J18 and J22 circuit breakers and bus protection

RRP BUS 4.07

Revised proposal 2021–2026

CitiPower

December 2020

Contents

1 Overview

Our original proposal explained that J18 and J22 oil-filled circuit breakers, which were first installed on our network in the early 1960s, are increasingly exposing our staff and communities to significant safety and reliability risks. To address these risks, we proposed a targeted program to replace 96 of the J18 and J22 oil-filled circuit breakers at selected, high-consequence zone substations.

The AER's draft determination did not accept our proposed replacement program for J18 and J22 circuit breakers, on the basis insufficient supporting evidence had been provided to demonstrate that the proposed volumes were prudent and efficient.[1] Instead, the AER provided a substitute amount that would allow for the replacement of 27 of these circuit breakers, reflecting our historical level of expenditure.

In our revised proposal, we reconsidered the proposed replacement volumes in light of the draft determination and additional condition data, including dielectric loss angle (DLA) analysis testing. This test data is not yet incorporated into our condition based risk management (CBRM) models, but indicates the proposed replacement of J18 and J22 circuit breakers at two of the five selected zone substations can be deferred.[2] Additional bus protection and permanent online partial discharge monitoring will support the management of safety risks as an interim measure. For the remaining three zone substations, however, the most efficient and prudent course of action is to replace the J18 and J22 circuit breakers.

We also address the AER's draft determination in relation to bus protection, which only allowed our historical expenditure for the 2021–2026 regulatory period. It is important that the J18 and J22 circuit breaker replacement program is considered alongside the bus protection program. As explained in this business case addendum, our revised proposal accepts the draft determination to adopt historical expenditure, subject to providing an incremental allowance for the replacement of older, slower operating bus protection schemes on J18 and J22 switchboards due to their risk and the replacement program.

In our view, this revised proposal appropriately balances the risks posed by the J18 and J22 circuit breakers against the benefits of deferring expenditure where this can be achieved without compromising safety.

This business case addendum should be read in conjunction with the following documents:

- our original business case (CP BUS 4.07)
- our revised plant and stations, and protection models (CP RRP MOD 4.09 and CP RRP MOD 4.10).

For the reasons provided in this addendum, our revised replacement capital expenditure forecast for J18 and J22 circuit breakers and bus protection is presented in table 1.1.

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1 AER, *Draft Decision, CitiPower Distribution determination 2021 to 2026, Attachment 5 Capital expenditure*, September 2020, p. 34.

2 As set out in section 3.1, we are in the process of reviewing and updating maintenance forms to standardise and streamline the capture of visual inspection ratings, partial discharge, oil leak and electrical test results to drive the asset health index within the CBRM. These inputs are currently vacant in the existing model, as data migration exercise is required to convert and import the historical maintenance activities.

Table 1.1 Capital expenditure forecasts: J18 and J22 circuit breaker replacement and bus protection ($ million, 2019)

Expenditure	2021/22	2022/23	2023/24	2024/25	2025/26	Total
J18 and J22 circuit breakers						
Original proposal	1.4	1.5	1.5	1.8	0.8	7.1
Draft determination	0.4	0.4	0.4	0.5	0.4	2.0
Revised proposal	0.8	1.4	0.6	0.8	0.8	4.4
Protection						
Original proposal	4.9	4.9	4.9	5.0	5.0	24.6
Draft determination	2.8	2.8	2.8	2.9	2.9	14.2
Revised proposal	4.0	4.0	2.8	2.5	2.5	15.8

