Re-use and Second use of Rechargeable Batteries

October 2014 / v.14

The European Association for Advanced Rechargeable Batteries
Re-use and Second use of Rechargeable Batteries
September 2014

Foreword

This publication is prepared to provide information regarding the subject matter covered. The document has been prepared with the information available at the time of its publication. It is communicated with the understanding that the authors are not engaged in rendering legal or other professional services on issues covered by this report.

Authors.

This publication has been prepared by RECHARGE aisbl.

The membership of RECHARGE includes suppliers of primary and secondary raw materials to the battery industry, rechargeable battery manufacturers, original equipment manufacturers, logistics partners and battery recyclers.

RECHARGE is following the continuously changing regulatory and legislative environment for rechargeable batteries and is a recognized expertise centre for advanced portable and industrial rechargeable battery technologies.

RECHARGE aisbl
Avenue de Tervueren, 168. B-3.
B-1150 Brussels. Belgium.

www.rechargebatteries.org

W.Tomboy - Director Industrial Batteries - wtomboy@rechargebatteries.org
C. Chanson - General Manager - cchanson@rechargebatteries.org
J-P Wiaux - Director General - jpwiaux@rechargebatteries.org
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1. Executive Summary

With the market development of new rechargeable battery technologies\(^1\) offering longer service life and the possibility to be used to power other applications that the one they were designed for originally, the “re-use” or the “second use” of rechargeable batteries has been proposed to enhance their service life and/or to optimize their cost/performance ratio. (offered on the market).

The purpose of this information paper is to define & evaluate “re-use and second use” of rechargeable batteries, describe the legal context, decide whether minimum requirements are needed to define re-use and second use of such batteries, investigate how the extended producer responsibility applies for re-use and second use of rechargeable batteries, evaluate whether RECHARGE needs to encourage their “re-use and second use”.

But also other terminology is often used at random: second hand, double use, re-purposing, re-furbisment, re-manufacturing, repairing, re-designing, re-conditioning. These terms need to be placed in its correct context to avoid confusion and misunderstanding of the issues.

In the Batteries Directive 2006/66/EC, the term “re-use” is not defined. Such a definition is supplied in the Waste Framework Directive and/or other daughter Directives such as the WEEE and the ELV Directives.

The term “second use” is not defined at all in the various Waste Directives (neither in the Waste Framework Directive nor in other Daughter Directives) that are governing the end of service life of substances, mixtures, equipments or articles.

When “batteries” are concerned, the absence of a legal background raises the issue of the Extended Producer Responsibility for batteries that are either re-used or offered for a second use.

Beyond the need for harmonized definitions across the different Waste Directives, there is also a need to clarify the minimum requirements under which the legal context could be developed.

1.1. Definitions

Waste means any substance or object which the holder discards or intends or is required to discard (Waste Framework Directive 2008/98/EC (WFD) - Article 3.1).

Battery is not defined in the WFD.

Waste battery or accumulator means any battery or accumulator which is waste within the meaning of the WFD (Batteries Directive 2006/66/EC - Article 3.7).

Re-use is defined as any operation by which batteries that are not waste are used again for the same purpose for which they were initially conceived. (Waste Framework Directive 2008/98/EC - Article 3.13).

\(^1\) In this document, the term batteries will mainly refer to rechargeable batteries as defined in § 2 p. 7.
The definition of **re-use** is based on the ‘same/original purpose’. One could argue about the fact that batteries – being a component – in case of re-use, need to be re-used in the original application in order to secure all technical performances and safety aspects, as also indicated in the End-of Life Vehicles Directive 2000/53/EC, Article 2.6, where **re-use** means any operation by which components of end-of life vehicles are used for the same purpose for which they were conceived.

**Second use** is not defined in any of the Waste Directives. It could mean that the battery is used for a different application than for the original purpose it was initially designed for and placed on the market for the 1st time.

In order to support these definitions and the interpretation, RECHARGE proposes to establish a set of Minimum Requirements that need to be fulfilled before authorizing the re-use or the second use of batteries after a first service life.

### 1.2. Minimum Requirements

RECHARGE proposes the use of minimum requirements to evaluate **re-use** or **second** use of advanced rechargeable batteries.

<table>
<thead>
<tr>
<th>Proposed Minimum Requirements</th>
<th>Re-use</th>
<th>Second use</th>
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<tbody>
<tr>
<td><strong>Application</strong></td>
<td></td>
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<tr>
<td>- Identical use</td>
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<td></td>
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<tr>
<td>- Re-furbishment or re-conditioning by qualified professionals</td>
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<tr>
<td>- Control of equivalent performances e.g. through the Battery Management System</td>
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<td>- Quality, Safety and Performance standards to be observed</td>
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<tr>
<td>- Etc…</td>
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<tr>
<td><strong>Producer Responsibility</strong></td>
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<tr>
<td>- Producer identified</td>
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<td></td>
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<tr>
<td>- Warranty offered by Producer</td>
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<tr>
<td><strong>Safety</strong></td>
<td></td>
<td></td>
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<tr>
<td>- Technical requirements maintained</td>
<td></td>
<td></td>
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<tr>
<td>- Safety Standards respected (tests)</td>
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</table>

If yes, “re-use” is acceptable

- In absence of a legal basis, additional criteria might be required – e.g.
- Compatibility issue between 1st & 2nd Application

- Responsibility for the technical performances
- Producer Responsibility to be defined: technical and end of life
- Compliance with safety testing requirements before second use

**TABLE 1. Non Exhaustive list of minimum requirements to be considered for allowing re-use or second use of batteries.**

### 1.3. Conclusions & RECHARGE position

**Re-use**

- When the minimum requirements listed in Table 1 are fulfilled, RECHARGE supports the re-use of batteries for their original applications.
- This requires that quality, performances and safety standards are observed before placing the battery for a second time on the market.
- There is also a need for a definition of ‘re-use’ in the Batteries Directive 2006/66/EC.
Second Use

- RECHARGE only supports the second use of batteries when the battery remains under the responsibility of the producer acting as the first entity placing the battery on the market.
- In absence of a legal basis and clear minimum requirements, RECHARGE does not support second use of batteries as there are too many unknown factors that could impact product’s reliability and end users safety.

Legal basis

In both cases, re-use or second use, there is an urgent need to develop an appropriate legal basis to define the Extended Producer Responsibility to extend the service life of rechargeable batteries.

With regard to the lithium-ion battery for e-mobility

- The EV-battery is very expensive, has a long warranty period (mostly > 5 years), has a long lifetime (7 to 10 years), components can be replaced individually (module, stack, cell) to enlarge the lifetime of the battery and reduce the warranty or service costs.
- The EV-battery will be kept for its initial purpose as long as possible.
- The EV-battery will have aged before the possibility for going into a second life application.
- This results in a risk of product obsolescence as the chemistry of lithium batteries is changing fast & significantly.
- Therefore, to predict the potential second life of an EV lithium battery, produced several years ago, will be very uncertain.

Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>BD</td>
<td>Batteries Directive 2006/66/EC</td>
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<tr>
<td>ELV</td>
<td>End of Life Vehicle (Directive 2000/53/EC)</td>
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<tr>
<td>EOL</td>
<td>End Of Life</td>
</tr>
<tr>
<td>EOW</td>
<td>End Of Waste</td>
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<tr>
<td>EPR</td>
<td>Extended Producer Responsibility</td>
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<td>PRO</td>
<td>Producer Responsible Organisation</td>
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<tr>
<td>PPP</td>
<td>Polluter Pays Principle</td>
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<tr>
<td>CPT</td>
<td>Cordless Power Tools</td>
</tr>
<tr>
<td>SLI</td>
<td>Starting – Lighting – Ignition (automotive battery)</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>UNECE</td>
<td>United Nations Economic Commission for Europe</td>
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<tr>
<td>TFEU</td>
<td>Treaty for a European Union</td>
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<tr>
<td>ARN</td>
<td>Auto Recycling Netherlands</td>
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<tr>
<td>BAJ</td>
<td>Battery Association of Japan</td>
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<tr>
<td>PRBA</td>
<td>The Rechargeable Battery Association (USA)</td>
</tr>
<tr>
<td>KBIA</td>
<td>Korean Battery Industry Association</td>
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</tbody>
</table>
2. Introduction

The purpose of this RECHARGE information paper is to define & evaluate “re-use and second use” of rechargeable batteries, describe the legal context, decide whether minimum requirements are needed to define re-use and second use of batteries, investigate if the extended producer responsibility will change with re-use and second use of batteries evaluate whether RECHARGE needs to encourage their re-use and second use.

In the context of this paper, and according to the Batteries Directive 2006/66/EC, batteries are defined as follows:
- Portable – any battery, button cell, battery pack that is sealed, can be hand-carried, is neither and industrial nor an automotive battery
- Automotive – any battery used for automotive starter, lighting or ignition power (SLI)
- Industrial – any battery designed for exclusively industrial or professional uses or used in any type of electric vehicle (electric cars, wheelchairs, electric bicycles, airport vehicles, automatic transport vehicles).


The approach of RECHARGE is to consider the re-use and second use of portable and industrial rechargeable batteries. This document, is at first, not intended to cover the application of these principles to primary and SLI Automotive batteries.

Therefore, the principles of Re-use and second use would apply to rechargeable batteries offered on the market to power EEE such as mobile phones, laptops, tablets, power tools, e-bikes, electric vehicles (hybrid and full electric), etc...
3. Legal Framework

If the legal framework for the management of waste has been recently developed and improved, the application of the re-use and second use is a more recent approach taken by the legislator. It has not yet received a detailed attention in order to define the boundaries of its implementation.

One needs also to distinguish between the re-use or second use of substances versus components or articles. This distinction has not yet been considered by the legislator. In this information paper we shall concentrate on the re-use and second use of rechargeable batteries as components of the many different types of equipments listed above.

3.1. Waste batteries

In the Batteries Directive 2006/66/EC, Article 3.7. ‘waste battery’ is defined as: “Any battery or accumulator which is waste within de meaning of the WFD”. In the Waste Framework Directive 2008/98/EC (WFD) Article 3.1 ‘waste’ is defined as: “Any substance or object which the holder discards or intends or is required to discard”.

As waste needs to be controlled, and in case the producer cannot control that waste, than the producer will have a problem with Extended Producer Responsibility.

3.2. Re-use

Re-use is clearly defined and mentioned in a number of Waste Directives but “re-use” is not defined in the Batteries Directive 2006/66/EC(BD)

- Article 3.13 – Re-use is defined as any operation by which products or components that are not waste are used again for the same purpose for which they were conceived.
- Article 3.16 – Preparing for re-use - Means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.
- Article 11.1 - Member States shall take measures to promote the re-use of products and preparing for re-use by encouraging re-use and repair networks, quantitative objectives or other measures.

3.2.2. End-of Life Vehicles Directive 2000/53/EC - (ELV):
- Article 2.6 - Any operation by which components of end-of life vehicles are used for the same purpose for which they were conceived.

3.2.3. Waste Electrical & Electronic Equipment Directive 2012/19/EU - (WEEE):
- Article 3.2 - In addition, the definition of re-use, preparing for re-use, recycling, laid down in Article 3 of Directive 2008/98/EC shall apply (same as WFD).
- Article 14.3 - Member States shall adopt appropriate measures so that consumers participate in the collection of WEEE and to encourage them to facilitate the process of re-use, treatment and recovery.
- Priority should be given to preparing for re-use of WEEE and its components. Producers should be encouraged to integrate recycled material in new equipment.
3.3. Second use

Second-use is not mentioned in any of the Directives listed above in 3.2. Re-use.

3.4. Difference between re-use and second use

Besides these legal definitions, RECHARGE offers the following interpretation of the terms re-use and second use:

3.4.1. Re-use meaning the complete or partial re-use of the battery for the original purpose the battery was designed for, possibly after inspection or remanufacturing (refurbishment), and as it was put on the market for the 1st time.

3.4.2. Second use meaning the use of the battery for a different application than for the original purpose it was designed for and placed on the market for the 1st time.

3.4.3. Double use. More recently, the terminology ‘double use’ emerged from the literature. Double use meaning that the battery is simultaneously used for its original application and used for a secondary application, different from the original application. These double applications batteries could either by provided by the producer putting the battery for the first time on the market, or by a new producer putting the ‘double use’ battery on the market, or by the user/owner of the battery. Extended producer responsibilities have also to be considered in this case.

A detailed comparison of definitions used in the various Waste Directives is available in a separate document.

Caution
It is interesting to note that second use is not mentioned as such. Some caution is advised to readers as in many documents the terminology “second use” is being utilized to describe either second hand use, or second life or even to describe re-use...

Figure 1. below provides a schematic view of the various service life options of a rechargeable battery, throughout the life cycle, and according to the process flow, or by application.
FIGURE 1. Terminologies used across the life cycle of batteries, and based on process or application.
4. Political & Regulatory Context

4.1. At European Union level

In the EU Waste hierarchy, re-use and second use come after waste prevention.
In view of resource efficiency, waste prevention also implies to provide a longer service lifetime of the battery.
Re-use and second use come prior to recycling.
Recycling means that the battery is handed over – as a waste - for end-of-life treatment.

The 2011 European Roadmap to a Resource Efficient Europe concludes that if waste is to become a resource to be fed back into the economy as a raw material, then much higher priority needs to be given to re-use and recycling (waste is becoming a resource).

In an EU Communication ‘Towards a circular economy: A zero waste programme for Europe’ Circular Economy is introduced in support of sustainable growth.
Circular Economy keeps the added value in products for as long as possible and eliminates waste.
They keep resources within the economy when a product has reached the end of its life, so that they can be productively used again and again and hence create further value.

It is obvious that the priorities of the legislator evolve into the direction of:
1. extending the product life
2. re-use
3. recycling

4.2. At United Nations level

In the Electric Vehicle Regulatory Reference Guide (Draft Version of December 2013), prepared by the UNECE EV and the Environment Informal Working Group, it is mentioned that:

Battery re-use post-mobility represents a wide gap that will be challenging to govern given the highly variable nature of battery wear and inherent differences in chemistry, construction, and power management. Given that batteries dominate the cost of electrified vehicles and are typically deemed unusable from a mobility standpoint after degrading to between 70 and 80% of fully-chargeable capacity, there is a compelling reason to take a serious look at re-using these batteries in other applications. In order to ensure the success of battery re-use, guidelines and regulations that govern the implementation, as well as ensure the reliability and durability of such systems are crucial. This is likely to be challenging given that used batteries can be subject to a wide range of usage behaviors that can in turn influence the consistency of their performance over time. There may also be a need for additional regulation/legislation in this field to prevent misuse or abuse of rechargeable batteries offered for second use. In addition, the question of the application of the extended producer responsibility is raised in the case of the end of life management of these batteries after their second use.
There are no standards or regulations pertaining to battery re-use currently in place world-wide. China is said to be in the process of formulating battery re-use standards. Existing EU legislation in the form of Directive 2005/64/EC provides a general framework for the reusability of vehicle components, systems and separate technical units, however there are no specific provisions for battery packs of electrified vehicles.

