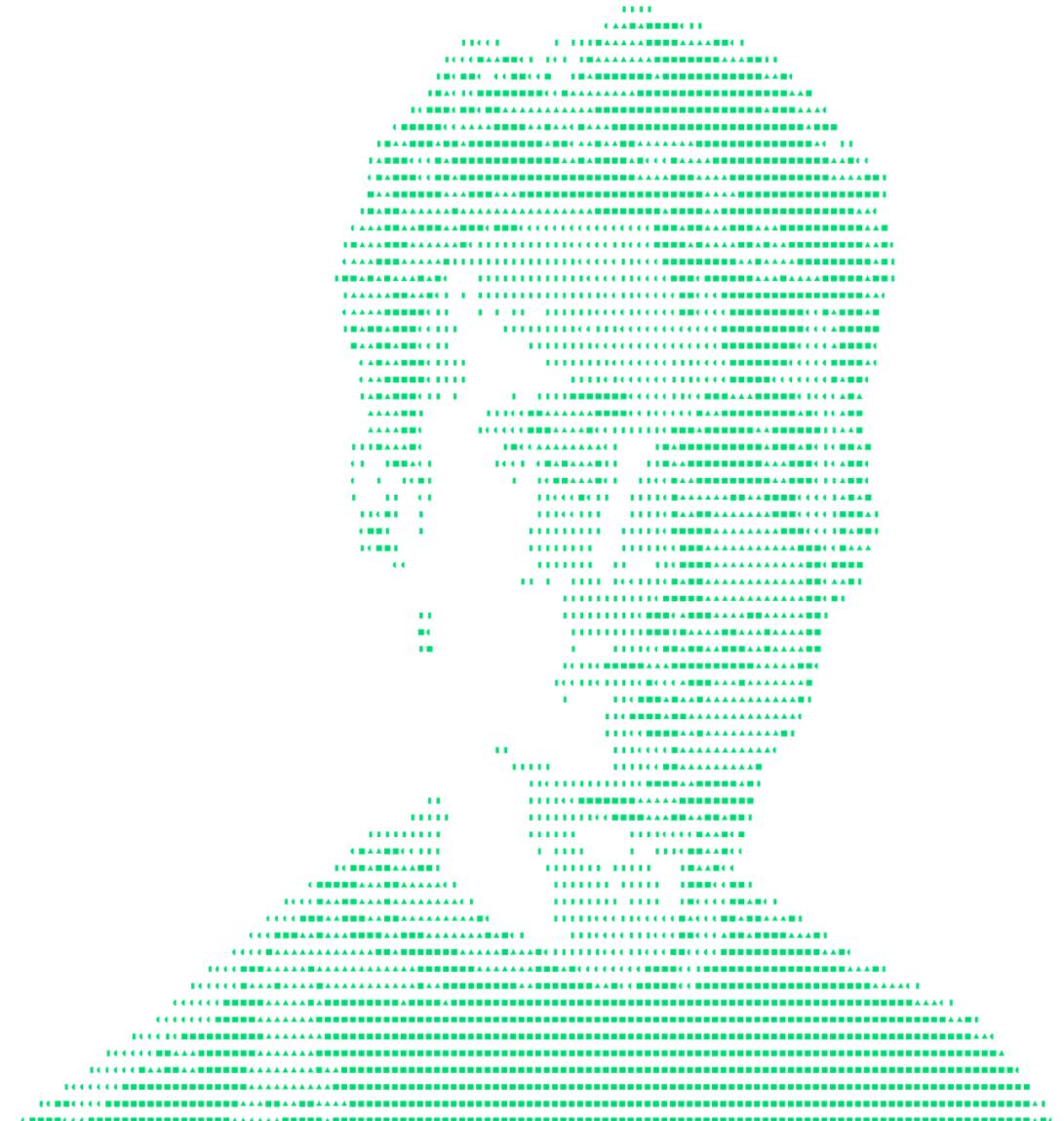


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Trends in EV Market 2022



TAYSAD ELEKTRİKLİ ARAÇLAR GÜNÜ-KOCAELİ/TOSB
21st September 2022



Who are we?

Serving our clients with competitive insights for more than 25 years



25

Years



600+

Staff
worldwide



Global

Footprint with
17 locations



40 Million

Images and digital
twins in our database



1500+

Analyzed
vehicles



650+

OEM and Supplier
customers



100+

New vehicles
per years



>650k

Users worldwide



Insights
Technology Insights
Performance Insights
Cost Insights
Market Insights

Platform
Benchmarking Software-as-a-Service



Benchmarking support delivered to
all major OEMs and over 200 of their
suppliers



A highly effective benchmarking
methodology with standardized &
repeatable processes

