EFESO

MANAGEMENT CONSULTANTS

# IS MEGA CASTING THE WAY TO GO?

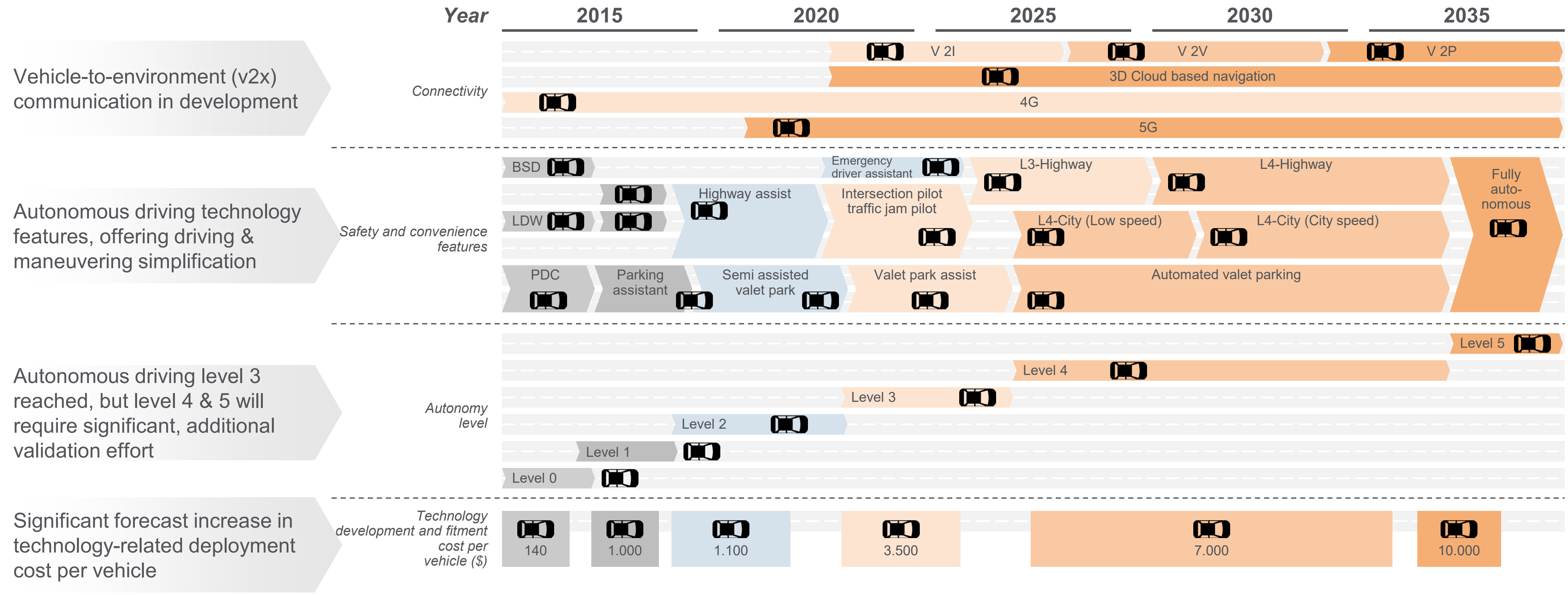
A cost & carbon study on the advantages and disadvantages of welded automotive body assemblies vs integrated castings

