FEV CONSULTING

24. MAY 2023

KILIAN SAGNER,
SOFIA ARTOLA

THE BATTERY SHOW
EUROPE

WILL LI-ON BATTERY RECYCLING EVER BECOME COST-EFFECTIVE?

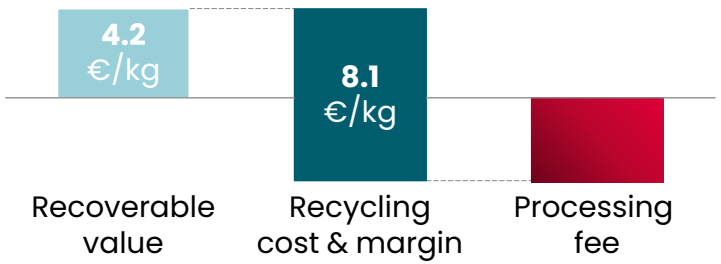
FEV CONSULTING

Decreasing costs & improved material recovery will make battery recycling cost-competitive, putting a price on end-of-life batteries instead of a fee

// For NMC cells // Constant material prices

−3.90 €/kg

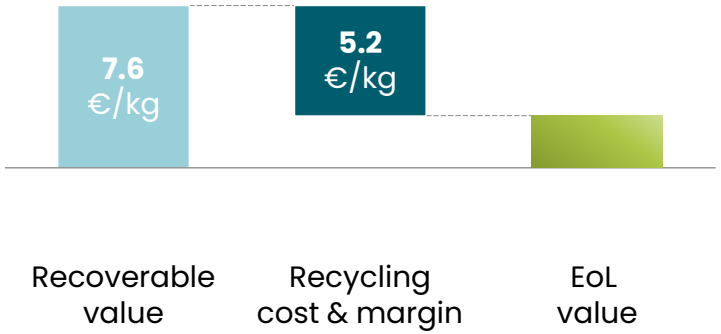
Processing fee



Today

+2.40 €/kg

EoL battery value



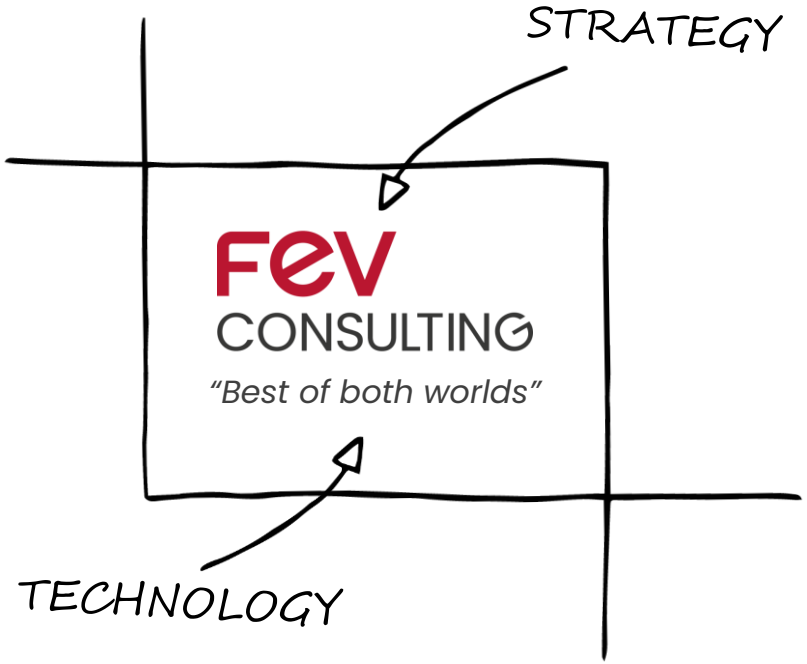
2040

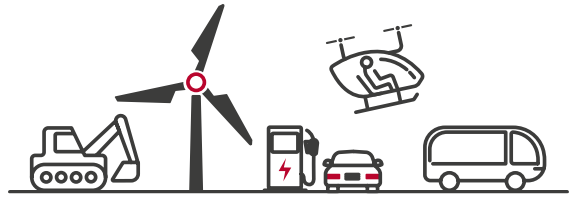
Note: EoL = End of Life; constant material prices relating to May 2021 before steep increases;
costs today assume black mass production at 8k t/a (future: 15k t/a) and metal extraction at 10k t/a (future: 150k t/a)

FEV Consulting offers solutions for top management issues in a techno-strategic environment – strong project collaboration with FEV engineers