Global presence

Worldwide competitive insights

Paris area & Hary - FR

- A2Mac1 Group Office
- Benchmarking Center
- Dynamic Benchmarking advanced Lab

Munich - DE

- Sales & Support Office
- Electronics & Costing advanced Lab

Vancouver - CA

Sales & Support Office

Detroit - US

Benchmarking Center

Querétaro - MX

Benchmarking Center

United Kingdom - UK

Sales & Support Office

Chennai - IN

Benchmarking Center

Vienna - AT

Sales & Support Office

Turkey - KR

Sales & Support Office

Shanghai - CN

Benchmarking Center

Tokyo - JP

Sales & Support Office

Seoul - KR

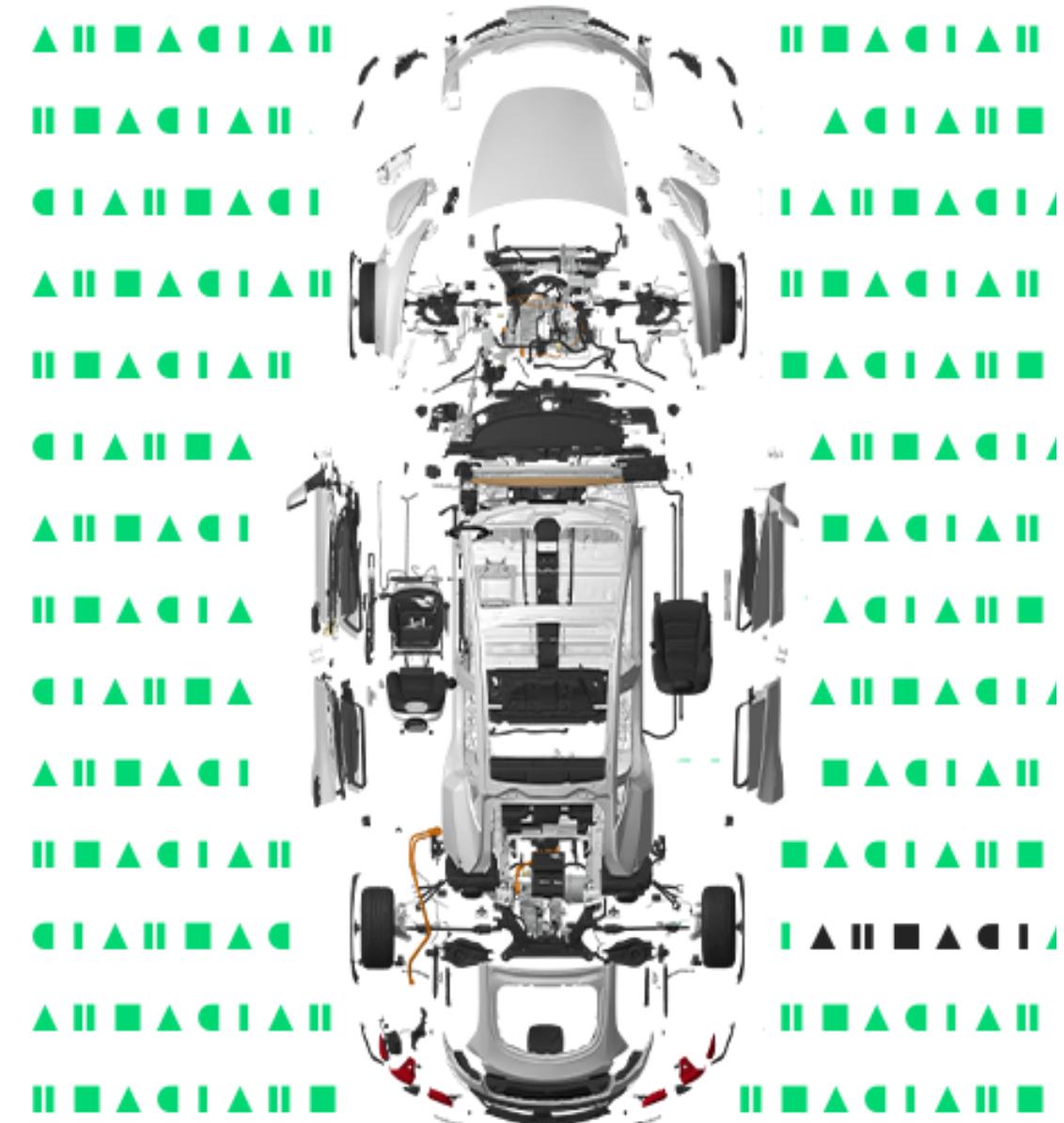
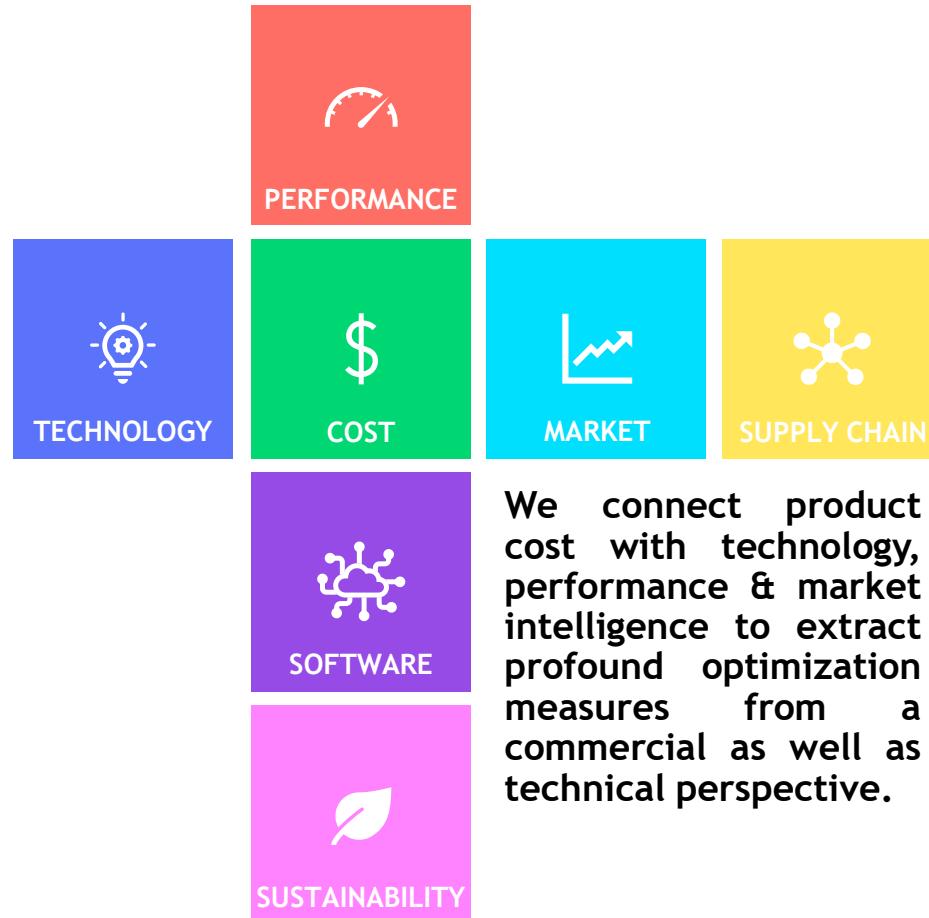
Sales & Support Office

Bangkok - TH

Benchmarking Center

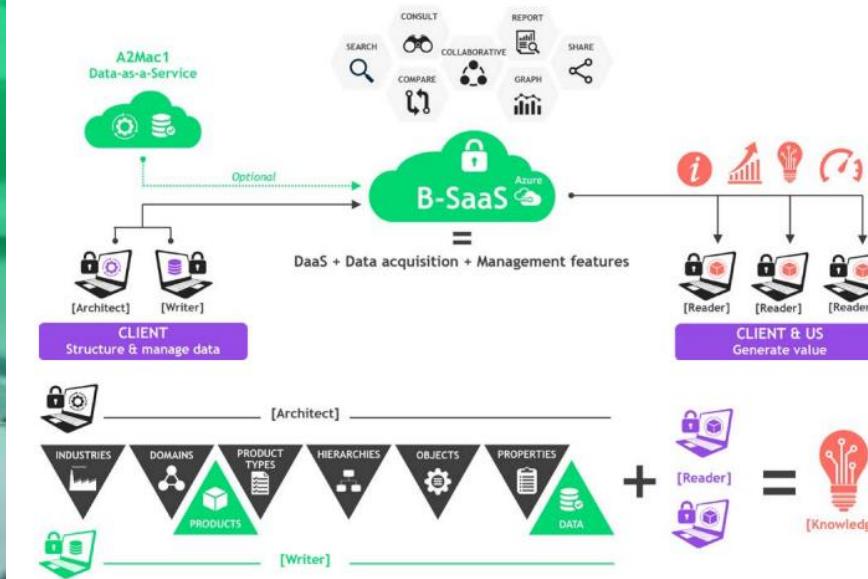
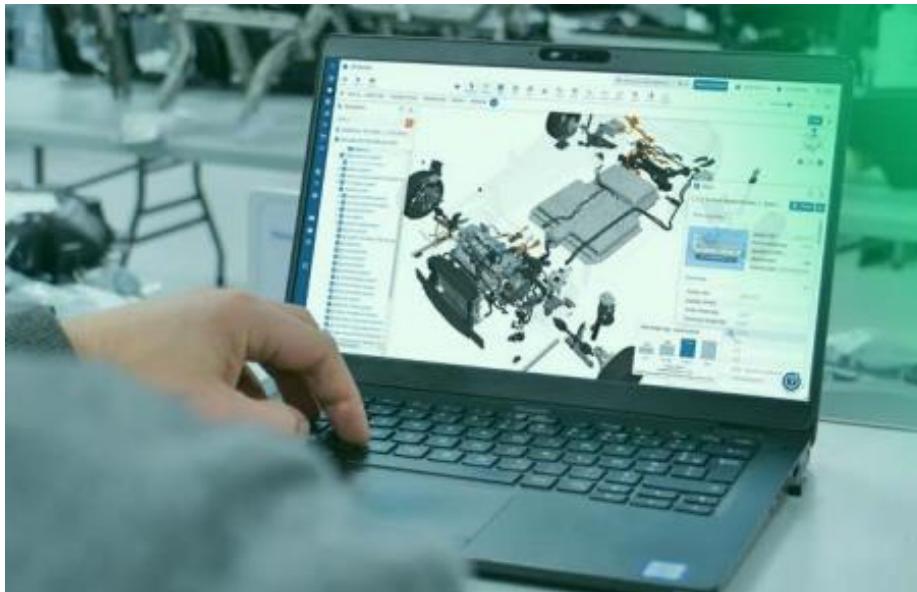


Our approach to provide customer with holistic 360° Vehicle Insights



Platform

State-of-the-art platform to transform your data into game-changing insights



Powerful data management
and structure

- Integrated tools to input data, including photo editor
- Capacity to manage large and complex sets of data
- Capacity to integrate specific client applications



Intuitive web-based platform with
easy-to-use UI

- Customized data display (incl. multiple hierarchies)
- Comparison
- Advanced search
 - 3D Explorer
 - Multi language
- Collaborative tools



Advanced security level and capacity to
segregate sensitive contents



Automated user management

They trust us

OEM References



They trust us

Non-OEM References



Challenges & Motivation for 360° Vehicle Insights dimensions



TECHNOLOGY INSIGHTS

High innovation pressure due to new market entrants in the EV space
eMobility tech maturity increases
Tech-quantum leap enabled by players such as Lucid



