Transgrid

People. Power. Possibilities.

Asset resilience for large rotating machinery and fixed assets: comparisons and contrasts

Jeremy Culberg

June 2025

Abbreviated Resume – Jeremy Culberg, Substations Asset Strategist

Electrical Engineering (2001 to now)

Hydro Tasmania

Tarong North / Tarong Energy / Stanwell Corporation

Redbank Power Station

CS Energy

Transurban

RCR Tomlinson (Rail)

TEMCO (smelter)

Transgrid

Roles varied, with heavy focus on:

Operate and Maintain

Major Refurbishment / Replacement

Asset Management

Project Work

Majority of the work has been at site, one step behind the frontline, or on the frontline itself.

Transgrid

Topics

1. ***How routine inspections and maintenance have changed with technology advances***

2. ***Exploring the asset management lifecycle, and how to confront ageing infrastructure and repair/ replacement considerations***

3. ***Using resilience modelling and analysis, and how best to harness the data***

4. ***Employing resilience enhancement and optimisation to safeguard your assets***

Transgrid

How routine inspections and maintenance have changed with technology advances

The Set Up

As a broad statement, the fundamentals of rotating machinery have remained largely static.

- There are still bearings, stator windings, rotor windings, excitation systems and the like.
- The biggest advances over the last 60 years have been in the control system and instrumentation.
- This is both in complexity (they can do more), and cost (it is generally cheaper to do the basics).

At a wider market level, labour costs have gone up.

The cost difference between repair and replace has shifted significantly (more on that later).

Transgrid

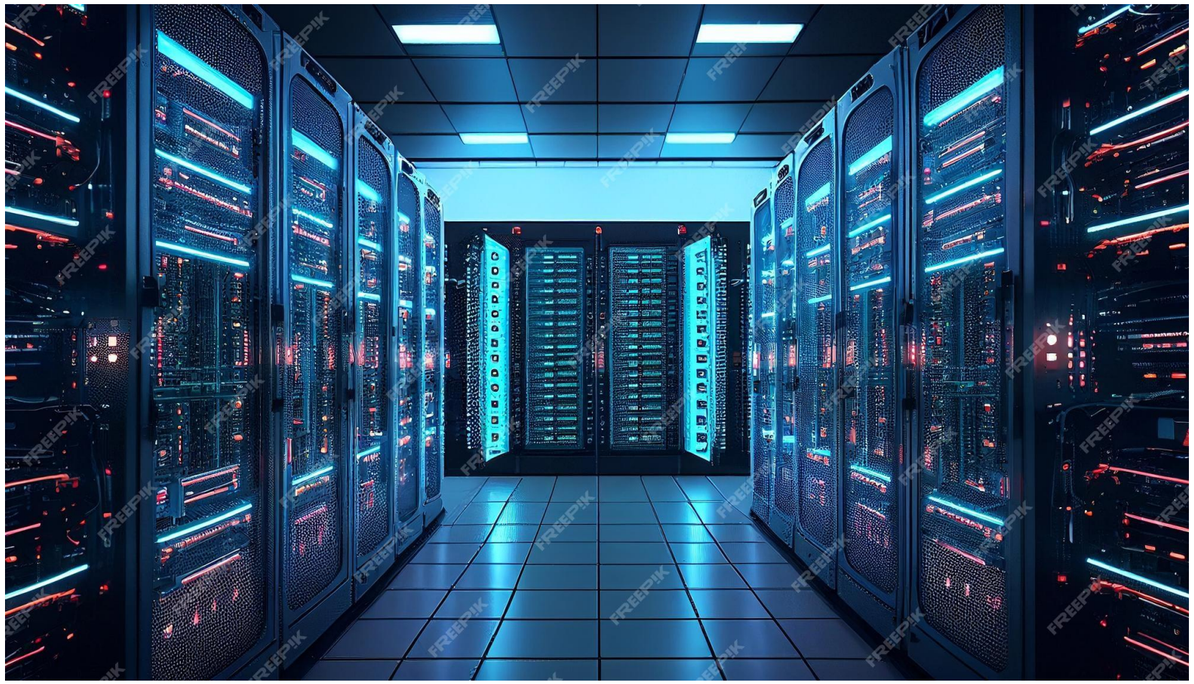
How routine inspections and maintenance have changed with technology advances

