REPORT

Distributed Energy Resources (DER) and Demand-Side Management (DSM

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Table of Content

Introduction

The transformation of energy systems towards more sustainable and decentralized models is crucial for addressing the global challenges of climate change and energy security. Distributed Energy Resources (DER) and Demand-Side Management (DSM) are pivotal in this transformation. This report critically examines the current state, market structure, policies, and potential approaches for DER and DSM in Australia, emphasizing specific regulatory frameworks and market dynamics. By analyzing these elements, the report aims to provide a comprehensive understanding of how Australia can enhance its energy efficiency, reduce greenhouse gas emissions, and improve grid reliability.

Overview of DSM/DER Activities and Facilities in Australia

Distributed Energy Resources (DER) encompass a variety of small-scale energy generation and storage technologies that are located close to the point of consumption. These include solar photovoltaic (PV) panels, wind turbines, battery storage systems, and combined heat and power (CHP) systems (AEMO, 2020). Demand Side Management (DSM), on the other hand, involves strategies and technologies aimed at reducing or shifting energy consumption to enhance grid stability and efficiency (Australian Government, Department of the Environment and Energy, 2020). Together, DER and DSM can significantly contribute to reducing greenhouse gas emissions, improving energy security, and lowering energy costs.

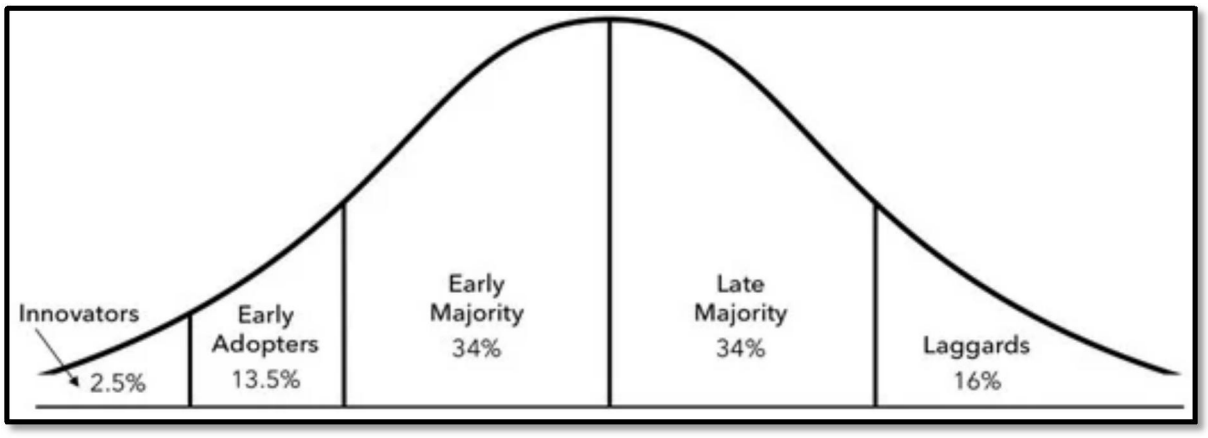


Figure 1: Phases of DER adoption in Australia (Source: Hargreaves *et al.* 2023

Standard innovation diffusion curve with the innovator to the early adopter, and finally to the laggards is shown in Figure 1. Renewable energy sources provide nearly 22% of energy where average installation costs for a 2-megawatt wind turbine are $3 to $4 million (Gupta, 2023). Centralized energy systems concentrate all power in a single location whereas DER consists of several small-scale units installed at many locations.

Global Context of DER/DSM

Globally, the adoption of DER and DSM is driven by the need to transition to low-carbon energy systems and mitigate the impacts of climate change. Countries like Germany and Denmark have made significant strides in integrating DER into their energy systems, supported by robust policy frameworks and incentives. For instance, Germany's Energiewende policy has been instrumental in promoting renewable energy and energy efficiency (Agora Energiewende, 2020). Similarly, the United States has seen substantial growth in DER deployment, particularly in states like California and New York, which have implemented ambitious targets for renewable energy and energy storage (EIA, 2020).