120

CONSULTANTS
AROUND THE GLOBE

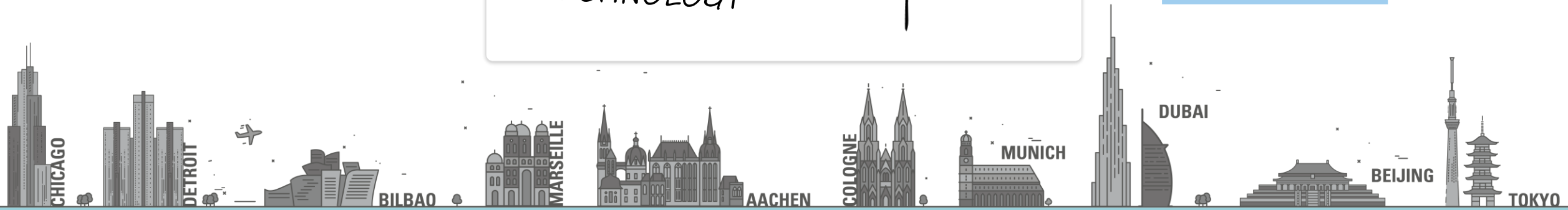




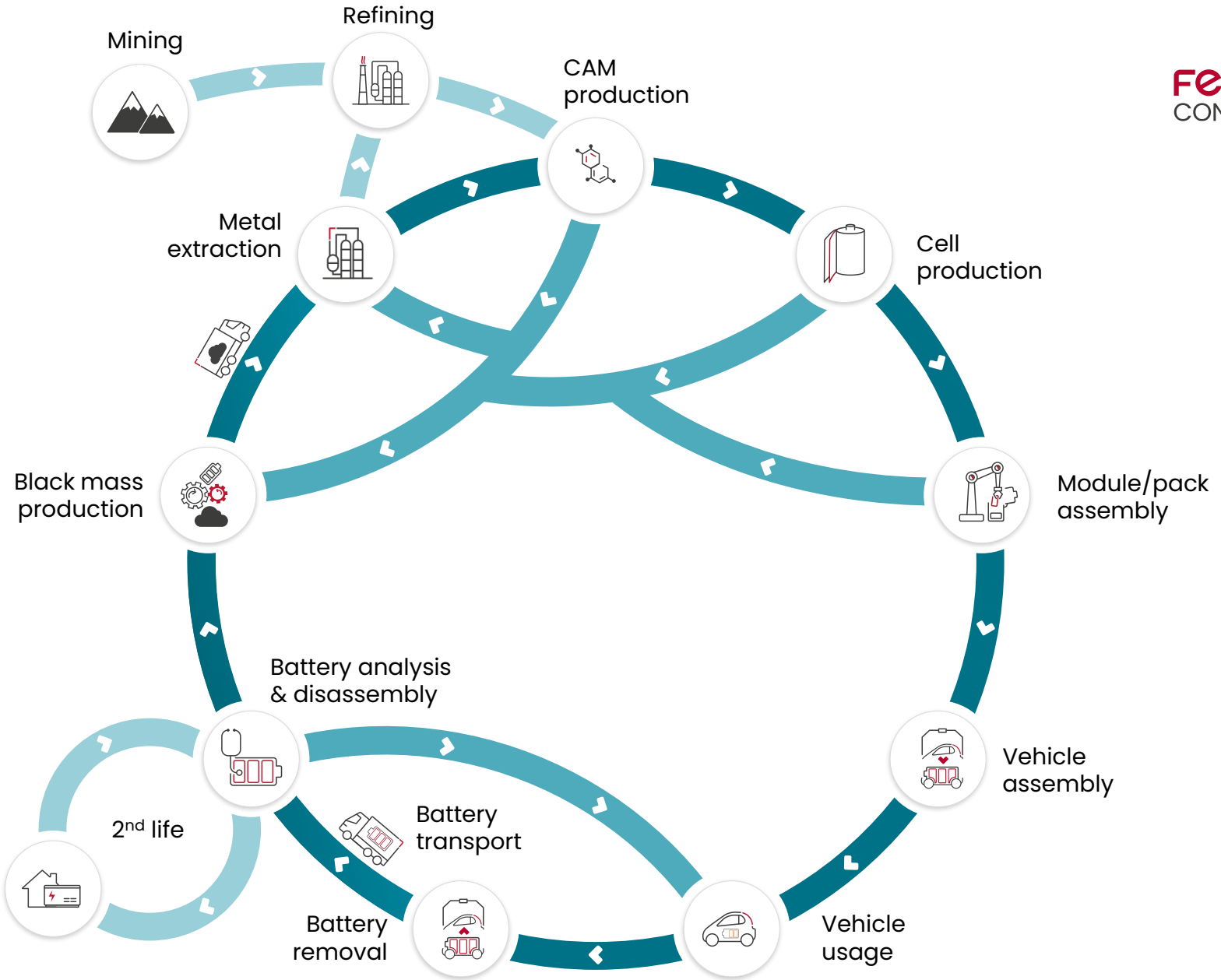
INDUSTRIES

Forbes 2022
WORLD'S BEST MANAGEMENT CONSULTING FIRMS
POWERED BY STATISTA

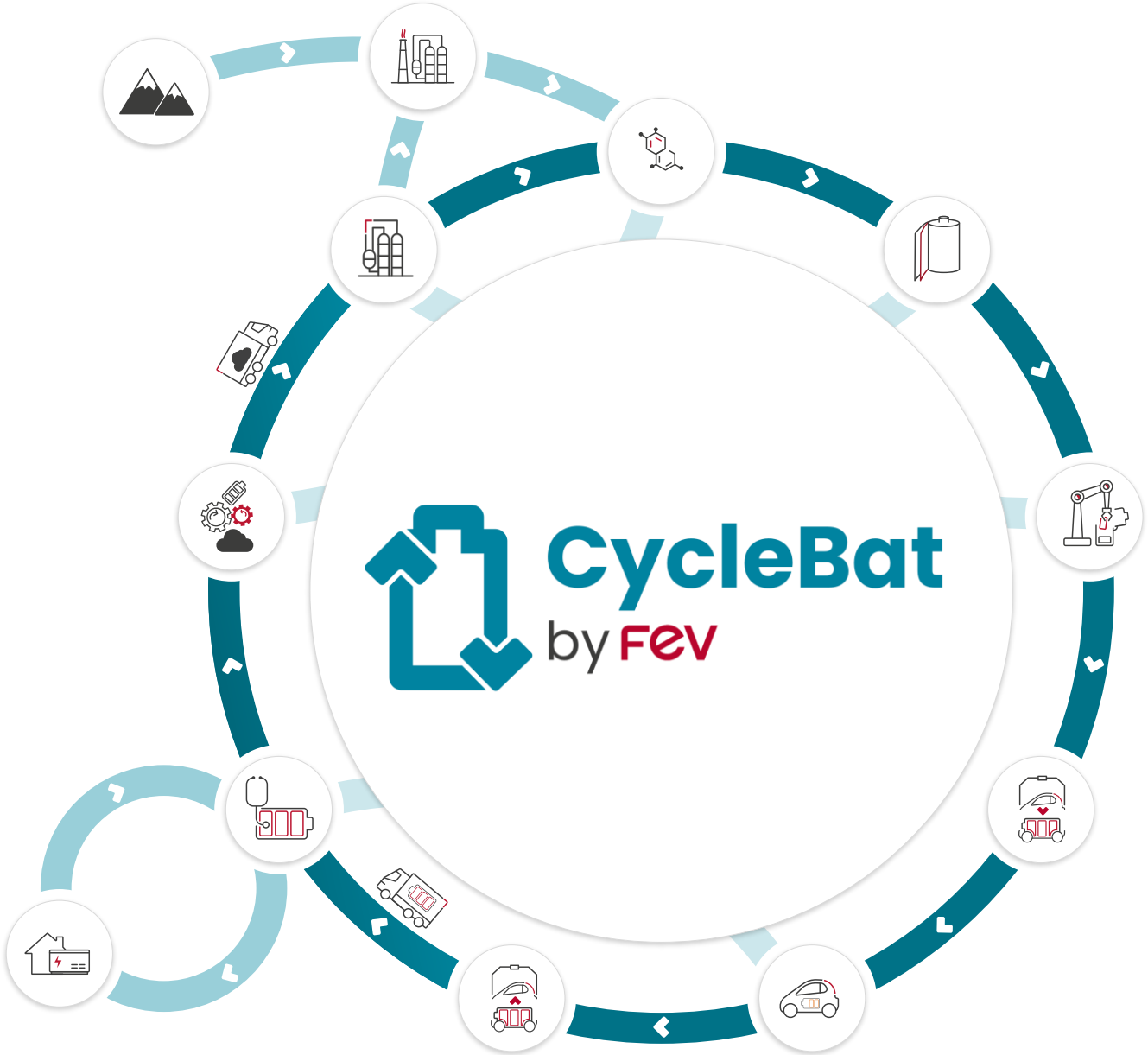
brandeins /thema
2022
Beste Unternehmensberater



