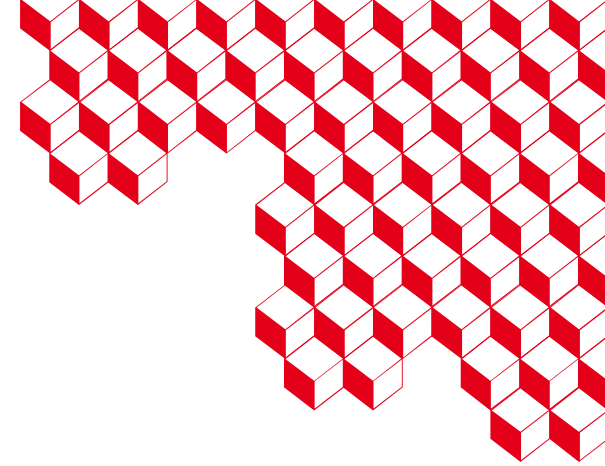
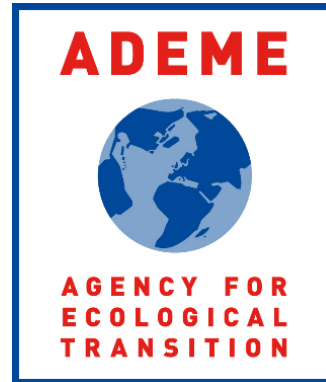




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# **Ecodesign approach based on prospective life-cycle assessment, to support R&D decision-making for new generations of batteries**

**Betsabé Elizabeth Rodríguez Buitrón**

Emmanuelle Cor, Elise Monnier, Fabien Perdu, Yvan Reynier, Sébastien Martinet

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# 1 ■ Context

# LCA & Ecodesign at the design phase

PRODUCT DEVELOPMENT PROCESS



IDEA



DESIGN



TEST



PROTOTYPE



NEW TECHNOLOGY  
LAUNCH

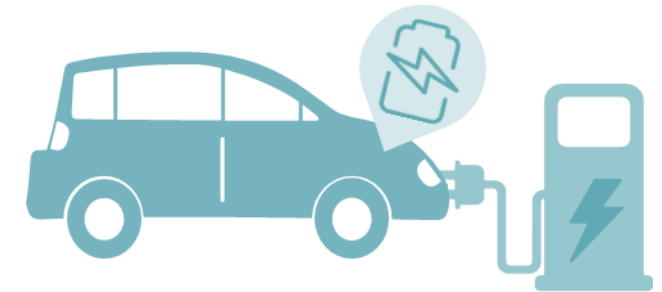
About 80% of the environmental footprint of new technologies is determined at the design phase [1]

- ✚ The integration of environmental requirements and the definition of ecodesign objectives at the R&D level is a **major challenge**.
- ✚ At this phase, LCA is mainly applied at a **low level of technology maturity**.
- ✚ Actors involved in technological research face **difficulties** relating to :
  - Choose from a wide variety of available tools/methods.
  - Available data lacking over the entire life cycle of the systems analyzed.
  - Results transposing of an LCA carried out on a pilot scale to the industrial scale.
  - Understanding the variation in terms of results during interpretation.
  - Etc.



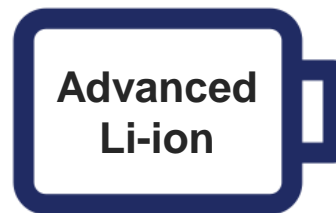
# Environmental performance criteria integration into technological development of new generations of batteries

The battery industry is evolving rapidly with the emergence of new high density energy technologies

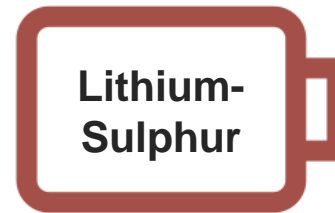


It's necessary to analyze the **technological feasibility according to a lifecycle approach**, to identify the environmental challenges of innovative technologies when they are at a low level of maturity.

## 3 study cases with different maturity levels:



Nickel-rich cathode and for the anode, graphite is to be replaced by silicon



Sulphur cathode and lithium anode



Solid electrolyte (ceramics, glass, polymers, or hybrids)



# 2. Research questions



## 2 Research questions :



1. How to guide researchers involved in the technological development of new generations of batteries in the assessment of the environmental impacts of their technologies?
2. How to support low TRL battery design teams in their R&D activities in order to limit the environmental impacts over the whole life cycle of batteries under development?

