Practical guidance for the development of inventories of used lead-acid batteries

Note

This guidance has been developed by the Secretariat of the Basel, Rotterdam and Stockholm Conventions at the request of the Conference of the Parties (COP) to the Basel Convention. At its 13th meeting in April 2017, the COP took note of the guidance and invited Parties and others to make use of it and inform the Secretariat on their experience in doing so.

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1 Introduction

1. Parties to the Basel Convention are required under Article 13, paragraph 3, of the Convention to transmit each year to the Conference of the Parties a national report on information related to the measures taken towards its implementation. Undertaking inventories can be an effective way of gathering information on the generation, transboundary movements and management of hazardous and other wastes for the purpose of national reporting. Such information and others are to be submitted, through the Secretariat of the Convention, using the national reporting format.[1]

2. This guidance aims to provide practical instructions to assist Parties and others in developing an inventory of waste lead-acid batteries. It is meant to be used in conjunction with the Methodological guide for the development of inventories of hazardous wastes under the Basel Convention [1] which provides complementary guidance on the methods of developing national inventories for the preparation of national reports. Accordingly, this guidance proposes an approach for developing an inventory that is consistent with the one contained in the Methodological guide.

3. The main objective of developing an inventory of waste lead-acid batteries is to obtain information on the amount of such waste generated in a country, its disposal and transboundary movement. Knowledge of the amount of waste generated provides a sound basis for their environmentally sound management (ESM) [2]. This information can be used to develop appropriate policies and strategies for the collection and disposal of waste lead-acid batteries and is an important input into the planning of recycling facilities that require substantial financial investment and regular throughputs of wastes. In addition, the development of the inventory can provide insight into the effectiveness of the system in place in a country to control the transboundary movements of waste lead-acid batteries.

2 Description of lead-acid batteries and their wastes

2.1 Classification of waste lead-acid batteries

4. For developing the inventory, establishing a classification of wastes that is used consistently will help ensure comparability of inventory information collected from various sources and over the years. Wastes should also be classified in a way that serves the objectives of developing the inventory, such as for the planning of disposal facilities. The format for national reporting under the Basel Convention requires that some of the information provided be categorized according to Annex I or Annex VIII codes. Therefore, in developing the inventory, using a classification of ULAB that is harmonized with the annexes of the Basel Convention will make it easier to integrate the outputs of the inventory into the national report.

5. The Technical Guidelines on the management of waste lead-acid batteries contains a detailed description of lead-acid batteries (LAB) and their operation [3]. The lifetime of a battery is the period of time during which a battery is capable of being discharged and recharged, and retains the charge applied. Once the battery is no longer capable of being recharged or cannot retain its charge, it has reached the end of its useful lifetime and becomes a "used battery" for the application for which it was designed. Such batteries are referred to as used lead-acid batteries (ULAB) in this guidance.

6. ULAB, the substances they contain and their components are included in Annex I and VIII to the Basel Convention as follows:

Annex I:

Y31: lead; lead compounds

Y34: acidic solutions or acids in solid form

Annex VIII:

A1160: waste lead-acid batteries, whole or crushed

A4090: waste acidic or basic solutions, other than those specified in the corresponding entry on list B (note the related entry on list B B2120)

2.2 Lead-acid batteries and their applications

7. Understanding of the patterns of use of LAB helps to determine the potential generators of LAB wastes. LAB are best known for their use in automotive vehicles as the electrical power supply for

[1] UNEP/CHW.12/INF/16/Rev.1; available through the electronic reporting system at http://www.basel.int/Countries/NationalReporting/ElectronicReportingSystem/tabid/3356/Default.aspx

Starting, Lights and fuel Ignition (The SLI Battery) but they serve many other uses. LAB can be classified in the following main categories:

(a) Automotive: supply power to the starter and ignition system to start the engine in vehicles powered by gasoline, such as cars, motorcycles, planes, etc. They are typically known as starting, lighting and ignition (SLI batteries).

(b) Motive: supply power to the motor and other parts of electric vehicles e.g. electric cars and fork lift trucks.

(c) Stationary storage applications in the industrial and commercial sectors: used for energy storage in an industrial and commercial setting and typically not meant to be mobile.

(d) Stationary storage applications in the domestic sector: used for energy storage in a home or office setting and typically not meant to be mobile.

