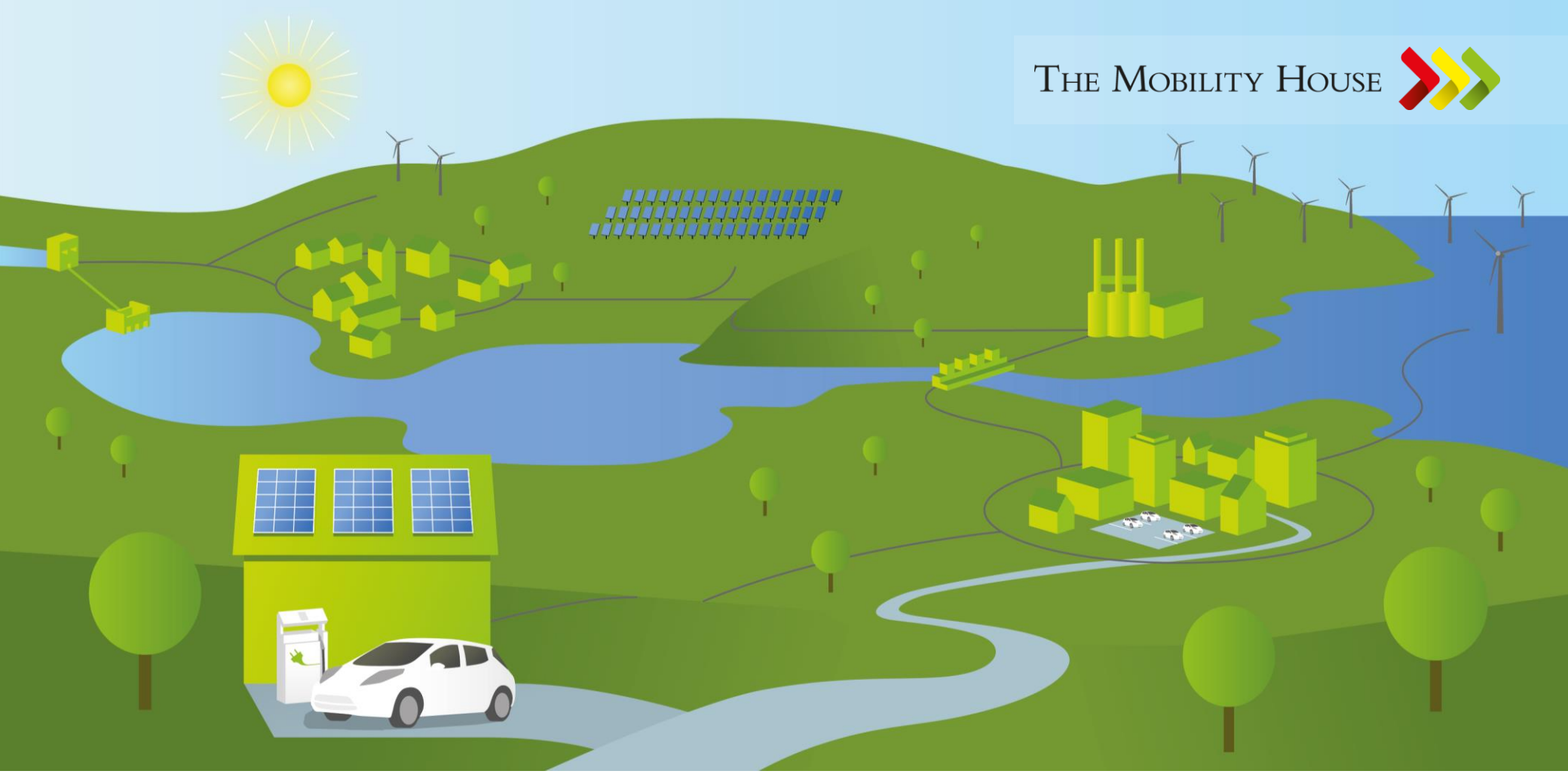
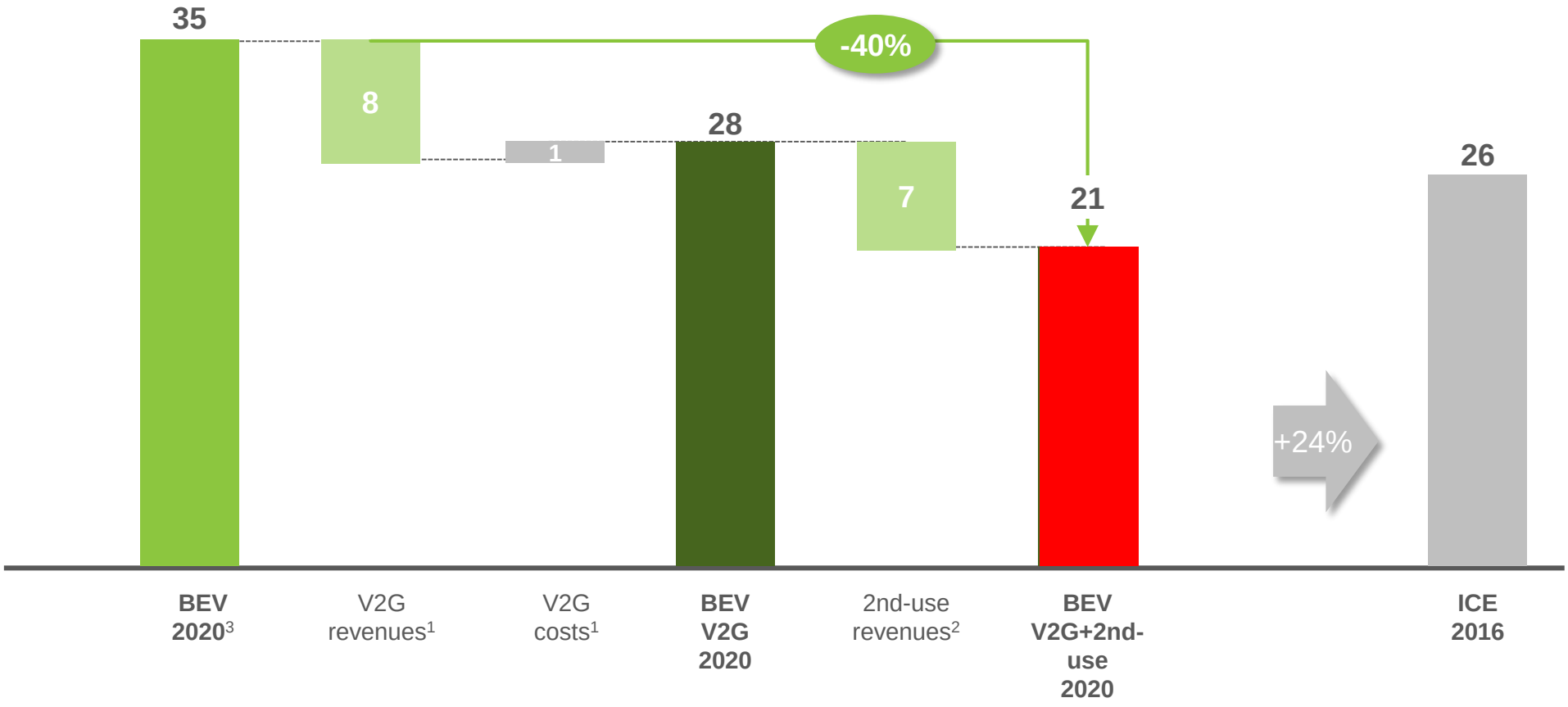


ELSA – Storage solutions and new services with EV batteries

Aachen, May 2nd, 2016

TMH assumes between 5-15kEUR of 2nd-use value for a car manufacturer

TCO without/with energy management (in k€ for 48 month)



[1] savings from ancillary services, peak shaving, intraday arbitrage, …; Costs = TMH operation; w/o charger
[2] savings from 2nd-use; 100% of OEM share (70%) passed on to the customer; w/o recycling savings
Battery size 60kWh

Source: The Mobility House, P3 Group, ADAC

2nd-use storage

Source: The Mobility House

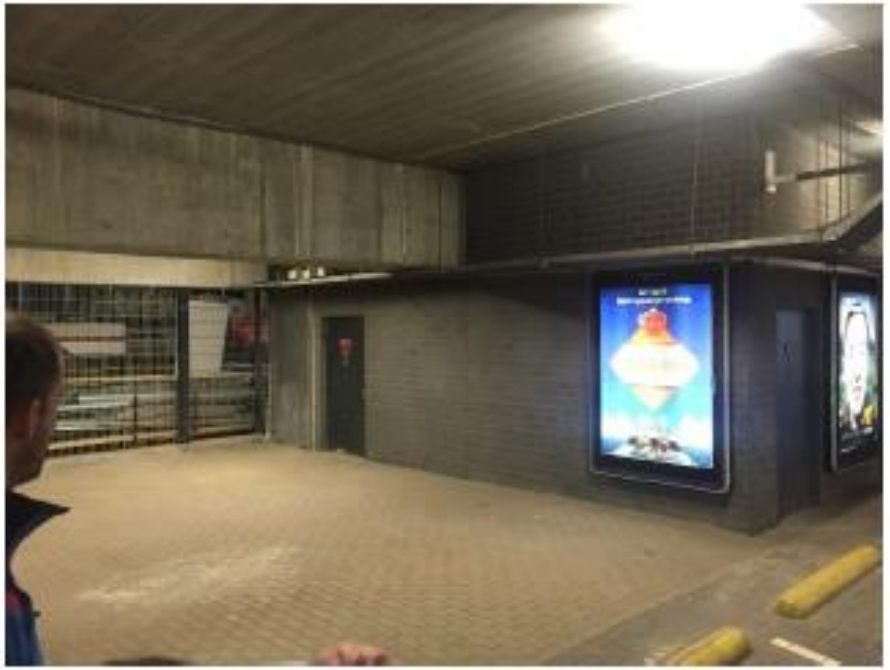
2nd-use storage

Source: The Mobility House

2nd-use storage

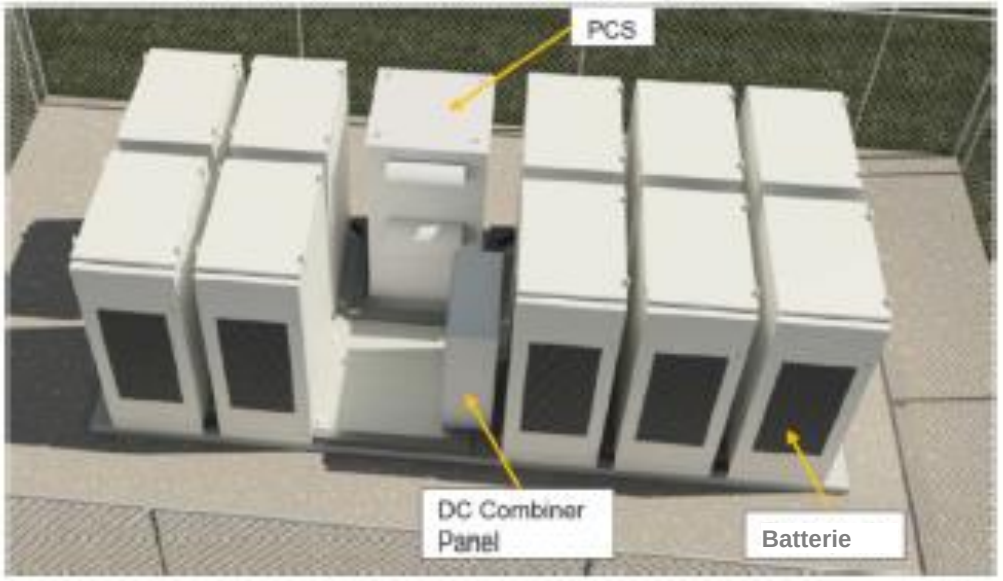
Source: The Mobility House

1st or 2nd-use storage



Source: The Mobility House

1st use EV battery storage



Source: The Mobility House

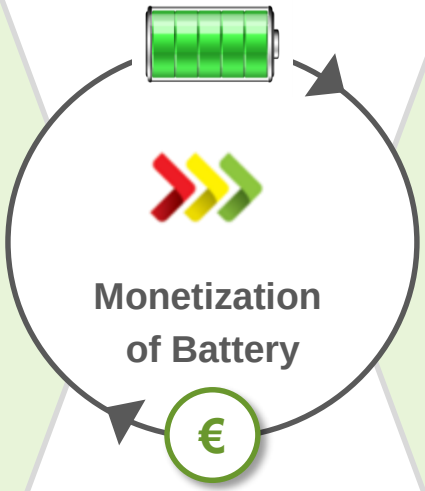
The disruptive forces of two industries fuel each other

