EFESO
MANAGEMENT CONSULTANTS

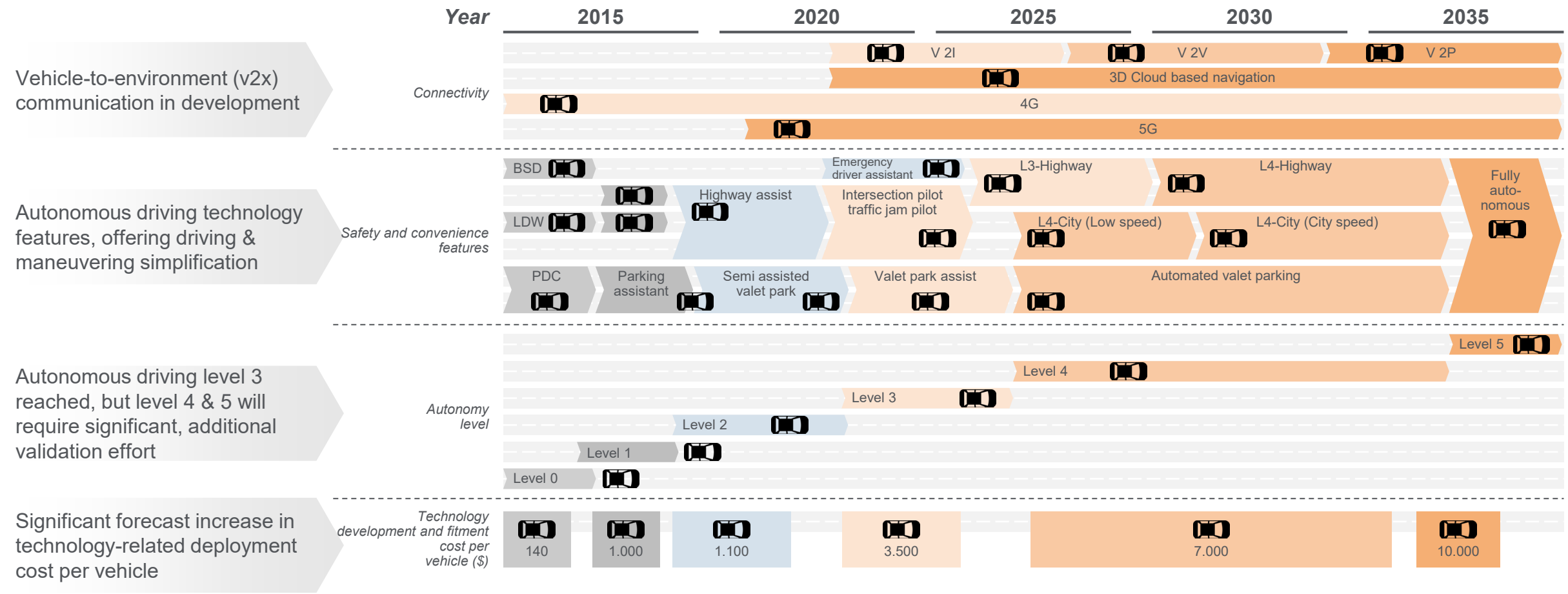
IS MEGA CASTING THE WAY TO GO?

A cost & carbon study on the advantages and disadvantages of welded automotive body assemblies vs integrated castings

COST & VALUE ENGINEERING
INSIGHT

The connected and autonomous vehicle technology roadmap offers significant growth opportunities, yet will add substantially to the baseline cost per car