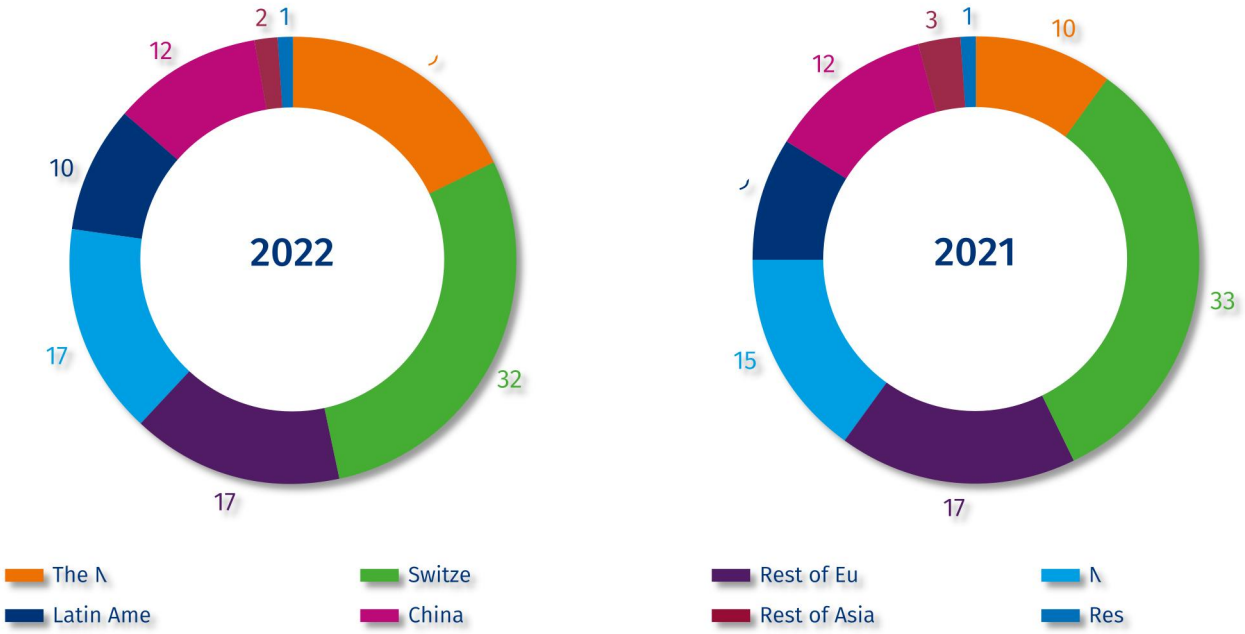


Figure 2: Royal DSM's sales worldwide from 2021 to 2022, by destination region

(Source: DMS Annual Report 2022)

The Australian Energy Market

Australia's energy market is characterized by a diverse mix of energy sources, including coal, natural gas, oil, and a growing share of renewable energy (Clean Energy Council, 2021). The country's vast natural resources and geographical expanse present both opportunities and challenges for energy distribution and management.

Energy Flow and Infrastructure

Australia’s electricity infrastructure is extensive, with a well-developed transmission and distribution network. The National Electricity Market (NEM) is the primary electricity market, covering the eastern and southern states, including New South Wales, Queensland, South Australia, Tasmania, and Victoria. The NEM is managed by the Australian Energy Market Operator (AEMO), which ensures the reliable operation of the electricity system (AEMO, 2020).

The market comprises several key players, including electricity generators, transmission network service providers (TNSPs), distribution network service providers (DNSPs), and retail electricity suppliers. The major sources of electricity generation are coal (comprising around 54% of total generation), natural gas (20%), hydro (6%), wind (10%), and solar (9%) (Department of Industry, Science, Energy and Resources, 2020).

Emissions by Sector

The electricity sector is the largest contributor to Australia's greenhouse gas emissions, accounting for approximately 33% of total emissions. Other significant sectors include transport (18%), direct combustion (17%), and fugitive emissions (11%)【7†source】. The heavy reliance on coal-fired power plants is a major driver of these emissions, necessitating a shift towards cleaner energy sources.

Policy and Regulation Landscape

Australia has implemented several policies and regulations to promote the adoption of DER and DSM. The Renewable Energy Target (RET) aims to achieve 33,000 GWh of renewable energy

generation by 2020, while state-level initiatives, such as Victoria's Solar Homes Program, provide incentives for residential solar PV installations (Victoria State Government, 2020). Additionally, the National Energy Productivity Plan (NEPP) outlines measures to improve energy efficiency across various sectors (Australian Government, Department of Industry, Science, Energy and Resources, 2019).

