

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

SCALE-UP E-DRIVE

Transformation Hub Scale-up E-Drive

Transformation Impact Assessment by DLR

DLR

bayern innovativ

DLR

e-mobil BW

RWTH AACHEN UNIVERSITY

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Overview of Transformation Hubs

SCALE-UP E-DRIVE

- The core mission is **dissemination of knowledge in the automotive transformation**
- **Focus: Automotive SMEs** (small and medium sized enterprises)
- The aim is to **raise awareness of technology change** and **support transformation processes**
- 11 Transformation Hubs funded in Germany with different focus topics



Transformation Hub Scale-up E-Drive

SCALE-UP E-DRIVE

Project Overview

Focus on SMEs

- The Scale-up E-Drive Transformation Hub specifically supports small and medium-sized enterprises in **the field of electric powertrains and new components**.
- The goal is to support the development of products in the field of electric powertrains in a sustainable, cost-efficient, market-oriented, and future-proof manner.
- Scale-up E-Drive offers **support** by presenting pre-competitive content and specialized background knowledge in a concise and neutral manner, simplifying research, connecting participants with relevant support services, and facilitating collaboration and knowledge exchange.

Project Details

- Duration: 01/2023 – 12/2026
- Funding: 6.4 million euros
- Further information: hub-edrive.de

Project partners

bayern innovativ

DLR

e-mobil BW

RWTH AACHEN UNIVERSITY

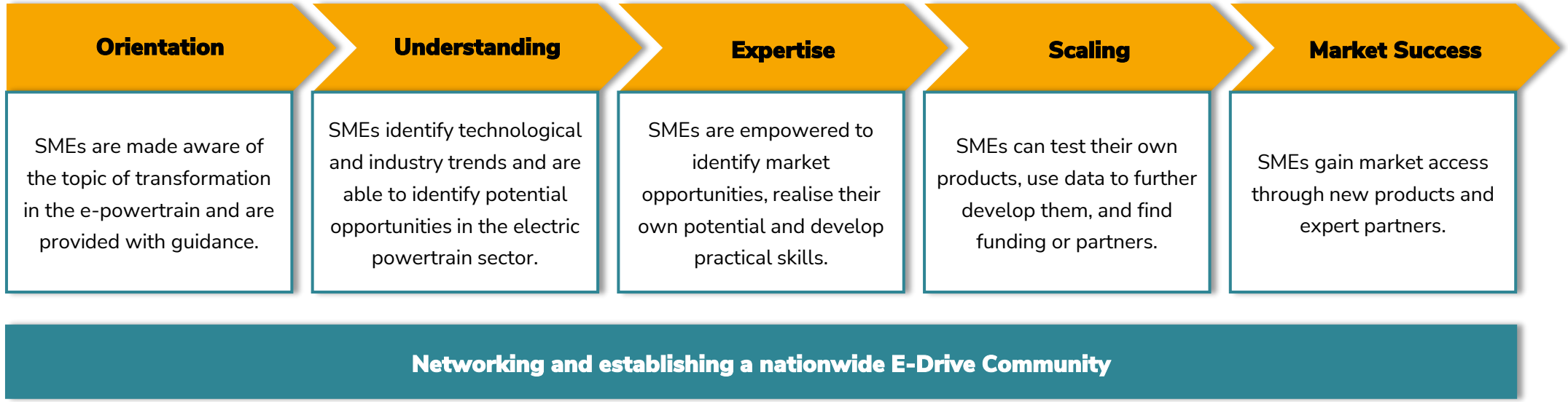
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Project Targets

Transformation Hub Scale-up E-Drive

SCALE-UP E-DRIVE

- Support for **small and medium-sized** enterprises in the transformation processes relating to **electric vehicle powertrains**
- Contributing to **the preservation of value creation and employment** in Germany



Services Offered by the Scale-up E-Drive Transformation Hub

SCALE-UP E-DRIVE



Initial consultation

First point of contact for those interested in the field of electric powertrains



Decentralized test center

Database for sharing knowledge about available testing and inspection infrastructure



Publications

Knowledge transfer on technology and market trends



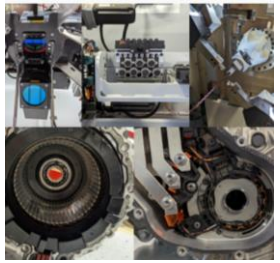
Skill assessment, trade shows, conferences

Establishment of a Germany-wide network for electric powertrains



Events

Exchange on product innovations and process solutions

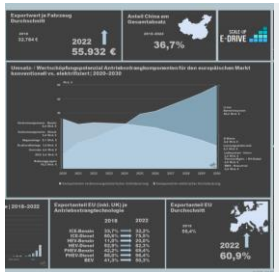


Stationary and mobile showcases

Training courses, workshops, and seminars

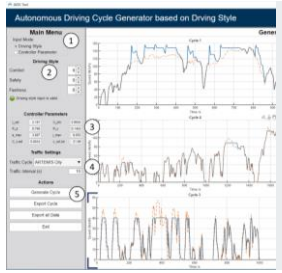
Services Offered by the Scale-up E-Drive Transformation Hub

SCALE-UP E-DRIVE



Benchmark studies & fact sheets

Monitoring and detailed analysis of market developments and technological trends



Open-source data hub

Publication of models and data from investigated technologies and dependencies



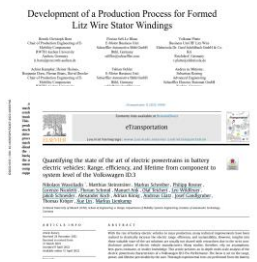
Podcast & video format

Interviews and expert discussions with leading figures from industry and academia



E-drive-news

Information portal with relevant news on current developments in the field of electric powertrains



Research Monitor

Database of funded projects and initiatives



Consortium Studies & White Papers

Joint research on current challenges in the development and manufacturing of electric powertrain products

Transformation Hub Scale-up E-Drive

SCALE-UP E-DRIVE

Four Pillars of Our Offerings

Initial Consultation
We help SMEs identify opportunities for transformation and develop own methods, processes, and products.

Knowledge Transfer
We provide information on topics related to the electric powertrain through various media content.

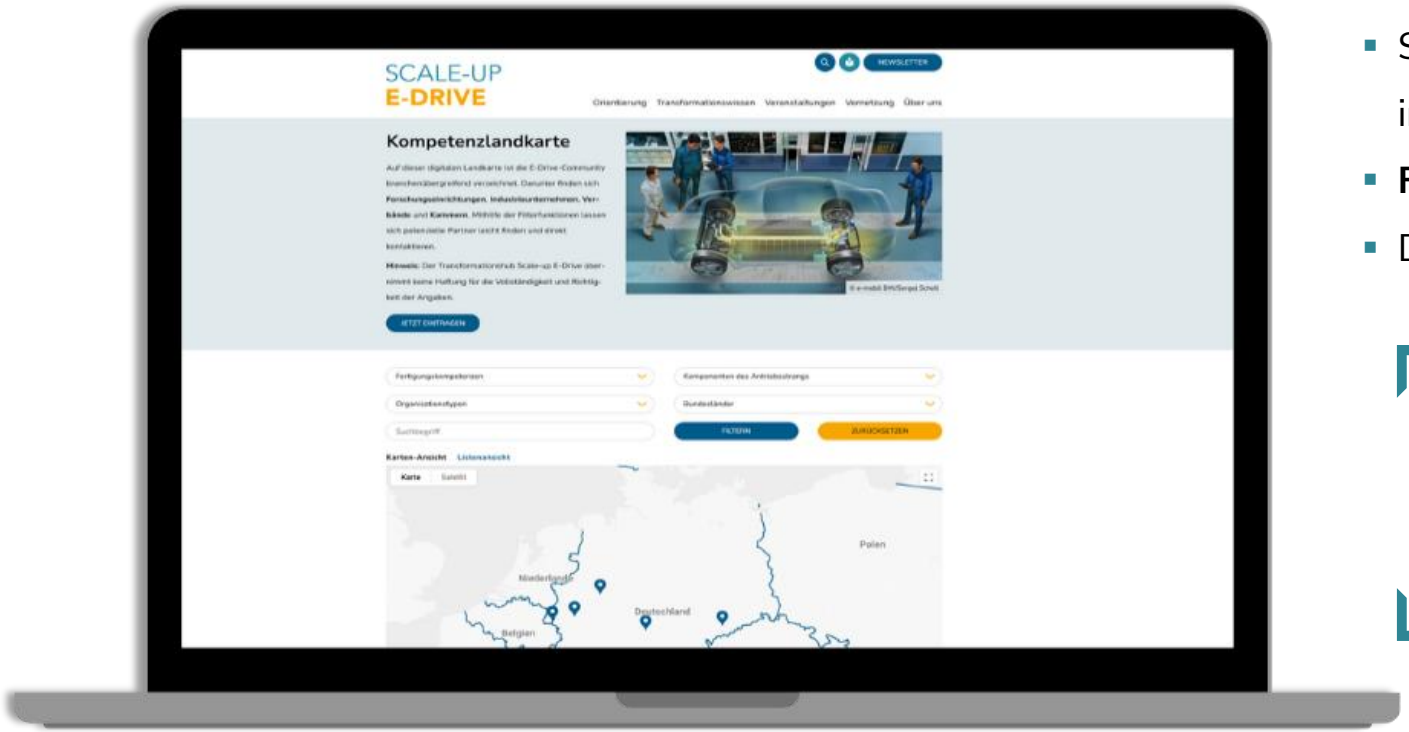
Exchange & Networking
We promote exchange throughout the entire value chain.