The latest developments at the UNECE level include the recently developed regulation on uniform provisions concerning the recyclability of motor vehicles. It has been based on the existing provisions of Directives 2000/53/EC (End-of-life vehicles) and 2005/64/EC (Recyclability, reusability and recovery of vehicles and components) and therefore does not include specific provisions for electrified vehicle battery re-use. Battery re-use or second-use as it is sometimes called is somewhat of a research topic at the moment. Some believe that re-purposing of these batteries could result in an EV ownership cost reduction which could subsequently spur EV adoption rates. Automakers such as BMW, Nissan, and General Motors in partnership with companies like ABB and Vattenfall are actively exploring possible second-use applications for retired EV battery packs. Applications being studied range from home or neighborhood back-up power systems, to more advanced grid power buffering strategies (smart grid). The figure below shows a microgrid backup system powered by 5 used Chevrolet Volt batteries, which was the result of a collaboration effort between ABB and General Motors. Automakers such as Renault, have introduced a new business model within the framework of battery pack re-usability. In this model, the battery pack is leased to the vehicle owner, while actual ownership of the battery pack is retained by the manufacturer. When these battery packs reach the end of their operational life, the automaker replaces them with new battery packs at a fraction of the cost of the actual battery. Through this approach, battery packs are either remanufactured as replacement battery packs or are utilized in second-use applications.
5. Overview of initiatives aiming at the re-use or second use of rechargeable batteries

5.1. Research and pilot projects

5.1.1. A number of research initiatives and pilot projects have been developed to evaluate the economics and viability of second use of (mainly industrial) batteries for electro-mobility. These projects link the industrial battery used in e-mobility with the household electricity grid in a so-called combined energy storage. As long as the project is run under the responsibility of the battery producer, there does not seem any issue with extended producer responsibility as the producer controls this close-loop system. Here are some examples of such projects:

a) 2BCycled – Netherlands – a research project with the aim to determine the business case for second life for discarded EV-batteries, evaluating the economic potential of the local household/pv system. As part of the project, two Volkswagen Golfs, converted to use electrical drive systems, recently were expertly dismantled. One of them will become part of the training programmes organised by ARN for the dismantling of electrical and hybrid cars. The second vehicle will be supplied to the University of Applied Sciences of Arnhem and Nijmegen – where it will be used for study purposes. The aim of the dismantling project is to investigate whether batteries from hybrid or fully electrically-powered cars can be given a second life, at the end of the useful life of the vehicle. Once the operating radius has fallen by 20-30 per cent, batteries for this mobile application are disposed of. For other (stationary) applications, there may well be possibilities for using the batteries. Possible options include households where the battery can be used for storing renewably-generated energy. There are also possible applications in more rural areas without mains electricity, as backup for a diesel generator in combination with solar cells.

b) VW will equip 20 households in the Berlin area from November 2013 onwards with E-Up electric modified cars, enabling their batteries to feed electricity into the grid.

c) Toyota Motor Corporation in Japan will sell electricity management systems for energy storage, using NiMH batteries from hybrid vehicles.

d) Sumitomo is starting the world’s first used electric vehicle battery energy storage system with Nissan. The system will use Nissan Leaf lithium-ion batteries to regulate energy from a solar plant in Osaka, Japan.
The system (600kW/400kWh) includes 16 used lithium-ion EV batteries and aims to provide energy fluctuations from a nearby solar farm. Sumitomo launched the system through a joint venture “4R Energy Corporation” with Nissan Motor Co. founded back in September, 2010 to find new business models for used lithium-ion EV batteries.

e) **Tesla Motors** detailed its ambitions to build the world’s largest battery manufacturing facility costing $2 billion. Besides aiming to bring down costs for Tesla’s large batteries (85 kWh), the value proposition ties in nicely with its sister company, SolarCity, who is already using Tesla’s energy storage systems to store solar energy for both residential and commercial purposes.

f) During the **InterBattery 2014 Exhibition in Seoul, South Korea** in October 2014, a great emphasis has been put on the role of grid interface and of batteries in modern Korean society including e-mobility.

5.2. **Economic considerations**

5.2.1. **In a study from June 2011 on second life of EV lithium batteries from the French Environmental Agency ADEME**, the following conclusions were tabled:

- Car manufacturers, regardless of the economic model (batteries rented or purchased with the car) think that some of the batteries will be used well below a reduced capacity of 80% or 70% of the nominal capacity. So the second life would be the continuation of the first life. In this case, actual flows of batteries available for second life would be lower than the total quantity of batteries that would have reached the thresholds of the end of first service life.

- The issue of “batteries’ economic value” at the ultimate end of their life must be considered.

- When this value is positive, recycling is an alternative to second life. However, the value of recovered products (metals, chemicals) may be lower than the cost of recycling. It is likely that the final stage of recycling continues to be a net cost and cannot have a positive impact on the value chain of batteries reducing its initial cost. Therefore the potential use in second life must be carefully evaluated when the initial price of the battery is fixed.

- If we assume a first life period of 7 to 10 years, the volumes available for a second life would only become significant beyond 2020, even in the most favorable scenario to the development of a market for electric and plug-in hybrids vehicles.

- In conclusion, this study shows that in the current state of knowledge it is appropriate to consider a “second life” for the batteries of carbon free vehicles. Several uses appear promising in so far as they could give to batteries a positive residual value at the end of their first life and thus have a beneficial impact on the development of carbon free vehicles market.
5.2.2. **Renault’s new business model** when launching their electric vehicles is also innovative in the sense that the ownership of the industrial battery stays within the financial structure offered by Renault (when selling the vehicle, the battery is leased separately). This approach is a practical solution to control the complete value chain and allows to decide on economic or technical grounds, after thorough inspection and/or repair or refurbishment, whether such battery should be re-used, go for second use, or be offered for recycling. The French manufacturer continues to push ahead with ambitious plans to dominate the electric vehicle market with the Twizy and Zoe, plus the fleet-focused Kangoo EV. However, with new battery technology likely to boost the range of cars within the next 18 months to two years, Renault has factored in the technical ability to swap the batteries and upgrade the control systems of the EVs it has already sold. This process could, in theory, be easier because Renault leases the batteries to owners instead of selling them outright. The technical possibility to upgrade the batteries exists. It's not a simple upgrade, because you have increased energy density in the batteries and then the car’s electronics and control systems need to be upgraded to take that into account.

5.3. **Barriers to Re-use and Second Use**

5.3.1. **Frost & Sullivan**, concluded in a study that EV batteries will have to compete with dedicated batteries used currently for e.g. standby power applications. Among others they considered the following barriers:
- Lithium batteries have to compete in terms of cost, power, and energy storage, as most of the characteristics of lithium batteries degradation at reuse are still uncertain.
- The costs of refurbishing and connecting them into a grid are likely to be high and will be more than building new dedicated batteries for those applications.
- As there are different chemistries and varied battery specifications without standardization, modules of batteries must be matched with their chemistries/manufacturer/specifications while refurbishing and repackaging. This is to ensure similar module configuration while creating larger battery packs for second life.
- There is an inherent perceived negative value attached to any re-used product in the consumer mindset. This is further augmented due to the need for reliable and robust systems needed in the utility operations. EV batteries have to prove their reliability for second life.

