The Opportunity for Distribution Networks in Delivering the Energy Transition

July 2023

Executive summary

- Australia is undertaking a fundamental shift to decarbonise electricity generation. Federal and State Government targets will see the proportion of renewable generation capacity grow from less than 50% in 2020 to over 80% in 2030. Under current plans and forecasts for a predominantly centralised transition, this will require development of over 30 GW of utility scale renewable generation and storage plus new transmission infrastructure to connect this generation to the wider network

- There are significant challenges to delivering this scale and pace of investment. The transition timeline requires a doubling of the renewable build rate, which will strain workforce availability, logistics and international supply chains. Additionally, large-scale energy projects have suffered from cost increases and schedule delays, and increasingly are experiencing community opposition due to impacts to local amenity.

- It is now almost certain that the planned utility-scale buildout will be delayed, leading to a material risk that the operation of coal fired generators will need to be extended. NSW, with the planned closure of Eraring in 2025, and Victoria, with the planned closure of Yallourn in 2028, are particularly exposed. While there is a sufficient pipeline of renewable projects to backfill these closures, a year delay to project delivery in NSW would see generation capacity fall short of requirement in 2026

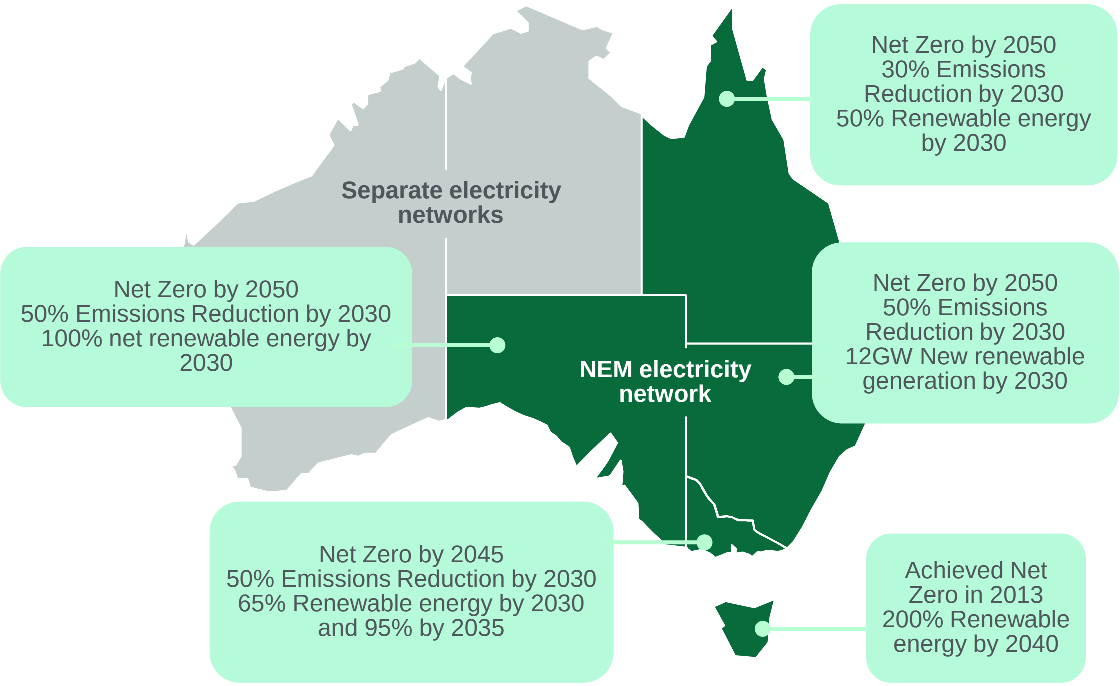
- Accelerating the uptake of rooftop solar in the distribution network, complimented by distributed batteries, represents an opportunity to mitigate such potential delays in utility scale build-out. AEMO's ISP Step Change forecast sees rooftop solar penetration reach 45% of households in 2030, but there remains headroom above this level. Penetration continues to grow post 2030, reaching 51% in 2040

- L.E.K. has assessed an accelerated rooftop solar scenario, whereby the 51% penetration of 2040 is brought forward to 2030. This scenario delivers an incremental 5.2 GW of generation capacity in 2030 and is achievable within historical execution capacity. To support this incremental solar capacity 2.7 GW of distributed batter storage would also need to be added to the network, to manage the impact to minimum demand

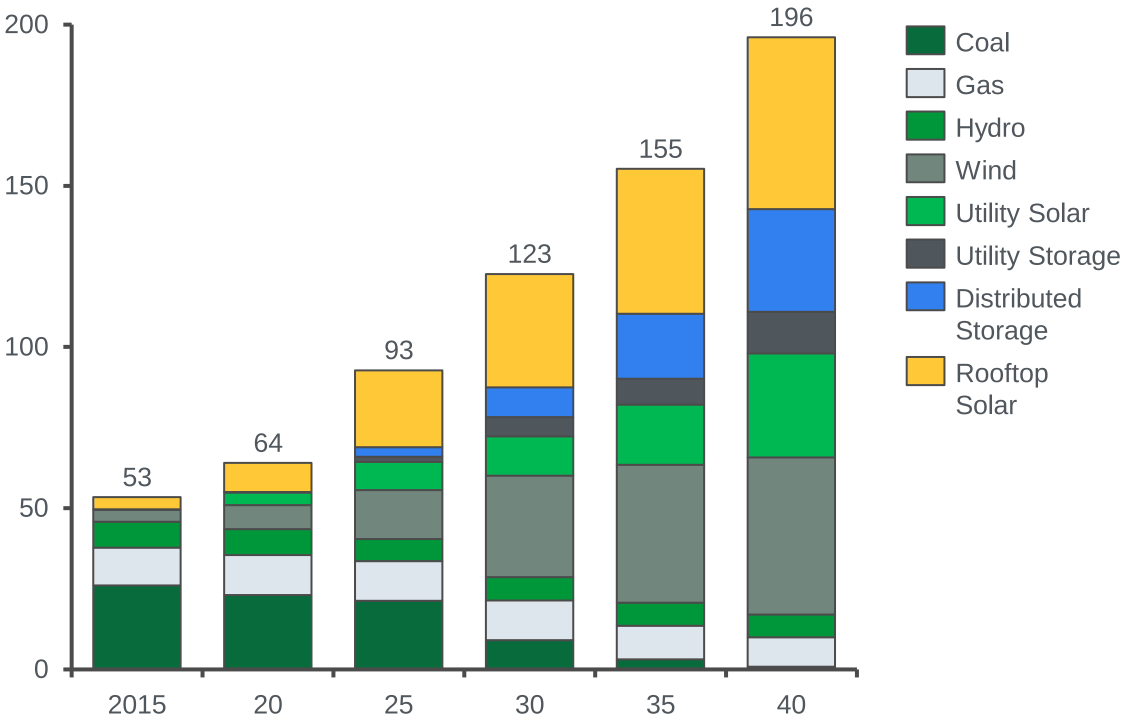
- Delivering this incremental rooftop solar and storage would cost up to $5.8 billion, which compares favourably with utility-scale generation projects. Relative to the challenges with utility-scale developments, this scenario further represents reduced execution risk and is readily implementable. While more detailed and localised analysis would facilitate tighter quantification, at a screening level this scenario represents an attractive opportunity for Governments to mitigate the risks to delivering on their energy transition ambitions

