Further, faster, together

Opportunities for collaboration between Germany and Australia on industrial energy management and decarbonisation

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AUSTRALIA – GERMANY
Energy Partnership

eec adelphi

About this report

This report is the second in the Further, faster, together series and replicates the successful *Further, faster, together: Opportunities for collaboration between Germany and Australia on energy efficiency in buildings* report.

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adelphi is one of Germany's leading independent think tanks on climate, environment, energy and development. adelphi has been supporting the BMWK in their energy cooperation with Australia since 2016.

The **Energy Efficiency Council (EEC)** is the peak body for Australia's energy management sector. A not-for-profit membership association, the EEC works to:

- Drive world-leading policy on efficiency, electrification and demand flexibility;
- Ensure Australia has the skilled workforce to deliver Australia's energy transition; and
- Support businesses and households to rapidly decarbonise.

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Contents

1. Introduction

Energy efficiency policy, programs, and technology are an important area for bilateral cooperation between Australia and Germany.

In September 2019, cooperation between Australia and Germany on these matters was formalised during the third meeting of the Australia-Germany Energy Working Group. This included the establishment of an industry-led Sub Working Group on energy efficiency, currently co-chaired by Luke Menzel, CEO of the Australian Energy Efficiency Council, and Susann Bollman, Member of the Executive Board, Head of Projects and Financial Forum, Energy Efficiency, at the German Business Initiative for Energy Efficiency (DENEFF). With the upcoming formalisation to the Australia-Germany Energy and Climate Partnership, the group will be renamed as the Working Group for Energy Efficiency and Net Zero Transition.

The creation of the Working Group recognised that both the German and Australian Governments are acting to harness energy efficiency to lower carbon emissions and support the broader energy transition. The aim of the Working Group is to accelerate efforts in both nations through enhancing cooperation between Australia and Germany in energy efficiency.

Germany has adopted 'energy efficiency first' as a central principle of its *Energiewende* (energy transition) because energy savings can drive cost-effective reductions in greenhouse gas (GHG) emissions and ensure that the shift to renewable generation is affordable. Similarly, Australia has identified energy efficiency as key to lowering carbon emissions across the economy.

Both Germany and Australia have made emissions reduction in industry a central priority of their economic and climate policies.

While the two nations have a shared strategic interest in the development of new fuels like green hydrogen, they have also noted the important role of the demand side – energy efficiency, energy management, electrification and demand flexibility – in industrial decarbonisation.

This report focuses on opportunities most applicable to energy intensive industrial subsectors common to both countries, whose GHG emissions are considered 'easier to abate'. These include industries such as food processing and paper and pulp manufacturing. However, some opportunities identified have application beyond these areas.

While both countries produce basic metals and non-metallic minerals, these energy-intensive production processes, despite being 'harder to abate' are:

- well studied, with technology and policy analyses providing detailed pathways to decarbonisation;[1]
- subject to policy that will drive higher energy performance and emissions reductions; and
- generally involve large, international companies that are better equipped to address energy management and emissions reduction.

They are therefore not the focus of this report, being well covered elsewhere.

Given the strong relationship between Australia and Germany, opportunities to accelerate efforts to drive down industrial emissions through collaboration should be identified and acted on. This can be achieved through:

[1] For example see 'Pathways to industrial decarbonization: Positioning Australian industry to prosper in a net zero global economy' prepared by Climateworks and CSIRO and the report prepared by the German Federation of Industry: Klimapfade 2.0 – Ein Wirtschaftsprogramm für Klima und Zukunft [Climate Pathways 2.0 – An economic program for the climate and the future]

- Knowledge exchange, encompassing policy, programs, technology innovation and business models; and
- Commercial exchange, ensuring technology and expertise of each nation can be leveraged to accelerate a cost-effective energy transition.

This report outlines the key policies to address energy efficiency, energy management, and electrification in the industrial energy sector in Germany and Australia. It is not intended as an exhaustive account of policy in both nations. Rather, it provides a high-level survey of selected initiatives as a means of orienting experts in each nation as to the policy landscape in the other.

The report explores opportunities for collaborative efforts, considering the relative strengths and priorities of each nation. Research was conducted into other topics including the uptake of demand flexibility and the energy as a service finance market. Although there are markets for both of these mechanisms in Germany and Australia, it was concluded that they are not a priority for collaboration but that a watching brief should be maintained. Information on the demand response markets in Germany and Australia is included at Appendix 5.

Four opportunities for collaboration between Australia and Germany have been identified as particularly pertinent:

1. **Leveraging energy management systems to achieve climate management goals and targets**

   As energy use can account for a large proportion of an organisation's emissions, there is an overlap between energy management and emissions management which can be optimised by an organisation with a net zero goal.

   As has been identified in recent work from DENEFF, there is an opportunity to develop a climate management system, building on the structure and content of an energy management system. This climate management system could also align to the International Sustainability Standards Board's standards as well as German (European) and Australian reporting standards.

   The development of such a system would require significant effort and further exploration is warranted. At an online workshop to consider research to date, government and industry could help clarify appetite for such an effort and the necessary next steps.

   A short report characterising the outcomes of this workshop would complement the DENEFF study and form a good basis for further work.

   Please see section 5 for more information.

2. **Exploration of the viability of Energy Efficiency and Climate Action Networks in Australia, informed by the German experience.**

   Australia should build on Germany's successful experience with Energy Efficiency and Climate Action Networks and explore how Communities of Practice which follow the German model could be adapted for the Australian context.

   adelphi has produced a global guide[2] on Energy Efficiency Networks setting out the challenges, success factors and impacts of the networks in Germany. A knowledge sharing workshop would be a practical next step.

   This online workshop could include key German organisations such as the German Energy Agency (DENA), adelphi and Fraunhofer ISI as well as relevant Australian stakeholders.

[2] The guide is available here.

A short report characterising the outcomes of this workshop would complement the adelphi report and form a good basis for further work.

Please see section 6 for more information.

3. **Australia should focus on widening the scope of Australian Minimum Energy Performance Standards (MEPS) to align with the European standards to meet higher IEC efficiency classes.**

   Given the proportion of industrial energy use associated with electric motors and pumps, a focus on the energy efficiency of this equipment is critical to reducing electricity use and emissions.

   Australia should align regulation with European standards to ensure that higher efficiency motor standards are met, and distinctions are made between the load size of motors and the efficiency rating.

   Please see section 7 for more information.

4. **Australia and Germany should work together to strengthen supply chains and accelerate deployment of industrial heat pumps.**

   Manufacturers and food processors are increasingly looking to heat pumps as a keystone technology for decarbonisation. Germany is well placed to be a leading manufacturing base of industrial heat pumps, with many manufacturers being headquartered there. Both Australia and Germany have a strategic interest in rapidly developing the ecosystem of skills, supply chains and industry experience in the utilisation of industrial heat pumps.

   There is an opportunity for agencies such as ARENA in Australia and relevant stakeholders in Germany to work closely with industry and government on this agenda.

   An Australian delegation to Germany to connect with heat pump manufacturers, process heat experts and policymakers – culminating in a workshop that explores collaboration opportunities on industrial electrification – would be a productive next step in building this relationship.

   Please see section 7 for more information.

2. Australian and German industrial context

'Industry' is defined in a variety of ways by different countries, sectors and organisations.

The Australian and New Zealand Standard Industrial Classification (ANZSIC) sets out 19 divisions within the 'industrial' group.[3] This includes divisions such as agriculture; mining; manufacturing; construction; transport; professional services; education and training; and arts and recreation services.[4]

Germany's Federal Statistical Office organises data through the 'Classification of Economic Activities, Edition 2008 (WZ 2008)'.[5] This classification system contains 21 sections relevant to 'industry' including: agriculture, mining; manufacturing; construction; transport; financial services; and education.[6]

These classification systems are broad, and don't perfectly align with the colloquial definition of 'industrial' being used in both countries.

2.1 Industrial landscapes of Germany and Australia

2.1.1 Germany's industrial landscape

Germany is the fourth largest economy in the world with a nominal GDP of US$4.46 trillion in 2023.[7] The production industry (excluding construction) accounts for 24.3% of GDP and is dominated by four sectors: automotive; mechanical engineering (which is the largest industry, employing 1.1 million people[8]); chemical; and electrical.[9] Germany is a net exporter of goods, being the third largest exporter in the world. In 2023, motor vehicles accounted for 17% of exports, followed by machinery (14.2%) and chemical products (8.9%).[10]

A large proportion of Germany's manufacturers are small and medium-sized companies (SMEs). 99% of all businesses in Germany are SMEs, accounting for more than half of Germany's economic output and almost 60% of jobs.[11]

Despite accounting for approximately 25% of GDP, manufacturing accounted for approximately 30% of final energy demand and 40% of electricity use in 2021.[12]

2.1.2 Australia's industrial landscape

Australia is the world's 12th largest economy with nominal GDP being around US$1.72 trillion in 2023.[13] Australia is also a net exporter of goods, with raw materials making up the majority of exports.

The composition of Australian industry has changed, particularly over the last three decades. While activities such as mining have continued to contribute strongly to Australia's economy, the share of

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[3] Australian Bureau of Statistics, Division definitions: Australian and New Zealand Standard Industrial Classification (ANZSIC).
[4] Australian Bureau of Statistics, Numbering system and titles: Australian and New Zealand Standard Industrial Classification (ANZSIC).
[5] Statistisches Bundesamt, Classification of Economic Activities, issue 2008.
[6] Ibid.
[7] World Bank, GDP-Germany
[8] Deutschland.de, Germany as an industrialised country – the main facts
[9] Statista, Germany: share of economic sectors in gross domestic product(GDP) in 2022
[10] Statistisches Bundesamt, Economy, Foreign Trade
[11] Bundesministerium fur Wirtschaft und Klimaschutz, The German Mittelstand as a model for success
[12] von Graevenitz, Kathrine and Rottner, Elisa. "Energy Use Patterns in German Manufacturing from 2003 to 2017" Jahrbücher für Nationalökonomie und Statistik, vol. 243, no. 3-4, 2023, pp. 319-354. https://doi.org/10.1515/jbnst-2022-0031
[13] World Bank, GDP-Australia

economic activity from the manufacturing of energy-intensive finished products has declined. For example, in 1990, Australia had five vehicle manufacturers whereas today there are none.

In place of manufacturing, the services sector, which tends to use far less energy per unit of output, has grown quickly. The manufacturing sector's share of industry output has declined from 14.9% in 1990 to 5.7% in June 2023. Mining's share has increased from 4.9% to 14.3% and the health and education sector's share has increased from from 9.9% to 12.8% over the same period.[14]

In 2021, Australia's manufacturing sector was responsible for around 13% of national GHG emissions.[15] In the same time period, the mining sector was responsible for almost 21% of Australia's total emissions.[16] When looking at final energy consumption, manufacturing and mining account for 20.6% and 21.2% respectively of Australia's energy consumption.[17] This is substantially more than all sectors other than transport, which accounts for over a third of Australia's final energy consumption.[18]

2.2 Comparison of Australian and German industry

The industrial sectors of Germany and Australia have clear differences.

Australia is more focused on the upstream production of raw materials for export via its mining sector, while its manufacturing of high value-added products has declined over time.

In contrast, Germany's mining sector is less central to its economy, while its manufacturing sector is much more significant, and continues to produce high value-added products.

Manufacturing comprises a significant proportion of energy consumption in both Germany and Australia. Services has a higher energy consumption in Germany, and mining has a significantly higher energy consumption in Australia.

