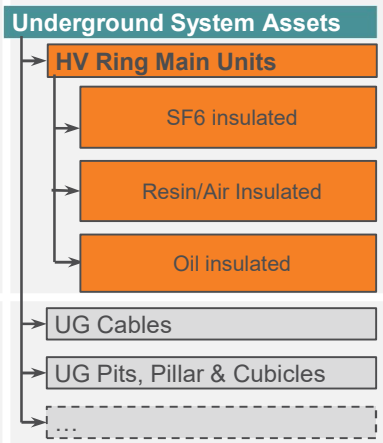
HV Ring Main Units Investment Case

High Voltage Ring Main Units are a switching devices that support the safe operations and segmentation of Essential Energy distribution network. RMU's are installed in zone, chamber and padmount substations. The majority of units are typically installed underground in urban settings.

Scope

This investment case for High Voltage Ring Main Units (HV RMU) includes the HV switchgear and its related ancillaries which directly support the reliability, safety, and maintainability of the underground power distribution network.

The investment is required to meet the capital expenditure objectives (NER 6.5.7) for quality, reliability, safety and security of electricity supply and to meet regulatory and legislative obligations for Standard Control Services.



Forecast $FY24

The HV RMU forecast accounts for 3.54% of the total Repex portfolio for FY25 to FY29.

FY25	FY26	FY27	FY28	FY29
$7.5M	$7.9M	$7.9M	$8.1M	$8.3M

Asset Profile/Health

Asset Profile

RMUs are a factory assembled, enclosed set of switchgear used at the load connection points of a ring-type distribution network. They are located in critical areas and are often exposed to the public.

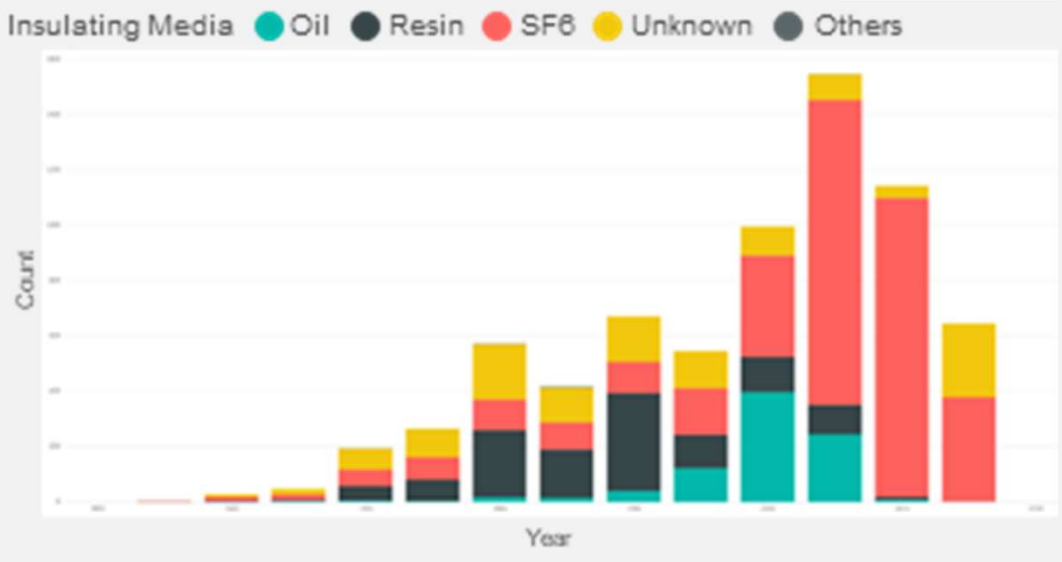
The network is comprised of approximately 6,850 RMUs, consisting of SF6 insulated (~50%), resin/air insulated (~19%), oil insulated (~12%) & others (vacuum insulated, rotary and fuse switchgear, ~3%) units.

Older RMUs are primarily oil & resin insulated gear, prone to fire and explosive failures if not maintained. New models are moving towards SF6 insulated.

