Reducing Emissions from Non-Road Spark Ignition Engines and Equipment
Consultation Regulation Impact Statement
Appendix 4

Final report to

Department of the Environment, Water, Heritage and the Arts

COST BENEFIT ANALYSIS OF OPTIONS TO MANAGE EMISSIONS FROM SELECTED NON-ROAD ENGINES: ADDITIONAL SCENARIOS

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LIST OF ACRONYMS

BAU	Business as usual
CO	Carbon monoxide
CO_2	Carbon dioxide
DEWHA	Department of the Environment, Water, Heritage and the Arts
Grd-1	Gardening equipment scenario one
Grd-2	Gardening equipment scenario two
Grd-1a	Gardening equipment scenario one a
Grd-2a	Gardening equipment scenario two a
HC	Hydrocarbon
MMA	McLennan Magasanik Associates
NPV	Net Present Value
NEPM	National Environment Protection Measure
OB-1	Marine outboard scenario one
OB-2	Marine outboard scenario two
OB-3	Marine outboard scenario three
OB-4	Marine outboard scenario four
OB-1a	Marine outboard scenario one a
OB-2a	Marine outboard scenario two a
PM	Particulate matter (subscripts indicate the PM size in microns (e.g. PM_{10} indicates particulate matter smaller

	than 10 µm)
PWC	Personal watercraft
PWC-1	Personal watercraft scenario one
PWC-2	Personal watercraft scenario two
PWC-3	Personal watercraft scenario three
PWC-4	Personal watercraft scenario four
PWC-1a	Personal watercraft scenario three a
PWC-2a	Personal watercraft scenario four a
NOx	Oxides of nitrogen
US EPA	United States Environment Protection Agency

EXECUTIVE SUMMARY

In 2008, the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA), on behalf of the Environment Protection and Heritage Council (EPHC), commissioned McLennan Magasanik Associates (MMA) to develop a cost benefit analysis of options for reducing air pollutant emissions from selected non-road engines. That report shall be referred to as "the original report" hereinafter. The current report considers two new scenarios developed through consultation with industry and other stakeholders. The implementation timetable assessed in this report begins in 2012 and hence the scenarios are most readily compared to scenarios 1 and 2 from the original report (scenarios 3 and 4 of the original report considered introduction beginning in 2010).

The emission standards assessed in the original report were based on United States Environmental Protection Agency (US EPA) emission standards contained within their proposed rule, which was released for stakeholder comment in 2007. Following stakeholder comment, the US EPA established new emission standards for selected engine classes and evaporative emissions standards for all engine classes in their final rule, which was promulgated in October 2008.

The scenarios modelled in this report are described in Table 1-1 below. A detailed breakdown of the costs is shown in Table 1-2 under the same inflation rate, nominal interest rate, health costs, fuel costs and service costs used in the original report. Table 1-2 also shows modelling results from the original report to aid comparison.

Table 1-1 Policy scenarios modelled in the current report

Name	Scenario description
OB-1a	US 2010 outboard exhaust and evaporative emission standards from the US EPA final rule implemented in Australia in 2012.
OB-2a	US 2006 outboard exhaust emission standards from the US EPA final rule implemented in Australia in 2012, and US 2010 exhaust and evaporative emissions standards implemented in Australia in 2015.
PWC-1a	US 2010 personal water craft exhaust and evaporative emission standards from the US EPA final rule implemented in Australia in 2012.
PWC-2a	US 2006 personal water craft exhaust emission standards implemented in Australia in 2012, and US 2010 exhaust and evaporative emissions standards from the US EPA final rule implemented in Australia in 2015.
Grd-1a[1]	US Phase 2 gardening equipment exhaust and US EPA final rule evaporative emission standards implemented in Australia in 2012.
Grd-2a[1]	US Phase 2 gardening equipment emissions standards implemented in Australia in 2012 and US gardening equipment evaporative emission standards from final rule implemented in Australia in 2015.

1 For gardening equipment, only avoided emissions from lawn mowers, hedge trimmers, brush cutters and hand held blowers were assessed. Furthermore, due to data limitations, only the effects of implementing US Phase 2 standards were considered, ignoring the effects of Phase 3 regulations scheduled for introduction in 2011/12.

Table 1-2 Detailed breakdown of net present value in for engines and fuel systems sold up to 2030 of costs for all scenarios modelled ($2008m)

Option	Scenario name	Service costs	Expenditure costs	Fuel costs	Health costs	Total costs	NPV
BAU	OB-BAU	2,606	4,873	3,938	3,544	14,961	-
	PWC-BAU	97	316	281	139	834	-
	Grd-BAU	1,610	7,818	7,203	1,713	18,344	-
Commonwealth regulation scenarios for US EPA proposed rule standards	OB-1	2,458	4,624	3,451	2,312	12,846	2,115
	OB-2	2,462	4,619	3,445	2,304	12,829	2,132
	OB-3	2,422	4,559	3,358	2,072	12,412	2,549
	OB-4	2,425	4,554	3,352	2,065	12,396	2,565
	PWC-1	92	307	248	85	732	101
	PWC-2	92	307	247	84	730	103
	PWC-3	91	305	243	76	715	119
	PWC-4	91	305	242	75	713	121
	Grd-1	1,671	7,980	6,773	1,272	17,695	648
	Grd-2	1,680	8,010	6,718	1,215	17,623	721
Industry agreement scenarios for US EPA proposed rule standards	OB-5	2,501	4,731	3,680	2,853	13,766	1,195
	OB-6	2,557	4,811	3,811	3,202	14,381	580
Final US EPA rule standards scenarios	OB-1a	2,461	4,635	3,441	2,221	12,759	2,202
	OB-2a	2,457	4,639	3,451	2,246	12,793	2,167
	PWC-1a	92	308	251	83	734	99
	PWC-2a	92	307	252	85	737	97
	Grd-1a	1,671	7,997	6,773	1,212	17,653	691
	Grd-2a	1,671	7,993	6,773	1,223	17,659	685

For outboard engines, the net present values (NPV) of the scenarios modelled in this report (OB-1a and OB-2a) are lower than the scenarios where US EPA 2009 standards are implemented in 2010 (OB-3 and OB-4 from the original report), primarily reflecting the later starting date. However, they are higher than scenarios OB-1 and OB-2, primarily reflecting the inclusion of the evaporative standards. This is also the case for the gardening equipment scenarios, where the NPV of scenarios Grd-1a and Grd-1b are higher than those for Grd-1, but lower than those for Grd-2.

For personal water craft (PWC) the NPV of the two new scenarios are lower than those for any of the scenarios modelled in the original report. This is because the exhaust emissions standards used in scenarios PWC-1a and PWC-2a (see Error! Reference source not found.) are slightly more relaxed than those considered in the original report and one engine model that was disallowed under the previous standards is allowed under the new standards. This engine was the most powerful model on the stock list used in this analysis and hence has the highest fuel consumption and service costs. The increased fuel consumption, higher service costs, changes in overall emissions and increased costs of compliance to meet the evaporative standards are larger than the reduction in health costs resulting from the reduction in hydrocarbon evaporative emissions. If this engine is excluded from the stock list, however, the NPV of scenarios PWC-1a and PWC-2a are marginally higher than PWC-1 and PWC-2. This issue highlights the sensitivity of this analysis to the limited size of the stock list for PWCs, which makes the analysis sensitive to the characteristics of each engine. The analysis for outboard engines is far less sensitive to the characteristics of individual engines as a result of the relatively large number of engines included in the outboard stock list.[2]

The US EPA exhaust emission standards for outboard engines and PWC, proposed for introduction in 2012 into Australia and considered in this report are slightly less stringent than those considered in the original report. An assessment of the stock list for PWCs in this report shows that one model that did not comply with the proposed rule standards complies with the final rule standards. For outboard engines, six engines that did not previously comply are compliant with the new standards, and one engine is non-compliant with the final rule standards was compliant with the proposed rule standards. However, this does not have a significant impact on emissions and associated health costs.

The difference in the NPV of scenarios 1a and 2a are shown in Table 1-3 and the NPV of additional expenditure on fuel systems and health cost savings arising from the introduction of evaporative emissions standards are shown in Table 1-4. The Tables show that, for all engine classes, the early adoption of exhaust and evaporative emission standards results in a significant net benefit, with avoided health costs being in the order of five times any additional expenditure needed to comply with the standards.

Table 1-3 Difference between scenarios 1a and 2a for each engine class

Engine class	Difference between scenario 1a and 2a ($2008m)	Percentage Increase in NPV between scenario 1a and 2a
Outboard Engines	35	1.6
Personal Water Craft	2	2.5
Gardening Equipment	7	1.0

Table 1-4 NPV of additional expenditure on fuel systems and health cost savings arising from the introduction of evaporative emissions standards ($2008)

Scenario	Additional expenditure on fuel systems	Health cost savings
OB-1a	17.7	94.1
OB-2a	13.6	79.2
PWC-1a	0.3	1.2
PWC-2a	0.2	1.0
Grd-1a	17.3	60.1
Grd-2a	12.6	49.4

[2] 237 engines are included in the outboard engine stock list while 20 are included in the PWC stock list.

