AD HOC STUDY

# MODEL CALCULATIONS TO ASSESS THE ACHIEVABLE LEVEL OF COLLECTION FOR WASTE BATTERIES FROM E-BIKES IN GERMANY

No target for light means of transport until 2030 at least: A glaring and surprising weakness in the EC's proposal for the Batteries Regulation.

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## Updates & Corrections

- 8 April 2021: In chapter *1. Introduction*, paragraph 5 it must read: *As demonstrated below, it should be possible for such batteries to reach a minimum collection rate of 30 % in 2025 and 45 % **in 2030** (considering the calculation model in Annex XI of EC's draft proposal)*. Instead of 45 % in **2035** as it was displayed in the previous version. This correction is not based on new calculations, but was simply a typo.
- 8 April 2021: I chapter *1.2. Why is it important to collected waste batteries from light means of transport?* We added in paragraph 3 the new source Eunomia (2021) with information on costs caused by lithium-ion battery fires in the waste industry.

## Abbreviations

| Abbreviation | Description |
|---|---|
| EC | European Commission |
| EURIC | European Recycling Industries' Confederation |
| POM | Placed on the market |
| PRO | Producer Responsibility Organisation |
| UK | United Kingdom |
| WEEE | Waste of Electric and Electronic Equipment |
| ZVI | Zweirad-Industrie-Verband (Germany) |

# 1. Introduction

Art 48(4) in the EC's proposal obliges **the producers / PROs** to meet collection targets for portable batterie of 45 % by 31 December 2023, 65 % by 31 December 2025 and 70 % by 31 December 2030. Batteries from light means of transport, if falling under portable batteries, are excluded from the scope of this target. Art 55 obliges **the Member States** to meet the same collection target considering the same exclusion from the scope.

As a result, no collection target is established by the EC's proposal for portable batteries from light means of transport. Instead, the EC is tasked to conduct a review of the targets – including portable batteries from light means of transport **by 31.12.2030.**

The lack of any collection target for portable batteries from light means of transport is a glaring and surprising weakness in the Commission's proposal. In principle, it is correct that under the conditions of increasing mass placed on the market in combination with a long lifespan of the product, it is difficult to achieve high collection targets when considering the calculation model in Annex XI of the draft legislative proposal.

However, it is worth making some model calculations that take the past development and reasonable future developments of portable batteries for light means of transport into consideration.

As demonstrated below, it should be possible for such batteries to reach a minimum collection rate of 30 % in 2025 and 45 % in 2030 (considering the calculation model in Annex XI of EC's draft proposal).

Applying a deposit refund scheme of, for example, 10 % of the battery price would make it easy to achieve the target. A regular review of the target every third year would be needed, with the aim to assess if the target is challenging enough.

## 1.1. What are light means of transport?

The proposed definition in Art 2(9) reads:

*"light means of transport" means wheeled vehicles that have an electric motor of less than 750 watts, on which travellers are seated when the vehicle is moving and that can be powered by the electric motor alone or by a combination of motor and human power.*

Typical two-seat scooters with a maximum speed of 45 km/h generally require more than 750 watts, so they are not included in 'light means of transport'. Small scooters, hoverboards, Segways and the like are not included either, as the travellers are not seated. Essentially, e-bikes are the only light means of transport that remain.

## 1.2. Why is it important to collected waste batteries from light means of transport?

The joint report of the WEEE Forum and EURIC (2020)[1] evaluates the relevance of fires in WEEE treatment chain caused by waste batteries. A survey of more than 100 companies from 20 European countries showed an increasing number of fires in the WEEE treatment chain. More than a third of the recyclers surveyed reported very serious fire incidents in connection with defective lithium batteries. These fires usually lasted for several hours and could only be extinguished by the

[1] Ollion, L.,Anta, M., Herreras, L., Characterisation of fires caused by batteries in WEEE (2020),Survey results from the WEEE management chain–part A, a WEEE Forum and EuRIC report

intervention of the fire department. The study puts the average damage caused by the severe fires at €1.3 million.

Nigl & Pomberger (2020)[2] estimated for the period 2012 - 2017 an average damage cost through fire incidents in recycling and mechanical treatment plants (not WEEE exclusively but other waste management as well) accounted for about 6 M € per year for the region Steiermark, one of the nine regions in Austria. Extrapolating the cost for EU27 would sum up to a total amount of 2.15 billion € per year through fire incidents in recycling and mechanical treatment plants.

