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Costs and benefits of Australia phasing down mercury

Report prepared for the Department of the Environment and Energy

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Key points

- The Minamata Convention on Mercury is an international convention that commenced on 16 August 2017 and aims to reduce human-made mercury emissions.
- This cost–benefit analysis considered the financial, social, health and environmental impacts of ratifying the Minamata Convention, and was updated in response to submissions received by the Department of the Environment and Energy in 2017.
- The cost–benefit analysis compared three ratification options with a 'not ratifying' option:
  - Option 2—ratification with minimum requirements
  - Option 3—enhanced phase-down of mercury (ratification with a dental amalgam waste program)
  - Option 5—staggered phase-down of mercury (ratification with a dental amalgam waste program and with a five-year exemption for mercury-containing pesticides).
- Under the 'most likely' case, all the ratification options are likely to deliver a net benefit to the Australian economy, but Option 2 (ratification with minimum requirements) gives the highest net present value ($158 million) and benefit:cost ratio (4.2).
- The cost–benefit analysis also found as follows:
  - Ratifying the convention would have impacts on a small number of Australian industries that use mercury-added products, particularly sugarcane farming and street lighting.
  - Some other industries could potentially be affected (such as new coal-fired electricity generation and the smelting of nonferrous metals), but those impacts are not expected to arise during the analysis period, and so are valued at $0.
- There is substantial uncertainty in estimating the health benefits. A conservative estimate of the health benefits was used for the 'most likely' scenario. In addition, sensitivity analysis was undertaken by applying feasible upper and lower bound health benefits. Even when the lower bound health estimates were used, all options were still likely to deliver a net benefit.
- Possible environmental benefits of ratification have not been valued in the analysis due to a lack of data and scientific uncertainty on the impacts. Accordingly, the estimates of environmental benefits are considered conservative.

Executive summary

Mercury is a persistent global pollutant. Exposure to mercury poses a serious risk to the environment and human health worldwide. The World Health Organization has suggested that mercury may have no exposure threshold below which some adverse effects do not occur.[1]

The Minamata Convention on Mercury is a multilateral environmental agreement that seeks to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.

The convention came into force generally on 16 August 2017, after it had been ratified by 50 states or regional economic organisations. While Australia was an original signatory, it has not yet ratified the convention. Ratification would legally bind Australia to the convention's obligations.

Marsden Jacob Associates was commissioned by the Australian Department of the Environment and Energy to update a previous analysis of the impacts of phasing down mercury emissions and ratifying the convention, which was completed in 2015. The update was prepared following the receipt of submissions to the *National Phase down of Mercury Regulation Impact Statement: exposure draft* (the exposure draft).[2] This report presents our updated findings.

Approach

Two forms of economic analysis were used to assess the impact from a national phase-down of mercury in response to Australia's ratification of the Minamata Convention:

- A cost–benefit analysis considered the likely cost to the Australian Government and industry as well as benefits to the community (in terms of health and environmental benefits[3]) of each option compared to a base case.
- A regulatory burden measurement estimated the costs to be borne by industry in complying with amended regulations under the ratification options.

To inform the updated analysis, Marsden Jacob reviewed submissions to the exposure draft and consulted a range of key stakeholders. In addition, we reviewed published reports to ensure that impacts to industry were appropriately and adequately captured. The original analysis also drew on discussions with relevant government agencies and departments about changes required to facilitate the ratification of the convention.

1 World Health Organization, *Mercury in healthcare*, policy paper, 2006, www.who.int/water_sanitation_health/medicalwaste/mercurypolpap230506.pdf.

2 Department of the Environment and Energy, *National phase down of mercury: ratification of the Minamata Convention on Mercury, final Regulation Impact Statement: exposure draft*, Australian Government, December 2016, www.environment.gov.au/system/files/consultations/4068cac4-a2ba-4036-a9e0-7bdee4f558fd/files/minamata-mercury-ris-dec-2016.pdf. Public consultations on this document occurred from December 2016 to March 2017.

3 Note that, while mercury is a global pollutant, the cost–benefit analysis considered only the impact of Australia's mercury emissions on the Australian population and environment.

Options

To identify the costs and benefits of a national phase-down of mercury, Marsden Jacob, in conjunction with the department, developed two primary options that align to international best practice:

- **Option 1** (base case): Under the base case option, we considered what would occur if the convention is not ratified by Australia.
- **Option 2** (phase-down of mercury): In an alternative option, we considered what would occur if a national phase-down of mercury were to take place, such that Australia satisfies the requirements of the convention. We also considered what would occur if Australia were to go beyond those requirements to address specific domestic activities that significantly contribute to Australia's mercury emissions and releases.

We also considered two further options that are slight variants of Option 2:

- **Option 3** (enhanced phase-down of mercury): This option includes additional actions to capture waste amalgam from dental practices (akin to an expansion of Victoria's now completed Dentists for Cleaner Water Program).
- **Option 5** (staggered phase-down of mercury): This option also includes additional actions to capture waste amalgam but also seeks an exemption for pesticides containing mercury until 2025.[4]

Under both the base case and the ratification options, the convention was assumed to continue in its current form. As the convention restricts the trade of mercury and mercury-related products, its ratification by other countries would affect Australia regardless of Australia's decision to ratify. Mercury is a global pollutant, so the commencement of the convention would affect mercury concentrations in Australia, which derive from changes in other countries' emissions levels. However, for the purposes of this analysis, we have considered only the impact of Australia's mercury emissions on the Australian population and environment.

A more detailed description of each of the options is in Appendix A.

Results of the cost–benefit analysis

The results of the cost–benefit analysis are summarised using two main metrics:

- The *net present value* is the present value of benefits delivered by the policy less the present value of costs incurred. It measures the expected benefit (or cost) to society of implementing each option.
- The *benefit:cost ratio* is the ratio of the present value of benefits to the present value of costs.

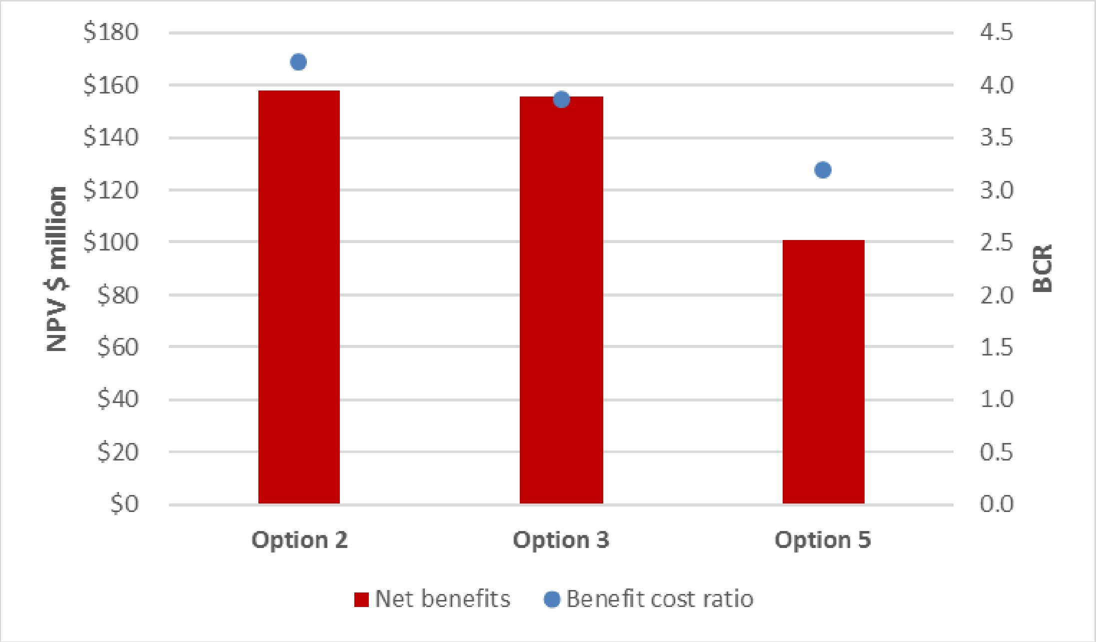
For each of the options (2, 3 and 5), a 'most likely' outcome was identified and was the focus of the analysis. In addition, 'best case' and 'worst case' outcomes were developed for use in sensitivity analyses.

[4] The 2016 Regulation Impact Statement (RIS) considered a further policy choice (Option 4) that included the early (2017) phasing out of mercury-containing pesticides. However, due to delays in Australia and other countries in ratifying the Minamata Convention, the convention came into force generally on 16 August 2017. Therefore, it is now impractical to consider implementing Option 4, and that option is not considered in this analysis.

The 'most likely' net present values for options 2, 3 and 5 were estimated to be $158 million, $156 million and $101 million, respectively.[5]

Option 2 had the greatest net present value under the 'most likely' case and is therefore expected to deliver the greatest benefit to the community. In addition, Option 2 had the highest benefit:cost ratio, with a result of 4.2. This means that for every $1 invested a return of $4.20 is expected. These results are summarised in Figure 1.

Figure 1: Net present value (NPV) and benefit cost ratio (BCR) for each option



Source: Marsden Jacob analysis.

Results from the regulatory burden measurement

Regulatory burden measurement (RBM) was undertaken in line with Australian Government guidance.[6] It focused only on private-sector costs and the costs of government-owned corporations.

The RBM values are provided as a simple average of costs to industry over the first 10-year period (2018 to 2027) using 2017 values. These costs include administrative compliance costs, substantive compliance costs and delay costs.

5 All values in the cost–benefit analysis are provided in 2017 Australian dollars and are calculated in real terms. These 'most likely' values are calculated using a 7% real discount rate.

6 Department of the Prime Minister and Cabinet, *Regulatory Burden Measurement Framework: guidance note*, Australian Government, February 2015, www.dpmc.gov.au/office-best-practice-regulation/publication/regulatory-burden-measurement-framework-guidance-note.

Table 1: Options 2, 3 and 5—average annual regulatory costs to business, variance from business as usual ($ million)

Change in costs ($ million)	Option 2—Ratification (minimum requirements)	Option 3—Ratification with dental amalgam waste program	Option 5 ratification + amalgam separators + 5-year exemption for Shirtan Liquid Fungicide
Industries with air emissions (coal-fired generation, cement, nonferrous metal smelting and waste incineration)	$0.00	$0.00	$0.00
Sugarcane growers	$1.94	$1.94	$0.84
Oil and gas	$0.00	$0.00	$0.00
Dental sector	$0.00	$0.00	$0.00
Public lighting	$0.00	$0.00	$0.00
Total	**$1.94**	**$1.94**	**$0.84**

Government activities affected

The Australian Government and the state and territory governments all have roles in Australia's regulation of mercury. The international trade in mercury and mercury-added products is primarily controlled by the Australian Government, while mercury emissions from point sources and the manufacture of mercury-added products are primarily regulated through licence arrangements implemented at the state and territory level.

The following Australian Government agencies have been identified as needing to act to ensure that Australia meets its obligations under the Minamata Convention:

- the Department of the Environment and Energy
- the Therapeutic Goods Administration, through the Department of Health
- the Australian Pesticides and Veterinary Medicines Authority, through the Department of Agriculture and Water Resources
- the Australian Customs and Border Protection Service
- the Department of Industry, Innovation and Science
- the Department of Defence.

We considered the costs associated with amended regulations and changes to government activity related to the control of mercury in terms of set-up costs and changes to ongoing costs. In each case, the costs are estimated to be minimal.

Industries affected

Marsden Jacob's analysis found that industry impacts are driven by three articles of the convention. Table 2 maps the impact from each of those articles to the key industry impacts.

Table 2: Impact from each of the three Minamata Convention articles to the key industry impacts

		Key industries					
Key articles	Article	Dental sector	Sugarcane growers	Coal-fired generation and aluminium production	Nonferrous metals processing	Cement production	Other
	4 Mercury-added products	Phase-down of amalgam (measures in Annex A, Part 2)	Mercury-containing pesticides				Street lighting
	8 Emissions			New plant Existing plant	New plant Existing plant	New plant Existing plant	Waste incineration and coal-fired boilers New plant Existing plant
	11 Wastes	Amalgam—sink waste interceptors		Fly ash			Recycling

Under the 'most likely' outcome (Option 2—minimum ratification), only sugarcane growers and street lighting customers would be directly affected.

Environmental benefits

Environmental impacts from changes that reduce mercury emissions and releases to land or water would be likely to benefit key environmental assets, such as the Great Barrier Reef. However, those benefits have not been valued due to a lack of data and scientific uncertainty about the impacts. For this reason, the only environmental benefit considered quantitatively in this analysis is carbon savings from the adoption of more energy-efficient non-mercury street lights. The quantitative results of the cost–benefit analysis, presented above, should be viewed in this light.

Health benefits

Human health impacts of mercury exposure, by contrast, have been well documented and researched. Human exposure to methylmercury occurs primarily through the ingestion of seafood and freshwater fish.

Mercury exposure has been associated with a range of health effects, including neurological effects, effects on the kidneys and cardiovascular effects. The most studied outcomes of mercury effects are of effects on the cognitive development of children, particularly the loss of intelligence quotient (IQ), and developmental effects.

Marsden Jacob's central estimate of the health costs of mercury emissions in Australia is $5,017 per kilogram, which is associated with IQ and developmental effects.[7]

This 'most likely' outcome results in present value health benefits of $180.7 million under Option 2 across the 20-year time frame of the analysis. Those benefits are estimated to increase to $183.9 million under Option 3, but decline to $120.8 million under Option 5.

Additional health benefits have been identified where changes introduced to meet obligations under the convention would reduce or eliminate health and safety incidents. These have been quantified as contributing present value benefits of $1.2 million under each ratification option (options 2, 3, and 5) for the 'most likely' case.

7 All values (including the health benefit) are given in 2017 dollars. The original cost–benefit assessment estimated the health benefit at $4,862 per kilogram in 2015 dollars.

We modelled two sensitivity scenarios that incorporated a 10-year lag time between reduced mercury emissions and reduced exposure:

- Scenario 1: ‘high estimate’—avoided health costs linked to both the IQ and cardiovascular impacts of mercury
- Scenario 2: ‘low estimate’—avoided health costs for the IQ impacts of mercury only.

These sensitivities show that health benefits would negligible in the early years of reduced exposure and then increase over time. Taken together, the scenarios provide reasonable upper bound (Scenario 1) and lower bound (Scenario 2) estimates of the health benefits of phasing down mercury emissions under options 2, 3 and 5.

Summary of changes between the 2015 and 2017 analyses

In developing the revised cost–benefit analysis, we made the following changes in response to requests from the department and submissions from stakeholders on the previous Regulation Impact Statement (RIS):

- The options considered were revised slightly, as set out in Section 1.3.
- The impact on government was reviewed to take account of additional information and altered government structures.
- The impact on industries was revised based on stakeholder responses and additional information (such as the development of the ‘best available technology’ and ‘best environmental practice’ guidance for Article 8 of the convention), as set out in Section 5.
- Cost unit estimates were revised based on stakeholder input and are provided in this report in $2017 values, whereas they were provided in $2015 values in the previous cost–benefit analysis and RIS. The estimates are detailed in Section 5.
- Benefits estimates were revised to account for new research that estimates the cardiovascular impacts of mercury on the population (included as a sensitivity) and to escalate the estimates of impacts on IQ to $2017 values. The estimates are detailed in Section 6.

1. Introduction

Exposure to mercury poses a serious risk to the environment and human health worldwide. It can cause a range of serious health impacts, which can include cognitive impairment (mild mental retardation); permanent damage to the central nervous system; kidney and heart disease; infertility; and respiratory, digestive and immune problems. The World Health Organization advises that foetuses and people who are regularly exposed to high levels of mercury (such as through their diet or workplace exposure) are most sensitive to the effects of mercury.[8] Mitigating, resolving and, in particular, remediating the problems caused by mercury can be costly.

The most common sources of environmental and human exposure to mercury in Australia include certain species of fish; air emissions from coal-fired power stations and nonferrous metal smelters; mercury-containing pesticides; damaged fluorescent and low-energy lamps; leaking mercury-containing thermometers and batteries; and amalgam dental fillings. At the ends of their lives, many of these products are sent to landfill or incinerated, resulting in further emissions and releases of mercury into the environment. Mercury in the environment can also threaten the health of wildlife exposed to mercury in its food.

One of the key approaches to addressing the issue of mercury exposure is to prevent its emission and release from anthropogenic (human-generated) sources.

The Minamata Convention on Mercury is a multilateral environmental agreement that addresses the adverse effects of mercury through practical actions to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.

Australia signed the convention on 10 October 2013 and is now considering ratifying the convention, which will make Australia a full party to it. Ratification would legally bind Australia to the convention's obligations.

In 2015, Marsden Jacob Associates was commissioned by the former Australian Department of the Environment to undertake a cost–benefit analysis of ratification of the convention by Australia, including a regulatory burden measurement of private-sector costs associated with ratification.

The *National Phase Down of Mercury Final Regulation Impact Statement: exposure draft* was open to public submissions from December 2016 to March 2017.[9] Following the department's formal consultation with the Australian states and territories, industry and the community, Marsden Jacob was asked to review issues raised in submissions from interested stakeholders and update the cost–benefit analysis for the preparation of a final Regulation Impact Statement (RIS) and National Interest Analysis.

The results from our updated analysis are presented in this report. Marsden Jacob understands that this analysis will be used to inform any government decision on whether Australia should ratify the convention.

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8 World Health Organization, *Mercury and health*, factsheet no. 361, last updated March 2017, www.who.int/mediacentre/factsheets/fs361/en/ (accessed 18 December 2017).

9 Department of the Environment and Energy, *National phase down of mercury: ratification of the Minamata Convention on Mercury, final Regulation Impact Statement: exposure draft*, Australian Government, December 2016, www.environment.gov.au/system/files/consultations/4068cac4-a2ba-4036-a9e0-7bdee4f558fd/files/minamata-mercury-ris-dec-2016.pdf.

1.1 Ratifying the Minamata Convention

The Minamata Convention is a global treaty to protect human health and the environment from the adverse effects of mercury.

The convention requires ratified parties to address mercury throughout its life cycle, including its production, its intentional use in products and processes, its unintentional release from industrial activity, and end-of-life aspects including water, contaminated sites and long-term storage.

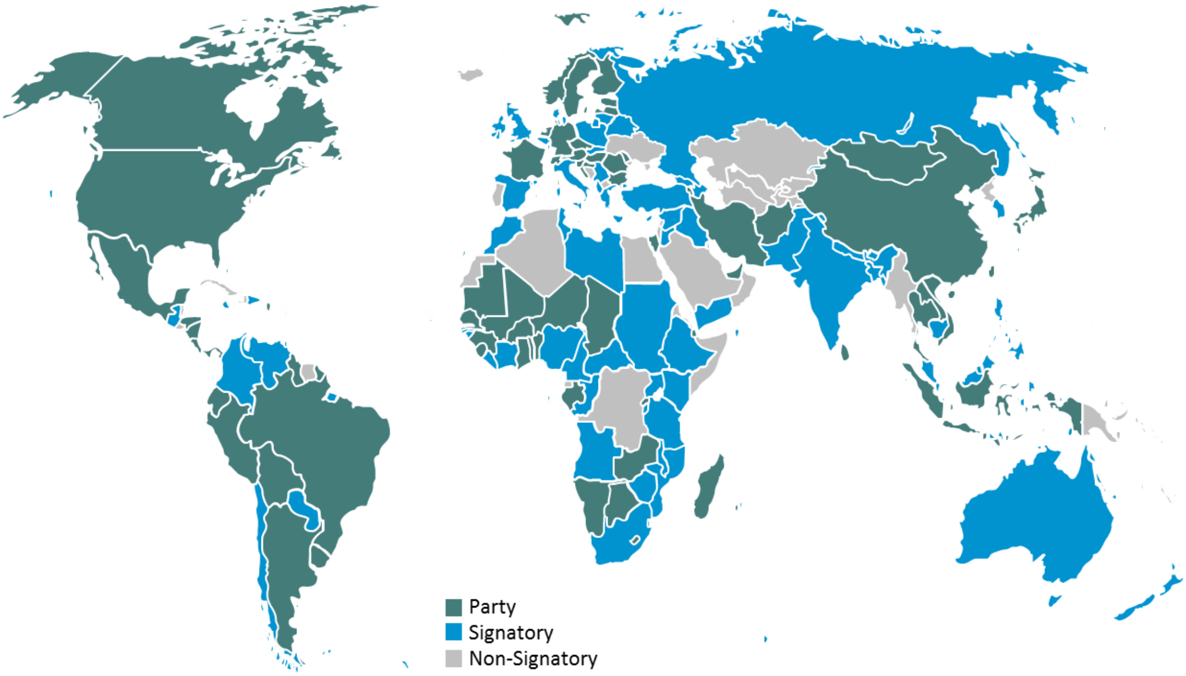
The convention was agreed at the fifth session of the Intergovernmental Negotiating Committee in Geneva, Switzerland, on 19 January 2013, and the text was adopted and opened for signature at a diplomatic conference (the Conference of Plenipotentiaries), held in Kumamoto, Japan, from 10 to 11 October 2013. Australia signed the convention at that meeting.

When did the convention come into force?

The convention entered into force generally on 16 August 2017, 90 days after 50 countries ratified the agreement. The first Conference of the Parties took place from 24 to 29 September 2017 in Geneva. The second conference is scheduled to convene from 19 to 23 November 2018.

There are currently 128 signatories to the convention, and 91 countries as well as the UK and European Union have already ratified and are parties to the convention (Figure 2).[10]

Figure 2: Parties and signatories to the Minamata Convention



Note: This map should be seen as indicative, as it is constantly changing and not all countries are displayed effectively at this scale.

Source: Marsden Jacob analysis, 2017.

[10] As at 13 December 2017. For an up-to-date list of signatories, refer to www.MercuryConvention.org/Countries/tabid/3428/Default.aspx.

Ratification of the convention

Ratification of the convention[11] would elevate Australia to be a ‘party to the convention’ and legally bind Australia to the convention’s obligations now that the convention has come into force.[12]

The domestic ratification process involves an examination of the convention by the Australian Parliament through the Joint Standing Committee on Treaties. Typically, this includes a public submission, hearing and reporting process.

Ultimately, the power to enter into the convention is an executive power of the Australian Government under Section 61 of the Australian Constitution. Ratification occurs when the Executive Council approves the depositing of an instrument of ratification with the United Nations, stating that Australia agrees to be bound by the articles of the convention.

Becoming a party would allow Australia to participate in important future decision-making for the convention by its Conference of the Parties, for example on guidance for atmospheric emissions.

1.2 Key obligations of the convention

The convention consists of 35 articles and five annexes detailing obligations that seek to ‘protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds’.[13]

The convention sets out several ‘firm’ obligations, which impose specific requirements, as well as a few actions that parties to the convention may choose to take (but which are not specifically required).

The following briefly summarises the key obligations that the convention imposes on parties:

- **Restrict mercury supply sources and trade (Article 3)**, such as by ensuring no development of new mercury mines, phasing out primary mercury production, and restricting the export and import of mercury in the absence of written consent agreements between countries.
- **Phase out the manufacture, import and export of specific mercury-added products (Article 4)**, including batteries, switches and relays; various lighting products with mercury content exceeding set limits; all mercury vapour lights; cosmetics with mercury content above a set limit; certain pesticides, biocides and topical antiseptics; and various non-electrical measuring devices where no mercury-free alternative is available (as listed in Annex A of the convention).
- **Phase out specific manufacturing processes in which mercury or mercury compounds are used (Article 5)**, such as various chemical production processes and production processes in which mercury or mercury compounds are used as catalysts (as listed in Annex B of the convention).
- **Develop initiatives to reduce artisanal and small-scale gold mining (Article 7)** in which mercury amalgamation is used to extract gold from ore.
- **Control or reduce air emissions of mercury and mercury compounds (Article 8)** for source categories listed in Annex D of the convention (including coal-fired power generation; smelting

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11 Australia is currently a signatory to the convention. Being a signatory does not create any legally binding obligations but does demonstrate the intent to examine the treaty domestically and consider ratifying it. If Australia ratifies, it will become a party to the convention 90 days after it has deposited the instrument of ratification. After that time, Australia would be legally bound by the obligations in the convention unless specific exemptions had been sought.

12 The convention came into force generally on 16 August 2017, which was 90 days after the 50th country had ratified.

13 United Nations Environment Programme (UNEP), *Minamata Convention on Mercury: text and annexes*, October 2013, p. 6, www.mercuryConvention.org/Convention/tabid/3426/Default.aspx.

and roasting processes for specific nonferrous metals; waste incineration facilities; and cement clinker production facilities).

- **Control or reduce releases of mercury and mercury compounds (Article 9)** to land and water from relevant point sources (not otherwise listed in the convention) by undertaking appropriate measures such as setting limit values, using the best available techniques and best environmental practices and promoting alternative measures.
- **Ensure the environmentally sound interim storage of mercury (Article 10)** in accordance with relevant sections of the Basel Convention (to which Australia is already a party).[14]
- **Control and manage mercury wastes (Article 11)** in accordance with the relevant sections of the Basel Convention.

In addition, Article 21 imposes reporting obligations under the convention relating to articles 3, 5, 7, 8 and 9. The convention also requires parties to contribute financially towards activities undertaken for the convention's administration, as well as fulfilling some reporting, monitoring and information exchange requirements.

1.3 Project approach and scope

The purpose of this report is to present a clear, concise and comprehensive explanation of likely costs and benefits from Australia's decision to phase down mercury, positioning the country to become a ratified party to the Minamata Convention. It is an update on the original Marsden Jacob report, *Costs and benefits of Australia phasing-down mercury*, which was delivered to the department in May 2015.

1.3.1 Options

To identify the costs and benefits of a national phase-down of mercury, Marsden Jacob, in conjunction with the department, developed four options[15] for ease of reference and to align to international best practice:

- **Option 1** (base case): Under the base case, we considered what would occur if the convention were not ratified by Australia.
- **Option 2** (phase-down of mercury): We considered what would occur if a national phase-down of mercury were to take place, such that Australia satisfies the requirements to ratify the convention.

We also considered two further options that were slight variations to ratification (Option 2). Options 3 and 5 considered what would occur if Australia were to vary requirements to address specific domestic activities that significantly contribute to Australia's mercury emissions and releases.

- **Option 3** (enhanced phase-down of mercury): This was a slight variation to Option 2, as it considered additional actions for the capture of waste amalgam from dental practices (akin to an expansion of Victoria's now completed Dentists for Cleaner Water Program). This is the equivalent to Option 2B in the original Marsden Jacob report.

It was assumed in the original report that the convention would come into force from early 2016. Therefore, the previous analysis considered the early phase-out (in 2017) of pesticides containing mercury. However, due to delays in Australia and other countries in ratifying the agreement, and given

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14 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; entered into force on 5 May 1992.

15 As they appeared in the department's *Regulation Impact Statement: National Phasedown of Mercury—Ratification of the Minamata Convention on Mercury*, December 2016.

that the convention came into force generally on 16 August 2017 , it is now impractical to consider implementing Option 4. Instead, an alternative option (Option 5), which was not considered in the exposure draft RIS, was considered in this updated cost–benefit analysis.

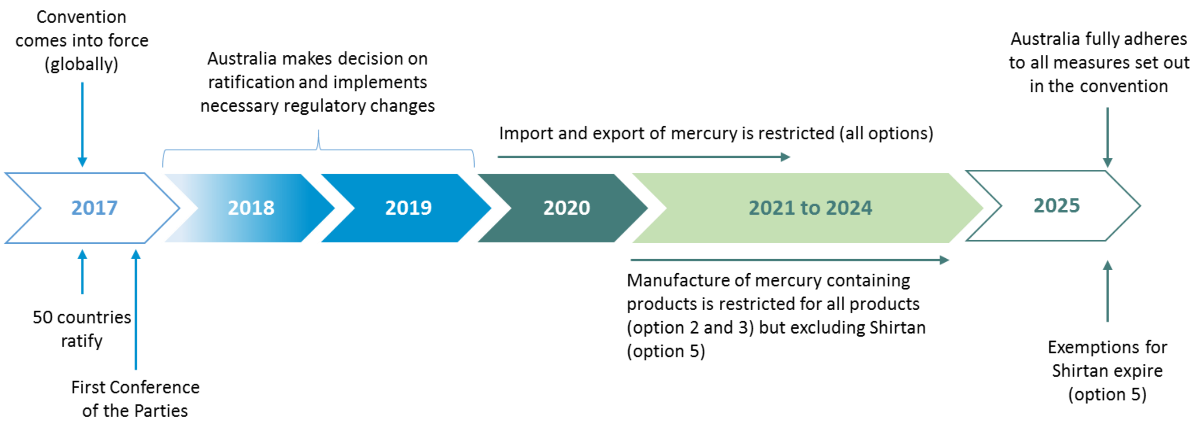
- **Option 5** (staggered phase-down of mercury): This was a slight variation to Option 3, as it considered additional actions for the capture of waste amalgam and an application by Australia to seek an exemption for mercury-containing pesticides until 2025.

Further details of the options applied in the analysis are in Appendix A.

Ratification timings

The likely timings for each of the options are set out in Figure 3. Irrespective of whether Australia ratifies the convention, the import and export of mercury will begin to be restricted, and the manufacture and trade of specified mercury-containing products will be restricted from 2020 onwards.

Figure 3: Likely timeline for entry into force of the Minamata Convention



Source: Marsden Jacob analysis.

All products listed in Annex A of the Minamata Convention are to be phased out by the end of 2020 (31 December 2020). Under the convention, exemptions can be sought to extend the period for the phase-out of specific products. In Australia, the exemption that could be considered is for the mercury-containing pesticide registered under the trading name of Shirtan Liquid Fungicide, which is used in sugarcane planting. To be sold in Australia, Shirtan Liquid Fungicide is registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA).[16]

Options 2 and 3 assume that no exemption would be made and that therefore the manufacture of Shirtan Liquid Fungicide would cease by 31 December 2020.

For the cost–benefit analysis, it was assumed that under options 2 and 3 the renewal of the annual registration for Shirtan Liquid Fungicide would not be sought after 2020.[17] Following the lapse of the registration, growers would then have 12 months in which to use the product.[18] This timing would effectively remove many transitional costs, as it would remove the risk that farmers and distributors of the product would be left with unsaleable or unusable stock. Under options 2 and 3, it is therefore envisaged that Shirtan Liquid Fungicide will cease to be used after 2021.

16 The use of Shirtan Liquid Fungicide in sugarcane planting is detailed in Section 5.2.

17 The process set out here for ceasing registration is one legal approach that could be used, but other legal approaches could be used. For the cost–benefit analysis, the approach used is less important than the resulting cost and the effects.

18 Under section 47D of the *Agricultural and Veterinary Chemicals Code Act 1994*.

Option 5 assumes that an exemption will be sought by Australia when ratifying the convention for the manufacture and use of Shirtan Liquid Fungicide in Australia. Under this option, it is assumed that manufacture will cease on 31 December 2025 and that the renewal of the annual registration will not be sought. As with options 2 and 3, growers would still have a 12-month period in which to use any remaining product. Therefore, under Option 5 it is envisaged that the use of Shirtan Liquid Fungicide will cease after 2026, but that many farmers would have switched products before then.