Source: CitiPower

2 Background

2.1 Our original proposal

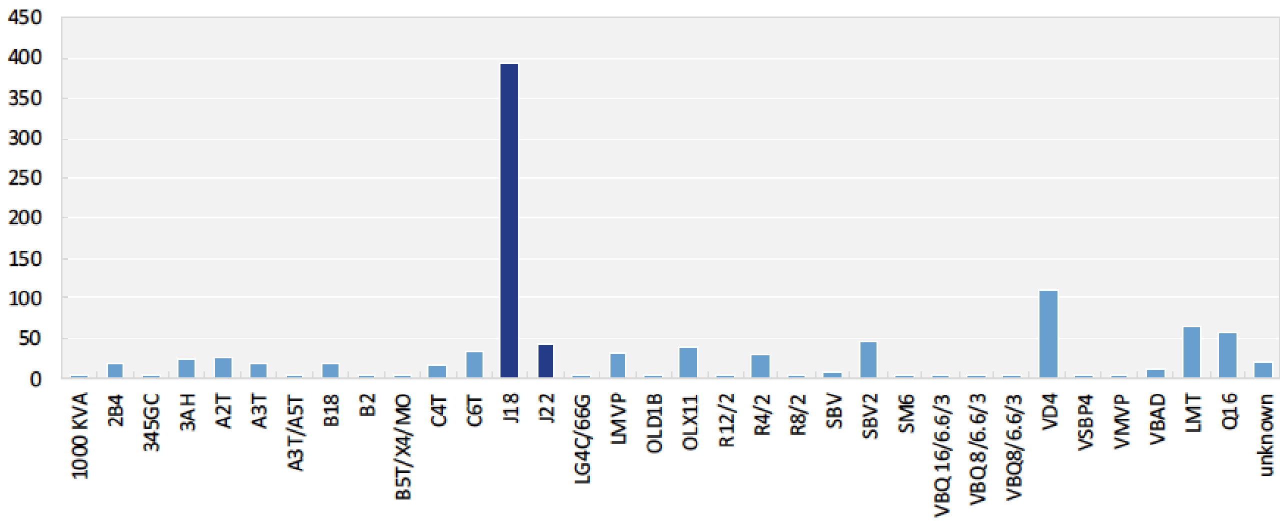
Our original proposal explained that failures in oil-filled circuit breakers are not common on our network, but when they do occur the results can be catastrophic.

Unfortunately, our Collingwood zone substation experienced an explosive failure of a J18 circuit breaker in 2016, with sufficient force to blow open the doors in the switch room and leading to the loss of supply to 1,200 customers. The metal cladding on the switchboard suffered extensive damage, requiring two circuit breakers to be decommissioned and their loads transferred to spare feeder positions. Extensive clean up and repairs were also required due to fire and heat damage.

Our business case submitted alongside our original proposal commented on the approach adopted by other distributors to address the risks associated with oil-filled circuit breakers.[3] The examples presented in that business case demonstrated that the safety risks associated with J18 and J22 circuit breakers have been recognised by distributors in Australia and internationally. For example, in 2016 TasNetworks completed a program to replace its oil-filled circuit breakers in zone substation sites with modern vacuum circuit breakers. Ausgrid is also replacing all 11kV oil-filled circuit breakers (with modern vacuum circuit breakers) in zone substations where they are not planning to replace the entire 11kV switchboard.[4]

We explained that J18 and J22 circuit breakers comprise approximately 40 per cent of the circuit breaker population on our network, as illustrated in figure 2.1.

Figure 2.1 Existing circuit breaker volumes (by model)



Source: CitiPower

Given the above background, in our original proposal we considered the following options to manage the increasing risks with these ageing assets:

- option one: continue to maintain, rather than replace, J18 and J22 circuit breakers
- option two: replace J18 and J22 circuit breakers when the relevant zone substation switchboard is upgraded

3 CP BUS 4.07, J18 and J22 circuit breakers, submitted January 2020, pp. 10-12.

4 Ausgrid, *Distribution and Transmission Annual Planning Report*, 2019.

- option three: replace the entire population of J18 and J22 circuit breakers
- option four: replace J18 and J22 circuit breakers at selected zone substations, where we are not planning to replace the entire switchboard
- option five: adopt a non-network solution.

Our original proposal concluded that option four was preferred and we undertook risk monetisation analysis at five selected zone substations, being Albert Park, Armadale, Fishermans Bend, Flinders/Ramsden and Toorak.

Our original proposal also included the installation of high-speed bus protection at sites that will remain with J18 and J22 oil circuit breakers, as an outcome of the failure experience at our Collingwood zone substation.