As reported in Eunomia (2021)[3] Lithium-ion (Li-ion) batteries are responsible for around 48% of all waste fires occurring in the UK each year, costing some £158 million (€183 million[4]) annually to waste operators, fire services and the environment. Extrapolating the cost for EU27 would sum up to a total amount of 1.23 billion per year.

As the model calculations show (see **Annex 1**), waste batteries from e-bikes will increase by a factor of 4 to 5 from 2015 to 2025. In 2030, the mass of spent batteries from e-bikes will be more than 10 times higher than in 2015. If no ambitious collection targets are set, the fire risk increases accordingly.

The arguments for moving to a circular economy remain anyway, but if one neglects the fire risks, one could conclude that the Li-ion waste batteries from light transport (or e-bikes) are negligible compared to the much larger quantities of traction batteries from electric vehicles.

# 2. Basic Information to form a model for waste generation from e-bikes

## 2.1. Sales and growth rates for e-bikes in Germany and the EU

For Germany, the ZVI published the number of sales for bikes and e-bikes for the period 2013 to 2019, as displayed in Table 2-1 below. For the assessment of potential market saturation effects, the total number of bikes in use is relevant, as displayed in Table 2-2. The outlook for the EU market can be seen in Table 2-3**,** displaying the sales of e-bikes in Germany and in the EU.

[2] Nigl & Pomberger (2020) Fire risk from lithium-ion batteries: can our systems still be insured? Berlin Recycling and secondary raw materials Conference

[3] Eunomia, Environmental Services Association (ESA) (2021): Cutting Lithium-ion Battery Fires in the Waste Industry

[4] Exchange rate by 13. April 2021 : 1.16

**Table 2-1: Sales of bikes and e-bikes in Germany for 2012 to 2020**

| | Standard Bike | | E-Bike | | Total Bikes | |
|---|---|---|---|---|---|---|
| | sales amount | growth rate | sales amount | growth rate | sales amount | growth rate |
| **2012** | | | 380 000 | | | |
| **2013** | 3 390 000 | | 410 000 | 7.9 % | 3 800 000 | |
| **2014** | 3 620 000 | 6.8 % | 480 000 | 17.1 % | 4 100 000 | 8 % |
| **2015** | 3 820 000 | 5.5 % | 540 000 | 12.5 % | 4 360 000 | 6 % |
| **2016** | 3 450 000 | -9.7 % | 610 000 | 13.0 % | 4 060 000 | -7 % |
| **2017** | 3 130 000 | -9.3 % | 720 000 | 18.0 % | 3 850 000 | -5 % |
| **2018** | 3 200 000 | 2.2 % | 980 000 | 36.1 % | 4 180 000 | 9 % |
| **2019** | 2 950 000 | -7.8 % | 1 360 000 | 38.8 % | 4 310 000 | 3 % |
| **2020** | 3 100 000 | 5.1 % | 1 950 000 | 47.1 % | 5 000 000 | 16 % |

Source: Zweirad-Industrie-Verband[5]; Source for 2012: Statista

**Table 2-2: Bikes and e-bikes in use in Germany, 2016 - 2020, in million units**

| | Standard Bike | E-Bike | Total Bikes |
|---|---|---|---|
| **2016** | 70.0 | 3.0 | 73.0 |
| **2017** | 70.0 | 3.5 | 73.5 |
| **2018** | 71.0 | 4.5 | 75.5 |
| **2019** | 70.0 | 5.4 | 75.4 |
| **2020** | 72.0 | 7.1 | 79.1 |

Source: Zweirad-Industrie-Verband[6]

[5] https://www.ziv-zweirad.de/marktdaten/

[6] Zweirad-Industrie-Verband (ZVI): Wirtschaftspressekonferenz am 10.3.2021 in Berlin, Zahlen, Daten, Fakten zum Fahrrad Markt in Deutschland

**Table 2-3: Sales of e-bikes in Germany and the EU, 2016 - 2020, in million units**

| | Sales of e-bikes in Germany | Sales of e-bikes in the EU | Share of sales in Germany of total EU sales |
|---|---|---|---|
| **2012** | 0.38 | 0.854 | 44.5 % |
| **2013** | 0.41 | 0.907 | 45.2 % |
| **2014** | 0.48 | 1.139 | 42.1 % |
| **2015** | 0.54 | 1.357 | 39.8 % |
| **2016** | 0.61 | 1.74 | 35.1 % |
| **2017** | 0.72 | 2.20 | 32.7 % |
| **2018** | 0.98 | 2.92 | 33.6 % |
| **2019** | 1.36 | 3.60 | 37.8 % |
| **2020** | 1.95 | 5.10 | 38.2 % |

Source: Zweirad-Industrie-Verband[6] and Confederation of the European Bicycle Industry (CONEBI)

## 2.2. Lifetime of the e-bike battery

Different estimations have been published predicting the lifetime of an e-bike battery, ranging from 2 to 5 years[7], with BMZ – one of the large suppliers – mentioning a lifetime of 4 to 6 years[8]. Others argue that, the batteries have 500 to 1000 full load cycles, which is equivalent to 10 to 20 years use phase if one full load is applied once per week.