BATTERY CIRCULAR ECONOMY



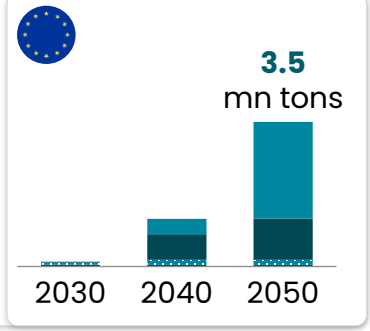
FEV CONSULTING



FEV CONSULTING

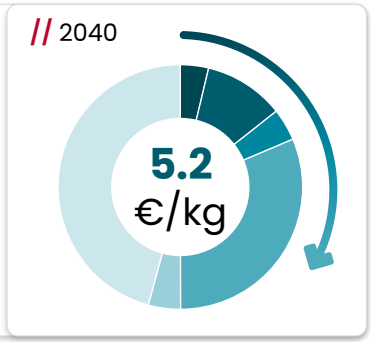
CycleBat market by FEV

Recycling Demand

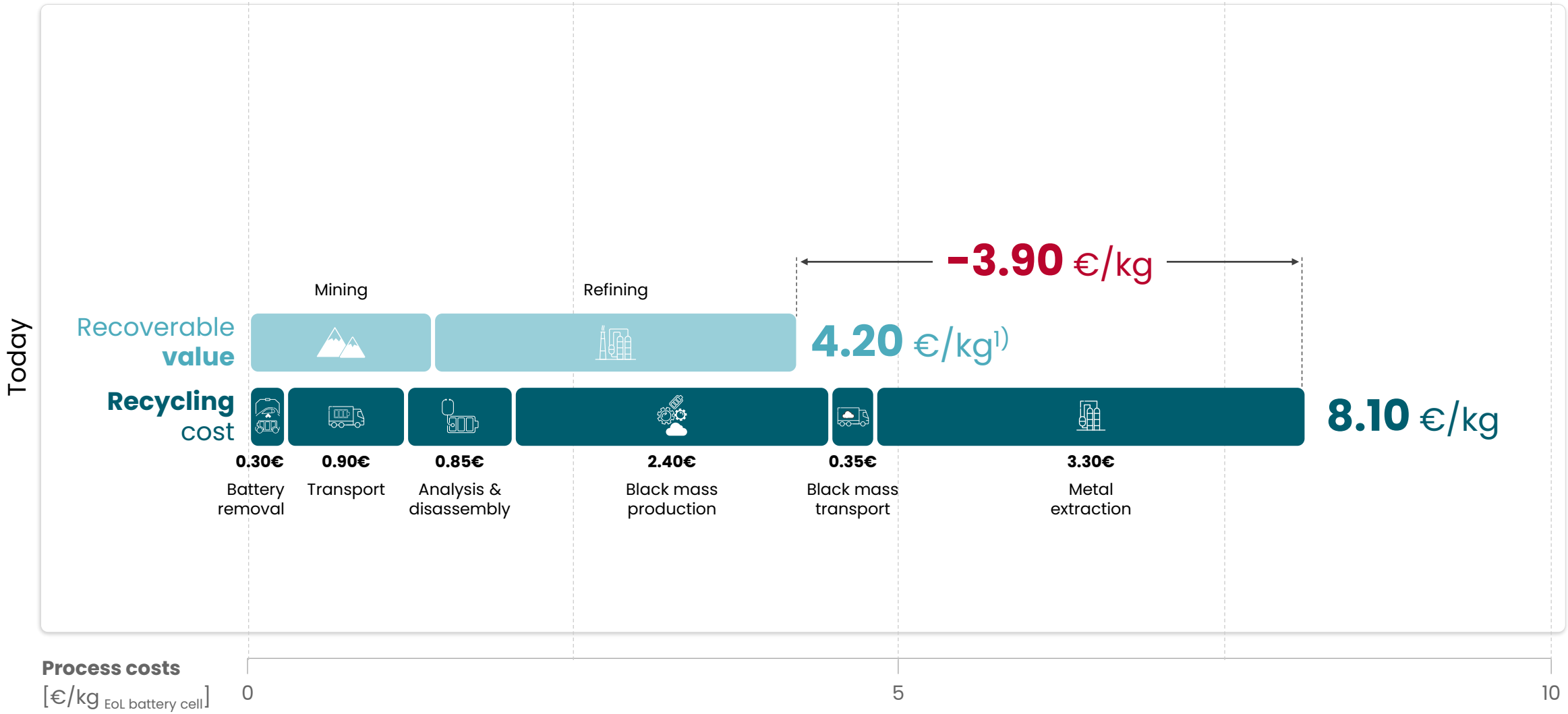


CycleBat value chain by FEV

Costs & Carbon Footprint

