

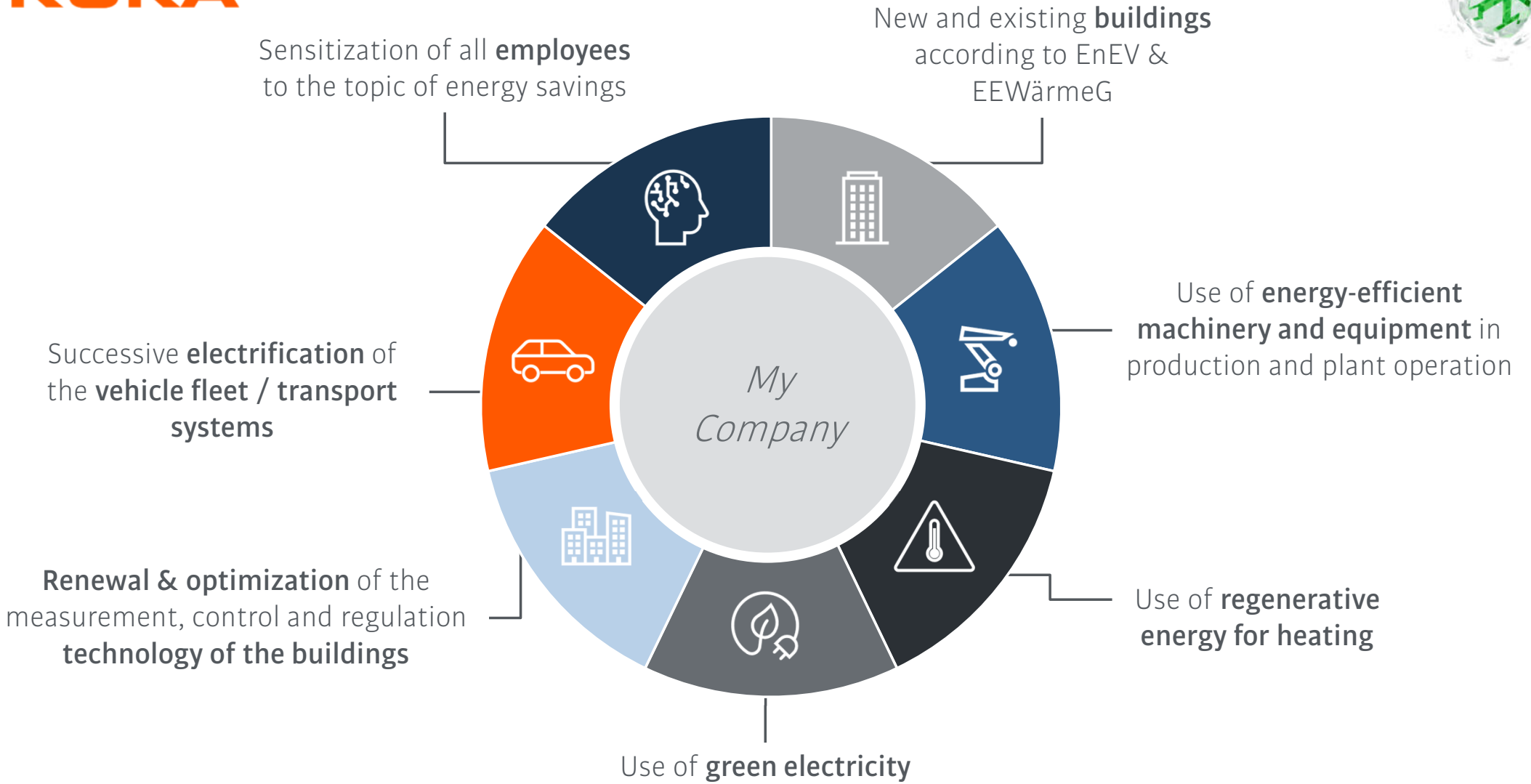
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Sustainability

