Weight Conversion Factors for Rechargeable Batteries

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At the United Nations University, Kees' main tasks are to lead the statistical work, build institutional capacity in countries on waste statistics, e-waste statistics and waste policies, give policy advice to countries on e-waste, the supervision of staff and strategic development of the team. He is one of the founders of the Global E-waste Statistics Partnership. Kees is currently the co-chair of the Taskforce on Waste Statistics of the UNECE Conference of European Statisticians that is tasked to develop a framework for waste statistics that is fit to monitor current and future circular economy policies, and waste policies. Next to that, Kees has been selected by the Dutch government as a member of the board of directors of the Dutch Waste Electronical and Electronic Appliances Register since 2015. In 2018, the Global E-waste Monitor 2017 won the European Advanced SDG award from the Diplomatic Academy in Vienna. At Statistics Netherlands, Kees has received the Innovation Award for the Dutch Green Growth publication in 2012. Previously, Kees worked at Statistics Netherlands, as the deputy head of the team Environment Statistics. He earned his PhD at the Faculty of Chemistry at Utrecht University on hydrogen storage.

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1. Objective and Scope

The scope of the project was to develop unit to weight conversion factors for all sizes and material types/chemistries of loose rechargeable batteries and rechargeable batteries embedded within or sold with products or devices that can be sold as standalone or replacement batteries sold in Ontario. Batteries weighting over five (5) kilograms are out of scope of this project as they are exempt from the Ontario Batteries Regulation. As a requirement, the battery average weights need to include the weight of the casing/housing of the batteries.

Prior to developing unit to weight conversion factors, it was necessary to define a reference classification of the most common chemistries of rechargeable batteries, identify the most common standard sizes and typical applications.

This report provides an overview of the methodologies used to develop unit to weight conversion factors, presents the results, details the validation steps that were undertaken to consolidate the results and draws the conclusions.

2. Methodology

This chapter presents the methodologies used to:

1) Identify the most common rechargeable battery chemistries
2) Identify standard rechargeable battery sizes
3) Identify the typical applications by chemistry
4) Calculate the average weight of rechargeable batteries by standard size
5) Calculate the average weight of rechargeable batteries by typical application

Steps 1 and 2 above had to be undertaken in this study because of the absence of a globally harmonized classification of the chemistries and standard sized of rechargeable batteries.

2.1 Classification by Chemistry

Literature research was conducted to identify the most common rechargeable battery chemistries on the market. See section 3.1 for the results.

The following sources were consulted to define a comprehensive classification of rechargeable batteries:

1) Linden's Handbook of Batteries, Fifth Edition (Kirby, 2019)
2) The EU ProSUM project (Prospecting Secondary raw materials in the Urban mine and Mining wastes)[1]. (Husiman et al, 2017)
3) The EU Orama project (Optimizing quality of information in RAw MAterial data collection across Europe). (Wagner et al, 2019)

Other sources were consulted to assess the comprehensiveness of the classification and to check whether it reflects current market trends and captures the majority of rechargeable batteries placed on the market at global level. To mention one, Avicenne Energy 2018 report that since 2005 the chemistry groups that dominate the market are Lead acid (PbA), Lithium ion (Li-ion), Nickel-Metal Hydrade (NiMH) and Nickel-Cadmium (NiCd).

[1] Prospecting Secondary raw materials in the Urban mine and Mining wastes (ProSUM) project. One of the aims of the project was to deliver the first Urban Mine Knowledge Data Platform: a centralized database of all available data and information on arisings, stocks, flows and treatment of waste electrical and electronic equipment (WEEE), end-of-life vehicles (ELVs), batteries and mining wastes. For further information please consult: http://www.prosumproject.eu/

2.2 Classification by Standard Sizes

Several producer catalogues were consulted to identify the most common sizes per chemistry group, the catalogues that were consulted are listed in Annex 1. See section 3.2 for the results.

While PbA, NiCd, NiMH and other loose batteries/cells are commercialized with standard sizes (e.g. A, AA, AAA, C, D, 9V etc.), Li-ion loose batteries/cells are hardly available in standards sizes for several reasons:

- users could inadvertently put them in a charger not designed for Lithium-ion batteries creating a potentially dangerous situation; and
- loose Li-ion cells are usually combined together in battery packs that are normally embedded in consumer electronics and other applications.