8. Increasingly, LAB are being used to make energy generation more efficient, through load shedding and peak loading provisions. In this context, LAB are also the main choice of storage media for renewable energy, such as solar, hydro and wind, including for home systems in developing countries. There is also a growing interest in the use of electric vehicles to reduce pollution; the most common ones powered by LAB are public buses and small taxis. An overview of the main categories of LAB, their applications and users is provided in **table 1**. Users of LAB are potential sources of information on the generation of ULAB. Actors involved in the management of ULAB are also potential data sources for the inventory. Figure 1 illustrates the flow of materials and waste among the actors of a closed-loop system for the management of ULAB.

Table 1. Main applications of LAB

Category of LAB	LAB applications	Main users
Automotive	Cars, trucks, buses, motorcycles, etc	Individuals, businesses, public transport sector
Motive power	Light electric vehicles (electric cars and hybrids, bicycles, etc)	Individuals, businesses, public transport sector
	Heavy duty vehicles e.g., fork trucks, airport plane tractors	Transport businesses, warehouses, airports
Stationary storage applications: industrial and commercial	Electricity supply: back-up power systems and load levelling for grid supply networks	Electricity supply companies
	Renewable energy storage (solar, hydro and wind) systems	Electricity supply companies
	Emergency services: back-up power systems to supply electric power in the event of power outage for critical services	Police, hospitals and government institutions
	Large-scale Uninterrupted Power Supply (UPS) systems: back-up power to protect against power outage	Banks, shops, hotels, factories, providers of IT and financial services
	Telecommunications systems: back-up power systems for mobile phone towers and field facilities	Mobile phone / telecommunications providers
	Energy storage for street lighting systems powered by solar panels	Urban agglomerations, towns, villages.

Category of LAB	LAB applications	Main users
Stationary storage applications: domestic	Desktop UPS systems	Houses and small businesses
	Renewable energy storage systems (solar, hydro and wind) supplying voltages from 110 – 220 volts	Houses and small businesses in remote areas
	Back-up power systems (usually consisting of a bank of LAB connected to an inverter/charger and is connected to the electric grid for recharging): provides electrical power when grid supply fails	Houses and small businesses
	Back-up power for security systems	Houses, businesses

