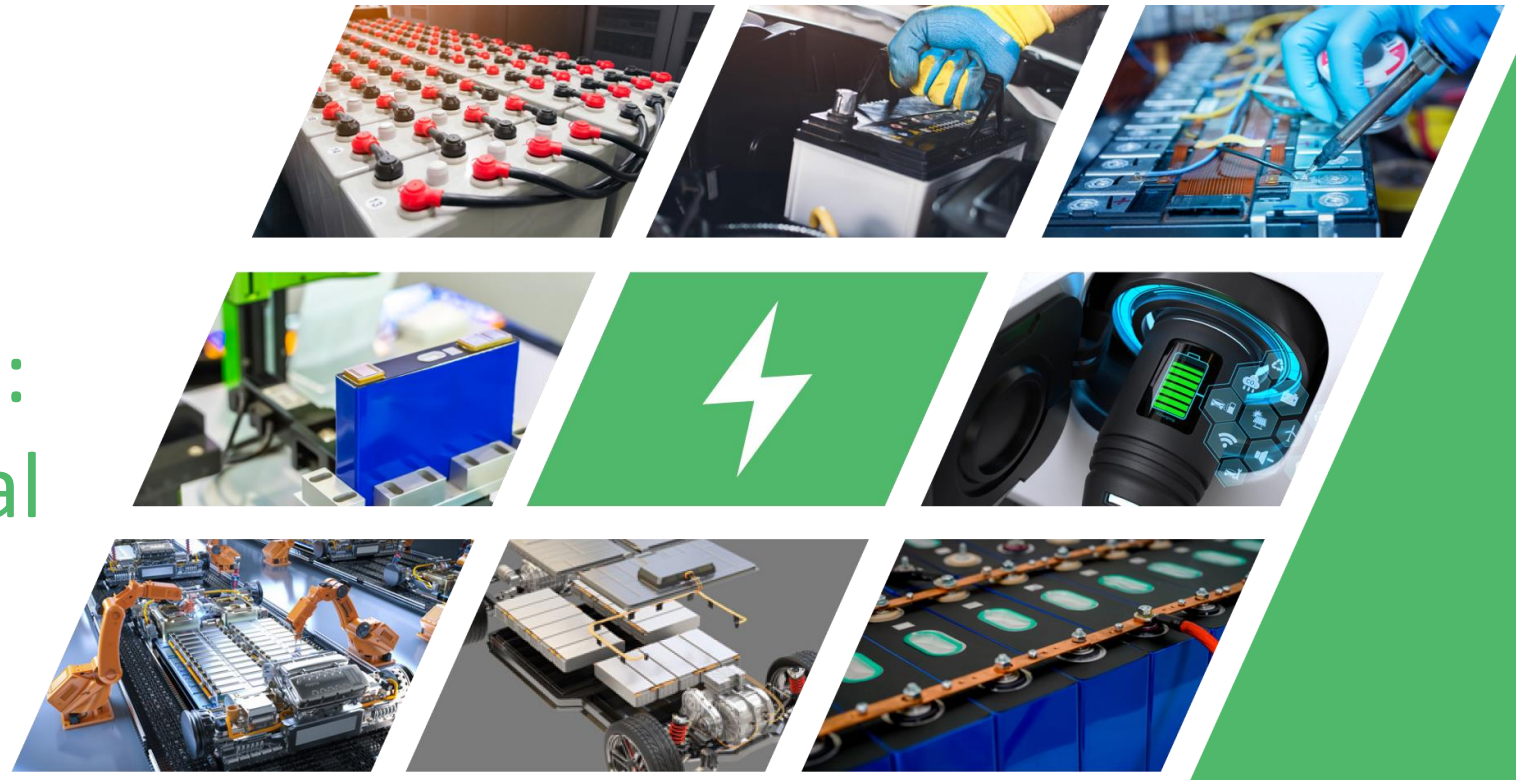
BA⚡E

Battery Passport for
Transparency and Circularity

Towards a Circular Economy in Batteries: The Role of the Digital Battery Passport



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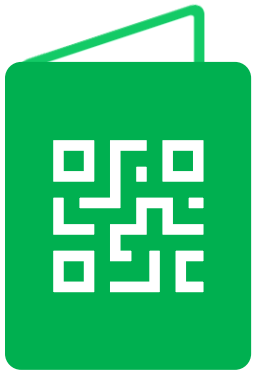
Towards a Circular Economy in Batteries: The Role of the Digital Battery Passport



- Motivation
- BASE project
- What is a battery?
- How is it made?
- Modelling concept

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Motivation

Regulation 2023/1542 concerning batteries and waste batteries:

“From Feb 2027, all batteries … must have a Battery Passport in EU”

- → transform the Union into a fair and prosperous society,
  - with a modern, **resource-efficient and competitive economy**
  - where there are **no net greenhouse gas emissions** in 2050 and

- → ensure that products marketed and sold in the Union are **sourced and manufactured in a sustainable manner.**

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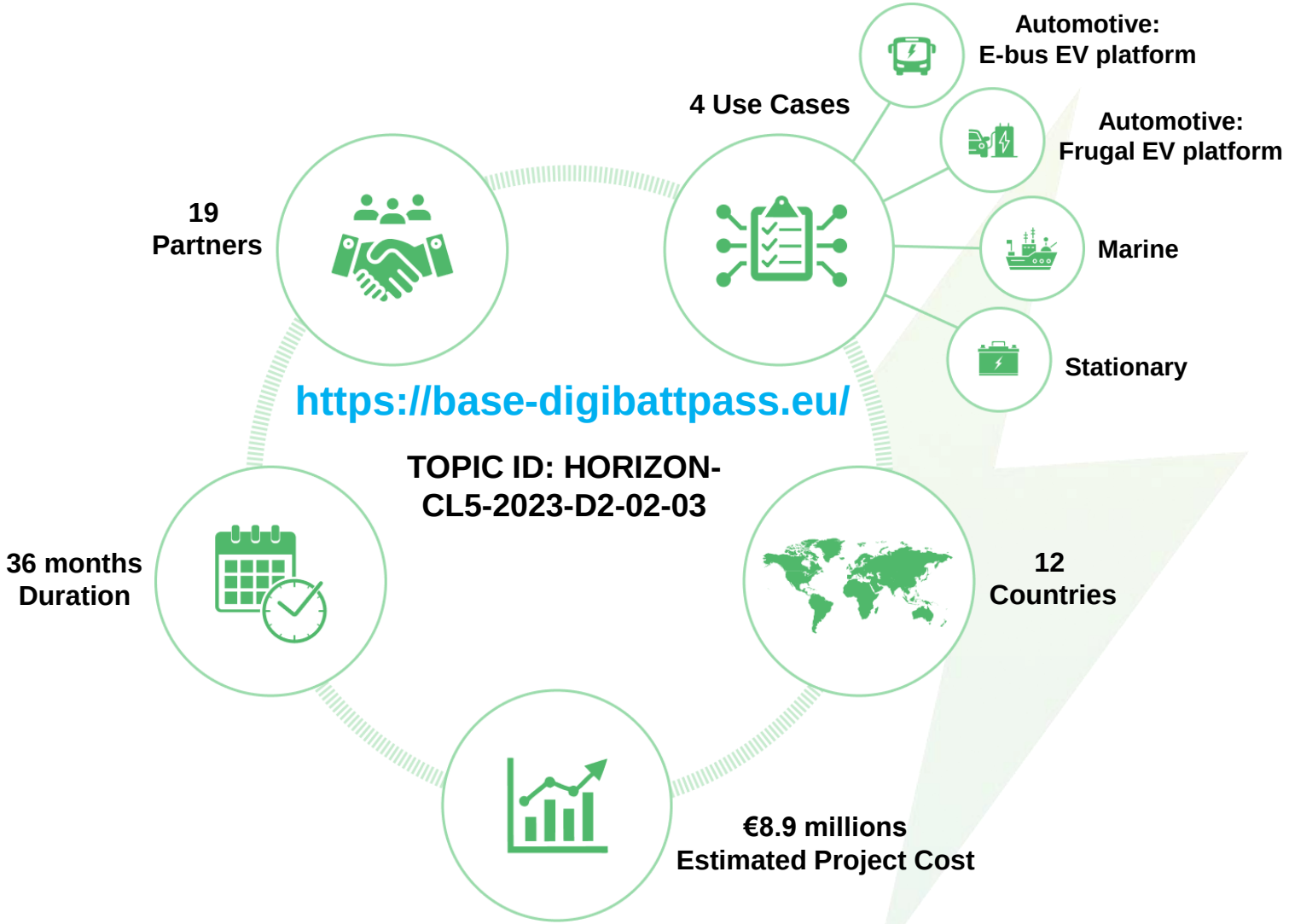
Project information



Consortium Partners

Fraunhofer
TECHNOVATIVE SOLUTIONS
cleantron cleantech batteries
Seraph.
ARTECH International BVBA
FORD OTOSAN
Corvus Energy
Mercedes-Benz
adscensus
NAVTEK NAVAL TECHNOLOGIES INC.
EXITCOM recycling for future
ELECTRIFYINGFUTURE BeePlanet factory
SQM Solutions for human progress
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european eLi Lithium Institute
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Use Cases and Demonstration

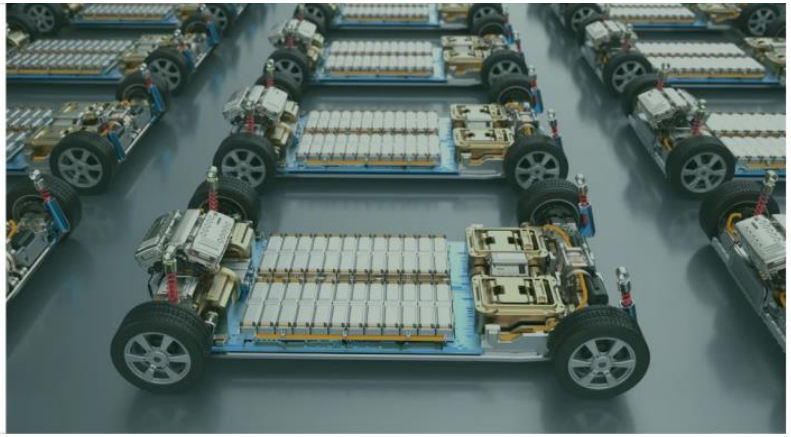
General Objectives for each Pilot

- Secure and reliable access to federated DBP infrastructure
- Systematic immutable data inputs to DBP
- Transparency, accuracy, and reliability of battery indicators
- DBP data provisions with a realistic product development lifecycle
- Interoperable data sharing among value network members
- Real physical data for circularity index tuning, ESGE analysis and business impact analysis

