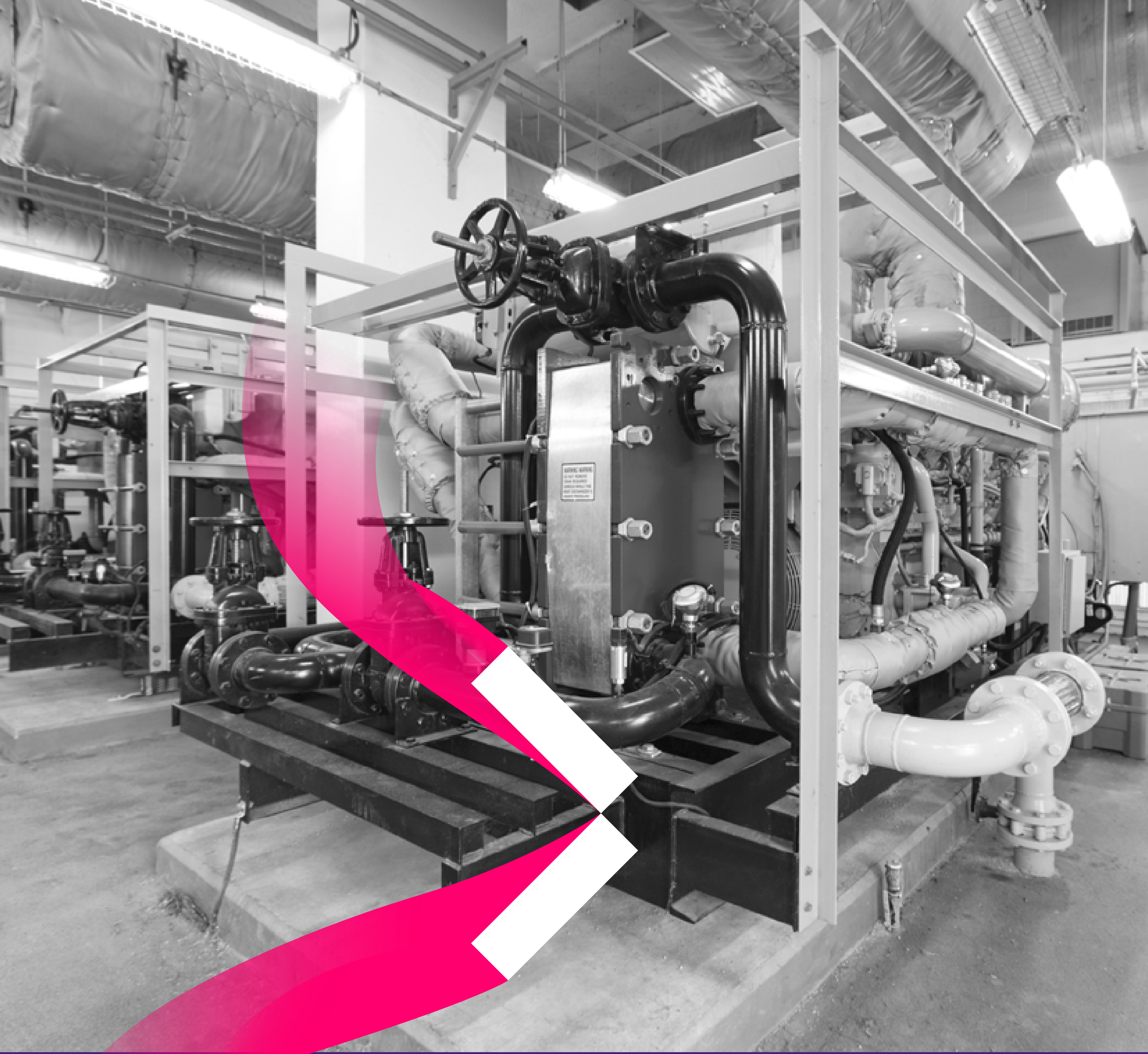


Ensuring continuity of power during emergencies

Elevating your backup generation testing practices to achieve a new standard of preparation

enel x

Contents

Continuity of power is vital

It's not practice that makes perfect; rather, it's perfect practice that makes perfect. It is, after all, the seemingly small disciplines and commitment to high standards that makes us who we are…

General Martin Dempsey, US Army

Continuity of power is vital for almost every business, whether it's a hospital protecting critical, life-saving equipment, a grower or food processor trying to maintain produce at the right temperature, a data centre working to keep banking applications available to customers, or a water utility providing essential community services. In all these cases, loss of power would come at a significant cost. That's why many Australian businesses choose to install a backup generator onsite so that their critical operations can continue as usual if a power outage occurs.

While many businesses do have backup generators, we've found that they're infrequently used. When this is the case, when the generators are called on, they usually trip or fail. It's therefore important to test this backup power infrastructure on a regular basis to ensure it will be ready to respond when needed. Most organisations recognise this need and conduct some form of testing.

