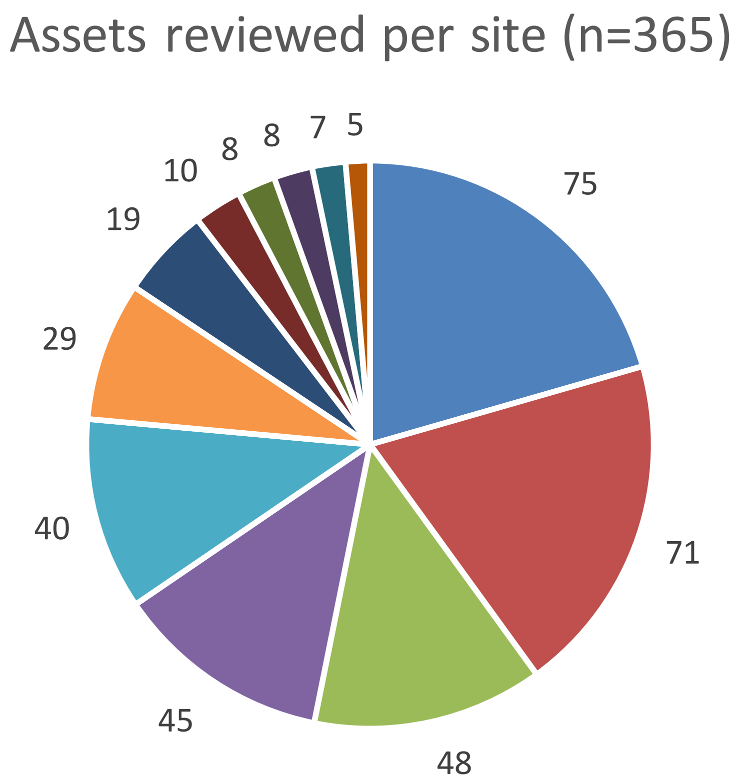
Customer assets connected to REFCL networks: a preliminary risk study

