

# Power Sector Decarbonization Action Plan Series: Australia

*October 31, 2023*

# Webinar & Speaker Introductions

Moderated by Dr. Doug Arent, National Renewable Energy Laboratory

*October 31, 2023*

# Agenda

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- Overview of the Clean Energy Solutions Center and 21<sup>st</sup> Century Power Partnership
- Australia's action plan for power sector decarbonisation (DCCEEW)
- Grid integration and transformation, energy forecasting projects (CSIRO)
- Battery storage (Energy Renaissance)
- Q&A

# Webinar Speakers



**Doug Arent**

Executive Director of Strategic Public-Private Partnerships, **National Renewable Energy Laboratory**



**Prateek Joshi**

Energy Engineer, **National Renewable Energy Laboratory**



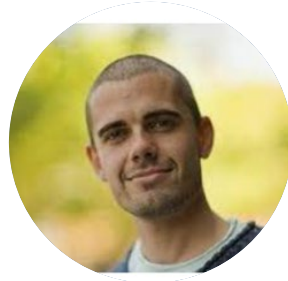
**Jal Desai**

Systems Engineer, **National Renewable Energy Laboratory**



**Sandra Choy**

Assistant Director, **Department of Climate Change, Energy, the Environment and Water**



**John McKibbin**

Energy Networks Research Leader, **Commonwealth Scientific and Industrial Research Organisation**



**Brian Craighead**

CEO, **Energy Renaissance Pty Ltd**

# Overview of the Clean Energy Solutions Center

Presented by Jal Desai, National Renewable Energy Laboratory

*October 31, 2023*

# The Clean Energy Solutions Center

## OBJECTIVE

To accelerate the transition of clean energy markets and technologies.

## RATIONALE

Many developing governments lack capacity to design and adopt policies and programs that support the deployment of clean energy technologies.

## AMBITION/TARGET

Support governments in developing nations of the world in strengthening clean energy policies and finance measures

## ACTORS

### Leads:



### Operating Agent:



### Partners:

More than 40 partners, including UN-Energy, IRENA, IEA, IPEEC, REEEP, REN21, SE4All, IADB, ADB, AfDB, and other workstreams etc.

## ACTIONS

- **Deliver** dynamic services that enable *expert assistance, learning, and peer-to-peer sharing of experiences. Services are offered at no-cost to users.*
- **Foster** dialogue on emerging policy issues and innovation across the globe.
- **Serve** as a first-stop clearinghouse of clean energy policy resources, including policy best practices, data, and analysis tools.

## UPDATES

### Website:

[www.cleanenergyministerial.org/initiatives-campaigns/clean-energy-solutions-center](http://www.cleanenergyministerial.org/initiatives-campaigns/clean-energy-solutions-center)

### Factsheet:

[www.nrel.gov/docs/fy22osti/83658.pdf](http://www.nrel.gov/docs/fy22osti/83658.pdf)

**Requests:** Now accepting Ask an Expert requests!

# The Clean Energy Solutions Center



## **Ask an Expert Service**

- Ask an Expert is designed to help policymakers in developing countries and emerging economies identify and implement **clean energy policy** and finance solutions.
- The Ask an Expert service features a network of more than **50** experts from over **15** countries.
- Responded to **300+** requests submitted by **90+** governments and regional organizations from developing nations since inception



## **Training and Capacity Building**

- Delivered over **300** webinars training more than **20,000** public & private sector stakeholders.



## **Resource Library**

- Over **1,500** curated reports, policy briefs, journal articles, etc.



For additional information and questions, reach out to Jal Desai, NREL, [jal.desai@nrel.gov](mailto:jal.desai@nrel.gov)

# Overview of the 21<sup>st</sup> Century Power Partnership

Presented by Prateek Joshi, National Renewable Energy Laboratory

*October 31, 2023*



# 21CPP Objectives: Power System Transformation

*Accelerate the transition to clean, efficient, reliable, and cost-effective power systems.*

**Evolving Generation  
Portfolios**

**Electrification of  
Transport,  
Buildings, and  
Industry**

**Smart Grid, Energy  
Efficiency &  
Demand Response**

**Cross Cutting Issues:  
Operations,  
Transmission,  
Distributed Generation,  
Market Design**

**Coordinated Power  
System Planning,  
Building, and Operating  
Best Practices**

*Peer-learning, knowledge-  
sharing, and technical  
assistance*

*Coordinating with related CEM Campaigns*

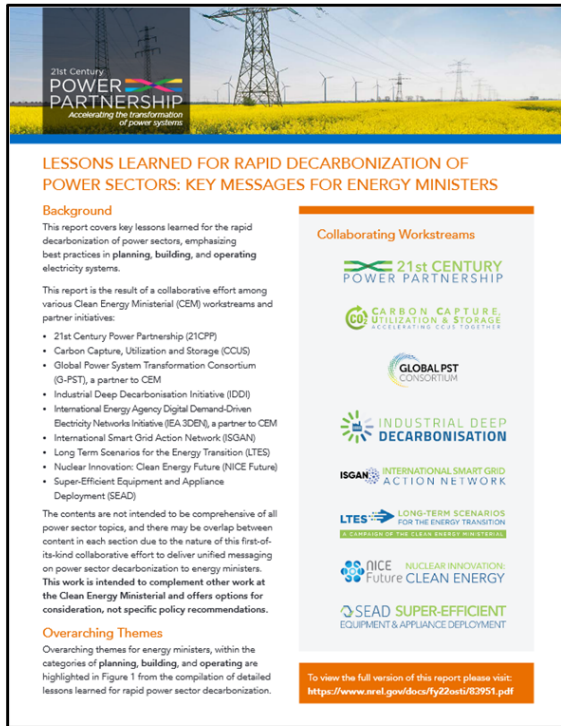
# 21CPP: Focus Areas

## Annual Program of Work often includes:

- “Thought Leadership” studies that focus on generic power system transformation topics across the world
- In-country technical assistance, often as part of a larger development assistance effort, focused on *Planning, Building, and Operating best practices for decarbonizing power systems*.
  - High-resolution grid integration studies often highlight this work.
- Information exchange, capacity building, fellowship programs, and other exercises to share lessons-learned and knowledge transfer.