Cost–benefit analysis

The cost–benefit analysis sought to determine the incremental impact of ratification options compared to the base case (non-ratification) option by considering likely cost impacts on business, government and the wider community and benefits to human health and the environment.

To do this, costs and benefits were identified under each option and the net present value (NPV) of the alternative option was then assessed relative to the base case.

The analysis was undertaken over a 20-year period (2018 to 2037), as it was determined that most of costs would be up front, while the benefits stream would continue to increase over time. Costs and benefits beyond the 20-year period are uncertain; therefore, we assumed that any material differences between the base case and phase-down options would be negligible beyond that point.

The cost–benefit analysis result was tested through sensitivity analyses using alternative discount rates and key cost and benefit variables.

Regulatory burden measurement

The regulatory burden of the phase-down options relative to the base case was quantified in a manner consistent with Australian Government guidance on regulatory burden measurement (RBM).[19]

The RBM analysis focused only on private-sector costs and the costs of government-owned corporations.

Values in the RBM are provided as a simple average of costs to industry over the first 10-year period and are disaggregated by cost type (administrative, substantive and delay costs).

A detailed description of the cost–benefit analysis and RBM frameworks applied in this report is in Appendix C.

Costs and benefits

Marsden Jacob classified costs and benefits under the groupings set out in Table 3.

Note that, while mercury is a global pollutant, the cost-benefit analysis considers only the impact of Australia's mercury emissions on the Australian population and environment.

To inform the development of this report, we conducted brief interviews and questionnaires with a range of industry stakeholders. Details of the contacts made through this process are in Appendix D.

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19 Department of the Prime Minister and Cabinet, *Regulatory Burden Measurement Framework: guidance note*, Australian Government, February 2016, www.pmc.gov.au/sites/default/files/publications/005-Regulatory-Burden-Measurement-Framework.pdf.

Table 3: Summary of costs and benefits

Stakeholder	Option 1 Base case (non-ratification)	Option 2 Minimum requirements to ratify	Option 3 Ratification with additional dental amalgam recovery practices	Option 5 Ratification with additional dental amalgam recovery practices and with exemption for Shirtan until 2025
Costs				
Government	As per current costs	Costs associated with meeting ratification: ▪ development of guidelines ▪ financial resources required and mechanisms ▪ regulation, compliance costs. Changes to ongoing regulation, compliance costs.	Similar to 2	Similar to 2
Industry	As per current costs but with potential for trade-related measures	Costs associated with meeting ratification: ▪ increased costs to implement phase-out of mercury-added products by end of 2020 ▪ costs for new and existing point sources (e.g. gold production and coal-fired power plants). Changes to ongoing costs (and revenues) as a result of ratification.	Similar to 2 Increased costs for installation and operation of mercury traps and separators in dental clinics	Similar to 2 Reduced costs for delayed phase-out of mercury-containing pesticides Increased costs for installation and operation of mercury traps and separators in dental clinics
Benefits/avoided costs				
Health outcomes	Health outcomes consistent with current trends / experience but with some improvement due to other countries' decisions to ratify	Potential for improved health outcomes within Australia as a direct result of changes made by Australia	Benefits from increased removal of mercury from sewerage systems	Reduced benefits from delayed phase-out of mercury-containing pesticides Benefits from increased removal of mercury from sewerage systems
Environmental outcomes	Environmental outcomes consistent with current trends / experience but with some improvement due to other countries' decisions to ratify	Potential for improved environmental outcomes within Australia as a direct result of changes made by Australia	Benefits from increased removal of mercury from sewerage systems	Reduced benefits from delayed phase-out of mercury-containing pesticides Benefits from increased removal of mercury from sewerage systems

2. Cost–benefit analysis

2.1 Cost–benefit analysis overview

The results of the cost–benefit analysis are summarised in Table 4 and Figure 4.

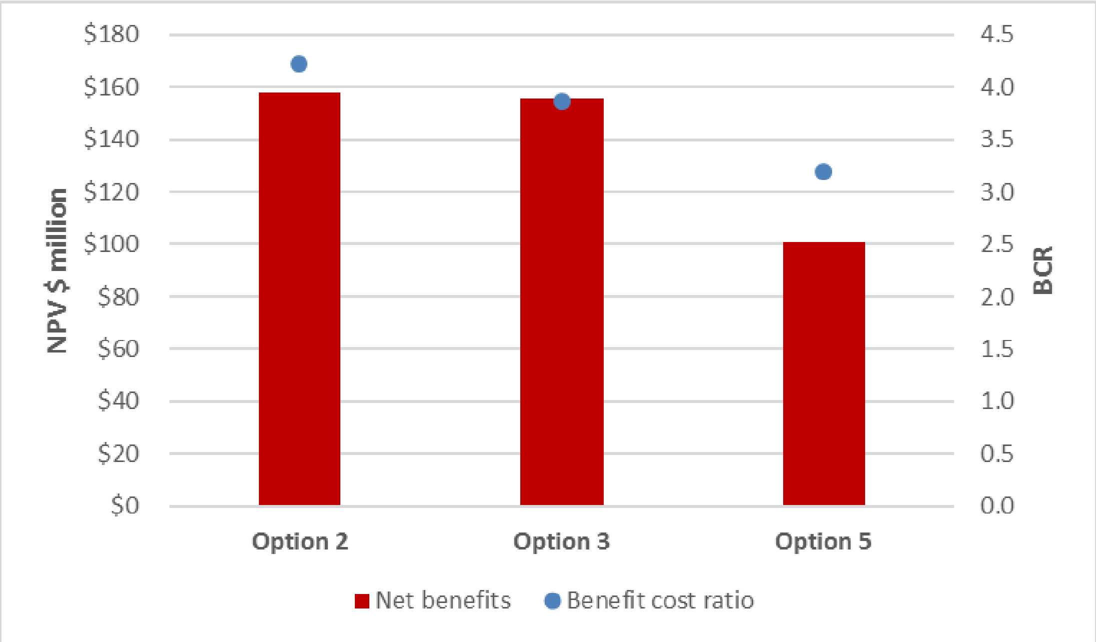
The results include two main metrics:

- The *net present value* (NPV) is the present value (PV) of benefits delivered by the policy less the PV of costs incurred. It measures the expected benefit (or cost) to society of implementing each scenario.
- The *benefit:cost ratio* (BCR) is the ratio of the PV of benefits to the PV of costs.

For each of the options (2, 3 and 5), 'most likely' case NPV and BCR estimates are provided in Table 4 and Figure 4.[20] The NPVs for options 2, 3 and 5 are estimated to be $157.7 million, $155.7 million and $100.9 million, respectively.[21] Option 2 has the greatest NPV and is therefore expected to deliver the greatest benefit to the community. In addition, Option 2 has the highest BCR.

This outcome reflects the fact that Option 2 delivers smaller benefits, but at a lower cost than Option 3; however, the differences in net benefit are marginal. A clear outcome is that the delayed phase-out of mercury-containing pesticides under Option 5 is not preferred, as it leads to substantially smaller health and environmental benefits.

Figure 4: Summary of the cost–benefit analysis ($ million)



Source: Marsden Jacob analysis, 2017.

[20] The best case and worst case figures are provided in Appendix A.

[21] All values in the cost–benefit analysis are provided in 2015 Australian dollars and are calculated in real terms. The 'most likely' values are calculated using a 7% real discount rate.

Table 4: Cost–benefit analysis results for options 2, 3 and 5 (values in $ million)

Stakeholder		Ratification (Minimum Requirements) Option 2	Ratification with Dental Amalgam waste program Option 3 -	Ratification & Amalgam waste program & 5-year exemption for Shirtan Option 5
Costs		($ millions)		
Government	Article 13—Financial contributions	$1.1	$1.1	$1.1
	Department of the Environment and Energy	$2.4	$2.4	$2.4
	Other	$2.4	$2.4	$2.4
Industry	Article 8—Air emissions	$0.0	$0.0	$0.0
	Cane growers	$23.4	$23.4	$15.0
	Dental sector	$0.0	$5.3	$5.3
	Public lighting	$20.0	$20.0	$20.0
	Oil and gas	$0.0	$0.0	$0.0
Benefits/avoided costs		($ millions)		
Health outcomes	Reduction in mercury emissions and releases	$180.7	$183.9	$120.8
	Reduced health and safety costs	$1.2	$1.2	$1.2
Environmental outcomes	Carbon emissions savings (public lighting)	$5.3	$5.3	$5.3
	Energy savings (public lighting)	$19.6	$19.6	$19.6
	Environmental benefits	Not quantified	Not quantified	Not quantified
Totals	**Total cost**	**$49.2**	**$54.5**	**$46.1**
	Total benefit	**$206.9**	**$210.1**	**$147.0**
	Net benefits	**$157.7**	**$155.7**	**$100.9**
	Benefit:cost ratio	**4.2**	**3.9**	**3.2**

Note: Changes to public lighting would result in both carbon savings and energy efficiency savings, which are accounted for separately.

Duration of analysis

The results are all provided on the basis of a 20-year cost–benefit analysis (2018 to 2037), in line with Australian Government guidance on cost–benefit analyses.[22] Note that some costs and all benefits would continue to accrue after 2037; therefore, the calculated net benefits are conservative. However, extending the period of analysis is not likely change the ranking of the policy options.

22 Department of the Prime Minister and Cabinet, *Regulatory Burden Measurement Framework: guidance note.*

2.2 Sensitivity analysis

To test the outcomes of the cost–benefit analysis, Marsden Jacob performed two forms of sensitivity analysis. First, the analysis considered the most likely outcome under alternative discount rates. Second, the analysis considered 'most likely', 'best case' and 'worst case' outcomes for each option.

2.2.1 Discount rate

Table 5 summarises the NPVs estimated for the 'most likely' case under each of the options. It shows that Option 2 provides the highest benefit under each discount rate. Note that Option 2 is only marginally better than Option 3 under each discount rate.

Table 5: Sensitivity analysis showing the NPV for each option ($ million)

	Net present value		
Discount rate	Option 2	Option 3	Option 5
3%	$243.0	$240.5	$174.9
7%	$157.7	$155.7	$100.9
10%	$115.5	$113.7	$65.5

Source: Marsden Jacob analysis.

2.2.2 Best case and worst case analysis

Given the importance of certain key variables to outcomes of the analysis, we developed 'most likely', 'best case' and 'worst case' outcomes that reflect alternative assumptions about the impacts of ratification on those variables. The alternative assumptions applied to these variables under each outcome are summarised in Table 6.

The 'worst case' assumptions applied to three key variables (power generation, gold smelters and sugarcane) are discussed in more detail in Appendix B.

Table 6: Assumptions applied to key variables in most likely, best and worst-case outcomes

Variable	Most likely case	Worst case	Best case
Power generation	No new power facilities or no additional requirements (no cost and no mercury saved)	No new power facilities with additional requirements (no cost and no mercury saved)	No new power facilities or no additional requirements (no cost and no mercury saved)
Gold smelters	No new facilities or no additional requirements (no cost and no mercury saved)	One new facility with additional requirements (additional cost and additional mercury saved)	No new facilities or no additional requirements (no cost and no mercury saved)
Sugarcane pesticide on germination rates	Annual impact on sugarcane germination (3% requires replanting)	Annual impact on sugarcane germination (6% requires replanting)	No impact on sugarcane germination
Public lighting—asset replacement	Light replacement costs $470–$1,300 per light	Zero costs and benefits for lighting[a]	Light replacement costs $373–$1,075 per light

Variable	Most likely case	Worst case	Best case
Greenhouse gas savings from public lighting	Value of tonne of CO_2e = $36.00	Value of tonne of CO_2e = $36.00	Value of tonne of CO_2e = $36.00
Health and safety benefits	30% reduction in workplace incidents	10% reduction in workplace incidents	60% reduction in workplace incidents
Health benefits of a reduction in mercury	Health damage based on IQ ($5,017 per kg of mercury)	Health damage based on IQ ($5,017 per kg of mercury) but delayed up to 10 years	Health damage based on IQ ($5,017 per kg of mercury) and heart attacks ($22,578 per kg) but delayed up to 10 years
Options 3 and 5 Number of dental amalgam separators installed	2,056	685	6,114

CO_2e = carbon dioxide equivalent.

a As set out in Section 5.4, under the worst case scenario it is assumed that the international supply of mercury vapour lamps would diminish, resulting in no difference between the base case and the ratification options. This would result in no cost and no benefit attributable to lighting.

For each of the options (2, 3 and 5), the ‘most likely’ case, ‘best case’ and ‘worst case’ NPV and BCR estimates are provided in Table 7.

Option 2 has the highest NPV and BCR under both the ‘most likely’ case and the ‘best case’ outcomes (by a small margin), but Option 3 has the highest NPV under the ‘worst case’ outcome (by a small margin) and Option 5 has the highest BCR under the ‘worst case’ outcome.

Note that Option 2 is consistently the preferred option based on the highest NPV and BCR. However, if the cost of amalgam separators were to fall, then Option 3 would become the preferred option.

Table 7: Cost–benefit analysis results for options 2, 3 and 5 (values in $ million)

Stakeholder	Element	Ratification (minimum requirements) Option 2 Most likely case	Best case	Worst case	Ratification + dental amalgam waste recovery program Option 3 Most likely case	Best case	Worst case	Ratification + dental amalgam waste recovery program + 5-year exemption for Shirtan Option 5 Most Likely Case	Best Case	Worst Case
Costs				$ (millions)			$ (millions)			$ (millions)
Government	Article 13—Financial contributions	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1
	Department of the Environment and Energy	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4
	Other	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4
Industry	Article 8—Air emissions	$0.0	$0.0	$5.6	$0.0	$0.0	$5.6	$0.0	$0.0	$5.6
	Cane growers	$23.4	$0.9	$62.6	$23.4	$0.9	$62.6	$15.0	$0.4	$29.7
	Dental	$0.0	$0.0	$0.0	$5.3	$15.9	$1.8	$5.3	$15.9	$1.8
	Public lighting	$20.0	$15.9	$0.0	$20.0	$15.9	$0.0	$20.0	$15.9	$0.0
	Oil and gas	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Benefits/avoided costs										
Health outcomes	Reduction in mercury emissions and releases	$180.7	$689.2	$125.3	$183.9	$702.6	$127.7	$120.8	$484.2	$88.0
	Reduced health and safety costs	$1.2	$2.5	$0.4	$1.2	$2.5	$0.4	$1.2	$2.5	$0.4
Environmental outcomes	Carbon savings (public lighting)	$5.3	$5.3	$0.0	$5.3	$5.3	$0.0	$5.3	$5.3	$0.0
	Energy savings (public lighting)	$19.6	$19.6	$0.0	$19.6	$19.6	$0.0	$19.6	$19.6	$0.0
	Environmental benefits		Not Quantified			Not Quantified			Not Quantified	

		Ratification (minimum requirements)			Ratification + dental amalgam waste recovery program			Ratification + dental amalgam waste recovery program + 5-year exemption for Shirtan		
		Option 2			Option 3			Option 5		
Stakeholder	**Element**	**Most likely case**	**Best case**	**Worst case**	**Most likely case**	**Best case**	**Worst case**	**Most Likely Case**	**Best Case**	**Worst Case**
Totals	**Total cost**	**$49.2**	**$22.6**	**$74.0**	**$54.5**	**$22.6**	**$75.8**	**$46.1**	**$38.0**	**$42.9**
	Total benefit	**$206.9**	**$716.6**	**$125.7**	**$210.1**	**$714.1**	**$128.1**	**$147.0**	**$511.6**	**$88.4**
	Net benefits	**$157.7**	**$694.0**	**$51.7**	**$155.7**	**$691.5**	**$52.4**	**$100.9**	**$473.6**	**$45.6**
	Benefit:cost ratio	**4.2**	**31.7**	**1.7**	**3.9**	**31.6**	**1.7**	**3.2**	**13.5**	**2.1**

2.2.3 Cost–benefit analysis drivers

It is important to note the differing costs of mercury reduction—even under a 'worst case' outcome—relevant to the likely reduction in mercury output.

Ceasing the manufacture (and import and export) of mercury-containing pesticides under Article 4 is expected to prevent approximately 4,300 kilograms[23] of mercury entering the Australian environment per year after 2020 at an average annual cost of approximately $2.3 million (under the 'most likely' outcome). This equates to $632 per kilogram of mercury.

2.3 Likely impact on consumers

In considering the costs of a phase-down in mercury, it is useful to consider whether costs imposed on business and government through requirements to reduce mercury usage, emissions, or both are likely to be passed on to consumers. The extent to which costs can be passed on and therefore the likely impact to consumers will vary depending on the industry structure and the form of cost imposed.

To consider the impact on consumers, it is necessary to first dissect the forms of costs that arise for business and government.

2.3.1 Forms of costs for business and government

The costs imposed on industry and government identified in the cost–benefit analysis include some costs that would directly affect a company's bottom line and other costs that represent an opportunity cost.

Bottom-line costs

Additional requirements imposed through the phase-down in mercury will affect a company's total costs of operation under the following circumstances:

- Staff costs are increased by either requiring additional staff or paying existing staff more for either working longer hours or taking on more responsibility.
- Capital or operating costs increase because of additional compliance requirements.

Costs of this kind will affect a company's total costs of operation and may be passed on to consumers.

Opportunity costs

Some costs, such as the reallocation of staff and management time, can be considered an opportunity cost, as staff and management costs might not increase (where staff and management are not paid by the hour). This is particularly likely where the additional costs are not substantial. In this case, the imposition of a new requirement may prevent staff from undertaking other roles, such as business development. Alternatively, the additional tasks may affect staff's and management's personal time.

Costs of this kind do not directly affect a company's total costs of operation and so are not likely to be passed on to consumers.

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23 We note that the quantity of Shirtan used per year has decreased slightly since the 2015 cost–benefit analysis. This has resulted in the quantity of mercury being prevented from entering the environment decreasing from 5,280 to 4,300 kg/year. This estimated volume is based on sales predictions by Alpha Chemicals, which formulates Shirtan.

2.3.2 Ability of industry to pass on costs to consumers

Where a company's total cost of operations is increased, it may seek to pass on those additional costs to consumers.[24] However, the ability of a company to do so will vary from one product to another and is beyond the scope of this cost–benefit analysis.[25]

It is likely that some costs will be passed on to consumers; however, this will not be uniform across the industries considered in this analysis.

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24 We note that industry did not indicate whether any individual costs would be passed on to consumers.

25 Factors influencing a company's ability to pass on higher costs to consumers include:

- levels of buyer power and supplier power
- the availability of substitutes
- the threat of entry into the market by new actors
- existing levels of competition in the market for that product.

3. Regulatory burden analysis

Our regulatory burden measurement (RBM) was undertaken in line with Australian Government guidance.[26] It focused only on private-sector costs and the costs of government-owned corporations.

The RBM values are provided as a simple average of costs to industry over the first 10-year period (2018 to 2027) using 2017 values. They have been disaggregated by cost type:

- **Administrative compliance costs** are primarily driven by the need to demonstrate compliance with the Minamata Convention, such as through annual reporting.
- **Substantive compliance costs** are directly attributable to ratification and fall outside of the usual business costs. These costs may include the capital costs of plant upgrades as well as operational costs from process changes or additional staff training.
- **Delay costs** include the time taken for the preparation of applications (referred to as ‘application delay’) and the time taken for approvals (referred to as ‘approval delay’). Estimating the cost savings relating to removing delays requires a strong understanding of the realistically achievable time frames, the likely delays that could be avoided and the value (potential cost) of any avoidable delay.

The regulatory burden analysis aligned with the ‘most likely’ outcome analysis of industry impacts and so did not include costs that were identified only under the ‘best’ or ‘worst’ case outcomes.

3.1 Regulatory burden costs, by industry

The regulatory burden costs for each of the industries affected are discussed in this section.

3.1.1 Industries with potential air emissions

For industries with potential air emissions, the only costs identified in the initial 10-year period were costs associated with contributing to the preparation of the national plan. However, it is not compulsory for Australia to prepare a national plan, and it is likely that the Australian Government would seek the voluntary support of the industries associated with emissions to help prepare any national plan, rather than mandate participation by legislation. Therefore, costs for industry to contribute to the possible plan were not considered to be regulatory burden.[27] No other costs were identified through discussions with industry and government, as ratification was found to have negligible impact on existing facilities, and no new facilities are expected to be developed in the initial 10-year period.

The average regulatory burden for industries with potential air emissions under each scenario (options 2, 3 and 5) over the period from 2016 to 2027 was $0 per year.

26 Department of the Prime Minister and Cabinet, *Regulatory Burden Measurement Framework: guidance note*

27 According to the convention, a party with relevant sources *shall* take measures to control emissions and releases, and *may* prepare a national plan setting out the measures to be taken to control emissions and releases and its expected targets, goals and outcomes. Any plan shall be submitted to the Conference of the Parties within four years of the date of entry into force of the convention for that party.

3.1.2 Sugarcane industry

As detailed in the cost–benefit analysis, the phase-out of mercury-containing pesticides would have impacts on several stakeholder groups: sugarcane growers (who use Shirtan Liquid Fungicide, a mercury-containing pesticide), Crop Care (which distributes Shirtan), and Alpha Chemicals (which manufactures it).

A range of potential costs were considered and discussed with the industry peak body.

A potential offset benefit was identified, as the alternative product also provides protection against other fungi and diseases. Industry advised that the removal of mercury-containing pesticides from the market would produce changes in emergence and budding in adverse conditions. However, published research has found that alternative pesticides (that do not contain mercury) have a greater benefit to emergence and budding in adverse conditions (see Section 5.2).

A full discussion of the costs and benefits of each option is in Section 5.2.

Options 2 and 3

The average regulatory burden for sugarcane growers under options 2 and 3 over the period from 2018 to 2027 would be about $1.9 million per year. Those costs are detailed in Table 8.

Table 8: Regulatory burden estimate for the sugarcane industry

Cost	Most likely	Average cost per year over years 1–10
Costs at Alpha Chemicals, Crop Care and other distributers	This includes: • Alpha Chemicals transition costs (manager's time) • Crop Care to develop new product and get Sinker label changed • Crop Care and distributers increased resourcing to help canefarmers transition to alternatives	$99,400
Area that requires replanting	3% requires replanting	$1,837,500
Total		**$1,936,900**

Note that the significant majority of the regulatory burden estimate is due to a provision for 'areas that require replanting'. As discussed in Section 5.2, this cost is uncertain, is not strongly supported by scientific evidence and could be zero or negligible. If this element were excluded, then the regulatory burden estimate would be around $100,000, not $1.94 million.

Option 5

Under Option 5, mercury-containing pesticides would be exempted until the end of 2025.

The average regulatory burden for sugarcane growers under Option 5 over the period from 2018 to 2027 would be $840,000 per year.

3.1.3 Dental sector

In assessing the regulatory burden for dental industries, Marsden Jacob considered the impact of ratification both on manufacturers of amalgam and on dental surgeries.

No regulatory burden impacts on either manufacturers of amalgam or dental surgeries were identified through discussions with industry and government under Option 2.

We considered whether there would be additional administrative costs for mercury imports; however, those costs appear to be unchanged from the base case. A full discussion of the costs and benefits of each option is in Section 5.3.

Option 2

No regulatory burden costs for the dental sector were identified under Option 2.

Options 3 and 5

Under options 3 and 5, a total of 7,400 dental practices would be encouraged to install and maintain amalgam separators at an installation cost of $1,000 each and an annual waste collection and recycling cost of $250 each.

However, as the program would be voluntary, there would be no compliance costs or regulatory burden under a strict interpretation of that concept.

3.1.4 Lighting

Lighting is affected under Article 4 (mercury-added products) and was considered in terms of domestic and commercial lighting as well as public lighting. A full discussion of the costs and benefits of each option is in Section 5.4.

Domestic and commercial lighting

No regulatory burden costs for domestic and commercial lighting were identified though discussions with industry stakeholders and government.

Public lighting

The ownership, responsibilities and governance structures for street lighting assets are complex and vary depending on the type of installation and maintenance arrangements. However, the ownership can be largely separated in terms of the Australian Standards classifications for Category P (residential streets and public open spaces) and Category V (main or major road) lighting.

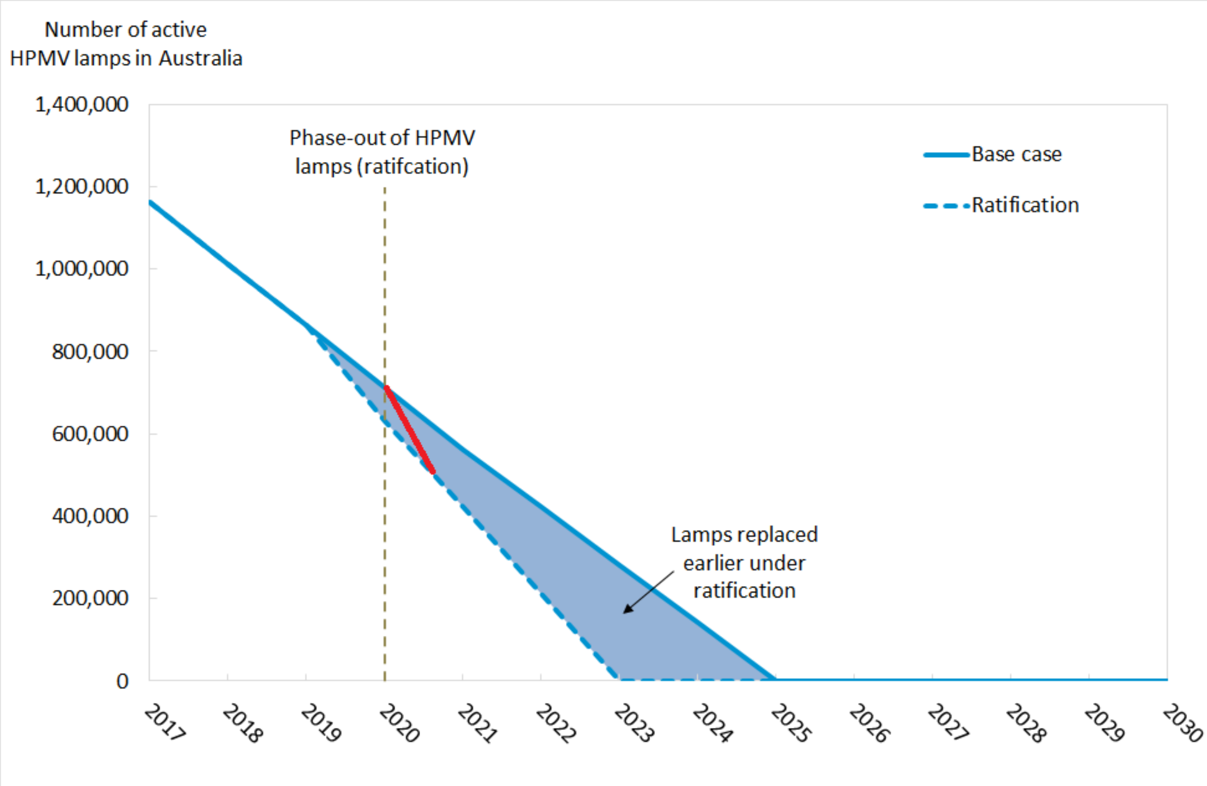
Mercury vapour street lighting using high-pressure mercury vapour (HPMV) lamps on minor residential roads in Australia tends to be managed by electricity distribution networks on behalf of local councils, on the basis that the lamps are attached to the electricity network power poles. In most circumstances, the maintenance of the lights by the network businesses requires those assets to be ‘gifted’ to the distribution business.

Distribution businesses are responsible for only a very small proportion of main road lighting. Government departments, such as main roads departments, tend to be responsible for both the management and the costs associated with main road lighting.

Under ratification of the Minamata Convention, our analysis (outlined in Section 5.4) found that only lower wattage street lighting on residential roads (50 W, 80 W and 125 W lamps) would be phased out more quickly than current trends would predict. Higher wattage lighting on main roads (250 W, 400 W and 700 W lamps) would be unaffected by ratification.

For the RBM, we modelled the phase-out of mercury vapour lamps so that the numbers of lamps followed the base case up to the year 2020 and then stepped down rapidly in one year (thereafter following the ratification scenario used in the cost–benefit analysis). This is depicted by the red line in Figure 5.

Figure 5: Modelled phase-out of mercury vapour luminaires



While ratification would bring forward capital replacement programs (under the 'most likely' scenario), there would be no regulatory burden as those costs would have occurred in the 10-year period anyway. This is because the total cost is the same and still occurs in the period for the RBM (10 years).

While there is no regulatory burden, bringing forward the conversion of lights also brings forward the associated energy savings (an average of $2.6 million per year). However, this saving is realised by the users (that is, local councils) that pay the energy costs and therefore is *not* an offset of the regulatory burden for distribution businesses.

3.1.5 Waste and recycling

No regulatory burden costs for the waste and recycling sector were identified through discussions with industry and government. A full discussion of the costs and benefits of each option is in Section 5.5.

3.1.6 Oil and gas

No regulatory burden was identified for the oil and gas industry within the duration of the regulatory burden assessment.

3.2 Regulatory burden summary and conclusions

Regulatory burden for each option is summarised in Table 9.

Table 9: Average annual regulatory costs to business compared to business as usual for options 2, 3 and 5 ($ million)

Change in costs	Option 2—minimum requirements	Option 3—ratification + amalgam separators	Option 5—ratification + amalgam separators + delayed removal of Shirtan
Coal-fired generation	$0	$0	$0
Aluminium	$0	$0	$0
Cement	$0	$0	$0
Nonferrous metal smelting (gold, lead, zinc, copper)	$0	$0	$0
Waste incineration	$0	$0	$0
Sugarcane growers	$1.94	$1.94	$0.84
Oil and gas	$0	$0	$0
Dental sector	$0	$0	$0
Public lighting	$0	$0	$0
Total	**$1.94**	**$1.94**	**$0.84**

4. Government costs

The Australian Government and the state and territory governments all have roles in Australia's regulation of mercury. Australia's international trade in mercury and mercury-added products is primarily regulated by the Australian Government, while mercury emissions from point sources and the manufacture of mercury-added products are primarily regulated through licence arrangements implemented at the state and territory level.

Marsden Jacob's investigation focused primarily on Australian Government impacts. As is discussed below, this is because we were advised that many of the requirements of the Minamata Convention are already being met via existing arrangements.

4.1 Affected agencies

Australian Government agencies

The following Australian Government agencies have been identified as needing to act to ensure that Australia meets it obligations under the convention:

- the Department of the Environment and Energy, which would be responsible for ratification, implementation and ensuring that plans and guidelines are developed and meet requirements
- the Department of Health, in relation to education and information for people working with mercury, research and the possible deregistration of products
- the Australian Pesticides and Veterinary Medicines Authority (APVMA), in relation to the registration of pesticides
- Australian Border Force, an agency under the Department of Home Affairs, in relation to changes to monitoring and possible compliance and enforcement in the trade in mercury and mercury-added products
- the Department of Industry, Innovation and Science, for ensuring that any contributions to mercury research are shared or communicated consistent with the convention's expectations
- the Department of Defence, in relation to the impacts of mercury restrictions on its activities, given the convention's exclusion of military-related uses in several articles.