Table 1-5 shows the change in the NPV for implementing US 2010 exhaust and evaporative emission standards in Australia for various years. These scenarios are comparable to scenarios 1a described above, but with different implementation years.

Delaying the introduction of emissions standards results in a reduction in NPV of between $274m and $209m per annum over the 2010 – 2016 period.

Table 1-5 NPVs of implementing US 2010 exhaust and evaporative emission standards in Australia in various years

Start year	NPV				
	OB	PWC	GRD	Total	Reduction
2010	2,641	117	768	3,526	-
2011	2,414	108	729	3,252	274
2012	2,201	99	692	2,992	259
2013	2,002	91	653	2,747	246
2014	1,815	84	615	2,514	233
2015	1,640	77	576	2,294	221
2016	1,476	70	538	2,085	209

1 INTRODUCTION

Non-road engines such as those used in gardening equipment, lawn mowers and outboard motors, have been shown to be significant contributors to urban air pollution. This is because they are utilised in large numbers and are not subject to the degree of pollution control regulation that exists for engines used in on-road vehicles. Many continue to be powered by highly-polluting two stroke carburetted engines that do not comply with international standards. For example, older style outboard engines that do not comply with United States Environmental Protection Agency (US EPA) 2006 emission limits are likely to emit around 10 times the amount of key pollutants, when compared against compliant engines.

In 2008, the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA), on behalf of the Environment Protection and Heritage Council (EPHC), commissioned McLennan Magasanik Associates (MMA) to develop a cost benefit analysis of policy options for reducing emissions from selected non-road engines. The cost benefit analysis report is a key input to the development of a regulatory impact statement (RIS), commissioned by EPHC, which will assess a range of options to reduce emissions from non-road spark ignition engines and equipment. That report shall be referred to as "the original report" hereinafter.

The emissions standards assessed in the original report were based on those contained within the US EPA proposed rule, which was released in May 2007 (United States Environmental Protection Agency, 2007). Following stakeholder consultation on the proposed rule, the US EPA developed their final rule in October 2008, which includes new exhaust emission standards for marine outboard engines and personal watercraft, to be introduced in 2010 (US 2010 exhaust standards). The final rule also includes evaporative emission standards for all engine classes over a similar time period (United States Environmental Protection Agency, 2008b).

Following discussion on the RIS between governments and industry, representation was made by some industry members to change the implementation timetables assessed in the original report. The current report explores two further scenarios which incorporate the new US EPA standards and two alternative implementation timetables.

2 BACKGROUND

The background to this report is covered in the original report and the reader is referred to that report for details. As an extension report, the analysis conducted in the original report has been duplicated as closely as possible to aid in comparison with the results contained in the original report. This section presents the scenarios modelled in this analysis. These are presented in Table 2-1.

Table 2-1 Policy scenarios modelled in the current report

Name	Scenario description
OB-1a	US 2010 outboard exhaust and evaporative emission standards from the US EPA final rule implemented in Australia in 2012.
OB-2a	US 2006 outboard exhaust emission standards implemented in Australia in 2012, and US 2010 exhaust and evaporative emission standards from the US EPA final rule implemented in Australia in 2015.
PWC-1a	US 2010 personal water craft exhaust and evaporative emission standards from the US EPA final rule implemented in Australia in 2012.
PWC-2a	US 2006 personal water craft exhaust emission standards implemented in Australia in 2012, and US 2010 exhaust and evaporative emission standards from the US EPA final rule implemented in Australia in 2015.
Grd-1a[3]	US Phase 2 gardening equipment exhaust and US EPA final rule evaporative emission standards implemented in Australia in 2012.
Grd-2a[3]	US Phase 2 gardening equipment emission standards implemented in Australia in 2012 and US gardening equipment evaporative emission standards implemented in Australia in 2015.

The US EPA final rule includes new exhaust and evaporative emissions standards that were not assessed in the original report. The final rule also includes evaporative and emission standards for stern drive and inboard engines and equipment. Standards contained within the final rule of October 2008, and how these differ from those within the proposed rule of May 2007, are described in Appendix B.

The original report considered voluntary industry regulation, National Environment Protection Measure (NEPM) and Commonwealth legislation scenarios. Establishing national emission standards under a NEPM will require additional time, when compared against Commonwealth legislation, for jurisdictions to develop appropriate regulations. Therefore, the costs and benefits of delaying the implementation of emission standards from one to five years were assessed.

[3] For gardening equipment, only avoided emissions from lawn mowers, hedge trimmers, brush cutters and hand held blowers were assessed. Furthermore, due to data limitations, only the effects of implementing US Phase 2 standards were considered, ignoring the effects of Phase 3 regulations scheduled for introduction in 2011/12.

3 APPROACH AND MODEL DESCRIPTION

The modelling conducted in this work follows that of the original report. The reader is referred to the original report for a detailed description of the modelling method. This section is limited to describing the methods, data and assumptions used in incorporating exhaust and evaporative emissions standards from the US EPA final rule (United States Environmental Protection Agency, 2008b). This modelling does not consider the effects of averaging, banking and trading (ABT), or delaying the standards until 2013 for small businesses, which are components of the final rule. Therefore, the costs and benefits assessed in this report assume full compliance with current US EPA exhaust and evaporative emission standards for all engines.

For all engine types, the cost of compliance with evaporative emissions standards are those used in the US EPA final rule (United States Environmental Protection Agency, 2008b). These costs are converted to Australian dollars using a currency conversion factor of $1.00AU = $0.75US. A higher value for the Australian dollar would reduce costs.

The calculations employed by the US EPA in their modelling of evaporative emissions standards are complex and rely on data that is unavailable in Australia. Hence, it was not feasible to repeat this analysis for Australia. We have used the summary results presented in tables 6.5-5 (page 6-74) and 6.6-5 (page 6-87) of United States Environmental Protection Agency, (2008a). These estimates are shown in the following subsections.

3.1 Outboard engines and personal watercraft emissions model

This analysis assumes that every new engine comes with a fuel system and hence the additional costs of complying with the evaporative emissions standards are included in the purchase price of an engine. In practice it is likely that some engines will be purchased separately from the fuel system and that some boats will have multiple engines and a single fuel tank. This assumption is therefore likely to overstate the additional costs of compliance. As the price elasticity of demand for outboard engines is non-zero this will result in a marginally larger reduction in the number of engines purchased under this model than might be expected in reality. In turn this will overstate the emissions reduction that might be expected. This effect is not likely to be significant, however, since the price of compliance is very small compared to the purchase price of outboard engines that are likely to be fitted to boats with built in fuel tanks.

The current US exhaust and evaporative emission standards, including the dates of their introduction, for outboard marine engines and personal water craft (PWC) are shown in Appendix 1. Note that we have assumed that all engines over 55hp will be fitted to a boat with a built in fuel tank.

The annual reduction in evaporative emissions was estimated by dividing the lifetime reduction in HC emissions by the average life. The additional per engine cost of complying with the evaporative emissions standards decreases linearly from the short term costs in 2012 to the long term costs over a 10 year period.

3.2 Inboard and stern drive emissions model

Consultation with industry has confirmed that the large majority of inboard and stern drive engines will comply with the proposed exhaust emissions standards. For this reason, a cost benefit analysis of these engines was not conducted. However, implementation of the proposed emissions standards for these engines protects against the possibility of engines not currently sold in Australia in significant numbers and not compliant with the proposed emissions standards entering the market in the future.

Reliable information on the number of boats currently in use and which are likely to come into use through the study period could not be obtained. For this reason, we have analysed the likely impacts of evaporative emissions standards on a single boat.

The US EPA regulatory impact analysis for the final rule (United States Environmental Protection Agency, 2008a) provides estimates of the average per unit costs and benefits of compliance with both evaporative and exhaust emissions for various engine classes, including boats with stern drive and inboard motors. These estimates are shown in Table 3-1.

Table 3-1 Compliance costs and benefits of US 2011 evaporative standards for stern drive and inboard engines

Average life (years)	Lifetime reduction in HC emissions (kg)	Short term costs ($ per engine)	Long term costs ($ per engine)
17	103.4	99	83

3.3 Gardening equipment emissions model

As for the original report, the analysis provided herein only considers the impacts of introducing Phase 2 exhaust emissions standards in Australia for the gardening equipment sector. This is because no information is available on the proportion of engines that would meet phase 3 emissions standards. The reader is referred to the original report for a description of these standards.

For evaporative emissions, the US EPA provides estimates of short- and long-term costs of compliance, lifetime HC reductions and the average lifetime for each type of equipment (United States Environmental Protection Agency, 2008). These are shown in Table 3-2. Annual reductions in evaporative emissions were estimated by dividing the lifetime reduction in HC emissions by the average lifetime. The additional per engine cost of complying with the evaporative emissions standards is assumed to decrease linearly from the short-term costs in 2012 to the long-term costs over a 10 year period.