# 3. Parameters for the Model calculations

## 3.1. Quantities put on the market

For the model, it is necessary to have both data for the sales in the past and in the future. Figure 3-1 shows two scenarios for how the development of sales in Germany might develop. For the years before 2012, a growth rate of 8% is assumed for both scenarios.

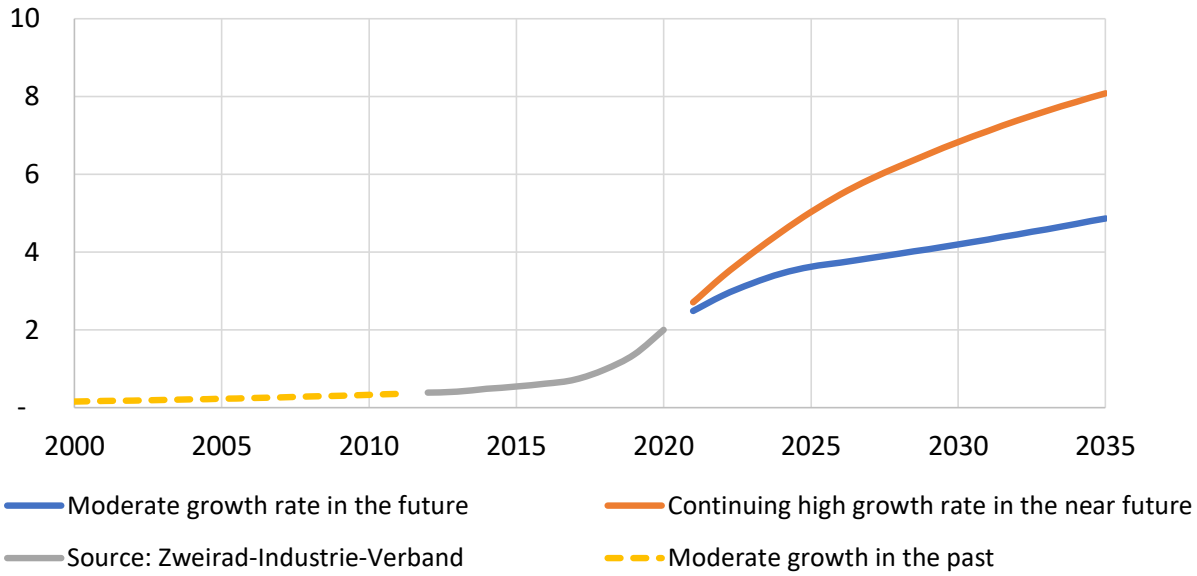
The scenario ‘continuing high growth rate in the near future’ assumes annual sales of 5 million e-bikes in year 2025, which is equivalent to the total sales of all bikes (standard plus e-bikes) in 2020. Until 2035, e-bike sales will continuously increase to a level of 8 million annual sales, four times higher compared to year 2020.

The scenario with more moderate growth rates foresees an increase in sales until 2025 of up to 3.6 million e-bikes annually and by 2035 up to 4.9 million.

7 Home page of fahrrad.de: https://www.fahrrad.de/ueber-e-bikes-akku.html last accessed: 2021-03-18.

8 BMZ (02/2020): E-BIKE RATGEBER Batterieleitfaden https://www.bmz-group.com/images/PDF-Downloads/Batterieleitfaden_DE_Doppelseiten.pdf