State and territory agencies

The 2015 cost–benefit analysis stated:

> *Beyond the potential impact on state utilities, which is considered in the industry costs section*[28]*, no cost impacts on State or Territory governments were identified.*[29]

One jurisdiction addressed this comment specifically in its confidential response to the RIS, stating:

> *It is acknowledged that, if ratified, implementation of the Minamata convention using existing legislative and policy frameworks in Australia to regulate the use and disposals*

28 We note that local governments and some state governments will be directly affected in relation to street lighting and coal-fired power generation. As those impacts are related to government agents performing functions in a manner akin to industry participants rather than acting in a regulatory capacity, they are considered in Section 5 ('Industry costs).

29 This position was supported through informal discussions with one state.

of mercury would minimise regulatory duplication and costs impacts to state or territory governments.

The potential for additional cost impacts to state and territory governments will depend on the final implementation mechanism. In this regard [we] would support further collaboration between the Commonwealth and States and Territories on an implementation framework. This could also include consideration of national level guidance materials on limits, monitoring and compliance requirements, and clarification of the role of existing standards …

Based on the qualified agreement included in one jurisdiction's response, we have not altered the assumption that the cost impacts on state or territory governments will be minimal, although this would change if the existing legislative and policy frameworks are not used.

4.2 Costs

Several types of government costs would occur under the phase-down scenarios that would not arise in the base case scenario. These costs are categorised as set-up costs (also known as 'changeover costs' and ongoing costs:

- **Set-up costs** are the costs of transitioning to the new requirements in the form of capital costs, staff time, management time and consultant fees per year during the changeover period.

  They include costs to negotiate ratification and costs to ensure that regulations and guidelines meet obligations under the convention, which may involve amending existing documents, developing new regulations and guidelines, or both. 'One-off' implementation costs that arise at or near the start of the convention are also included in this classification of costs.

- **Ongoing costs** are costs in staff time, management time and consultant fees per year.

  They include changes to compliance monitoring and regulatory regimes (for example, due to changed export or import restrictions, or the need to demonstrate compliance with national plans.

To quantify the cost impacts associated with ratification, Marsden Jacob was informed by discussions with the Department of the Environment and Energy and other government entities.

Impacts for each of type of government costs (set-up costs and ongoing costs) are outlined in this section with reference to those discussions and research undertaken as part of this project.

The department indicates that an ongoing allocation of two full-time employees (equating to around $250,000 per year) is expected to cover set-up costs, such as ratification costs, as well as ongoing costs, such as the costs of administration and reporting of the convention.

4.2.1 Set-up costs

Set-up costs would be incurred primarily by the Department of the Environment and Energy, but some inputs from other government agencies would be required.

Four main set-up activities have been identified:

- ratification and maintenance of the convention
- developing, in conjunction with Australian Border Force, a general notification process for mercury imports
- reporting on point sources of emissions
- deregistrations of mercury-added products.

Ratification of the convention

Should Australia decide to ratify the Minamata Convention, the Department of the Environment and Energy will be the agency responsible for meeting Australia's obligations under the convention.

Funds from the department's existing budget could be allocated towards:

- attending the Conference of the Parties meetings
- arranging and agreeing on any necessary consents with trading parties (as applicable).

General notification to the convention secretariat

The department indicates that, under Article 3, it is proposed that Australia would develop a general notification to set out any terms and conditions under which Australia provides its consent as an importer of mercury.

Reporting on point sources

The National Pollutant Inventory, as Australia's national pollutant release and transfer register, satisfies the obligation within the Minamata Convention that requires parties to collect and disseminate information on annual quantities of mercury and mercury compounds that are emitted, released and disposed of through human activities.

Development of guidance

If Australia ratifies the convention, a key set-up cost will be for the negotiation of guidance for elements of the convention, such as waste guidelines under Article 11. This process will require input from Australian state and territory governments, industry and the community and negotiation with other countries at the Conference of the Parties.

The Department of the Environment and Energy would coordinate consultation on the guidance and has indicated that it would incorporate this work within the planned departmental budget.

Deregistration costs of mercury-added products

Under Article 4 and Annex A of the convention, the manufacture, import and export of specific mercury-added products is phased out. The domestic deregistration of listed products appears to be an effective method to ensure that some products are no longer manufactured or imported for sale in Australia. Examples of products for which deregistration could occur are pesticides and biocides that are registered by the APVMA.

As consultation on ending the use of those products has commenced (as part of the consultation on the convention), it appears that the costs of product deregistration to government would be minimal.

Mercury-containing topical antiseptics

After 2020, the manufacture, import and export of mercury-containing topical antiseptics (mercurochrome 1% and mercurochrome 2%) will be restricted in accordance with Part 1 of Annex A under the phase-down scenarios.

Topical antiseptics, as with other therapeutic goods, must be entered in the Australian Register of Therapeutic Goods (ARTG), which is administered by the Therapeutic Goods Administration (TGA) on behalf of the Department of Health, before they can be lawfully supplied in or exported from Australia, unless otherwise authorised by the TGA.

The TGA provided correspondence to the effect that the phase-out of these products would have minimal impact:

> *In Australia there are two topical antiseptics containing mercury that are registered on the Australian Register of Therapeutic Goods (ARTG) (Mercurochrome 1% and Mercurochrome 2%). To our knowledge these products are not being sold commercially in Australia. Therefore, the impact of a phase out will be minimal.*[30]

Non-electronic measuring devices

After 2020, the manufacture, import and export of mercury-containing non-electronic measuring devices listed in Part 1 of Annex A would be restricted under the phase-down options.

The list of non-electronic measuring devices includes mercury-containing thermometers and sphygmomanometers (blood pressure meters). Both medical thermometers and all blood pressure meters are listed on the ARTG.

Therapeutic goods must be entered in the ARTG before they can be lawfully supplied in or exported from Australia, unless otherwise authorised by the TGA. Hence, the removal of these items from the ARTG by the end of 2020 would ensure that Australia is compliant with its obligations under the convention.

The TGA has indicated that the proposed phase-out of measuring devices listed in Part 1 of Annex A would not impose any additional costs:

> *The Therapeutic Goods Administration has no objections to accepting the proposed phase out of measuring devices listed in Part 1 of Annex A of the Minamata Convention. Thermometers and sphygmomanometers containing mercury are being replaced by digital products reflective of medical technological advances.*[31]

Pesticides and biocides

The manufacture, import or export of pesticides and biocides under Part 1 of Annex A of the convention would be phased out by the end 2020 under options 2 and 3. Under Option 5, an exemption would be sought extending to the end of 2025 the phase-out of the pesticide, Shirtan Liquid Fungicide, which is the only mercury-containing pesticide listed in Australia.

Before agricultural and veterinary chemicals, such as Shirtan liquid fungicide, can be sold in Australia, they must first be registered with the APVMA, which is a statutory body established in 1993 with responsibilities outlined in the *Agricultural and Veterinary Chemicals (Administration) Act 1992* and the *Agricultural and Veterinary Chemicals Code Act 1994*. The APVMA resides within the Agriculture portfolio.

From an administrative perspective, if it is considered sufficient to allow the registration to lapse – then this would simply be a matter of Crop Care not renewing its registration of Shirtan Liquid Fungicide and this would involve minimal costs to government. However, if it were considered necessary to actively deregister Shirtan Liquid Fungicide, then this would require the AVPMA to be directed by regulation to take positive action to cancel the registration of Shirtan with the attendant cost to the Commonwealth Government. The costs for the active deregistration of Shirtan Liquid Fungicide have not been included in the cost benefit analysis as this is not considered an explicit requirement of the Minamata Convention.

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30 Correspondence from the Department of Health on the impact of the Minamata Convention on Mercury, 5 March 2015.

31 Correspondence from the Department of Health on the impact of the Minamata Convention on Mercury, 5 March 2015.

4.2.2 Ongoing costs

Discussions with relevant government stakeholders revealed that most ongoing requirements stipulated in the convention are minimal and impose negligible costs. In many instances, this is due to Australia's existing standards, such as those for the reporting of mercury emissions and transfers in the National Pollutant Inventory.

Customs and Border Protection

Outside of the Department of the Environment and Energy, the only identified potential ongoing cost imposed on government was on Australian Border Force.

The DIBP manages the security and integrity of Australia's borders.

Should Australia ratify the Minamata Convention, trade in prohibited and restricted mercury and mercury added-products would be monitored and controlled by Australian Border Force.

In forming lists of prohibited and restricted imports, the DIBP refers to lists managed by relevant government departments and to international conventions, as applicable:[32]

- *Hazardous waste*: Permits are issued by the Minister for the Environment and Energy; requests to import are processed by the Hazardous Waste Section of the Department of the Environment and Energy. Hazardous waste, as defined by the Basel Convention, includes mercury waste.
- *Incandescent lamps*: Permits are issued by the Minister for the Environment and Energy; requests to import are processed by the Energy Division of the Department of the Environment and Energy. Refers to the general lighting services that have attributes as specified in Australian Standard AS 4934.2-2011—Incandescent lamps and general lighting services, Part 2: Minimum energy performance standards requirements.
- *Pesticides and other hazardous chemicals*: Requests to import or export pesticides listed in the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (the Rotterdam Convention) and the Stockholm Convention on Persistent Organic Pollutants (the Stockholm Convention) are administered by the Department of Agriculture and Water Resources.[33] Requests to import or export industrial chemicals listed in the Rotterdam or Stockholm conventions are administered by the National Industrial Chemicals Notification and Assessment Scheme under the Industrial Chemicals (Notification and Assessment) Regulations 1990, along with Customs import and export regulations in some instances.
- *Therapeutic drugs and substances*: Permits are issued by the Minister for Health; requests to import are processed by the Therapeutic Goods Administration. Listed drugs and substances include abortifacients, aphrodisiacs, other substances controlled for health reasons, laetrile and thalidomide. While antibiotics are treated separately, the process is similar.

We note that the DIBP currently monitors imports for a broad range of other hazardous chemicals, such as asbestos-containing materials, chemicals banned under the Stockholm Convention, ozone-depleting substances under the Montreal Protocol on Substances that Deplete the Ozone Layer, and synthetic greenhouse gases under the Kyoto Protocol. Within this framework, it has been proposed that the ratification of the Minamata Convention would add a small additional cost. Based on the current arrangements for the Rotterdam Convention, it is estimated that two additional staff (equating

32 See the DIBP website for details: www.border.gov.au/Busi/cargo-support-trade-and-goods/importing-goods/prohibited-and-restricted.

33 Under the Agricultural and Veterinary Chemicals (Administration) Regulations 1995, the Customs (Prohibited Exports) Regulations 1958 and the Customs (Prohibited Imports) Regulations 1956.

to $250,000 per year in costs) would be needed to undertake the permitting of mercury imports and exports and to oversee the audit and enforcement of restrictions on mercury trading.

Department of Defence

The Department of Defence indicated that it has audited its use of mercury-added products. The department indicated that it plans to minimise and, if possible, eliminate any reliance on mercury-added products. However, the department proposes to use the exclusion available under Annex A of the convention:

> *The following products are excluded from this Annex:*
>
> *(a) Products essential for civil protection and military uses …*

Using this exclusion, the phase-down scenarios do not impose any additional costs over the base case.

4.2.3 Compliance with specific articles

In addition to discussions with relevant departments, Marsden Jacob reviewed the requirements of the convention to ensure that all elements were captured.

Table 10 summarises the articles identified as requiring government action and the actions involved under the 'ratify' scenarios.

Table 10: Government impacts, by article of the Minamata Convention

Article	Description	Impact	Bases for estimate
Article 13—Financial contributions	Each party to the convention is required to provide, within its capabilities, resources for national activities that are intended to implement the convention.	$120,000 per year	Australia's contribution is estimated to be a biannual (once every 2 years) payment of US$175,000.[a]
Article 14—Capacity building	Parties shall cooperate and provide, within their respective capabilities, timely and appropriate capacity building and technical assistance to developing country parties.	$0	Existing funding to the Asia–Pacific region ultimately managed by the Department of Foreign Affairs and Trade, and financial mechanisms established under the Minamata Convention, are expected to be able to be allocated towards initiatives which would meet the requirements of this article.
Article 17—Information exchange	Each party shall facilitate the exchange of information in relation to mercury and mercury compounds as specified under the article either directly or through the Secretariat, or in cooperation with other relevant organisations. Each party shall designate a national focal point for the exchange of information under the convention, including the consent of importing parties under Article 3.	Minimal (included in Department of the Environment and Energy estimates)	Information exchange covers scientific, technical, economic, legal, health and safety information, but the article is not specific about any direct action required from parties. Australia's national focal point for exchanges of information would be with the Department of the Environment and Energy. Any costs associated with information exchange would be absorbed within departmental costs outlined above.

Article	Description	Impact	Bases for estimate
Article 18—Public information	Each party shall promote and facilitate provision to the public of available information on health and environment effects; alternatives to mercury; topics included in paragraph 1, Article 17—Information exchange; results of research, development and monitoring; and activities undertaken to meet obligations under the convention. Education, training and public awareness related to the effects of exposure to mercury and mercury compounds on human health and the environment.	Minimal additional requirements (absorbed within existing budgets of the departments and government agencies)	Reporting on activities undertaken to meet obligations under the convention has been included in the department's estimate.
Article 19—Research, development and monitoring		$0	Existing funding to the Asia–Pacific region managed by the Department of Foreign Affairs and Trade is expected to be able to be allocated towards initiatives that would meet the requirements of this article. Funding for domestic activities could be accessed through a range of mechanisms, including the National Environmental Science Program, or through the Australian Research Council. Other entities are also available for funding.
Article 21—Reporting	Reporting to the Conference of the Parties, through the Secretariat, on measures taken to implement the provisions of the convention. Includes reporting information outlined in articles 3, 5, 7, 8 and 9.	Minimal (included in Department of the Environment and Energy estimates)	The timing and format of reporting was decided at the first meeting of the parties. However, based on the Basel Convention requirements, costs based on a two-year reporting cycle have been estimated by the department to be minimal.
Article 22—Monitoring data	Effectiveness evaluation	$0	Effectiveness evaluations would be undertaken as part of the Conference of the Parties process, relying on data provided under other articles (e.g. Article 21).

a Pers. comm., Department of the Environment and Energy, 2017.

4.3 Conclusion

In relation to each of these articles, the Department of the Environment and Energy has suggested that some minor costs may be incurred; however, resources will be limited to the two current full-time employees and would therefore be managed within the current budget. The government costs are summarised in Table 11.

Table 11: Summary of government costs

Activity	Estimated annual cost	NPV of estimated cost (7% over 20 years)
Article 13—Financial contributions	$120,000	$1,128,000
Department of the Environment and Energy budget	$250,000	$2,350,000
Permitting, audit and enforcement of imports and exports	$250,000	$2,350,000
Other government departments	$0	$0
Total	**$620,000**	**$5,828,000**

5. Industry costs

Marsden Jacob's of submissions to the department's consultations in 2014 and 2017 has identified the following industries as likely to be affected by Australia's ratification of the Minamata Convention:

- industries with potential air emissions
  - coal-fired power generators and industrial boilers
  - nonferrous metals smelting and roasting (lead, zinc, copper and industrial gold)
  - waste incineration
  - cement production
- sugarcane growers
- the dental sector
- the lighting sector
- the waste and recycling sector
- oil and gas producers.

Our analysis found that industry impacts are driven by three articles of the convention.

Table 12 maps the impact from each of those articles to the key industry impacts.

Table 12: Industry impacts, by article of the Minamata Convention

Key articles	Article	Dental sector	Sugarcane growers	Coal-fired generation and aluminium production	Nonferrous metals processing	Cement production	Other
		Key industries					
	4 Mercury-added products	Phase-down of amalgam (measures in Annex A, Part 2)	Mercury-containing pesticides				Street lighting
	8 Emissions			New plant Existing plant	New plant Existing plant	New plant Existing plant	Waste incineration and coal-fired boilers New plant Existing plant
	11 Wastes	Amalgam—sink waste interceptors		Fly ash			Recycling

Notes: Provisions for the phase-down of dental amalgam are set out in Article 4, paragraph 3 and in Annex A, Part II, which states: 'Measures to be taken by a Party to phase down the use of dental amalgam shall take into account the Party's domestic circumstances and relevant international guidance and shall include two or more of the measures from the following list [of 9 possible measures]'. This is discussed in detail in Section 5.3.

5.1 Industries with potential air emissions

Article 8 of the convention sets out requirements for controlling and, *where feasible*, reducing emissions of mercury and mercury compounds to the atmosphere from a number of point source categories specified in Annex D of the convention, including:

- coal-fired power plants
- coal-fired industrial boilers
- smelting and roasting facilities used in the production of nonferrous metals (lead, zinc, copper and industrial gold)
- waste incineration facilities
- cement clinker production facilities.

Importantly, each party to the convention may establish criteria to identify the sources (such as individual facilities) covered by a source category listed in Annex D. The criteria for identifying point sources within a category are flexible, as long as the criteria for any category include at least 75% of the emissions from that category (Article 8, paragraph 2(b)).

While aluminium production is not specifically mentioned in Annex D, many aluminium refineries and smelters include coal-fired power generation, which is included. Hence, this section of the report is also relevant to the aluminium sector.

5.1.1 New sources and existing sources

Article 8 differentiates between existing sources of emissions (existing plants and facilities) and new sources of emissions (either existing plant that has undergone 'substantial modification'[34] or new plant and facilities).

New sources are also defined with reference to the date of entry into force of the convention for the party concerned, which we have assumed to be 1 January 2020 under options 2, 3 and 5. New sources are sources the construction or substantial modification of which commences at least one year after the date of entry into force of the convention.

As set out in Box 5 in Appendix B, in our interpretation of Article 8 (paragraphs 2 and 4), Australia could choose a starting date to apply the definition of 'new source'.[35]

Using 1 January 2020 as the nominal date for ratification, the starting date for 'new sources' would need to be between 1 January 2021 (one year after ratification) and 31 December 2024 (five years after ratification). If Australia were to choose a later date (such as the end of 2024), ratification would not impose tighter requirements on any new facilities that commenced construction during 2022, 2023 or 2024. Any facilities that commenced construction during that time would then be treated as 'existing facilities'.

Existing sources are defined as any sources that are not defined as new sources.[36]

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34 'Substantial modification' means modification that results in a significant increase in emissions, excluding any change in emissions resulting from by-product recovery (as applicable). Each party to the convention must (individually, in relation to its own matters) decide whether a modification is substantial or not. See Article 8, paragraph 2(d) of the convention.

35 Article 8, paragraph 4

36 Article 8, paragraph 5.

Using the timetable set out in Section 1.1, we assume that new sources would be those for which construction commences after 1 January 2021. This assumption is based on Australia ratifying the convention in early 2020, consistent with the remainder of the report.

The obligations required for existing and new emissions sources differ.

Obligations for existing sources

For existing emissions sources, each party to the convention is required to select one or more of five possible measures for implementation within 10 years of the convention coming into force:

> *(a) A quantified goal for controlling and, where feasible, reducing emissions from relevant sources;*
>
> *(b) Emission limit values for controlling and, where feasible, reducing emissions from relevant sources;*
>
> *(c) The use of best available techniques and best environmental practices to control emissions from relevant sources;*
>
> *(d) A multi-pollutant control strategy that would deliver co-benefits for control of mercury emissions;*
>
> *(e) Alternative measures to reduce emissions from relevant sources.*

After discussions with industry and the department, we consider that the least costly option to enable Australia's compliance with the Minamata Convention is the introduction of (b) emission limit values for controlling and, where feasible, reducing emissions from relevant sources.

We also note that a party's selection of measures under the convention should 'take into account its national circumstances, and the economic and technical feasibility and affordability of the measures'.[37] Marsden Jacob's interpretation is that the convention does not seek to impose mercury emissions reduction measures to the extent that they prevent individual plants being viable. Similarly, the recognition of national circumstances may be interpreted in Australia's context in a few different ways, including Australia's current levels of emissions compared to other countries', the requirement for economies of scale, isolation factors, and the lack of alternative treatment or production methods (such as might be available in interconnected or larger European and American economies).

Obligations for new sources

Article 8, paragraph 4 of the convention specifies that:

> *For its new sources, each Party shall require the use of best available techniques and best environmental practices to control and, where feasible, reduce emissions, as soon as practicable but no later than five years after the date of entry into force of the Convention for that Party. A Party may use emission limit values that are consistent with the application of best available techniques.*

The finalised guidance on best available techniques (BAT) and best environmental practices (BEP) was agreed at the first Conference of the Parties in September 2017. The convention came into force generally on 16 August 2017.[38]

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37 Article 8, paragraph 5, p. 20

38 UNEP, Conference of the Parties to the Minamata Convention on Mercury, *Guidance in relation to mercury emissions (article 8) referred to in paragraphs 8(a) and 8(b)*, 12 April 2017 http://unepmercurycop1.mediafrontier.ch/wp-content/uploads/2017/08/1_7_e_emissions.pdf.

While the guidance has been published, the cost–benefit analysis needed to consider both the change in capital and operating costs for each facility and the change in emissions that would result under ratification (options 2, 3 or 5) that would not arise if Australia were not to ratify the convention (Option 1).

The remainder of this section sets out and discusses the ‘most likely’ outcome that would arise. Potential risks raised by the interpretation of the BAT and BEP guidance are discussed more fully in Appendix B.

5.1.2 Nonferrous metals processing

In the convention, ‘non-ferrous metals’ is defined to mean lead, zinc, copper and industrial gold. Smelting and roasting processes are used in the production of those metals.

In Australia, the roasting of gold is the largest point source of mercury emissions into the atmosphere. The Gidji gold smelting facility north of Kalgoorlie releases approximately 1 tonne of mercury per year.[39] This quantity has fallen following recent upgrades to the smelter facility that were undertaken irrespective of the convention.[40]

Base case

Under the base case, we assumed that current operations would continue in line with existing planned upgrades. We also considered the likelihood of new or substantially modified facilities.

Based on consultations, no new facilities are expected for lead, zinc and copper in the next 20 years. New industrial gold facilities are possible within the study period (up to two facilities are considered to be feasible). However, discussions with industry suggest that the gold sector is more optimistic about growth, which could result in new smelters or roasters being constructed. In the gold sector, we understand that two smelters are currently being built, which would be considered ‘existing sources’ under the convention if Australia were to ratify. There is significant interest in developing further deposits, but it is unclear whether any of them would result in the development of a new smelter or roaster. The need for additional gold smelters or roasters would depend on a range of factors, such as location, ore type and the capacity of other smelters in the region.

Ratification

Potential new industrial gold facilities could face additional capital and operating costs if Australia were to ratify the convention and technology requirements under the guidelines were more expensive than for technology that would otherwise be used. However, there is much uncertainty about the longer term need for new facilities. Given the uncertainty about whether a new facility will be needed, the current legislative requirements that would be imposed on a new facility, and the requirements that would be imposed under the convention, the additional costs were negligible under the ‘most likely’ scenario. Indicative costs (and mercury capture) are discussed under the ‘worst case’ outcome in Appendix B. However, we note that the costs were relatively low (we estimated capital expenditure at $4.4 million and operating costs at $840,000 per year).

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39 National Pollutant Inventory, 2015–16 data currently unpublished.

40 Data from National Pollutant Inventory, previous telephone conversation with Department of Environment and Water Regulation (March 2015) and some background information available on KCGM webpage http://superpit.com.au/environment/air-quality/ accessed, December 2017.

Due to the high level of uncertainty, we used the following scenarios:

- 'Best case'—no new gold smelters
- 'Most likely'—no new smelters
- 'Worst case'—one new smelter (nominally constructed in 2027).

For existing facilities, concerns were raised by some industry members that imposing emission limit values could impose capital and operating costs if the limits were set below current operating levels. However, the cost would be negligible if the emission limit values are set in consultation with the industries. The department advised that existing emission limit values that are set through state-level industry licensing would already fulfil the requirement, and that facilities not covered by existing limits would have emission limits set in consultation with the industry and the state regulator to minimise cost impacts.

Conclusion

Based on discussions with industry and government, Marsden Jacob concluded that ratification could impose small set-up costs on industry for providing voluntary information to a likely national plan, when it is developed, but would be unlikely to impose costs on existing facilities. While ratification could impose costs on any new facilities constructed, as new facilities are considered probable only for industrial gold, are not likely within the immediate 10-year period and are uncertain beyond that period, costs associated with nonferrous metal processing obligations under the convention do not feature under the 'most likely' scenario of our cost–benefit analysis.[41]

5.1.3 Coal-fired power generation

Nineteen coal-fired power stations generate electricity in Australia. When coal is burned, trace amounts of mercury in the coal are released.

Australian coal is relatively low in mercury content compared to coal from such countries as the United States, and the mercury content varies from one resource to another. Estimated air emissions from some of Australia's coal-fired power stations are shown in Table 13. We note that three of the four current largest emitters are based in Victoria, and that Victorian brown coal has a lower calorific value and higher mercury content.

Table 13: Estimated air emissions of mercury and compounds from coal-fired generators, 2015–16 (kilograms)

Plant	Location	Estimated air emissions of mercury
AGL Loy Yang	Traralgon, Victoria	427
ENGIE Hazelwood[a]	Morwell, Victoria	406
Loy Yang B Power Station	Traralgon, Victoria	384
EnergyAustralia Yallourn	Yallourn North, Victoria	297
Millmerran Power Station	Grays Gate, Queensland	268

[41] Costs imposed on industry are modelled under the 'worst case' outcome in Appendix B.

Plant	Location	Estimated air emissions of mercury
Bayswater Power Station	Muswellbrook, New South Wales	224
Northern Power Station[a]	Port Augusta, South Australia	183
Callide Power Plant	Biloela, Queensland	111
Callide Power Station (A & B)	Biloela, Queensland	82
Stanwell Power Station	Gracemere, Queensland	72
Gladstone Power Station	Gladstone, Queensland	72
Muja Power Station	Collie, Western Australia	71
Tarong Power Station	Nanango, Queensland	49
Collie Power Station	Collie, Western Australia	34

a Hazelwood Power Station was closed in March 2017; Northern Power Station was closed in May 2016.

Source: National Pollutant Inventory, 2015–16: Mercury and compounds.

Base case

In 2015, the Electricity Supply Association of Australia (ESAA)[42] noted that:

> *Forecasts of electricity demand indicate that there is no need for additional generation capacity, of any fuel source, for at least a decade. Falling demand for electricity has resulted in a significant oversupply of generation capacity.* [43]

The ESAA noted that eight power stations were built in the previous 20-year period and that 'it is impossible to accurately forecast demand beyond 2025 or foresee the type of generation technology required.' [44]

Since the previous cost–benefit analysis was completed in May 2015, some power stations have been closed and are in the process of decommissioning. They include Hazelwood Power Station in Victoria and Northern Power Station in South Australia—two of the larger mercury emitters. Other power station closures include Anglesea Power Station (August 2015), Kwinana Power Station (October 2015) and Playford Power Station (May 2016). In addition, Liddell Power Station in Muswellbrook, New South Wales, is predicted to close sometime in 2022.[45] The Australian Energy Council commented that:

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42 In November 2016, the ESAA became part of the Australian Energy Council and Energy Networks Australia.

43 ESAA submission to Marsden Jacob and the Department of the Environment in response to questions posed, unpublished, March 2015.

44 ESAA submission to Marsden Jacob and the Department of the Environment in response to questions posed, unpublished, March 2015.

45 Australian Energy Council submission to the Department of the Environment and Energy in response to the draft exposure RIS, March 2017.

> *The schedule for closure for existing coal-fired electricity generation plant (and no new plant in the investment pipeline) mean that mercury emissions from coal fired generation is likely to decrease.*

The ESAA's advice is consistent with information contained in the Australian Energy Regulator's annual *State of the energy market* report. Since 2012–13, capacity additions to the National Electricity Market (NEM)[46] have largely been in wind and solar plant, while most plant retirements have been of coal-fired power stations.[47] Significant retirement of coal-fired capacity has occurred in 2016 and 2017 with the retirement of the Northern Power Station, which removed 546 MW of capacity (and ended coal-fired electricity generation in South Australia), and the Hazelwood Power Station, which removed 1,600 MW (and closed Australia's most emissions-intensive power station).[48]

Currently, there appears to be no interest in new coal-fired generation. Energy experts within Marsden Jacob have indicated that, if a new plant were proposed, it would be unlikely to be a conventional coal-fired plant. Any interest in coal-fired generation plants in the future is likely to be in new technology such as high-efficiency, low-emissions (HELE) plants.

Some coal advocates have highlighted the fact that the Japanese Government has announced plans to build as many as 45 new coal-fired power stations using HELE technology. However, energy capacity constraints in Japan are different from those faced in Australia, as Japan has sought to move away from the large number of nuclear reactors supplying approximately 30% of its electricity in the wake of the Fukushima accident.[49]

The Australian Energy Council noted that, despite capacity closures in Australia, the likelihood of investment in a new coal-fired power station was low:[50]

> *Despite the Federal Government's stated intent to encourage all energy investment options, including HELE coal-fired plants, there are no current investment proposals to develop new coal-fired power stations in Australia and those that have previously been proposed are no longer on the table.*

We note that a new coal-fired generation plant using new HELE technology and burning Australian coal is likely to meet emissions levels equivalent to the BAT/BEP guidance. Therefore, the additional cost of further pollution control is minimal when investing in a new plant.

Given the information provided, Marsden Jacob assumed that no new facilities would be constructed during the assessment period.

Ratification

Under the 'most likely' outcome, it was considered that no additional costs would be incurred and no change in mercury emissions would occur. This outcome would arise either if no new facilities were constructed, or because the BAT and BEP guidance does not impose additional requirements beyond business-as-usual levels.

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46 The NEM is the wholesale electricity market for eastern and southern Australia, covering Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania.

47 Australian Energy Regulator (AER), *State of the energy market*, May 2017, p. 37.

48 AER, *State of the energy market*, p. 29.

49 Australian Energy Council (AEC), *Will coal play a role in the NEM?*, 2017, www.energycouncil.com.au/analysis/will-coal-play-a-role-in-the-new-nem/ (accessed 14 November 2017).

50 AEC, *Will coal play a role in the NEM?*.

5.1.4 Aluminium

While aluminium production is not specifically listed under Article 8 of the convention,[51] a few aluminium refineries and smelters include coal-fired power generation, coal-fired industrial boilers, or both.

In aluminium production, mercury is released from two principal sources:

- the combustion of coal (at alumina refineries)
- the alumina refining process.

Only mercury emissions released through the combustion of coal are currently captured by the wording under Article 8.

In discussions with the aluminium industry, it was noted that Appendix D could be expanded in the future to include emissions from alumina refining processes. While that may be the case, such an assumption is beyond the scope of this cost–benefit analysis and so is not considered further.

Given that the aluminium industry's interest in Article 8 is based on coal-fired generation, the same figures were applied to the aluminium sector as for the coal-fired generation sector.