5.3.2. **A study from August 2012, funded by the State of California and the U.S. Department of Energy**, concluded that ‘the devil is in the details’ meaning that second life application isn’t quite as simple as it sounds:
- California has an independent operator system (ISO) that manages flow for 80 percent of California’s electricity. It matches generation with load and maintains electric frequency of the grid. Integrating the batteries into that system will be complicated.
- Not all batteries are created equal when it comes to suitability for energy storage. A lot depends on the manufacturing process and quality control.
- As a conclusion, the decision was made to extend the study with another 6 years: integrating the used batteries in to a mini-grid on the UC San Diego campus to see how they fare in actual usage.
5.3.3. A study in 2014 suggests OEMs should use a modular design for PHEV and EREV vehicle battery packs to offer capacity choices to customers.

Car manufacturers should develop a modular design for plug-in hybrid and extended range electric vehicles (PHEVs and EREVs), allowing them to offer a choice of storage capacity to meet individual customer requirements rather than forcing a “one size fits all” approach, according to the results of a German-market-specific TCO study by a team from the Institute of Vehicle Concepts, German Aerospace Center (DLR).

PHEV and EREV combine emission free driving of battery electric vehicles with the unrestricted driving range of conventional cars powered by gasoline or diesel. However, the battery is still a very critical component due to the high production cost and heavy weight. Therefore, the right sizing of the battery is the key for electric powertrains to meet customer expectations and become cost competitive against conventional technologies.

The authors of the study stress that they are not suggesting OEMs to offer each customer an individual battery size, but rather than they offer, as an example, three different battery sizes dedicated to drivers with low, average and high mileage. The development of a modular design for battery packs could help OEMs to change the size with less effort and few implications on the rest of the vehicle. This is rather similar to the approach taken by Tesla Motors with its two—originally three—pack capacity sizes offered in the Model S.

In the study, the DLR team analyzed the impact of different driving profiles on the optimal battery setup from the total cost of ownership (TCO) perspective. Results showed that the battery size has a significant effect on the TCO.

The results of the study imply that higher battery capacities would reduce the overall WTW GHG emissions. If the political target is to reduce the GHG emissions even further by encouraging OEMs to design high battery sizes for PHEVs and EREVs, the public authorities may influence the results of TCO by different measure.

The study assumes a rational customer who has objective to minimize the total cost of ownership. In reality, the behavior of consumers may not be fully rational. Consumers may prefer high electric range due to several reasons. This phenomenon may be analyzed in the future and the factors that may distort a rational choice may be identified.

Whether a modular-design approach with varying battery capacities will allow for re-use and/or second use is still to be investigated.
5.3.4. In the International Electrotechnical Commission - IEC Electrical Energy Storage White Paper of December 2011, the Vehicle-to-Grid (V2G) concept was mentioned as follows:

4.3 Vehicle to grid concept

Depending on the probable development and spread of electric vehicles, there will be a great potential for power to be fed back from car batteries into the grid. The federal government of Germany has forecast up to one million EVs by 2020 [bmw.110]. Including hybrid and pure EVs the average capacity is about 20 kWh per vehicle. In a scenario in which about 30% of these capacities are used, we would have about 6 GWh available for energy storage. Compared to pumped hydro storage in Germany with capacities of about 40 GWh in 2011 this would represent about 15% extra.

A field where development is needed is the reinforcement of the low-voltage power grid, whose infrastructure is not yet ready for the power feed-in of a large number of electric vehicles – the grid’s limited transmission capacity would be overstretched. For the communication between vehicles and grid operators an intelligent system will also be needed, one acceptable to the consumer. Consumer acceptance will play a major role in the success of the V2G concept. Different business models are under discussion, e.g. one where the car owner is not the owner of the battery but rents or leases it, or pays for the electricity at a rate which covers the battery cost.

5.3.5. Electro-mobility manufacturers require very high specifications at the design, development & testing phases for batteries in their HEV-PHEV-EV vehicles for numerous quality and safety reasons, making this battery for use other than for its original purposes difficult from a technological and economic point of view:

- The sensitivity of the battery performance to the usage conditions
- The high price of the battery in a vehicle
- Car manufacturers are applying life testing conditions representative of their own vehicles.
- Use “battery life duration model” allowing the management of the battery to perform best
  - The battery minimum electrical performance (End of life criteria) depends on the Battery management system requirements.
  - The battery smart management can change according Battery State of Health;
    o favorize the vehicle efficiency (i.e. while using more power from the battery),
    o enhance the battery life (i.e. while limiting the power).
- The CO2 emissions of an HEV is under the BMS control, it cannot be directly linked to the battery performance or duration.
5.4. Large scale programs in USA

5.4.1. Around Christmas 2013, the USA Pentagon transported **13 Nissan Leafs** to a Southern California Edison charging facility in Pomona as part of a $20-million program involving dozens of vehicles at Los Angeles Air Force Base and the Naval Air Weapons Station at China Lake. The department pays about $200 per month to lease a Nissan Leaf. Using a vehicle to store energy, they claim, could generate enough revenue to offset most of that cost.

5.4.2. Electric cars may hold solution for power storage – This is an example of ‘**double use**’ In a Delaware pilot project, the ‘**Cash Back Car** concept’ electricity is stored in and retrieved from the batteries of idle vehicles. Car owners would be paid. The retrofitted Mini Coopers and other vehicles plugged into sockets where a Chrysler plant once stood do more than suck energy out of the multi-state electricity grid. They also send power back into it. The pilot project at the University of Delaware has had enough success to set off a frenzy of activity in the auto and electricity industries. Entrepreneurs and government agencies see the technology as a possible solution to a vexing dilemma: how to affordably store renewable energy so it can be available when it is needed, not only when the wind blows or the sun shines. The idea is that utilities would pay vehicle owners to store electricity in the batteries of electric vehicles when the power grid has a surplus and drain electricity back out of them when demand rises. The plan takes advantage of a key fact about cars: They spend most of their time parked. The technology makes idle vehicles a source of storage for utilities and cash for car owners. Of course, nothing with electricity is simple.
5.4.3. In a publication of the Mineta National Transit Research Consortium of June 2014, the potential of remanufacturing, repurposing, and recycling of post-vehicle-application lithium-ion batteries has been evaluated. Lithium-ion batteries used in vehicles will continue to expand with their electrification. A fundamental question is what to do with such batteries post-vehicle-application, which means the battery has fallen below regulatory standards for use in on-road vehicles.

Such a battery has additional economic value that can be reclaimed in one of three ways:
1) Remanufacturing for reuse in vehicles
2) Repurposing by reengineering for an off-road, stationary storage application; and
3) Recycling, disassembling each cell in the battery and safely extracting the precious metals, chemicals and other byproducts.

Results show that by 2035, the number of available post-vehicle-application batteries ranges from 1.4 million (low) to 6.8 million (high), enough batteries to justify remanufacturing, repurposing, and recycling efforts.

A cost-benefit analysis was done independently for each of the three types of post-vehicle-application processing. Costs included those for operations, transportation, material handling, infrastructure development, and facility development. Benefits included avoided costs for storage of batteries and production of new batteries as well as sales of repurposed batteries and recovered materials in recycled batteries.

