Factsheet: Electric mobility and recycling

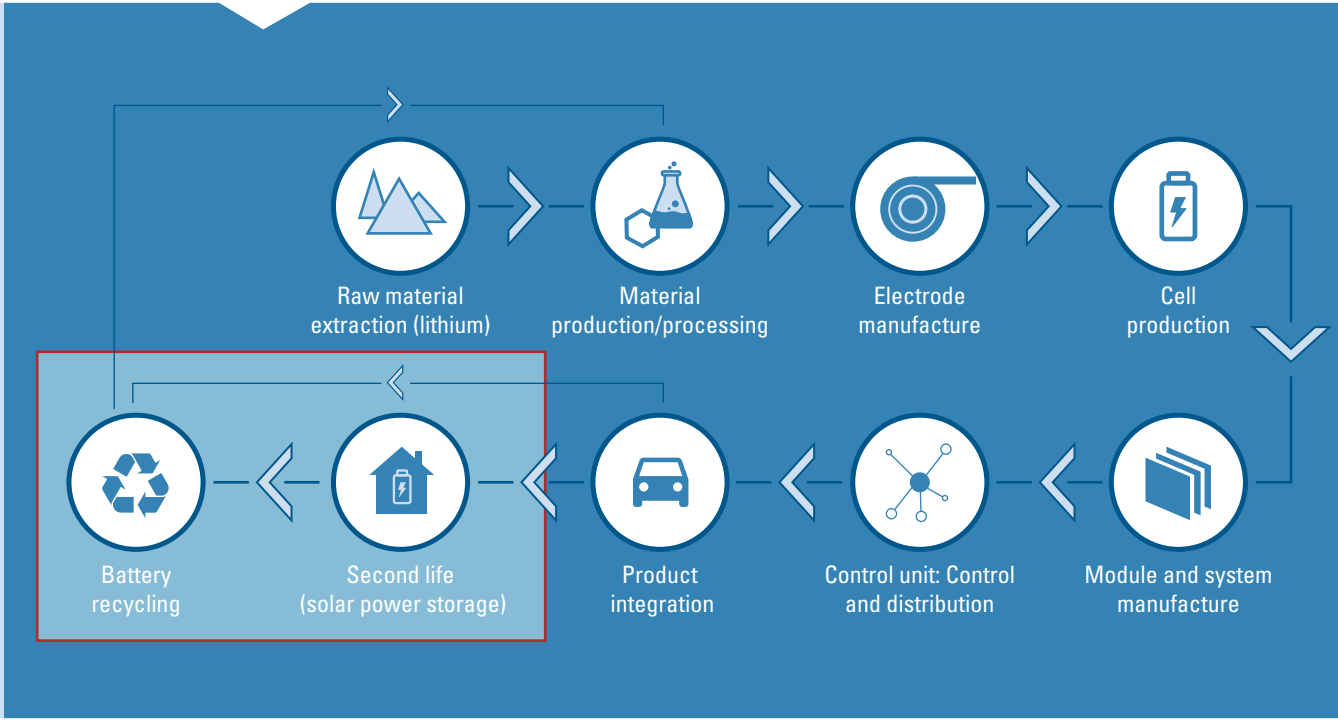
What happens to lithium-ion batteries from e-vehicles?