2.2 Draft determination

The draft determination acknowledged there is a case for replacing J18 and J22 circuit breakers. The AER, however, was not satisfied with the prudency and efficiency of the proposed program of work. In particular, the AER concluded the proposed replacement volume was higher than the prudent and efficient level—for example:[5]

- the proposal to replace J18 and J22 circuit breakers at high consequence locations does not align with the results of our CBRM model, which indicates these circuit breakers have remaining lives of between 10 and 17 years
- the likelihood of consequence is assumed to be 100 per cent in all cases, and this is likely to overstate the risk cost and, therefore, the case for asset replacement.

The AER noted that EMCa's review also concluded that the information we had provided was insufficient to demonstrate that the forecast costs are efficient and prudent. In particular, EMCa made the following observations:[6]

- the preferred option was selected from what appears to be a qualitative assessment only, without providing a decision framework for categorising zone substations as high risk
- our model indicates the optimal replacement time is in the past, which casts doubt on whether the model is used to assist with investment decision making or in determining the optimal timing for asset replacement
- our model is sensitive to changes to the input assumptions, and substituting these inputs for 'more reasonable values' allows the optimal replacement time to be deferred
- we used historical costs for the basis of our replacement program, yet EMCa considered the information provided was insufficient to demonstrate the forecast costs are efficient and prudent.

In relation to protection capital expenditure, the AER noted that our proposed investment in secondary protection and control assets at zone substations was 84 per cent higher than our historical expenditure over the current regulatory period. The AER did not accept this forecast, and instead, provided a substitute estimate that reflected our historical average expenditure.

Specifically, the AER stated that insufficient justification had been provided on how the replacement projects were selected, and we had not demonstrated the relationship between our CBRM tool and our forecast

5 AER, *Draft Decision, CitiPower Distribution determination 2021 to 2026, Attachment 5 Capital expenditure*, September 2020, p. 44.

6 EMCa, *Review of aspects of CitiPower's regulatory proposal 2021–26*, September 2020, pp. 82–83.

expenditure.[7] Similarly, while EMCA noted that a case for an increase had been established, the extent of the proposed increase and the timing of replacement projects had not been justified.

7 AER, *Draft Decision, CitiPower Distribution determination 2021 to 2026, Attachment 5 Capital expenditure*, September 2020, pp. 42–43.

3 Revised proposal

We maintain that it is prudent and efficient to actively manage the risk associated with our J18 and J22 circuit breaker population. This is consistent with the reasons set out in our original proposal, including:

- these circuit breakers were commissioned during the period 1963–1973, across 22 zone substations, and are approaching their technical asset life (60 years)
- insulation tests have shown evidence of degradation of the circuit breaker internal insulation, and equipment obsolescence means that it is not possible or cost effective to replace the degraded components
- the safety risks associated with J18 and J22 circuit breakers have been recognised by distributors in Australia and internationally, and we have experienced a recent catastrophic failure of an oil-filled circuit breaker on our network
- the consequences of failure for our large population of J18 and J22 circuit breakers are material, as these assets are not arc-fault contained, and the consequences are even greater without modern fast-acting protection schemes
- J18 and J22 circuit breakers comprise almost 40 per cent of our total circuit breaker population, giving rise to increasing operational risks that are best managed in a structured program (i.e. before further failures occur, as experienced across the industry).

However, based on additional condition data, our revised proposal now includes the replacement of J18 and J22 circuit breakers at only three zone substations. A summary of the works required at these sites is outlined in table 3.1, including how we will manage risks at the two zone substations where we will defer works.