The Australian Government has implemented several policies to promote renewable energy and improve energy efficiency. Key policies include:

- **Renewable Energy Target (RET):**was a significant policy that aimed to achieve 33,000 GWh of renewable electricity generation by 2020. The achievement of this target marked a milestone in Australia's transition towards a more sustainable energy system (Clean Energy Regulator, 2020).

- **National Energy Productivity Plan (NEPP):**· This plan outlines measures to improve energy efficiency across various sectors, aiming for a 40% improvement in energy productivity by 2030 (Australian Government, 2019).

- **Updated Renewable Energy Targets**: Various states and territories have set their own renewable energy targets beyond 2020. For example, the Australian Capital Territory (ACT) aims for 100% renewable electricity by 2025, while South Australia targets 100% net renewable electricity by 2030 (Clean Energy Council, 2021).

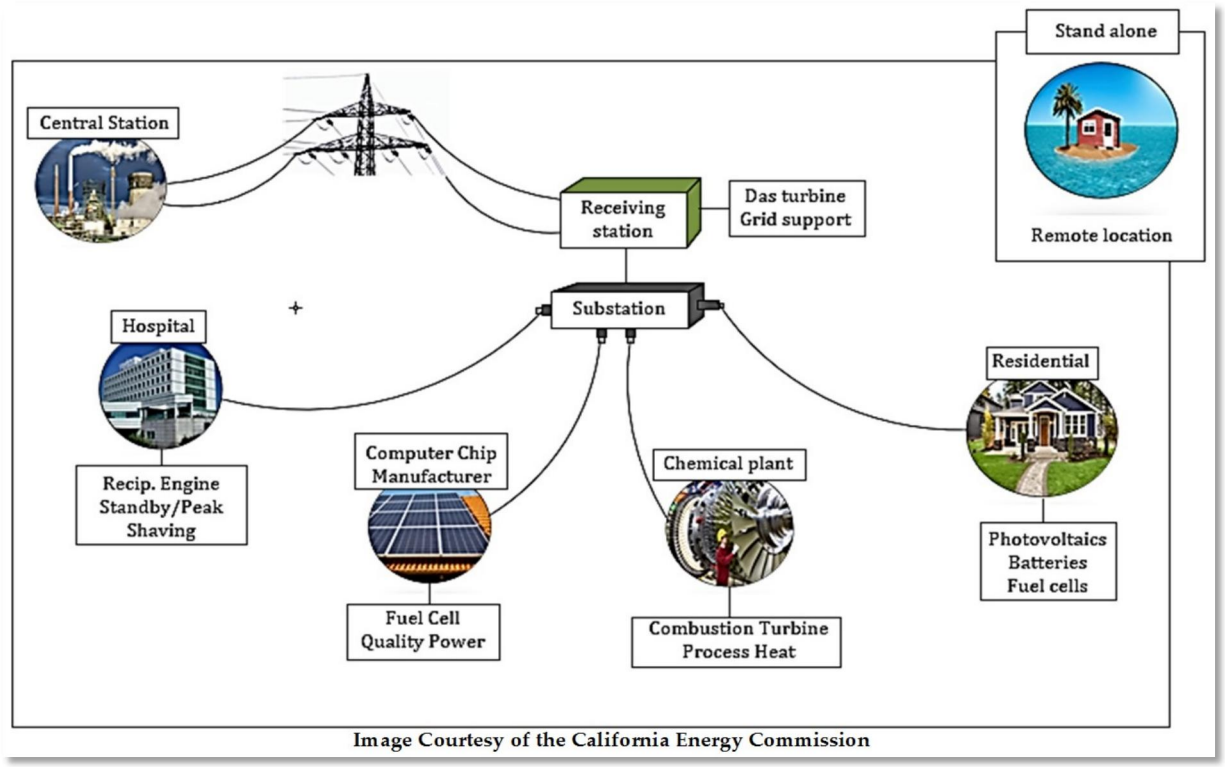
- ## Supporting Mechanisms:

  To support these targets, several mechanisms and policies are in place, including:

  - **Feed-in Tariffs**: Providing financial incentives for small-scale renewable energy generators.
  - **Small-scale Renewable Energy Scheme (SRES)**: Offering rebates for the installation of eligible renewable energy systems.