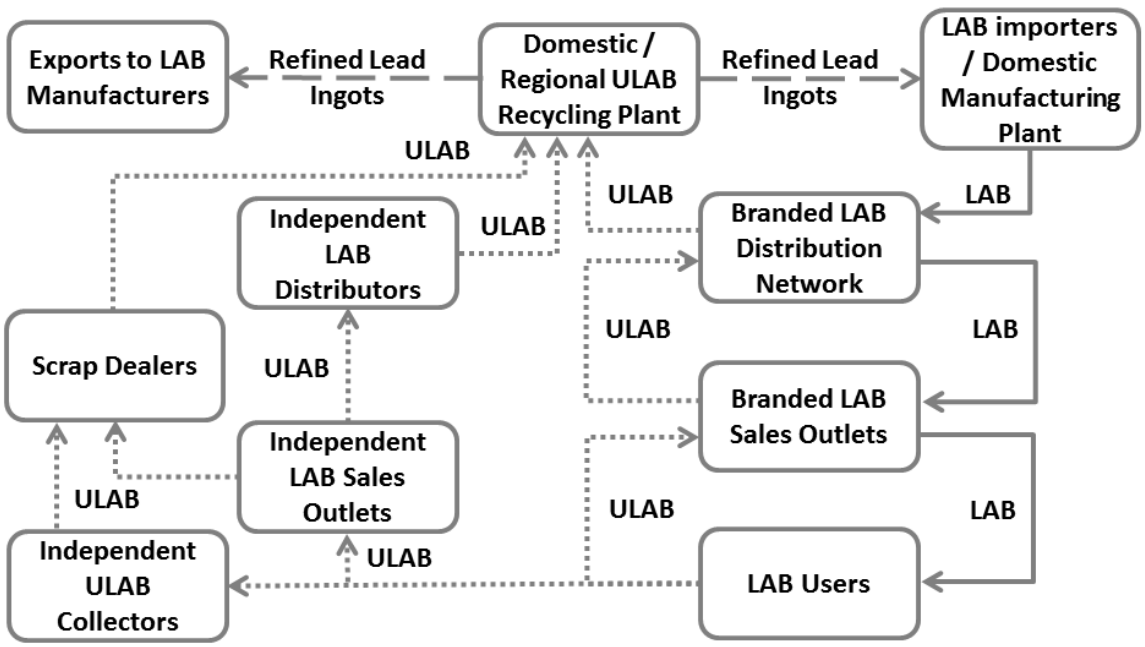

Figure 1. An example of the closed-loop system showing the generation and management of ULAB. The boxes represent the main actors involved in the life-cycle of LAB. The dashed lines show the flow of lead ingots, the solid lines show the flow of LAB and the dotted lines show the flow of ULAB.

3 Defining the scope of the inventory

9. Important questions to be answered in defining the scope of the inventory include: its purpose (including for completing the national report under the Basel Convention), desired outcomes, category of ULAB to be included (see table 2 and section 4.1.1), geographical area to be covered and specific exclusions and limitations due to e.g. access to information sources. When data will be collected from a defined geographic area, the results of the inventory will have to be extrapolated to the entire country to compute a national estimate.

4 Methodologies for developing the inventory

10. This guidance provides a methodology for developing a first generation inventory of ULAB. This methodology is appropriate for the early stages of development of a national system for the environmentally sound management of ULAB when a national system for collecting data from waste generators is not yet fully developed.

11. The methodology for developing the inventory relies on readily available statistics on the use of LAB and estimates of other key parameters needed for calculating the amount of ULAB generated. A more detailed and comprehensive inventory will require data collected from waste generators and other stakeholders through surveys and field visits. Progressing towards a more detailed inventory requires a larger investment of resources but also results in more accurate outputs.

12. The inventory of ULAB is developed in two steps. First, data is collected on the amount of LAB in use for each LAB application (section 4.1.1). In the second step, the amount of ULAB generated is estimated based on the lifespan of the LAB and their respective weight (section 4.1.2).

4.1 Collecting information on LAB use

13. A cost-effective way to gather data on LAB use is to request information from stakeholders using standard questionnaires. These should be designed to obtain data in a consistent manner that will allow the ULAB amount to be estimated for each LAB application. Questionnaires should contain an explanation of how the data should be entered. The annex to this guidance contains an example of a questionnaire for collecting information on LAB use for energy storage applications in the industrial and commercial sectors. It can be adapted for other categories of LAB. Follow-up phone calls to stakeholders after they receive the questionnaires can help ensure a high response rate.

14. Likely sources of information for various applications of LAB and the information to be requested are provided in **table 2**. The information collected for the inventory can be recorded in a database that will set a baseline for future updates. **Table 3** provides an example of a format for such a database. This format can also be used to compute the total amount of ULAB generated.

15. When developing a strategy for data collection, the following considerations are helpful:

(a) In many countries, for the first generation inventory, data on the use of some applications of LAB can be obtained indirectly from national or local authorities rather than from LAB users. For example, in most countries motor vehicles that use the public roads must be registered with a designated government agency that can be contacted to obtain data on the total number of vehicle registrations. Since each motor vehicle contains a LAB unit, the total number of LAB units used in the transport sector can easily be estimated.

(b) For some applications, it will be necessary to contact a number of different sources. If information is lacking from one source, such as the number of vehicle registrations from the ministry of transport, the information may be available from another source, such as the finance ministry, which should have records of vehicle imports and domestic sales in order to collect tax revenues.

(c) In some countries without a LAB manufacturing industry, for certain applications such as renewable energy storage systems for domestic use, there may be only a few importers/suppliers of LAB who can be asked to provide sales data.

(d) The applications listed in table 2 may not be important for all countries. For example, there may be very few solar street lights that use LAB for energy storage in a given country or geographic area.

16. When possible, the following information should also be collected from LAB users, either through the questionnaire or interviews:

Number of LAB used per system or equipment: for some applications, it is important to request information on the actual number of LAB being used in each system or equipment or plant. Individual automobiles usually contain a single LAB, but depending on the electric load requirements, a home solar system, for example, may contain bank of 2 to 12 LAB. The number and the weight of LAB used for industrial stationary storage applications vary across countries.