Table 3.1 Overview of proposed work

Zone substation	Summary of actions to be taken in the 2021–2026 regulatory period
Albert Park	• Deteriorating circuit breakers will be replaced with modern vacuum retrofits and arc deflecting doors • The switchboard is in good condition, so its replacement can be deferred • Supplementary bus protection is to be installed in 2021 to mitigate safety risk to field staff in the event of a bus fault prior to replacement of the bus (i.e. a bus fault which can be caused by the bus insulation itself or failure of connected equipment, such as the circuit breaker, current or voltage transformers, or cable box)
Armadale (deferred)	• The circuit breaker and switchboard condition data indicate replacement of those assets can be deferred • Risk associated with the deteriorating circuit breakers and switchboard will be managed through online partial discharge monitoring and routine maintenance activities, prior to the likely replacement of the switchboard • To mitigate the safety risk to field staff in the event of a bus fault, supplementary bus protection is to be installed in 2021, prior to the replacement of the bus (i.e. a bus fault which can be caused by the bus insulation itself or failure of connected equipment, such as the circuit breaker, current or voltage transformers, or cable box)
Fishermans Bend	• Deteriorating circuit breakers will be replaced with modern vacuum retrofits and arc deflecting doors • The switchboard is in good condition, so its replacement can be deferred • Supplementary bus protection is to be installed in 2020/2021 to mitigate safety risk to field staff in the event of a bus fault prior to replacement of the bus (i.e. a bus fault which can be caused by the bus insulation itself or failure of connected equipment, such as the circuit breaker, current or voltage transformers, or cable box)
Flinders/Ramsden (deferred)	• Risk associated with the deteriorating circuit breakers and switchboard will be managed through online partial discharge monitoring and routine maintenance activities, prior to the likely replacement of the switchboard
Toorak	• Deteriorating circuit breakers will be replaced with modern vacuum retrofits and arc deflecting doors • The switchboard is in good condition, so its replacement can be deferred

Source: CitiPower

Our revised proposal also includes our bus protection program at sites with J18 and J22 circuit breakers. For the reasons set out in section 3.1.6, the risk of catastrophic failure and resulting potential for injury or fatality can be cost effectively reduced by upgrading mechanical bus protection to high speed digital protection. This is not a substitute for our circuit breaker replacement program, but rather, is a supplementary risk mitigation control (safety improvement) until the non-arc fault contained switchboard or circuit breakers are replaced. This program is part of our response to the circuit breaker failure at our Collingwood zone substation.

Our revised proposal forecast is summarised in table 3.2.

Table 3.2 Revised proposal: J18 and J22 circuit breaker replacement and bus protection program ($ million, 2019)

Expenditure	2021/22	2022/23	2023/24	2024/25	2025/26	Total
J18 and J22 circuit breakers						
Albert Park zone substation	-	-	-	0.8	0.8	1.6
Armadale zone substation	-	-	-	-	-	-
Fishermans Bend zone substation	0.8	0.8	-	-	-	1.7
Flinders/Ramsden zone substation	-	-	-	-	-	-
Toorak zone substation	-	0.6	0.6	-	-	1.1
Total (circuit breakers)	**0.8**	**1.4**	**0.6**	**0.8**	**0.8**	**4.4**
Protection						
Historical protection	2.8	2.8	2.8	2.9	2.9	14.2
Less historical J18/22 protection	*(0.4)*	*(0.4)*	*(0.4)*	*(0.4)*	*(0.4)*	*(1.8)*
J18/22 protection	1.5	1.5	0.4	-	-	3.5
Total (protection)	**4.0**	**4.0**	**2.8**	**2.5**	**2.5**	**15.8**

Source: CP RRP MOD 4.09 and CP RRP MOD 4.10

Notes: The AER's substitute estimate (our historical costs) for bus protection implicitly included some funding for bus protection, which we have netted out

3.1 Response to draft determination

As outlined previously, the AER and EMCa both recognised the need for replacing J18 and J22 circuit breakers, and increased investment in protection assets. In this section, we respond to the AER and EMCa's specific concerns with our original proposal.

3.1.1 Our revised proposal is informed by, but is not determined, by our CBRM

The AER raised concerns that our CBRM model did not support the proposed replacement program, as it implies that the remaining asset lives of the circuit breakers at our proposed zone substations are between 10 and 17 years. EMCa also commented that the preferred option appeared to have been selected on a qualitative basis and that we had not provided details of the decision framework to identify and prioritise the high-risk sites.

