Industrial Air Compressors: Technical Discussion Paper

Disclaimer

Executive Summary

The Equipment Energy Efficiency (E3) Program enables collaboration between the Australian Government, states and territories and the New Zealand Government to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances. The E3 Program undertakes a range of activities under the *Greenhouse and Energy Minimum Standards Act 2012* (the GEMS Act) in Australia and the Energy Efficiency (Energy Using Products) Regulations 2002 in New Zealand, to improve the energy efficiency of appliances and equipment sold in Australia and New Zealand. These include energy rating labelling, setting Minimum Energy Performance Standards (MEPS) and education and training.

Industrial products (pumps, air compressors and boilers) were identified as high priority and a focus for immediate attention in the E3 Program 2017/18 prioritisation plan. The Commonwealth Department of Industry, Science, Energy and Resources, on behalf of the Committee overseeing the Equipment Energy Efficiency (E3) Program began work with the Industrial Equipment Technical Working Group (TWG) to investigate policy options for improving the efficiency of industrial equipment. This discussion paper presents the work of the TWG and the department to date on air compressors.

The Australian air compressor market annual sales revenue is estimated at $189 million, and between $60-100m in New Zealand. The air compressor market in both countries is import/assembly based; anecdotally there is no manufacturing remaining. The major import markets are the EU, US and China.

In both Australia and New Zealand, air compressors are significant consumers of electricity, accounting for approximately 10 per cent of total industrial electricity use. There are currently no energy efficiency requirements for air compressors in Australia and New Zealand.

Air compressors compress air by mechanical means, which is then stored, treated and distributed to a network for use. Air compressors are used mainly in the manufacturing and minerals sectors, where compressed air is used to power tools and machinery such as actuators and conveyor belts. The majority of industrial air compressors use rotary screws, a form of positive displacement technology.

The discussion paper seeks input from the broader industry to improve upon the available data and findings of the TWG, to inform the development of the Consultation (RIS).

Contents

1. Introduction

1.1. Overview of Discussion Paper

Section 1 outlines the purpose of the paper and the role of the Industrial Equipment Technical Working Group (TWG).

Section 2 discusses the policy context, including the role of the Equipment Energy Efficiency (E3) Program in regulating equipment for energy efficiency under the *Greenhouse and Energy Minimum Standards Act 2012* (the GEMS Act) in Australia and the *Energy Efficiency (Energy Using Products) Regulations 2002* in New Zealand. It also highlights the role of standards and testing in implementing, monitoring and enforcing compliance under the Act and Regulations.

Sections 3 discusses the implications of improving energy efficiency of air compressors, including:

1. An overview of the air compressor market in Australia and New Zealand
2. An overview of the technologies and their use in Australia and New Zealand
3. The product coverage and scope of policy for these products in Australia and New Zealand
4. An overview of test methods and standards currently in use
5. International standards and approaches to air compressor efficiency
6. An early consideration of the impacts of imposing standards in the Australian and New Zealand markets, including consideration of additional measures

Section 4 presents a set of questions for stakeholders.

Appendix 1 is a summary of the TWG views and recommendations.

Appendix 2 and 3 summarise the technical requirements of the EU and US standards respectively.

1.2. Purpose of this Discussion Paper

The aims of this paper are:

- To improve the available data which is being used to inform the policy options and cost benefit analysis
- To better understand the state of the air compressor industry in Australia and New Zealand
- To trigger a discussion among experts, industry representatives and other stakeholders about which compressor technologies, test methods and standards are common within the industry

- To inform stakeholders on the outcomes of the TWG.

This paper asks stakeholders to review and to provide comment on:

- Industry and company level market and efficiency data for the Australian and New Zealand air compressor markets
- The specifications that would best define the air compressors used in Australia and New Zealand
- The technical standards and test methods that could form the basis for energy efficiency testing and performance standards
- The ability of these test methods and standards to cover the range of air compressors supplied in Australia and New Zealand
- The impacts that these standards, if applied through a MEPS regulation, could have on industry and product markets in Australia and New Zealand
- Additional energy efficiency measures in the industry, such as information materials or other incentives.

This paper assumes that stakeholders are familiar with current technology as it applies to their industry and application.