Australia’s energy transition targets will see a fundamental shift in the generation mix in the NEM

Net Zero by 2050
43% Emissions Reduction by 2030
82% Renewable energy by 2030



Generation capacity in the NEM (AEMO Step Change scenario*) (FY2015-40F)
GW



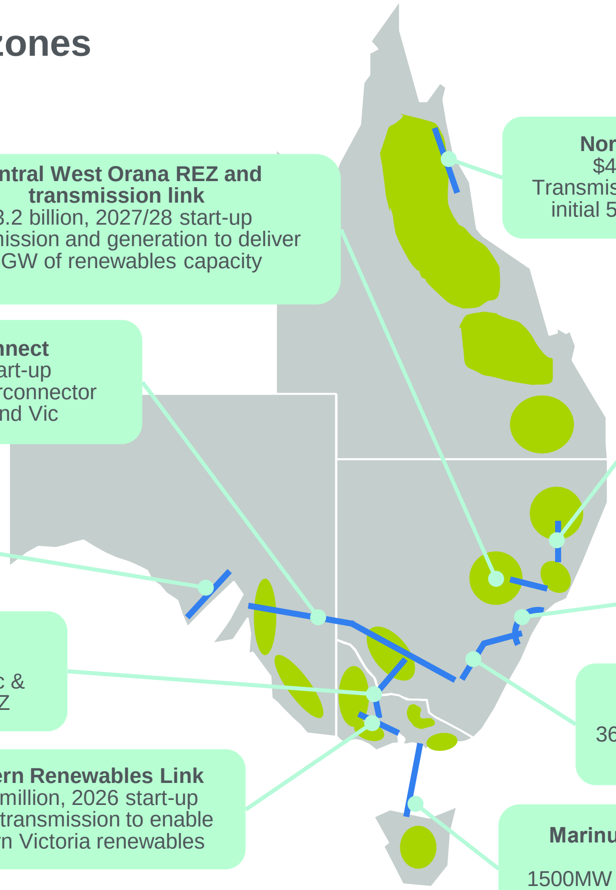
29%	45%	64%	83%	91%	95%	**% Renewable**

Note: All references to AEMO ISP and associated data utilise the Step Change scenario
Source: AEMO 2022 ISP (Step Change scenario); AER State of the Energy Market; Australian Federal and State Governments

Significant investments in renewable generation and new transmission infrastructure over the next 10+ years are planned to deliver this transition

NOT EXHAUSTIVE

Key NEM renewable energy zones and transmission projects



In total by 2035…

Over 5,000km of new transmission

Over 30 GW of REZ-hosted utility scale wind and solar generation

Over $25 billion in transmission investment

Legend

- Transmission network projects
- Renewable Energy Zones (REZ). Areas with high wind and solar potential and prioritised for development

Note: * Planning and consultation is underway regarding further REZ investment as part of the 2023 Queensland Renewable Energy Zone Roadmap

Source: AEMO 2022 ISP (Step Change scenario); AER; ElectraNet; PV magazine; AFR; Marinus Link; Transgrid; EnergyCo

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There are, and will continue to be, significant challenges to delivering this scale and pace of investment

1	**Required pace of development**	The required build rate is faster than Australia has delivered to date, and comes at the same time as all other economies are seeking to execute the same
2	**Cost and schedule challenges**	The investment costs are very large, and, based on experience from other large infrastructure projects, are likely to increase as projects are better defined
3	**Maintaining social licence**	There are increasing social licence challenges particularly with new transmission, which is likely to delay execution and / or increase cost

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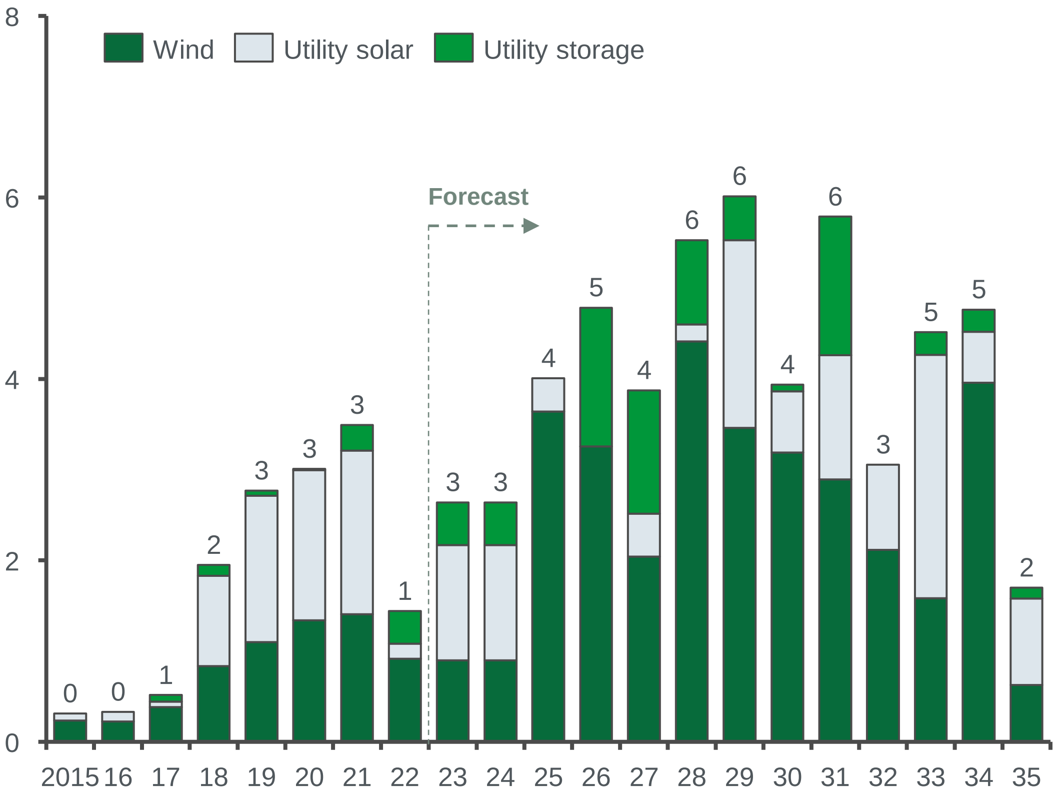
The required doubling of utility scale renewable generation build rate (and tripling the pace of wind farm development) will be challenged by workforce availability, logistics and supply chain constraints