Use-Case-1

Automotive: E-bus EV platform production pilot for MERCEDES-BENZ

Use-Case-2



Automotive: frugal EV platform production pilot for FORD Motors

Use-Case-3

Marine: electric tugboat production pilot

Use-Case-4

Stationary: 2nd-life electric energy storage production pilot

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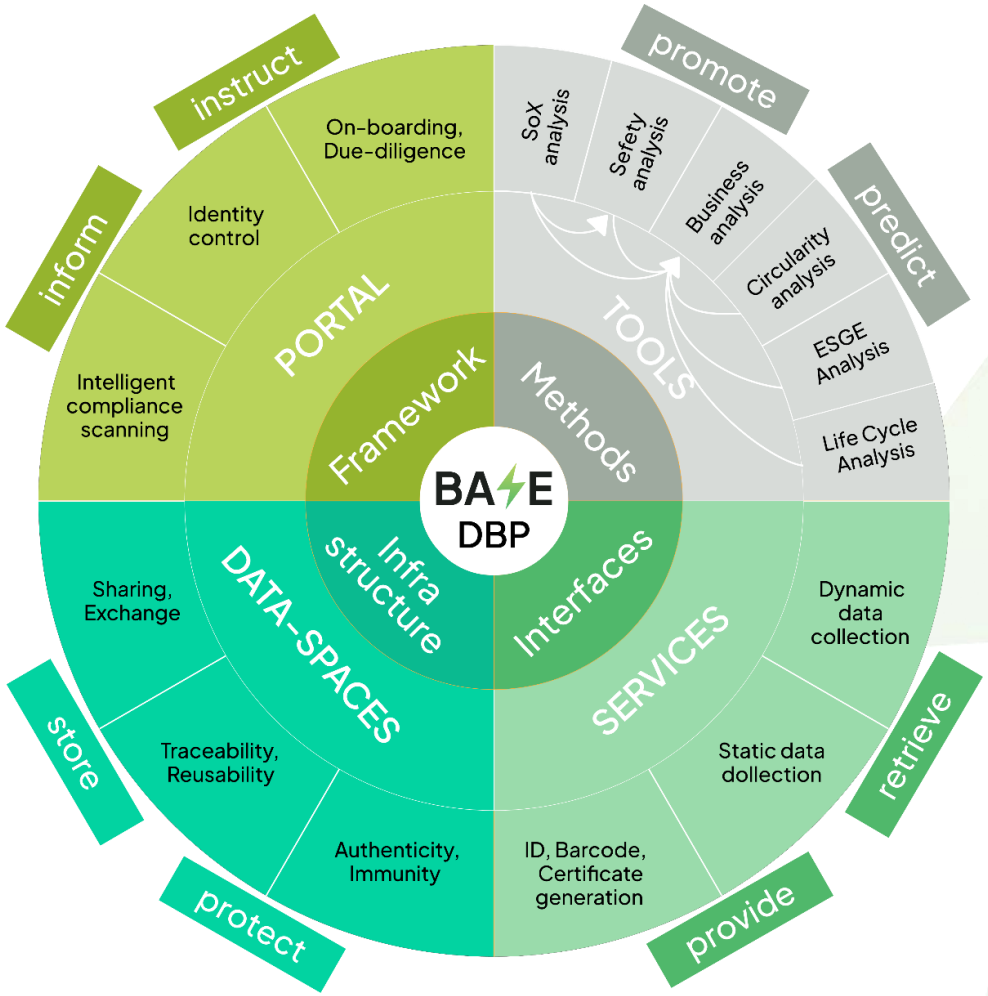
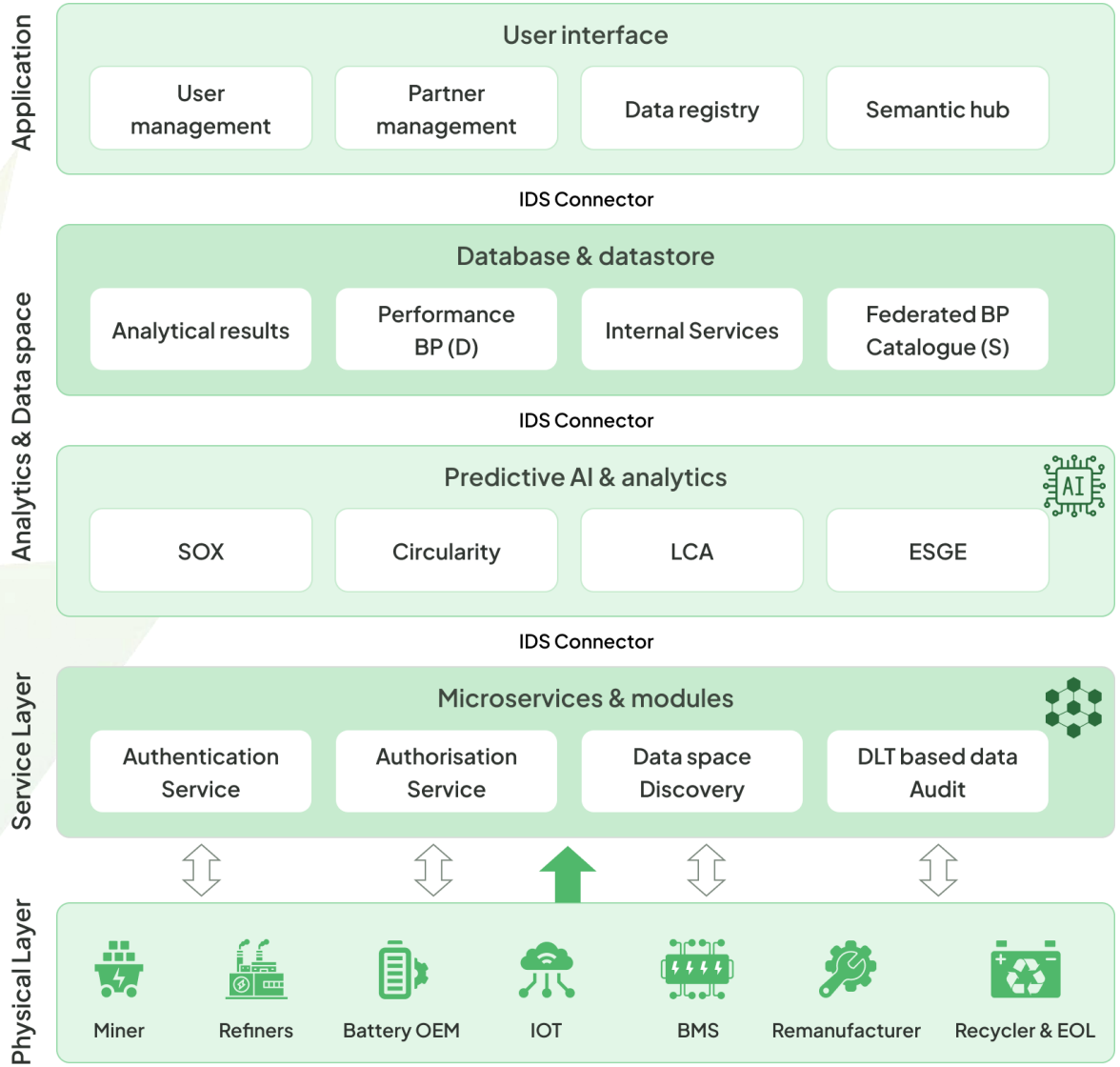
Concept & Architecture



https://base-digibattpass.eu/



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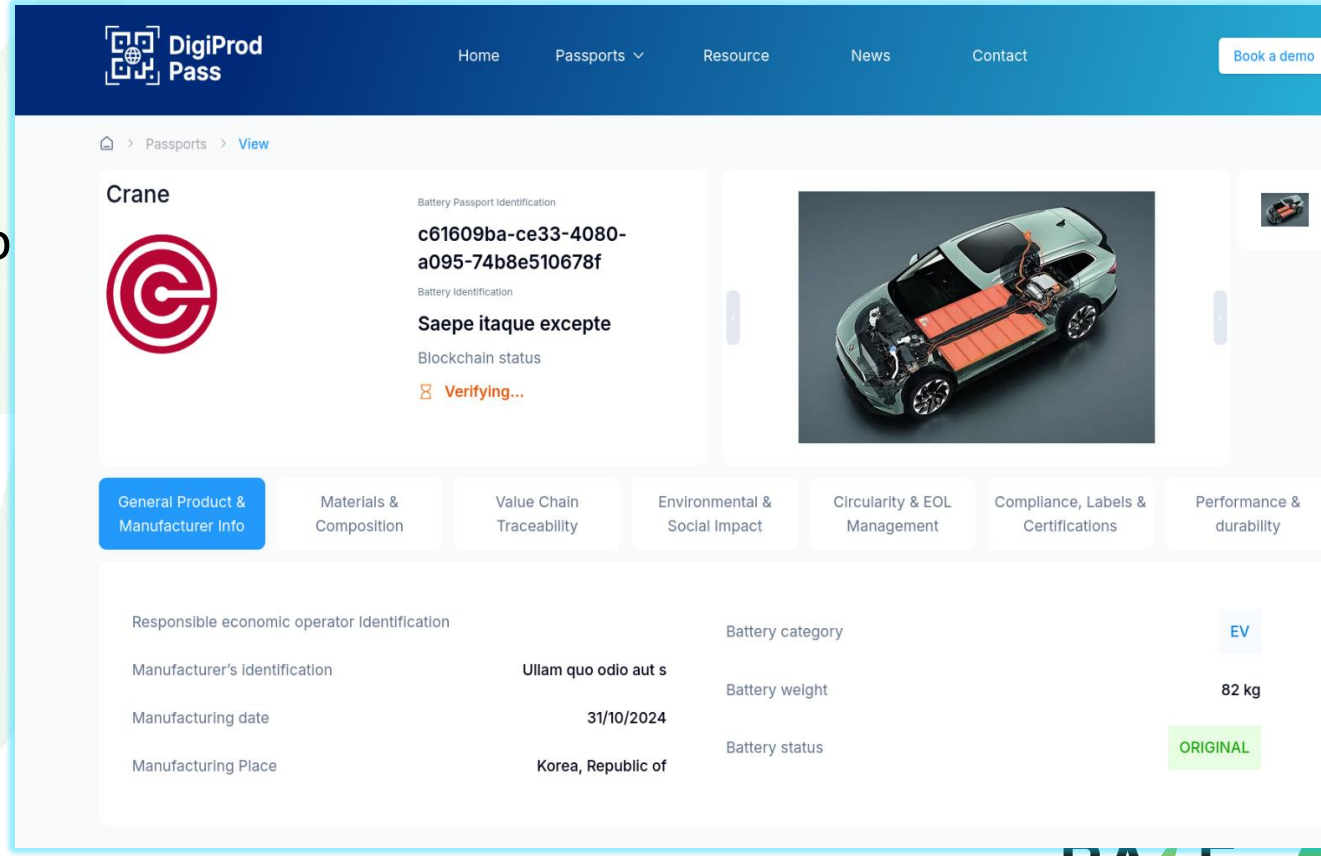
Digital Battery Passport

Batteries for LMT, EV and industria storage >= 2 kWh

- QR code links to DBP service
- Information about
  - General Product & Manufacturer Info
  - Materials & Composition
  - Value Chain Traceability
  - Environmental & Social Impact
  - Circularity & EOL Management
  - Compliance, Labels & Certifications
  - Performance & durability



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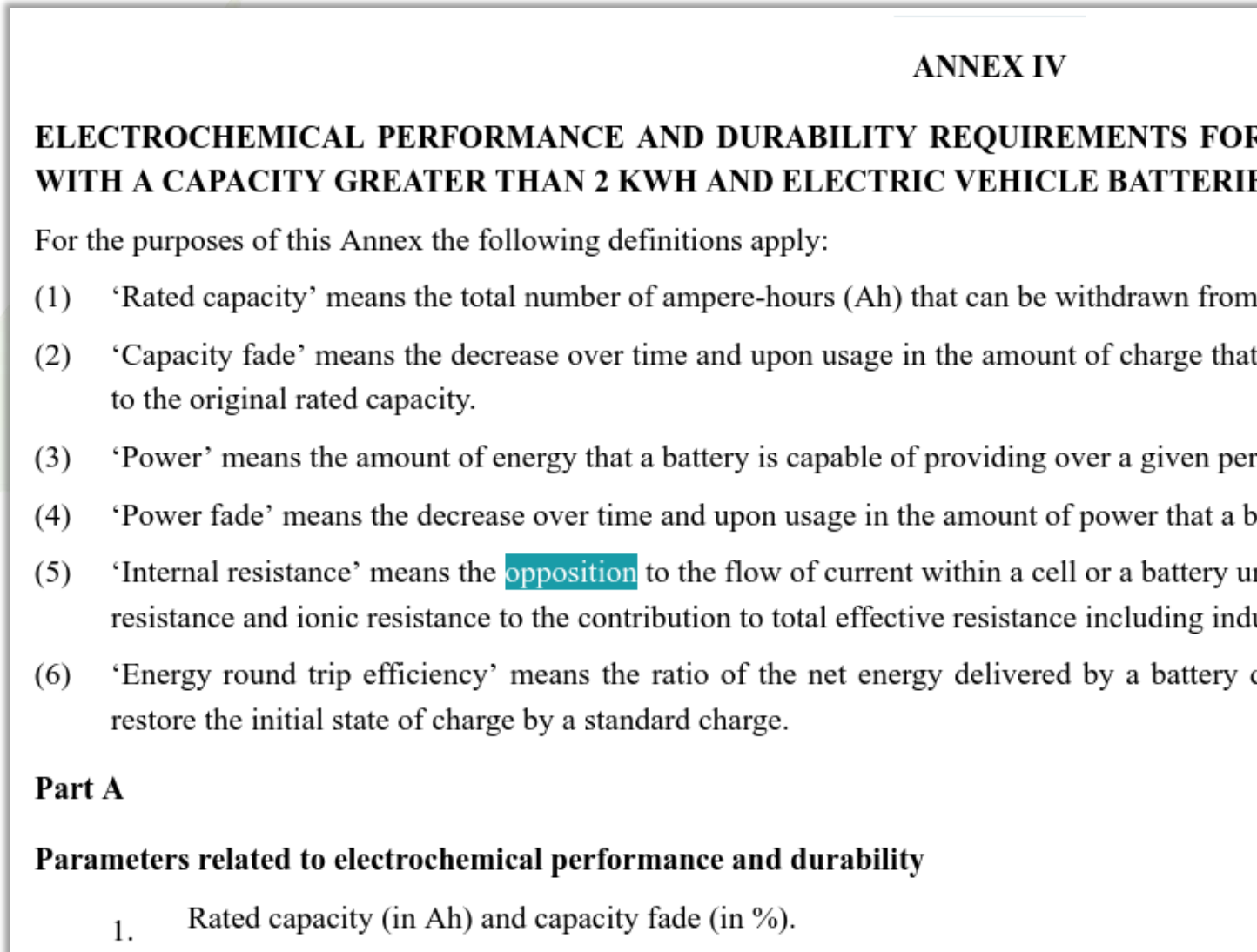
Regulation 2023/1542 concerning batteries and waste batteries

Legal text = guideline we must adhere to

- text available in 24 languages
- *take meaning* from this text to develop legally compliant service

- challenges:
  - hard to read
    - long, repetitive sequences
    - grammatical errors
    - mistranslations
  - subject to changes
  - possibly incomplete/incorrect
    - (minor) logical gaps
    - legal definitions in conflict with scientific/real world definitions



ANNEX IV

ELECTROCHEMICAL PERFORMANCE AND DURABILITY REQUIREMENTS FOR
WITH A CAPACITY GREATER THAN 2 KWH AND ELECTRIC VEHICLE BATTERIE

For the purposes of this Annex the following definitions apply:

(1) 'Rated capacity' means the total number of ampere-hours (Ah) that can be withdrawn from

(2) 'Capacity fade' means the decrease over time and upon usage in the amount of charge that to the original rated capacity.