- **Demand Response Programs**: Encouraging consumers to shift their energy usage to off-peak periods, thereby reducing peak demand and enhancing grid stability (AEMO, 2019).

Australia is committed to reducing its greenhouse gas emissions by 26-28% below 2005 levels by 2030 under the Paris Agreement, with a long-term goal of achieving net-zero emissions by 2050. The primary drivers for DER adoption include declining costs of renewable energy technologies, supportive government policies, and increasing consumer awareness.



Market Structure Facilitating DSM/DER

Australia's energy market is characterized by a competitive landscape, with distinct roles for generation, transmission, distribution, and retail. Different regulatory frameworks, market mechanisms, and technological changes have guided the construction of an Australian Energy Market designed for demand-side management (DSM) and the realities of distributed generation (Li *et al.* 2020). At the National Electricity Market (NEM), a wholesale market separating electricity trade from generation becomes a matter of mere brokerage between seller and buyer.

Australian Energy Market Operator (AEMO) ensures that the supply-demand axis is always kept in balance.

The regulations set by such organizations as the Australian Energy Regulator (AER) and the Australian Energy Market Commission (AEMC) are aimed at facilitating the integration of demand-side management (DSM) and distributed energy resources (DER). Renewable energy targets offer both national and local bonuses for example initiatives like the Renewable Energy Target (RET) and state-specific incentives eventually result in intense pressures for investment Retailers as well as aggregators play vital roles in enabling DSM. They do so through launching innovative rate plans, offering energy management services in various fashions, and so on.

Electricity Infrastructure and Key Players

- **Generation:** The generation sector comprises a mix of coal, gas, hydro, and renewable energy sources. Prominent players include AGL Energy, Origin Energy, and Energy Australia.

- **Transmission and Distribution:** Managed by companies such as TransGrid (NSW), Powerlink (QLD), and AusNet Services (VIC), responsible for transporting electricity from generators to consumers【7†source】.

- **Retail:** Consumers have the freedom to choose their electricity retailer, fostering competition and innovation in energy management services【7†source】.

Purpose of DSM/DER Utilization

The implementation of DER and DSM in Australia can provide numerous benefits, including reducing reliance on fossil fuels, lowering greenhouse gas emissions, enhancing energy security, and promoting economic growth.

