A REVIEW OF DATA ON LEAD-ACID BATTERIES ENTERING AUSTRALIA AND ARISING AS WASTE

Prepared for: Department of the Environment, Canberra

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ABOUT THE AUTHORS

The Institute for Sustainable Futures (ISF) was established by the University of Technology, Sydney in 1996 to work with industry, government and the community to develop sustainable futures through research and consultancy. Our mission is to create change toward sustainable futures that protect and enhance the environment, human well-being and social equity. We seek to adopt an inter-disciplinary approach to our work and engage our partner organisations in a collaborative process that emphasises strategic decision-making.

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1 INTRODUCTION

1.1 Background

The Hazardous Waste Section of the Australian Government Department of the Environment (DoE) commissioned ISF to undertake a brief review of selected data on quantities of lead-acid batteries in Australia, both as products and waste. The key numbers to be reviewed included the annual amounts of:

- lead-acid batteries entering the Australian market (mostly through imports); and
- annual arisings as wastes.

The purpose of the review is to recommend a preferred set of numbers which are to be used in making regulatory decisions under the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*.

Used lead-acid batteries (ULABs) are a common type of hazardous waste subject to applications for export approval under the Act. Applicants often wish to export ULABs to countries such as the Republic of Korea where large markets and facilities exist for the recycling of ULABs and the return of recovered materials to further manufacture. Some domestic capacity to receive and recycle ULABs exists in Australia. This can be as simple as breaking the batteries and on-selling the components or extend into processing outputs from the battery-breaking process (such as lead paste) and then selling those recycled materials (such as higher-grade lead). The Act currently asks the decision-maker to take into account, when assessing an application for the export of hazardous waste, whether there is domestic capacity to deal with those wastes in a safe, efficient and environmentally sound manner. Under the Act, if appropriate domestic capacity exists, then it is preferable that the hazardous waste goes to those sites rather than being exported.

For the decision-maker to decide between claims that waste ULABs should or should not be exported, it is necessary to understand the sizes of the markets for the product and the wastes. This project is to provide clarity and justification as to what numbers should be referenced in assessment decisions.

The key source documents for the review include:

- Two studies (one with stock modelling) of battery markets and battery waste arisings in Australia, prepared by Warnken ISE (Warnken ISE 2010; 2012). These studies cover a range of battery types, with only the lead-acid and used lead-acid battery aspects relevant for this review.
- Australian Bureau of Statistics (ABS) data on imports into Australia of lead-acid batteries ABS (2013).

An overview of the report structure in shown in the diagram below.
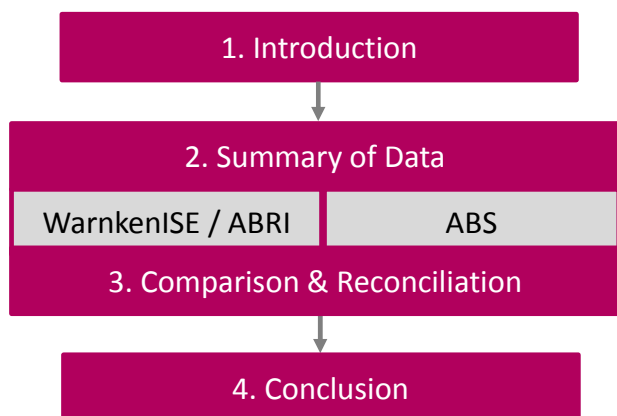
2 SUMMARY OF AVAILABLE DATA

2.1 Australian Battery Recycling Initiative study (by Warnken ISE 2010)

The Australian Battery Recycling Initiative (ABRI) commissioned a study into consumption, recycling and disposal of all forms of batteries in Australia. The resulting report, produced by Warnken ISE (2010), details estimates for numbers and tonnages of lead-acid batteries broken down into three broad categories, namely:

- Handheld – batteries less than 1kg

- Automotive starting, lighting and ignition (SLI) – used to support starter motors in cars and trucks

- Large and industrial uses – includes starter motors for machinery, marine batteries, electric vehicles such as golf carts and mobility scooters, and stationary standby batteries.

Tables 1 and 2 present the tonnage and count outputs, respectively, from the Warnken ISE (2010) modelling in terms of inputs, stocks and arisings. Inputs represent consumption of lead-acid batteries (equivalent to sales of batteries) in Australia, stocks are functional batteries (i.e. in use), and arisings (shown in Table 3) are the amount of lead-acid batteries that are not functional or unwanted (waste batteries). Arisings include formally stockpiled (bulk storage in warehouses or industrial facilities in accordance with relevant legislation), informally stockpiled batteries (accumulated at point of use e.g. workshops, garages, embedded in products), recycled, landfilled, illegally exported and rebirthed waste batteries. All reported numbers apply to the 2009/10 financial year. Table 3 presents the breakdown of lead-acid battery arisings by type.

A second report prepared by Warnken ISE for ABRI looked at battery flows in Western Australia (Warnken ISE 2012). A review of this report revealed that the underlying analyses took the same approach as those adopted in the Warnken ISE (2010) study and are therefore not elaborated on further in this review.