Therefore, for Li-ion batteries/cells the most common shapes were identified (cylindrical, prismatic, pin, button and pouch). As for pouch cells, due to the high level of variability of sizes, capacity and weight in the pouch group, pouch standard cells of different capacity measured in milliamp hour (mAh) were grouped into 5 representative categories:

- 55-500 typical nominal mAh
- 501-1000 typical nominal mAh
- 1001-2000 typical nominal mAh
- 2001-5000 typical nominal mAh
- >5001 typical nominal mAh

2.3 Typical Applications

A list of the most common applications was developed by conducting a literature review and comparing it to the outcome of some EU projects that have already identified the typical applications and that have linked them to the respective chemistry groups. See section 3.3 for the results.

Similarly to the classification, the proposed list of applications by chemistry group has been validated by comparing it with what was developed for:

1) The EU ProSUM project (Prospecting Secondary raw materials in the Urban mine and Mining wastes). (Huisman et al, 2017)

2) The EU Orama project (Optimizing quality of information in Raw Material data collection across Europe). (Wagner et al, 2019)

Additional applications were added to their respective chemistry groups in the case evidence of the usage of certain chemistry for certain application was found in literature (Kirby, 2019); (Liang et al, 2019) (FDK Corporation, 2020); (VARTA, 2020), (Samsung SDI, 2020) etc.

The categories of applications were created around a representative average product based on global numbers (Huisman et al, 2017). The list might not be exhaustive as more products can be associated to the different categories. The representative average products are the following:

1. <u>Other portable:</u> MP3, cordless phones, shavers, toothbrushes, power banks, drones, hover boards, cordless mice, remote controls etc, hand-handled devices;
2. <u>Cordless tools:</u> gardening tools, cordless tools, power tools;
3. <u>Industrial excluding mobility:</u> forklifts, energy storage for industrial use, other non-portable;

4. Lighting: security lighting, shielded or full cut-off lamps, luminaires, control and power lines, portable light fixtures
5. Cell phones: cellular phones, smartphones
6. Camera/games: camcorders, digital cameras, games, racing cars
7. E-bikes: e-bikes
8. Tablets: tablets
9. Medical: medical equipment (e.g. measuring instruments, medical carts and beds, portable defibrillators, wheelchairs and other instruments)
10. Portable PC: laptops, portable PCs, net-books, ultra-books
11. Personal Mobility Devices/Light Electric Vehicle: golf carts, personal mobility devices
12. Telecom: e.g. phone exchanges
13. UPS: Uninterruptible Power Supply (UPS)
14. Grids: grid energy storage

2.4 Average Weights by Standard Size

Desktop research was conducted to compile a comprehensive list of average weights by battery size (including the casing/housing). Catalogues of several manufacturers and retailers were consulted, including Linden's Handbook of Batteries Fifth Edition (Kirby, 2019), the list of catalogues can be viewed in Annex 1.

In the case of PbA, NicD, NiMH and other battery cells, which can be found in standard sizes, average weights from different data sources were found to be comparable and consistent. If the average weight from two different data sources was different, the higher value was chosen.

In contrary, Li-ion cells can be found in uncountable different sizes and capacity. Having reviewed the catalogues of several producers, it can be concluded that Li-ion battery cells are normally classified by shape (e.g. Cylindrical, Pin, Button, Prismatic and Pouch). In the case of the first four shapes (Cylindrical, Pin, Button an Prismatic) the variation of the average weight among cells of different capacity (mAh) was not significant, therefore the average weights presented in section 3.4 is the average of the weights of cells having different capacities. On the other end, due to the high level of variability in the pouch group, it was necessary to group the cells by capacity:

- 55-500 typical nominal mAh
- 501-1000 typical nominal mAh
- 1001-2000 typical nominal mAh
- 2001-5000 typical nominal mAh
- >5001 typical nominal mAh

The average weight for each group was calculated making the average of the weights of cells having capacities within the specified range per group.

2.5 Average Weights by Typical Application

The calculations of average weights by application were based on internal confidential data from SCYCLE developed during the ProSUM Project. The results obtained by applying the methodology described in this paragraph are presented in the results section 3.5, however the background data cannot be shared because of confidentiality issues. The main steps of the methodology for the calculation of the average weights by application are described below.

The average weight of secondary batteries by application (g/unit) was obtained by dividing the average energy usage per application (Wh/unit) by the average energy flow per grams of battery (Wh/g).