Incremental renewable generation capacity in the NEM (FY2015-35F)
GW



There are significant challenges to this build rate…

Skilled workforce availability

- It is variously estimated that **up to 100,000 skilled workers will be required** to deliver the energy infrastructure required by 2030
- **These workers require specialised skills**, such as electrical and grid engineers, while others, such as construction mangers, see competition from other large infrastructure projects
- **Infrastructure Australia has highlighted skilled workforce shortages as a major risk** to the energy transition

Logistics infrastructure constraints

- Developing additional 30GW of renewables capacity by 2030 will **require c.750 wind turbines & c.1.6 million solar panels per year***
- This will place **significantly strain on logistics infrastructure**. As example, road alterations & shutdowns were required for 16 months to deliver 200 turbines for the Clarke Creek wind farm
- Import of materials from international manufacturers will also place **further pressure on already strained ports**

International supply chain competition

- Australia is **decarbonising at the same time as other, larger, economies**
- The IEA estimates that the current **global annual capacity build of c.300GW/yr (100x Australia's rate)** will need to increase to over 1,000GW by 2030 to reach Net Zero by 2050
- However, **manufacturing capacity of wind turbines may be challenged to meet this demand**, which will lead to competition for supply (however, it is also recognised that solar cell and battery manufacturing have successfully scaled up with demand)

Note: Historical data from AER reports has been converted from CY to FY to align with AEMO basis; * Calculated based on 4kW wind turbine and 450W solar panel capacity
Source: AEMO 2022 ISP (Step Change scenario); AER State of the Energy Market; IEA State of Clean Technology Manufacturing, Net Zero by 2050; Productivity Commission; Infrastructure Australia; ARENA

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2 The costs of delivering required transmission projects are large and likely to grow

Many projects are still in the development stages, with the potential for cost escalation from design changes and material & labour escalation

Project progression

Project	Cost Estimate*	Stage
New England REZ	$4.8 billion	Early scoping
Sydney Ring	$1 billion	Early scoping
VNI West (KerangLink)	$3.3 billion	Detailed planning
Marinus Link and Tasmania 'Battery of the Nation'	$7.1 billion	Detailed planning
Central-West Orana REZ	$3.2 billion	Detailed Planning
HumeLink	$3.3 billion	Detailed planning
Western Renewables Link	$300 million	Detailed planning
Northern Queensland REZ**	$45 million	Detailed Planning
Project Energy Connect	$2.3 billion	Execution
Eyre Peninsula Link	$300 million	Completed

Multiple current energy transition projects have experienced significant cost increases and delays

snowy 2.0

- Snowy 2.0 is the largest committed renewable energy project in Australia and links two existing dams with a new underground power station
- **When first announced in 2017 the project was set to cost $2 billion, with a target completion date of 2021**
- The project cost estimate has repeatedly increased. In February of this year the **project cost was increased to $5.9 billion, with startup delayed until the end of 2027**
- The project was impacted by the collapse of construction company Clough in December 2022, and media reports and market observers predict further cost and schedule increases due to ongoing construction delays

Project EnergyConnect

- Project EnergyConnect is transmission interconnector between South Australia and New South Wales, with an added connection to Victoria
- The project **cost has increased almost 50% from $1.5 billion in 2018 to $2.3 billion in 2022**
- The project has been impacted by increased labour and material costs across the sector, supply chain shortages, community opposition and the Clough collapse

NSW GOVERNMENT

- Several other NSW government projects have also had notable increased costs and time bloat
- Central-West Orana REZ has **seen costs increase from $650 million to $3.2 billion, and the schedule has shifted from July 2025 to 2027-8**
- Hunter Transmission **Project costs have increased from $880 million to $990 million**
- While the New England REZ has not yet experienced cost increases, the project is **now slated for 2029 instead of July 2027**

Notes: *As of June 2023
** Planning is underway regarding additional REZ investments as part of the 2023 Queensland Renewable Energy Zone Roadmap

Source: ABC News; AFR; The Australian; The Sydney Morning Herald; The Guardian; Project EnergyConnect; Snowy Hydro

3 Social licence is increasingly a challenge, particularly for new transmission infrastructure

While there is broad support for decarbonisation, many energy infrastructure projects are experiencing local opposition due to the visual impact of overhead lines, construction disruption and safety concerns

The impacts of these social licence challenges have been…

- Project delays due to community-driven legal processes and Government inquiries. These processes can stall project progression, and their outcomes can extend schedules through additional approval requirements or route changes
- An attempt to fast-track the Western Renewables Link development process is currently being litigated in the Supreme Court of Victoria (*case study opposite*)

- Cost increases resulting from schedule delays, route re-design, and in some instances changing from overground to underground transmission lines
- Undergrounding lines can increase costs by up to 16x. However, following local council and community push-back, Acciona Energia agreed to underground 15km of transmission lines from its Mortlake South Wind Farm

- Provision of ongoing payments to landowners who host transmission infrastructure may be necessary to garner community support and get projects approved
- Projects in Queensland, New South Wales and Victoria have offered to pay landowners, with Queensland the most generous at $300,000 per km over the project life. Despite offers of $200,000 per km in Victoria, many impacted do not feel this is sufficient compensation and continue to protest projects:

  "…It's an arbitrary number that's not enough to mean anything…"