PBSC meeting June 2017

Tony Marxsen

Twelve sites reviewed

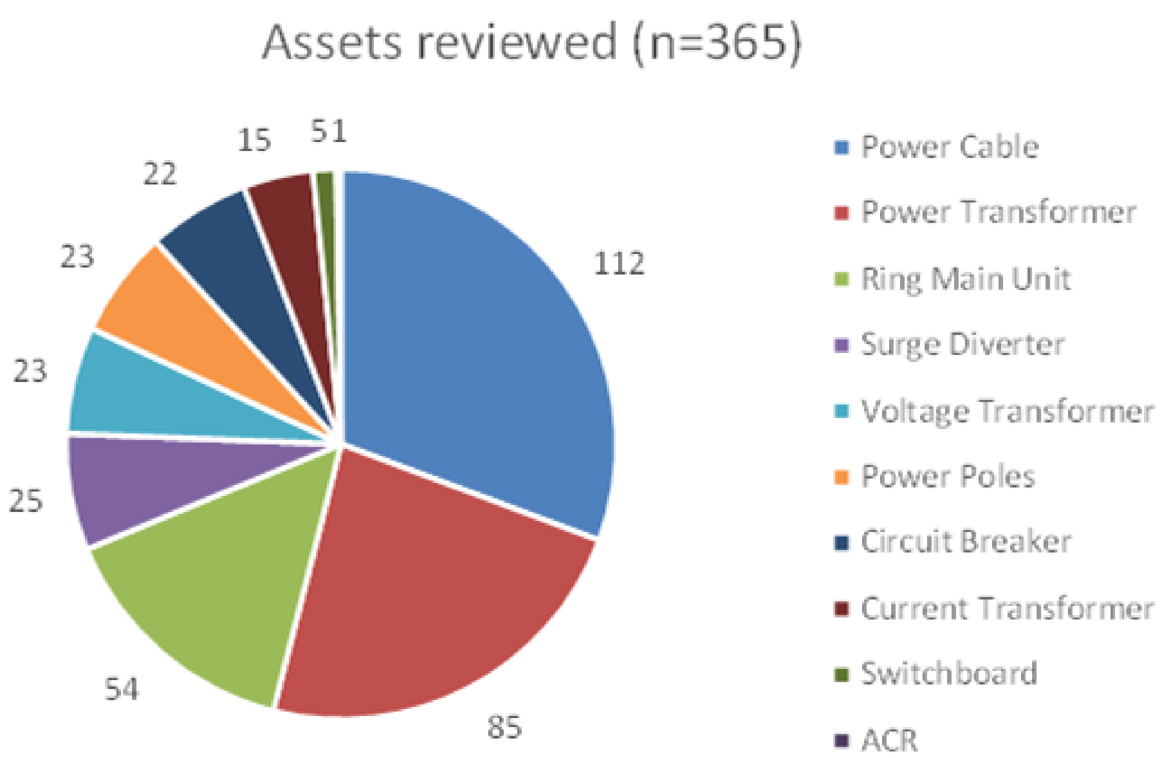


A mix of large and small, simple and complex, overhead and underground, old and new, across Victoria.

Desktop review of data from customer and DB, followed by site visit.

Customers were welcoming and supportive.

365 assets of ten types reviewed

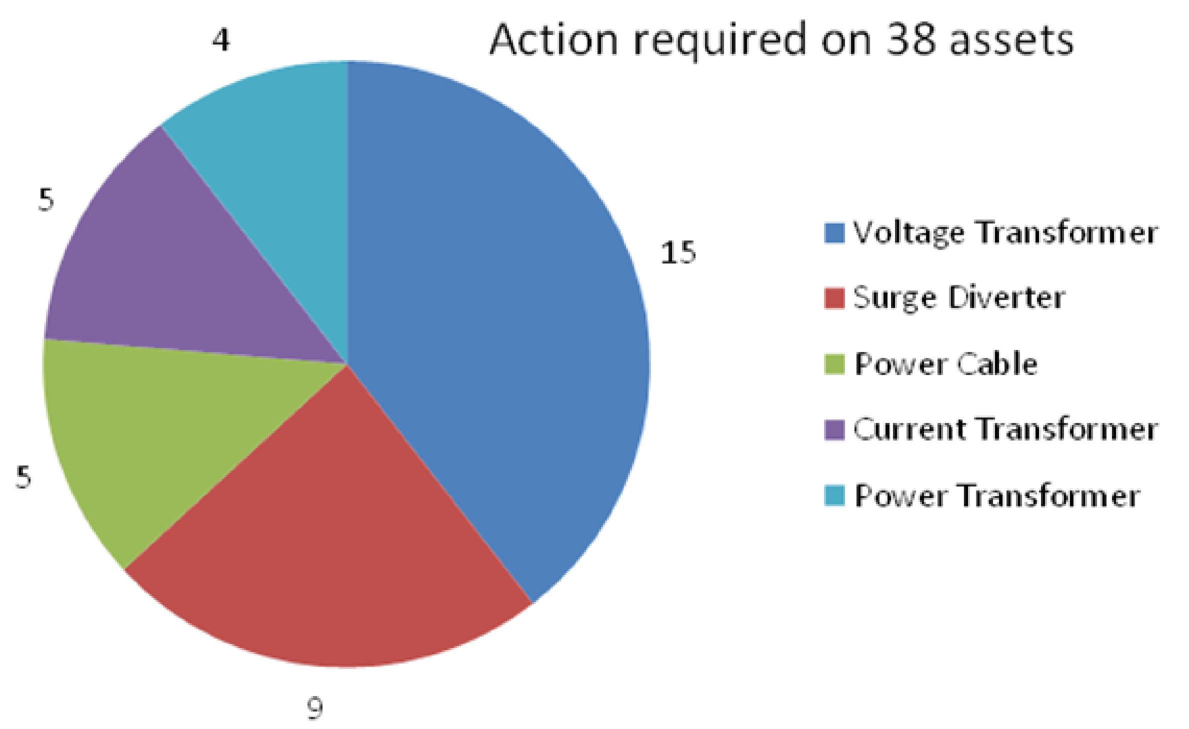


Another 51 assets were found to be either owned by the DB or never connected to the network, e.g. back-up generators.