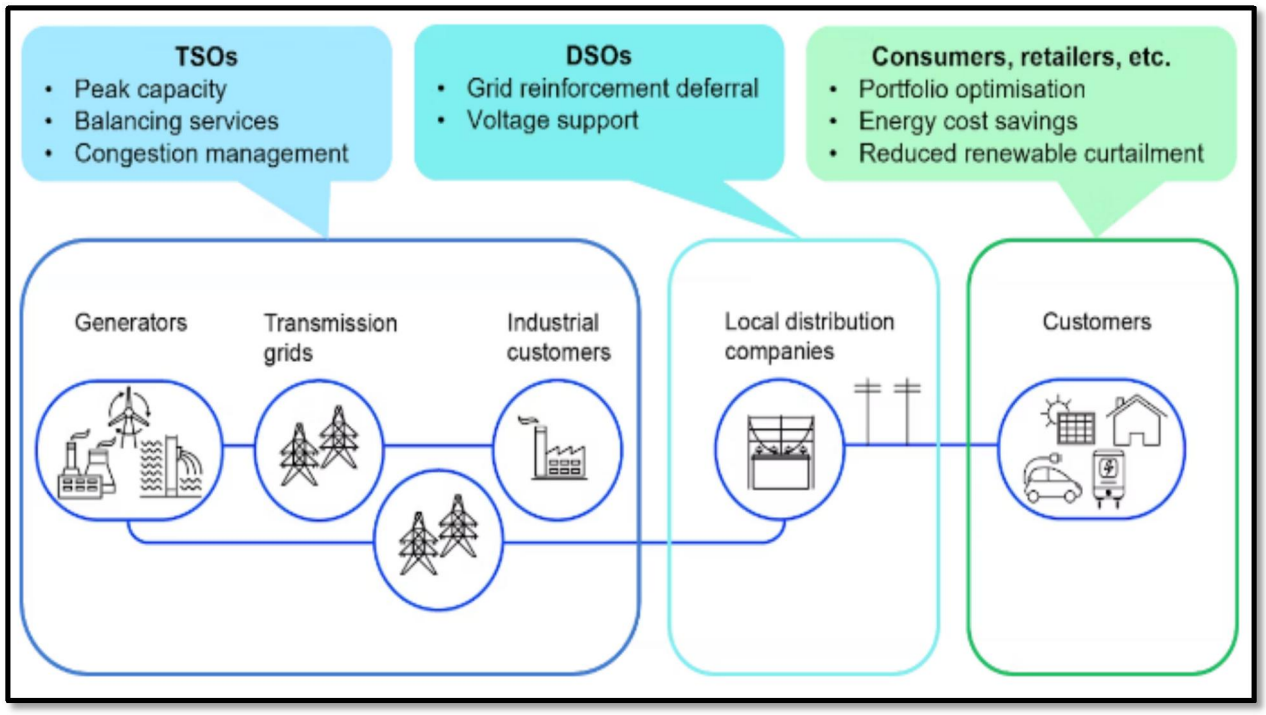


Figure 4: Multiple Grid's benefits of digitally enabled DERs

(Source: IEA, 2020)

Reducing Fossil Fuel Usage and Emissions

Australia's energy sector is one of the largest sources of greenhouse gas emissions, accounting for around 34% of total emissions (Australian Government, Department of the Environment and Energy, 2020). By increasing the deployment of DER, such as solar PV and wind turbines, Australia can significantly reduce its dependence on fossil fuels. For example, rooftop solar PV installations have the potential to reduce emissions by offsetting the need for coal-fired power generation. Similarly, battery storage systems can store excess renewable energy and supply it during periods of high demand, further reducing the reliance on fossil fuels (Hornsdale Power Reserve, 2020).

Strategic Installation of DER

DER can be deployed in high-consumption and high-emission sectors. For example, industrial facilities can use solar PV and battery storage to manage peak demand and reduce operational costs .

Broader Benefits:

- **Individual Level:** Consumers benefit from lower energy bills, increased energy independence, and the potential to earn revenue through feed-in tariffs .
- **Industry Level:** Businesses can achieve cost savings, enhance their sustainability credentials, and improve operational efficiency by integrating DER and participating in DSM programs .
- **Utility Level:** Utilities can defer expensive infrastructure upgrades, improve grid stability, and manage peak demand more effectively .
- **National Level:** The widespread adoption of DER contributes to national energy security, reduces greenhouse gas emissions, and supports economic growth through job creation in the renewable energy sector .

Alternative Approaches

To further enhance DSM and DER in Australia, several alternative approaches can be considered:

Solar photovoltaic (PV) systems

Among all the available energy resources sunlight is the most freely available energy source. That is why the solar PV system is the most used DG system. Solar PV panels convert sunlight into electricity which helps people to get quality and reliable sources of electricity in the era of technological advancement (Mustafa *et al.* 2020).