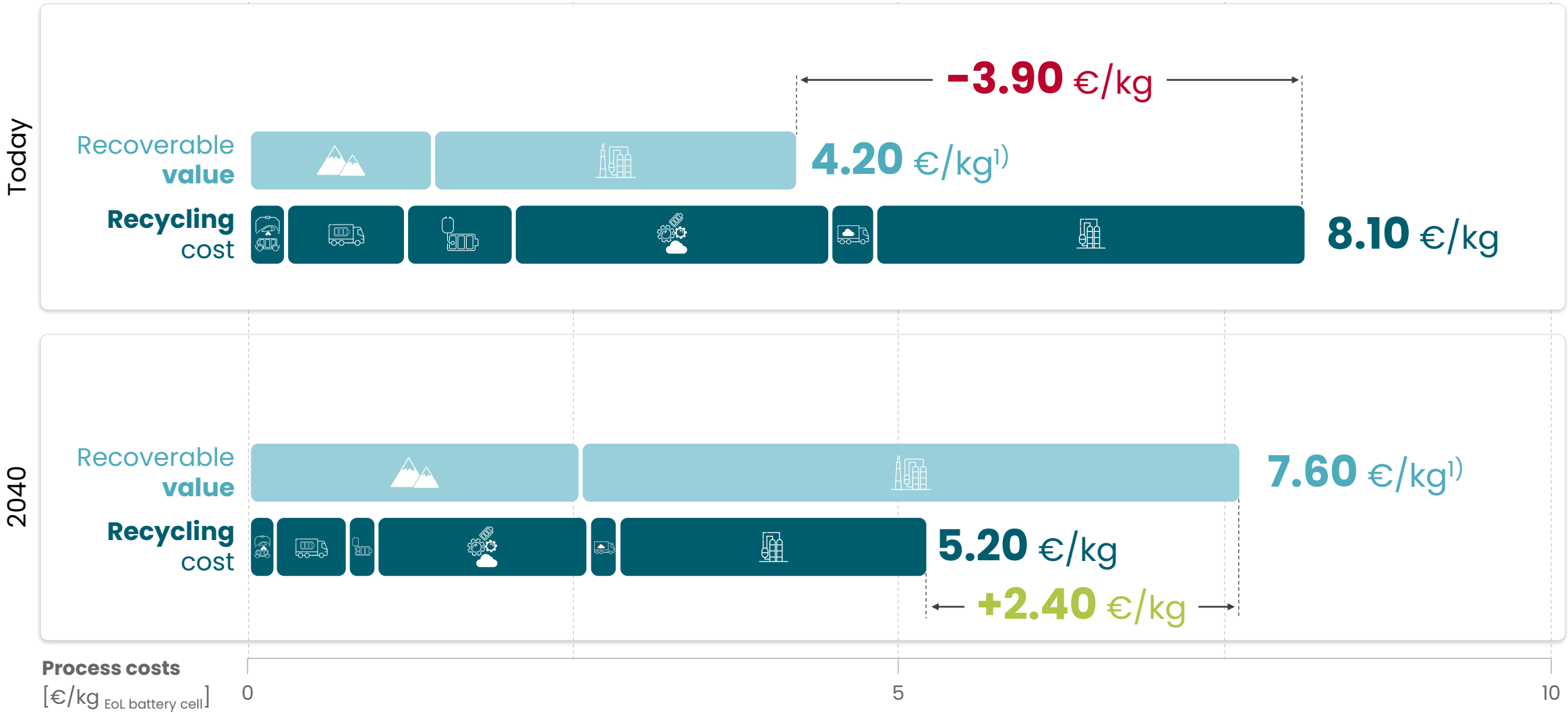


Today, producing recycled battery materials is more expensive than virgin material mining & refining, resulting in recycling gate fees being charged



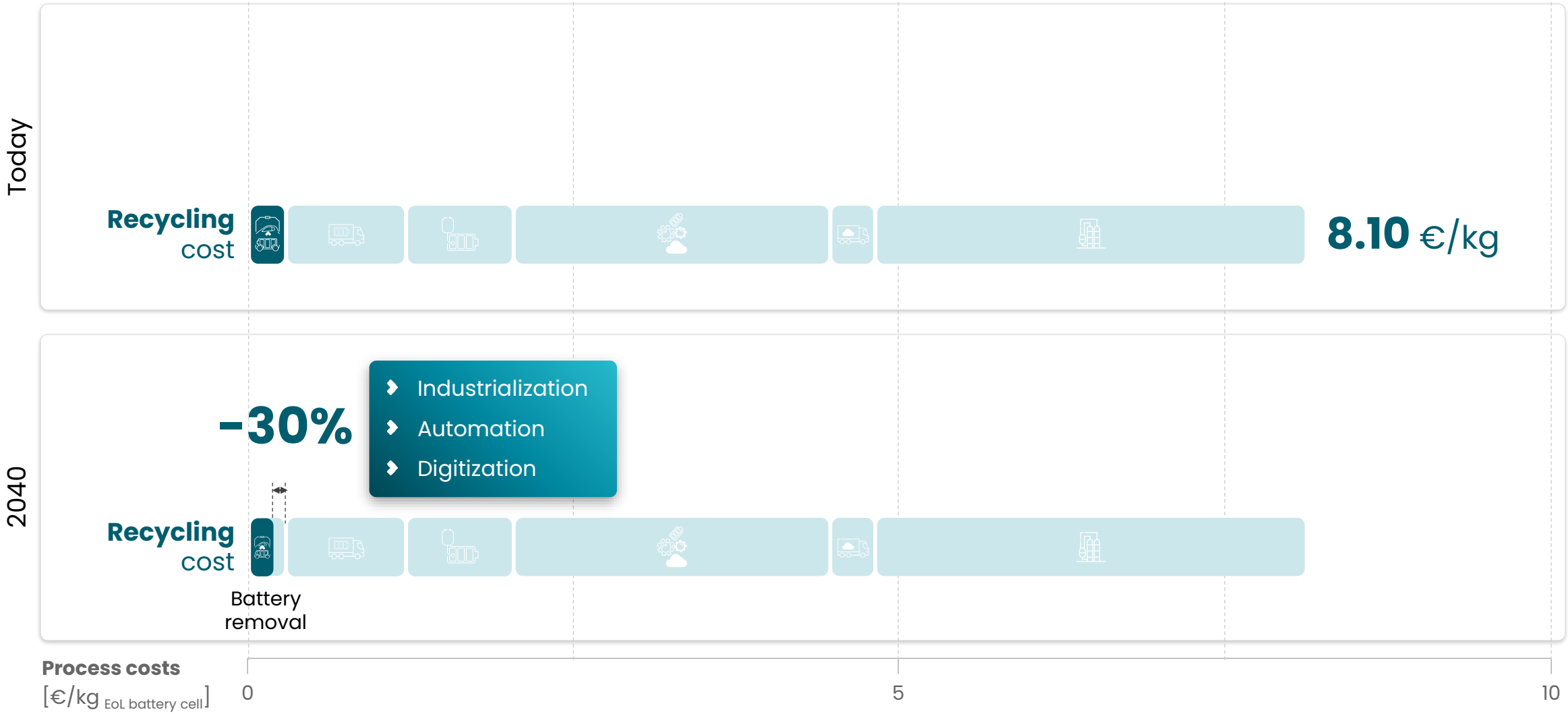
1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