5.1.5 Cement

In cement production, mercury is introduced into the clinker burning process via both raw materials and fuels. The mercury content of those inputs varies. Raw materials (such as limestone and clay or their natural mix, lime marl, and sand) have lower mercury content per kilogram than fuel used in the cement industry (such as coal or other fuels).[52] The burning process releases the trace mercury content of these inputs as emissions.

The Cement Industry Federation indicated that there are three companies with five integrated cement and clinker facilities in Australia. Industry also commented that mercury emissions from Australian cement facilities compare well to emissions from international facilities.

National Pollution Inventory data suggests that integrated cement plant mercury emissions in 2014–15 equated to 0.017 grams per tonne of clinker. This is an order of magnitude less than the European Union legislated limit, which is equivalent to around 0.11 to 0.13 grams per tonne of clinker.[53]

Base case

The cement industry indicated that it is highly unlikely that any new facilities would be developed in Australia in the next 20 years.[54] It was also noted that no new facilities were constructed during the

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51 See Appendix D of the Convention, which lists lead, zinc, copper and industrial gold as the nonferrous metals covered by the convention.

52 European Cement Research Academy, *Technical report: guidance document on BAT-BEP for mercury in the cement industry—initial outline (TR-ECRA 0049a/2013/M)*, 31 May 2013, Table 3 and Table 4 on p. 9,

53 The European regulation states a maximum 0.050 mg/Nm^3 (normal cubic meter). This equates to ~0.11 to 0.13 g/t-clinker. See Alan Kreisberg, *Rationale, objectives and priority areas of the Cement Industry Partnership on Mercury*, PowerPoint presentation to the UNEP Cement Industry Partnership Geneva Meeting, 18 June 2013, www.unep.org/chemicalsandwaste/Mercury/GlobalMercuryPartnership/MercuryreleasesfromtheCementIndustry/Meetings/tabid/106280/Default.aspx.

54 Cement Industry Federation, *Submission: National phase down of mercury—final Regulation Impact Statement—exposure draft*, March 2017.

previous 20 years (between 1995 and 2015). However, all operating integrated cement plants underwent significant technology upgrades to reduce emissions over that time.

Ratification

Of the five current facilities, only one plant (in Queensland) is not covered by an existing emission limit value through state approvals; however, the current licence for that plant is still likely to meet the obligations of Article 8 due to the range of measures within the convention that can be applied to existing plant. The cement industry confirmed that ratification of the convention would not affect cement manufacturers.[55]

Conclusion

Through consultations, industry confirmed that no ongoing costs arising from the convention are expected for existing facilities and that no new facilities are expected to be constructed during the next 20 years.

Therefore, no impact as a result of ratification has been estimated for the cement industry in the cost–benefit analysis.

5.1.6 Waste incineration

'Incineration is a combustion process that uses rapid oxidation, excess air and high temperatures to produce conditions whereby hazardous and toxic waste products are thermally broken down and destroyed.'[56] Where waste contains mercury or traces of mercury, the incineration process releases mercury emissions.

Australia has not traditionally used waste incineration as a method for solid waste disposal. However, there are currently two waste incineration facilities with existing approvals in Western Australia (at Kwinana and Port Hedland).[57] In addition, there have been some reviews of the policy and approvals required for waste-to-energy projects (which include incineration as well as other forms of energy capture).[58]

Base case

Four waste incineration facilities have gained approval in Western Australia, but at this stage none of the facilities has commenced construction. How many additional new facilities will be planned throughout Australia in the period to 2035 is not known.

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55 This was based on the fact that all plants are currently covered by existing approvals and no new facilities were expected to be built in the next 20 years. Cement Industry Federation, *Submission: National phase down of mercury—final Regulation Impact Statement—exposure draft*, March 2017.

56 Unilabs Environmental, *Characterisation and estimation of dioxin and furan emissions from waste incineration facilities*, report prepared for Environment Australia, June 1999, p. 34.

57 Metropolitan Waste and Resource Recovery Group, *Metropolitan waste and resource recovery implementation plan 2016*, September 2016.

58 For example, Victorian Government, 'Turning waste into energy', *EngageVictoria*, no date, https://engage.vic.gov.au/waste/wastetoenergy; Environment, Planning and Sustainable Development Directorate—Environment, *Energy from waste*, ACT Government, 9 August 2016, www.environment.act.gov.au/energy/cleaner-energy/energy_from_waste.

Ratification

Under the convention, new facilities are defined broadly as facilities 'the construction or substantial moderation of which is commenced at least one year after the date of entry into force of the Convention'. Depending on the timing of construction, some or all the four facilities with existing approvals could be classified as either existing facilities or new facilities.

The Western Australian Environmental Protection Authority has prepared informal advice under section 16(e) of the *Environmental Protection Act 1986* (WA) on best practice for waste incineration.[59]

From the authority's advice, it appears that Western Australia already adopts best practice techniques in granting approvals. That view was confirmed in discussions with staff from the office of the Environment Protection Authority. Those discussions also suggested that similar advice and sources of information on best practice have been used by the authority in approving the plants as would inform the BAT and BEP guidance. For this reason, it is likely that the Western Australian plants are likely to already align with international BAT and BEP guidance.

Conclusion

Importantly, as there were no consultation submissions on this topic, the cost–benefit analysis has not been revised.

The four waste incineration facilities that have gained approval in Western Australia but for which construction is yet to commence are likely to incorporate best practice techniques akin to the BAT and BEP guidance likely to be developed under the convention. How many other new waste incineration facilities are likely to be built in other parts of Australia is not known.

As legislative requirements for solid waste incineration have not been set for other jurisdictions, the Western Australian requirements are likely to be used as a starting point for other states. For this reason, Marsden Jacob concluded that ratification would not impose any additional costs on new facilities.

5.2 Sugarcane growers

Mercury is used in some pesticides and biocides. However, in Australia only one product registered with the APVMA is listed as containing mercury. Shirtan Liquid Fungicide is a mercury-containing pesticide that is widely used by sugarcane growers for the control of pineapple disease (caused by the fungus *Ceratocyctis paradoxa*).

Growers that use Shirtan Liquid Fungicide apply the chemical to sugarcane setts prior to planting (fields are replanted approximately every five years). The process of sugarcane planting is briefly discussed in Box 1.

While there are alternative products available (discussed below), Shirtan has substantial market penetration. Around 80% of new plantings are treated. This equated to an average of 44,000 litres per year over the period from 2011 to 2014, but dropped to around 36,000 litres per year in 2017.[60]

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59 Environmental Protection Authority, *Environmental and health performance of waste to energy technologies: strategic advice*, report 1468, Western Australian Government, 4 April 2013, www.epa.wa.gov.au/sites/default/files/Publications/Rep%201468%20Waste%20to%20energy%20s16e%20040413.pdf.

60 Information provided in discussions with Alpha Chemicals, 2017.

The active ingredient of Shirtan Liquid Fungicide is 120 grams of mercury per litre, present as methoxyethylmercuric chloride (referred to as MEMC).[61]

Box 1: Overview of sugarcane planting

Sugarcane is a semi-perennial crop. Fields are replanted every 4–6 years using cuttings (referred to as 'setts').

Sugarcane is cut annually; in the years between replantings, the root stock and base of the plant are left in place.

Cane farmers indicate that planting is the most expensive part of the cropping cycle, and that disease management is a key element of planting.

5.2.1 Relevant articles of the convention

Article 4 ('Mercury-added products') restricts the manufacture, import or export of mercury-added products after a specified phase-out date. Pesticides, biocides and topical antiseptics have a compulsory phase-out date of 2020.

Article 4 also requires parties to collect and maintain information on mercury-added products and their alternatives and make that information publicly available.

If Australia ratifies, Article 4 would not specifically require the APVMA to remove mercury-containing pesticides from its list of registered products; however, as discussed in Section 4.2, it is recognised that this would provide a mechanism to ensure that the product ceases to be produced and made available to the market.

5.2.2 Alternative products

Alternative non-mercury pesticides are available in the market. Various propiconazole-based pesticides are available under differing trade names and are registered for the control of both pineapple sett rot and smut.

Sinker is a relatively new flutriafol-based pesticide that is currently the only registered proprietary formulation used for the control of sugarcane smut and pineapple disease; however, alternative flutriafol-based pesticides are likely to become available in around one year.[62] Once competitors supplying flutriafol-based pesticides can enter the market, costs to farmers are expected to drop and be more competitive with the current mercury-containing pesticide.

Crop Care has noted that:[63]

> *… Sinker Fungicide has been demonstrated to be highly effective against pineapple disease with comparable control to Shirtan and superior control to Propiconazole based products. However, the uptake of Sinker in preference to Shirtan has been extremely limited to date, and has gradually increased from 5% since its registration in 2013 to 15% in 2016.*

61 Crop Care Australia, *Material safety data sheet: Shirtan Liquid Fungicide*, 2011.

62 Once the data used for registration with the APVMA becomes publicly available. Information provided by Crop Care in 2015.

63 Crop Care, *Submission to national phase down of mercury*, March 2017.

Previous analysis indicated that propiconazole-based fungicides cost approximately half as much as Shirtan[64] (which costs $27 per hectare),[65] and those relative costs were confirmed in discussions with the industry.

Some industry participants suggest that the popularity of Shirtan is due to a belief that the chemical stimulates rapid germination of sugarcane compared to alternative products, particularly in adverse conditions (such as cold weather). Crop Care reportedly spoke with researchers who estimated that each year around 10% to 20% of the sugarcane crop planted is at risk due to poor conditions and that it is under those conditions that they believe using Shirtan is advantageous. Crop Care estimated that the risk to crops might be realised 30% of the time (if the mercury-containing pesticide were not used)—equating to 3,150 hectares per year. Where crops are damaged, the most likely response is to replant the crop at a cost of $1,000 to $1,500 per hectare. This information would value the loss of Shirtan Liquid Fungicide at $3,937,500 per year. There is no published scientific information available that supports the belief that Shirtan assists with germination. Given the uncertain nature of this value, it was not included under the 'most likely' case assessment.

The belief that Shirtan improves germination rates was reported in an (unsighted) journal article from 1970[66] but has since been disproven by more recent studies, which found that:

> *results from the current study indicated that MEMC* [the mercury compound in Shirtan] *did not provide higher or faster germination compared to the two triazole fungicides or the uninoculated control. The reason for the discrepancy between the current and the previous study is not clear.* [67]

Selected results from an experiment in this more recent research analysis are shown in Figure 6. The mercury-containing pesticide is listed as MEMC (referring to the active ingredient) and produces a germination rate of only 14% in comparison to 23% for the flutriafol-based product. In the text accompanying the graph, it is observed that:

> *conditions were cold and wet after a late winter planting.*

Those planting conditions appear to align with the description of 'adverse conditions' that industry stakeholders are primarily concerned about. It follows that more recent research has found that existing mercury-free alternative products have a greater beneficial impact on sugarcane germination than the mercury-containing pesticide, even when used in adverse conditions.

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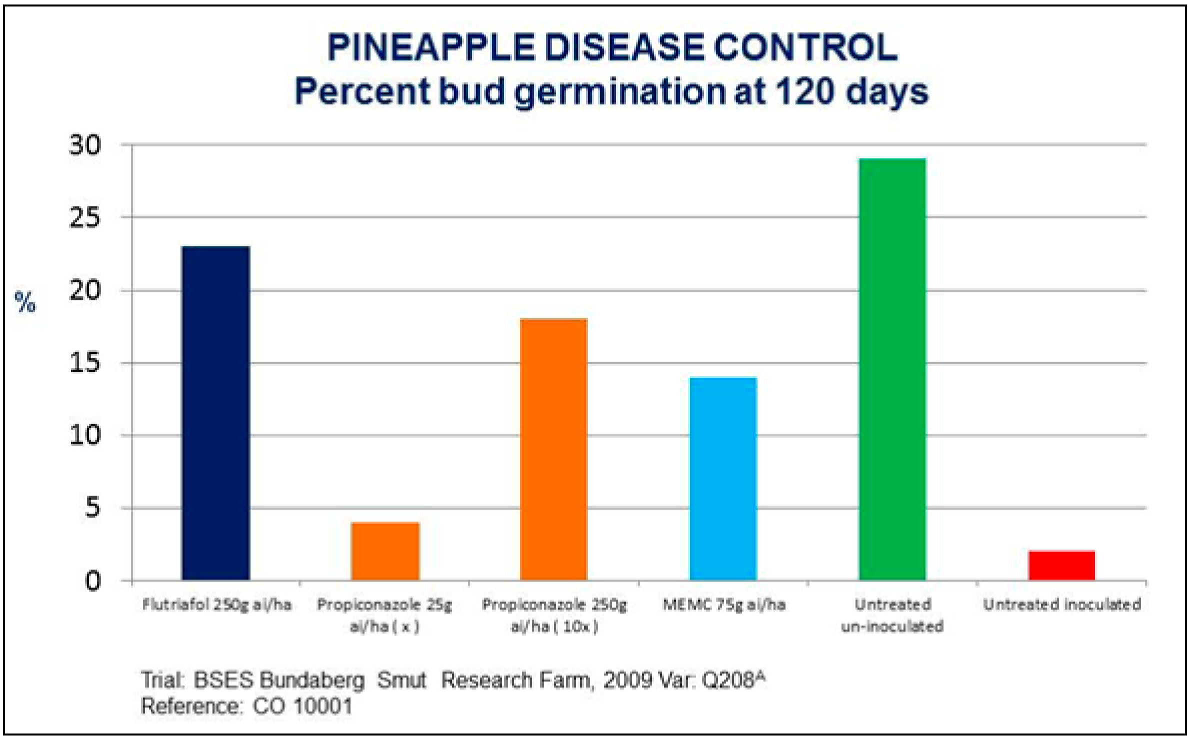
64 Siobhan Dent, John Switala, Mark O'Sullivan, *Modelling the role of an assumed 'eco-efficient' production system: Queensland's sugar cane industry*, presentation at Outlook 2003.

65 Information provided by Crop Care.

66 DRL Steindl, 'The control of pineapple disease and the stimulation of germination in cane setts in Queensland', *Sugarcane Pathologists Newsletter*, 1970, 5:53–54

67 SA Bhuiyan, BJ Croft, GR Tucker, 'Efficacy of the fungicide flutriafol for the control of pineapple sett rot of sugarcane in Australia', *Australasian Plant Pathology*, 2014, 43:413–419, DOI 10.1007/s13313-014-0282-y.

Figure 6: Comparison of bud germination at 120 days for differing pesticide treatments



Source: Crop Care, 'Crop Care launches Sinker fungicide in sugarcane', media release, 23 May 2013.

Alpha Chemicals (which formulates Shirtan Liquid Fungicide) believes that the mercury-containing pesticide is popular because organic-based pesticides can become less effective over time if not managed properly, as fungi can develop a tolerance to those products.[68] We note, however, that pesticide resistance management plans are standard practice, and can include integrated disease management programs to ensure that the products are used appropriately and manage resistance without sacrificing disease control.

The Canegrowers Association has indicated that there are negligible costs in changing from one pesticide to another. From discussions with the distributor of Shirtan, it appears likely that under a phase-down scenario its agents may need to spend more time with canegrowers to educate them about alternative products and the need to change.

5.2.3 The impact of ratification on mercury released

The average amount of Shirtan Liquid Fungicide used in recent years is 36,000 litres per year.[69] This equates to 4,320 kilograms of elemental mercury being released into the Australian environment each year.

Sugar Research Australia monitors mercury residues in soils throughout sugarcane-growing regions but has not detected evidence of 'significantly increased' mercury levels.[70] The Department of the Environment noted that the form of mercury in this pesticide does not readily

68 Pers. comm., Alpha Chemicals, 18 October 2017.

69 Pers. comm., Alpha Chemicals, 18 October 2017.

70 Canegrowers Association, submission to the Department of the Environment's public consultation paper on the possible ratification of the Minamata Convention, 30 June 2014.

transport through the soil profile; rather, it is more likely to attach to soil particles and flow overland, becoming agricultural run-off.

Mercury in water bodies is primarily associated with dissolved organic matter and suspended particulate matter, such as clay particles. The particulates eventually settle into sediment layers. Mercury concentrations of up to 100 $\mu g/kg^{-1}$ (an order of magnitude higher than background concentrations) have been identified in Great Barrier Reef sediment cores. Those concentrations were attributed to the contemporary application of mercury-based pesticides on sugarcane farms.[71]

5.2.4 Assessment of costs and benefits under each option and scenario

Base case

Under the base case, it appears that Shirtan would continue to be used at current levels into the foreseeable future.

It was noted that, if Australia does not ratify the convention, imports of mercury to produce the mercury-containing pesticide would be possible only from other countries that have not ratified.[72] Alpha Chemicals indicated that this was not a concern, as a source of mercury (from a waste stream) had been identified within Australia.

Ratification

Under the phase-down options, the manufacture of Shirtan would have to cease by the end of 2020 unless Australia sought an exemption under Article 6 of the convention for the continued manufacture of the fungicide. While one of the alternative products is cheaper (and the other product is the same price), this cost differential represents a transfer between parties and does not affect economic costs for Australia, as both products are manufactured in Australia.

Due to the number of uncertainties associated with the likely impacts and resulting costs and benefits for different stakeholders, we have developed three scenarios (‘best case’, ‘worst case’ and ‘most likely case’) for each option. The allocation of outcomes is summarised in Table 14.

As Option 2 (minimum ratification) and Option 3 (ratification with a program to capture dental amalgam) have the same impact on Shirtan Liquid Fungicide and the sugarcane industry, we consider those options together.

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71 Great Barrier Reef Marine Park Authority (GBRMPA), *Water quality guidelines for the Great Barrier Reef Marine Park*, revised edition, 2010, p. 74, which states: ‘Great Barrier Reef sediment cores have identified mercury concentrations of up to … an order of magnitude higher than background concentrations. These concentrations were attributed to the contemporary application of mercury-based fungicides on sugar cane farms.’

72 Under Article 3, paragraph 6b, parties to the convention are prohibited from exporting mercury to non-parties for a prohibited use, and the manufacture of Shirtan Liquid Fungicide is a prohibited use under Article 4 and Annex A.

Table 14: Summary of costs and benefits of phase-out of Shirtan Liquid Fungicide

<table>
<tr><th>Option</th><th>Costs and benefits</th><th>Best case</th><th>Most likely case</th><th>Worst case</th></tr>
<tr><td rowspan="8">Option 2—minimum ratification and

Option 3—Ratification with Dental Amalgam waste program</td><td rowspan="2"><u>Costs</u>
Costs to Alpha Chemicals</td><td>Zero job losses</td><td>One job loss</td><td>Three job losses</td></tr>
<tr><td colspan="3">Managing the transition will require approximately 20% of managers’ time and 10% of chemists’ time for three years</td></tr>
<tr><td rowspan="2">Costs to Crop Care</td><td colspan="3">$340,000 to develop a new product</td></tr>
<tr><td colspan="2">$100,000 to get label changed (to permit Sinker to be used to dip as well as to spray)</td><td>Label change does not happen
1,000 planters convert to spray at a cost of about $20,000 each</td></tr>
<tr><td rowspan="2">Costs to canegrowers</td><td colspan="3">Increased cost of using Sinker product (expected to be negligible)</td></tr>
<tr><td>0% of crops require replanting</td><td>3% of crops require replanting</td><td>6% of crops require replanting</td></tr>
<tr><td><u>Benefits</u>
Environment / society</td><td colspan="3">Phasing down of Shirtan use (and mercury released) from 2020; ceasing from 1 January 2022</td></tr>
<tr><td rowspan="8">Option 5
Ratification, with use of dental amalgam intercepts and an exemption for Shirtan until 2025</td><td rowspan="2"><u>Costs</u>
Costs to Alpha Chemicals</td><td>Zero job losses</td><td>Zero job losses</td><td>Two job losses</td></tr>
<tr><td colspan="3">Managing the transition will require 10% of managers’ time and 5% of chemists’ time for three years</td></tr>
<tr><td rowspan="2">Costs to Crop Care</td><td colspan="3">$340,000 to develop a new product</td></tr>
<tr><td colspan="3">$100,000 to get label changed (to permit Sinker to be used to dip as well as to spray)</td></tr>
<tr><td rowspan="2">Costs to canegrowers</td><td colspan="3">Increased cost of using Sinker product (expected to be negligible)</td></tr>
<tr><td>0% of crops require replanting</td><td>3% of crops require replanting</td><td>6% of crops require replanting</td></tr>
<tr><td><u>Benefits</u>
Environment / society</td><td colspan="3">Phasing down of Shirtan use (and mercury released) from 2024; ceasing from 1 January 2026</td></tr>
</table>

Alpha Chemicals

Under options 2 and 3, direct costs would be imposed upon Alpha Chemicals.

As sugarcane growers transition from using Shirtan Liquid Fungicide to using non-mercury-containing forms of pesticide, there would be transition costs imposed on Alpha Chemicals. Those costs are estimated to be approximately 20% of management time as Alpha Chemicals seeks to diversify its business. It has also been estimated that approximately 10% of chemists' time would be used in the transition period. Those costs would be imposed regardless of the scenario.

Ratification could result in some job losses at Alpha Chemicals under the 'most likely' and 'worst case' scenarios if Shirtan is phased out at 2020, due to impacts on Alpha Chemicals' business. There would be an impact on the company's income, as Shirtan is a profitable product for the business.

Under Option 5 (ratification but with an exemption sought for the manufacture and sale of Shirtan until 2025), the additional 5-year period would give Alpha Chemicals more time to manage the transition.

Accordingly, costs to Alpha Chemicals would be expected to be smaller in value. There would still be transition costs, but they have been estimated to be approximately 10% of management time and 5% of chemists' time to make the changes.

Job losses are also expected to be lower under Option 5: zero losses are expected in the 'most likely' outcome, and two job losses are expected in the 'worst case' scenario.

Crop Care

As Crop Care is the business responsible for the distribution and sale of Shirtan Liquid Fungicide, it will face associated costs regardless of when the restrictions come into place. It has been estimated that it would cost approximately $340,000 to develop a new product line that would be rotated with Sinker to maximise effectiveness and delay the development of resistance by fungi, and that cost would be imposed regardless of timing. In addition, a proportion of this cost would be for marketing and education to ensure that growers were aware of alternative products and how to use them.

Any of the ratification options would require either the permitted use of Sinker to be expanded to allow the dipping of sugarcane setts or the conversion of around 50% of planters to spraying of pesticides (estimated to be 1,000 planters at a cost of about $20,000 each).

Costs to sugarcane growers

The Canegrowers Association indicated that costs associated with changing from one pesticide to another would be minimal if the growers were aware that there is a viable alternative.[73] The Queensland Canegrowers Association's position is that, should ratification occur, Shirtan Liquid Fungicide would be phased out in 2020.[74]

73 Although Sinker is the main pesticide cited as an alternative to Shirtan Liquid Fungicide, a number of other non-mercury pesticides are in the market. This information is available to growers through the Sugar Research Australia website; see, for example, Sugar Research Australia, *Registered fungicides for disease control in sugarcane*, information sheet IS13011, 2013, https://sugarresearch.com.au/wp-content/uploads/2017/02/Fungicides-IS13011.pdf (accessed 19 November 2017).

74 Canegrowers, *Submission response to the National Phase-down of Mercury—exposure draft*, March 2017.

It is also assumed that there may be some requirement for replanting because of increased rates of crop failure, which may be linked to the phase-out of Shirtan Liquid Fungicide. It has been assumed that some replanting (6%) will be required under the ‘worst case’ scenario.[75]

5.2.5 Conclusion

The results for each of the options and scenarios are summarised in Table 15. For simplicity, the ‘best case’ and ‘worse case’ cost estimates are compared against the central health estimate. The results reveal that, while the costs would be lower under Option 5, the benefits would be significantly reduced and therefore the net benefits would be lower.

75 It was previously estimated that replanting would be necessary around 4.5% of the time on the basis that 15% of the canegrowing area is prone to cold and wet conditions at the time of planting, and that those conditions arise around 30% of the time.

Table 15: Present value results for industries associated with canegrowers

		Options 2 and 3			Option 5		
Stakeholder	**Element**	**Likely case**	**Best case**	**Worst case**	**Likely case**	**Best case**	**Worst case**
Alpha Chemicals	Job losses	$93,900	$0	$140,800	$0	$0	$93,900
	Management time	$139,500	$139,500	$139,500	$68,900	$68,900	$68,900
Crop Care (and other distributors)	New product development	$308,100	$308,100	$308,100	$260,600	$260,600	$260,600
	Increased resources to help cane farmers transition	$362,400	$362,400	$362,400	$0	$0	$0
Crop Care / farmers	Sinker: change specification or convert planters	$87,300	$87,300	$16,897,400	$76,300	$76,300	$76,300
Farmers	Replanting costs	$22,384,900	$0	$44,769,800	$14,618,800	$0	$29,237,500
Total cost		**$23,376,100**	**$897,400**	**$62,618,000**	**$15,024,600**	**$405,800**	**$29,737,200**
Health benefits (using the central estimate)		**$180,719,900**	**$180,719,900**	**$180,719,900**	**$117,569,900**	**$117,569,900**	**$117,569,900**
Net benefits		**$157,343,800**	**$179,822,500**	**$118,101,900**	**$102,545,300**	**$117,164,100**	**$87,832,700**

Note: The values shown are present value results discounted to 2018; accordingly, the items correspond with the items in Table 14, but the values appear smaller due to discounting.

5.3 Dental sector

Dental amalgam is a material used for dental fillings and contains mercury. The Minamata Convention does not prohibit the manufacture, import, export or use of amalgam fillings; however, Article 4 requires parties to undertake two or more of the measures listed in the convention to phase down the use of dental amalgam, encourage the use of alternative mercury-free products and promote practices to reduce the release of mercury and mercury compounds from those sources.[76] Australia is already compliant with this obligation.

Articles 3 and 11, which deal with the mercury trade and the management of mercury waste, respectively, are also relevant to the dental industry. Mercury is (or could be) imported under Article 3 for dental amalgam manufacture, as trade in mercury for that purpose is not restricted. Waste dental amalgam can be captured by installing separation devices at dental surgeries, preventing it from entering wastewater systems.

In Australia, the use of dental amalgam is declining. The industry estimates that dental amalgam is used in roughly 25% of new fillings in Australia.[77] Most dental fillings now make use of alternative products, such as resin composite and glass-ionomer. Declining use of dental amalgam is expected in the future largely due to increasing consumer and dental professionals' preference for alternatives.[78] This trend is expected to continue, despite the alternatives being higher in cost (they are roughly 50% to 100% more expensive) and potentially having a shorter useful life.[79]

Although Australia already conforms to the minimum requirements under the convention and the impacts on the dental industry under Option 2 are therefore limited to those identified under the base case (Option 1), the Department of the Environment and Energy is considering encouraging dental practices to install amalgam separators under options 3 and 5.

5.3.1 Base case

Under the base case, in which Australia does not ratify the convention, impacts will be driven by changes in Australia's ability to import mercury for the continued manufacture of dental amalgam and therefore our ability to export amalgam manufactured in Australia.

Australia's ability to import mercury

Australia's ability to import mercury for the continued manufacture of dental amalgam depends largely on decisions by other countries in relation to the future of mercury. The convention does not restrict trade in mercury for dental amalgam (subject to consents being agreed between parties); however, other restrictions will result in the mining of 'new' mercury becoming less common over time, as the convention restricts the development of new mercury mines and requires the closure of

76 See Annex A, Part II of the convention.

77 According to separate submissions by the Australian Dental Industry Association and the Australian Dental Association to the Department of the Environment's Minamata Convention on Mercury ratification consultation and discussions with dental industry experts.

78 Department of Health, *Submission to Department of the Environment: Ratification of the Minamata Convention consultation*, 17 July 2014, p. 2.

79 Based on discussions with dental industry experts.

existing mines within 15 years.[80] Therefore, the supply of mercury internationally will decline because of the convention coming into force.

Marsden Jacob does not expect that the convention will affect the supply of mercury to Australia for dental amalgam in the immediate future (10–15 years).

For the cost–benefit analysis, changes that depend on other countries' actions were assumed to be the same, regardless of Australia's decision on ratification. Therefore, there is no difference as these changes would occur in both the base and ratification cases and the impacts net off.

In 2014 the Australian Dental Industry Association (ADIA) stated that 'There is only one Australian producer of dental amalgam, SDI Limited.' [81,82] However, demand for mercury amalgam fillings appears to be falling. SDI Limited now estimates that it requires around 12 tonnes of mercury per year to support its manufacturing processes (down from 4–5 years ago, when it was using about 20 tonnes per year).[83]

It was also reported that some of the mercury used by SDI Limited for the production of dental amalgam is imported, and that those imports could be affected if Australia does not ratify the convention. Under the base case, it remains unclear whether recycling could generate sufficient mercury to meet demand for dental amalgam in the absence of mercury imports.

The convention will directly affect the availability of domestically sourced mercury for amalgam, as it will reduce some sources (such as street lights and lamps) but will increase other sources of waste mercury from captured smelters, refineries and oil and gas production.

Import and export of Australian-manufactured amalgam

In addition to supplying the Australian market, SDI Limited manufactures dental products for export, including mercury-based amalgam. Currently, it is estimated that approximately 95% of its products are exported, mainly because the number of dental practices in Australia (estimated to be around 7,400) is low compared to the number of dentists in other markets globally (for example, it is estimated that Brazil alone has around 200,000 dentists).

Should the supply of mercury to Australia become limited (as discussed above), the ability to manufacture amalgam in Australia would be limited, in which case the ability to continue exporting to other countries would become irrelevant.

Future demand for mercury-based dental amalgam in Australia

Many factors suggest that the use of amalgam after 2020 may decline regardless of Australia's decision on ratification.

First, the use of mercury-based amalgam appears to be declining over time because of individual preferences for 'white filling' substitutes. In 2014, the Department of Health submitted to the Department of the Environment's consultation on ratification that:

> *Amalgam use has been declining rapidly in Australia in the last few years due to a response to the demand for 'white fillings'. The impact that a phase-down would have on the dental*

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80 Article 3, paragraphs 3 and 4

81 In addition, one company (Kerr Australia) was identified as importing and exporting amalgam fillings.

82 Australian Dental Industry Association (ADIA), *Submission on the Minamata Convention on Mercury ratification*, 30 June 2014, p. 7.

83 SDI Limited, discussion and notes, 19 October 2017.

> *restorative materials industry does not appear to be great. There are only two active suppliers of amalgam in Australia and use is declining.* [84]

The ADIA noted that, although there was a lack of data in relation to dental practices using amalgam that contains mercury, research suggests that globally there was a 24% reduction in amalgam production between 2010 and 2015.[85]

Second, ratification of the convention by larger international markets may influence decisions by the suppliers of mercury-based amalgam to Australia (such as SDI Limited and Kerr Australia).