OPERATIONS

INSIGHT

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

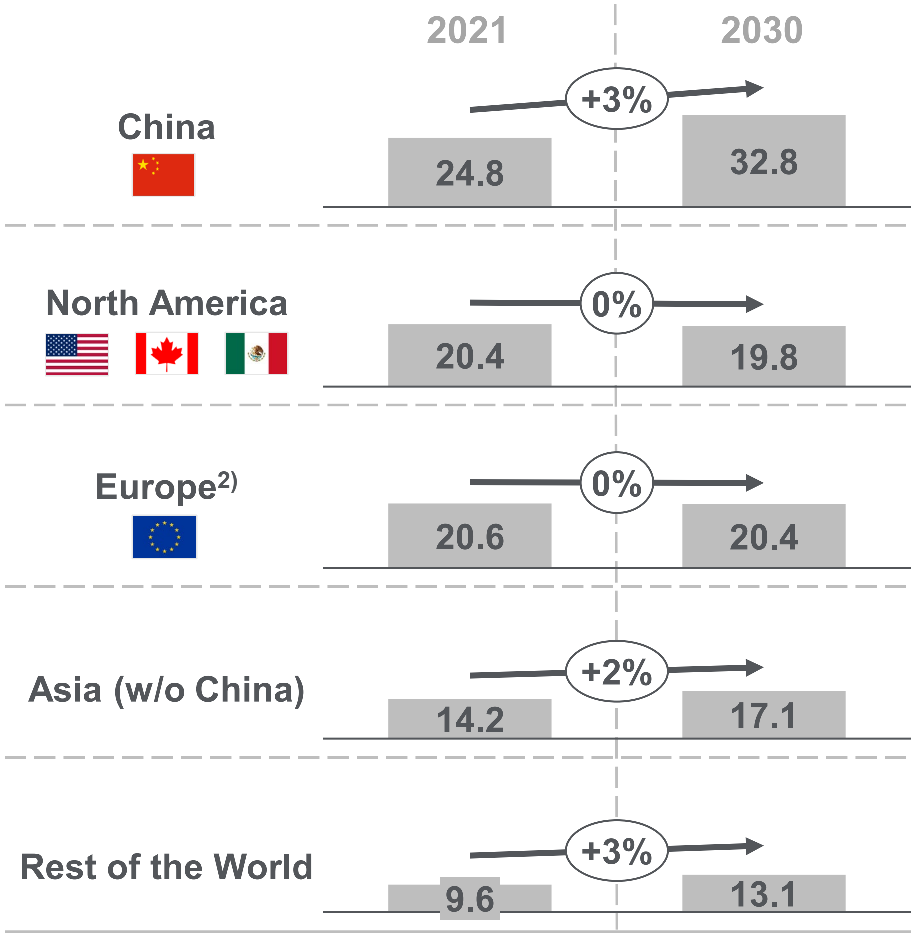
## Technology innovation drivers

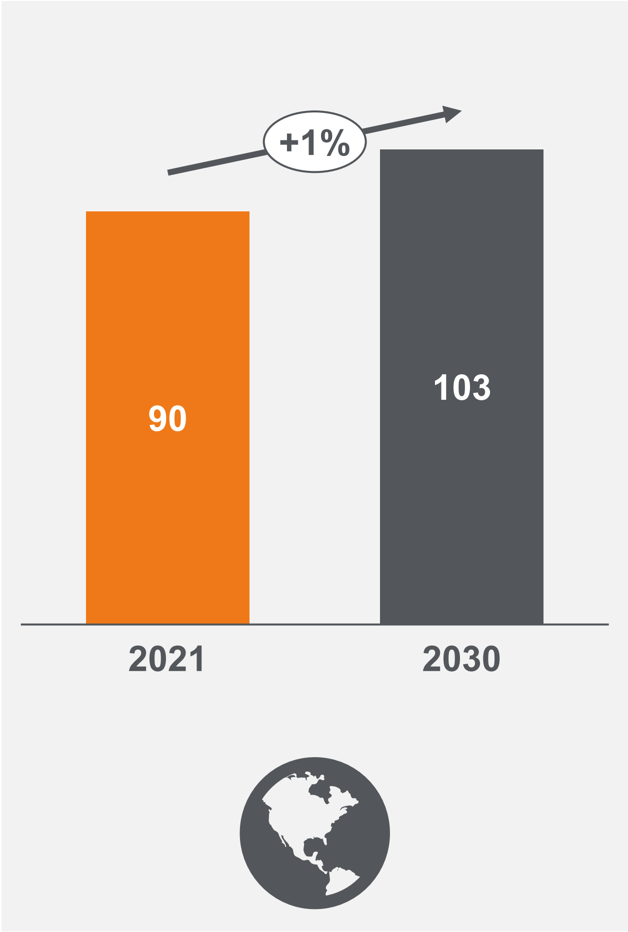



Source: EFESO research

# 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?**

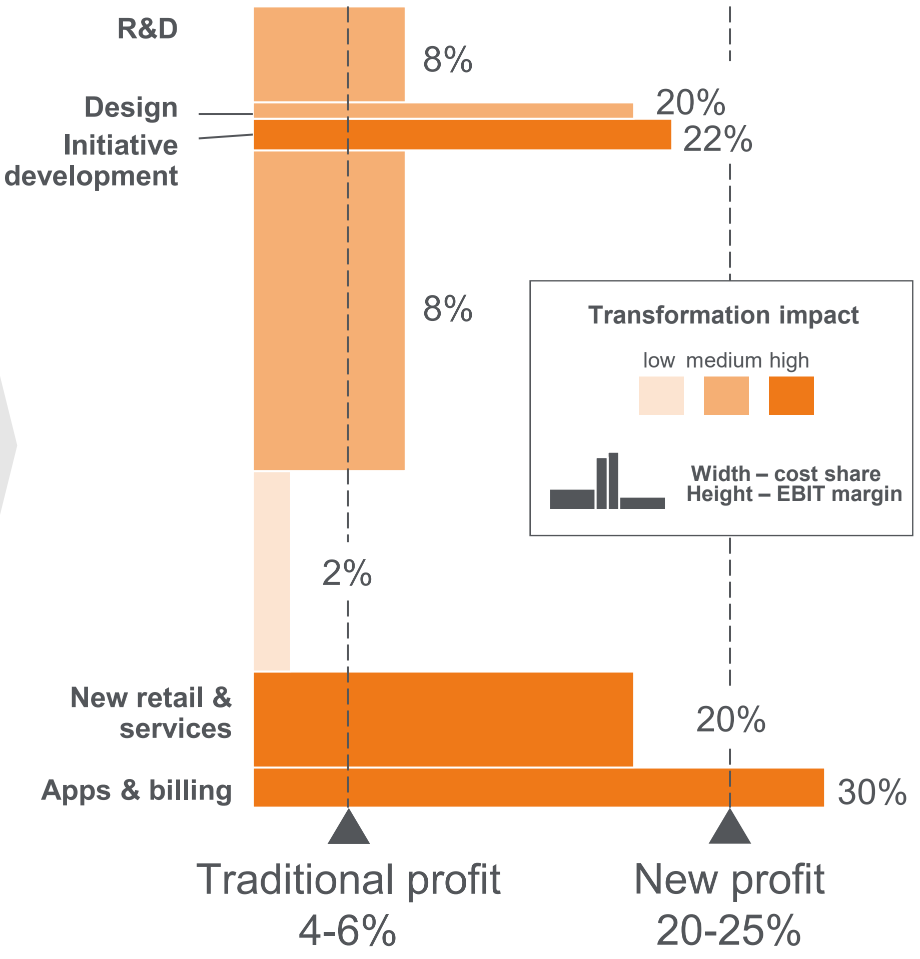
**Services to become the cash cow?**

**Lower margin and repair frequency?** ! *Manu-facturing*

**Integrated supply chain & logistics?**

**B2B vs. B2C?**

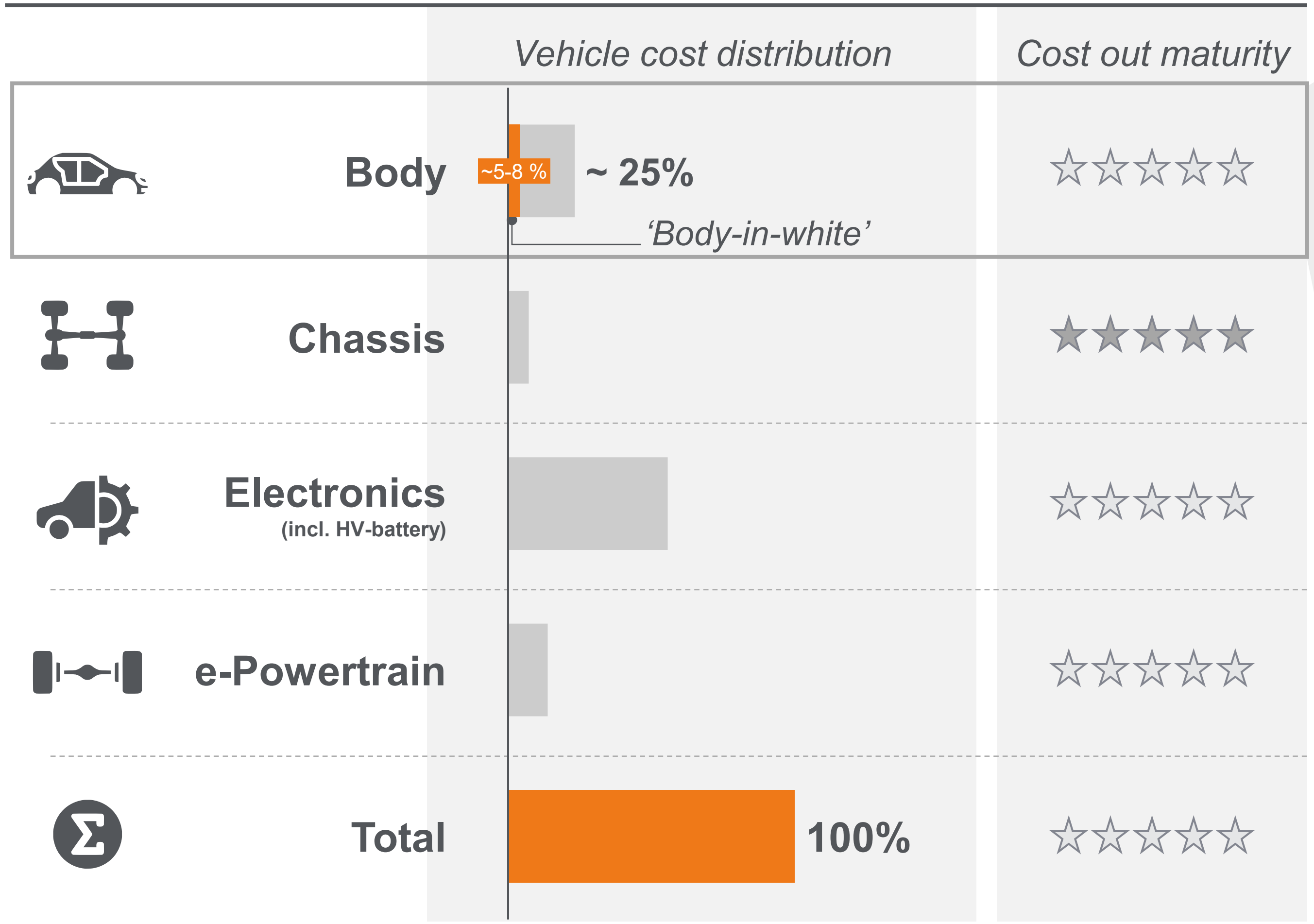
## Impact on an OEM's profit pool




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

**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**

## Hyundai IONIQ 5

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

| | |
|---|---|
| **General info** | ▪ **Platform / trim level:** E-GMP / Project 45 (MY 2021)<br>▪ **Technical features:** Single Speed 4WD, 800V, 72kWh, 225kW<br>▪ **Dimensions / weight:** 4.635 x 1.890 x 1.605 mm / 2.140 kg<br>▪ **Price (2021):** €59.550 |
| **Vehicle body highlights** | ▪ **5-star Euro NCAP** safety rating, despite comparatively poor performance in pedestrian protection<br>▪ Self-supporting structure in **steel-shell design** (357kg)<br>▪ No tailored blanks, uses **standardized sheet metal** grades<br>▪ **Reinforced** passenger compartment and **floor**<br>▪ **Scalable platform** with individual parts<br>▪ **Aluminum** continuous **casting** profile in the sills<br>▪ Shell structure made of **high-strength steel**<br>▪ No spare wheel recess, no bulkhead structure<br>▪ Short version of front crash system<br>▪ Use of **plastics** in rear **crash-management** system<br>▪ High material utilization thanks to **compact body panels** |