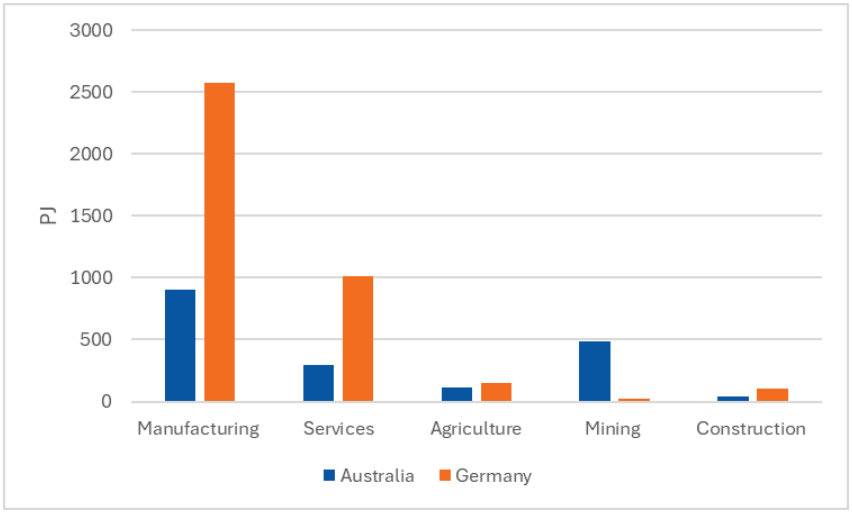

Figure 1 - Industry and services energy consumption in Germany and Australia (2021)[19]

[14] Reserve Bank of Australia, Snapshot comparison 1990-2023
[15] Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2023, 'National inventory by economic sector', *National Greenhouse Accounts*.
[16] Ibid.
[17] DCCEEW 2022, 'Table 10 Australian total final energy consumption, by industry', *Australian Energy Update 2022*, p.18.
[18] Ibid.
[19] Compiled using data from the IEA's Energy End-uses and Efficiency Indicators Data Explorer website

Figure 2 shows a comparison of energy consumption in industrial subsectors in Germany and Australia.

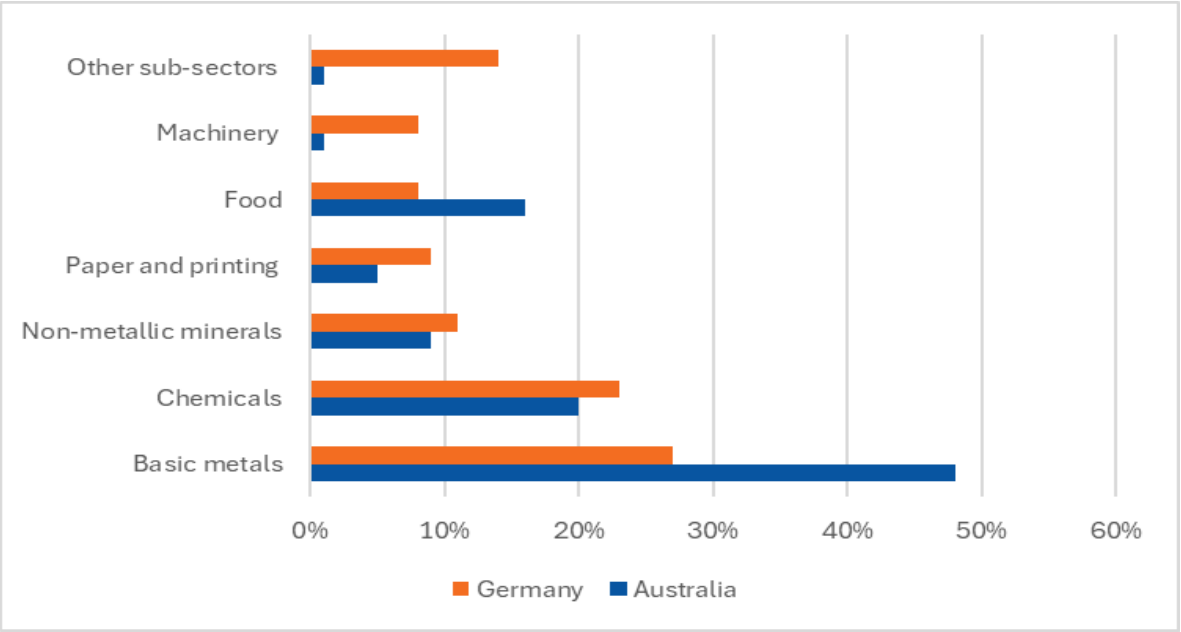

Figure 2 - Manufacturing energy consumption by subsector Germany and Australia (2021)[20]

The GHG emissions in some of these sub-sectors are considered 'easier to abate.' These include industries such as food processing and paper and pulp as their heat requirements are lower than those for basic metals and chemical production, opening up the opportunity to electrify production processes.

Electrification of these industries can also offer potentially large sources of flexible load to the grid, crucial for helping to balance electricity supply and demand as both Germany and Australia seek to increase the penetration of variable renewable energy sources.

Despite this potential and the 'easy to abate' opportunities offered, in both Australia and Germany these industries are not currently decarbonising at the rate required, indicating the presence of barriers to action.

Therefore, Australia and Germany should increase collaboration on the manufacturing industries which share the following characteristics:

- substantial presence in both Germany and Australia;
- energy intensive production processes;
- have access to mature, efficient electric technologies, however deployment is not yet at the required pace to achieve net zero targets;
- face pressure to decarbonise, including due to climate-related financial disclosure requirements, but often have less experience in emissions reduction; and
- where collaboration could help address barriers to accelerating the clean energy transition.

[20] Compiled using data from the IEA's Energy End-uses and Efficiency Indicators Data Explorer website

3 Energy and climate policy context

3.1 Australia and Germany's decarbonisation targets

It has been estimated that in 2023, energy accounted for more than three-quarters of GHG emissions globally.[21] This makes reducing energy use critical to reducing emissions.

Improving energy efficiency is widely seen as the lowest cost way to reduce emissions, and organisations such as the International Energy Agency have called on the world to step up efforts in energy efficiency to help achieve net zero by 2050.[22]

In response to the call to achieve net zero, both Australia and Germany have introduced increasingly ambitious climate targets in recent years.

3.1.1 Germany's decarbonisation targets

Germany has an interim emissions reduction target of 65% below 1990 levels by 2030 (previously 55%) and has committed to net zero by 2045 (previously 2050).

As a European Union (EU) Member State, much of German legislation and policy is framed by EU regulation and policy. The EU announced the European Green Deal in 2019, which "sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind".[23]

Since then, the EU has introduced a raft of policy and legislation to deliver the European Green Deal.[24] In October 2023 it was announced that the "Fit for 55" package of measures to reduce net GHG emissions by at least 55% by 2030, compared to 1990 levels was complete. [25] The EU now has legally binding climate targets covering all key sectors of the economy.

3.1.2 Australia's decarbonisation targets

Australia has a legislated net zero emissions target by 2050 and a 43% emissions reduction target on 2005 levels by 2030. This is an increase from the previous target of 26-28% reduction on 2005 levels by 2030.

The Australian Government has also committed to developing six detailed sectoral decarbonisation plans for the following sectors: electricity and energy; industry; resources; the built environment; agriculture and land; and transport.

All Australian states and territories have net zero targets of their own, with some committed to reach net zero emissions as early as 2045. Most states and territories also have interim targets with varying levels of ambition.

3.2. Energy markets

Australia and Germany have different energy markets, underpinned by differing policy ecosystems. More detail on this can be found in Appendix 1.

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[21] International Energy Agency (IEA), 2023, Greenhouse Gas Emissions from Energy Data Explorer
[22] IEA, 2023, Doubling global pace of energy efficiency progress by 2030 is key step in efforts to reach net zero emissions
[23] European Commission 2019 press release
[24] European Commission, The European Green Deal website
[25] European Commission, Fit for 55: Delivering on the proposals website

4 Australia and Germany's industrial energy policies

Overarching policy and legislative support to achieve Australia and Germany's decarbonisation targets are set out below. Further supporting policies which are not referenced in detail in this report are set out in Appendix 2.

4.1 Energy efficiency

Australia and Germany have both committed to increase energy efficiency through legislation and/or policy measures. It will be crucial for both countries to reduce demand to meet emissions reduction targets and maintain security of supply.

4.1.1 Germany

The Energy Efficiency Act (EEA) was introduced on 13 November 2023. The following targets for energy consumption (compared to 2008) are set out in the EEA. The EEA contains a review clause for targets after 2030 to be reviewed in 2027:

- 2030 targets
    - Primary Energy Consumption reduced by 39.3%
    - Final Energy Consumption reduced by 26.5%
- 2045 targets (derived from decarbonisation scenarios)
    - Primary Energy Consumption reduced by 57%
    - Final Energy Consumption reduced by 45%

The EEA implements EU requirements set out in the EU Energy Efficiency Directive (EED) which was first adopted in 2012 and updated in 2018 and 2023. The 2023 amendments came into effect on 10 October 2023. The changes significantly raised the EU's ambition on energy efficiency, formally establishing 'energy efficiency first' as a fundamental principle for the first time.

4.1.2 Australia

In 2024, the Australian Government released its National Energy Performance Strategy (NEPS), a national plan to coordinate action to improve energy performance in the residential, commercial and industrial sectors. This includes measures to improve energy efficiency, encourage electrification and boost flexible demand resources.

4.2 Legislated emissions reductions

4.2.1 Germany

Germany's emissions trading scheme (ETS) which was established through the Fuel Emissions Trading Act 2019 was amended in 2022. The national ETS complements the EU ETS (see below) by covering the heat generation, transport and waste incineration sectors which are not covered by EU ETS. Following the introduction of the national ETS, a wide range of sectors in Germany are now subject to a carbon price.

The EU Emissions Trading System (EU ETS) works on the 'cap and trade' principle and operates across the EU, Iceland, Liechtenstein and Norway. A limit is set on GHGs that can be emitted by 'installations' and aircraft operators covered by the scope of the system. The cap is expressed in emissions allowances (one allowance giving the right to emit one tonne of carbon dioxide equivalent). Every year, companies must surrender enough allowances to account for their emissions or receive heavy fines. Companies receive some allowances for free but can also buy allowances on the EU carbon market or trade allowances as needed. The cap is reduced annually in

line with EU climate targets. Since 2005, the EU ETS has helped bring down emissions from power and industry plants by 37%.[26]

The EU Effort Sharing Regulation (EU ESR) sets binding national emission reductions targets for the 2021-2030 period for the following sectors: domestic transport (excluding aviation), buildings, agriculture, small industry and waste. Germany's target is a 50% reduction (compared to 2005 levels).[27]

Under the EU ESR, the EU-wide emissions reduction effort is shared between all EU Member States, mostly based on a country's wealth as measured by GDP per capita. The EU ESR was adopted in 2018 and amended in 2023 to deliver the European Green Deal. As for the EU ETS, each Member State is provided with a number of emission allocations (corresponding to a tonne of CO2 equivalent) for each of the years in the period, and the number of allowances decreases every year. The EU ESR provides Member States with a set of flexibilities for offsetting emissions.

4.2.2 Australia

Australia's Safeguard Mechanism has been in place since 1 July 2016 and requires Australia's highest GHG emitting facilities – facilities that emit more than 100,000 tCO2-e – to keep their emissions below an emissions limit. Under this program, facilities needed to avoid emissions increases beyond business-as-usual or manage excess emissions (primarily through offsets, by using Australian carbon credit units (ACCUs)).

Since 1 July 2023 facilities covered by the Safeguard Mechanism must reduce emissions in line with Australia's climate targets. Facility baselines will adjust with annual production, but overall emissions limits tighten each year. If emissions from a Safeguard facility is below their baseline, they may be eligible to receive Safeguard Mechanism credit units (SMCs). If a Safeguard facility exceeds their baseline for a financial year commencing on or after 1 July 2023, they have several options to manage their excess emissions.

Australia's equivalent to the EU ETS – the Carbon Pricing Mechanism (designed to be a cap-and-trade scheme) was repealed in 2014. However, the Safeguard Mechanism does provide a pathway for facilities covered by the regulation to trade credits, effectively creating a 'baseline and credit' trading scheme.

[26] European Commission, 'What is the EU ETS?' website
[27] European Commission, 'Effort sharing 2021 – 2030: targets and flexibilities' website

5. Energy management systems & climate management systems

Given that in 2023, energy accounted for more than three-quarters of total greenhouse gas (GHG) emissions globally, it is imperative that energy use is reduced. [28] Decreased energy demand offers countries like Australia and Germany additional energy system benefits by reducing the need for more generation, transmission, and distribution assets.

Energy management systems (EnMS) are recognised as an essential tool in better managing and reducing energy use, helping businesses to drive continuous improvement in energy performance.