What has changed

- Instrumentation has got more complex (can do more)
- And/or much cheaper to do the basics.
- Computing power is massively cheaper
- There are now decades ved experience with various “Online Condition Monitoring” systems

Which leads to:

- Automation of many measurements that used to require a person with a clipboard (temperatures, pressures, voltages, current, etc).
- Automation of many calculations (thermal efficiency for example).
- Automation of exceptions



Transgrid

How routine inspections and maintenance have changed with technology advances

What has changed

Remote sensing options:

- Variously, drones and robots have got cheaper and more capable.
- The AI that sits behind the image processing has improved.
- Remote operation is a massive opportunity.

This means that rather than send a person to 'check it out', a drone or robot can be directed to first pass inspections. In addition, either can do routine patrol inspections. These inspections can be driven from operators 100s of kilometers removed from the plant.

Some forms of Non-Destructive Testing / inspection have meant that disassembly is not required as often (borescopes, ultrasound)

LIDAR and satellite imagery has got cheaper to use.

All of which reduces the need for humans to be as involved

Transgrid

Exploring the asset management lifecycle, and how to confront ageing infrastructure and repair/ replacement considerations

Most organizations I have worked for, or with, push assets well beyond what the OEM recommends as a life.

I have worked on equipment that was well into its fifth decade of service, when all the ‘standard life’ is 30 years, or 40 years with some effort.

In all cases, how big is the pool of money?

What sort of opportunities / constraints are in place around having plant out of service?

Labour is expensive, and the skills to repair some types of equipment is disappearing.

Parts can be very challenging to source.

Transgrid

Exploring the asset management lifecycle, and how to confront ageing infrastructure and repair/ replacement considerations

What do we do?

Replace some equipment, preferably before it fails!

Retain decommissioned sibling units to keep the rest going

Life extension works – for example replacing bushings on transformers, or rewinding a generator.

Closely monitoring equipment as it approaches “end of life”

It becomes a balancing act between the cost of action, and the cost of inaction.

The cost of some components has gone down dramatically over the last 40 years. And so has the expected life.

- always worth checking the cost of new versus repair.

Transgrid

Using resilience modelling and analysis, and how best to harness the data

A transformer built today, and a transformer built 40 years ago are both identifiable as being “largely the same”.

Similar commentary across many asset classes, from circuit breakers, to instrument transformers, to isolated phase busbar.

For that matter, a generator (or large motor), other than the insulation material, is all but identical to models constructed in the 1960s.

All of which means that the history from the last 60 years of operation can inform what are the weak points, vulnerabilities, and strengths of the various makes and models out there.

Transgrid

Using resilience modelling and analysis, and how best to harness the data

For new variants of equipment, such as non-SF6 circuit breakers, many of the fundamentals have not changed.

Clearances may be slightly larger, however the concept of a mechanical spring drawing apart contacts, with a puff of insulating medium quenching the arc is not changed.