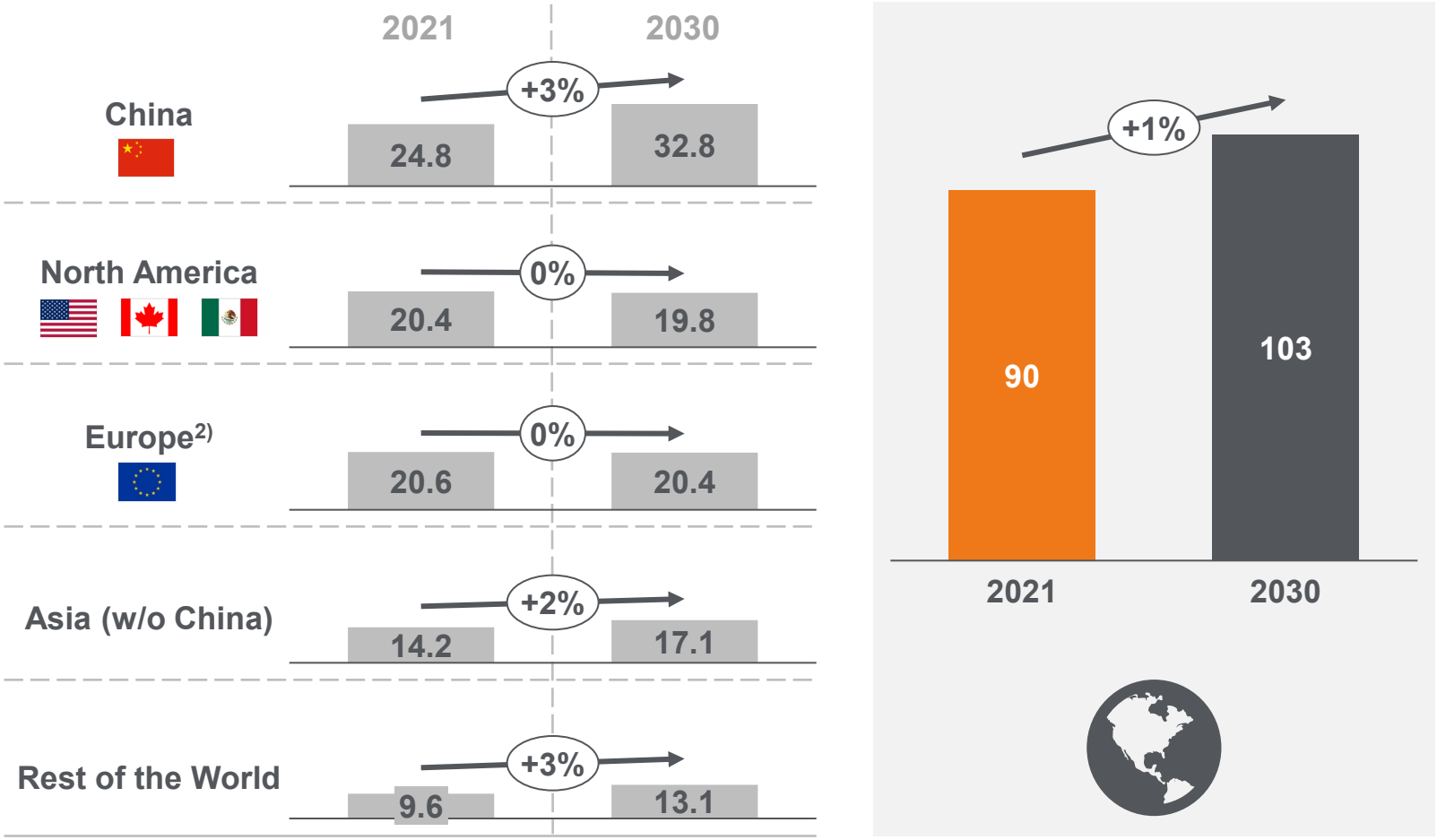
Technology innovation drivers



Source: EFESO research

While the costs of technology development are increasing fast, global sales will only increase by a CAGR of ~ 1% in the period leading up to 2030

Global light vehicle sales forecast[1] *(CAGR 2021 - 2030 in %, million units)*



EFESO Insight

- In the coming years, the global automotive market will be challenged by significant technological changes combined with slow growth rates
- While market growth is slow, insofar as the switch from ICE towards xEV is concerned, the growing level of autonomous driving provides significant market opportunities in a variety of supply areas (e.g., electric powertrain, safety critical applications, interiors, etc.)

- The key focus for Tier-X suppliers is to carefully plan and manage their future product portfolios to guarantee modularity and scalability, therefore allowing multi-customer applications
- The big challenge is managing the costs of what can be termed the 'commodity business', while planning for innovation in growth areas

- OEMs will not price-in additional costs to consumers, in order to avoid high volume risks – suppliers/OEMs will need to concentrate on efforts to drive down technology costs by 2030

1) Subsumes light commercial vehicles and passenger cars – Forecast until 2027 purely based on HIS, thereafter growth forecasted on a regional basis by keeping North America and Europe constant and applying the 2025-2027 CAGR for all other regions 2) Region is defined by HIS, i.e., Europe also includes Russia and Turkey | Source: HIS, EFESO research

Consequently, automotive firms are urgently re-evaluating their global operating models and most attractive profit 'pools'. Cost share remains a top issue!

