 150,969		$ 313,157
SERVICE LINES		$ 58,386	$ 18,463	$ 38,398		$ 57,739
TRANSFORMERS		$ 212,368	$ 170,407	$ 150,341		$ 150,624
SWITCHGEAR		$ 284,684	$ 287,639	$ 208,728		$ 108,354
Total		**$ 1,105,334**	**$ 914,406**	**$ 954,679**		**$ 869,075**

Ref: REPEX application - revised proposal.xlsx