## 3 Hypothesis:



1. Parametric prospective LCA approach
2. Tools for technical teams: Ecodesign toolbox
3. Adapted to a battery R&D context: needs & resources of the battery research teams



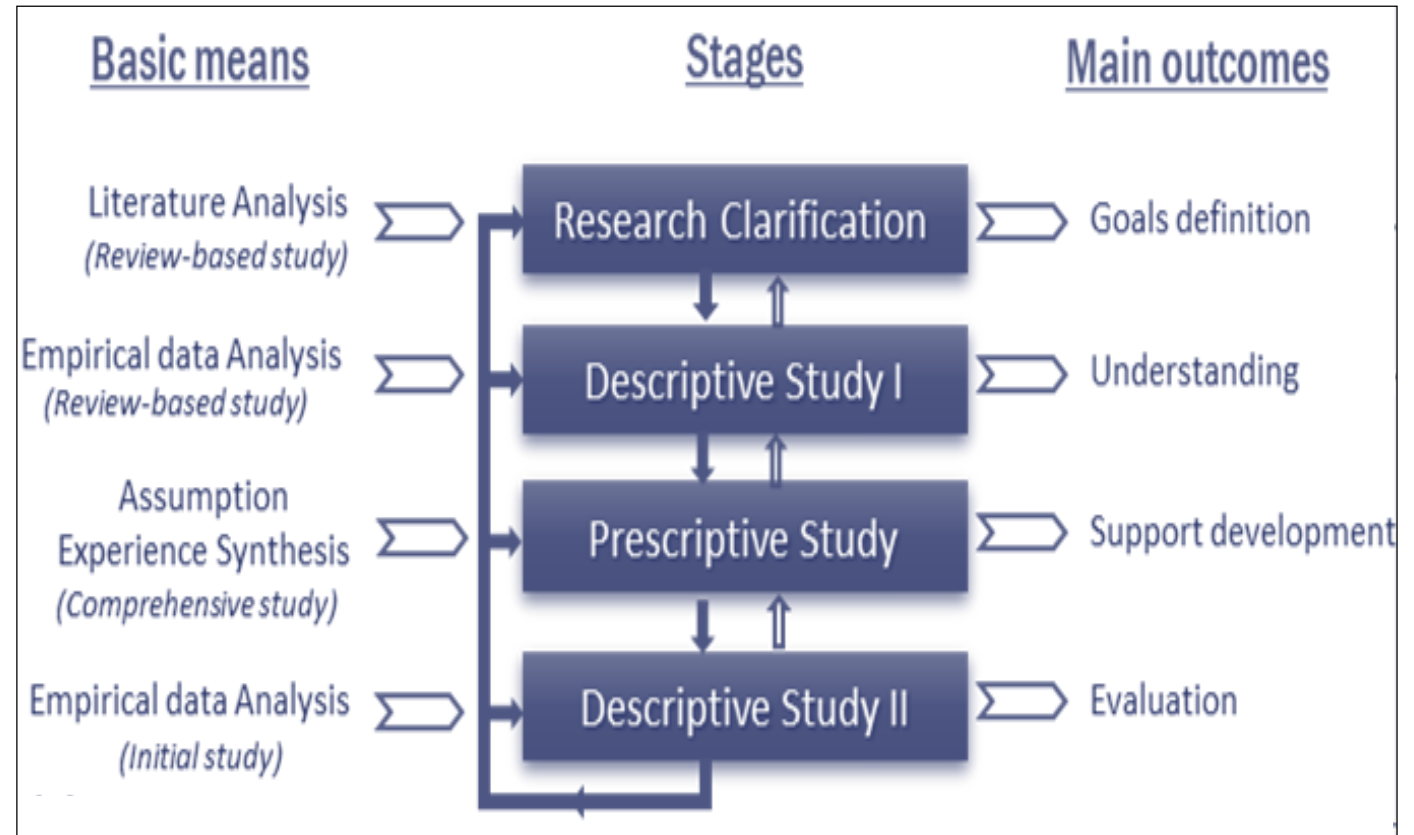
# 3 ■ Research approach

# Design Research Methodology (DRM)

- ✦ Framework adapted from Blessing and Chakrabarti [2].
- ✦ It addresses the complexity of ecodesign research in terms of the need for multidisciplinary knowledge.