Table 1: Tonnage of batteries in Australia in 2009/10 (kt) (Warnken ISE 2010)

Category	Inputs (kt)	Stocks (kt)	Arisings (kt)
Handheld	1.3	2.2	0.7
SLI	85.7	224.2	80.3
Large and Industrial	46.7	179.2	41.3
TOTAL	**133.6**	**405.6**	**122.2**

Table 2: Count of batteries in Australia in 2009/10 (millions of batteries) (Warnken ISE 2010)

Category	Inputs (million batteries)	Stocks (million batteries)	Arisings (million batteries)
Handheld	1.82	3.20	1.00
SLI	5.84	15.44	5.41
Large and Industrial	1.57	5.98	1.42
TOTAL	**9.23**	**24.62**	**7.83**

Table 3: Breakdown of arisings in 2009/10 (kt) (Warnken ISE 2010)

Fate of lead-acid batteries	Handheld	SLI	Large/Industrial	TOTAL
Reprocessed in Australia	0.3	66.1	34.0	100.3
Landfill	0.2	2.0	1.0	3.2
Stockpiled formal	0.0	4.0	2.0	6.0
Stockpiled informal	0.2	1.7	0.9	2.7
Rebirth	-	1.3	0.7	2.0
Illegal export	-	5.3	2.7	8.0
TOTAL	0.7	80.3	41.3	122.2

2.2   Australian Bureau of Statistics import data

The Australian Bureau of Statistics (ABS, 2013) produced a customised report for the DoE that gives statistics on the number of lead-acid batteries imported into Australia as a stand-alone item (ABS 2013). The ABS breaks these numbers down into 7 categories:

(1) 850710 Lead-acid electric accumulators (incl. separators therefor), of a kind used for starting piston engines (a)

(2) 8507101077 Lead-acid type electric accumulators of a kind used as replacement components in passenger motor vehicles

(3) 8507109078 Lead-acid electric accumulators, of a kind used for starting piston engines for motor vehicles (excl those used as replacement components in passenger motor vehicles)

(4) 8507109090 Lead-acid accumulators, of a kind used for starting piston engines (excl those used as replacement components in passenger and other motor vehicles)

(5) 8507200079 Lead-acid electric accumulators (incl separators therefor); for traction purposes (excl those used for starting piston engines)

(6) 8507200080 Lead-acid accumulators of regulated sealed valve type with a capacity greater than 65 Amp/hr at C20 (for 20 hour rate) at 25 degrees Celsius (excl. for traction purposes, or lead-acid, of a kind used for starting piston engines)

(7) 8507200081 Lead-acid type electric accumulators (excl those of a kind used for starting piston engines, those used for traction purposes, and regulated seal valve types with capacity > 65 amps/hr at C20)

The ABS (2013) data shown in Table 4 contains import figures by importer for the financial years 2008/09 through to 2012/13. Note that data from the FYE 2009/10 was used for all comparisons with the Warnken ISE (2010) data.

Table 4: Stand-alone imports of batteries to Australia in 2009/10 (ABS, 2013)

Category	Quantity (kt)	Battery Count (millions)
(1)	59.85	3.82
(2)	44.95	2.20
(3)	9.02	1.09
(4)	5.88	0.52
(5)	1.05	0.05
(6)	2.74	0.10
(7)	23.87	2.08
TOTAL	147.35	9.88

2.3   Other data

2.3.1 National hazardous waste data assessment

In 2013 recent a study into hazardous waste flows and composition across Australia, KMH Environmental (2013) estimated that municipal solid waste (MSW) comprised some 34.5 kt lead-acid batteries based on an average per household hazardous waste generation rate (35 kg per year) and typical composition (4% lead-acid batteries), both of which came from NSW data.

2.3.2 Hydromet arisings estimate

Hydromet Corporation is a major Australian ULAB recycler, processing up to 36 kt ULABs per year. The company's website states that total annual (reference year unknown) generation of ULABs in Australia amounts to 7.3 million motor and industrial batteries, which is estimated to amount to 90-110 kt/year (HydroMet, N.D.). No reference or basis for these figures is given.

2.3.3 SITA waste car batteries estimate

A page on the website of the waste and resource recovery company SITA suggests that Australia produces some 70 kt of spent car batteries per year (SITA, 2014). Again no reference or basis for the estimate is provided.

3 DATA COMPARISONS AND RECONCILIATION

Based on the numbers reviewed in Section 2, there are three distinct issues that need to be examined and rectified:

1) Imports of stand-alone lead-acid batteries from ABS (2013) at 147 kt/year are substantially higher than lead-acid battery inputs from Warnken ISE (2010) at 134 kt/yr

2) The amount of total lead-acid battery arisings generated currently has a wide range between sources, namely 90-110 kt/year Hydromet (N.D.) and 122 kt/year Warnken ISE (2010)

3) The amount of lead-acid batteries arising in the MSW stream of 34.5 kt/year reported by KMH Environmental (2013) amounts to 43% of all non-industrial SLI lead-acid batteries reported to be arising in Warnken ISE (2010), which would appear an excessively large fraction of used automotive batteries being handled domestically.

A systematic approach was taken to identifying potential sources of discrepancy, which involved:

- Inspection and checking of the ABS (2013) (FYE 2009/10) and Warnken ISE (2010) data/calculations.

- Examination of other data to find misalignments or errors

- Identification of agreement between the different data sources

- Detailed exploration of significant disagreements between datasets to gauge the robustness of the different numbers.

The outcomes of below of each stage of analysis are described below.