Average weight of each LAB: Table 3 provides information about the average weights of LAB units for various applications. For most LAB applications, however, there is a range of weights due to variations in the amount of lead and acid in the battery. For example, the average weight of a 12 volt SLI LAB is 14 kilos, but the best quality SLI LAB will weigh 17 kilos. The information provided in table 3 can serve as a guide for an initial inventory but more precise information on the weight of LAB used in a country should be collected from users, importers and manufacturers of LAB in the course of the inventory.

Useful life factor (ULF): This is the average useful life that the users obtain from the LAB and is calculated as the inverse of the lifespan of the LAB. It provides the proportion of LAB that has the probability of becoming waste in any period of 12 months. For example, for a type of LAB that needs replacing every five years on average, the ULF will be 0.2, implying that 20% of this type of LAB will be replaced in any 12 month period. Because of wide variations in the ULF depending on battery quality, climate and use pattern, country-specific information should be obtained from users of LAB in the course of the inventory.

Table 2. Information to be requested for developing the inventory and their likely sources

Category of LAB	LAB Applications	Information requested	Possible information sources
Automotive and motive	Motor vehicles (cars, buses, etc) and electric vehicles.	Number of vehicles registered	Ministry of transport (or other vehicle registration agency)
Stationary storage applications: Industrial	Electricity supply: back-up power systems	• Number of LAB per system • Lifespan and weight of LAB	Electricity supply companies; ministry of energy or natural resources
	Renewable energy storage systems	• Number of LAB per system • Lifespan and weight of LAB	Electricity supply companies
	Emergency services: back-up power systems	• Number of LAB per system • Lifespan and weight of LAB	Ministries and local authorities responsible for education, health care and emergency services.
	Telecommunication and mobile phone facilities	• Number of LAB per system • Lifespan and weight of LAB	Telecommunications and mobile phone companies
	Street lighting	• Number of streetlights in operation • Lifespan and weight of LAB	Municipal authorities in charge of maintenance
Stationary storage applications: Domestic	Uninterrupted Power Supply (UPS) units	• Number of LAB per system • Lifespan and weight of LAB	Major suppliers of computer equipment
	Renewable energy storage systems	• Number of home solar systems sold • Number of LAB system • Lifespan and weight of LAB units	Ministries of energy, environment and natural resources, renewable energy systems suppliers
	Back-up power systems	• Number of home back-up power systems sold • Number of LAB per system • Lifespan and weight of LAB	Ministries of energy, environment and natural resources, home power systems suppliers

Category of LAB	LAB Applications	Information requested	Possible information sources
	Security systems	• Security systems installed • Number of LAB used per system • Lifespan and weight of LAB	Major security system suppliers

4.2 Estimating the amount of ULAB generated

17. For each application of ULAB listed in the database, the amount of ULAB generated per year is calculated according to the following formula:

Step 1: Number of LAB in use = number of systems/equipment in use[a] x number of LAB per system/equipment[b]

Step 2: Amount of LAB in use (kg) = Number of LAB in use x average weight of LAB unit[c] (kg)

Step 3: Amount of ULAB **generated** (kg) = Amount of LAB in use (kg) x Useful life factor[d]

Step 3b: Amount of ULAB **generated** (metric tons) is equivalent to amount of ULAB **generated** (kg) x 0.001

a, b, c and d refer to data in the respective columns of table 3

18. Example calculation:

In a country with 3 telecommunications stations, each using 1 back-up system that contain 12 LAB with a lifespan of 8 years (i.e, a ULF of 0.125). Assuming an average weight of 30 kg for each LAB (see table 3), the amount of ULAB generated annually will be calculated as follows:

1. Number of LAB in use = 3 x 12 = 36
2. Amount of LAB in use = 36 x 30 kg = 1080 kg
3. Amount of ULAB generated annually= 1080 x 0.125 = 135 kg which is equivalent to 0.135 metric tons

19. After the quantities of ULAB generated have been calculated for each category and application of LAB listed in the database, they are summed up to provide the total amount of ULAB generated.

