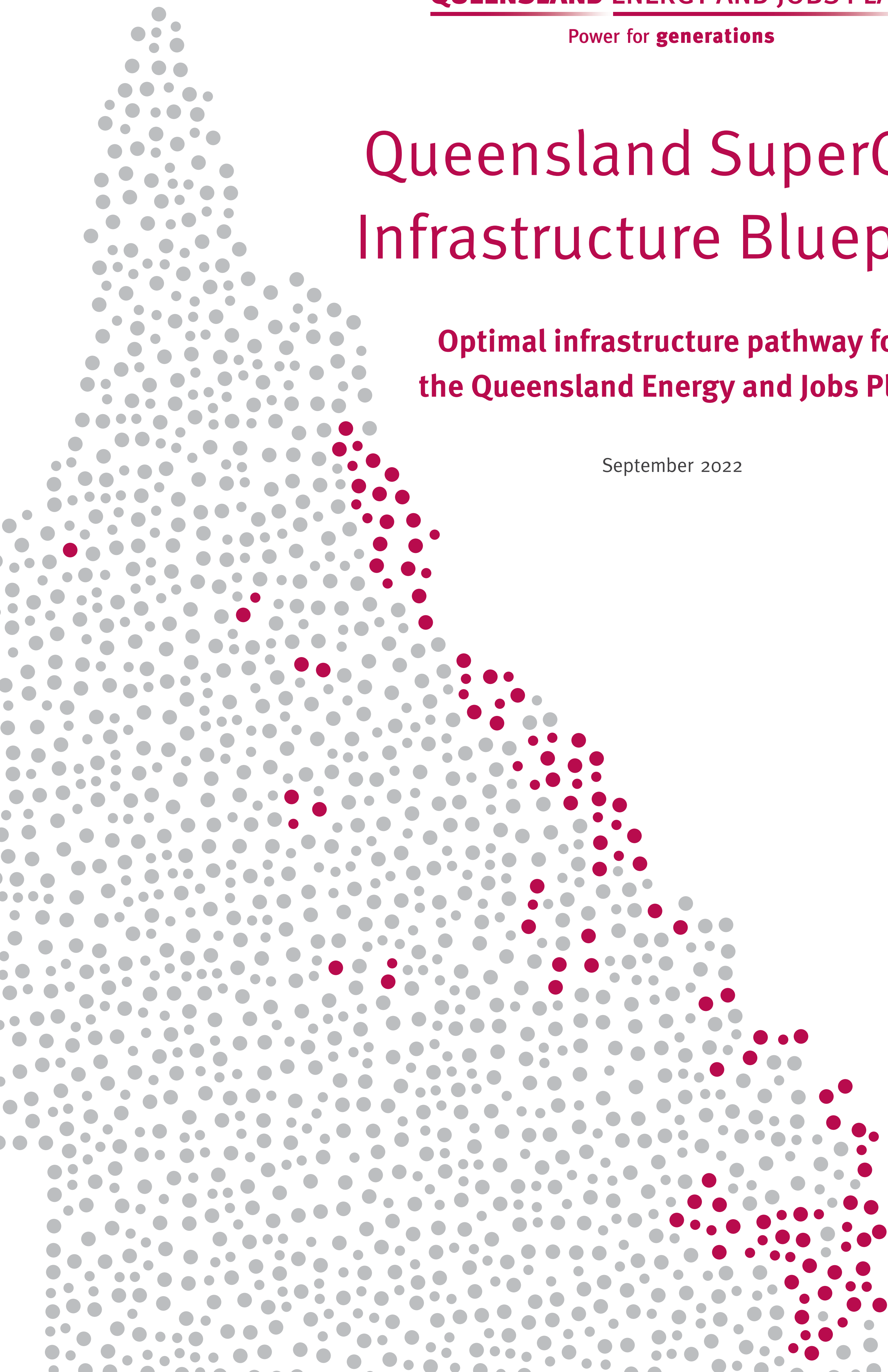
QUEENSLAND ENERGY AND JOBS PLAN
Power for **generations**

Queensland SuperGrid Infrastructure Blueprint

Optimal infrastructure pathway for the Queensland Energy and Jobs Plan

September 2022



Queensland Government

Executive summary

International investors, large industrial customers, small businesses, and households are all seeking access to clean, reliable and affordable electricity. Queensland can deliver this with timely, coordinated investments in renewable generation, storage and transmission infrastructure that transform the electricity system.

The Queensland SuperGrid Infrastructure Blueprint is designed to implement the foundational infrastructure to enable Queensland to decarbonise the existing electricity system and load in Queensland. It acknowledges major new loads are likely to eventuate, which will impact the optimal infrastructure pathway and includes a section on how these new loads and energy requirements can be incorporated into future Infrastructure Blueprints.

This Blueprint outlines the optimal infrastructure pathway to transform Queensland's electricity system. It has been developed based on energy market modelling and expert advice, and follows these principles:

- Achieve the Queensland Government's 50 per cent Queensland Renewable Energy Target by 2030 (QRET) and support continued growth of renewable energy generation.
- Support achievement of the Queensland Government's 30 per cent economy-wide emissions reduction target on 2005 levels by 2030.
- Deliver a reliable, secure system with competitively priced energy.
- Ensure publicly owned coal-fired power stations continue to play a role in the energy system, with sites progressively becoming clean energy hubs that provide critical system strength, storage, and firming services rather than coal-fired generation.
- Provide confidence to capital markets and investors that Queensland has a clear pathway to transform the electricity system.

To transform Queensland's electricity system, investments will be delivered across four key large-scale infrastructure areas:

1. **Renewable investments:** Substantial new renewable generation is critical to transform Queensland's electricity system and deliver affordable, reliable and clean power. Given the variable nature and capacity factors of renewable generation, around 25,000 megawatts (MW) of large-scale renewable generation (total) and around 7,000 MW of new rooftop solar generation is required to meet forecast demand in 2035 (without reliance on coal-fired generation).

   Significant large-scale renewable generation, beyond the 25,000 MW, will be required to support large new loads, including the emergence of an export-scale hydrogen industry or high electrification scenarios.

   Queensland Renewable Energy Zones (QREZ) are a key government lever to support the coordinated, efficient connection of the 25,000 MW of required large-scale renewable generation. Phase 1 developments in all three QREZ regions are underway, and will support the connection of an initial 6,000 MW of renewable capacity. Further developments will occur across all regions to progressively unlock additional capacity.

2. **Storage, firming and dispatchable capacity:** Queensland will need at least 6,000 MW of long duration storage[1] for a highly renewable system, complemented by approximately 3,000 MW of grid-scale storage and up to 3,000 MW of new low-to-zero emission gas-fuelled plant[2] to cover 'dunkelflaute'[3] conditions.

   Large-scale, long duration assets (e.g. pumped hydro energy storage (PHES)) have long planning, construction and delivery times, high development and capital costs, significant approval requirements and uncertainty, and therefore are unlikely to be developed by the private sector on a merchant basis. Such assets are of high strategic importance to the Queensland energy system, through the provision of strategic storage reserves and will support Queensland's macro-economic strategy. The Queensland Government, subject to final investment decisions, will develop and deliver the 2,000 MW/24—hour Borumba PHES in southern Queensland by 2030 and a second PHES in northern Queensland — the Pioneer-Burdekin PHES.

   There are numerous smaller capacity and shorter duration (generally less than 12 hours) pumped hydro projects proposed and being developed by the private sector which are expected to form an important role in firming renewable generation.

3. **Major network transmission and system strength:** Queensland's electricity system will become increasingly decentralised, and the transmission network must evolve to transport renewable energy around the state to when and where it is needed. Four new high-voltage (up to 500kV) backbone transmission projects will be constructed by the mid-2030s, connecting the two 24-hour PHES assets and areas of strong renewable resources with Queensland's demand centres. This includes:

   1. two transmission connections of 80 and 60 kilometres (km) each (140km total) to connect Borumba to the grid in southern Queensland

   2. a 290km line to move more energy between southern and central Queensland

   3. a 750km line to connect central Queensland to a north Queensland 24-hour PHES and north Queensland load

   4. a 370km line to connect Townsville to Hughenden (there is an opportunity to extend this connection to the North West Minerals Province).

[1] Based on independent internal and external assessments, at current consumption levels, at least 6 GW of long duration storage will be required when renewables reach 90-95 per cent market penetration. The independent modelling includes 5.3 GW of new long duration storage by 2032. Long duration storage is considered as having the ability to operate at maximum capacity for a period of 24 hours or longer.

[2] This is in addition to the existing 1745 MW of open cycle gas turbines installed in Queensland as at July 2022.

[3] Dunkelflaute – a word coined in Europe to describe periods of time, usually in winter in which little to no renewable energy generation is possible by wind or solar. Literally – *dark doldrums or dark wind lull.*

These new high-voltage transmission lines will allow the huge volumes of renewable and stored energy to be moved between northern and southern Queensland more efficiently and will ultimately unlock the renewable energy resources at Hughenden. The optimal transmission staging and delivery timing, for lowest cost outcomes, is linked to PHES delivery.

There is also the growing role of distributed and customer energy resources in the electricity system, led by consumers installing more solar on their rooftops, growing interest in home battery systems and the uptake of electric vehicles. To obtain the best value from these customer energy resources, changes are also needed at the distribution network level.

4. **Clean energy hubs:** Coal-fired power stations provide critical dispatchable power and system services, keeping the state's energy system reliable and secure. In the future, renewable energy generators, PHES, batteries and low emissions gas-fuelled plant will collectively provide the dispatchable capacity currently provided by coal. The Queensland Government will invest to repurpose publicly owned coal-fired power stations into clean energy hubs, capitalising on their skilled workforces, strong network connections and existing infrastructure. This reinvestment and repurposing of coal-fired power stations will occur in a coordinated manner, ensuring energy security for all Queenslanders.

Government investments will fund new technology and the conversion of existing assets to provide critical storage, firming and system strength services to support the increasing amounts of renewable generation in the Queensland system. Investment has already commenced, with grid-scale battery projects approved for installation at multiple power station sites. To avoid the possibility of energy security risks, initial generator conversions will be reversible, and units will only be converted to synchronous condensers once sufficient replacement renewable generation, storage, and transmission is in place to ensure ongoing reliability in the system.

Managing risks and uncertainty

Queensland's energy system is rapidly transforming, and the optimal pathway outlined in this Blueprint will need to adapt and evolve over time to address changes in the market outlook, emerging risks and new opportunities. Each of the infrastructure investments identified and proposed in this Blueprint will be subject to contemporary assessment along the transformation program, and this may result in the adjustment of scope or timing of existing investments and potentially the incorporation of new infrastructure investments.

To manage the uncertainty in the outlook, and to address emerging risks and opportunities, the Blueprint will be updated on a biennial basis. Appropriate governance arrangements will also be implemented (as detailed in the Queensland Energy and Jobs Plan).

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Introduction

Purpose

This document (the Blueprint) is a key supporting document for the Queensland Energy and Jobs Plan (the Plan). It is a technical document that outlines the major electricity infrastructure investments required to transform the system – investments to achieve the Queensland Government's 50 per cent Queensland Renewable Energy Target (QRET), support emissions reduction outcomes, and support continued renewable energy growth, while maintaining an affordable, reliable electricity supply. The investments outlined in this document will build Queensland's SuperGrid.

The Blueprint:

- describes the Queensland context and development of the optimal infrastructure pathway
- describes the optimal infrastructure pathway to transform Queensland's electricity system, based on a least cost approach
- describes the options and considerations for increased load development

This Blueprint is a point-in-time document and updates will occur on a biennial basis to reflect new infrastructure investments, changing market conditions and the market outlook, with the first update released in 2025.

The Blueprint is predominantly designed to implement the foundational infrastructure to enable Queensland to decarbonise the existing system and load in Queensland. It acknowledges major new loads are likely to eventuate, which will impact the optimal infrastructure pathway – these changes are contemplated in the 'Increased load development' section.

This document does not outline the investments and policies required in the distribution network to support greater coordination and integration of customer energy resources and devices.

While social, environmental and community impacts have informed and will continue to inform Queensland Government planning, the Blueprint itself is not intended to comment on these aspects.

While social, environmental and community impacts are not addressed in the Blueprint, small-scale infrastructure and demand side measures do contribute to a decarbonised energy system and form an integral part of the broader Plan.

Objectives

The optimal infrastructure pathway has been developed based on energy market modelling and expert advice and is structured to achieve the following objectives:

- Achieve the Queensland Government's 50 per cent Queensland Renewable Energy Target by 2030 (QRET) and support continued growth of renewable energy generation.
- Support achievement of the Queensland Government's 30 per cent economy-wide emissions reduction target on 2005 levels by 2030.
- Deliver a reliable, secure system with competitively priced energy.
- Ensure publicly owned coal-fired power stations continue to play a role in the energy system, with sites progressively becoming clean energy hubs that provide critical system strength, storage, and firming services rather than coal-fired generation.
- Provide confidence to capital markets and investors that Queensland has a clear pathway to transform the electricity system.

Methodology

The Queensland Government commissioned energy market modelling to understand the optimal pathway to decarbonise Queensland's electricity system. This modelling is based on the Australian Energy Market Operator's (AEMO) *Step Change* demand forecast for 2022 which sees demand increasing over the next 10-year window.

Refinements to the modelled infrastructure pathway have been made based on operational and technical input and advice from experts to form an optimal infrastructure pathway.

Specifically, this Blueprint has been prepared to meet the objectives listed above, using the following inputs:

- Energy market modelling to identify the generation and storage capacity needed to decarbonise the electricity system (independent market and economic modelling).
- Analysis from Powerlink and the Department of Energy and Public Works (EPW) on the scope, size, timing, and cost of delivering the PHES projects.
- Analysis from Aurecon on the feasibility of converting coal-fired power stations to synchronous condensers (Aurecon: Synchronous Condenser Conversions of Coal Fired Units, February 2022).
- Analysis from Powerlink and the EPW on the location, sizing, and timing of QREZs.
- Analysis from Powerlink on the future transmission investments required to support the energy transformation, including connecting potential new generation, storage, and firming assets.
- Information gathered from relevant technical experts.

The Blueprint is flexible and proposed mechanisms have been built in to allow for regular updating and oversight to adapt to changes in both supply and demand for electricity over time.

Context

Queensland's electricity system

Queensland's electricity system has historically consisted of mainly 'dispatchable generation'. Dispatchable generation is generation that can be scheduled on or off and increased or decreased on command to ensure supply always meets demand. It includes coal-fired generators, gas turbines and hydro-electric plants. In Queensland, there is around 8,100 MW of coal-fired generation and approximately 3,000 MW of gas-fired generation. In 2021–22, the grid-supplied maximum demand (as generated)[4] was 10,100 MW.

Figure 1 depicts Queensland's coal-fired and gas-fired generators, which have been predominately located near the resource basins (i.e. coal-fired generators (maroon icons) located near the coal fields and gas-fired generators (grey icons) located on gas fields).