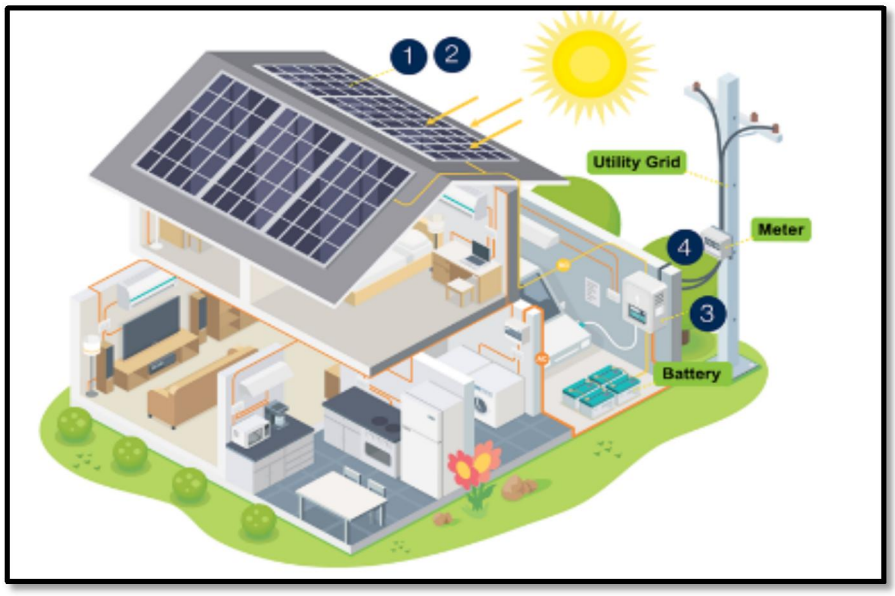


Figure 5: Solar photovoltaic (PV) systems

Wind Turbines

Wind turbines use blades to gather the wind's kinetic energy and then convert it into electricity (Bošnjaković *et al.* 2022). Moreover, it takes minimal space to set up and the source is totally economical for people.

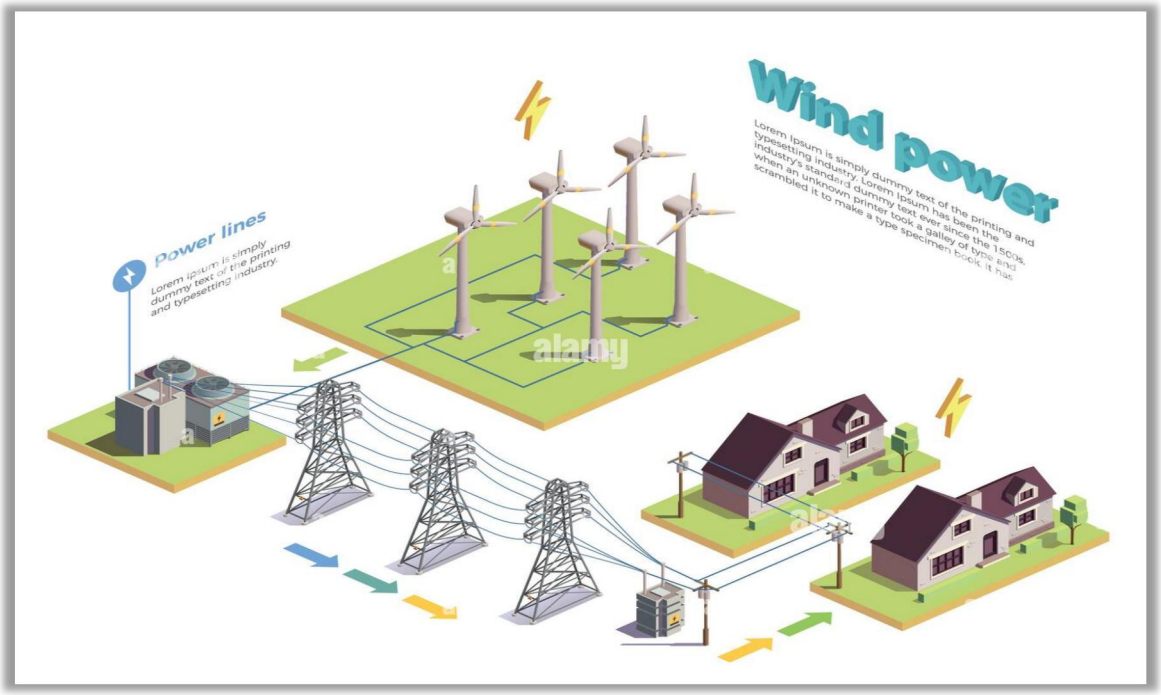


Figure 6: Wind Power Overview

Hydroelectric power plants

In the case of a Hydroelectric power plant, the water flows through a pipe which helps to turn blades in a turbine then the generator produces electricity through spinning (Alvarez *et al.* 2020). In that scenario, it can be seen that the whole process is very clean and does not produce any waste as well as harmful gasses.