Business Disruption

Automotive Industry

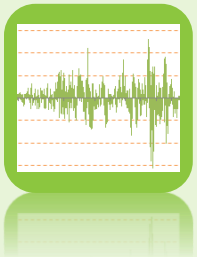
- Growing storage capacity through EVs
- Decreasing battery costs
- Increasing smart connectivity

Abundance of Storage



Power Industry

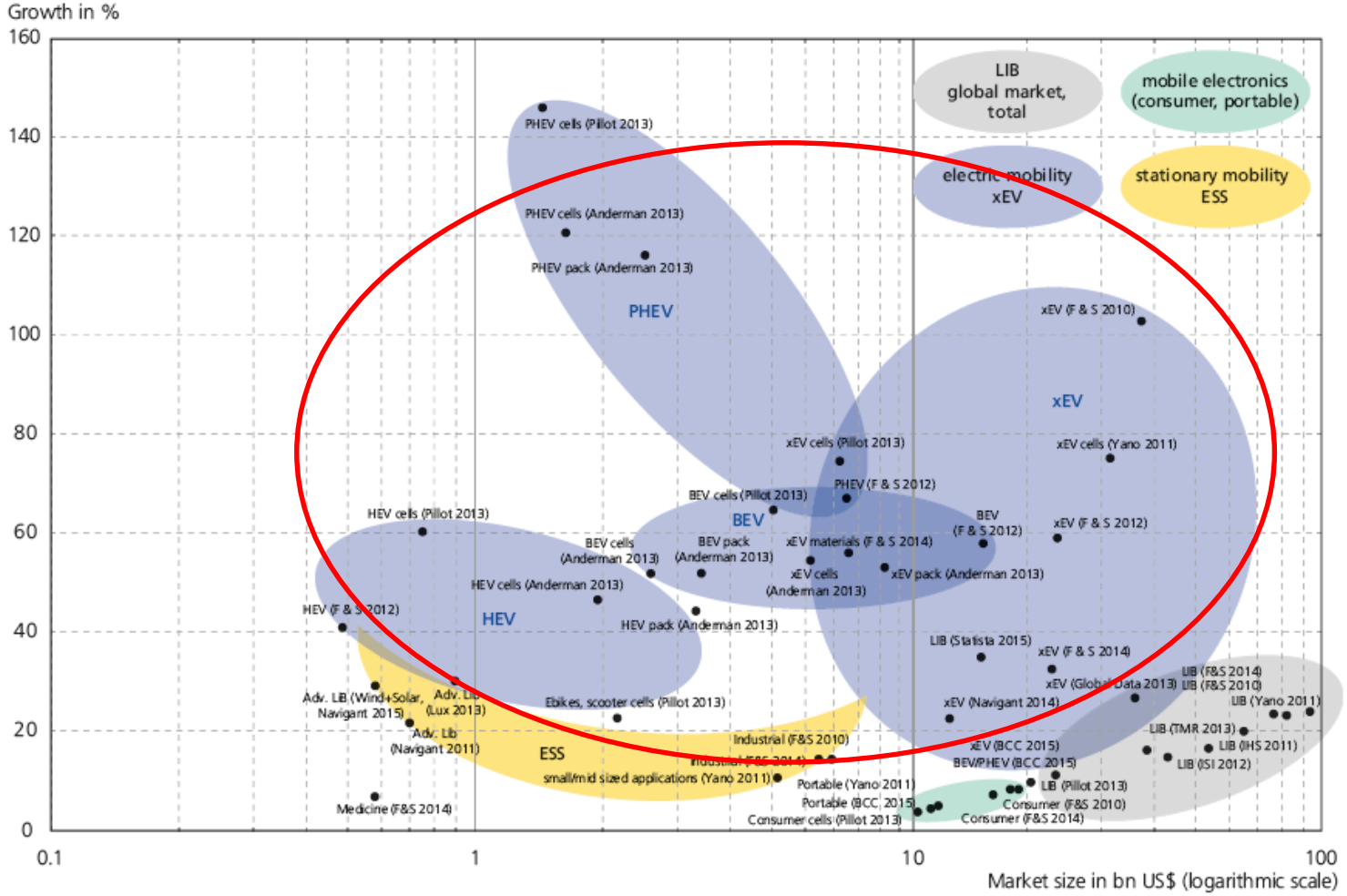
- Growing grid volatility through renewables
- Decdecentralized production
- Changing consumption patterns



Need for Storage

Electric vehicle batteries have the highest growth rates of all battery applications

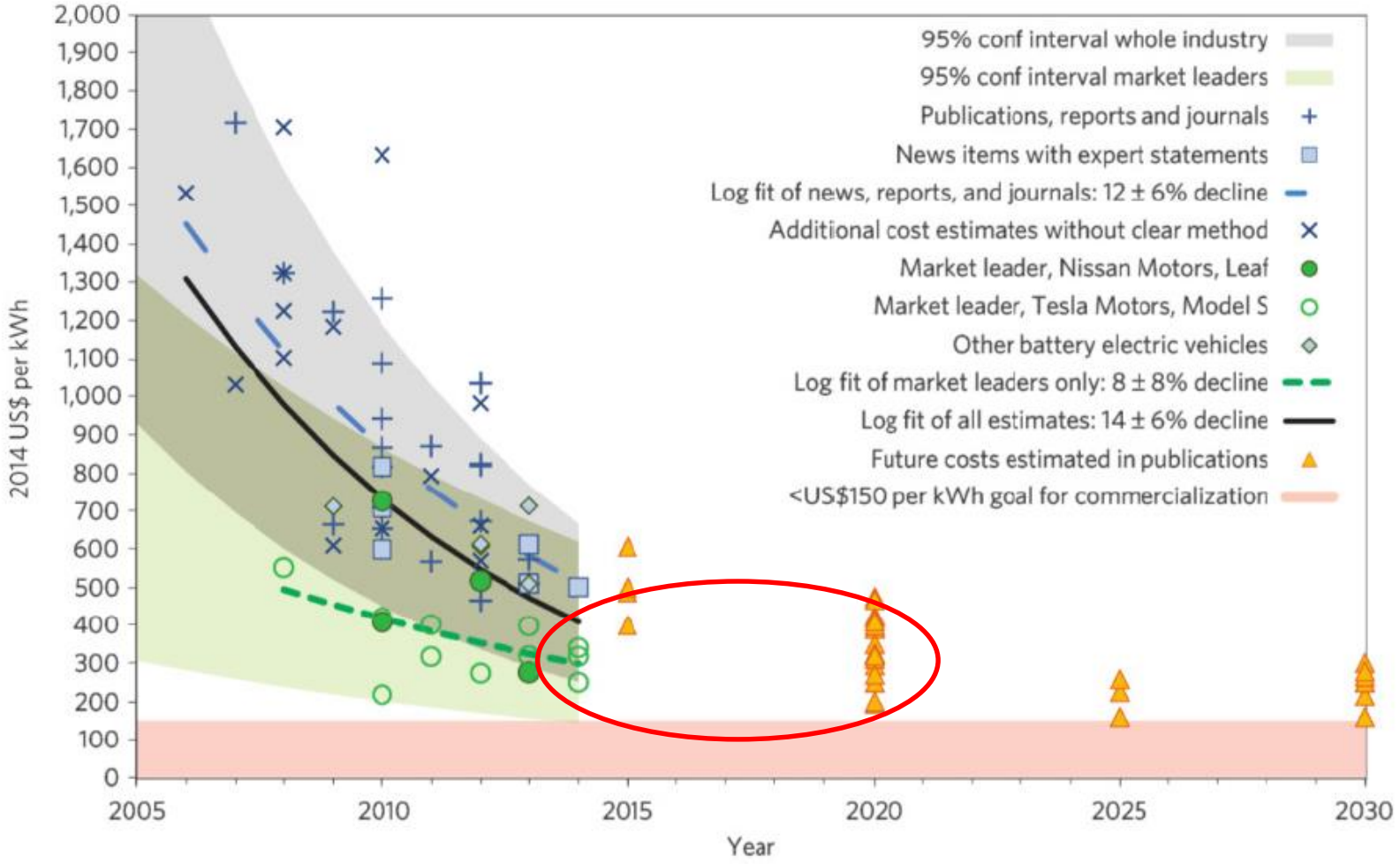
Global LiB markets 2020 by segments



Source: EES Magazine

EV production scale effects and purchasing power result in the cheapest available batteries