With increasing volumes and technical progress, the battery recycling cost structure will look fundamentally different in 2040 compared to today



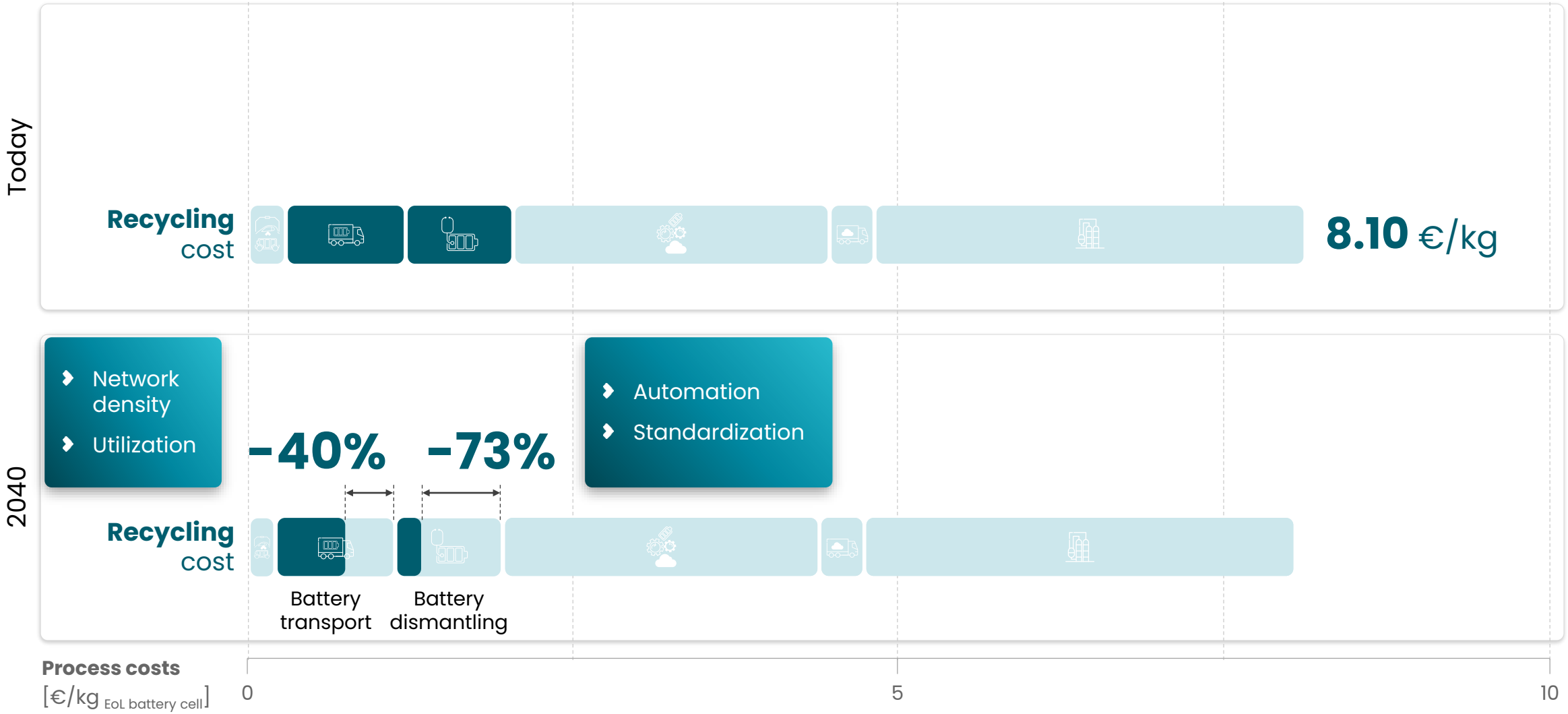
1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

Industrialization, automation & digitization will decrease vehicle dismantling and battery removal costs by 30% by 2040