Table 3. An example of a format for the database on ULAB

LAB Category	LAB Applications	No. of systems (a)	No. of LAB per system (b)	No. of LAB in use	Average LAB weight (kg) (c)	Amount of LAB (metric ton)	Lifespan (years)	ULF (d)	Amount of ULAB generated (metric ton)
Automotive	Cars		1		14				
	Trucks		1		30				
	Buses		1		30				
	Motorcycles		1		5				
Motive power	E-bikes and scooters		1		10				
	Electric vehicles – Cars		1		40				
	Electric vehicles – Three Wheelers		1		30				
	Heavy duty electric vehicles – buses airport plane tractors, etc		1		60				

LAB Category	LAB Applications	No. of systems (a)	No. of LAB per system (b)	No. of LAB in use	Average LAB weight (kg) (c)	Amount of LAB (metric ton)	Lifespan (years)	ULF (d)	Amount of ULAB generated (metric ton)
Stationary storage: Industrial & commercial	Electricity supply – Back-up and load levelling systems				70				
	Solar energy systems				65				
	Wind turbine power systems				65				
	Back-up-Emergency services				65				
	Back-up UPS units – Commercial				65				
	Telecommunication/mobile phone stations				30				
	Street lighting		1		5				
Stationary storage: Domestic	Desktop - Uninterrupted Power Supply (UPS) units		1		11				
	Renewable energy systems				30				
	Back-up power systems		1		30				
	Security systems		1		2				
								Total	

4.3 Refining the first generation inventory

20. For an initial inventory, the amount of ULAB generated can be estimated for the automotive sector only. Since this sector accounts for the largest share of the market for LAB in most countries, the inventory output will provide an estimate of the bulk of ULAB generated. Information on vehicle registration can be obtained directly from government authorities. A small survey of key actors such as vendors of automobile and LAB as well as repair shops can provide information on the lifespan of LAB for various types of vehicles.

21. To refine the first generation inventory, data can be collected from additional sources of information such as those listed in table 3 if these are relevant for the country. Field visits and interviews to collect more detailed information for the most important applications will also provide a more complete and accurate picture of the amount of ULAB generated nationally.

5 Preparing national summaries and forecasts

22. If the inventory has been developed based on information from a limited geographic area, then the estimated amount of ULAB generated in that area has to be extrapolated to the whole country to obtain a national estimate. Forecasting in the early years following the development of an initial inventory of ULAB may be difficult. If policies affecting the transport sector, renewable energy generation and telecommunications are well established, then forecasting the changes in LAB use can be performed with a degree of certainty. However, if these policies are unknown or changing, then it will be necessary to prepare historical databases for the previous 5 or 10 years and examine the trends in LAB use in the various categories in order to prepare a forecast.

23. Information on the total amount of hazardous wastes generated is requested in table 6 of the national reporting format. Parties have the option of providing detailed information concerning specific hazardous wastes categorized according to the codes of Annex I or VIII to the Basel Convention or national codes. Further instructions can be found in the Manual for completing the format for national reporting under the Basel Convention [4].

6 Obtaining data on options for waste disposal and recovery

24. Information on options for the final disposal and recovery of hazardous wastes and other wastes available in a country are to be provided in table 2 and table 3 of the national reporting format, respectively. It is therefore important to collect on existing facilities for the disposal and recycling of ULAB in the course of developing the inventory. Information on the amount of ULAB processed by these facilities can also be cross-checked against the amount of ULAB generated to assess the accuracy of the latter (see section 9). When such facilities do not yet exist, information collected on alternative disposal practices will help in devising an appropriate strategy for the ESM of ULAB

7 Obtaining data on the transboundary movements of ULAB

25. Parties to the Basel Convention have the obligation to designate one or more authorities (competent authorities) for approving the transboundary movements of hazardous and other wastes. Competent authorities should therefore maintain a record of annual imports and exports of ULAB. Parties should provide this information in table 4 (export) and table 5 (import) of their national report.

8 Updating the Inventory

26. Applying the methodology described in section 4 provides an estimate of the amount of ULAB generated in a given year. To monitor the amount of ULAB generated every year it is recommended to establish a procedure for collecting the needed information from sources on a regular basis so that the inventory can be updated. For instance, a procedure could be established to send out the questionnaires to the data sources at a given date each year. Similarly since information on the import and export of ULAB will likely vary from year to year, the data can be updated by obtaining it from the competent authorities on an annual basis (see section 7).