**Figure 3-1: Yearly sales of e-bikes in Germany in million units**

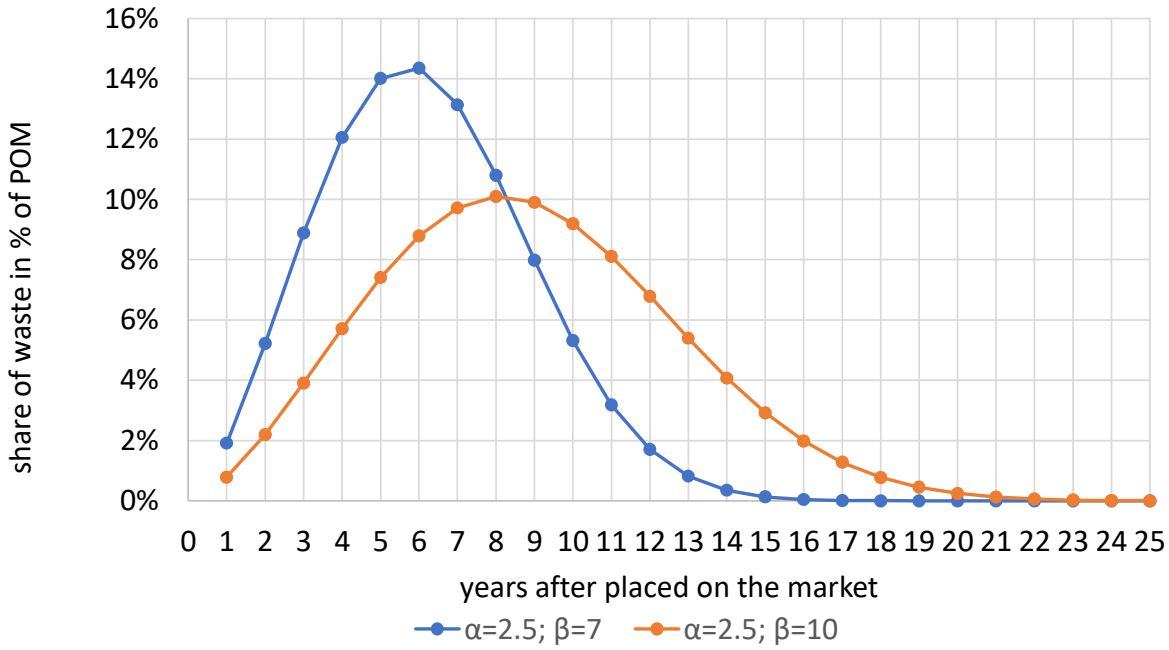



The growth rates considered for the two scenarios are displayed in **Annex 2**.

## 3.2. Waste generation

To address by when the waste from e-bike batteries will occur after being placed on the market (POM), a Weibull distribution with an alpha of 2.5 and beta between 7 and 10 (the last considered as conservative assumptions) is displayed in Figure 3-2 below. The functions for the blue scenario assume that around 2 % of the batteries placed on the market will become waste after their first year in use. The maximum of waste will be generated in the sixth year after POM, with 14 % of the batteries that had been placed on the market six years before becoming waste. For the worst-case scenario (orange colour), the share of waste during the first year is 1 % only and the maximum of waste would be expected to be generated in the eighth year, with 10 % of the batteries placed on the market eight years previously becoming waste. For the model, no major 'hoarding period' is taken into consideration as a deposit refund scheme is assumed to be in force. Deposit refund schemes are considered the most appropriate option to support a high collection rate and avoid that waste is dumped in wrong disposal pathways and thus reducing fire risks at home and at (non-battery) waste treatment facilities.

**Figure 3-2: Share of waste in percent of POM after a lifespan in years**




The life span of the e-bike and motor is expected to last longer than the battery. For the model, we take into consideration that each battery sold together with the new e-bike will be replaced by a new battery when the first battery becomes waste. This aspect is considered in the model for both the batteries placed on the market and the batteries available for collection.

The model calculates the waste batteries available for collection in the same year when the new batteries are placed on the market. As a simple add-on it is also possible to calculate the percentage of waste batteries available from e-bikes according to the calculation for the collection of portable waste batteries in Annex XI of the EC's proposal for the Batteries Regulation (collection compared to the mass placed on the market in the same year and the two previous years).

## 4. Results of the model calculations

Applying the mentioned conditions, it is possible to calculate the waste batteries available for collection in a given year, as displayed in Table 4-1. The table also indicates the total increase in sales for year 2035 compared to the sales in 2020. A factor 2.4 means that the sales for 2035 are expected to increase from 2 million in 2020 to 4.8 million in 2035.

More detailed figures display the results of the Calculation in **Annex 1**.