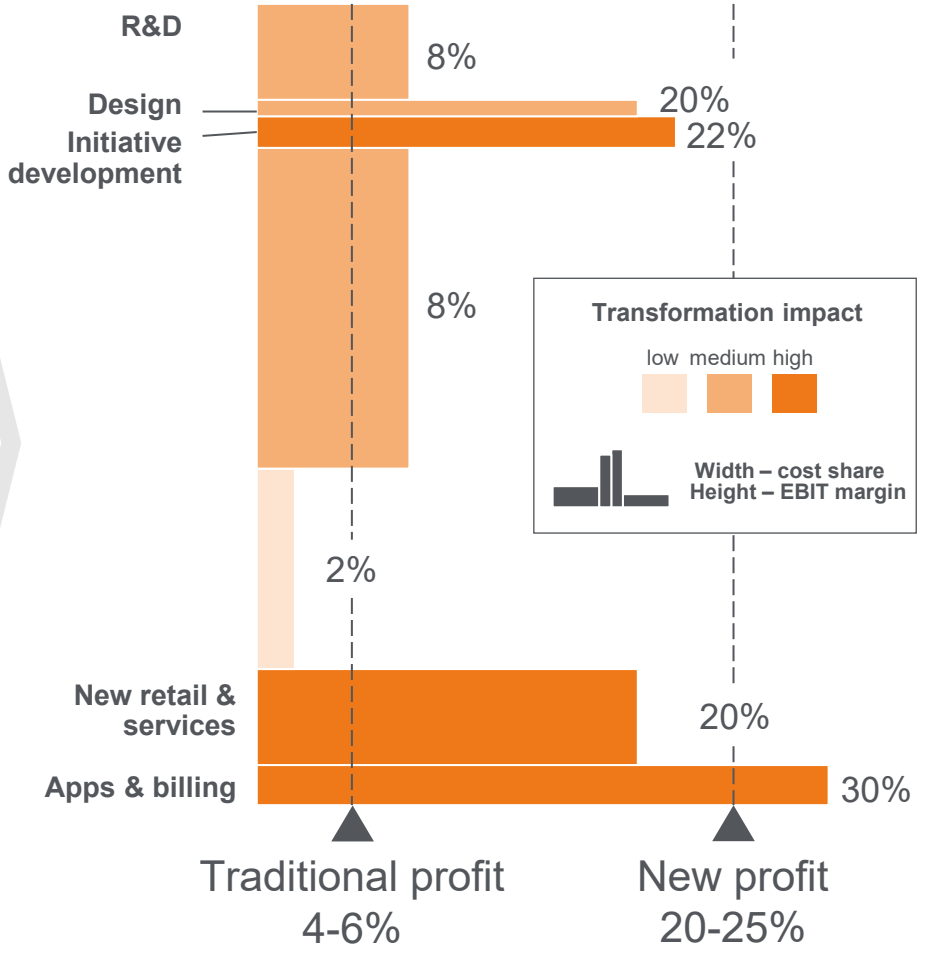
Key trends

- Technological transformation
- Increasing competition
- European law & regulation
- New cooperation models
- Structural changes
- Customer requirements

Examples

- Engine vs. connected vs. battery?
- Cost and CO_2 to become the new currencies?
- New tech entrants in supply chain? ! *Material & purchasing*
- End of global supply chains?
- Services to become the cash cow?
- Lower margin and repair frequency? ! *Manu-facturing*
- Integrated supply chain & logistics?
- B2B vs. B2C?