- Data in Wh/unit was derived by dividing the total Wh placed on the market per application at global level (source: global Avicenne data, obtained through the ProSUM project) by the total numbers of units placed on the market per application at global level (source: Avicenne 2015/2018 and SCYCLE internal data)
- Data in Wh/g per chemistry was compiled from scientific and public literature (e.g. Linden's Handbook of Batteries, Fifth Edition (Kirby, 2019)). Based on the type of application, some changes were applied to the Wh/g per chemistry, depending whether the application has more "power” or more “energy" requirements.
- The numbers were finally consolidated to increase coherence.

In this project, missing average weights were derived, where possible, assuming that:

[1] the average energy usage per application (Wh/units) is the same for batteries embedded in the same products and the average energy flow per grams of battery (Wh/g) is the same for all applications using the same type of battery;

[2] the average weight of NiMH batteries employed in industrial excluding mobility is assumed to be the same as for NiCd batteries used for the same application;

[3] the average weight of Li-ion batteries employed in industrial excluding mobility is assumed to be the same as for LiMn2O4 batteries used for the same application.

The average weights obtained using this methodology did not include the weight of the casing or housing of the battery cells/packs. Therefore it was necessary to identify the average share of the weight of the casing or housing out of the total weight of the battery cell/pack by chemistry group and add it to the weight of the reagents and other internal parts of the battery cells/packs. Literature review was conducted to research the information on the share of the casing/housing out of the total weight of batteries (Jung et al, 2016), (Raw Materials Company INC., 2020), (Herrmann, 2014). However, there is not much information available within the literature relating to the weight of battery casings/housings and this factor is highly dependent on battery chemistry, size and application. Results are shown in section 3.5.

3 Results

3.1 Classification by Chemistry

Table 1 shows the identified classification of rechargeable batteries. Three most representative chemistry groups were identified: Lead acid, Nickel and Lithium-ion. A fourth group called “other” includes other less common and niche chemistries e.g. Alkaline Metal Oxide.

Table 1: Classification of rechargeable batteries

Chemistry group	**Chemistry sub_group**	**Chemistry abbr.**	**Chemistry**
Lead acid	Lead acid	PbA	PbSO4
Nickel	Nickel-Cadmium	NiCd	NiCd
	Nickel-Metal Hydride	NiMH	NiMH
Lithium-ion	Lithium Cobalt Oxide	LCO	LiCoO2
	Lithium Nickel Manganese Cobalt Oxide	NMC	LiNiMnCoO2
	Lithium Nickel Cobalt Aluminium Oxide	NCA	LiNiCoAlO2
	Lithium Manganese Oxide	LMO	LiMn2O4
	Lithium Iron Phosphate	LFP	LiFePO4

Other[2]	Other (e.g. Alkaline Metal Oxide)	Other	Other

3.2 Classification by Standard Sizes

Table 2 shows the classification of rechargeable batteries by size. Most common sizes were identified for the Lead acid, Nickel and Other group, while Li-ion batteries have been classified according to the most common shapes and capacity groups as described in the section 2.2.

Table 2: Classification of rechargeable batteries by size

Chemistry group	Chemistry sub_group	Chemistry abbr.	Chemistry	Size
Lead acid	Lead acid	PbA	PbSO4	4 V
				6 V
				12 V
Nickel	Nickel-Cadmium	NiCd	NiCd	9 V "square"
				A
				AA
				AAA
				C
				D
				F
				N
				Sub C
	Nickel-Metal Hydride	NiMH	NiMH	9 V
				A
				AA
				AAA
				C
				D
				F
				N
				Sub C
Lithium-ion	Lithium Cobalt Oxide, Lithium Nickel Manganese Cobalt Oxide, Lithium Manganese Oxide, Lithium Iron Phosphate	LCO, NMC, NCA, LMO, LFP	LiCoO2, LiNiMnCoO2, LiNiCoAlO2, LiMn2O4, LiFePO4	Cylindrical single cell
				Prismatic single cell
				Pin cell
				Button cell
				Pouch cell (55-500 typical nominal mAh)
				Pouch cell (501-1000 typical nominal mAh)
				Pouch cell (1001-2000 typical nominal mAh)
				Pouch cell (2001-5000 typical nominal mAh)
				Pouch cell (>5001 typical nominal mAh)
Other	Other (e.g. Alkaline Metal Oxide)			AAA
				AA
				C

[2] The category "other" includes niche batteries (e.g. Alkaline Metal Oxide batteries, Lithium metal batteries etc.)

				D

3.3 Typical Applications

Table 3 shows the correspondence between the chemistry sub-groups and the identified typical applications.