Introduction

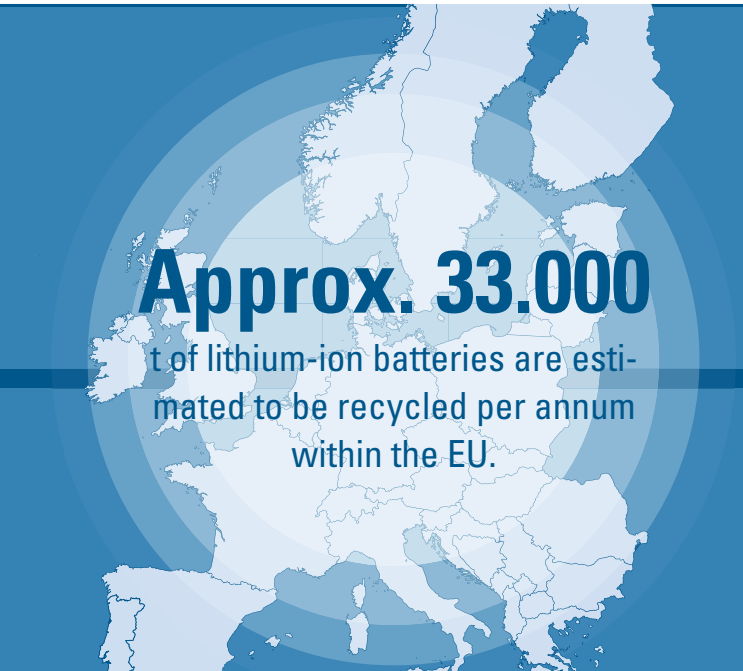
Put simply, recycling and second life are fundamental prerequisites for sustainable electric mobility. The number of e-vehicles on the road is rising, and so too is the awareness of the raw materials they need as well as the issue of disposal. Firstly, voices demanding the re-use of car batteries for both ecological reasons (environmental degradation from mining of raw materials) and social reasons (working conditions and human rights standards) are becoming loud. In this respect recycling is a precondition for societal acceptance of electric mobility in Europe. Secondly, because of the limited availability of resources, recycling is also a question of economic sustainability. China in particular, has recognized the economic potential of recycling. However, neither a market nor an efficient system of recycling yet exists to ensure that car batteries are recycled at the moment.

Lifecycle of a lithium-ion battery for cars

The ramp-up of production figures for e-vehicles increases the demand for lithium-ion batteries in the automotive sector. Until now there has been a particular emphasis on cell manufacture and battery production with the goal of ramping up the number of units. This came with an increase in demand for raw materials such as lithium and cobalt, which were satisfied by the establishment and securing of primary raw material supply chains. In addition there has been no market for used lithium-ion batteries from the automotive sector, which is why industrial recycling processes have been unable to establish themselves. The lifecycle illustrated here in this graphic still must be realised for all electric vehicles.



Recycling capacity and demand in the EU



Approx. 33.000

t of lithium-ion batteries are estimated to be recycled per annum within the EU.

Growing interest

from vehicle manufacturers in recycling

Example

1,500 t for 2020

planned through VW pilot plants

By 2035

sufficient recycling capacities, steep increase expected thereafter

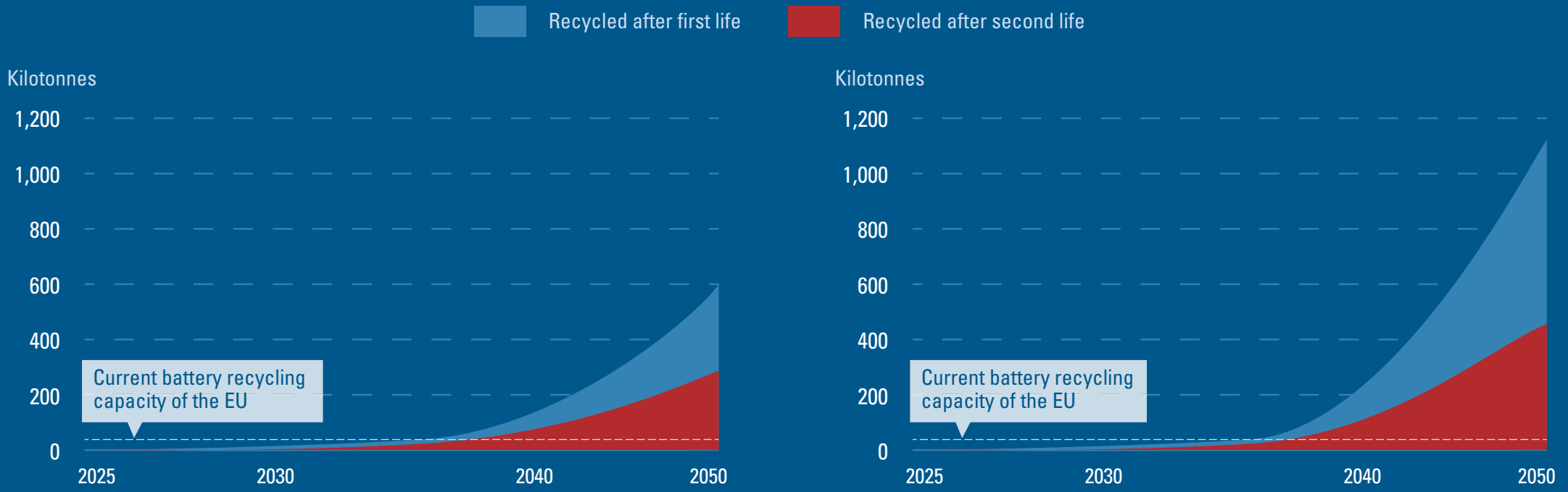
(Element, Energy, 2018)