  - Emma Germano, Victorian Farmers Federation President, Feb 2023

Case study: Western Renewables Link

- The Western Renewables Link is a proposed 190km overhead electricity transmission line, carrying renewable energy from Bulgana in western Victoria to Sydenham in north-west Melbourne
- The proposed design would install 500 kV high-voltage transmission lines as high as 85 meters above ground, which has led to protests and legal challenges from impacted farmers, landowners, and community groups
- Those impacted are questioning why the transmission line is not being built underground, and if protests are successful proposed spend would increase from $300 million to $3-4.8 billion
- The Moorabool and Central Highlands Power Alliance (MCHPA) started court proceedings in the Supreme Court of Victoria against Victorian Energy and Resources Minister Lily D'Ambrosio in May, arguing that the minister's February order to fast-track the project was unlawful
- MCHPA is calling for the relevant cost benefit analysis to be redone with a Regulatory Investment Test of Transmission, and the directions hearing will take place in June. The lengthy process continues to slow down project development

Community group challenges Victoria's energy minister in court over Western Renewables Link

Energy infrastructure payments of $200K deemed 'slap in face' to Victorian farmers

Western Renewables Link protest turns ugly as farmers accuse representatives of 'running into bushes'

'Everyone's against it': the powerlines dispute in one of Victoria's most marginal electorates

Crop farmer "gutted" by Western Renewables Link equity loss, compensation negotiations underway

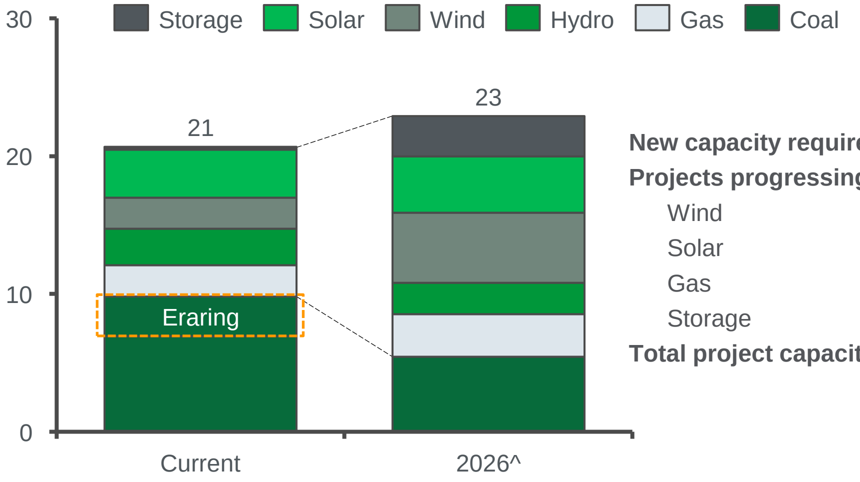
Landholders offered $8000 sweetener for power line disruption

Source: ABC News; Renew Economy; The Guardian; Herald Sun; The Age; Western Renewables Link

As a result of these challenges, the centralised, utility-scale transition will almost certainly be late. Without alternative action, Governments may be required to extend the life of coal fired generation

- In NSW, the Eraring coal fired generator is scheduled to shutdown in 2025
- While there are projects progressing with sufficient capacity to cover this withdrawal, a 1-year delay to these projects would leave NSW short
- In this event, the Government may be forced to extend the life of Eraring

Current and forecast utility scale generation capacity in NSW* (May 2023, FY2026F)
GW



New capacity required +6.6 GW
Projects progressing 33**

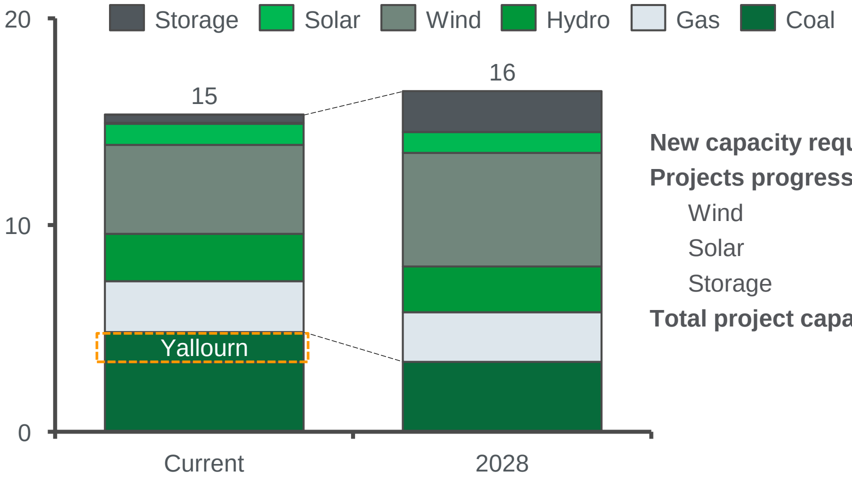
Wind	+1.0 GW
Solar	+1.7 GW
Gas	+1.4 GW
Storage	+3.0 GW
Total project capacity	**+7.1 GW**

If these projects are delayed by 1 year, total capacity added ahead of 2026 drops to 5.9 GW; below the amount required

- Victoria faces a similar situation with the scheduled closure of the Yallourn coal fired generator in 2028. However, Yallourn's smaller capacity contribution, and greater lead time for renewables development sees a less acute challenge
- However, if delays of 3.5 years were experienced on the current project schedules then Victorian generation capacity would fall short without Yallourn

Current and forecast utility scale generation capacity in Victoria* (May 2023, FY2028F)
GW

Note also that Victoria's longer term 2030 / 35 renewable targets rely on Tasmania's Marinus link project, which represents a similar delay risk



New capacity required +2.6 GW
Projects progressing 16**

Wind	+1.2 GW
Solar	+0.7 GW
Storage	+2.2 GW
Total project capacity	**+4.1 GW**

A 3.5-year delay to these projects would be required for capacity added by 2028 to drop below requirement (delay delivers +2.3 GW)