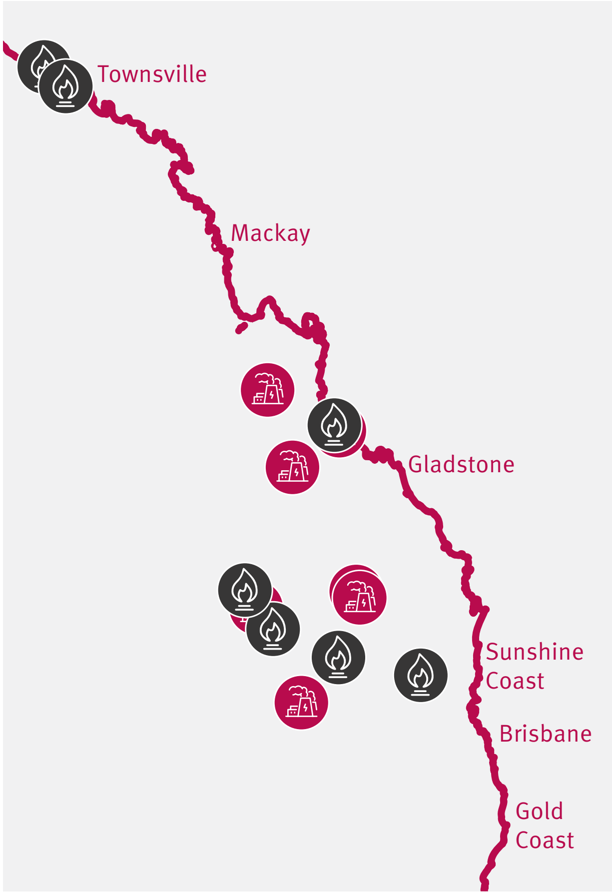


Figure 1: Queensland's coal-fired and gas-fired generators

With substantial dispatchable generation, there has been limited need for storage in Queensland. Energy can be stored in the coal stockpiles and gas pipelines. The energy system is now evolving. There is increasing amounts of variable renewable energy generation which must be complemented with storage and firming to ensure that increasingly intermittent supply matches demand. Additionally power system demand is forecast to increase significantly due to electrification, including electric vehicles and growth in domestic and export hydrogen.

[4] 'as generated' is the energy output at the individual generator terminals. It does not include internal consumption, demand that is offset by rooftop solar or transmission losses.

Increasing renewable generation

Renewable generation is variable in nature – it is entirely dependent on the weather to operate and is volatile on a day-to-day basis. Figure 2 shows the normalised annual output profile of large-scale wind and solar generation in Queensland. It is much more volatile on a day-to-day basis (Figure 3).

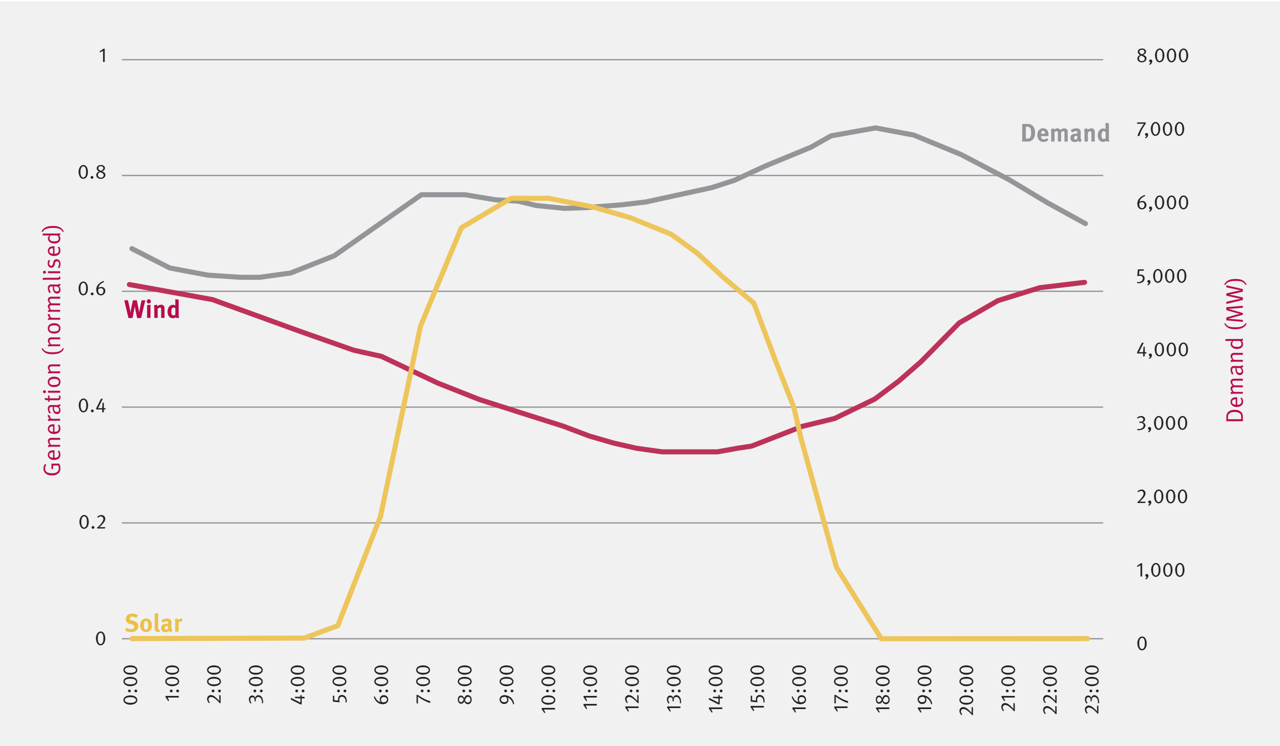


Figure 2: The normalised annual output profile of large-scale wind and solar generation in Queensland. Wind generation peaks overnight and solar generation peaks in the mid-morning, both outside times of peak Queensland electricity demand.

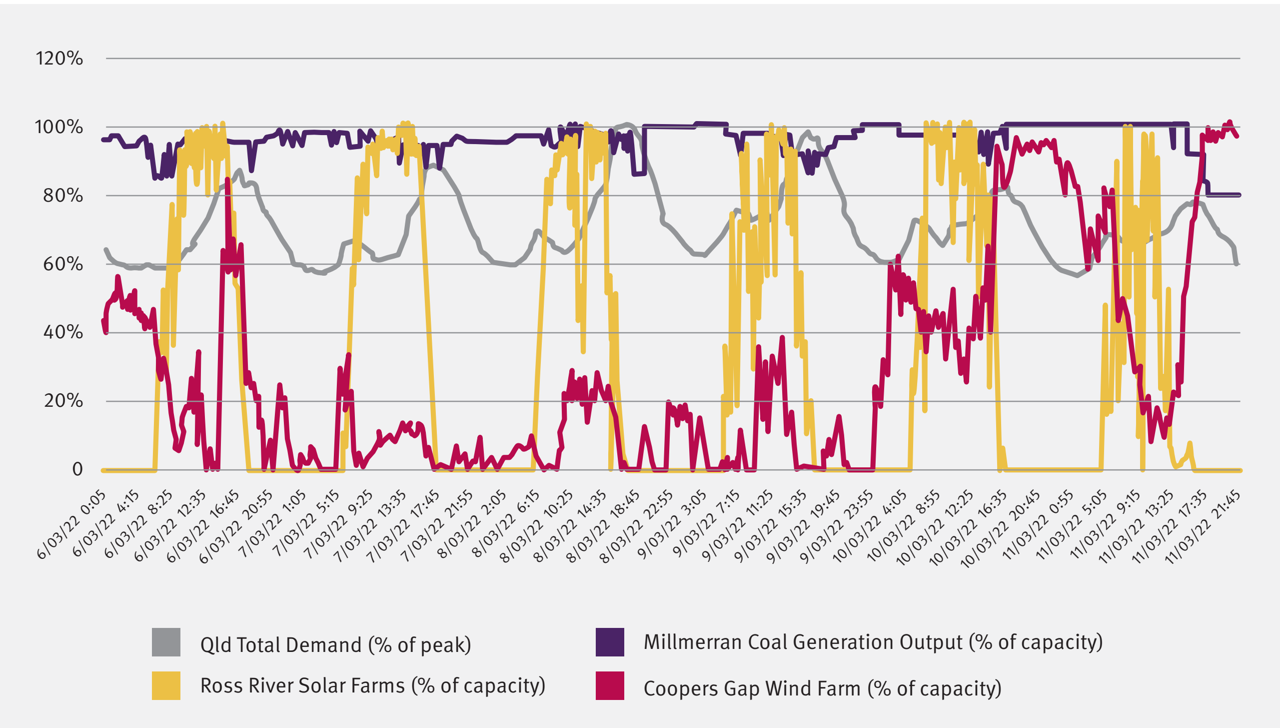


Figure 3: The historical output of different energy sources during a high demand week (the actual output from representative generators). This demonstrates the day-to-day volatility of renewable generation.

Renewable generation characteristics

The characteristics of renewable generation will influence the design and operation of Queensland's future clean energy system.

1. Solar generators only export power when the sun is shining, and the amount of generation varies considerably based on the season. Generally, large-scale solar generators have a maximum potential annual capacity factor[5] of around 25 to 33 per cent. This means large-scale solar generators are, on average, producing around 25 to 33 per cent of their nominal capacity. Further, solar output in Queensland does not typically coincide with peak demand which is usually between 6pm and 7pm after the sun has gone down[6]. Solar output can also be below 10 per cent (e.g. due to widespread cloud) for extended periods, as occurred in Queensland in early 2022.

2. Wind has higher annual capacity factors than solar (i.e. 32 to 53 per cent depending on the location) and, in Queensland, has a more nocturnal characteristic output profile (windier at night than day). This means wind sometimes contributes to peak capacity but, as shown in Figure 3, is still variable. As with solar generation, wind output can be close to zero for extended periods in some weather conditions (e.g. heatwaves).

Extended periods of extremely low wind and solar output are infrequent, but not rare. The term 'dunkelflaute' translates to *dark doldrums or dark wind lull* and is used in Germany to describe multi-day periods of very little wind and solar generation. In Australia, this same phenomenon is often referred to as a *renewable drought*. Regardless of the terminology used, it is important that any renewables-based system has a way to deal with these periods.

To meet Queensland's current maximum demand of around 10,100 MW, Queensland will need a substantial amount of installed renewable generation capacity (much more than if this demand was met from dispatchable generation capacity). With a combined average capacity factor of 33 per cent for wind and solar, Queensland would need a minimum of 24,000 MW of variable renewable generation to supply the equivalent energy of the current 8,000 MW of coal-fired capacity. This factor of three is a minimum or 'best case'. It assumes that Queensland will store all the variable renewable generation produced and use it exactly when needed. In practice, some over-build of renewable capacity will be required, resulting in a level of 'energy spill' from time to time.

[5] Capacity factor is the ratio of actual output over a given period of time to the maximum potential output over that period.

[6] The peak demand period has shifted from the middle of the day to early evening, which has been driven by the uptake of rooftop solar.

Firming and storage

As renewable energy is variable in nature, it needs to be 'firmed' and this means it must be stored when available and discharged when it is needed. The concept of 'firming' means matching the variable output of renewable generators to instantaneous demand. This can occur via battery storage systems and fast start dispatchable generation that can be 'switched on' as required to meet demand. Deep or long duration storage that effectively holds large amounts of energy in reserve for use during extended periods of low or no wind and solar generation is also required in a renewables-based system.

Firming and storage can take several forms:

- **Intra-day storage** – Batteries are ideal for providing intra-day storage. They can absorb 'excess'[7] solar energy from the grid throughout the day, store it, and discharge it later to meet demand. The time between storage and discharge could be minutes or even hours. Battery technology is most competitive in the one-to-four hour duration range. Medium duration PHES assets (4–12 hours duration) are also competitive in this intra-day space and are currently being developed by multiple private sector proponents in Queensland.
- **Long duration storage** – Long duration PHES (typically 24 hours or longer), coordinated batteries or multiple medium duration storage facilities (4 to 12 hours duration), provide this type of long duration storage. Long duration storage stores energy while renewable generation is plentiful and discharges it when there is insufficient instantaneous generation to meet demand – this may be for several days during wind and solar drought conditions. Long duration storage can also provide intra-day storage benefits, plus the ability to manage short-term low renewable generation such as rainy days or periods of windless nights, along with the ability to contribute to managing extended renewable droughts.
- **Dispatchable and peaking generation** – this refers to types of generation that can be quickly switched on to provide firming or backup capacity to support variable renewable generation. Gas-fuelled generators provide dispatchable generation as they can generate at peak periods or during extended renewable generation drought conditions. Gas-fuelled generators can start up and respond far more rapidly than coal-fired power stations. They can also run longer – indefinitely as long as there is a gas supply – and are lower in capital cost to build and maintain than PHES assets.

  Gas-fuelled generators, such as open cycle gas turbines and gas-fuelled reciprocating engines have comparatively high marginal running costs, but the cost of installed capacity is low. They currently represent the lowest capital cost per megawatt way to provide backup and peaking generation[8] to a renewables-based system[9].

  In the future, Queensland may convert existing turbines and install new gas turbines that can be fuelled by renewable hydrogen or a renewable hydrogen blend, further reducing emissions.
- **Transmission interconnection** – large capacity transmission interconnection to other states can provide supplementary firming capacity. This interconnection capacity can transfer generation from other states that is either dispatchable or has diverse weather characteristics compared to Queensland's renewable generation.

Based on current demand forecasts[10] and energy market modelling, Queensland is expected to need at least 6,000 MW of long duration storage for a highly renewable system, complemented by up to 3,000 MW of grid-scale storage, and up to 3,000 MW of new low-to-zero emission gas-fuelled generation and the existing interconnection to New South Wales to meet demand.

[7] 'excess' is a colloquial term for energy that would otherwise be constrained off or spilled.

[8] Peaking generation refers to the 'last' megawatt required to meet demand at any point in time. At times of very high demand, this is usually met by the highest operating cost generator.

[9] CSIRO Gencost 2021-22 Final Report.

[10] The Australian Energy Market Operator's *Step Change* demand assumptions in the 2022 Draft Integrated System Plan.

Applications of storage

Different energy storage technologies provide different market services.

- **Short (or shallow) duration storage** includes grid-connected energy storage with durations less than four hours. The value of this category of storage is more for capacity, fast ramping, and frequency control ancillary services (FCAS) than for its energy value.

- **Medium duration storage** includes energy storage with durations between four and 12 hours (inclusive). In addition to providing many of the same services as short duration storage, medium duration storage provides additional value in its intra-day energy shifting capabilities, driven by the daily shape of energy consumption by consumers, and the diurnal solar generation pattern.

- **Long duration (or deep) storage** includes energy storage with durations typically of 24 hours or more. In addition to the services provided by medium duration storage, long duration storage is able to manage short term periods of low renewable generation, such as rainy day or windless night, contribute to meeting demand in renewable droughts and provides smoothing of energy over weeks or months.

PHES assets provide inertia and other services that support power system security and are 'dispatchable' plants that can switch on as required.

PHES sites in Queensland

The Queensland Government investigations into suitable PHES sites identified potential medium duration and long duration storage sites. This is based on:

- medium duration sites typically having energy storage of 4-12 hours, with capacity ranging from 300 to 1,000 MW or more
- long duration sites assessed having generation capacity of more than 1,000 MW and storage duration of at least 24 hours.

There are also other projects in between these typical sizes, and all these projects could perform an important role in the broader storage requirements for Queensland.

Medium duration sites can provide several services to the electricity system including the 'time shifting' of energy daily and the provision of system strength and reliability services. The shorter storage duration (typically 4-12 hours at maximum generation capacity) means these sites are generally not able to provide significant capacity in the event of regular shortfalls in variable renewable generation, including renewable energy droughts.

Medium duration sites are of the size considered to be commercially viable by the private sector and developers have proposed several projects of this size in Queensland. These projects typically rely on selling electricity to the grid as an arbitrage product and as such provide a more limited replacement of dispatchable, baseload generation to support high volumes of renewable output.