1.3. Making a submission

Written submissions on the issues raised in this paper should be provided by e-mail by 4 December 2020. Submissions should include the subject line 'Compressor Consultation'.

A set of questions is provided in Section 4. Stakeholders are encouraged to work through these questions while reviewing the paper

Submissions can be sent to:

Australian Government Department of Industry, Science, Energy and Resources.

E: GEMS.Industrial@industry.gov.au

Energy Efficiency and Conservation Authority (EECA) of New Zealand

E: star@eeca.govt.nz

1.4. Role of the Technical Working Group

The E3 committee formed the TWG in 2018 to provide a technical understanding of industrial pumps, compressors and boilers and investigate how the E3 Program could be expanded to include these products in Australia and New Zealand.

The TWG comprised members from industry, peak bodies, academia, the Department of Industry, Science, Energy and Resources (DISER), and the New Zealand Energy Efficiency and Conservation Authority (EECA).

The Energy Efficiency Advisory Team (EEAT)[1] asked the TWG to investigate and put forward a set of considerations in this paper, concerning primarily:

1. The technical underpinnings of the industry, including the descriptions of the products themselves and the specifications that define the types of pumps, boilers and air compressors used in Australia and New Zealand.

2. Which test methods are applied to test the energy efficiency of the equipment? A consistent, repeatable and reliable method for assigning equipment with an energy efficiency rating is an essential component of energy efficiency policy.

3. What technical considerations are there for Minimum Energy Performance Standards (MEPS)/energy rating labels for industrial equipment? A Consultation Regulation Impact Statement (RIS) would then seek information to find the balance between maximum savings on energy costs and greenhouse emissions, and any potential costs.

The TWG was made up of three sub-groups, one each for pumps, air compressors and boilers. An industry lead was appointed to assist the TWG Chair. The objective of the TWG air compressor sub-group was to provide EEAT with a set of recommendations for:

1. What air compressor equipment could be covered by the E3 Program or other policies

2. Which specifications and characteristics could best define the ‘scope’ of the products to be included or excluded, and why

3. What proportion of energy is used by air compressors in the Australian and New Zealand

4. Which test methods and standards could be used as a basis for assessing efficiency of air compressors

5. Which of these test standards and methods would be effective and appropriate for use in Australia and New Zealand, based upon the types of products in the Australian and New Zealand market, including the availability of test facilities and consideration of the relative costs.

The TWG held four workshops in 2019. In the workshops, the TWG investigated a set of issues, product specifications, current test methods and efficiency standards. Informal

[1] E3 Program - https://www.energyrating.gov.au/about-e3-program/who-we-are

discussions were also held with industry stakeholders and participants at various trade shows and exhibitions. The department used this information to develop this paper.

Boilers and pumps are covered in separate Technical Discussion Papers. Concurrent work also began on a draft Consultation RIS which will build upon the findings of the TWG and information provided in response to this paper.

2. Policy Context

2.1. The E3 Program

The E3 Program[2] is a cross jurisdictional program through which the Australian Government, states and territories and the New Zealand Government collaborate to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances.

The E3 Program undertakes a range of activities to improve the energy efficiency of appliances and equipment sold in Australia and New Zealand. These include energy rating labelling, setting MEPS and education and training.

The objectives of the E3 Program are:

- To reduce energy bills for households and businesses in a cost effective way by driving improvements to the energy efficiency of new appliances and equipment sold
- To improve the energy efficiency of new appliances and equipment that use energy and to also improve the energy performance of products that have an impact on energy consumption
- To reduce appliance and equipment related greenhouse gas emissions through a process which complements other actions by jurisdictions.

On 1 October 2012, the GEMS Act[3] came into effect in Australia, creating a national framework for product energy efficiency in Australia. The GEMS Act is the underpinning legislation for the E3 Program in Australia. The Energy Efficiency and Conservation Authority (EECA) administers the E3 Program in New Zealand through the *Energy Efficiency (Energy Using Products) Regulations 2002*.