Remanufacturing was shown to be profitable, primarily due to the avoided costs of producing new batteries when a remanufactured battery could be used instead. Repurposing is a less well defined application area that can be profitable depending on research and development expenses. Recycling in isolation is not profitable, as lithium-ion batteries are composed of relatively inexpensive materials. However, recycling can support closed-loop supply chains reusing materials in the production of new batteries as well as supporting the principles of environmentalism and sustainability.
5.5. Alternative approaches

5.5.1. FORD
The approach of Ford is interesting as they bring in the definition of ‘re-purpose’ to extend the life cycle of the battery, and at the same time they see some opportunity for ‘secondary use’ (actually evaluating some options):

- **Re-manufacture**
  - Presently not feasible for automotive applications

- **Re-purpose**
  - Extend useful life of battery pack
  - Presently economically infeasible
  - Keep out of landfills
  - Also inserts another degree of uncertainty for recyclers (duration of life cycle unknown)

- **Recycle**
  - Recover material value
  - Keep out of landfills

Recycling is the most feasible strategy to implement in the short term, but reuse could help mitigate end of life disposal costs and reduce life cycle impacts.

- **Secondary Use Opportunities**
  - Secondary use (post in-vehicle phase) of EV batteries offer the potential for recovering some of the original value:
    - Possible uses:
      - Golf carts
      - Smart Homes
        - Residential use or selling electricity to utility company
      - Load Leveling
        - Storing of energy for the grid during off-peak time for use in higher-cost peak periods when more expensive generators are required.
      - Transmission Support and Grid Storage Applications
        - Back up grid stabilization for black/brown outs (commercial and residential)
        - Battery system provides stabilizing pulses for transmission lines.
      - Renewable Firming
        - Re-engineered batteries can be used as stationary energy storage to stabilize energy generated from non-constant renewable sources (wind and solar)
        - Will enable renewable power plants to generate uniform energy which will lead to more efficient energy usage

Multiple secondary use options are being evaluated.
With regard to lithium battery recycling, Ford has the following view:

**Li-Ion HVBs**
- Most of the value in cathode
  - Consumer electronics predecessors: LiCoO₂
  - Automotive applications: LiMexOy (Me = Ni/Co/Mn/Fe)
    - LESS Co = LESS cost + LESS value
    - Low(er) material value (intrinsic value < cost to recycle)
    - Some nickel, cobalt but efforts to reduce further

In a 2014 Ford presentation on regulatory impact on lithium battery safety, Ford indicates that defected lithium batteries will be ‘de-energized’. To run the de-energize procedure the battery pack needs to be opened. Discharge must be handled by a trained expert team. After the de-energize procedure the battery will get shorted permanently. No re-use is allowed, and de-energized units must go into recycling process. One of the reasons is that the Cu substrate of the anode can be corroded during deep discharge, leading to short circuits and risk of runaway during the following recharge. A fully discharged battery has probably damaged electrodes.

We notice that the term ‘de-energized’ is used here. De-energize is similar to discharge (for example going from 4V per cell down to 3V per cell). If the battery is discharged/de-energized further towards 0V per cell, then we can talk about over-discharged which is in fact non-reversible. The battery can be at many different levels of charge, and this might have an impact on potential further use of such battery. The different levels and terminologies of charge used in literature (whether the industry or regulator agree on these levels is uncertain at this date) can be:
- over-charged / charged / discharged / de-energized / de-activated / over-discharged.

It is therefore quite important in the decision-making process for possible further re-use or second use to know the exact history of the battery. Only with professional diagnostic equipment used by experts who have the knowledge on how the get the history out of the battery management system BMS can that advice or decision be taken.

The professional advice provided by Ford is therefore quite relevant.

### 5.5.2. BMW

Car maker BMW Group and Vattenfall, the north European power company, have begun a research project looking at the secondary use of high-voltage EV batteries from MINI E and BMW ActiveE vehicles in stationary power storage applications. BMW and Vattenfall say lithium-ion batteries after the end of their use in an electric vehicle have a storage capacity of around 80% and “many years” of potential work. Both companies have already worked together on EV fleet tests.

When BMW introduced the new i3 electric vehicle late 2013, BMW clearly understood that it is not under control of the battery when an i3 becomes an ELV. This is also the case if a customer beyond the warranty period will replace the battery by a cheaper aftermarket battery. BMW expects that aftermarket alternatives or refurbished batteries will hit the market at some time in the future. The Vattenfall project fits in this understanding, as does the innovative this certificate for the e-battery:
5.6. When a cordless power tool – CPT – comes back to the producer for repair and refurbishment and is replaced on the market under the responsibility of the OEM, all technical, commercial and legal aspects are covered for a re-use of the CPT (including its battery).

5.7. For stationary applications, there might be potential in an integrated multi-system environment to combine new and second use industrial batteries. This remains to be demonstrated.

5.8. V2G (vehicle to grid) – V2H (vehicle to home)
In the final draft for review (March 2014) of the Roadmap EV Infrastructure, Annex to the European Roadmap Electrification of Road Transport, some conclusions were drawn regarding the technology field development, especially with regard to V2G and V2H. V2G implies that utility firms will be able to use the distributed storage provided by EV batteries as back-up capacity to help meet unusual demand spikes while V2H refers to the possibility of use electricity stored in the EV battery to be distributed to residential homes and appliances. The following comments are from this draft report:

However, there are some issues that could impede Vehicle-to-Grid from becoming a reality in the short term:

- Battery technology: The EV and its battery are still in their early development stages. It is unlikely that either the car owner will risk interconnecting at this early stage because the life battery reduction.
- Smart meters and Smart Grids are not a reality yet in the all the EU countries and they are an essential component of V2G.
- The cost and complexity of the distribution systems required: Two-way inverters would need to be developed and installed on a wide scale to bring V2G to fruition.
• Unproven economic justification: It is not evident yet that the economic incentives justify V2G from the utility perspective. In order to support V2G, a business case must be in place: the difference between the energy buying and selling price must justify economically all the cost involved (metering cost, converter, battery depreciation, etc.)
• Lack of regulatory base: In order to facilitate the V2G development a clear regulatory framework need to be developed that allows EV owners to sell energy to the grid, among other aspects.
• The complexity of knowing when to draw power from the vehicle: How much charge in the battery at the end of the day depends on how far the user needs to drive to home. Will the car be taken out again soon after reaching home?

In summary, although discussed often for its promise, V2G will not be viable for the large scale application in the next decade. For now, utilities need only to ensure their investments are based on V2G standards so they can support V2G in future years, once the issues outlined above have been resolved. To date, the big car OEMs and utilities are cooperating on this issue and one emerging standard is the SAE J1772.

5.9. Preliminary conclusions: market challenges vs technical evolution

- It is not clear yet whether these initiatives are driven by economics, by a product strategy, or whether these projects are used as a pilot to evaluate the boundary of the technology.
- Inevitably, these new approaches (re-use and second use of articles, components,...) raise the legal matter of product liability and extended producer responsibility. This is still a very grey zone as it is not always clear when the product responsibility is transferred.
- The expensive EV lithium batteries have a long warranty period (up to 5 years, or even more), they have a very long lifetime (7 to 10 years), components of the battery can be replaced individually (module, stack, cell) to enlarge the lifetime of the battery and reduce the warranty or service cost for the manufacturer or the consumer.
- This all makes that this EV lithium battery will be kept for its initial purpose as long as possible.
- As a consequence, this battery will have aged before the possibility for going into a second life application. This results in a risk of product obsolescence as the chemistry of lithium batteries is changing fast & significantly.
- To predict the potential second life of an EV lithium battery, produced several years ago, will be very uncertain.
6. Extended Producer Responsibility and EU Directives on Waste

6.1. The EU Extended Producer Responsibility (EPR) Principle is mandatory
Within the context of the Waste Directives such as WEEE, Batteries, and ELV Directives. Member States shall ensure that producers set up schemes for the collection and recycling of WEEE, batteries and accumulators, and vehicles.