Seminars & Workshops
We promote the development of technical expertise among our workforce through seminars and workshops.

Competence Map

Join the E-Drive Community now!

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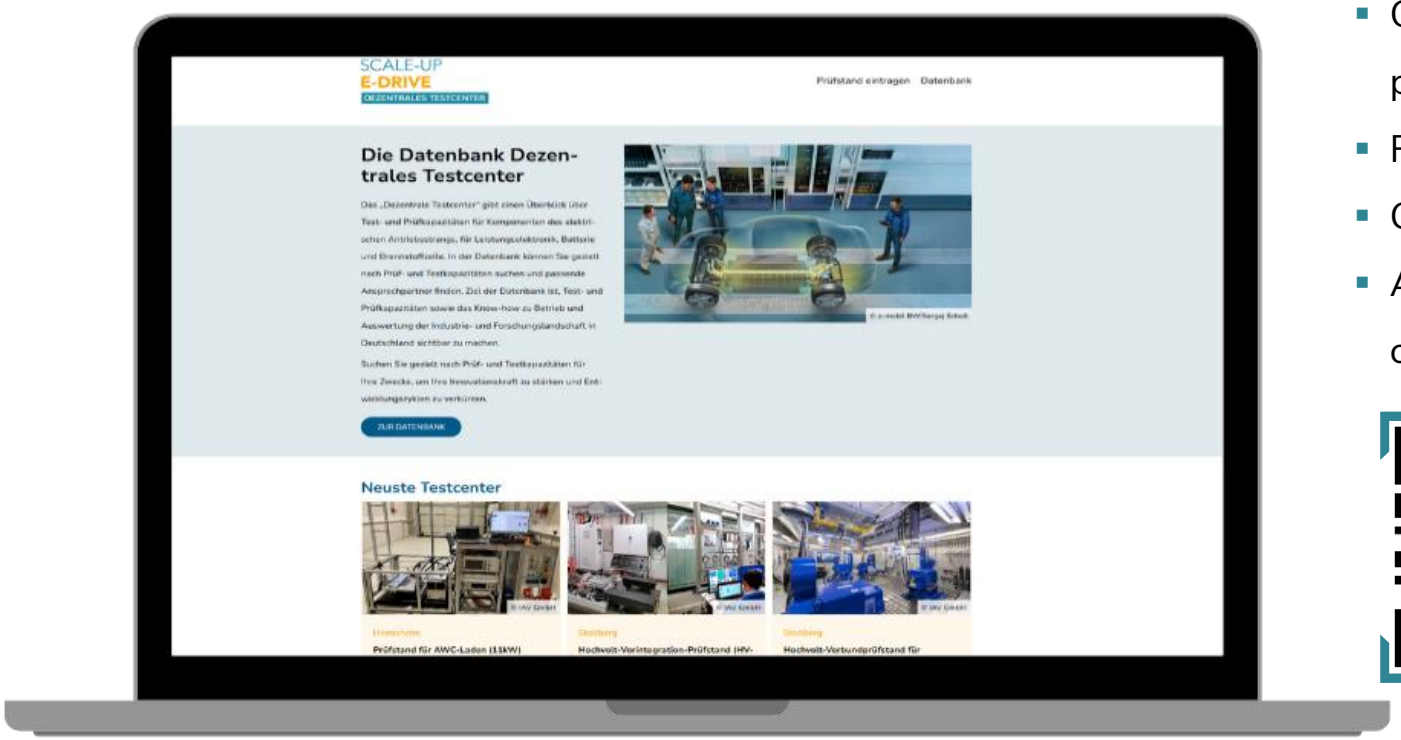
- Specializing in **electric powertrains** (research institutions, industrial companies, associations & chambers)
- **Filter options** for targeted partner searches
- Direct **contact with potential partners** is possible

Scan the QR code & join the E-Drive Community!

Test Center

Join the E-Drive Community now!

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- Overview of **testing and validation** capabilities for electric powertrains, power electronics, batteries and fuel cells
- Free listing of your own **test benches** in the database
- Greater visibility & new partners
- An active contribution to promoting **innovation** in the field of electric drive technologies

Scan the QR code & join the E-Drive Community!

Mobile Showcase

Electric Drive Technology Right on Site

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- Exhibits and research findings you can explore
- Various electric motors from different manufacturers
- VW ID.4 rear axle and Porsche Taycan rear axle

Would you Like the Mobile Showcase to Visit you? Contact us!

Event formats

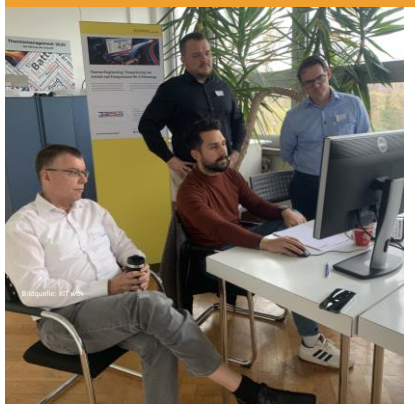
Online & on site

Sign up now!

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Thermal Management Seminar

18.06. 07.07. ...



- An introduction to new manufacturing technologies and thermal management for electric vehicles, with practical examples
- Interactive sessions, active discussion and practical insights
- Focus on modern development methods, simulation techniques and validation processes

Power Electronics Seminar

16.07. 23.09. 13.10.



- Knowledge of power electronics and current developments, including the fundamentals of electrical engineering
- Insights into key components, manufacturing techniques and quality assurance
- Exchange ideas and build networks with other participants

Pitch Center, Aachen

17.07.



- 10 companies are pitching to Schaeffler, Mahle, Daimler Truck and BMW
- 5-minute presentation + personal discussion about collaboration
- Applications must be submitted by 18 May: please send a one-page text document to j.schleicher@pem.rwth-aachen.de

Mobile Showcase, Across Germany



- Exhibits & research findings you can explore
- Various electric motors from different manufacturers
- VW ID.4 and Porsche Taycan rear axle
- **Would you Like the Mobile Showcase to Visit you? Contact us!**

Transformation Dashboards

Monitoring Technological Change in the Powertrain

SCALE-UP E-DRIVE

- Providing industry-specific insights via **transformation dashboards**.
- Focus: Supporting and **empowering SMEs** in their digital transformation
- Focus on **trends and developments** across all areas of transformation