However, there are critical shortfalls in common testing practices that leave many organisations exposed to undiagnosed risks that could lead to a system failure during a real power emergency.

This paper outlines a new approach to testing, designed to realistically simulate the conditions of a power emergency, and in doing so, raise your organisation's standard of preparation.

Interestingly, rather than coming at an increased cost, this new testing approach will actually generate a significant new source of revenue for your business.

Regular testing and maintenance is critical

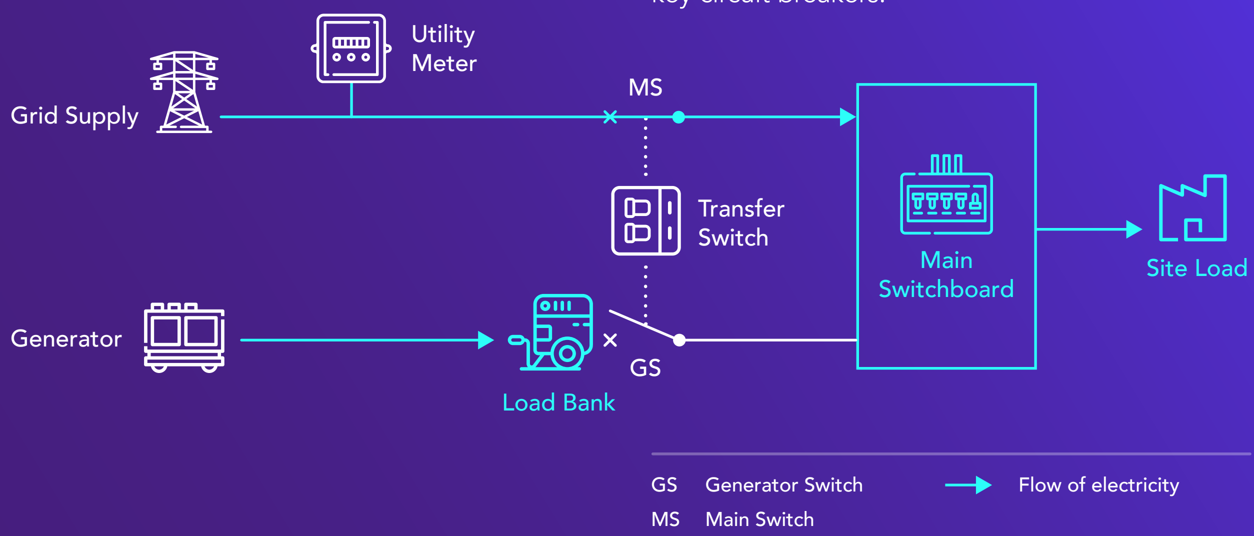
Everyone agrees that it's important to properly test and maintain backup generation infrastructure to ensure it's ready to respond in an emergency situation when there's a failure of grid power. However, common testing practices often fail to fully simulate the response required during a grid power failure.

To transfer to backup systems, many facilities have to experience a 'break to make', meaning they undergo a temporary power outage before the facility is running on its backup power systems. With this in mind, several common practices have been developed to avoid any power outages for essential equipment during backup generation testing. While practical, these approaches each have some potential flaws.

Common practice: Load bank testing

One testing approach is to bring a 'load bank' to the facility. A load bank can be thought of as a large heater that draws and dissipates power from the generator. The backup generator is disconnected from the facility switchboard, connected to the load bank, and run independently from the facility.

This is normally done once per year. This allows the generator to be run at its full power output, which is good for the generator's health. However, since the generator is disconnected from the facility, this fails to test the full sequence of response that the system will need to provide in an emergency. In short, it neglects everything downstream of the load bank connection point, including automated transfer switches and other key circuit breakers.



Common practice: 'Black start' testing

Another common practice is to simulate a power outage and test a site's ability to respond using its backup generation system. This is often viewed as a major inconvenience by businesses due to the outage. Such tests end up being scheduled in the very early hours of the morning or on weekends to reduce impact on normal business operations.

This is normally done once per year. While the practice tests the full sequence of response the system needs to provide in an emergency, it's usually not carried out at ambient conditions and site demand that's representative of a true emergency, which means critical failure risks may be missed during testing.

Recommended generator testing best practice

Both engine manufacturers and generator service companies produce updated guidelines detailing best practice generator maintenance.

We've summarised some of their recommendations below, which we believe are indicative of industry consensus.

Caterpillar

Caterpillar states[1] that a good maintenance and testing program is key to a long generator life. They recommend testing at least once per month, with an operational load check where the generator runs on at least 50% of the site's load for one to two hours.

Power & Drive Solutions

At a minimum, generators should be run every month on the site's load at no less than 50% capacity for one hour. Ideally, it should be done more frequently and as close to the maximum generator capacity as possible, as full-load testing is the best way to identify a potential failure or malfunction during a real emergency.