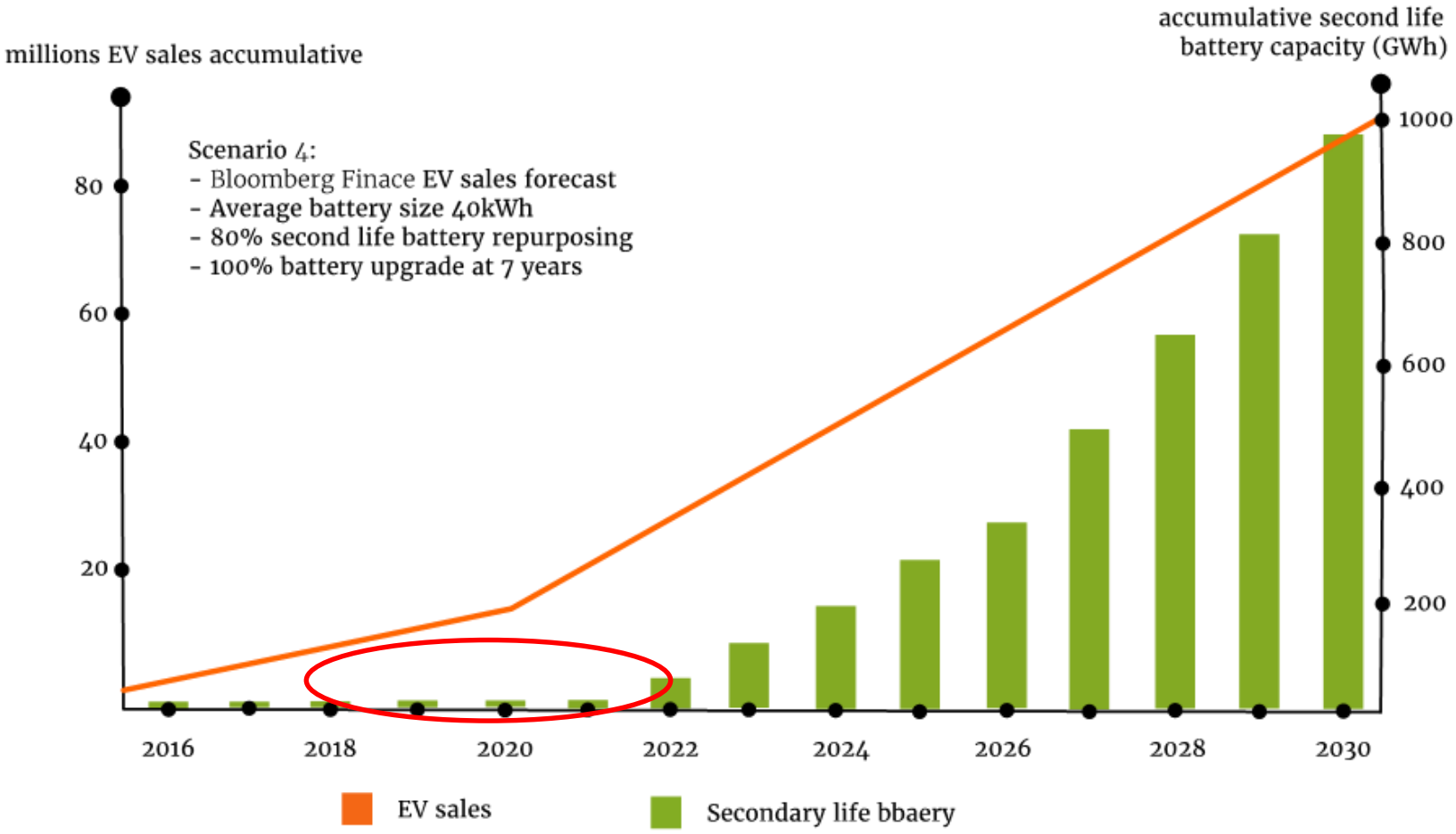
BEV LIB packs cost development by source



Source: IHS

1000 GWh 2nd-use batteries can be assumed in 2030 worldwide

Global accumulative sales of EV and 2nd-use batteries



Source: BES

Batteries are very well suited to manage short-term imbalances

Battery Storage Overview

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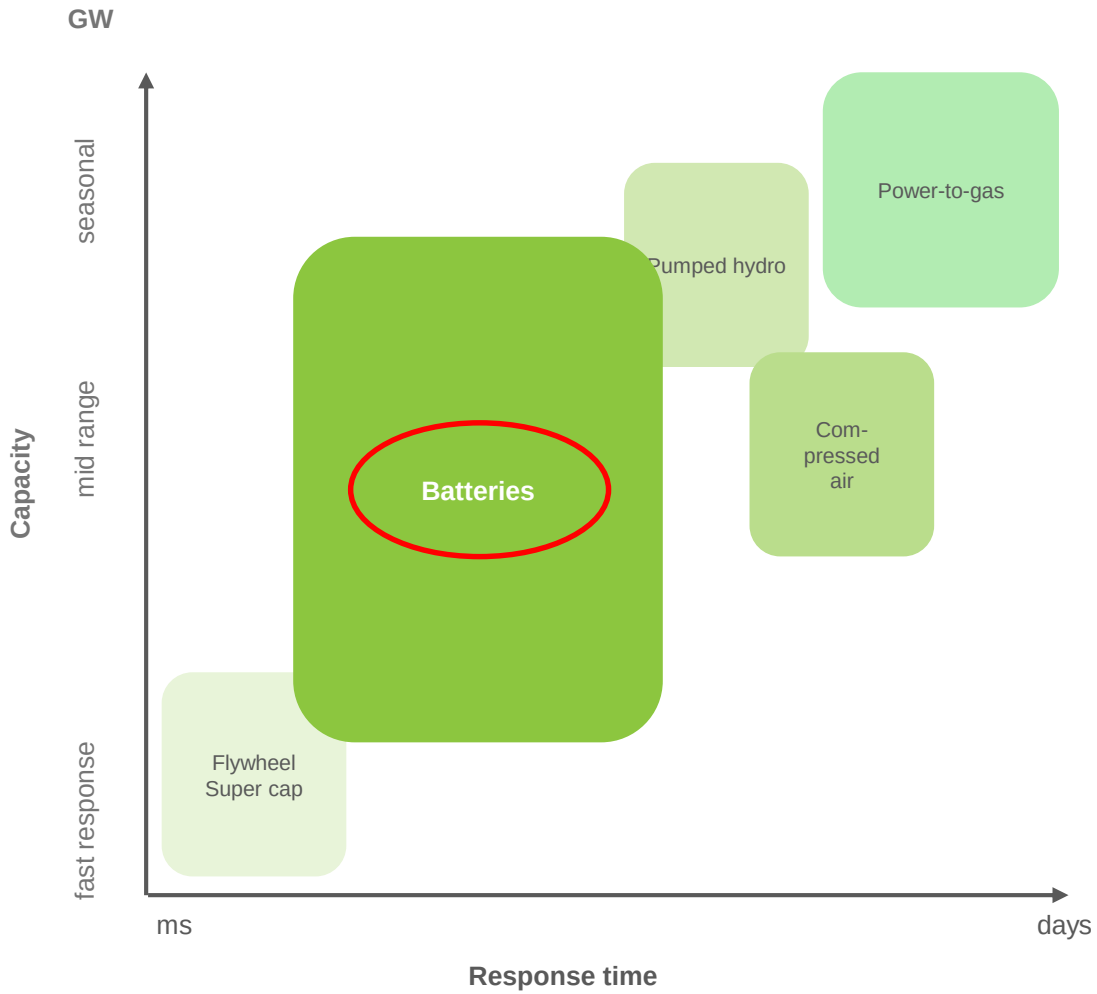

Source: The Mobility House, IHS

Vehicle batteries are the most competitive storage solution in the market

Merit Order Short-Term Storage

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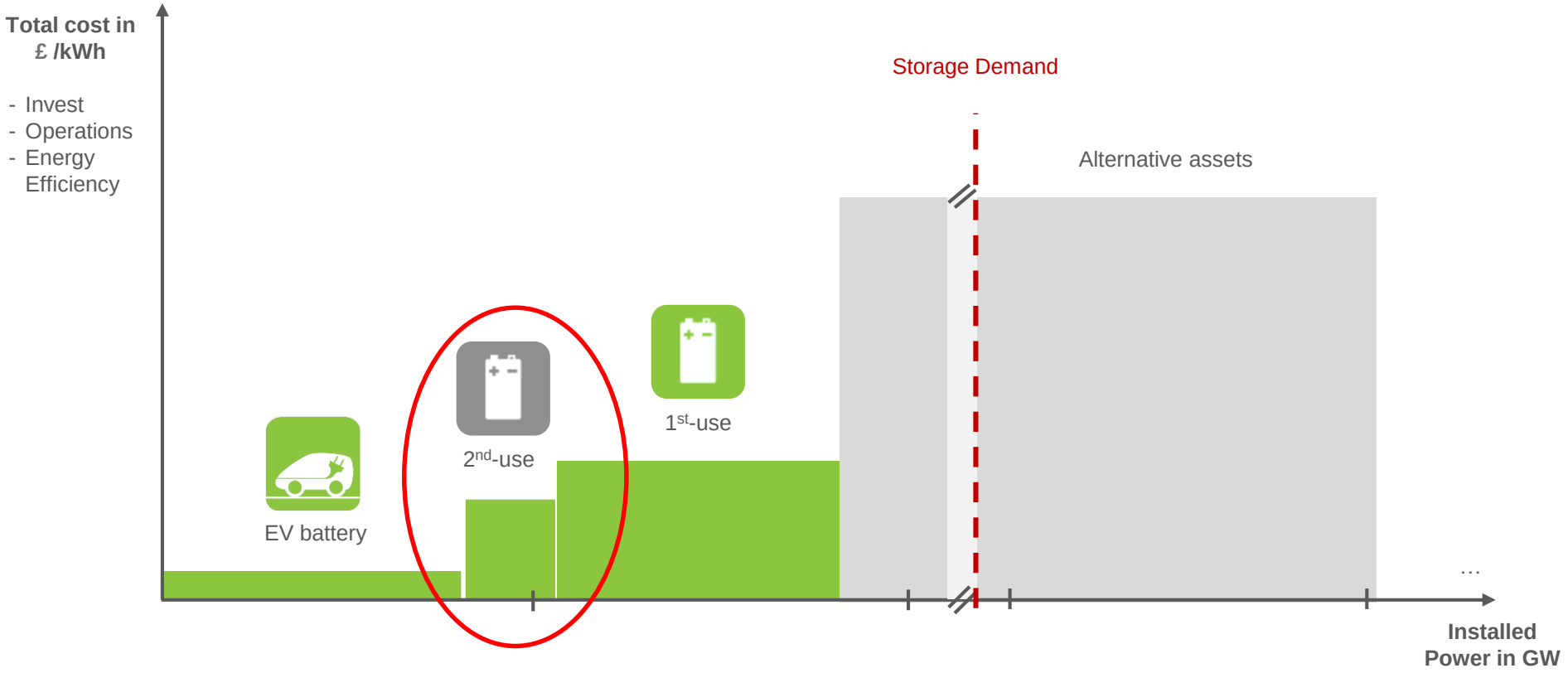
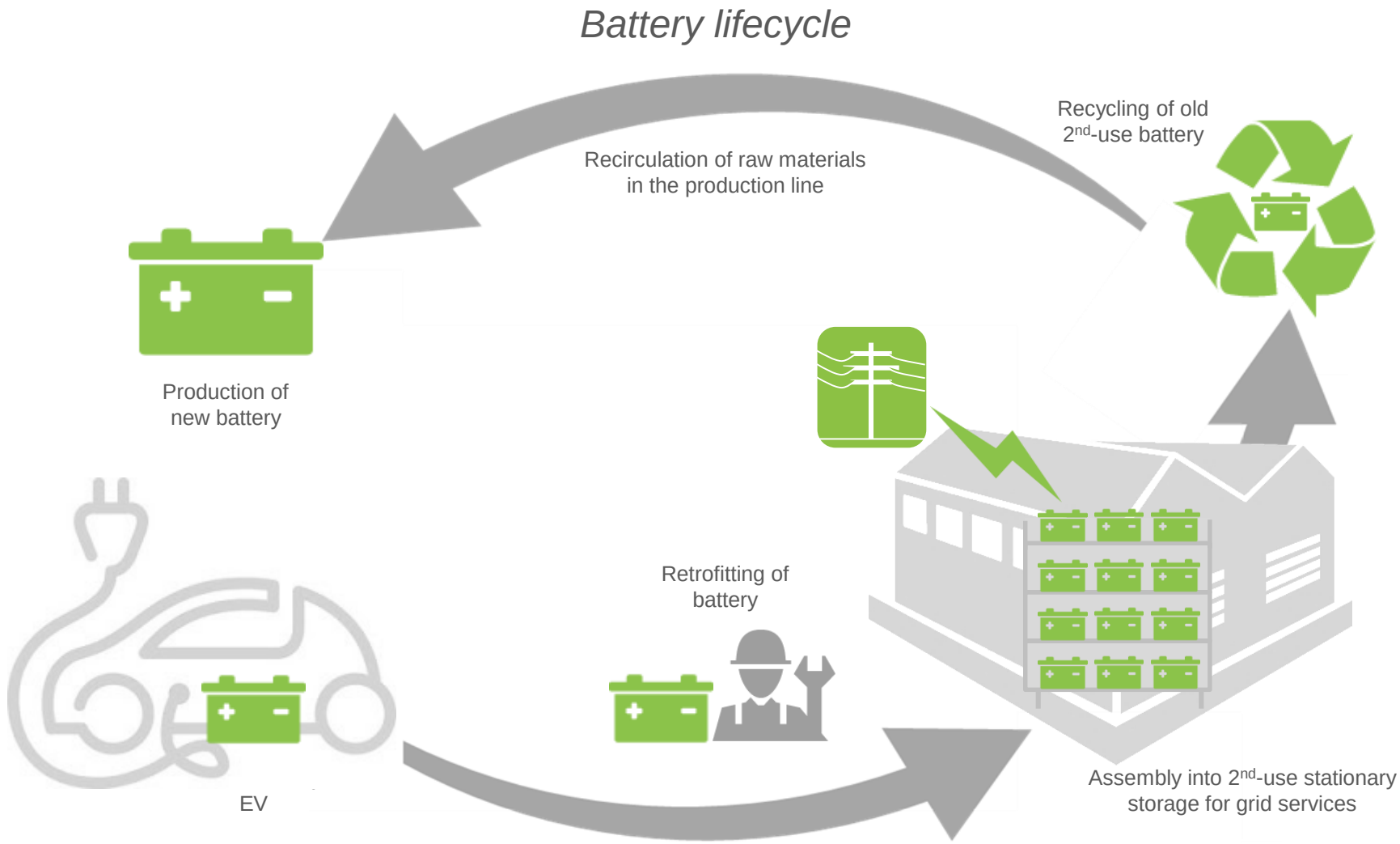