**Table 4-1: Waste batteries from e-bike available for collection**

| | | | | |
|---|---|---|---|---|
| Weibull α | 2.5 | 2.5 | 2.5 | 2.5 |
| Weibull β | 7 | 10 | 7 | 10 |
| scenario growth rate | moderate | moderate | high | high |
| Factor of increase in e-bike sales from 2020 to 2035 | 2.4 | 2.4 | 4.0 | 4.0 |
| Waste batteries from e-bikes available for collection compared to the average mass placed on the market in the same year and the two previous years (according to Annex XI of EC's proposal) | | | | |
| 2025 | 53 % | 37 % | 47 % | 31 % |
| 2030 | 73 % | 55 % | 65 % | 46 % |
| 2035 | 85 % | 68 % | 79 % | 61% |

Source: own calculations

## 5. Conclusion

Li-ion batteries sent to the wrong disposal route pose a high risk of large fires and air pollution, as demonstrated in several cases and known to be a threat to all recycling facilities (not just battery recycling facilities).

Therefore, it is necessary to ensure that almost all waste batteries from e-bikes (or generally light means of transport) are collected. In contrast to these known conditions, the EU has proposed in the Battery Regulation to envisage a collection target only after 30 December 2030.

The model calculations demonstrate that, even under difficult conditions, it would be possible to achieve collection targets for e-bike batteries of more than 30 % in 2025 and more than 45 % in 2030 when applying the given calculation rule in Annex XI of the EC's proposal.

The model calculations are presented for the German situation. However, Table 3 also shows figures for the EU that suggest similar developments in the EU. Since the Confederation of the European Bicycle Industry (CONEBI) has aggregated data for the EU, it can be assumed that data for most EU countries should also be available.

### 5.1. Different options for setting a more ambitious collection target:

a) Establishing by 2025 a collection target of (at least) 90 % of waste batteries generated from light means of transport, as proposed by the joint NGO position paper[9]. The problem is the missing methodology on how to measure the volume of waste batteries generated in a specific country and year.

[9] Enhancing the sustainability of Batteries: A joint position Paper on the EU Battery Regulation Proposal, prepared by ECOS, EEB, DUH, T&E (17.03.2021 – first round position paper)

b) Implementing a collection target for waste batteries from light means of transport based on the method established in Annex XI, with the following levels: 30 % by 2025, 45 % by 2030, and 60 % by 2035.
c) A combination of options a and b:
A collection target based on the method established in Annex XI with the following level: 30 % by 2025. From 2030, when more experience has been gained on the life span, the functioning of deposit refund schemes, and data for longer time series on volumes placed on the market is available, the collection target should be 90 % of waste batteries generated from light means of transport. The Commission shall, by 31.12.2026, adopt an implementing act establishing a common methodology for the calculation of the quantity of waste batteries generated from light means of transport in each Member State.

Reporting on and monitoring the collection rate should start immediately at the latest by 2023, since data are required in advance of setting the first target to apply for the year 2025. Considering the uncertainties for the forecast, the target shall be reviewed every third year at the latest, beginning in 2023, to assess if the targets are achievable or not challenging enough.

A deposit refund scheme is the best option to support high collection rates and avoid waste dumping in wrong disposal pathways and would make the options for ambitious collection targets achievable.