## Research based on :

- the vision of the existing situation
- the vision of the desired situation
- the vision of the support that can transform, and maintain this



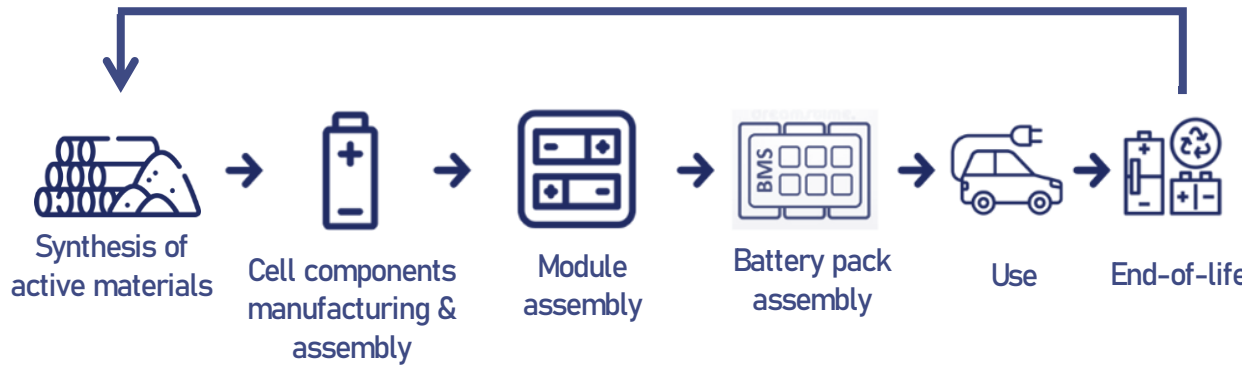
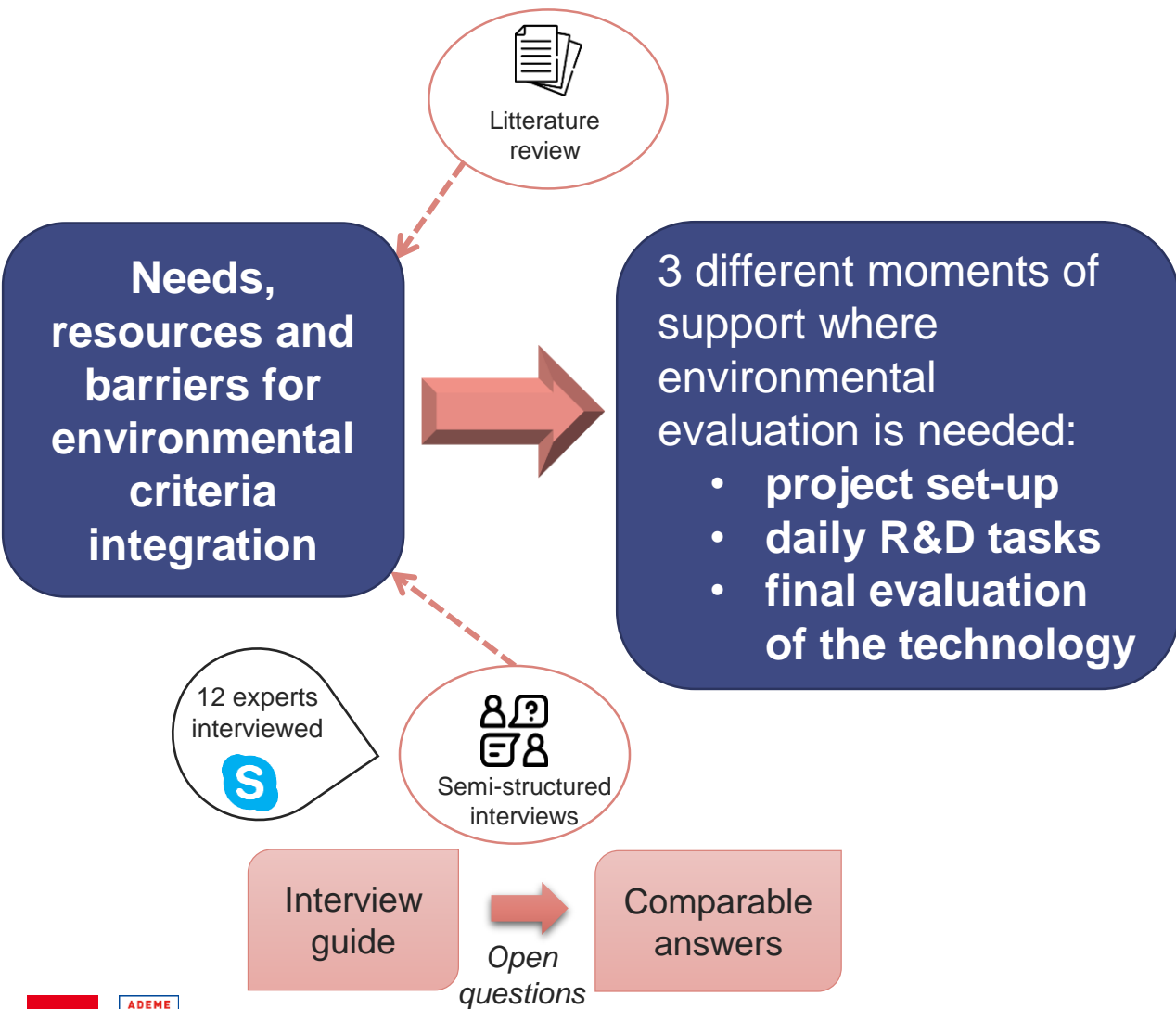
Design Research Methodology (DRM) framework adapted from [2].