Compared to networks, site are cable rich and surge diverter poor.

Asset failure risk was assessed in three bands.

38 (10%) high risk assets identified

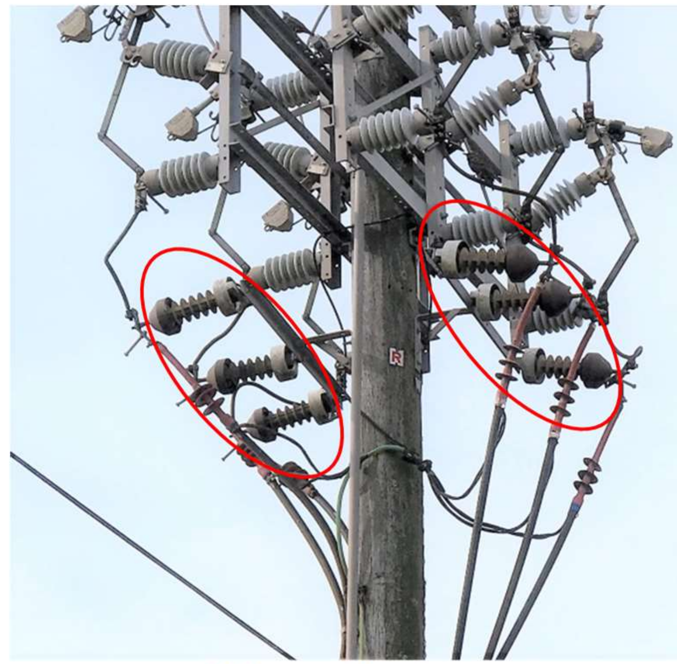


Available information indicates these are highly likely to require replacement.

Four power transformers already in customer replacement planning.