3.1 Data inspection and checks

3.1.1 Warnken ISE (2010) data

The estimates of lead-acid batteries imported into Australia could be back-calculated from the numbers presented in the Warnken ISE (2010) report. In performing the back-calculations one relatively small issue was found in the large and industrial batteries category. Namely, Warnken ISE (2010) indicates that 90% of batteries used in traction or stationary standby batteries were lead-acid and batteries in marine or construction/forestry/farming and mining categories were 100% lead-acid. However when calculating the number of lead-acid battery inputs based on this logic, the total lead-acid battery inputs to Australia comes out slightly higher than the reported number (135.8 kt instead of 133.6 kt). It is assumed that this issue was due to the 90% lead-acid battery assumption for traction or stationary standby batteries being inadvertently applied to all batteries in the large and industrial sector.

Quoted and back-calculated numbers from this analysis are given in Table A1 in Appendix A, with the summary of the back-calculated numbers shown in Table 5.

Table 5: Warnken ISE (2010)[1] split into mass categories

Battery size	Warnken ISE (2010) Inputs	
	Mass (kt)	Battery Count (millions)
0-1 kg	1.3	1.82
1-5 kg	0.8	0.26
5-20 kg	78.0	5.36
20-50 kg	51.1	5.36
50-100 kg	4.6	0.02
100-3000 kg	0	0
TOTAL	**135.8**	**9.28**

3.1.2 ABS (2013) data

The ABS (2013) data (FYE 2009/10) was examined in close detail to attempt to find irregularities. Several issues were identified including:

1) Confusing category codes

2) Possibly incorrect units

3) Duplicate records in the dataset

The first issue is the ABS categorisation of the lead-acid batteries is not clear, nor is it reflective of usage. For example, Warnken ISE (2010) assumed that "*8507200081 Lead-acid type electric accumulators (excl those of a kind used for starting piston engines, those used for traction purposes, and regulated seal valve types with capacity > 65 amps/hr at C20)*" referred to handheld batteries with a mass of less than 1 kg, however the median mass of batteries of this type is 10.6 kg. Similarly, "*8507109090 Lead-acid accumulators; of a kind used for starting piston engines (excl those used as replacement components in passenger and other motor vehicles)*" has a median battery mass of only 3.8 kg, despite this category presumably referring to SLI batteries for specialist machinery.

One of the possible reasons for the above discrepancies could be due to incorrect units being used in the ABS data. For example, one record for 50 batteries of type "*8507109078 Lead-acid electric accumulators, of a kind used for starting piston engines for motor vehicles (excl those used as replacement components in passenger motor vehicles)*" had a gross mass of 700 t, or 14 tonnes per battery. It is considerably more likely that a battery used for starting a piston engine would be 14 kg rather than 14 tonnes. This issue in particular is difficult to quantify as lead-acid batteries come in a range of sizes from <1 kg to up to 3t (Warnken ISE 2010). However the ISF has attempted to partially resolve this issue by removing any battery with an average mass of more than 3 t.

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[1] Note that all the batteries are assumed to be the average mass estimated by Warnken ISE (2010), and the numbers presented incorporate both quoted and back-calculated numbers from the Warnken ISE study.