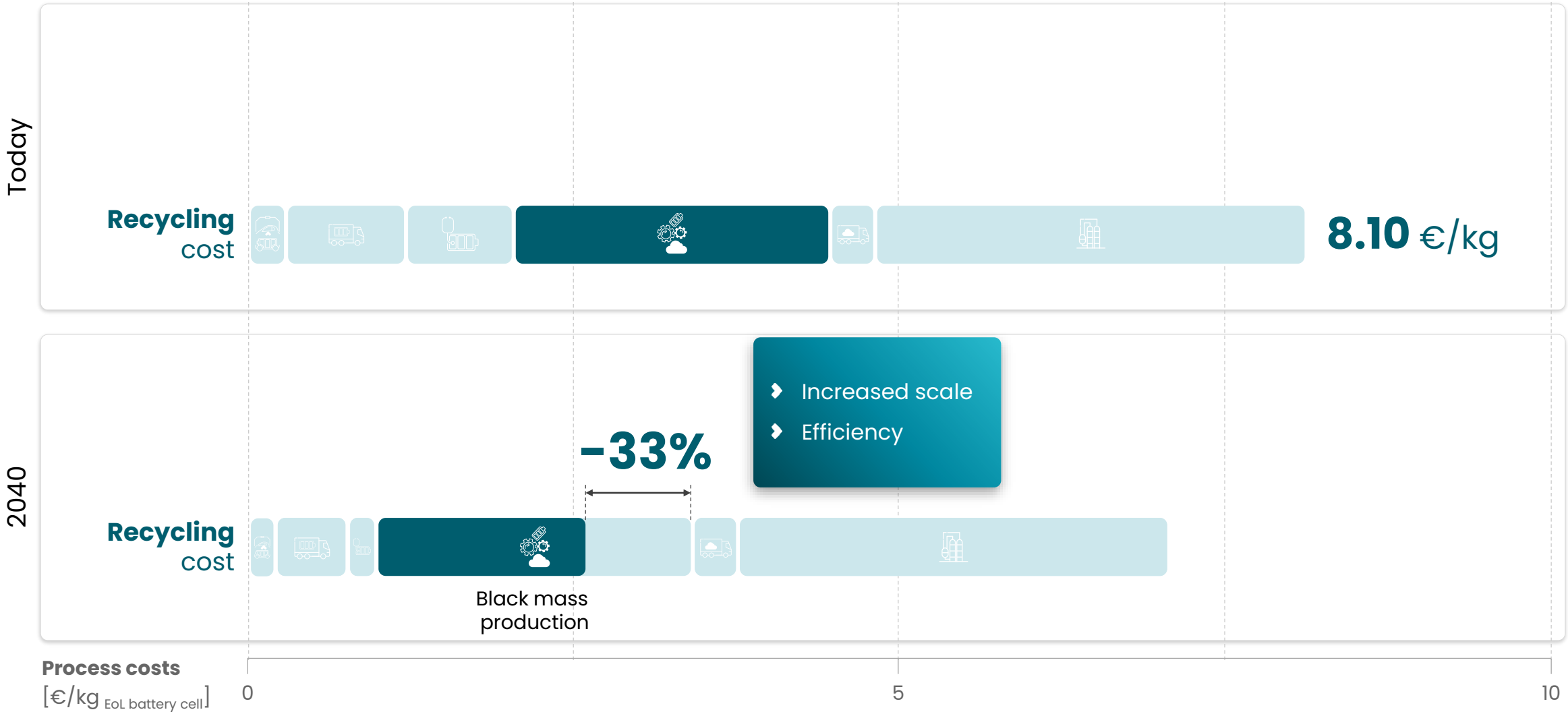
1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

Higher network density & utilization will lower battery transport costs, while automation & standardization will improve analysis & dismantling efficiency



1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

Black mass production will still be decentralized across multiple „spokes“, but increasing volumes & efficiencies will decrease costs by 33%

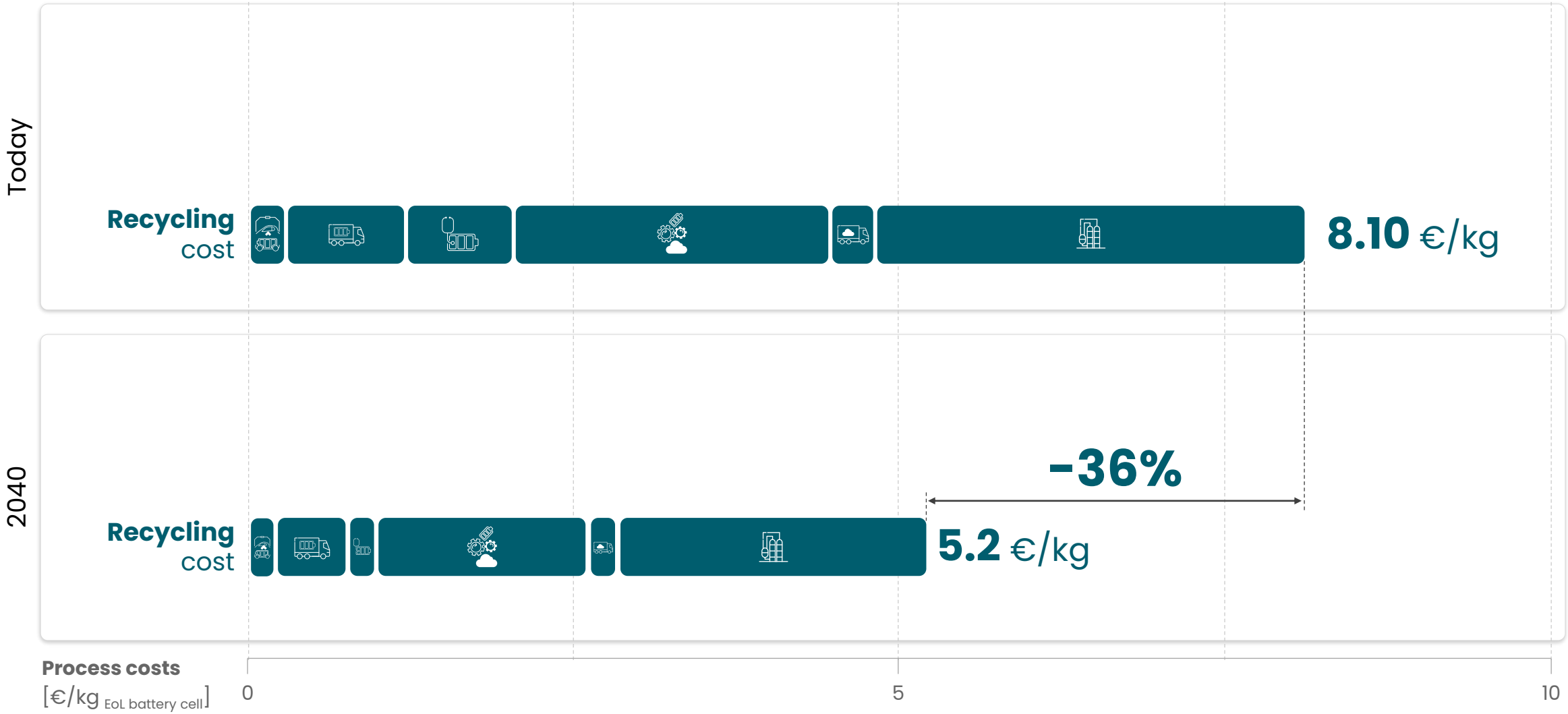


1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

Metal extraction will become more complex to enable Li-recovery – however, scaling the processes to industrial scale will reduce cost overall