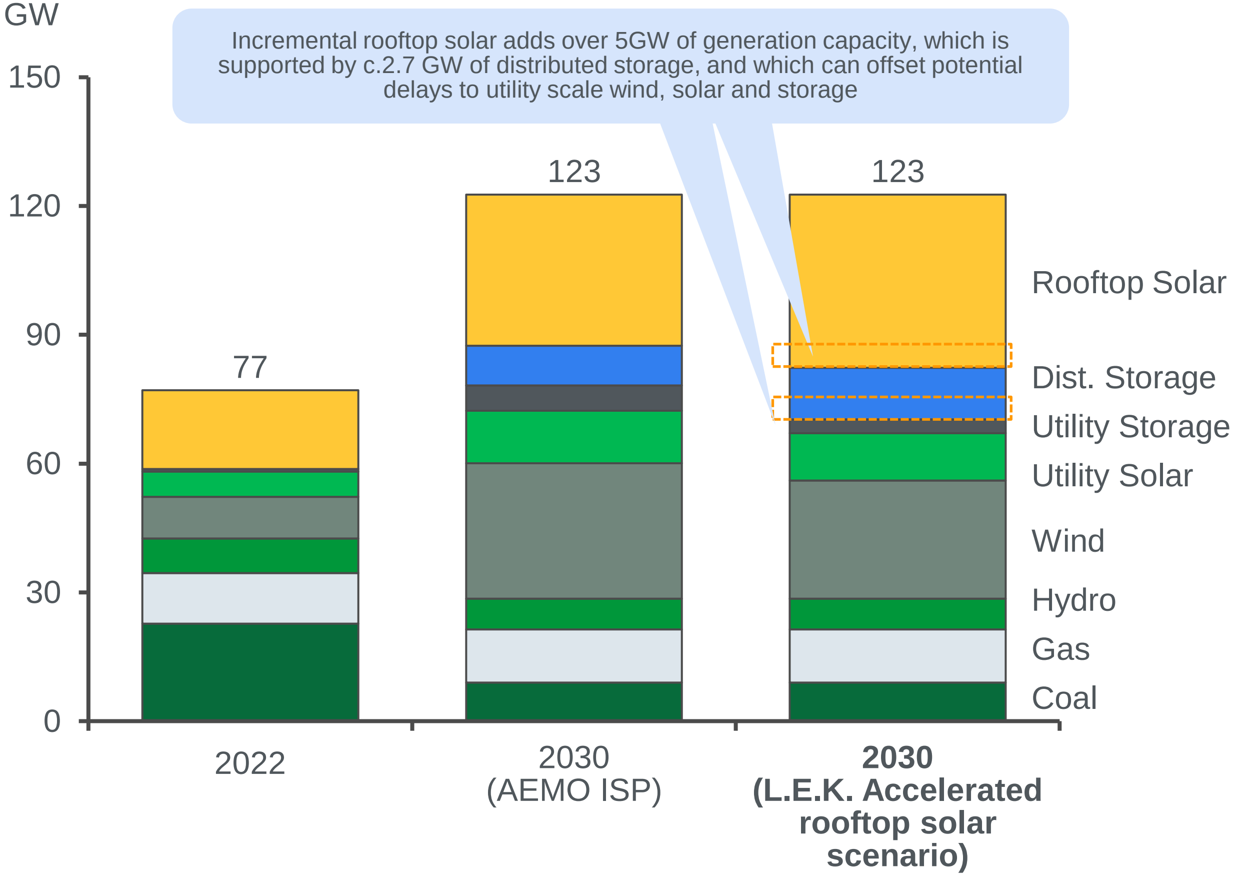
Notes: * Totals do not include rooftop solar PV; ** Project list includes only Committed and Anticipated projects, and those Proposed projects which expected full commercial use dates prior to end-FY2025 for NSW and FY2028 for Victoria; ^ Eraring closure is scheduled for 3Q2025, hence 2026 represents first year post-closure
Source: AEMO 2022 ISP (Step Change scenario), NEM Generation Information

Accelerating the penetration of rooftop solar in the distribution network, complemented by distributed batteries, represents an opportunity to mitigate delays in utility scale build-out

Given the risks to timely delivery of large-scale renewable energy projects, and the criticality of new generation capacity to offset retiring coal, L.E.K. has assessed a scenario leveraging accelerated rooftop solar

1. Accelerating rooftop solar PV uptake, within the constraints of forecast household penetration and historical execution capacity, could add 5.2 GW of generation capacity by 2030
2. To manage load profiles and minimum demand constraints, the incremental rooftop solar would need to be coupled with 2.7 GW of distribution network-level battery storage
3. At a screening level of assessment, this rooftop solar and distributed batteries scenario could be delivered for $5.8 billion, and would represent a relatively low risk and 'doable' opportunity to mitigate delays in large-scale project delivery

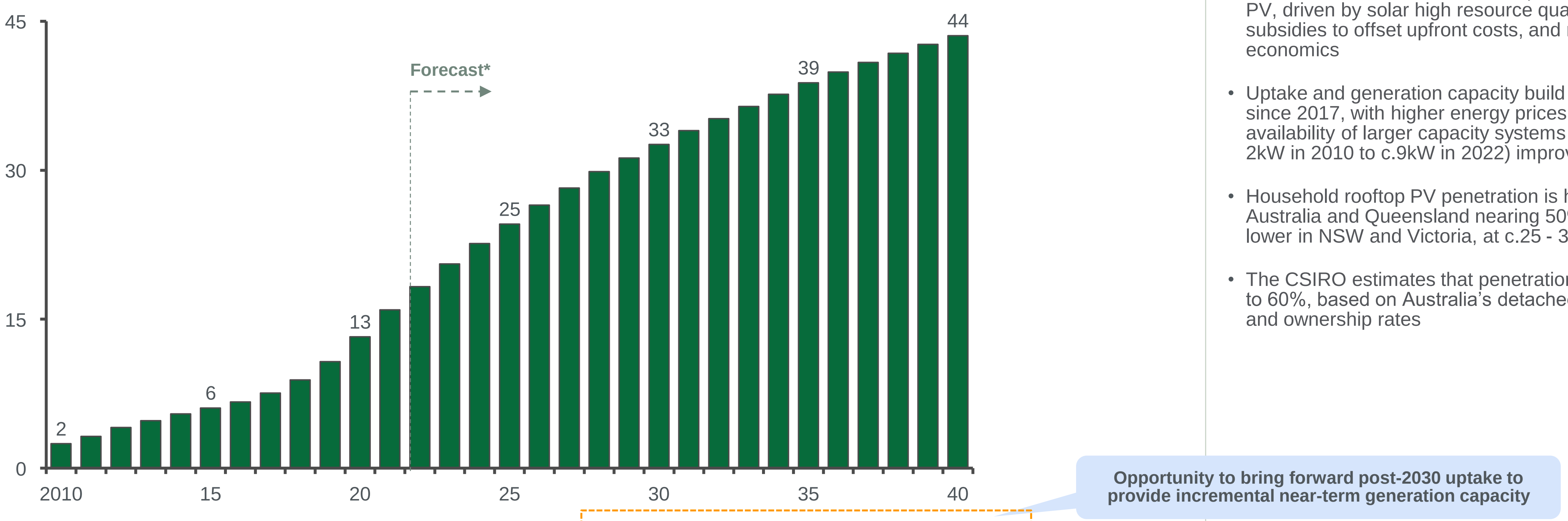
Current and forecast generation capacity in the NEM, by scenario (FY2022, FY2030)