NOW
NOW-GMBH.DE

The scenarios clearly show that with growing numbers of e-vehicles, the currently available recycling capacities in the EU will no longer be sufficient from 2035.

Scenario 1: Basis

Scenario 2: Accelerated market ramp-up of electric vehicles



Recycled batteries in the EU per annum

Based on two scenarios of the study: “Low carbon cars in Europe: A socioeconomic assessment”, by Element Energy and Cambridge Econometrics (2018)

Scenario 1:

The average target of 95g CO2/km in 2020 will be met as determined in the EU regulation on the reduction of CO2 emissions of passenger cars (from 2009)

Scenario 2:

Pure combustion engines will no longer be produced from 2035, and hybrid vehicles no longer produced from 2040.

Excursus: Recycling of vehicle batteries in China

In China regulation and pilot projects go hand in hand in order to exploit the potentials of batteries for second life applications and resource recovery.

Potentials

By 2029

3 million used EV battery packs per year will be available, amounting to approx. 108 GWh storage capacity.

Annual market for battery recycling:

2018
5.2 billion RMB

2022
30 billion RMB

Regulation

Battery tracking

Since 2018

All batteries are registered on a tracking platform with an identification number. The passage through all stations on the supply chain must be proven by the relevant actors.

Directives

for the establishment of collection plants for electric car batteries (on the part of the manufacturers) have been adopted – the size is dependent on vehicle sales of the manufacturer per region.

Implementation

17 cities and regions

(including the cities of Peking, Shanghai and Xiamen, the provinces of Jiangsu, Anhui & Guangdong) are beginning pilot programmes.

At the end of December 2018

it was announced that 45 NEV*-producing companies installed a total of 3,204 collection facilities in 31 provinces.

* New Energy Vehicles

Sources: IDTechEx Research (2018), SGEC monitoring report January 2020

Overview of recycling processes

In the recycling of lithium-ion accumulators, none of the three common methods has yet gained prominence over the others. The advantages and disadvantages are outlined here:

Pyrometallurgical

Heats the batteries in a smelting oven at high temperatures. Remaining alloys & slag contain e.g. lithium & aluminium oxide.

Advantages

+ Minimal pretreatment
+ All battery chemicals can be recycled together

Disadvantages

– High energy requirement
– Low recovery rates when not combined with hydrometallurgical processes

Recovered metals:

Co, Ni, potentially also Cu and Fe alloying. In combination with hydrometallurgical processes, also cobalt oxide, nickel hydroxide, lithium carbonate.

Hydrometallurgical

Use of acids or alkalis to dissolve metal

Advantages

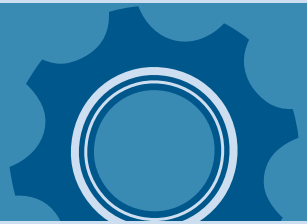
+ High recovery rates
+ All metals can be recovered
+ Many of the reactants used can be reused within the process

Disadvantages

– Is being optimized for certain battery chemicals, i.e. different chemicals can be poorly recycled together
– Presorting and identification of battery chemicals necessary
– Greater need for chemicals (reactant)
– Formation of toxic gas

Recovered metals:

All metals but no graphite. Very high recovery rates.