6.2. EPR uses financial incentives
To encourage manufacturers to design environmentally-friendly-conscientious products by holding producers responsible for the costs of managing their products at end of life, EPR is based upon the principle that producers have the greatest control over product design and marketing and that consequently, these same companies have the greatest ability and responsibility to reduce waste and improve resource efficiency. EPR may take the form of a re-use, buy-back, or recycling program. The producer may also choose to delegate this responsibility to a third party, a so-called producer responsibility organization (PRO), which is paid by the producer for used-product management. In this way, EPR shifts the responsibility for waste management from government to private industry, requesting producers, importers and/or sellers to internalize waste management costs in their product prices and ensuring the safe management of their products at end of life.

6.3. Extended Producer Responsibility goes back to the Polluter-Pays-Principle (PPP)
That is included in the Treaty for a European Union (TFEU), Article 191 “Community policy on the environment shall (...) be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay”.
- The principle is that the polluter should bear all costs, so that external costs are internalized. Rather than the direct polluter, the ‘polluter’ is the economic agent who can play a decisive role in avoiding pollution, e.g. through design efforts.

6.4. There are 3 key Principles of the European Waste Policy
1) Subsidiarity
2) Hierarchy of waste management options: prevention/re-use/recycling/recovery/disposal
3) Extended Producer Responsibility.
Within the Framework of the EU Waste legislation (the basis is the Waste Framework Directive – WFD 2008/98/EU) the priority waste streams towards which these 3 principles apply are the Packaging waste, the End-of-life Vehicles (ELV), the End-of-life Batteries, and the Waste from Electrical and Electronic Equipment (WEEE).

6.5. Extended Producer Responsibility is established in the Waste Framework Directive
Recital 1: “...in accordance with the polluter-pays-principle, a requirement that the costs of disposing of waste must be borne by the holder of waste, by previous holders, or by the producers of the product from which the waste came.”

6.6. Article 8. of the same WFD indicates that Member States may take measures to ensure that the producer of products fulfills the requirements of the EPR:
1. In order to strengthen the re-use and the prevention, recycling and other recovery of waste, Member States may take legislative or non-legislative measures to ensure that any natural or legal
person who professionally develops, manufactures, processes, treats, sells or imports products (producer of the product) has extended producer responsibility. Such measures may include an acceptance of returned products and of the waste that remains after those products have been used, as well as the subsequent management of the waste and financial responsibility for such activities. These measures may include the obligation to provide publicly available information as to the extent to which the product is re-usable and recyclable.

2. Member States may take appropriate measures to encourage the design of products in order to reduce their environmental impacts and the generation of waste in the course of the production and subsequent use of products, and in order to ensure that the recovery and disposal of products that have become waste take place in accordance with Articles 4 and 13. Such measures may encourage, inter alia, the development, production and marketing of products that are suitable for multiple use, that are technically durable and that are, after having become waste, suitable for proper and safe recovery and environmentally compatible disposal.

3. When applying extended producer responsibility, Member States shall take into account the technical feasibility and economic viability and the overall environmental, human health and social impacts, respecting the need to ensure the proper functioning of the internal market.

4. The extended producer responsibility shall be applied without prejudice to the responsibility for waste management as provided for in Article 15(1) and without prejudice to existing waste stream specific and product specific legislation.

However, EPR can be taken to a mandatory level by the Member States when implementing the WFD, Article 8.3: taking into account the technical feasibility, economic viability and environmental, human health and social impacts, and respecting the need to ensure the proper functioning of the internal market. EPR can also be taken to a mandatory level by the EU legislators in specific waste legislation, such as Batteries, ELV, WEEE.


(a) Article 8.1a. Extended producer responsibility means the producer’s operational and/or financial responsibility for a product extended to the post-consumer state of a product’s life cycle.
(b) Article 8.2. Member States shall take appropriate measures to encourage the design of products in order to reduce their environmental impact and the generation of waste in the course of the production and subsequent use of products, without distorting the internal market. Those measures shall include measures to encourage the development, production and marketing of products that are suitable for multiple use, that are technically durable and that are, after having become waste, suitable for re-use and recycling in order to facilitate proper implementation of the waste hierarchy. The measures shall take into account the full life cycle impacts of products.
(c) Article 8.3. When developing and applying extended producer responsibility, Member States shall comply with the minimum requirements laid down in Annex VII (?).
6.7. Conditions and challenges of Extended Producer Responsibility

- For EPR to work, the producer needs to be identifiable and having an impact on the problem, and if other actors in the market also impact the problem then the producer must have the means to influence these other actors.

- Amongst the challenges of EPR to work, are the diversities of collection, treatment and collective compliance schemes within the EU, competition between producers or between collective schemes should not be hindered.

- EPR can influence decisions made by producers during the complete product life-cycle to focus more on the environmental impacts of products put on the market, which in the end might influence consumer behavior, and contribute towards a “recycling society”.

6.8. The link between Extended Producer Responsibility and the Batteries Directive 2006/66/EC can be found in the definition of ‘producer’ in Article 3.12.: “any person in a Member State that, irrespective of the selling technique used, including by means of distance communication...places batteries, including those incorporated into appliances or vehicles, on the market for the first time within the territory of that Member State on a professional basis”. So, the battery producer, placing the battery on the market for the 1st time is well-defined:


- In case the battery is re-used (after refurbishment or remanufacturing) by the producer, the producer is still controlling the waste management flow of the battery.

- In case the battery is offered for a second use by a third party for another application than for what the battery was designed for initially and put on the market for the 1st time, then the producer should have the means to control the waste problems which might be created by the new commercial actor who is acting as a producer placing the battery for a second time on the market. There may be cases where the producer (first placing on the market) will keep the ownership of the battery offered for a second use. This scenario does not create any concern as the “first producer” will keep the responsibility of the battery through its second use and its end of life.

6.8.2. Case 2.

- But there will be cases where the “second use” will request a transfer of ownership and a second placing on the market. It is also anticipated that the second use will not be known by the first producer. Therefore, the possibility to have a battery offered for a second use is opening the question of the responsibilities of the second producer which are not defined in the Batteries Directive.

6.8.3. Preliminary Conclusions.

- As a result of the development of new batteries technologies opening the road to a wider range of applications (Lithium-Ion, Nickel-Metal Hydride, Sodium-Nickel-chloride, etc...)... several additional technical and regulatory issues are raised by this transfer of ownership and the possibility to use the battery for a different application than the one offered during the first placing on the market. In particular the battery management system must probably be adapted to the new application. The UN Model Regulation for the transport of Dangerous Goods applies
to Lithium batteries. For safety reasons, it requires specific testing requirements in accordance with defined technical specifications. This needs to be secured before the second use of the battery.

- For re-use, the conditions for EPR can be respected. For second use, the conditions for EPR could potentially not be respected because they are kept out of control of producer who has placed the battery on the market for the first time.
- The duties of the EPR for batteries extend to the registration as a producer, reporting of quantities of batteries placed on the market, marking requirements, participation to collection schemes for portable batteries and take back obligations for industrial and automotive batteries.

Note - An interpretation and declaration of one OEM: “The original manufacturer can only have the product responsibility for risks/damage during use or foreseeable misuse in connection with the original purpose of the product as he had put it on the market. Whenever the product is applied for a purpose other than the purpose it was designed and sold for by the manufacturer, he cannot be liable. Any economic operator who uses a product that was designed for a different purpose in or in connection with an own product will bear the responsibility as the “manufacturer” also for that product.”