A 5 year RMU maintenance recovery program was initiated in 2017 to assess the baseline condition and bridging gaps in asset data availability. The condition information from the recovery program will significantly influence the RMU probability of failure and risk models (including inspection/maintenance activity and intervals).

The age profile of the HV Ring Main Unit fleet is shown in the following Figure and used as a proxy for asset health.

Insulating Media	Count	Age
Oil	~900	~20
Resin/Air	~1350	28.5
SF6	~3730	11.7



This risk section provides an overview of the HV RMU risk model. It is supported by documents and **6.03.02 Network Risk Management Manual, 6.03.03 Appraisal Value Framework and 6.03.04 System Capital Risk and Value Based Investment** methodology.

Probability of Failure

RMU defect/failures and subsequent maintenance tasks have been identified through the Failure Mode Effects Analysis (FMEA) cause codes recorded. Subsequent analysis, including reviewing the free text field, focussed only on asset failures that led to a functional failure. Analysis of historical data from 2015 – 2019 identified ~320 asset replacements . Modelling the RMU survival rates (comparing failed assets to operating ones within the population after filtering assets with unknown/missing attributes) led to the Weibull distribution attributes shown on the right.

Where,
α - Life expectancy of units in service until 66% fail in service,
β - Shape/curve factor, corresponds to the rate of deterioration

Sub-population		Mean α (in years)	Mean β	Lower CI (95%)	Upper CI (95%)
Resin, all locations	Weibull	69	2.64	61	79
Resin, <= 5km from coast	Weibull	58	2.86	51	66
Resin, > 5km from coast	Weibull	93	2.32	84	104
SF6, <= 5km from coast	Weibull	67	1.41	46	98
SF6, > 5km from coast	Weibull	258	1.28	126	529
All oil locations	Weibull	196	1.61	69	559

Consequence of Failure

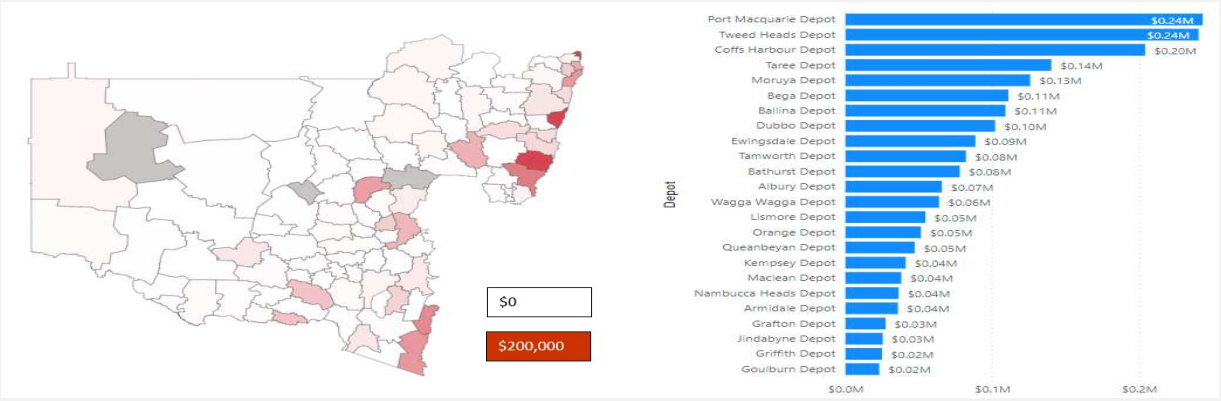
The consequence from failure of a RMU describes the impact of a functional failure. Consequences have been evaluated using the Appraisal Value Framework . Event Trees have been developed at an individual RMU level to determine the key contributors to consequence criticality associated with each asset.

For RMUs, consequences (shown on the right) are determined using the **6.03.03 Appraisal Value Framework** categories, with categories ranked based on consequence cost assuming the failure of all RMUs in the network.