Finally the ABS data appears to contain duplicate records. Specifically the categories used in the ABS dataset include 6 Statistical code levels and one HS code level (ABS, 2006). While some of the entries in the HS code level are unique (presumably because the raw data collated by ABS does not identify what Statistical code level the lead-acid battery is), some of the HS code level category entries are replicated in a specific Statistical code level. As such, all HS code level categories that have a Statistical code level entry were removed from the dataset, reducing the dataset by 1017 records. The summary of the ABS dataset with the duplicates and records indicating battery mass of greater than 3 tonnes removed is presented in Figure 2 and Figure 1 and show the imports by ABS category in counts and mass, respectively. The data used to produce the plots are given in Appendix A, with the summary for the 2009/10 data shown in Table 6 (overleaf).
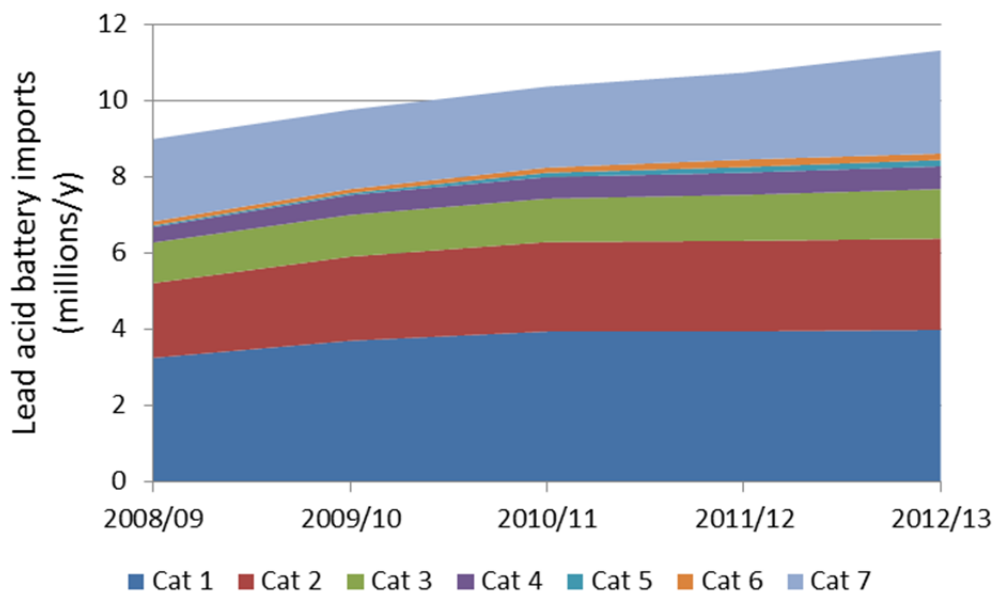
Figure 1: Imports of lead-acid batteries calculated from ABS (2013) data (millions/year)
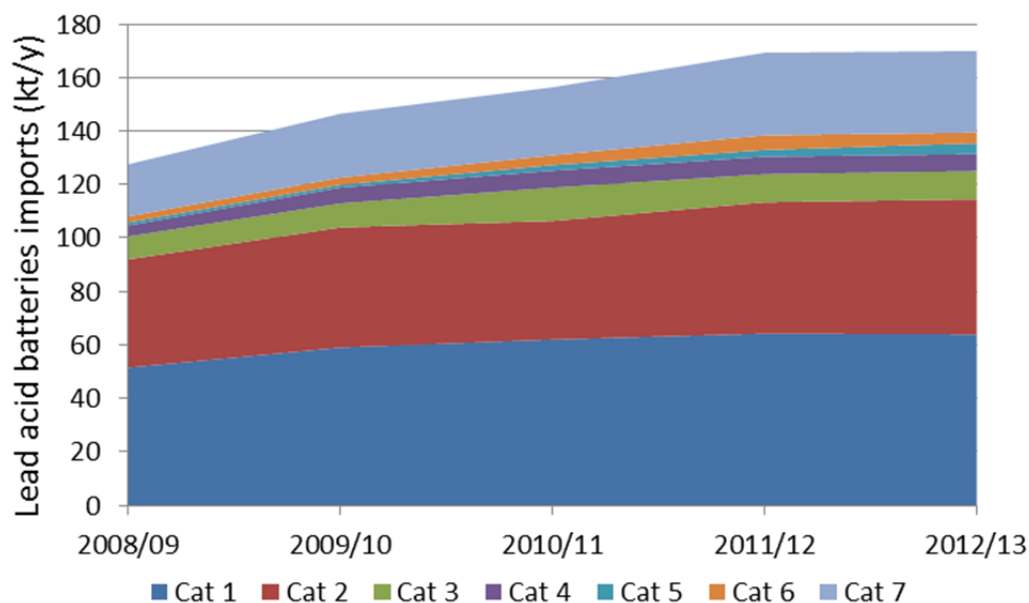
Figure 2: Imports of lead-acid batteries calculated from ABS (2013) data (kt/year)

Table 6: ABS (2013) data presented by mass categories

Battery size	ABS (2013) stand-alone imports	
	Mass (kt)	Battery Count (millions)
0-1 kg	0.2	0.50
1-5 kg	4.6	1.23
5-20 kg	76.5	5.67
20-50 kg	59.1	2.28
50-100 kg	3.9	0.06
100-3000 kg	2.2	0.01
TOTAL	**146.4**	**9.76**

3.2   Misalignments and errors

A minor disagreement between the various data sources was identified:

- A high estimate of lead-acid batteries entering the MSW stream from KMH Environmental (2013) relative to battery replacement estimates from Warnken ISE (2010).

The issue related to the large relative size of the estimated quantity of lead-acid batteries in the MSW stream appears to stem from a simple error in the KMH Environmental (2013) estimate. In table 12 of the report, the mass of waste lead-acid batteries arising from households is listed as 4 kg per year, when according to the text of the report it should be 4% of 35 kg per year (1.4 kg per year). Using the correct mass of annual lead-acid battery waste, the total annual load of batteries entering the MSW stream is about 12 kt per year, or 15% of total SLI and handheld batteries (the types of batteries that can enter the MSW stream) arising from Warnken ISE (2010). Warnken ISE (2010) estimates that do-it-yourself car battery replacements made up 30.8 kt (35%) of 85.7 kt SLI battery inputs. Some fraction of this flow would be handled through commercial and industrial waste collection, since some do-it-yourself replacement would involve businesses replacing their car/truck fleet batteries, and a fraction ULABs from domestic vehicles being handed over to battery vendors. In addition, informal stockpiling would reduce the number of batteries entering the collected MSW stream.

3.3   Comparison of Warnken ISE (2010) and ABS (2013) numbers

3.3.1 Methodology

In order to compare ABS (2013) stand-alone imports with Warnken ISE (2010) inputs a method of standardising the two streams will need to be found. The following relationship presumably exists between the two datasets:

$$inputs = \begin{pmatrix} standalone \\ imports \end{pmatrix} + \begin{pmatrix} embedded\ imports \\ cars\ and\ trucks \end{pmatrix} + \begin{pmatrix} embedded\ imports \\ other\ equipment \end{pmatrix} + \begin{pmatrix} domestic \\ production \end{pmatrix} - exports\ (1)$$

A comparison between Warnken ISE (2010) numbers and ABS (2013) estimates for the same time period (2009/10) can be created by rearranging equation 1 as:

$$inputs + exports - \begin{pmatrix} embedded\ imports \\ cars\ and\ trucks \end{pmatrix} = \begin{pmatrix} standalone \\ imports \end{pmatrix} + \begin{pmatrix} embedded\ imports \\ other\ equipment \end{pmatrix} + \begin{pmatrix} domestic \\ production \end{pmatrix} (2)$$

The left hand side of equation 2 can all be estimated from Warnken ISE (2010) numbers, whereas the right hand side can be determined by ABS numbers (stand-alone imports) + some unknown but positive value (embedded imports in other equipment and domestic production). This means that equation 2 can be conceptualised as:

$$Warnken\ ISE\ (2010) = ABS\ (2013) + \varepsilon \qquad\qquad\qquad\qquad (3)$$

Where ε is a positive unknown value. The left hand side can be estimated using Warnken ISE (2010) to be:

Inputs: Warnken ISE (2010) estimate of inputs has already been calculated to be 135.8 kt or 9.28 million batteries as is shown in Table 5.

