

**Joint Meeting of the RID Committee of Experts and the
Working Party on the Transport of Dangerous Goods**

Geneva, 15–25 September 2015

Item 2 of the provisional agenda

**Harmonization with the United Nations Recommendations
on the Transport of Dangerous Goods**

**Carriage of waste electrical and electronic equipment
containing Lithium Batteries**

Attachement 1 to INF.14

DRAFT

Lithium Batteries contained in Electrical and Electronic Equipment

A report prepared by RECHARGE aisbl.

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Brussels, August 21, 2015

Lithium Batteries contained in Electrical and Electronic Equipment

1. INTRODUCTION.

This report is aiming at responding to the request of the German Competent Authority for additional information regarding the presence of Lithium-Metal Primary (Li-M) and Lithium-Ion Rechargeable (Li-Ion) batteries in Waste Electrical and Electronic Equipment (WEEE) collected in EU in compliance with Directive 2012/19/EU.

- i. The report is reviewing the major applications where Lithium batteries (Li-M and Li-Ion) are used and is quantifying their market volume/share by application. The data are reported by weight and number of units. These represent best estimates on the basis of the information available to RECHARGE.
- ii. The technical characteristics of the battery by application range are described: energy, voltage, capacity, Lithium content...
- iii. An estimation of the ratio by weight between the battery and the equipment is presented in Tables 4 & 5.
- iv. The conclusions are drafted based on this information with considerations,
 - a. to the ratio of Lithium-batteries in collected WEEE, and
 - b. to the types of WEEE streams that need to receive particular attention on a safety point of view or that can be relaxed from the most stringent requirements.

2. REVIEW OF THE LITHIUM BATTERY MARKET (Li-M and Li-Ion).

The market for Primary Lithium-Metal (Li-M) and Rechargeable Lithium-Ion (Li-Ion) batteries has been estimated on the basis of data published on the energy content of batteries produced and sold per specific application and from number of cells or batteries sold in the world¹. It includes also an estimation of the market share of Europe per application. When available, the sales of equipment containing Lithium batteries are considered together with an average weight of the battery for a given application.

Figure 1A indicates the major applications where **Lithium-Ion Batteries** are “Placed on the Market”. The data are presented as the yearly weight of batteries sold per application. Indeed, more than 90%

¹ AVICENNE. Market Survey of Lithium Rechargeable Batteries 2013.

of these batteries are purchased with the battery incorporated in the appliance or packed with the appliance. It is estimated that the replacement market is approximately 10% of the total market for

Li-Ion batteries design for a specific equipment. From a total of 65'600 Tonnes, the large majority of these batteries is placed on the market in communication equipment, cordless Tools and mobility applications. When the number of batteries placed on the market is considered, the communication equipment takes 90 % of the market by weight.

Figure 1B indicates the market for Li-Ion batteries by units per year. As shown on this Figure, when the number of batteries placed on the market is considered, the communication equipment takes 90 % of the market by unit.

Figure 2A indicates the estimated quantities by weight of **Primary Lithium-Metal batteries** Placed on the Market yearly in Europe. The data refers to year 2013. For these batteries, there is a replacement market in addition to the first sales market. The Data are obtained from a Frost and Sullivan Market Survey² and have been checked internally with RECHARGE's Members. Figure 2A indicates that the dominant technology are the Li-MnO₂ and the Li-SOCL₂ systems.

Figure 2B indicates the market for Li-Metal Primary batteries by units sold per year. In this case, the Li-MnO₂ system dominates the market.

² FROST & SULLIVAN. Market Survey of Primary lithium Batteries 2012.