It is assumed that no current equipment is currently compliant with the proposed evaporative emissions standards based on comments by industry representatives.

Table 3-2 Compliance costs and benefits of US 2011 evaporative standards for garden equipment

	Average life (years)	Lifetime reduction in HC emissions (kg)	Short term costs ($ per engine)	Long term costs ($ per engine)
Handheld	4.2	0.635	1.09	0.92
Class I	5.3	0.635	4.07	2.93

4 RESULTS

4.1 Outboard engines

This section reports modelling results for the two additional scenarios for outboard engines, based on compliance with US EPA final rule standards. Table 4.1 shows a detailed breakdown of the NPV for each regulated scenario for outboard engines, compared against business as usual.

Table 4-1 NPV of scenarios for outboard engines sold up to 2030 ($2008m)

Option	Scenario name	Service costs	Expenditure costs	Fuel costs	Health costs	Total costs	NPV
BAU	OB-BAU	2,606	4,873	3,938	3,544	14,961	-
Final rule standards scenarios	OB-1a	2,461	4,635	3,441	2,221	12,759	2,202
	OB-2a	2,457	4,639	3,451	2,246	12,793	2,167

Figures 4.1, 4.2, 4.3 and 4.4 illustrate the projected impacts, to 2030, of regulation against business as usual. Note that service costs and purchase costs were calculated using a zero price elasticity of demand for these vessels. This assumption was made to provide a better reflection of the effect of the change in price arising from regulation. Fuel consumption, emissions and the emissions savings from the evaporative standards alone are also reported for each of the scenarios modelled.