(3) 'Power' means the amount of energy that a battery is capable of providing over a given per

(4) 'Power fade' means the decrease over time and upon usage in the amount of power that a b

(5) 'Internal resistance' means the opposition to the flow of current within a cell or a battery u resistance and ionic resistance to the contribution to total effective resistance including indu

(6) 'Energy round trip efficiency' means the ratio of the net energy delivered by a battery restore the initial state of charge by a standard charge.

Part A

Parameters related to electrochemical performance and durability

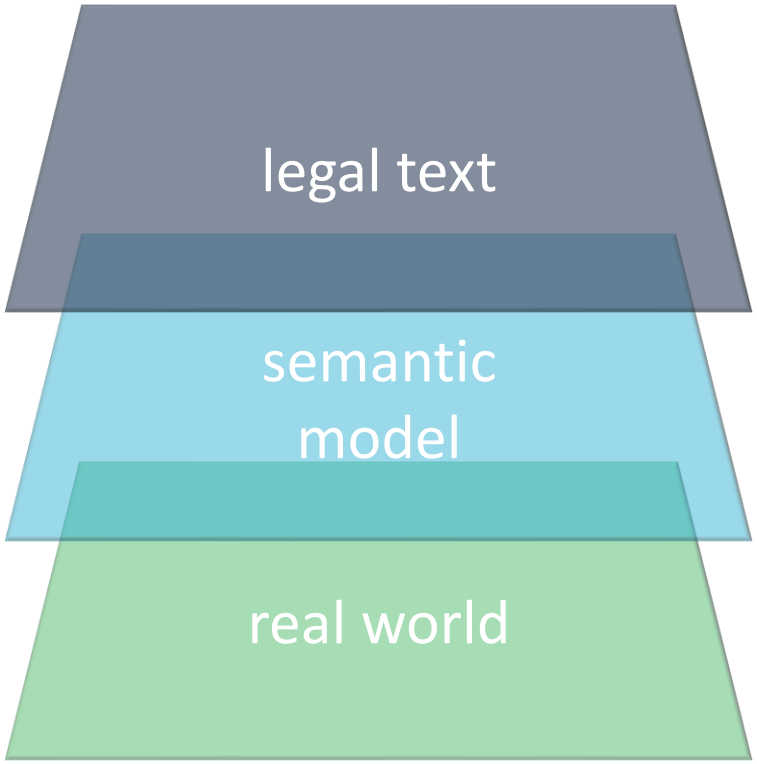
1. Rated capacity (in Ah) and capacity fade (in %).

Mission of BASE

→ provide a legally compliant service
- safety of data (DLT)
- role specific access

→ special features
- SOX analysis (safety indicators)
- RUL prediction (improve life cycle management)
- ESGE toolkit/score (guide sustainable decision-making)
- LCA tool (environmental/circularity indicator)

→ model needs to be
- understandable (verifiable)
- adaptable (updates)
- transferable (chemistry agnostic)



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Lithium ion batteries

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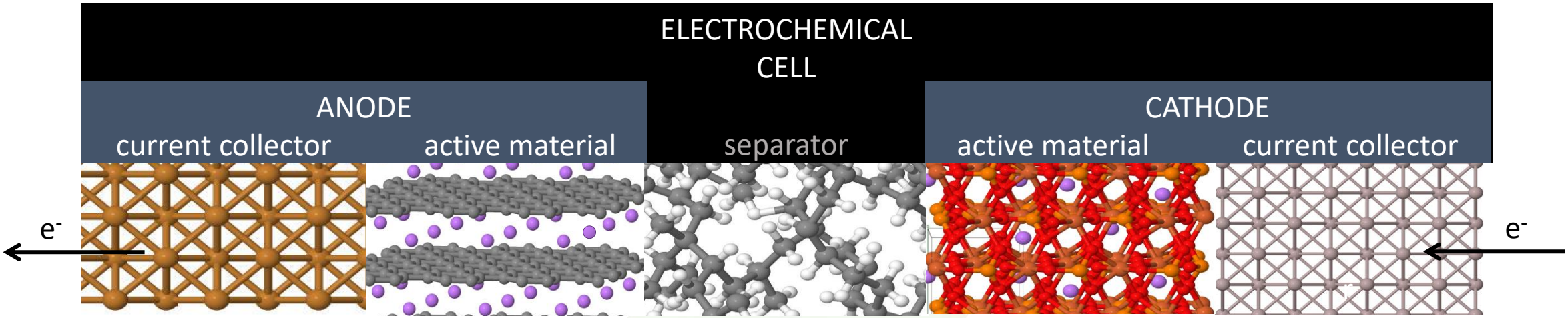
Lithium ion batteries



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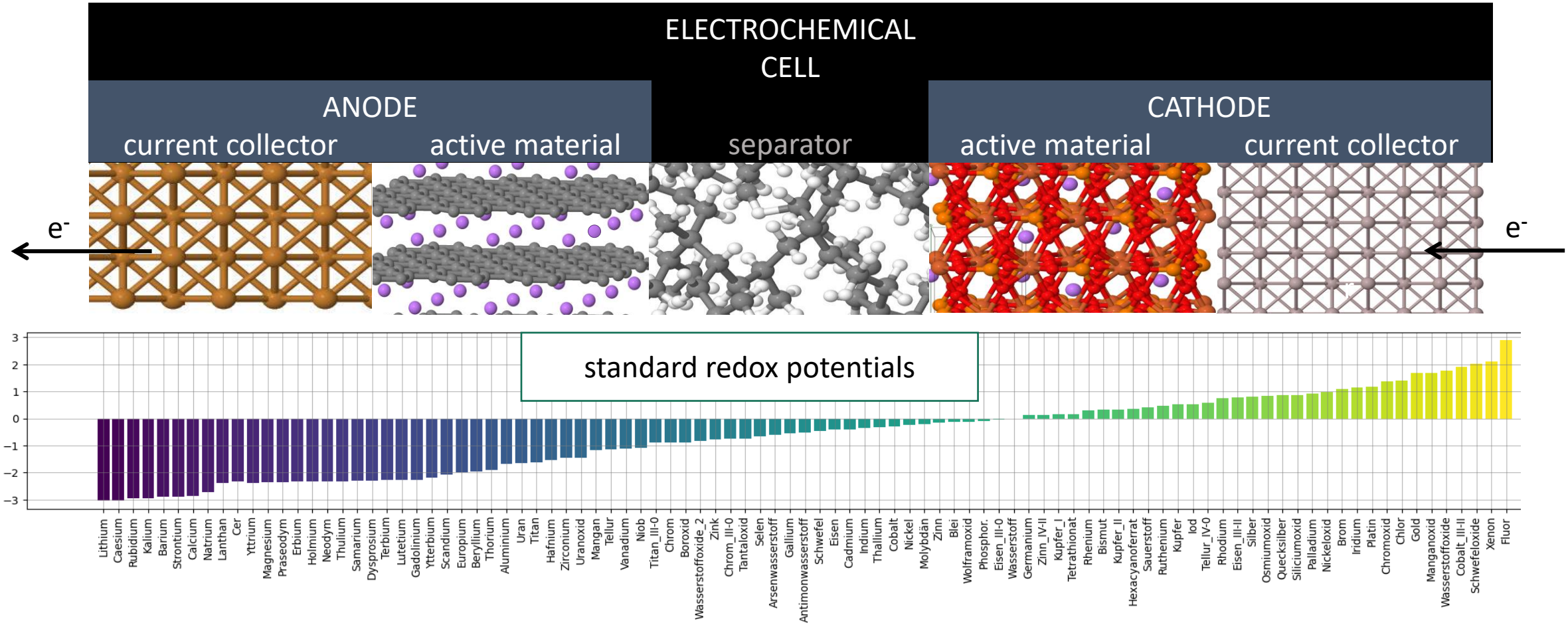
Lithium ion batteries



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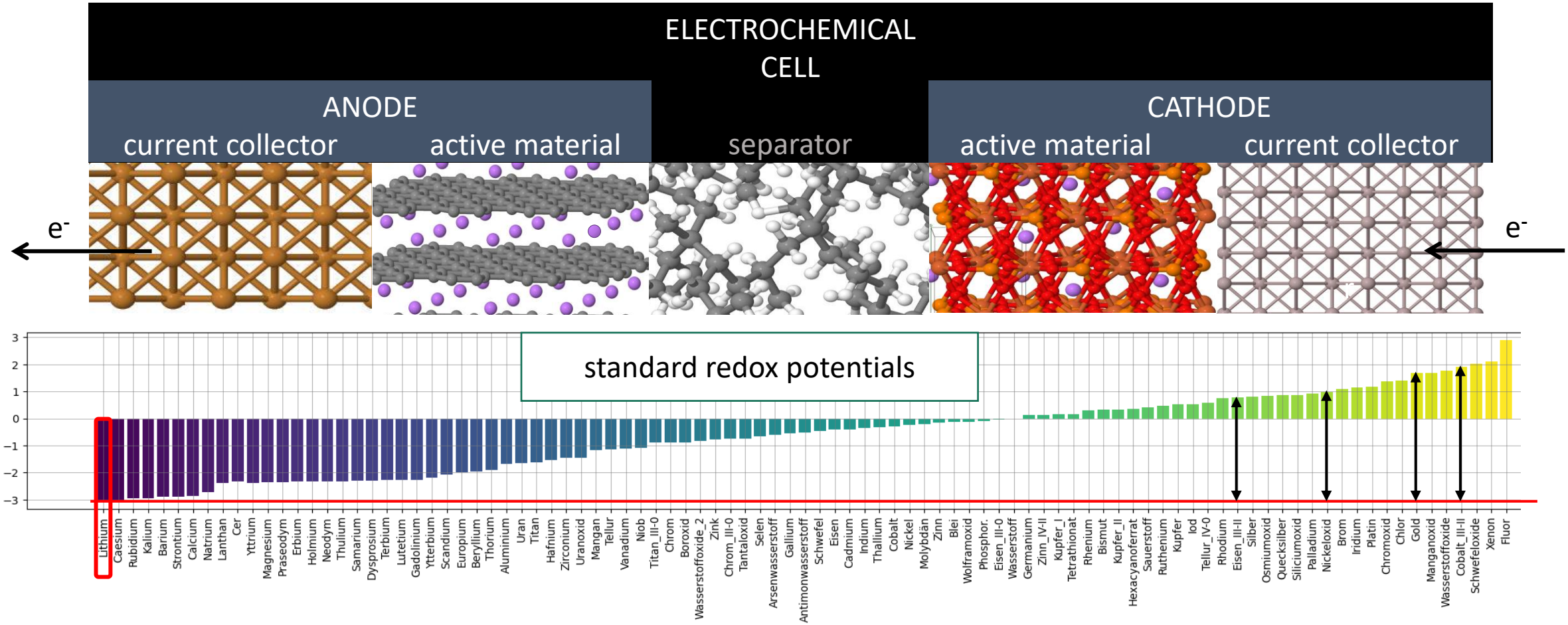
Lithium ion batteries



chemistry → specific voltage **ionic mobility → amperage** **amount of material → capacity**