Automotive Industry

Vehicle Markets

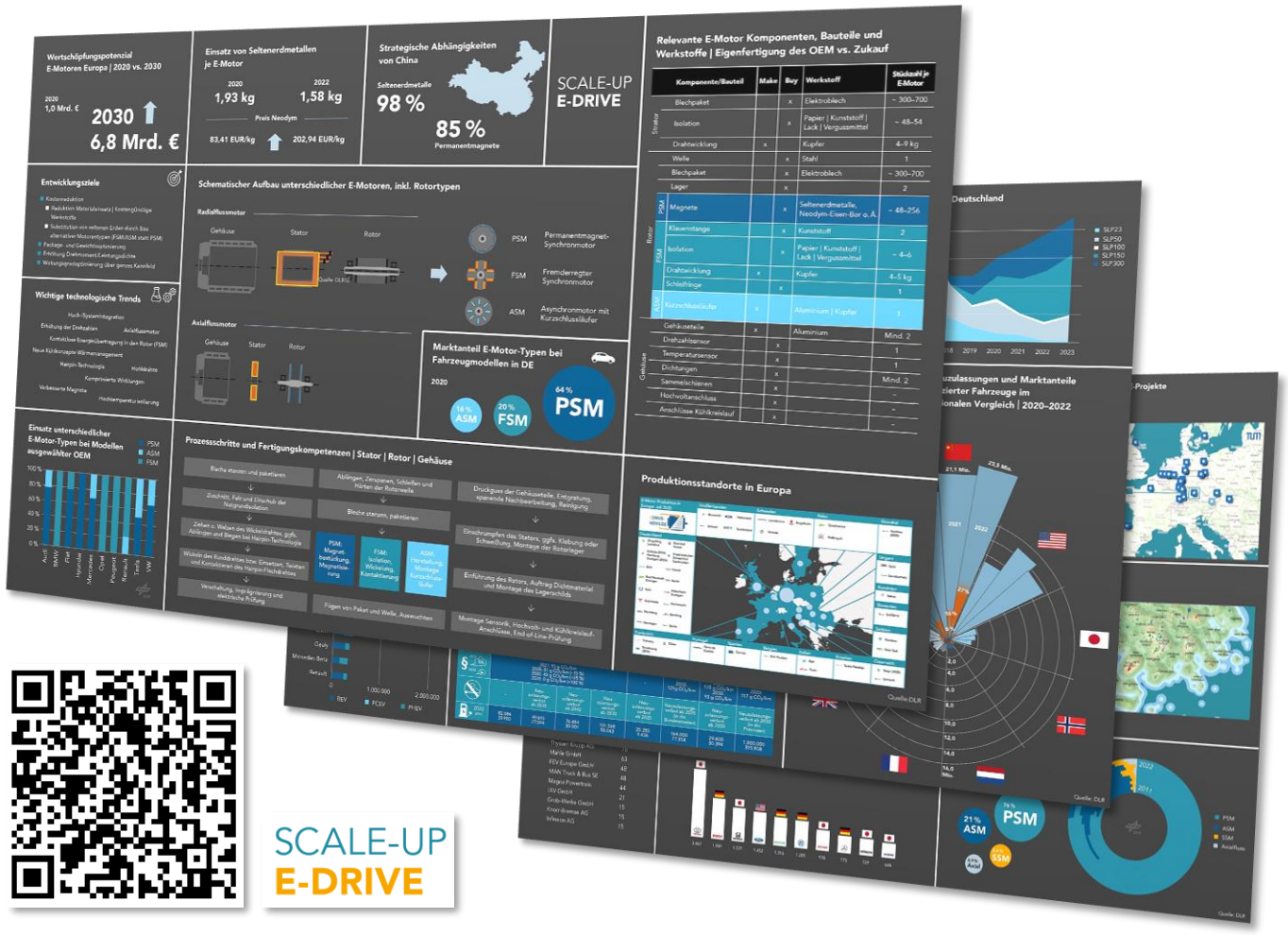
Technology Trends

Manufacturer Strategies

R&D Activities

Supply Chains

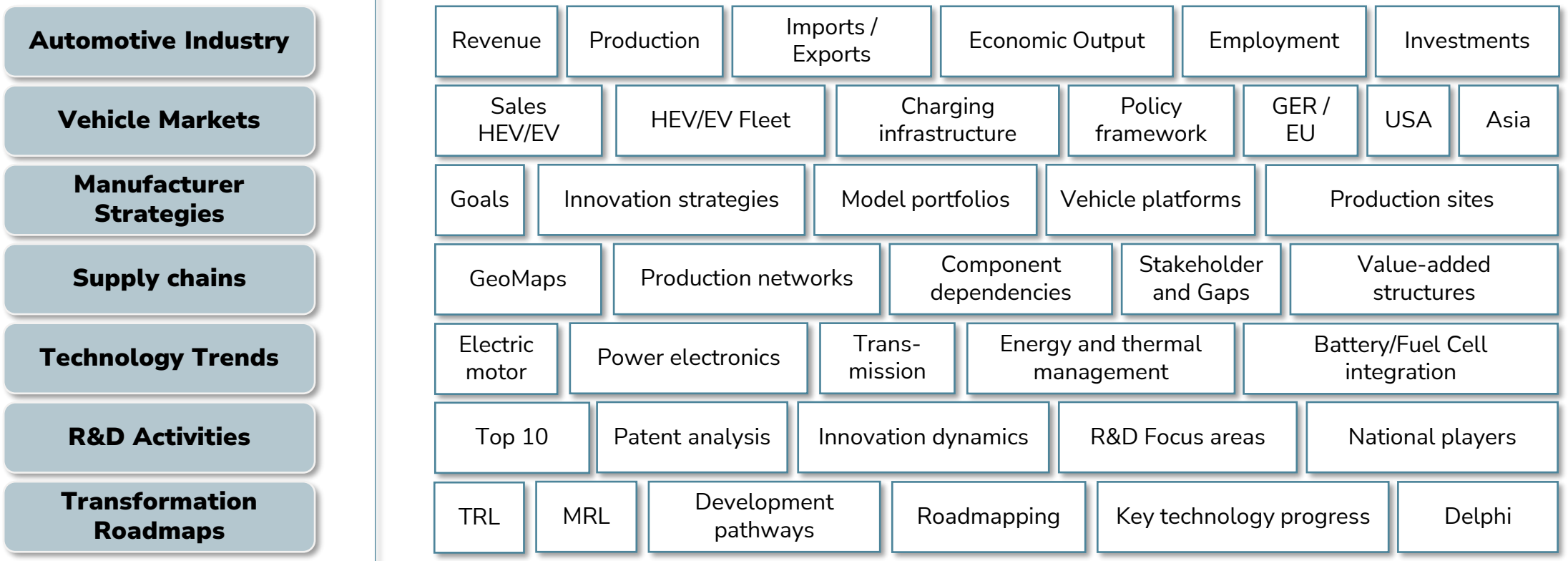
Transformation Roadmaps



Transformation Impact Assessment by DLR

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Relevant indicators and focus of transformation monitoring



Value creation in the automotive industry in Germany

2010
€68 billion

2019
€102 billion

Share of Chinese manufacturers in global battery cell production

2020
83%

2022
84%

Imports of lithium-ion battery cells from China

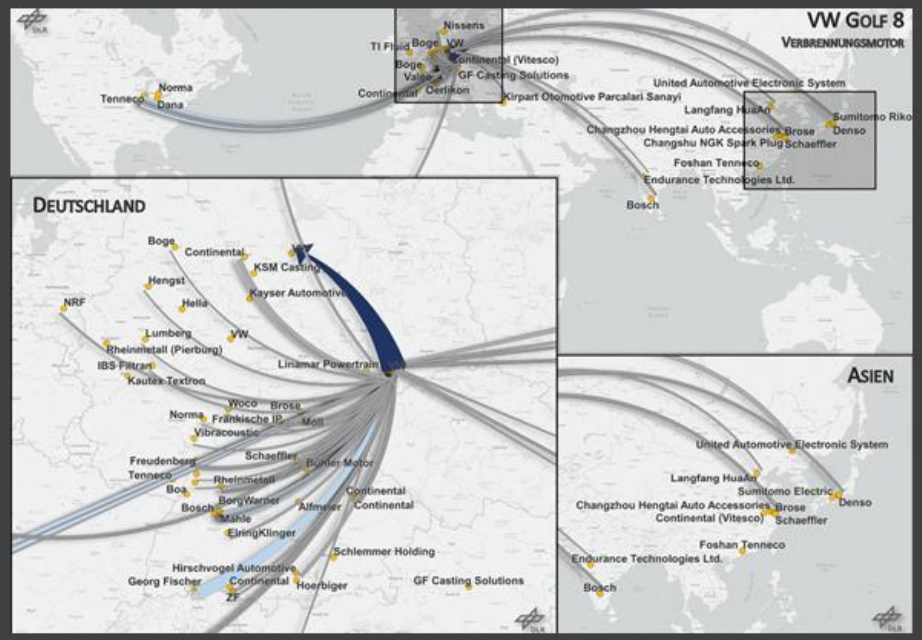
2018	2022
Import volume €0.7 billion	Import volume €5.6 billion
Import share 78%	Import share 41%