How is the process?



Source: The Mobility House

EV batteries are retrofitted to be used in stationary applications

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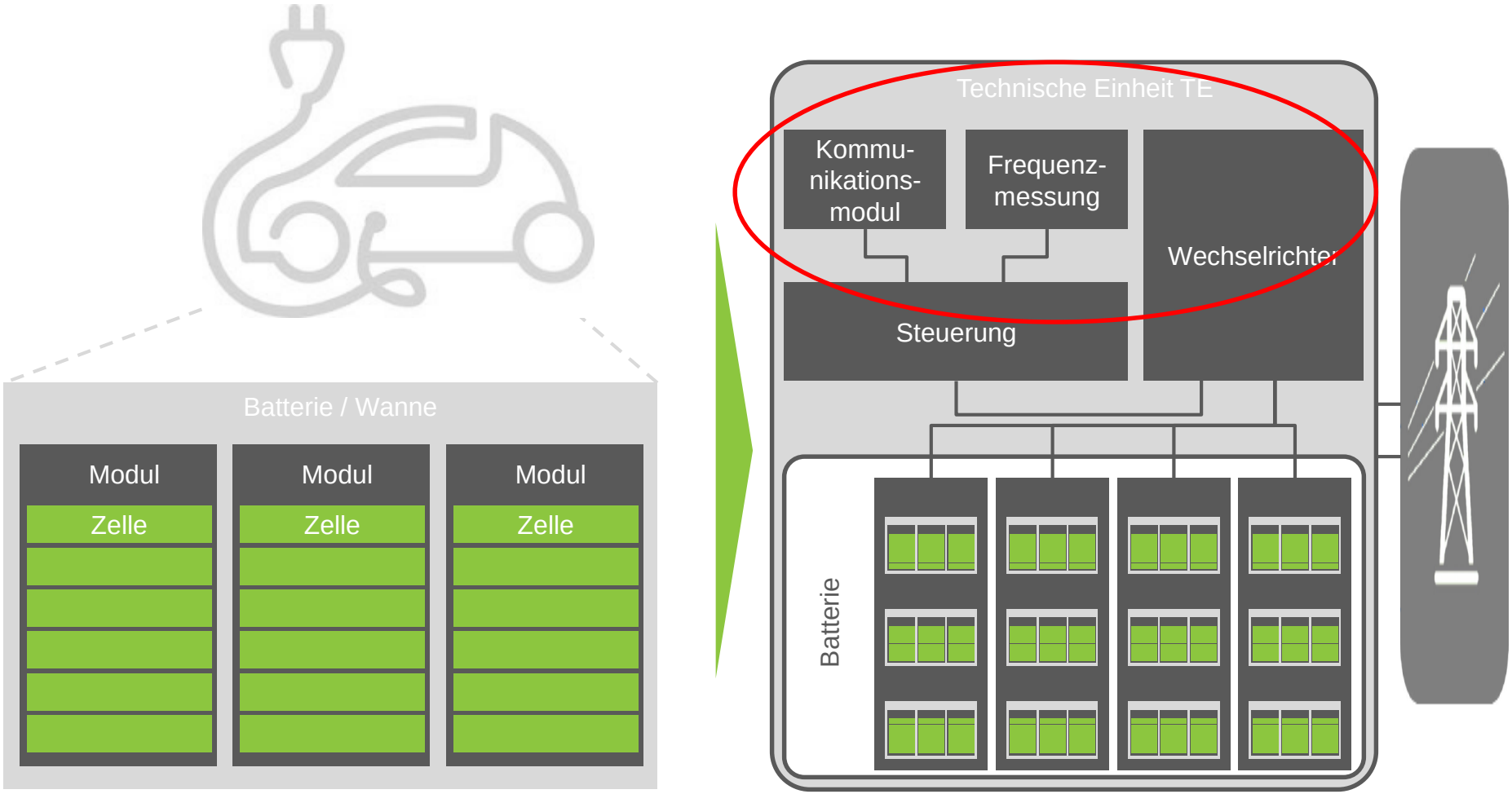
Components stationary storage



Source: The Mobility House

2nd-use applications should be already considered during software and hardware specification

Battery system requirements for 2nd-use

Software

- BMS system/charging communication should support multiple batteries connected to stationary applications
- Communication protocols should support fast reaction times and high system availability
- Battery data tracking eases 2nd-use quality evaluation

Hardware

- 2nd-use to be considered in design and dimensioning of components
- OEM designed and sourced inverter concept support cost efficiency

To realize a 2nd-use storage various process steps and stakeholders need to be coordinated

Stationary storage process model

Battery sourcing	Battery applications	Battery logistics	Technical retrofit	Location setup	Financing setup	Commercia-lization	Recycling
• Source 2nd-use from OEM • Source 1st use from OEM, … • Define cooperation models with OEM • Define financing models • Define pricing categories • Prepare sourcing contracts • Source 3rd party batteries	• Define applications (utility, industrial, commercial) • Contract applications • Define technical specifications	• Define Dealer/OEM logistics • Perform logistics	• Define technical realization partners • Realize site manager • Analyze and categorize batteries • Define retrofit concept • Retrofit batteries • Source accessory (inverter, …) • Realize complete site assembly (racks, inverter, …)	• Scout and evaluate locations • Define locations • Perform approval process • Setup location • Perform logistics • Install and implement site • Perform onsite inspections and approvals	• Define financial partners • Prepare contractual designs • Provide financial setup	• Perform pre-qualification • Establish communication and control and swarm management • Perform maintenance and repair • Perform accounting • Perform trading, balancing group management, metering • Provide control room	• Perform recycling if OEM batteries • Define partner for non OEM batteries • Contract partner

OEM value chain integration also not decided today

OEM battery value chain

2nd-use storage application are multiple …

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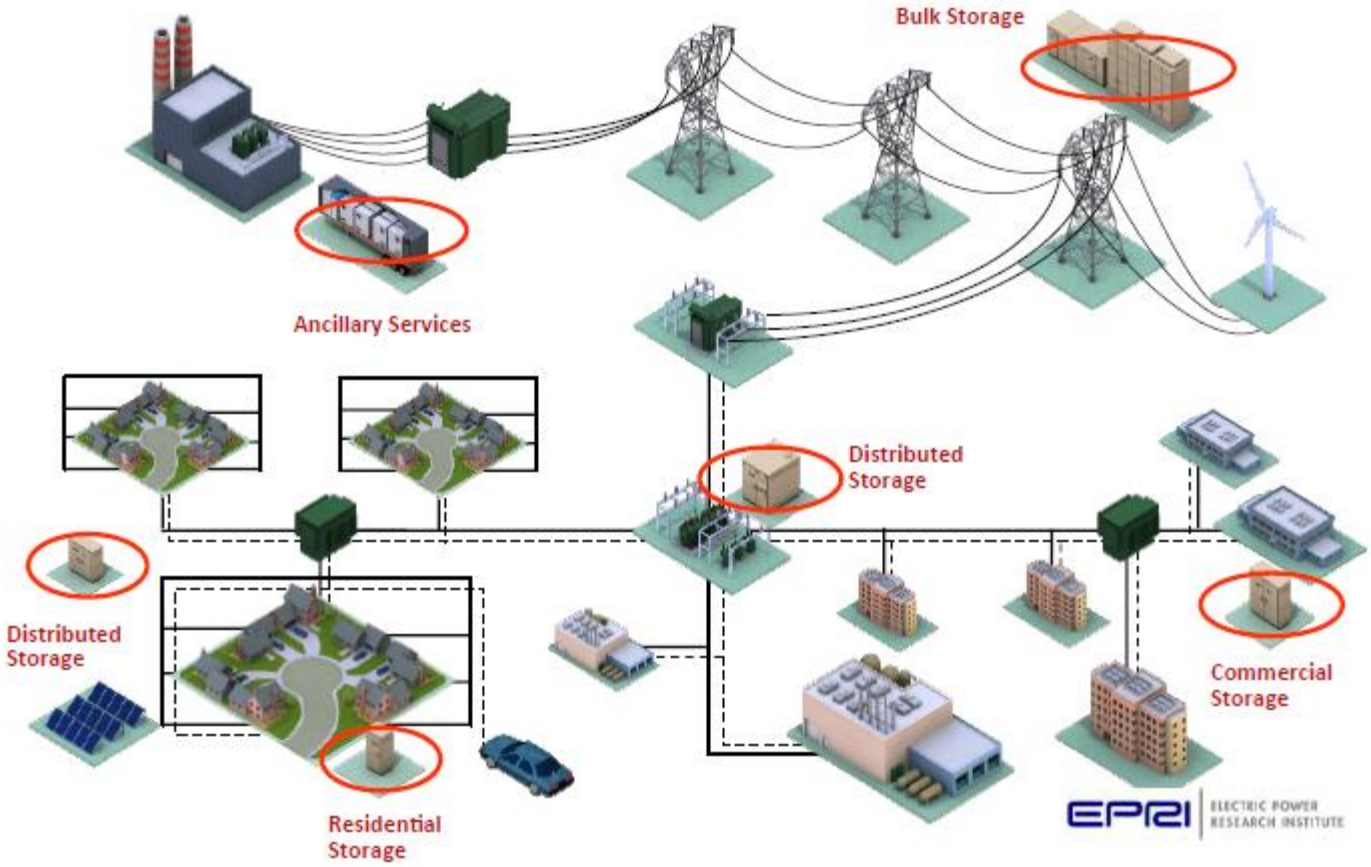
Stationary storage applications