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 poten-tial for **further savings and optimization**
- (−) **Limited supply base**, currently an invest focus for vehicle OEMs, with few castings suppliers to base planning on

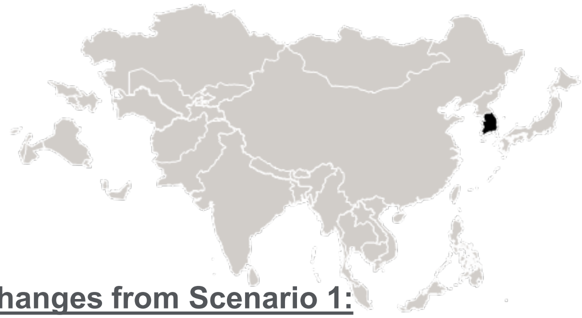
# We have outlined three evaluation scenarios, the aim being to identify and capture key sensitivities and effects in cost and $CO_2e$ footprint

## 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

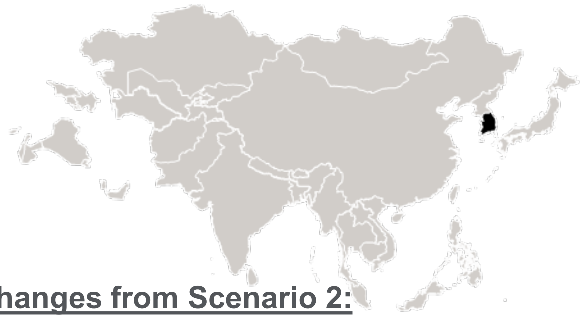


➢ **Changes from Scenario 1:**

- **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:**

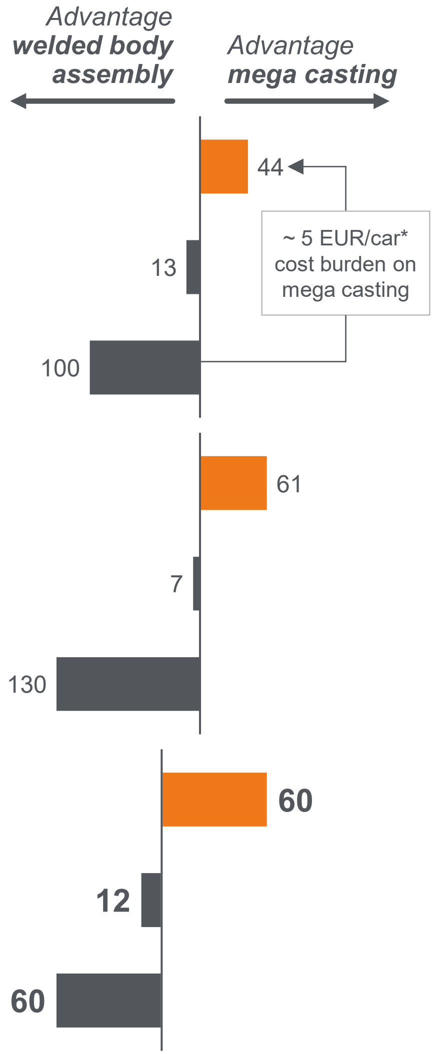
- **Reduced $CO_2e$** value for steel in **SK** with Reference value from **Norway**
- **Reduced $CO_2e$** value for aluminum in SK
- **Green** electricity location **SK** with reference value from **Norway**

**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 $CO_2$e footprint burden estimated at ~ 5 EUR/car additional cost