Mechanical/physical

Shredding plus either low return methods (Cu, Al) or advanced methods, in which cathode powder stays intact.

Advantages

+ No chemical requirement
+ Can be automated

Disadvantages

– Explosive reaction possible: O2-free environment necessary or deep freezing of batteries before shredding
– Advanced methods technically complex

Recovered metals:

Lithium carbonate; at present still combined with hydrometallurgical processes.

Sources: Dahlöff et al (2019), Steward et al (2019), Element Energy (2019) | Al=Aluminium, Co=Cobalt, Cu=Copper, Fe=Iron, Li=Lithium, Ni=Nickel

List of European companies with recycling processes for lithium-ion batteries

Company	Recycling process				Recovered materials
					
Accurec Recycling GmbH			✓		Li, Cu, Fe, Ni, Co, Al, plastic
AEA Technology		✓			Li, Co, R&D – not on industrial scale
Akkuser Oy				✓	Only shredding – output to metal refineries
Batrec Industrie AG	✓		✓		unknown
Chemetall GmbH		✓			Cu, Co, Ni, Li (small scale)
CrisolteQ Oy / Fortum		✓			Li, Co, Ni – Fortum also tests second life applications
Duesenfeld GmbH		✓			Li, Co, Ni, Fe, Cu, Al
Eramet Group			✓		Li, Co, Ni, Fe, Cu, Al
Glencore plc	✓		✓		Battery collection only in Europe – exports to Canada
GP					Only battery collection
Nissan Automobil AG				✓	Only battery conversion
Promesa GmbH & Co. KG				✓	Only battery shredding
Redux Recycling GmbH			✓		Fe, Al, Cu, plastic
SNAM	✓				Co, Cu, Al, Fe + conversion
Umicore AG & Co. KG	✓	✓			Li, Co, Ni, Cu
Veolia Environnement S.A.		✓			Li, Ni, Fe
UP				✓	Only battery collection
WasteCare				✓	Only battery collection

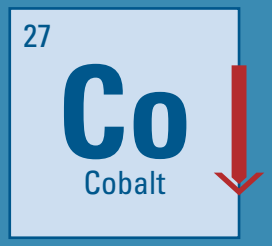
Status: 2019, Source: Element Energy (2019)

NOW-GMBH.DE

Profitability factors of recycling

The profitability of battery recycling is dependent on four main factors:

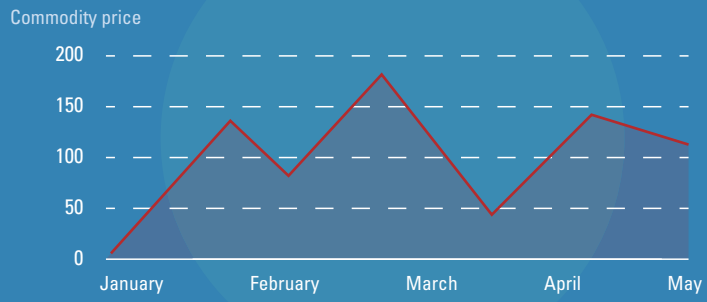
1



Battery chemistry and energy density

The most valuable metal in today's lithium-ion batteries is cobalt. Yet the chemical compositions of the batteries are already being intensively worked on. These types of innovation processes affect the return of the different metals and thus the profitability of the process as a whole. In parallel, the energy densities of lithium-ion batteries are becoming higher: batteries are becoming more compact and require less material. Consequently the amount of metal decreases per recycled battery.