Source: EPRI

… and adress various stakeholders

Stationary storage applications by stakeholder

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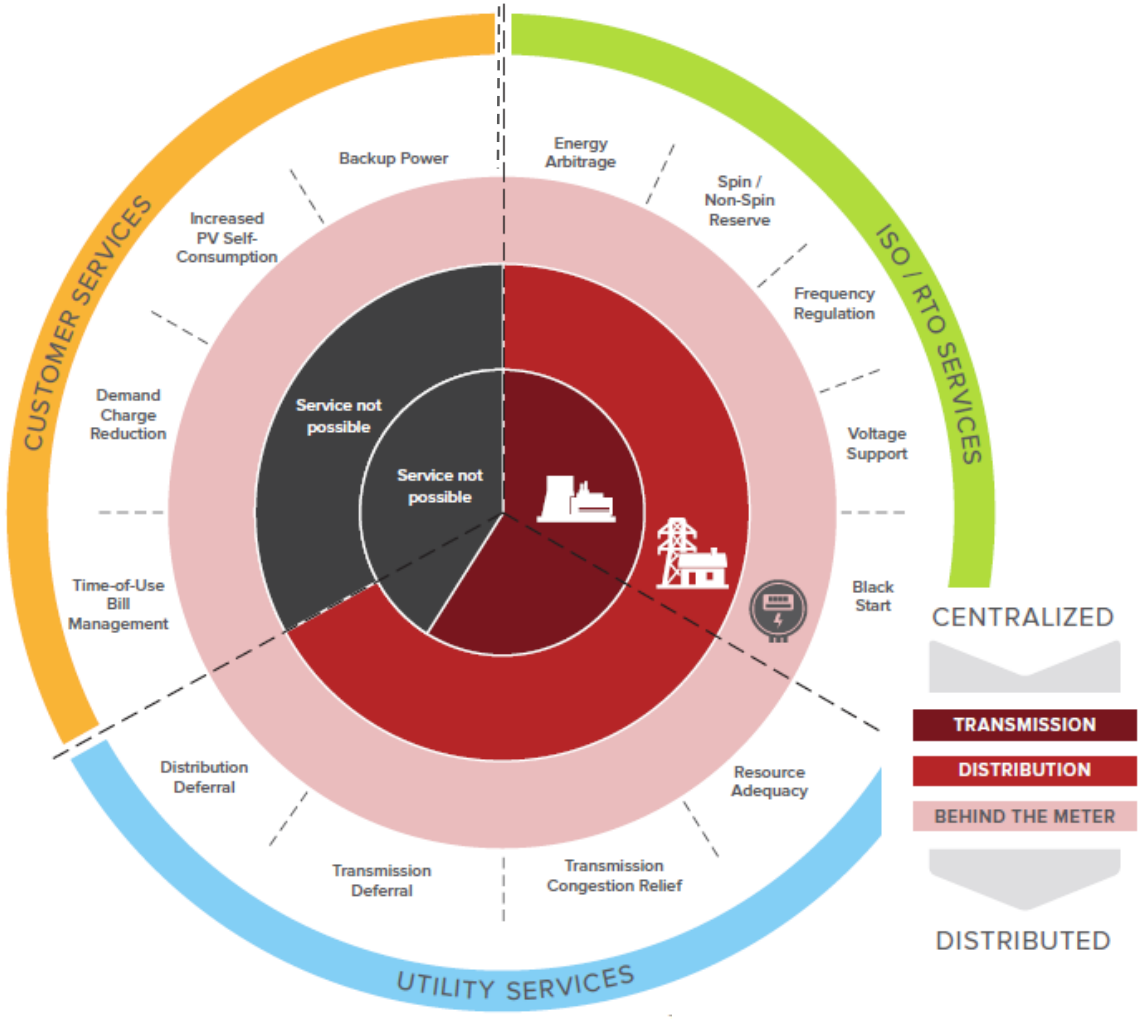
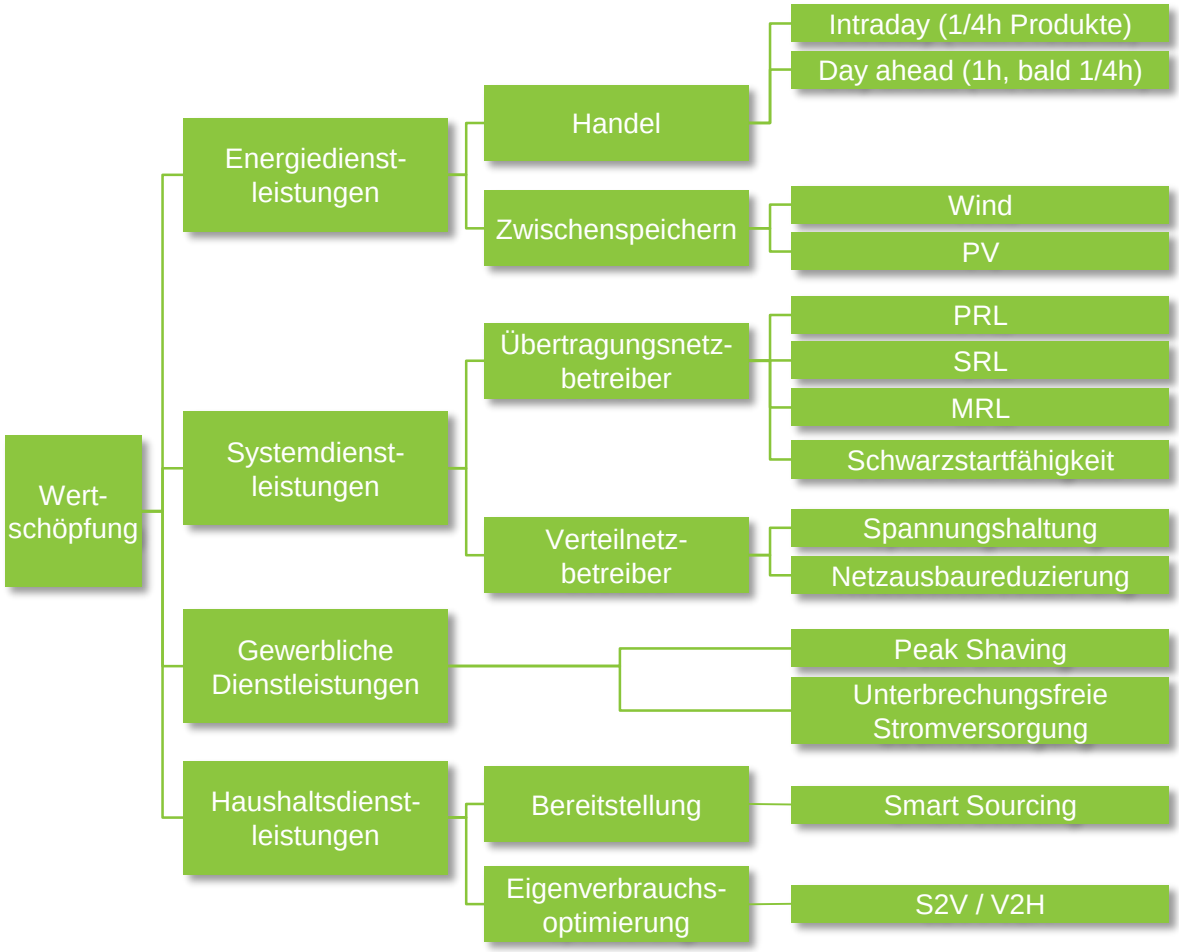