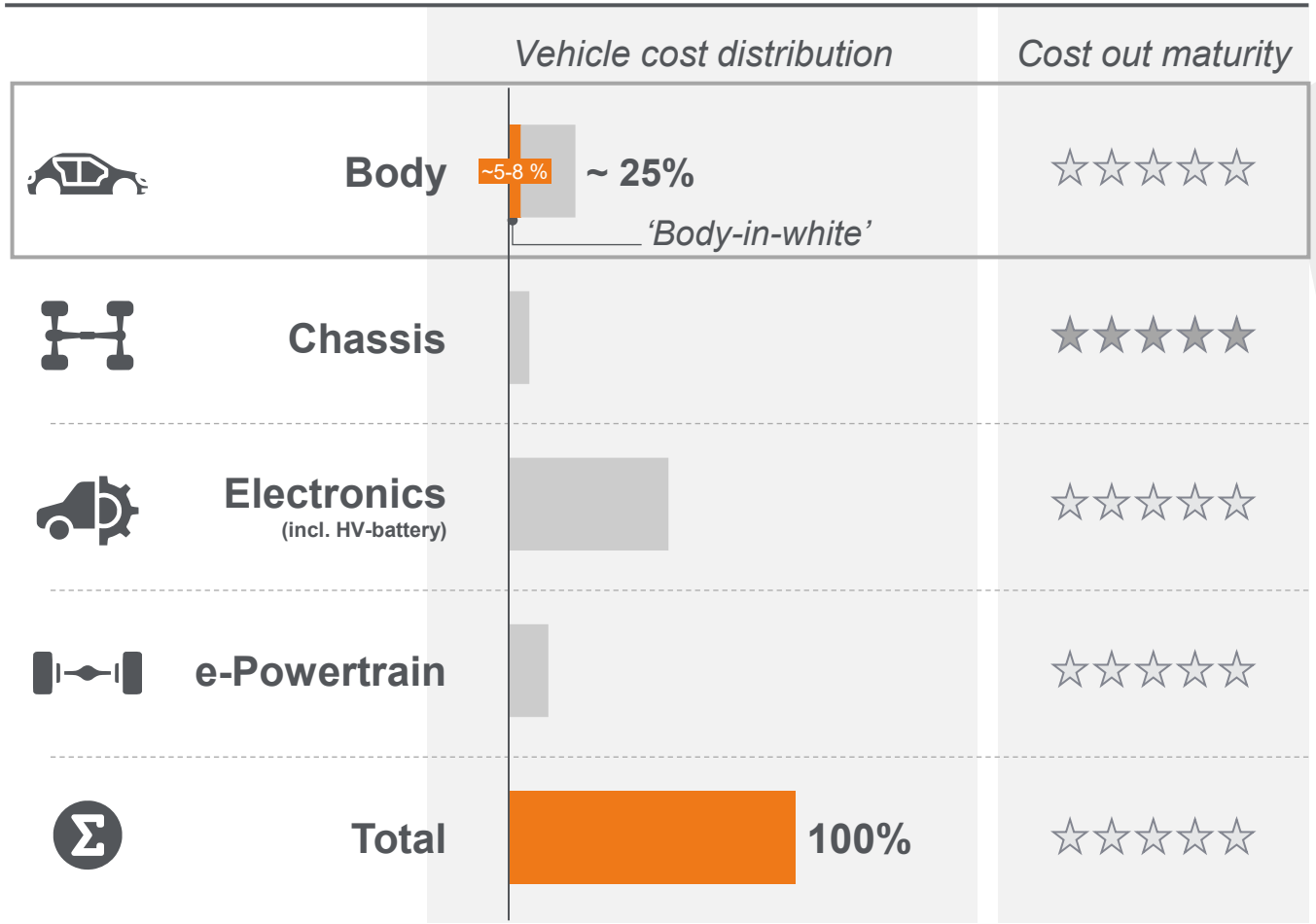
Impact on an OEM's profit pool



Source: Handelsblatt; MIT Center for Digital Business research; EFESO research

Within the overall manufacturing challenge, the automotive body still provides a significant opportunity to reach comparable cost-out maturity

Cost distribution & cost out maturity – electric vehicle



Body engineering impact

- Historically, automotive 'Body-in-white' has been a dedicated core competency of OEMs, because of the fundamental systems engineering interfaces
- Long-term capital investment cycles for manufacturing equipment discourage the accommodation of disruptive concept changes
- OEMs rely mostly on internal 'best-of'; benchmarking input for optimized design and material selection
- Besides state-of-the-art industrialization of press- and body-shops, significant complexity, cost and weight are driving efforts to find better alternative engineering solutions (e.g., lightweight metals, carbon structures, modular bolt-on body kits)
- Sustainability requirements (e.g., decarbonization) are now regarded as decision-making criteria

Recent achievements by TESLA raise key questions as to the attractiveness of mega casting production technologies in automotive and other manufacturing industries

Manufacturing cost impact

➔ Will mega casting be able to deliver significant cost savings over and above conventional concepts?