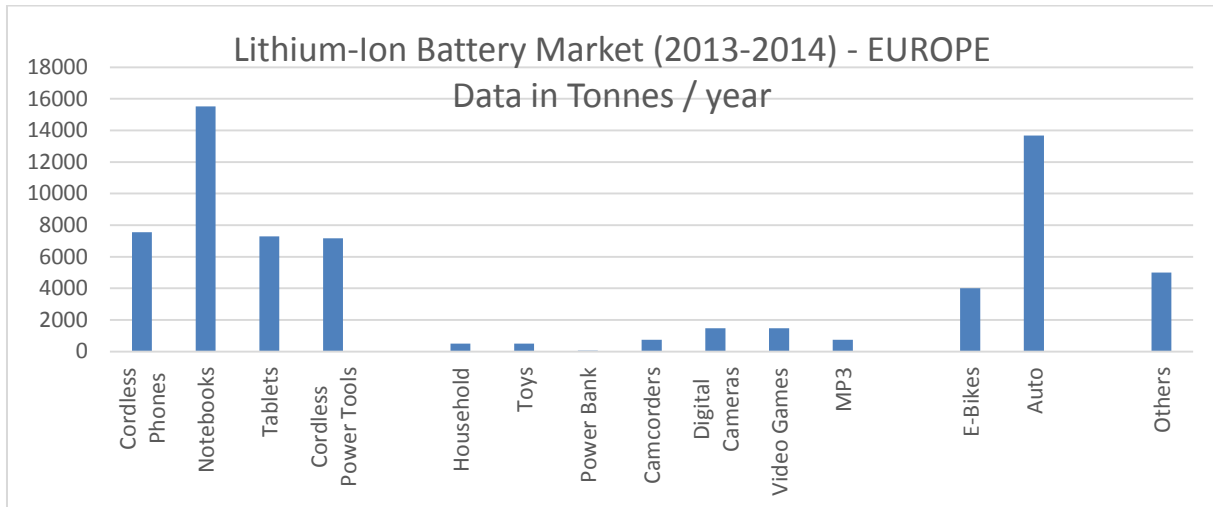


FIGURE 1 A.

Estimation of the Lithium-Ion Rechargeable Battery market in Europe (2013-2014 estimates). Data by Weight per Application: Total of 65'683 Tonnes of Li-Ion batteries per year.

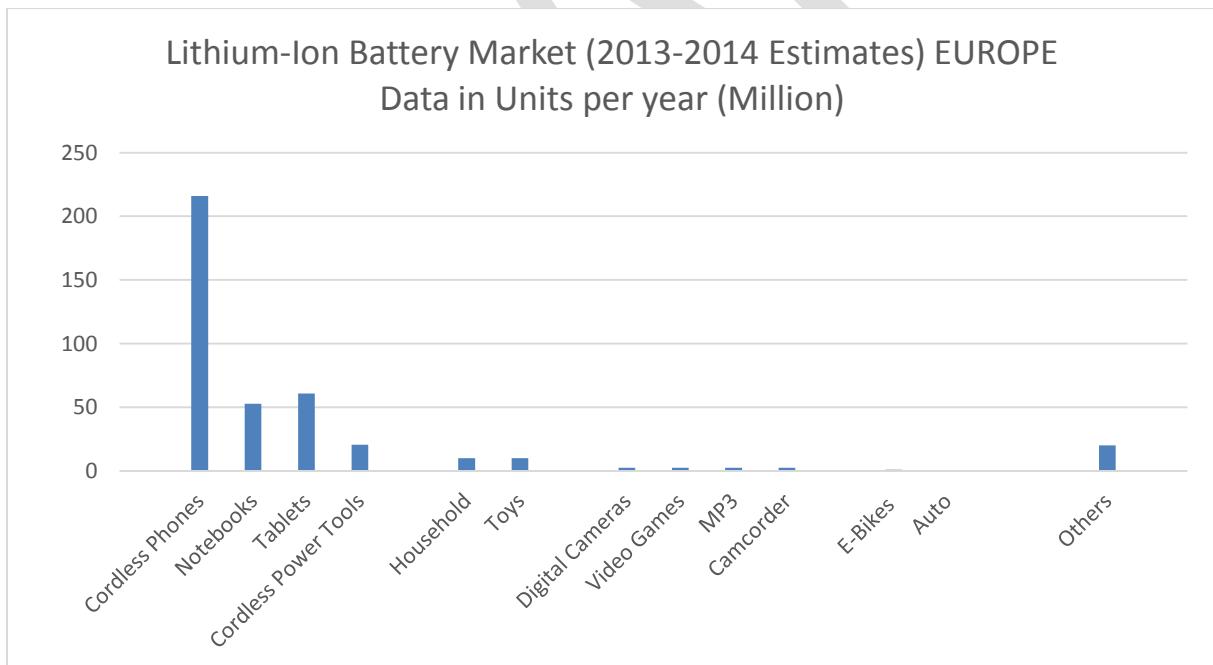


FIGURE 1 B.