Source: The Mobility House, Rocky Mountain Institute

Products in Germany vary in access and profitability …

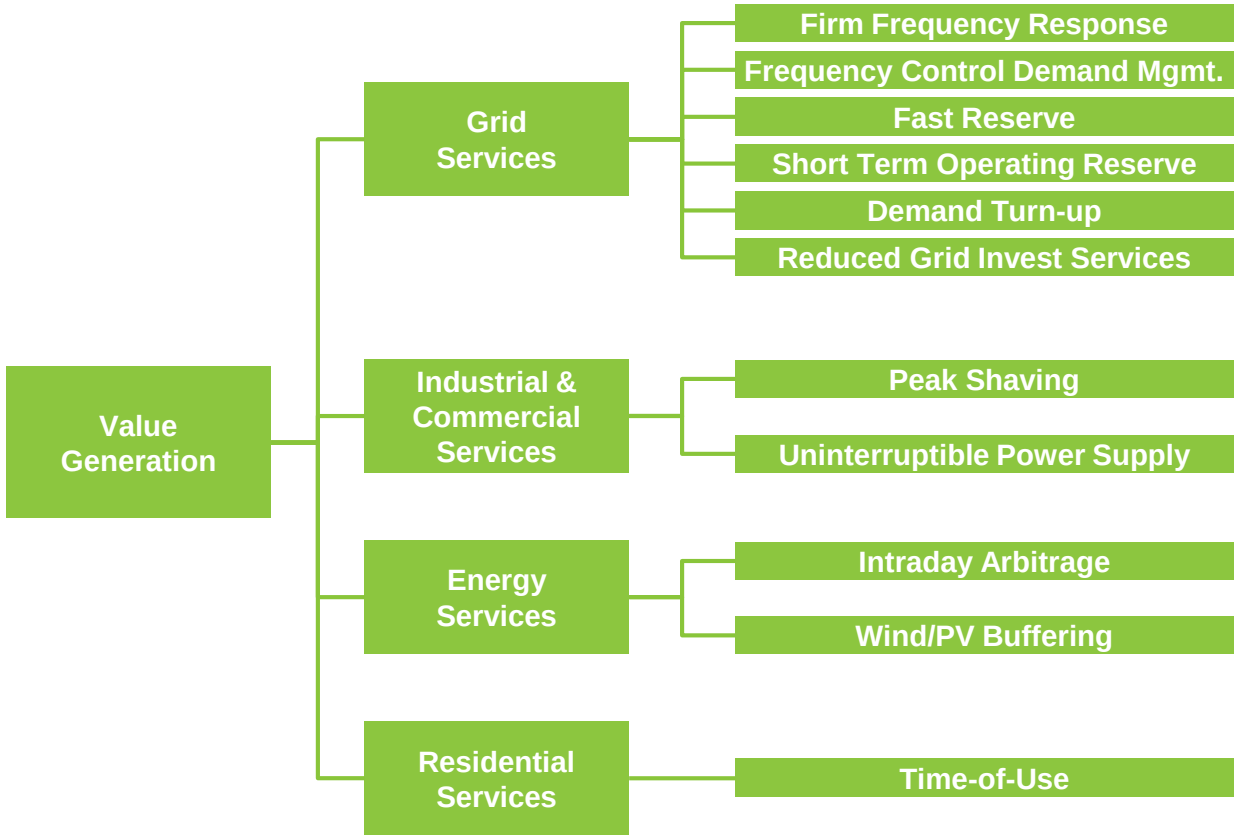
SELECTION

Products applicable for storage



… from products in UK. New product emerge subsequently

Products applicable for storage



CONFIDENTIAL
Source: The Mobility House, National Grid

Value of storage increases over time

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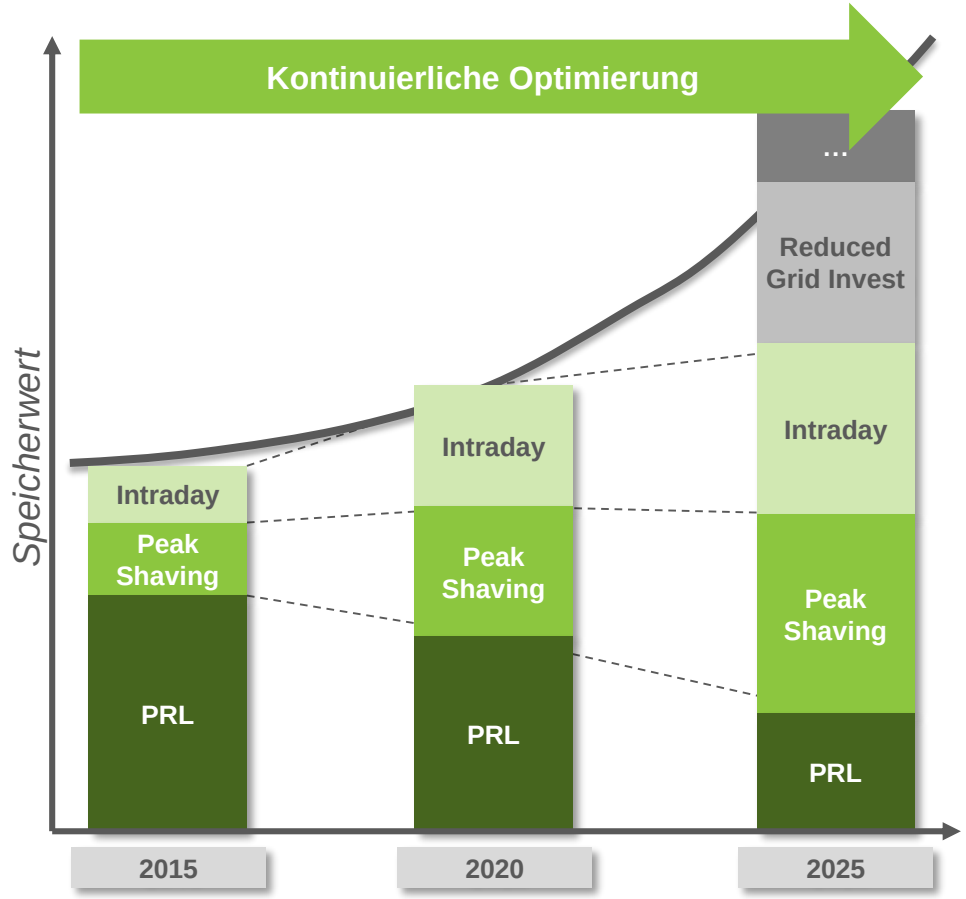
Development of storage value



Smart product stacking is a key success factor

Overview of operating modes

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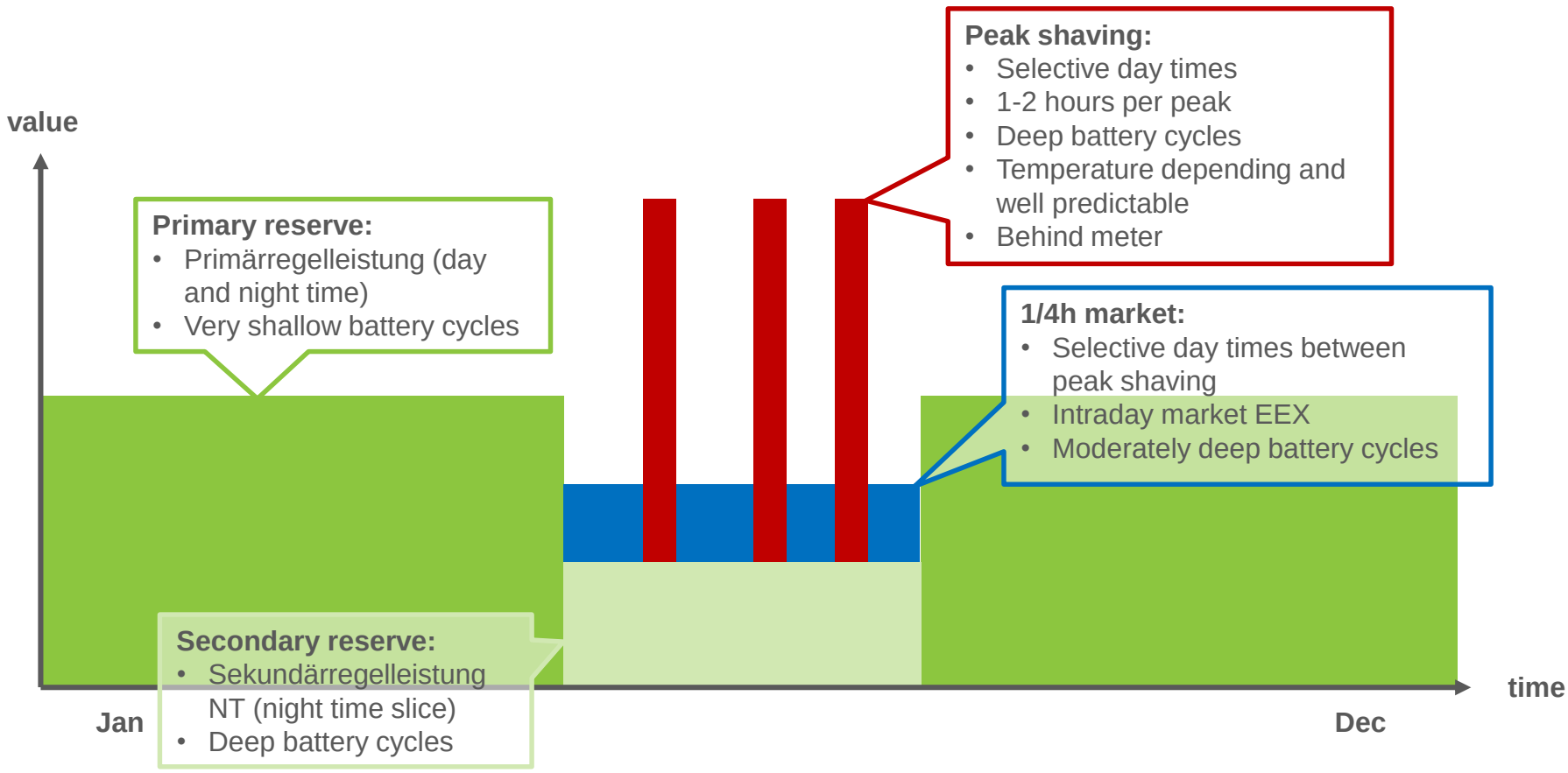

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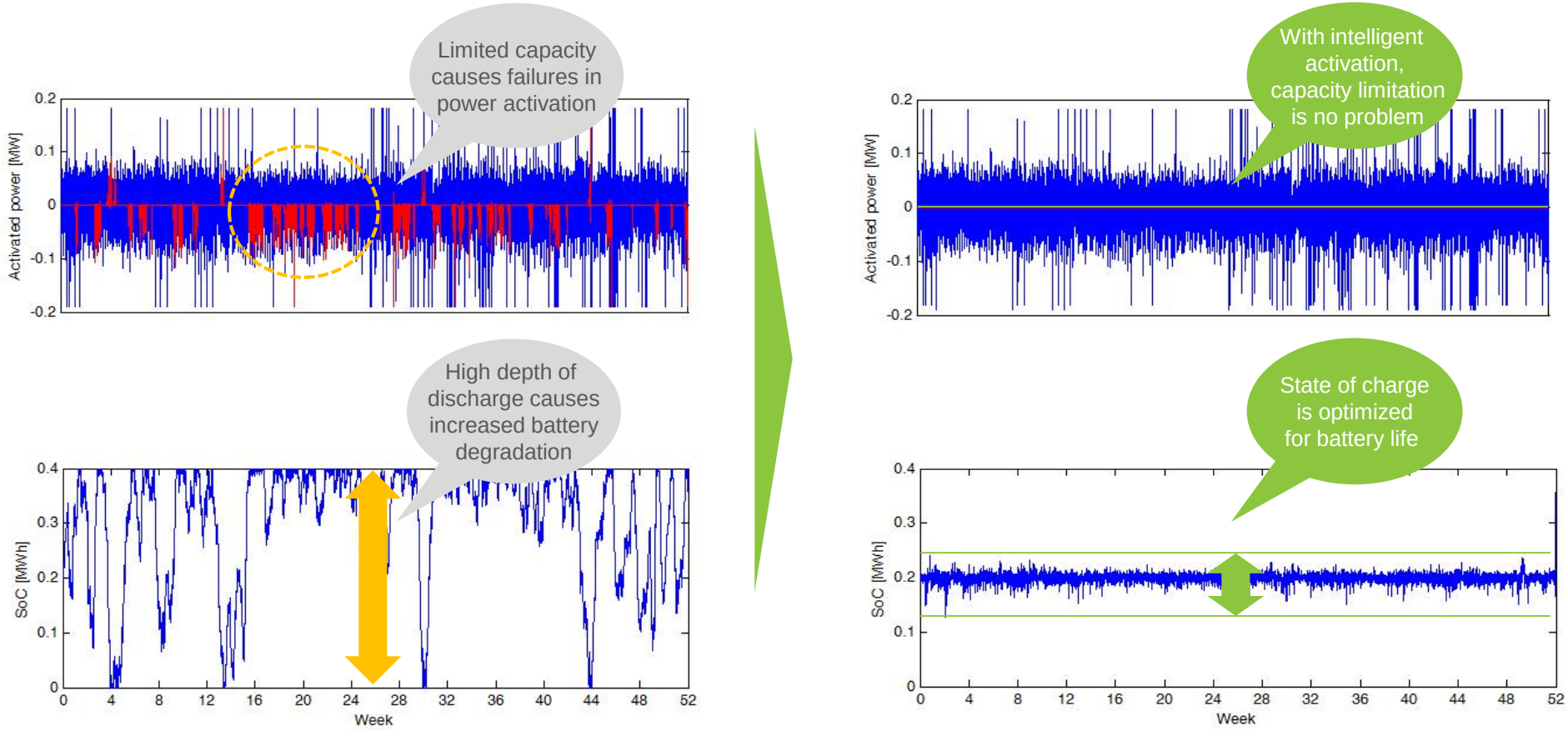
Source: The Mobility House