Table 3: List of applications by chemistry sub-group

Chemistry sub_group	Chemistry abbr.	Chemistry	Applications
Lead acid	PbA	$PbSO_4$	Others portable
			Cordless tools
Nickel-Cadmium	NiCd	NiCd	Cordless tools
			Industrial excl mobility
			Lighting
Nickel-Metal Hydride	NiMH	NiMH	Cordless tools
			Others portable
			Industrial excl mobility
Lithium Cobalt Oxide	LCO	$LiCoO_2$	Cell phones
			Cameras/games
			e-bikes
			Industrial excl mobility
			Tablets
			Portable PC
			Medical
Lithium Nickel Manganese Cobalt Oxide	NMC	$LiNiMnCoO_2$	Portable PC
			Tablets
			Cell phones
			Cameras/games
			Cordless tools
			Others Portable
			e-bikes
			Industrial excl mobility
			Personal Mobility Devices/Light Electric Vehicle
			Telecom
Lithium Nickel Cobalt Aluminium Oxide	NCA	$LiNiCoAlO_2$	Industrial excl mobility
Lithium Manganese Oxide	LMO	$LiMn_2O_4$	Cameras/games
			Others portable
			e-bikes
			Industrial excl mobility
Lithium Iron Phosphate	LFP	$LiFePO_4$	Others portable
			e-bikes
			Industrial excl mobility
			Uninterruptible Power Supply (UPS)
			Grids

3.4 Average Weight by Standard Size

Table 4 summarizes the average weight by the most common standard sizes that can be found on the market resulting from the methodology described in section 2.4. Average weights are inclusive of the casing/housing of the battery.

Table 4: Average weights of secondary batteries by standard size

Chemistry group	Chemistry sub_group	ProSUM abbr.	ProSUM_Chemistry	Size	Av weight (g/unit)
Lead acid	Lead acid	PbA	$PbSO_4$	4 V	1.3
				6 V	1.6
				12 V	2
Nickel	Nickel-Cadmium	NiCd	NiCd	9 V	35
				A	32
				AA	21.5
				AAA	10.5
				C	73
				D	145
				F	231
				N	10
				Sub C	52.9
	Nickel-Metal Hydride	NiMH	NiMH	9 V	42
				A	40
				AA	27.1
				AAA	13
				C	80
				D	162.8
				F	261.3
				N	11
				Sub C	55
Lithium-ion	Lithium Cobalt Oxide, Lithium Nickel Manganese Cobalt Oxide, Lithium Manganese Oxide, Lithium Iron Phosphate	LCO, NMC, NCA, LMO, LFP	$LiCoO_2$, $LiNiMnCoO_2$, $LiNiCoAlO_2$, $LiMn_2O_4$, $LiFePO_4$	Cylindrical single cell	41.8
				Prismatic single cell	21.7
				Pin cell	1.0
				Button cell	2.5
				Pouch cell (55-500 typical nominal mAh)	5.2
				Pouch cell (501-1000 typical nominal mAh)	15.8
				Pouch cell (1001-2000 typical nominal mAh)	30
				Pouch scell (2001-5000 typical nominal mAh)	55
				Pouch cell (>5001 typical nominal mAh)	112
Other	Other (e.g. Alkaline Metal Oxide batteries)			AAA	11
				AA	22
				C	58
				D	104

3.5 Average Weight by Typical Application

Table 5 summarizes the average weights by typical application resulting from the methodology described in section 2.5. In the table, a [reference number] is added any time the average weight was derived by using the assumption [1], [2] or [3] explained in the methodology section 2.5.

Average weights are inclusive of the casing/housing of the battery. As a result of a literature review, a factor of 10% (Jung et al, 2016) was chosen for PbA batteries, and 25% (Raw Materials Company INC., 2020) & (Herrmann, 2014) for all other types of batteries (NiMH, NiCd and Li-ion). Although data was not available for all types of chemistry sub-groups, a conservative approach was used while choosing 25% for all types of batteries other than PbA for consistency and clarity reasons.