Our CBRM does not yet reflect the full condition of our circuit breaker population

Our CBRM for circuit breakers (including J18 and J22 assets) is in its infancy, and further work is being undertaken as we align our asset management approach with the ISO 55000 framework. The existing model includes an initial health assessment using asset age, location, and duty which is then modified using the available condition assessment data. Condition inputs in the circuit breaker model include external visual inspection rating, oil leaks and circuit breaker partial discharge.

At this stage, however, our CBRM does not provide a complete description of asset health. In particular, we are in the process of reviewing and updating maintenance forms to standardise and streamline the capture of visual inspection ratings, partial discharge, oil leak and electrical test results to drive the asset health index within the model. This is why these inputs in the CBRM appear vacant.

Once these condition factors are confirmed for future maintenance activities, a data migration exercise will convert and import the historical maintenance activities into the CBRM model. Importantly, the absence of this information in the CBRM is not reason to exclude consideration of these inputs.

Additional condition information supports our program

Notwithstanding the limitations of our existing CBRM, the available information from the testing of J18 circuit breakers to date has shown degradation of the internal insulation. This suggests the health index should be higher than the data presented in support of our original proposal.

Critically, there is a wealth of condition data for these circuit breakers outside of the CBRM, and we used this information to select the highest risk sites. This includes:

- circuit breaker maintenance data—condition data from time or condition-based maintenance programs is stored within the SAP system as PDF files (and due to this format, this data is not currently used as an input into the CBRM)
- circuit breaker test data—since 2008, we conducted offline DLA testing of zone substation circuit breakers
- switchboard test data—since 2019, we conducted offline DLA testing of zone substation switchboards.

Our decision criteria also have regard to switchboard condition data, as the two asset types are interdependent. In this context, we have used the following information sources to identify and prioritise high-risk sites:

- switchboard DLA test results—if results indicate switchboard DLA is satisfactory, consider circuit breaker replacements; if results not conclusive, undertake further tests
- circuit breaker DLA test results—increasing trend indicates where there is a higher probability of insulation failure of the circuit breaker
- if there has been a bus extension with modern switchgear (i.e. meaning there is a risk of damaging new equipment)
- if the high-speed bus protection has been installed or will be installed by end of the 2021–2026 period.

Although a deterministic framework for selecting high priority zone substations has not been developed, this does not undermine the case for replacing the proposed volume of J18 and J22 circuit breakers (or the selected sites). Rather, we undertake these works on a 'no-regrets' basis—for example:

- there are known safety issues associated with these assets that have been recognised across jurisdictions
- we have a disproportionately high volume of these circuit breakers, and this gives rise to increasing operational risks (noting these were not costed in the risk-monetisation modelling provided with our original proposal)

- should any J18 and J22 circuit breaker replacements that are part of our proposed program in the 2021–2026 regulatory period become redundant—for example, if the need to replace the entire switchboard becomes economic, noting the age and risks associated with many of CitiPower's zone substation assets—the breadth and characteristics of our J18 and J22 population means that any newly installed circuit breakers will be retro-fitted at other sites (as our J18 and J22 program continues)
- we have reduced the number of selected zone substations (and corresponding circuit breakers) for our revised proposal.

The results of this analysis, for all sites with J18 and J22 circuit breakers, are summarised in table 3.3.

Table 3.3 Additional circuit breaker test results

Zone substation	Replace switchboard based on DLA	Bus protection upgrade by 2026	Circuit breaker DLA assessment	Switchboard bus extension	Replace circuit breaker
FB	No	Yes	Increase in maximum and average station dissipation factor across years	No	Yes
NR	Further tests scheduled	Completed	Limited data set; one high cap bank circuit breaker, the others low	Yes	No
AP	No	Yes	Increase in maximum and average station dissipation factor across years	Yes	Yes
SK	Further tests scheduled	Yes	Limited data set; one high feeder circuit breaker, the others low	Yes	No
TK	No	Completed	Increase in maximum and average station dissipation factor across years	Yes	Yes
MG	Further tests scheduled	Yes	Modest increase in maximum and average station dissipation factor across years	Yes	No
SO	Further tests scheduled	Completed	Increase in maximum and average station dissipation factor across years	Yes	No
B	Yes (fault damage)	Completed	Increase in maximum and average station dissipation factor across years	No	Yes
FR	Further tests scheduled	No	Insufficient data	No	No
NC	Further tests scheduled	Yes	Insufficient data	No	No
AR	Yes	Yes	Increase in maximum and average station dissipation factor across years	No	No
DA	Further tests scheduled	No	Insufficient data	Yes	No