Overall, regular testing means businesses can optimise their generator's performance and significantly improve its life expectancy. Plus, any unforeseen issues will arise in a controlled testing environment and not when the generator is called on during an emergency.

Managing Director, Power & Drive Solutions

Australian Department of Defence

Generators should be tested once per month with a dummy load bank or the building equipment load. Testing should also include a simulated mains failure at a minimum of once per year. They recommend routine testing at 100% of site load to make sure the generator is able to supply the full load required.

1 Caterpillar, Generator Set Operator & Maintenance Instruction Manual, 2014.

Even well-maintained backup power systems can have problems when called upon

Backup power generation systems are complex. The generator itself has several points of potential failure, for example fuel quality, filters, coolant and batteries. All of these are usually inspected during routine maintenance, monthly or quarterly. In addition, programmable logic controllers, automated transfer switches, ancillary circuit breakers, and alarms among other elements also must operate flawlessly to ensure reliable emergency response.

Given this complexity, coupled with the fact that these systems are very rarely tested under true emergency conditions, it's not surprising that problems often arise when they are called upon during power outages. Here are some instances we've come across during generator testing and power outages.

"

During generator testing, a power outage was simulated at a cold storage facility. When the automated transfer switch (ATS) switched the site over to generator power, and individual loads began to restart, the generator immediately tripped. The compressors initially produced high in-rush currents which exceeded transient generator capacity and led to a trip. In addition, various circuit breakers in the main switchboard failed to engage, which prevented some key loads from automatically restarting.

Cold storage facility

"

A cold storage facility had three backup generators configured to parallel together and generate as a single system. During testing that simulated 'black start' operation, the control logic did not operate correctly. The generators tripped when an end-to-end test was carried out as part of the equipment installation, due to failure of existing generator paralleling logic. If this had happened during an actual blackout and personnel had not been nearby, critical systems would have been without power and could have put stock at risk.

Cold storage facility

"

During testing we discovered that one of our generator's circuit breakers operated intermittently and wouldn't always close. The hospital's supply redundancy could have been compromised if the breaker wouldn't close when our demand was greater than our backup generator's capacity. Once the fault was identified, the 'sticky' breaker was replaced.

Swan Hill Department of Health and Human Services

Moving towards more realism in generator testing practices

Businesses have many responsibilities and competing priorities, and have limited resources they can deploy. As such, testing approaches for backup generation systems need to be practical. Just as there is a limit to how much insurance one is willing to purchase, there is a limit to how much investment can be made into backup power testing.

That said, improved emergency readiness is not about spending more money or testing more often, but it's about ensuring the testing conditions are as realistic as possible.

Training lessons from the military services

When you are testing your backup infrastructure, you are training for an emergency. Arguably, no one has perfected the art of training like our military services.

One of the key principles of military training is that it must be realistic and as close as possible to putting the team in the environment and situations they will face in combat.

Training realism is one of the key measures of military training effectiveness, and it includes:

The task

Does the exercise encompass all actions the team will need to accomplish?

The conditions

Do the circumstances of training simulate actual combat conditions?

The standards

Does training require the right performance (speed, accuracy, etc.)?

These same measures should be used when assessing testing practices for potential power emergencies.

The realism checklist

Drawing an analogy to military training, we have developed a 'realism checklist' that can be used to assess the effectiveness of your testing practices. This was developed through a series of in-depth interviews with leading experts in backup generation testing and maintenance.

The task

Does the testing encompass all actions the backup system will need to take during a power emergency?

- All components of the backup system need to be tested, including fuel, coolant, switchboards, ATS, and so on
- All loads that need to be supported during an emergency need to be transferred to backup power during testing
- When grid power returns and the generator is prompted to ramp down, site load should be transferred successfully back to grid power via switching, and the generator should ramp down with no hiccups.

The conditions

Do the circumstances of testing simulate actual conditions during a power emergency?

- Businesses rarely replicate true emergency conditions when testing their generators
- Emergency conditions often correlate with high ambient temperature and high site electricity demand
- Businesses that run a black start test do so when operational impact is low. This often occurs overnight or during the winter when site demand is also low
- Where load banks are the only form of testing carried out, emergency conditions are not replicated at all.

The standards

Does training require the right performance (speed, accuracy, etc.)?

- When grid power is lost and the generator is prompted to start, it must ramp up at adequate speed
- It must hold voltage and frequency at expected site demand
- It must provide sustained support at high ambient temperatures
- Your staff must be trained to respond to power outages quickly
- It's essential that testing is carried out on a regular basis.

For all backup systems, metrics should be established based on the above characteristics, and system performance against each should be measured during every test. Tests should also be carried out with sufficient regularity, simulating real emergency conditions wherever possible.