VTs and surge diverters: high risk examples

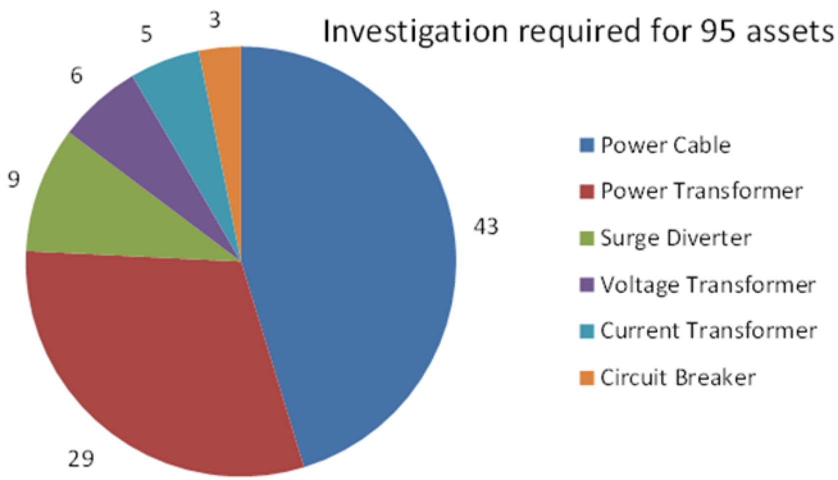
Embedded metering transformers

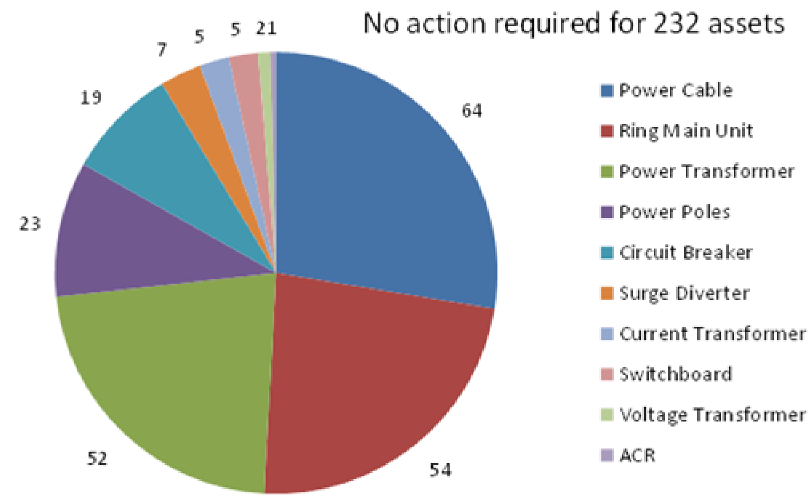


Old surge diverters

Many VTs and CTs embedded in switchgear could not be accessed for assessment.

90% low or medium risk assets

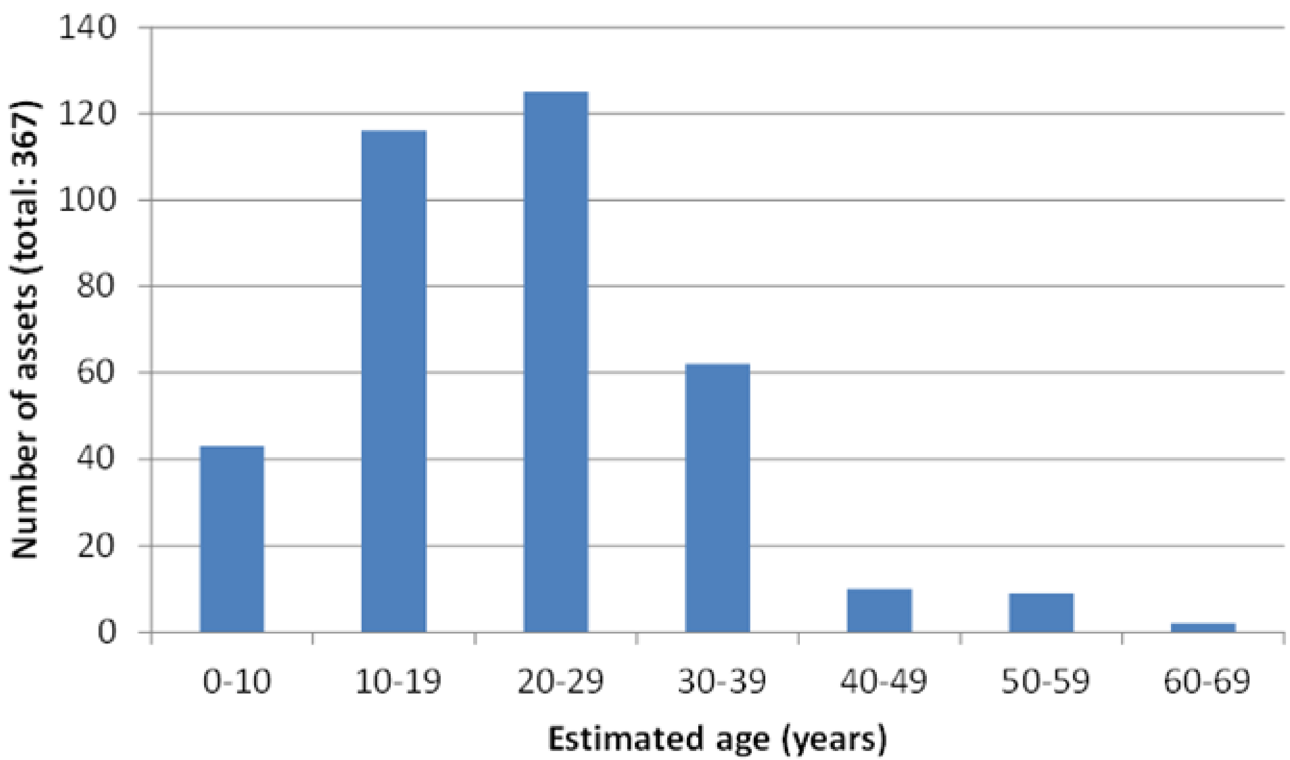




DGA tests of transformers and PD tests of cables will divide these 95 assets into 'high risk' or 'no action categories.