BC	Further tests scheduled	Yes	Constant high dissipation factor across multiple years; minimal change in amplitude	Yes	No
RD	Further tests scheduled	Yes	Constant high dissipation factor across multiple years; minimal change in amplitude	No	No
CW	Further tests scheduled	Yes	Insufficient data	No	No
Q	Further tests scheduled	Yes	Requires additional analysis	No	No
L	Further tests scheduled	Yes	Insufficient data	No	No

Source: CitiPower

3.1.2 Our likelihood of consequence assumptions are directly linked to the defined failure mode

The AER commented that our risk monetisation overstated risk costs by adopting a likelihood of consequence which is 100 per cent in all cases, independent of the load and the time of failure. The AER concluded, therefore, that the case for our proposed expenditure was also overstated.

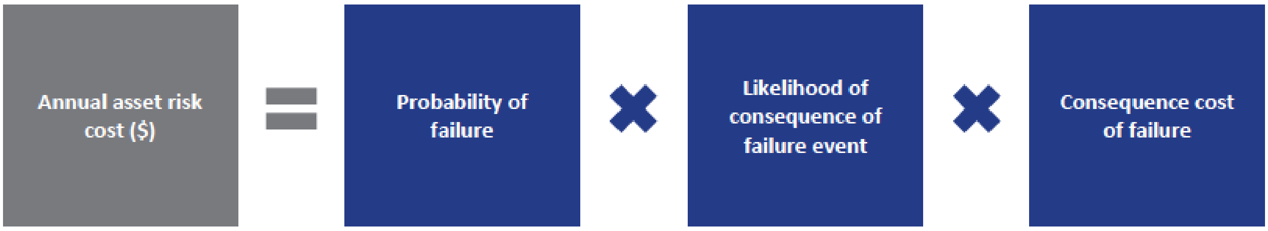
In our original business case, we explained that the likelihood of consequence is set to 100 per cent on the basis that when a particular failure type occurs, it is known to have a particular consequence. That is, the likelihood of consequence is directly linked to the definition of the failure mode (and naturally the probability of that failure mode occurring)—for example, as the definition of a significant or a major failure is a failure that results in an outage, and the consequences are determined using actual values of load and capacity, then the likelihood of the consequence occurring must be set to 100 per cent. In other words, by definition, these failure modes could not occur without causing loss of the asset and some consequence must occur if there is a significant asset failure.

It is useful to work through the example of the Significant Failure mode consequences in the J18 risk monetisation models. In the 'Inputs' tab of each J18 model we have used the expertise of EA Technology to define Catastrophic, Major and Significant failure modes and their probability of occurrence each year. A Significant Failure mode is defined as a failure that results in damage requiring replacement of one failed circuit breaker. This failure type has a 100 per cent likelihood that the upstream protection will operate and result in an outage of the relevant circuit breaker bus until the situation can be assessed and switching carried out to transfer the load. It would not be possible for the circuit breaker failure mode to occur without resulting in a significant outage. The time taken to attend site, make safe and carry out switching has been set based on experience, and a conservative estimate is used in the model. Failure modes are defined based on historical failures and the experience of failures of this type is used to define the consequences.

Similarly, we explained that the value of the safety consequence of asset failure takes into account the likelihood that a failure of each type would result in injury or death. As the likelihood of the consequence is included in defining the value of consequence, the likelihood of consequence value is set at 100 per cent (otherwise the likelihood of consequence would be double-counted in calculating the expected safety risk). Refer to the 'Inputs' tab of each J18 risk monetisation model (i.e. line 178), which outlines the weighted likelihood of consequence values underpinning these safety consequences.