COST INSIGHTS

Costs as key competitiveness criteria in disruptively changing automotive environment (EV vs. ICE)
New players in the market



PERFORMANCE INSIGHTS

High pressure to achieve more efficient designs
Features / Functions / Performance key for positioning in the market & as differentiator



MARKET INSIGHTS

OEMs seeking for orientation in changing environments with new markets, new players & more complex platform strategies



SUSTAINABILITY INSIGHTS

Governmental rules cause high pressure on Sustainability over lifetime
Management gets new KPIs such as CO2 emission savings



SOFTWARE INSIGHTS

Substantially increasing cost share in the vehicle
Vehicle as a smartphone on 4 wheels
Complete ecosystem to be considered



SUPPLY CHAIN INSIGHTS

Trend towards reshaped value chains
Increased in-house share providing opportunities
More complex localization, modularization & platform strategies

360° Vehicle Insights



Changing & challenging environment

Customer demands: Low prices

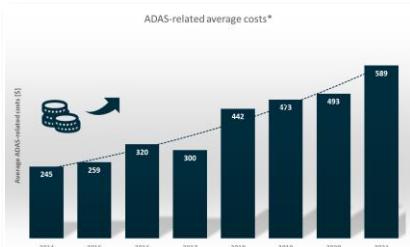
Cut cost for electric vehicles



- EVs are in competition with combustion engine driven vehicles
- Sales prices of EV to be competitive
- Ensure sufficient ROI for OEMs and Suppliers (high pre-invests!)

Cost optimization on system level required

Customer demands: Features & performance



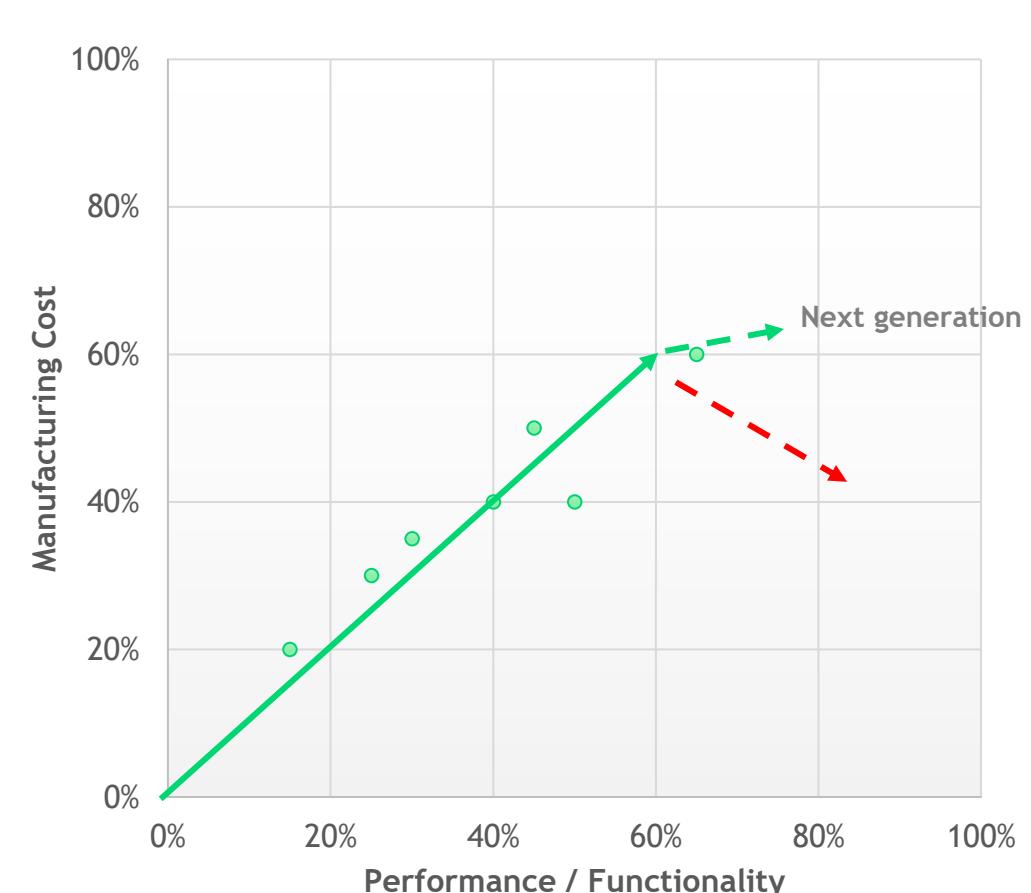
Increasing regulatory requirements

- Systems such as driver monitoring are mandatory from legislation in many countries

Demand for advanced / smart features

- Features such as surround view & autonomous parking are demanded by the customer
- Smart connected vehicle

Differentiation of OEMs through performance parameters!



Traditional: More performance / function at same cost level

New requirement: More performance @ lower cost!