Carbon footprint impact

➔ Will mega casting deliver significant carbon footprint savings over conventional concepts?

CapEx impact

➔ Will production & tooling equipment investments for mega casting offer a competitive pay-back time?

Life cycle impact

➔ Will mega casting offer any particular advantages during the usage and end-of life phases?

Automotive industry strategy

➔ Will other OEMs follow the TESLA giga casting approach to manufacturing large body parts?

Cross-industry adopters

➔ Are there other suitable products & applications which benefit from automotive mega casting innovation?

A comprehensive, competitive cost & CO_2 analysis on the vehicle body engineering concepts employed for the Hyundai IONIQ 5 EV

Hyundai IONIQ 5

Project 45 package | all-wheel drive | 72 kWh battery capacity

General info

- **Platform / trim level:** E-GMP / Project 45 (MY 2021)
- **Technical features:** Single Speed 4WD, 800V, 72kWh, 225kW
- **Dimensions / weight:** 4.635 x 1.890 x 1.605 mm / 2.140 kg
- **Price (2021):** €59.550

Vehicle body highlights

- **5-star Euro NCAP** safety rating, despite comparatively poor performance in pedestrian protection
- Self-supporting structure in **steel-shell design** (357kg)
- No tailored blanks, uses **standardized sheet metal** grades
- **Reinforced** passenger compartment and **floor**
- **Scalable platform** with individual parts
- **Aluminum** continuous **casting** profile in the sills
- Shell structure made of **high-strength steel**
- No spare wheel recess, no bulkhead structure
- Short version of front crash system
- Use of **plastics** in rear **crash-management** system
- High material utilization thanks to **compact body panels**

Benchmarking

Tear-down and **BOM** build-up (bottom-up)

Product cost analysis (bottom-up)

Production tooling and **CapEx*** evaluation

CO_2e analysis (bottom-up)

OEM validated

Source: Hyundai, EFESO analysis
* Production machinery & equipment

Welded body assembly is well established but offers limited potential for cost savings; mega casting, even at this early stage, shows considerable potential in multiple areas

Welded body assembly – in a nutshell

- \+ Mature technology for **~ 100 years,** currently found in every vehicle
- − **Complex** supply chain
- − **Marginal cost-down** opportunities
- \+ **Well-established** supply base in best-cost countries

Mega casting – in a nutshell

- \+ Mature base technology, innovation in **scaling-up** machinery, tooling and process to new products and applications
- \+ **Simple** (factory) supply chain
- \+ Relatively young technology implementation, **currently in the ramp-up phase;** high potential for **further savings and optimization**
- − **Limited supply base**, currently an invest focus for vehicle OEMs, with few castings suppliers to base planning on

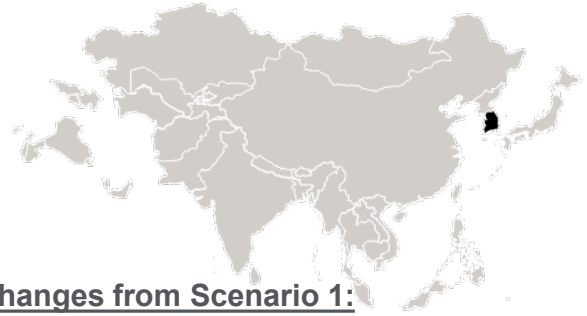
We have outlined three evaluation scenarios, the aim being to identify and capture key sensitivities and effects in cost and CO_2e footprint

1 Scenario 'baseline calculation'

- Assembly plant steel/casting: **South Korea (SK)**
- **Supply base** for single **steel** parts: **China**
- **CO_2e** value for steel in **China**
- **CO_2e** value for aluminum in **SK**
- Current electricity mix for location in **China**
- Current electricity mix for location in **SK**
- **Volume** scenario **100k & 500k** per year
- **Lifetime** – **7 years for** each scenario
- Specific **casting tool** concept considered in part price
- Specific **steel tool** concept considered in part price
- **Transportation** of **single steel parts** from China to SK considered in **cost** and **CO_2e**