Source: AEMO 2022 ISP (Step change scenario), NEM Generation information; Clean Energy Regulator;

❶ Australia has seen strong uptake of rooftop solar PV, which AEMO forecasts will continue

Rooftop solar PV generation capacity in the NEM, as per AEMO ISP (Step Change scenario)* (2010-40F)
GW



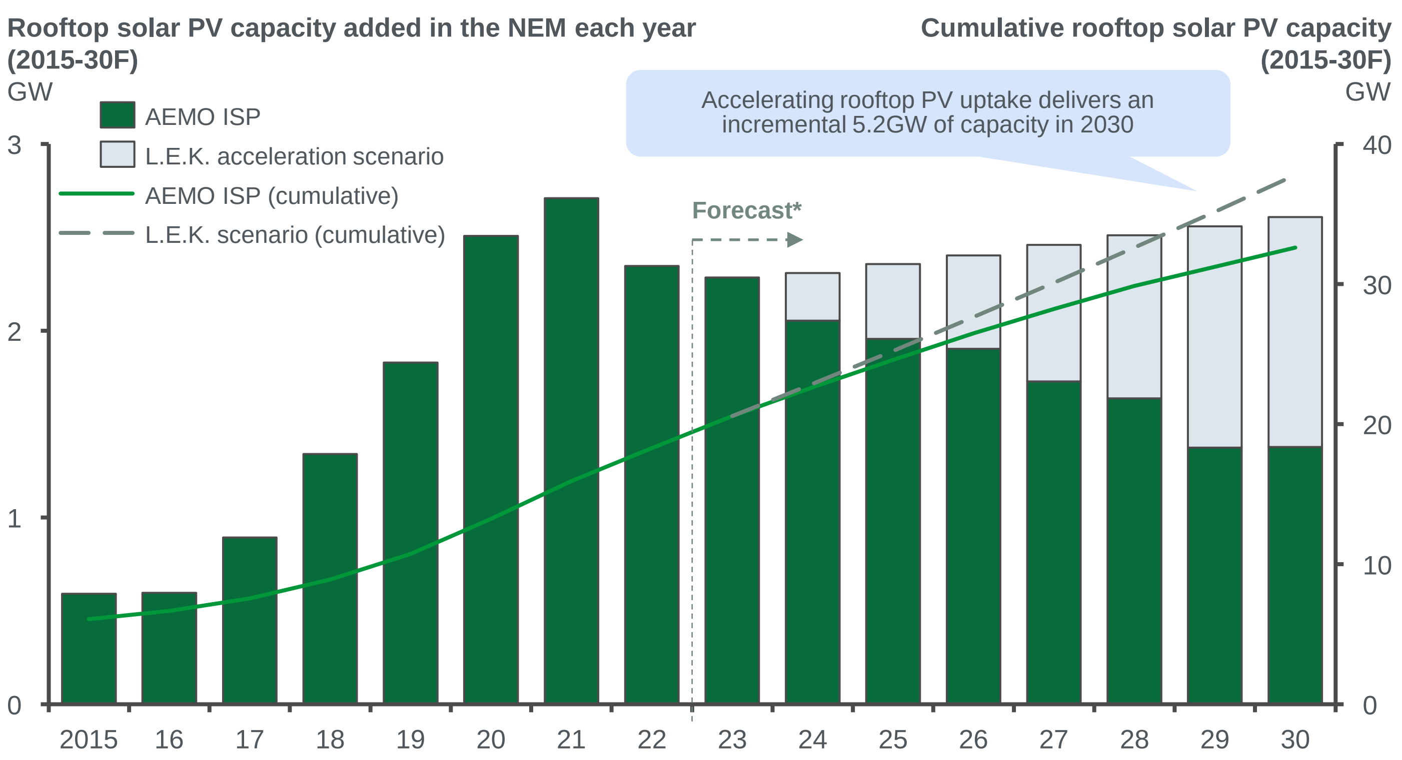
3%	**17%**	**28%**	**41%**	**48%**	**52%**	**54%**	**Rooftop^ penetration**

There is still significant opportunity to increase Australia's rooftop solar PV uptake

- Australia leads the world in the uptake of rooftop solar PV, driven by solar high resource quality, Government subsidies to offset upfront costs, and resulting attractive economics
- Uptake and generation capacity build have accelerated since 2017, with higher energy prices and the availability of larger capacity systems (increasing from 2kW in 2010 to c.9kW in 2022) improving economics
- Household rooftop PV penetration is highest in South Australia and Queensland nearing 50%. Penetration is lower in NSW and Victoria, at c.25 - 30%.
- The CSIRO estimates that penetration can reach close to 60%, based on Australia's detached housing stock and ownership rates

Note: * Note that at YE2022 the total installed rooftop solar PV capacity exceeded AEMO ISP 2022 baseline start point. The AEMO ISP projection has been rebaselined to reflect this higher 2022 installed base; ^ Based on estimates of the number of residential and commercial rooftops in NEM regions.
Source: AEMO 2022 ISP (Step Change scenario); Clean Energy Regulator; ABS; DCCEEW; L.E.K. Research and Analysis

1 Accelerating the uptake of rooftop solar could bring forward over 5 GW of generation capacity by 2030



Rooftop^ penetration

AEMO ISP	34%	39%	43%	46%	48%
L.E.K. Accelerated rooftop PV scenario	34%	39%	44%	49%	54%

- Accelerating rooftop solar PV uptake represents an opportunity to deliver incremental generation capacity into the NEM by 2030
- The L.E.K. scenario accelerates the forecast 2040 household penetration (51%) forward to 2030, which results in over 5 GW of incremental generation capacity
- While an acceleration from AEMO's ISP (Step Change scenario), this scenario still sees annual capacity additions remain below the level achieved in 2020/21 (i.e. within historical execution capacity)
- Driving additional rooftop solar PV uptake could be achieved through increased Government subsidies, or other incentives, to offset the upfront installation cost and decrease the payback timeframe
  - Programs such as Victoria's Solar Homes have supported accelerated uptake since 2018, and could be expanded via broader eligibility or increased subsidies

Note: * Note that at YE2022 the total installed rooftop solar PV capacity exceeded AEMO ISP 2022 baseline start point. The AEMO ISP projection has been rebaselined to reflect this higher 2022 installed base; ^ Based on estimates of the number of residential and commercial rooftops in NEM regions.