In 2022, A2MAC1 sees 7 key trends in the EV space

Move towards alternative cell chemistries



Increased risk in battery costs



Cost hike to achieve Level 3 Autonomous Driving through evolving technologies



Next level of integration in Power Electronics



Quantum leap in power density of eDrive



Innovative Thermal management strategies

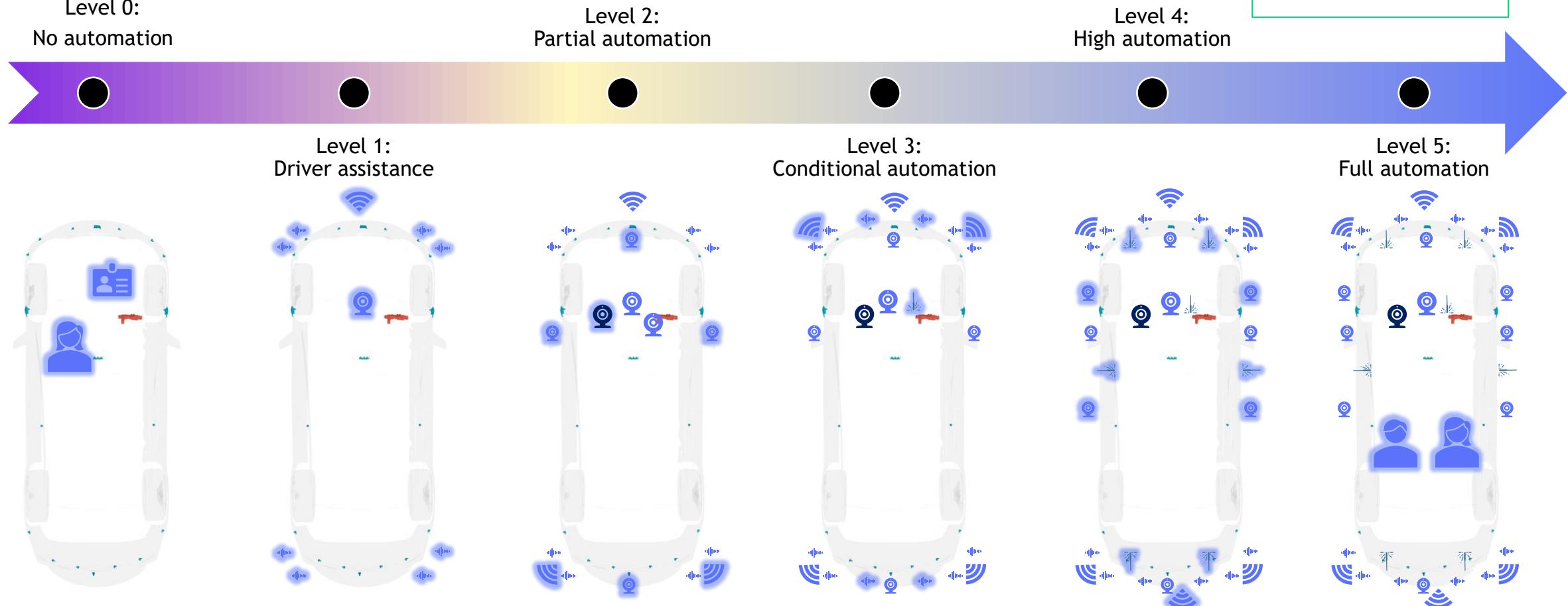


Integration & collaboration as booster for innovation





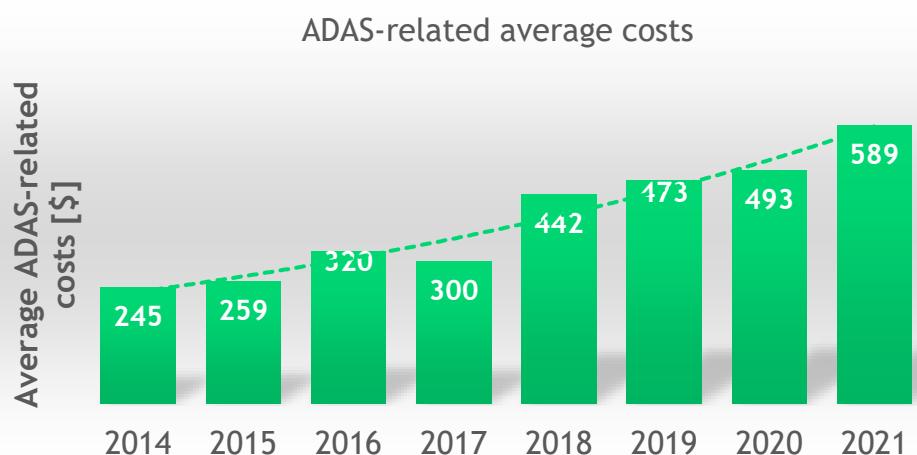
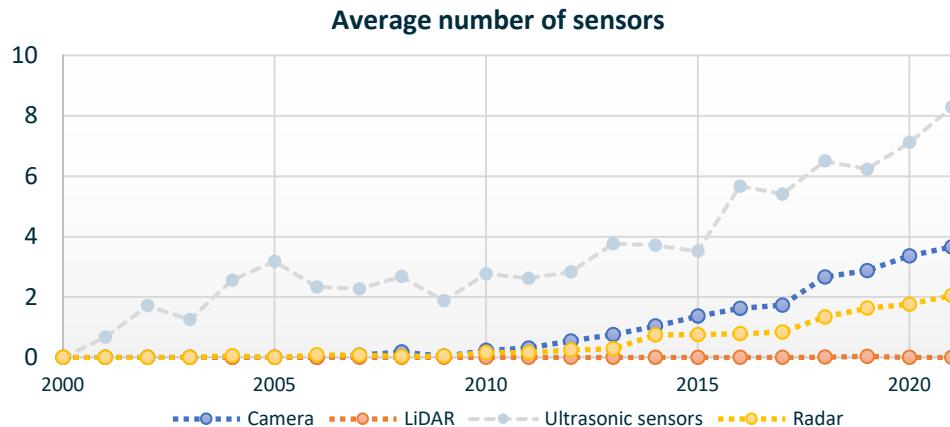
Road to Autonomous Driving





2022 EV Trends: Further cost jump to achieve Level 3 ADAS

Cost increase for ADAS functions gets further acceleration due to number of sensors & wide-scale market launch of LiDAR



Main 2022 ADAS trends

- Cameras are continuously developing in ADAS sensor suites
- Further increase in cameras and their applications is expected in the upcoming years
- Solid-state LiDARs are a new category of high-end sensor modules introduced in vehicles produced in 2022.
- High-class vehicles such as Lucid Air or Mercedes EQS use laser scanners for advances towards autonomy levels 3 and 4.

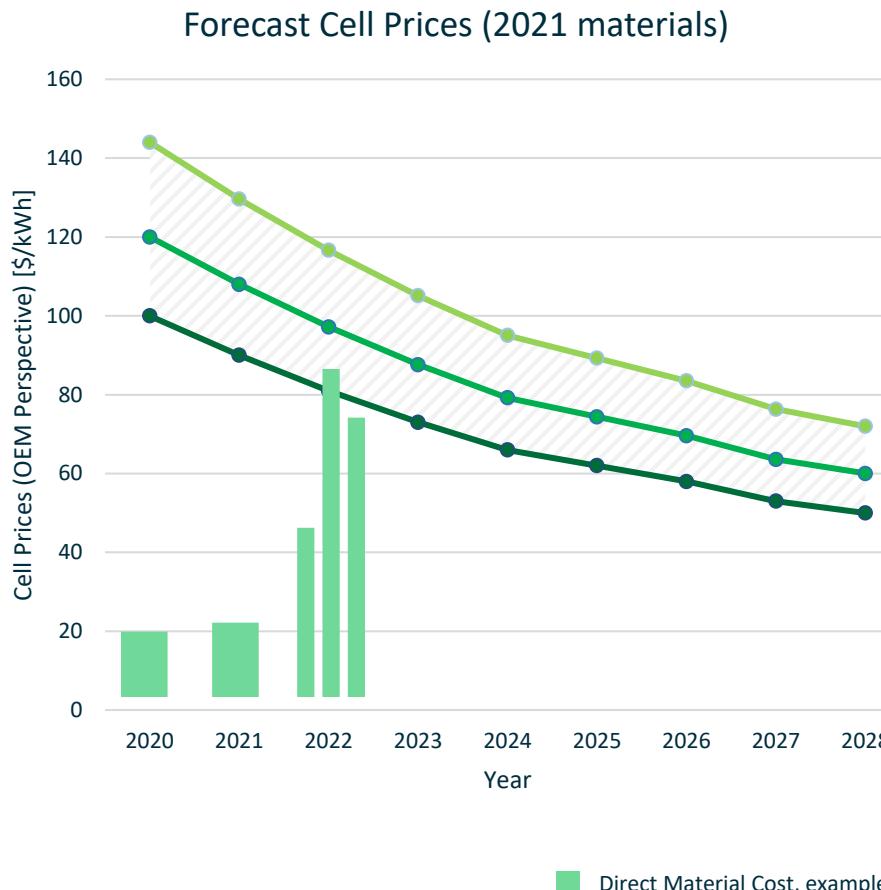
Case study: 2022 Lucid Air

- Large cost share of ECUs due to powerful centralized ADAS processor and redundancy measures to ensure desired performance
- Lucid Air ADAS system is verifying the prediction that the ADAS system cost share gains importance with every step towards full vehicle autonomy
- Large quantity of cameras and introduction vehicles with LiDAR pave the way for sophisticated, advanced driver assistance functions



2022 EV Trends: Increased risk in Battery costs

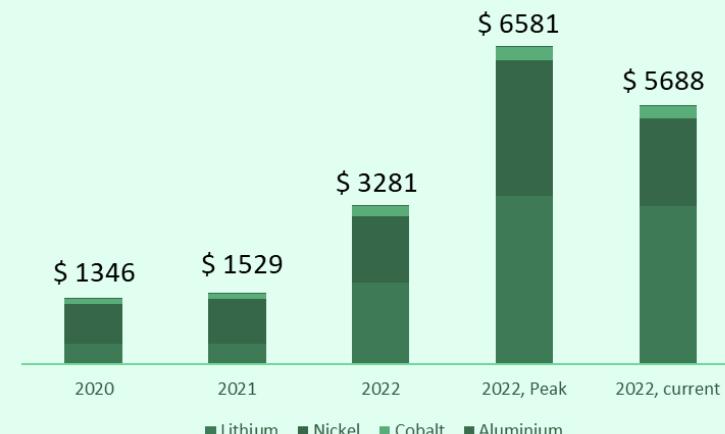
2022 is the first year, battery cell costs are increasing substantially due to raw material cost fluctuations



Dramatic battery raw material price increase in 2022

Nickel: +300% (peak)
 Cobalt: +250% (peak)
 Lithium Carbonate: +600% (peak)
 Lithium Hydroxide: +800% (peak)