Future exports of mercury-based dental amalgam

Dental amalgam capsules are exported from Australia, so permission to import would need to be given by the importing country. On the basis that the convention stipulates the phasing down of dental amalgam, permission appears likely to be granted unless the country chooses to ban amalgam fillings. To date, a small number of countries (such as Sweden, Norway and Denmark) have chosen to ban them. In addition, the European Union has banned the use of amalgam for 'vulnerable populations' (children under 15 years old and pregnant or breastfeeding women).[86] However, those decisions to ban or restrict the use of amalgam are considered to have been made independently of the Minamata Convention.

5.3.2 Option 2: Ratification (minimum requirements)

Under the phase-down options, in which Australia ratifies the convention and adheres to the convention's requirements, impacts to the dental industry would be driven by:

- any measures Australia chooses to undertake to facilitate the phase-down of amalgam, consistent with Article 4
- impacts on mercury for import and mercury products for export.

As noted above, the introduction of the convention will potentially have some impacts on the international trade in mercury and mercury-added products; however, following discussions with stakeholders, we concluded that the impacts will be the same whether Australia ratifies or not. For that reason, this did not affect the cost–benefit analysis and was not considered further.

Options to meet Article 4 measures

Under Article 4, paragraph 3 of the convention, parties are required to undertake specific measures for mercury-added products. For dental amalgam, those measures are as follows:

> *Measures to be taken by a Party to phase-down the use of dental amalgam shall take into account the Party's domestic circumstances and relevant international guidance and shall include two or more of the measures from the following list:*
>
> *(i) Setting national objectives aiming at dental caries prevention and health promotion, thereby minimizing the need for dental restoration;*
>
> *(ii) Setting national objectives aiming at minimizing its use;*

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84 Department of Health, *Submission to Department of the Environment: Ratification of the Minamata Convention consultation*, 17 July 2014, p. 2.

85 ADIA, pers. comm., follow-up letter, November 2017.

86 European Commission, 'Questions and answers: EU mercury policy and the ratification of the Minamata Convention', media release, 18 May 2017, http://europa.eu/rapid/press-release_MEMO-17-1344_en.htm.

(iii) Promoting the use of cost-effective and clinically effective mercury-free alternatives for dental restoration;

(iv) Promoting research and development of quality mercury-free materials for dental restoration;

(v) Encouraging representative professional organizations and dental schools to educate and train dental professionals and students on the use of mercury-free dental restoration alternatives and on promoting best management practices;

(vi) Discouraging insurance policies and programmes that favour dental amalgam use over mercury-free dental restoration;

(vii) Encouraging insurance policies and programmes that favour the use of quality alternatives to dental amalgam for dental restoration;

(viii) Restricting the use of dental amalgam to its encapsulated form;

(ix) Promoting the use of best environmental practices in dental facilities to reduce releases of mercury and mercury compounds to water and land.

Based on discussions with the department and stakeholders, Australia appears to be compliant with at least two of these measures. In particular:

- Australia has updated its oral health plan[87] to cover 2015 to 2024 (aligning with measure '*i*' under Article 4, paragraph 3)
- professional organisations and dental schools already educate and train dental professionals and students in the use of mercury-free dental restoration materials (aligning with measure '*v*' under Article 4, paragraph 3)
- in Australia, no insurance policies and programs favour dental amalgam use over mercury-free dental restoration (aligning with measure '*vi*' under Article 4, paragraph 3).

Given that Australia is already compliant with the requirement to meet two or more measures, no additional costs or benefits are expected to arise because of ratification under Option 2.

5.3.3 Options 3 and 5: Ratification, with installation of dental amalgam separators encouraged by government

The generation of mercury waste from dental amalgam occurs mainly through the removal of old fillings. Some mercury residue also enters wastewater streams when new mercury-containing fillings are installed.

Under options 3 and 5, an additional measure (beyond the minimum requirements of the convention) that affects the dental industry is considered: dental practices would be encouraged to voluntarily install dental amalgam separators that would reduce the release or mercury and mercury compounds to the environment due to the removal and installation of amalgam fillings (aligning with measure '*ix*' under Article 4, paragraph 3).

The program that would be adopted under these options has been described by the department as being akin to the voluntary Dentists for Cleaner Water Program (described in Box 2), which ran in Victoria from 2008 to 2011 and provided rebates for dental practices that installed dental amalgam separators.

87 The National Advisory Committee on Oral Health is drafting the new 2014–2023 national oral health plan for the COAG Health Council's endorsement; see http://oralhealthplan.com.au/.

Box 2: Dentists for Cleaner Water Program

The Dentists for Cleaner Water Program was an initiative developed by the Australian Dental Association (Victorian Branch), the Victorian water industry and the Victorian Environment Protection Authority that aimed to reduce mercury releases to the environment.

The voluntary program facilitated the installation of dental amalgam traps and separators in private-sector dental practices across Victoria by offering a rebate for the installation of amalgam separators during the period between July 2008 and June 2011. The program offered a flat $1,000 rebate or up to a maximum of 20% of the total costs associated with the purchase and installation of amalgam separators, whichever was the greater amount, in the first year. From 1 July 2010, the rebate was revised to $500 or up to a maximum of 10% of the total costs associated with the purchase and installation of these items, whichever was the greater amount.[88]

The program resulted in the installation of a total of 725 amalgam separators serving about 1,450 dental chairs across Victoria for a total government investment of $1 million.[89]

An evaluation of the program estimated that the amalgam waste collected by CMA Ecocycle over three and a half years averaged about 324 kg/year (based on drained net weight calculations and an assumed 30% moisture factor).[90] Divided between the 725 amalgam separators (and assuming one amalgam separator per dental practice), this equated to 0.45 kg/year of mercury collected per separator.

Under options 3 and 5, we assumed the operation of a voluntary program similar to Victoria's Dentists for Cleaner Water Program. For clarity, we did not assume that the program would include the subsidising of amalgam separators; rather, we assumed that the government investment would be limited to an information program.

The outcome would be that a proportion of dentists would install amalgam separators and there would be subsequent benefits from the reduced flow of mercury into the environment. However, the impact of the program would depend on the voluntary take-up of any incentive offered (such as a tax rebate), in which case the costs of purchase and installation of the amalgam separators would be attributable to the program, as would any mercury savings.

The cost of the take-up of amalgam separators by dentists was calculated for the cost–benefit analysis as the mathematical product of the number of dental practices that would install amalgam separators and the cost of the separators.[91]

Voluntary take-up

Feedback from stakeholders suggests that the number of dental practices in Australia ranges from 7,000 to 8,000; the most likely estimate is close to 7,400.[92]

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88 ADIA, *Issues paper: Dental amalgam use, separation & recycling in Australia*, June 2012, p. 16.

89 Dentists for Cleaner Water Program (DCWP), *Evaluation report*, p. v.

90 DCWP, *Evaluation report*, p. vii.

91 This approach was modified from the approach taken for the previous cost–benefit analysis, which considered the number of dentists and assumed installation rates consistent with the number of dentists per practice. The approach has been modified to reflect stakeholder feedback that indicated that that approach 'may over-state the number of businesses by as much as 100%' (ADIA submission, p. 14).

92 Discussions and information provided by the ADIA and SDI Limited, November 2017.

Currently, Victoria is the only state with a large number of amalgam separators. Taking this into account, and the ADIA's feedback that the 30% voluntary take-up estimates in the Dentists for Cleaner Water Program were at the higher end (indicating that the number of amalgam separators that could be installed in Victoria is still quite high), Marsden Jacob developed three scenarios with variable take-up rates:

- The 'most likely' scenario assumed that the take-up of the program would be similar to the rates achieved for the Victorian program. In states and territories other than Victoria, this would result in 30% of dental practices installing amalgam separators. For Victoria, a similar impact was assumed, resulting in take-up by an additional 30% of the remaining practices.
- The 'best case' scenario assumed that take-up would be 90%. This scenario represented the upper boundary of what might be expected if the government were to make the program mandatory, rather than voluntary.
- The 'worst case' scenario assumed a lower take-up than that achieved for the Victorian program. We assumed that only 10% of practices would install amalgam separators in response to the program.

The number of dental practices and the number of installations assumed to occur under each scenario are outlined in Table 16.

Discussions with stakeholders suggested that some practices might install only one unit on one chair for multiple dentists to use when working with mercury-based amalgam. Therefore, our modelling assumed at least one installation per dental practice where practices install separators.

Table 16: Estimated numbers of dental practices and installations of amalgam separators required

Jurisdiction	Number of dental practices[a]	Number of installations		
		Most likely	Best case	Worst case
New South Wales	2,635	791	2,372	264
Victoria	1,818	382	1,091	127
Queensland	1,429	429	1,286	143
South Australia	512	153	460	51
Western Australia	734	220	660	73
Tasmania	94	28	84	9
Northern Territory	37	11	33	4
Australian Capital Territory	140	42	126	14
Currently unknown	2	1	2	0
Total	**7,400**	**2,056**	**6,114**	**685**

a Total number of dental practices as per ADIA estimate. The number of practices in each state and territory was calculated based on the proportion of dentists operating in each jurisdiction as per Australian Bureau of Statistics data, *Counts of business entry and exit—Operating at end of financial year 2013*.

Costs

For the original cost–benefit analysis, the prices quoted by CMA Ecocycle ($900 for installation and $500 for annual servicing) were used.

Feedback from industry suggested that those costs were difficult to verify, but that they might be higher. The ADIA stated that there were no specific costings for investing in amalgam separator units, as the cost could range from $600 to $5,000 depending on how many chairs a practice operates.[93] The Australian Dental Association (ADA), similarly quoted higher costs:[94]

> *… it is the ADA's understanding that the current cost of purchasing and installing amalgam separators and traps can range from about $2000 for a battery-style unit, to over $7000 in which separation is one element of a multifunction suction device.*

In contrast, a confidential respondent commented that separators cost around $500 and that the ability to claim tax deductions for the installation of the units needed to be taken into consideration.

A broad range of installation costs and annual servicing fees were reported. For example, the ADIA estimated that the collection and recycling of waste amalgam (of which approximately 50% will be mercury) would cost $1,320 over five years.[95] The ADA suggested that annual maintenance and waste collection contracts start at around $250.[96]

Based on that feedback, Marsden Jacob increased the average installation costs ($1,000) and reduced the ongoing costs ($250 per year) used in the cost–benefit analysis.

Consistent with the previous modelling, it was assumed that the best time to install amalgam separator units in an established dental practice would be during a fit-out. The ADIA noted that new dental practices are typically installing amalgam separators as standard and further confirmed that the average time between major retro fits or upgrades was 7–15 years.[97]

Box 3 gives an overview of amalgam separator technologies.

Box 3: Overview of amalgam separators

Amalgam separators complying with International Standard ISO 11143:2008 are capable of 95% amalgam removal and can greatly reduce mercury loads to sewers from individual dental surgeries.

The standard addresses the characteristics of three types of dental amalgam separators:

- Centrifugal systems: These systems use centrifugal force to draw out amalgam particles from the wastewater.
- Sedimentation systems: These systems reduce the speed of wastewater flow, which allows amalgam particles to settle out.
- Filter systems: Depending on the type of filter used, these separators remove not only coarser amalgam particles but also some finer and colloidal amalgam particles.

In Australia, amalgam separators are mainly supplied by Cattani Australia, Ecocycle Australia, Durr Dental, Ritter Dental (formerly Gritter Dental) and Sirona Dental Systems.

Mercury removed

Our estimates of the mercury that would be recovered through the use of separators installed in response to ratification drew on an evaluation of the Dentists for Cleaner Water Program; the

93 ADIA, written advice, 3 November 2017.

94 ADA, submission, p. 3.

95 ADIA, written advice, 3 November 2017.

96 ADA, submission, p. 3.

97 ADIA, written advice, 3 November 2017.

evaluation reported estimates of the mercury recovered that were different from those reported by the program.

Analysis of the Dentists for Cleaner Water Program provided forecast estimates of the mercury that would be recovered in Victorian surgeries. Independent forecast estimates suggested that 95 kilograms of mercury would be recovered from 725 surgeries in Victoria, giving a recovery rate of 0.13 kilograms per surgery per year.[98,99]

If those results were replicated for between 685 (the 'worst' case) and 6,169 (the 'best' case) dental practices across Australia, this would result in the recovery of between 90 and 808 kilograms of mercury per year. In the 'most likely' case, 2,056 dental practices would recover 269 kilograms per year.[100]

Discussions with the Western Australian Water Corporation indicated that mercury in the sewer system was largely captured in biosolids, which, depending on the water utility and contaminant levels, may be used as a form of soil improver for agricultural areas. Marsden Jacob considered whether the improved value of biosolids should be included in the cost–benefit analysis; however, the water corporation advised that other contaminants (particularly copper) are a more important limiting factor on this use of biosolids and that mercury levels are found to be at or below ambient levels of mercury in the soil. For this reason, the benefit assessment focused only on the reduced quantity of mercury released to the environment.

5.3.4 Conclusion

If Australia ratifies the Minamata Convention, the impacts on the dental industry will be limited to the impacts from any measures that the government chooses to undertake to facilitate the phase-down of amalgam consistent with Article 4 and any impacts on mercury imports for the production of mercury amalgam and subsequently the export of amalgam.

Australia is already undertaking several of the measures identified as being consistent with Article 4, and the impact of the convention on the import of mercury for dental amalgam production and its subsequent export is expected to be minimal. Therefore, under Option 2 there would be no difference between the base case and ratification.

Under options 3 and 5, a voluntary program that encourages dental practices to install amalgam separators would be put in place. The program would be expected to have similar impacts to those experienced by Victorian dental practices that participated in the Dentists for Cleaner Water Program. The capital costs and installation costs of amalgam separators would be incurred, along with ongoing operational costs for a period of 10–15 years (after which dental practices are likely to undergo major refurbishments). Savings from mercury would occur during that period.

The net impact of each of the options relative to the base case, including the 'most likely', 'best case', and 'worst case' scenarios, are outlined in Table 17.

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98 URS Australia, *Evaluation of Dentists for Cleaner Water*, 2013, Table 5-4.

99 Analysis of data provided in the ADIA submission to the 2014 Minamata Convention consultation reveals a higher estimate of 0.214 kilograms per unit per year (314 kilograms of mercury across 664 units over 2.2 years).

100 For the purpose of the cost–benefit analysis, it was assumed that these interception units would be installed over a 4-year period.

Table 17: Net impacts on the dental industry ($ million)

	Most likely case	Best case	Worst case
Total cost	$5.297	$15.891	$1.765
Health benefits (using the central health estimate)	$9.657	$28.972	$3.219
Net benefits	**$4.360**	**$13.080**	**$1.453**

5.4 Lighting sector

Many electric lamps used domestically and commercially include some quantity of mercury. Mercury-containing lamps include small compact fluorescent lamps (CFLs) used mostly in homes, linear fluorescent lamps (LFLs) or linear fluorescent tubes commonly used in offices, and high-intensity discharge lamps such as high-pressure mercury vapour (HPMV) lamps, high pressure sodium lamps (HPS) and metal halide lamps (MH) (the last two are not subject to the ratification process), used for street lighting and sportsgrounds.

Article 4 of the Minamata Convention restricts the manufacture, import or export of CFLs and LFLs with mercury quantities above specified limits and all HPMVs after 2020. In the absence of Australia seeking an exemption, the manufacture, import and export of these products would be prohibited after 2020 under all phase-down scenarios.

Lamp types affected by the convention

Mercury-added products that are banned from manufacture, import or export are listed in Part 1 of Annex A of the convention.

Lighting Council Australia has noted that the levels of mercury in most of the mercury-containing lamps already align with, or are below, the limits set out in the convention.[101] The council also noted that some other lamps (not listed in Annex A) include some levels of mercury but are not affected by the convention. [102]

As Australia has existing controls on lamp efficiency, the lamps affected by Article 4 and Annex A are restricted to HPMV lamps. For clarity, LFLs and CFLs are also discussed briefly in this section.

While some lamps, such as HPMV lamps, are banned under the convention, alternative luminaire products are widely available. They include light-emitting diode (LED) lights, high-pressure sodium vapour lights and metal halide alternatives. While high-pressure sodium vapour lights and metal halide lights both contain mercury, albeit in smaller quantities, they are not restricted under the convention.

Following stakeholder submissions, the cost–benefit analysis was updated to reflect the higher likelihood that LED lights, rather than those types of lights, would replace HPMV lamps (as assumed in the previous report).

[101] Lighting Council of Australia, *Submission in response to draft exposure RIS*, March 2017.

[102] Marsden Jacob sought clarification from the department on the coverage of lamps that contain mercury but that are not specifically listed in the convention. The department confirmed that metal halide and high-pressure sodium lights are out of the scope of the convention.

5.4.1 Compact fluorescent lamps and linear fluorescent lamps

Historically, some CFLs and LFLs had relatively high levels of mercury (up to 40 milligrams per lamp). However, developments in manufacturing technologies have significantly reduced the mercury content in fluorescent lamps, so that most lamps being manufactured globally now contain less than 5–10 milligrams per lamp.[103]

Regulations under the *Greenhouse Energy Minimum Standards Act 2012* require CFLs of less than 30 W, which are mostly used in homes, to have a maximum of 2.5 milligrams of mercury per lamp (which is more stringent that the convention) and CFLs greater than 30 W and LFLs (used mostly in commercial and public buildings) to have a maximum of 5 milligrams (which complies with the convention).[104] For this reason, ratification is not expected to have any impact on CFLs and LFLs.[105]

5.4.2 High-pressure mercury vapour lamps

The use of HPMV lamps in street lighting is widespread across Australia. The lamps are also used at sportsgrounds, commercial sites, industrial sites, military facilities, universities, mines, airports and hospitals.

Information collated by the Institute of Public Works Engineering Australasia (IPWEA) on behalf of the department and stakeholder feedback suggests that the number of HPMV lamps being used in street lighting in Australia is currently around 912,000.[106] Industry estimates that there are between 200,000 and 500,000 additional HPMV lamps in industrial and commercial sites that could also be affected by the convention. HPMV lamps used in Australian street lights are generally subject to a 3–3.5-year replacement cycle to ensure that the brightness of the lamps meets Australian lighting standards.

Table 18 outlines the number of HPMV luminaires estimated to be in service throughout Australia in 2016, by wattage. The vast proportion of HPMV luminaire use are 50 W and 80 W MV lamps.

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103 Yuanan Hu, Hefa Cheng, ‘Mercury risk from fluorescent lamps in China: current status and future perspective’, *Environment International*, 2012, 44:141–150; MM Aman, GB Jasmon, H Mokhlis, AHA Bakar, ‘Analysis of the performance of domestic lighting lamps’, *Energy Policy*, 2013, 52:482–500.

104 The relevant determinations are at www.energyrating.gov.au/products/lighting/linear-fluorescent and www.energyrating.gov.au/products/lighting/cfl.

105 Reduced mercury levels (as opposed to banning) for fluorescent lamps, such as CFLs and LFLs, would also apply with ratification. The Greenhouse and Energy Minimum Standards Determinations for CFLs and LFLs have already been amended to meet or exceed the Minamata Convention levels from December 2017. The impact of this change was low, as most fluorescent products sold into the Australian market have mercury levels below the revised levels.

106 Stakeholder consultation and IPWEA, *Street Lighting and Smart Controls (SLSC) Program Roadmap*, prepared for the Department of the Environment and Energy by Strategic Lighting Partners and Next Energy, December 2016, Table 12, p. 48.

Table 18: Mercury vapour light stocks, Australia, 2016

Type of light	Types of HPMV lamps	Number of HPMV lamps
Commercial and industrial sites	50 W and 80 W	200,000 to 500,000[a]
P4/5 Residential roads	50 W and 80 W	785,000
P3 Intermediate roads	125 W	79,000
V3 Low traffic volume main roads	250 W	33,000
V1 Low–medium traffic volume main roads	400 W	14,000
V1 High-speed, high traffic volume main roads	700 W	1,000

a Modelling assumes 400,000.

Source: Stakeholder consultation and IPWEA, *Street Lighting and Smart Controls (SLSC) Program Roadmap*, prepared for the Department of the Environment and Energy by Strategic Lighting Partners and Next Energy, December 2016, Table 12, p. 48.

In Australia, HPMV street lights are mainly owned and maintained by distribution companies, local councils and other government organisations and statutory bodies.

The phase-out of these mercury vapour luminaires is underway, is expected to continue and may accelerate regardless of Australia's decision on ratifying the Minamata Convention. Reasons for this include the following:

- The costs of alternative mercury-free products, such as LED luminaires have declined, and that has shifted the balance of capital installation costs, maintenance costs and energy costs. Alternative LED luminaires offer a lower energy usage for the same light output and generally have a lower cost maintenance schedule compared to mercury vapour alternatives. Industry experts advise that investment in changing to non-mercury lights currently provides a payback of less than 10 years (estimated to be 5–6 years in Victoria).
- The Australian Standard for street lighting (AS/NZS 1158—Lighting for public roads) recommends lighting standards for Category V (main or major roads) and Category P (residential streets and public open spaces) sites. Although the standard is voluntary, it is widely accepted and adhered to by industry.
- Changes made in 2010 to AS/NZS 1158 for Category V installations require that HPMV lamps not be used in new Category V lighting schemes.[107] As a result, the number of Category V HPMV fixtures is likely to reduce after 2020, as most stakeholders responsible for this category of lights will already be looking to change out HPMV installations on energy-efficiency grounds. Accordingly, we assumed that 250 W, 400 W and 700 W mercury vapour lamps would not be affected by the ratification decision.[108]

Future supply of mercury vapour street lights

Although several light types and fixtures are constructed in Australia from imported parts, no mercury vapour lamps are manufactured here. Therefore, Australia is dependent on imports for the supply of mercury vapour lamps for use in street light luminaires.

[107] Category V installations use higher wattage lights (250 W, 400 W, 700 W and some 125 W mercury vapour lamps) but not the lower wattage mercury vapour lights used in residential streets.

[108] Numbers of these lights have been included in the analysis to provide a complete picture. However, our modelling phased the number of these lights down to zero under both the base case and the phase-down scenarios at the same rate; hence, the net influence on the cost–benefit analysis was zero.

Changes to the global market for HPMV lamps mean that the availability of lamps may be restricted after 2020 regardless of Australia's decision on ratification. For that reason, the future availability of lamps requires consideration under both the base case (non-ratification) and the phase-down scenarios.

Ratification of the convention by countries that currently manufacture and export HPMV lamps will affect Australia's ability to import this technology after 2020 as manufacturers and exporting countries respond to the convention, even if Australia does not ratify.

Discussions with street lighting suppliers in Australia indicated that most mercury vapour lamps are now manufactured in China and Belgium. This aligns with analyses of lighting import data that covers sodium, mercury and metal halide lamps.[109] The data shows that most imported lights come from China (59%). France (11%), Germany (8%) and Belgium (6%) also provide relatively substantial quantities, and smaller quantities of imports come from India (3%), Japan (3%) and Slovakia (3%). Of the exporting countries, only India and Belgium are yet to ratify the convention. None of the countries that have ratified has sought an exemption for the continued manufacture of HPMV lamps.

Lighting Council Australia highlighted its concern about the global supply:

> *… it is important that Australia ratifies the agreement. China has already flagged that it will not export any mercury-containing lamps to countries that have not ratified the Convention and it is expected that Europe will do the same. Lighting Council Australia expects that if the Australian Government does not ratify the Convention it is unlikely that lighting suppliers will be able to import compliant low-pressure mercury containing lamps from our major lamp trading partners in China and Europe from 2020.*[110]

Even if an exporting country chooses not to ratify the convention, the global nature of the lighting market may cause individual manufacturers to suspend the production of mercury vapour lights. Those changes are likely to be driven by demand-side changes. We note that mercury vapour street lights are being phased out in the United States and European Union markets.[111,112]

Disposal of mercury vapour lamps

In the cost–benefit analysis, we assumed that all mercury vapour lamps would be either recycled or disposed of to appropriate landfills. Based on that assumption, we did not include any health benefits from the phasing out of mercury-containing lamps.

The safe disposal of HPMV lights is indirectly covered by the Minamata Convention through the references to the definitions and guidance supporting the Basel Convention.[113]

CFLs and LFLs available in Australia would not be captured under the Minamata Convention due to the low quantities of mercury present in those types of lights in Australia.

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109 The trade data does not distinguish between quantities of mercury lamps and other types of lights; however, it is reasonable to assume that these countries currently manufacture (or could manufacture) HPMV lamps.

110 Lighting Council Australia, *Submission in response to draft exposure RIS*, March 2017.

111 United States Government, *United States of America: Notification under Article 4*, paragraph 2, 2013, p. 3, www.mercuryconvention.org/Portals/11/documents/submissions/USA%20declaration_Art%204%20para%202.pdf.

112 Havells Sylvania, 'Sylvania Relimina is the answer to mercury replacement', media release, 1 April 2014, www.havells-sylvania.com/en_DK/press-centre/sylvania-relumina-is-the-answer-to-mercury-replacement (accessed 12 April 2015).

113 Note that, while the Basel Convention applies only to transboundary movements (that is, exports) of hazardous wastes, the reference in the Minamata Convention appears to apply this guidance and threshold levels to the domestic disposal of wastes.

However, the Basel Convention recommends the separation of waste containing mercury from other wastes, when feasible, and the recovery of the mercury from those sources. Furthermore, technical guidelines for mercury under the Basel Convention require the consideration of several items in the design of collection programs applicable to CFLs and LFLs.

FluoroCycle, a voluntary product stewardship program, is an example of an Australian program already targeting these lamps.[114] Voluntary product stewardship programs of this type seek to increase the national recycling rate for waste mercury-containing lamps to help reduce the amount of mercury being sent to landfill. Companies that are signatories to FluoroCycle commit to recycling all their waste mercury-containing lamps.

Marsden Jacob understands that a few other Australian distribution businesses responsible for the maintenance of street lights (and therefore the disposal of waste mercury vapour lamps) are also considering becoming signatories to the scheme and may already recycle street-light waste. However, a significant proportion of Australia's street lights continue to be disposed to landfill.[115]

Each mercury vapour lamp can contain up to 200 milligrams of mercury—more than ten times the amount found in a fluorescent light in a typical office building.[116] As FluoroCycle states:

> *It is the accumulation of mercury in landfill across Australia that is a cause for concern across the wider environment .... Mercury in landfill converts to the toxic methylmercury and spreads through the wider environment through air, water and soil.*[117]

As the Basel Convention, and consequently the Minamata Convention, do not provide for any specific measures to be undertaken in relation to the disposal of waste mercury-containing lamps, our analysis has not included the quantification of avoided mercury waste to landfill.

5.4.3 Base case

Under the base case (in which Australia does not ratify the convention), the phase-out of mercury vapour street lights will continue and is likely to be accelerated by changes in the international market (such as manufacturing countries becoming signatories to the convention), meaning that the availability of HPMV lamps will be increasingly restricted.

Irrespective of whether Australia ratifies the convention, there is uncertainty about the availability of HPMV lamps in the global market in the future as other countries respond to the convention.

We accounted for that uncertainty by considering 'most likely', 'best case' and 'worst case' outcome scenarios within the base case:

- Under the base case used for the 'most likely' and 'best' outcomes, the global supply of HPMV lamps for import to Australia would be reduced after 2020; however, those products would continue to be available for a short period after the convention takes effect globally. We assumed

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114 Basel Convention, *Technical guidelines for the environmental sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury*, www.basel.int/Implementation/MercuryWastes/TechnicalGuidelines/tabid/2380/Default.aspx.

115 FluoroCycle estimates that the proportion of lights sent to landfill could be as high as 95%; FluoroCycle, *Why should we recycle our wast lighting?*, no date, www.fluorocycle.org.au/why-recycle.php (accessed November 2017).

116 Amanda Rishworth MP, 'Industry recognised for fluoro-light recycling', media release, 14 June 2013, www.fluorocycle.org.au/pdf/media/Media%20Release%20-%20Industry%20recognised%20for%20fluoro-light%20recycling%20-%2014%20June%202013.pdf

117 FluoroCycle '*Why should we recycle our waste lighting?*'

that HPMV products will not be available after 2025.[118] Based on a lamp life of 3–3.5 years, this means that all the lamps would be removed by 2028.

- Under the ‘worst case’ outcome, the base case was altered and was the same as in the ratification scenarios. The global supply of HPMV lamps would stop in 2020 and, in the absence of stockpiling, all fixtures would have to be replaced with non-HPMV alternatives by the end of 2023, as the lamps have an average life of 3–3.5 years.

5.4.4 Ratification

Under all the phase-down options, Australia would be required to restrict the importation and manufacture of HPMV lamps after 2020.[119] We assumed that all luminaires would have to be replaced with non-HPMV alternatives by the end of 2023, consistent with the 3–3.5-year average life of the lamps.

Some stakeholders have expressed concern about the ability of entities responsible for street lighting to meet the timelines required to modify the high number of HPMV lights in Australia.

However, those timelines may apply irrespective of whether Australia ratifies the convention, as the global market for HPMV lamps is expected to be significantly affected by the convention taking effect globally.

5.4.5 Comparison of base case and ratification options

Under both the base case and the phase-down options, the phase-out of HPMV street lights for minor and main roads is expected to continue. Main road lights (250 W, 400 W and 700 W lamps) are expected to be phased out at the same rate, regardless of ratification. However, as outlined above, the replacement of HMPV lights for minor roads and residential street lights (50 W, 80 W and 125 W lamps) by non-mercury alternatives *would* be accelerated under some scenarios if Australia ratifies.

Figure 8 shows the phase-out of HPMV lamps under the base case and ratification options for Australia. The figure shows the phase-out of all types of HPMV lamps under the ‘best case’ and ‘most likely’ scenarios.

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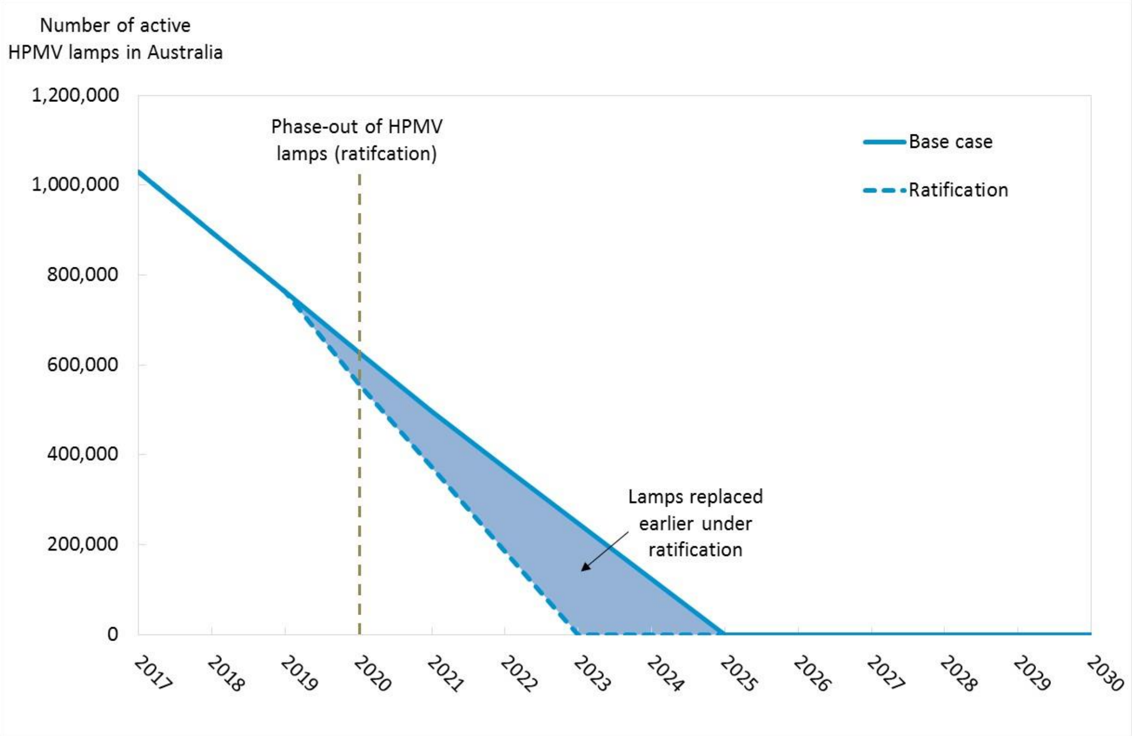
118 This is the latest phase-out date if exporting countries seek the maximum two 5-year exemption periods for the phase-out of HPMV lamps.