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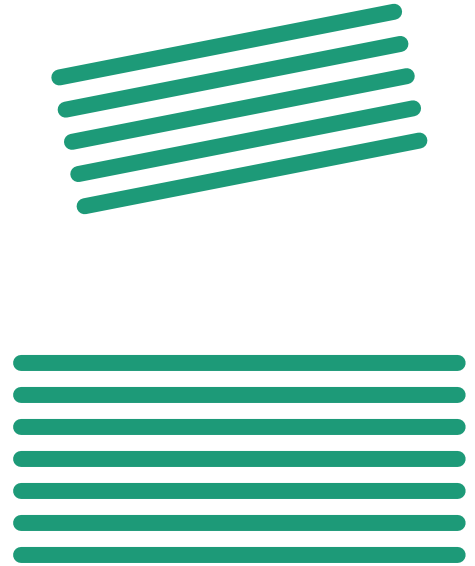
Morphologies

cylindrical

pouch



prismatic

(coin)

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Battery systems

electrochemicalCell = smallest functional unit

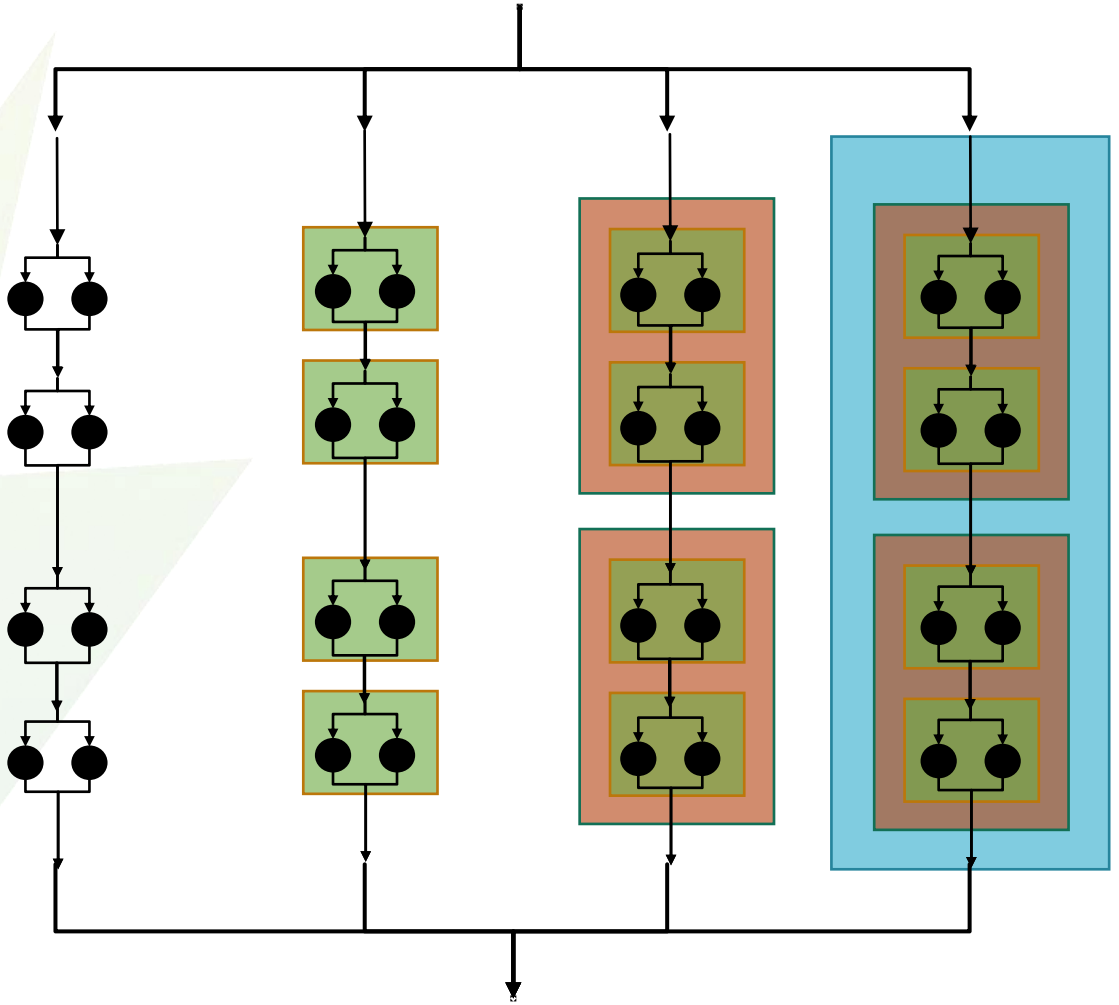
- serial connection → target voltage
- parallel connection → target power

→ application specific electrical diagrams

- for better contact, cell connections welded

→ fixed units:

  - nested, encapsulated subunits, arbitrary names
  - other components
    - battery management system
    - sensors
    - thermal management
    - …



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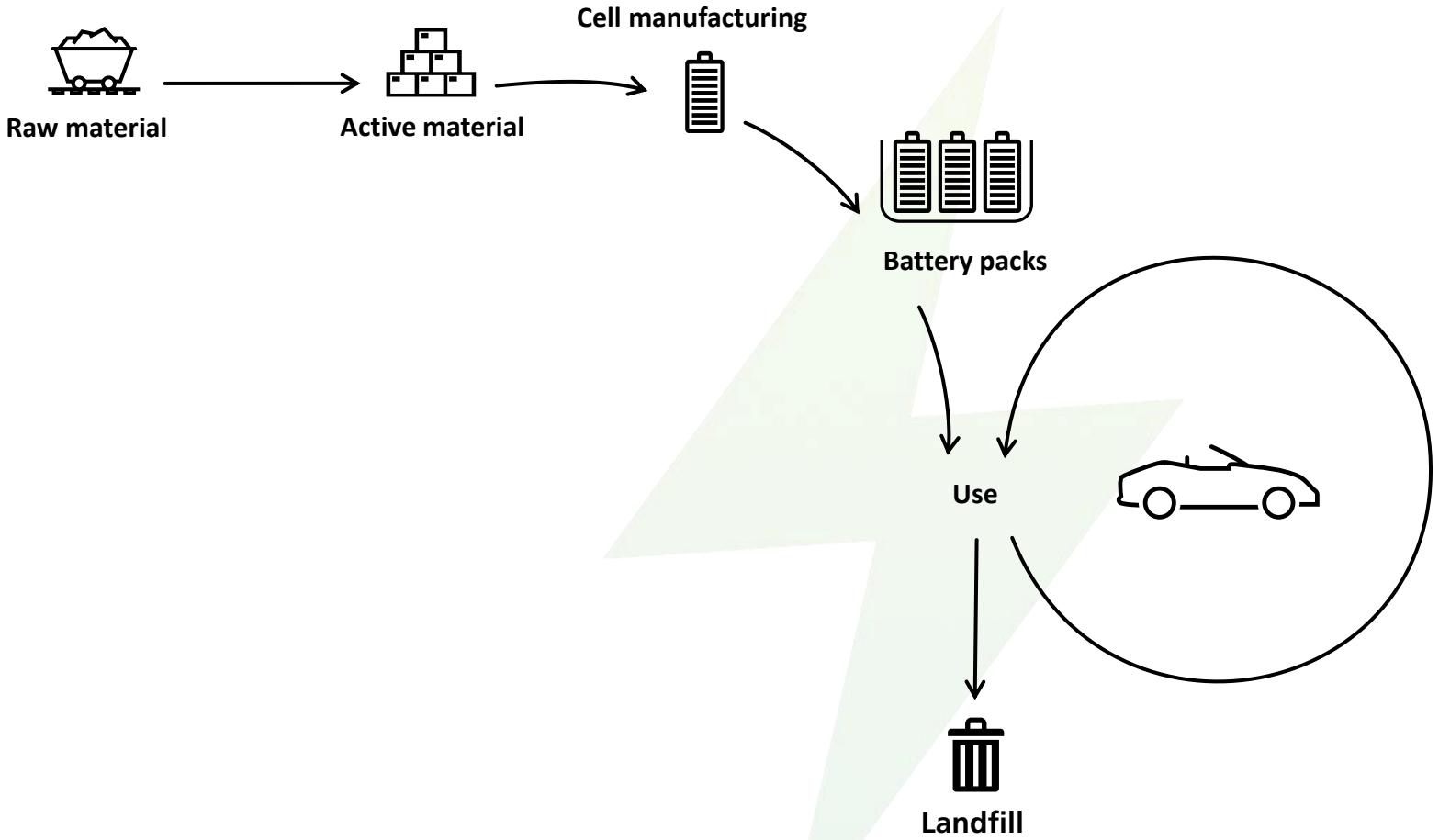
Lifecycle



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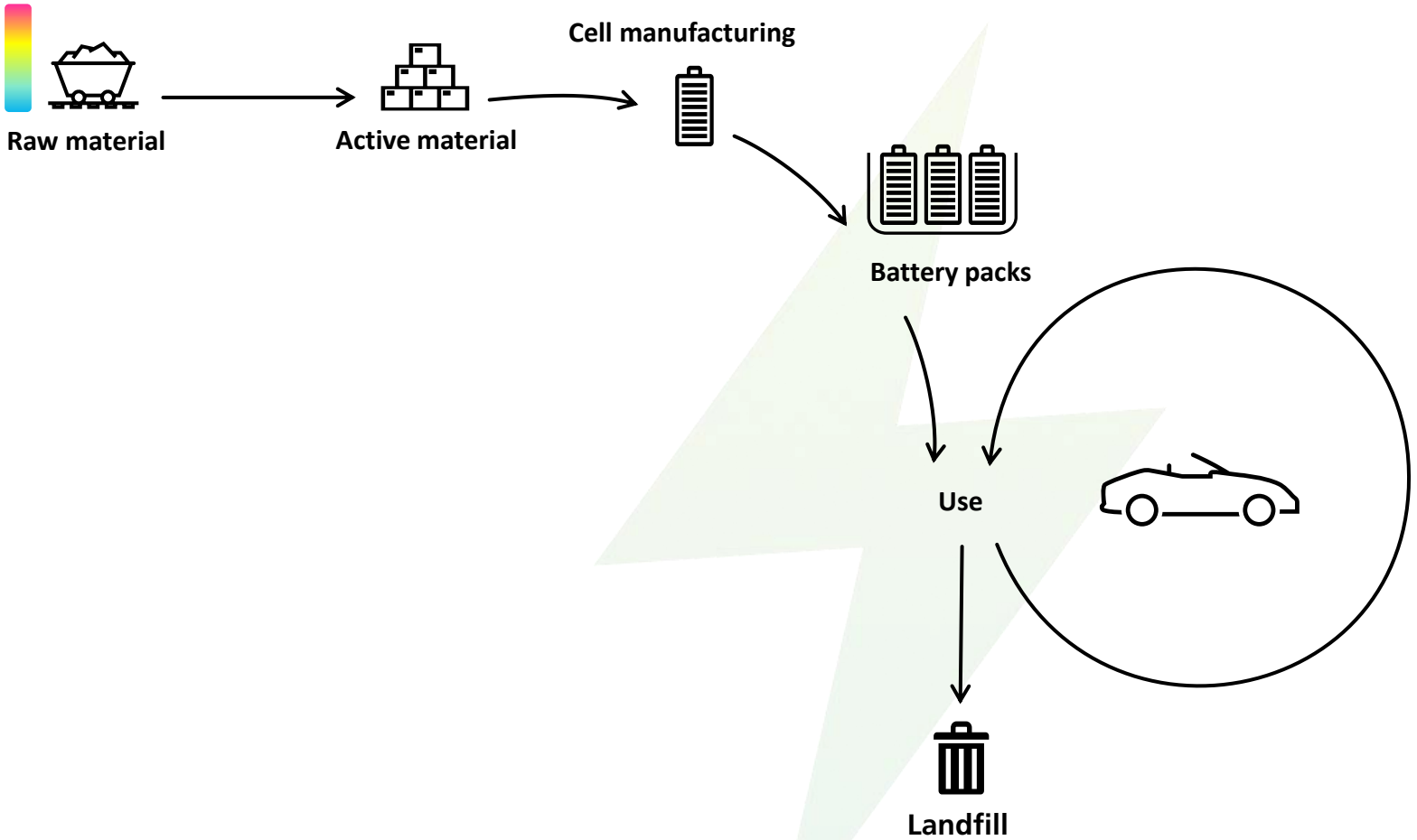