In 2018-19, the E3 Program contributed more than $1.2 billion to the Australian economy and $200 million to the New Zealand economy in avoided energy costs.[4]

Industrial products (pumps, air compressors and boilers) were identified as high priority and a focus for immediate attention in the 2017/18 prioritisation for the E3 Program.[5]

[2] About the E3 Program - https://www.energyrating.gov.au/about-e3-program
[3] GEMS Act 2012 - https://www.legislation.gov.au/Details/C2012A00132
[4] E3 Achievements 2018-19 - https://www.energyrating.gov.au/document/e3-achievements-report-2018-2019
[5] E3 Prioritisation Program 2017-18 - https://www.energyrating.gov.au/document/e3-prioritisation-plan-2017-18

2.2. Air Compressor Market Overview

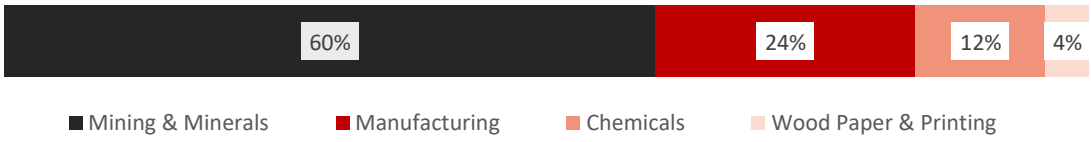
Market scale and value

There is limited information on the air compressor market, including installed stock, import data and annual sales. The most recent statistics are provided by IBISWorld, which aggregates at the industry level.

The total annual sales revenue for air compressors is estimated to be $189 million in 2019/20[6] in Australia, and $60-100 million in New Zealand[7]. The mining and minerals sector accounts for 60 per cent. Manufacturing accounts for the majority of the remainder of energy end use of air compressors across a range of applications. There is limited air compressor manufacturing remaining in Australia and New Zealand. Most air compressors are now imported, predominately from Europe, the United States and China.

A breakdown of major market sectors for Australia is included in Figure 1**.** There is insufficient information to replicate this for New Zealand.

Figure 1 Major Market Segments in the Compressor Industry in Australia (Adapted from 2010 E3 Discussion Paper)



Energy Use

The Compressed Air Association of Australasia estimate that 10 per cent of all industrial electricity in Australia is used in powering compressed air systems.[8] Due to both their high operating hours and expected life of over 15 years, electricity consumption is the largest cost associated with operating air compressor systems, accounting for an estimated 86 per cent of total costs over the life of the compressor.[9]

[6] Pump and Compressor Manufacturing in Australia - IBISWorld
[7] Industrial and Mining Equipment Wholesaling - IBISWorld
[8] Air technology Fact Sheet - http://compressedair.net.au/wp-content/uploads/2016/02/001CAAAFact-Sheet-CopyCompressed-Air-Technology290416.pdf
[9] Background paper on air compressors - Sustainability Victoria

2.3. Role of policy, standards and testing

MEPS specify the minimum level of energy performance that appliances, lighting and electrical equipment (products) must meet or exceed before they can be legally offered for sale in Australia and New Zealand. MEPS are one of a range of potential measures that could improve industrial equipment energy efficiency.[10]

Other approaches include energy rating labelling schemes (either voluntary or mandatory), introduction of voluntary standards where industry 'self-regulates', and incentives and support for manufacturers to develop and introduce more efficient products while phasing out less efficient products. These policy options will be explored in a Consultation RIS on policy options.

For any of these options, test standards must form the foundation to ensure product energy efficiency claims can be consistently tested and verified. This offers greater certainty of outcomes for policy makers, suppliers and end users.

Existing international standards could be adopted by Australia and New Zealand, or be incorporated into a new standard. The aim is the identification of an agreed method that can be readily adopted by industry in both countries.

There are currently no existing domestic standards covering energy efficiency or test methods for air compressors in Australia or New Zealand. The previous Australian standard AS 4637-2006 *Measurement of Pump Displacement and Free Air Delivery of a Reciprocating Air Compressor Package* has been withdrawn, meaning it may still provide reference but is no longer reviewed or updated.

The TWG identified the following international performance standards and test methods which are relevant to air compressors sold in the Australian and New Zealand markets:

- ISO 1217:2009 Displacement Compressor Acceptance Tests / Amd.1:2016
- ISO 5389:2005 Turbo Compressors - Performance test code
- ISO 8573-1:2010 Contaminants and Purity Classes

With the exception of MEPS applied to some electric motors packaged with air compressors, there is currently no other regulatory oversight of the energy efficiency of air compressor units in either Australia or New Zealand.