Tesla Model Y Battery Cell Materials



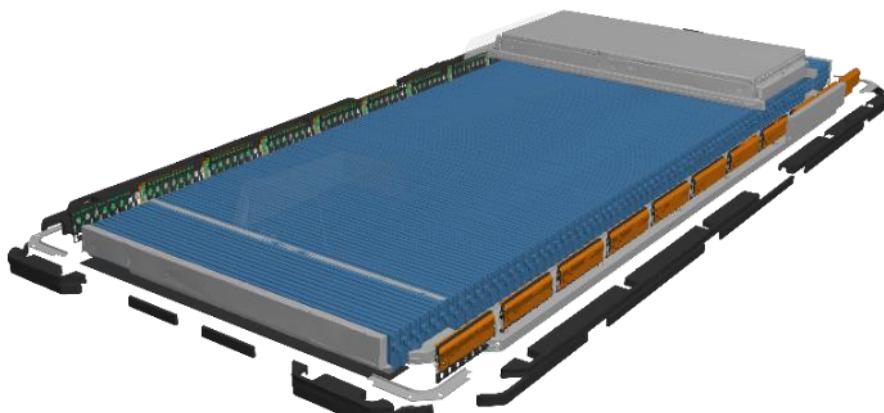
Tesla NCA	Weight per Car [kg]
Lithium	7.69 kg
Nickel	58.52 kg
Cobalt	3.27 kg
Aluminum	1.50 kg
(Oxygen)	35.5 kg

* Without processing, taxes, shipping, overheads, ...

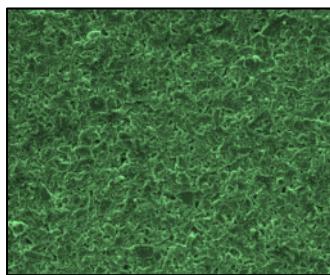


2022 EV Trends: Move towards alternative Cell chemistries

Market is moving away from conventional NMC cell chemistry to more application-tailored chemistries

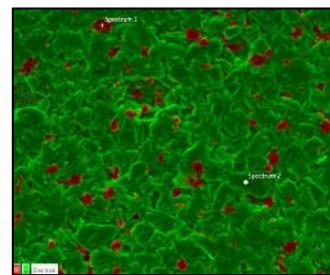


BYD Han LFP Blade Battery



VW ID.3

Carbon
Silicon



Porsche Taycan

BEV Cell chemistry

- Till date OEMs are driven by maximizing the range of vehicles by maximizing energy density and specific energy
- Range of 400-500km can be achieved easily, other parameters can be optimized

High performance / fast charging

- Anode chemistry must be adapted
- New solutions will be available next year
- Possible solutions:
 - Graphene instead of Graphite
 - Silicon anodes with adjusted electrolytes
 - Solid electrolytes

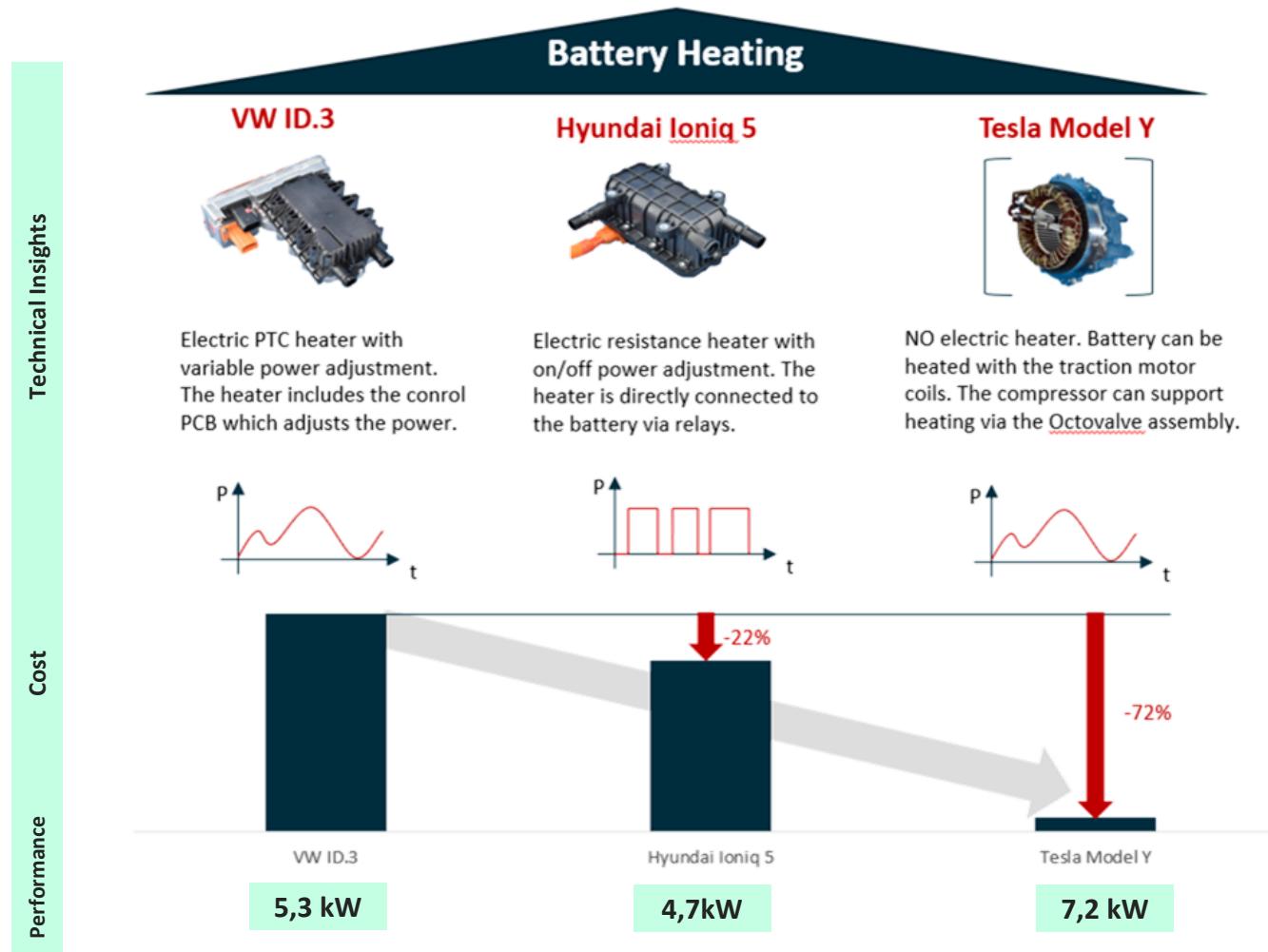
LFP Batteries

- Used in stationary applications and commercial vehicles (mainly in China)
- Latest developments lead to similar battery specific energy, whilst reducing cost and dependence on Nickel and Cobalt
- Tesla implements LFP cells to reduce cost of entry level vehicles in the Chinese market



2022 EV Trends: Innovative battery preheating strategy

Recent launches in automotive market show high level of integration of different functionalities.

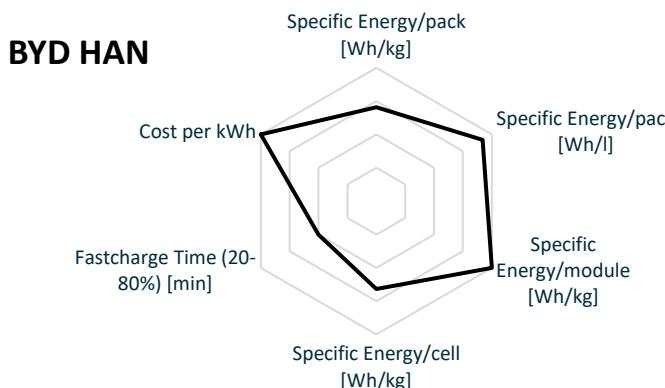
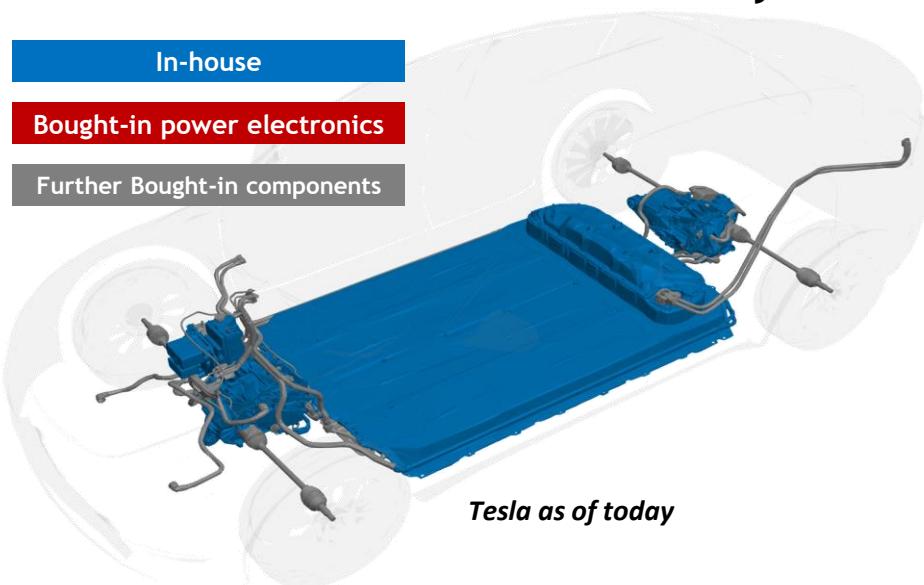