… and secures battery lifetime

Comparison unmanaged/managed grid services



2nd life application depends on DoD development

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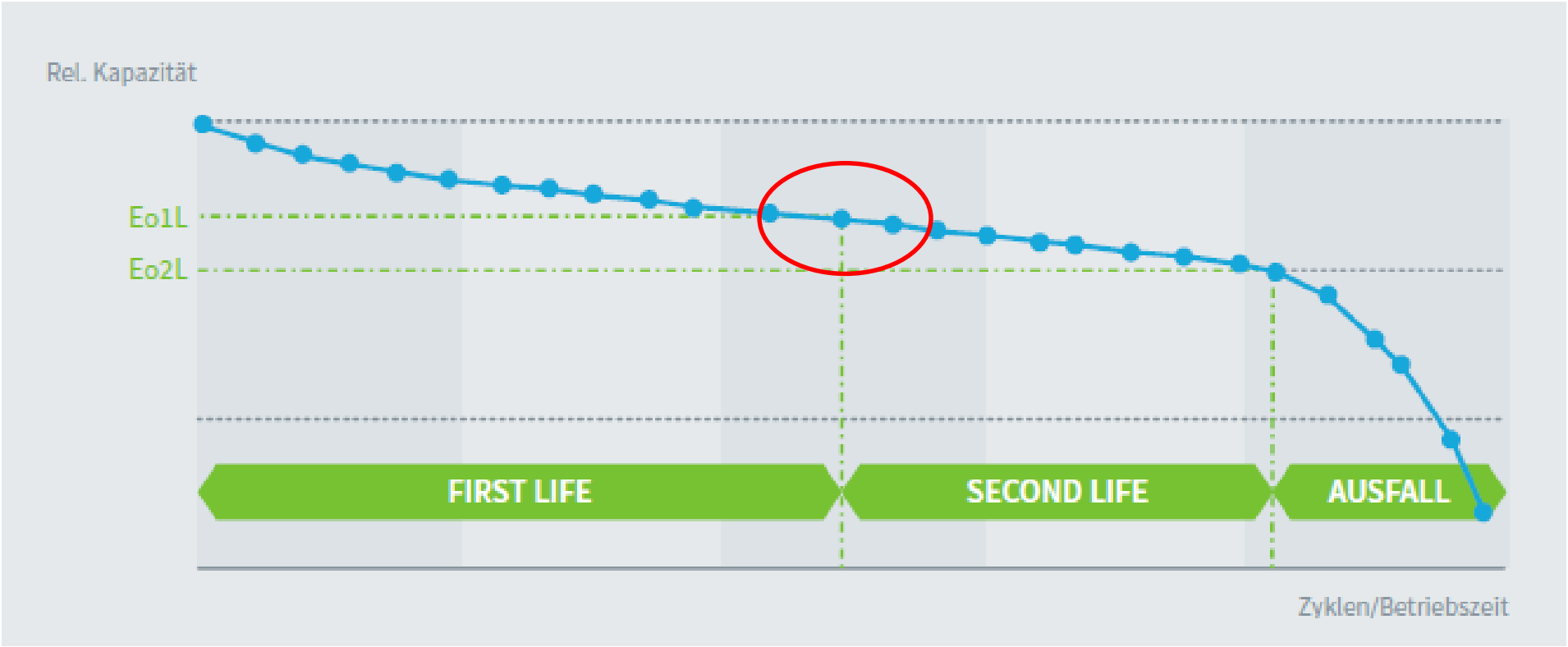
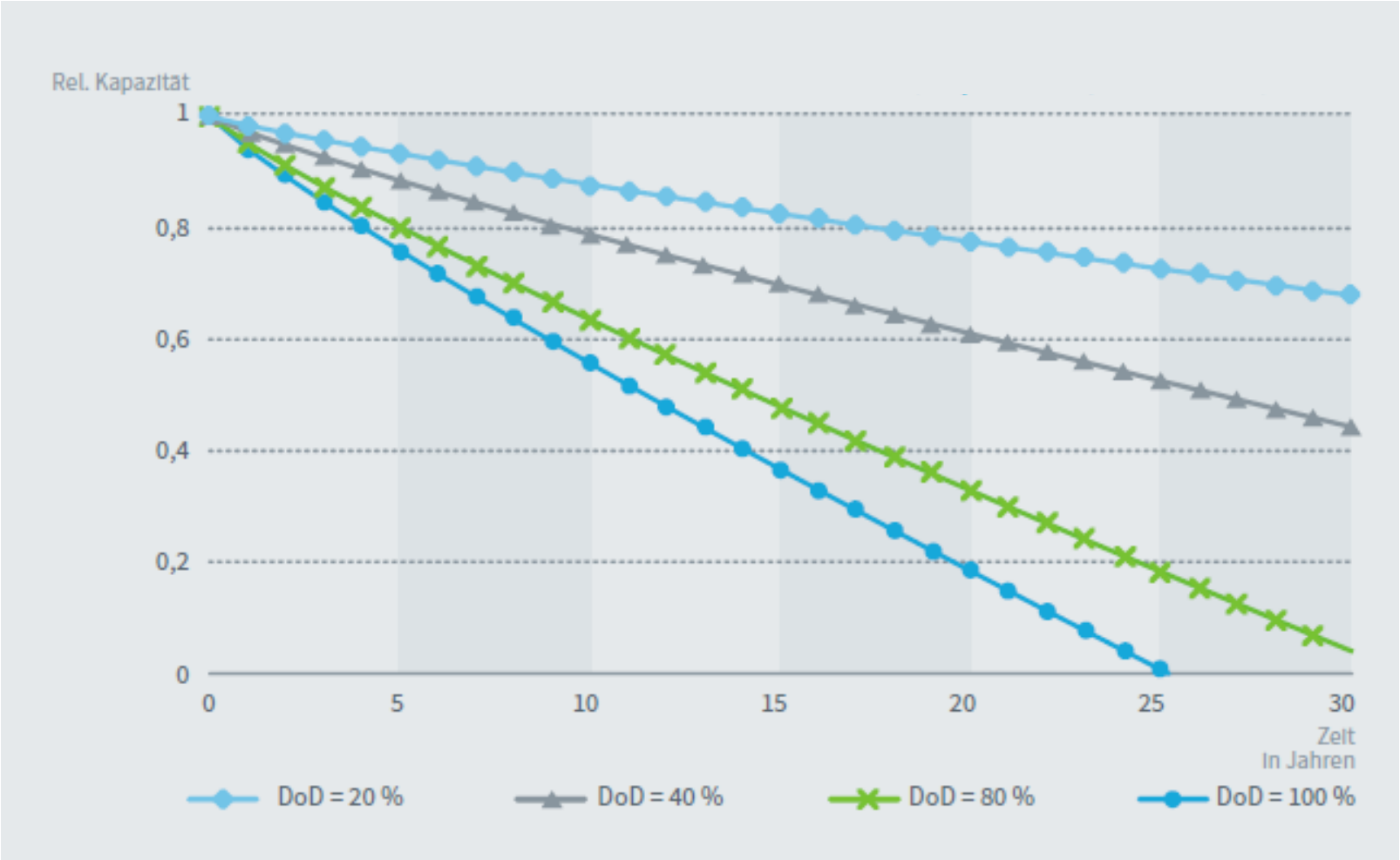
Capacity development over time