The Compressed Air Association of Australasia's Protocol 2000+ is an industry Code of Practice committed to by all members to ensure that their products meet all relevant state, federal and international standards and best practice for performance, safety and compliance. [11]

[10] Improving the Energy Efficiency of Industrial Products – https://www.energyrating.gov.au/document/discussion-paper-improving-energy-efficiency-industrial-equipment
[11] Protocol 2000+ - https://compressedair.net.au/compliance/

3. Air Compressors

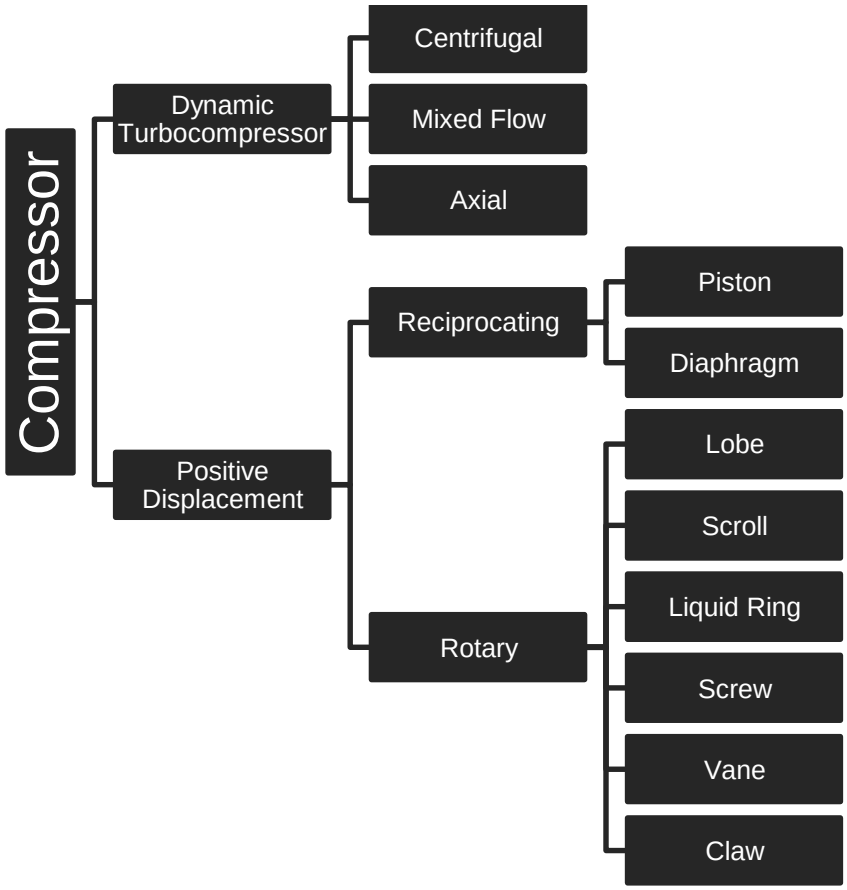
Air compressors compress air and other gasses by mechanical means, which is then stored, treated and distributed to a network for use. Air compressors are used mainly in the manufacturing and minerals sectors, where compressed air is used to power tools and machinery such as actuators and conveyor belts.

3.1. Compressor Technology

Available technologies

Similar to pumps, air compressors may be classified as rotodynamic or positive displacement. The majority of air compressors used in industrial settings are positive displacement rotary screw compressors, due to their relatively cheap cost, steady air delivery and simple and quiet operation. A breakdown of compressor technologies is included in **Figure 2** below.

Figure 2. Major compressor technology available in Australia & New Zealand[12]



[12] Adapted from https://compressedair.net.au/resources/

The selection of air compressor type and size depends on the application. Table 1 shows the typical application ranges for different air compressor types.

Table 1. Types of compressors and their applications.