Showcase / Example

- Various heating strategies exist on the market for Heating / Preconditioning the Battery during low-temp fast-charging conditions
- Combining the Measurement data and analyzing the heating power in relation to the cost, it can be proven that Tesla can reduce the cost for this function by 72% over VW ID.3 with the tradeoff of requiring higher heating power
- Another cost reduction measure is using a 2 level-regulation strategy like Hyundai allowing for a smaller heating power requirement while saving cost for control electronics

2022 EV Trends: Vertical integration & collaboration as booster for innovation

Further vertical integration driven by companies as Tesla & BYD and collaboration with supplier ecosystem are a booster for further innovation on system level.



Established players and new entrants are increasing vertical integration to control value-add, design & profitability

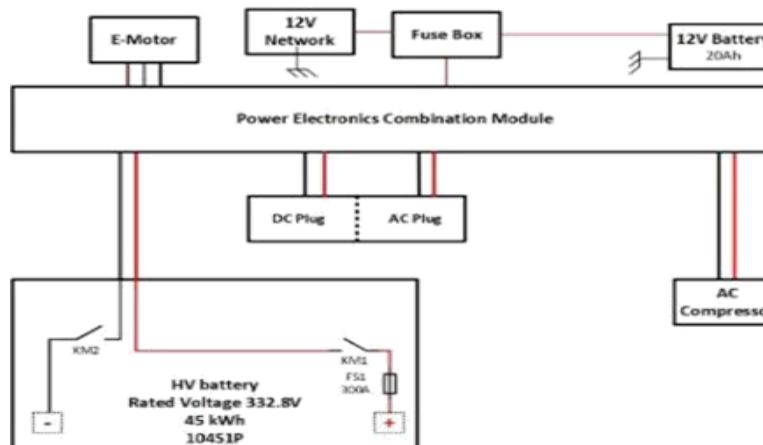
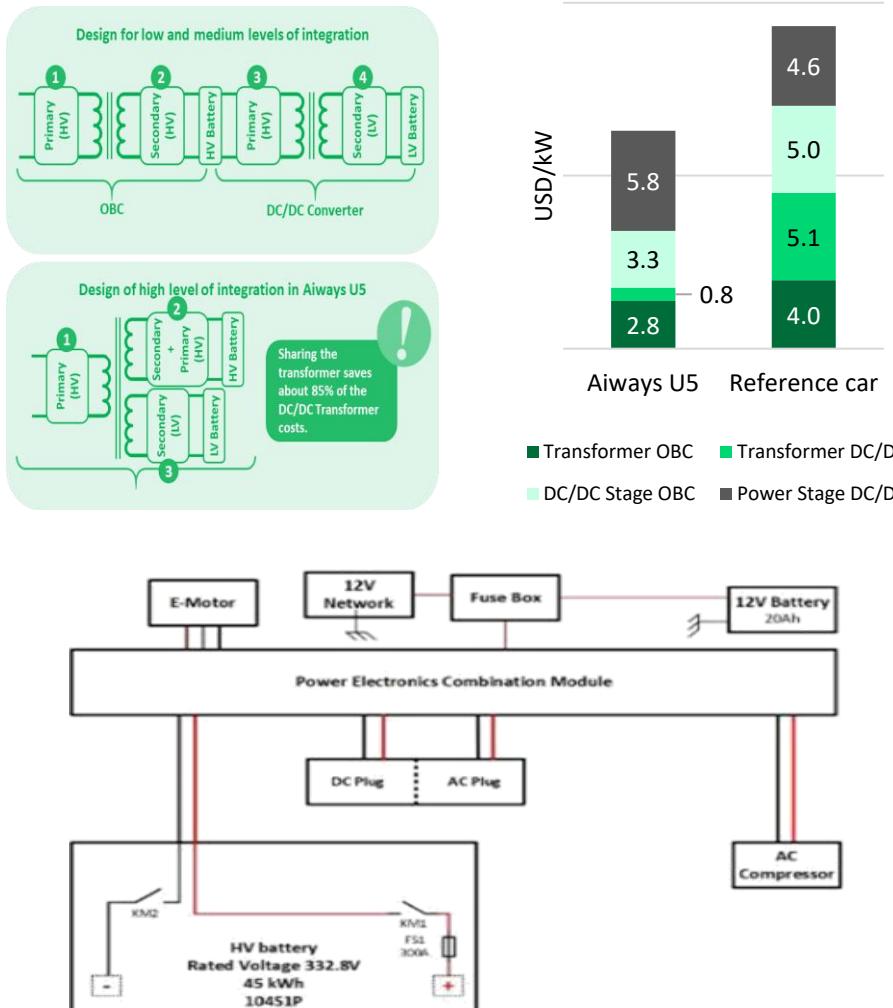
- Tesla implements a vertically integrated supply chain approach for the powertrain
- Battery, Motor & Gearbox are produced in-house
- Power electronics, such as Inverter, Onboard charger & DC-DC converter are developed and produced in-house
- Traditional OEMs are focusing on vertical integration strategy on the most valuable items of the vehicle powertrain

LFP batteries are 20-30% cheaper albeit with low energy density

KPIs	Aiways U5	BMW iX3	BYD Han	Hyundai Ioniq 5
Specific Energy/pack [Wh/kg]	172	155	134	190
Specific Energy/pack [Wh/l]	229	180	211	221
Specific Energy/module [Wh/kg]	218	224		178
Specific Energy/cell [Wh/kg]	239	245	167	216
Fastcharge Time (20-80%)	36	31	30	15
Cost per kWh	121%	119%	100%	130%

2022 EV Trends: Next level of integration in Power Electronics

As technology matures, first OEMs are ready to launch fully-integrated Power Electronics concepts.



Integration of power electronics modules

- Even lowest degree of integration of power electronics modules (i.e., OBC and DCDC just share the housing) can lead to cost reduction.
- Higher degree of integration involves sharing of power path, power transformers and control functions.
- High degree of integration can improve the powertrain electrical architecture and therefore minimize HV cable cost.