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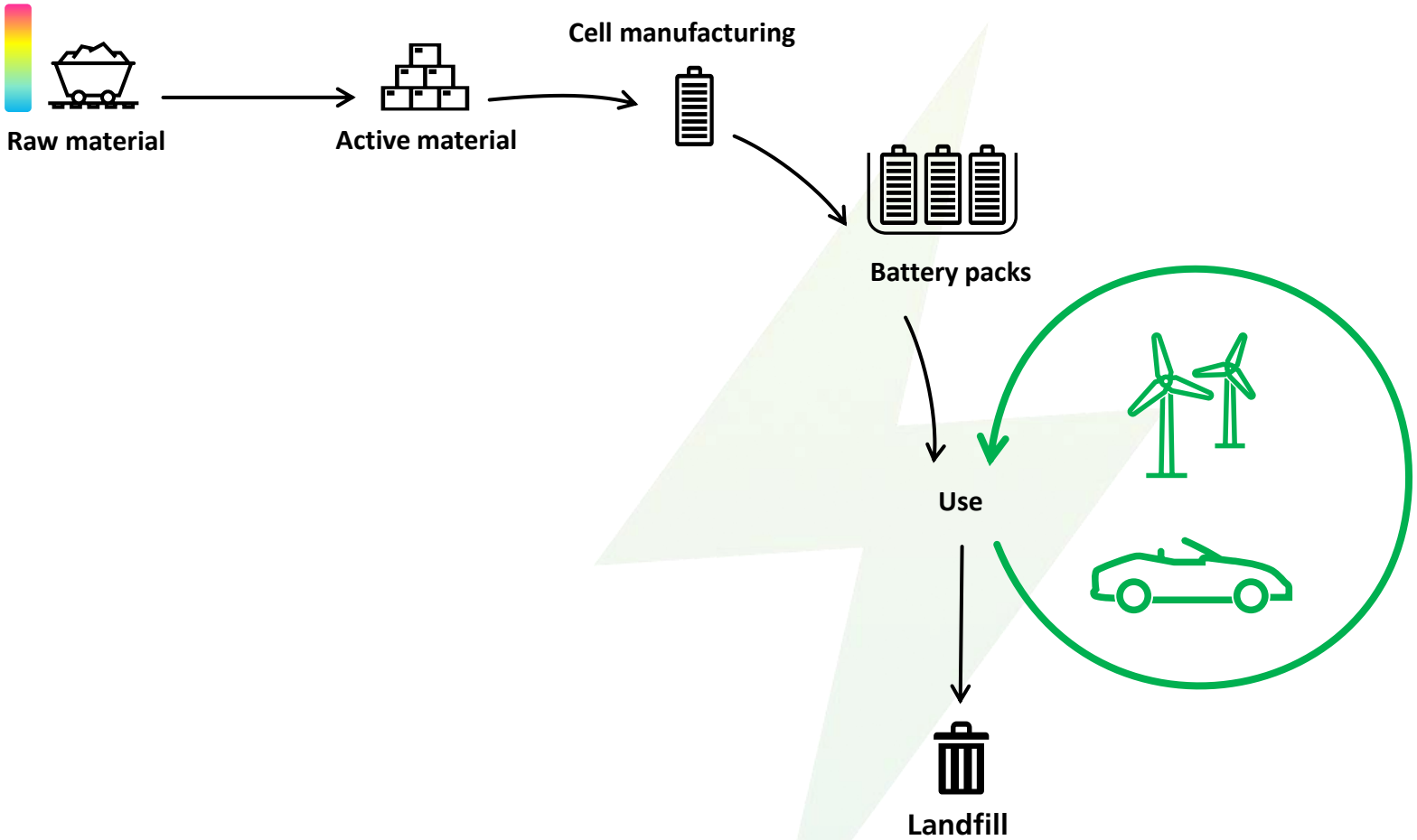

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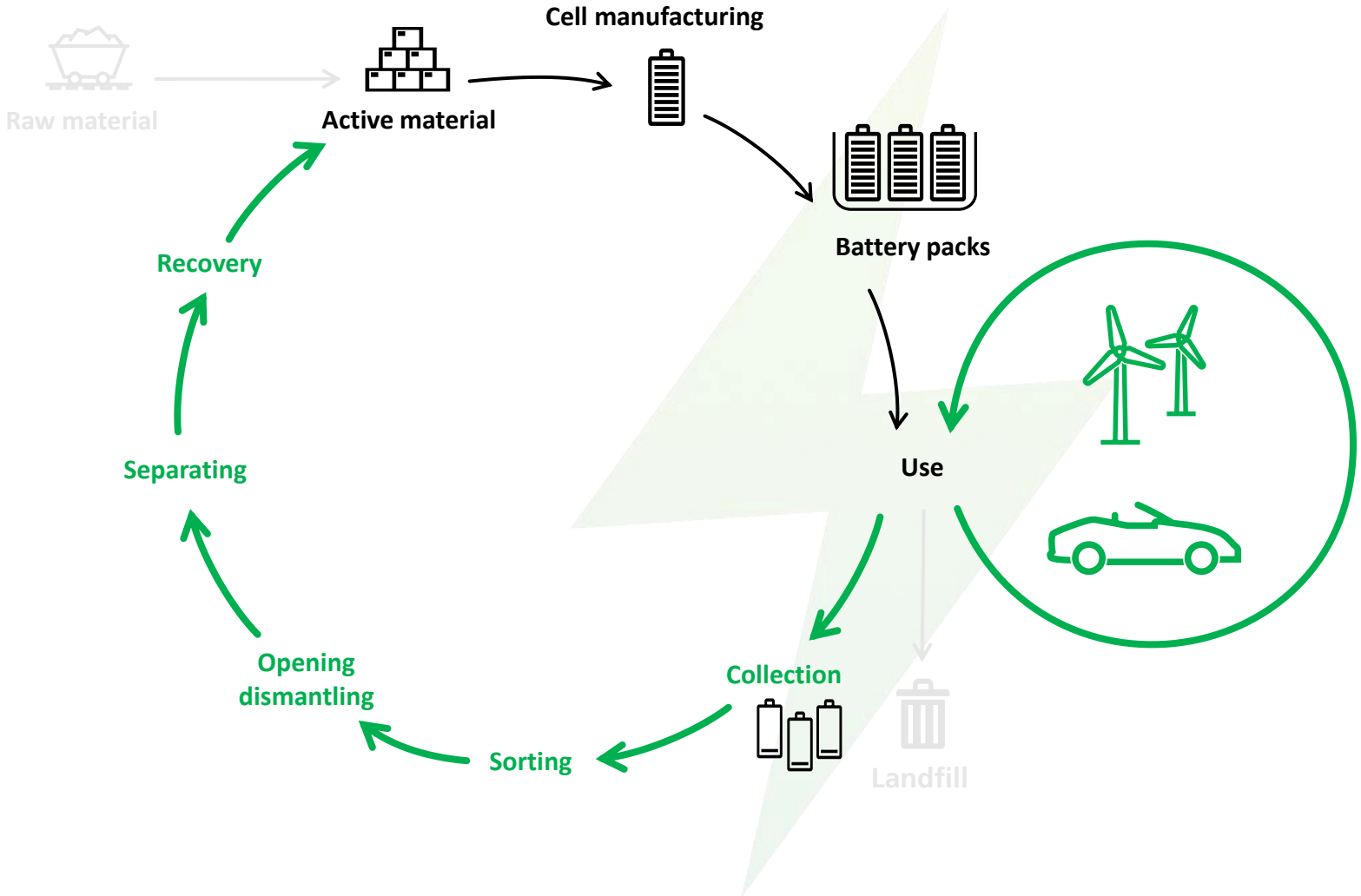

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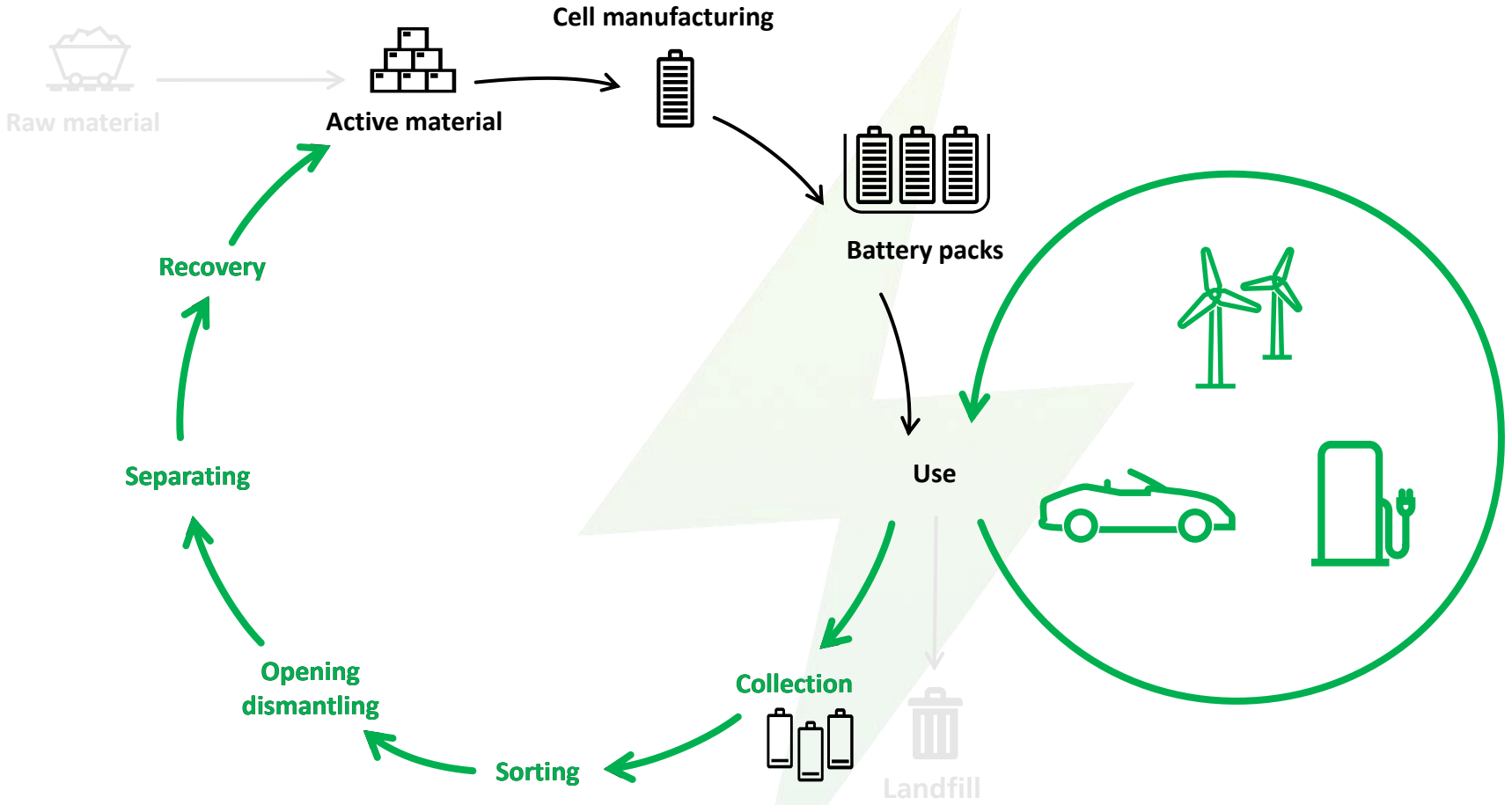