5.1 What is an energy management system?

Energy management systems (EnMS) are a systematic, organisation-wide process established to drive continuous improvement in an organisation's energy performance. While energy management systems include policies, plans and processes, it is executive buy-in and a dedicated energy manager and team with the necessary resources that is crucial to deliver ongoing energy management improvements. An EnMS is often confused with technology or software; it is neither, but may use these aids to help assist the process.

EnMS provide businesses with:

- A framework to manage energy with structured policies, processes and action plans to implement energy saving opportunities, enabling businesses to implement continual improvement in energy management and build on experience and trusted expertise;
- Organisational engagement with buy-in from senior management and other stakeholders, which facilitates the prioritisation of energy management practices throughout the business, including the ongoing allocation of resources rather than ad hoc project funding as a reflection of the organisation's acknowledgment of the cumulative benefits to the organisation;
- Improved corporate social responsibility (CSR) with a framework and organisational engagement to reduce emissions through strategic energy management;
- Improved risk management with a structured risk management mechanism through the implementation of an energy management system; and
- Ongoing energy use and cost reduction with the establishment, implementation and preservation of the necessary systems and processes to manage energy on site.[29]

The International Organisation for Standardization (ISO) has developed a standard for energy management systems: ISO 50001:*2018 Energy management systems – Requirements with guidance for use*. An ISO 50001 compliant energy management system enables businesses to develop their own systems and processes for managing energy and follows the plan, do, check, act cycle to ensure continuous improvement. Continuous compliance is independently audited annually.

The Plan-Do-Check-Act cycle is central to EnMS, and management systems more broadly. It enables continuous improvement in energy management.

[28] IEA, 2023, Greenhouse Gas Emissions from Energy Data Explorer

[29] This information initially appeared in the Energy Efficiency Council's briefing 'Navigating a dynamic energy landscape: a briefing for manufacturers'.

Figure 3 – An illustration of the Plan-Do-Check-Act approach in relation to EnMS

5.2 What are the benefits of an energy management system?

An EnMS provides all levels of staff (including top management) with a comprehensive knowledge of an organisation's energy use. This facilitates the identification of areas of improvement enabling the organisation to reduce energy use (and therefore costs), enhance productivity and competitiveness and make energy led decisions.

5.2.1 Energy savings

The Climate Group's latest EP100 annual report notes that companies with an EnMS report a 7% annual improvement in energy productivity.[30]

A German Study of the Impact of Energy Management Systems found that when a systematic approach to energy management is adopted, there is no drop in the level of energy efficiency increases over time.[31] The study notes 'looking at a time period from less than five years to over 20 years, it becomes clear that in percentage terms the reported savings of 3% to 4% are almost identical to those noted at the start' (see figure 4). After 20 years, further energy efficiency opportunities continue to exist and be exploited.

[30] Climate Group 2023, *Climate critical: The energy efficiency imperative*, p. 6.

[31] Deutsch, N et al 2022, A Study of the Impact of Energy Management Systems – Final Report, Bundesstelle für Energieeffizienz [German Federal Agency for Energy Efficiency]

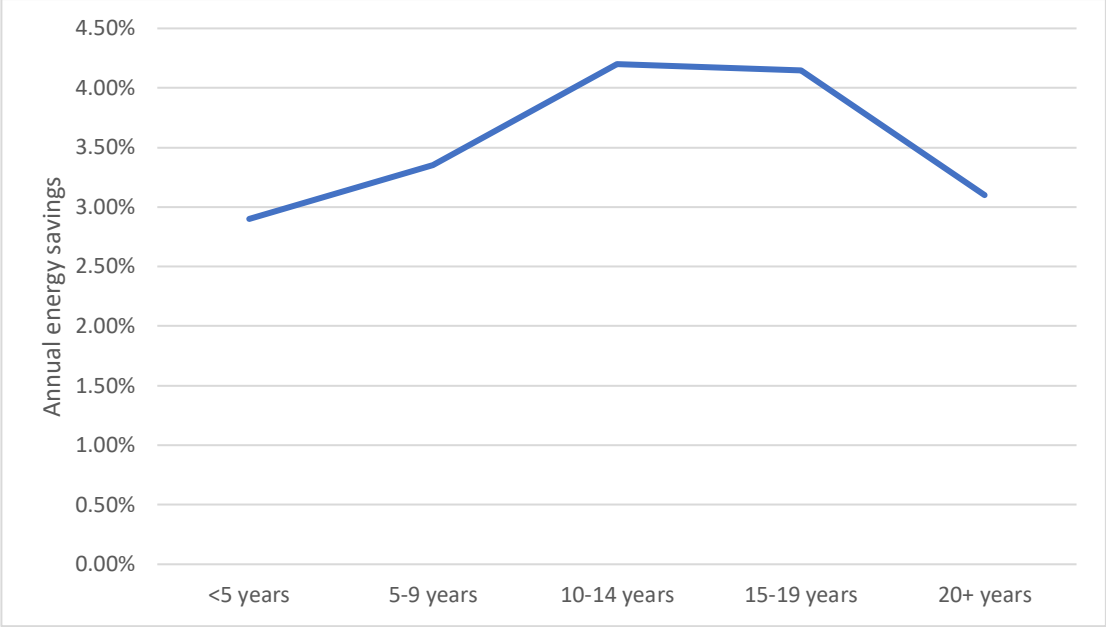

Figure 4 - Annual energy savings attributed to EnMS implementation over time[32]

5.2.2 Emissions savings and climate management

The same study of the Impact of Energy Management Systems found that "the large-scale introduction of EnM[S] systems in accordance with ISO50001 can make a significant contribution to the achievement of climate targets" and that "The potential large-scale introduction of EnM[S] systems according to ISO 50001 at [German] companies with an annual energy consumption of more than 10 GWh would reduce CO2 consumption by approximately 158 megatons over the next 23 years (by 2045)".[33]

This research makes it clear that an EnMS can be used to support emissions management. As a further step to link EnMS implementation with emissions reduction, an EnMS can be adapted to support measuring, reducing and reporting emissions with relatively trivial changes.

There is currently no internationally agreed standard for an emissions or climate management system. However, there are elements of a climate management system in existence. These include:

- Standards for measurement and verification of GHG emissions in the ISO 14064 standards);
- Emerging standards for setting and implementing emissions reduction policies and transition plans; and
- The systems for setting and achieving reduction goals in the ISO 50001 energy management system standards.

The German Business Initiative for Energy Efficiency (DENEFF, *Deutsche Unternehmensinitiative Energieeffizienz)* has prepared a plan to adapt the standard energy management system approach into a climate management system.[34] DENEFF's guidance incorporates scope 1, 2 and 3 emissions and represents a total approach to emissions reduction.

[32] Redrawn from Deutsch, N et al 2022, *A Study of the Impact of Energy Management Systems – Final Report*, Bundesstelle für Energieeffizienz [German Federal Agency for Energy Efficiency], p.30

[33] Deutsch, N et al 2022, A Study of the Impact of Energy Management Systems – Final Report, Bundesstelle für Energieeffizienz [German Federal Agency for Energy Efficiency], p.12

[34] German Business Initiative for Energy Efficiency (DENEFF) 2021, *From energy management to climate management through 5 stages – in 14 steps*, Berlin.

5.2.3 Less exposure to climate risk

An organisation that has an EnMS in place is well placed to manage the risk associated with transitioning to a low carbon economy.

The adoption of the systematic, continuous plan, do, check, act approach of an EnMS may make it easier to comply with market based and government climate and/or energy based regulations. For example, policies and processes related to energy management can be expanded to include climate matters - see section 5.2.2.

5.2.4 Support for a more dynamic grid

An EnMS can provide the data and systems to support a more dynamic grid. Organisations with a deeper understanding of their energy use can take advantage of incentives to support the grid such as changing the time of use to take advantage of low energy prices, sell energy to the grid during peak prices or benefit from demand response programs.

5.3 Germany

5.3.1 Energy Management Systems

In 2022, 5523 certificates of ISO 50001 compliance, covering 16,452 German sites were in place, the most of any country in the world.[35] In addition to promoting ISO 50001 compliance, Germany has several other approaches in place to support industrial energy management. This includes the European Commission's Eco-Management and Audit Scheme (EMAS) which was developed by the European Commission in 1993 for companies to improve their environmental management. Compliance is generally monitored annually by a government approved expert.[36]

Germany has encouraged the uptake of energy management using various methods as set out below.

5.3.1.1 Incentives

Germany has incentivised the uptake of EnMS since 2009 under the Renewable Energy Sources Act 2000 (EEG). The EEG came into force in April 2000 with the aim of promoting the expansion of renewables through a variety of measures including a government-set feed-in tariff. The EEG introduced a surcharge to all electricity consumers to finance this scheme.[37]

A 2009 revision introduced a special equalisation scheme for energy-intensive businesses if they introduced an EnMS, as well as meeting energy cost and intensity thresholds. The definition of an EnMS was relatively wide, including a certified EnMS according to EN 16001, ISO 14001, EMAS, or if a company met the requirements of a mandatory verification process whereby energy consumption and the potential to reduce it is assessed and evaluated.[38]

In 2012 the EEG was further amended which changed the requirements of the special equalisation scheme. Under this act, having an ISO 50001, EN 16001 or EMAS compliant system in place was a prerequisite for a reduction of the charge for energy intensive companies (for those companies with an electricity consumption of at least 5GWh per year).[39]

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[35] ISO, The ISO Survey

[36] Other mechanisms that encourage transparency in energy consumption and help identify areas for improvement, but do not provide for ongoing continuous improvement include standards for energy audits (in accordance with regulation DIN EN 16247-1) and 'alternative systems' introduced under the German Regulations on Systems for Improving Energy Efficiency (SpaEfv).

[37] German Federal Ministry for Economic Affairs and Climate Action n.d, *State imposed components of the electricity price*

[38] Government of Germany, *Act Revising the Legislation on Renewable Energy Sources in the Electricity Sector and Amending Related Provisions of 2008 [Translation]*, 2008, and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2010, *DIN EN 16001: Energy Management Systems in Practice*

[39] C Rohde, Fraunhofer ISI, *Climate change policy measures in industry, the example of Germany*

More recently, incentives for smaller energy users introducing an EnMS have been put in place.

The benefit of reduced taxes became available under the Energy Transition Financing Act (EnFG) which was issued in July 2022. Under this act, electricity-intensive companies (in assigned industries) with electricity consumption of above 1 GWh per annum are eligible to a tax reduction if they meet certain conditions, including having an EnMS in place.[40]

What constitutes an 'EnMS' for the purposes of this act depends on the electricity consumption of the company:

- For companies that consumed more than 1GWh in the past financial year, the definition of EnMS includes a certified energy management system based on ISO 50001 or EMAS.
- For companies that consumed less than 5GWh in the past financial year the definition of EnMS includes a non-certified energy management system based on:
    - ISO 50005:2021 at least corresponding to implementation level 3; or
    - membership in an energy efficiency and climate action network registered with the Initiative for Energy Efficiency and Climate Action Networks (ISO 50001), or
    - carrying out an energy audit.[41]

5.3.1.2 Regulatory measures

European legislation has also been key to driving the uptake of EnMS in Germany. In order to transpose the 2012 EU Directive for Energy Efficiency 2012/27/EU (Art. 8), the German Energy Services Law imposed an obligation on qualifying businesses (non-SMEs) to undertake energy audits by 5 December 2015 and every four years thereafter. If an audit was not undertaken, a fine of EUR 50,000 could be imposed. Businesses would be exempt from this obligation if they had implemented an ISO 50001 or EMAS compliant system.[42]

Following the introduction of the German Energy Services Law and the Renewable Energy Sources Act in 2012 the number of certifications of ISO compliance in Germany increased from 42 in 2011 to 9024 in 2016. The number of EMAS-registered organisations also saw an increase between 2012 and 2017, however this increase did not continue to 2020 but an increase has been seen since 2020 (see figure 5 below).[43]

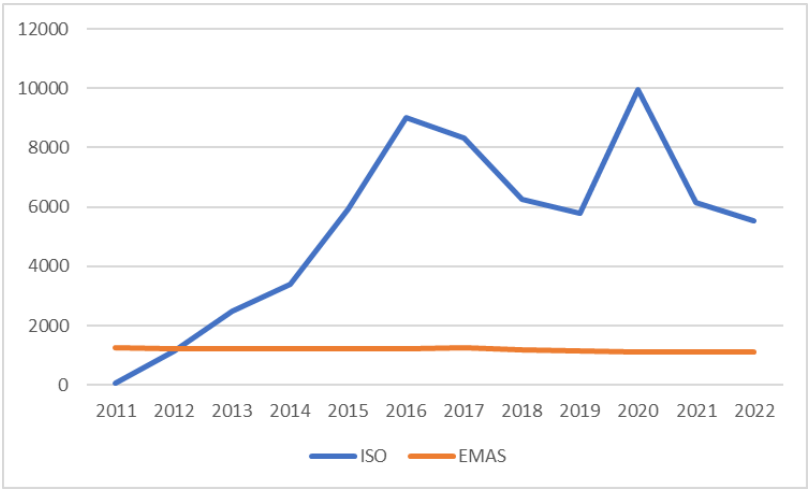

Figure 5 - Number of EMAS-registered and ISO 50001 compliant organisations

[40] German Federal Office for Economics and Export Control, *Special compensation application process*, translated from German.
[41] German Government, *Energy Financing Act* [Gesetz zur Finanzierung der Energiewende im Stromsektor durch Zahlungen des Bundes und Erhebung von Umlagen], translated from German.
[42] C Rohde, Fraunhofer ISI, *Climate change policy measures in industry, the example of Germany*
[43] Data sources: ISO Survey data, various years, and German Federal Ministry of the Environment, *Indicator: Environmental Management*.