The table displays the summary of the asset criticality for RMUs by depot. The primary differentiator of criticality for RMUs is the Network consequence, with radial fed sub transmission RMUs having the highest consequence cost on average.

Component	Consequence		
	Total ($ million)	Average($)	Median($)
Safety	$127	$18,587	$18,587
Network	$39	$5,728	$4,177
Bushfire	$30	$4,364	$433
Environment	$5	$759	$0
Financial	$229	$33,444	$33,444

Risk heatmap of highest risk depots (Scaled)



Risk Model Calibration

Asset risk is calculated by applying the PoF and CoF models to individual assets. Asset risk is then aggregated to the total population level to determine the asset class risk.
Model outputs have been calibrated against top-down performance figures for unassisted failures. The table opposite compares the unscaled model outputs with the monetised top-down performance. For implementation, scaling factors are applied to risk model outputs, to align risk forecasts with realised performance.

Value Measure	Safety	Network	Bush fire	Financial	Total
Unscaled Model Outputs	$970k	$300k	$89k	$1.68M	$3.13M
Top-Down Performance	$570k	$540k	$40k	$990k	$2.1M

Forecasting Approach

The replacement Capex forecast (FY25-FY29) has been calculated using Essential Energy's optimisation software (Copperleaf) which uses a risk based methodology to maximise the value of the investment portfolio within constraints established by Essential Energy that are consistent with our Corporate Risk Framework, Asset Management System, applicable standards, rules, regulations and licence conditions. To assure efficiency our portfolio has been constrained to meet customer and stakeholder expectations.

In line with NER capital objectives, the objectives of our total replacement portfolio have been informed through extensive stakeholder engagement and consist of:

- Maintain reliability performance (network risk)
- Long term reduction of bushfire start risk by 20% over 20 years (2.5% FY25-29)
- Maintain safety performance

The replacement quantities of HV RMU consist of:

1. Forecast **conditional replacement** volumes.

A probabilistic evaluation has been developed through detailed analysis of historical asset performance to establish Weibull parameters (refer 6.03.03.18) for a subset of categories within this asset class. These have not been utilised in deriving the forecast volumes except as a means of comparison.

Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of HV RMU assets by applicable unit rates.

Refer to **6.03.04 System Capital Risk and Value Based Investment** methodology for details on the **portfolio** wide optimisation planning approach and risk outcomes, and **10.01.04 Capital Unit Rates** for unit rates.

Optimised Portfolio Outcomes

Risk Trend (2024-29 Optimised portfolio)
Due to limitations in the PoF development for a number of sub-category assets in this program, a risk profile is not available. Forecasts have been based on maintaining the current levels of replacement to maintain the population.

In the lead up to the revised 2024-29 regulatory period Essential Energy will continue to improve the PoF modelling for the sub-category assets to validate and adjust forecast volumes as appropriate to manage portfolio risks.

As the forecast is a flat projection based on 2019-24 allocations with no age uplift this approach is conservative in nature i.e. no increase in volumes of replacement.

Asset Grouping

The HV RMU assets have been grouped into one broad categories for investment optimisation purposes:

1. **Conditional** replacement - where an inspection has identified a defect that must be rectified in a predetermined timeframe by asset replacement;