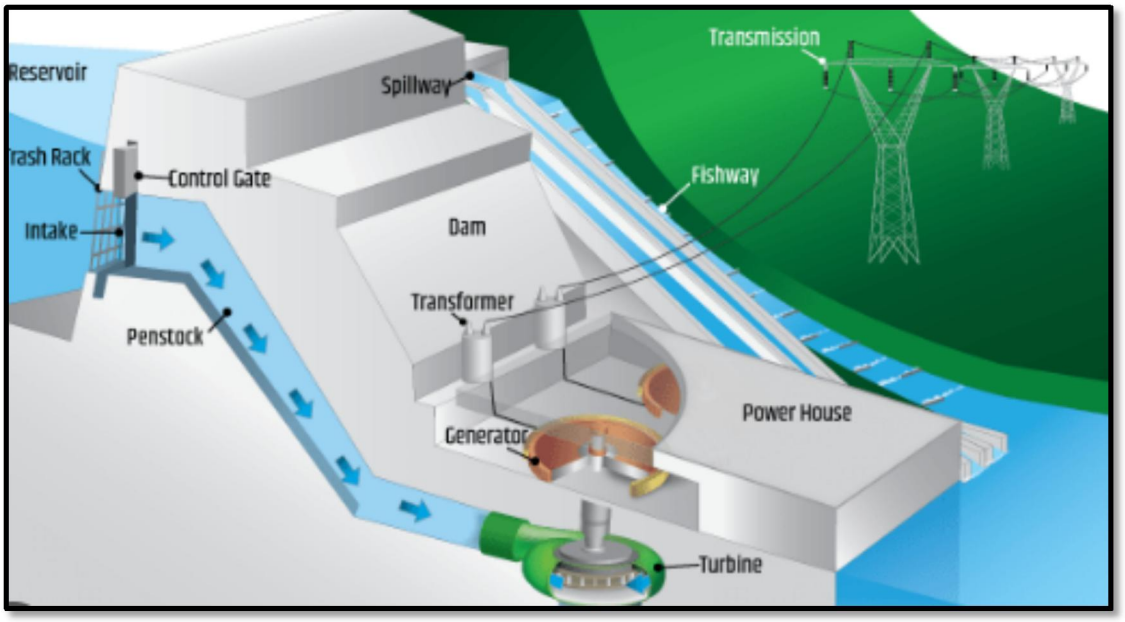


Figure 7: Hydroelectric power plants

Combined heat and power systems (CHP)

In the CHP system electricity and thermal energy are produced from the same fuel. Hence, it has a huge impact on saving fuels or natural resources of energy. Along with that, it uses hot and chilled water in commercial as well as institutional and residential buildings for generating heat through renewable energies.

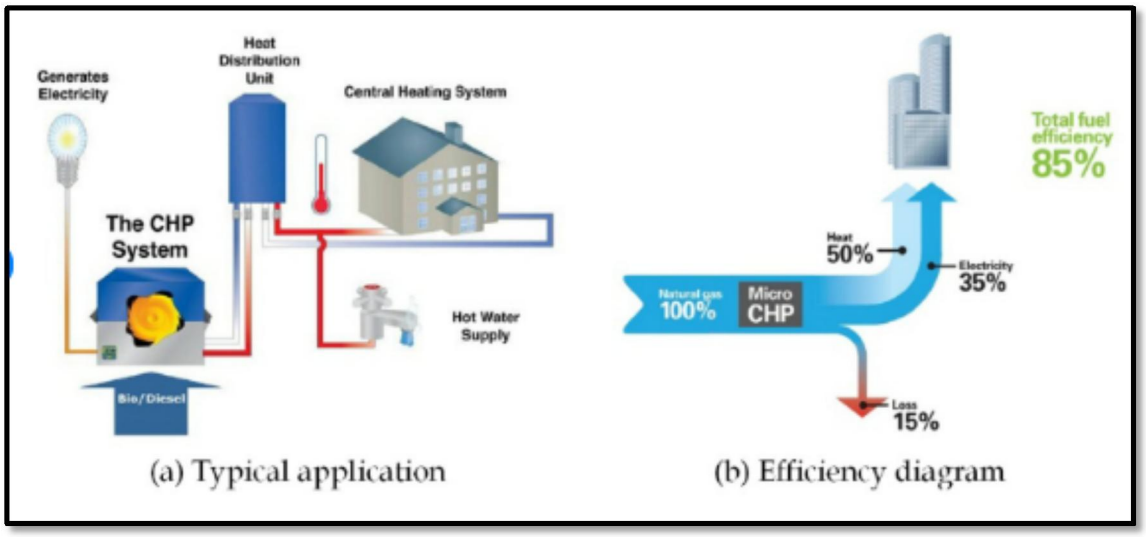


Figure 8: Combined heat and power systems (CHP)