We understand the risk monetisation model, reproduced in figure 3.1, ordinarily distinguishes between the probability of failure; the likelihood of a failure event; and the consequence cost of a failure. However, it is reasonable to combine the latter two elements in a single variable, providing that the components are estimated appropriately. Or stated alternatively, that these two variables are combined does not necessarily infer that risk costs are overstated, so long as the probability of the failure type is appropriate to the failure type, and not just the probability of a generic 'failure'.

Figure 3.1 Risk monetisation model



Source: CitiPower

3.1.3 We use our monetisation model to identify optimal timing

EMCa highlighted the optimal timing identified by our model indicated that replacement 'should' have occurred sometime in the past. This observation led EMCa to cast doubt on whether we use the model to assist with the investment decision making and its optimal timing.

We recognise the analysis of the optimal timing indicates the replacement of circuit breakers at some zone substations is already economic. However, this does not imply that the models are not used to inform the investment decision and the optimal timing. Instead, as communicated to the AER and EMCa, it is because we are continuing to develop our understanding of the performance of our assets and refining our approach to determining optimal investment decision.

In any event, our customers have benefited from the continuing use of J18 and J22 circuit breakers in the intervening period. It is clear, however, that our modelling indicates the savings in continuing to use these assets are now offset by growing performance and safety risks. EMCa's observation that the modelling indicates that replacement should have already occurred does not invalidate these modelled results.

3.1.4 Changes to input assumptions should be supported by transparent evidence

EMCa stated that when substituting 'more reasonable values' for a number of the assumptions used in our modelling, the optimal replacement time that we proposed can be deferred.[8]

EMCa did not disclose the basis for why their substitute assumptions, in isolation or in combination, are more reasonable than our forecasts. Similarly, they did not disclose what combination(s) of sensitivities it relied on (or placed greater weight on) to support its decision. It is clear from the sensitivity models, however, that EMCa only countenanced down-side sensitivities. That is, its sensitivity analysis was asymmetric.

The nature of risk-modelling is that changing assumptions will lead to different timing of the proposed expenditure. Contrary to EMCa's sensitivity analysis, the risks associated with the J18 and J22 circuit breakers should not be understated, particularly given the experience on our network (i.e. the major failure at our Collingwood zone substation), and the decisions by other networks to replace these circuit breakers.

Further, the consequences of a fatality or serious injury as a result of an explosion are likely to exceed the direct actuarial costs, as it will have significant operational consequences. For example, a failure event is likely to cause significant operational issues, driven by safety bodies such as Energy Safe Victoria (ESV) and industrial action from field resources. Restrictions on our ability to operate these circuit breakers live, or to undertake

8 EMCa, *Review of aspects of CitiPower's regulatory proposal 2021–26*, September 2020, pp. 93

maintenance in a live substation, would result in a significant increase in network constraints and decrease in system reliability, especially given the large number of these assets on our network. Our risk model did not recognise this consequential cost and, in this regard, is likely to understate the optimal replacement volume.

Our view is that the cost modelling is an input to prudent and efficient decision making, recognising that not all consequences from an asset failure can be anticipated and quantified. In this regard, it is imprudent to reduce the replacement volumes by adjusting input assumptions without compelling evidence to support the change or considering the wider context (including giving weight to 'un-costed' risks).

3.1.5 Our unit costs reflect historical efficiencies

EMCa commented that our approach of basing forecast unit costs on our actual historical expenditure is insufficient to demonstrate the forecast costs are efficient and prudent. We understand this refers to concerns the efficiencies generated through our transformation program completed in the 2016–2020 regulatory period have not been reflected in our forecast.

As outlined previously to the AER and EMCa, our 'World Class' program did not materially change our approach to delivering major plant projects. Rather, the re-negotiation of contract arrangements was more focused on high-volume assets, and programs/works delivered by third parties. For example:

- the procurement of equipment for major projects, including civil works, have always been (and continues to be) sourced through open tenders in competitive markets
- efficiencies delivered through streamlining our internal procurement process are reflected in reduced overheads, so do not impact direct-cost forecasts.