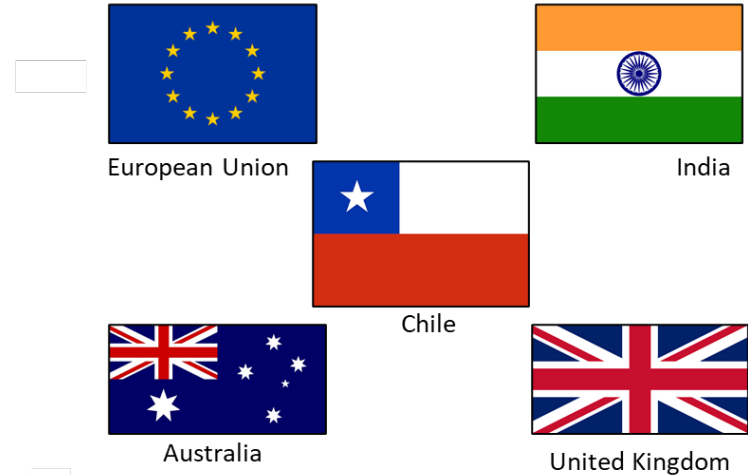
# 21CPP: Recent Activities

**2021-2022:**  
Released a collaborative report for energy ministers on lessons learned for rapid decarbonization of power sectors.



## 2022-2023:

Worked with a first cohort of countries to develop Action Plans for power sector decarbonization based off the report.



**March 2023:** Workshop on transmission planning and operations

**May 2023:** Workshop on resource adequacy and grid flexibility

# 21CPP: Planned Activities

## 2023-2024:

Webinar series to discuss details of Action Plans in the first cohort.



Work with a second cohort of countries to develop Action Plans to be released at CEM15 in Brazil.

Potential for technical workshops, thought leadership report, etc.

**Do not cite.**



**Australia**

# DEEP DIVE: AUSTRALIA'S ACTION PLAN FOR POWER SECTOR DECARBONISATION



**Australian Government**

**Department of Climate Change, Energy,  
the Environment and Water**



# Acknowledgement of Country

Our department recognises the First Peoples of this nation and their ongoing connection to culture and country. We acknowledge First Nations Peoples as the Traditional Owners, Custodians and Lore Keepers of the world's oldest living culture and pay respects to their Elders past, present and emerging.



# AUSTRALIA'S ENERGY CONTEXT



**35.9%**

Australia's electricity generation from renewable sources, 2022.



**80%**

of Australia's electricity consumption occurs on the East and South-Eastern coast.



## Two main electricity markets

**Wholesale Electricity Market (WEM)**

20 TWh of annual electricity generation.

**6 GW** installed electricity generation capacity.

**1.5 GW** of solar rooftop PV.

**National Electricity Market (NEM)**

200 TWh of annual electricity generation.

**65 GW** installed electricity generation capacity.

**15 GW** of solar rooftop PV.

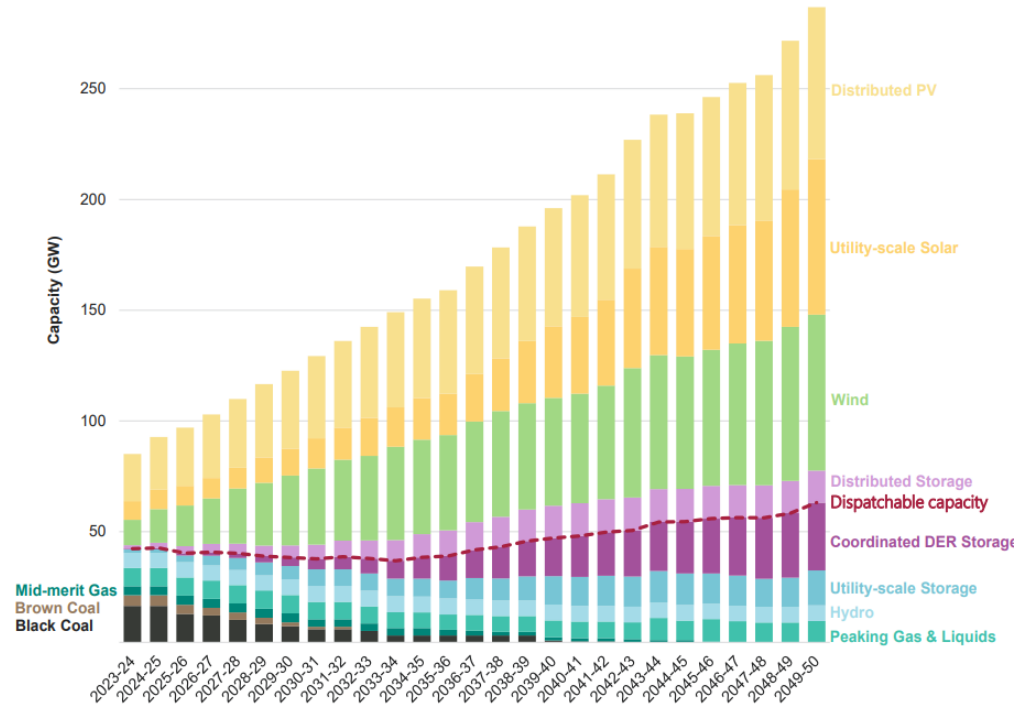
Source: Clean Energy Australia Report, 2023