Case study: BYD Dolphin Flagship

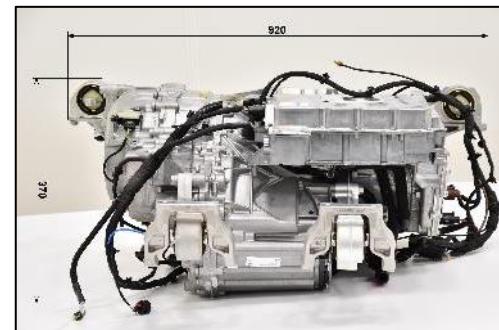
- BYD Dolphin is a good example of low cost, city car with relatively small battery capacity of 47kWh and cost of less than 15 k\$.
- BYD Dolphin integrates inverter, OBC and DC/DC in one unit, which is mounted on top of e-motor assembly.
- With this special design, BYD also minimizes effort for HV cable cost, with only 2 main HV cable in powertrain

2022 EV Trends: Quantum leap in power density of eDrive

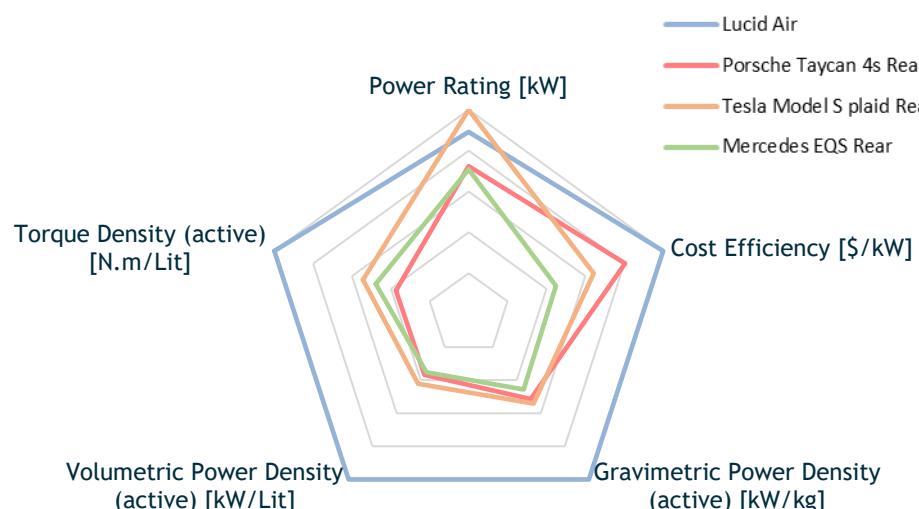
Disruptive Technological innovations, such as the first motor in market with continuous hairpins, enable a jump in KPIs.



Lucid Air, 410 kW



Porsche Taycan 4s, 270 kW



Main 2022 e-Drive Trends

- High integration of E-drive modules result in smaller volume and provide more space for occupant package.
- SiC provides better performance than IGBT but at a higher cost
- RC-IGBT (reverse current IGBT) is the best available alternative. This technology has been seen in BMW ad Ford EVs

Case study: 2022 Lucid Air

- Outstanding performance of Lucid Air E-Motor versus main competitors thanks to:
 - High integration degree between motor and gearbox
 - Innovative continuous hairpin winding (wave winding) to maximize the power output
 - Higher e-drive input voltage (>900V) for higher rotation speed without loosing torque
 - SiC technology makes the Inverter unit compacter and more efficient

FACT: Lucid E-drive has 2.3x the volumetric power density and 1.8x gravimetric power density than the Tesla model S plaid rear e-drive!

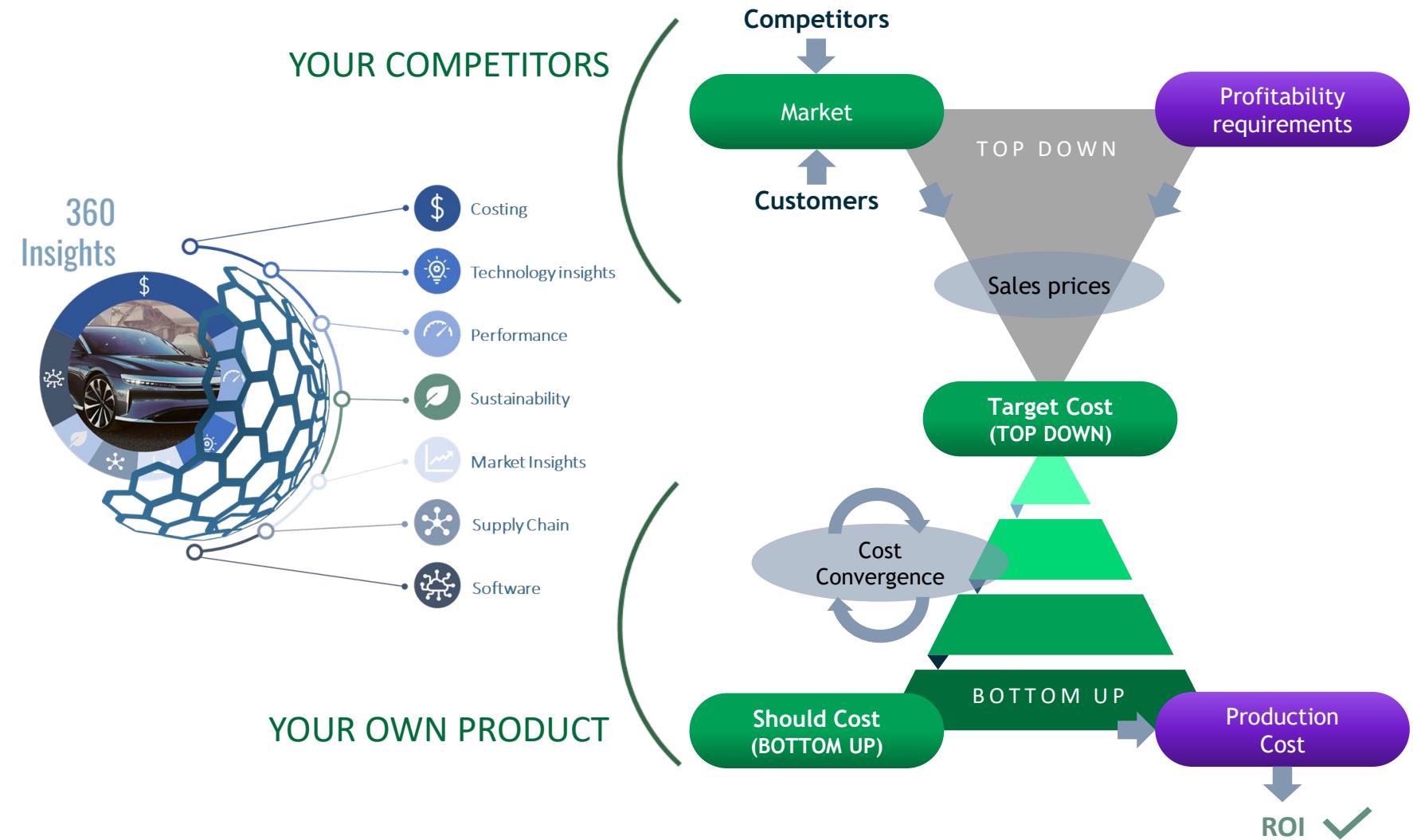
2022 EV Trends: How A2MAC1 supports to keep costs in target!

Our 360° offer is unique on the market and allows us to be at the **state of the art** and following all dimensions of performance.

Our data and knowledge allow us to bring you the best of the best to make your product a **profitable investment**.

Whether you are an investor or the main architect of your venture, we can help you position yourself in the market, identify your **improvement potential** or highlight your technological advances.

Beyond the **Technical Due Diligence** related to investment, our core business allows us to accompany you to optimize the **costs of your solutions**, or to bring you the maturity to implement them to be **profitable** through the optimization of your **design**, your **supply chain** or your **means of manufacturing**.