Long duration sites can provide the system services offered by medium sized projects, but their longer storage duration (24 hours compared to 4-12 hours typical of medium-sized projects) means they also provide strategic storage reserves to the system. These projects have long lead times (8 to 10 years), greater approval complexity and uncertainty, and a high development and capital cost. This means they are unlikely to be developed by the private sector in the medium-term on a merchant/commercial basis.

The Queensland Government has assessed numerous sites as being suitable for PHES in Queensland. A PHES needs a source of water, and two reservoirs separated by a significant change in elevation (known as head). A larger head will generally provide for lower cost electricity generation and storage on a per-unit basis as the volume of water required per megawatt hour is lower. Another important requirement is for the tunnel or pipeline (penstock) connecting the upper and lower reservoir to be short and steep for a given head difference. The preference is for a horizontal distance (length) to head ratio of less than 10 to minimise costs.[11] Given the larger amount of energy stored, the cost of the dams required to store water is a more important consideration for long duration PHES than medium duration PHES.

[11] Noting Borumba PHES has a length to head ratio of 8.8 (2,900m horizontal separation, 330m head)

How does Pumped Hydro work?

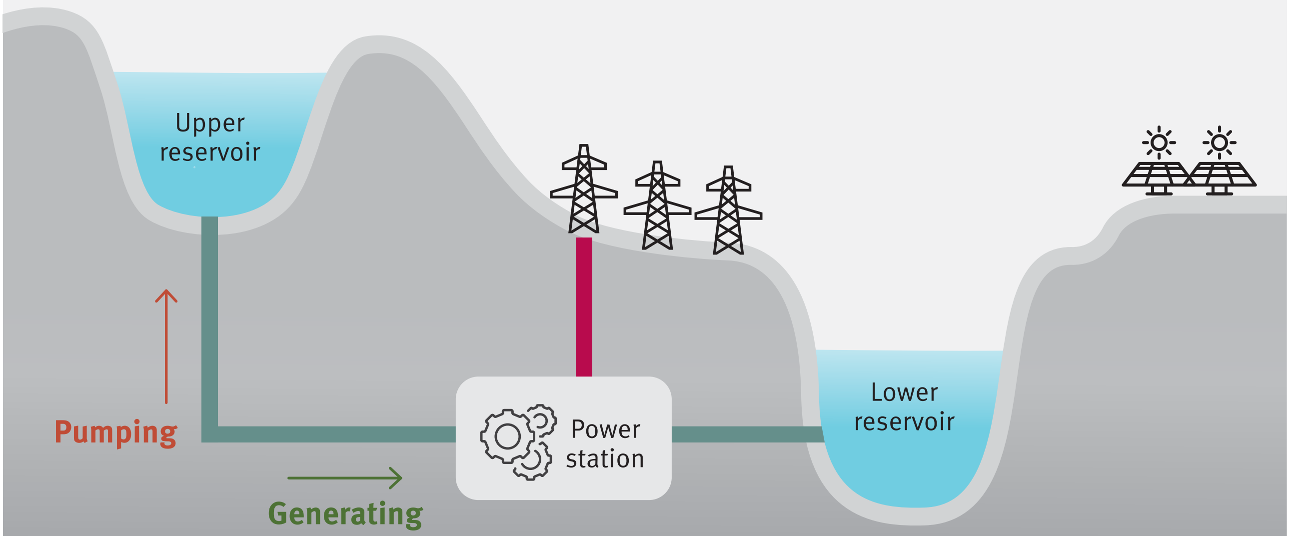
Pumped hydro acts like a giant battery.

- it uses electricity from the grid or nearby renewables to pump water from a lower reservoir into an upper reservoir when energy prices are low
- when energy is needed, water is released from the upper reservoir into the lower reservoir, generating energy as it passes through a turbine
- hydroelectricity can be generated almost immediately and at any time, so power can be fed into the grid when it is needed.

Drives reliable power for a clean energy economy

Stores renewable energy like solar and wind

Provides on demand power when we need it



Two sites in Queensland

- Borumba close to both central and southern Queensland
- Pioneer-Burdekin the battery of the north – the largest in the world

Figure 4: Diagrammatic representation of a PHES plant.

The Queensland Government has undertaken three stages of studies into potential opportunities for hydroelectric and PHES systems in Queensland. Stages 1 and 2 of the studies (delivered in 2016 and 2017 respectively) assessed the role of hydroelectric generation and PHES in the transformation of Queensland's electricity system, possible sites for both hydroelectric and PHES, and identified candidate sites for further study. Stage 3 of the studies concentrated on assessing the role of large-scale, long duration PHES – typically at least 1,000 MW of generation capacity with 24 hours storage duration.

The Queensland Government analysis used data from a range of sources including the 1,770 sites in the Australian National University (ANU) and Australian Renewable Energy Agency's (ARENA) Project – An Atlas of Pumped Hydro Energy Storage. The Queensland Government undertook a risk-based, multi-criteria assessment to identify the best PHES sites at the lowest cost, and least impact when considering:

- topology/cost – to minimise construction costs a preference for higher head sites, with short horizontal distance between reservoirs and favourable topography that support smaller dams
- capacity and storage duration – a preference for larger capacity, longer duration sites based on identified system needs and the potential to achieve economies of scale
- distance to major load centres, connection, and transmission network strength – large distances and weak networks can result in higher network augmentation costs
- environment – primarily relates to inundation of land within the reservoirs. A preference for sites that minimise such impacts, especially to environmentally sensitive areas (e.g. national parks, World Heritage areas)
- community impacts – the infrastructure needs to meet the broader community expectations in respect to impact on the natural and built environment, and human amenity
- geology – highly variable geology with faulting, igneous rock overlays and mineralisation present risks to tunnelling, and higher cost to build
- hydrology – poor hydrology can cause limitations and additional costs associated with the initial fill of the reservoir, ongoing operations, and design for floods

Native title holders were also identified and considered as part of the studies of potential PHES sites.

Based on these assessments, the Queensland Government identified the Borumba and Pioneer-Burdekin PHES sites as favourable sites.[12] These selected sites offer favourable technical and cost characteristics. Final investment decisions are yet to be made on any of the sites, however PHES is recognised as a critical asset for the transformation.

Engagement with First Nations people will occur as part of any work on identified PHES sites.

[12] Both of these sites and projects are subject to subsequent final investment decisions.

Development of renewable generation

The Queensland Government has established three QREZ regions – Northern, Central and Southern. QREZ development is based on important infrastructure cost minimisation and competitive benefit drivers and is critical to delivering a least cost transformation of Queensland's electricity system. Unlocking QREZ regions will include community engagement and input into the longer-term development pathways for these regions. Broad community engagement will be undertaken in line with release of the Plan and this Blueprint.

Key drivers for QREZ developments:

- Developing 'declared REZs' within the QREZ regions in areas of good quality, concentrated renewable resources that have transmission access (i.e. efficient use and connection of renewable resources). This will ensure the development of Queensland's optimally located renewable resources is efficiently aggregated to lower total system cost, benefiting consumers.
- Constructing efficient transmission infrastructure to connect renewable generators, with the objective of high utilisation of the transmission assets' capacity – this will keep the unit costs of connection as low as possible for renewable proponents. This benefit should then flow on to consumers.
- Connecting renewable generators into parts of the transmission system that have adequate transfer capacity so the generators should have acceptable transmission network related constraints. This will assist in ensuring that the renewable generation is as efficient and as low cost as possible.
- Developing connection and access processes that provide accelerated timeframes for connection of proponents. This concept will be finalised in 2023 and may provide Queensland with a competitive advantage compared to other states by delivering fast access to markets for proponents.

Integration of renewables, firming and storage

Queensland's renewable generation and dispatchable capacity will be located across the state and transported (at times long distances) to meet demand.

Queensland has an expansive existing 275kV transmission network incrementally developed to connect large generators – predominantly coal-fired power stations – to the load centres across the state. For a reliable future clean energy system, the existing 275kV system will be reinforced with new high-voltage Alternating Current (AC) transmission (up to 500kV). An alternative option, of reinforcing the network with a High Voltage Direct Current (HVDC) system, was also considered. While such a system may be used in the future, the high-voltage AC system proposed is a lot more flexible, with much lower costs for intermediate substations compared to HVDC and is better aligned to the immediate technical needs of the transmission system. The three key factors that necessitate a higher voltage system are:

1. **Power transfer capacity** – when renewable generation is at high levels, large amounts of power needs to be transported to load centres in south east Queensland, central and north Queensland, plus the Borumba and Pioneer-Burdekin PHES sites. Similarly, when renewable generation is at low levels, the PHES installations will be required to meet much of the demand resulting in large amounts of power being transferred to the load centres. Peak transfer amounts could be thousands of megawatts. Transfers of this magnitude, for example from the Pioneer-Burdekin PHES to large load centres in central and southern Queensland, would be difficult to achieve with a 275kV system due to inadequate capacity in the existing lines and the high energy losses incurred over this distance at this voltage.
2. **Line losses, costs and corridor acquisition issues** – a 500kV line has around three times the power capacity of a 275kV line and around one third of the losses, delivering a lower-cost solution over the long run. While a 500kV line has a higher capital cost than 275kV (around twice the cost per km), the use of a major double circuit 500kV line from northern Queensland to southern Queensland will enable high power transfers with a reasonable levels of losses.
3. **Re-use of 275kV system** – the existing 275kV network will continue to operate once the new high-voltage system is built and will support the new high-voltage backbone transmission in operation. In the early construction phases of the high-voltage network, the 275kV network will be important for enhancing overall system security and reliability outcomes, subsequently being leveraged to deliver renewable energy to PHES sites and load centres.

Customer energy resources

The Blueprint assumes a level of customer energy resource (CER) co-ordination across the distribution network, consistent with the approach adopted by AEMO in preparing the Integrated System Plan (ISP), and commitments made under the Plan for a smarter distribution grid.

Nevertheless, the scale of investment led by households and businesses across Queensland is significant. More than 4,100 MW of rooftop solar has been installed to date with an additional 7,400 MW of solar, 5,800 MW of distributed batteries and 1.6 million electric and plug-in hybrid vehicles forecast by 2035[13]. The energy generated by rooftop solar alone is expected to be more than sufficient to cover the charging requirements of electric vehicles and domestic battery systems (Figure 5).

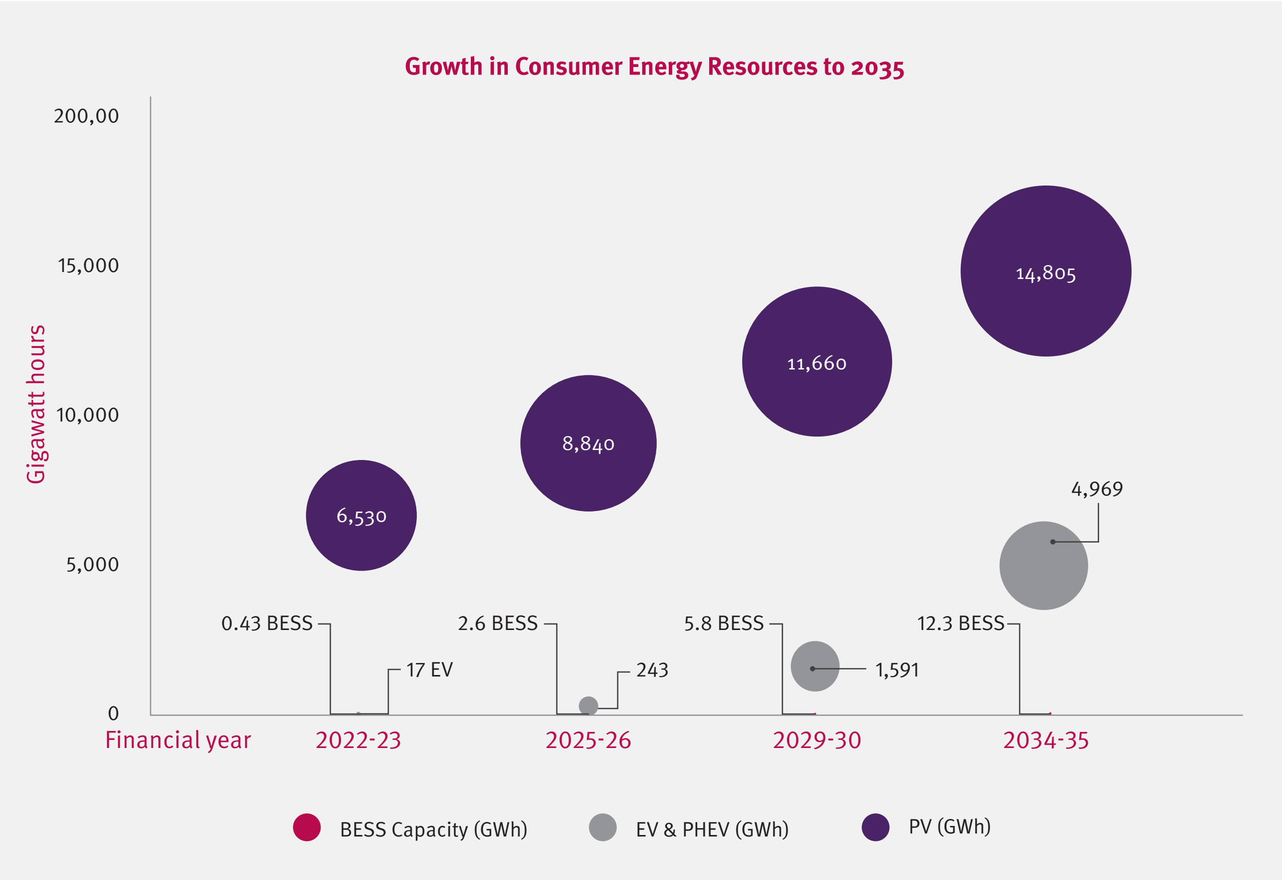


Figure 5: Forecast uptake of technology in the Distribution Network to 2035. Source data – AEMO ISP 2022, Step Change scenario.

[13] Figures reflect AEMO ISP 2022 *Step Change* scenario.

CER, predominantly rooftop solar, is already impacting the operational demand profile and shaping demand across the electricity system. The Plan seeks to build a smarter distribution grid to ensure CER is effectively integrated and customers can continue to connect their CER devices.

Historically, the electricity system was categorised by one way flow of electricity from generators to energy customers, with limited active role for people and businesses – a grid with limited integration. CER provides an opportunity for customers to participate in the electricity system in a variety of ways, and for the development of a two-way integrated and inclusive energy market – a smart, integrated grid.

The future energy system will be more complex, consisting of millions of interconnected devices and network assets including network batteries. It will require an 'Internet of Energy' that has visibility of connected equipment and supports the efficient orchestration of energy flow at the distribution level. The volume of energy flow will also be significantly greater than it is now and bi-directional. The energy system will need to be responsive to customer loads emerging at different locations and times as transport electrification accelerates.

The ability to simultaneously manage local and system network constraints, interface with customers and respond to market signals while maintaining security and reliability will be critical. This requires a more dynamic, linked and transparent system that can provide the appropriate signals to market, network and customer systems. Operational technology systems including distributed energy resource management systems (DERMS) that are integrated with network distribution management systems (DMS) will be key enablers. This system-level approach will support customer decision-making, efficient and secure network management and delivery of positive customer outcomes aligned to government renewable energy targets.

While distribution network level considerations are not the focus of the Blueprint, they remain a priority for government. Significant innovation and adoption of sophisticated operational technology and physical systems will be required to integrate CER into the electricity system.