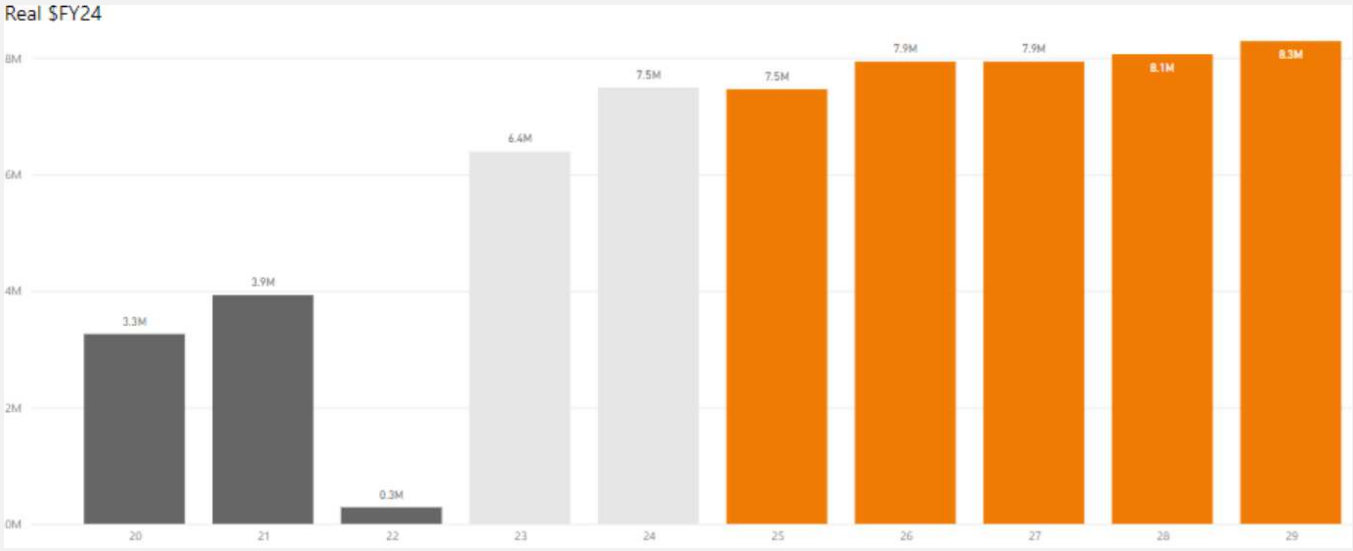
Options

1. HV RMU replacement expenditure has been modelled on a replace with like-for–like replacements.

- As RMUs are a feature of underground distribution networks, there are no opportunities to consider non-network solutions as an alternative to RMU replacement.
- Value calculators determine the most prudent and efficient investment choice available at the time for a specific project. For example, options include: like-for-like replacement, new types or materials.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for HV RMU across the 2024-29 period is $39.7M, averaging $7.9M per annum. Actual and projected expenditure for the remainder of the 19-24 period is $21.4M.



Data source: Actuals: Internal delivery reports, Forecasts: Copperleaf
Note: All values are in FY2023-24 real dollar terms

Justification

We are confident that our approach delivers an efficient and prudent level of investment as:

- **Clear drivers from Asset Management Objectives** for Reliability, Quality, Safety and Compliance (as detailed in **Attachment 10.01 Strategic Asset Management Plan**).
- **NER Capex Objectives:** form the basis of our proposal
- **Review and moderation:** Our forecasts have been tested and reviewed by our executive management and the Board, subject to top-down challenges (as detailed in **6.03.04 System Capital Risk and Value Based Investment**) and the forecasts moderated based on feedback and discussion.
- **Critical Environmental Factors:** Risk associated with HV RMU due to factors such as safety.

The major benefits from the proposed HV RMU investments (against the **change nothing** scenario) are:

- **Improved network risk and maintainability**: Investment in this asset class will reduce network risk through replacement of HV RMU P of degraded condition and/or in high risk locations with more resilient materials of acceptable condition; and
- **Improved service level outcomes:** management of asset health will result in fewer unplanned failures thus reducing unplanned outages and over time will improve network reliability.

Forecast HV RMU Repex expenditure for the 2024-29 period is $39.7M. The increase from 2019-24 actual/forecast of $21.4M is due to historic reported expenditure based on internal delivery reports being allocated to distribution power transformers. This reallocation has reduced the Distribution Power Transformer forecasts as shown in (**Attachment 10.02.20**).

Key Assumptions

Probability of Failure

- PoF models used in the risk model utilise Weibull analysis.
- Asset condition / health has not been considered in this iteration of the model.
- Consequence of Failure uses **6.03.03 Appraisal Value Framework**

System Interaction Effects (Consequence of Failure)

- Interactions between UG System assets were accounted for at an enclosed substation level. In this iteration, failures of RMUs were modelled with a 10% chance of elevation to “whole-of-substation financial replacement” consequence on major failures.