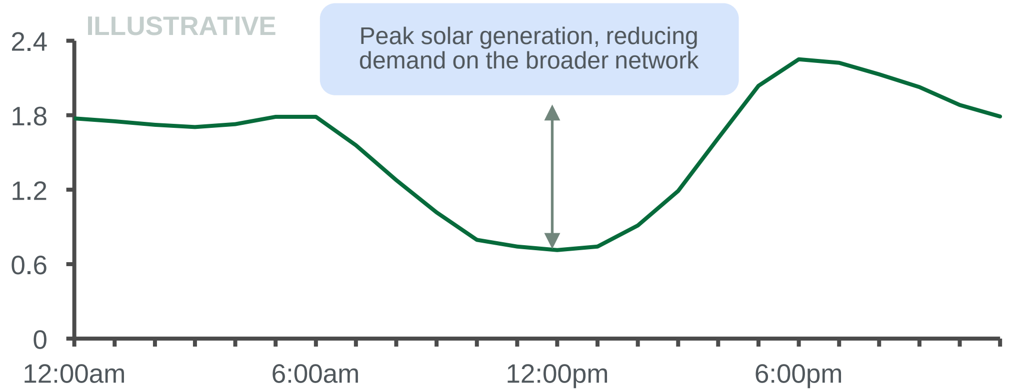
Source: AEMO 2022 ISP (Step Change scenario); Clean Energy Regulator; ABS; Solar Homes; L.E.K. Research and Analysis

2 Accelerating rooftop solar PV does present challenges for networks to manage minimum demand…

Peak solar generation in the middle of the day reduces the demand that households place on the network

- By its nature, solar PV generation is greatest during the middle of the day. For households with solar installed, this generation will offset (and potentially exceed) their usage, which reduces demand for electricity from the network
- With increasing rooftop solar PV uptake, this demand 'trough' in the middle of the day has become more pronounced. For distribution networks this 'trough' is measured as their minimum demand

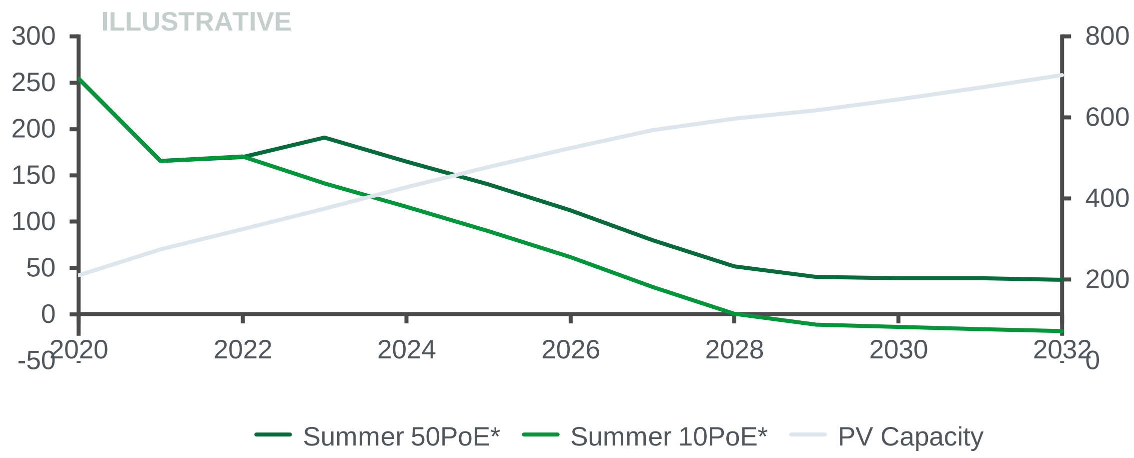
24-hour network operational demand (Illustrative summer day)



This impacts distribution networks via reducing minimum demand, which presents technical challenges for equipment and operations

- With increased rooftop solar PV penetration distribution networks have seen minimum demand decline significantly
- Declining minimum demand is creating technical challenges such as reverse power flows and impacts to network protective functions. With continued decline, networks reach operability thresholds at which point major technical upgrades, or curtailment of solar generation, is required

Distribution Network Minimum Demand Forecast (2020-32F) / **Solar PV generation capacity (2020-32F)**



Note: PoE is Probability of Exceedance, with forecasts provided for both 10% and 50% probability scenarios

Source: AEMO; Office of Energy Efficiency & Renewable Energy; AER DAPR reports

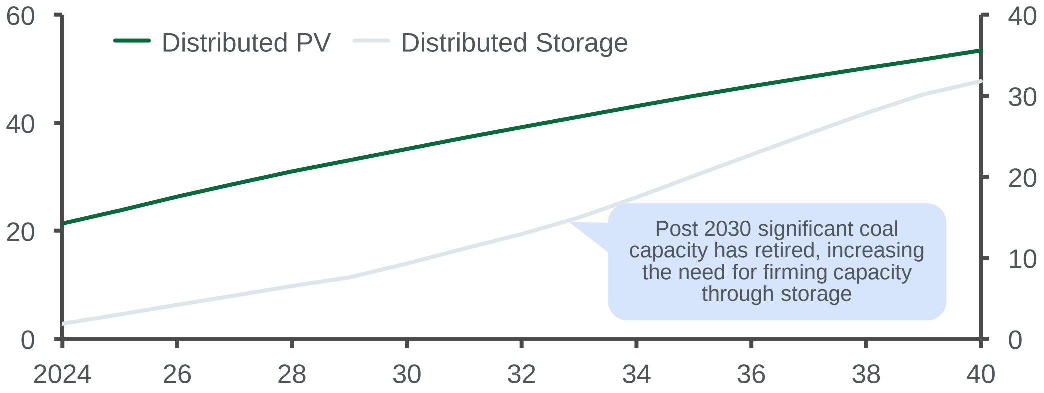
❷ … however, this could be addressed through increasing batteries in the distribution network

AEMO's ISP recognises the challenge presented by minimum demand

- Over the forecast an increasing penetration of distributed storage is incorporated in parallel with distributed solar generation, both to address minimum demand and to provide firming capacity (i.e., capacity that can be turned on / off as needed)
- Prior to 2030 storage is added at a slower rate, but this accelerates post 2030 driven significantly by the need for dispatchable firming capacity