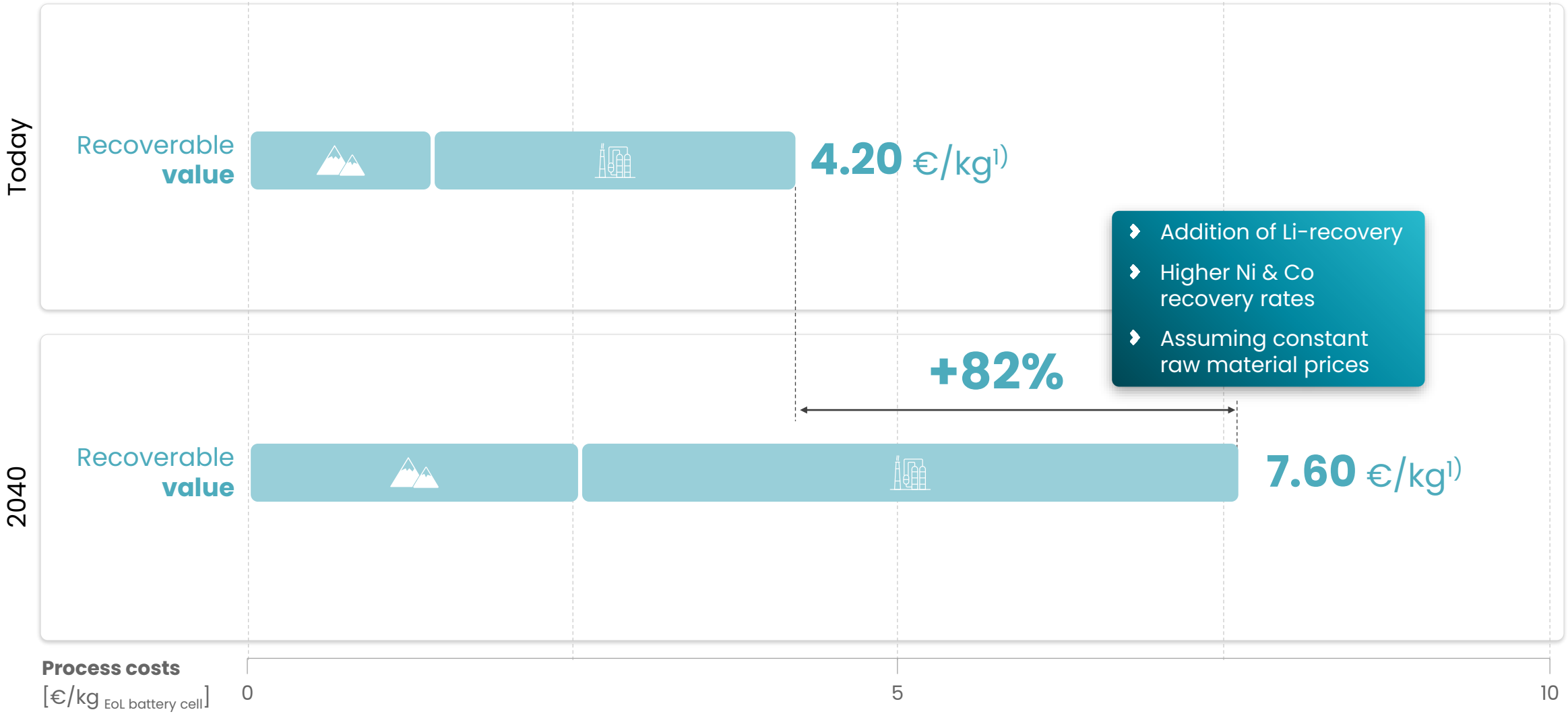
1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

Overall, the cost of recycling will be reduced significantly through a combination of technological advancements and economies of scale



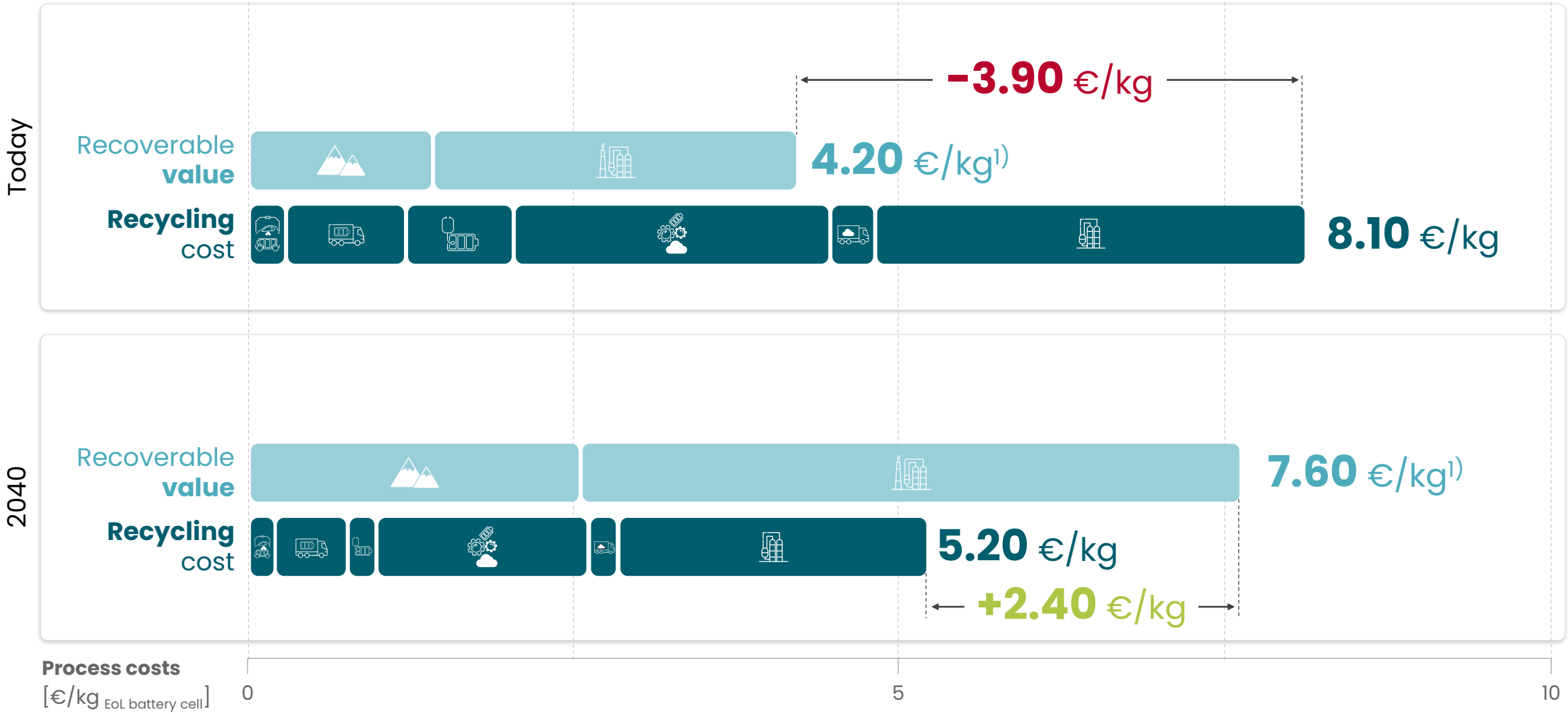
1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