In order to increase the uptake of energy management, under the Energy Efficiency Act (EEA) companies with an annual energy consumption which exceeds 7.5 GWh per annum must implement energy or environmental management systems in accordance with ISO 50001 or EMAS respectively. The German government estimates that around 12,000 companies will be covered by this legislation, with approximately 3,500 implementing an ISO 50001 compliant EnMS or EMAS for the first time.

5.3.1.3 Funding programs to support energy management

In order to encourage the uptake of energy management in small and medium sized businesses not targeted by the tax incentive, funding programs were put in place to support energy audits, ISO certification, metering and software.

5.3.1.4 Capability building

Although German energy advisers are clearly familiar with energy management systems and their application, workforce development to the level and capacity required is still an important issue in Germany. The Energy Efficiency Expert list for Government Funding Programs hosted by the German Energy Agency (DENA) consists of energy consultants that are eligible to advise applicants in federal funding schemes. These experts are required to participate in regular training sessions with specific energy related content.

5.4 Australia

EnMS adoption in Australia lags behind many other countries, including Germany. This is due to industry's historical access to cheap energy, and a lack of regulations or incentives that would require or encourage adoption.

According to the International Organisation for Standardisation (ISO), in 2022 there were only 17 sites in Australia registered as being ISO 50001 compliant. Although having an ISO 50001 compliant EnMS is only one measure of EnMS uptake, experts advise that adoption of formal EnMS systems is uncommon in Australia.

Support for implementing an EnMS has primarily been provided by state and territory governments through various initiatives focussed on raising awareness of the benefits of energy management rather than through the kind of regulatory requirements observed in Germany.

The New South Wales (NSW) Government has been a leader in terms of promoting EnMS in Australia. Its Energy Management Services (EMS) program was a five-year program from 2017 to 2022 that aimed to engage businesses and business advisors develop their energy management skills. [44] The program included delivery of an Energy Management Maturity Diagnostic via a facilitated workshop, development of an EnMS action plan leveraging diagnostic findings and provision of on-going support services in select areas of EnMS improvements identified through the diagnostic and action plan. These support services were delivered to participating businesses by external energy advisors, that were on a pre-existing – and now defunct – panel of preferred providers.

The Australian Government does not currently have any policies that explicitly target the improvement of industrial energy management. However, this was not always the case. The Energy Efficiency Opportunities (EEO) program, which was closed in 2014, was celebrated internationally for "enhancing capacity [of] large energy users to act to reduce energy and thus business costs."[45]

Under the EEO program, corporations consuming more than 0.5 PJ of energy per year were required under law to identify energy efficiency opportunities every five years, providing an incentive to invest in energy efficiency and management opportunities. While liable entities were not required to

[44] KPMG, 2022, Energy Management Services Program Outcome Evaluation
[45] IEA, 2018, Australia 2018 Review, p. 208.

implement solutions to identified problems, the program provided high-level visibility of these opportunities, reducing information barriers to investing in energy efficiency and management.

The Australian Government has several indirect policies that encourage engagement with energy management, including:

- The National Greenhouse and Energy Reporting (NGERS) Act which requires businesses to report their energy use and GHG emissions if they meet certain thresholds of energy use or GHG emissions. There are facility thresholds and corporate group thresholds that target the largest energy users or emitters. For example, the facility thresholds are 25kt or more of GHG emissions (scope 1 and scope 2); production of 100TJ or more of energy or consumption of 100TJ or more of energy.
- Safeguard Mechanism – as set out at section 4.2.2, the Safeguard Mechanism is an extension to the NGERS framework that requires large GHG emitters to not exceed designated emissions baselines. This not only requires liable entities to measure and report their emissions, but also to actively manage their emissions to avoid exceeding their designated emissions baseline.
- Climate related financial disclosure (please see section 5.5 below).

Energy advisors in Australia are familiar with advising business on elements of an EnMS, but training across all requirements of a sustainable energy management system has only recently been introduced.

In order to formally upskill the workforce in relation to energy management, and in support of the coaching offer under the NSW EMS program, in 2020 the Energy Efficiency Council (EEC) developed the EnMS Advisor training course to support energy services advisors. The training is owned by the NSW Government, with the EEC holding an exclusive delivery license.

The EEC also worked with the Australian Federal Government and the Victorian Government, alongside the NSW Government, to develop a professional certification pathway for EnMS Advisors; the Certified EnMS Advisor certification, which has been available since 1 July 2022. There are currently 20 individuals registered as a Certified EnMS Advisor.

5.5 EnMS, Climate related financial disclosure (CRFD) and transition planning

Stakeholders including investors, regulators and customers are demanding transparency of how an organisation is managing climate-related risks and opportunities, and whether they have a credible plan to reach net zero. The International Sustainability Standards Board (ISSB) was established in 2021 to develop comprehensive baseline global standards for climate disclosure and sustainability reporting. The first two ISSB standards were released in June 2023.

There is a global movement towards mandatory climate-related disclosure aligning to the ISSB standards. It is expected that this will lead to an increase in supply chain pressure on businesses that are not required to report. That is, companies with reporting requirements (that include Scope 3 emissions) will seek information on the carbon footprint of their suppliers and actions being taken by those suppliers to reduce their emissions. Guidance and clarity on what should be included in a transition plan is being developed globally, with the UK's Transition Plan Taskforce being considered best practice at this point in time.

The European Commission, The European Financial Reporting Advisory Group and the International Sustainability Standards Board (ISSB) have confirmed a high degree of alignment on climate-related disclosures under the European Sustainability Reporting Standards (ESRS) which will apply in Germany.

The Australian Accounting Standards Board (AASB) has noted that the work of the ISSB will be used as a baseline for Australian reporting.

The advent of climate-related financial disclosure is likely to put an increased focus on organisations' management of emissions, and the risks that the transition to a net zero economy could pose to them.

5.5.1 Climate related financial disclosure

The Corporate Sustainability Reporting Directive (CSRD) will apply in Germany. The CSRD requires large companies, as well as listed SMEs, to report on sustainability matters according to the European Sustainability Reporting Standards (ESRS). Reporting under these standards will begin in 2025 (with the rules being applied from 2024). The ESRS contains standards covering a range of environmental, social and governance issues.

Climate-related financial disclosure is currently expected to become mandatory for some companies in Australia from January 2025 with coverage expanding steadily between 2025 and 2027. The proposed regime will require liable companies to report their emissions and their exposure to the physical and transition risks associated with climate change.

5.5.2 Transition planning

In Germany, under the EEA, companies with an annual energy consumption of more than 2.5 GWh on average throughout the last three calendar years must create and publish feasible plans to implement final energy saving measures identified as economical as identified through an energy or environmental management system, or on the basis of an energy audit. Companies must have these implementation plans independently confirmed by certifiers, environmental experts or energy auditors before publication.

This requirement and funding for transition plans (known as transformation plans in Germany) has led to a strong uptake in Germany. The German government funds 40-60% of the cost of plan development (70% if the company participates in an Energy Efficiency and Climate Action Network).

In Australia, the proposed legislation only requires the disclosure of a transition plan if the company has one.
Climate related financial disclosure and transition planning is a focus topic in Germany and Australia.

Opportunity for German Australian collaboration: Leveraging energy management systems to achieve climate management goals and targets.

As energy use can account for a large proportion of an organisation's emissions, there is an overlap between energy management and emissions management which can be optimised by an organisation with a net zero goal.

Under the CRFD standards in Germany and the proposed CRFD standards in Australia, many corporate entities will be required to comprehensively measure their energy use and emissions, as well as their climate risks.

As has been identified in recent work from DENEFF, there is an opportunity to develop a climate management system, building on the structure and content of an energy management system. This climate management system could also align to the International Sustainability Standards Board's standards as well as German (European) and Australian reporting standards.

The development of such a system would require significant effort and further exploration is warranted. At an online workshop to consider research to date, government and industry could help clarify appetite for such an effort and the necessary next steps.

A short report characterising the outcomes of this workshop would complement the DENEFF study and form a good basis for further work.

6. Capability building to deliver on energy efficiency opportunities

6.1 Germany's Energy Efficiency and Climate Action Networks Initiative

One of Germany's key knowledge-sharing initiatives is the Initiative for Energy Efficiency and Action Networks which arose from the initial Initiative for Energy Efficiency Networks. An Energy Efficiency Network (EEN) is a collaborative energy management approach in which a group of 8 to 15 organisations identify energy savings potential, set a collective target, implement measures, and monitor the results.

6.1.1 History of Energy Efficiency Networks in Germany

The concept was first developed in Switzerland and was adopted in Germany in 2002. It was piloted between 2002 and 2013, and in 2014 the Initiative for Energy Efficiency Networks (IEEN) was launched as a voluntary agreement between the German Government and 22 business associations with a target of creating 500 EENs by the end of 2020.

Since January 2021, the German Federal Government and business associations have continued the network initiative as the Initiative for Energy Efficiency and Climate Action Networks (IEEKN), extending the scope to include climate change mitigation measures. This extended framework intends to establish 300-350 new networks by the end of 2025, saving 9-11 TWh of final energy and 5-6 million tons of greenhouse gas emissions.

There are currently about 400 networks in place with over 3000 companies as members.

adelphi have produced a global guide[46] which sets out the practices and lessons learnt in Germany which informed section 6.1 of this report.

6.1.2 Governance of the networks

The networks have the following governance structure:

- A steering committee comprised of two Federal Ministries (for Economic Affairs and Climate Action, and for Environment, Nature Conservation, Nuclear Safety and Consumer Protection) and more than 20 leading industry associations and chambers of commerce.
- An administrative office - the German Energy Agency (DENA) fulfils this role and coordinates registration of the networks and is a central point for enquiries.
- A Monitoring Institute - adelphi and Fraunhofer ISI fulfil this role and provide independent monitoring to document the work of the networks and measure the impacts of the implemented measures.

6.1.3 Members of each network

Each network registered with the initiative will usually have the following members:

- The Network Operator – responsible for forming the network and supporting its work.
- The Network Moderator – responsibilities include organising and moderating network meetings, sourcing external expertise, communicating results.
- Energy Experts – responsible for carrying out the initial energy consultation and then recommending optimisation measures.
- Participating companies – exchange of experiences and information.

[46] The guide is available here.

6.1.4 Requirements of each network

In order to be registered, the network must comply with the following:

- It must have at least 5 participating companies.
- All of the participating companies must have undertaken a qualified energy consultation.
- The network must set a savings goal.
- The participating companies must carry out regular, moderated meetings.

6.1.5 Setting up a network

Setting up a network involves the following key steps:

1) The Network Operator initiates the network and the participants agree on the duration of the network (a maximum of 4 years) and the moderator who will support the network.
2) The participating companies analyse their energy saving potential and identify measures to implement. This analysis leads to each company setting an energy savings target in megawatt hours per year and optionally a greenhouse gas savings target in tonnes of CO2 equivalent per year. The participating companies' individual savings targets are then aggregated into a cumulative network target.
3) Measures are implemented and regular meetings are organised to exchange learnings.
4) Analysis of the energy savings realised is undertaken at the end of the term and is mandatory for all networks.