Estimation of the Li-Ion Battery market in Europe (2013-2014 estimates). Data presented in Number of Units (Million) per application.

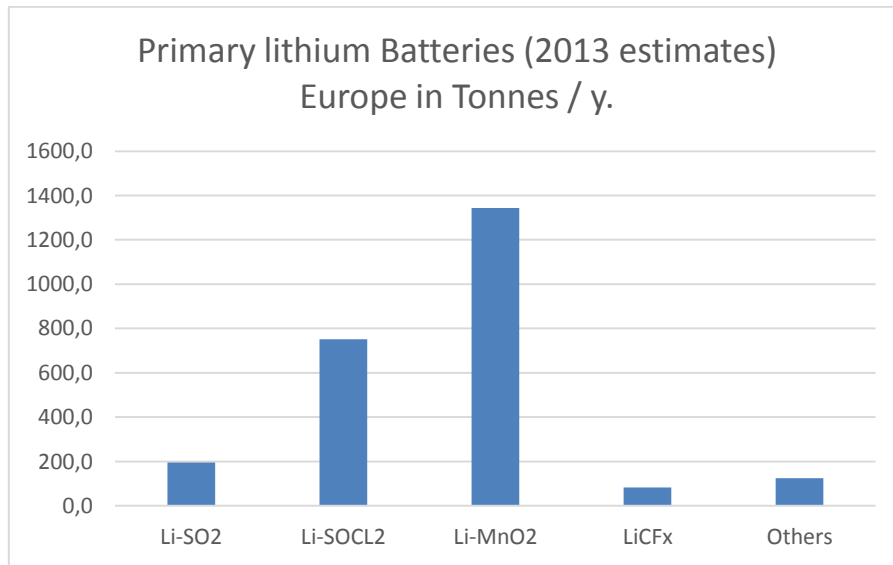


FIGURE 2 A.
Estimation of the Lithium-Metal Primary Battery market in Europe (2013-2014)
Total of 2'500 Tonnes of Lithium-Metal Primary batteries per year.