# 4. Ecodesign ■ approach proposal

# R&D context definition & an overview of the current integration of environmental criteria

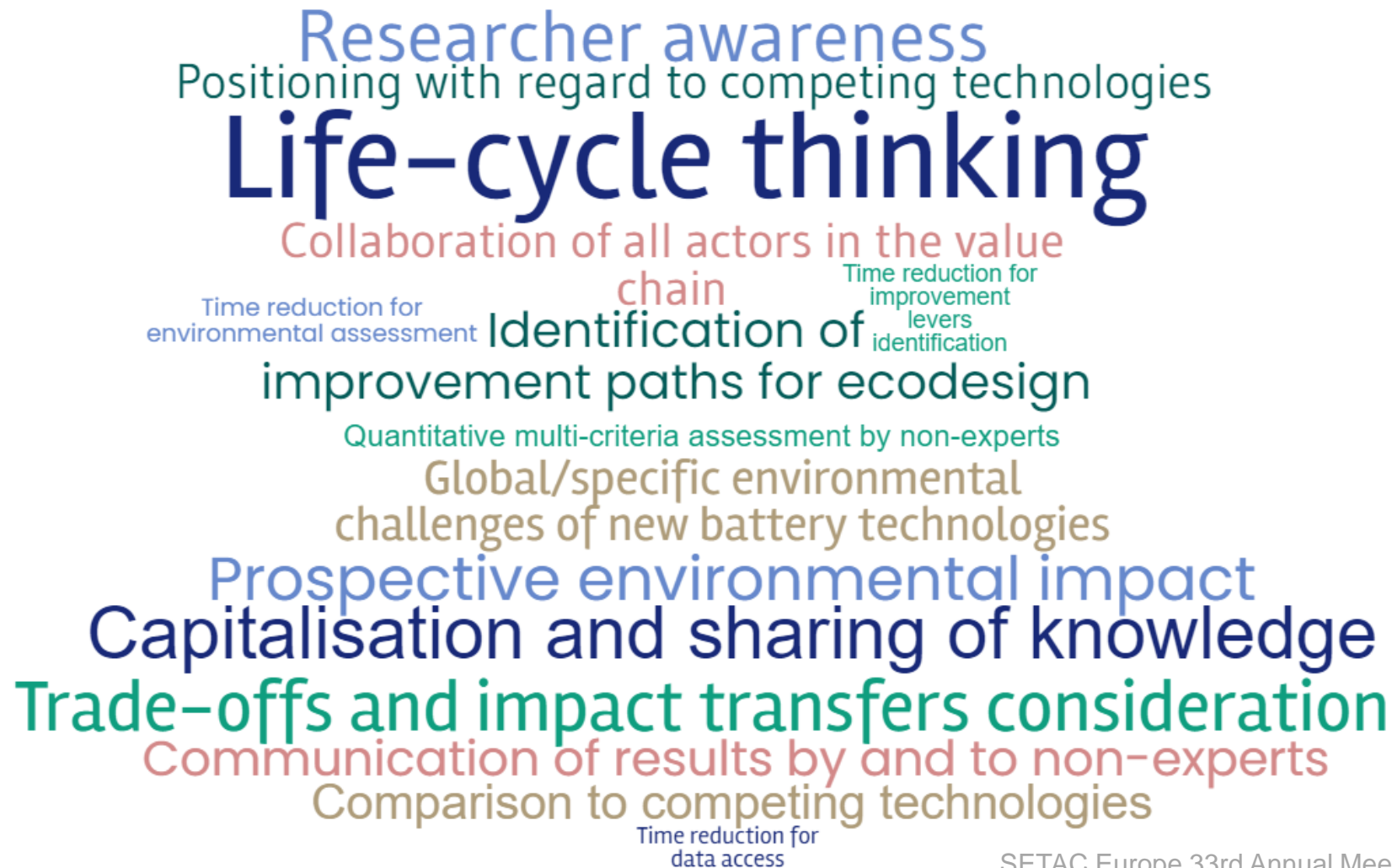


**Profile of experts interviewed :**

	Expertise	Environmental perspective
EXP 1	Electronic management (BMS)	-
EXP 2	Synthesis of active materials	Awareness
EXP 3	Synthesis of active materials	-
EXP 4	Manufacturing/Assembly of cells	-