Exports: Warnken ISE (2010) estimates that 0.12 million batteries in vehicles were exported from Australia in 2008/09. It is assumed that a similar number was exported in 2009/10. By further assuming these batteries had an average mass of 14.3 kg (the average weight that Warnken ISE (2010) assumes for passenger vehicles) this would result in 1.7 kt of batteries exported. It is assumed for simplicity that these batteries were all from passenger vehicles.

Embedded imports – cars and trucks: Warnken ISE (2010) estimates that 84% of new vehicles were imported in 2009/10. If this percentage is constant across the various vehicle categories then the amount of embedded imports from cars and trucks can be determined from Warnken ISE (2010) to be 12.5 kt or 0.92 million batteries as is shown in Table 7.

Table 7: The amount of embedded lead acid battery imports from cars and trucks

Embedded imports	Mass (kt)	Count (million batteries)
Motorcycle	0.3	0.10
Passenger Vehicles	9.1	0.63
Light Commercial	2.4	0.16
Rigid Trucks	0.4	0.02
Articulated Trucks	0.1	-
Non-Freight Carrying Trucks	-	-
Buses	0.1	-
TOTAL	**12.5**	**0.92**

The left hand side of equation 2 can now be determined entirely from Warnken ISE (2010) to be: 135.8 +1.7 – 12.5 = 124.9 kt and is presented in Table 8.

The right hand side of equation 2 is partially estimated from ABS (2013) to be 146.4 kt as shown in Table 5 and, as it only contains the stand-alone imports portion, it is an under estimate of the right hand side of equation 2. It is apparent that these two sources contain a large disagreement of at least 21.5 kt.

Table 8: Comparison between Warnken ISE (2010)[2] and ABS (2013) data using alternative mass categories for the period 2009/10.

Battery size	Warnken ISE (2010) (Left hand side of equation 2)		ABS (2013) (Partial estimate of right hand side of equation 2)		Difference (ABS – Warnken ISE) Note this is a conservative estimate of the actual difference	
	Mass (kt)	Count (x 10^6)	Mass (kt)	Count (x 10^6)	Mass (kt)	Count (x 10^6)
0-1 kg	1.3	1.82	0.2	0.50	-1.1	-1.32
1-5 kg	0.5	0.16	4.6	1.23	4.1	1.07
5-20 kg	68.1	4.69	76.5	5.67	8.4	0.98
20-50 kg	50.4	1.79	59.1	2.28	8.7	0.49
50-100 kg	4.6	0.02	3.9	0.06	-0.7	0.04
100-3000 kg	0	0	2.2	0.01	2.2	0.01
TOTAL	**124.9**	**8.49**	**146.4**	**9.76**	**21.5**	**1.27**

[2] Note that all the batteries are assumed to be the average mass estimated by Warnken ISE (2010), and the numbers presented incorporate both quoted and back-calculated numbers from the Warnken ISE study.

As can be seen from Table 8 the Warnken ISE (2010) values are approximately 14% below the ABS numbers for both the count and mass basis. Further, since ABS is an under representation of the right hand side of equation 2, this discrepancy could be even larger than is presented. Hence there are over 1.3 million lead acid batteries unaccounted for in Warnken ISE (2010) that are presumed to exist based on the ABS (2013) data. In order to examine the discrepancy closer two approaches will be used:

1) The calculations from Warnken ISE (2010) will be examined to determine if there is any way for the discrepancy to be accountable in this data set. This examination will be based in three steps, first handheld batteries calculations will be examined, then SLI and finally large and industrial batteries.

2) The ABS data will be further scrutinised.

3.3.2 Warnken ISE detailed data examination

3.3.2.1 Handheld batteries

Warnken ISE (2010), estimates that the number of input handheld lead-acid batteries to be 1.3 kt. By comparison ABS (2013) import data indicates that imported lead-acid batteries of 1 kg or less to be 0.2 kt (see Table 8). The number of handheld batteries estimated by Warnken ISE (2010), are similarly higher than ABS (2013) figures with 1.8 million versus 0.5 million. The reason for this difference is likely due to Warnken assuming the ABS code: 8507200081 Lead-acid type electric accumulators (excl those of a kind used for starting piston engines, those used for traction purposes, and regulated seal valve types with capacity > 65 amps/hr at C20) represented handheld batteries of a mass less than 1 kg, when the median mass of these batteries is 10.6 kg. Both the ABS and Warnken ISE numbers are relatively small (<1% or less on a mass basis) hence this misalignment in the data is presumably a relatively minor issue.