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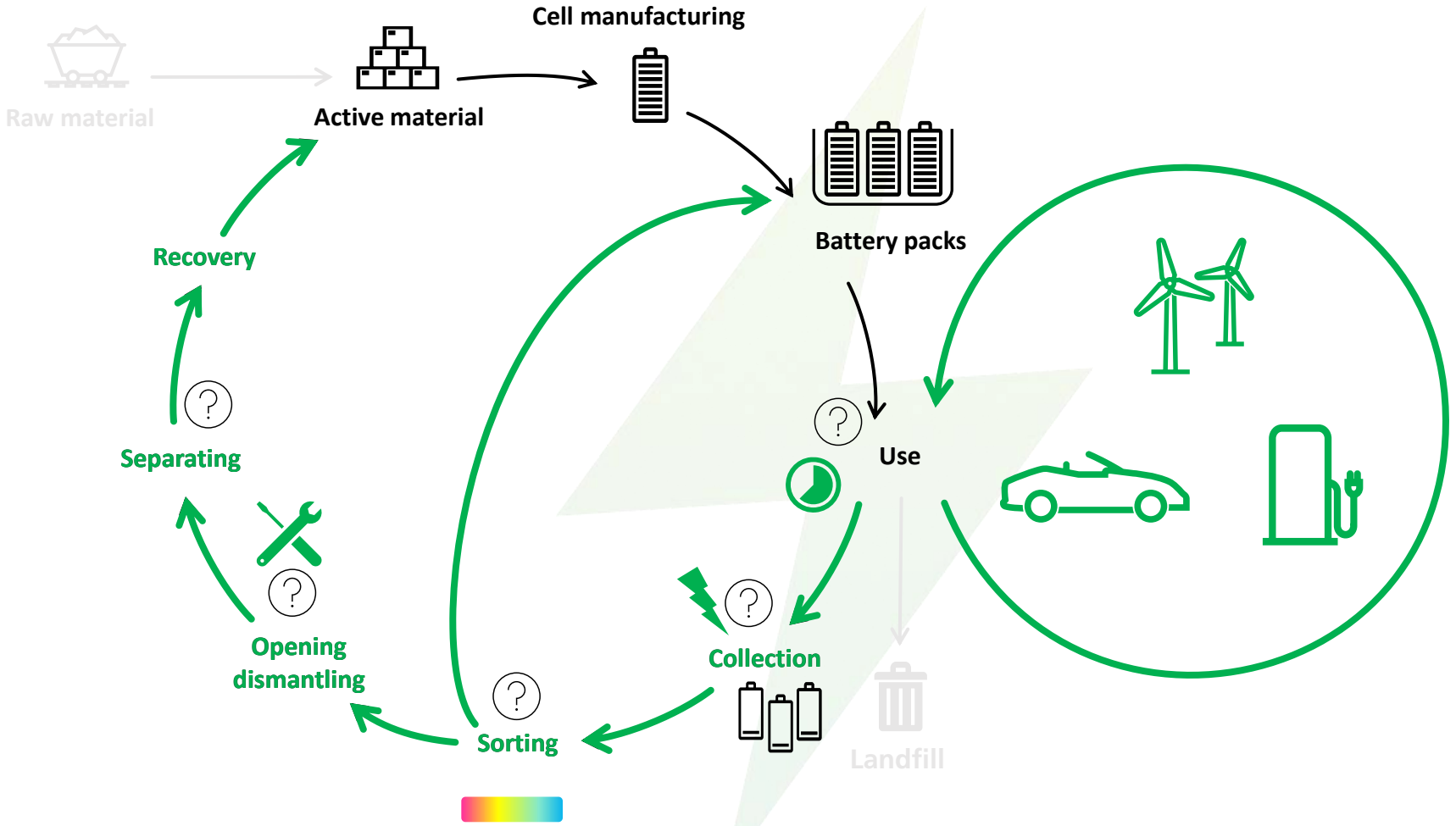

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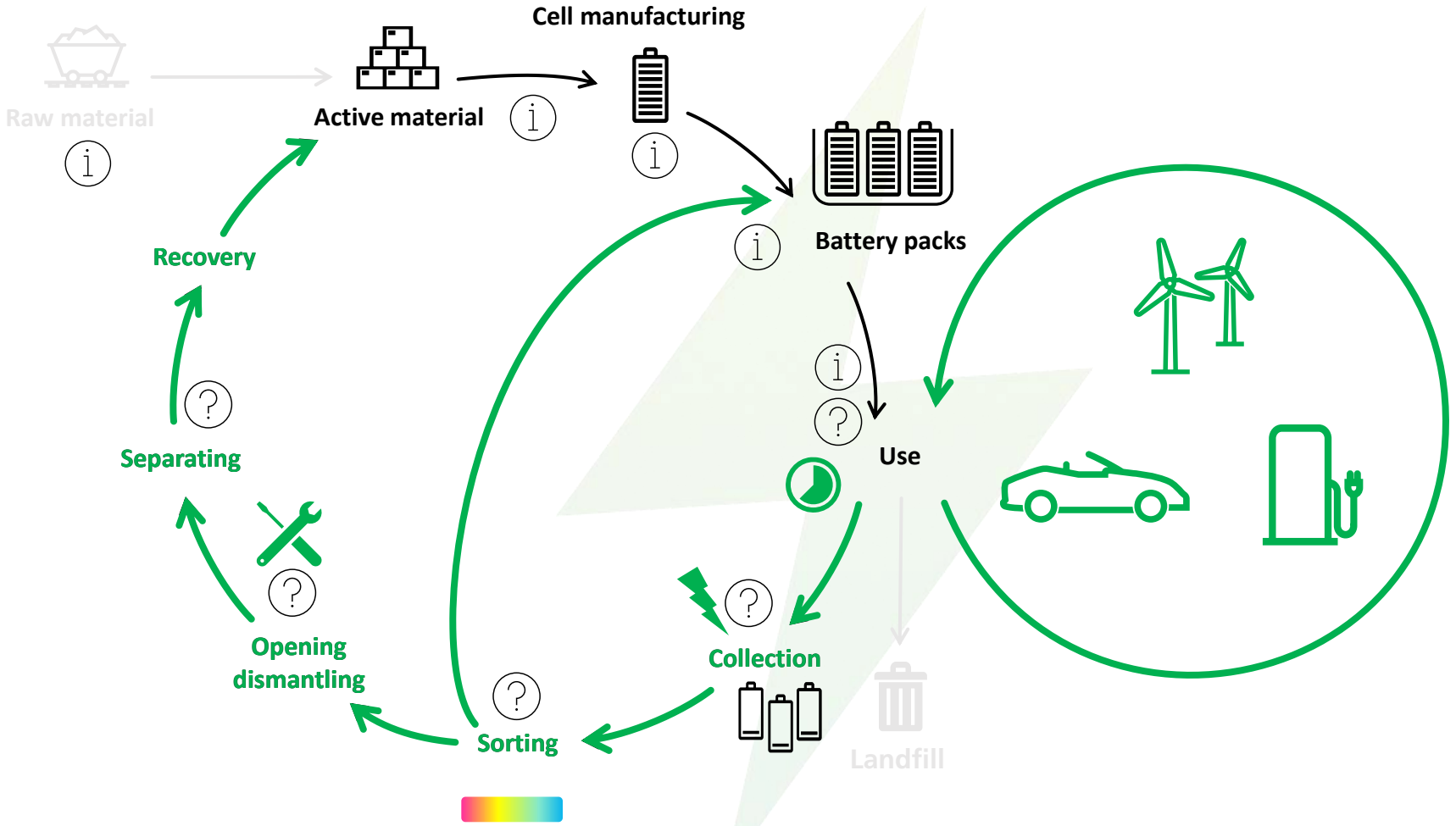

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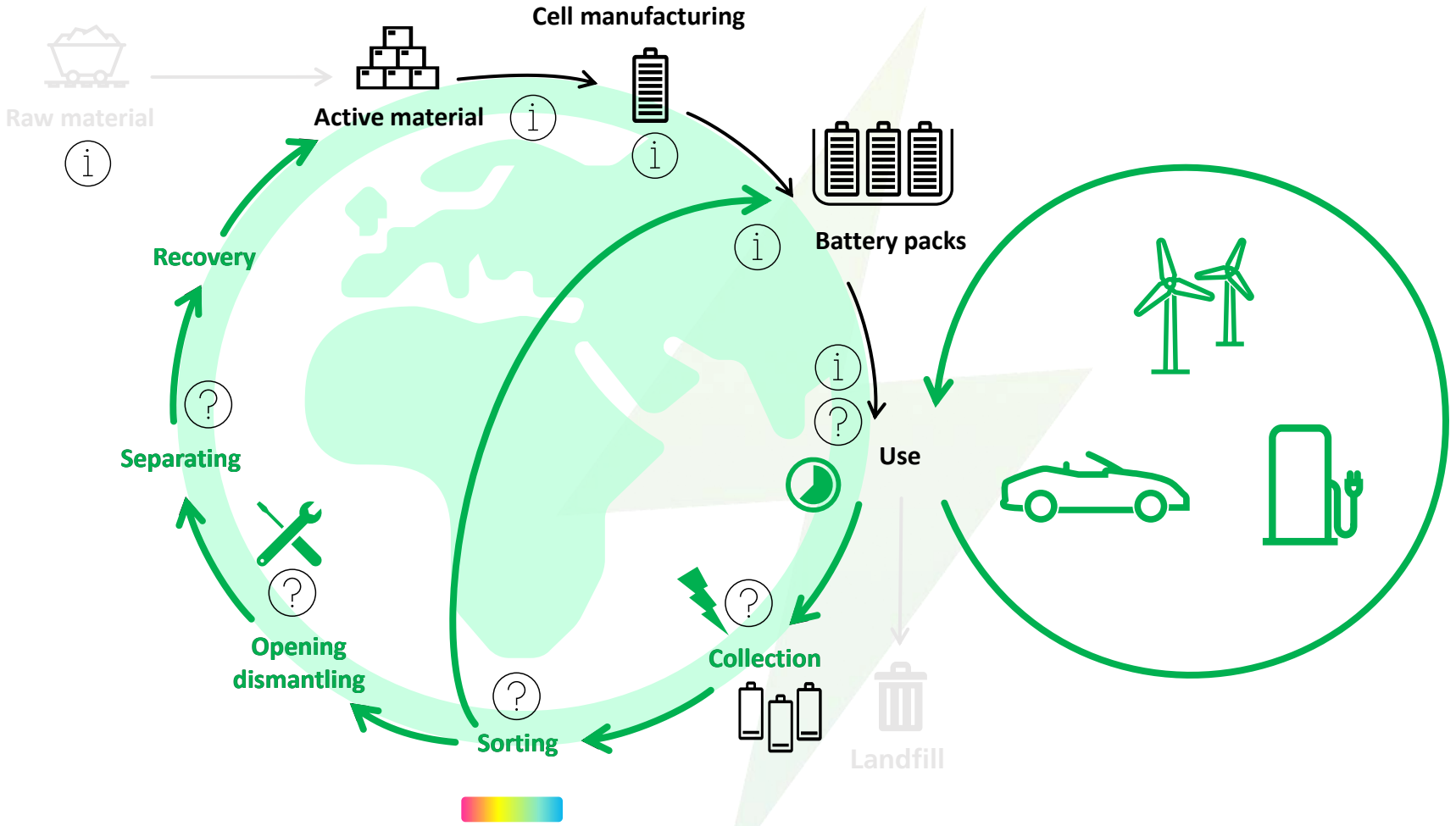

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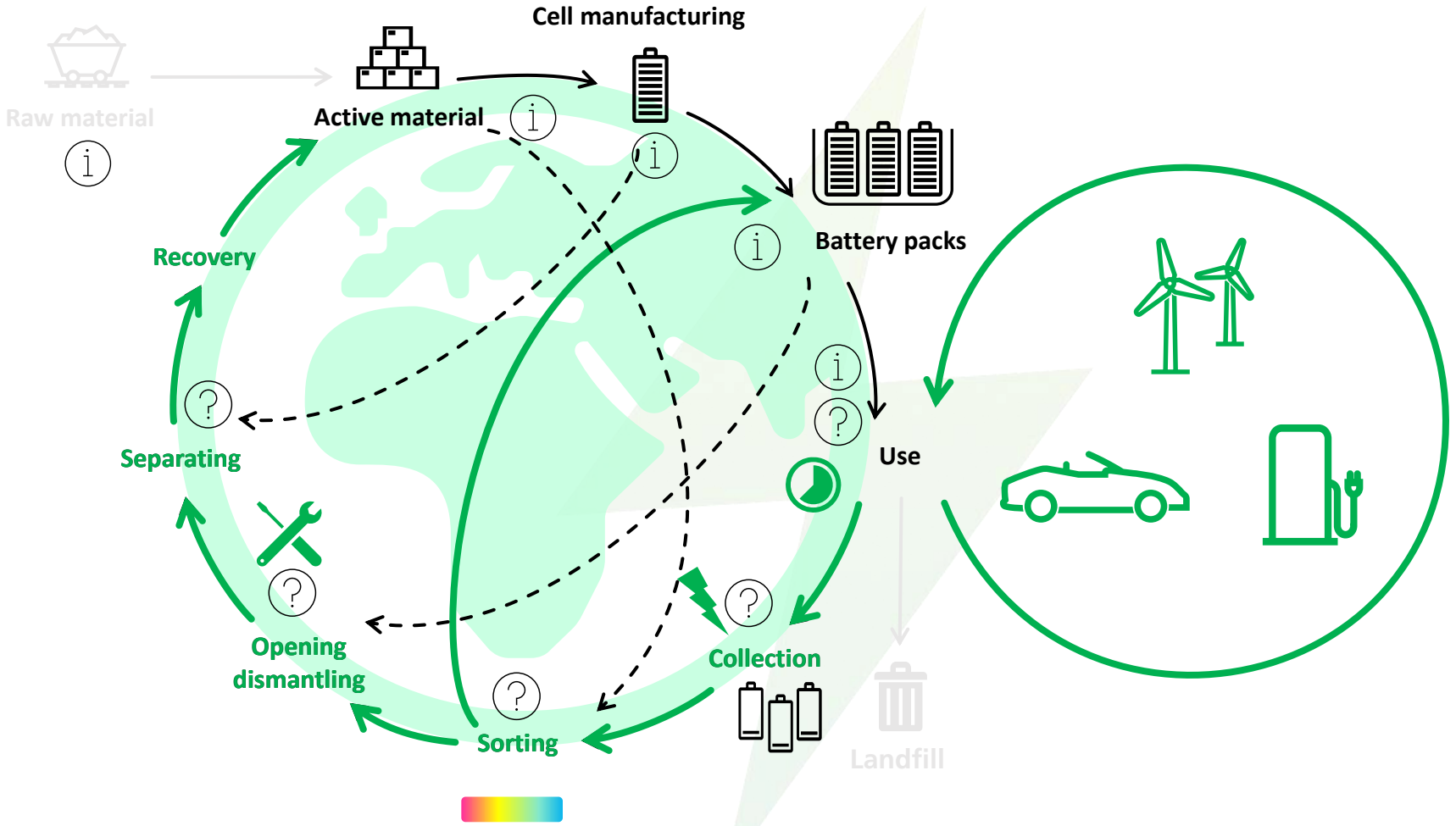