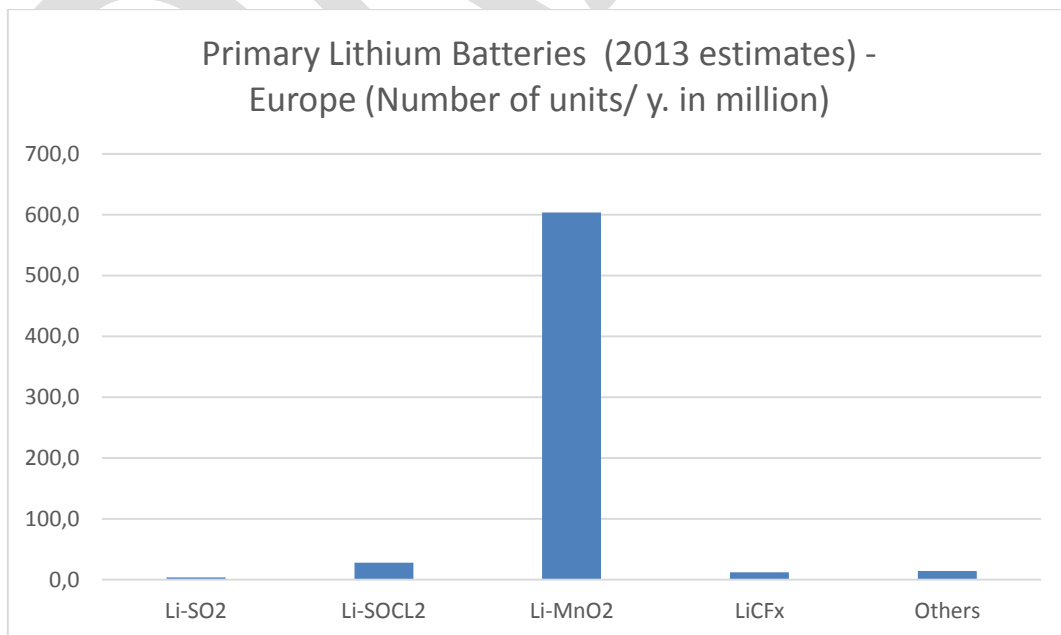


FIGURE 2 B.
Estimation of the Lithium-Metal Primary Battery market in Europe (2013-2014)
Data presented in Number of Units (Million)

3. LITHIUM BATTERIES and Electrical and Electronic Equipment (EEE)

3.1. Rechargeable Lithium-Ion Battery Market.

The analysis of the data presented in Figure 1 A and 1 B for Li-Ion batteries placed on the market shows the following trends.

- i) When one excludes the E-mobility market and one considers the consumer market, a majority by weight and by unit of Lithium-Ion batteries are sold in IT equipment (mobile Phones, Laptops, Tablets,...).
- ii) On the Industrial Market, there is a lower number of batteries sold but their energy content is much higher. Batteries for E-mobility have an energy content well above the 100 Wh limit: e.g. E-Bikes and Electric Vehicles.
- iii) As illustrated in Figure 3, Lithium-Ion cells and batteries placed on the consumer market have an energy content of less than 20 Wh per cell or 100 Wh per battery (Yellow boxes).
- iv) There is still a majority of Cordless Power Tools equipped with batteries of less than 100 Wh energy content, but there is an increasing quantity of cordless power tools equipped with batteries above 100 Wh. These batteries are also found in gardening and innovative professional equipment (e.g. portable power modules of 1.0 kWh).