6.1.6 Funding of the networks

The work of the Administrative Office (DENA) and the Monitoring Institute is commissioned by the Federal Ministry for Economic Affairs and Climate Action (BMWK).

Network operators and network moderators can be employees at one of the participating companies, an external energy consultant or auditor, or an employee of an industry association or chamber of commerce. Companies participating in networks are not paid. External consultants are paid by the companies or, depending on the state, funded by state government support.

While networks do not receive any direct financial support from the German Federal Government, some state governments offer both institutional support and direct financial support programmes for network activities. Participants could also apply for different federal government grants for energy efficiency consulting or investments.[47]

As of May 2023, a 10% bonus is awarded to IEEKN companies for the implementation of transformation plans (transition plans) under the German funding program "Energy and Resource Efficiency in the Economy". There is also some sporadic support for participating companies at federal state level, for example, the funding of modernisation costs, costs for external consultants or the evaluation of measures.

6.1.7 Success of the networks

A 2018 study on EENs found that the “long-term effects [of participation in an EEN]– whether energy cost savings, CO_2 emission reductions or innovative ideas in processes and own products and services – are unexpectedly high” and noted that benefits include:

- Average energy savings (within 4 years) of 2.3% per year;

[47] Durand, Antoine et al. 2018: Energy efficiency networks: lessons learnt from Germany

- Average CO_2 emissions reduction of 2.4% per year;
- Innovative ideas of participating companies as they gain more competence and know-how;
- Disseminating know-how within larger companies, with some groups setting up internal EENs;[48]

This study also found that participating in an EEN improved internal decision making. It noted that 80% of companies only use risk indicators (payback periods) and no profitability indicators (e.g. internal interest rate, present net value) for their decisions on energy efficiency measures and that payback periods of more than 2 to 3 years are mostly not accepted for energy efficiency investments.

After participation in an EEN for three to four years, 5% of the participants changed their decision routines and included a profitability measure (mostly the internal rate of return).

A 2024 report by adelphi and Fraunhofer ISI found that:

- "2479 companies participating in 239 networks reported a total of 10,525 energy efficiency measures implemented. In 9713 of these, the energy savings were quantifiable; the remaining measures were primarily organisational, such as training and information campaigns".
- The 9713 quantifiable energy-saving measures resulted in total annual savings of 7432 GWh of final energy, 9350 GWh of primary energy (only the non-renewable share is considered) and 2686 kt CO_2. The 239 networks analysed achieved 91% of their average network target of 34.15 GWh/a, as reported as part of the monitoring process. [49]

6.2 Australia

Australia has had a diversified and fragmented approach to knowledge sharing through networks. Knowledge sharing initiatives in Australia tend to involve a mix of state-based, business-driven, and community initiatives, rather than a coordinated national approach.

6.2.1 The New South Wales (NSW) Government's Sustainability Advantage Program

The NSW Sustainability Advantage program works with organisations to "accelerate the adoption of sustainable practices".[50]

As well as providing members with practical assistance to develop strategies or identify and implement efficiency measures, Sustainability Advantage acknowledges sustainability outcomes achieved by its members, with four levels of recognition. Sustainability Advantage members are also given the opportunity to attend regular events to share experiences and learn from experts about international best practice and new research.

Since 2007, Sustainability Advantage has worked with more than 800 NSW members, helping them to save over $120 million every year.

> Opportunity for Australian German collaboration: Exploration of the viability of Energy Efficiency and Climate Protection Networks in Australia, informed by the German experience.

[48] Ibid.
[49] Barckhausen, Anton; Rohde, Clemens; Jensterle, Miha; Neusel, Lisa; Adak, Beyza 2024: Monitoring der Initiative Energieeffizienz-Netzwerke. Siebter Jahresbericht. Berlin: adelphi.
[50] For more information, see the Sustainability Advantage website

Australia should build on Germany's successful experience with Energy Efficiency and Climate Action Networks and explore how Communities of Practice which follow the German model could be adapted for the Australian context.

adelphi has produced a global guide[51] on Energy Efficiency Networks setting out the challenges, success factors and impacts of the networks in Germany. A knowledge sharing workshop would be a practical next step.

This online workshop could include key German organisations such as the German Energy Agency (DENA), adelphi and Fraunhofer ISI as well as relevant Australian stakeholders.

A short report characterising the outcomes of this workshop would complement the adelphi and Fraunhofer ISI report and form a good basis for further work.

[51] The guide is available here.

7. Electrification technologies

Australia and Germany are both significantly increasing the proportion of renewable energy generation.

Germany has a target for renewables to meet 80% of electricity demand by 2030. In Australia, the Renewable Energy Target is a legislated requirement that has been in operation since 2001, with the original aim to source an additional 2% of Australia's electricity generation from renewable sources. In 2009, this target was increased to 20% by 2020. The 20% target was achieved in 2019. In 2023, the "Powering Australia" plan introduced an aspirational target to reach 82% renewables (on a generation basis) into the National Energy Market (NEM) by 2030.

It will be crucial for both countries to promote electrification, flexibility and consider time of use to retain security of supply as the proportion of renewable energy supply to the grid increases.

In both countries, electrification of industry using high efficiency equipment powered by renewable electricity will be key to the transition to net zero emissions.

This section examines some key cross-cutting efficient electric technologies for industry, and the context for each technology in both countries. It covers:

- high efficiency motors (used across manufacturing, including in pumps); and
- heat pumps (replacements for boilers that are used for heat throughout many industrial facilities).

Although this report focuses on the technology, it is important to note that the efficiency of a product is also affected by the circumstances of its use. Maintenance, optimisation, and integrated design is needed to ensure operational efficiency. An energy management system can assist an organisation in monitoring and improving on these areas.

7.1 Super-efficient motors and pumps

Globally, electric motors are responsible for over 40% of electricity use.[52] There are approximately 8 billion electric motors in use in the EU alone, which consume nearly 50% of the electricity the EU produces.[53]

In Australia, it is estimated that electric motors account for nearly 30% of total electricity consumption in all industries.[54]

Given the proportion of industrial energy use associated with motors and pumps, a focus on the energy efficiency of this equipment is critical to reducing electricity use and emissions.

Electric motors have a range of residential, commercial and industrial applications, including the operation of pumps, compressors and fans. A summary of applications is set out in Appendix 3. The International Electrotechnical Commission (IEC) has contributed to the global definition of energy-efficient electric motor systems through the test standard IEC 60034-2-1 for electric motors and the IEC 60034-30-1 classification scheme. Under these standards, the energy efficiency of electric motors is calculated as the ratio of the mechanical output power to the electrical input and is expressed in International Energy efficiency classes (IE), with IE5 being the highest-class energy efficiency.

[52] IEA, 2011, Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems
[53] European Commission, Energy Efficiency Products, Ecodesign and Energy Label website
[54] Sustainability Victoria website, Reduce motor running costs in your business

These IE-classes are used by international governments to specify the efficiency levels for their minimum energy performance standards (MEPS). Both Australia and Germany have adopted MEPS (Germany through implementation of European legislation).

The EU first set motor MEPS in 2009, upgrading these MEPS with the 'Regulation on electric motors and variable speed drives (EU) 2019/1781' to cover a larger scope of motors and increase efficiency requirements.

The Greenhouse and Energy Minimum Standards (GEMS) Act is the underpinning legislation for the Australian Government's Equipment Energy Efficiency (E3) Program.

Commenced in 1992, the E3 Program is an initiative of the Australian Federal government, the Australian states and territory governments and the New Zealand Government to improve the energy efficiency of appliances and equipment.

A comparison of German and Australian MEPS is set out in Table 1 below.

	Australia	Germany (under European legislation)
Applicable standard	The Greenhouse and Energy Minimum Standards Determination 2019.	Commission Regulation (EU) 2019/1781 amended by (EU) 2021/341 under Ecodesign Directive 2009/125/EC defines the scope for direct-on-line operated low voltage induction motors and variable speed drives.
Scope	Induction motors rated for direct-on-line (DOL) operation and inverter duty motors that can be DOL operated.	Induction motors rated for direct-on-line operation. IC418 (TEAO), Ex motors with protection types Ex ec, Ex db, Ex dc, Ex tb and Ex tc are covered.
Output	From 0.73kW up to but not including 185kW	From 0.12 kW to 1000 kW
Speed	2-, 4-, 6- and 8-pole motors	2-, 4-, 6- and 8-pole motors
Voltage and Frequency	Up to 1100 V, rated for 50Hz and/or 60 Hz sinusoidal voltage	From 50 V up to 1000 V, rated for 50 Hz, 60 Hz and 50/60 Hz sinusoidal voltage
Motor efficiency	IE2 or IE3	0.12kW – 0.75kW – IE2 0.75kW – 75kW – IE3 75kW – 200kW – IE4 Over 200kW – IE3

Table 1: Overview of electric motor standards in Germany and Australia[55]

[55] The source for most of the information in this table is ABB's Minimum Efficiency Performance Standards for electric motors presentation.

It is noted that:

- some motors designed for specific purposes are excluded from the regulations in both countries; and
- in Australia, industrial users using larger motors (which are not covered by the Australian standards set out in Table 1) will often follow the IEC standard. This standard is considered best practice due to its maturity and transferability for international companies.

Australia and Germany support the following international initiatives and collaboration efforts:

- The Super-Efficient Equipment and Appliances Deployment (SEAD) Initiative which promotes energy-efficient appliances, lighting and equipment to reduce energy use and emissions. Electric motors are a current focus of SEAD which has set a goal doubling the efficiency of these products sold globally by 2030; and
- The 4E Electric Motor Systems Annex (EMSA) which promotes opportunities for energy efficiency in motor systems by sharing best practice information and through the development of internationally aligned test standards.

As demonstrated by Table 1, European standards apply to a wider scope of motors. The European standard also clearly defines individual efficiency rating required depending on the size of the load, mandating the higher efficiency level of IE4 for the most commonly used size of motor.

Australia should amend its standards to provide the same level of clarity and ambition.

Opportunity for German Australian collaboration: Australia should focus on widening the scope of Australian MEPS to align with the European standards to meet higher IEC efficiency classes.

7.2 Steam, hot water and process heating

7.2.1 Heat pump potential

Steam, hot water and process heating are commonly powered by fossil gas in both Australia and Germany. They are essential resources for many manufacturers, with estimates of their industrial energy consumption ranging from one-sixth to one-third of total consumption.[56]

Heat pumps are an efficient technology for heating and cooling that can be powered by renewable electricity. They can be used to decarbonise buildings and industry over a range of applications, from domestic hot water to industrial heating processes. Industrial heat pump systems for heating up to 95°C are readily available, and systems that can heat up to 110°C are becoming more common.

However, for the temperature range above 100°C, only a few commercially viable technologies are *currently* available.

Figure 6 below provides a summary of the development pathway for higher temperature heat pumps.

[56] The source for this information is the EEC's briefing 'Navigating a dynamic energy landscape – A briefing for manufacturers'.