# AEMO'S PLAN FOR THE SYSTEM – INTEGRATED SYSTEM PLAN

- ‘Whole of system plan’ for supplying affordable and reliable electricity to homes and businesses in the eastern and southeastern states
- Identifies where investment is needed to meet the future needs of the National Electricity Market, including;
  - future transmission projects
  - generation, storage projects
  - demand-side developments
- The AEMO’s Integrated System Plan identified approximately \$12.8 billion investment is needed to develop renewable energy zones and interconnect regions of the National

Electricity Market.




Source: AEMO (2022), ISP, Step Change Scenario






# EXPECTED CHANGES TO 2050 (STEP CHANGE SCENARIO) - AEMO

 Grid-scale wind and solar  
**to increase 9-fold**




 Distributed solar PV  
**to increase 5-fold**



 Firming capacity  
**to increase by a factor of 30**  
(Batteries, virtual power plants, pumped hydro,



 Electricity usage from the grid  
**to nearly double**



Source: AEMO (2022), ISP, Step Change Scenario



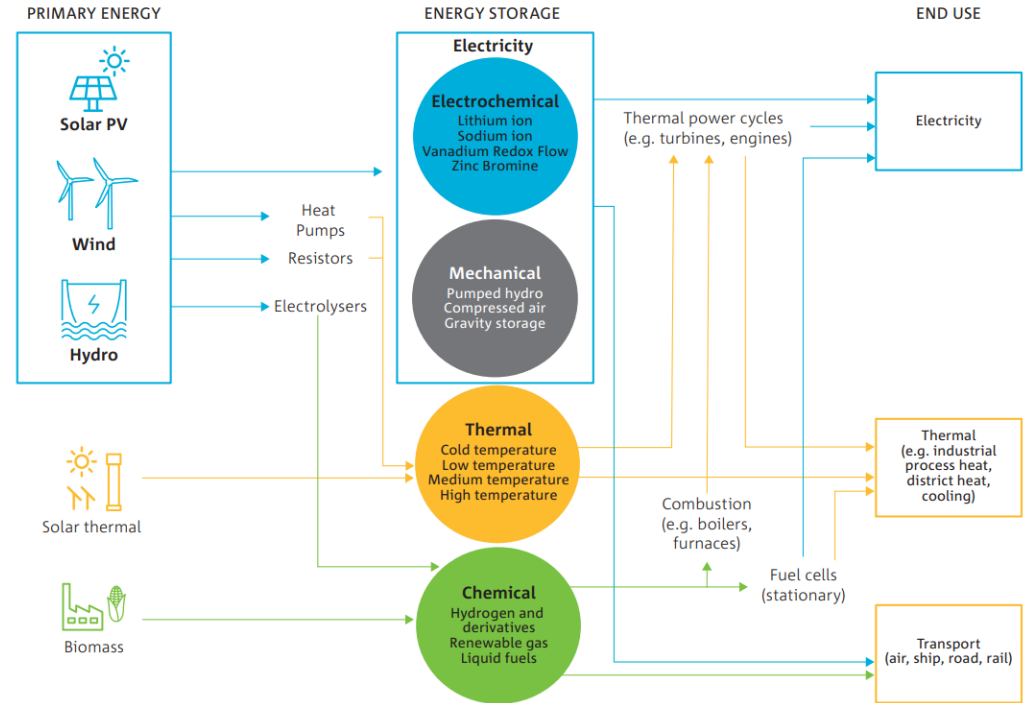
# CSIRO'S RENEWABLE ENERGY STORAGE ROADMAP

## The Renewable Energy Storage Roadmap

- Additional 13 GW of storage capacity will be required by 2030.

## Key recommendations: Energy storage analysis process by end use

- Role of storage
- Deployment considerations – site & region specific
- Technology options



Notes: Graphic developed in consultation with ITP Thermal. Terminology: PV, photovoltaic.

Source: CSIRO (2023) *Renewable Energy Storage Roadmap*



## A COORDINATED APPROACH



An interim 2030 emissions reduction target of 43%



A Renewable Energy Target of 82% by 2030



A net-zero emissions target by 2050

## Powering Australia

- The Powering Australia Plan is focussed on accelerating Australia's emissions reduction and delivering reliable and affordable energy.
  - Reducing emissions, creating jobs, and cutting power bills through boosting renewable energy.
- Focuses on the medium to long term changes necessary to transform our economy and electricity grid through:
  - **Decarbonisation**
  - **Electrification**
  - **Energy efficiency**
  - **Technology innovation and development**