## 5.2. Conditions for a deposit refund system

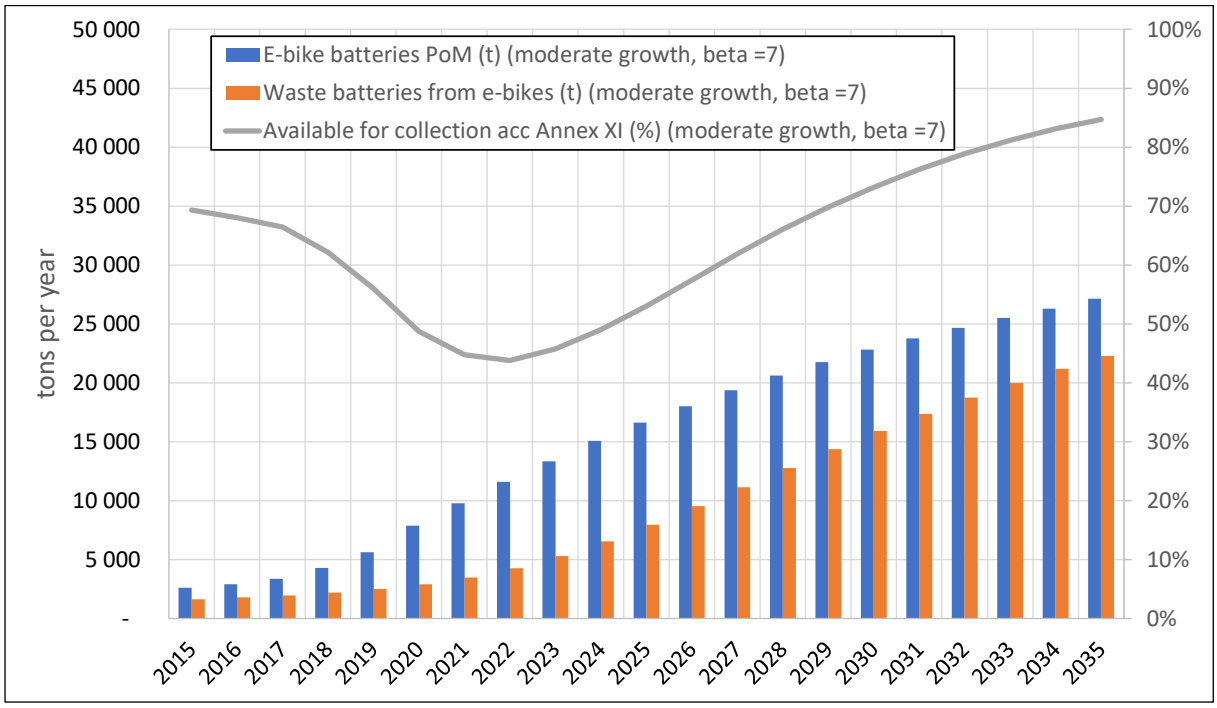
Regardless of whether a mandatory deposit is introduced at the EU level or countries introduce deposit systems due to ambitious EU collection targets, the following conditions for deposit systems still need to be clarified:

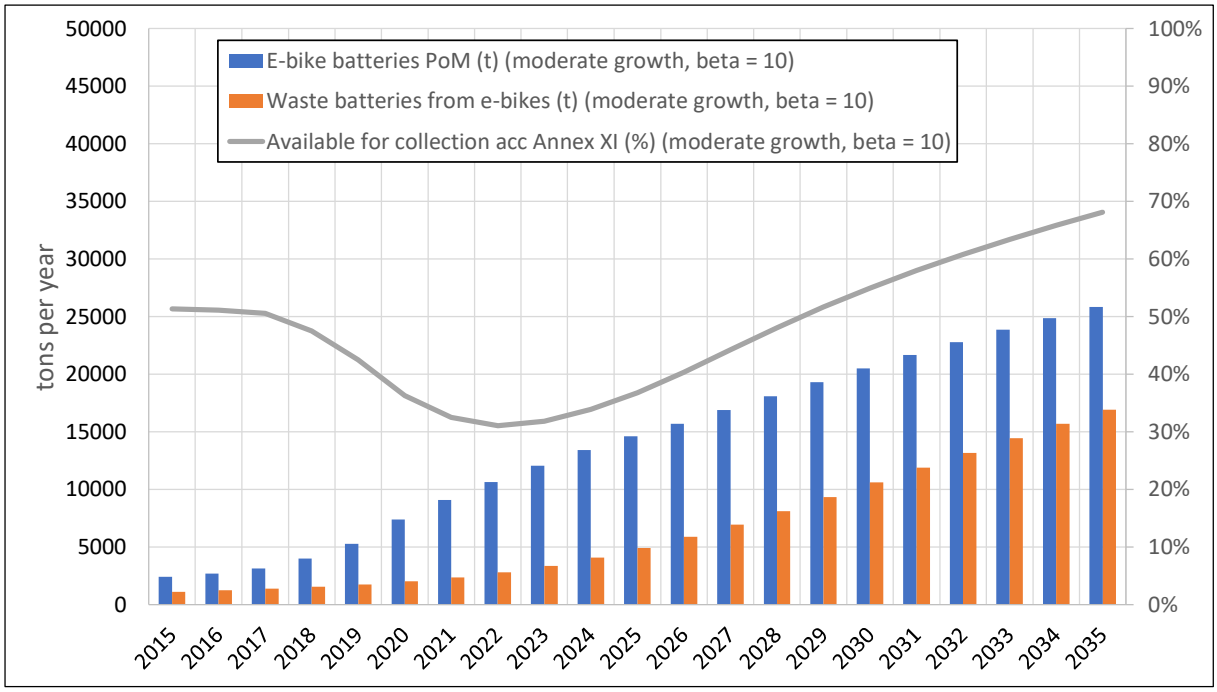
- How high should the deposit amount be? (20- 30 € per battery?)
- What will be the collection point / pay-out point?
- How to avoid battery tourism between countries with different deposit amounts? (Deposit will only be paid for "customary quantities" (e.g. maximum 2 used batteries), new replacement battery only against used battery, deposit payment upon presentation of original invoice/warranty, or other).
- How to avoid fake batteries (only case with weight, without battery cells) for the purpose of deposit return? (Batteries for deposit return must be checked, identification system with code system, reasonable (not too high) deposit amount, or other).