EXP 5	Recycling	-
EXP 6	Synthesis of active materials & Use	Training
EXP 7	Assembly of modules/pack	Awareness
EXP 8	Synthesis of active materials	-
EXP 9	Synthesis of active materials	-
EXP 10	Electronic management (BMS)	-
EXP 11	Synthesis of active materials	-
EXP 12	Synthesis of active materials	Awareness

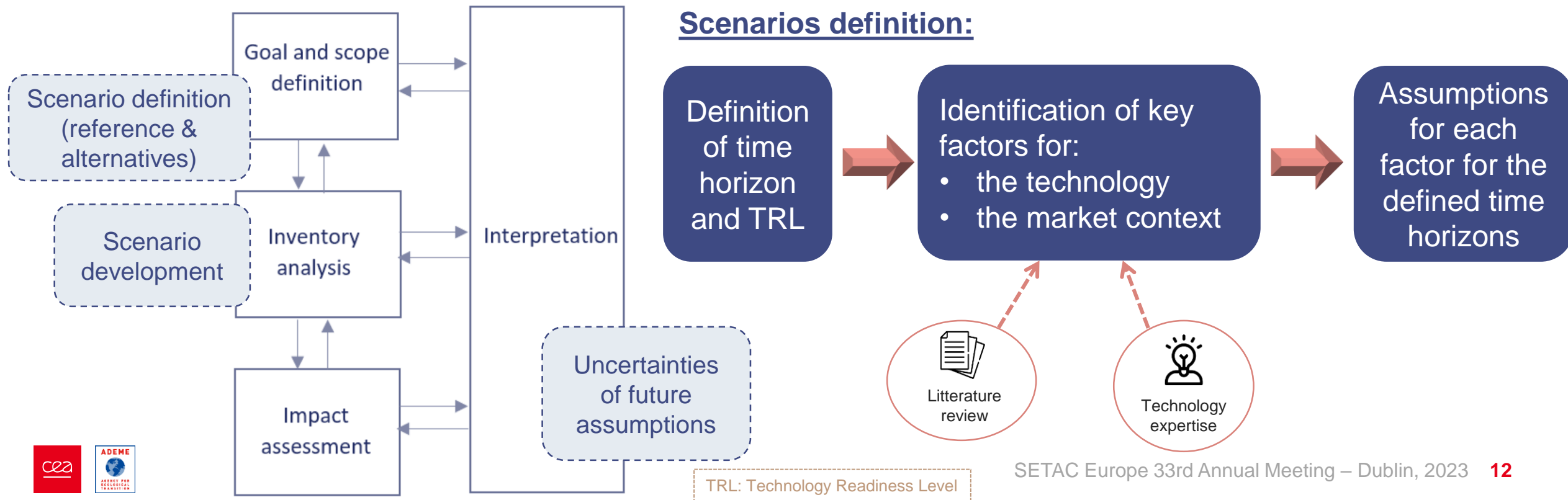
# Specifications of the ecodesign approach