119 The convention covers both the manufacture and the importation of HPMV lamps; however, our analysis focused solely on the importation of these types of lamps, as Australia does not manufacture HPMV lamps.

Figure 7: Estimated phase-out of HPMV lamps under the base case and the 'best case' and 'most likely' phase-down scenarios, 2017 to 2030



Source: Marsden Jacob analysis, 2017.

Assuming that the disposal of street lamps by energy distribution businesses aligns with current waste disposal regulations and is not captured by the convention, no substantial benefits would result from the reduction in mercury emissions due to the early replacement of these lights.

However, early replacement under the phase-down options would bring forward:

- capital investment (replacing the luminaires earlier and paying out AER-approved residual values earlier)
- energy-efficiency benefits (and cost savings)
- greenhouse gas savings.

Marsden Jacob understands from industry experts that the hardware for alternative technologies is priced to mercury vapour equivalents over the life of the technology (allowing for differing maintenance schedules) but is more energy efficient.

Bringing forward capital investment

Under the phase-down scenarios, the capital investment in replacing the lights will be brought forward. Our analysis assumed the following nominal average costs per street light, along with estimates accounting for luminaire capital costs and installation labour.

Updated costs used in modelling for this report were developed in stakeholder consultations that differentiated between luminaire types. We note that stakeholder feedback suggests that these costs are conservative in some instances, as:

- pricing is indicative of large-volume purchases of luminaires, and spot replacements are likely to significantly costlier (50% to 100% higher)
- some lighting installations require additional brackets to be installed to support heavier luminaires, which may add an additional $200 to $400 to the costs of each.

Table 19 shows replacement costs for legacy lighting.

Table 19: Replacement costs for legacy lighting, per luminaire

Legacy lighting type	Best case	Most likely
Commercial and industrial sites	$373	$470
P4/5 Residential roads	$373	$470
P3 Intermediate roads	$410	$485
V3 Low traffic volume main roads	$675	$850
V1 Low–medium traffic volume main roads	$950	$1,200
V1 High-speed, high traffic volume main roads	$1,075	$1,300

Source: Stakeholder consultation (unpublished).

We note that the actual cost of capital replacement of street lights would vary significantly from these estimates. This is because luminaire technology changes do not often occur in isolation. Rather, upgrades to street-lighting luminaires may coincide with projects to underground power lines or upgrades to existing power poles or occur independently of decisions about distribution network infrastructure. For this reason, the estimates provided in this report should not be taken to represent the cost to any individual street-light customer.

Under the 'most likely' scenario, using the nominal average values outlined in Table 19 and a discount rate of 7%, bringing forward capital investment would increase the cost by a present value of $59.87 million. This falls to $46.89 million (NPV) under the 'best case' outcome. The 'worst case' outcome is not shown, as the costs and benefits would be the same under that outcome regardless of ratification.

Energy consumption savings

Assuming that street lights across Australian are active for an average of 11 hours per day (the average number of 'dark hours'), and that the cost of supply for electricity to street lights remains consistent with current tariff rates:

- 198,230 MW of electricity would be saved between 2016 and 2025
- those energy savings would be valued at $21.00 million (NPV).

Greenhouse gas emissions

Our analysis of the value of emissions reductions resulting from the early replacement of mercury vapour street lights with more efficient non-mercury alternatives indicates that early replacement could result in greenhouse gas savings of approximately 158,000 tonnes of carbon dioxide equivalent (tCO_2-e).[120]

In 2011, the Australian Treasury nominally set the cost of carbon at $29/$tCO_2$-e ($36/tCO_2-e in $2017), reflecting a medium-term abatement cost. This is the value we used in the analysis.

5.4.6 Conclusion

Regardless of Australia's decision on ratification, the phase-out of mercury-containing HPMV lamps is underway and is expected to continue.

120 Our analysis made use of standard greenhouse gas emissions conversion rates averaged for Australia and the energy consumption values (in kilowatt hours) predicted in our analysis.

Parts of the lighting sector that are not expected to be affected by Australia's ratification are users of CFLs and LFLs and sectors that use higher wattage categories of HPMV lamps that would be classified as Category V street lighting under Australian Standards. Regulation already requires that CFLs and LFLs conform to the mercury levels for those types of lamps under the convention, and the Australian Standard applicable to Category V lights will also have been amended to conform with the convention by the time Australia ratifies.

In contrast, the street-lighting sector and industrial and commercial users of lower wattage HPMV lamps (50 W, 80 W and 125 W) are expected to be strongly affected by the convention. The impacts will occur regardless of whether Australia ratifies, as the global supply of those types of lights is expected to be restricted, in line with other countries' decisions to ratify the convention.

Under the 'worst case' scenario, the base case and ratification options are expected to be the same: all imports of HPMV lamps would be restricted from 2020, and lighting fixtures would require replacement by 2023, consistent with the standard replacement cycle for the lamps (which will no longer be available).

Under the 'most likely' and 'best case' scenarios, there was a slightly lagged effect under the ratification option compared to the 'worst case' scenario. Under these scenarios, we assumed that under the base case (in which Australia does not ratify) there would be a small amount of supply still available after 2020, and that this would enable the replacement of fixtures to extend out to 2025. In contrast, the ratification option under these scenarios requires replacement earlier and by 2023.

Table 20 summarises the modelled results. Under both the 'most likely' and the 'best case' scenarios, the energy cost savings and greenhouse gas emissions savings outweigh the additional costs from bringing forward expenditure to replace existing fixtures.

Table 20: Summary of results for the lighting sector ($ million)

	Most likely	Worst	Best
Net changeover costs	$19.95	$0	$15.88
Net energy cost savings	$19.63	$0	$19.63
Net value of greenhouse gas emissions savings	$5.33	$0	$5.33
Net benefit (cost)	**$5.00**	**$0.00**	**$9.07**

5.5 Waste and recycling sector

Article 11 of the Minamata Convention ('Mercury wastes') requires parties to the convention to take a number of measures in mercury waste management and recycling.

Under paragraph 3(a) of Article 11, parties are required to take appropriate measures so that mercury waste is managed in a sound manner, taking into consideration guidelines developed under the Basel Convention (to which Australia is already a party). At the international level, the Conference of Parties of the Minamata Convention will cooperate with the Basel Convention.

Australia's compliance with the Basel Convention means that any incremental impacts arising from Australia's ratification of the Minamata Convention are likely to be minimal.

Based on discussions with various stakeholders, it appears likely that the Minamata Convention will drive an increase in some mercury-containing wastes, such as additional flue gases that will be required to be captured in fabric filters, while reducing mercury emissions.

The concern for operators in the waste sector is the way that the Minamata and Basel conventions will interact. Under the Minamata Convention, separate processes for transporting waste need to be established for countries that have ratified the Minamata Convention but not the Basel Convention (currently, the only country in that position is the United States).

Contract Resources, a stakeholder that handles mercury-containing materials, has expressed concern that ratification appears to 'preclude the import of mercury for ethical uses and the export of ethical products containing mercury'.[121] This could have impacts on markets such as the market for dental amalgam.

The major concern for Contract Resources is that, if markets decline, mercury would have to be stabilised and sent for long-term storage. It states that technological advances mean that long-term stabilisation of mercury is possible; however, this would increase operating costs, as capital investment would be required (and any costs would be passed on to the waste producer). Importantly, the costs for the disposal of mercury wastes are captured under the costs for each of the source areas and so are not considered again here.

5.6 Oil and gas production

5.6.1 Obligations under the convention

While oil and gas production is not specifically mentioned in the Minamata Convention, those sectors are potentially affected by Article 9 ('Releases'), which focuses on land and water releases of mercury from 'significant anthropogenic point sources'.

If Australia were to ratify, the key impacts arising under Article 9 would be as follows:

- Australia may develop a national plan (within 4 years) outlining control measures that will be implemented.[122]
- Controls would need to be introduced on *significant anthropogenic point sources* (no time frame is specified) and it is considered that the simplest control measure would be the implementation of release limit values (importantly, this covers both new and existing sources).[123]
- Australia would also need to identify relevant point source categories (within 3 years) and maintain an inventory of releases from relevant sources (within 5 years).

While Article 9 includes provisions for adopting guidance on best available techniques (BAT) and best environmental practices (BEP), that guidance has not yet been developed, and the timing is uncertain.

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121 Contract Resources, *Submission on National Phase Down of Mercury* 17 March 2017.

122 While a national plan is not an obligation, once a plan is developed it must be submitted to the Conference of Parties within 4 years of ratification.

123 Other potential measures (specified under Article 9 Paragraph 5) are
(b) The use of best available techniques and best environmental practices to control releases from relevant sources;
(c) A multi-pollutant control strategy that would deliver co-benefits for control of mercury releases;
(d) Alternative measures to reduce releases from relevant sources.

For that reason, they have not been not included in the cost–benefit analysis.[124] Article 9 also does not stipulate that new sources must comply with BAT and BEP guidance.

Each state or territory jurisdiction would be responsible for managing releases in that jurisdiction. The Australian Government would be responsible for Commonwealth land.

Box 5 shows current federal legislative arrangements for managing mercury in petroleum and gas reserves.

Box 4: Current federal legislative arrangements for managing mercury in petroleum and gas reserves

In Commonwealth waters (waters 3–200 nautical miles from the coast) and state waters where the state has conferred functions and powers on the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA),[125] mercury is managed through environmental plans required under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009.

The legislation is objective based and so does not include specific release limit values. However, regulation 10A specifies the criteria the acceptance of environment plans.

Individual environmental plans may set release limit values for a particular project, which (following discussions with the Department of the Environment and Energy) would appear to fall within the definition of Article 9, paragraph 5 of the Minamata Convention.

The legislation sets a requirement that all risks be managed to be ‘as low as reasonably practicable’ (ALARP).

5.6.2 Mercury in petroleum and gas reserves

Mercury levels vary from one petroleum or gas reserve to another. For example:

- Measurements of 200–250 parts per billion of mercury have been made in a reserve in Bass Strait.
- Measurements taken from a Browse Basin exploration well indicate that reservoir fluids may contain mercury. Concentrations are expected to range between 38 and 83 $\mu g/Sm^3$ (micrograms of mercury per standard cubic metre) in the gas stream and between 35 and 41 $\mu g/Sm^3$ in the condensate stream.[126]

124 The paper on BAT and BEP in relation to Article 9 was included in the first Conference of the Parties meeting; however, no provisions were developed; UNEP, Conference of the Parties to the Minamata Convention on Mercury, first meeting, http://unepmercurycop1.mediafrontier.ch/wp-content/uploads/2017/08/1_24_e_releases.pdf. We note that, if Australia ratifies, the government may get to have input on the BAT and BEP guidance (depending on timing).

125 Department of Industry and Science, *Update on legislative and regulatory amendments*, Australian Government, 25 March 2015, www.industry.gov.au/resource/UpstreamPetroleum/OffshorePetroleumExplorationinAustralia/Documents/AustralianPetroleumNews.pdf.

126 Browse FLNG development: Draft environmental impact statement EPBC 2013/7079, November 2014, p. 55, www.woodside.com.au/Our-Business/Developing/Browse/Documents/Environmental%20Impact%20Statement/Browse%20FLNG%20Development%20Draft%20EIS.PDF.

5.6.3 Potential points of mercury release in oil and gas production

Five potential releases of mercury were identified in conversations with industry and NOPSEMA (drill cuttings; produced water; mercury in the petroleum and gas streams; air emissions of mercury; and the disposal of mercury).

Drill cuttings

Drilling mud sometimes includes barite, which is added for its high specific gravity.[127] Barite can include low levels of mercury. While there is no quality specification for barite, it appears that mercury levels are less than 1 part per million.

Produced water

Formation water (water released from geological formations) and condensed water (water collected from the gaseous phase of the petroleum and natural gas) are collectively referred to as 'produced water'.

Depending on the site (and the levels of mercury), produced water can be treated and mercury removed prior to disposal.

However, as mercury tends to be hydrophobic and tends to gravitate into the hydrocarbon reservoir itself, the levels in produced formation water tend to be very low. For example, they can be an order of magnitude lower than Australian and New Zealand Environment and Conservation Council (ANZECC) release guidelines, even for bioaccumulation.

Mercury in the petroleum and gas streams

Mercury tends to bind to the gas phase of the natural gas and is removed before and/or during the liquefied natural gas (LNG) process trains.

Depending on the mercury content of the local geology, some plants use specific mercury-removal units that capture the mercury onto an adsorbent material that is replaced periodically and disposed of as hazardous waste.

Air emissions of mercury

Air emissions of mercury from petroleum and gas facilities are not covered by the Minamata Convention, which has a specific list of industries covered for air emissions.

Disposal of mercury

Wastes containing mercury are already covered by the Basel Convention, and the Minamata Convention does not impose additional requirements on those wastes.

5.6.4 Conclusions

Existing facilities

For existing facilities, controls would need to be introduced on *significant anthropogenic point sources*, and the simplest control measure would be the implementation of release limit values. While

[127] Barite is a mineral consisting of barium sulphate ($BaSO_4$).

the timing is unclear, it is assumed that this would need to occur within 10 years of the convention being introduced.

Based on discussions with industry, it appears that most offshore facilities already have release limit values as part of their environmental plans or have committed to adhering to published levels such as those in the ANZECC water quality guidelines.[128]

New facilities

Article 9 does not stipulate that new sources must comply with a higher standard than existing sources.

We note that the legislation covering petroleum activities in Commonwealth waters sets a requirement that all risks be managed to be ‘as low as reasonably practicable’ (ALARP) and that some proponents appear to state that they are managing risks that are reduced to ALARP where they are using BAT.[129]

Accordingly, it appears that the current legislative requirements (at least for offshore oil and gas) are likely to meet any future requirements (even though those requirements are beyond the scope of the cost–benefit analysis).

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128 Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC–ARMCANZ), *Australian and New Zealand guidelines for fresh and marine water quality*, vol. 1, October 2000, www.agriculture.gov.au/SiteCollectionDocuments/water/nwqms-guidelines-4-vol1.pdf.

129 See Browse FLNG Development, *Draft environmental impact statement*, EP BC 2013/7079, November 2014. p. 55.

6. Health and environmental outcomes

6.1 Overview

Exposure to mercury poses a serious risk to the environment and human health worldwide. The World Health Organization has suggested that mercury may have *no exposure threshold below which some adverse effects do not occur*. Mercury can cause a range of serious health impacts, including cognitive impairment (mild mental retardation); permanent damage to the central nervous system; kidney and heart disease; infertility; and respiratory, digestive and immune problems. The World Health Organization strongly advises that pregnant women, infants and children avoid exposure to excess mercury, as exposure is a threat to the development of the child *in utero* and early in life.[130] Mitigating, resolving and, in particular, remediating the problems caused by mercury can be costly.

The most significant benefits that would arise from Australia's ratification of the Minamata Convention would be improved environmental and health outcomes.

Identifying the benefits and linking them to action undertaken in Australia is complicated by the ability of mercury emissions to move globally through atmospheric and oceanic processes.

In considering health and environmental benefits arising from ratification, we used the following simplifying assumptions:

- Mercury that is likely to be disposed of through hazardous waste or recycling processes is unlikely to enter the environment.
- All mercury emissions are considered equally toxic, irrespective of the medium (air, land or water) and the form of mercury (elemental mercury and mercury compounds).
- There is no time lag between reducing emissions and deposition and reducing exposure in the most likely estimate of health benefits.[131]

The analysis focused only on Australian emissions affected by the Minamata Convention and the resulting benefit to the Australian population and environment.

6.2 Approach

In assessing the benefits, Marsden Jacob considered the benefits arising from:

- improved environmental conditions
- improved health across the Australian population
- reduced incidence of workplace accidents involving mercury exposure.

However, due to the lack of firm data, the improved environmental conditions are only considered qualitatively.

[130] World Health Organization, *Mercury and health*, fact sheet no. 361, 2017, www.who.int/mediacentre/factsheets/fs361/en/.

[131] As set out in section 6.4 the impact of delayed health benefits were considered in the worst case scenario

6.3 Environmental benefits

Mercury is found naturally in small quantities throughout the environment, both in the atmosphere and in aquatic and terrestrial ecosystems. However human-generated releases of mercury into the environment can result in concentrations of mercury that are harmful.

Mercury released into the air may settle into water bodies and affect water quality. Once mercury settles in water bodies, it is converted to methylmercury (bioavailable mercury) through microbial activity.

Methylmercury can then accumulate in fish at levels that may harm the fish and animals that eat them. Birds and mammals that eat fish are more exposed to methylmercury than other animals in water ecosystems. Similarly, humans are affected predominantly through their consumption of fish containing high concentrations of methylmercury.

By extension, predators that eat fish-eating animals are also at risk from increased mercury emissions in the environment.

The United States Environmental Protection Agency (USEPA) states that, depending on the level of exposure, the effects of methylmercury exposure on wildlife include mortality (death), reduced fertility, slower growth and development, and abnormal behaviour that affects survival. In addition, research indicates that the endocrine system of fish, which play an important role in their development and reproduction, may be altered by the levels of methylmercury found in the environment.[132]

Tracing the impact of mercury emissions in the environment is challenging for a number of reasons:

- First, mercury accumulation in water bodies depends on mercury emitted from local, regional, national and international sources.
- Second, the amount of methylmercury in fish in different water bodies is a function of a few factors beyond the amount of mercury deposited from the atmosphere, including local non-air releases of mercury; naturally occurring mercury in soils; the physical, biological and chemical properties of the water body; and the age, size and types of food that the fish eat. As a result, fish from lakes with similar local sources of methylmercury can have significantly different methylmercury concentrations, and releases of mercury may have variable detrimental effects depending on the ability of the system to absorb the excess quantities.

In Australia, there is a paucity of data on environmental levels of mercury, which prevents a quantitative analysis of the likely benefits arising from ratification of the Minamata Convention.

This section provides a summary of information collated for Australia that is relevant to the environmental impacts from mercury emissions in Australia; however, the information does not contribute directly to the cost–benefit analysis.

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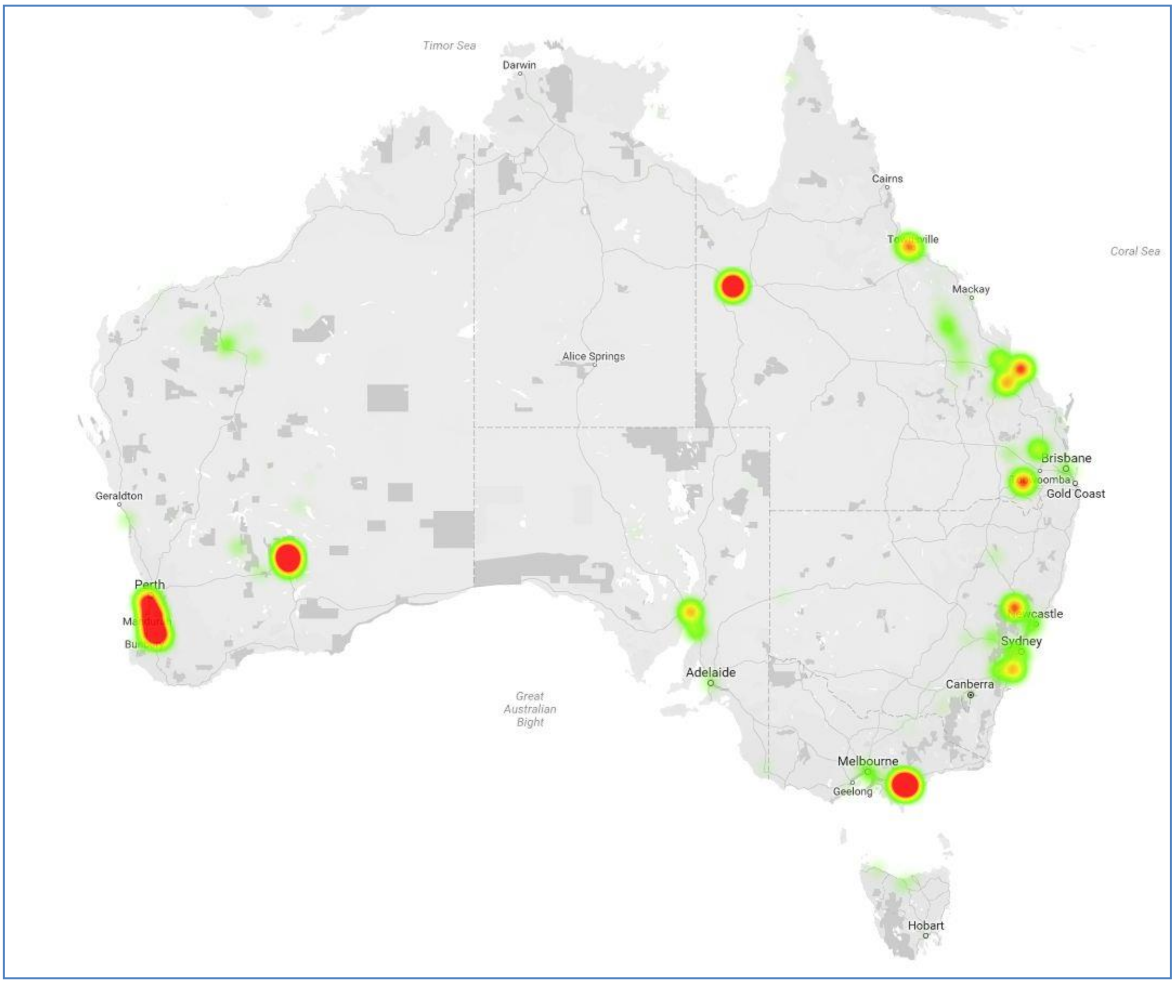
132 USEPA, *Environmental effects: fate and transport and ecological effects of mercury*, www.epa.gov/mercury/eco.htm (accessed 13 April 2015).

6.3.1 Spatial distribution of mercury emissions and concentrations

A 2009 report by the CSIRO provides an overview of both mercury emissions and mercury levels across Australia.[133] An updated analysis of mercury sources can be derived from the National Pollutant Inventory, and this is displayed graphically in Figure 8. Hotspots can be identified around known point sources of mercury emissions, such as Kalgoorlie in Western Australia and the Latrobe Valley in Victoria.

Figure 8: Mercury emission hotspots—the spatial distribution of anthropogenic mercury emissions



Source: National Pollutant Inventory, 2017, unpublished.

6.3.2 Environmental levels of mercury in Australia

There is limited available information about ambient mercury levels in Australia, although many studies have focused on potential pollution sources. A 2011 study conducted in Albany, Western Australia, by Goetze and Mackey analysed mercury levels in sediments (Table 21).[134] Only one sample exceeded the high trigger level in the ANZECC guidelines for mercury in sediments. The high and low trigger levels are 1 mg/kg and 0.15 mg/kg, respectively.

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133 ME Cope, MF Hibberd, S Lee, HR Malfroy, JR McGregor, CP Meyer, AL Morrison, PF Nelson, *The transportation and fate of mercury in Australia: atmospheric transport modelling and dispersion*, Appendix 1 to report RFT 100/0607 to the Department of Environment, Water, Heritage and the Arts, Centre for Australian Weather and Climate Research, 2009.

134 R Goetze, P Mackey, *Selenium and mercury concentrations in the sediments and pilchards (*Sardinops sagax*) of King George Sound and the broader Albany waters*, Albany Port Authority, 2011.

Table 21: Mercury concentrations in sediments of Albany, Western Australia

		Sediment concentration (mg/kg dry weight)	
Sample location	**Date of sample**	**Total**	**Bioavailable**
King George Sound	April 2011	<0.2	<0.2
King River mouth	April 2011	0.7	<0.2
Kalgan River mouth	April 2011	0.58	<0.2
Princess Royal Harbour	April 2011	0.23	<0.2
Wellstead Estuary	April 2011	3.6[a]	<0.2
Shannon River	April 2011	<0.2	<0.2

a Exceeds the ANZECC guideline high trigger value, 1 mg/kg.

Source: R Goetze, P Mackey, *Selenium and mercury concentrations in the sediments and pilchards (*Sardinops sagax*) of King George Sound and the broader Albany waters*, Albany Port Authority, 2011.

A study conducted in Port Curtis in Queensland found mean concentrations of mercury of 0.01 mg/kg in sediments, and a maximum value of 0.055 mg/kg.[135]

A further study conducted in Port Curtis found mean mercury levels in sediments of 0.02 mg/kg, with the 95th percentile level of 0.2 mg/kg. The 95th percentile concentration exceeded the low trigger level in the ANZECC guidelines.[136]

6.3.3 Mercury levels in fish

Several studies have investigated the levels of mercury in fish in Australia. Table 22 summarises the publicly available historical data, highlighting fish species that have been found to have mercury exceeding the Food Standards Australia New Zealand (FSANZ) guidelines.[137]

135 MA Jones, J Stauber, S Apte, S Simpson, V Vicente-Beckett, R Johnson, L Duivenvoorden, ‘A risk assessment approach to contaminants in Port Curtis, Queensland, Australia’, *Marine Pollution Bulletin*, 2005, 51(1–4):448–58.

136 Port Curtis Integrated Monitoring Program, *Port Curtis ecosystem health report 2008–2010*, 2012, www.pcimp.com.au.

137 Food Standards Australia New Zealand (FSANZ), *Mercury in fish: background to the mercury in fish advisory statement*, March 2004, www.foodstandards.gov.au/publications/Pages/Mercury-in-fish---background-to-the-mercury-in-fish-advisory-statement.aspx.

Table 22: Mercury concentrations in fish in Australia

Sample location	Date of sample	Fish species	Concentration (µg/g wet weight)
Gippsland Lakes Source: G Fabris, T Theodoropoulos, A Sheehan, B Abbott, 'Mercury and organochlorines in black bream, *Acanthopagrus butcheri*, from the Gippsland Lakes, Victoria, Australia: evidence for temporal increases in mercury levels', *Marine Pollution Bulletin*, 1999, 38(11):970–976			
Lake Wellington	1997	Black bream – *Acanthopagrus butcheri*	0.35
Blonde Bay	1997	Black bream – *Acanthopagrus butcheri*	0.17
Spoon Bay	1997	Black bream – *Acanthopagrus butcheri*	0.24
Masons Bay	1997	Black bream – *Acanthopagrus butcheri*	0.22
Lake Victoria	1997	Black bream – *Acanthopagrus butcheri*	0.24
Point King	1997	Black bream – *Acanthopagrus butcheri*	0.18
Tambo	1997	Black bream – *Acanthopagrus butcheri*	0.22
Swan Bay	1997	Black bream – *Acanthopagrus butcheri*	0.2
Flanagan Island	1997	Black bream – *Acanthopagrus butcheri*	0.18
Jones Bay	1997	Black bream – *Acanthopagrus butcheri*	0.16
Mean, Gippsland Lakes	1997	Black bream – *Acanthopagrus butcheri*	0.22 0.18
Mean, Gippsland Lakes	1978–79	Black bream – *Acanthopagrus butcheri*	0.11[a]
Source: Food Standards Australia New Zealand, 2005			
Wildcaught (Australia)	2003–04	Abalone	0.0005
		Eel	0.211
		Lobster	0.048
		Mackerel	0.072
		Prawn	0.040
		Scallop	0.005
		Pink snapper	0.190
		Coral trout	0.126
		Tuna	0.343
		Whiting	0.023
Aquaculture (Australia)	2003–04	Barramundi	0.022
		Marron	0.040
		Red claw	0.010
		Yabby	0.060
		Eel	0.055
		Kingfish (yellowtail)	0.040
Source: Food Standards Australia New Zealand, 2011			
Unknown	Unknown	Prawns	0.014

Sample location	Date of sample	Fish species	Concentration (µg/g wet weight)
		Fish portions, frozen	0.040[b]
		Fish fillets, battered	0.12[b]
		Tuna, canned in brine	0.029[b]
Source: NSW Health Department, 2001			
New South Wales	1997–98	Shark	0.48 2.3
		Swordfish	0.98[d] 1.65[e]
		Marlin	0.57[d] 0.95[e]
		Fin fish (generally)	0.15[d]
Source: R Goetze, P Mackey, *Selenium and mercury concentrations in the sediments and pilchards* (Sardinops sagax) *of King George Sound and the broader Albany waters*, Albany Port Authority, 2011			
Albany	2011	Pilchard – *Sardinops sagax*	0.042[d]
Bremer Bay	2011	Pilchard – *Sardinops sagax*	0.052[d]
Esperance	2011	Pilchard – *Sardinops sagax*	0.058[d]

a Exceeds ANZFA standard = 0.5 µg/g.

b Exceeds Standard A 12 = 1 mg/kg (NSW Health Department, 2001).

c Exceeds FSANZ 2004 (upper) = 1.0 mg/kg.

d Exceeds FSANZ, 2004 (lower) = 0.5 mg/kg.

e Exceeds FSANZ 2004 (crustacean/mollusc) = 0.5 mg/kg.

6.3.4 Great Barrier Reef

Given the high environmental values of the Great Barrier Reef and the presence of industries with potential mercury emissions (sugarcane production along the Queensland and northern New South Wales coastal plain, aluminium smelting at Gladstone, and coal-fired power generation), we specifically considered whether mercury levels could be attributed to environmental damage.

Water-quality issues and objectives

The 2013 Reef Water Quality Protection Plan identified the key pollutants in the region:

> *Sediment, nutrients and pesticides leaving agricultural land and draining into the reef lagoon remain the largest contributors to elevated pollutant levels.* [138]

A breakdown of the key pollutants for each region of the Great Barrier Reef is set out in Figure 9. The matrix shows that pesticides pose a very high risk in the Burdekin and Mackay Whitsunday regions.

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138 Australian Government and Queensland Government, Reef Water Quality Protection Plan 2013, p. 5, www.reefplan.qld.gov.au/resources/assets/reef-plan-2013.pdf.