Figure 4-1 Outboard engines service costs and expenditure, scenario OB-1a

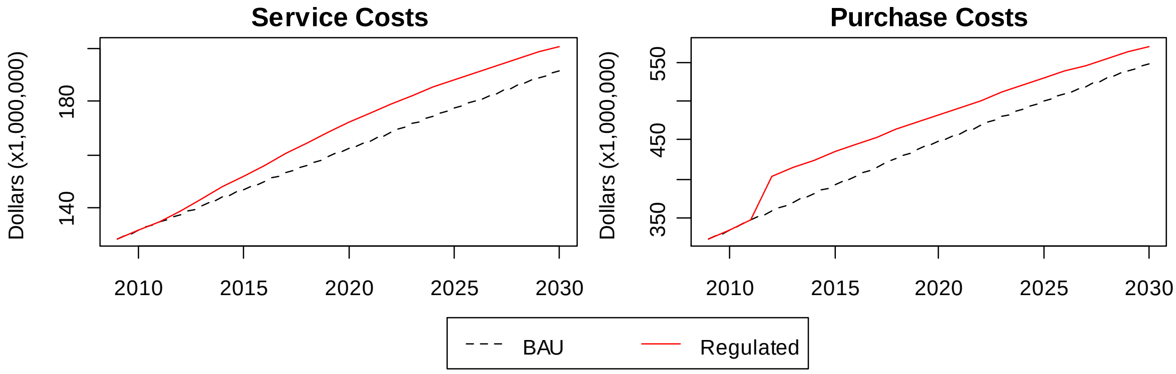


Figure 4-2 Outboard engines fuel consumption and emissions, scenario OB-1a

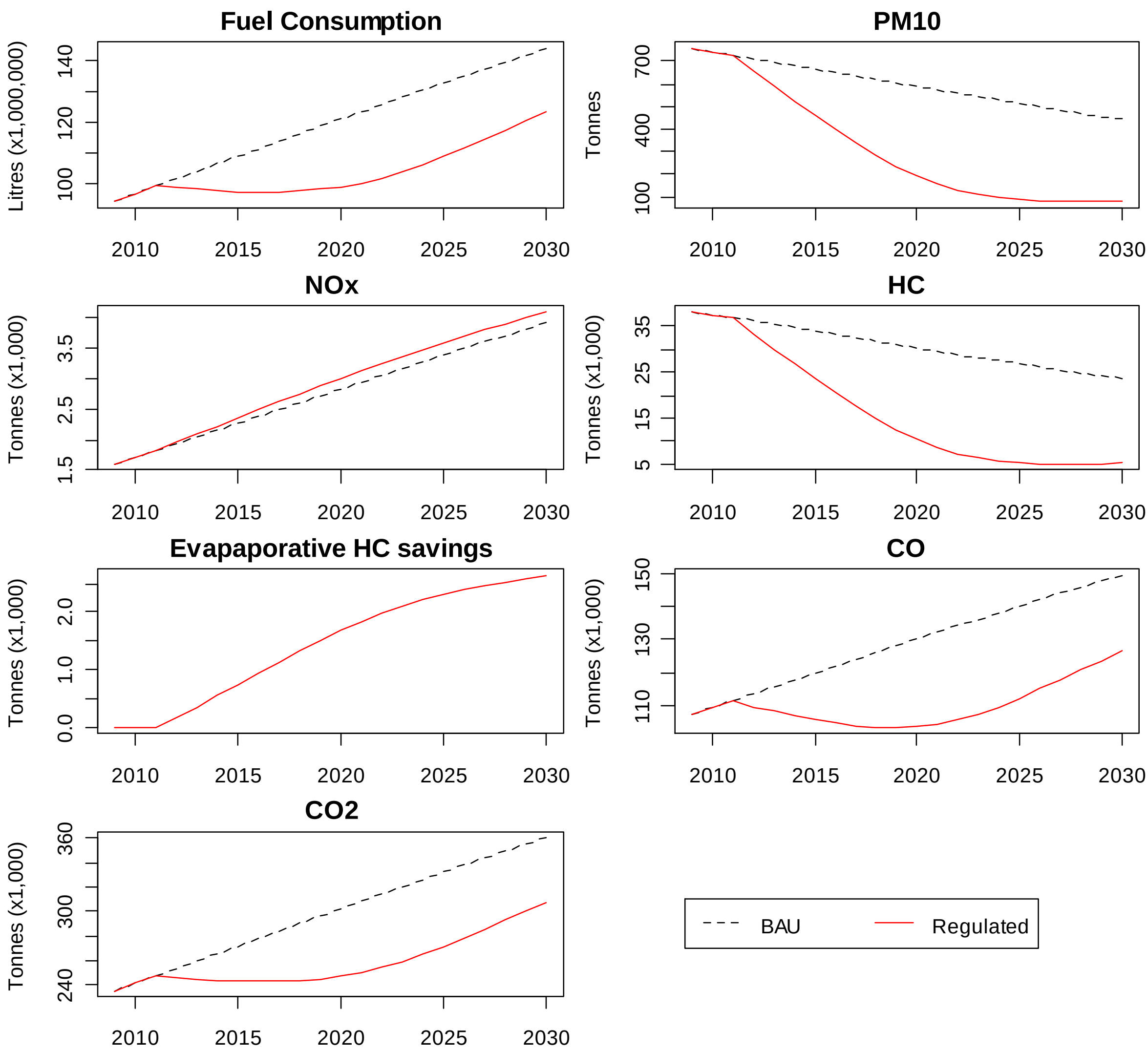


Figure 4-3 Outboard engines service costs and expenditure, scenario OB-2a

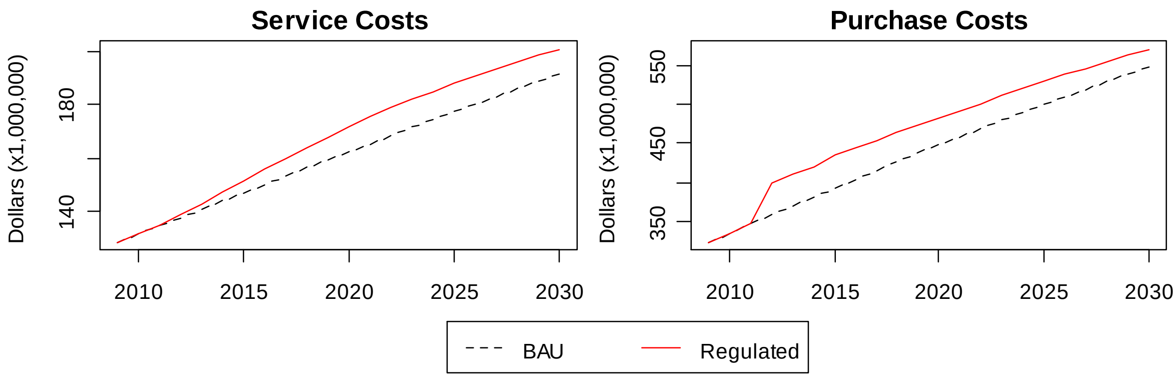
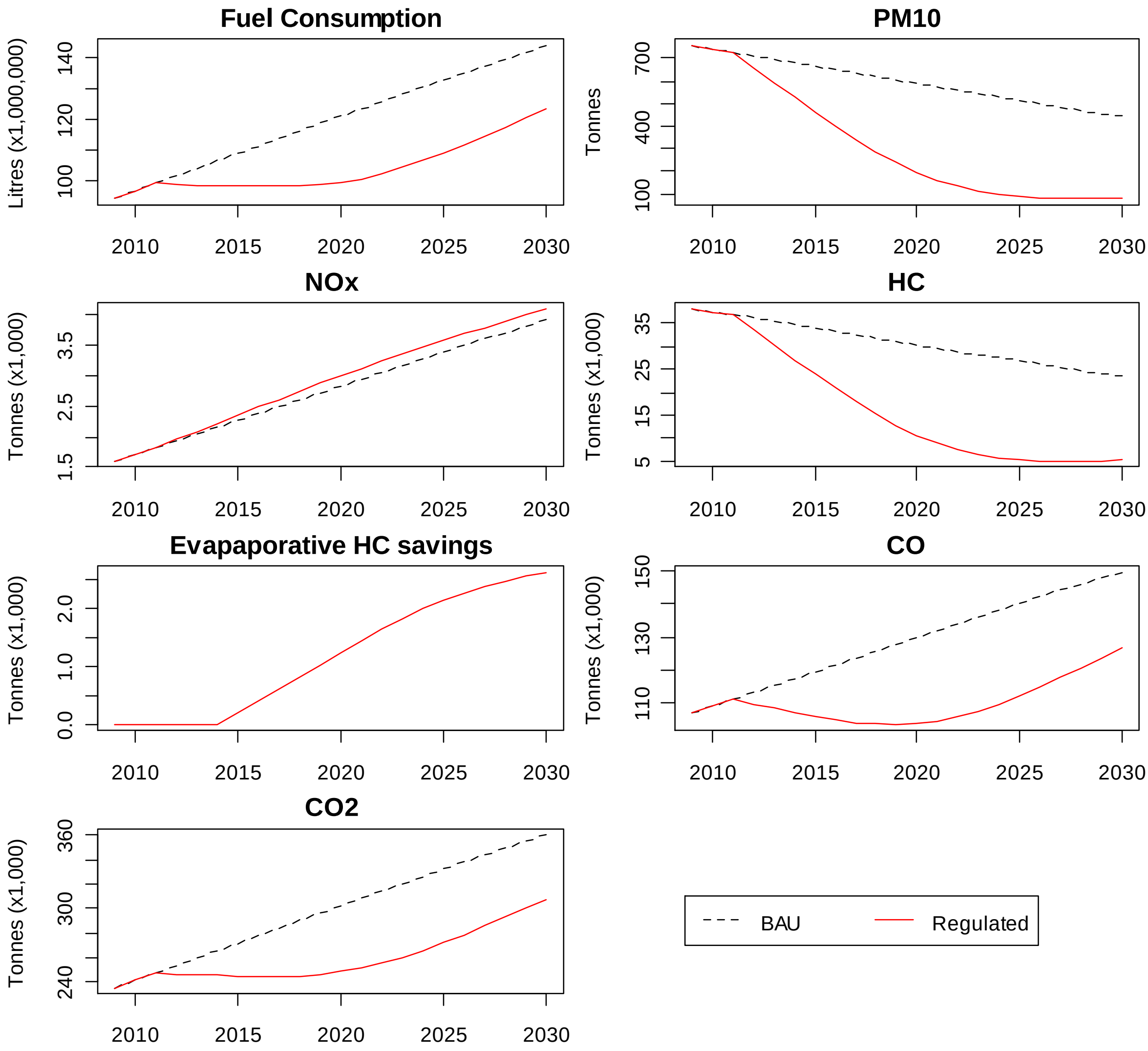


Figure 4-4 Outboard engines fuel consumption and emissions, scenario OB-2a



4.2 Personal watercraft

This section reports modelling results for the two additional scenarios for personal watercraft, based on compliance with US EPA final rule standards. Table 4.2 shows a detailed breakdown of the NPV for each regulated scenario for personal watercraft, compared against business as usual.

Table 4-2 NPV of scenarios for personal watercraft sold up to 2030 ($2008m)

Option	Scenario name	Service costs	Expenditure costs	Fuel costs	Health costs	Total costs	NPV
BAU	PWC-BAU	97	316	281	139	834	-
Final rule standards scenarios	PWC-1a	92	308	251	83	734	99
	PWC-2a	92	307	252	85	737	97

Figures 4.5, 4.6, 4.7 and 4.8 illustrate the projected impacts, to 2030, of regulation against business as usual. Note that service costs and purchase costs were calculated using a zero price elasticity of demand for these vessels. This assumption was made to provide a better reflection of the effect of the change in price arising from regulation. Fuel consumption, emissions and the emissions savings from the evaporative standards alone are also reported for each of the scenarios modelled