9 Assessment of results and conclusions

27. It is important to assess the results of the inventory to identify measures that can make it more complete. Key elements to be assessed include the reliability of the data collected and the accuracy of the results. The assessment may also identify potential gaps in the control system for the implementation of the Basel Convention.

28. On approach to assessing the accuracy of the ULAB inventory is to compare the amount of ULAB generated to independent information on the flows of the ULAB in the country. For a country where secondary lead smelters operate, assuming that all ULAB are recycled by these facilities, the amount of ULAB processed by the smelters should be equal to the sum of the amount imported and generated domestically subtract the amount exported, if any. If a country exports all the domestically generated ULAB for disposal (recycling), the amount of ULAB generated should be close to the amount exported.

29. Licensed lead smelters should keep records of the amount of ULAB recycled. As described above, information on the amount of ULAB imported and/or exported legally should be available from the competent authorities for the Basel Convention. However, depending on how ULAB are classified and notified to the competent authorities, the information provided may not be easily translated into quantities of ULAB (in tons) and directly compared to the amount of ULAB generated. For example, the following descriptions are used by various countries for waste shipments classified under Y31: lead waste, scrap from used lead acid batteries, lead compounds, lead plates. Furthermore, if ULAB is shipped together with other wastes, the competent authority may record the weight of the consignment but not of each waste within.

30. Discrepancies between the amount of ULAB generated and the amount disposed/recycled domestically and/or exported could be due to a number of reasons that are worth investigating. They could indicate inaccuracies in the data collected, poor record keeping, differences in classification, missing data, etc. In some cases, consulting other sources of information may also help to resolve discrepancies; for instance, information on the transboundary flows of ULAB could also be obtained from customs authorities and the Comtrade database[2].

31. Discrepancies could also point to potential gaps in the control system for the transboundary movements of ULAB and areas where measures are needed to ensure the environmentally sound management of this waste. For example, deficits in the export of ULAB could be an indication that some ULAB is exported illegally, without notification to the competent authorities. In some countries, a

[2] https://comtrade.un.org/

proportion of ULAB generated is disposed of through informal recycling rather than licensed lead smelters.

10 References

[1] ICC (Committee for Administering the Mechanism for Promoting Implementation and Compliance of the Basel Convention). 2014. Methodological guide for the development of Inventories of hazardous wastes and other wastes under the Basel Convention. Available at: http://www.basel.int/portals/4/download.aspx?d=UNEP-CHW.12-9-Add.1.English.pdf

[2] UNEP. 2017. Revised factsheets on specific wastestreams. UNEP/CHW.13/INF/7

[3] UNEP. 2003. Technical Guidelines for the Environmentally Sound Management of Waste Lead-acid Batteries. Basel Convention series/SBC No. 2003/9. Available at: http://www.basel.int/Implementation/Publications/TechnicalGuidelines/tabid/2362/Default.aspx

[4] UNEP. 2017. Manual for completing the format for national reporting under the Basel Convention. Available at http://www.basel.int/Countries/NationalReporting/Guidance/tabid/1498/Default.aspx

Annex

Example of a questionnaire for the survey of LAB use in stationary storage applications

Dear Sir/Madam,

This questionnaire is for collecting data on lead-acid batteries (LAB) to determine the amount of waste that results from their use. The information you provide will only be used for the purpose of developing an inventory of used lead-acid batteries. Thank you for your cooperation.

Section A: Respondent information

Name	
Role/title	
Organization	
Address	
Telephone	
E-mail	
Date of completion	

Section B: Information on the use of lead-acid batteries

1. Please check the application for which LAB are used in your organization. For each application, indicate the number of systems/equipment /plant that contain LAB.
2.

Applications	**Check if applicable**	**Number of systems/equipment**
Electricity supply: back-up power and/or load levelling systems		
Solar energy storage systems		
Telecommunication and mobile phone facilities		

3. For each system/equipment reported above, please provide answers to the following questions in the table below:

    a) How many LAB does the system/equipment contain?
    b) What is the average weight (in kilograms) of a LAB contained in the system/equipment?
    c) What is the lifespan of the LAB used? (The lifespan is the number of years between the time of first use of the LAB to the time of its disposal)

System/equipment	(a) Number of LAB	(b) Average weight (kg)	(c) Lifespan (years)
1			
2			
3			