Figure 9: Priority pollutants for each region of the Great Barrier Reef

Region	Overall relative risk	Priority pollutants for management		
		Nitrogen	Pesticides	Sediment
Cape York	LOW			
Wet Tropics	VERY HIGH			
Burdekin	HIGH	*		
Mackay Whitsunday	MODERATE			
Fitzroy	HIGH			
Burnett Mary	UNCERTAIN**			

Mercury concentrations of up to 100 µg/kg, an order of magnitude higher than background concentrations, have been identified in Great Barrier Reef sediment cores. Those concentrations were attributed to the application of mercury-based pesticides on sugarcane farms.[139]

According to recent research, coral reefs are under threat from land-based pollutants, and the vulnerability of the early life stages of coral is a particular concern. MEMC, which is the active ingredient in Shirtan (fungicide used on sugarcane in Australia), is extremely toxic to corals at barely detectable concentrations, affecting coral fertilisation and metamorphosis and causing coral bleaching and host tissue death.[140] Mass spawning on the Great Barrier Reef generally occurs during November and December each year, often coinciding with the first rains of the wet season in tropical North Queensland, which potentially increase the risk of contamination from agricultural run-off. The use of MEMC is banned all other countries partly because of its adverse effects on the environment.[141]

6.3.5 Valuing impacts on ecosystem services

Marsden Jacob considered whether the environmental benefits of ratification could be assessed using a valuation methodology such as one based on ecosystem services. In particular, 'provisioning services' (services provided by the environment, such as food and fresh water) appear to be directly affected by mercury and can potentially be valued.

Review of previous studies

We reviewed the literature to identify previous studies that have estimated the value of ecosystem impacts from mercury emissions or the benefit that would arise from reduced ecosystem impacts if mercury were phased down. A limited number of values relating to environmental damage or ecosystem services were identified.

139 GBRMPA, *Water quality guidelines for the Great Barrier Reef Marine Park*, revised edition 2010, p. 74.

140 KL Markey, AH Baird, C Humphrey, AP Negri, 'Insecticides and a fungicide affect multiple coral life stages', *Marine Ecology: Progress Series*, 2007, 330:127–137.

141 SA Bhuiyan, BJ Croft, GR Tucker, G.R 2014, 'Efficacy of the fungicide flutriafol for the control of pineapple sett rot of sugarcane in Australia', *Australasian Plant Pathology*, 2014, 43:418.

The United Nations Environment Programme (UNEP) has reported that:

> *in 2008 the global environmental external costs due to human activity included … USD 22 billion due to mercury emissions.*[142]

It appears that this valuation[143] includes both the health effect on humans and the impact on the environment and therefore should not be considered separately from health benefits (discussed in Section 6.4 of this report).

The development of the Minamata Convention has prompted several studies on mercury contamination both at the international level[144] and at the jurisdiction level.[145] We note that none of those reports values the ecosystem damage attributable to mercury or the benefits that would arise from a phase-down of mercury.

The literature review did identify some studies that valued the costs of fishing advisory notices about high mercury levels to recreational and commercial fishers.[146]

Estimating values for Australia

As fish and other seafood are a key source of food and are a segment of the ecosystem where mercury is known to biomagnify (increase through the food chain), we considered the potential for valuation.

However, the valuation of environmental effects was not pursued further for two reasons. First, there is a lack of literature on agreed methodologies for valuing environmental damage arising from mercury emissions. Second, there is a lack of data linking mercury emissions in Australia to resultant levels of mercury in fish or resultant impacts on key environmental assets, such as the Great Barrier Reef.

Finally, we considered the potential impact on Australia's fisheries. Australia currently has limited guidance on the consumption of seafood, which is reviewed as required.[147] Importantly, Australia does not have a history of closing fisheries due to mercury contamination. Therefore, the likely benefit of reduced mercury in fish would be relatively small; the most likely impacts would arise from a reduced requirement for warnings for pregnant women and infants about potential health effects.

In conclusion, it appears likely that reduced mercury emissions and releases to land or water would result in environmental benefits, including to key environmental assets such as the Great Barrier Reef. However, those benefits are not readily valued and so are noted qualitatively in the cost–benefit analysis.

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142 UNEP, *Costs of inaction on the sound management of chemicals*, 2013.

143 While this global value was reported, the supporting calculation was not identified.

144 For example: UNEP, *Global mercury assessment, 2013: sources, emissions, releases and environmental transport*.

145 See ICF International, *Study on EU implementation of the Minamata Convention on Mercury: draft final report (revised)*, 30 June 2014.

146 P Jakus, M McGuinness, A Krupnick, *The benefits and costs of fish consumption advisories for mercury*, Resources for the Future, Washington DC, October 2002, http://ageconsearch.umn.edu/bitstream/10853/1/dp020055.pdf.

147 FSANZ, *Mercury in fish*.

6.4 Health benefits of phasing down mercury

6.4.1 Health effects of mercury

Human exposure to methylmercury occurs primarily through the ingestion of seafood and freshwater fish.

Mercury exposure has been associated with a range of health effects, including neurological effects, effects on the kidneys and cardiovascular effects.[148]

Several cost–benefit analyses have been conducted internationally to inform decisions in relation to actions to reduce mercury levels:

- US EPA, *Regulatory impact analysis for the final mercury and air toxics standards*, EPA-452/R-11-011, December 2011 (the US EPA study)[149]
- L Trasande, C Schechter, KA Haynes, PJ Landrigan, ‘Applying cost analyses to drive policy that protects children: mercury as a case study’, *Annals of the New York Academy of Sciences*, 2006, 1076:911–923 (the Trasande study)
- M Bellanger, C Pichery, D Aerts, M Berglund, A Castano et al. (2013), ‘Economic benefits of methylmercury exposure control in Europe: monetary value of neurotoxicity prevention’, *Environmental Health*, 2013, 12:3
- C Pichery, M Bellanger, D Zmirou-Navier, N Frery, S Cordier, A Roue-Legall, P Hartemann, P Grandjean, ‘Economic evaluation of health consequences of prenatal methylmercury exposure in France’, *Environmental Health*, 2012, 11:53
- A Giang, N Selin, ‘Benefits of mercury controls for the United States’, *Proceedings of the National Academy of Sciences of the United States of America*, 2016, 113(2):286–291
- Organisation for Economic Co-operation and Development (OECD) Working Party on Integrating Environmental and Economic Policies, *Economic assessments of the benefits of regulating mercury: a review*, SACAME workshop, 30–31 August 2017, Ottawa, Canada
- L Trasande, J DiGangi, DC Evers, J Petrlik, DG Buck, J Samanek, B Beeler, MA Turnquist, K Regan, ‘Economic implications of mercury exposure in the context of the global mercury treaty: hair mercury levels and estimated lost economic productivity in selected developing countries’, *Journal of Environmental Management*, 2016, 183:229–235.

The cost–benefit analysis that was published with the exposure draft of the RIS in December 2016 focused on the impact of mercury on cognitive development, expressed as the loss of intelligence quotient (IQ) points. This remained our central estimate of the value of mercury and is set out in sections 6.4.2 to 6.4.4. In addition, we considered new research on the impact of mercury on acute myocardial infarctions (heart attacks) and the possible impact of introducing a delay between the release of mercury and the development of health impacts into the analysis.

6.4.2 Evidence of effects on cognitive development

The most studied outcomes of mercury effects are of effects on cognitive development in children, particularly loss of IQ, and developmental effects. The effects of mercury on the developing brain are

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148 Agency Toxic Substances and Disease Registry, *Toxicological profile for mercury*, 1999, www.atsdr.cdc.gov/toxprofiles/tp46.pdf; US EPA, *Regulatory impact analysis for the final mercury and air toxics standards*, EPA-452/R-11-011, December 2011, www.epa.gov/ttnecas1/regdata/RIAs/matsriafinal.pdf.

149 Available at www.epa.gov/ttnecas1/regdata/RIAs/matsriafinal.pdf.

like those observed for lead exposure. Loss of IQ, impacts on motor activities and attention disorders are the most commonly observed outcomes associated with biomarkers of mercury exposure, such as blood mercury and hair mercury. Therefore, loss of IQ is commonly used as the basis of health risk assessments for mercury and associated cost–benefit analyses.

Three longitudinal developmental studies have been conducted, in Seychelles, the Faroe Islands and New Zealand:

- The subjects of the Seychelles longitudinal prospective study were 779 mother–infant pairs from a fish-eating population.[150] Infants were followed from birth to 5.5 years of age and assessed at various ages on a number of standardised neuropsychological endpoints. The independent variable was maternal hair mercury levels.
- The Faroe Islands study was a longitudinal study of about 900 mother–infant pairs.[151] The main independent variable was cord-blood mercury, although maternal hair mercury was also measured. At 7 years of age, children were tested on a variety of tasks designed to assess functioning in specific behavioural domains.
- The New Zealand study was a prospective study in which 38 children of mothers with hair mercury levels during pregnancy greater than 6 ppm were matched with children whose mothers had lower hair mercury levels.[152] At 6 years of age, a total of 237 children were assessed on a number of neuropsychological endpoints similar to those used in the Seychelles study.

Health effects in previous cost–benefit analyses

In all these analyses, the health outcome used as the basis of the health risk assessment was loss of IQ in children.

All the health risk assessments used dose–response relationships that relate loss of IQ in children with maternal blood or hair mercury levels or cord blood mercury levels; however, the dose–response relationship varied among the studies.

The dose–response relationship used by the 2011 US EPA study was derived using data from the Faroe Islands, Seychelles and New Zealand cohort studies. The resulting dose–response relationship is a loss of 0.18 IQ points/ppm maternal hair mercury per child.

What this means is that for each child there is a loss of IQ associated with a 1 ppm increase in mercury levels in its mother's hair. It is assumed that no adverse effects are observed at maternal blood levels below 3.5 µg/L.

The 2006 Trasande study derived dose–response relationships from only the Faroe Islands and Seychelles studies and consequently obtained results higher than those derived by the US EPA. The dose–response relationship used in the Trasande study suggests a loss of 0.465 IQ points/ppm

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150 Myers et al., 1995a-c, 1997; Davidson et al., 1995, 1998

151 P Grandjean, P Weihe, RF White, F Debes, S Araki, K Yokoyama, K Murata, N Sørensen, R Dahl, PJ Jørgensen, 'Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury', *Neurotoxicology and Teratology*, 1997, 19:417–428.

152 T Kjellstrom, P Kennedy, S Wallis, C Mantell, *Physical and mental development of children with prenatal exposure to mercury from fish, Stage 1: Preliminary test at age 4*, report 3080, National Swedish Environmental Protection Board, 1986; T Kjellstrom, P Kennedy, S Wallis, A Stewart, L Friberg, B Lind, T Wutherspoon, C Mantell, *Physical and mental development of children with prenatal exposure to mercury from fish, Stage 2: Interviews and psychological tests at age 6*, report 3642, National Swedish Environmental Protection Board, 1989.

maternal hair mercury and 0.093 IQ points/ppb of mercury in cord blood. Those values are higher than those used in the US EPA study.

For this cost–benefit analysis, both sets of dose–response relationships were used. The US EPA study estimates were used for the core analysis, and the Trasande study values were used in a sensitivity analysis to give a higher bound of the potential impact.

Mercury levels in the Australian population

The only available Australian data on maternal blood mercury levels is from a study conducted in Perth and the south-west of Western Australia.[153]

That study found that mean maternal blood mercury levels were 0.83 µg/L; the highest value was 5.8 µg/L.

The US EPA has determined that the conversion of maternal blood mercury to maternal hair mercury occurs at a ratio of 1:250. Converting the maternal blood mercury levels in the Western Australian cohort to maternal hair mercury results in concentrations of 0.21 ppm (mean) and 1.5 ppm (maximum).

The Western Australian study found that 5% of women in the cohort had blood mercury levels above the no-effects level of 3.5 µg/L. The blood mercury was attributed to the consumption of fish and seafood. Those findings are consistent with other studies conducted overseas. The conclusion that all methylmercury exposure is due to fish and seafood consumption is also consistent with the findings of the most recent Australian Total Diet Survey.[154]

If the Western Australian results are applicable to the general Australian population, the loss of IQ and associated economic costs associated with mercury in Australia can be estimated.

From Table 22, the mercury levels in fish from various locations in Australia are similar. The Australian Total Diet Survey concludes that exposure to methylmercury in Australia is due almost entirely to the eating of fish and shellfish. It appears that the extrapolation of the Western Australian blood and hair mercury levels to the whole Australian population is a reasonable assumption.

There were 305,377 births in Australia in 2015.[155]

Assuming that 5% of women of childbearing age, as found in the Western Australian study, have blood mercury levels above the no-effects level of 3.5 µg/L, this translates to 15,269 children born in 2015 in Australia who may be affected by exposure to mercury.

Calculation of IQ losses in Australia

To calculate the loss of IQ related to maternal hair mercury, the following equation was applied:

$$\textit{Loss of IQ per child} = \textit{dose–response} \times \textit{maternal hair mercury concentration}$$

This is consistent with the approach used by the US EPA study.

Using this approach and applying Australian birthrates for 2015, the loss of IQ was calculated for four scenarios based on the US EPA study's dose–response relationship and the Transande study's dose–

[153] AL Hinwood, AC Callan, M Ramalingam, M Boyce, J Heyworth, P McCafferty, JO Odland, 'Cadmium, lead and mercury exposure in non-smoking pregnant women', *Environmental Research*, October 2013, 126:118–124.

[154] FSANZ, *Mercury in fish: advice on fish consumption*, FSANZ, Canberra, 2013.

[155] Australian Bureau of Statistics (ABS), *Births, Australia 2015*, cat. no. 3301.0, November 2016.

response relationships for the mean and maximum hair mercury levels estimated from the Western Australian study:

1. US EPA dose–response relationship (loss of 0.18 IQ points/ppm maternal hair mercury per child) and *mean* hair mercury levels (0.21 ppm)
2. US EPA dose–response relationship and *maximum* hair mercury levels (1.5 ppm)
3. Trasande dose–response relationship (a loss of 0.465 IQ points/ppm maternal hair mercury) and *mean* hair mercury levels (0.21 ppm)
4. Trasande dose–response relationship and *maximum* hair mercury levels (1.5 ppm).

Assuming a linear dose–response relationship above maternal blood mercury levels of 3.5 µg/L, the results of the risk calculations for the estimated number of affected children in 2015 in Australia are shown in Table 23.

Essentially, the table outlines the current expected annual loss of IQ points for Australia, given the current mercury levels in the population.

Table 23: Annual loss of IQ points in the Australian population due to maternal exposure to mercury

Scenario	Loss of IQ points
1. US EPA dose–response relationship and *mean* hair mercury levels	577
2. US EPA dose–response relationship and *maximum* hair mercury levels	4,123
3. Trasande dose–response relationship and *mean* hair mercury levels	1,491
4. Trasande dose–response relationship and *maximum* hair mercury levels	10,650

Source: Analysis by Toxikos Pty Ltd prepared for the 2015 analysis, updated to current population.

6.4.3 Valuation of loss of IQ

The loss of IQ in children has been valued as part of previous analyses of the impacts of mercury and other heavy metals.

In 2008, Spadaro and Rabl identified five estimates ranging from US$11,245 to US$22,300 per IQ point and concluded that US$18,000 per IQ point was a suitable value (all the values were in US$2005).[156] Converting this to Australian dollars and escalating by the Consumer Price Index to

[156] JV Spadaro, A Rabl, 'Global health impacts and costs due to mercury emissions', *Risk Analysis*, 2008, 28(3):603–613, www.arirabl.org/publications/spadarorabl-hg08-fig.pdf, at p. 609, cites the following estimates, which are all in US$1999 or US$2000:

- US$11,245 per IQ point: C Griffiths, A McGartland, M Miller, 'A comparison of the monetized impact of IQ decrements from mercury emissions', *Environmental Health Perspectives*, 2007, 115(6):841–847
- US$14,500 per IQ point: SD Grosse, TD Matte, J Schwartz, R Jackson, 'Economic gains resulting from the reduction in children's exposure to lead in the United States', *Environmental Health Perspectives*, 2002, 110(6):563–569
- US$15,000 per IQ point: T Muir, M Zegarac, 'Societal costs of exposure to toxic substances: economic and health costs of four case studies that are candidates for environmental causation', *Environmental Health Perspectives*, 2001, 109(Suppl. 6):885–903

obtain a A$2016 value gives a total of $30,030 per IQ point lost. This value is for the United States and so cannot be applied to Australia without further consideration.

6.4.4 Estimation of the value of IQ loss caused by mercury

Based on the value per IQ point lost and developing a dose–response formula, Spadaro and Rabl provided a 2008 estimate of the value of the harm caused by mercury of US$4,380 per kilogram of mercury released to the environment in the United States and a global estimate of US$1,500 per kilogram, assuming a threshold above which mercury levels have an impact on the child's IQ.[157]

Table 24: Spadaro and Rabl's estimate of harm caused per kilogram of mercury released into the environment (US$/kg 2008)

	United States	Global average
	US$/kg (2008)	
With threshold	$4,380	$1,500
Without threshold	$9,993	$3,400

Source: JV Spadaro, A Rabl, 'Global health impacts and costs due to mercury emissions', *Risk Analysis*, 2008, 28(3).

Spadaro and Rabl also proposed a formula for identifying the likely cost in other countries (referred to as 'benefit transfer').

The United States costs based on the IQ decrement are adjusted to other countries using the gross domestic product (GDP) per capita expressed as purchasing power parity (PPP) as a weighting factor:

$$C_i = C_{USA} \frac{(GDPppp / capita)_i}{(GDPppp / capita)_{USA}}$$

where C_i is a damage cost in a specific country and C_{USA} is the damage cost in the United States.

Using this formula, the value of mercury costs in Australia is A$5,017 per kilogram (A$2017, Table 25).

Table 25: Australian estimate of harm caused per kg of mercury (benefit transfer)

	Harm / kg mercury	
	US$ (2008)	A$ (2017)
With threshold	$2,028	$5,017
Without threshold	$4,598	$11,447

Source: Marsden Jacob analysis.

- US$16,500 per IQ point: G Rice, JK Hammitt, 'Economic valuation of human health benefits of controlling mercury emissions from US coal-fired power plants', in *Northeast States for Coordinated Air Use Management (NESCAUM)*, 2005, www.nescaum.org/topics/mercury.
- US$22,300 per IQ point: L Trasande, PJ Landrigan, C Schecter, 'Public health and economic consequences of methyl mercury toxicity to the developing brain', *Environmental Health Perspectives*, 2005, 113(5):590–596. (2005) indicate.

157 Spadaro & Rabl, 'Global health impacts and costs due to mercury emissions'.

6.4.5 Incorporating cardiovascular effects

Assessments of the health benefits of phasing down mercury have focused primarily on the loss of IQ in infants, which is associated with the exposure of pregnant women to mercury. However, mercury exposure has been associated with a range of other health effects, including effects on kidneys and cardiovascular effects. A lack of reliable dose–response relationships has meant that those other effects have not been included in the central analysis, but recent research (particularly by Giang and Selin in 2016[158]) indicates that it is feasible to quantify, in economic terms, the cardiovascular effects of mercury exposure. Based on the algorithms applied by Giang and Selin for the United States, an analysis of the annual effects of mercury exposure in Australia on fatal acute myocardial infarctions (heart attacks) yielded a preliminary estimate of about 400–500 deaths per year, or about 2% of all premature deaths due to coronary heart disease in Australia. This has an estimated cost of about $1.3 billion per year.

To reliably calculate the impacts of phasing down mercury on avoided acute myocardial infarctions, there needs to be a reasonable estimate of the relationship between changes in emissions and changes in exposure. That data is not available for Australia, and that is the main reason cardiovascular effects have not been included in the central analysis. Instead, we have drawn on data in Giang and Selin's paper. This provides an approximately 9:1 ratio of avoided cardiovascular health effects from reducing mercury emissions to avoided IQ health effects, as an indicative estimate of avoided cardiovascular health impacts in Australia from reducing mercury emissions.[159]

6.4.6 Incorporating an exposure time lag

In our analysis, we assumed that there is no time lag between reducing emissions and deposition and reducing exposure. There is some debate as to whether this is an appropriate approach, as in real-world ecosystem dynamics the responses of ecosystems to changes in mercury inputs can range from a few months to decades. Some analysts suggest that, because of this uncertainty, time lags that account for ecosystem and ocean response timescales need to be incorporated into any analysis of the benefits / avoided costs of reducing mercury.[160]

Introducing time lags raises more questions than it resolves from an economic and policy perspective, particularly about intergenerational impacts and the appropriate use of discount rates and analysis time frames. For example, the approach of the US EPA is generally not to introduce time lags.[161]

Nevertheless, consistent with the approach adopted by Giang and Selin, we adopted a 10-year exposure time lag in our sensitivity analysis when estimating both IQ and cardiovascular health benefits. We assumed the achievement of a full response to a change in emissions and deposition only after the lag time, and a linear increase in response throughout the lag period.

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158 A Giang, N Selin, 'Benefits of mercury controls for the United States', *Proceedings of the National Academy of Sciences of the United States of America*, 2016, 113(2):286–291.

159 A key difference in the assumptions we have applied in our analysis from those applied by Giang and Selin, is that whereas they have assumed a risk factor in all adults for acute coronary events per milligram of hair mercury concentration of 0.1 (based on equal risk for males and females), we have assumed a risk factor of only 0.05. This is consistent with the literature, which shows little or no correlation between mercury exposure and cardiovascular disease in females.

160 For example, OECD Working Party on Integrating Environmental and Economic Policies, *Economic assessments of the benefits of regulating mercury: a review*, SACAME workshop, 30–31 August 2017, Ottawa, Canada.

161 US EPA, *Regulatory impact analysis for the final mercury and air toxics standards*, US EPA, Washington DC, 2011.

6.4.7 Health sensitivity results

Two sensitivity scenarios were modelled:

- The high-value estimate assessed avoided health costs linked to both the IQ and cardiovascular impacts of mercury and assumed a 10-year lag between reduced emissions and reduced exposure.
- The low-value estimate assessed avoided health costs for the IQ impacts of mercury only and assumed a 10-year lag between reduced emissions and reduced exposure.

Taken together, these scenarios provided reasonable upper bound (Scenario 1) and lower bound (Scenario 2) estimates of the health benefits of phasing down mercury emissions under options 2, 3 and 5. The results are presented in Table 28.

Table 26: Present value of mercury prevented from entering the environment under sensitivity scenarios 1 and 2 ($ million)

Scenario	Present value of avoided health impacts ($ million)		
	Avoided IQ loss	Avoided cardiovascular impacts	Total
High-value estimate (IQ and cardiovascular impacts with time delay)			
Option 2	125.3	563.9	**689.2**
Option 3	127.7	574.7	**702.4**
Option 5	88.0	396.0	**484.0**
Low-value estimate (IQ impacts with time delay)			
Option 2	125.3	–	**125.3**
Option 3	127.7	–	**127.7**
Option 5	88.0	–	**88.0**
Central (IQ only, no time delay)			
Option 2	180.7	–	**180.7**
Option 3	183.9	–	**183.9**
Option 5	120.8	–	**120.8**

6.4.8 Conclusion

Human exposure to mercury occurs primarily through the ingestion of seafood and freshwater fish containing methylmercury. Although anthropogenic emissions of mercury tend not to be bioavailable, all forms of mercury can be transformed into methylmercury through aquatic processes.

Although mercury exposure has been associated with a range of health effects, including neurological effects, effects on the kidneys and cardiovascular effects, the loss of IQ in the population resulting from methylmercury intake by pregnant women is of primary concern, as there is a direct impact on the developing foetus *in utero*.

Previous studies have developed a benefit transfer methodology that, when applied to Australia, estimated the likely impact of mercury emissions on IQ loss at $5,017 per kilogram of mercury.

Based on the 9:1 ratio discussed above, we estimated the impact of mercury emissions on heart attacks in Australia at $22,578 per kilogram of mercury.

6.5 Quantifying reductions in the amount of mercury emitted

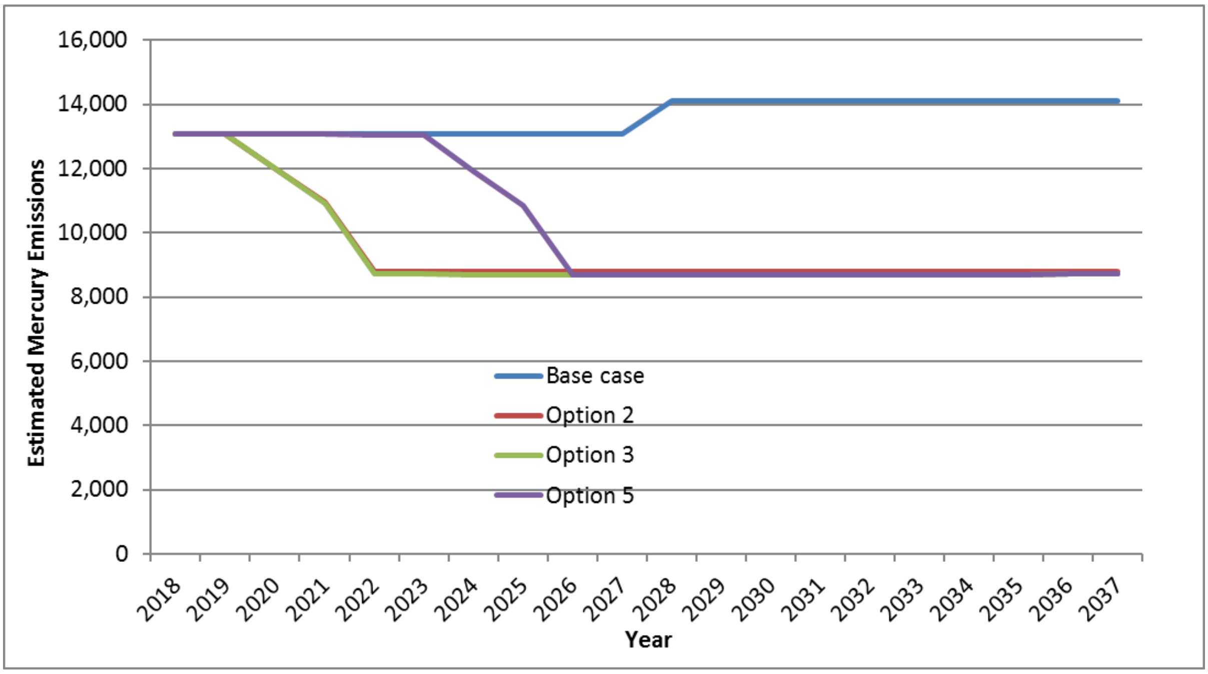
Base case

Under the base case (no ratification) option, it is expected that mercury emissions would remain steady in the short term and would continue to increase in the future as mercury-emitting sources are expanded and new sources are constructed.

Ratification

Under the phase-down options, it is expected that there would be a step change in mercury emissions in the short term, while emissions would be likely to remain stable in the long term because new sources in the future would be subject to stringent controls. The expected mercury emissions are shown in Figure 10. The base case remains steady until 2027, when it has been identified that new sources could be developed. As options 2 and 3 overlie each other initially, those options are not easily seen on the graph.

Figure 10: Expected mercury emissions under the base case and options 2, 3 and 5 (kilograms)



Note: The base case shows an increase in 2027 of 1,000 kilograms. This relates to a possible gold smelter that is included in the 'worst case' scenario. Under the 'most likely' scenario, the base case would be steady.

Source: Marsden Jacob analysis, 2017.

The total masses of mercury prevented from entering the environment are set out in Table 27, and the values of those savings are shown in Table 28.

For each of the options (2, 3 and 5), a low estimate of mercury saved is provided, based on the range of possible new facilities under Article 8 of the Minamata Convention.

Table 27: Total mass of mercury prevented from entering environment (kg/year)

Year number	1	2	3	4	5	6	7	8	9–18	19	20
Options	2018	2019	2020	2021	2022	2023	2024	2025	2026–2035	2036	2037
2	0	0	1,080	2,160	4,320	4,320	4,320	4,320	4,320	4,320	4,320
3	0	0	1,080	2,182	4,365	4,387	4,410	4,410	4,410	4,387	4,365
5	0	0	0	22	45	67	1,170	2,250	4,410	4,387	4,365

Table 28: Total value of mercury prevented from entering the environment ($ million)

Year number	1	2	3	4	5	6	7	8	9–18	19	20	Present value
Options	2018	2019	2020	2021	2022	2023	2024	2025	2026–2035	2036	2037	
2	0.00	0.00	5.42	10.84	21.68	21.68	21.68	21.68	21.68	21.68	21.68	**180.72**
3	0.00	0.00	5.42	10.95	21.90	22.01	22.13	22.13	22.13	22.01	21.90	**183.94**
5	0.00	0.00	0.00	0.11	0.23	0.34	5.87	11.29	22.13	22.01	21.90	**120.79**

6.6 Workplace safety benefits

A final potential benefit of ratification of the convention is a reduction in acute mercury exposure, such as through workplace accidents.

Ratification appears likely to reduce the exposure of some workers to mercury, such as by ending the use of mercury-containing pesticide by canegrowers and reducing the use of mercury vapour lamps. In contrast, there would potentially be a small increase in the number of workers employed in mercury disposal and mercury recycling.

Workers compensation data

In considering the cost of mercury and mercury compounds in workplace injuries and illness, Marsden Jacob sought workers compensation data from the National Data Set for Compensation-Based Statistics (NDS). The NDS contains records of accepted workers compensation claims, which are derived from state, territory and federal workers compensation authorities.

Within the NDS, incidents relating to mercury and mercury compounds can be identified, as all incidents are classified using the Type of Occurrence Classification System. The system uses four classifications to describe the type of injury or disease sustained by the worker and the way in which it was inflicted:

- nature of injury/disease
- bodily location of injury/disease
- mechanism of injury/disease
- agency.

The agency (also referred to as the 'breakdown agency') identifies the object, substance or circumstance that was principally involved in, or most closely associated with, the point at which things started to go wrong and which ultimately led to the most serious injury or disease.

There is a category within 'agency' for mercury and mercury compounds, which allows the ready identification of those incidents.

Due to the low number of incidents, Safe Work Australia was not able to provide an annual breakdown of incidents of compensation paid.[162]

However, over the period from 2000–01 to 2011–12, the total number of accepted claims was 59 and the total compensation paid was $687,167. Over the 11-year period, this equated to an average of 5.3 claims per year and an average value of compensation paid of $57,264.

Estimating the total value of workplace injuries and illnesses

Reliable data on the total cost of workplace injuries and illnesses in Australia is not available for each year, or by category. However, reasonable estimates can be derived by comparing the annual value of WorkCover payments with the total estimated cost of injury and illness reported by Safe Work Australia in *The cost of work-related injury and illness for Australian employers, workers, and the community, 2008–09.*

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[162] Due to confidentiality concerns.

The cost of work-related injury and disease to workers, their employers and the community for the 2008–09 financial year data was estimated to be $60.6 billion. This can be compared to the estimated workers compensation premiums paid by employers ($6.5 billion in the 2008–09 financial year).[163]

This indicates that, across all injuries, on average the total cost of injury and illness is 10 times the compensation paid.