Alternative infrastructure pathway considerations

This Blueprint outlines a point-in-time optimal infrastructure pathway to deliver a clean, reliable and affordable Queensland electricity system. The foundation components of the optimal infrastructure pathway include:

- **Long duration storage:** Long duration storage is critical to ensuring ongoing security and reliability of supply for Queensland's future electricity system with high levels of renewable generation. PHES assets will be the cornerstone of the future system. Borumba PHES is identified for delivery and a further large site/s will be needed, with this Blueprint identifying the Pioneer-Burdekin PHES in North Queensland as the preferred site. The Queensland Government has committed additional funding to support investigations into additional sites.
- **Adequate transmission:** Strong transmission networks are required to connect renewable generation with the major storage sites and loads. This will allow for the transfer of renewable energy across locations and time of use.

While long duration storage and adequate transmission are essential, other elements of the optimal infrastructure pathway may change over time due to market forces, technology costs and actual system demand. These elements are:

- **Additional storage or flexible scheduled generation:** meeting peak demand when renewable generation outputs are low can be achieved in several ways. Queensland can increase storage capacity in terms of peak output capacity and duration (volume) to ensure storage-based generation is available when required. Trying to back up a renewable energy system exclusively with storage is a high-cost pathway, with much of the storage capacity underutilised 99 per cent of the time[14]. There could be choices depending on market design.

  Strategic use of low capital cost gas-fuelled plant (such as gas turbines or gas reciprocating engines using either gas or hydrogen blends in the short-term and/or 100 per cent renewable hydrogen[15] in the longer term) may be an effective way to reduce the cost of meeting Queensland's total storage/peaking capacity requirements. While these plants have higher marginal running costs, modelling[16] has shown their infrequent use results in a lower overall cost of energy. Grid-scale batteries and short duration PHES assets will also play a role in contributing back-up and firming services on an intra-day basis.

- **Demand side participation:** Customers will have increasing opportunities to use their CER to supply storage infrastructure via their own batteries and electric vehicles. Demand side participation, where large single or aggregated loads can flex on and off, will act as a storage (or 'soak' mechanism) in the energy system of the future. As new technologies emerge and cost profiles change, the optimal storage mix may change.

- **CER uptake and level of orchestration:** CER uptake is forecast to rapidly increase. Importantly, analysis assumes this will increasingly be accompanied by a level of orchestration to manage distribution-level grid considerations and greater customer interaction with electricity markets. This assumption will help to ensure the distribution-transmission level interface is not negatively impacted by CER uptake (e.g. due to system security or power flow).

- **Transmission interconnection:** Queensland has two interconnections to NSW, the 330kV AC Queensland-NSW Interconnector (QNI) capable of transferring up to around 1,450 MW plus a 180 MW direct current (DC) connection at Terranora. An upgraded QNI capacity may help meet demand in Queensland during scarcity events (e.g. periods of high demand combined with low renewable generation, or during transmission outage conditions), reducing the need for additional storage capacity and/or flexible dispatchable generation requirements in Queensland. A strong interconnection also improves competition in the energy market, improving customer outcomes and reduces spillage of renewables through opportunity to export excess energy.

- **Solar and wind generation:** the optimal infrastructure pathway consists of an approximate 50/50 split of large-scale solar and wind capacity (modelled result is 48:52 solar to wind). Wind is developed initially, with solar being developed alongside PHES assets. This mix is based on the market pricing achieved by wind and solar, not the input costs – the solar capital cost is currently around 60-70 per cent of wind generation but without storage its value is reduced by rooftop solar generation.[17]

  These relative technology costs are likely to change over time. This will influence the energy mix. Community acceptance for technologies and local development may also influence the mix of generation assets (i.e. visual amenity impacts of wind may result in a system with more solar and storage).

Given these trade-offs and considerations, active oversight of Queensland's energy transformation and regular review of the optimal infrastructure pathway is vital. The governance process to deliver active oversight and review is described in the Plan.

[14] Internal modelling carried out by the Queensland Government, externally reviewed.

[15] Given plant would be expected to operate in times of low renewable generation including dunkeflaute, large volumes of hydrogen storage would be required, which could potentially be provided by geologic hydrogen storage such as salt caverns or depleted gas fields.

[16] Independent modelling June 2022 shows that development of around 3,000 MW of OCGT capacity is part of the least cost development pathway.

Optimal infrastructure pathway - Queensland's way forward

This Blueprint outlines the optimal infrastructure pathway to 2035 to deliver a clean, reliable and affordable Queensland electricity system.
The scale and pace of activity and investment required to deliver this new infrastructure is significant. Staging the works provides opportunities to optimise cost outcomes by spreading out demand for labour, materials and approvals while building in future flexibility. Staging the works also allows for early renewable connections and the opportunity to deliver the benefits of renewable energy earlier.

Achievement of the Infrastructure Blueprint requires investment across four focus areas.

1. **Renewable investments** – substantial new renewable generation investment is critical. Given the variable nature and capacity factors of renewable generation, around 25,000 MW of large-scale renewable generation (total) and around 7,000 MW of new rooftop solar generation is required to meet forecast demand in 2035 (when all publicly owned coal fired power stations are repurposed into clean energy hubs). QREZ will be a key government lever for the coordinated, efficient connection of new large-scale renewable generation. It will optimise the renewable and storage connections in a declared location, accelerate connection arrangements and reduce costs to consumers.

2. **Storage and dispatchable capacity** – Queensland is forecast to require at least 6,000 MW of long storage to ensure reliability. Dispatchable low emission gas-fuelled generators are expected to economically provide further back up power while grid scale batteries and medium duration PHES systems provide firming and smooth daily renewable energy output.

3. **Major network transmission and system strength augmentation** – new transmission infrastructure is required to connect renewable generator investments and storage with Queensland's existing and future energy demand centres. Conversion of some existing generators to synchronous condensers will bolster system strength as renewable generation increases.

4. **Clean energy hubs** – Government owned coal-fired power stations will be progressively repurposed into 'clean energy hubs' that provide system strength, storage, and firming services.

While the Blueprint does not address small-scale infrastructure, the distribution network and CER, these do contribute to a decarbonised energy system and form a key part of the Plan.

[17] This occurs because rooftop solar acts as a reduction in demand on the system. As rooftop solar and utility solar are generating at the same time, rooftop solar "eats into" the load (and therefore the revenue) that could be supplied/earned by utility solar. Large storage assets, like PHES help alleviate this issue as they provide a "sink" for utility solar, allowing this energy to be discharged when the sun goes down.

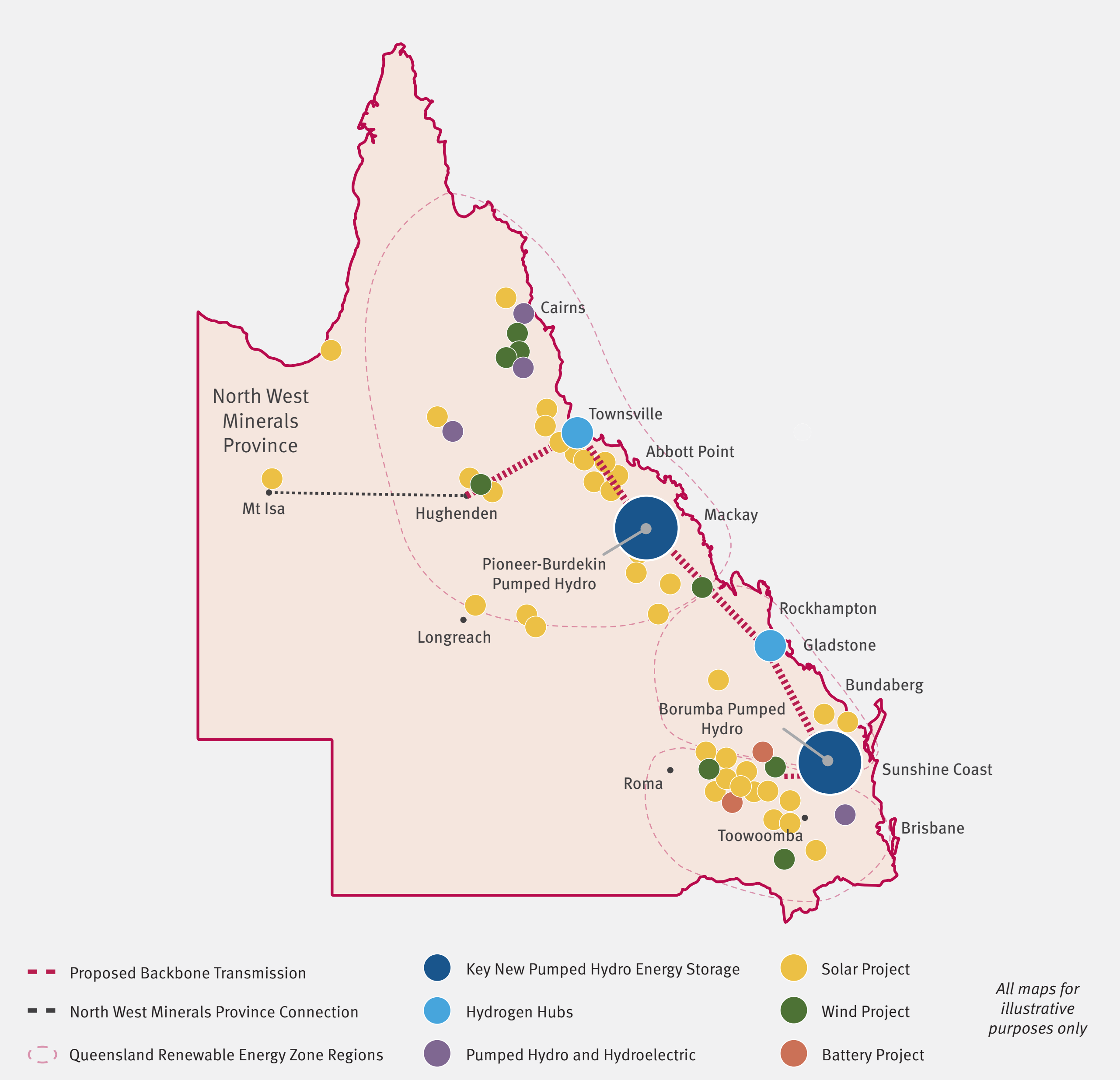


Figure 6: Queensland's future electricity system will deliver affordable, reliable and clean power, with two foundational PHES assets and new backbone transmission to move large volumes of renewable and stored energy to where and when it is needed.

Renewable investments

Independent modelling indicates Queensland will require approximately 25,000 MW of total large-scale renewable generation capacity by 2035 (in addition to a further 7,000 MW of rooftop solar). This consists of:

- 2,882 MW of existing operational wind and grid-scale solar capacity (as of June 2022)
- 12,200 MW of new wind generation capacity, which equates to around 2,700 turbines, each with an average capacity of 4.5 MW. The total land area for 2,700 wind turbines is approximately 540,000 hectares (allowing 200 hectares for each turbine, based on separation distance of multiplying the blade diameter by a factor of 10)
- 10,000 MW of new large-scale solar capacity, which equates to around 40,200 hectares for solar farms, based on an average of 4 hectares per MW (all inclusive) for large-scale solar installations in Queensland.

Renewable capacity	Unit	2022-24	2024-28	2028-35	Total
Solar capacity (aggregated)	MW	3,620	500	7,990	**12,110**
Wind capacity (aggregated)	MW	1,610	2,980	8,300	**12,890**
Total renewable capacity	MW	5,230	3,480	16,290	**25,000**

Table 1: Renewable energy capacity will be progressively developed, with around 12,900 of large-scale wind generation and around 12,100 MW of large-scale solar generation anticipated by 2035. Solar build rates slow until Borumba PHES is closer to completion, increasing demand for low-cost solar energy.

While the land area required for this renewable energy development appears large, it is a small portion of Queensland's total area (i.e. 185.3 million hectares). This means the area required for wind represents 0.3 per cent of the state's land area: and 0.02 per cent for solar. As these are rules of thumb, even a doubling of the area ratio is still less than 1 per cent of the state's land area.

This modelling uses AEMO 2022 *Step Change* demand assumptions. If demand significantly increases (e.g. renewable hydrogen export industry or large-scale electrification), additional large-scale renewable generation will be required. The infrastructure proposals in this Blueprint provide a foundation for future growth, and further generation needs will be captured in future Blueprint reviews and updates.

Queensland Renewable Energy Zones

Queensland Renewable Energy Zones (QREZ) are a key enabler to coordinate the efficient connection of new renewable generation. The Queensland Government has established three QREZs – the Northern, Central, and Southern regions. Development of smaller declared Renewable Energy Zones (REZs) within these regions over time will coordinate efficient investment in electricity transmission and renewable generation infrastructure.

A key design element of the declared REZs is the coordination of generation sources with REZ infrastructure. This may include allowing installed generation capacity to exceed the nominal transmission capacity (based on an optimised assessment of capacity factors and generation 'shape') leading to higher transmission asset use and maximum investment opportunities.

This design concept will support least cost connection and development of the required 25,000 MW of large-scale renewable generation (total) by 2035.

QREZ phased development

Development of QREZs will occur over three phases:

- **Phase 1: Building on our strong foundations (2022–2024):** QREZ development in this timeframe is focussed on early pilot zones in areas with available network capacity or that require limited transmission investment to unlock high investor interest through scale efficiencies in connections. The Queensland Government and Powerlink will advance early investments to bring forward projects and keep investment flowing.
- **Phase 2: Scaling and expanding opportunities (2024–2028):** QREZ development in this timeframe will expand to better match renewable generation to local demand and efficiently connect new renewable capacity as the generation mix in Queensland changes, unlocking new zones across Queensland for higher levels of renewable energy generation.
- **Phase 3: Preparing for net zero (2028–2035):** QREZ development in this timeframe will support further network enhancements and expansion of renewable generation to decarbonise the electricity system, to power growing industrial demand from hydrogen export, industrial electrification, and to begin the electrification of broader energy demand in Queensland.

Phase 1 QREZ development

Northern QREZ region

The government has invested $40 million (from the $145 million QREZ funding allocation) to upgrade transmission infrastructure between Cairns and Townsville (Figure 7).

This investment will provide up to 500 MW of renewable energy connection potential in Far North Queensland. Several investors have shown interest in this area, with the 157 MW Kaban Wind Farm under construction (expected to be operational in 2023).