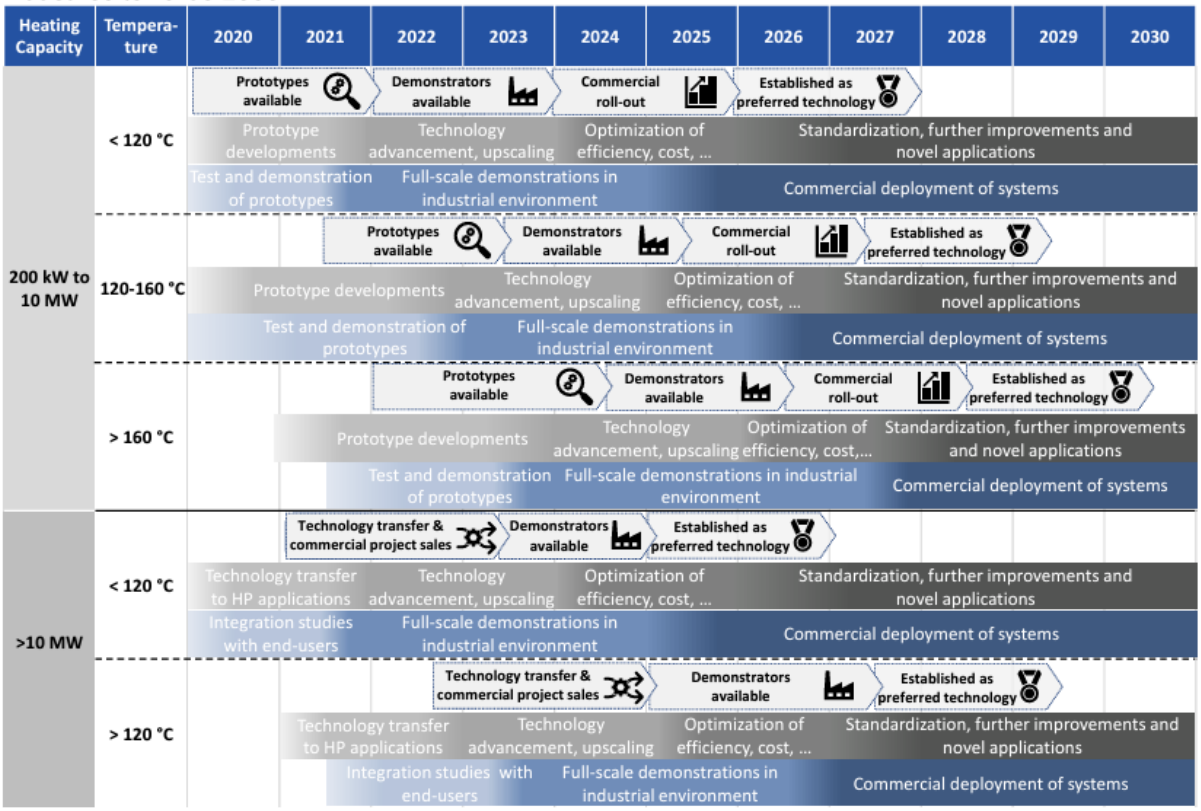

Figure 6 Overview of the technology development perspectives for high-temperature heat pumps towards 2030 based on the insights from Annex 58.[57]

Industrial heat pumps could also be used to optimise demand flexibility for increased variable renewables utilisation. With the increasing penetration of renewable electricity in Australia and Germany, flexibility on time of use will become increasingly important. A heat pump can be scheduled to come on during times of low (or negative) electricity cost or high solar PV production to soak up renewable electricity in a thermal battery which can then be dispatched as it is needed. The heat pump can also be turned off if needed to help reduce demand on the grid and provide grid stability as well as optimising on-site electricity costs. The ability of a facility to adopt some or all of these flexibility practices will vary depending on production needs.

7.2.2 Barriers to heat pump uptake

The International Energy Agency (IEA) has highlighted the importance of heat pumps in a global transition to net zero, however, there are barriers to their uptake which need to be addressed.

These barriers include a lack of knowledge, financial barriers, supply chain barriers, challenges to retrofit heat pumps in industrial settings, and a lack of examples which demonstrate success. More on these barriers and methods to overcome them can be found in Appendix 4.

While both Australia and Germany are taking steps to address these barriers, further work is needed to harness the potential of heat pumps to decarbonise industry in both nations.[58]

[57] IEA, Technology Collaboration Programme, Annex 58, High-Temperature Heat Pumps, Task 1 – Technologies, Task Report

[58] For more details on barriers in Australia, see the 'Harnessing heat pumps for net zero' report. For further information about the uptake in Europe, please see 'Strengthening Industrial Heat Pump Innovation – Decarbonising Industrial Heat'.

7.2.3 Australia

Australian industry accounts for 44% of the nation's end-use energy and 52% of that is for supplying process heat with natural gas as the leading source of energy.[59] Modern heat pump technology could be deployed in all Australian climate zones across a range of low temperature industrial processes.

Further development in heat pumps is showing their potential for application in medium-temperature applications (90ºC to 150ºC), and in the mining sector for alumina processing.

The report 'Harnessing heat pumps for net zero' by the EEC and the Australian Alliance for Energy Productivity (A2EP) has found that heat pumps could deliver emissions reductions of 391 Mt CO2e in industrial processes to 2050[60].

The Australian Federal, state and territory governments have introduced a limited range of programs and incentives to drive the uptake of heat pumps in industrial applications. Examples of current programs include:

- General energy efficiency grants, such as the Federal Energy Efficiency Grants for Small and Medium Sized Enterprises with a pool of $63 million offering grants up to $25,000 to cover up to 100% of eligible project expenditure.
- The Australian Federal Government's Small Business Energy Incentive provides $314 million in tax relief for energy performance upgrades, including for heat pumps (available until July 2024).
- Major incentive schemes including the Victorian Energy Upgrades program and the New South Wales Energy Security Safeguard scheme. The New South Wales scheme encompasses both the NSW Energy Savings Scheme and NSW Peak Demand Reduction Scheme, both of which include methods that specifically target support for heat pump applications.
- The $400 AUD million Industrial Transformation Stream supports the reduction of direct and indirect emissions at existing industrial facilities, or clean energy developments, in regional Australia. See Appendix 2 for more information.
- The $40 million National Industrial Transformation Program. See Appendix 2 for more information.

7.2.4 Europe and Germany

Heat pumps are considered a key technology to achieving the EU's carbon neutrality goal by 2050. A report by Global Market Insights Inc sets out that the European Industrial Heat Pump Market size is set to surpass USD 765 million by 2032[61].

The European Commission is working on an action plan, for release in 2024 which will aim at accelerating heat pump deployment in the EU through 4 building blocks:

- Heat pump accelerator – a partnership of all relevant stakeholders (the Commission, EU countries, financial institutions, training providers and the sector itself) to ensure wide deployment.

[59] Australian Alliance for Energy Productivity
[60] EEC and A2EP, 2023, Harnessing heat pumps for net zero
[61] Global market insights website

- Communications and skills – providing accessible information on heat pump solutions to all relevant stakeholders.
- Legislative work - including a phase-out by 2029 of stand-alone boilers.
- Financing - mapping of financing opportunities for heat pump deployment. [62]

Germany has lagged behind its European neighbours in adopting heat pumps with over 80% of Germany's heating demand supplied by fossil fuel energy in 2021.[63] In 2018, around 20% of the final energy demand in Germany was for process heat, much of it generated by burning fossil fuels and to supply heat at temperatures below 150°C.[64]

The German Government does not currently provide funding specifically for industrial heat-pumps, but other programs are applicable including:

- the Applied non-nuclear research funding in the 7th energy research program of the German Federal Ministry for Economic Affairs and Energy, where further development of heat pumps with a focus on new temperature levels and increased efficiency is one topic.
- The Federal funding for energy and resource efficiency in the economy (EEW) funding package (please see Appendix 2 for more information).

Higher temperature heat pumps are currently under development by several research institutions and companies in Germany as changing market conditions drive increasing interest.

There is mounting pressure on industry to decarbonise both from regulators and customers, but also due to the increasing cost of using fossil fuel. The price of electricity has previously been a barrier to heat pump uptake. In 2022 the average non-household energy prices were approximately 20 ct/kWh electricity and 8 ct/kWh gas.[65]

This electricity to gas price ratio of 2.5 has decreased in recent years, being around 5 in 2020. As prices for CO2 certificates are due to increase from 25 €/t in 2021 to 55 €/t in 2025 this ratio is expected to decrease further.

Opportunity for Australian German collaboration: Australia and Germany should work together to strengthen supply chains and accelerate deployment of industrial heat pumps.

[62] European Commission, Energy, Heat Pumps website
[63] German Federal Ministry for Housing, Urban Development and Building website
[64] Fraunhofer ISE, Heat Pumps in the Industry website
[65] German Federal Statistical Office, press release no. 151 of 17 April 2023

Manufacturers and food processors are increasingly looking to heat pumps as a keystone technology for decarbonisation. Germany is well placed to be a leading manufacturing base of industrial heat pumps, with many manufacturers being headquartered there. Both Australia and Germany have a strategic interest in rapidly developing the ecosystem of skills, supply chains and industry experience in the utilisation of industrial heat pumps.

There is an opportunity for agencies such as ARENA in Australia and relevant stakeholders in Germany to work closely with industry and government on this agenda.

An Australian delegation to Germany to connect with heat pump manufacturers, process heat experts and policymakers – culminating in a workshop that explores collaboration opportunities on industrial electrification – would be a productive next step in building this relationship.

Appendix 1

German and Australian Energy Markets

Germany's energy market

The "Energiewende", a long-term energy and climate plan to transition Germany to climate neutrality has been a key feature of Germany's energy policy landscape for over a decade. As a result of the plan, the German energy sector has been transformed through the closure of all nuclear energy assets, a planned phase out of coal by 2038 at the latest, and a substantial increase in renewables.

In early 2022, approximately one-third of Germany's primary energy supply consisted of gas, oil, and coal imported from Russia. [66] By February 2023, this reliance on Russia had significantly decreased, with less than 1% of German energy imports coming from Russia, particularly after the disabling of the Nord Stream 1 gas pipeline. However, the reduction in energy imports from Russia has been partially compensated with additional imports from the Netherlands, Belgium, and Norway and fossil fuels still play a significant part in Germany's energy mix – see Figure 7. [67]

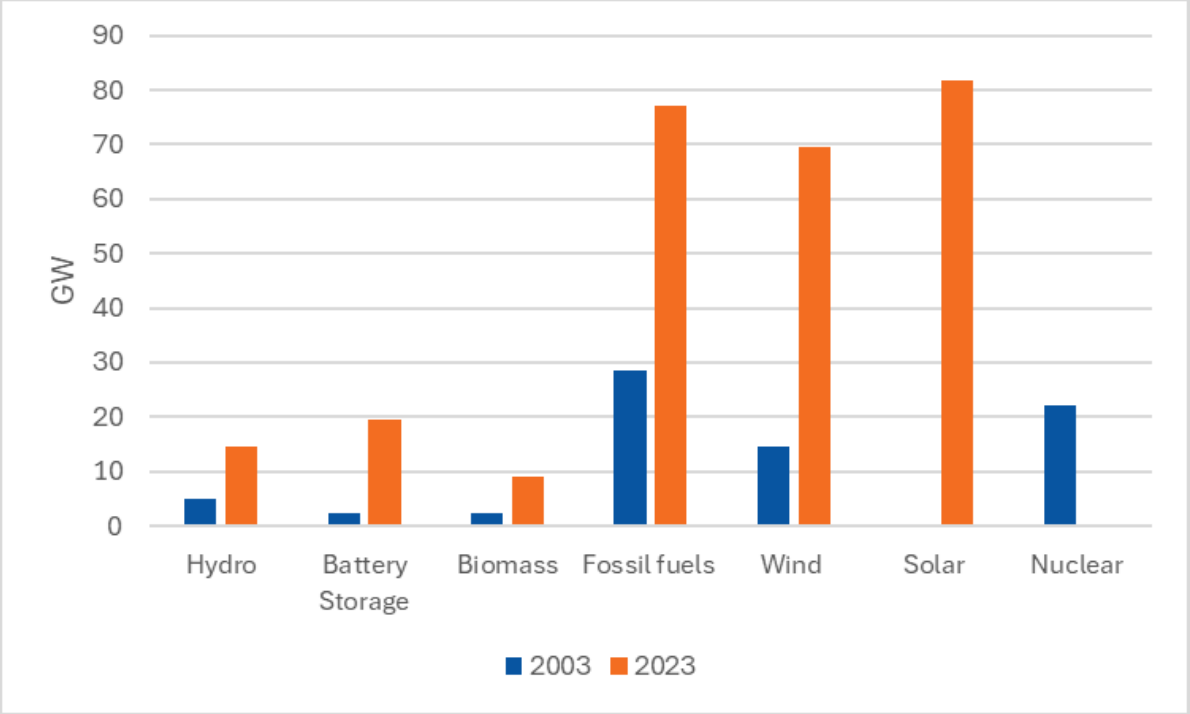

Figure 7 Installed net power generation capacity in Germany 2003 and 2023[68]

Despite a continued reliance on fossil fuels, German renewable energy supply is increasing, and the country is on track to meet its target for 80% of electricity supply to come from renewables by 2030. Renewable energy accounted for 42.3% of domestic supply and 48.3% of electricity consumed in 2022.[69]

Germany's power grid is very reliable, with one of the lowest power interruption rates in the world.[70] However, increasing penetration of renewable electricity raises particular challenges for Germany, due to its variable generation profile and the risk of 'dunkelflaute', - prolonged periods of minimal sun or wind.