Lithium-Ion Battery Market (2013-2014) - EUROPE
Data in Tonnes / year

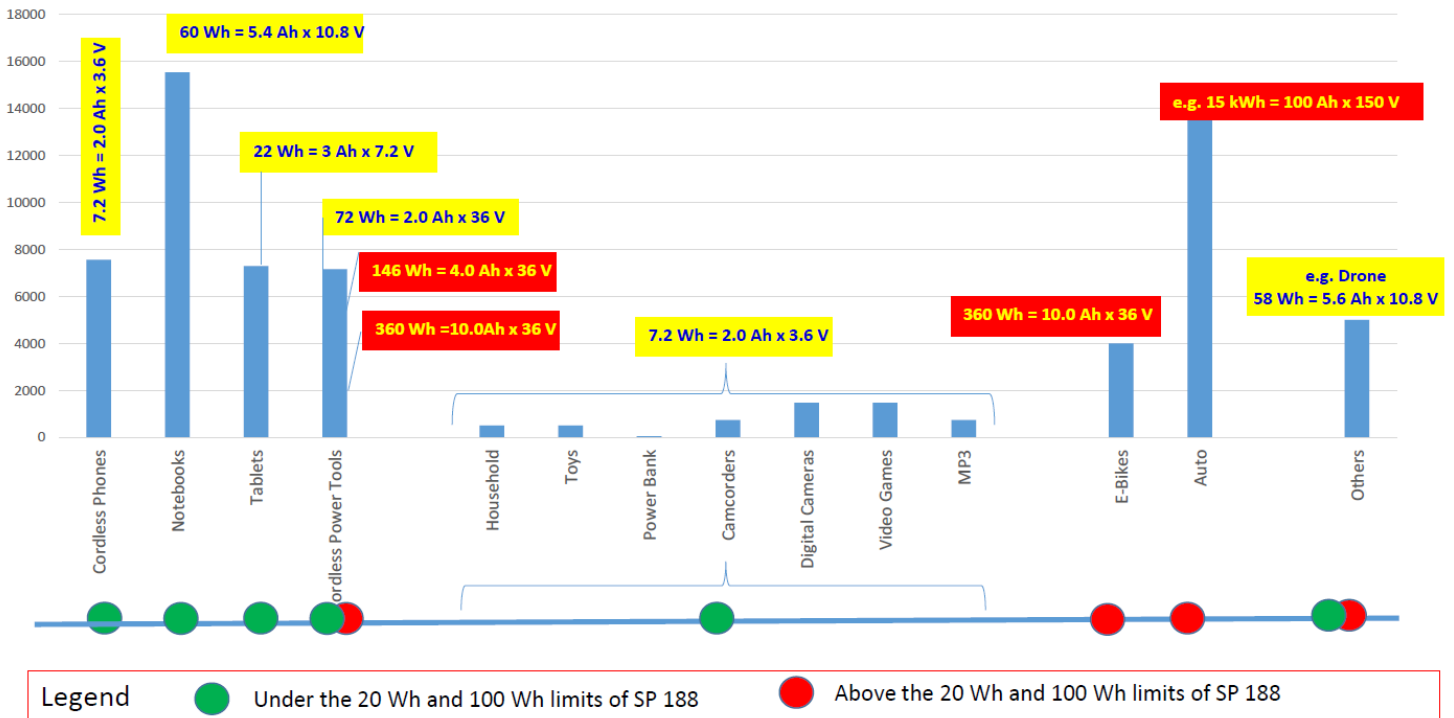


FIGURE 3.
Energy content of Lithium-Ion Batteries Placed on the market by application.
Relation with SP188 of the UN Model regulation for the Transport of Dangerous Goods.

3.2. Primary Lithium-Metal Battery Market.

As shown in Figure 2A, the market of Lithium-Metal Batteries is mainly distributed between Li-MnO₂ and Li-Thionyl Chloride (LiSOCl₂) systems.

As illustrated in Figure 2B, Li-MnO₂ is dominating the market by units as they are mainly used as small cells in a wide variety of appliances on the consumer market. The LiSOCl₂ system is used mainly in professional applications.

On the consumer market, the Li-MnO₂ is mainly sold as button cells. These batteries are used in a wide variety of applications either as main power or as memory back up applications. This is illustrated in TABLE 1 published by VARTA³

³ VARTA HANDBOOK OF BATTERIES

As shown in TABLE 2, the Lithium content of these button cells is less than 1.0 g. For the consumer market, they are based in a large majority on the Li-MnO₂ chemistry.

One considers that several hundreds of million of such cells are introduced on the EU market either directly as cells or as part of a larger equipment.

In Table 3, the information presented relates to higher energy density Lithium-Metal batteries that may contain more than 1.0 g of Lithium per cell or more than 2.0 g of Lithium per battery. Their Lithium content is larger than the exception limits of SP188. They are mainly LiSOCl₂ batteries with a high Lithium Metal content and are mainly used in industrial, military and space applications.

4. LITHIUM BATTERIES WITHIN APPLICATIONS

4.1. Rechargeable Lithium-Ion Batteries.

Table 5 supplies information about the major applications where Li-Ion batteries are used. It also supplies an estimation of the ratio between the weight of batteries and the weight of equipment.

The rechargeable Li-Ion battery is mainly used as the main power source in the listed applications described in Table 5.

Being the main source of power for the appliance, it is observed that the battery represents 10 to 20% by weight of the appliance's weight in a large majority of applications.

4.2. Primary Lithium Metal Batteries.

As mentioned, on the consumer market, the major use of Li-M batteries is the memory back up application. In this case, the battery represents less than 0.1 % by weight compared to the weight of the appliance. This is illustrated in TABLE 4.

In several applications, the Li-M battery is a major source of power, it is the case for the Li-MnO₂ systems in e.g. calculators, watches and some electronic games. The quantity of Lithium embarked in these batteries remains below 1.0 g per cell or 2.0 g per battery.

When the Li-SOCl₂ system is used to power equipment, it is generally in industrial applications which are returned in dedicated streams via waste management companies and professional carriers.