- Specific requirements to be addressed for an integration of ecodesign in the technological research of new generations of batteries :



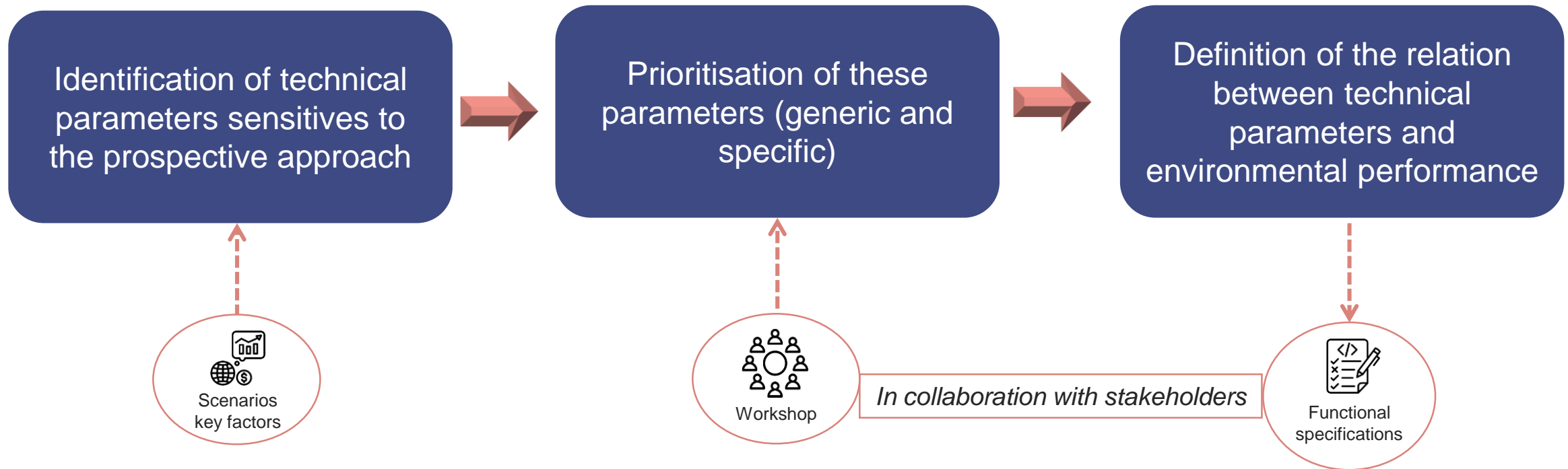
# Prospective life cycle assessment of battery systems

- ✦ “*Studies of emerging technologies in early development stages, when there are still opportunities to use environmental guidance for major alterations*” – Arvidsson et al., 2018
- ✦ Focus on potential environmental impacts arising from **technologies even still at the R&D stage by defining future scenarios.**
- ✦ Some authors review and provide recommendations but at present **no generic framework is defined.**



# Parametric prospective life cycle assessment of battery systems

- ⚡ Screening and comparing alternatives when detailed data is not available.
- ⚡ Based on a **set of predefined technical parameters** used to model the battery system :



**Approach deployed through a parameterised tool allowing its implementation in the design decision-making process**

# Parametric prospective life cycle assessment of battery systems : A simplified tool

- ✦ The proposed tool uses **available data** (*literature and expert view*) to **systematically, iteratively and transparently** (*background database available and evolving*) evaluate the environmental performance
- ✦ Some of the **features that support the design decision-making** include :

Technology modelling at different levels of detail

3 levels (basic, intermediate and advanced)

Specific assessment for material criticality

Critical material content in the battery :  
Li, Co, Ni and Si

Specific assessment for ecodesign indicators

Recyclability index & Disassembly index

Comparison of different lab-scale technologies

Cell parametrisation (electrochemical core scale)

Comparison with commercial technologies

Calculation of environmental impact results for different functional unit

Unit of electricity stored and supplied by the system, kg of battery, battery, etc.