Type/Range	Function or Application	Operating Range	Typical Technologies
Standard air compressors	Diverse applications in manufacturing, including tool operation and powering conveyers.	7-15 bar	Screw and piston (oil injected)
Low pressure air compressors	Many are used in waste water treatment (oxygenation)	50 mbar – 3.5 bar	Various types
Oil free/non-lubricated air compressors	For applications requiring oil-free supply of air (food, medical, chemical sectors)	1 – 1,000 bar (depending on technology)	Piston, turbocompressor, screw, rotary lobe
Process gas compressors, air/inert gases	Used in the air separation industry, regeneration or processes in the chemical, pharmaceutical, oil and gas industries	1 – 1,000 bar (depending on technology)	Piston, turbo, screw, rotary lobe
Hobby air compressors	Very diverse range of applications (tyre inflation, tools, spraying)	0-10 bar	Piston

Adapted from EcoDesign preparatory study on electric motor systems/Compressors ENER Lot 31 Final report of task 1, 2, 3, 4, 5[13]

3.2. International Standards and Test Methods

When the TWG conducted its work in 2019, there were no international energy efficiency standards or regulations in place for air compressors. Since then, there have been a number of significant international developments. The European Union *Ecodesign preparatory study on Compressors*[14] has been released and is currently under review for implementation. The US *Energy Conservation Program: Energy Conservation Standards for Air Compressors*[15] will come into enforcement in March 2025. The Peoples Republic of China (PRC) has released GB 19153-2019 *Minimum allowable values of energy efficiency and energy efficiency grades for displacement air compressors*[16]*,* due to come in force in July 2020. The department is contacting international counterparts in these jurisdictions regarding each standard.

[13] Available at https://www.eco-compressors.eu/documents.htm
[14] Ecodesign preparatory study on Compressors - https://www.eco-compressors.eu/documents.htm
[15] Energy Conservation Standards for Air Compressors - https://www.federalregister.gov/documents/2020/01/10/2019-26355/energy-conservation-program-energy-conservation-standards-for-air-compressors
[16] Minimum allowable values of energy efficiency and energy efficiency grades for displacement air compressors - https://www.codeofchina.com/standard/GB19153-2019.html

US Standards

The United States Department of Energy (DOE) has published a final rule to establish an energy efficiency standard for displacement type rotary, lubricated air compressors. The rule was published in January 2020, and is due to come into enforcement in March 2025. It is estimated the rule will cover over 95 per cent of the air compressor market in the US.

The DOE based their analysis on Compressed Air & Gas Institute (CAGI) datasheets, which are the most complete source of industry technical data in the US.

The DOE rule exceptions include:

- Reciprocating air compressors as they are not widely used and data was limited.
- Single phase and brushed motors are not included due to their technical constraints and smaller size, and were deemed unlikely to have risk of substitution to avoid compliance.
- Compressor configurations used in niche applications, which are manufactured in low volumes.

The test method is specified in the US's Code of Federal Regulations in Appendix A to Subpart T of 10 CFR 431.[17] This test method provides the step-by-step procedures and requirements on equipment, setup, measurement and calculations in order to determine the efficiency metrics for air compressors. It includes a list of mandatory and optional equipment which must be included in the test, such as the air-end (compressor unit), driver (motor), connections and any auxiliary equipment. Testing must be conducted at full load for fixed speed air compressors, and at 40, 70 and 100 per cent loads for air compressors fitted with variable speed drives. Many provisions in the test method simply state to follow ISO 1217:2009, however provide additional requirements and clarifications where the standards are ambiguous.

The DOE standards are based on readily available industry tech data (CAGI datasheets), which give performance data for a range of common air compressors in the industry. The datasheets include pressure, flow rate, motor nominal horsepower, full-load input power (in kilowatts), motor efficiency and package specific power for individual models.

Isentropic efficiency is the metric used for determining compliance, which compares the energy required by the real compressor with that of a thermodynamically 'ideal' compressor using an isentropic process[18]. Isentropic efficiency is relatively constant across different pressures, which allows for easier comparison of compressors. The minimum isentropic efficiency requirement is based on a normal distribution of the air compressors included in the CAGI datasheets, tested to ISO 1217:2009.

The efficiency requirements of the US standards are included in Appendix 1.

Learnings from the US

The US DOE initially suggested using specific power, but after analysis noted that specific power is pressure and flow dependent, thus the metric is less suited for product comparison,

[17] Subpart T Compressors - https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431

[18] An isentropic process is one which does not transfer heat or matter, i.e. the entropy remains constant.

compared to package isentropic efficiency; and “introduces unnecessary complexity into any conservation standard that would rely on such a metric.”