# BUILDING THE SYSTEM: TRANSMISSION

## Rewiring the Nation (RtN)

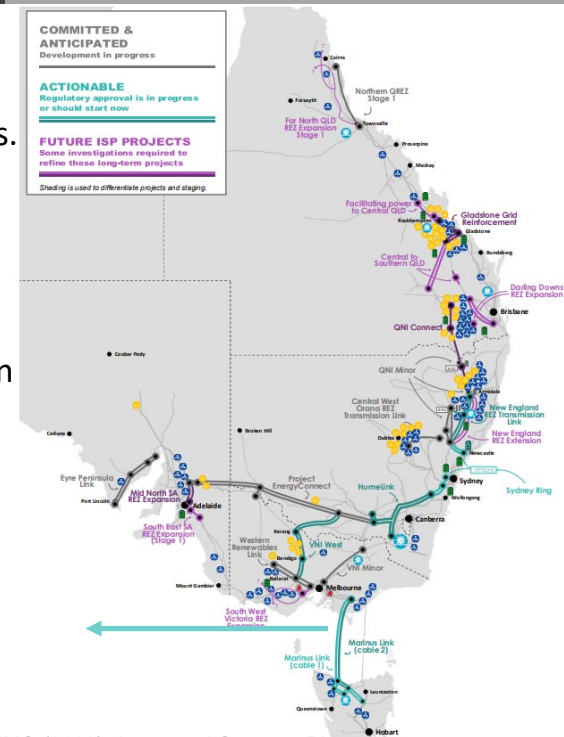
- invest up to \$20 billion to expand, upgrade and modernise Australia’s electricity grid, including infrastructure, interstate electricity transmission and renewable energy zones.
- Delivered by the Rewiring the Nation Office (RtNO) and the Clean Energy Finance Corporation (CEFC).

## Renewable Energy Zones

- High quality resource areas where clusters of large-scale renewable energy projects can be developed using economies of scale. Solar, Wind (land & offshore) and Hydro.
- REZ connects multiple renewable generators in one location - more cost effective and efficient in utilising resources.

## First Nations Community Microgrids

- The Regional Microgrids Program will allocate \$75 million for projects in First Nations communities



Source: AEMO (2022), Integrated Systems Plan

## ENERGY STORAGE

### Capacity Investment Scheme

- The CIS will bring on at least 10 billion of new investment and 6GW of clean dispatchable renewable capacity by 2030
- Commonwealth support for up to 550MW of firming capacity, in addition to 380 MW already committed by the New South Wales government.

### Community Batteries for Household Solar program (\$200 million)

- Community batteries are key to supporting the growth of more variable renewable energy sources as solar and wind.
- To install 400 batteries across Australia and provide shared storage for up to 100,000 households



Source: Ausgrid (2023), Community Battery Pilot



## ENERGY PERFORMANCE AND EFFICIENCY

### Energy Savings Package

- A \$1.7 billion Energy Savings Package to make energy efficiency upgrades more accessible to homes, local councils and businesses including:
- \$310 million for the Small Business Energy Incentive to provide additional tax deductions on electrification and energy efficiency expenditure.

### Household Energy Upgrades Fund

Improving household energy performance

- \$1 billion to the Clean Energy Finance Corporation (CEFC) to support home upgrades that save energy.
- \$300 million to support upgrades to social housing, co-funded and designed in partnership with the states and territories.

### Nationwide House Energy Rating Scheme

- To inform Australians about the energy performance of existing homes and make informed choices re. energy upgrades in their households.



### Improving commercial building energy performance

- National Australian Built Environment Rating System (NABERS).
- The national Commercial Building Disclosure (CBD) program.
- Updates to the National Construction Code standards for new buildings in line with net zero.



# CLEAN ENERGY WORKFORCE - skills for a net zero future

- Jobs & Skills Australia's **Clean Energy Generation** report provide valuable insights into workforce needs for the transformation to a clean energy economy
- The **New Energy Apprenticeships Program** will provide direct financial assistance to support 10,000 Australian Apprentices complete training in the clean energy sector

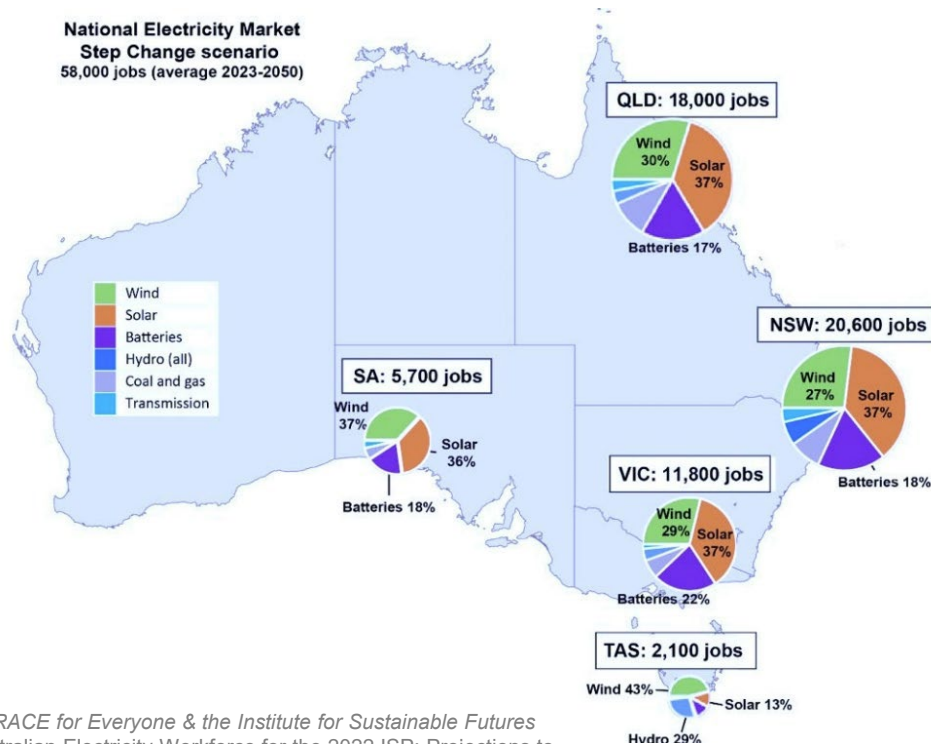


Image Source: RACE for Everyone & the Institute for Sustainable Futures (2023), The Australian Electricity Workforce for the 2022 ISP: Projections to 2050