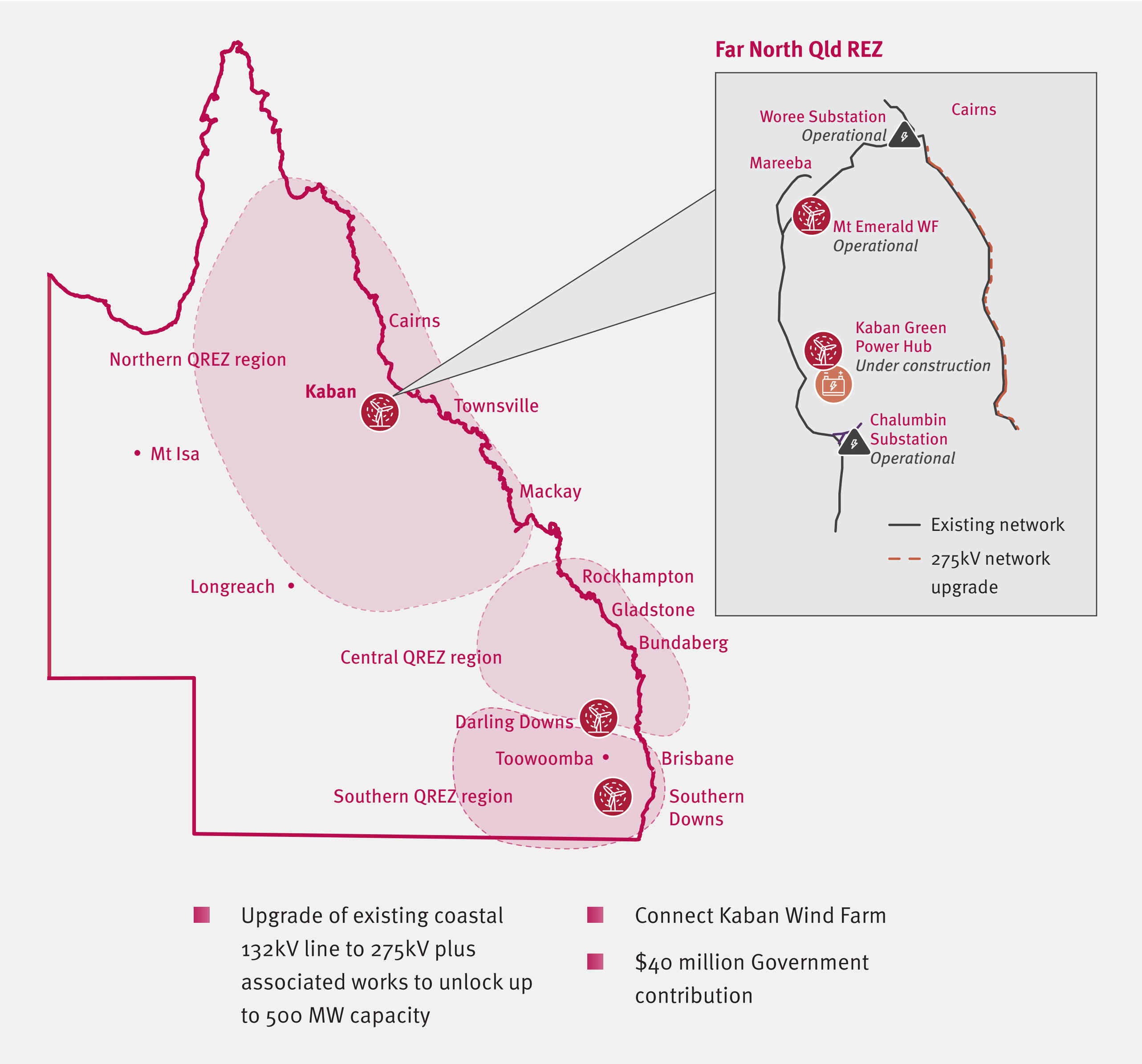


Figure 7: $40 million investment in the Northern QREZ region, which has unlocked up to 500 MW of capacity and supported the connection of the Kaban project.

Central QREZ region

Powerlink will invest $365 million into the Central QREZ to enable up to 3,300 MW of new renewable capacity to connect to the grid. While this investment provides some incremental renewable connection capacity, its primary purpose is the reinforcement of the Gladstone system to support decarbonisation of the region. This investment includes:

- a new double circuit 275kV line connecting into Gladstone (Calvale to Calliope River) (unlocking up to 1,800 MW[18] of renewable generating capacity)
- a new transformer to support 132kV capacity in Gladstone (to maintain reliability)
- a new synchronous condenser (to provide system strength with the changing energy mix)
- a battery connection (to support system strength and enable renewable capacity)
- a second circuit upgrade to enable further REZ capacity in the Banana Range (unlocking up to 1,500 MW of capacity).[19]

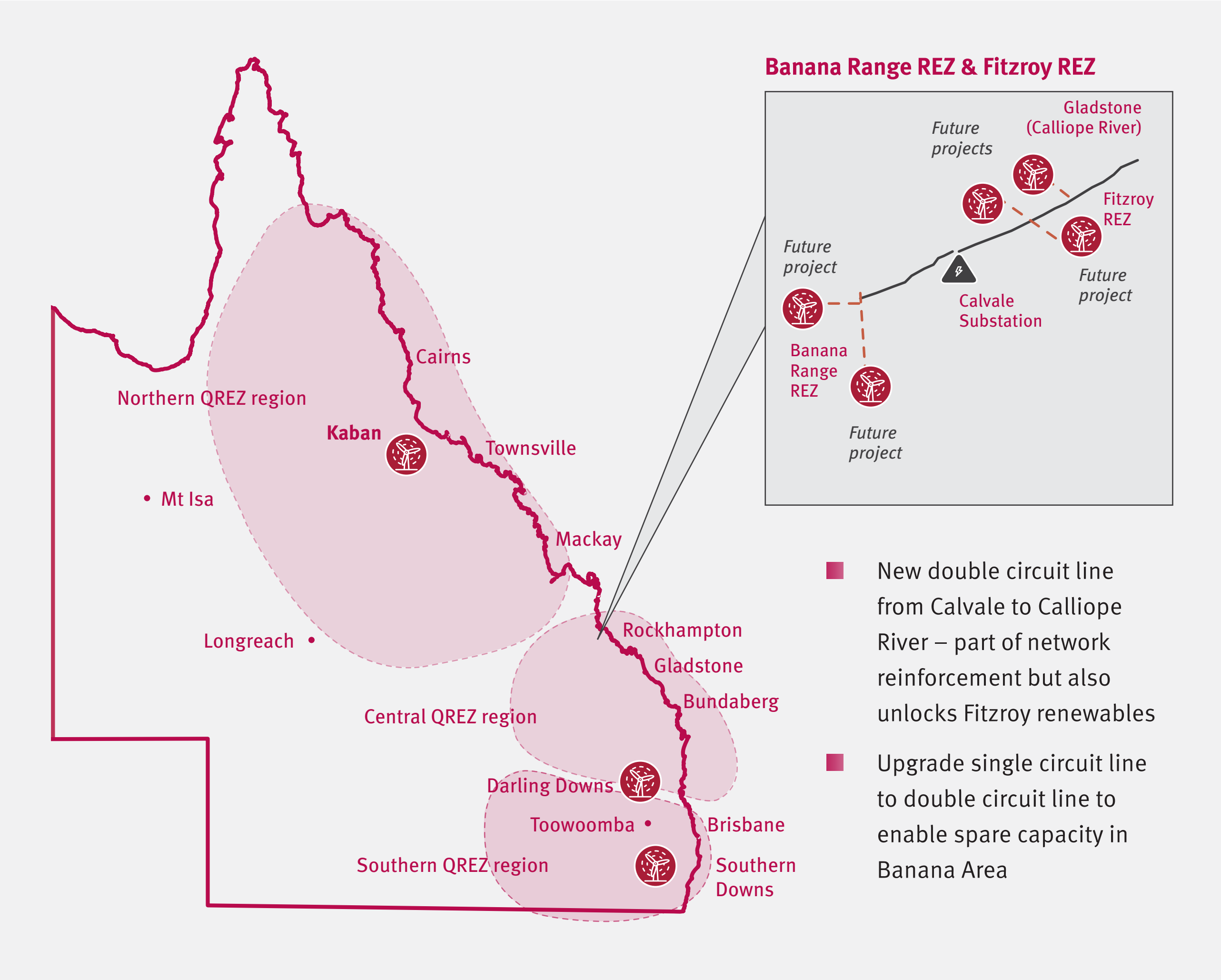


Figure 8: This initial investment in the Central QREZ region will unlock additional renewable energy capacity and supports existing industrial consumers in the region to transition to clean, reliable and affordable electricity.

[18] The amount of renewable generation able to be connected on this line section will vary depending on generation and transmission line flow patterns. Initial estimates in the QREZ Technical Discussion Paper indicated a potential of 800 MW; however, further analysis indicates this could be up to 1,800 MW of renewable capacity. Powerlink is currently carrying out further analysis to optimise the use of this line for capacity support in the Gladstone area plus the delivery of additional renewable generation connection capacity.

[19] Community consultation has commenced on this transmission project

Southern QREZ region

The Queensland Government and Powerlink are currently delivering two investments in the Southern QREZ region – the Southern Downs and Darling Downs REZs.

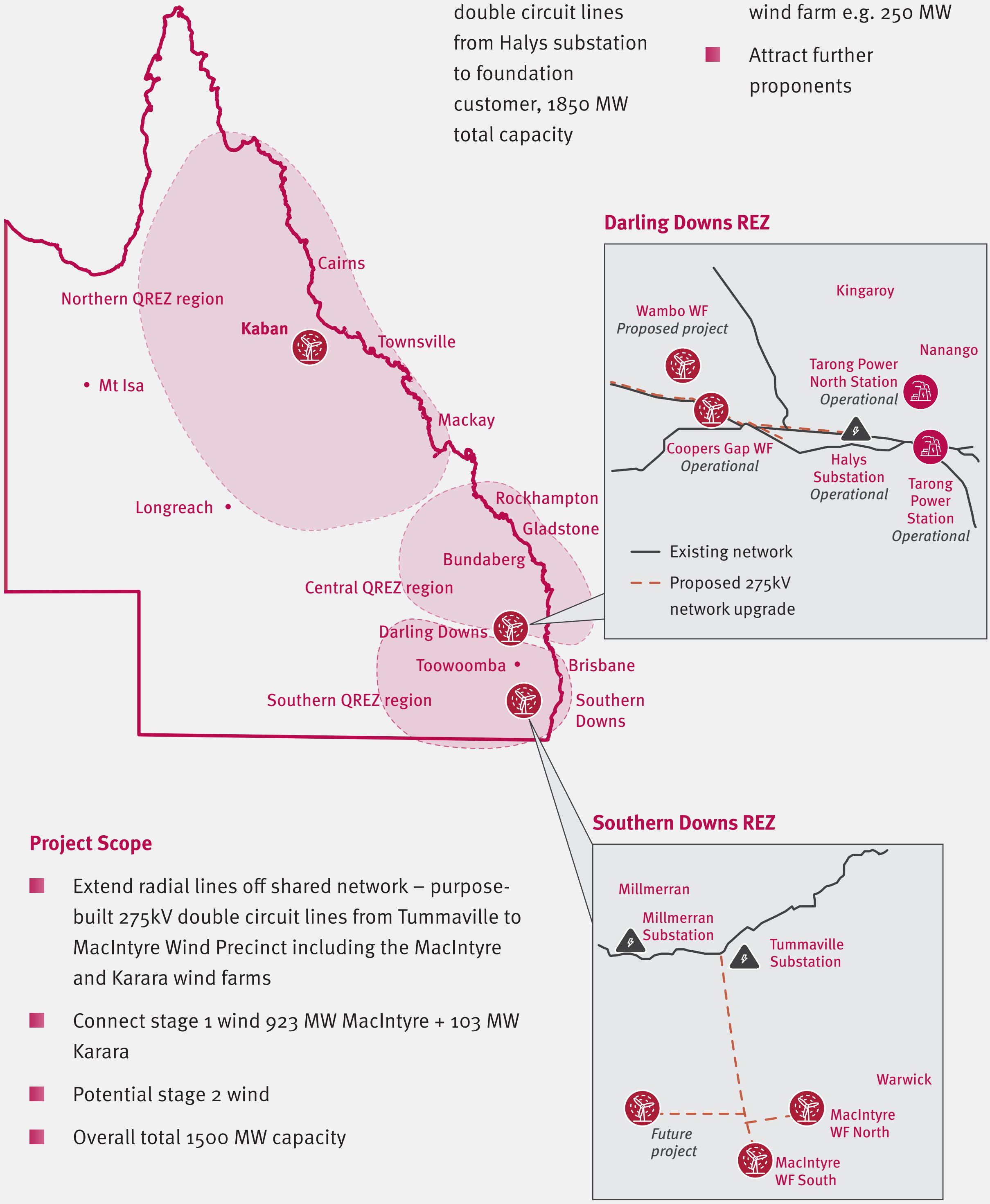
Powerlink is providing additional capacity on the Southern Downs at MacIntyre, which includes an investment of $167 million for transmission infrastructure. This includes connecting the MacIntyre and Karara wind farms, which have a combined generation capacity of 1,026 MW. Installation of a grid-connected battery and other localised augmentations in the southern QREZ region will increase the available generation capacity of the Southern Downs REZ significantly, with likely renewable generation hosting capacity of up to 1,500 MW.

Powerlink is providing additional capacity on the Darling Downs, which involves construction of a dedicated 275kV line to several wind developments in the area, the first of which is expected to be the 500 MW Wambo Wind Farm.[20] The total renewable generation connection capacity of the Darling Downs REZ is 1,850 MW and there is adequate wind and solar development interest in the area to fill this capacity.

[20] Phase 1 of this project is 252 MW.

Project scope

- Purpose-built 275kV double circuit lines from Halys substation to foundation customer, 1850 MW total capacity
- Connect initial stage 1 wind farm e.g. 250 MW
- Attract further proponents



Project Scope

- Extend radial lines off shared network – purpose-built 275kV double circuit lines from Tummaville to MacIntyre Wind Precinct including the MacIntyre and Karara wind farms
- Connect stage 1 wind 923 MW MacIntyre + 103 MW Karara
- Potential stage 2 wind
- Overall total 1500 MW capacity

Figure 9: The Southern Downs and Darling Downs investments in the Southern QREZ region could unlock up 3350 MW of renewable energy capacity.

Future phases of QREZ development

Further development of the three QREZs will occur in stages to support connection of the 25,000 MW of large-scale renewable generation (total) required by 2035. Powerlink and the Queensland Government have identified the preliminary renewable capacity for each region (Table 2):

- more than 6,000 MW of capacity in the Northern QREZ region
- more than 8,000 MW of capacity in the Central QREZ region, and
- around 11,000 MW of capacity in the Southern QREZ region.

Project	Unit	2022-24	2024-28	2028-35	Total
Northern QREZ	MW	1220	300	4600	**6,120**
Central QREZ	MW	1010	1580	5500	**8,090**
Southern QREZ	MW	2940	1665	6190	**10,795**
Total renewable capacity	MW	5170	3480	16290	**25,000***

*Table 2: QREZ regions will be progressively developed to support the connection of the 25,000 MW (*rounded) of large-scale renewable capacity required by 2035.*

The Queensland Government will release a QREZ Roadmap for community engagement and feedback to outline the proposed approach for developing each of the three QREZs. This Roadmap will include the immediate capacity proposed to be unlocked and the longer-term capacity for each region to meet demand and the targets set out in the Plan. The capacity identified in the QREZ Roadmap will be based on technical and strategic criteria and detailed land use mapping of priority areas.

Importantly, engagement on the QREZ Roadmap will ensure communities are directly involved in the development of renewables in their region and community.

Under the QREZ framework, in each region, individual REZs will be announced by the Queensland Government, following a ministerial declaration, and informed by recommendations from the designated planning body (proposed to be Powerlink) and detailed stakeholder consultation on the QREZ Roadmap. Further details on the process for identification and declaring REZs will be in the QREZ Roadmap.

Early strategic investment as part of Phase 1 of QREZ development will be incorporated into a legislative framework. The QREZ Roadmap forms a critical component of the governance framework for implementing the Plan and investment pathway in this Blueprint.

Blueprint
This Blueprint outlines the total large-scale renewable energy capacity required to transform Queensland's electricity system and meet demand.

↓

QREZ Roadmap
The QREZ Roadmap will outline potential investigation areas for QREZ investment and progressive development.