> "
> *On 31 January 2020 it was 46 degrees Celsius and our generator was running at a very high temperature. We opened the plant room doors to allow more airflow to cool it down. The site also had to shed some non-essential loads to maintain a safe operating range for the generator. By exercising the generator during this heatwave, when hospital demand was extremely high, and when a grid disruption was most likely, we were able to really test the performance of the generator and its ability to back up the hospital.*
>
> Regional hospital

Virtual power plants: A way to raise your testing game (and your revenue)

We believe that the best way to test your backup generation infrastructure is to conduct a full load transfer at times when the power grid is under stress. While this may seem risky at first glance, it represents the most realistic simulation of a grid emergency, and therefore can provide the truest test of your preparedness for a power outage.

There is a compelling new way to do this – **enrol your backup generator to participate in a virtual power plant (VPP)[2] designed to protect the power grid from outages.** VPPs are large portfolios of distributed energy resources (generators, batteries, industrial equipment) that work together to provide **critical grid response** when large power stations suddenly fail, or when the demand for power on the system is extremely high relative to the available supply from large power stations.

The reality is that if the grid fails, it's probably going to fail on a stinking hot day in summer right when you don't want it to. So, I think it [VPP participation] gives us the strength of conviction to say, "We know that on a bad day, a high load day and a high temperature day, that our generators can do the job.

Enel X VPP client: Echuca Regional Health

How VPPs protect against power outages

Some VPPs are designed to unlock new ways to trade energy and generate economic value. Here, we are speaking specifically about VPPs that support **critical grid response** by protecting the grid against power outages. There are two key ways VPPs protect the grid, and properly configured backup generators can do both.

Frequency control

Large power stations and transmission lines can suddenly fail. The system needs resources that can quickly respond to prevent any cascading failures on the power grid. Today, VPPs provide more than 15% of frequency control reserves.

Critical peaking

A shortage of power supply to meet demand usually occurs on hot summer afternoons when demand is very high, or when significant power station capacity is offline for maintenance. When this occurs, the power market operator issues a 'Lack of Reserves' (LOR) notice[3], and power prices usually spike to very high levels. In our experience, there will be a LOR more than 70%[4] of the times that a well-designed VPP is called upon.

2 Enel X currently operates the largest VPP in Australia (Bloomberg New Energy Finance – December 2019).

3 Australian Energy Market Operator.

4 Based on internal Enel X analysis of the correlation between high wholesale energy prices and LOR notices.

Benefits of VPP participation

1. Robust generator testing

Test your backup infrastructure under the most realistic conditions possible.

2. Advance reaction to grid problems

Know about threats to the grid in real-time, and safely transfer to backup power before any outage occurs.

3. Infrastructure upgrades

Participation can enable upgrades to backup power systems that will improve the reliability of key equipment and reduce the disruption to business when switching to backup power.

4. New revenue

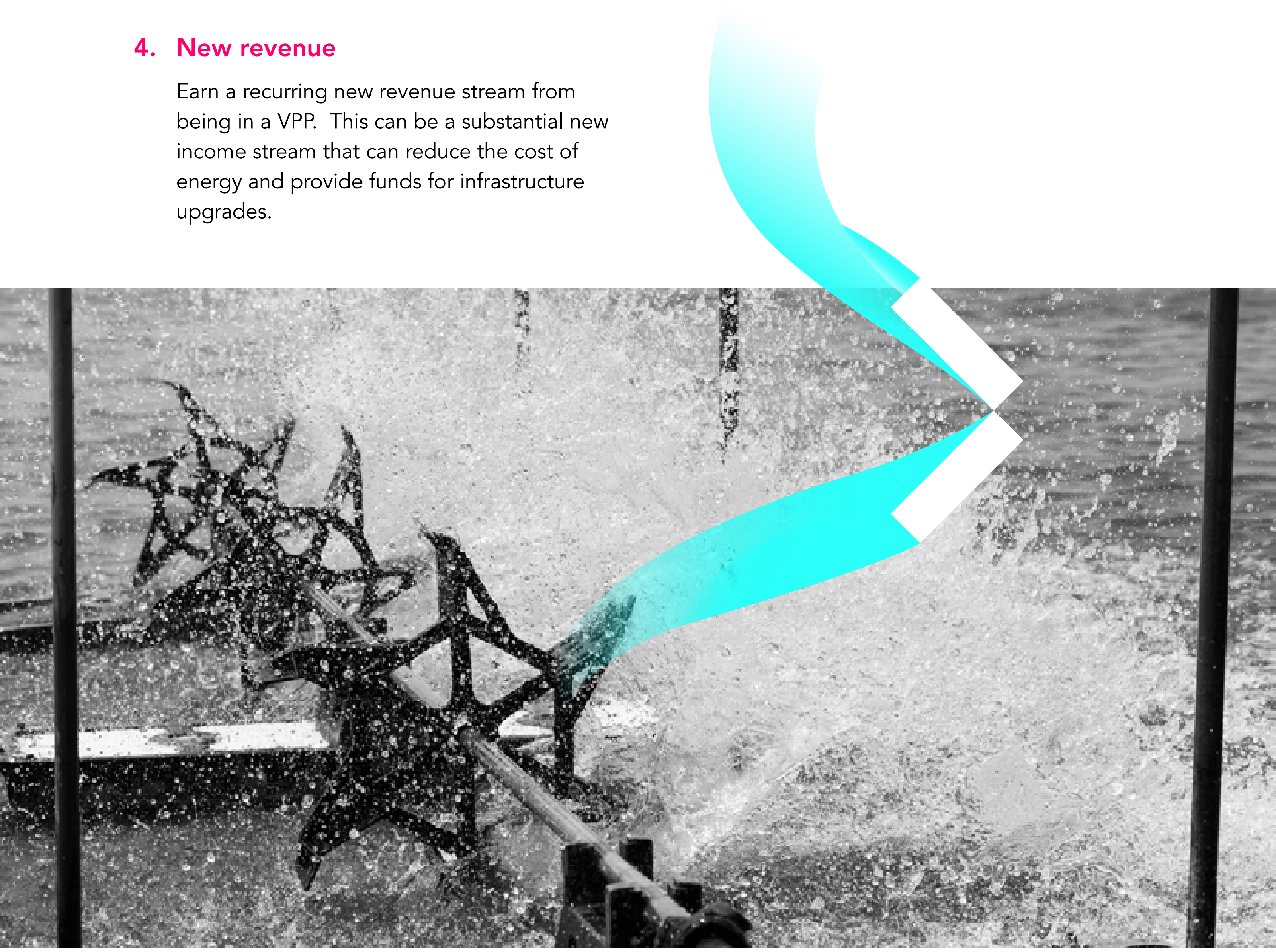
Earn a recurring new revenue stream from being in a VPP. This can be a substantial new income stream that can reduce the cost of energy and provide funds for infrastructure upgrades.