## REFERENCES

- AEMO (2022) 2022 Integrated System Plan (ISP), <https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en>
- AEMO (2022) Operations Technology Roadmap, <https://aemo.com.au/-/media/files/initiatives/operations-technology-roadmap/executive-summary-report-for-the-otr.pdf?la=en>
- AEMO (2022) Engineering Roadmap to 100% <https://aemo.com.au/en/initiatives/major-programs/engineering-framework>
- Australia Government (2023) The national Commercial Building Disclosure (CBD), <https://www.cbd.gov.au/program/overview/overview>
- Ausgrid (2023), Community Batteries Pilot, <https://www.ausgrid.com.au/In-your-community/Community-Batteries/Community-Battery-Pilot>
- Clean Energy Council (2023) Clean Energy Australia Report, <https://assets.cleanenergycouncil.org.au/documents/Clean-Energy-Australia-Report-2023.pdf>
- CSIRO (2023) Renewable Energy Storage Roadmap, [https://www.csiro.au/-/media/Do-Business/Files/Futures/23-00033\\_SER-FUT\\_REPORT\\_RenewableEnergyStorageRoadmap\\_WEB\\_230310.pdf](https://www.csiro.au/-/media/Do-Business/Files/Futures/23-00033_SER-FUT_REPORT_RenewableEnergyStorageRoadmap_WEB_230310.pdf)
- DCCEEW (2023) Capacity Investment Scheme, <https://www.energy.gov.au/government-priorities/energy-supply/capacity-investment-scheme>
- DCCEEW (2023) Community Batteries for Household Solar program, <https://www.dcceew.gov.au/energy/renewable/community-batteries>
- DCCEEW (2023) Community Energy Upgrade Fund, <https://www.energy.gov.au/news-media/news/100-million-community-energy-upgrades-fund>
- DCCEEW (2023) Community solar banks, <https://www.dcceew.gov.au/energy/renewable/community-solar-banks>
- DCCEEW (2023) Delivering cheaper, cleaner and smarter energy to households, <https://www.dcceew.gov.au/sites/default/files/documents/delivering-cheaper-cleaner-and-smarter-energy-households-fs.pdf>





## REFERENCES

- DCCEEW (2023) New energy apprenticeships to power Australia's path to net zero <https://www.energy.gov.au/news-media/news/new-energy-apprenticeships-power-australias-path-net-zero>
- DCCEEW (2023) Trajectory for Low Energy Buildings <https://www.energy.gov.au/government-priorities/buildings/trajectory-low-energy-buildings>
- Jobs and Skills Australia (2023) The Clean Energy Generation: workforce needs for a net zero economy, <https://www.jobsandskills.gov.au/publications/the-clean-energy-generation>
- NABERS (2023) What is NABERS? <https://www.nabers.gov.au/about/what-nabers>
- Prime Minister of Australia (2022) Rewiring The Nation To Supercharge Victorian Renewables <https://www.pm.gov.au/media/rewiring-nation-supercharge-victorian-renewables>
- Renewables <https://aemo.com.au/en/initiatives/major-programs/engineering-framework>
- Hon Chris Bowen MP, Minister for Climate Change and Energy (2023), Joint media release: \$3 billion Rewiring the Nation deal to power WA jobs and growth, <https://minister.dcceew.gov.au/bowen/media-releases/joint-media-release-3-billion-rewiring-nation-deal-power-wa-jobs-and-growth>
- Hon Chris Bowen MP, Minister for Climate Change and Energy (2023), Registration opens for dispatchable renewable energy projects in SA and Vic <https://minister.dcceew.gov.au/bowen/media-releases/joint-media-release-registration-opens-dispatchable-renewable-energy-projects-sa-and-vic>



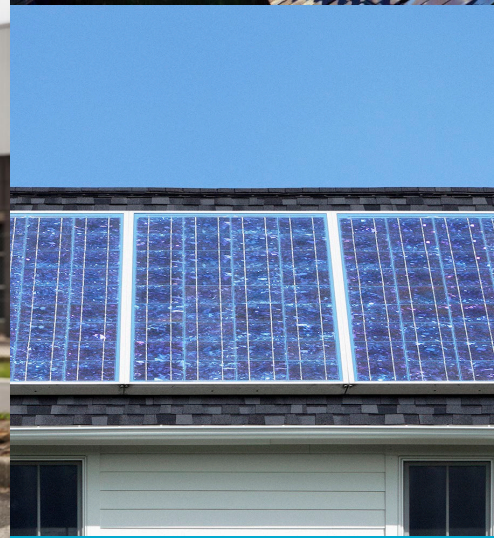
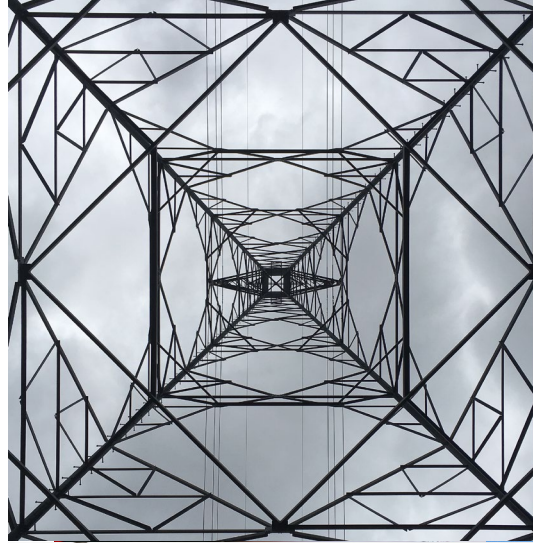
# Power Sector Decarbonisation in Australia