From the analysis of Table 4, it is confirmed that the weight ratio of Lithium-M batteries in most consumer applications remains in the range of 1 for 1000.

When industrial take back schemes are considered, attention should be paid to the fact that some of these Li-M batteries have a higher residual energy content and therefore should be carried under fully regulated conditions.

5. CONCLUSIONS.

The Transport of WEEE containing Lithium-Ion batteries.

Modern portable EEE appliances, instruments and equipment use extensively Lithium batteries.

When one excludes the E-mobility market and one considers the consumer market, a majority by weight and by unit of Lithium-Ion batteries are sold in IT equipment (mobile Phones, Laptops, Tablets,...). Some of these batteries are returned and collected with primary alkaline batteries (not-lithium based) via the Portable Batteries Compliance Collection Schemes, but a significant number is returned with WEEE.

Lithium Ion Rechargeable Batteries are the major source of power for mobile electrical equipment, they may represent by weight a significant ratio of the appliance (typically in the range of 10-20%).

Dedicated attention should be brought for the carriage of these batteries and equipment in accordance with the new Special Provisions SP377 and P909 of the UN Model Regulation for the Transport of Dangerous Goods, in particular when they have been sorted out.

Industrial Li-Ion batteries have to be taken back by producers when reaching an end of life. The conditions of transport are also regulated by the UN Model Regulation for the Transport of Dangerous Goods (SP376 & P909).

The Transport of WEEE containing Lithium-Metal batteries.

Lithium-Metal Primary Batteries are used mainly for memory back-up applications and, in a limited number of equipment, as a main power source.

When used as **Memory Back-up**, they represent by weight of small fraction of the EEE (generally less than 0.1 %). Their Lithium content is well below the 1.0 g limit per cell and 2.0 g limit per battery indicated in the SP188 of the UN Model Regulation for the Transport of Dangerous Goods.

They are generally fixed on the printed circuit board of the equipment, difficult to access, and therefore well protected during transport either as new or as waste.

As a result, the transport of WEEE containing Memory Back-up batteries should be considered with some relaxation from the Transport Requirements of UN Model Regulation for the Transport of Dangerous Goods.

When **industrial take back schemes** are considered, attention should be paid to the fact that some of these Primary Li-Metal batteries may have a high residual energy content and therefore should be carried under the current regulation for the Transport of Dangerous Goods.

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Brussels, August 20915.

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TABLE 1.
List of applications for Lithium-Metal Primary Batteries.
(From VARTA Handbook and SAFT Selector Guide)

SOURCE: VARTA Technical Handbook	Button Cells		Cylindrical Cell Spirally wound		Cylindrical Cell Bobbin	
	Main Power Source	Memory Back-Up	Main Power Source	Memory Back-Up	Main Power Source	Memory Back-Up
Telecommunications						
Std. Desk Tel.		+		+		+
Cordless Tel.		+		+		+
Cellular Tel.		+				
Mobile Radio		+		+		+
PABX				+		+
Consumer Products						
Electronic Games	+					
Watch / Clock	+		+			+
Calculator	+					
Compass				+		+
Car Radio		+				
Video Recorder		+				
Washing & Dishwash. Mach.		+				
Cooking Oven		+				
Utility Meters						
Gas Meter			+		+	
Heat Distribution Meter					+	
Electric Meter					+	
Water Meter			+		+	
Office Automation						
Computer		+				+
Copy Machine				+		+
Printer		+				
Fax		+				
Vending Machine		+				
Electronic Typewriter		+				
Process Control Equipment						
Taxi Meter		+				
Transponder			+			
Intel. Tagging	+					
Electric Parking Meter			+		+	
Data Logger						+
Dive Computer					+	
Automotive						
Car Lock	+					
Dashboard	+	+				
Security (e.g. tire,...)		+				

TABLE 2.
List of most currently used Li-MnO₂ button cells and cylindrical cells
in relation to their Lithium Metal content.
(Courtesy from VARTA).