SCENARIO **1: Trend**

2 Scenario



➢ **Changes from Scenario 1:**

- **Supply base** for single **steel** parts: **South Korea**
- **CO_2e** value for steel in **SK**
- **No transportation** of **single steel parts** considered in **Cost** and **CO_2e**

SCENARIO **2: Production site South Korea**

3 Scenario

➢ **Changes from Scenario 2:**

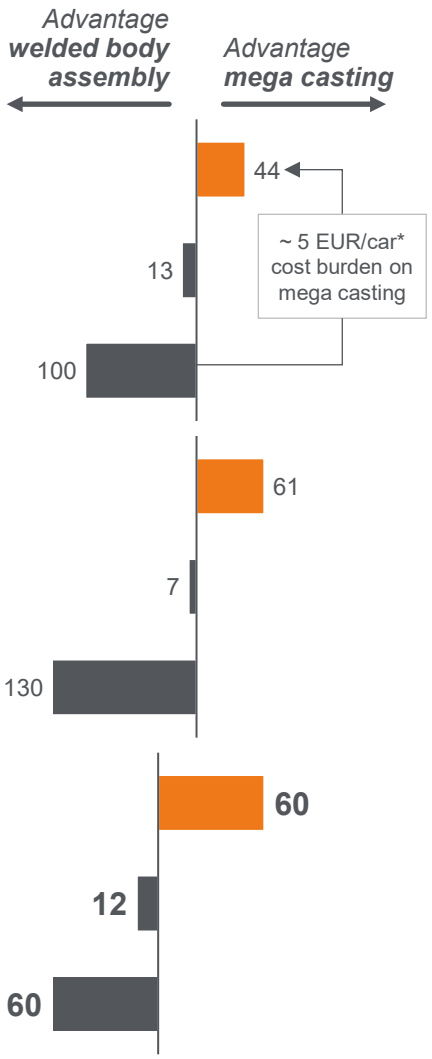
- **Reduced CO_2e** value for steel in **SK** with Reference value from **Norway**
- **Reduced CO_2e** value for aluminum in SK
- **Green** electricity location **SK** with reference value from **Norway**

SCENARIO **3: Green energy and material**

Sources: Input data based on ecoinvent; sustamize and EFESO internal databases

Mega casting technology offers significant production cost advantages at 100k/a, the aluminium CO_2e footprint burden estimated at ~ 5 EUR/car additional cost

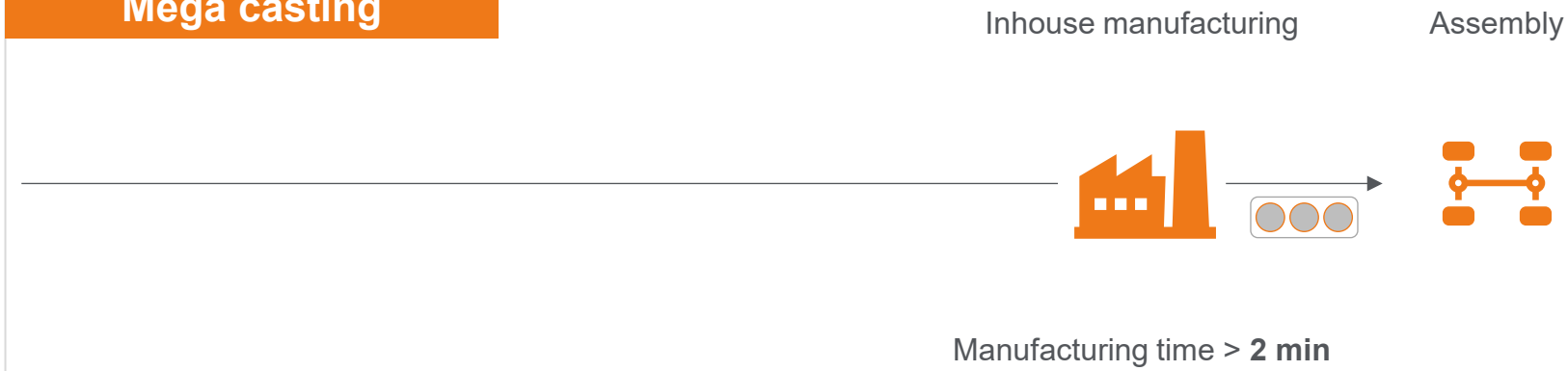
Manufacturing scenarios	Key learnings	
1 Scenario: Trend	100k/a **cost advantage** for a **mega casting** production site in South Korea and best sourcing pipeline for steel subcomponents, produced in China and sent for assembly to South Korea	EUR/ car
	500k/a **cost advantage** for **welded body assembly,** due to mass production volume effect, mega casting has only a small effect on price reduction	EUR/ car
	PCF advantage for **welded body assembly**, mainly driven by lower emissions value for materials compared to mega casting. Valid for all scenarios	kg CO_2e
2 Scenario: South Korea	100k/a **cost advantage** for a **mega casting** production site in South Korea, and higher manufacturing site cost for production site in South Korea compared to China, w/o transportation	EUR/ car
	500k/a **cost advantage** for **welded body assembly** due to mass production volume effect, mega casting has only small effect on price reduction	EUR/ car
	PCF advantage for **welded body assembly**, mainly driven by lower material value compared to mega casting	kg CO_2e
3 Scenario: Green	All volume scenarios were calculated with a Scenario 2 process landscape and optimized cost for energy and CO_2e values. 100k/a **cost advantage** for **mega casting** production site in South Korea, 500k/a **cost advantage** for **welded body assembly**	EUR/ car
		EUR/ car
	PCF advantage for **welded body assembly**, mainly driven by lower material value compared to mega casting	kg CO_2e