↓

REZ Management Plans
Detailed REZ Management Plans will be developed for each declared REZ outlining the specific infrastructure investment, location, and capacity.

The QREZ designated planning body will develop detailed REZ Management Plans for each declared REZ in a coordinated way to ensure that the timing of renewable development aligns with other key Blueprint activities.

Storage, firming and dispatchable capacity

Purpose

> On the optimal infrastructure pathway, Queensland's future clean energy system includes at least 6,000 MW of long duration storage for energy security and reliability.[21]

This Blueprint only outlines the delivery of large-scale PHES assets, as development and construction of these assets is expected to be led by government. Other forms and technologies of storage and intra-day firming may form part of a clean, reliable and affordable energy system. This may include utility scale batteries, medium PHES and low or zero emissions gas fuelled turbines or reciprocating engines firing a gas-hydrogen fuel blend and up to 100 per cent renewable hydrogen fuel in the future.[22] These are anticipated to be developed by a combination of the private sector and government owned energy corporations.

Existing and committed infrastructure

As renewable energy penetration progressively increases beyond the current 20 per cent level and further toward the 50 per cent Queensland Renewable Energy Target,[23] utility and distributed scale battery energy storage systems (BESS) will initially be required to provide firming and assure security of supply on an intra-day basis. There is already multiple utility-scale BESS proposed or under construction in Queensland as shown in Table 3.

[21] This quantum may change over time depending on actual future demand outcomes.

[22] Source: https://solutions.mhi.com/power/decarbonization-technology/hydrogen-gas-turbine/. Accessed 12 May 2022

[23] Queensland renewable generation as a percentage of consumption for Jan 21 to Dec 21 was 20.4 per cent.
Source: https://www.epw.qld.gov.au/about/initiatives/renewable-energy-targets. Accessed 22 June 2022.

Project	Proponent	Capacity (MW)	Storage duration (Hours)	Storage capacity (MWh)	Expected operation date
Wandoan South BESS	Vena Energy	100	1.5	150	2022
Bouldercombe	Genex Power	50	2	100	Late 2023
Southern REZ BESS	Stanwell	150	2	300	Late 2023
Central REZ BESS	Stanwell	150	2	300	Mid 2024
Chinchilla BESS	CS Energy	100	2	200	Late 2023
Greenbank BESS	CS Energy	200	2	400	2024

Table 3: Utility BESS projects proposed or under construction in Queensland as of June 2022.

In North Queensland, the Kidston PHES project is under construction at the old Kidston gold mine (capacity of 250 MW for 8 hours – expected operation in 2024) and the 570 MW Wivenhoe PHES is operational. Wivenhoe was commissioned in the 1980s to optimise power system operations, moving low-cost energy generated during off-peak periods into the morning and evening peak periods. It can perform the same functions into the future – shifting renewable energy to higher demand times of the day and acting as a load to soak up ‘excess’[24] solar energy at certain times of the year.

[24] ‘excess’ is a colloquial term for energy that would otherwise be constrained off. The addition of the pumping load to the system creates demand and enables this generation to be online.

PHES development

Borumba PHES

A PHES project at Borumba Dam near Imbil in south-east Queensland will provide a 2,000 MW/24hr asset and is a foundational investment in Queensland's future electricity system.[25]

This is a priority large-scale PHES project because it is situated in an advantageous location, on a site owned and flagged as a potential pumped hydro site by Powerlink for the past 20 years. It is close to the existing transmission network and the significant south-east Queensland energy load.

On the optimal infrastructure pathway, the Borumba PHES is operational in 2030 when renewable energy is anticipated to exceed 50 per cent of Queensland's electricity supply.

In 2021, Powerlink commenced work on the studies for a Borumba PHES. The detailed assessment report on the project is anticipated to be completed in the first half of 2023. This will include identification and costing of the preferred design and a potential pathway to construction and full operation of the PHES in 2030.

Project costs are to be determined as part of the detailed cost analysis, dependent on completion of geotechnical investigations and finalisation of the preferred design.

The pathway to construction will identify any environmental and approval issues associated with the PHES, and appropriate project management and mitigation strategies.

The commissioning timing of the Borumba project will influence the pace of transformation. To maintain security of supply, only limited amounts of coal-fired generation – replaced by renewable energy and storage – can be removed from the electricity system before Borumba PHES is operational.

Phase	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Detailed analytical report[1]	FEED/technical studies									
EIS[2]	Environmental/technical studies									
Early works		Site access								
Civil works				Construct upper and lower dam, caverns, tunnels						
Transmission		Design and corridor acquisition			Build transmission					
Turbines						Install and commission				
Upper reservoir								Fill reservoir		
Final commissioning and handover									Operational	

Table 4: The preliminary high-level works program for the Borumba PHES. This will change once feasibility works are finalised.

1. Detailed analysis report requires front end engineering design (FEED) and other studies (environmental, commercial assessment) to be completed
2. EIS and approvals includes state and federal approvals, including EIS and EPBC for the site approvals for the transmission corridor

[25] Actual plant capacity is subject to completion of final front end engineering design but is anticipated to be 2000 MW/24hour.

Pioneer-Burdekin PHES

On the optimal infrastructure pathway, additional large-scale long duration storage is operational in 2032. The preferred site is in the western Pioneer Valley, near Mackay in North Queensland, with the upper reservoirs located at the head of the Burdekin River catchment, and the lower reservoir in the Pioneer River catchment.

This PHES site has favourable topography, with a large vertical separation between reservoirs (head), favourable horizontal distance between reservoirs (length) and relatively low cost dams. It is also located close to high-quality wind and solar resources in the Central QREZ region and could unlock large volumes of renewable energy.

The site also has an even greater storage potential than the Borumba PHES, and is able to accommodate 5,000 MW with 24 hours of storage.

The PHES project could be delivered over two stages. The first stage is 2,500 MW/24hrs (60 GWh) delivered by 2032 and the second stage is a further 2,500 MW/24hrs (60 GWh), commissioned by 2035.

The components of each stage would comprise the same infrastructure as the Borumba PHES (power station, turbines, headrace tunnel, tailrace tunnel, main access tunnel and emergency, cable, and ventilation tunnels).

Environmental, including water, approvals are key for this project.

Major network transmission and system strength

Purpose

> Queensland's existing transmission system must evolve to efficiently move renewable and stored energy across the state, both geographically and at different times of day.

Delivery program for initial connections

The optimal pathway has four key stages of major transmission reinforcement to provide initial connection capacity to support the initial PHES developments and achieve a clean, reliable and affordable electricity system, including by providing access to the State's high quality renewable energy resources. All stages are proposed as high voltage (up to 500kV) double circuit transmission assets.

- **Stage 1** – Borumba Connections
- **Stage 2** – Central Queensland Connection
- **Stage 3** – Pioneer-Burdekin PHES and NQ Connection
- **Stage 4** – Townsville to Hughenden Connection

Powerlink will undertake further detailed planning and assessment to determine the optimal timing and corridors for these stages of major transmission reinforcement. Details on the initial four stages of major transmission reinforcement are identified in Figure 6 (page 26) and in Table 5. It should be noted that line lengths, routes, costs and timeframes are high-level estimates and are subject to ongoing review and refinement. All years referred to in the text are financial years.

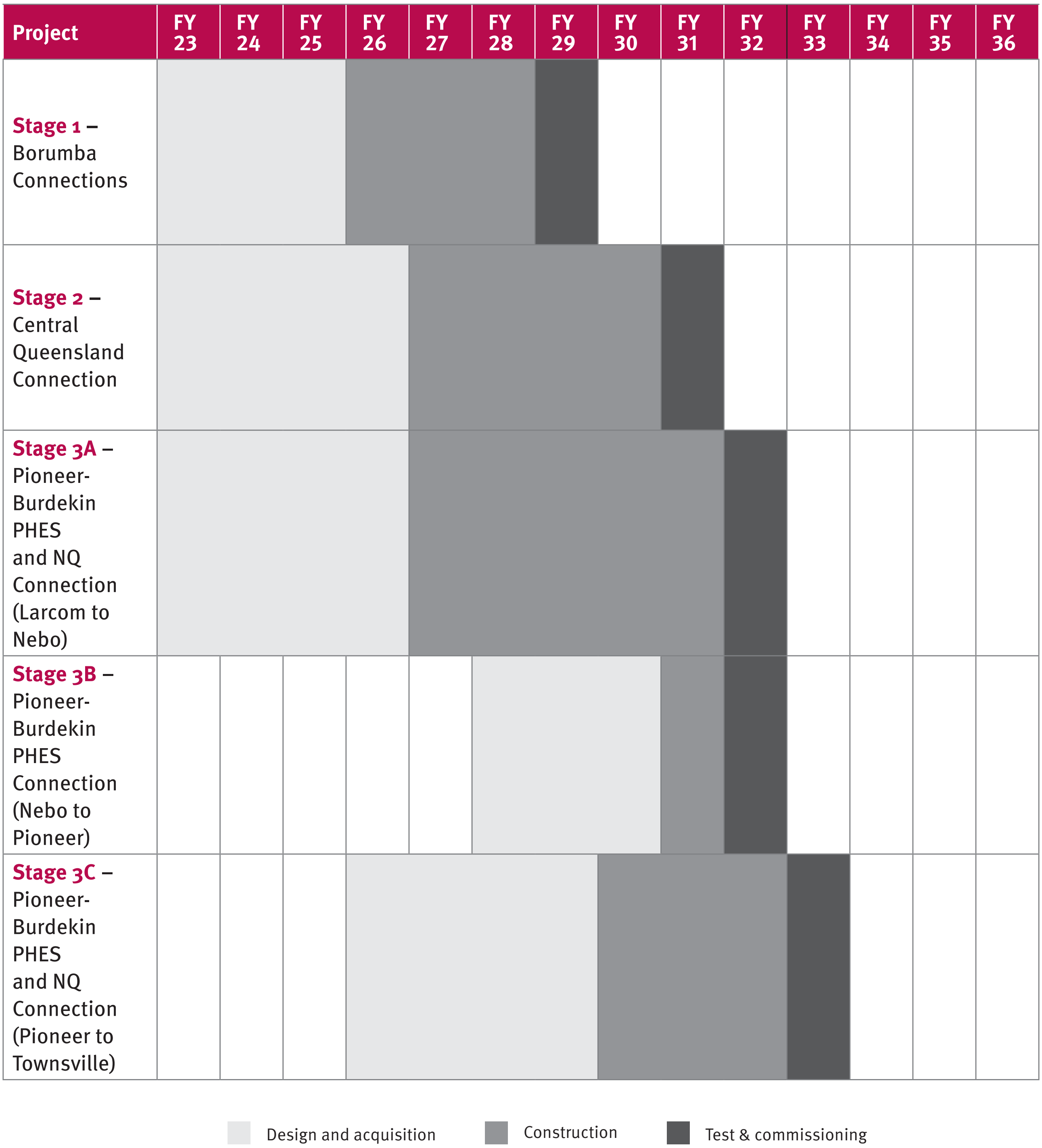


Table 5: The new backbone transmission projects will be progressively delivered by the mid-2030s, with design and corridor acquisitions commencing in 2023.

Stage 1: Borumba connection

On the optimal pathway, the Borumba PHES project is operational in 2030 and connected to the grid via new high voltage (up to 500kV) transmission. It is a cornerstone of Queensland's future clean energy system, providing critical storage and firming for increasing levels of variable renewable generation. Connection and operation of Borumba PHES will allow Queensland's reliance on coal-fired generation to reduce, allowing further coal-fired units to be repurposed into 'clean energy hubs'.

To be operational in 2030, the Borumba PHES must connect to the grid no later than 2029 to support project commissioning. The Borumba connection involves two transmission lines around 140km in length in total with an estimated cost of approximately $800 million.

Stage 2: Central Queensland connection

Central Queensland hosts much of Queensland's coal-fired generation and is a large industrial load centre, including Queensland's largest single load (the Boyne Island Aluminium Smelter). New major transmission lines (up to 500kV) will be constructed into Central Queensland to supply renewable energy generation and firming, supporting decarbonisation of these large industrial loads.

The Central QREZ investment (estimated completion 2026) will provide additional transmission capacity into the region and support connection of up to 3,300 MW of renewable generation capacity (out of the 25,000 MW total required by 2035). On the optimal infrastructure pathway, additional high voltage transmission will be constructed by 2030 to connect Borumba PHES into the Central Queensland load centre. This connection, coupled with the additional renewable capacity from the Central QREZ investment, will enable greater reliance on renewable generation and provide important storage and firming capacity for the region.

On the optimal infrastructure pathway, the 290km, high voltage Central Queensland connection is delivered by 2030 at an estimated cost of $1.3 billion. This requires easement acquisition and approvals to commence in 2023 and conclude in 2026, and construction to commence in 2027.

Stage 3: Pioneer-Burdekin PHES and NQ Connection

A second large-scale PHES is fundamental to decarbonising Queensland's electricity system and maintaining a reliable electricity supply. This Blueprint assumes the second PHES site will be the Pioneer-Burdekin PHES. The transmission requirements will alter based on the PHES developments, and this will be considered as part of future Blueprints.

The Pioneer-Burdekin PHES will be connected to both northern and central Queensland, providing access to both load centres and high-quality renewables. Given the long distances between the PHES asset and load centres, this transmission connection will be high voltage (up to 500kV) to reduce losses and provide adequate power transfer capacity.

Easement acquisition and approvals will take a considerable amount of time. Easement acquisition and approval commencements must align with the expected operational date for the second PHES. On the optimal infrastructure pathway, the second PHES commences operation in 2032.

This connection will be approximately 750km and cost approximately $3.4 billion. Detailed design and engineering works will refine the proposal.

Stage 4: Townsville to Hughenden

The Hughenden area has excellent renewable energy resources that can support new large industrial loads and demand in North Queensland, including renewable hydrogen. The renewable resources are extensive and very good quality, with high-capacity factors and significant geographic diversity compared to wind generation in other parts of the State.

A high voltage (up to 500kV) transmission line will need to be constructed from near Townsville to Hughenden by 2035, which in combination with the Pioneer-Burdekin PHES and the other high voltage transmission lines, will unlock the first significant amount of renewable resources.

Construction timing is important in terms of minimising overall infrastructure and energy cost. Due to the long distances between generation resources in the Hughenden area and existing demand in central and southern Queensland, this line will incur large transmission losses (costs) if its sole purpose is to supply energy southwards. Construction of this high voltage connection should commence once the Pioneer-Burdekin PHES and the high voltage connection to central and southern Queensland is operational – with completion expected by 2035. This will allow for the transportation of excellent renewable resources to existing large load centres, supporting industrial decarbonisation and system transformation.

The Stage 4 connection is approximately 370km at a cost of $1.7 billion. The transmission line could be extended from Hughenden to Mount Isa. The Hughenden to Mount Isa connection could be constructed at a lower voltage (i.e., 275 or 330kV).

The Queensland Government recognises the important role the North West Minerals Province (NWMP) could play in our future energy system. Critical minerals from the region could contribute to manufacturing opportunities as part of the Plan's pipeline of clean energy infrastructure.

Recognising this, the Queensland Government views a connection of the NWMP to the National Electricity Market (NEM) as an important part of the future Queensland SuperGrid. This Infrastructure Blueprint already includes the Townsville to Hughenden connection. Further connection from Hughenden to Mount Isa will integrate a new region into the NEM and must occur in close consultation with national market bodies. The Queensland Government is currently engaging with key stakeholders, including the Australian Government, on the best way to deliver the connection to the NWMP while aligning with Queensland's renewable energy ambitions.