[66] OECD Economic Outlook, Volume 2023 Issue 1: Preliminary Version
[67] US Department of Commerce, International Trade Administration, Germany – Country Commercial Guide
[68] Data source: Energy-Charts.info
[69] US Department of Commerce, International Trade Administration, Germany – Country Commercial Guide
[70] Lean Energy Wire, 2021, Set-up and challenges of Germany's power grid

Germany's electricity grid

The Federal Network Agency (Bundesnetzagentur) provides regulatory oversight to ensure that the grid is available for use by all market players, review charges for its use and is also responsible for implementing legislation designed to accelerate the development of the transmission grid.

In Germany, the transmission grid is owned by four transmission system operators (TSOs) which are responsible for the operation, maintenance, and development of their respective sections of the grid. As the TSOs have monopolies in their areas of operation, the Federal Network Agency puts a cap on what they can charge in grid fees.

Germany is connected to the European electricity system, the largest interconnected electricity grid in the world. The EU has set a target of a 15% interconnectedness level (expressed as the ratio of import capacity to total installed capacity in a power market) by 2030, applicable to all EU countries. Based on data available from 2017 – 2021 Germany has an interconnectivity rate between 10% to 15%. New interconnectors, including a link between the UK and Germany are planned.

Australia's energy market

Australia's unique geography and geological resources have historically provided the country with an abundance of cheap energy sources, including coal, gas and hydroelectricity. Consequently, until the end of last century, energy policy was focussed largely on maximising energy exports.

However, like Germany, Australia's energy system is undergoing a rapid transition. Australia is well endowed with renewable energy resources and renewable energy accounted for 35.9% of total electricity generation in 2022, with just over a quarter of this renewable energy generation being from rooftop solar.[71]

Australia has a national target to increase the portion of renewable energy in the National Electricity Market to 82% by 2030. Alongside the national target, Australia's states and territories have individual ambitions and baselines to work against. For example, in 2022 Tasmania had 99.1% of renewable energy penetration and a target of 150% renewable electricity generation by 2030, whereas Queensland had 22.6% of renewable energy penetration and a target of 70% renewable energy by 2032.

The increase in variable supply raises the same challenges to the Australian grid, which is already being frequently tested by extreme weather conditions.

[71] Clean Energy Council, 2023, Clean Energy Australia Report

Australia's electricity grids

While the bulk of Australians are served by one, interconnected grid, there are also standalone grids in other parts of the country.

The Australian Energy Market Operator (AEMO) operates two electricity markets and power systems:

- The National Electricity Market (NEM), which spans Queensland, New South Wales, the Australian Capital Territory, South Australia, Victoria and Tasmania. The NEM is an interconnected power system with more than 300 registered participants, including market generators, transmission network service providers, distribution network service providers and market customers. AEMO is responsible for both the wholesale market and the power system, as well as the retail market that underpins the wholesale market.
- The Wholesale Electricity Market (WEM) in Western Australia. Like the NEM, the WEM is an electricity market that enables wholesale electricity sales between its approximately 88 WEM participants. The market supplies energy to south-west WA and operates on the South West Interconnected System (SWIS). AEMO manages both the WEM and the SWIS.

The Northern Territory has three regulated networks which are owned and operated by Power and Water (a government-owned corporation).

Some Australian Government policies only apply to the NEM, rather than to all of Australia's electricity networks.

Appendix 2

Comparison of policies supporting industrial energy management and decarbonisation

Germany	Australia
Carbon border adjustment mechanism (CBAM)	
The EU's CBAM aims to equalise the price of carbon between EU products and imports. It entered its transitional phase on 1 October 2023. During this phase it will only apply to imports of cement, iron and steel, aluminium, fertilisers, electricity and hydrogen. While initially no financial adjustments are required, importers of these products will have to report on the volume of their imports and the embedded GHG emissions, with the first report to be submitted by 31 January 2024. The European Commission will use this data the refine its approach before 2026 when importers will need to buy and surrender the corresponding number of "CBAM certificates" to the GHGs embedded in imported CBAM goods.	The Australian Government has announced a review on whether to introduce a CBAM in Australia, following the EU's lead. An evaluation of policy options and the feasibility of an Australian CBAM is due to be finalised by October 2024.
Tax incentives	
Super depreciation (expected 2024) - 'super depreciation' involves tax benefits for companies through accelerated depreciation of climate protection investments.	The Small Business Energy Incentive (available until 1 July 2024) provided a tax deduction to help small businesses make investments like electrifying their heating and cooling systems and installing batteries and heat pumps.
Innovative funding schemes	
The Carbon Contracts for Difference (CCfD) mechanism aims to share the carbon pricing risk between the German Government and private companies for large decarbonisation projects. Germany is the first EU Member State to use this funding approach.[72] CCfD's take the form of a civil contract between the German Government and the decarbonising company. Under this contract companies will be compensated for additional expenses associated with "green" facilities compared to conventional facilities ("CapEx" and "OpEx") for 15 years. Once the "green" facilities outperform conventional	Australian Government funding to support companies decarbonise and to comply with regulation tends to be provided via traditional grant funding programs or tax incentives. Large industry sector emitters have not faced a carbon price since 2014 so funding models such as the German CCfD have not been applicable. However, now that the Safeguard Mechanism has been strengthened, requiring large emitters to reduce their emissions to meet targets that strengthen over time, the price of Safeguard Mechanism credit units (SMCs) and Australian Carbon Credit Units (ACCUs) is expected to increase over time. This might make

[72] For the announcement see the Federal Ministry for Economic Affairs and Climate Action website

technologies and running costs reduce, the margin will be repaid to the state. The program is conducted through a bidding process, with contracts awarded to the companies which project the lowest costs per avoided tonne of CO2. To be eligible, the company must operate within sectors that participate in the ETS, must produce the equivalent of at least ten kilotons of CO2 per year and the new facility must save at least 90% of that CO2-equivalent by the time the contract expires. The Preparatory Procedure, which gathered information to organise the bidding rounds, began on 6 June 2023. The first round of bidding began in March 2024 and will run for four months.	CCfD-style funding models possible, as the rising cost of carbon will provide certainty that the government will recoup its investment over time. Australian markets are familiar with the concept of contracts for difference as they have been used/will be used in the following: • Victoria's Renewable Energy Reverse Auction in 2018 (VRET 1) which provided funding to 800MW of new renewable capacity through 5 projects. • Commercial power purchase agreements; and • The Capacity Investment Scheme, which will use a contract for difference style approach to underwrite renewable energy, storage and demand response projects.
Funding – grants and loans	

• The "Federal funding for energy and resource efficiency in the economy (EEW)" introduced two funding programmes for energy/resource efficiency and renewable process heat:
  ○ The "Grant and loan" program which has 6 funding modules:
  ▪ Module 1: Cross-sectional technologies
  ▪ Module 2: Process heat from renewable energy
  ▪ Module 3: Measurement, control and regulation technology
  ▪ Module 4: Energy-related optimisation of plants and processes
  ▪ Module 5: Transformation concepts
  ▪ Module 6: Electrification in small businesses
  ○ The "Funding Competition" program, which aims to increase energy efficiency while reducing the CO2 emissions of industrial/commercial plants and processes. It is open to all technologies (except those with fossil fuel lock-in). The program focusses on larger projects with a maximum funding amount of EUR 15m per project and is a competitive tendering process, awarding funding to
	• AUD 400 million Industrial Transformation Stream (ITS) (part of the Powering the Regions Fund) is managed by the Australian Renewable Energy Agency (ARENA) and supports the reduction of direct and indirect emissions at existing industrial facilities, or clean energy developments, in regional Australia. ARENA has allocated AUS 150 million toward the Round 1 Focus Areas for: supporting the decarbonisation of process heat used in industrial processes; and off-road transport decarbonisation.
	• The Energy Efficiency Grants for Small and Medium Enterprises program supported SMEs in upgrading or replacing inefficient technologies to improve energy efficiency.
	• AUD 40 million National Industrial Transformation Program administered by ARENA. This fund is intended to support a range of technology solutions targeting industrial emissions abatement including electrification and energy efficiency to fuel switching.

bids with the most economic cost-benefit ratio (euro per saved ton of GHG emissions).	
Sustainable Finance	
The EU introduced an Action Plan on Sustainable Finance in 2018 which defined 10 packages of measures that have been translated into corresponding regulations. These include: • The Taxonomy Regulation – introducing a standardised EU classification system setting out criteria that investments must meet to qualify as sustainable. • The Sustainable Finance Disclosure Regulation which creates transparency regarding ESG criteria of financial products; and • The Corporate Sustainability Reporting Directive – as set out in section 5.5 EnMS, Climate related financial disclosure (CRFD) and transition planning companies will have to publish information on sustainability. These regulations are applicable in Germany, which adopted its Sustainable Finance Strategy in May 2021. The private sector has also made a voluntary commitment to support sustainable finance. More than 20 organisations in the German financial sector, with assets of more than 5.5 trillion euros in Germany, have agreed to align their credit and investment portfolios with the goals of the Paris Agreement. However, analysis by Fraunhofer ISI has noted that the bank's targets vary in ambition and measuring progress is challenging as there is no accepted consensus on how "Paris compatibility" should be interpreted specifically for banks.[73]	Over the past decade, there has been growth in Australian green and sustainable financing markets, however Australia's contribution to sustainable finance is well below other markets. While markets in green bonds, loans and securitisation have grown in popularity these instruments remain a small proportion of the overall market. A barrier to 'green' finance is a lack of a centrally administered definition for what constitutes as 'green' in Australia. The Australian Government has acknowledged the market's increasing focus on climate matters and released its 'Sustainable Finance Roadmap[74]' in June 2024. The Roadmap sets out a range of measures to further the development of Australia's sustainable finance market. This includes implementing climate–related financial disclosure; developing a sustainable finance taxonomy; supporting credible net zero transition planning; and developing sustainable investment product labels.
Funding – hard to abate sectors	
The "Decarbonisation in Industry" funding program supported projects in energy-intensive industry that reduced process-related GHG emissions, which	The AUD 400 million Critical Inputs to Clean Energy Industries (CICEI) program (part of the Powering the Regions Fund) supports the domestic manufacturing

[73] Fraunhofer ISI, 2023, Working Paper, Sustainability and Innovation, German banks on the way to climate neutrality? A review of the situation.
[74] Australian Government website: Sustainable Finance Roadmap

cannot be avoided or can only be avoided with difficulty given the current state of technology, as largely and permanently as possible. [75] This funding program will be replaced by module 1 of the Federal Funding for Industry and Climate Action program which has not yet been launched[76]. As part of the Important Project of Common European Interest (IPCEI) grants have been made to steel makers to aid their transition to producing green steel (through the use of green hydrogen).[77]	capability of industries that produce inputs that are essential to the development of Australia's clean energy industries (primary steel production, cement, lime, alumina and aluminium sectors). The AUD 600 million Safeguard Transformation Stream (STS) (part of Powering the Regions Fund) supports decarbonisation investments at trade-exposed facilities covered by the Safeguard Mechanism. There are also significant federal and state green hydrogen funding programs such as the HyGATE Initiative which supports pilot, trial and demonstration projects along the hydrogen supply chain and facilitates collaboration between Australian and German partners.[78]

[75] Decarbonisation funding program in industry website
[76] As at 1 July 2024
[77] Federal Ministry for Economic Affairs and Climate Action and Niedersachsen, 2023, press release
[78] For a full list of hydrogen related funding opportunities in Australia see CSIRO's HyResource website.