Using this multiplier, the average total value of workplace injuries and illnesses relating to mercury and mercury compounds is $573,000 per year.[164]

Estimating the impact of ratifying the Minamata Convention on workplace injuries involving mercury

Given the opaque nature of the workers compensation data, it was not possible to reliably determine the impact that ratifying the convention would have on reducing workplace injuries and illnesses.

However, it appears likely that under the base case there would be some reduction in workplace incidents as imported mercury products are phased out.

It also appears reasonable to assume that Australia choosing to ratify the convention would reduce those incidents further, but the extent of that reduction is not easily determined. For this reason, Marsden Jacob modelled a 10% reduction, a 30% reduction and 60% reduction in workplace incidents attributable to ratifying the convention. Table 29 shows those scenarios and the resulting benefits.

The timing of the reduction of exposure would vary from one industry to another as the various articles of the convention take effect and as industry prepares for the implementation of each article. For simplicity, it was assumed that the benefit would commence in 2019.

Table 29: Reduction in incidence of work incidents involving mercury

Scenario	% reduction in incidents	Annual benefit (commencing 2019)	Present value (2019–2035) 7% discount rate
Low	10%	$62,470	$497,865
Medium	30%	$187,409	$1,493,595
High	60%	$374,818	$2,987,189

163 Safe Work Australia, *The cost of work-related injury and illness for Australian employers, workers, and the community, 2008–09*, p. 28.

164 This figure assumes that all compensation data is given in 2015 values.

Appendix A: Details of the options considered

Option 1: Base case

Under the base case, Australia chooses not to phase down mercury and does not ratify the Minamata Convention. While Australia is a signatory to the convention, that does not create any legal obligations if Australia does not ratify.

For clarity, we assumed that the base case had the following characteristics:

- No significant change in industry numbers would occur as a direct response to Australia not ratifying; that is, non-ratification would not lead to the development of new industries manufacturing mercury-based products or to mercury-processing facilities relocating to Australia.
- Existing plants would not change from their current processes or practices as a direct result of a non-ratification decision. We note that some plants may already have plans to reduce mercury usage or emissions; those are captured in Section 1 ('Industry costs') in both the base case and the phase-down options).

For many industries, the base case would involve minimal change from current circumstances. However, the convention coming into force and decisions by some key trading patterns in relation to ratification would affect Australia's ability to import mercury and mercury-added products in the future. The base case formed the basis for the identification of business-as-usual costs, which were used in the assessment of regulatory burden.

Under both the base case and the phase-down options, some other government policies may affect mercury emissions. For example, a planned review of the National Environment Protection Measure for the National Pollutant Inventory may have an impact on collecting and reporting mercury emissions.[165] However, given the status of this policy (consultation on a discussion paper), the impacts of the proposed National Clean Air Agreement have not been included in this cost–benefit analysis.

Options 2, 3 and 5: Phase-down of mercury

Under the three phase-down options, Australia will actively identify several measures to phase down mercury and will therefore be able to ratify the Minamata Convention. For the calculation of the cost–benefit analysis, we assumed a nominal start date for Australia's ratification on 1 January 2020.

The convention came into force generally on 16 August 2017. Once Australia becomes a party to the convention, it will be legally bound by the obligations in the convention.

Timing for meeting obligations is detailed in each of the articles of the convention. Some obligations apply immediately following the date of entry into force of the convention by a party, while others are required within a set period of that date.

Furthermore, in certain circumstances, exemptions that would extend (but not eliminate) specified phase-out time frames (for example, for trade in mercury in certain circumstances) may be permitted.

[165] Department of the Environment and Energy, *National Clean Air Agreement*, Australian Government, no date, www.environment.gov.au/protection/air-quality/national-clean-air-agreement.

The following assumptions were used to inform the phase-down options for this cost–benefit analysis:

- Imports of mercury to Australia would be restricted from 2020 onwards to permitted uses only. Trade consent would be agreed for the purposes of mercury use in the manufacture of mercury-containing pesticides from 2016 to 2020 only. **No exemptions would be sought**.
- All products listed in Annex A would be phased out in accordance with initial dates (by the end of 2020). This includes mercury vapour (HPMV) street lights, which would no longer be able to be imported after 2020, and the production of mercury-containing pesticides, which would be banned after 2020. **No exemptions would be sought under options 2 and 3. Under option 5, an exemption would be sought for mercury-based pesticides**.

Sub-options under the phase-down of mercury scenario

Under the ratification option, three sub-options were considered:

- Option 2—Australia takes the minimum actions required to comply with the Minamata Convention.
- Australia ratifies but undertakes two variations to the requirements of the convention:
  - Option 3—ratification, with additional encouraged interception and removal of waste amalgam from dental practices (an expansion of the Victoria's Dentists For Cleaner Water Program)
  - Option 5—ratification, with additional encouraged interception and removal of waste amalgam from dental practices and with delayed phase-out of mercury-containing pesticides, the manufacture of which is to cease by 2025, rather than 2020.

Considerations in developing the cost–benefit analysis

In developing and considering the options, Marsden Jacob identified some key considerations.

Impact of the convention on current arrangements

In assessing the base case (non-ratification), it is important to note that the option will differ from the current situation in several ways due to the impact of the convention entering into force. It is expected that the base case would vary from the current situation in the following ways:

- Trade in mercury would decline over time from 2017 onwards.
- The availability of mercury-added products for import would be reduced after 2020. Of the products listed in Annex A, Australia manufactures only dental amalgam. The availability of other mercury-added products[166] to the Australian market would therefore depend on decisions by trading partners to exempt certain products or to not ratify.

  Given that several significant markets have either ratified (the United States, the European Union and China) or intend to ratify, trading partners that manufacture these products would adapt their products to match the requirements of customers from countries that have ratified.

166 Such as certain batteries, switches and relays; various lighting products with mercury content exceeding set limits; all mercury vapour lights; cosmetics with mercury content above a set limit; pesticides, biocides and topical antiseptics; and various non-electrical measuring devices for which no mercury-free alternative is available.

Uncertainty in predicting future impacts

The exact outcome of ratifying the convention cannot be determined at this point due to the difficulties of predicting future industry options. This is considered in detail in Appendix B.

Appendix B: Risks and uncertainties

The exact outcome of ratifying the Minamata Convention cannot be determined at this point with certainty due to the difficulties of predicting future industry scenarios.

For example, to accurately estimate the costs and benefits of Article 8 of the Convention on one industry (such as coal-fired power generation), it is necessary to know:

- the number, timing and scale of the construction of (or upgrade of) industries covered by Annex D of the convention up to 2037
- the current legislative requirements (for example, for state environmental protection approvals) that are in place for facilities that do not operate in all jurisdictions, and the resulting costs and emissions levels
- the competitive interaction between affected industries (such as coal-fired power generation) and alternative technology (such as alternative generation sources).

To overcome this inherent difficulty, Marsden Jacob envisaged a likely outcome of the convention for each industry, based on detailed discussions with industry experts and government officials.

Two key areas that drive changes to both the costs and the benefits under the ‘worst case’ outcome compared to the ‘most likely’ case are discussed in detail below.

The points listed here relate to the nature and content of best available techniques (BAT) and best environmental practices (BEP) guidance under Article 8 and whether the pesticide currently used during sugarcane planting has an impact on germination rates.

6.6.1 BAT and BEP guidance under Article 8

Article 8, paragraph 4 of the convention specifies that:

> *For its new sources, each Party shall require the use of best available techniques and best environmental practices to control and, where feasible, reduce emissions, as soon as practicable but no later than five years after the date of entry into force of the Convention for that Party. A Party may use emission limit values that are consistent with the application of best available techniques.*

The guidance on BAT and BEP has been developed by a technical working group and was published by the Intergovernmental Negotiating Committee in 2016.[167] It was then agreed at the first Conference of the Parties in September 2017.[168]

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167 UNEP, *Guidance on best available techniques and best environmental practices: introduction*, 2016, www.mercuryconvention.org/Portals/11/documents/forms%20and%20guidance/English/BATBEP_introduction.pdf.

168 UNEP, *Guidance in relation to mercury emissions (article 8) referred to in paragraphs 8(a) and 8(b)*, 12 April 2017, http://unepmercurycop1.mediafrontier.ch/wp-content/uploads/2017/08/1_7_e_emissions.pdf.

Note that estimating the costs of guidance on BAT and BEP requires a prediction of the number of new facilities (or substantially modified facilities) that will be constructed in the next 20 years, as well as a simplifying assumption that state-based environmental approvals will not alter over that period.[169]

As discussed in detail in Section 5.1, new facilities (or substantial modifications of existing facilities) are considered quite unlikely for base metal smelting and cement clinker production. In addition, it appears likely that current approvals for waste incineration are set at a BAT and BEP level. For this reason, the uncertainty relates only to possible new facilities for gold smelting and coal-fired power generation.

Box 5: Timing for commencement of new facilities under Article 4 and Annex D

Article 4 states (emphasis added):

2. For the purposes of this Article:

> *(c) 'New source' means any relevant source within a category listed in Annex D, the construction or substantial modification of which is commenced at least one year after the date of:*
>
> > *(i) Entry into force of this Convention for the Party concerned; or*
> >
> > *(ii) Entry into force for the Party concerned of an amendment to Annex D where the source becomes subject to the provisions of this Convention only by virtue of that amendment;*

4. For its new sources, each Party shall require the use of best available techniques and best environmental practices to control and, where feasible, reduce emissions, as soon as practicable but no later than five years after the date of entry into force of the Convention for that Party. A Party may use emission limit values that are consistent with the application of best available techniques.

Our interpretation of Article 8 is that Australia could choose a starting date to apply the definition of 'new source'.

Using 1 January 2020 as the nominal date for ratification, the starting date for 'new sources' would need to be between 1 January 2021 (one year after ratification) and 31 December 2024 (five years after ratification).

If Australia chose a later date (such as the end of 2024), ratification would not impose tighter requirements on any new facilities that commenced construction during 2022, 2023 or 2024. Any facilities that commenced construction during that time would then be treated as 'existing facilities'.

Gold smelting

For gold smelting, the Minerals Council of Australia indicated that there may be interest in a new gold smelter or roaster in the next 20 years, but that this depends on location and metallurgy.[170]

169 Note that, if the BAT/BEP guidance is strict, that will impose additional costs on new facilities but not on existing facilities. That would create an incentive to continue to operate existing facilities for longer, rather than to invest in new facilities. This incentive would potentially delay the construction of new facilities and so could increase the level of mercury emissions (over the base case) in the short to medium term. Industry did not identify this perverse incentive during consultations. As noted below, there not expected to be new facilities in some industries and there is substantial uncertainty about the likely number of new facilities in other industries. For this reason, this potential for a perverse incentive is noted but is not considered quantitatively.

170 Pers. comm., 10 November 2017.

Under the 'most likely' outcome, it was determined that either no facilities would be constructed or the BAT and BEP guidance would not require any additional constraints beyond business-as-usual costs. This would result in no change in mercury emissions (that is, no mercury saved) and no additional costs.

Under the 'worst case' outcome, it was assumed that one new facility would be constructed in 2027 and that a Boliden Norzink plant would be installed to meet the requirements of the BAT and BEP guidance. The guidance describes the process as follows: [171]

> *The Boliden Norzink process (also called the Outotec chloride scrubber process or the Outotec BN process) removes elemental mercury from waste gases of primary ore smelters …*
>
> *The process takes place in a packed bed tower. Vaporous elemental mercury contained in the waste gas is oxidized by a water based scrubber solution of mercury(II) chloride …*

Based on academic references to the Boliden Norzink process, we estimated capital expenditure at $4.4 million and operating costs at $840,000 per year.[172,173]

The quantity of mercury captured due to BAT and BEP guidance would depend on the nature of the gold ore processed and the business-as-usual level of environmental legislation. For this reason, 1,000 kilograms of mercury per facility per year was used as an indicative figure only.

Note that these numbers ($4.4 million capital investment and 1,000 kilograms of mercury) are estimated without knowledge of the specifics of any location or business-as-usual costs arising from the environmental legislative requirements that would currently be applied.

Coal-fired power generation

Based on the coal-fired power generation industry's advice that it expects to be in compliance with the requirement to have emission limit values, ratification would have no impact on the mercury emitted from existing coal-fired power generators.

For new and substantially modified coal-fired power generation, the benefits would depend on the number of new (or substantially modified) plants built.

The Australian Energy Council has indicated that there is no interest in new coal-fired power stations in Australia.[174]

That view was supported by two energy analysts, who noted that industry participants and potential entrants are concerned that the cost of renewables has dropped sharply in recent years and that there is a risk that investors would be left with a stranded asset.

Both analysts noted that any new power stations would be fundamentally different from conventional coal-fired power stations and would use high-efficiency, low-emissions technology, carbon capture

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171 UNEP, *Guidance in relation to mercury emissions (article 8) referred to in paragraphs 8(a) and 8(b)*, p. 77.

172 UNEP, *Study on mercury sources and emissions, and analysis of cost and effectiveness of control measures: 'UNEP Paragraph 29 study*, https://wedocs.unep.org/bitstream/handle/20.500.11822/11713/Final_Report_Para29_5_Nov_2010.pdf.

173 European Commission, *Cost effectiveness of options for a global legally binding instrument on mercury—in the perspective of the European Union*, 2012 http://ec.europa.eu/environment/chemicals/mercury/pdf/Report-Support-Hg-Negotiations.pdf.

174 This was noted in the council's submission to the exposure draft of the RIS and reiterated in follow-up conversations.

and storage technology, or both. These forms of technology would deliver co-benefits from managing carbon dioxide as well as sulphur oxides, nitrogen oxides and mercury.

As Article 8 allows flexibility in meeting levels consistent with BAT and BEP guidance, we can assume negligible cost impacts even if a new coal-fired power station were built.

This outcome means that coal-fired generation is expected to have no cost and deliver no benefit in the form of mercury reductions.

Canegrowers

Some industry participants suggest that the popularity of the current mercury-containing pesticide (Shirtan Liquid Fungicide) is due to a belief that the chemical stimulates the more rapid germination of sugarcane relative to alternative products, particularly in adverse conditions (such as cold weather). Crop Care reportedly spoke with researchers who estimated that each year around 10% to 20% of the sugarcane crop planted is at risk due to poor conditions and that it is under those conditions that growers believe the mercury-containing pesticide is advantageous. Crop Care estimated that the risk to crops might be realised 30% of the time (if the mercury-containing pesticide were not used), which equates to 3,150 hectares. Where crops are damaged, the most likely response is to replant the crop at a cost of $1,000 to $1,500 per hectare. This calculation would value the loss of Shirtan Liquid Fungicide at $3,937,500 per year. However, there is no published scientific information available that supports this belief about the stimulation of germination, which appears to contradict published data (see Figure 6 on page 44). Given the uncertain nature of this value, it was not included under the 'most likely' case assessment and was included only in the 'worst case' outcome.

Results for all scenarios and options

		Ratification—minimum requirements Option 2			Ratification with dental amalgam waste program Option 3			Ratification with exemption of Shirtan to 2025 Option 5		
Stakeholder	Element	Likely case	Best case	Worst case	Likely case	Best case	Worst case	Likely case	Best case	Worst case
Costs		($ million)			($ million)			($ million)		
Government	Article 13—Financial contributions	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1	$1.1
	Department of the Environment and Energy	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4
	Other	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4	$2.4
Industry	Article 8—Air emissions	$0.0	$0.0	$5.6	$0.0	$0.0	$5.6	$0.0	$0.0	$5.6
	Cane growers	$23.4	$0.9	$62.6	$23.4	$0.9	$62.6	$15.0	$0.4	$29.7
	Dental practices	$0.0	$0.0	$0.0	$5.3	$15.9	$1.8	$5.3	$15.9	$1.8
	Public lighting	$20.0	$15.9	$0.0	$20.0	$15.9	$0.0	$20.0	$15.9	$0.0
	Oil and gas	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Benefits/avoided costs		($ million)			($ million)			($ million)		
Health outcomes	Reduction in mercury released	$180.7	$689.2	$125.3	$183.9	$702.6	$127.7	$120.8	$484.2	$88.0
	Reduced health and safety costs	$1.2	$2.5	$0.4	$1.2	$2.5	$0.4	$1.2	$2.5	$0.4
Environmental outcomes	Carbon savings (public lighting)	$5.3	$5.3	$0.0	$5.3	$5.3	$0.0	$5.3	$5.3	$0.0
	Energy savings (public lighting)	$19.6	$19.6	$0.0	$19.6	$19.6	$0.0	$19.6	$19.6	$0.0
	Environmental benefits	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified
Totals	**Total cost**	**$49.2**	**$22.6**	**$74.0**	**$54.5**	**$22.6**	**$75.8**	**$46.1**	**$38.0**	**$42.9**
	Total benefit	**$206.9**	**$716.6**	**$125.7**	**$210.1**	**$714.1**	**$128.1**	**$147.0**	**$511.6**	**$88.4**
	Net benefits	**$157.7**	**$694.0**	**$51.7**	**$155.7**	**$691.5**	**$52.4**	**$100.9**	**$473.6**	**$45.6**
	Benefit:cost ratio	**4.2**	**31.7**	**1.7**	**3.9**	**31.6**	**1.7**	**3.2**	**13.5**	**2.1**

Appendix C: Cost–benefit analysis and regulatory burden measurement framework

For this engagement, Marsden Jacob undertook a cost–benefit analysis and a regulatory burden measurement (RBM) consistent with Australian Government policy.

The cost–benefit analysis considered the expected cost impacts on, and benefits to, business, government and the wider community that would arise from ratifying or not ratifying the Minamata Convention, as well as identifying and assessing the costs and benefits to human health and the environment. The final cost–benefit analysis identified the net present value of costs and benefits over 20 years and the distribution of costs and benefits. It included several sensitivity analyses.

The RBM focused on quantifying the regulatory burden for industry (and government-owned corporations, as applicable) only and consisted of a simple average annual cost over a 10-year period.

The framework and process used for the cost–benefit analysis and RBM are briefly outlined in this appendix.

Cost–benefit analysis

The cost–benefit analysis was conducted in line with guidance published in July 2016 by the Department of the Prime Minister and Cabinet.[175]

The analysis sought to determine the incremental impact of the ratification option compared to the base case (non-ratification) option. To do this, we identified the range of impacts accruing to categories of stakeholders and then compared the net present values of the two options.

Stakeholder groups

We classified costs and benefits under the groupings set out in Table 30.

[175] Department of the Prime minister and Cabinet, *Cost benefit analysis: guidance note*, February 2016, www.pmc.gov.au/resource-centre/regulation/cost-benefit-analysis-guidance-note.

Table 30: Summary of costs and benefits

Stakeholder	Base case (non-ratification)	Ratification prior to 2016
Costs		
Government	As per current costs	Costs associated with meeting ratification: ▪ development of guidelines ▪ financial resources required and mechanisms ▪ regulation, compliance costs. Changes to ongoing regulation, compliance costs.
Industry	As per current costs but with potential for trade-related measures	Costs associated with meeting ratification: ▪ increased costs to implement phase-out by 2020 of mercury-added products ▪ costs for new and existing point sources (e.g. gold production and coal-fired power). Changes to ongoing costs (and revenues) because of ratification.
Benefits/avoided costs		
Health outcomes	Health outcomes consistent with current trends/experience but with some improvement due to other countries' decisions to ratify	Potential for improved health outcomes within Australia as a direct result of changes made by Australia.
Environmental outcomes	Environmental outcomes consistent with current trends/experience but with some improvement due to other countries' decisions to ratify	Potential for improved environmental outcomes within Australia as a direct result of changes made by Australia.

Cost types

When considering cost impacts for both business and government, Marsden Jacob sought to identify 'set-up costs' and 'changeover costs' separately from ongoing costs. For clarity, we used the following definitions:

- **Changeover costs** are the costs of transitioning to the new requirements in capital costs, staff time, management time and consultant fees per year during the changeover period.
- **Ongoing costs** are costs in staff time, management time and consultant fees per year.

Changeover costs are likely to appear as an increase in costs occurred in Year 1 but may also appear later in the study period as certain aspects of the convention come into force after a period of time. The costs attributable to ratification are those changeover costs that would not have occurred in the absence of ratification or would otherwise have been brought forward in time as a result of ratification.

Ongoing costs appear as the annual cost of compliance from Year 2 onwards (under the convention). To inform an understanding of ongoing costs attributable to the convention, we sought information from industry and government as to:

- **current costs**—what are the costs of compliance with the current regulations, given as average costs in terms of staff time, management time and consultant fees per year?

- **future costs** (absent the convention)—if the convention is not ratified, are current costs a good estimate of future costs? (Note that these may be the same as the current costs, or future projections based on current costs.)

Based on the above definitions, we established the costs for the first year and subsequent years of the study as follows:

First year cost impact = $\boxed{\text{changeover costs}}$ + $\boxed{\text{ongoing costs}}$ – $\boxed{\text{current costs}}$

Ongoing cost impact = $\boxed{\text{ongoing costs}}$ – $\boxed{\text{future costs (absent the convention)}}$

Approach to estimating the cost of staff time

The staff time costs identified in this assessment tended to be portions of an employee or one to two employees at the most. For this reason, in estimating the cost of staff time the approach used was to focus on the 'marginal cost' of staff time.

Using this approach, we considered the staff salary and on-costs as well as overheads that are directly linked to an individual staff member (such as the costs of telephones, computers and cars). This approach ignored broader corporate overheads such as building costs and corporate functions such as human resources and finance on the basis that those costs would not be affected by the change in a portion of an employee or individual employees.

As the convention affects a broad range of industries and government agencies, the likely costs will vary from one industry to another. Unless an industry indicated otherwise, an assumed annual cost of $100,000 per full-time employee (FTE) was used. The only variations to this value were for the Department of the Environment and Energy, for which it was assumed that the cost of two FTEs was $250,000 per year.

Benefit types

Where applicable, benefits were categorised using the same terminologies that applied for costs (that is, changeover benefits and ongoing benefits). However, benefits are more likely to appear as 'avoided costs' in the phase-down options or as 'avoided losses'. Health and environmental benefits lend themselves to this type of classification.

Discount rates

The costs and benefits from ratification are presented as net present values over the 20-year study period.

Consistent with Office of Best Practice Regulation requirements and guidance, we applied a few discount rates that reflected the time value of money and the opportunity cost for investment (in the case of business costs).

An annual real discount rate of 7% was used as the standard discount rate. In addition, we performed sensitivity analyses based on real discount rates of 3% and 10%.

Sensitivity analysis

Several of the inputs into the modelling are uncertain, so we performed sensitivity analyses by identifying an 'optimistic' and a 'pessimistic' estimate of each input. In addition, if there were one or two variables that dominated the cost–benefit outcome, we considered a sensitivity analysis of those individual inputs.

Regulatory burden measurement

RBM was conducted in line with guidance[176] and focused only on private-sector costs and the costs of government-owned corporations.

The RBM values are provided as a simple average of costs to industry over the first 10-year period and are disaggregated by cost type:

- **Administrative compliance** costs are costs that are primarily driven by the need to demonstrate compliance with the convention, such as through annual reporting.
- **Substantive compliance costs** are directly attributable to ratification and fall outside of the usual business costs. These costs may include the capital costs of plant upgrades as well as operational costs from process changes or additional staff training.
- **Delay costs** include the time taken for the preparation of applications (referred to as 'application delay') and the time taken for approval (referred to as 'approval delay'). Estimating the cost savings from removing delays requires a strong understanding of the realistically achievable time frames, the likely delays that could be avoided, and the value (potential cost) of any avoidable delay.

RBM focuses on costs that are imposed on industry that would not otherwise be incurred. Costs from actions that industry would undertake anyway or that are requirements of existing legislation were considered 'business as usual' costs and were excluded.

[176] Department of the Prime Minister and Cabinet, *Regulatory Burden Measurement Framework: guidance note*.

Appendix D: Industry consultation

Overview

Extensive consultation with industry was undertaken in the development of the cost–benefit analysis. In developing the original analysis, Marsden Jacob reviewed submissions made to the Department of the Environment's public consultation process, which took place between March and June 2014, and subsequently conducted a series of targeted discussions in which clarification on specific matters was sought.

The department published an exposure draft of the final Regulation Impact Statement (RIS)[177] as well as the original cost–benefit analysis[178] in December 2016 and invited public comments on the documents by March 2017. Submissions provided in response to the exposure draft were considered in the update of the cost–benefit analysis and in targeted discussions with stakeholders that had provided submissions.

Summaries of the consultations by the department and the discussions conducted by Marsden Jacob are provided below.

Public consultation by the Department of the Environment

In 2014, the department undertook a public consultation process that sought comment on each of the key articles of the Minamata Convention.[179]

A consultation paper was published in March 2014, and submissions were invited by 30 June 2014.[180]

The consultation paper highlighted the obligations of the convention that would require action if Australia were to become a party by ratifying the convention. Comments were sought from all interested stakeholders on the impacts on Australia of meeting the obligations of the convention.

Fourteen public submissions were received in response to the consultation paper and were reviewed for the development of the original cost–benefit analysis.

In December 2016, the department released the exposure draft of the final RIS and the cost–benefit analysis. The exposure draft recommended the ratification of the convention and sought further views on the impacts of Australia meeting the obligations of the convention.

Public submissions were received from 22 stakeholders, and a further seven stakeholders provided confidential submissions. Each of the submissions was reviewed to establish whether inputs to the original cost–benefit analysis required updates.

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177 Department of the Environment, *National phase down of mercury: Ratification of the Minamata Convention on Mercury: final Regulation Impact Statement: exposure draft*, Australian Government, December 2016, www.environment.gov.au/system/files/consultations/4068cac4-a2ba-4036-a9e0-7bdee4f558fd/files/minamata-mercury-ris-dec-2016.pdf.

178 Marsden Jacob Associates, *Final report: Costs and benefits of Australia phasing-down mercury*, report prepared for the Department of the Environment, Australian Government, May 2015, www.environment.gov.au/system/files/consultations/4068cac4-a2ba-4036-a9e0-7bdee4f558fd/files/final-report-cost-benefits-mercury.pdf.

179 Department of the Environment and Energy, *The Minamata Convention: a response to a global concern*, Australian Government, no date, www.environment.gov.au/protection/chemicals-management/mercury

180 Department of the Environment and Energy, *Invitation to comment on the proposal for Australia to ratify the Minamata Convention on Mercury*, Australian Government, March 2014, www.environment.gov.au/system/files/pages/6f253b28-f22f-4002-92fe-6f9824d531b6/files/minamata-convention-invitation-comment.pdf.

Follow-up consultation for the development of the cost–benefit analysis

In the preparation of the original cost–benefit analysis and subsequently the update of the analysis, Marsden Jacob held targeted discussions with industry stakeholders to inform the development of the industry impact analysis. For the update of the cost–benefit analysis, discussions were undertaken only where stakeholder submissions indicated that values used in the analysis required updating.

Table 31 lists the organisations and individuals with which discussions were held and summarises the general focus of the discussions. Discussions were also held with organisations that provided confidential submissions; those organisations are not listed in the table.

Table 31: Organisations consulted in targeted follow-up discussions

Organisation consulted	Topic	Original cost–benefit analysis	Updated cost–benefit analysis
Minerals Council	Mining—Article 8, nonferrous metals and coal	✓	✓
Cement Industry Federation	Cement industry and Article 8	✓	–
Energy Supply Association	Article 8—air emissions	✓	–
Aluminium Council	Article 8—air emissions	✓	–
Mount Isa Mines Limited	Article 8—air emissions	–	✓
Australian Energy Council	Article 8—air emissions	–	✓
Dr Peter Nelson, Professor at Macquarie University	Article 8—air emissions	–	✓
Queensland Canegrowers Organisation (Canegrowers)	Shirtan fungicide and alternatives	✓	✓
Crop Care	Shirtan and alternatives	✓	✓
Alpha Chemicals	Shirtan and alternatives	✓	✓
National Farmers Federation	Shirtan and alternatives	–	✓
NOPSEMA	Mercury in petroleum and gas	✓	–
Australian Petroleum Production and Exploration Association	Mercury in petroleum and gas	✓	–
Western Australian Department of Mines and Petroleum	Mercury in petroleum and gas	✓	–
Western Australian Department of Health	Data on mercury in people	✓	–
Western Australian Department of Environmental Regulation	Data on mercury in environment	✓	–
Safe Work Australia	Data on workers compensation claims relating to mercury	✓	–
Western Australian Water Corporation	Mercury in sewerage and wastewater treatment plant sludge	✓	–
EcoCycle	Mercury sources and recycling	✓	–

Organisation consulted	Topic	Original cost–benefit analysis	Updated cost–benefit analysis
Southern Dental Industries (SDI Limited)	Impact of reduced mercury imports on dental amalgam and use of recycled amalgam	✓	✓
Australian Dental Association	Use of mercury in dental amalgam and mercury separator costs	✓	–
Australian Dental Industry Association	Use of mercury in dental amalgam and mercury separator costs	✓	✓
Ironbark Sustainability	Quantum of mercury vapour street lights in Australia and the status of current replacement programs	✓	–
Energex	Mercury vapour street lights, replacement programs and lamp distributors	✓	✓ (Energex and Ergon)
Gerald Lighting	Sales of mercury vapour street lights and future demand	✓	–
Southern Sydney Region of Councils	Mercury vapour street lights, replacement programs and lamp distributors	–	✓
Lighting Council Australia	Mercury vapour lamps	–	✓
Contract Resources	Mercury waste disposal	–	✓
Queensland Department of Environment and Heritage Protection	Data on mercury in the environment	✓	–
Queensland Department of Science, Information Technology, Innovation and the Arts	Data on mercury in the environment	✓	–
CSIRO	Data on mercury in the environment	✓	–
National Toxics Network	Health impacts of mercury	–	✓

Acronyms and abbreviations

ADA	Australian Dental Association
ADIA	Australian Dental Industry Association
ALARP	as low as reasonably practicable
ANZECC	Australian and New Zealand Environment and Conservation Council
APVMA	Australian Pesticides and Veterinary Medicines Authority
ARTG	Australian Register of Therapeutic Goods
BAT	best available techniques
BCR	benefit:cost ratio
BEP	best environmental practices
CFL	compact fluorescent lamp
DIBP	Department of Immigration and Border Protection
ESAA	Electricity Supply Association of Australia
FSANZ	Food Standards Australia New Zealand
FTE	full-time equivalent
HELE	high-efficiency, low-emissions
HPMV	high-pressure mercury vapour
IPWEA	Institute of Public Works Engineering Australasia
IQ	intelligence quotient
LED	light-emitting diode
LFL	linear fluorescent lamp
LNG	liquefied natural gas
MEMC	methoxyethylmercuric chloride
MW	megawatt
NDS	National Data Set for Compensation-Based Statistics
NEM	National Electricity Market

NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NPV	net present value
OECD	Organisation for Economic Co-operation and Development
PV	present value
RBM	regulatory burden measurement
RIS	regulation impact statement
TGA	Therapeutic Goods Administration
UNEP	United Nations Environment Programme
US EPA	United States Environmental Protection Agency
W	watt