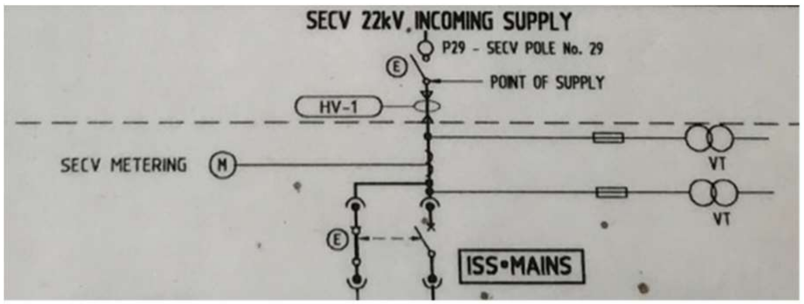
Typical examples are young cables (post-2000), VTs rated to 1.9Un/8h, switchgear rated 24/50/150kV, transformers with good DGA results, etc.

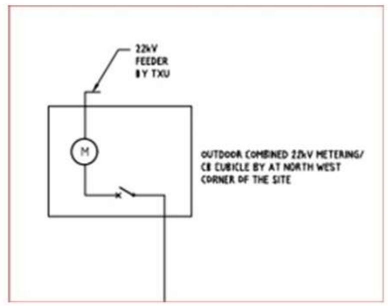
Ageing assets

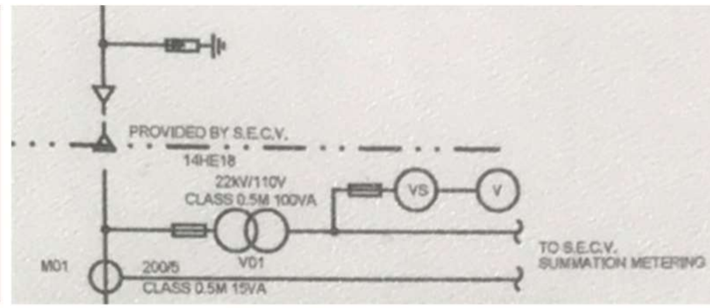


By the end of the REFCL rollout, many assets will be approaching their end-of-life phase.

Who owns what?







Some high risk assets are at or near the point of supply. Ownership is unclear in many cases and there is conflicting data.

Data sources are Supply Agreements, drawings, possession of keys, location relative to fence, etc.

Materiality of the risk

- United Energy experience:
  - FSH network: 180km overhead plus 30km cables. REFCL installed six years ago.
  - Five seconds voltage displacement.
  - Six possible cross-country faults out of 500+ voltage displacements. Many with little or no cross-country current flow. Only two in fire season.
  - Main culprit: surge diverters – many faults self-cleared before second fault.
  - 11 cable failures but only three during or shortly after voltage displacement
- Danish experience:
  - Cable failures down tenfold with dry-cured XLPE (introduced 1980)
  - 46% of cable failures are during (10%) or within two hours (36%) of REFCL voltage displacement
- International comparisons:
  - European cable failure rates 13% of North American (REFCL vs non-REFCL?)

Materiality of the risk

Table 2: comparison of customer asset numbers with network asset numbers

Asset type	12 customer sites	130 customer sites	9 rural networks[17]	45 rural networks	Customer assets as % of total	Weighting[18] (% of FSH CC faults)	Added risk
Cable	19 km	205 km	227 km	1,135 km	18.1%	15%	2.7%
Transformer	85	920	9,227 eq	46,135 eq	2.0%	15%	0.3%
Surge div	25	271	27,428	113,300	0.2%	70%	0.1%

This is risk of cross-country fault, regardless of whether current flows or not.

Presence of customers on network increases risk by about 3% nearly all due to cable.