2



Commodity prices

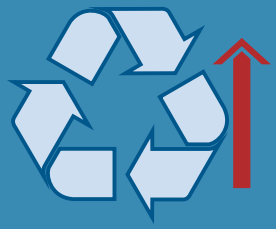
Prices can vary widely, making economic planning more difficult and increasing the risk for recycling companies.

3

Battery volume

Uncertainties regarding volumes of batteries to be recycled make capacity planning and justifying investment more difficult. It can however be assumed that the signals of the constantly growing market for battery electric vehicles affect the recycling industry in a positive way.

4



Regulation & recycling efficiency

If recycling rates and quotas for individual metals are raised and intensified in regulatory frameworks, planning security for the industry increases.

Source: Element Energy, 2019

Second life

Second life batteries from e-vehicles have multiple applications. They range from domestic storage, emergency power supply, power supply buffering, drives for industrial trucks, to their use in peak load management of large consumers or the provision of control power to electricity grid operators. The use of second life compared to direct recycling is being discussed by experts. In the use and evaluation of second life accumulators the following factors should be observed:

Strengths

+ Second life in stationary and mobile applications possible in principle
+ Additional revenues or cost savings possible
+ Replacement of environmentally-damaging batteries (for example lead-acid batteries)
+ Reduction in greenhouse gas emissions and demand for resources

Weaknesses

– Uncertainty regarding condition after first life
– Uncertainty regarding life cycle in second life
– Safety-related concerns
– Reprocessing costs

Opportunities

+ Growing market for electric mobility
+ Growing demand for stationary energy storage
+ Increasing environmental and resource awareness
+ Delay in incurring recycling costs
+ Increase in economic efficiency due to funding measures
+ Development of new business models
+ Design for second life: modular building block strategy possible

Risks

– Little availability of used batteries
– Uncertainty regarding development of battery price
– Lack of willingness to pay because of low level of acceptance of used products
– Energy-intensive recycling processes cannot, in part, be implemented from an economic point of view
– Unclear legal situation (e.g. accountability, recycling duty)
– Lack of standardisation
– High demands on the logistical supply chain
– Adaptation of user behaviour in first life: longer use in the vehicle

Ffe (2016): Study: Second life concepts for lithium-ion batteries from electric vehicles. Analysis of after-use applications, economic and ecological potential.

NOW
NOW-GMBH.DE

Challenges and recommendations for recycling and the second life of lithium-ion batteries from e-vehicles

One of the greatest challenges for afteruse and recycling is the diversity of battery chemicals which make a standardised approach and subsequent industrial processes difficult. In addition, batteries are sometimes installed in the vehicles in a complicated manner, so that they either cannot be removed at all or only removed with great difficulty. The demand for second life accumulators for power storage has not materialized, despite its high potential. Ultimately, the transport and storage of batteries are associated with risk and therefore complex and expensive.

Aside from overcoming technical challenges, political action is needed. Two legal acts in particular are crucial for electric car batteries and their recycling. EU directive 2006/66/EG (EU battery directive) regulates battery-specific requirements for collection, recycling and disposal techniques. In Germany this directive was implemented by the Battery Act (BattG). A first hearing on the redraft took place in the German parliament in September 2020. The focus of the amendments is the strategic establishment or improvement of the recycling economy for old batteries and the associated environmental protection. To achieve higher second-life use and recycling quotas, here are some reasonable requirements:

Legal definitions

Adaptions of legal definitions in the context of traction batteries for electric cars, in order to simplify/facilitate their reconditioning or repurposing.

Higher collection quotas

Higher general collection quotas for batteries (currently 45%).

Specific raw material quotas

Adoption of specific raw material quotas for scarce commodities such as lithium.

Ecodesign specifications

Adoption of specifications for the eco-design of batteries.

Tracking system

Adoption of a tracking system for traction batteries for electric cars.

(Sources: Element Energy 2019; Federal Environment Agency 2019; Eco-Institute 2020)

NOW-GMBH.DE

Contact

Kira Weinmann

Manager, Communications and Knowledge Management

Telephone: +49 30-311 61 16-53

Email: kira.weinmann@now-gmbh.de