3.3.2.2 SLI batteries

SLI batteries calculations for motor vehicles in Warnken ISE (2010) are based on new motor vehicle sales and the size of the motor vehicle fleet, which are attributed to government sources (notably ABS and Department of Innovation, Industry, Science and Research). These fleet and new car sales data are then combined with estimates for the size of the battery for the various vehicle types (14.3 – 31.6 kg) and the average life of these batteries (typically 3 years). All of these assumptions and the calculations appear to be correct and sensible. The total inputs of lead-acid batteries used for SLI in vehicles of 85.7 kt from Warnken ISE (2010) are therefore considered an accurate reflection of the real figure.

Warnken ISE (2010) estimated replacement automotive SLI batteries to amount to ~70 kt. Given the closeness of this to the figure reported by SITA (2014), it is possible that the SITA estimate was drawn from the Warnken ISE (2010) report.

3.3.2.3 Large Industrial batteries

Warnken ISE (2010) highlights that the large and industrial battery category contains the greatest uncertainty, which we suggest is mainly due to:

- Fork lifts numbers potentially being too low due to only the manufacturing being used to estimate the fleet size, leaving out other potentially significant sectors that use forklifts

- Assumptions related to golf carts and mobility scooters

- Stationary standby batteries calculations being based on data taken from the UK

The Warnken ISE (2010) calculation of forklifts (both electronic and IC) and material handling equipment was made by assuming a fleet size based on the number of manufacturing businesses only. However these types of equipment are used in a wider section of the business community would include warehousing,

supermarkets and other large chain retail businesses (e.g. Bunnings, Coles, Woolworths, Ikea). As a result the Warnken ISE (2010) estimate of 8 kt or 0.33 million lead acid batteries for forklifts and material handling equipment could be a significant underestimate of the actual value.

The estimate of the number of golf carts and mobility scooters in Australia is possibly conservatively calculated. Warnken ISE (2010) estimates the national golf cart fleet based on an assumed 25 carts per golf course across Australia, which is not readily verified. On account of a paucity of data, the number of mobility scooters is then assumed to be the same as the number of golf carts. Finally, similarly sized carts used for baggage handling (airports, large train stations) and at sporting arenas have not been accounted for. While these categories only accounts for 1.2 kt or 0.06 million lead-acid batteries, the uncertainty in this number remains considerable.

The calculations of the stationary standby batteries in Australia are also highly uncertain. This category accounts for 13.5 kt or 0.38 million lead acid batteries (Warnken ISE 2010). Importantly the calculation is based on an extrapolation of UK data on large standby battery arisings, which could be inaccurate as:

1) Australia and UK presumably have different per capita levels of penetration in solar and wind technologies
2) Australia and UK presumably have different percentages of solar and wind technologies coupled to standby batteries.

As a result the amount of lead acid batteries used for stationary standby purposes could be substantially different in reality.

These three categories are likely to be underestimated, the combined number of batteries from these sectors is 0.8 million or 22.7kt. Although these numbers are in disagreement it is unlikely that they account fully for the misalignment between the ABS and Warnken ISE datasets.

3.3.3 ABS detailed data examination

The ABS (2013) dataset presents imports for financial years from 2008/09 to 2012/13 inclusive. Apparent growth rates in imports, shown in Figure 3, are unusually high, with an overall annual growth rate of 7.3% over the five years. Growth by category, however, is highly variable, with every size category having at least one year of negative growth and one year of greater than 20% growth. Of the categories presented, batteries in the 5-20 kg range should have a stable growth rate over time as they are typically used for replacement batteries in cars and light commercial vehicles which presumably require replacement fairly randomly and only linked to the size of the overall vehicle fleet. However in 2010/11 growth in this category spikes at 32% and in the following year drops to -10%. In addition, the overall growth rate for 5-20 kg batteries of 9.7% per annum seems unrealistically high given new car sales have grown at only 5.2% for the same period. Finally, the overall growth for the period was 7.3% per annum. This high apparent growth is considerably higher than the growth assumptions used by Warnken ISE (2010) of only 3.4% per annum.