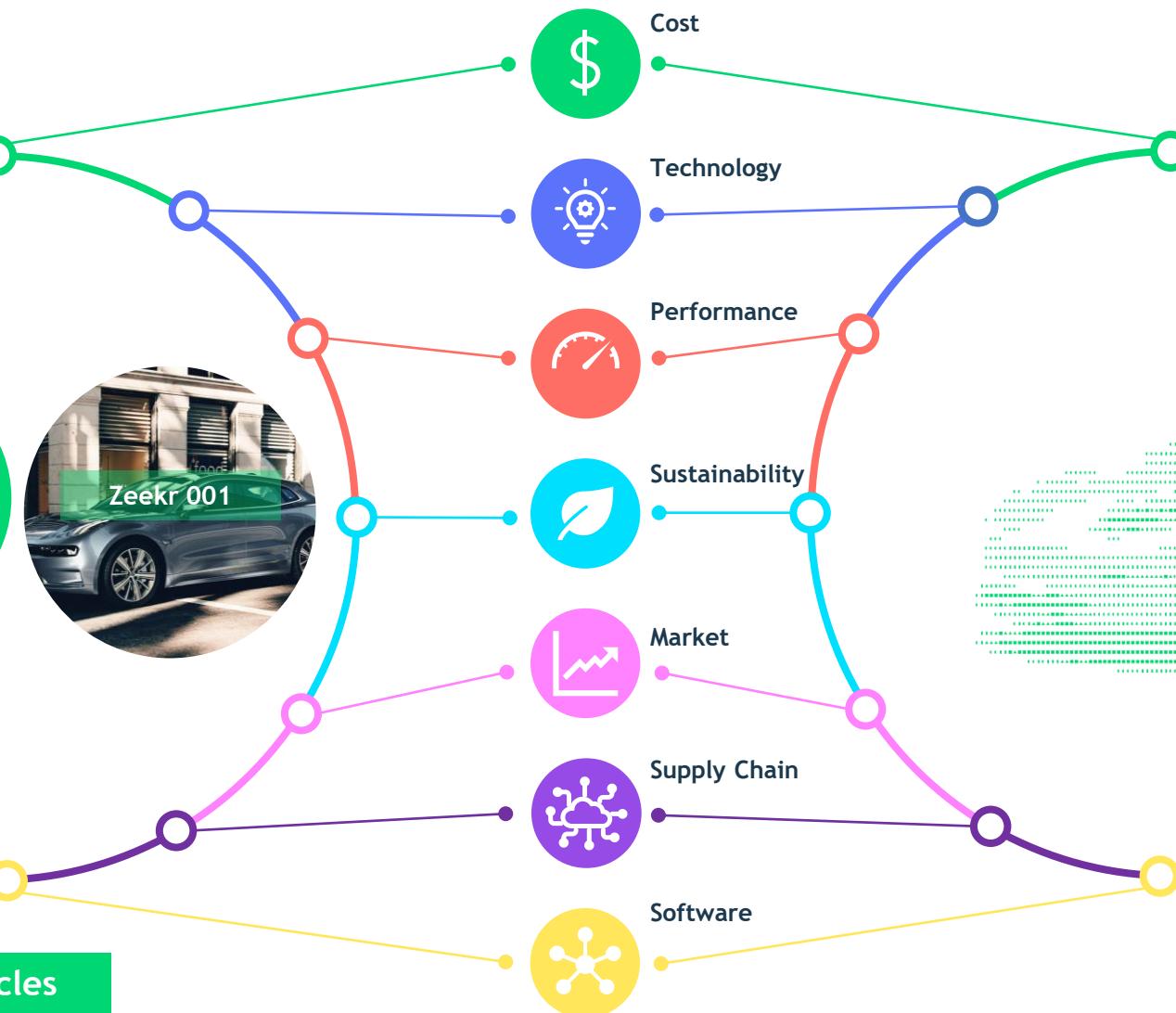
A2MAC1 leverages the full data to generate Insights & Improvement ideas



360° Vehicle Insights on all relevant Competitive Vehicles & Platforms, high-innovative vehicles as well as cost-challengers



+1500 further vehicles



These 360° Vehicle Insights are then benchmarked vs. your vehicle, calculated based on your provided base data

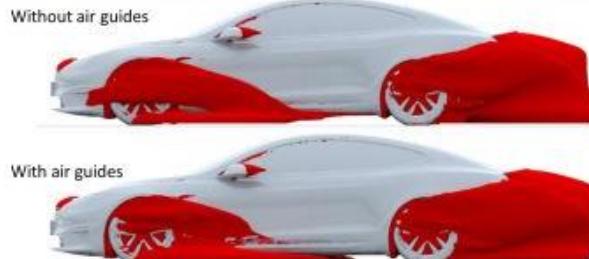
Holistic view is key to be cost competitive...

Aerodynamic improvements seen on the Model S plaid serve as performance optimization as well as cost reduction measures

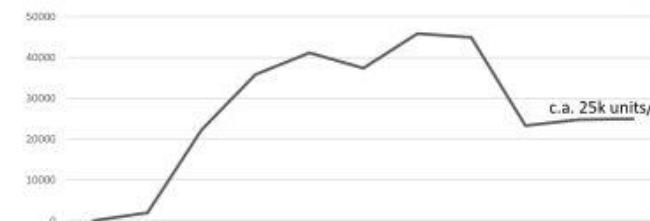


Tesla Model S Plaid : front bumper air guides
PP+PE MD10, 0.57kg total, injection molding, glued and ultra-sonic welding on bumper

PERFORMANCE IMPACT
Drag Coefficient: 0.003 Est. range impact*: 1.5km

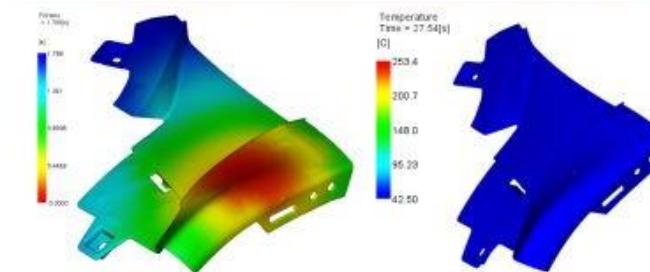


Aerodynamics standard pressure, with vs without airguides
Assumptions : standard body high, (*) 1 Cd point decrease = 0.5km range increase



Tesla Model S Sales Volume
Note : 2021 based on Models S and X combined

COST IMPACT
Mfg Cost : 3.85€ Assembly cost : 3.42€



Injection simulation to determine Should Cost®
Assumptions: 1000 unit/batch, 10 & 15 shifts/week, etc.
EXW Price, Product/Process engineering costs not included

Parameter	Value	Unit
Cost for Aero improvement guides:	8.9	\$
Battery Cost: 2021	15.0	\$
Battery Capacity:	100	kWh
Cost / Wh	0.15	\$/Wh
Energy Consumption (WLTP, researched)	170	Wh/km
Battery Cost /km of range	0.15	\$/km
Range Gain	1.7	km
Energy used for 1.5km	289	Wh
Battery Cost for 298 Wh or 1.5km Range	43.5	\$
Savings per Vehicle	34.6	\$

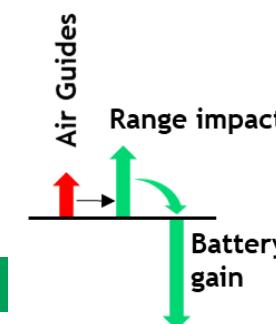
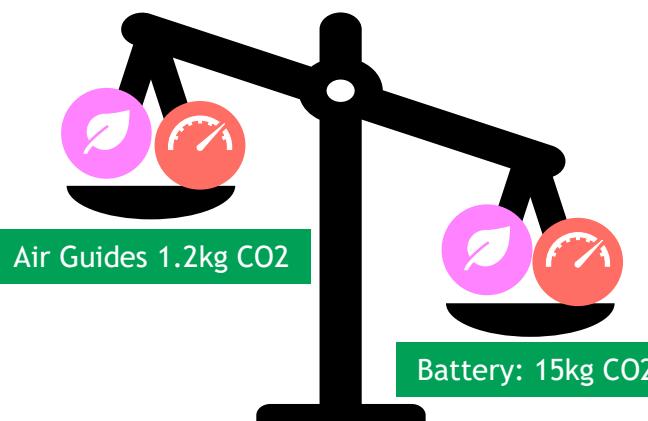
...and to keep the ambitious climate targets of tomorrow



The air guides save \$34 per vehicle



The air guides reduce the production CO₂ footprint of the car by 13.8kg



Cell cost x Range gain

Measure	Parameter	Unit
Total CO ₂ cost for Aero Improvement	1.2	kg
Cells CO ₂ cost	60	Kg/kWh
Battery Capacity	100	kWh
WLTP-Consumption	170	Wh/km
Energy Usage for 1,5km range gain	255	Wh
Battery CO ₂ Savings, if range gain is used for capacity Reduction	15	kg
Savings per Vehicle in Production	13.8	kg

X 1.5

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Thank you



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Decode the future