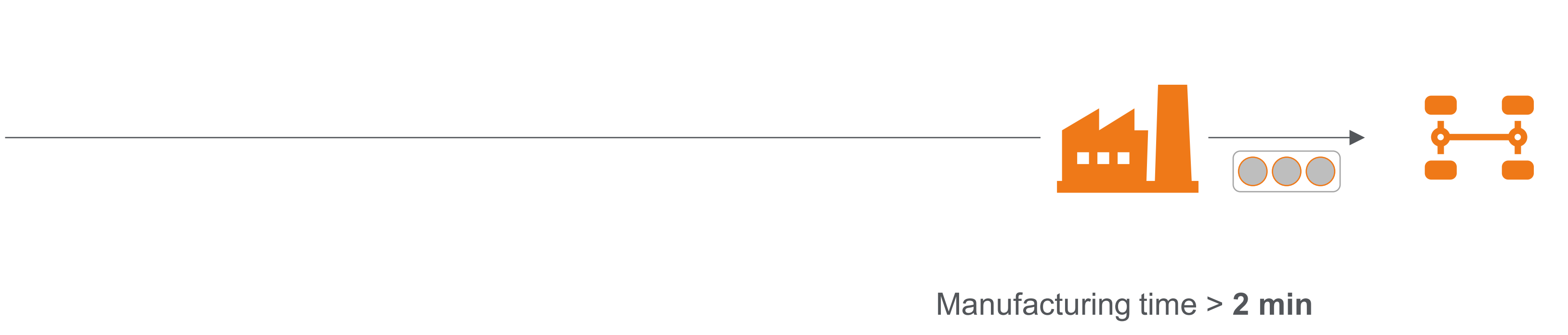
| Manufacturing scenarios | Key learnings | |
|---|---|---|
| 1 Scenario: Trend | 100k/a **cost advantage** for a **mega casting** production site in South Korea and best sourcing pipeline for steel subcomponents, produced in China and sent for assembly to South Korea | EUR/ car |
| | 500k/a **cost advantage** 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 $CO_2$e |
| 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 $CO_2$e |
| 3 Scenario: Green | All volume scenarios were calculated with a Scenario 2 process landscape and optimized cost for energy and $CO_2$e 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 $CO_2$e |




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

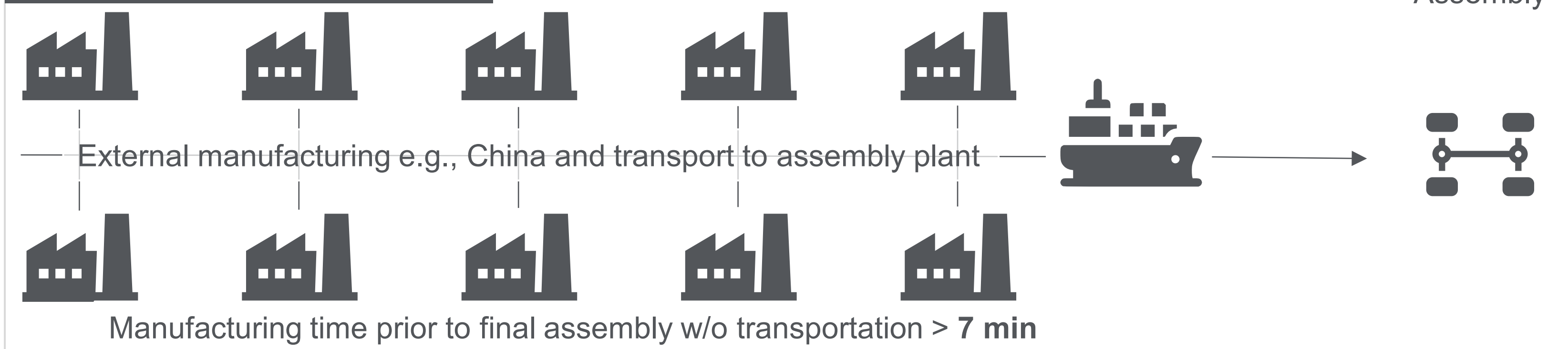
# The complex supply industry for welded body assembly is already well established, but substantial initial investments will be necessary to introduce mega casting

## 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 $CO_2$e 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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