Potential future network connections

The above transmission network development includes a high capacity, high voltage backbone, supported by the existing 275kV network. This configuration does not provide full redundancy and reliability under some operational conditions. Queensland may require additional transmission lines in the 2030s to accommodate increased load development (for example large scale renewable hydrogen projects), the location of further renewable energy developments, additional PHES developments and/or as a risk mitigation mechanism for operability and reliability considerations.

Powerlink is considering a range of both transmission and non-transmission risk mitigation measures to support this low-cost configuration, including special protection schemes and network support from PHES, batteries, generation, and loads. Monitoring the emergence of large new loads and renewable energy developments will continue.

Enhanced interconnector (QNI) capacity may eliminate or reduce the need for additional storage, peaking capacity or additional transmission reinforcements in Queensland. Assessment and decisions on whether additional major network reinforcements or alternatives are required will be necessary in the future.

Delivery considerations

Delivery of this major transmission infrastructure program will be a significant challenge. It represents the largest transmission construction program ever undertaken in Queensland, over a relatively short period of time. Prerequisites for delivery include:

- Early engagement with the community to support corridor acquisitions –this work must commence as quickly as possible to ensure landholders, First Nations Peoples and broader community stakeholders are able to have meaningful and early input into the potential transmission corridors. This should include targeted local benefits arrangements.
- Ensuring a coordinated, timely approach to planning, acquisition and works approvals processes between Powerlink and various Federal and State Government departments. This may include exploring opportunities to streamline and improve existing approval processes and regulations, where appropriate, and commencing applications for approvals (such as environmental approvals) as early as possible.
- Early engagement with relevant partners (contractors, industry, and unions) to secure labour resources in a time of major transmission construction across Australia. This is likely to require a visible forward program plus some level of precommitment to works programs to secure partner resources.
- Early engagement with equipment suppliers to obtain plant and equipment in a timely and cost-effective manner.

System strength and inertia

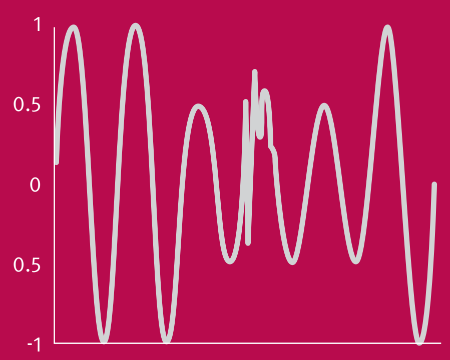
The Blueprint outlines critical steps to maintain system strength and security as the generation mix changes. Existing coal-fired generators are the main suppliers of system strength and inertia to the electricity system. In the future these technical services, which are critical for system stability, will need to be provided by alternative sources. This may include new synchronous machines developed as part of the PHES installations, existing coal-fired generators being converted to operate as synchronous condensers, standalone synchronous condensers, and large-scale batteries. Key elements included in this Blueprint:

- Repurposing coal-fired units (where feasible) into synchronous condensers to provide system strength and inertia and to continue to meet AEMO's operational requirements.
- Investing in (at least) two greenfield synchronous condensers (estimated at $80 million each) to provide general system strength and inertia. The timing for delivery is dependent on the timing of new renewable generation and repurposing of coal-fired generators.
- Implementing synchronous condensers and/or batteries as part of QREZ developments to provide additional system strength to support new renewable generation. The installation will be coordinated as part of the QREZ connection program, including costs.

To ensure reliability and resilience of supply, initial coal-fired unit conversions to synchronous condensers will be designed to be reversible. This allows units to return to service for forecast renewable droughts or contingency events such as coincident long duration forced outages of other generators.

System strength and inertia

System strength is one determinant of how well the power system can return to normal operation following a disturbance or fault or how quickly the power system voltage waveform can be restored to the consistent sine wave. In practical terms, power systems with system strength can maintain more stable voltages following changes in power flows.



System strength contribution and inertia are design and operational characteristics of synchronous generation technology that are not yet easily replicated in invertor connected generators and batteries. They are provided by synchronous generation as a by-product of energy production, and by synchronous condensers. As synchronous machines change operating patterns (e.g. when they are displaced in the bid stack or retire) the power system loses both system strength and inertia.

Local increases in the level of invertor connected resources can increase the need for system strength in that part of the power system since these resources currently require system strength to operate stably.

System strength is expressed in the National Electricity Rules by reference to fault levels while inertia to rates of change in frequency (RoCoF). They are related because inertia is critical for the power system's resilience to changes in active power (megawatts). In spite of these similarities, their remediation is different. For example, if synchronous condensers are used to address a fault level shortfall, they will provide enough fault level, but will not address an inertia shortfall unless they are coupled with a rotating mass or flywheel.

Clean energy hubs

At present, the role of coal-fired units extends beyond the generation of electricity – these units provide critical system services, dispatchability, system strength and inertia. On the optimal infrastructure pathway, as coal-fired generation reduces, these services must be replaced by other services that can maintain a reliable, secure electricity supply.

In Queensland, there is around 8,100 MW of coal-fired generation provided through 22 units located across eight power stations. This equates to supplying approximately 70 per cent of Queensland's annual electricity demand. CS Energy and Stanwell ("GenCos") wholly own, operate and control 12 coal fired units, as well as CS Energy having a 50% interest in the Callide C Power Station and dispatch control over the Gladstone Power Station. Millmerran is privately owned, operated, and controlled.

Stanwell and CS Energy will progressively repurpose existing publicly owned coal-fired units into 'clean energy hubs'. This means converting the generating units to synchronous condensers,installing batteries and/or installing new generation at the power station sites. Clean energy hubs will provide critical system strength, inertia, firming and storage, and help replace the system services provided by coal-fired generation.

Over time, the operating state of coal-fired units will change. Four operating states have been identified: (1) generating electricity, (2) reserve: operating seasonally, (3) repurpose: operating as a synchronous condenser, or (4) reinvest: decommissioned. These terms are defined below.

1. **Generating electricity:** the current operating condition (excluding overhauls/forced outages etc).
2. **Reserve - operating seasonally:** removing one (or more) units from service during periods of sustained low electricity demand on the network. In Queensland this typically corresponds to the autumn and spring periods where ambient temperatures are usually mild and there is minimal heating or cooling loads. Removing and storing one (or more) units from service allows the remaining units to operate at higher loads/capacity factors, improving efficiency and economics. These stored units can also provide reserve generation capacity insurance, as they could be able to be recalled in under two weeks.
3. **Repurpose - operating as a synchronous condenser:** the unit is not exporting power, but instead, the generator is providing system strength and inertia for the network whilst importing a small amount of power.
4. **Reinvest:** the unit is decommissioned and permanently removed from operation as a generating unit and replaced with renewable energy or other energy investments (where appropriate).

By 2035, the Queensland system is anticipated to have sufficient supply and storage to support zero regular reliance on coal generation. Figure 11 indicates the declining reliance on coal-fired generation as new storage and renewable energy capacity becomes operational. Privately owned power stations will make their own decisions in the context of growing renewable energy and storage, but the system is being designed to operate without reliance on coal by 2035.

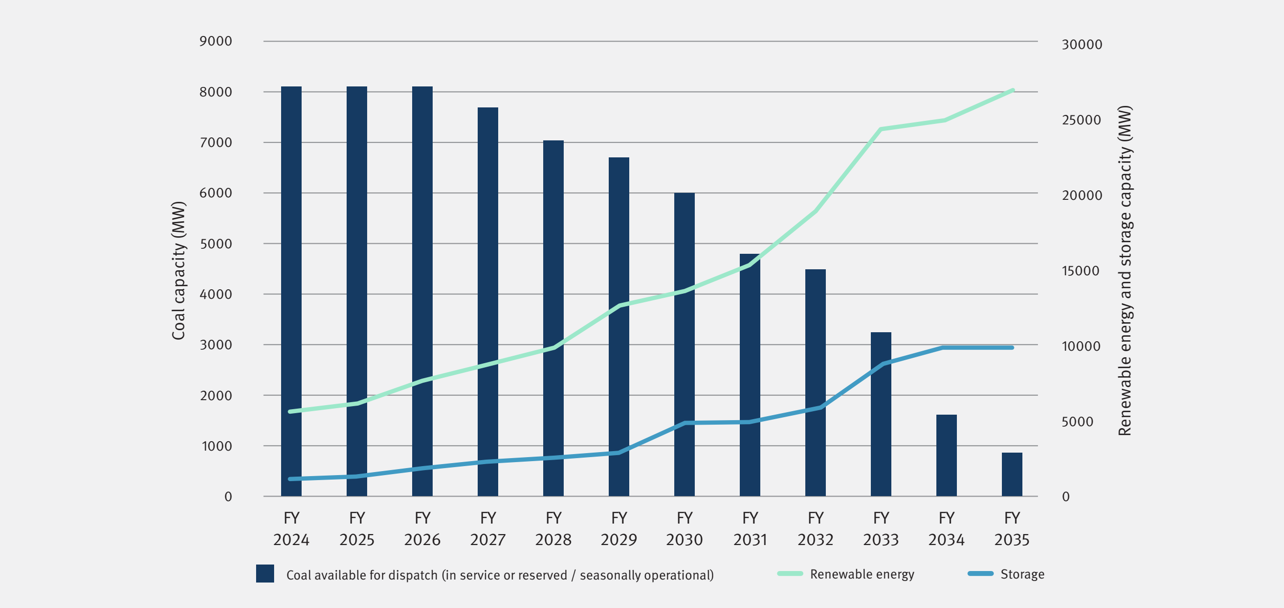


Figure 11: Gradual withdrawal of all coal-fired power stations in Queensland as more renewable energy and storage is built to support a system without coal generation by 2035.

Figure 12 illustrates an indicative reduction and reliance on coal-fired generation that is publicly owned, operated, or dispatched. The blue bars show the coal capacity available for dispatch (in service or seasonal operation), the yellow bars show the capacity that has been converted (i.e. into synchronous condensers) and the red line displays the coal in service.

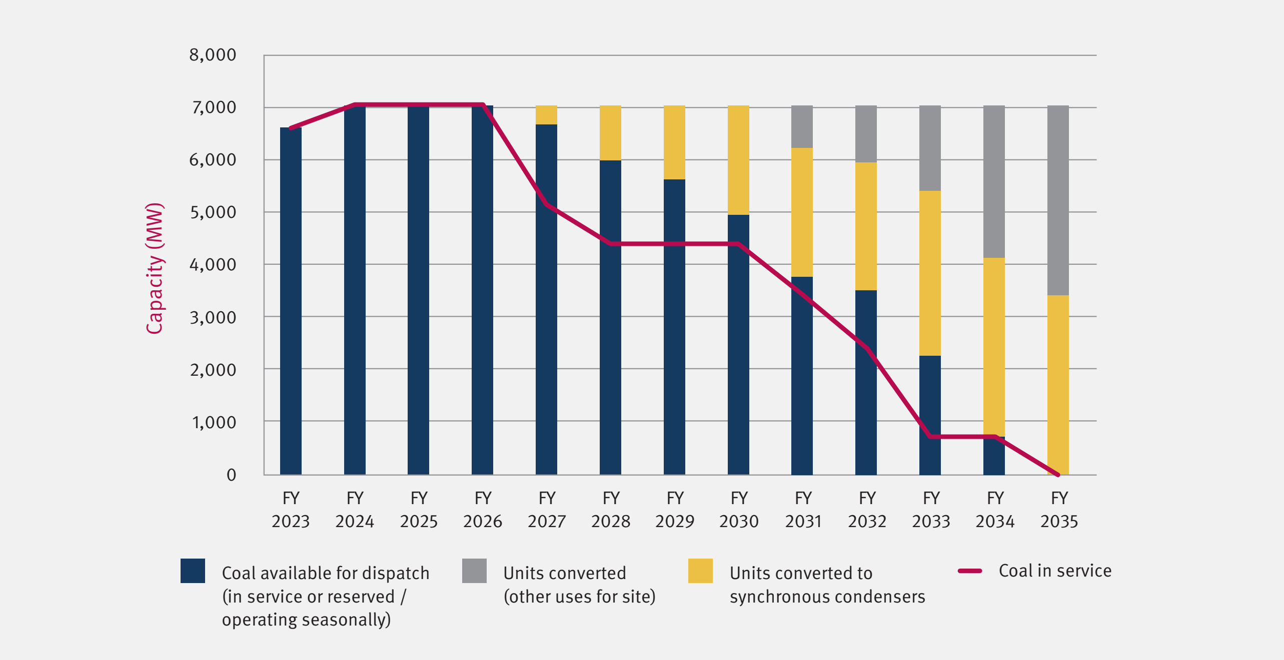


Figure 12: Publicly-owned coal portfolios will progressively transform to clean energy hubs. Coal repurposing is a secondary consideration to energy security, which is dependent on the timing of the PHES assets. MW capacities refer to nameplate capacity.

Delivery program

The Infrastructure Blueprint will ensure peak electricity demand in Queensland is met at all times.
This will be achieved through a controlled and managed conversion of publicly owned coal-fired power stations into modern clean energy hubs, where reliability is paramount.

The Blueprint outlines how the State will lead investment to create a system that is no longer regularly reliant on coal-fired generation by 2035.
The modernisation process of publicly owned coal-fired power stations will commence in 2027. The Government will ensure that significant new wind, solar, hydrogen-ready gas peakers, batteries and long duration storage is in place at critical steps in the energy transformation.

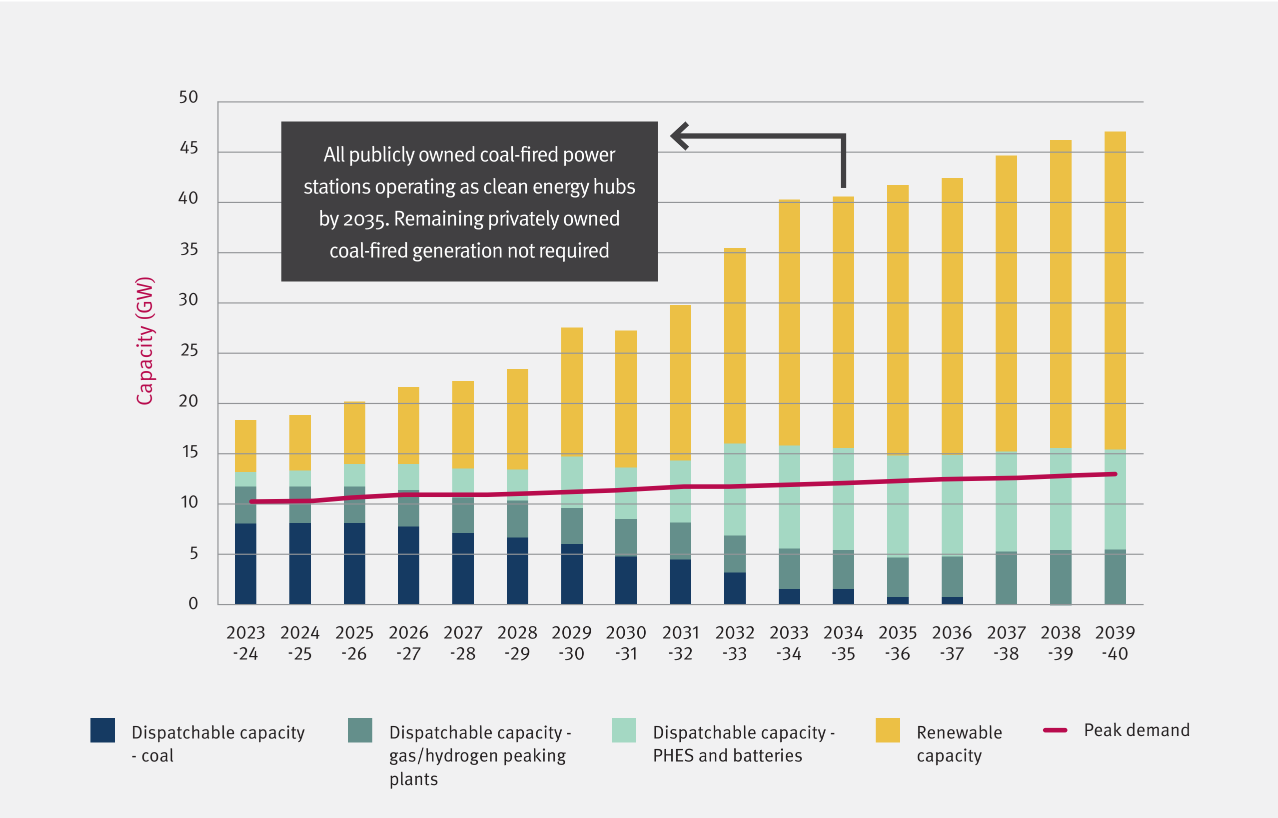


Figure 13: This figure outlines the modelled dispatchable capacity to 2040 of Queensland's future energy system, including from both coal and other sources. It also demonstrates that Queensland is expected to have sufficient dispatchable capacity to meet peak demand at all times.