In this Q&A there are several critical paragraphs on producer responsibilities:

**What is the definition of ‘battery producer’?**
According to the definition given in Article 3 of the Directive, the ‘producer’ is the person in an EU Member State who supplies or makes available to a third party batteries or accumulators (including those incorporated into appliances or vehicles) within the territory of that Member State for the first time on a professional basis. This definition applies regardless of the selling technique used and irrespective of whether the batteries are supplied in return for payment or free of charge. A ‘battery producer’ may also be a person who imports batteries into the customs territory of the European Union.

**Who is the ‘battery producer’? - Examples**
- A battery manufacturer or importer in an EU Member State sells batteries to a retailer who in turn sells them to customers (‘end-users’) in that Member State.
  In this case, the battery manufacturer or the importer is the ‘producer’ in that Member State, as they are placing the batteries on the market for the first time in that Member State.

- A retailer sells batteries in a particular EU Member State, but he bought those batteries in a different country.
  In this case, as the retailer is placing these batteries on the market in this EU Member State for the first time, the retailer is the ‘producer’.

- An equipment/car manufacturer in a particular EU Member State buys batteries from a battery manufacturer or importer in that Member State. These batteries are then put into equipment/cars which are sold in the same Member State.
In this case, the battery manufacturer or importer is the ‘producer’ in this Member State as he is selling to the equipment/car manufacturer and thus placing the batteries on the market in that country for the first time.

- **An equipment/car manufacturer or importer in a particular EU Member State buys batteries in a different country. He incorporates these batteries into equipment/a car which he then sells in his home country.**
  In this case, the ‘battery producer’ in this Member State is the equipment/car manufacturer or importer himself, since it is he who places the batteries on that market for the first time.

- **A company imports batteries from a non-EU parent company for its independent subsidiary located in an EU Member State**
  In this case, the independent European subsidiary is the ‘producer’, as it is the subsidiary which places the batteries on the market in that Member State for the first time.

- **Batteries or battery cells are sold in an EU Member State to a battery pack assembler and are then sold within the same Member State.**
  In this case the battery pack assembler is the ‘producer’, as he makes the battery pack available on the market in that country for the first time on a professional basis.

- **A battery manufacturer in a particular EU Member State sells batteries to a private label owner in that Member State. These batteries are then sold in the same Member State (under the label of the private owner and not under the label of the battery manufacturer).**
  In this case, the private label owner is the ‘producer’, as he places the batteries with its own label on the market in that country for the first time.
6.10. Other comments

In the Batteries Directive 2006/66/EC, Article 3.7, ‘waste’ is defined as: “Any battery or accumulator which is waste within the meaning of the WFD”. In the Waste Framework Directive 2008/98/EC (WFD) Article 3.1 ‘waste’ is defined as: “Any substance or object which the holder discards or intends or is required to discard”. If the producer cannot control that waste, than the producer will have a problem with Extended Producer Responsibility.

In the Directive 2001/95/EC on General Product Safety - Article 2 (e) Producer shall mean:
(i) the manufacturer of the product, when he is established in the Community, and any other person presenting himself as the manufacturer by affixing to the product his name, trade mark or other distinctive mark, or the person who reconditions the product,
(ii) the manufacturer’s representative, when the manufacturer is not established in the Community or, if there is no representative established in the Community, the importer of the product,
(iii) other professionals in the supply chain, insofar as their activities may affect the safety properties of a product.

In the Directive 85/374/EEC on liability for defective products - Article 3 -Producer means the manufacturer of a finished product, the producer of any raw material or the manufacturer of a component part and any person who, by putting his name, trade mark or other distinguishing feature on the product presents himself as its producer.

In the same Directive - Article 7 – it is mentioned: The producer shall not be liable as a result of this Directive if he proves:
(a) that he did not put the product into circulation
(c) that the product was neither manufactured by him for sale or any form of distribution for economic purpose nor manufactured or distributed by him in the course of his business,
(f) in the case of a manufacturer of a component, that the defect is attributable to the design of the product in which the component has been fitted or to the instructions given by the manufacturer of the product

The European Resource Efficiency Platform adopted the second part of its resource efficiency manifesto of policy recommendations, on 31 March 2014.

The European Resource Efficiency Platform’s objective is to provide high-level guidance to the European Commission, Members States and private actors on the transition to a more resource-efficient and circular economy.

One of the recommendations included ‘Boosting Extended Producer Responsibility’: EPR schemes can be more efficient if they are transparent and operate according to certain minimum principles across the Single Market.

Including a better definition of producer responsibility and better monitoring by Member States.

Calls on the EU to address this is the Waste Policy Review in May 2014. This was done with the EU Commission Proposal of 2 July 2014 for a Directive of the European Parliament and of the Council, amending Directives 2008/98/EC on waste, which includes a proposal is made to make some amendments, additions, or replacements of Article 8. Extended producer responsibility.
7. Positions of other Battery Associations.

7.1. Battery Association of Japan – BAJ

BAJ Recommendation Regarding the Reuse of Lithium-Ion Secondary Batteries – July 10, 2014

The concept of promoting the reuse of lithium-ion secondary batteries is spreading, from the viewpoint of using resources effectively. The battery has developed as a power supply for portable devices, and its applications are extending into the energy field, such as electrical storage devices and driving systems for cars, etc. after switching to a low-carbon society starts as an action against global warming.

However, it is said that the development history of lithium-ion secondary batteries was narrow and difficult, amid a dilemma between convenience brought by high energy and assurance of safety. We have overcome this situation while maintaining a very delicate balance between the two. Accordingly, the battery requires us to fully understand its characteristic advantages and disadvantages to take sufficient safe handling measures.

The Battery Association of Japan, which has led the world in the development and production of lithium-ion secondary batteries and made a contribution in the fields of technology, quality, and safety, now summarizes the concepts of reusing the batteries based on repeated reviews. Recommendations have been made in accordance with the following basic concepts:

1) ensuring the personal safety,
2) recycling and effectively using resources,
3) reducing business risks of the entities related to lithium-ion secondary batteries and developing their businesses, and the hope that lithium-ion secondary batteries will continue to contribute to the world.

1. Recommended concepts of reuse

<table>
<thead>
<tr>
<th>Consumer or Industrial use</th>
<th>Authorized use (A battery can have more than one application from the beginning.)</th>
<th>Unauthorized use (Application not intended initially)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery system or assembly (e.g. battery pack or module with a special protective function*5)</td>
<td>Permitted *1</td>
<td>Prohibited *3</td>
</tr>
<tr>
<td>Single battery (e.g. cell with a special protective function*5 removed)</td>
<td>Prohibited *2</td>
<td>Prohibited *4</td>
</tr>
</tbody>
</table>

*5) A special protective function includes safety functions like overcharge protection, over-discharge protection, and short-circuit protection.
2. Reason for opposition to the unauthorized products

We guarantee the safety of a system*6 using lithium-ion batteries, by verifying the safety of single batteries, controllers, and their close combination of mutual safety functions, assuming operating environments and applications.
To do this, the battery and device manufacturers shall exchange enough information with each other and carry out a risk assessment before they produce and sell their products. Therefore, we strongly recommend that use of the unauthorized products is prohibited, because they are not verified.

3. Reason for the opposition to reconstructed battery assembly after disassembling a battery assembly into single batteries*

Used systems*6 show different levels of degradation in capacity and different chronological changes for each battery pack, module, or its single battery (single cell). With our current technology, however, it is difficult to guarantee the safety when reconstructing a battery pack, module, or battery system from the disassembled single batteries. Therefore, we strongly recommend that use is prohibited.