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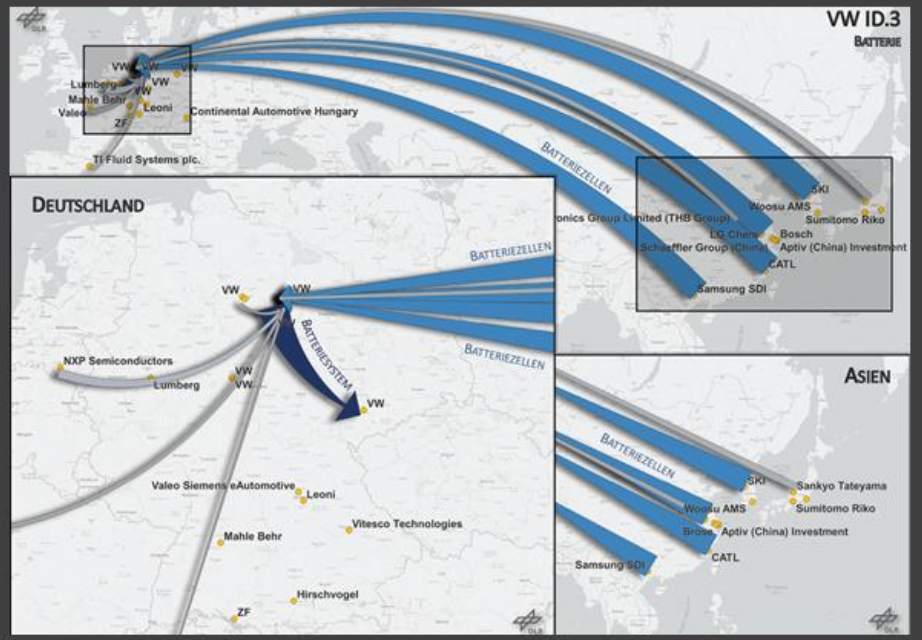
Number of companies related to "Electric motors (automotive)" in Germany

2023
343

Supply chain / value chain networks VW Golf 8 internal combustion engine



Supply Chain / Value Chain Networks for the VW ID.3 Battery System



Production sites VW Golf 8 Germany



Production sites VW ID.3 Germany



Localization of new value creation in comparison of conventional and electrified vehicle models

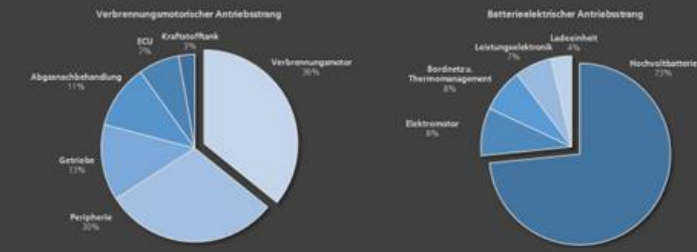
330i vs. i4	-13% ↓	+40% ↑
E-Class vs. EQE	-32% ↓	+49% ↑
Q3 vs. Q4 e-tron	-21% ↓	+31% ↑

Changes in supply chains / value creation structures Complete powertrain | VW Golf 8 vs. VW ID.3

Struktur Zulieferernetzwerk "Antriebsstrang" VW Golf 8 vs. ID.3

Modell	Plattform	Anteil Komponenten DE	Anteil Komponenten EU	Anteil Komponenten Asien	Wertschöpfungsanteil am Antriebsstrang OEM	Wertschöpfungsanteil am Antriebsstrang Zulieferer
VW Golf 8	MQB	60,0%	75,5%	12,9%	20,8%	69,3% (79,2%)
VW ID.3	MEB	27,3% ↘	36,4% ↘	32,7% ↑	30,9% ↗	56,61% (69,1%) ↘

New value-added shares in the electric powertrain



Contact: benjamin.frieske@dlr.de // Sources: Destatis (2024a, 2024b), DLR (2024), e-mobil BW (2022), istari.ai (2024), Transformationswissen BW (2021), ZVEI (2022, 2023)

Transformation Dashboard: "Changes in Value Creation Structures"

Stringent new EU regulations

- EU Climate Action Package "Fit for 55"
- Action Plan for the Circular Economy
- Regulation on batteries and waste batteries
- CO_2 -Border Adjustment Mechanism
- Directive on End-of-Life Vehicles

New vehicle features from Chinese automakers

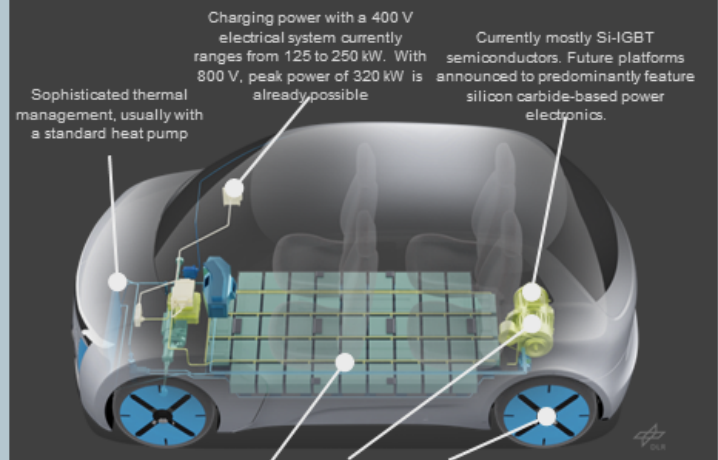
- In-car Entertainment (Li Auto)
- X-in-1 (Dongfeng)
- Battery swap (NIO)
- HarmonyOS (Huawei)
- Flying car (Xpeng)
- Karaoke (World Champion)
- Smart Cockpit (BYD)
- Robo Cars (JiYue)
- Tank Turn (YangWang/BYD)

R&D investments by German OEMs and suppliers until 2027

€250 billion

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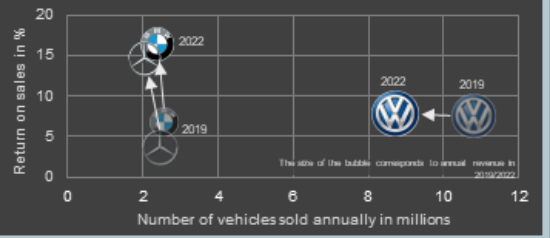
Current and Future Platforms for Battery-Electric Vehicle Models



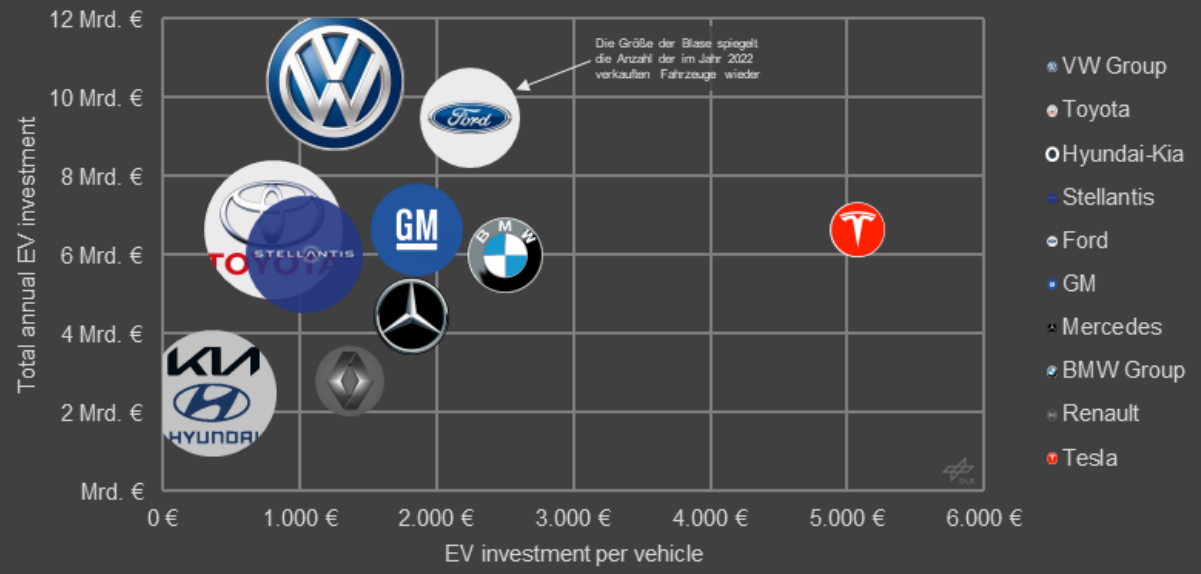
Brand	Platform	System voltage	El. motor	Drive Axle	Number of vehicles produced in 2023
Tesla	GEN III PF	400 V	PSM	Rear, all-wheel drive	
VW Group	MEB	400 V	PSM	Rear, all-wheel drive	
Hyundai-Kia	E-GMP	800 V	PSM	Rear, all-wheel drive	
Toyota	E-TNGA	355 V	SSM	Front, all-wheel drive	
Mercedes	EVA2	400 V	PSM	Rear, all-wheel drive	
Renault	CMF-EV	400 V	SSM	Front, all-wheel drive	
Tesla	Model S PF	400 V	PSM	Rear, all-wheel drive	
GM	BEV3	400 V	PSM	Front, Rear, All	
VW Group	J1	800 V	PSM	Rear, All-Wheel	
Stellantis	STLA (M)	400 V	PSM	Front, all-wheel drive	2023
Stellantis	STLA (L)	400/800 V	PSM	Rear, all-wheel drive	2024
VW Group	PPE	800 V	PSM	Rear, all-wheel drive	2024
Ford	GE2	N/A	N/A	Rear, all-wheel drive	2025
Mercedes	MMA	800 V	PSM	N/A	2025
BMW Group	New Class	800 V	SSM	Rear, all-wheel drive	2025