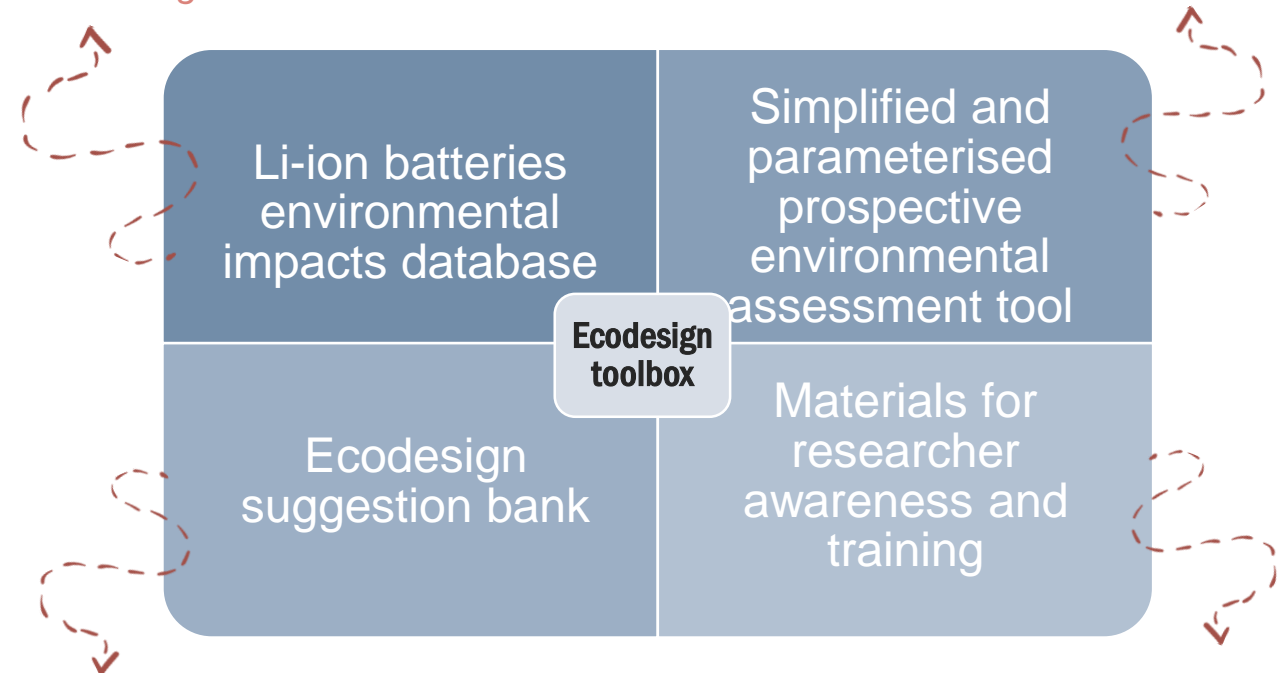


# Accompanying the technical teams with a ecodesign toolbox

- ⚡ **Operational materials** that support the application of the ecodesign method and the capitalisation of knowledge.
- ⚡ Support for decision-making during **each ecodesign step**.
- ⚡ **Adaptable** to specific requirements of the 3 moments of support.
- ⚡ Composed by:
  - **Original tools.**
  - **Existing tools within the technical teams.**
  - **Adaptation of existing tools in the literature**, for a R&D context and for a battery application.

*Technical and environmental performance data for the 3 new battery technologies and commercial reference technologies*

*Computer tool for parametric prospective environmental assessment of battery systems*



*Collection of ecodesign tools (Design rules-according to "DfX" approaches, guides for creativity sessions, etc.)*

*Series of slideshows explaining the LCA methodology and the main environmental issues and challenges arising from the battery sector*



# 5. Conclusions & Perspectives



# Experimental validation

⚡ During the last phase of the DRM, it should be validated that this approach makes possible:

The identification and assessment of the environmental impacts of low TRL battery technologies

The identification and proposal of improvements in the environmental performance of new technologies

The satisfaction of the researchers' needs

⚡ How ?