Technical challenges and  
opportunities

Dr John McKibbin  
Energy Networks Research Leader  
CSIRO

31 October 2023

Australia's National Science Agency





# Australia's Opportunity

Australia has committed to a net zero emissions, implying a **substantial transformation** of the energy system and the economy

Through the rapid uptake of renewable energy, **Australia is at the forefront** of the challenges and opportunities of energy system transformation globally

We are therefore building the **future energy operating system** in real time



# Three challenges for power system transformation

## Transmission systems



Adoption of large scale wind, solar and batteries and other *inverter based resources* (IBR)

## Distribution systems



Adoption of rooftop solar and batteries and other *distributed energy resources* (DER)

## Customer systems



Electrification of heating, cooling, hot water, transport and other *flexible loads*





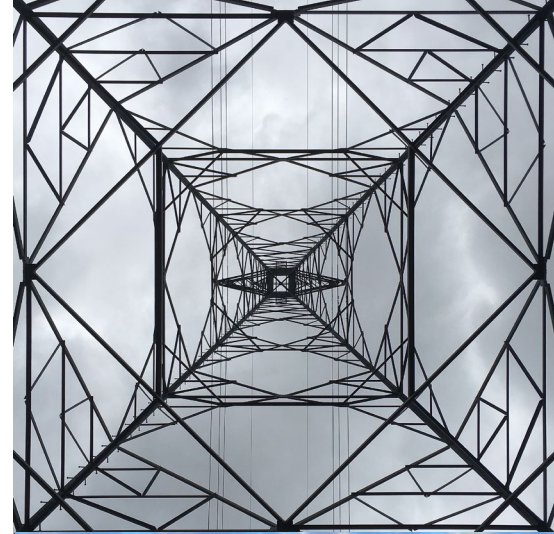
# Challenge 1: Transmission systems and inverter based resources

Large fossil-fuel based generators are being replaced by **variable renewable energy** (VRE) or **inverter-based resources** (IBR) such as wind, solar and large scale batteries

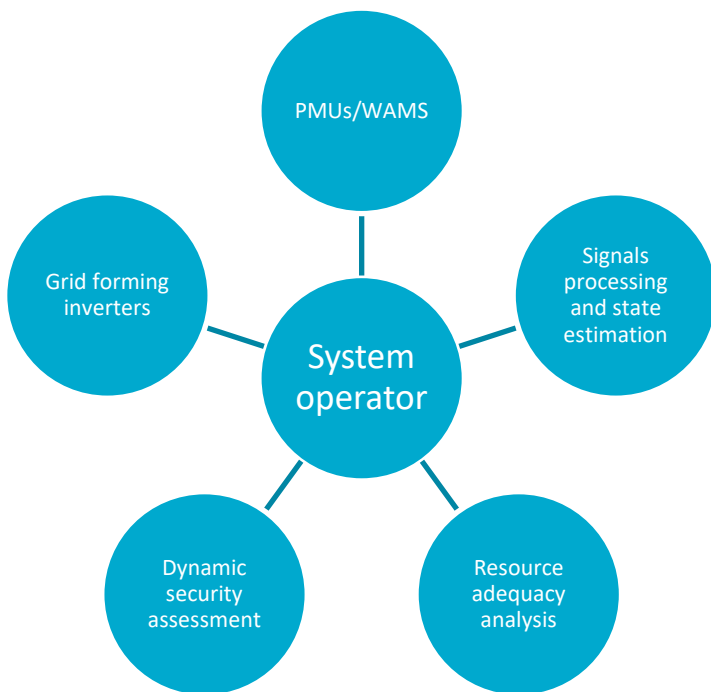
Current target to operate the power system with 100% IBR by 2025, already happening in some regions.

However the existing power system currently relies on synchronous generators to provide stability features such as system inertia and system strength.

This forces the system operator to maintain spinning reserve (mostly gas generators)



# Future power transmission systems



**System operator** provides real time *visibility*, *predictability* and *control*

- **Phasor measurement units** and other telemetry sources gather high sample rate measurements across the transmission system
- **Signals processing** and **state estimation** applied to provide real-time visibility of the system and detect faults and other anomalies
- **Resource adequacy analysis** using advanced weather forecasting, demand forecasting and generation forecasting to assess the supply-demand balance and identify shortfalls
- **Dynamic security assessment** incorporating fast electromagnetic transient analysis (EMT) to analyse and manage system security contingencies in real time
- **Grid forming inverter controls** turn IBR from an operational challenge to a responsive stability resource

# Global Power System Transformation Initiative

- An international consortium of power system operators and research institutes assisting with the transition to reliable, renewable energy systems
- CSIRO and Australian Energy Market Operator (AEMO) leading Australian consortium with leading universities and consultancies





## Challenge 2: Distribution systems and distributed energy resources

**Distributed energy resources** (DER) such as solar PV and batteries are forecast to provide over half of installed generation capacity in the national electricity market

However distribution networks were not designed for this, with minimal visibility or control of the distribution network.