To define these conditions for a deposit system, the participation of the manufacturers and the distributors of e-bikes is inevitable.

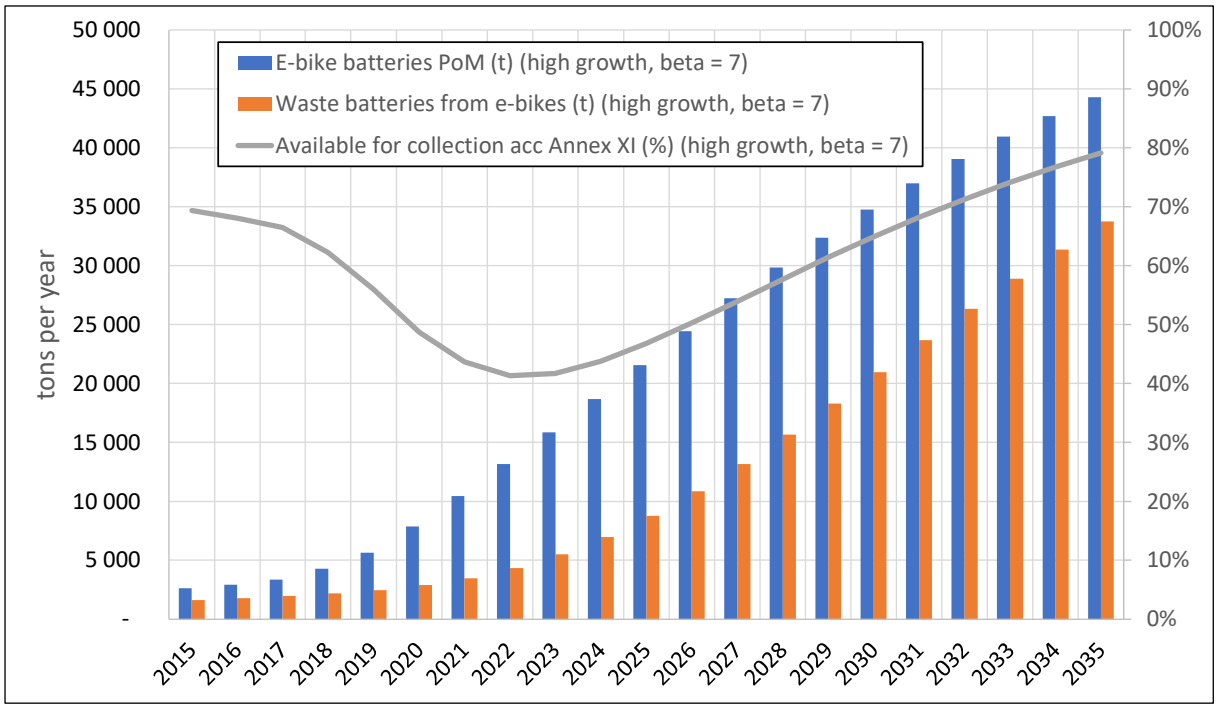
## Annex 1: Detailed Results of the model calculation