Appendix 3

Summary of electric motor applications by output power

Electric motor output power	Application
Less than 0.75 kW	Generally mass-produced packaged applications, e.g. hard drives and refrigerator compressors. These motors are used in the residential and commercial sectors and in 2011 accounted for about 9% of all electric motor power consumption.[79]
Mid-size motors with output power of 0.75 kW to 375 kW.	Different technologies are available at this size. Asynchronous alternating current (AC) induction motors are most common and consume the most energy. Commonly integrated into pre-packaged electromechanical products (such as pumps, fans, compressors, etc.) or sold as stand-alone motors. Commonly used in industrial but also commercial applications, less frequently in the residential sector. In 2011 these motors accounted for about 68% of all electric motor power consumption.
More than 375 kW	Usually high-voltage AC motors that are custom-designed, built to order and assembled within an electromechanical system on site. A typical electromechanical system involves a motor, an electrical control system, a variable-speed drive (VSD) and a mechanical load. In 2011 these motors comprised just 0.03% of the electric motor stock but accounted for about 23% of all motor power consumption, making them very significant consumers of global power (about 10.4%).[80]

[79] IEA, 2011, Working Paper, Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems
[80] Ibid.

Appendix 4

Barriers to heat pump adoption and mechanisms to address them.

Barrier	Mechanisms to address these barriers
Lack of knowledge Including lack of consultant and installer knowledge of the capabilities of heat pumps as well as the processes in which they can be applied. End-user knowledge about heat pump technology and its suitability for their processes.	Information about heat pumps and tools to assist end users have been developed by various industry bodies, including the Heat Pump Estimator tool by The Australian Alliance for Energy Productivity (A2EP) which is designed to help plan industrial and commercial heat pump projects.
Financial barriers Heat pumps have higher payback periods which can be due to high initial capital costs, or to an unfavourable price of electricity relative to oil or gas. Gas and oil burners can remain operational over a long period making their replacement with a heat pump less attractive.	End-users increasingly have decarbonisation goals which may overcome longer payback periods if equipment can assist with reaching these goals.
Supply chain barriers There is a lack of manufacturers of heat pumps, particularly for higher temperature applications.	The Australian and German heat pump markets are growing but for heat pumps with supply temperatures above 100°C research and support is needed to develop and demonstrate the market.
Lack of demonstration of success There have been limited cases to demonstrate and prove the reliability of heat pumps in an industrial environment.	Industrial heat pump pilot projects are underway and case studies are available to demonstrate success.[81]
Challenges when retrofitting Heat pumps are much easier to adopt in a greenfield site. Upgrading an existing production line is more complex.	

[81] Future Heat website

Appendix 5

Flexible demand

As mentioned in section 7 Australia and Germany are both significantly increasing the proportion of renewable energy generation feeding into the respective electricity grids, posing challenges for the grid due to the variability of renewables.

Flexible demand is one cost-effective tool for managing the increasing variability of electricity supply and maintaining grid reliability and security. End-users of electricity with flexible loads can support higher consumption of renewable electricity by shifting their major loads to times of high renewable penetration and curbing demand when renewable generation is low.

Flexible demand is defined by ARENA as 'the capability to vary customer demand in response to generation, network, or market signals.'

Electricity users can be remunerated in exchange for providing sources of flexible demand to the grid, such as frequency modulation. While typically, large energy users are the providers of flexible demand services, smaller consumers can also provide flexible demand services via aggregators, who pool dispersed sources of flexible demand together and arrange remuneration.

As well as providing a financial reward to end-users, flexible demand can also avoid the need for expanding the grid with new generation, transmission, or storage assets.

Europe

Over 20 years ago, the EU embarked on a mission to create a pan-European competitive and open energy market. Following the 2015 'Energy Union Strategy' and the subsequent 'Clean Energy for all Europeans' legislative package in 2019, the creation of the internal energy market appeared to be approaching its completion and today electricity is being traded across borders.

However, guaranteeing the stability of the grid was still a national matter with member states developing bespoke mechanisms to balance the grid. To ensure more cost-competitive procurement of balancing power, the European Commission introduced Regulation (EU) 2017/2195 (originally called the Electricity Balancing Guideline) in 2017 to harmonize the balancing markets between member states.

National transmission system operators (TSOs) have worked through the ENTSO-E (European Network of Transmission System Operators for Electricity) to define five key areas to implement the Electricity Balancing Guideline including the creation of three trading platforms. However, in 2022 only a limited number of EU member states had joined the EU balancing platforms. The platforms are:

- The platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (PICASSO) for the exchange of balancing energy from frequency restoration reserves with automatic activation. PICASSO went into operation in June 2022 and has 4 member states connected. (Czech Republic, Austria, Germany and Italy).
- The Manually Activated Reserves Initiative (MARI) is the platform for the exchange of balancing energy from frequency restoration reserves with manual activation (mFRR). MARI went into operation in October 2022 and has 3 member states connected (Czech Republic, Austria, Germany).
- The Trans European Replacement Reserves Exchange (TERRE) platform for exchanging replacement reserves (RR). TERRE went into operation in January 2020 and has 6 member states connected (Czech Republic, France, Italy, Spain, Switzerland, and Portugal).

In order for Europe to meet its target to increase the share of renewable energy in the EU energy mix to 42.5% (as set out in the Fit-for-55 package published in 2022) research has shown that by 2030, the electricity system in Europe will need double the current amount of flexibility resources.[82]

Although there have been efforts to increase the amount of flexibility resources in the EU, progress made within the individual member states is varied with each member state facing barriers. Barriers across the member states, and recommendations to overcome them have been detailed in the European Union Agency for the Cooperation of Energy Regulators (ACER) 2023 Market Monitoring Report *Demand response and other distributed energy resources: what barriers are holding them back?* and include a lack of a legal framework to allow market access, restrictive requirements to providing services and unavailability or lack of incentives.[83]

Germany

Providers of flexible demand in Germany can participate in the following mechanisms:

- The spot market (or wholesale market) is traded in 15-minute blocks. Industry participation is very limited and only available where facilities are equipped with their own controllable flexible demand sources.
- The balancing market, in which balancing service providers can offer their flexibility to all TSOs, was established in 2010. In 2016, 62 providers were prequalified with 2500MW of flexible loads.[84]
- The Ordinance on Interruptible Load Agreements interruptible loads act (AbLaV) entered into force in 2013 and was revised in 2016. It allows transmission system operators to advertise their needs for sheddable loads for balancing or redispatch. In total they tender 750 MW of immediately sheddable loads (reaction time within seconds) as well as quickly available loads (max. 15 minutes reaction time). To open the market to more customers, bid sizes and bidding cycles were revised. Pooling of loads by third party aggregators is now available and the minimum size for participation was reduced from 50MW to 5MW. The participation of distributed energy reserves at the medium voltage is also permitted. These revisions facilitate the participation of smaller customers and smaller loads. Prior to the changes only 13 businesses at the most participated, in 2020, about 60 providers prequalified, with most of those participating from the industrial or energy sector.[85]

Despite the potential benefits of demand management in Germany, and steps taken to promote its use, uptake is low amongst end-users.

Australia

As set out in Appendix 1 Australia has distinct electricity markets which provide different opportunities for demand management.

In the National Electricity Market (NEM), there are programs that support the delivery of demand response:[86]

[82] European Environment Agency and European Union Agency for the Cooperation of Energy Regulators, 2023, Flexibility solutions to support a decarbonised and secure EU electricity system
[83] European Union Agency for the Cooperation of Energy Regulators, 2023 Market Monitoring Report, Demand response and other distributed energy resources: what barriers are holding them back?
[84] Wohlfarth, K., Klobasa, M. & Eßer, A. Setting course for demand response in the service sector. Energy Efficiency 12, 327–341 (2019)
[85] Wohlfarth, K et al, 2020, The flexibility deployment of the service sector - A demand response modelling approach coupled with evidence from a market research survey
[86] This information has been taken, and updated from the EEC's Demand Response 101

- Wholesale demand response
    - The Wholesale Demand Response Mechanism (WDRM) was introduced in October 2021. The WDRM enables large energy users to offer reductions in demand directly into the electricity market, in competition with generators, and be paid (either directly or via an aggregator) the spot market rate for demand response provided. As at 13 June 2023, 65.3MW of total capacity was registered in the WDRM. Between June 2022 to June 2023 there were 26 days when demand response was dispatched via the WDRM – a total of 222 MWh was dispatched with an average weighted price of 284 $/MWh to 2,193 $/MWh.[87] Uptake of the mechanism has been slow, but there are processes in place to improve this.
    - Energy users can also make a commercial agreement with their electricity retailer to voluntarily reduce their consumption when electricity prices are high, to reduce the amount paid for electricity during high price periods.
- Network demand response
    - Electricity networks can offer consumers incentives to reduce their overall demand for electricity or their demand during peak periods. Opportunities vary by State and specific location. For example, Queensland's Peak Smart program provides rebates to consumers who install eligible air conditioners and allow the network to remotely put the unit in energy efficiency mode during periods of network congestion.
- Emergency demand response
    - Emergency demand response is used when there is insufficient electricity being dispatched through the market to meet consumers' needs. Energy users can offer to reduce their demand for electricity in return for incentive payments to keep the grid stable and avoid involuntary load-shedding. In the NEM, this occurs through the Reliability and Emergency Reserve Trader (RERT) mechanism. Most of the capacity provided through this mechanism is demand response provided by commercial and industrial energy users.
- Ancillary services
    - Ancillary services flexible demand resources are used to keep the frequency of the electricity system stable. Electricity users that can respond very quickly to a frequency disturbance can be paid to provide Frequency Control Ancillary Services (FCAS), which means reducing or increasing their demand for electricity in order to keep the electricity grid operating at or near to 50 Hertz. The NEM introduced a new, very fast FCAS service in 2022, requiring participants to provide a response within 1 second of a frequency disturbance, and many flexible demand resources participate.

A different system operates in the Wholesale Electricity Market (WEM):

- The Reserve Capacity Mechanism (RCM) ensures there is sufficient generation and demand side capacity in the South West interconnected system (SWIS) to meet demand. AEMO manages the RCM by setting a 'Reserve Capacity Requirement' two years ahead which is then made publicly available. Each market participant who purchases energy from the WEM is allocated a share of the Reserve Capacity Requirement and is required to obtain 'Capacity Credits' to cover their requirement. A facility can apply to become a 'Certified Facility' and be allocated capacity credits if they are verified as having the technical capability to provide capacity. Capacity credits can be traded between suppliers and market participants. If a

[87] AEMO, 2023 Wholesale Demand Response, Annual Report

market participant does not purchase enough capacity credits to cover its requirement, it will be charged for the shortfall. Demand side programmes are eligible to offer and provide capacity through the RCM.

- Supplementary reserve capacity (SRC) can be procured by AEMO if, at any time after the day that is six months before the start of a capacity year, it determines that insufficient capacity is available to satisfy demand. This occurred ahead of summer 2023/24, and AEMO procured 160 MW of capacity via the SRC mechanism, most of which was demand side capacity.

Governments are also implementing their own programs to address the accelerating challenge of delivering reliability as the nation's coal-fired power stations retire, and to address their own commitments to net zero.

For example, the New South Wales (NSW) Government introduced the Peak Demand Reduction Scheme in 2022 to reduce peak demand in summer. Under this scheme a peak demand reduction target is set for electricity retailers and large energy users. To meet their target, retailers and large energy users create or buy peak reduction certificates for eligible activities that reduce energy usage during hours of peak demand.[88]

The Federal Government has introduced the Capacity Investment Scheme (CIS), which is designed to encourage investment in renewable and dispatchable capacity in the NEM. The CIS is being rolled out on a state/territory basis, through a series of competitive tenders with the Federal Government providing revenue underwriting to successful bidders. The first tender in NSW allowed demand response to participate, but it is unclear whether this will be the case in future tenders. Given the different market structure in the WEM, the Federal Government is currently consulting on the application of the CIS in WA.

Modelling by ARENA has shown that demand response could save consumers up to AUD 18 billion to 2040. [89] Commercial and industrial energy users have had the opportunity to benefit from demand management for years through commercial arrangements with retailers, aggregators and/or distributors (or in some cases transmission operators).

However, more opportunities for demand management are available in commercial, industrial and residential settings, with AEMO forecasting that a huge increase in flexible demand resources will be needed to ensure the reliability of the grid.

[88] More information on the NSW program is available on the NSW government's website
[89] ARENA, 2022, Load Flexibility Study Technical Summary