4. Battery Association of Japan’s concepts

As shown in Sections 2 and 3 above, the Battery Association of Japan strongly recommends that use is prohibited for the reuse*7 in cases *2 to *4 of the table because the safety is not guaranteed and there are some risks bringing about unsafe factors to consumers and society.
However, this strong recommendation does not prevent the companies concerned from making efforts to develop safe products and technology in the future, even in cases *2 to *4.

5. Glossary

*1 Presently, in a system*6 that consists of lithium-ion batteries (including a battery system) and a device using lithium-ion batteries, the both shall have a one-to-one relationship in order to guarantee the safety of the system*6 using lithium-ion batteries.
It is possible to build up a system*6 for authorized use in which more than one device(application) has one common battery with the one-to-one relationship shown above guaranteed.

*2 Application resulting from the disassembly of a battery pack or module into single batteries and the reconstruction of a system*6 for authorized use with a battery assembly reconstructed from the single batteries.

*3 Application resulting from the reconstruction of a system*6 for unauthorized use with a battery pack or module maintained.

*4 Application resulting from the disassembly of a battery pack or module into single batteries and the reconstruction of a system*6 for unauthorized use with a battery assembly reconstructed from the single batteries.
*5 Special protective function: Refers to the function of monitoring and controlling the safety of lithium-ion batteries, such as a battery management unit (BMU) or a battery management system (BMS). There are two cases: one is a case where the function is built in a battery pack or module, and the other is a case where it is incorporated into a device that uses lithium-ion batteries.

*6 System: Refers to a battery system (battery assembly) and a whole device using batteries, both being designed to guarantee the safety of the lithium-ion battery.

*7 Reuse: Means that a used product is collected and treated properly as necessary for reuse as another product or for the use of its recyclable parts (excerpt from 3R Policies by the Ministry of Economy, Trade and Industry). Therefore, we allow a lithium-ion battery to be reused only in case *1 (battery assembly reused in an authorized product) of the table, provided it is treated properly.

*8 Others: Refer to JIS C 8712 (IEC62133) and JIS C 8715 (IEC62619).
For more information about the JIS, access the website of the Japanese Industrial Standards Committee (JISC) http://www.jisc.go.jp/eng/ -
PRBA – The Rechargeable Battery Association
Position on Reconditioned Lithium ion Cells and Batteries

1. Reconditioning lithium ion cells and batteries may offer an opportunity to re-use a product of significant value. However, the cells and batteries must be managed appropriately to assure that safe products are made available to the market.

2. Use of lithium ion cells and batteries that are reconditioned (also referred to as “refurbished,” “re-purposed,” “re-used” and “second use”) may present a significant safety risk for consumers, product manufacturers, shippers, transporters and other entities involved in their handling. The risk increases if the cells and batteries are used as components in products for which they were not originally designed.

3. Lithium ion cells and batteries are manufactured to very strict specifications, which may anticipate only use in one type of application. In addition, new cells and batteries must meet mandatory testing requirements imposed by governmental agencies.

4. Lithium ion cells that are removed from batteries or battery packs at the end-of-life may be compromised due to the hundreds of cycles (i.e., charging and discharging) to which they have been subjected, abusive use or damage during the dismantling process.

5. As a cell / battery is put to use, some degradation occurs and the individual cell capacity variation increases. Ensuring safe operation requires a sophisticated monitoring and control by the battery management system. Systems designed for particular new batteries may not be suitable for use with reconditioned cells or batteries.

6. In light of the foregoing considerations, PRBA strongly opposes the practice of reconditioning lithium ion cells and batteries unless the following conditions are met:
   a. The entity reconditioning the cells and batteries is the original manufacturer of the cells or batteries or has direct knowledge of the cell degradation characteristics and safety systems that are necessary to maintain safe operation of cells in the anticipated application and is authorized to recondition the cells or batteries by the original cell manufacturer;
   b. Except for reconditioned batteries shipped for testing purposes, batteries are tested or retested, as applicable, in accordance with the UN Manual of Tests and Criteria;
   c. The batteries are marked “RECONDITIONED” or with substantially similar language; and
   d. The entity that reconditions the cells and batteries is identified on the unit and assumes all legal responsibilities and liabilities associated with the use and final disposal of the cells and batteries.
8. RECHARGE proposes the use of Minimum Requirements to evaluate re-use or second use of advanced rechargeable batteries

RECHARGE proposes the following minimum requirements to support either re-use or second use.
- In case these minimum requirements are met, then RECHARGE will support.
- In case one of the minimum requirements is not met, than RECHARGE will not support.
- In any case, when there is doubt on the respect/observation of the Extended Producer Responsibility concerning the end-of-life waste management of the battery, RECHARGE will not support.

<table>
<thead>
<tr>
<th>Proposed Minimum Requirements</th>
<th>Re-use</th>
<th>Second use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Identical use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Re-furbishment or re-conditioning by qualified professionals</td>
<td>Re-use: If yes, “re-use” is acceptable.</td>
<td>Second use: In absence of a legal basis, additional criteria might be required – e.g. - Compatibility issue between 1st &amp; 2nd Application</td>
</tr>
<tr>
<td>- Control of equivalent performances e.g. through the Battery Management System</td>
<td></td>
<td>Second use: - Responsibility for the technical performances</td>
</tr>
<tr>
<td>- Quality, Safety and Performance standards to be observed</td>
<td></td>
<td>Second use: - Producer Responsibility to be defined: technical and end of life</td>
</tr>
<tr>
<td>- Etc...</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Producer Responsibility</strong></td>
<td></td>
<td></td>
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<tr>
<td>- Producer identified</td>
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<tr>
<td>- Warranty offered by Producer</td>
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<tr>
<td><strong>Safety</strong></td>
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<tr>
<td>- Technical requirements maintained</td>
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<tr>
<td>- Safety Standards respected (tests)</td>
<td></td>
<td>Second use: - Compliance with safety testing requirements before second use</td>
</tr>
</tbody>
</table>

**TABLE 1.** Non Exhaustive list of minimum requirements to be considered for allowing re-use or second use of batteries.
9. Conclusions

9.1. Based on the following observations:

- According to the EU policy on Waste translated in various Waste Directives, re-use and recycling are to be promoted.
- There is a need to define “re-use” in the context of the Batteries Directive.
- There is most probably the need to distinguish between the re-use of a substance and the re-use of an article or component.
- Second use is not defined and proposed in any of the Waste Directives.
- There is a need to establish minimum requirements associated with the application of reuse or second use of rechargeable batteries after their first service life.
- Second use might conflict with Extended Producer Responsibilities regarding the complete management of the waste stream.
- Second use might create safety issues for end users.

9.2. RECHARGE position on these issues is the following:

- When the proposed minimum requirements of Table 1 are fulfilled, RECHARGE supports the re-use of rechargeable batteries for their original applications. This requires that quality, performances and safety standards are observed before placing the rechargeable battery for second time on the market.

- RECHARGE only supports the second use of batteries when the battery remains under the responsibility of the producer acting as the first entity placing the battery on the market.

- In absence of a legal basis and clear minimum requirements, RECHARGE does not support second use of batteries as there are too many unknown factors that could impact product’s reliability and end users safety.

- The most critical factor is to maintain the Extended Producer Responsibility and the transfer of ownership under a legal framework for the re-use and second use of batteries

Note:
Supporting document: ‘Comparison of definitions within the different Waste Directives’.