- **A workshop**
- **3 hypothetical application cases**
- **14 indicators** will be measured and observed

For example:

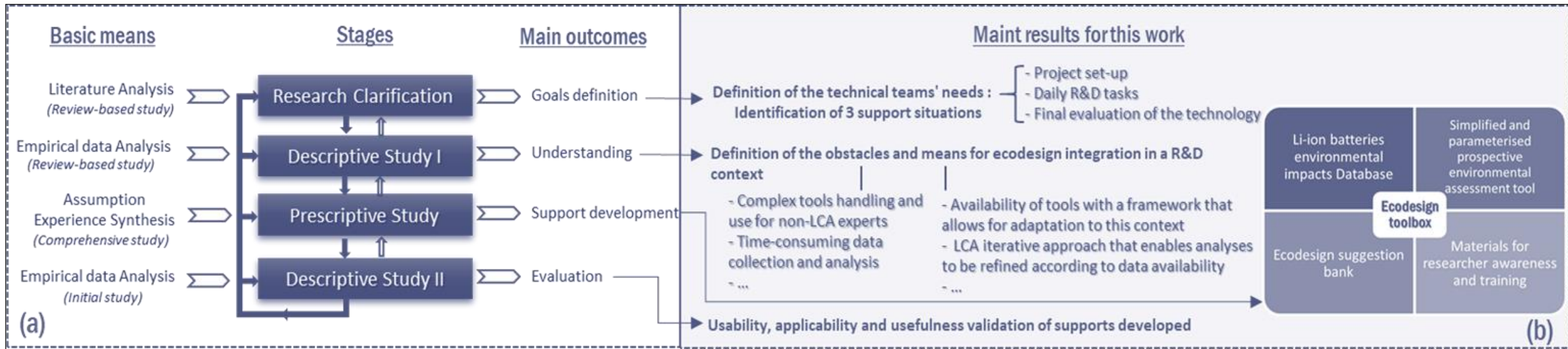
- 🎯 *Relevance of the improvements identified and proposed by the researchers according to technical and environmental criteria*
- 🕒 *Average time needed to carry out a multi-criteria environmental performance assessment by non-experts*
- 🕒 *Average time to identify environmental areas for improvement by non-experts*



Source: Pexels

# Summary

The application of the DRM has allowed :



(a): Design Research Methodology (DRM) framework adapted from [2]. (b): Main results of this work related to the application of the DRM approach.

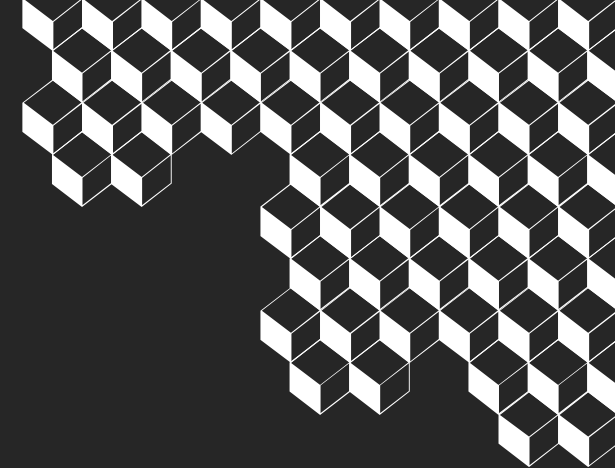
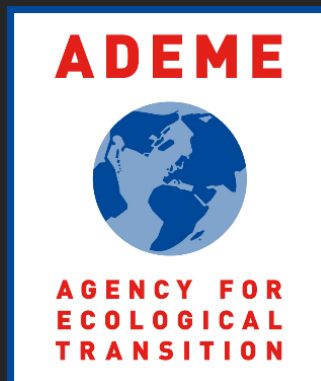
This ecodesign approach aims to support researchers through design decision-making by helping them to understand and assess the environmental impacts, and to identify the levers for improving the environmental performance of new generations of batteries.

In the long term, the objective is to guide researchers in their decision-making all along the design process:

- **externally**, with the definition of ecodesign objectives for future technological choices in industry
- **internally**, with the proposal of new research themes in their work teams



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# Thank you for your attention !

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- *Emmanuelle Cor : [emmanuelle.cor@cea.fr](mailto:emmanuelle.cor@cea.fr)*
- *Elise Monnier : [elise.monnier@cea.fr](mailto:elise.monnier@cea.fr)*
- *Fabien Perdu : [fabien.perdu@cea.fr](mailto:fabien.perdu@cea.fr)*
- *Yvan Reynier : [yvan.reynier@cea.fr](mailto:yvan.reynier@cea.fr)*
- *Sébastien Martinet : [sebastien.martinet@cea.fr](mailto:sebastien.martinet@cea.fr)*

**Any questions?**

***[betsabe.rodriquezbuitron@cea.fr](mailto:betsabe.rodriquezbuitron@cea.fr)***