Limitations on application of the model

- Does not handle conditional failure of an asset and its rectification/replacement.
- With the data restraints outputs required review, validation and interpretation from SMEs, prior to proposing specific asset replacements and applying changes to budgets and resource levels.

Strategic Direction

Lifecycle Stages

Acquisition

Selection Criteria

Supply as per CEOS5122 (for EE) and CEOM7004 (for ASP) procured assets.

Switchgear Replacement Guidance

- Oil Filled - Installed Oil filled switchgear which shall be replaced with SF6 insulated switchgear, upon reaching the end of life as assessed from condition measurements.
- Resin Filled - Replacement switchgear to be SF6 where possible. Where it is not possible like for like is allowable after assessment. The assessment will have to consider likelihood of pollution build up and exposure versus distance from the coast.
- SF6 Filled - Replacement with a complete new or refurbished unit as per the relevant investment case and Underground Renewal and Refurbishment Guideline (CEOM7804).

Procurement

Current period contracts with two vendors for EFACEC FLUOFIX switchgear and RM6 switchgear.

Assets ordered as required. Consistent lead times (12 to 14 weeks).

Actions

- **Asset Onboarding.** Assess & address QA/data gaps in ASPs RMU handover.
- **Innovation.** (In-progress) Identify and procure IAC compliant SF6 slimline units.
- **UG System Reliability**. Assess risk of RMU type faults on network operation and maintenance.

Ops & Maintenance

Preventative Maintenance (Inspections):

Guidelines as per CEOP2474, subject to change following the UG system strategy review.

Frequency. Scheduled every 5/10/15 years based on switchgear type (insulating media) and distance from coast. Critical assets, as per CEOP2034, are inspected annually.

Activities. Combination of generic (checking for aging and environment initiated factors) and switchgear specific (checking for type faults) activities.

Corrective Maintenance (Repairs):

Replace defective components and address installation errors. Clean RMU compartment for contamination

Breakdown Maintenance:

Breakdown maintenance events caused by a functional failure result in an intervention

Actions

- **Cause Descriptions.** Align eMWL & EAM task codes to FMECA (to achieve desired granularity).
- **Cost Data**. Capture unit labour and material costs at an activity level. (EAM)
- **Inspection Frequency**. Adjust interval based on asset risk profile (using data from maintenance recovery program).
- **Technology.** Build business case for remote RMU operation & monitoring.

Intervention

Serviceability

Assets replaced upon identification during inspections. Replacement criteria and prioritisation as per CEOM7804.

Prioritisation

As per defect severity (assigned by the field staff) and risk assessment by planning.

Design is involved if the replacement asset is not like for like.

Disposals

Individual Assets

RMUs disposed of as per CEOM7094.

SF6 Switchgear

Disposal managed by OEM/contractors with assets tracked across the process with QR code.

Oil Insulated Switchgear

Disposed as per EE policy with asset checked for hazardous materials (incl PCBs).

Hazardous Materials

- SF6 GHG Footprint. Add cost of SF6 environmental impact into lifecycle decisions.
- Oil Insulated RMU Disposal Plan. Develop disposal plan as per CEOP8074 to appropriately manage systems/data out of service

Asset Support

	Current Approach	Actions
Process & Information	The data quality and availability has improved to intermediate maturity through the maintenance recovery phase.	• Create asset register for baseline truth. • Create configuration management plan for clear record-keeping of underground assets.
People & Training	Annual refresher training for authorised switching operators.	• Review CEOS5008 and internal process for training engagement (Period Contract) • Operation procedures to be in-place prior to equipment roll out
Supply Chain	RMUs are sourced individually or as a part of padmount substation. An Australian supplier has been selected for rapid supply of critical spares and technical support.	• Investigate demand for spares and support for legacy switchgear assets and potential gaps. • Investigate integrating the EAM system to improve the visibility and traceability of spares.