Simultaneously the addition of lithium recovery and improved recovery rates for nickel and cobalt will increase the future recoverable value



1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

End-of-life batteries will thus have a price tag in the future – in contrast to the processing fee demanded today



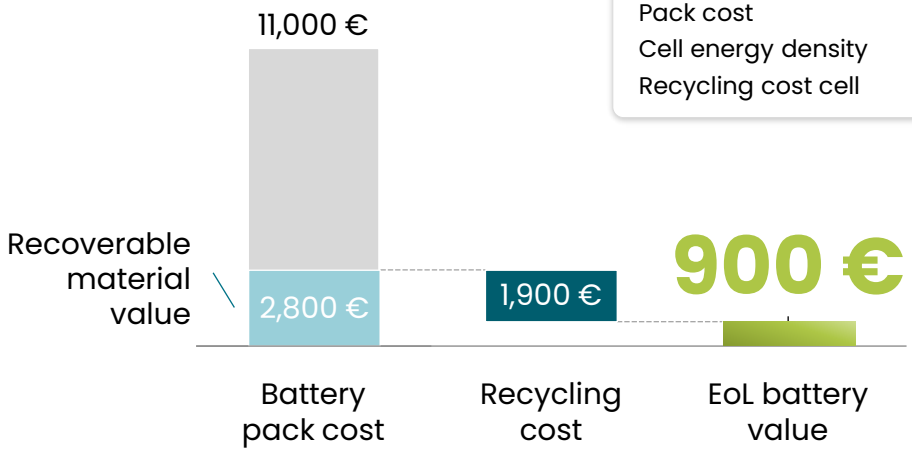
1) Costs to produce virgin raw material equivalent to recyclates recoverable from 1kg of NMC811 battery cell; Assumes constant material prices relating to May 2021 before steep increase

While NMC cells will have a positive end-of-life value, LFP cells may become a liability if no suitable recycling process is developed

1,700 €/vehicle
EoL battery value gap

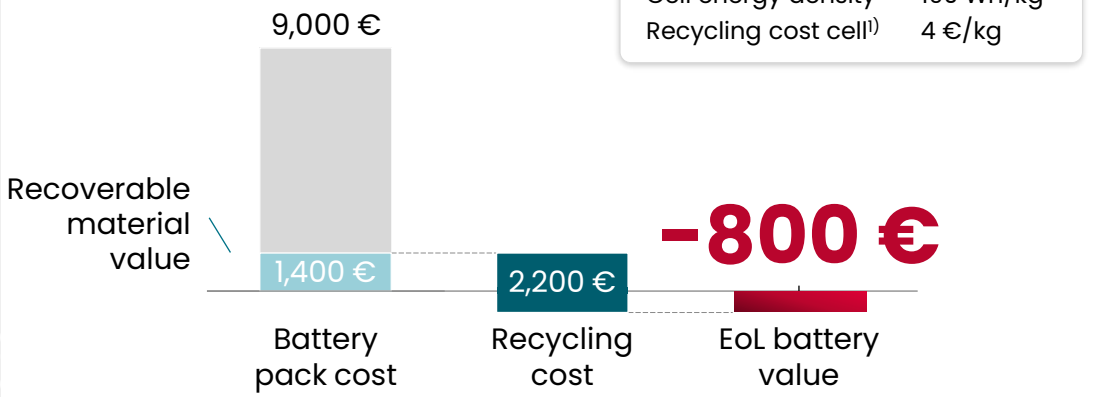
NMC

Pack capacity	100 kWh
Pack cost	110 €/kWh
Cell energy density	280 Wh/kg
Recycling cost cell	5 €/kg



LFP

Pack capacity	100 kWh
Pack cost	90 €/kWh
Cell energy density	190 Wh/kg
Recycling cost cell[1)]	4 €/kg



Note: EoL = End of Life; raw material prices relate to May 2021 before steep increases; 1) High level estimate

FEV CONSULTING

End-of-life batteries can be a potential revenue pool or a liability for decades – implications to be considered in design & business models

Key facts

~25%

Recoverable value of original pack cost

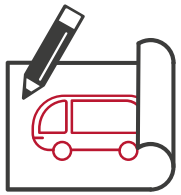
1,700€

EoL value gap between NMC & LFP per car[1)]

15–20

Years of impact of today's EoL battery strategy

Success factors



Battery design accounting for circularity

Ecosystems & partnerships for EoL battery access

New business models as EoL car values increase

Note: 1) EoL = End-of-life (battery), 100kWh battery assumed

GET IN TOUCH!

KILIAN SAGNER
SENIOR CONSULTANT
sagner@fev.com

SOFIA ARTOLA
SENIOR BUSINESS ANALYST
artola@fev.com

FEV CONSULTING