1 million 2 million

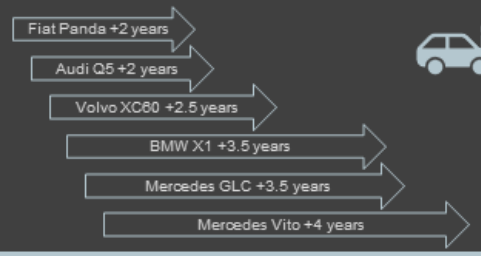
German manufacturers' focus on margins rather than volume | 2019 vs. 2022



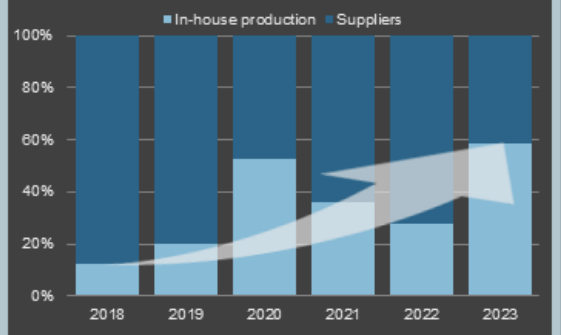
Annual R&D investments in the field of electric vehicles



Extension of production cycles for conventional vehicle models

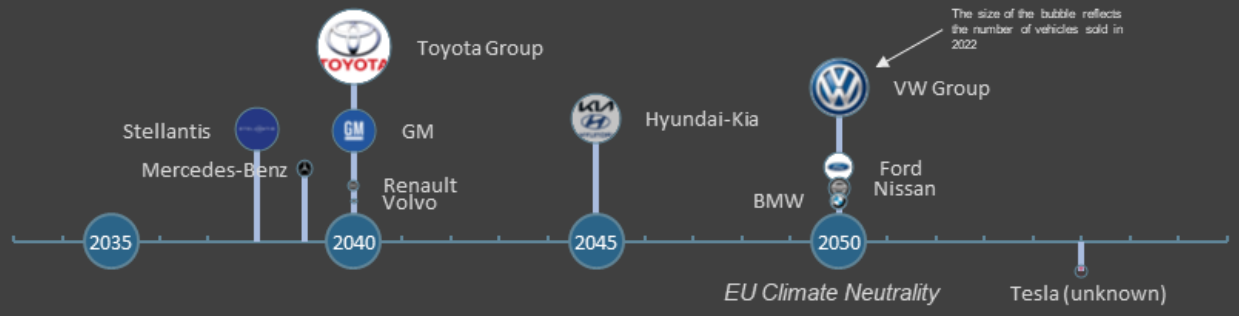


Increased in-house production of electric motors for European vehicle models

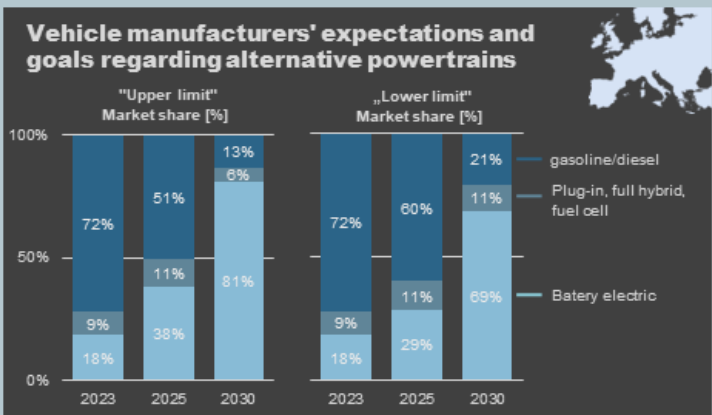


CO_2-neutrality goals of vehicle manufacturers

CO_2-neutral across all stages of the value chain, including supply chains and the product lifecycle



Vehicle manufacturers' expectations and goals regarding alternative powertrains



Contact: benjamin.frieske@dlr.de // Sources: DLR (2024), Marklines (2024a, 2024b), Reuters (2022a), S&P Global Mobility (2024a), VDA (2023)

New registrations of electric passenger cars in Germany | incl. hybrid

2022	2024	2025H1
1.31 million	1.34 million	0.79 million

Share of total new registrations

49.6%	47.6%	56.6%
BEV: 17.7%	BEV: 13.5%	BEV: 17.7%

Size of the vehicle markets | 2024
Passenger cars – all powertrains

DE	EU	USA	China
2.8 million	10.6 million	16.0 million	29.5 million
Share of the global market			
3.5%	13.2%	19.9%	36.6%

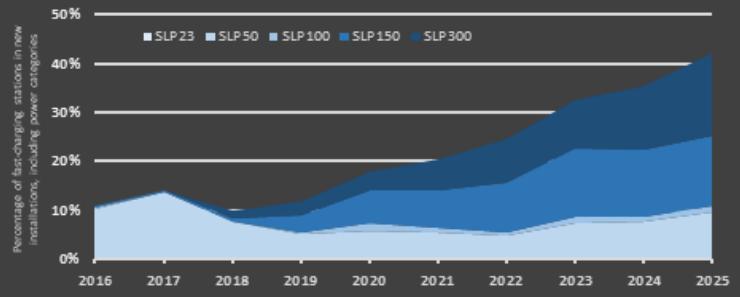
Motorization rate

China
238
Passenger cars per 1,000 inhabitants



USA	DE	EU
814	588	570

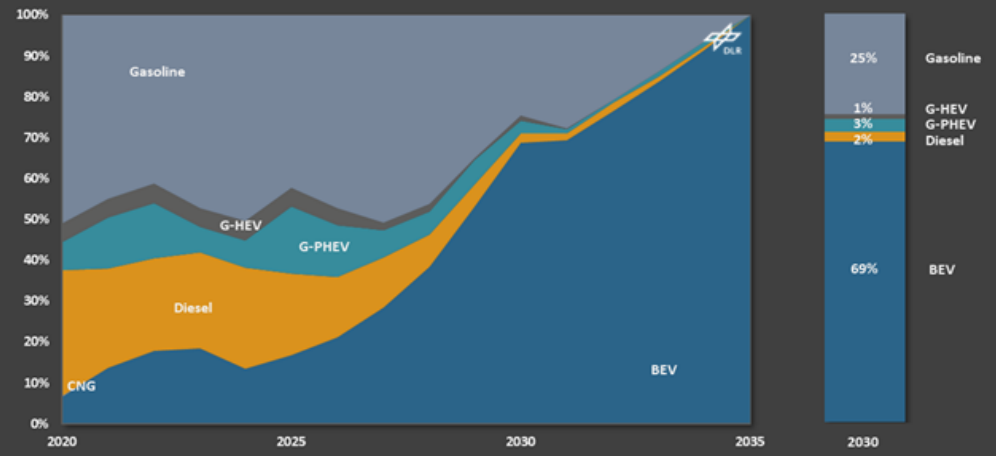
Expansion of the charging infrastructure in Germany 2016–2025H1



New registrations of electrified passenger cars internationally YoY Q2 2025

BEV	712,000	3,747,000	592,000
	+25.1%	+47.4%	+6.3%
PHEV	396,000	2,131,000	156,000
	+30.2%	+18.7%	-8.0%
Hybrid	1,804,000	440,000	1,008,000
	+17.9%	+11.5%	+40.0%