Following the publishing of the proposed rule, a number of small businesses wrote to the Department of Energy (DOE) expressing concern about the economic burden that the test procedures would impose on their business. The department has commissioned a trial air compressor test, to the ISO 1217:2009 test method standard, to determine the practical requirements and approximate testing costs for Australian and New Zealand compressor suppliers.

System approaches extend beyond the air compressor unit, to include the broader compressed air system. In the published ruling, the DoE notes that it had considered a system approach, but stopped short because:

- each system is often unique to a specific installation
- each system may include equipment from several different manufacturers
- a system can include several different air compressors, of different types, which may all have different efficiency.

The DoE also noted that a system based ruling would require the development of new standards for measuring network losses, and new requirements for certification, compliance and enforcement across a variety of designs, which it largely did not have the capacity to enforce. Under the E3 Program, MEPS are applied at the product level. Recommendation 39 of the *2019 Final Report of the Independent Review of the Greenhouse and Energy Minimum Standards Act 2012* (GEMS Act) is to investigate the potential of a systems approach to energy efficiency regulation. The 2019 NZ Review of Energy Efficiency Regulations also highlighted this as an area of strategic focus.

EU Standards

The European Union is considering the introduction of MEPS for a range of air compressor products. It initially identified a full range of positive displacement and dynamic compressors in 2012. The first study reported on standard air compressor packages. A second study in 2016 focused on low pressure and oil free compressor packages. An impact assessment of recommendations of the review is underway.

The study presents a number of possible metrics for expressing the energy efficiency of air compressors including:

Isentropic efficiency: compares the energy required by a real compressor with that of an ideal compressor using an isentropic process.

Isothermal efficiency: compares the energy required by a real compressor with that of an ideal compressor using an isothermal process.

Specific power: Specific power relates the input power to the airflow output (measured in kW/ (m^3/min)). The lower the specific power, the more efficient the compressor. For standard compressors (i.e. below approximately 7 bar operating pressure) a specific power of less than 6 kW/ (m^3/min) would be considered efficient.

The preparatory studies note that comparison of specific power at different pressures is not possible and therefore suggest that isentropic efficiency is a more appropriate method. No specific standard has been proposed, although isentropic efficiency and specific power are both defined in ISO 1217:2009.

Learnings from the EU standards

During development of the European standard, the EU assessed isentropic efficiency as the most appropriate method as it allows direct comparison between different units. It is easily calculated from common measurements and allows comparison of units under different operating parameters.

Whilst the *Ecodesign preparatory study on Compressors*[19] are draft reports, the proposal for standard air compressors aligns with the US final rule, except that the EU requirements do not differentiate between air cooled and water cooled compressors, and impose increasingly more stringent requirements over time.

Unlike the US standards, the EU has proposed regulation for low pressure and oil free compressors which are used in niche applications.

PRC Standards

The PRC standard GB 19153-2019 *Minimum allowable values of energy efficiency and energy efficiency grades for displacement air compressors* was revised in November 2019, and commenced on 1 July 2020. The revised standard appears more stringent than the US standards. The 2019 review also included minimum standards for piston-type compressors, evaluation methods for variable speed air compressors, and changed the range of ambient temperatures, all of which are not included in the US rule.

GB 19153-2019 provides tabulated data for single and multi-stage compressors with different input power and discharge pressure, measured in specific power, with isentropic efficiency included as an index.

[19] Ecodesign Prepatory Study for Compressors - https://www.eco-compressors.eu/documents.htm

4. Questions for Stakeholders

The following questions are provided for stakeholders to comment on elements of the paper, and to request information where the department and the TWG have identified information gaps. The list of questions are not exhaustive, and the department encourages stakeholders to expand on the questions or themes raised in the paper. Any additional comments are also welcome.

Information Collection Statement

All submissions may be used by the department for the purpose of policy development.

Individual submissions to the discussion paper will not be published, however a summary of key themes may be published on the E3 Program website. Any information provided by you as part of the consultation process which is marked as confidential by you will not be disclosed outside the E3 Program. Personal information will be handled in accordance with the Department of Industry, Science, Energy and Resources Privacy Policy[20].