Source: VDE

Different products cause different stress …

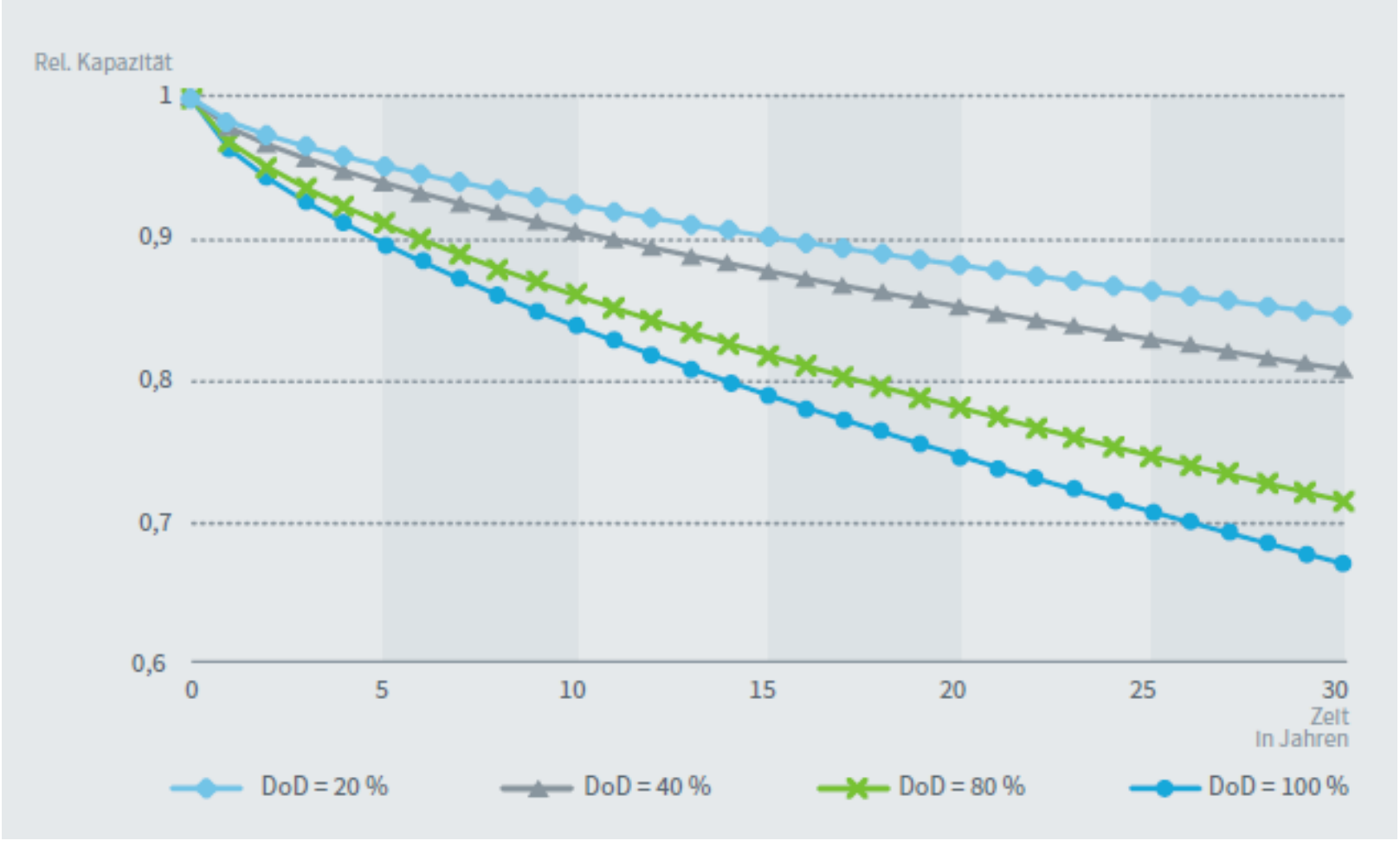
HES storage aging per DoD



Source: VDE

… over lifetime

PRL storage aging per DoD

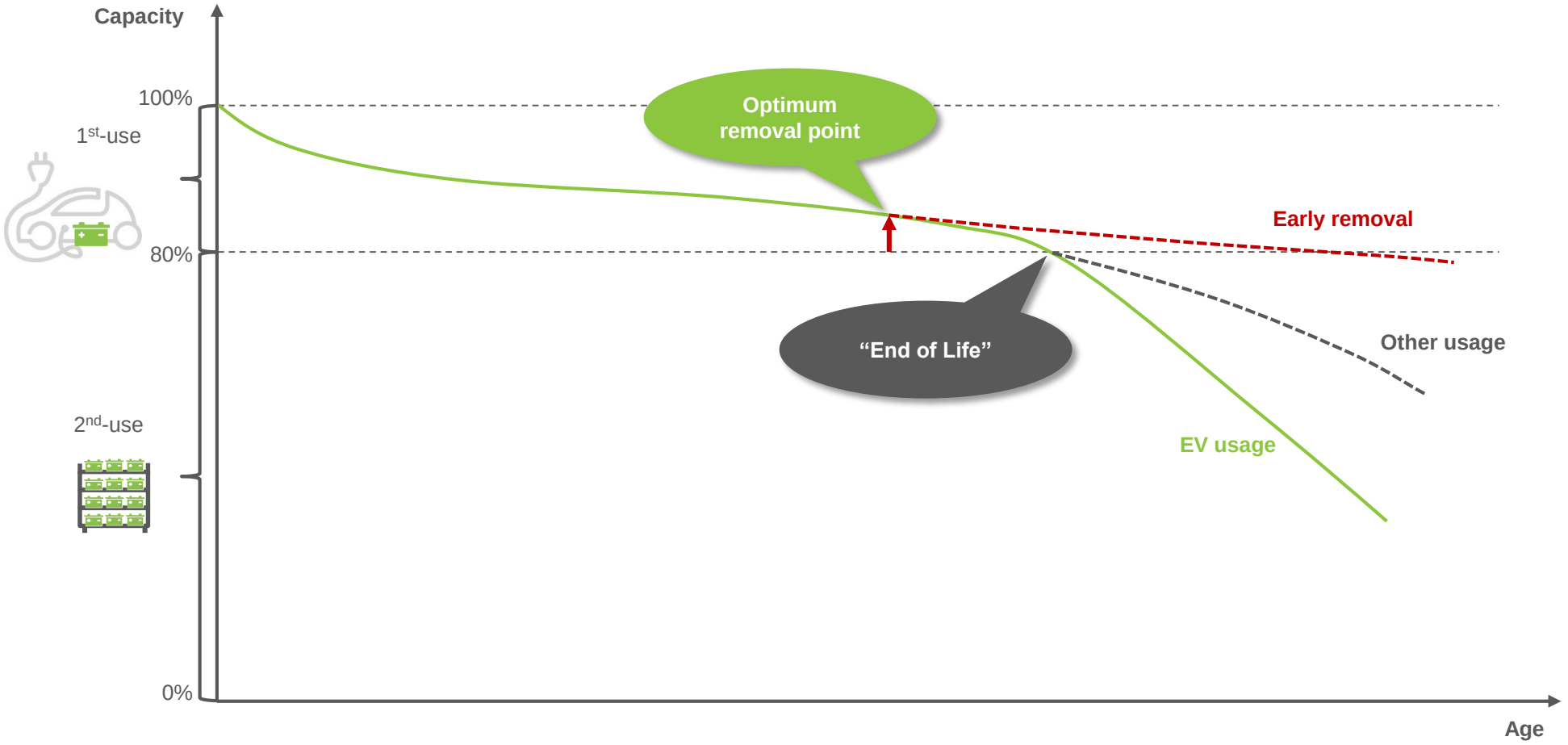


Source: VDE

The second life value is interdependent with 1st-use battery degradation and should be considered to maximize total value

SCHEMATIC

Battery 2nd-use optimization



Source: The Mobility House, TUM

Minimum retrofitting costs and optimized commercialization drive the case

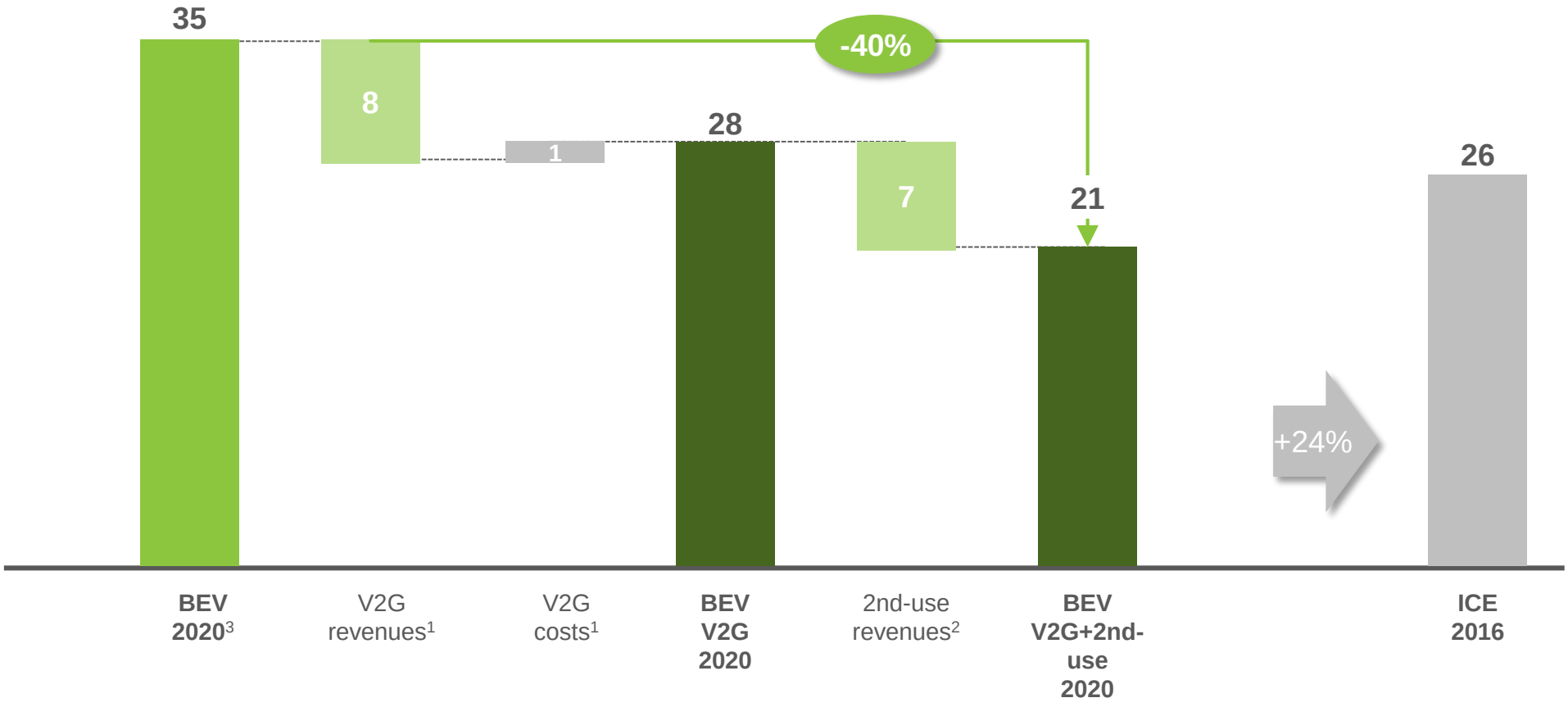
SCHEMATIC

2nd-use cost components

Source: DNV-GL

TMH assumes between 5-15kEUR of 2nd-use value for a car manufacturer

TCO without/with energy management (in k€ for 48 month)



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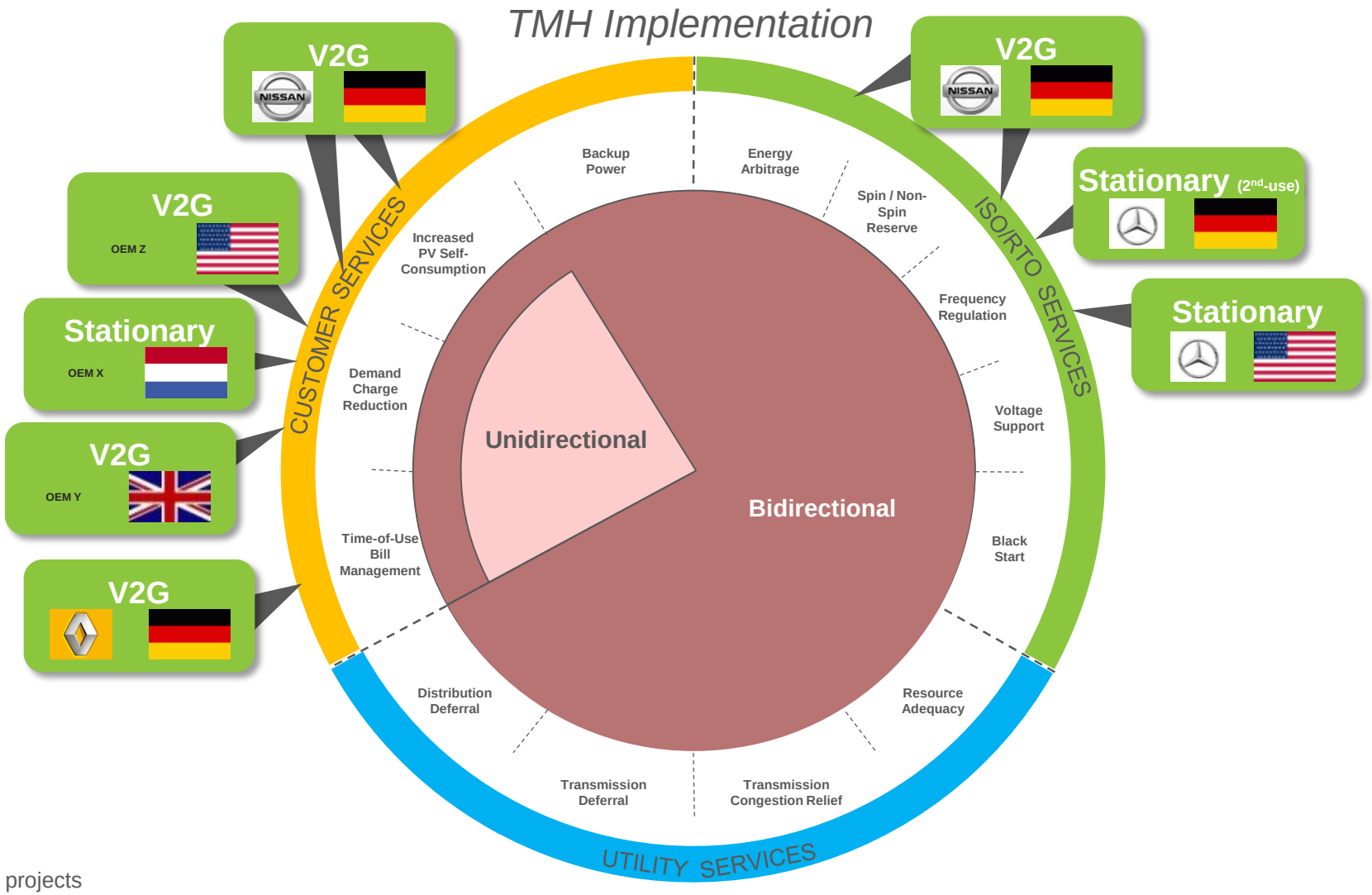
[2] savings from 2nd-use; 100% of OEM share (70%) passed on to the customer; w/o recycling savings
Battery size 60kWh

Source: The Mobility House, P3 Group, ADAC

TMH builds a variety of battery service applications



TMH projects

Source: The Mobility House, Rocky Mountain Institute

What else?

Regulatory framework

- Einen bezüglich Ausschreibungszeiten, Mindestmengen und Leistungserbringung **diskriminierungsfreien Zugang von dezentralen Speichern** und Schwarmlösungen zum Energie- und Regelleistungsmarkt.
- Eine **leistungsgerechte Vergütung von Netzdienstleistungen**, welche sich an wichtigen Leistungskennzahlen wie Genauigkeit und Reaktionsgeschwindigkeit orientiert.
- Kostensenkungen in der Netzinfrastruktur durch **dezentrale Speicher als gleichberechtigte Option** im Netzentwicklungsplan.

Source: The Mobility House