Survey Questionnaire

Please note the following information:

The Fraunhofer Institute for Manufacturing Engineering and Automation (IPA), Nobelstrasse 12, 70569 Stuttgart, Germany, is responsible for processing the data according to Article 4 Paragraph 7 DSGVO.

The survey exclusively serves the purpose stated in the invitation text or the invitation e-mail. The evaluation and publication of individual statements is anonymous.

In order to prove good scientific practice, the following personal data of the survey participants will be listed as sources upon publication: Title, first name, surname and company.

By participating in this survey you agree to the publication of this data in the following scientific publication: Frontiers in Energy Research - Electrochemical Energy Conversion and Storage.

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If you have any queries regarding data protection or if you have any questions about the content of this website, please contact;

Contact person for questions regarding content: Dr. Duygu Kaus

duygu.kaus@ipa.fraunhofer.de

Contact person for data protection at IPA: Christine Maier

datenschutz@ipa.fraunhofer.de

Data Protection Officer of the Fraunhofer-Gesellschaft: Ralph Harter

datenschutz@zv.fraunhofer.de

Lifetime of EV Battery Systems

According to recent studies [1, 2], the lifetime of an average EV battery system is approximately 8 years.

- **Expert Opinion 1:** Assuming a technologically progressive scenario, how long do you estimate the lifetime of an EV battery system in 2030?

    - **Answer:** ____ Years

- **Expert Opinion 2:** How high do you estimate the monetary price of a battery system after 4 or 8 years of use as compared to the price of a new battery? (Specified in percent, reference: NMC 532 battery system)

NMC 532 Batteries	Price (in Percentage)
Year 0	100 %
Year 4	____ %
Year 8	____ %

- **Expert Opinion 3:** In your opinion, by how many years will the average service life of a battery system (currently approximately 8 years) be extended by further use in the so-called "Second Life" (e.g. use as stationary energy storage)?

    - **Answer:** 8 + ____ Years

- **Expert Opinion 4:** Depending on the State of Health (SoH) of battery systems, there are different circular economy strategies for the transition to "Second Life" after the end of their usage in first phase.
Please set a minimum SoH limit, which you believe can be applied sensibly for the respective circular economy strategies listed below.

Circular Economy Strategy	SoH Limit Value
First use in EV	100%
Reuse/Repurpose	≤ ____ %
Remanufacturing	≤ ____ %
Recycling	≤ ____ %

[1] Bobba et al., Resources, Conservation and Recycling, 145, pp. 279–291, 2019
[2] Ahmadi et al., Int. J Life Cycle Assess., 22/1, pp. 111–124, 2017

- **Expert Opinion 5:** Please mark the extent to which you agree with the following statements regarding the development of battery systems until 2030.

Development until 2030:	**Do not agree**	**Undecided**	**Agree**
The diversity of battery systems would decrease	◯	◯	◯
The disassembly capability of battery systems would improve	◯	◯	◯
The recyclability of battery systems would improve	◯	◯	◯
The acquisition costs of battery systems would decrease	◯	◯	◯
The non-uniform wear of battery cells would decrease	◯	◯	◯
The State-of-Health assessment of battery systems would improve	◯	◯	◯
The traceability of battery systems would improve	◯	◯	◯
Raw material prices for battery material would rise	◯	◯	◯
The energy density of battery systems would increase	◯	◯	◯
The weight of battery systems would decrease	◯	◯	◯
The temperature tolerance of battery systems would increase	◯	◯	◯
The stability of battery systems would increase	◯	◯	◯
The capacity of battery systems would increase	◯	◯	◯

- **Expert Opinion 6:** Please rank the effect of the following factors on the implementation of respective circular economy strategies for EV batteries, from highest (1) to lowest (6) influence.

Influencing Factors	Rank (1-6)		
	Reuse/Repurpose	Remanufacturing	Recycling
Change of cell design			
Change in cell chemistry			
Falling price differences (used vs. new component)			
Rising raw material prices			
Improved State-of-Health evaluation			
Improved disassembling capability			

- **Expert Opinion 7:** How high do you estimate the return rate of battery systems at the end of their service life at present and in 2030?