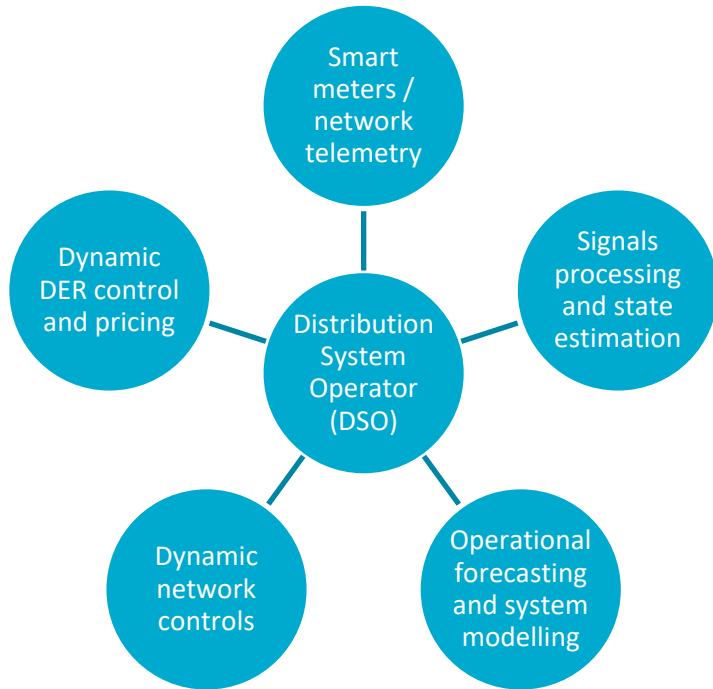
This leads to one of two problems:

- power quality or reliability issues, leading to overvoltage, premature failure of customer devices etc or
- conservative connection limits or static export limits on rooftop solar, leading to under-utilized generation and network capacity





# Future power distribution systems



**Distribution system operator (DSO)** has real time *visibility, predictability and control*

- **Smart meters** and **network monitoring devices** collect millions of data points across the distribution network
- **Signals processing** and **state estimation methods** applied to provide real-time visibility and detect faults and other anomalies
- **Operational forecasting** and **distribution system modelling** applied to project demand and generation across millions of customers and forecast available network capacity and performance
- **Dynamic network controls** including on-load tap changers (OLTC), reactive power compensation devices (PCD), phase switching devices (PSD)
- **Dynamic DER controls and pricing**, including dynamic export/import limits, dynamic network support incentives and dynamic network prices



# Distributed Energy Integration Program

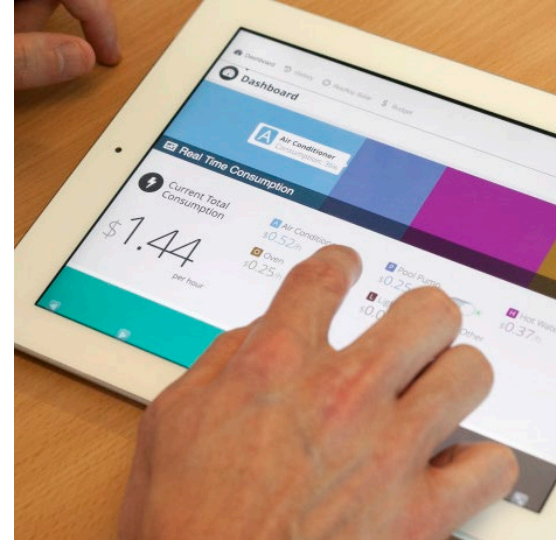
- A national consortium to facilitate the integration of DER in the Australian energy system
- CSIRO is working with several leading universities to:
  - develop interoperability standards and testing protocols
  - enhance visibility and predictability of DER
  - enhance capability and transparency of distribution network planning and operations



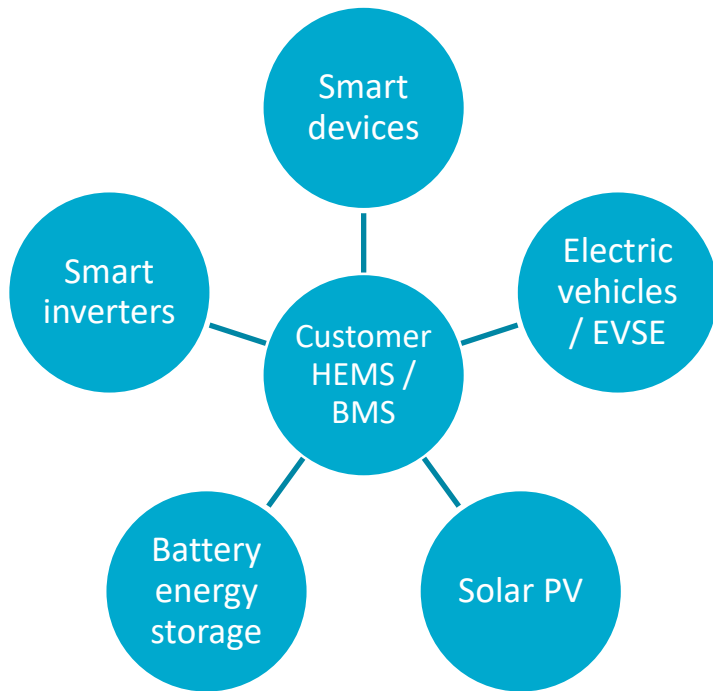


# Challenge 3: Electrification and customer flexibility

- Electrification of heating, cooling, transport, industrial processes and other demand side changes are driving a structural break or step change in energy use
- If unmanaged, this could translate to significant increase in generation and network load
- Potential to exacerbate already poor utilization of generation and network assets