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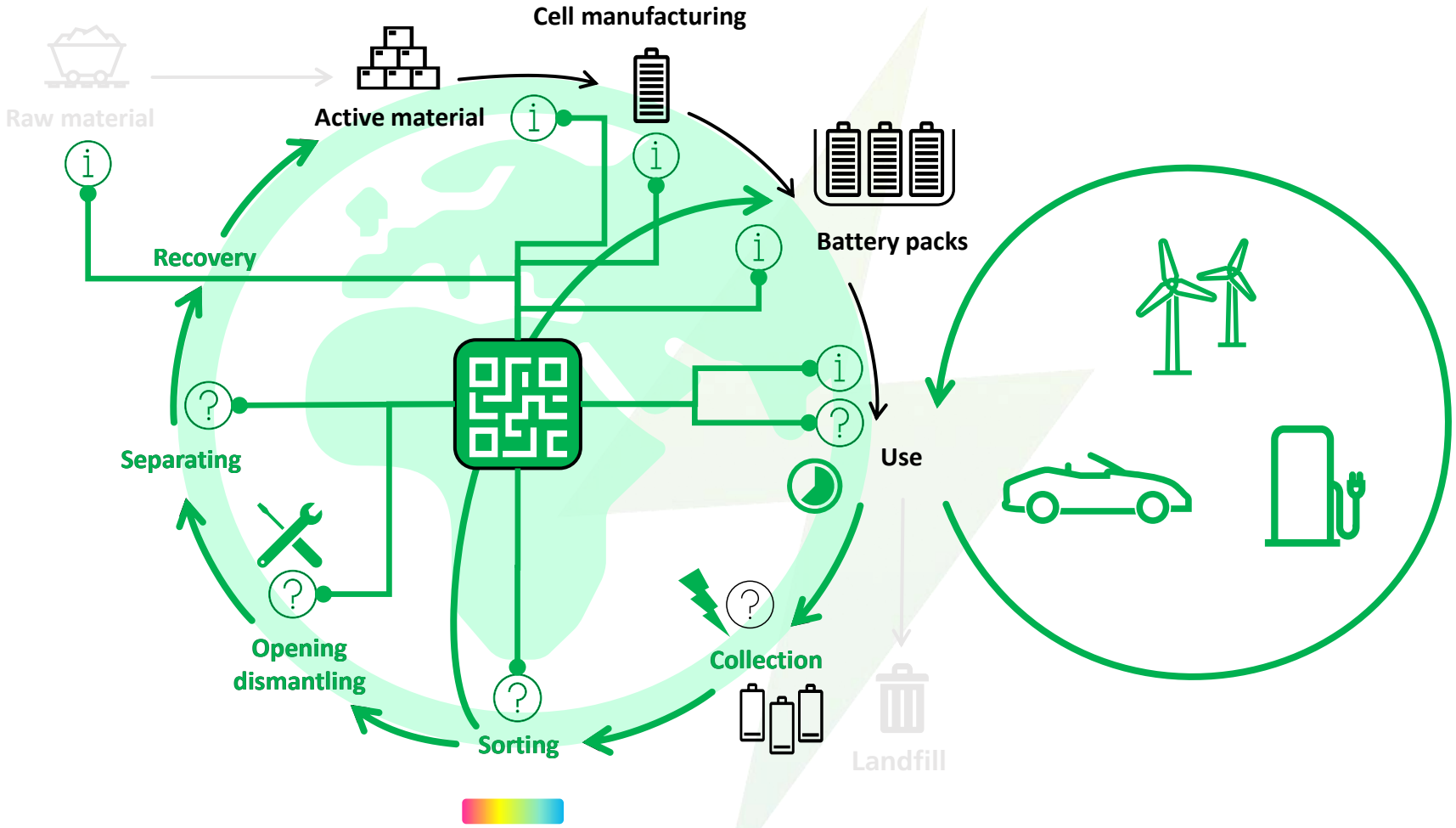

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Elementary Multiperspective Material Ontology

https://github.com/emmo-repo/EMMO

Representational ontology framework based on current materials modeling and characterization knowledge, relying on recognized authorities.

- standardized nomenclature (IUPAC/IEC)
- persistent identifiers
- CC BY 4.0

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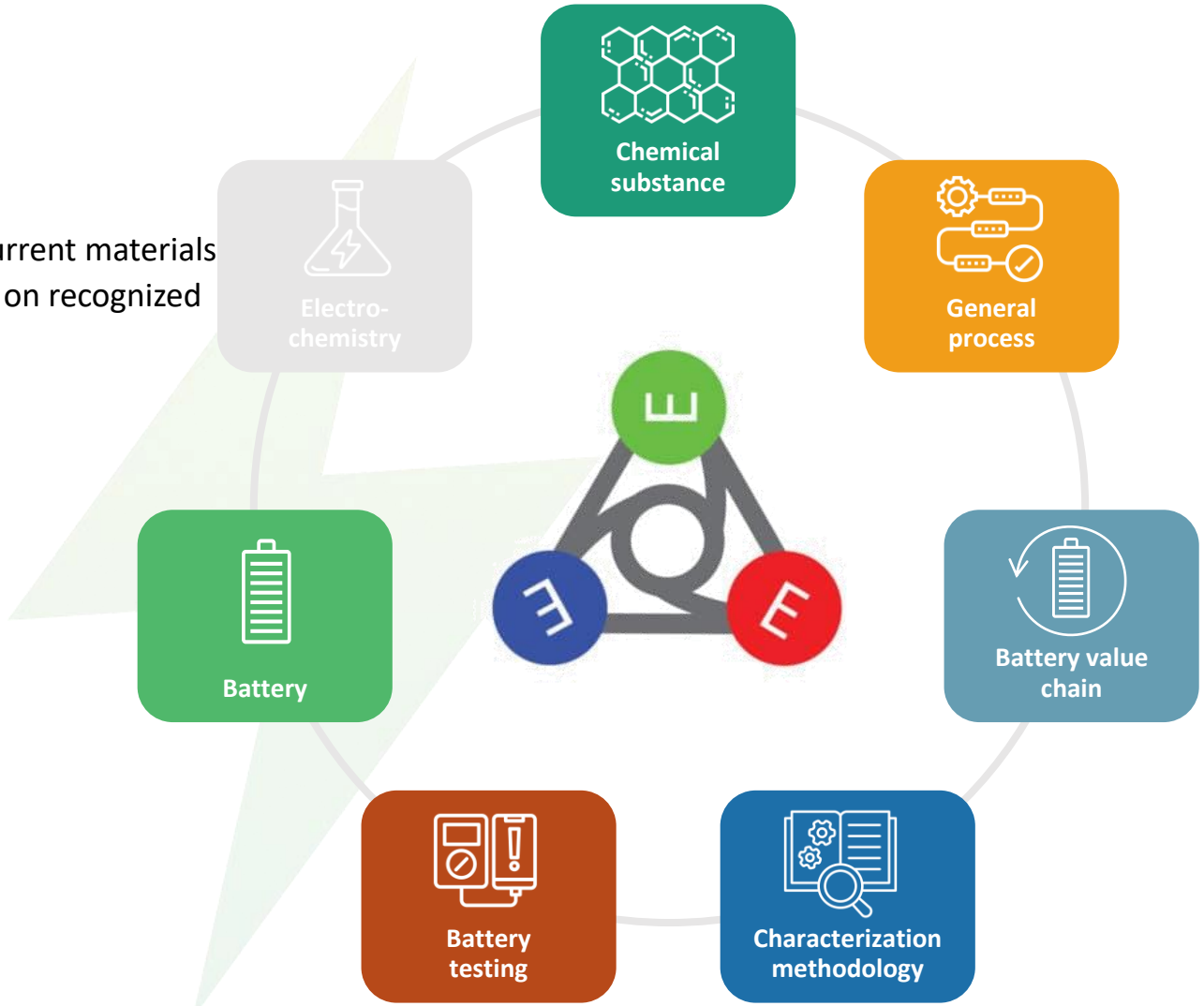

Extensions

- integrated with the EMMO universe
- focus on representing physical world

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Taking stock: historical time series data

(pattern of) original column names	PrefLabel of property	unit	comment	scope
time	TimeMeasurementResult	YYYY-MM-DDTHH:MM:SSZ	ISO 8601	installation wide
mean_system_current	CellCurrent	Ampere		installation wide
mean_current{rack_index}	CellCurrent	Ampere	rack_index: single digit	rack wide
voltage{rack_index}_c{cell_index:03}	CellVoltage	Volt	cell_index: three digits, leading zeros	cell specific
temperature{rack_index}_t{sensor_index:03}	CelsiusTemperatureMeasurementResult	degCelsius	sensor_index: three digits, leading zeros	sensor specific, stack wide
balancing{rack_index}_c{cell_index:03}		boolean	on(1),off(0)	cell specific
mean_SoC	StateOfCharge, average	%		installation wide
mean_max_cell_temperature_value	CelsiusTemperature, maximum, average	degCelsius	processed property	installation wide
mean_min_cell_temperature_value	CelsiusTemperature, minimum, average	degCelsius	processed property	installation wide
mean_avg_cell_temperature_value	CelsiusTemperature, average, average	degCelsius	processed property	installation wide

Observation Description File

- Original column patterns
- Proposal for unified definitions (prefLabels)

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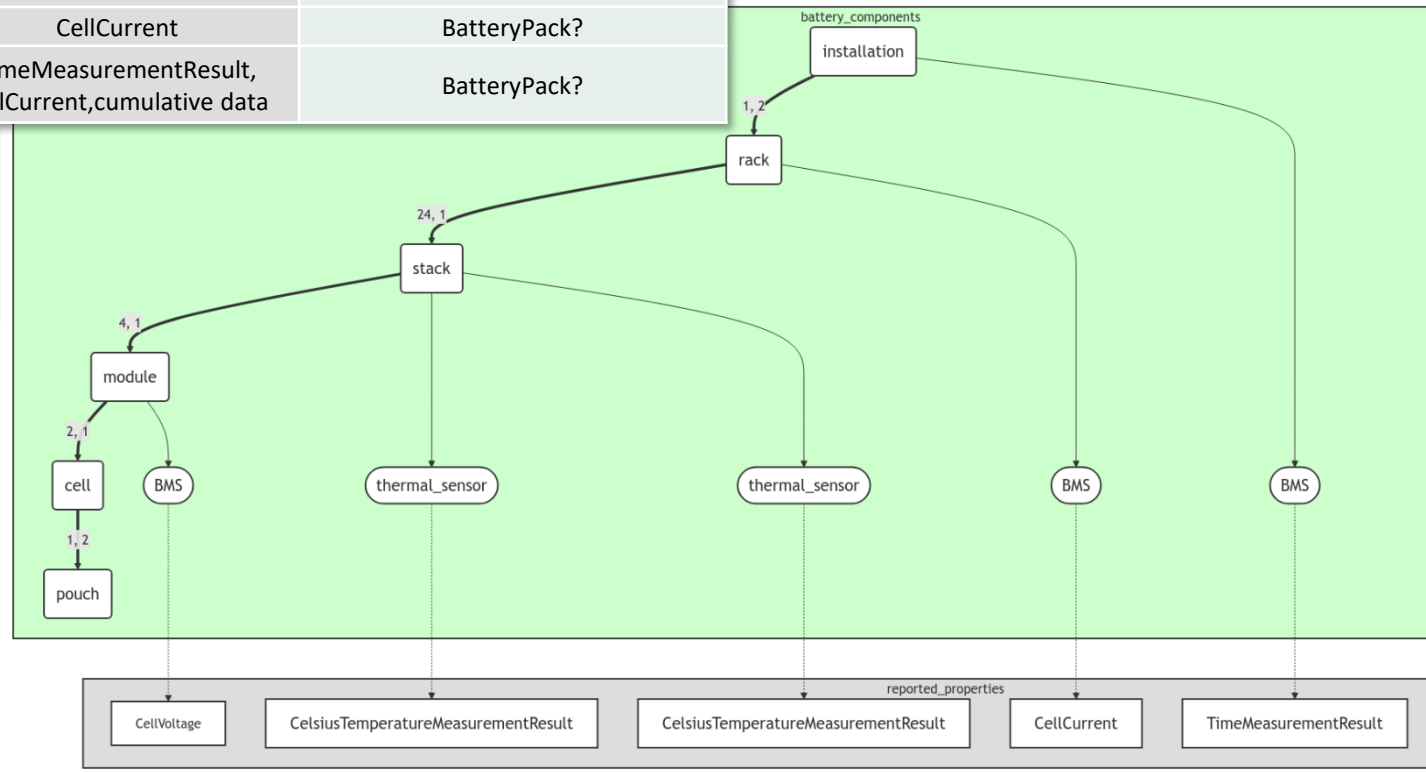
Taking stock: batteries & data