Types	Serial N°	Li [g]	mAh
Button			
	CR 1220	0,01	35
	CR 1616	0,02	55
	CR 1620	0,02	70
	CR 2016	0,03	90
	CR 2025	0,05	165
	CR 2032	0,07	230
	CR 2430	0,09	300
	CR 2450	0,17	620
	CR 2477	0,29	1000

Types	Serial N°	Li [g]	mAh
Cylindrical			
	CR 1/2 AA	0,30	950
	CR AA	0,58	2000
	CR 123A	0,58	1550

TABLE 3.
List of most currently used cylindrical cells (LiSOCl₂) in relation to their Lithium Metal content
and Capacity (Courtesy from VARTA).

Cylindrical

Types	Serial N°	Li [g]	mAh
Cylindrical			
	ER 1/2 AA	0,30	1200
	ER AA	0,62	2500
	ER C	2,20	8500
	ER D	4,90	19000

TABLE 4.
List of Applications : INDICATIVE (ESTIMATED) VALUES WEIGHT Battery vs WEIGHT Application
LITHIUM-METAL PRIMARY BATTERIES (Back-up applications).

WEEE CATEGORIES	SOURCE: VARTA Technical Handbook	Button Cells		Battery Weight (g)	Equipment Weight (g)	Weight Ratio Bat./Eq. In %
		Main Power Source	Memory Back-Up			
Telecommunications						
6	Std. Desk Tel.		+	1	1000	0,1
6	Cordless Tel.		+	1	250	0,4
6	Cellular Tel.		+	1	200	0,5
6	Mobile Radio / I-Pod PABX		+	1	100	1
Consumer Products						
5	Electronic Games	+		1	500	0,2
5	Watch / Clock	+		1	100	1
5	Calculator	+		1	100	1
5	Compass					
5	Car Radio		+	1	500	0,2
5	Video Recorder		+	1	1000	0,1
4	Washing & Dishwash. Mach.		+	1	10000	0,01
4	Cooking Oven		+	1	10000	0,01
Office Automation						
5	Computer		+	1	5000	0,02
6	Copy Machine			1	5000	0,02
5	Printer		+	1	5000	0,02
5	Fax		+	1	2000	0,05
6	Vending Machine		+	1	10000	0,01
5	Electronic Typewriter		+	1	1000	0,1
Process Control Equipment						
5	Taxi Meter Transponder		+	1	500	0,2
5	Intel. Tagging Electric Parking Meter Data Logger	+		1	50	2
5	Dive Computer	+		1	50	2
Automotive						
5	Car Lock	+		1	20	5
NR	Dashboard	+	+	1	5000	0,02
NR	Security (e.g. tire,...)		+	1	5000	0,02

TABLE 5.
List of Applications for Lithium-Ion Batteries
INDICATIVE VALUES WEIGHT Battery vs WEIGHT Application
RECHARGEABLE LITHIUM-ION BATTERIES

WEEE Category	List of Applications	RECHARGEABLE CELLS and BATTERIES		Estimated Weight Contributions		
		Main Power Source	Memory Back-Up	Battery Weight (g)	Equipment Weight (g)	Ratio Bat./Eq. In %
	Telecommunications					
6	Cellular Tel.	+		50	300	16,7
6	Personnal Assistant	+		50	300	16,7
6	Laptop/Notebook	+		300	2500	12,0
6	Tablet	+		120	1000	12,0
5	Power Bank	+		50	100	50,0
	Consumer Products					
5	Cordless Tools (Consumr)	+		250	2000	12,5
5	Cordless Tools (Pro)	+		600	3500	17,1
5	Gardening Eqt.	+		1000	10000	10,0
5	Household e.g. toothbrush	+		50	250	20,0
5	Toys	+		50	250	20,0
5	Camcorders	+		300	1500	20,0
5	Digital Camera	+		147	1000	14,7
5	Video Games	+		150	500	30,0
5	MP3	+		150	500	30,0
	Automotive					
NR	P-HEV	+		10000	2000000	0,5
NR	EV	+		350000	2000000	17,5
NR	E-Bikes	+		2000	20000	10,0
	Others					
5	Drones	+		250	2500	10,0
5	Medical Devices	+				
5	Others...	+				