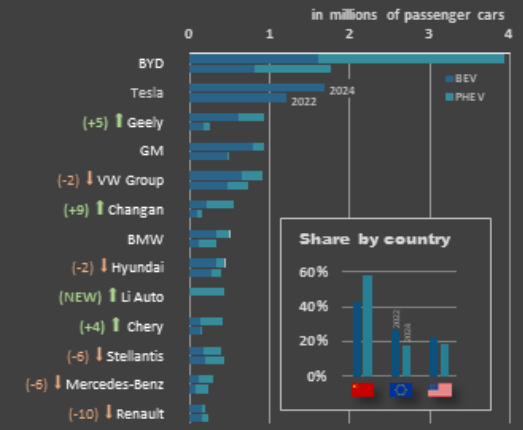
Trend in New Passenger Car Registrations in Germany | 2020–2035
DLR-VECTOR21 Progressive Scenario (2025 Update)



Global fleet of electrified passenger cars (in units)

2018	2025
3.2 million	58 million

New registrations of electric passenger cars by manufacturer | worldwide 2022 vs. 2024



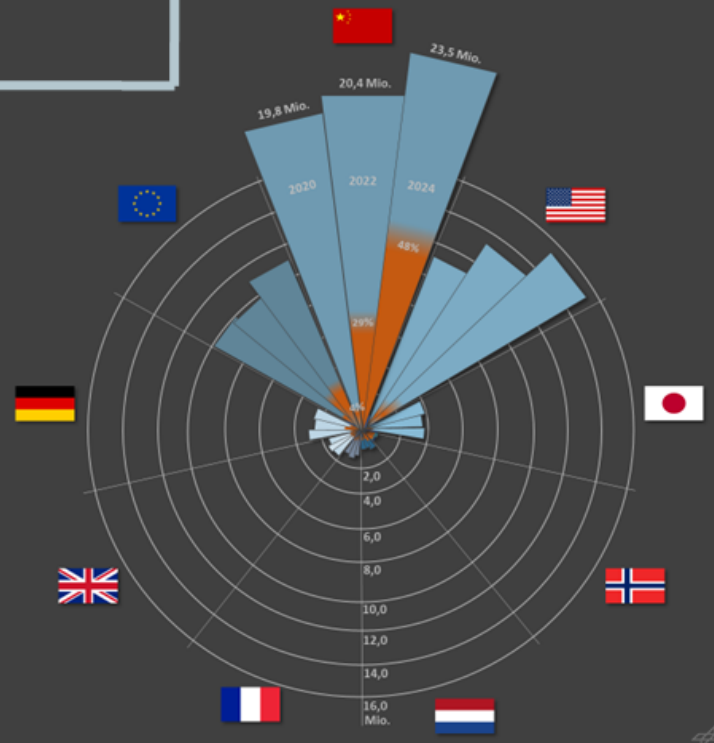
Market Situation and Framework Conditions in International Comparison

New registrations 2024 vs. 2022 | Purchase incentives | CO_2 targets | Combustion engine bans | Charging infrastructure

2024 / 2022 (incl. Hybrids)	570.000 / 831.000	451.000 / 340.000	182.000 / 107.000	550.000 / 370.000	114.000 / 156.000	1.521.000 / 993.000	104.000 / 98.000	11.300.000 / 5.900.000
2024 (Battery BEV/PHEV)	3.100.000	1.750.000	980.000	2.170.000	960.000	6.300.000	620.000	34.000.000
	-	BEV: bis 4.000 € PHEV: 0 €	-	BEV: 2.950 € PHEV: 0 €	-	BEV: bis 7.500 $ PHEV: bis 7.500 $	BEV: bis 4.900 € PHEV: bis 3.200 € FCEV: bis 14.800 €	-
WLTP cycle 2020 CO_2 § 2035	2021: 116 CO_2 g/km 2025-2027: 94 CO_2 g/km (-15 %) 2030: 50 CO_2 g/km (-55 %) 2035: 0 CO_2 g/km (-100 %)			2021: 120 CO_2 g/km 2025: 98 CO_2 g/km 2030: 27 CO_2 g/km	-	2021: 170 CO_2 g/km 2026: 105 CO_2 g/km 2030: 90 CO_2 g/km 2032: 68 CO_2 g/km	2018: 131 CO_2 g/km 2030: 106 CO_2 g/km	2020: 155 CO_2 g/km 2026: 102 CO_2 g/km 2030: 78 CO_2 g/km
	Neuzulassungsverbot ab 2035 (Europäische Union)		Neuzulassungs-verbot ab 2030	Neuzulassungs-verbot ab 2030	Neuzulassungs-verbot ab 2025	Neuzulassungs-verbot ab 2035 in einzelnen Bundesstaaten	Neuzulassungs-verbot ab 2035*	Kein Neuzulassungs-verbot
2024 / 2022	157.000 / 86.000	152.000 / 91.000	188.000 / 125.000	88.000 / 52.000	31.000 / 25.000	193.000 / 129.000	32.000 / 29.000	3.500.000 / 1.760.000

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New passenger car registrations and market shares of electrified vehicles in an international comparison | 2022–2024



Contact: benjamin.frieske@dlr.de // Sources: Federal Network Agency (2025), Chinese Government (2025), Eurostat (2025), EV Volumes (2025), Hasselwander and Rettich (2025), IEA (2025), KBA (2025), Marklines (2025), PwC (2025), U.S. Department of Transportation (2024)

Transformation Dashboard: "Development of International Vehicle Markets"

Patent applications for electric motors for automotive applications

2011–2022

83,325 patent families

Importance of Patent Markets

	2011	2021
DE	23.4%	30.9%
CN	22.3%	46.5%
JP	37.9%	10.3%

R&D share in China



2011: **19.7%**

2021: **41.9%**

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Research Monitor R&D Projects



TUM, Professur für Energiewandlungstechnik

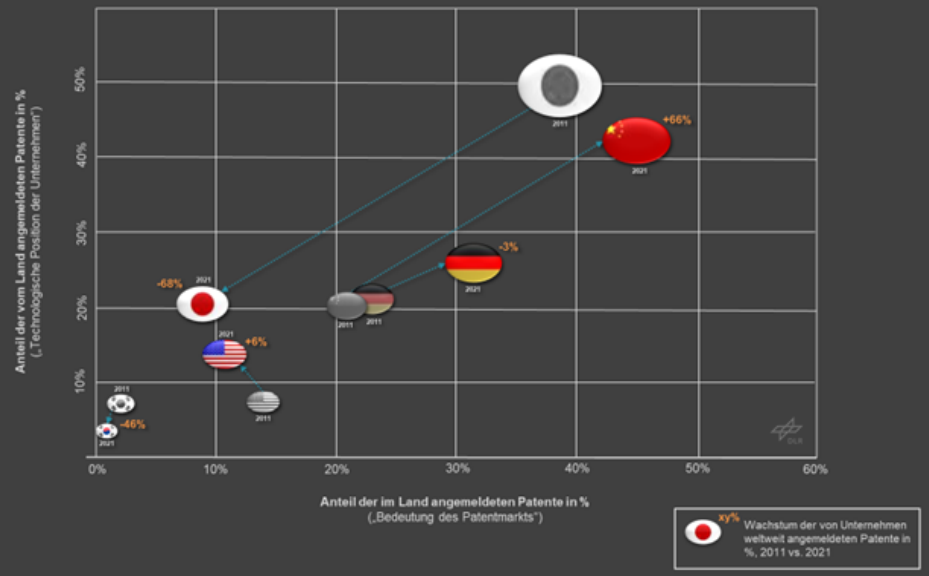
Auslegung und Dimensionierung elektrischer Antriebsstränge

Automatisiertes Maschinendesign

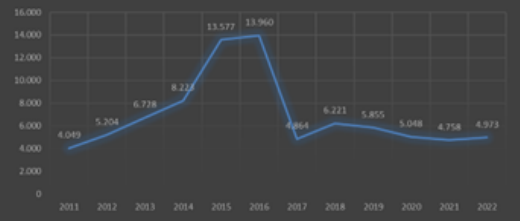
R&D Focus Areas in Patent Specifications

- **Rotor 22.5%**
  - Geometry | Surface | Position | Rotation | Speed Torque | Cooling & Lubricants | Phase & Pulse Control | Sensors | Bearings & Shaft | Magnets Coil & Winding | Magnetic Flux | Current Flow
- **Stator 17.0%**
- **Thermal Management 14.3%**
- **Housing, Connectors 10.7%**
- **Production processes 7.9%**