Any data provided as part of your submission will be treated as commercial-in-confidence. If the data is subsequently used in analysis, it will be aggregated and de-identified before publishing.

Air Compressor Market

1. Is the market data presented in the discussion paper representative of the Australian and/or New Zealand air compressor market(s)? Are you aware of other data sources?

2. What area of the compressor industry is your business involved in? (Manufacture, installation, servicing, sales etc.)

3. Could you provide an estimate of your business' annual turnover and market share for air compressors in Australia and New Zealand?

4. What is the approximate number of staff employed by your business?

5. How many air compressor models does your company supply? How are models defined (e.g. size, configuration)? Are you able to give information on their specifications?

6. How do you determine model numbers? Is the model number found on the compressor unit itself?

7. When compressor models are offered for supply to the market, are these units already built and ready for dispatch? Or are they representative of the models which are configured to suit a customer's specific requirements and built to order?

[20] https://www.industry.gov.au/data-and-publications/privacy-policy

8. How many of your air compressors are manufactured/assembled in Australia or New Zealand? If not manufactured locally, from where do you source your products, and why?

9. Are you able to provide annual sales data? What is the ratio of replacement air compressors sold vs new installations in Australia and New Zealand?

10. What are the typical avenues for selling air compressors? Are they direct to customer (online or in-store), or indirectly through wholesalers or engineering services? Can you provide approximate breakdown of the percentages?

11. Are you aware of any direct importing of air compressors for use for a commercial purpose? Can you provide examples for this type of supply?

12. Is there a market for small scale suppliers to import and sell compressors directly, in competition to you, via online platforms such as eBay or Alibaba? What is your estimate of the market share?

13. Are units sold individually, or with equipment as a compressed air system?

14. Do unit costs vary as compressors become more energy efficient? If so, how?

Standards

1. Are you aware of the ISO 1217:2009 test standards?

2. What is your level of engagement with the ISO test standards?

3. How would you describe the industry's engagement with these standards? Are there any issues you would like to share?

4. How are air compressors offered by your company tested for the Australian and New Zealand markets? What test data would you typically have available for your products? Are you able to provide some examples of test certificates/charts for your products that the department could use in its analysis?

5. Is harmonisation with international standards feasible for Australia and New Zealand?

Technology

1. Are there any compressor technologies not included in the discussion paper that should be?

2. Do you agree with the typical lifespan of air compressors highlighted above (15 years)? What age do you typically see compressors being retired/replaced?

3. What are the typical efficiencies of compressors sold in Australia/New Zealand?

Efficiency Information

1. Are operators of air compressor systems typically aware of their energy use?

2. Has your business accessed any of the available educational programs for improving air compressor system efficiency?

3. Do you/your suppliers provide any information on energy efficiency of air compressors sold? Do customers request this information?

4. Does the energy efficiency of a compressor have any role to play in purchasing and replacement decisions? If so, how?

5. Are there any components or other aspects of compressor design that have a large impact on energy efficiency?

Appendix 1. Technical Working Group Responses

This section summarises the TWG's views and recommendations.

Air Compressor Market Overview

The TWG noted the lack of comprehensive, consolidated industry data and relied on either internal or proprietary data sources, or inferred information to form a view of the market place. The TWG highlighted that the Australian air compressor market is much larger than New Zealand, both in its comparative size and also proportion of sectors with heavy air compressor use, such as mining & minerals and manufacturing.

Compressor Technology

The compressor technology outlined in the discussion paper was considered appropriate for the types of air compressors used in Australian and New Zealand industrial applications.

It was estimated that the majority of standard packaged air compressors operate at fixed speeds at approximately 7bar. These should be considered in the first instance.

The TWG agreed that refrigerant compressors have a significantly different characteristics and should be considered in a different category to packaged air compressors. Additionally, refrigerant compressors installed in packaged unitary air conditioning equipment are already captured under air-conditioning MEPS.

Current Approach

The TWG noted that there is currently no regulation of air compressor efficiency in Australia and New Zealand and there is no agreed method for implementing such regulation in the European Union. Whilst the US and PRC are now implementing energy performance standards, they had not implemented the rule at the time of the TWG Activities.