It is also important to recognise that the regulatory framework provides strong incentives to deliver efficiency savings (e.g. the capital expenditure sharing scheme). A forecast that is based on actual unit costs will capture historical efficiency gains and provides a reasonable basis for estimating future unit costs.

3.1.6 Our high-speed bus protection program is incremental to our historical expenditure

The AER did not accept our proposed increase in bus protection investment on the grounds that insufficient information had been provided to demonstrate its efficiency and prudency. A specific area of concern related to the relationship between our CBRM tool and our forecast protection expenditure.

We accept the observation that further work is required to establish the linkages between the CBRM tool and our proposed protection expenditure. Similar to the CBRM for our circuit breaker population, the application of the CBRM tool in relation to protection assets remains in a development phase, and further work is required before this tool can be relied upon to determine our protection expenditure forecasts.

Given the above, we broadly accept the AER's decision to allow our historical expenditure in relation to bus protection. For the following reasons, however, our revised proposal also includes an incremental amount for high-speed bus protection schemes on J18 and J22 switchboards:

- while our historical protection expenditure includes some expenditure in relation to J18 and J22 switchboards, it is not sufficient to address the emerging risks
- we are proposing a modest replacement program of J18 and J22 circuit breakers which means a significant number will remain in operation over the 2021–2026 period
- the risk of catastrophic failure, and resulting potential for injury or fatality, can be cost effectively reduced by upgrading mechanical bus protection to high-speed digital protection (i.e. the high-speed bus protection will reduce the fault energy if there is a failure event, and therefore reduce damage to plant and potential safety risk to personnel)

- although high-speed digital protection is not a substitute for our circuit breaker replacement program, it is a prudent safety improvement until the non-arc fault contained switchboards or circuit breakers are replaced.

The installation of high-speed protection equipment is also a 'no regrets' approach, as this same protection will be used when the remaining circuit breakers are replaced. For similar reasons, where we are proposing to replace J18 and J22 circuit breakers, we are also proposing high-speed digital bus protection as this is the current standard protection that is installed with such replacements.

Our total forecast for protection (i.e. the draft determination based on historical costs, plus our revised J18/22 protection forecast) is shown in table 3.4. This includes a deduction to the draft determination to recognise the (limited) expenditure for our proposed program included in our historical costs, such that the revised proposal only incorporates the prudent and efficient requirements at each of the specified zone substations for the 2021–2026 regulatory period. The full details of these calculations are provided in our protection capital expenditure model, included with our revised proposal.[9]

Table 3.4 Capital expenditure forecasts: total protection ($ million, 2019)

Expenditure	2021/22	2022/23	2023/24	2024/25	2025/26	Total
AER draft determination	2.8	2.8	2.8	2.9	2.9	14.1
Less historical J18/22 protection	*(0.4)*	*(0.4)*	*(0.4)*	*(0.4)*	*(0.4)*	*(1.8)*
AP bus protection	0.4	-	-	-	-	0.4
MG bus protection	0.4	-	-	-	-	0.4
AR bus protection	0.4	-	-	-	-	0.4
BC bus protection	0.4	-	-	-	-	0.4
CW bus protection	-	0.4	-	-	-	0.4
L bus protection	-	0.4	-	-	-	0.4
Q bus protection	-	0.4	-	-	-	0.4
RD bus protection	-	0.4	-	-	-	0.4
NC bus protection	-	-	0.4	-	-	0.4
Revised proposal	**4.0**	**4.0**	**2.8**	**2.5**	**2.5**	**15.8**

Source: CP RRP MOD 4.10

3.2 Revised proposal forecasts

Consistent with the reasons provided in this addendum, our revised capital expenditure forecast for J18 and J22 circuit breakers and bus protection is set out in table 3.5.

9 CP RRP MOD 4.10

Table 3.5 Capital expenditure forecasts: J18 and 22 circuit breaker and bus protection ($ million, 2019)

Expenditure	2021/22	2022/23	2023/24	2024/25	2025/26	Total
J18 and J22 circuit breakers	0.8	1.4	0.6	0.8	0.8	4.4
Protection	4.0	4.0	2.8	2.5	2.5	15.8

Source: CitiPower