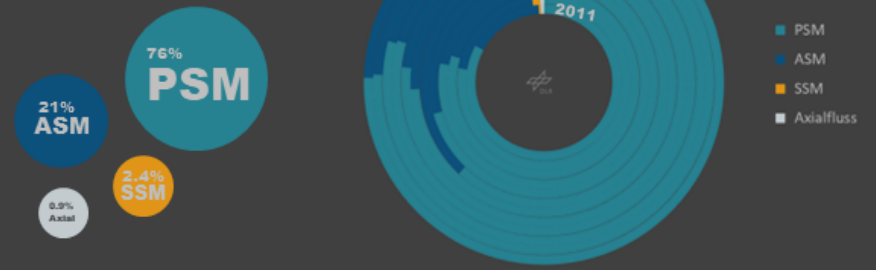
Benchmark of Technological Position | R&D Activities | 2011 vs. 2021



Trends in patent applications 2011–2021



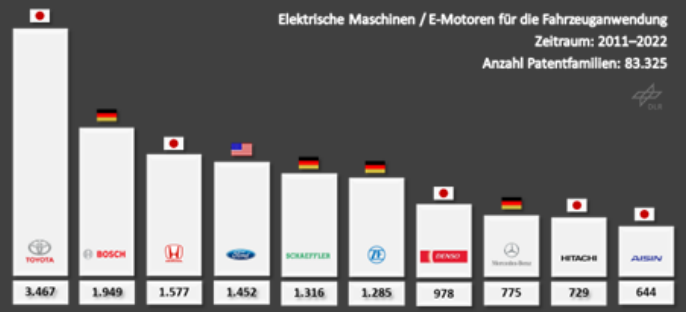
Trend in R&D shares of selected technologies 2011–2022



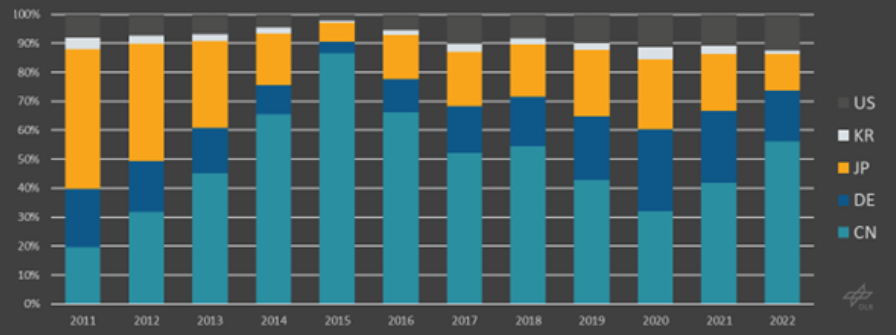
Patent Portfolios: Leading German Companies

Robert Bosch GmbH	1,949	Brose GmbH & Co. KG	118
Schaeffler AG	1,316	ThyssenKrupp AG	78
ZF Friedrichshafen AG	1,285	Mahle GmbH	63
Mercedes-Benz AG	775	FEV Europe GmbH	48
Volkswagen AG	550	MAN Truck & Bus SE	48
Audi AG	546	Magna Powertrain	44
BMW AG	536	IAV GmbH	21
Porsche AG	396	Grob-Werke GmbH	15
Continental AG	386	Knorr-Bremse AG	15
Siemens AG	288	Infineon AG	15

Top 10 Global Company Rankings



Trends in R&D shares of selected countries | 2011–2022



Contact: benjamin.frieske@dlr.de // Sources: CNIPA (2023), DLR (2023), e-mobil BW (2023), EPO (2023), KIPO (2023), USPTO (2023), Transformationswissen BW (2021), TU Munich (2023)

Value Creation Potential for Electric Motors in Europe | 2020 vs. 2030

2020
€1.0 billion

2030
€6.8 billion

Use of rare earth metals per electric motor

2020	2022
1.93 kg	1.58 kg
Neodymium price	
83.41 EUR/kg	202.94 EUR/kg

Strategic dependence on China

Rare earth metals
98%

85%
Permanent magnets

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Development Goals

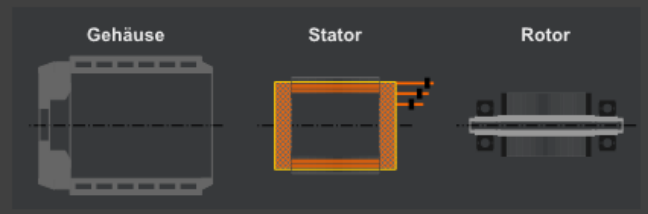
- **Cost reduction**
  - Reduction in material usage | Cost-effective materials
  - Substitution of rare earth elements with alternative motor types (FSM/ASM instead of PSM)
- **Package and weight optimization**
- **Increased torque/power density**
- **Efficiency optimization across the entire operating range**

Key technological trends

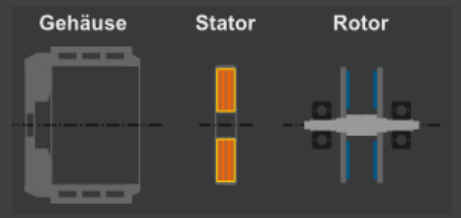
- High-level / system integration
- Increased rotational speeds
- Axial-flow motor
- New cooling concepts and thermal management
- Hairpin technology
- Hollow wires
- Contactless energy transfer to the rotor (FSM)
- Improved magnets
- Compressed windings
- High-temperature insulation

Schematic structure of various electric motors, including rotor types

Radial-flow motor



Axial-flow motor





PSM – Permanent magnet synchronous motor

FSM – Separately excited synchronous motor

ASM – Induction motor with squirrel-cage rotor

Market share of electric motor types in vehicle models in Germany

2022

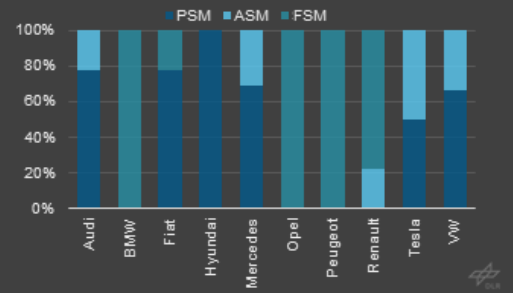




Relevant electric motor components, parts, and materials | OEM in-house production vs. outsourcing

		Component / Component	Make	Buy	Material	Quantity per motor
Stator		Stator core		x	Electrical steel	~ 300–700
		Insulation		x	Paper | Plastic | Varnish Encapsulant	~ 48–54
		Wire winding	x		Copper	4–9 kg
Rotor		Shaft		x	Steel	1
		Staple		x	Electrical steel	~ 300–700
		Stock		x		2
	PSM	Magnets		x	Rare earth metals, neodymium-iron-boron, etc.	~ 48–256
	FSM	Claw bar		x	Plastic	2
	FSM	Insulation		x	Paper | Plastic | Varnish Encapsulant	~ 4–6
	FSM	Wire winding	x		Copper	4–5 kg
	FSM	Slip rings		x		1
	ASM	Squirrel-cage motor	x		Aluminum | Copper	1
Housing		Housing parts	x		Aluminum	Min. 2
		Speed sensor		x		1
		Temperature sensor		x		1
		Gaskets		x		Min. 2
		Busbars		x		~
		High-voltage connection		x		~
		Cooling circuit connections		x		~

Use of different electric motor types in models from selected OEMs



Process steps and manufacturing expertise | Stator | Rotor | Housing

- Punching and packaging sheet metal
- Cutting, folding, and inserting the groove base insulation
- Drawing or rolling the winding wire, cutting to length and bending for hairpin technology
- Winding the round wire or inserting, twisting and connecting the hairpin flat wire
- Wiring, impregnation, and electrical testing

- Cutting to length, machining, grinding, and hardening the rotor shaft
- Punching and stacking laminations

PSM: Magnet assembly, magnetization

FSM: Insulation, winding, connection

ASM: Manufacturing, assembly of squirrel-cage rotors

- Assembling the laminated core and shaft, balancing

- Die-casting of housing components, deburring, machining, cleaning
- Shrinking of the stator, bonding or welding if necessary, assembly of the rotor bearings
- Insertion of the rotor, application of sealing material, and assembly of the bearing shield
- Assembly of sensors, high-voltage and cooling circuit connections, end-of-line testing