name of building block	name of electrical component	configuration	other component(s)	number of other component(s)	reported data	BB prefLabel
pouch		1s1p		0		PouchCell,LithiumManganese DioxideBattery
cell	pouch	1s2p		0		BatteryModule?
module	cell	2s1p	BMS	1	CellVoltage, balancing	BatteryModule?
stack	module	4s1p	thermal sensor	3	CelsiusTemperatureMeasurementResult	BatteryPack?
rack	stack	24s1p	BMS	1	CellCurrent	BatteryPack?
installation	rack	1s2p	BMS	1	TimeMeasurementResult, CellCurrent,cumulative data	BatteryPack?



Battery Description File

- Building hierarchy
- Level names differ between providers/users

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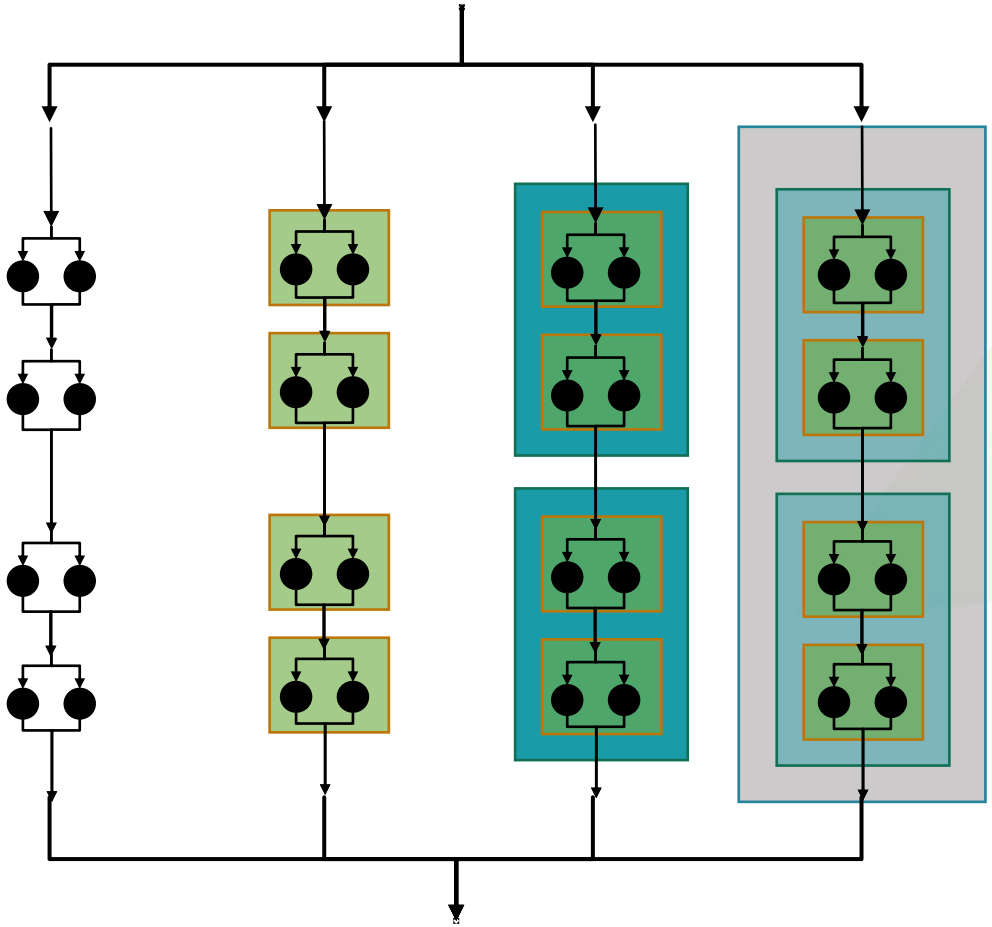
Breaking down batteries



- individual naming conventions
  - cell, pair, block, module,cell module, pack, stack, rack, array, string….

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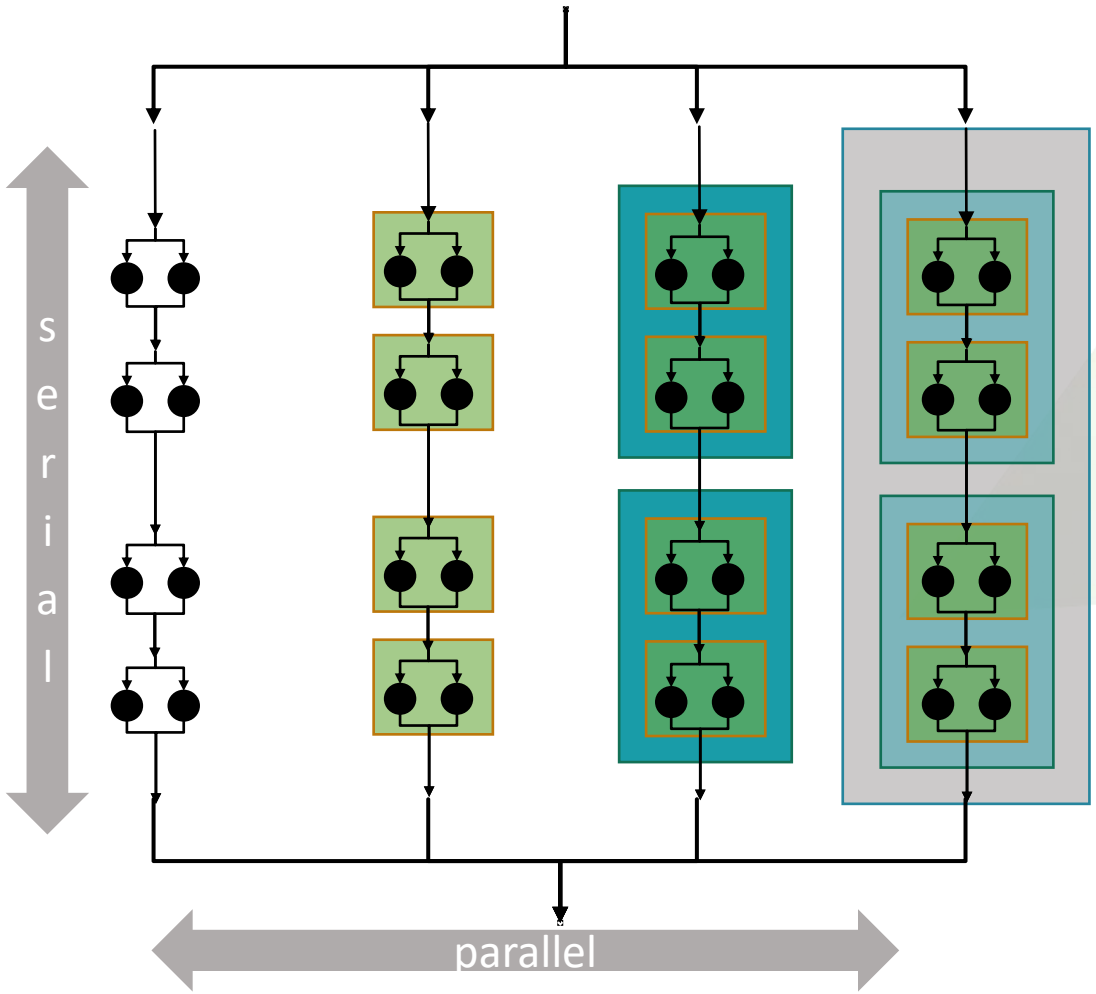
Breaking down batteries



- so far: individual naming conventions
  - cell, pair, group, block, module,cell module, pack, stack, rack, array, string….
- develop common, concise notation

  LFP<1s2p<2s1p<2s1p (bottom up)
  and/or
  2s1p>2s1p>1s2p>LFP (top down)

→nested arrays/json
  - linked json
  - pointers

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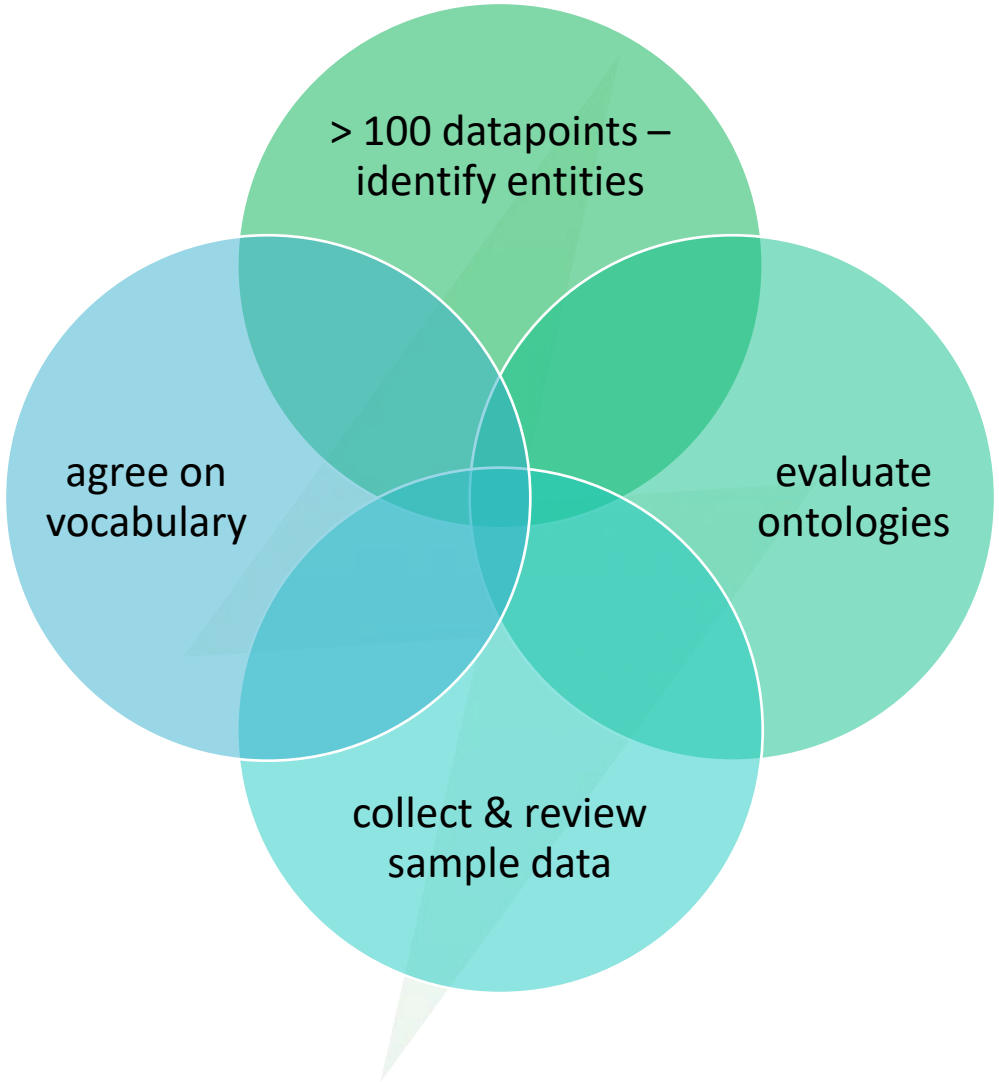
current state & next steps



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