As discussed earlier, some issues were detected in the ABS (2013) dataset, and it is possible that other issues in the dataset still exist that could contribute to the discrepancy between the Warnken ISE (2010) and ABS (2013) data.
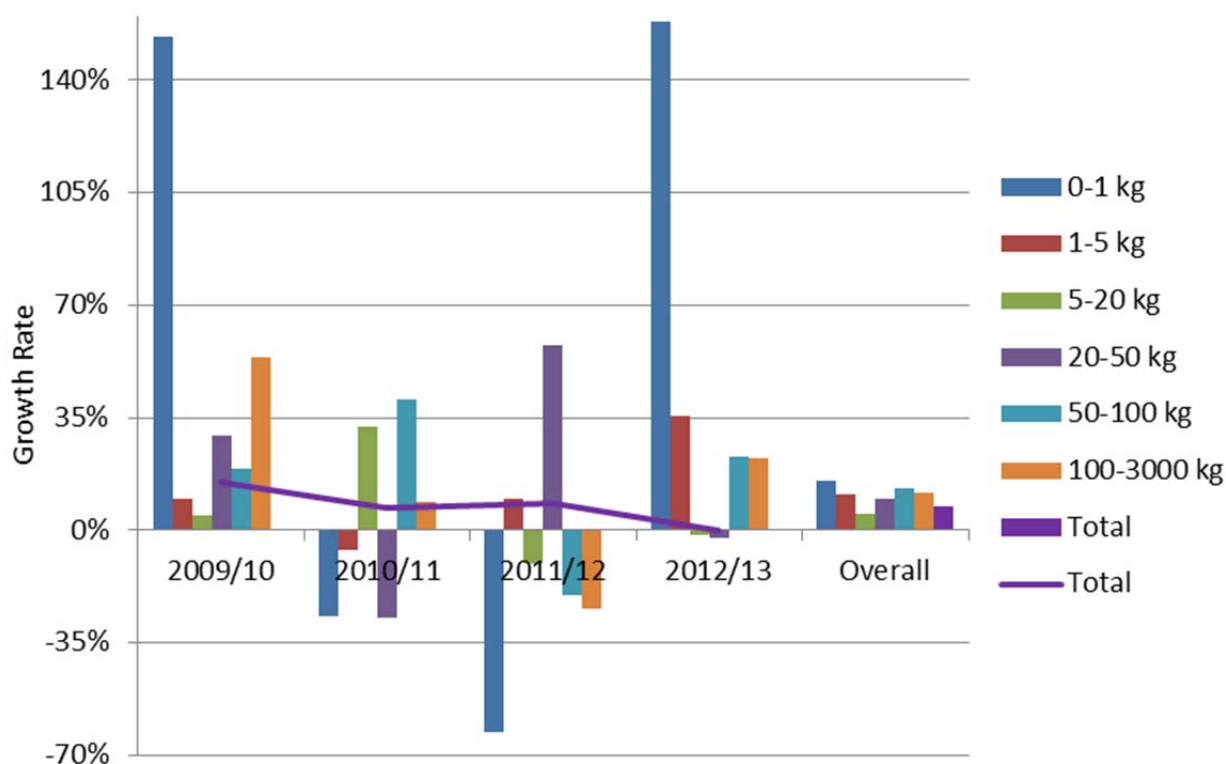
Figure 3: The high and variable growth rates in the various sizes of lead acid batteries.

3.3.4 Summary on the discrepancy between ABS and Warnken ISE

Some discrepancies have been found in the Warnken ISE (2010) data, namely a believed underestimation of three categories in large and industrial batteries, and a 1 million overestimate of the number of handheld batteries. Neither of these issues is likely to explain the discrepancy between the ABS and Warnken ISE numbers. The growth rates shown in the ABS data are difficult to explain and the extent of any anomalies which may be present in the data is not readily able to be ascertained.

4 CONCLUSION

A detailed review of data related to lead-acid batteries in Australia was undertaken to determine the most robust and reliable estimates of inputs to and arisings within the Australian market. The most comprehensive analysis of lead-acid batteries is presented in a report by Warnken ISE (2010) prepared for ABRI, which documents Australia-wide inputs, stocks and arisings of batteries. Accordingly the review entailed checking the calculations and assumptions used in the Warnken ISE (2010) report, and verification of the Warnken ISE (2010) outputs against alternative data sources, including a customised data report on lead-acid battery imports prepared by ABS (2013) and a handful of estimates of lead-acid battery arisings.

Other than one relatively minor apparent error in a calculation of large and industrial battery numbers, the Warnken ISE (2010) modelling appears to be robust. Estimates of large and industrial battery inputs are most likely to be low due to both the error referred to above as well as a number of key assumptions made necessary by a paucity of data. Conversely, exceptionally high apparent growth rates in the ABS (2013) lead-acid battery import data appear curious. Hence from the review undertaken in the herein report, it is believed that the numbers of lead-acid batteries from Warnken ISE (2010) are likely to be a conservative (lower-bound) estimate. Greater accuracy in the Warnken ISE (2010) estimates could only be achieved by obtaining better data on the national fleet of forklifts, golf carts, mobility scooters and large standby batteries, all of which were not available at the time of the original study and are unlikely to be accessible now without significant research effort.

Assuming the small error identified in the calculation of batteries in marine, construction/forestry/farming and mining categories is legitimate, then total inputs into the Australian market should be 136 kt in 2009/10. The calculation error would also flow through to the arisings, increasing them to 124 kt in 2009/10. Both figures should be treated as conservative, and a margin of 10-15% is plausible given the disagreement with the ABS data.

Given the uncertainty surrounding the ABS (2013) growth rates, two sets of numbers are **presented for the amount of lead acid batteries entering the Australian market in 2012/13**. Firstly, **150.1 kt or 10.3 million batteries** and an alternative estimate of 167.8 kt or 11.5 million batteries reflecting two different growth rate assumptions. The first **assumes an average growth rate of 3.4% from Warnken ISE** and the alternative estimate using 7.3% based on the ABS imports data growth rate.

The **corresponding amount of lead acid batteries arising as wastes in 2012/13 is 137 kt** or 153 kt respectively.