Cost of mitigation ($AUD million)

Site	Replace all cable		Replace selected		Assumed selected cables replaced
	No rebate	Rebate	No rebate	Rebate	
A	3.04	1.80	1.66	1.04	50% of 30yr old cables
B	2.64	1.85	0.72	0.56	20% of 22yr old cables
C	1.14	1.05	0.07	0.07	One 50+ year old cable
D	0.58	0.29	0.22	0.15	50% of 27yr old cables
E	0.51	0.38	0.47	0.30	
F	0.30	0.22	0.01	0.01	
G	0.06	0.06	0.06	0.06	
H	0.02	0.02	0.02	0.02	

'Rebate' is financial recognition of already expended life compared to 40 years nominal.

Findings

1. The primary risk is a cross-country fault should a customer asset fail to withstand higher than normal voltages during REFCL response to an earth fault elsewhere on the network.
2. The consequences of a cross-country fault can include:
   a. In high fire risk conditions, a fire. However, this is unlikely if either the original fault is not of a type that would normally cause a fire, or it is not a sustained fault.
   b. Customer asset damage and consequential loss of supply with interruption to normal site activity, lost production and potential loss of stock.
   c. Network asset damage and consequential loss of supply to other customers.
3. Based on six years of experience of a hardened REFCL network at Frankston South, cross-country faults are rare (perhaps one per cent of all earth faults).
4. Risk from customer assets represents a small increment (perhaps two per cent) of Victoria's total risk from cross-country faults.
5. Risk from customer assets is of the same nature and likely no greater 'per asset' than that arising from the same assets deployed in distribution networks.
6. Risks from customer assets may in many cases be cost-efficiently mitigated without isolation transformers between the customer site and the distribution network.
7. Customers and network owners have a common interest in prevention of asset failures. Mitigation costs may be reduced by early technical information sharing and collaboration.
8. Clarity about the boundary between customer assets and network assets would strengthen accountability for safety risks.

Recommendations

1. **Educate and work with customers:** Network owners should engage and communicate with customers at an on-site technical level, not just at a corporate level. Network technical experts should visit customer sites and brief electrical maintenance teams on the rationale for the REFCL roll-out, the technical implications for their assets and business operations, and explore with them possible cost-effective approaches to risk mitigation.
2. **Encourage and support customers to carry out tests to clarify risks:** Two specific sets of tests are recommended:
   a. Partial Discharge (PD) tests of high voltage cables on customer sites. Depending on the test results, arrange for remedial action on vulnerable cables. The PD test method and acceptance criteria should match the REFCL operating practices of the network that supplies the site. None of the customers reviewed are currently doing PD tests on any assets.
   b. Dissolved Gas analysis (DGA) tests of customer transformers where this is not already in place. Depending on test results, bring forward replacement or refurbishment of transformers that show indications of seriously deteriorated insulation. Many customers are already doing this though the extent varies.
3. **Inhibit further growth in risk:** Provide customers with technical specifications for REFCL-compatible surge diverters, voltage and current transformers, cables and power transformers. Encourage them to use these in their current and future asset purchases.
4. **Assess operations procedural options:** Work with customers to explore the viability of operational procedures to disconnect non-essential high voltage infrastructure during periods of high fire risk as an alternative to upgrading these assets.
5. **Negotiate complex sites:** In a small minority of sites, the issues may be very complex. The best outcome is most likely to be achieved if the distribution business and the customer collaborate to jointly identify and assess technical options to find the most cost-effective solution as a basis of a negotiated agreement on mitigation investment.
6. **Clarify residual uncertainties:** Investigate (by test if necessary) two specific potential risks where some uncertainty remains due to limited information:
   a. Performance of typical VTs under REFCL operation conditions.
   b. The over-voltage withstand capability of neon voltage indicators and associated high voltage capacitive taps in 22kV metal-clad switchgear.
7. **Clarify the asset ownership boundary:** Network owners and customers should liaise to identify the ownership of assets at or close to the site/network boundary, in particular metering transformers, supply cables and surge diverters.
8. **Include customer assets in REFCL commissioning tests:** The over-voltage soak tests carried out during REFCL commissioning must include customer assets if these tests are to provide assurance of bushfire risk reduction benefits.