Technological Advancements

Advancements in technology can play a crucial role in enhancing the deployment and management of DER and DSM. For instance, the integration of smart grid technologies can enable real-time monitoring and control of energy generation and consumption, improving grid stability and efficiency (AEMO, 2020). Smart meters, which provide detailed information on energy usage, can empower consumers to make informed decisions about their energy consumption, thereby promoting energy efficiency (Australian Energy Regulator, 2020).

Conclusion

In conclusion, the effective implementation of Distributed Energy Resources (DER) and Demand Side Management (DSM) is crucial for Australia's transition to a sustainable and resilient energy system. By leveraging technological advancements, policy reforms, and innovative business models, Australia can overcome the challenges associated with DER and DSM and achieve significant environmental, economic, and social benefits.

To move forward, Australia needs to adopt a comprehensive and integrated approach that includes the following key measures:

Enhancing Policy Support: Strengthening policies and incentives for DER deployment, such as feed-in tariffs and renewable energy rebates, and promoting demand response programs through dynamic pricing mechanisms.

Investing in Technology: Supporting research and development in advanced energy storage systems and smart grid technologies to improve the efficiency and reliability of DER and DSM.

Encouraging Public Participation: Promoting community energy projects and providing education and awareness programs to increase public engagement in the energy transition.

Learning from Global Best Practices: Drawing on successful examples from other countries to inform policy design and implementation, and fostering international collaboration to share knowledge and experience.

By taking these steps, Australia can not only reduce its greenhouse gas emissions and enhance energy security but also stimulate economic growth and create a more sustainable and resilient energy future.

References

- Australian Government, Department of the Environment and Energy. (2020). Australia's Emissions Projections 2020. [Online] Available at: https://www.industry.gov.au/data-and-publications/australias-emissions-projections-2020

- Australian Energy Market Operator (AEMO). (2021). Integrated System Plan. [Online] Available at: https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp

- Australian Energy Regulator (AER). (2021). State of the Energy Market 2021. [Online] Available at:

https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021

- Clean Energy Council. (2021). Clean Energy Australia Report 2021. [Online] Available at: https://www.cleanenergycouncil.org.au/resources/resources-hub/clean-energy-australia-report-2021

- Australian Government, Department of Industry, Science, Energy and Resources. (2020). Australia's Technology Investment Roadmap. [Online] Available at: https://www.industry.gov.au/data-and-publications/australias-technology-investment-roadmap

- CSIRO. (2021). Renewable Energy and Electricity. [Online] Available at: https://www.csiro.au/en/research/technology-space/energy/renewable-energy

- International Renewable Energy Agency (IRENA). (2020). Renewable Energy and Jobs – Annual Review 2020. [Online] Available at: https://www.irena.org/publications/2020/Sep/Renewable-Energy-and-Jobs-Annual-Review-2020

- Energy Networks Australia. (2020). Electricity Network Transformation Roadmap. [Online] Available at: https://www.energynetworks.com.au/projects/electricity-network-transformation-roadmap/

- Victoria State Government. (2021). Solar Homes Program. [Online] Available at: https://www.solar.vic.gov.au/solar-homes-program

- Hornsdale Power Reserve. (2021). Case Study: Hornsdale Power Reserve. [Online] Available at: https://hornsdalepowerreserve.com.au/

- Clean Energy Regulator (2020). Renewable Energy Target. [Online] Available at: https://www.cleanenergyregulator.gov.au/RET

- Australian Government, Department of Industry, Science, Energy and Resources (2019). National Energy Productivity Plan. [Online] Available at: https://www.energy.gov.au/government-priorities/energy-productivity-and-energy-efficiency/national-energy-productivity-plan

- Clean Energy Council (2021). Renewable Energy Targets. [Online] Available at: https://www.cleanenergycouncil.org.au/resources/resources-hub/clean-energy-australia-report-2021

- Australian Energy Market Operator (AEMO) (2019). Demand Response. [Online] Available at: https://aemo.com.au/initiatives/major-programs/demand-response