Figure 4-5 PWC engines service costs and expenditure, scenario PWC-1a

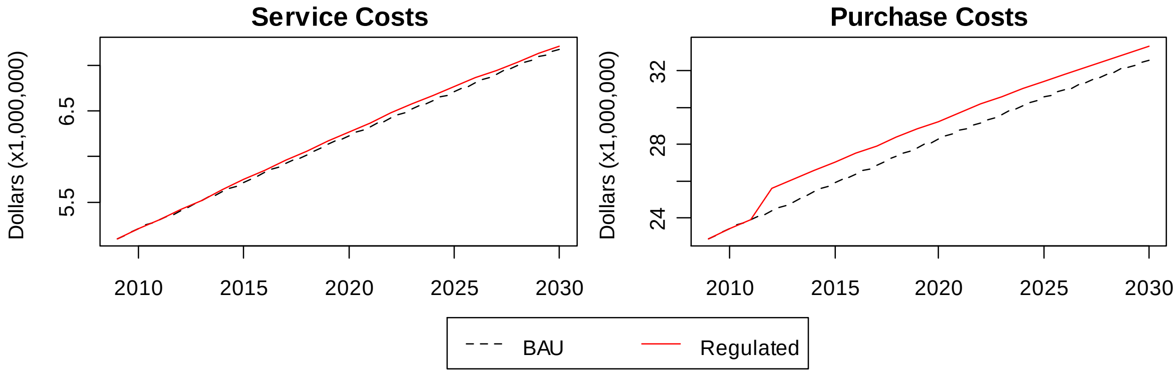


Figure 4-6 PWC engines fuel consumption and emissions, scenario PWC-1a

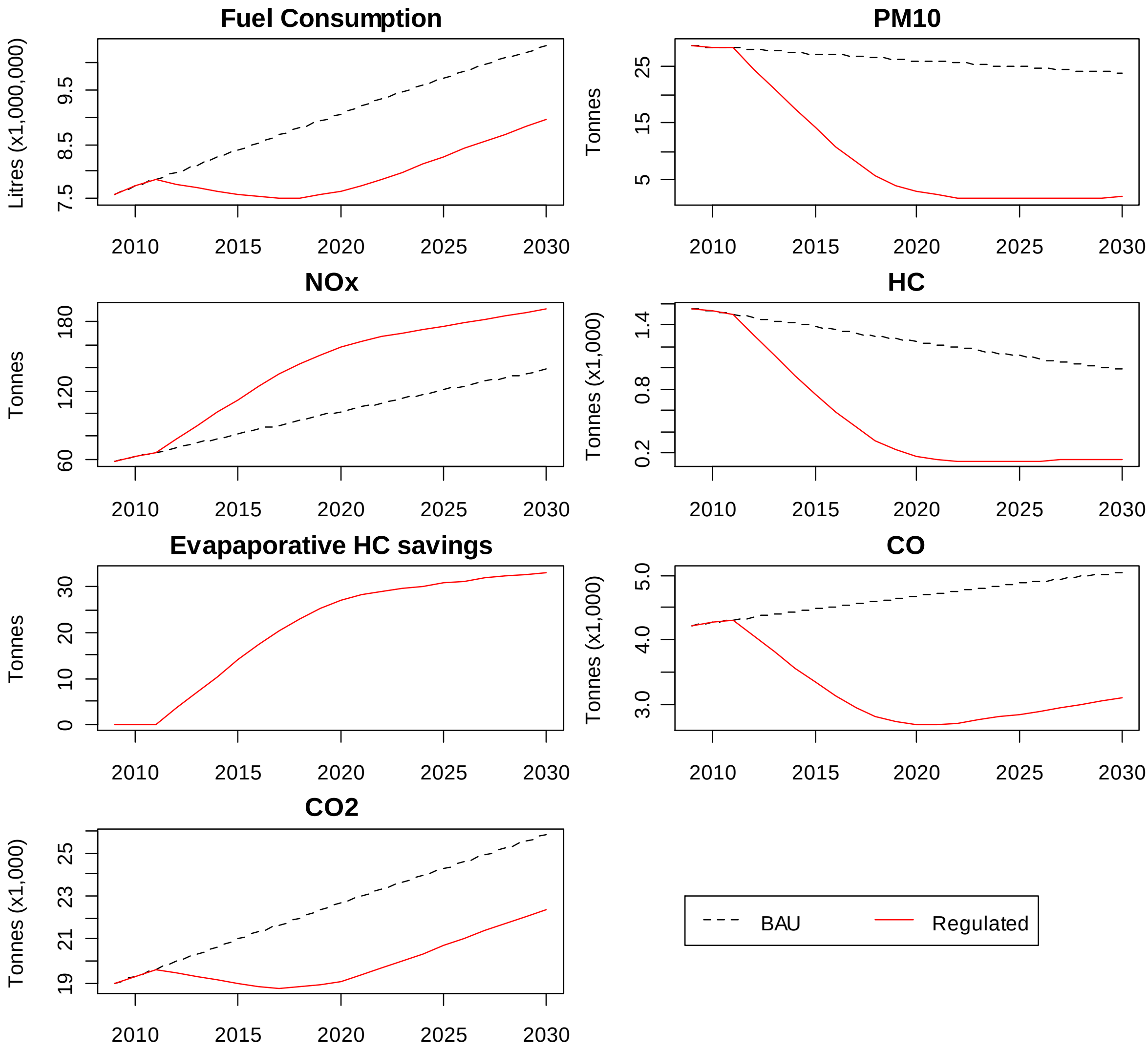


Figure 4-7 PWC engines service costs and expenditure, scenario PWC-2a

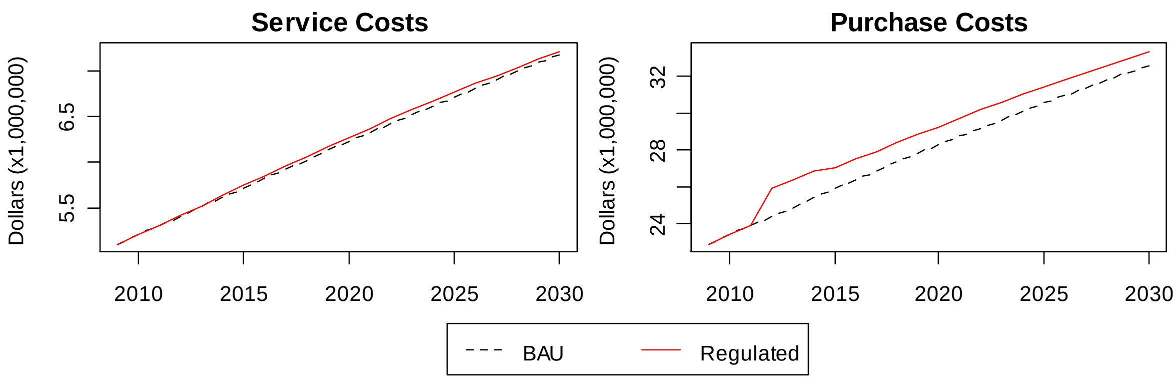
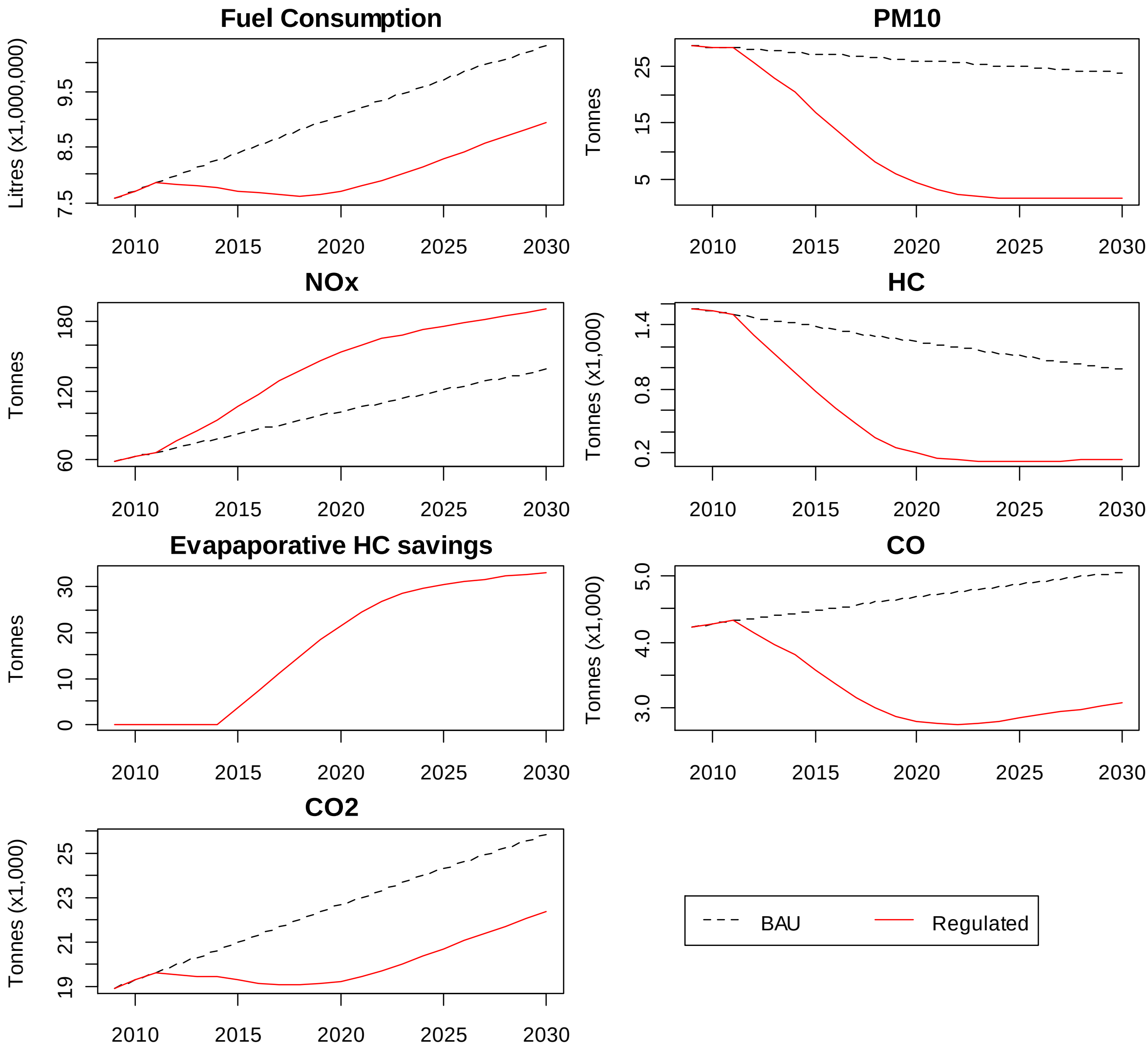


Figure 4-8 PWC engines fuel consumption and emissions, scenario PWC-2a



4.3 Inboard and stern drive engines

It was not possible to obtain sales data from industry for stern drive and inboard vessels. However, industry feedback indicated that all stern drive and inboard engines would be compliant with the US EPA final rule standards, as these engines are at the highest end of the market. However, the fuel systems used in stern drive and inboard vessels would need to be upgraded to comply with evaporative emission standards in the final rule. Therefore, costs and benefits of implementing evaporative standards, on an individual basis only, were estimated for stern drive and inboard vessels. Table 3-1 shows the NPV, to 2030, per vessel of avoided health costs as a result of implementing evaporative emission standards, using the following key assumptions: the annual emissions from each vessel are constant through the life of the vessel; European Community composite medium[4] health costs for

[4] Described in the original report.

hydrocarbon emissions of $3,356 per tonne, a nominal interest rate of 7% and an inflation rate of 4%. Under these assumptions, the NPV of avoided health costs is $271 per vessel. This value is much greater than either the short or long term compliance costs per vessel and ignores savings resulting from reductions in fuel consumption and, hence, is conservative.

4.4 Gardening equipment

This section reports modelling results for the two additional scenarios for gardening equipment, based on compliance with US EPA final rule standards. Table 4.4 shows a detailed breakdown of the NPV for each regulated scenario for gardening equipment, compared against business as usual.