With regards to test standards the TWG raised the following comments:

- ISO 1217 is the international standard most commonly used for defining compressor performance for displacement type air compressors and forms the basis of both the United States energy efficiency requirements and proposed European Union requirements.
- ISO 5389 is the international standard most commonly used for defining turbocompressor performance.
- ISO 8573 refers to quality of air provided by the air compressor and is therefore not directly related to energy performance.

The TWG noted that specific power is commonly quoted by air compressor manufacturers in Australia and New Zealand.

International Standards

The TWG discussed the use of specific power versus isentropic efficiency. Both the EU and the US standards recommend the use of isentropic efficiency over specific power, and both ISO 1217:2009 and ISO 5389:2005 define isentropic efficiency as the standard metric. The Chinese standard considers both specific power and isentropic power, although specific power is the key metric.

The TWG noted that Australia and New Zealand air compressor industry typically uses specific power rather than isentropic efficiency and that specific power is well understood.

Technical Working Group Recommendation

The TWG discussed a range of possible options for a test standard that could be used. The TWG considered an approach similar to the Minimum Efficiency Index (MEI) for pumps could be an effective mechanism for developing a MEPS benchmark for air compressors. However, with the release of the US DOE Final Rule in January 2020 (which occurred after the meeting of the TWG), the US market will be moving to a common standard and test procedure by 2025 and it may be appropriate to reconsider this approach.

The TWG initially recommended further investigation of MEPS for air compressors operating at fixed speeds up to approximately 10bar using the test methods of in ISO 1217:2009 and ISO 5389:2005. Further consultation with industry is required to develop appropriate efficiency standard levels and limits on the size of equipment to be included, given that most equipment is imported from overseas and there is insufficient data to support the determination of an appropriate standard. This needs to include a review of the applicability of the new US *Energy Conservation Standards for Air Compressors*, released in January 2020[21], for the Australian and New Zealand markets.

The TWG recommended an air compressor package be defined as comprising a compression element, driver, and transmission. It may also include any ancillary equipment as required by the manufacturer or where those items are included as part of the package. They should not include items that are part of the compressed air system such as receivers, downstream compressed air filters and terminal equipment.

[21] https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=63&action=viewcurrent

Appendix 2. United States Standards

The definition of air compressors covered by this rule are:

- rotary, lubricated, air compressors (i.e. no other gasses)
- not liquid ring compressors
- driven by a three-phase brushless electric motor
- with a full-load operating pressure of 2 – 15 bar
- not designed and tested to the requirements of The American Petroleum Institute standard 619, “Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries”

and have a capacity that is either:

- 7.45 – 149 kW (10-200hp) motor nominal power, or
- 1 – 35.4 m^3/min full-load actual volume flow rate

***figures converted to metric units**

Requirements for air compressors are included in the table below:

Equipment class	**Standard level (Package isentropic efficiency)**	η_{Regr} **(Package isentropic efficiency reference curve)**	**d (Percentage loss reduction)**
Rotary, lubricated, air-cooled, fixed-speed	$\eta_{Regr} + (1 - \eta_{Regr}) \times (\frac{d}{100})$	$-0.00928 \times ln^2(0.4719 \times V_1 + 0.13911 \times \ln(0.4719 \times V_1) + 0.27110$	-15
Rotary, lubricated, air-cooled, variable-speed	$\eta_{Regr} + (1 - \eta_{Regr}) \times (\frac{d}{100})$	$-01549 \times ln^2(0.4719 \times V_1 + 0.21573 \times \ln(0.4719 \times V_1) + 0.00905$	-10
Rotary, lubricated, water-cooled, fixed-speed	$0.02349\eta_{Regr} + (1 - \eta_{Regr}) \times (\frac{d}{100})$	$-0.00928 \times ln^2(0.4719 \times V_1 + 0.13911 \times \ln(0.4719 \times V_1) + 0.27110$	-15
Rotary, lubricated, water-cooled, variable-speed	$0.02349\eta_{Regr} + (1 - \eta_{Regr}) \times (\frac{d}{100})$	$-01549 \times ln^2(0.4719 \times V_1 + 0.21573 \times \ln(0.4719 \times V_1) + 0.00905$	-15