Table 5: Average weights of secondary batteries by application

Chemistry sub_group	ProSUM abbr.	ProSUM_Chemistry	Applications	Av weight g/unit
Lead acid	PbA	PbSO4	Others portable [1]	806
			Cordless tools	1556
Nickel-Cadmium	NiCd	NiCd	Cordless tools	1182
			Industrial excl mobility	2963
			Lighting	2963
Nickel-Metal Hydride	NiMH	NiMH	Cordless tools	923
			Others portable	42
			Industrial excl mobility [2]	2963
Lithium Cobalt Oxide	LCO	LiCoO2	Cell phones	28
			Cameras/games	215
			e-bikes	2802
			Industrial excl mobility [3]	2984
			Tablets	246
			Portable PC	341
			Medical	2984
Lithium Nickel Manganese Cobalt Oxide	NMC	LiNiMnCoO2	Portable PC	438
			Tablets	246
			Cell phones	53
			Cameras/games	215
			Cordless tools	495
			Others Portable	215
			e-bikes	2802
			Industrial excl mobility [3]	2984
			Personal Mobility Devices/Light Electric Vehicle	3284
			Telecom	2984
Lithium Nickel Cobalt Aluminium Oxide	NCA	LiNiCoAlO2	Industrial excl mobility [3]	2984
Lithium Manganese Oxide	LMO	LiMn2O4	Cameras/games	215
			Others portable	215
			e-bikes	2802
			Industrial excl mobility	2984
Lithium Iron Phosphate	LFP	LiFePO4	Others portable	215
			e-bikes	2802
			Industrial excl mobility [3]	2984
			Uninterruptible Power Supply (UPS)	2984
			grids	2984

4. Validation

4.1 Average Weight by Typical Application

The average weights by application calculated with the methodology described in the section 2.5 were validated by researching the battery specifications per chemistry and application in the market place, including the most common e-commerce platforms (e.g. Amazon, Ali Express, Ebay) and other specialized retailers (e.g. E-bike solutions, BatteryClerk etc.). The average weights by application and chemistry sub-group reported in Table 4 were compared to the average of the weight of at least 10 batteries of the same kind found on the marketplace.

In order to obtain a representative sample of products, batteries of a large variety of brands were selected. The brands of the batteries analyzed are listed in Annex 2.
In addition, the research covered all the applications listed in the section 2.3 and a large variety of applications' brands. See Annex 3 for the full list.

It was possible to obtain a representative sample of products for all applications except UPS, Telecom, Grids, Medical and Industrial Excluding Mobility due to the fact that those types of applications use specialized batteries with a high variability in terms of weight, which are hardly available on the marketplace. Furthermore, the weight of those batteries varies substantially across different applications. Nevertheless, a general validation was still possible by checking the catalogues of some battery providers (e.g. Dakota, UltraLife – see Annex 1).

The results of the validation effort show that on average the average weights calculated with the methodology described in section 2.4 are approximately 3% higher than the average weights researched in the marketplace. Looking more in depth at the comparison of the average weights for each chemistry sub-group and application, the differences are in the range of ± 3-20% as shown in Table 6 below.

Table 6: Comparison between average weights by application researched in the marketplace and the average weights calculated in this project (excluding UPS, Telecom, Grids, Medical and Industrial Excluding Mobility)

Chemistry group	Applications	Average from market place	Average weights from this project	Difference
NMC	Portable PC	372	438	18%
LCO	Portable PC	372	341	-8%
LCO	Cell phones	30	28	-7%
LiNMH	Cell phones	44	53	20%
Li-ion	Camera/games	226	215	-5%
Li-ion	E-bikes	3115	2802	-10%
Li-ion	Tablets	278	246	-12%
PbA	Cordelss tools	1666	1556	-7%
NiMH	Cordless tools	850	923	9%
NiCd	Cordless tools	420	495	18%
PbA	Other portable	874	806	-8%
NiMH	Other portable	30	31	3%
Li-ion	Other portable	197	215	9%
NMC	Personal Mobility Devices/Light Electric Vehicle	2750	3284	19%

Results show that generally the weights by application calculated in this project are higher than the ones found in the marketplace except for few products (cell phones – LCO, E-bikes, Tablets and Cordless Tools – PbA). This corroborates the results and confirms that the conservative approach adopted in this project lead to a positive approximation of the results rather than a negative one. However, it should be noted, that the results of this validation exercise might be dependent on the sample that was selected in the marketplace, and as a consequence, the results can be affected by the choices made, as there was no information on the total population of batteries available to draw a representative sample from.

5. Conclusions

Based on the results and validation efforts conducted in this study, it can be concluded that the proposed classifications of rechargeable batteries both by standard size and typical application are comprehensive and capture most of the chemistries, sizes and applications marketed in Ontario.

In addition, the average weights calculated with the methodologies described in the sections 2.4 and 2.5 can be considered reliable and validated with the results obtained from the validation process which show that on average they are approximately 2% higher than the average weights researched in the market place (with a possible error of ± 3-20% for the single applications). In parallel, it should be noted, that the results of this validation exercise are very much dependent on the sample that was selected in the marketplace, as a consequence, the results can be affected by the choices made.