Table 4-4 NPV of scenarios for gardening equipment sold up to 2030 ($2008m)

Option	Scenario name	Service costs	Expenditure costs	Fuel costs	Health costs	Total costs	NPV
BAU	Grd-BAU	1,610	7,818	7,203	1,713	18,344	-
Final rule standards scenarios	Grd-1a	1,671	7,997	6,773	1,212	17,653	691
	Grd-2a	1,671	7,993	6,773	1,223	17,659	685

Figures 4.9, 4.10, 4.11 and 4.12 illustrate the projected impacts, to 2030, of regulation against business as usual for the gardening equipment sector (lawn mowers, trimmer, brushcutters and hand held blowers only). Note that service costs and purchase costs were calculated using a zero price elasticity of demand for these vessels. This assumption was made to provide a better reflection of the effect of the change in price arising from regulation. Fuel consumption, emissions and the emissions savings from the evaporative standards alone are also reported for each of the scenarios modelled

Figure 4-9 Gardening equipment engines service costs and expenditure, scenario Grd-1a

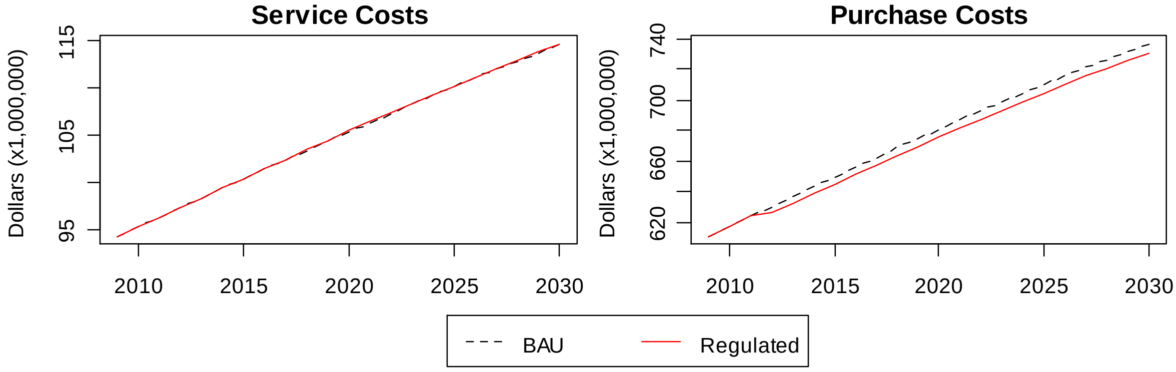


Figure 4-10 Gardening equipment engines fuel consumption and emissions, scenario Grd-1a

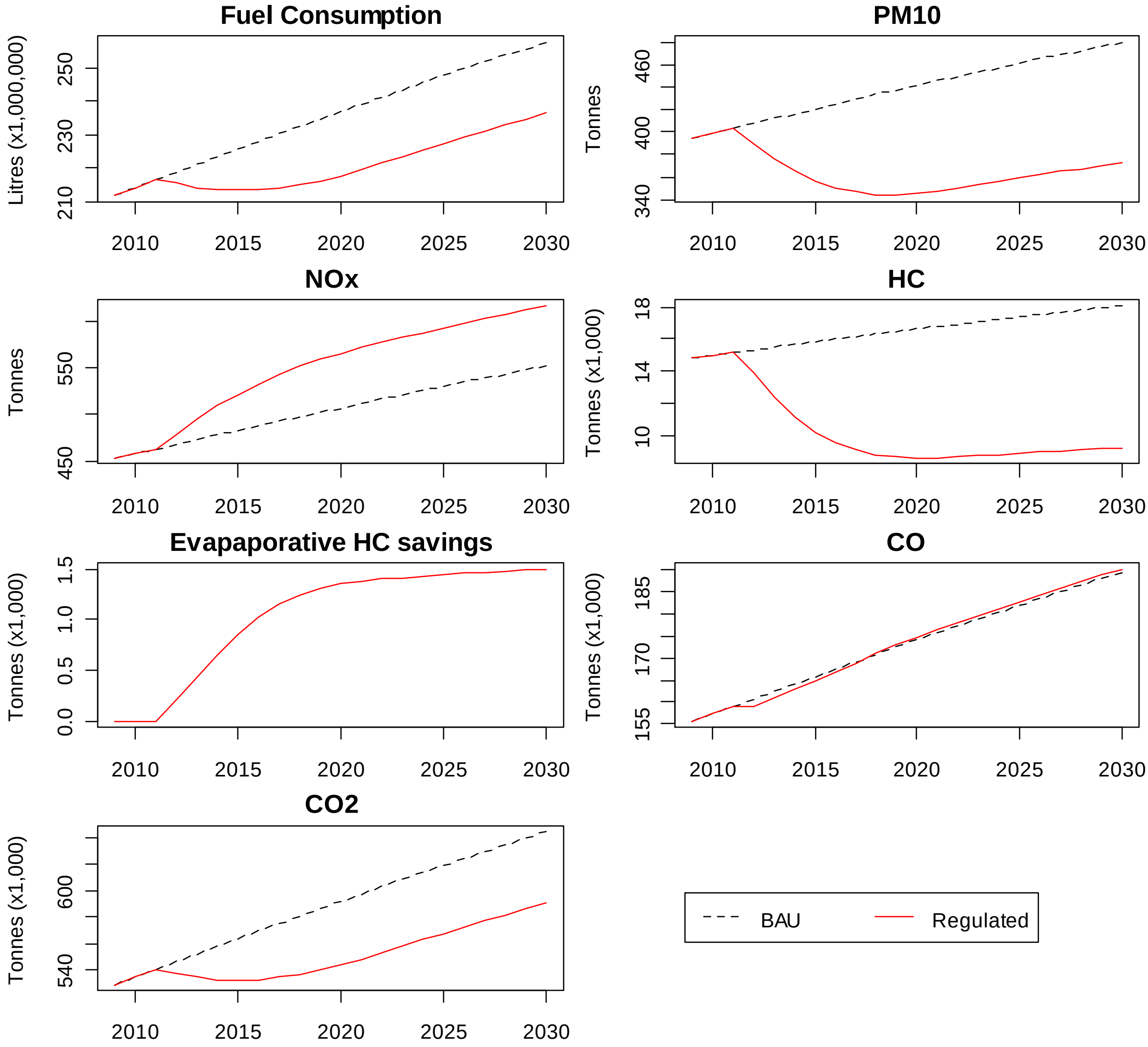


Figure 4-11 Gardening equipment engines service costs and expenditure, scenario Grd-2a

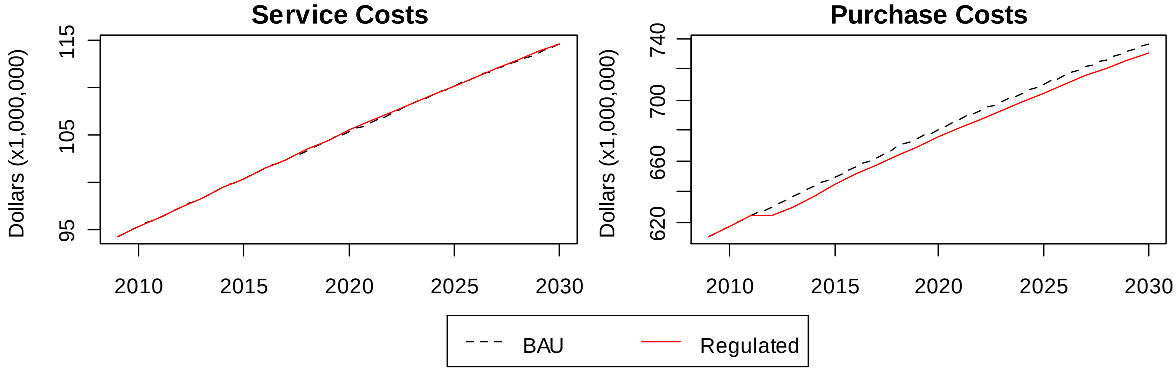
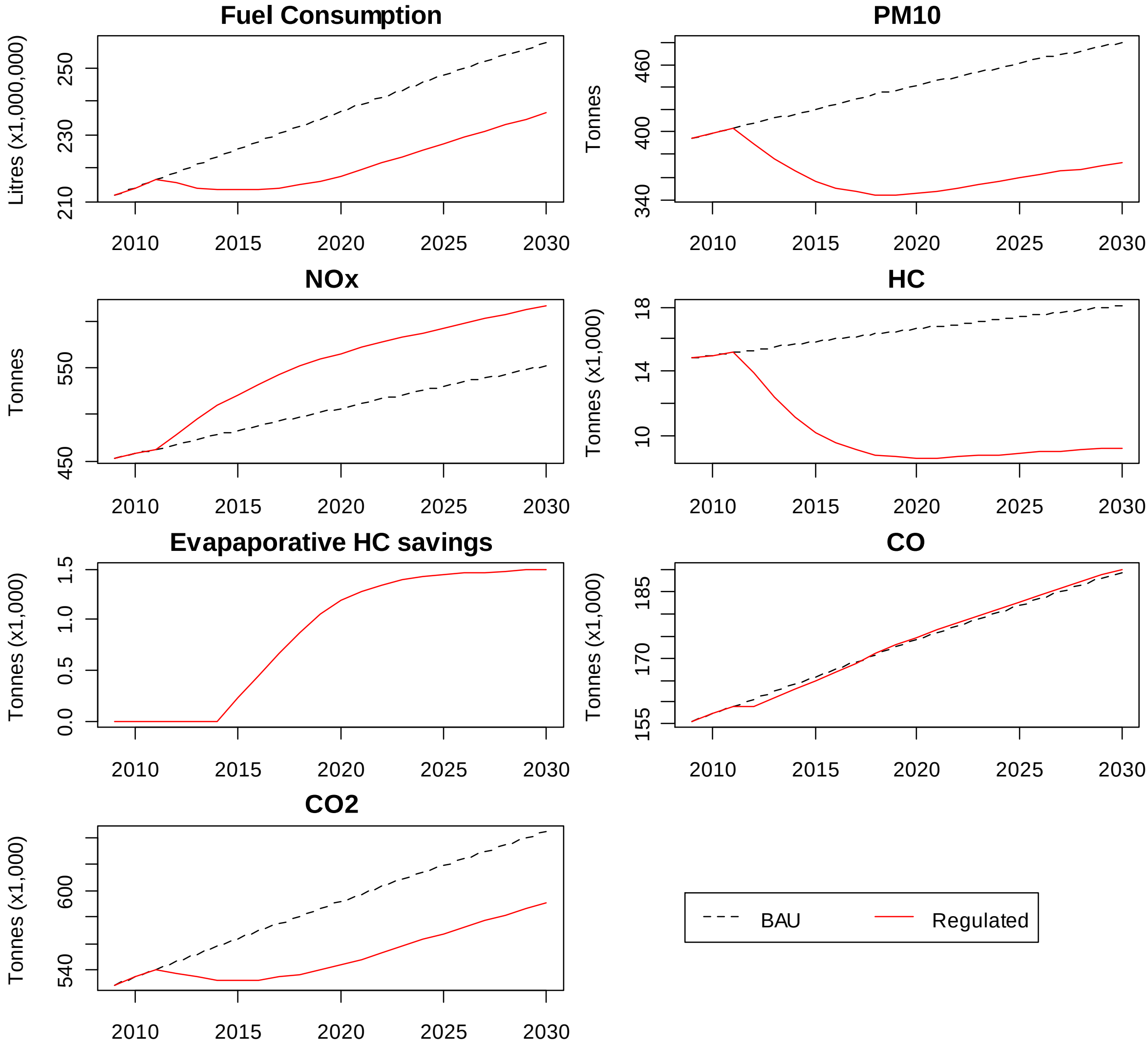