5   REFERENCES

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6 APPENDIX A

Table A1: Partially back calculated full breakdown of lead-acid battery inputs from Warnken ISE (2010)

Sector/ Type	Item	Average mass of battery (kg)	Battery count (millions)	Total mass (kt)	Quoted/ Back-estimated
Handheld	Handheld	0.7	1.82	1.3	Q
Vehicles	Motorcycle	3	0.26	0.8	Q
Earth moving	Bobcats	9.1	0.02	0.2	B
Industrial	Small IC forklifts	9.1	0.02	0.2	B
Vehicles	Passenger vehicle	14.3	4.41	63.2	Q
Vehicles	Light Commercial	15.7	0.86	13.5	Q
Earth moving	Compressors/Gensets	19.4	0.02	0.5	B
Mining	Ancillary equip	19.4	0.02	0.4	B
Marine	Marine	21.8	0.29	6.3	Q
Traction	Golf carts/Scooters	22.6	0.055	1.2	B
Traction	Small electric forklift	22.6	0.05	1.2	B
Traction	Large electric forklifts	25	0.24	5.9	B
Vehicles	Rigid Trucks	23.1	0.17	4.0	Q
Earth moving	Graders/Dozers/Front-end loaders/Excavators	27.9	0.10	2.9	B
Farming	Tractors/Harvesters/Trench Diggers	27.9	0.36	10.8	B
Forestry	Feller-bunchers/Chippers	27.9	0.01	0.3	B
Vehicles	Articulated Trucks	31.6	0.06	1.9	Q
Vehicles	Non-Freight carrying trucks	31.6	0.01	0.3	Q
Vehicles	Buses	31.6	0.07	2.1	Q
Industrial	Large IC forklifts	31.6	0.02	0.6	B
Stationary standby	Stationary standby	35	0.39	13.5	Q
Mining	Dump trucks/Dozers/Wheel loaders/Shovels	53.9	0.02	4.6	B
TOTAL			**9.28**	**135.8**	

Table A2: Median battery mass by Statistical code from the ABS (2013) data (FYE 2009/2010)

Category	Description	Median battery mass (kg)
(1)	8507101077 Lead-acid type electric accumulators of a kind used as replacement components in passenger motor vehicles	17.6
(2)	850710 Lead-acid electric accumulators (incl. separators therefor); of a kind used for starting piston engines (a)	12.8
(3)	8507109090 Lead-acid accumulators; of a kind used for starting piston engines (excl those used as replacement components in passenger and other motor vehicles)	3.8
(4)	8507200081 Lead-acid type electric accumulators (excl those of a kind used for starting piston engines; those used for traction purposes; and regulated seal valve types with capacity > 65 amps/hr at C20)	10.6
(5)	8507109078 Lead-acid electric accumulators; of a kind used for starting piston engines for motor vehicles (excl those used as replacement components in passenger motor vehicles)	4.6
(6)	8507200079 Lead-acid electric accumulators (incl separators therefor); for traction purposes (excl those used for starting piston engines)	25.2
(7)	8507200080 Lead-acid accumulators of regulated sealed valve type with a capacity greater than 65 Amp/hr at C20 (for 20 hour rate) at 25 degrees Celsius (excl. for traction purposes; or lead-acid; of a kind used for starting piston engines)	24.5

Table A3: Imports of lead-acid batteries calculated from ABS (2013) data (kt/year)

Category	2008/09	2009/10	2010/11	2011/12	2012/13
(1)	51.55	59.02	62.00	64.23	63.96
(2)	40.45	44.95	44.39	49.14	50.56
(3)	8.63	9.02	12.47	10.50	10.51
(4)	4.08	5.88	6.35	6.53	6.37
(5)	1.13	1.05	2.06	2.54	4.07
(6)	2.29	2.74	3.72	5.49	3.99
(7)	19.48	23.87	25.41	30.89	30.52
TOTAL	**127.57**	**146.43**	**156.40**	**169.28**	**169.23**

Table A4: Imports of lead-acid batteries calculated from ABS (2013) data (millions/year)

Category	2008/09	2009/10	2010/11	2011/12	2012/13
(1)	3.25	3.70	3.94	3.95	3.99
(2)	1.96	2.20	2.35	2.37	2.39
(3)	1.06	1.09	1.14	1.20	1.30
(4)	0.41	0.52	0.56	0.58	0.60
(5)	0.04	0.05	0.11	0.15	0.16
(6)	0.11	0.10	0.14	0.20	0.17
(7)	2.16	2.08	2.12	2.28	2.70
TOTAL	**8.99**	**9.76**	**10.36**	**10.73**	**11.31**

Table A5: Imports of lead-acid batteries calculated from ABS (2013) data (kt/year)

Battery size	2008/09	2009/10	2010/11	2011/12	2012/13
0-1 kg	0.08	0.20	0.14	0.05	0.14
1-5 kg	4.20	4.61	4.34	4.76	6.43
5-20 kg	73.01	76.48	101.10	90.67	89.15
20-50 kg	45.59	59.05	42.94	67.62	65.93
50-100 kg	3.29	3.93	5.52	4.40	5.40
100-3000 kg	1.40	2.16	2.35	1.78	2.18
TOTAL	**127.57**	**146.43**	**156.40**	**169.28**	**169.23**

Table A6: Imports of lead-acid batteries calculated from ABS (2013) data (millions/year)

Battery size	2008/09	2009/10	2010/11	2011/12	2012/13
0-1 kg	0.29	0.50	0.45	0.42	0.55
1-5 kg	1.49	1.23	1.28	1.40	1.77
5-20 kg	5.45	5.67	7.06	6.30	6.45
20-50 kg	1.69	2.28	1.47	2.52	2.43
50-100 kg	0.05	0.06	0.09	0.07	0.10
100-3000 kg	0.01	0.01	0.02	0.01	0.02
TOTAL	**8.99**	**9.76**	**10.36**	**10.73**	**11.31**