Forecast distributed PV capacity (FY2024-40F) GW

Forecast distributed storage capacity (FY2024-40F) GW



1.9 : 1	0.9 : 1	0.7 : 1	**Addition ratio Solar PV : Storage**

This ratio has been used to determine the battery storage required to support accelerated rooftop solar (*refer opposite*)

Source: AEMO 2022 ISP (Step Change scenario)

Assuming the rate of distributed storage addition prior to 2030 is reflective of managing minimum demand, a total 2.7 GW of battery capacity is required to support the accelerated rooftop solar PV scenario

Accelerated scenario Required battery storage capacity		Units
Total incremental solar PV capacity	5.2	GW
÷		
Ratio of distributed storage required	1.9	ratio
=		
Total distributed battery storage capacity	2.7	GW

This represents a screening estimate, with detailed, local network level, analysis required to fully assess the distributed battery storage capacity required

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3 As a screening assessment, L.E.K. estimates that $5.8 billion would be required to deliver this accelerated scenario, a quantum that compares favourably with utility-scale generation projects

Accelerated scenario cost – solar		Units	Source / commentary
Price of average solar system (9kW system)	8.8k	$	Average price for average sized system in 2023 (and size basis for AEMO ISP)
÷ kW in system	9	#	Calculation converting $/system to $/kW
= Price per kW of average system	978	$/kW	Calculation
× Forecast annual cost reduction	~4-9	% (per year)	Annual cost reduction curve as per CSIRO GenCost forecast* from 2023-2030
× Incremental rooftop solar PV capacity	5.2m	kW	Total incremental rooftop PV over the 2023-30 period (*refer slide 11*)
= **Total cost to deliver**	**3.7b**	$	Calculated total cost to deliver

Accelerated scenario cost - batteries		Units	Source / commentary
Price of average battery system^	1.0k	$	Average Australian market price for 2023
× Forecast annual cost reduction	~4-7	% (per year)	Annual cost reduction curve as per CSIRO GenCost forecast* from 2023-2030
× Incremental distributed battery storage capacity	2.7m	kW	Total incremental battery capacity over the 2023-30 period (*refer slide 13*)
= **Total cost to deliver**	**2.1b**	$	Calculated total cost to deliver

- While estimates reflect a total cost basis, the level of Government investment may be significantly smaller. For rooftop solar, **delivery cost could be predominantly driven by consumers**, with Government funding for partial **rebates and loan schemes incentivising consumers** and **supporting upfront costs**
- This level of **investment** is **comparative to or less than** other large scale utility developments, such as:
  - NSW government renewable energy plan in Central West Orana is expected to require **over $10billion** in private investment to deliver **over 3GW** of new capacity
  - Victoria is targeting **2GW** of offshore wind by 2032, costing **over $8b** (doubling to 4GW by 2035 and 9GW by 2040)

Note: Cost estimate excludes any distribution network augmentation expenditure (AugEx). This consideration is highlighted on page 16. However, AugEx requirements are anticipated to be small given the benefits batteries provide in time-shifting local energy supply to reduce peak demand; Investment in IT infrastructure to support networks in managing a greater penetration of will also be required. * Based on Global NZE by 2050 scenario. Note that GenCost forecasts see steeper decline in the near term before moderating in the late 2020's. These profiles have been applied directly to provide forecast cost in each year; ^ Current pricing and forecast reduction based on 2 hour storage duration

Source: CSIRO GenCost 2021-22 report; AEMO 2022 ISP (Step Change scenario); L.E.K. research and analysis

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Fully leveraging distribution networks represents an attractive option to support the energy transition - more detailed and localised analysis would enable tighter quantification of the benefit

Driving accelerated rooftop solar capacity, supported by firming battery storage, represents an attractive option to mitigate potential generation capacity shortfalls

Reduced execution risk

- Australia has **proven capacity to deliver large volumes of rooftop solar PV**. An accelerated uptake scenario remains within historical execution capacity and available housing stock
- Distributed generation and storage **leverages the existing distribution network**, removing the dependency that utility scale developments have on parallel transmission projects

Supported by community

- As evidenced by high uptake, there is **strong community support for household rooftop solar**; recognised as lowering household energy costs and contributing to the decarbonisation of the energy sector
- Similar support has been seen for community scale batteries. As a result, a distribution-system led rollout of solar and storage is **unlikely to experience the social licence challenges** of utility-scale projects

Readily implementable

- Federal and State Governments **already have a range of programs that support implementation** of rooftop PV and distributed batteries, and which could be readily expanded to support acceleration
- Through these programs, and other avenues such as energy efficient home regulations, there are a number of opportunities **to share costs with the private sector and consumers**

However, as a screening assessment, it is recognised that there are a number of additional considerations that would need to be addressed

Local network analysis

- Detailed network level analysis is required to **assess localised solar PV hosting capacity and the need / suitability of batteries**, which may impact the size and location of required storage
- Localised assessment is also required to **identify and address any network hardware constraints**, which may require additional network augmentation expenditure

Added network complexity

- High solar penetration, with resulting 2-way energy flows, presents a challenge for distribution networks. While this can be managed with distributed batteries, it brings **increased operational complexity**
- **Managing these dynamic operations**, with 2-way flows and battery charge / discharge, is not necessarily the expertise of network operators today and may **require enhancement of capabilities**

Battery regulations

- Implementation of distribution network batteries has been **challenged by regulatory constraints such as ring fencing and tariff structures**, which have impacted economics and limited uptake
- **A clear regulatory framework, and alignment on battery ownership** (e.g., by distribution network operators) and commercial structures, will be required to support wide-spread implementation

Source: L.E.K. research

The industry needs to work together to accelerate this outcome but time is of the essence

DNSPs must build the value proposition

- Proactively build the benefits case for increased solar & batteries in their networks
- Ready the network and supporting infrastructure for increased DER
- Actively advocate for the value through Energy Networks Australia (ENA)

Regulators need to create the path

- Rebalance the approach to decarbonising the grid by elevating the priority of investment in DER
  - Support NSP network investment
  - Unlock community batteries by opening them up for DNSPs to compete (without the constraint of ringfencing)

Policymakers enable the value

- Create a DER strategy to de-risk existing grid case transition
- Create the consumer incentives to update solar and batteries
- Support the engagement with consumers to maintain strong social licence of DER solutions

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