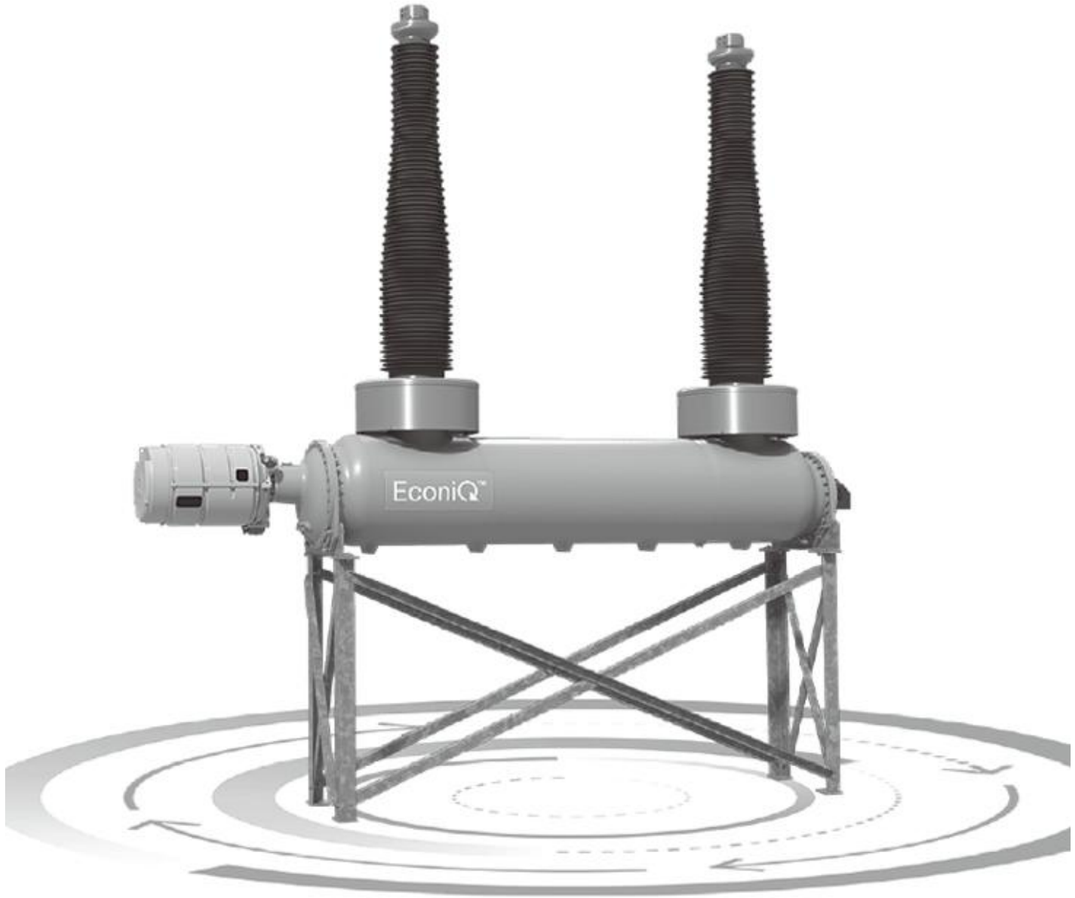
Similarly, vacuum circuit breakers may be getting larger, but the fundamentals of the technology are unchanged.

The question becomes, what do we need to be resilient for?

- climate change?

- technical support?

- market re-design?



Transgrid

Using resilience modelling and analysis, and how best to harness the data

Designing in resilience has a cost.

There is a level of “educated guess” as to what to design for.

Be an early adopter of new technology? Might get you a competitive advantage. Or you could be left with an unsuccessful venture (Betamax versus VHS, or BluRay versus HD-DVD)

Climate change seems reasonable to design for. How much temperature rise? What sort of flooding levels?

The long term loss of technically trained personnel?

Ultimately, it involves a wide ranging discussion, with a view to legal obligations (both local and international), “social license”, as well as engineering considerations.

Transgrid

Employing resilience enhancement and optimisation to safeguard your assets

What is Transgrid doing?

Transgrid is trialing some of the new technology options, so that if / when we are forced to pivot, we've already got some experience – non-SF6 circuit breakers and ester filled transformers being two examples.

New gear

- being fitted for instrumentation, so that retrofits are easy (DGA for example)

- where there's a clear case already, being fitted with instrumentation (SF6 density)

Older gear

Retrofits when the remaining life is estimated as "long" (at least a decade) and reasonably cost effective to do so.

Transgrid

Employing resilience enhancement and optimisation to safeguard your assets

What is Transgrid doing?

For synchronous condensers:

Transgrid has no lived experience.

Transgrid is engaging with the OEMs to have long term service agreements.

Additional condition monitoring equipment, such as partial discharge, flux probes.

Additional cameras, including thermographic, to provide greater capacity to remotely check the plant.

Conclusion

This talk has covered a series of diverse, if related topics.

Other than the control systems, an expert from 1960s could look at modern versions, and see so much that has only had minor refinements.

Resilience comes at a cost, and embedding that resilience in the design is always a compromise.

The history of our equipment continues to inform how it will operate into the future.

There are real opportunities when it comes to drones / robots / remote sensing technology to reduce the need for people to get close to the equipment.

ANY QUESTIONS?

Transgrid