Figure 4-12 Gardening equipment engines fuel consumption and emissions, scenario Grd-2a



4.5 Impacts of delaying emissions standards

Each year the implementation of emissions standards is delayed results in significant increases in costs to the Australian community resulting from higher emissions over this period. Table 1-5 shows the change in the NPV of implementing US 2010 exhaust and evaporative emission standards in Australia from 2010 to 2016. The 1a scenarios for outboard engines, personal watercraft and garden equipment evaluated in Sections 4.1, 4.2, 4.3 and 4.4 are based on the implementation of US EPA final rule standards in 2012, which is considered to be achievable, based on "standard" government legislative timetables. The NPV data from Sections 4.1, 4.2, 4.3 and 4.4 can be directly compared against the 2012 NPVs highlighted in Table 4-5, with additional health benefits accruing for earlier implementation and foregone health benefits for delayed implementation.

Therefore, accelerating the implementation of emissions standards to 2010 would result in an increase in NPV of $533m, while delaying implementation until 2016 would lead to a decrease in NPV of $909m.

Table 4-1 NPVs of implementing US 2010 exhaust and evaporative emission standards in Australia in various years

Start year	NPV				
	OB	PWC	GRD	Total	Reduction
2010	2,641	117	768	3,526	-
2011	2,414	108	729	3,252	274
2012	2,201	99	692	2,992	259
2013	2,002	91	653	2,747	246
2014	1,815	84	615	2,514	233
2015	1,640	77	576	2,294	221
2016	1,476	70	538	2,085	209

5 CONCLUSIONS

The net present value of benefits accounted for in this paper is more than sufficient (by a large margin) to justify the introduction of the proposed exhaust and emissions standards. As with the original report the analysis undertaken is extremely conservative. The reader is referred to the conclusion of original report for a summary of conservative assumptions used in these reports.

Feedback from the original report has identified other areas in which this and the original report may be conservative, including:

- the use of 7% as the nominal interest rate may be too high,
- there is evidence that the annual usage of outboard motors is much higher than assumed.[5]

As was found in the original report, despite the extremely conservative estimates of the benefits from adopting US emissions standards, adopting US emissions standards for small non-road, outboard and PWC engines is likely to provide around $3 billion in net benefits to the community.

The introduction of evaporative emissions standards alone provides benefits with an NPV or around $100m. The NPV from the introduction of the exhaust emissions standards prescribed in the US EPA final rule and assessed in this report are similar to those prescribed in the proposed rule assessed in the original report.

It is estimated that delaying the introducing emissions standards will cost the community around $250m per year of delay. This is also likely to be conservative as delays may cause the ‘dumping’ of non-compliant engines on the Australian market through the period in which Australian standards lag behind the US standards. Anecdotal evidence suggests that this is already happening in Australia. As a result, the cost to the community may be significantly larger than our estimates of $250m per year of delay.

The difference between the two implementation scenarios explored herein (1a and 2a) is around $44m. While this is a significant sum, if attempting to implement the more stringent standards considered in 1a results in a delay in the introduction of any standards by as little as two months over the time it would take to implement standards considered in 2a, these benefits would be lost.

Overall, MMA concludes that, of the policy options considered in this analysis, adopting the US emissions limits in Australia as soon as practicable and without phasing is likely to yield the greatest net benefits. Of the two scenarios considered in this report, scenario 1a will provide additional net benefits to the community of approximately $44m, though a delay of as little as two months induced by the pursuance of these more stringent standards would reduce these additional benefits to zero and any further delays would induce negative returns to these more stringent standards.

[5] We assume 26.5 and 28.9 hours for two stroke engines and four stroke outboard engines respectively, but recent survey suggest this may be closer to 70 hours or more.

6 REFERENCES

McLennan Magasanik Associates (2008). Cost benefit analysis of options to manage emissions from selected non-road engines.

United States Environmental Protection Agency (2007). Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment: Draft Regulatory Impact Analysis.

United States Environmental Protection Agency (2008a). Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment: Final Regulatory Impact Analysis.

United States Environmental Protection Agency (2008b). Control of Emissions from Nonroad Spark-Ignition Engines and Equipment: Final Rule.

APPENDIX A SENSITIVITY ANALYSIS

The results in this report are significantly impacted by the price elasticity of demand and the nominal interest rates used in the net present value (NPV) calculations. This appendix present sensitivity analyses of these two factors.

A.1 Sensitivity of results to elasticity assumptions

The change in costs under the regulated scenarios arises from two distinct effects:

1. The decrease in emissions from each engine,
2. The change in the number of engines sold induced by the price elasticity of demand for engines.

Table A-1 shows estimates comparable to those in Table 1-2 but under different assumptions about the price elasticity of demand. The "non-zero elasticity" section of the table gives costs under the elasticity assumptions used in this report and is identical to the estimates given in Table 1-2, which are presented here purely for ease of reference. The price elasticity of demand induces a change in the number of engines sold through changes in the price of engines; the number of outboard engines and PWCs sold decreases and the number of gardening equipment engines sold increases (because the cleaner gardening equipment engines are marginally cheaper than the less clean engines). In the case of outboard engines and PWCs, we have assumed a price elasticity of demand of -2.0 following the US EPA. It should be noted that in all cases we assume that this elasticity applies to the cost of the equipment – i.e. applies to the cost of the outboard engine or to the total cost of the PWC. In the former case a consumer may consider the cost of the entire vessel, not just the cost of the engine, when making a purchase decision. We have assumed that the elasticities calculated by the US EPA apply to the cost of the engine in this case, rather than to the vessel as a whole, though this is not explicitly stated in the US EPA reports.

The "zero elasticity" section of the table gives costs under the assumption of a zero price elasticity of demand for all engine types. The consequence of this assumption is that exactly the same numbers of engines are sold in each of the scenarios as are sold under the BAU. This analysis highlights changes in costs that are incurred purely from changes in the emissions per engine.

The "non-zero elasticity with zero elasticity assumed for purchase costs" section of the table assumes a zero elasticity for purchase costs, and a non-zero elasticity for all other quantities – i.e. the expenditure costs give the expenditure on engines assuming no change in the number of engines sold but changed prices, and the other quantities reflect the change in the number of engines. This is presented to provide an estimate of the change in utility to consumers of engines. It must be noted that this will overstate the change in utility, as the utility consumers derive from other products will increase / decrease from increased / decreased expenditure on other goods and services which is not captured in these calculations. In practice, consumers may also elect to buy smaller (cheaper) engines rather than not purchase at all, which is not captured in these calculations. There is also an implicit assumption that consumers factor health costs into the cost of an engine, which may not be valid.

The results in Table A-1 show that the results are quite sensitive to the elasticity assumptions, with a reduction of around 32% between the "zero elasticity" and "non-zero elasticity" scenarios, and a reduction of around 12% between the "non-zero elasticity with zero elasticity assumed for purchase costs" and "non-zero elasticity" cases. Note that for all cases, the net present value of regulation is still significant.