PCF: Product Carbon Footprint
*) Estimation based on current EU emission trade and taxation understanding

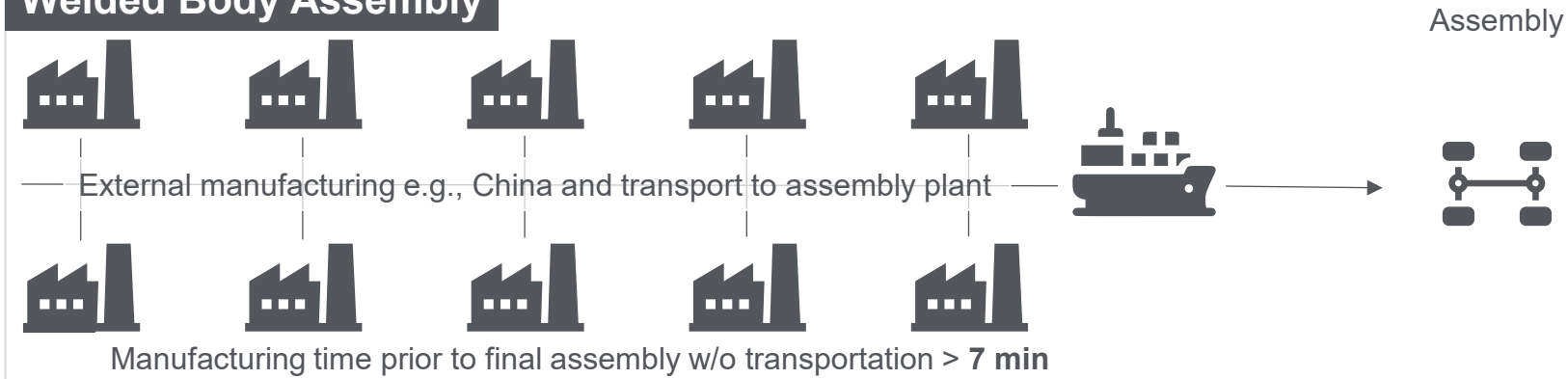
The complex supply industry for welded body assembly is already well established, but substantial initial investments will be necessary to introduce mega casting

Mega casting



- An OEM in-house process, so no transportation and packaging costs
- High initial investment for equipment and tooling
- New geometries or generations are covered with new tools
- Very young technology which will need further improvement

Welded Body Assembly



- Approx. 30 different manufacturing plants e.g., locations in China
- Negative effect on price and CO_2e footprint
- Future CBAM effect expected
- Large supply base, established over the last few decades
- New investment required for assembly line for new generation

Both technologies will be further optimized, in terms of materials and processes, in the future.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