Ensuring energy reliability and security

Coal-fired power stations will only be converted into modern clean energy hubs when energy reliability is assured and there is sufficient replacement generation, storage and supporting infrastructure in place. This process will commence in 2027, provided it does not impact reliability.

The Government will establish a Queensland Energy System Advisory Board to provide expert technical advice and assessment of the Queensland energy transformation every two years and to support regular updates to this Blueprint.

"Blueprint checkpoints" will enable the Government to check progress and confirm it is possible to move to the next phase of coal-fired power station modernisation. This progression will only occur once reliability is assured.

The process

The Queensland Government will work with individual Government-owned energy corporations to develop long term strategic plans to reflect the Government's commitment to gradually convert all publicly-owned coal-fired power stations into clean energy hubs by 2035 and to meet the State's renewable energy targets.

Phase 1: Gradual shift to seasonal operation or synchronous condenser conversion (which is reversible) for one or more units from 2027. These units will continue to operate in peak demand periods, such as summer and mid-winter, and maintain thermal generation in "reserve" as back up capacity.

Phase 2: Once the first long duration PHES is online, further conversion of units to seasonal operation and reversible conversion to synchronous condenser (except for Callide B power station which is currently scheduled to retire in 2028). Synchronous condensers provide essential stability to the system.

Phase 3: Once the second long duration PHES is online, further conversion of units to seasonal operation and reversible conversion to synchronous condensers, as well as ongoing operation as clean energy hub including potential on site storage, dispatchable capacity, hydrogen development, and operations and maintenance bases for publicly owned large-scale renewable energy.

Power Station	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30	30-31	31-32	32-33	33-34	34-35	→
Stanwell (4 units)	No Change				Phase 1			Phase 1 / Phase 2	Phase 2		Phase 3			
Tarong & Tarong North (5 units)	No Change				No Change / Phase 1	Phase 1		Phase 1 / Phase 2	Phase 2			Phase 3		
Callide B (2 units)	No Change				Phase 1	Phase 2	Phase 3							
Kogan Creek (1 unit)	No Change												Phase 1	Phase 3
Large-scale Renewable Capacity (total)		5.2	5.6	6.2	7.7	8.7	9.9	12.7	13.6	15.4	19.4	24.4	25.0	→
Dispatchable Capacity (total)		13.2	13.3	14.0	14.0	13.6	13.5	14.8	13.7	14.3	16.0	15.8	15.7	→
Peak Demand		10.3	10.4	10.7	10.9	11	11.1	11.3	11.5	11.7	11.7	12.0	12.1	

Figure 14: The above figure outlines the indicative modernisation schedule for Queensland's publicly owned coal-fired power stations. The final phasing will be confirmed with individual GenCos.

Increased load development

The emergence of large new loads on the Queensland electricity system, such as high electrification or those brought on by new industries and in particular a renewable hydrogen export industry, will require large-scale renewable energy, storage, firming and transmission developments beyond those outlined in the optimal pathway. Renewable hydrogen has the potential to greatly increase existing energy demand loads. The associated energy infrastructure should be considered specifically with industry development, and it must be coordinated. Coordination is necessary to ensure a new export industry is not developed at the expense of existing consumers and taxpayers.

The Queensland Government commissioned Advisian to undertake an extensive study to provide foundational information for the emerging renewable hydrogen industry in Queensland. To achieve this, the assessment aimed to clearly describe attributes in regions to help:

- inform policy and land-use planning
- facilitate Queensland Government cross-departmental coordination efforts
- understand hydrogen development potential based on resource availability.

Furthermore, the assessment looked at region specific impacts of potential hydrogen value chains on infrastructure corridors including separation distances, land availability, water availability, renewable generation capacity and network requirements. The study took a more in depth look at Queensland's priority ports: Townsville, Abbot Point, Hay Point/ Mackay and Gladstone. Other ports along the Queensland coast were also considered as part of a higher-level analysis.

Demand for renewable energy

Generally, existing regional electricity infrastructure development has been demand (load) driven. As a result, the capacity of existing infrastructure is reasonably well matched to existing demand in the regions. The introduction of a new electricity intensive industry, such as renewable hydrogen, will require more infrastructure and planning.

The electricity system and QREZs will need to expand to support additional demand for renewable energy into the future. This increased demand could be driven by the decarbonisation of transport and other major industrial sectors of Queensland's economy (such as major industry in Gladstone, Townsville, and the Bowen Basin). Each sector is competing for the same renewable energy resources and transmission access.

The potential for large scale renewable hydrogen projects, relying on the existing electricity system to supply hydrogen and production facilities is limited. High QREZ commitments to the NEM and industrial decabonisation mean that the variable renewable energy capacity of those close-to-load REZs will be highly sought after. Export scale hydrogen projects are each expected to have electricity demand between 1000 MW and 3000 MW, potentially requiring an additional 3000 MW to 9000 MW of installed generation capacity. These substantial additional generation assets will need to be appropriately planned for and utilised where possible to provide critical mass in helping unlock additional renewable resource areas.

Advisian suggests that hydrogen variable renewable energy could be expanded towards west Queensland.[26] This could involve hydrogen projects accessing the North Queensland Clean Energy Hub at Hughenden within the Northern QREZ region and the Barcaldine REZ in the Central QREZ region. Figure 13 shows these locations as Q2 and Q5 respectively.

[26] Ibid. Chapter 4, p10

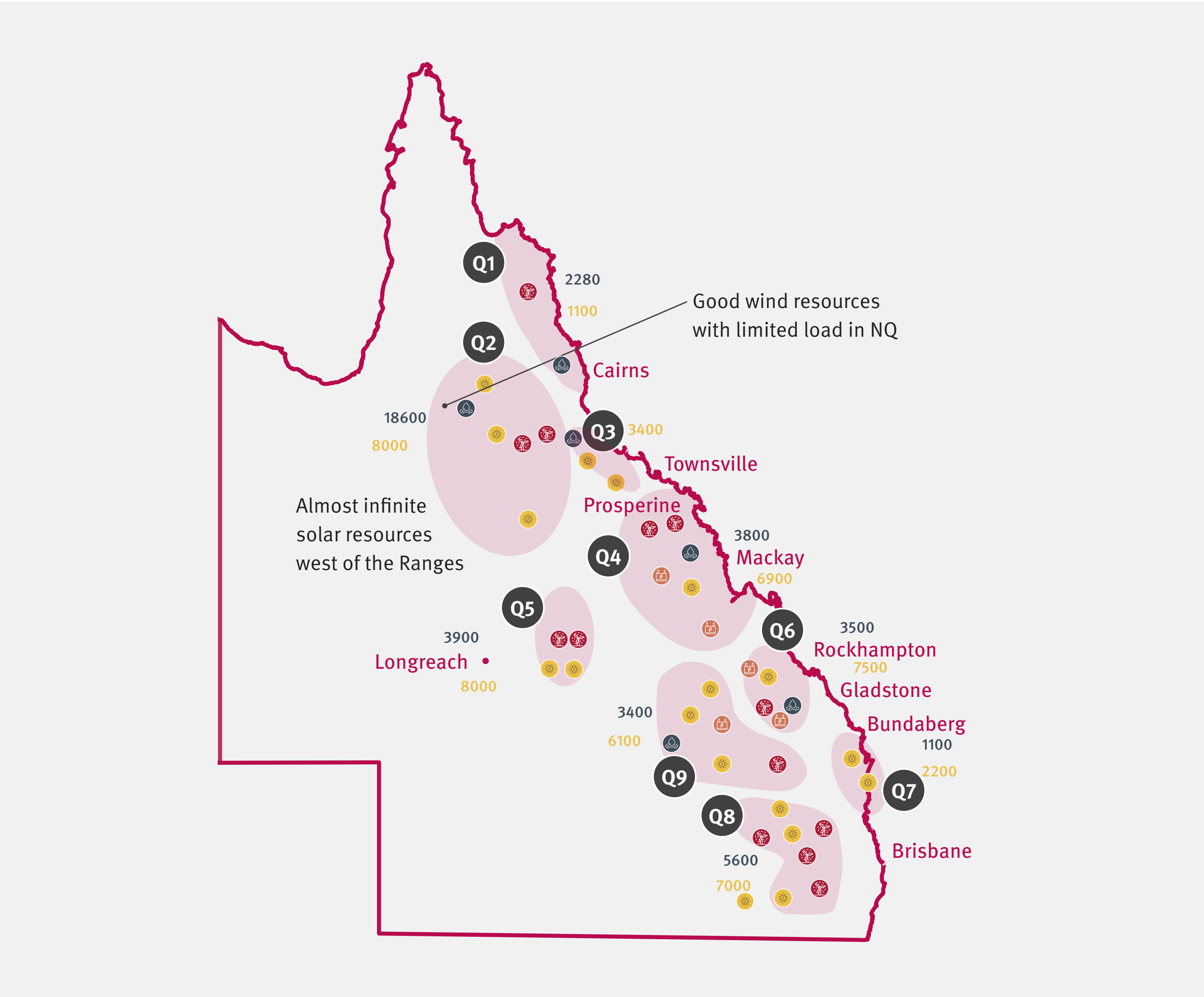


Figure 13: Renewable energy opportunities for hydrogen loads. Yellow numbers indicate potential solar resources, blue numbers indicate potential wind resources.

Requirement for energy storage

The Blueprint includes the construction of two large scale PHES (of at least 6000 MW at 24-hour capacity) as cornerstone assets for delivering the energy transformation. There are also other smaller scale storage projects proposed and/or under development in Queensland.

The scale of electrical energy storage potentially required for large new loads will present challenges. The introduction of storage combined with large loads such as hydrogen can be beneficial as it flattens the overall operating profile and increases asset utilisation. Methods for achieving this higher utilisation have been studied and include:

- diversification of renewable supply, such as combining both wind and solar sources of generation to improve capacity factors
- reliance on interconnectivity with other regions within Queensland and other states, where renewable energy supply is unaffected by certain weather events at a particular time of the year
- inclusion of localised short term energy storage (1-4 hours), such as BESS or metal hydride hydrogen storage to support short term variable renewable energy output reduction
- inclusion of medium-term storage, such as PHES, or large diameter interconnected gas pipelines

Queensland Government studies have identified potential sites suitable for large-scale PHES assets and these could be developed in the future to assist in meeting firmed power requirements for new large loads. The Blueprint does not consider PHES development beyond the Borumba PHES and the Pioneer-Burdekin PHES at this stage.

Preferred development

The Blueprint considers the augmentation and upgrades required to address demand as forecast under the AEMO Step Change scenario. This is expected to cover the requirements of the NEM decarbonisation and industrial decarbonisation (via electrification of existing industries).

The emergence of Queensland as a renewable hydrogen exporter has been foreseen and is supported through the Queensland Government's *Hydrogen Industry Strategy 2019-2024*. However, because of the emerging nature of the industry, additional facilitating infrastructure has not been specifically included in the Blueprint at this point in time. Advisian's report helps demonstrate that as the industry grows it could become, by far, the largest consumer of electricity in the state – representing an energy demand many multiples the size of the Boyne Smelter (Queensland's current largest load).

It is important that new large loads are coordinated to ensure best outcomes for consumers. Future updates of this Blueprint will monitor and consider the development of the hydrogen industry and how it can be accommodated within an optimal infrastructure pathway.

Costs

The Infrastructure Blueprint represents around $62 billion of industry wide capital investment in the energy system. It is important to note that this investment is over a timeframe of around 15 years involving both Government-owned Corporations (GOCs) and the private sector. Also, this estimate is not an incremental cost, with the system requiring renewals under any scenario (as existing assets approach end of life and the need to reach net zero emissions commitments by 2050).

The PHES investments have asset lives greater than 50 years. Once operational, they will deliver significant benefits to the system. The transmission and REZ investments are opportunities for the State to seek federal funding towards these investments to help manage the impacts.

There is a role for the private sector as well as GOCs in relation to new renewable generation developments, with a timeframe for delivering these investments of around 10-15 years. Reflecting Government policy, GOCs will maintain majority ownership of generation in the energy system.

The Queensland Renewable Energy and Hydrogen Jobs Fund (QREHJF) has been boosted to $4.5 billion funded from the 2021 coal royalties investment. The QREHJF allows Government to set priorities and utilise the GOCs to identify projects, deliver infrastructure and maximise consumer outcomes.

Key transformation steps

This Blueprint outlines a pathway to transform the electricity system and build Queensland's clean, reliable and affordable SuperGrid.
This transformation will be coordinated and well-sequenced to ensure system security and reliability are maintained throughout and post transformation.

Building on our strong foundations (2022–2024)

↓

Scaling and expanding opportunities (2024–2028)

↓

Preparing for net zero (2028–2035)

Building on our strong foundations (2022–2024)

The Plan will provide clear signals to investors and capital markets of Queensland's pathway to transform and decarbonise the electricity system. Following release, the first two years will focus on laying the foundations for a clean, reliable and affordable system – it is about delivering the right investment environment, providing market signals and critical decisions on large-scale, long duration PHES which will underpin the future system.

Scaling and expanding opportunities (2024–2028)

This phase is about continuing to build renewable energy capacity through the QREZs and commencing the repurposing of Queensland's publicly owned coal-fired power stations into clean energy hubs.

Preparing for net zero (2028–2035)

This final phase is about ramping up renewable energy generation, planning for how the energy system will achieve net zero emissions by 2050 and progressively repurposing the remaining publicly owned coal-fired power stations into clean energy hubs.

Conclusion

This Blueprint provides a point-in-time outline of the optimal infrastructure pathway to deliver a clean, reliable and affordable Queensland electricity system. This pathway is built around two foundational large-scale PHES developments, which will provide critical storage and firming services as Queensland's reliance on coal-fired generation reduces.

QREZ will be a key enabler of cost-effective and efficient connection and development of new large-scale renewable generation. New high-voltage transmission (up to 500kV) will efficiently connect QREZ and PHES to demand centres creating a SuperGrid transporting thousands of megawatts of renewable energy to consumers all over Queensland.

QUEENSLAND ENERGY AND JOBS PLAN

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2022