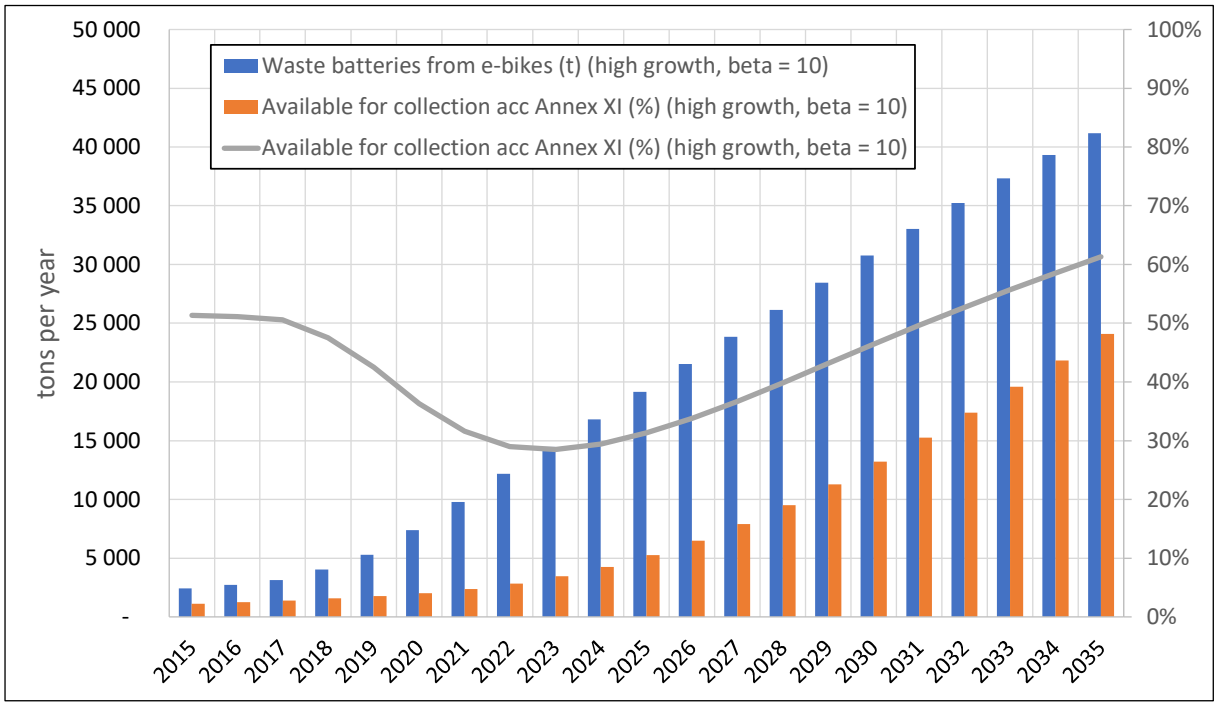
The figures below display for different scenarios for the German e-bike market the e-bike battery sales, waste batteries from e-bikes and the collection rate from available waste batteries, calculated according to Annex XI of EC's proposal.




Note: the total volume with beta = 10 is less as the original battery are used for a longer period and less replace-batteries are placed on the market




Note: the total volume with beta = 10 is less as the original battery are used for a longer period and less replace-batteries are placed on the market

## Annex 2: Growth rates considered for different scenarios

| | moderate growth rates in the future | high growth rates in the near future | |
|---|---|---|---|
| 2000 | 8.0% | 8.0% | |
| 2001 | 8.0% | 8.0% | |
| 2002 | 8.0% | 8.0% | |
| 2003 | 8.0% | 8.0% | |
| 2004 | 8.0% | 8.0% | |
| 2005 | 8.0% | 8.0% | |
| 2006 | 8.0% | 8.0% | |
| 2007 | 8.0% | 8.0% | |
| 2008 | 8.0% | 8.0% | |
| 2009 | 8.0% | 8.0% | |
| 2010 | 8.0% | 8.0% | |
| 2011 | 8.0% | 8.0% | |
| 2012 | 8.0% | 8.0% | |
| 2013 | 7.9% | 7.9% | Source: Zweirad-Industrie-Verband |
| 2014 | 17.1% | 17.1% | Source: Zweirad-Industrie-Verband |
| 2015 | 12.5% | 12.5% | Source: Zweirad-Industrie-Verband |
| 2016 | 13.0% | 13.0% | Source: Zweirad-Industrie-Verband |
| 2017 | 18.0% | 18.0% | Source: Zweirad-Industrie-Verband |
| 2018 | 36.1% | 36.1% | Source: Zweirad-Industrie-Verband |
| 2019 | 38.8% | 38.8% | Source: Zweirad-Industrie-Verband |
| 2020 | 47.1% | 47.1% | Source: Zweirad-Industrie-Verband |
| 2021 | 24.0% | 35.0% | |
| 2022 | 16.0% | 25.0% | |
| 2023 | 11.0% | 17.5% | |
| 2024 | 8.0% | 14.0% | |
| 2025 | 5.0% | 11.2% | |
| 2026 | 3.0% | 9.0% | |
| 2027 | 3.0% | 7.2% | |
| 2028 | 3.0% | 5.7% | |
| 2029 | 3.0% | 5.2% | |
| 2030 | 3.0% | 4.6% | |
| 2031 | 3.0% | 4.2% | |
| 2032 | 3.0% | 3.8% | |
| 2033 | 3.0% | 3.4% | |
| 2034 | 3.0% | 3.0% | |
| 2035 | 3.0% | 2.7% | |