Table A-1 Comparison of costs and benefits under different elasticity assumptions

Option	Scenario name	Service costs	Expenditure costs	Fuel costs	Health costs	Total costs	NPV
BAU	OB-BAU	2,606	4,873	3,938	3,544	14,961	-
	PWC-BAU	97	316	281	139	834	-
	Grd-BAU	1,610	7,818	7,203	1,713	18,344	-
Non-zero elasticity	OB-1a	2,461	4,635	3,441	2,221	12,759	2,202
	OB-2a	2,457	4,639	3,451	2,246	12,793	2,167
	PWC-1a	92	308	251	83	734	99
	PWC-2a	92	307	252	85	737	97
	Grd-1a	1,671	7,997	6,773	1,212	17,653	691
	Grd-2a	1,671	7,993	6,773	1,223	17,659	685
	Total-1a	4,225	12,941	10,465	3,515	31,146	2,992
	Total-2a	4,220	12,939	10,476	3,554	31,189	2,949
Zero elasticity	OB-1a	2,710	5,203	3,744	2,326	13,983	978
	OB-2a	2,707	5,194	3,747	2,352	14,000	961
	PWC-1a	97	326	263	86	771	62
	PWC-2a	97	326	265	88	776	57
	Grd-1a	1,611	7,772	6,765	1,208	17,357	987
	Grd-2a	1,611	7,767	6,765	1,218	17,363	981
	Total-1a	4,419	13,301	10,772	3,619	32,111	2,027
	Total-2a	4,415	13,288	10,777	3,658	32,139	1,999
Non-zero elasticity with zero elasticity assumed for purchase costs	OB-1a	2,461	5,201	3,441	2,221	13,324	1,637
	OB-2a	2,457	5,192	3,451	2,246	13,347	1,614
	PWC-1a	92	326	251	83	752	82
	PWC-2a	92	326	252	85	756	78
	Grd-1a	1,671	7,773	6,773	1,212	17,428	916
	Grd-2a	1,671	7,768	6,773	1,223	17,434	910
	Total-1a	4,225	13,299	10,465	3,515	31,504	2,634
	Total-2a	4,220	13,287	10,476	3,554	31,537	2,602

A.2 Sensitivity of results to interest rate assumptions

This section presents the sensitivity of the results to the nominal interest rates. In the body of this report we have used a nominal interest rate of 7%. Table A-1 presents the same results assuming nominal interest rate of 4% and 11%. As expected, the choice of interest rate has a significant effect on the NPV of costs and benefits arising from regulation. Under either of these alternative nominal interest rates, the benefits from regulation are still significant.

Table A-2 Comparison of costs and benefits under different nominal interest rate assumptions

Option	Scenario name	Service costs	Expenditure costs	Fuel costs	Health costs	Total costs	NPV
4% nominal interest rate	OB-BAU	3,725	6,361	5,797	4,956	20,839	0
	PWC-BAU	134	409	400	192	1,136	0
	Grd-BAU	2,196	10,025	10,060	2,385	24,665	0
	OB-1a	3,507	6,051	5,023	2,891	17,473	3,367
	OB-2a	3,501	6,055	5,036	2,924	17,517	3,322
	PWC-1a	128	398	354	107	987	148
	PWC-2a	128	397	355	109	990	145
	Grd-1a	2,284	10,268	9,409	1,631	23,591	1,073
	Grd-2a	2,284	10,262	9,409	1,645	23,599	1,065
	Total-1a	5,920	16,717	14,785	4,630	42,051	4,588
	Total-2a	5,913	16,715	14,800	4,678	42,106	4,533
11% nominal interest rate	OB-BAU	1,772	3,614	2,584	2,476	10,445	0
	PWC-BAU	67	237	191	98	594	0
	Grd-BAU	1,145	5,926	4,982	1,187	13,240	0
	OB-1a	1,682	3,441	2,291	1,693	9,106	1,339
	OB-2a	1,679	3,444	2,298	1,712	9,132	1,313
	PWC-1a	65	231	172	64	532	62
	PWC-2a	64	231	173	65	534	60
	Grd-1a	1,184	6,051	4,719	879	12,833	407
	Grd-2a	1,184	6,047	4,719	888	12,838	402
	Total-1a	2,931	9,723	7,182	2,636	22,471	1,808
	Total-2a	2,927	9,722	7,190	2,664	22,503	1,776

APPENDIX B SUMMARY OF US EPA FINAL RULE

B.1 Which engines and equipment are affected?

B.1.1 Spark ignition non-road engines rated below 25 horsepower (19 kW) used in household and commercial applications

- Lawn and garden equipment
- Utility vehicles
- Generators
- Construction, farm and industrial equipment

B.1.2 Spark-ignition engines used in marine vessels

- Outboard engines
- Personal watercraft
- Stern drive / inboard engines

B.2 What are the differences between the final rule (2008) and the proposed rule (2007)?

- Implementation date for Marine Outboard / Personal Watercraft (OB / PWC) and Stern drive / Inboard (SD / I) exhaust emission standards are being delayed by one year to allow manufacturers for time to convert entire product line-ups simultaneously, while adapting to supplier changes
- Marine SD / I exhaust emission standards for high-performance (>373 kW) reflect limitations of catalyst technology
- Cold weather evaporative emission standards, with phased-in marine diurnal standards

B.3 What are the new requirements?

B.3.1 Small non-road engines

- HC + NOx of 10 g / kW-hr for Class 1 engines starting in 2012
    - Walk-behind mowers
    - Small generators
    - Pressure washers
- HC + NOx of 8 g / kW-hr for Class II engines starting in 2011
    - Ride-on mowers
    - Zero-turn mowers
    - Large generators
- Standards expected to be met through improving fuel systems, engine combustion and, in some cases, adding catalysts
- No new emission standards for Class III, IV and V handheld engines

  - Leaf blowers
  - Chainsaws
  - String trimmers
  - Edgers
- CO of 5 g/kW-hr for SI marine generator engines (Phase 3)
- New evaporative emission standards for both handheld and non-handheld equipment that include requirements to control:
  - Fuel tank permeation
  - Fuel line permeation
  - Diffusion emissions

Table B-1 Evaporative standards, starting dates and estimated emission reductions for evaporative emission standards

Evaporative Controls	Class I (NHH)	Class II (NHH)	Classes III-V (HH)	Estimated HC Reduction
Hose Permeation	2009 15 g/m^2	2009 15 g/m^2	2012-2016 15 g/m^2	95%
Tank Permeation	2012 1.5 g/m^2	2011 1.5 g/m^2	2009 -2013 2.0 g/m^2	85%
Running loss	2012	2011	N/A	80%

B.3.2 Marine spark ignition engines

B.3.2.1 Outboard engines and personal watercraft engines

- All limits start in 2010
- HC + NOx of 30 g/kW-hr for engines less than 4.3 kW maximum power
- HC + NOx limit gradually increases for engines greater than 4.3 kW maximum power
- CO limit gradually increases for engines less than or equal to 40 kW maximum power
- CO of 300 g/kW-hr for engines greater than 40 kW maximum power
- Above standards expected to be met through improved fuelling systems and other in-cylinder controls

Table B-2 Exhaust emissions standards for outboard engines and personal watercraft

Pollutant	Power	Emission standard (g / kW-hr)
HC + NOx	P ≤ 4.3 kW	30
HC + NOx	P > 4.3 kW	$2.1 + 0.09 \times (151 + 557 / P^{0.9})$
CO	P ≤ 40 kW	500 – 5P
CO	P > 40 kW	300

B.3.2.2 Stern drive and inboard marine engines

- All limits start in 2010
- HC + NOx of 5 g / kW-hr
- CO of 75 g / kW-hr
- Standards expected to be met with three-way catalysts and closed-loop fuel injection
- Manufacturers required to diagnose engine failures in emission control system

B.3.2.3 High-performance stern drive and inboard marine engines above 373 kW

- HC + NOx of 20 g / kW-hr for engines producing between 373 and 485 kW starting in 2010
- HC + NOx of 16 g / kW-hr for engines producing between 373 and 485 kW starting in 2011
- HC + NOx of 25 g / kW-hr for engines producing greater than 485 kW starting in 2010
- HC + NOx of 22 g / kW-hr for engines producing greater than 485 kW starting in 2011
- CO of 350 g / kW-hr
- "Not-to-exceed" standards that require manufacturers to maintain minimum levels of emission controls under normal speed-load combinations

B.3.2.4 All marine spark ignition engines

- Fuel tank permeation standards
- Fuel line permeation standards
- Diurnal fuel tank vapour emission standards

Table B-3 Evaporative emissions standards, starting dates and estimated emission reductions marine spark ignition engines

Evaporative Controls	Personal Watercraft	Portable Tanks	Other Installed Tanks	Estimated HC Reduction
Hose Permeation	2009 15 g / m^2	2009 15 g / m^2	2009-2015 15 g / m^2	80%
Tank Permeation	2011 1.5 g / m^2	2011 1.5 g / m^2	2012 1.5 g / m^2	85%
Diurnal	2010 0.40 g / gal / day	2010 0.40 g / gal / day	2011-2013 0.40 g / gal / day	60% 0.40 g / gal / day