5. Support renewable power

Our transition to renewables requires significant new power capacity that can keep the system in balance as variable wind and solar power grows.

6. Contribute to lower power costs

Backup generators are one of the lowest-cost options for critical new power capacity[5]. By maximising their use in VPPs, we are minimising the need for expensive new investments in utility-scale assets that can drive up the cost of power for everyone.



5 Most VPPs will allow you to remove your backup generation from the VPP when necessary for maintenance or other operational reasons.

VPP-based testing: How it works in practice

A VPP is paid to provide services to the grid for responding quickly and reliably to certain changes in grid conditions. When you join a VPP, your backup generation system will be configured to respond as part of it[6]. This requires a technical integration between the platform and your generator control systems. In most cases, the objective is to connect the VPP to your existing emergency load transfer sequences for switching from grid supply to backup power and back again.

VPP activation sequence

Event start

- VPP called to provide support for a grid event
- VPP hardware sends digital signal to transfer switch, and site personnel are notified
- Transfer switch initiates generator start-up.

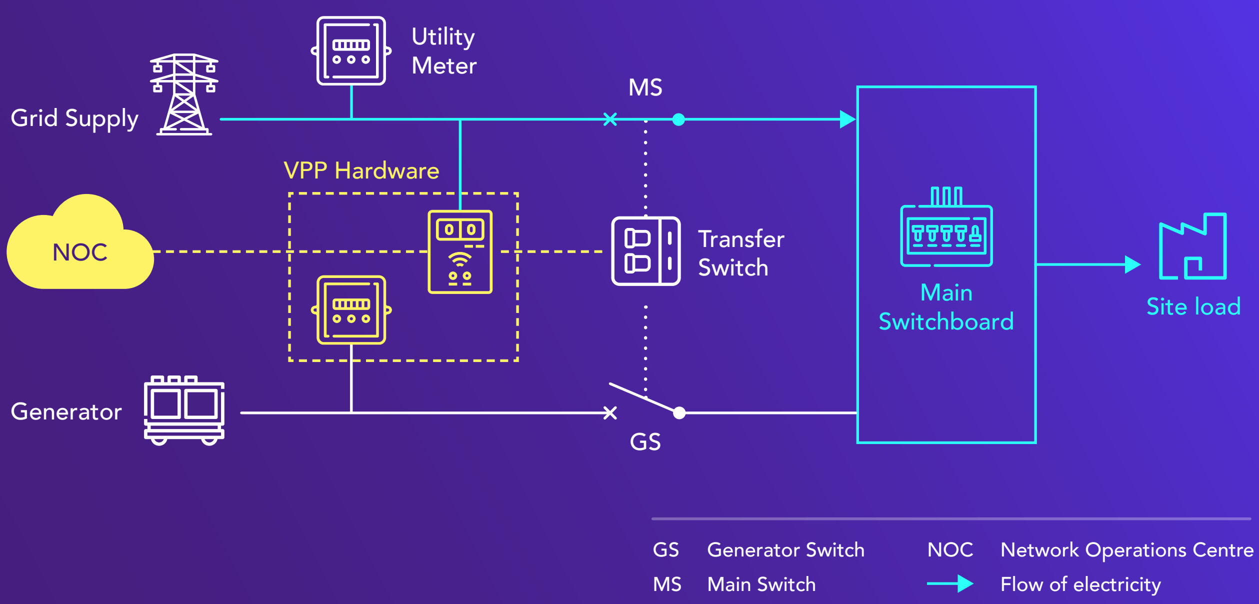
During the event

- Once the generator has ramped up, site load is transferred to generator power for the duration of the event.