Furthermore, it should be taken into account that given the high variety of batteries that can be found on the market (in terms of weight, voltage, capacity, size, shape, application etc), the average weights by application calculated in this project might not represent all products that could potentially fall in each of the application groups. Therefore, a consultation process involving relevant stakeholders in the battery market is recommended to further validate the results of this project and to collect feedback on the possible refinement of the average weights.

6. Recommendations

This paragraph presents recommendations on how to replicate in the future the methodology to calculate the average weights by standard size or by typical application.

6.1 Average Weight by Standard Size

Average weights by standard size presented in Table 4 can be updated in three different ways depending on the type of information that RPRA will be able to collect in the future:

1) By undertaking additional stakeholder consultations in subsequent years, it may be possible to collect feedback and additional input on the average weights of secondary batteries by standard size, the population of batteries on the Ontario market, which is helpful to draw a representative sample per size/chemistry/application. Stakeholders might highlight the importance of adding additional sizes and might in parallel be able to communicate the respective average weights. It is advisable to take into account inputs that might come from the stakeholders as they will reflect the characteristics of Ontario's market.
2) Since RPRA is now in the process of establishing a reporting system, it is advisable to collect both data in units and in weight. Collecting producer supply data in units could be integrated as a voluntary reporting option in the portal of RPRA, or through an ad-hoc questionnaire. In such a way, it will be possible in future to calculate the average weights by standard size using the information stored in RPRA's databases.

3) A third possibility is to conduct a second desktop research in the next coming years in order to compile updated information on the average weights that will reflect changes in technologies.

6.2 Average Weight by Typical Application

Average weights by typical application presented in Table 5 could be updated in the future by replicating the methodology described in the section 2.5. The average weight of secondary batteries by application (g/unit) can be calculated by dividing the average energy usage per application (Wh/unit) by the average energy flow per grams of battery (Wh/g).

1) Data on the energy usage per application (Wh/unit) could be collected through a survey distributed to relevant stakeholders or calculated dividing Canadian or Ontario data on Wh placed on the market per application by the total number of units placed on the market per application, if available. This data could possibly become available in the future via local or regional energy agencies.
2) Data on the average energy flow per gram of battery (Wh/g) could also be updated by consulting manufacturers or by conducting additional desktop research, similar to the process described in section 2.5.

Updated figures about the average weight of typical applications could be obtained by updating either one of the two parameters or both.

In addition, if there is evidence that the average weights of batteries within the same application group may vary substantially, it is recommended to create subgroups of the same application and calculate more specific average weights per "sub-applications". However, it might be difficult to collect data on Wh/unit or Wh/g for "sub-applications" that are representative of the group.

7. Annexes

a. *Annex 1 – Catalogues of producers or retailers consulted*

Name of producer/retailer	**Link**
Power Stream	https://www.powerstream.com/
Tenergy	https://power.tenergy.com/battery-size-chart/
Panasonic	https://eu.industrial.panasonic.com/sites/default/pidseu/files/downloads/files/panasonic-batteries-short-form-catalog-2018-for-professionals_interactive_08_11_18.pdf
Battery Space	https://www.batteryspace.com/batteryknowledge.aspx
EEMB	https://www.eemb.com/battery/rechargeable-battery/li-polymer-battery/standard-version.html
IBT power	http://www.ibt-power.com/Battery_packs/Li_Polymer/Lithium_polymer_cells.html
Energizer	https://data.energizer.com/
Large	https://www.large.net/low-temperature-battery/list-122/
Varta	https://www.varta-microbattery.com/en/products/
Dakota	https://dakotalithium.com/?v=3a52f3c22ed6
UltraLife	https://www.ultralifecorporation.com/ECommerce/category/products/medical

b. *Annex 2 – Brands of batteries considered in the validation process*

Ninja Batt
SiKER
FSKE
XITAI
iProPower
Green Cell
K KYUER,
PowerZJs,
Aryee
Beste Akku
Godox
D70 Lighting
CELLONIC,
ChilliPower,
Bright Way Group
BAKT
Bosh,
Schimano,
Ansmann
HQRP
CS

Cameron Sino
Ultracell
BB Battery
YUASA
FDK
Parrot
Dakota
Sigmas Tech

c. *Annex 3 – Brands of applications considered in the validation process*

Samsung
Acer
LG
Apple
Asus
Huawei
Wacom
Kindle
Parrot
Dell
Bosh
Canon
Sony
Fujifilm
Nikon
Oral-B
Philips
Cat
Logitec
Anker

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