  - **Answer - Present:** ____ %
  - **Answer - 2030:** ____ %

Factors that influence the life of EV Battery Systems

- **Expert Opinion 8:** Please rank the effect of the following factors on the lifetime of EV Battery Systems, from highest (1) to lowest (4) influence.

Influencing Factors	Rank (1-4)
SOC Range	
Temperature	
C-Rate	
Cycle Number	

- **Expert Opinion 9:** Please mark low, medium or high for how you estimate the development potential of each influencing factors mentioned below, until 2030.

Influencing Factors	Low	Medium	High
Wider SoC range	○	○	○
Increase of the temperature resistance	○	○	○
Increase of C-Rate	○	○	○
Increase of the maximum cycle number	○	○	○

Future Cell Chemistry Scenarios

- **Expert Opinion 10:** The current market shares of available NMC chemistries are listed below. Widespread use of solid state batteries or similar innovative concepts is usually not considered realistic until around 2030 [3]. NCA technologies used so far will be less prevalent in the future according to current knowledge [4, 5]. Accordingly, market penetration of NMC cathodes is expected by 2030. Please indicate the market shares of the individual NMC cathodes in 2030 under the assumption of a progressive scenario, which should reflect the trend of steadily increasing nickel shares.

NMC- Chemistry	Market Share	
	2019* (current)	2030 (progressive)
NMC 111	45%	____ %
NMC 532	35%	____ %
NMC 622	20%	____ %
NMC 811	5%	____ %
Total	100%	100%

[3] Dominko et al.,"Inventing the Batteries of the Future," Nov. 2019
[4] Simon et al., Resources, Conservation and Recycling, 104, pp. 300–310, 2015
[5] C. Pillot, "The Rechargeable Battery Market and Main Trends 2011-2020," International Battery Seminar and Exhibit, 2017.

Factors influencing the increase in Ni content in NMC

- **Expert Opinion 11:** Please rank the following factors in order of their effect on change in the cathode composition of NMC batteries from highest (1) to lowest (6) influence.

Influencing Factors	Rank (1-6)
Rising raw material prices	
Increase of energy density	
Reduction of battery weight	
Increase of temperature tolerance	
Improvement of stability (security)	
Increase of capacity	

- **Expert Opinion 12:** What are the additional challenges in the circular economy strategies of battery systems?

- **Expert Opinion 13:** What in your opinion are the necessary measures in order to meet these challenges?

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Alternative: Save the completed form and send it to: duygu.kaus@ipa.fraunhofer.de

Expert No:	Expert	Affiliation
1	Jens Tübke	Fraunhofer Institute for Chemical Technology ICT (Germany)
2	Helmut Ehrenberg	Karlsruhe Institute of Technology (Germany)
3	Maximilian Kaus	German Aerospace Center – DLR (Germany)
4	Birger Horstmann	
5	Thomas Mertens	BMW Group (Germany)
6	Benedikt Stumper	Institute for Machine Tools and Industrial Management- Technical University of Munich (Germany)
7	Sarah Hartmann	Fraunhofer Institute for Silicate Research ISC (Germany)
8	Frank Treffer	Umicore N.V. (Germany)
9	Kurt Vandeputte	
10	Jan Tytgat	
11	David Greenwood	The University of Warwick (UK)
12	Linda Gaines	Argonne National Laboratory (USA)
13	Jose Manuel Miguez Novoa	Ferro Globe (Spain)
14	Lisbeth Dahllöf	IVL Swedish Environmental Research Institute (Sweden)
15	Holger Kuhlmann	REDUX Recycling GmbH (Germany)
16	Harry Zhang	TÜV Süd AG (Germany)
17	Eric Spek	
18	Małgorzata Leszczyk	Eneris Group (Poland)
19	Daniel Bahro	Energie Baden-Württemberg EnBW (Germany)
20	Xue Wang	BOTREE Cycling Sci.&Tech. Co. LTD (China)

21	Johannes Öhl	Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS (Germany)
22	Duygu Kaus	Fraunhofer Institute for Manufacturing Engineering and Automation IPA (Germany)
23	Jan Koller	Fraunhofer Institute for Manufacturing Engineering and Automation IPA (Germany)
24	Steffen Kiemel	Fraunhofer Institute for Manufacturing Engineering and Automation IPA (Germany)
25	Soumya Singh	Fraunhofer Institute for Manufacturing Engineering and Automation IPA (Germany)