Event end

- VPP hardware sends a digital signal to the transfer switch
- Site load is transferred back to grid power (if available) and the generator is ramped down
- If grid power is unavailable, the generator will continue to power the site
- Site personnel are notified that the event has ended.

A site enrolled in a VPP normally consists of the following key components:



6 Most VPPs will allow you to remove your backup generation from the VPP when necessary for maintenance or other operational reasons.

How VPP participation fares on the ‘realism checklist’

We believe VPP participation offers the best opportunity to ensure your emergency preparedness. When measured against other common testing practices, it provides the most realistic testing of backup power infrastructure.

The task

Does the testing encompass all actions the backup system will need to take during a power emergency?	Load bank testing	Black start testing	VPP participation
Entire backup system	×	●	●
Transfers the right loads	×	●	●

The conditions

Do the circumstances of testing simulate actual conditions during a power emergency?	Load bank testing	Black start testing	VPP participation
High site load	×	×	●
Time when grid failures are likely	×	×	●

The standards

Does training require the right performance (speed, accuracy, etc.)?	Load bank testing	Black start testing	VPP participation
Speed of response	×	×	●
Required load supported	×	×	●
Fuel availability	×	●	●
Exhaust ventilation	×	×	●
Staff emergency readiness	×	×	●
Regularity	×	×	●

Emergency load transfer configurations

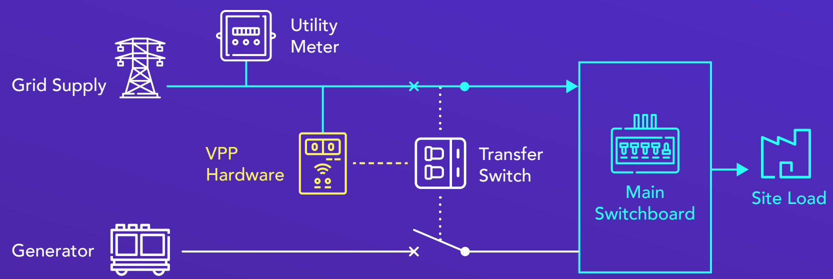
Every facility's backup generation infrastructure has unique characteristics to be considered for VPP participation. However, it's still useful to look at how VPP activation works for several common backup generation configurations.

#1: Break-before-make configuration

In this configuration, the site's grid power switch must first be opened (the 'break') from the grid before the generator supply switch can be closed (the 'make'), following which it can be supplied by the backup generator. This configuration will match the site's operation during a normal power outage, and typically means the site experiences a short power interruption when operated as part of a VPP. If the site has an uninterruptible power supply (UPS), then there will be no power interruption for the loads that it supports.

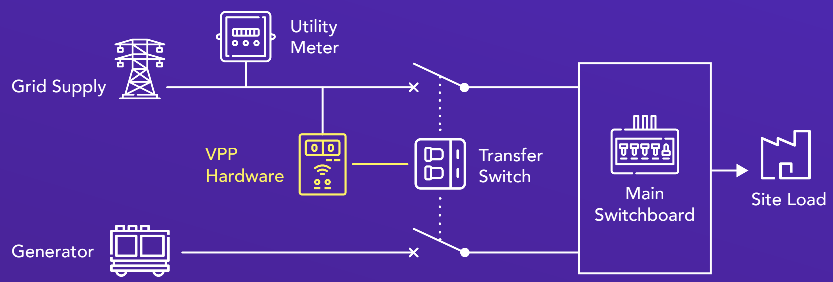
Before transfer

- Grid supplies power to the site
- Generator isolated from the rest of the site



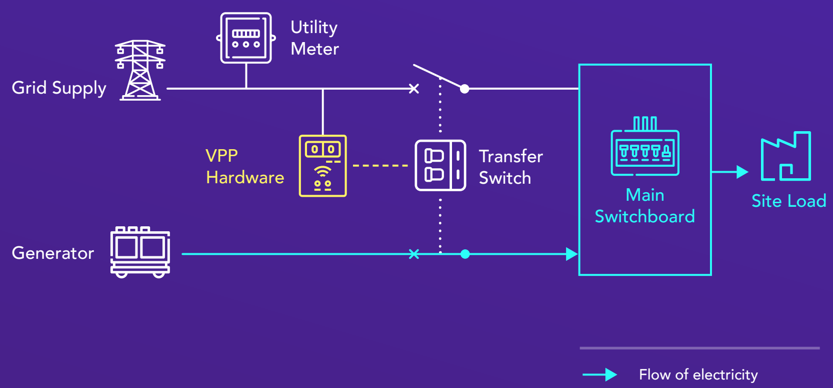
During transfer

- VPP notified to participate
- Generator begins to ramp up
- Transfer switch activated locally
- Main switch opens and site loses power for ~30 seconds
- If the site has UPS, there is no loss of power