Production sites in Europe



Contact: benjamin.frieske@dlr.de // Sources: A2Mac1 (2023), ADAC (2023), e-mobil BW (2020, 2021), Frieske et al. (2023), KBA (2021, 2022), PEM (2023a, 2023b)

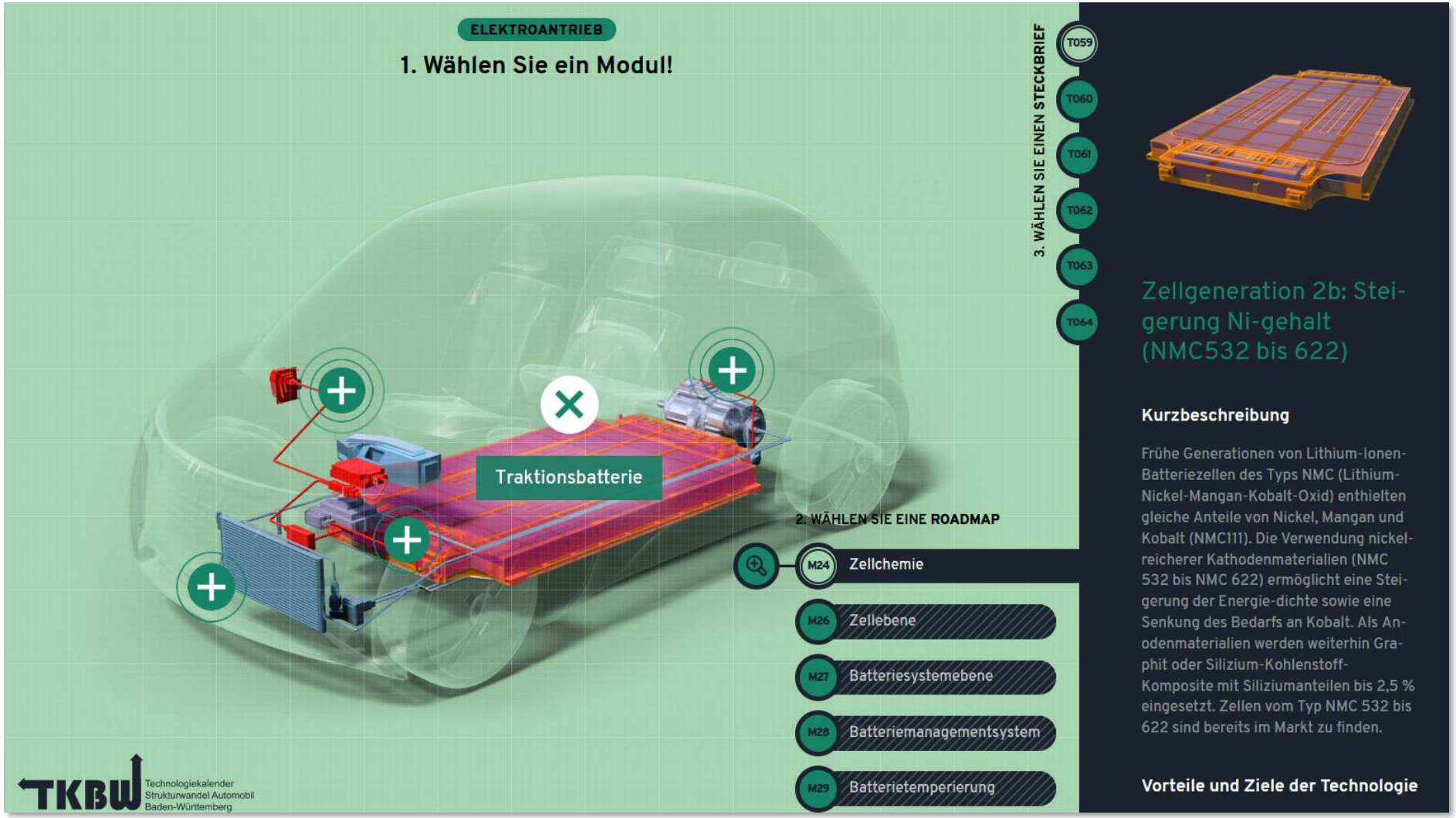
Roadmapping of New Components and Key Technologies

DLR Technology Calendar – Interactive WebApp



Roadmapping of New Components and Key Technologies

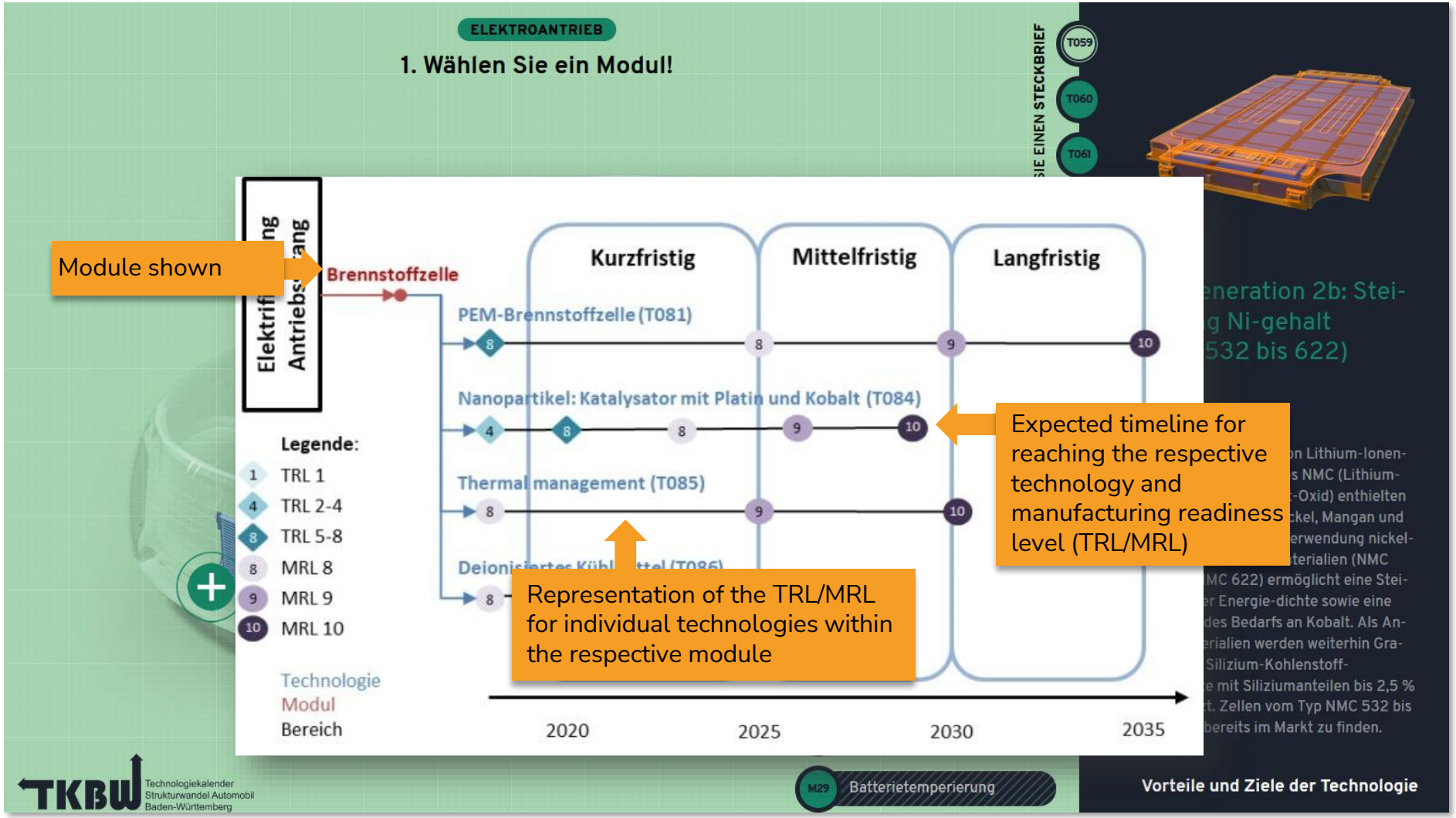
DLR Technology Calendar – Interactive WebApp



- 144 individual technologies
- 40 modules and systems
- Brief description / Advantages and objectives / Development status
- Roadmap for TRL development (Technology Readiness Level)
- Delphi expert survey

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Project Contacts



If you have any questions or suggestions, the team at the Transformation Hub Scale-up E-Drive is happy to assist you!

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