# Future power customer systems



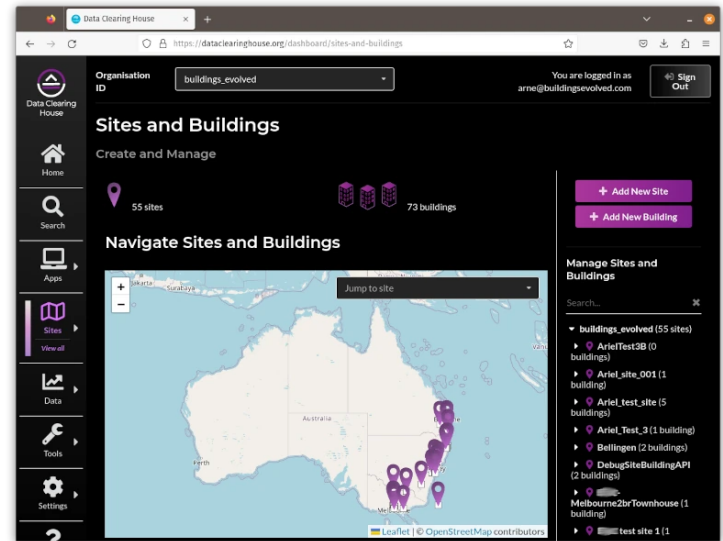
**Energy customers** have real time *visibility, predictability* and *control*

- **Home energy management systems (HEMS)** and **building management systems (BMS)** analyse and forecast power requirements and external conditions (pricing forecasts, weather forecasts)
- **Smart devices** including hot water systems, air conditioners, pool pumps provide *load flexibility* aligning demand with generation
- **Electric vehicles** and **battery storage systems** dynamically draw and inject power to balance supply and demand and provide system stability
- **Customer** has complete transparency, is rewarded financially for their contribution, and can opt-out at any time



# Energy Data Clearing House (DCH)

- A cloud-based IoT data management and application enablement platform
- Designed to support flexible generation, use and storage
- Will enable the participation of customers in the energy market as sources of flexible demand
- Also enhances visibility and predictability of DER for networks and system operator





# Thank you

Dr John McKibbin

Energy Networks Research Leader

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# The role of battery storage In Australia

POWER SECTOR: DECARBONISATION ACTION PLAN  
October 2023



# Australia

**One of the world's highest per capita emitters of carbon dioxide<sup>1</sup>**

**The energy sector (the largest contributor) accounts for over one-third of emissions<sup>2</sup>**

**Highest average solar radiation, yet solar energy accounts for ~7% of electricity generation<sup>3</sup>**

**Renewable energy adoption rate is among the fastest in the world<sup>4</sup>**

**Lead the world in adopting household solar battery storage, yet commercial and utility-scale battery adoption is still in its nascent stages<sup>5</sup>**

1. "Global Carbon Atlas" - Global Carbon Project, 2020

2. "Quarterly Update of Australia's National Greenhouse Gas Inventory" - Department of Industry, Science, Energy and Resources, 2021

3. "Australian Energy Update" - Department of Industry, Science, Energy and Resources, 2021

4. "Renewable Energy Statistics" - International Renewable Energy Agency (IRENA), 2020

5. "Global Energy Storage Outlook" - BloombergNEF, 2021



# power problem

**DECREASING RELIABILITY AND RESILIENCE<sup>1</sup>:** Australia's power grid is increasingly vulnerable to extreme weather events such as bushfires, cyclones, and floods, leading to frequent outages and grid instability.

**AGING INFRASTRUCTURE<sup>2</sup>:** Much of Australia's electricity infrastructure needs to be updated and designed to handle the complexities of modern, renewable energy sources, leading to inefficiencies and increased costs.

**CARBON EMISSIONS<sup>3</sup>:** Despite progress in renewable adoption, Australia's power sector is still heavily reliant on fossil fuels, contributing significantly to the nation's carbon emissions.

1. Source: "Electricity Network Transformation Roadmap: Final Report" - Energy Networks Australia and CSIRO, 2017
2. Source: "State of the Energy Market" - Australian Energy Regulator, 2020
3. Source: "Quarterly Update of Australia's National Greenhouse Gas Inventory" - Department of Industry, Science, Energy and Resources, 2021

# the role batteries play

STABILISE THE GRID <sup>1</sup> :	provide power during peak demand or outages, stabilising the grid
INTEGRATE RENEWABLES <sup>2</sup>	supports intermittent renewable energy sources (like solar and wind) by storing excess energy and releasing it when needed
REDUCE CARBON FOOTPRINT <sup>3</sup>	reduces carbon emissions and aligns with decarbonisation goals
REDUCE COSTS <sup>4</sup>	reduces the need for infrastructure upgrades and lowers electricity prices
IMPROVE ENERGY INDEPENDANCE <sup>5</sup>	increases energy security and reduces reliance on international supply chains

1. Source: "Grid Energy Storage" - U.S. Department of Energy, 2013
2. Source: "Australia's Renewable Energy Future" - Clean Energy Council, 2021
3. Source: "Emissions Reduction Fund" - Australian Government, 2020
4. Source: "Economic Benefits of Battery Storage" - Australian Energy Market Operator (AEMO), 2021
5. Source: "Australia's Critical Minerals Strategy" - Department of Industry, Science, Energy and Resources, 2019



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# Discussion and Q&A

# Rest of Webinar Series

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- European Commission spotlight: mid-November
- Others: to-be-scheduled

Stay tuned!

# Connect With Us Online

- **Clean Energy Solutions Center (CESC)**
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**Thank You!**