After transfer

- Generator supplies power to the site
- The site is isolated from the grid
- The site is now participating as part of the VPP



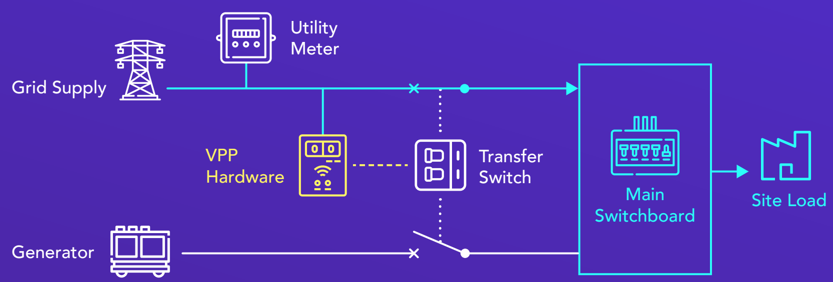
Emergency load transfer configurations

#2: Make-before-break configuration

In this configuration, the backup system is typically a similar size to or larger than the site it supports. It can be configured such that it synchronises with the grid when operated as part of the VPP, takes over power supply to the site, and then allows the site to be isolated from the grid. This is done with the permission of the distributor, and ensures that the site does not experience an interruption throughout the load transfer process.

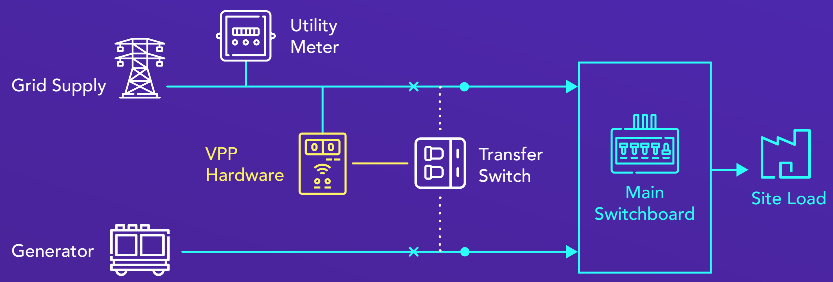
Before transfer

- Grid supplies power to the site
- Generator isolated from the rest of the site



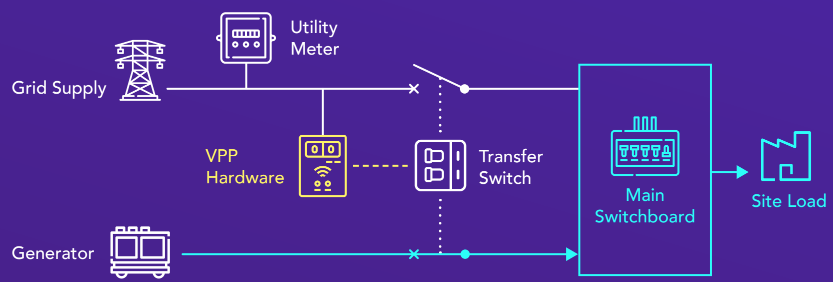
During transfer

- VPP notified to participate
- Generator begins to ramp up
- Transfer switch activated locally
- Main switch and generator switch closed simultaneously for ~1 second
- No loss of power to the site



After transfer

- Generator supplies power to the site
- The site is isolated from the grid
- The site is now participating as part of the VPP



Flow of electricity

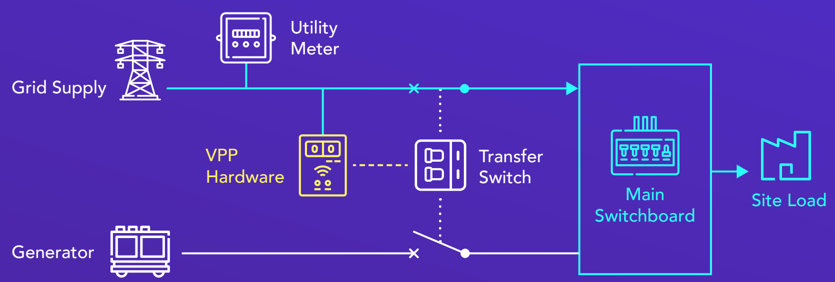
Emergency load transfer configurations

#3: Export configuration

In this configuration, the backup system is typically much larger than the site it supports. It can be configured such that it synchronises with the grid when operated as part of the VPP, takes over power supply to the site, and then exports its surplus capacity back to the grid. This is done with the permission of the distributor, and ensures that the site does not experience an interruption throughout the load transfer process.

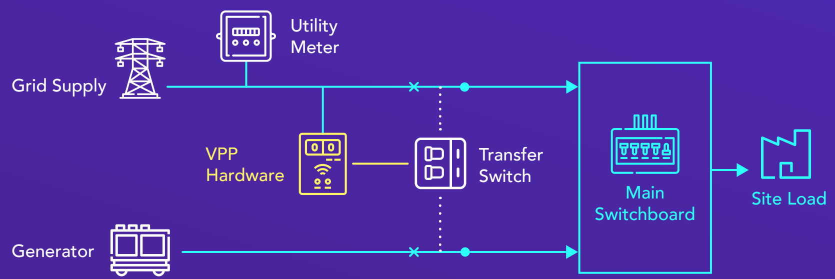
Before transfer

- Grid supplies power to the site
- Generator isolated from the rest of the site



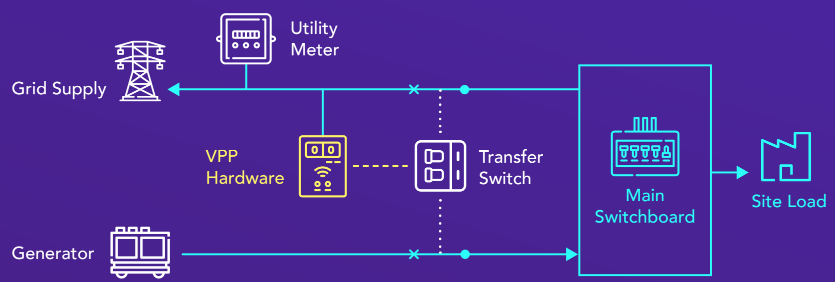
During transfer

- VPP notified to participate
- Generator begins to ramp up
- Transfer switch activated locally
- Main switch and generator switch closed simultaneously
- No loss of power to the site



After transfer

- Generator supplies power to the site
- Surplus power is exported to the grid
- The site is now participating as part of the VPP



Flow of electricity

What joining a VPP can look like for your business

Timeline for participation

Summer is when the grid is under the most stress from extreme weather, potential bushfires and storms. It's the time where the grid needs our help the most, and also the time where you can earn the most money from being in the market.

In general, sites can be VPP-ready within four months of enrolment, allowing for any necessary on-site technical integration. Therefore, the best time to join a VPP is by June, so you are properly configured for summer.

By joining a VPP, you'll ensure best practice testing of your generator set, while supporting the electricity grid and earning a new revenue stream.

Earnings potential

Revenue varies depending on site location and generator size. We've found that businesses with a backup generator of 1000 kVA can earn between $60,000 and $100,000 per year.

For a quick and rough estimate, you can take our generator calculator earnings potential survey here.

Learn more

Enel X operates the largest VPP in Australia. If you would like to learn more about how VPP participation can improve your emergency preparedness while generating new revenue for your business, get in touch with us today at info.enelxanz@enel.com

We would like to thank our partners Decon Technologies and Electro Data and Generation for sharing their industry knowledge and advice on backup generator maintenance best practice. Their insights and recommendations are throughout this whitepaper.

We'd also like to thank our customers Echuca Regional Health and the Swan Hill Department of Health and Human Services for sharing their backup generator and VPP participation experience with us, and readers of this guide.

> "
> *Most hospital sites have generators they have to test, so we might as well get paid for it. It [VPP participation] enhances resilience, and you can use the income from it to improve your systems and equipment to ensure you've got a reliable generation set. The income can help you install automatic switching, upgrade PLCs or increase fuel supply. It's a win-win because the reliability that we can provide to the grid is improved by putting the money into improving our own reliability systems.*
>
> Enel X client: Echuca Regional Health

> "
> *Enabling local businesses to fire up their backup generators and supply the electricity market will add a revenue stream for the businesses and deliver lower prices for everyone else. It is common sense to make use of resources that are currently under-utilised for the benefit of both the owners of the assets and the wider community.*
>
> Enel X Backup Boost Program partner:
> Dan van Holst Pellekaan, Minister for Energy and Mining, SA

About us

We were the pioneer of VPPs and critical grid response in the early 2000s, and are the clear global market leader today.

Our experience in Australia and New Zealand dates back to 2004. Since then, we've been working to break down regulatory and commercial barriers to grow the opportunity for local businesses.

400+ MW VPP
across Australia and New Zealand

6000+ MW VPP
across more than 15,000 clients globally

Unmatched market access
which means you get the most revenue for your VPP enrolment

24-7
trading operations and a software platform that constantly adapts to changes in the market

Corporate strength
and financial backing to fund any necessary upgrades to get you started

Speak to our team

If you have any questions about your generator or enrolling in our VPP, please get in touch.

info.enelxanz@enel.com

enelx.com.au