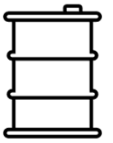


_energy efficiency in robotics and plant engineering

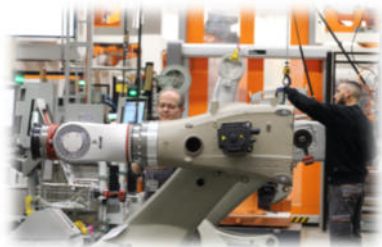






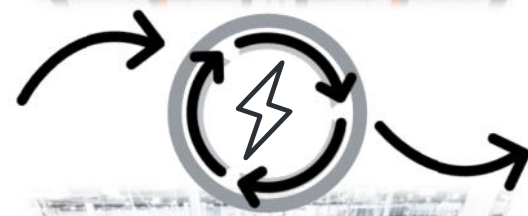
Lifecycle of a robot

-  Material usage
-  Production Environment
-  Sourcing & Transport



Robot production

Planning & Programming

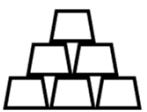


Production

End of Life



Material Disassembly



Circular Economy

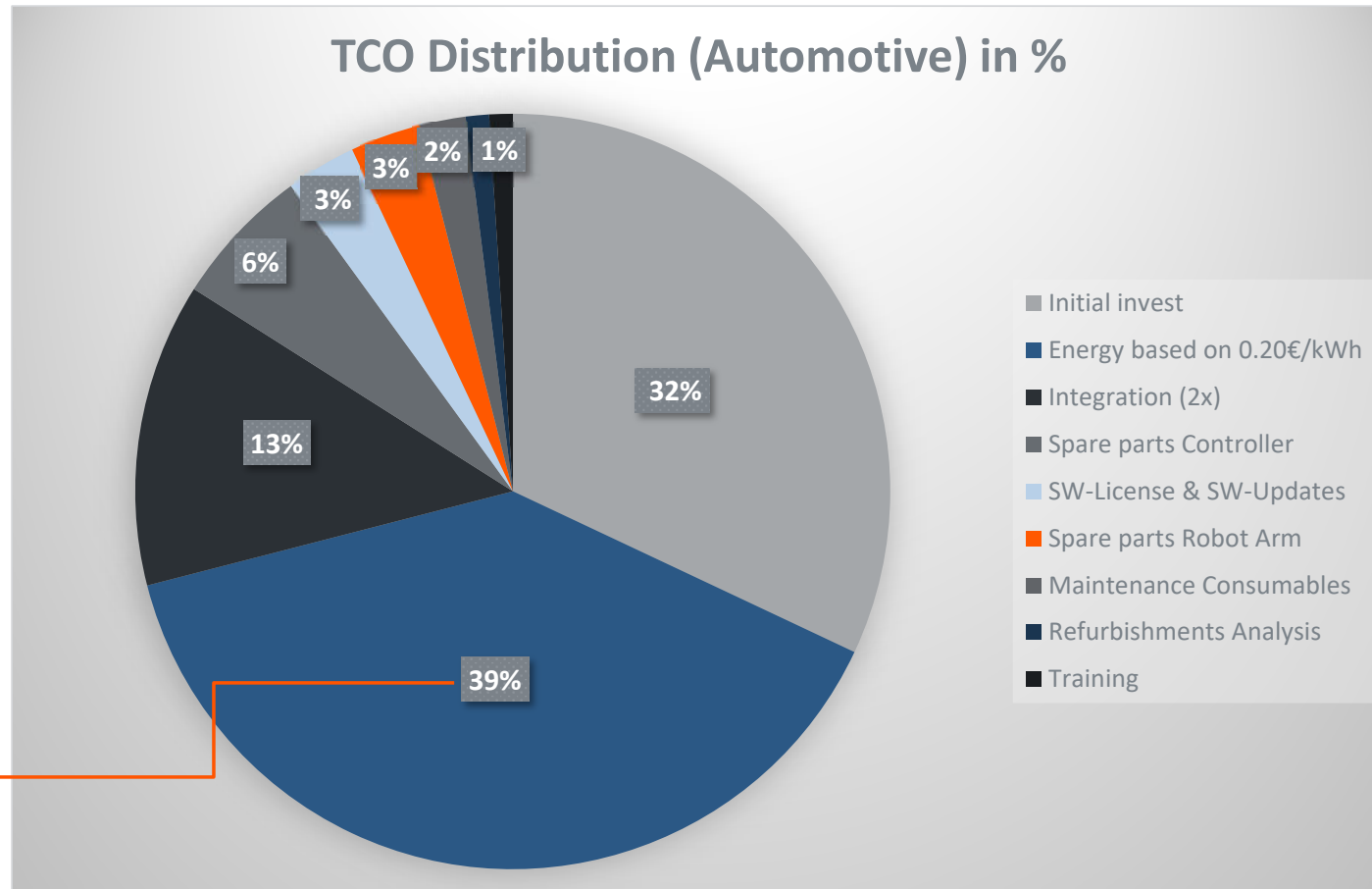


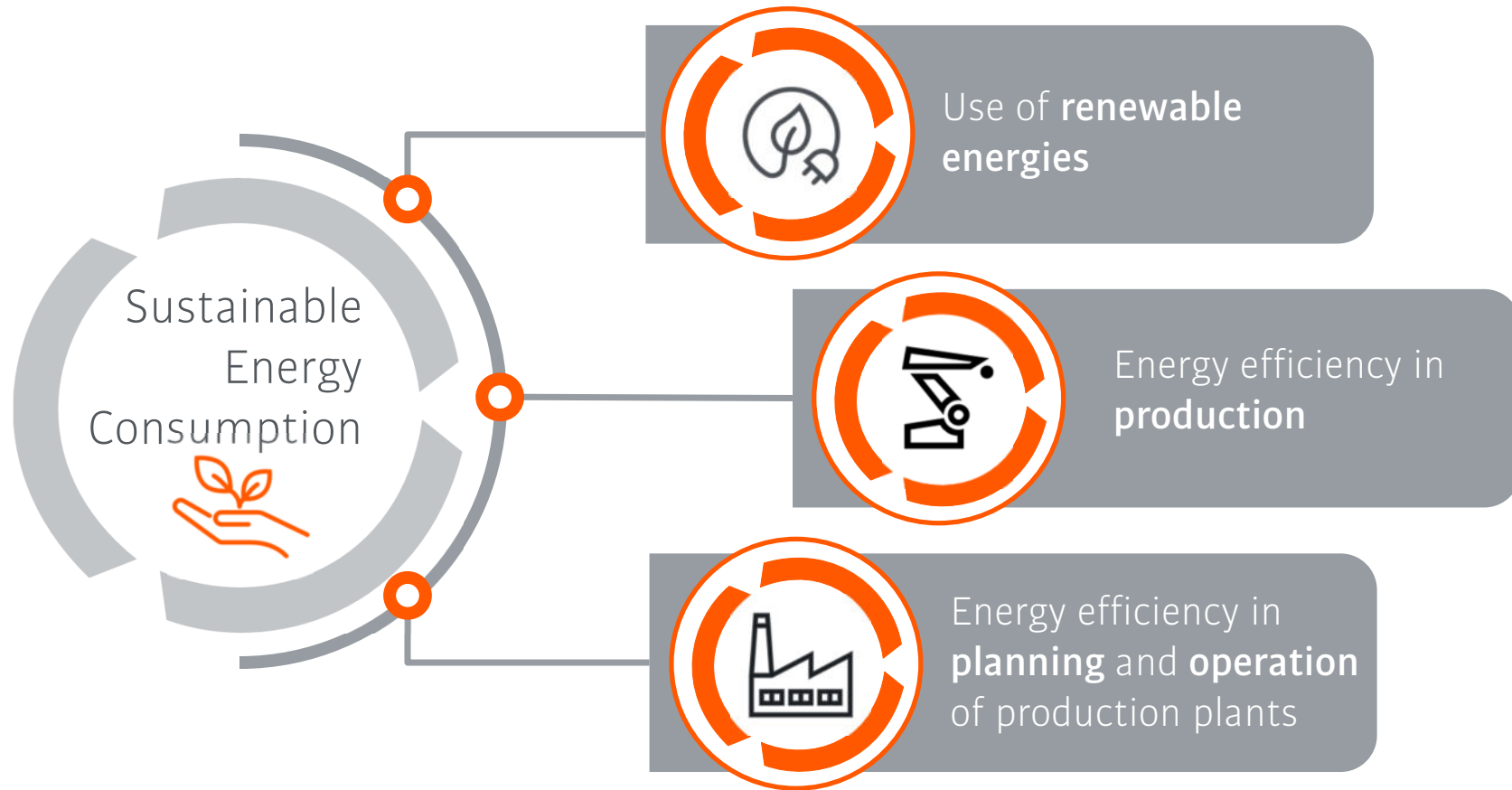


TCO Distribution (Automotive)



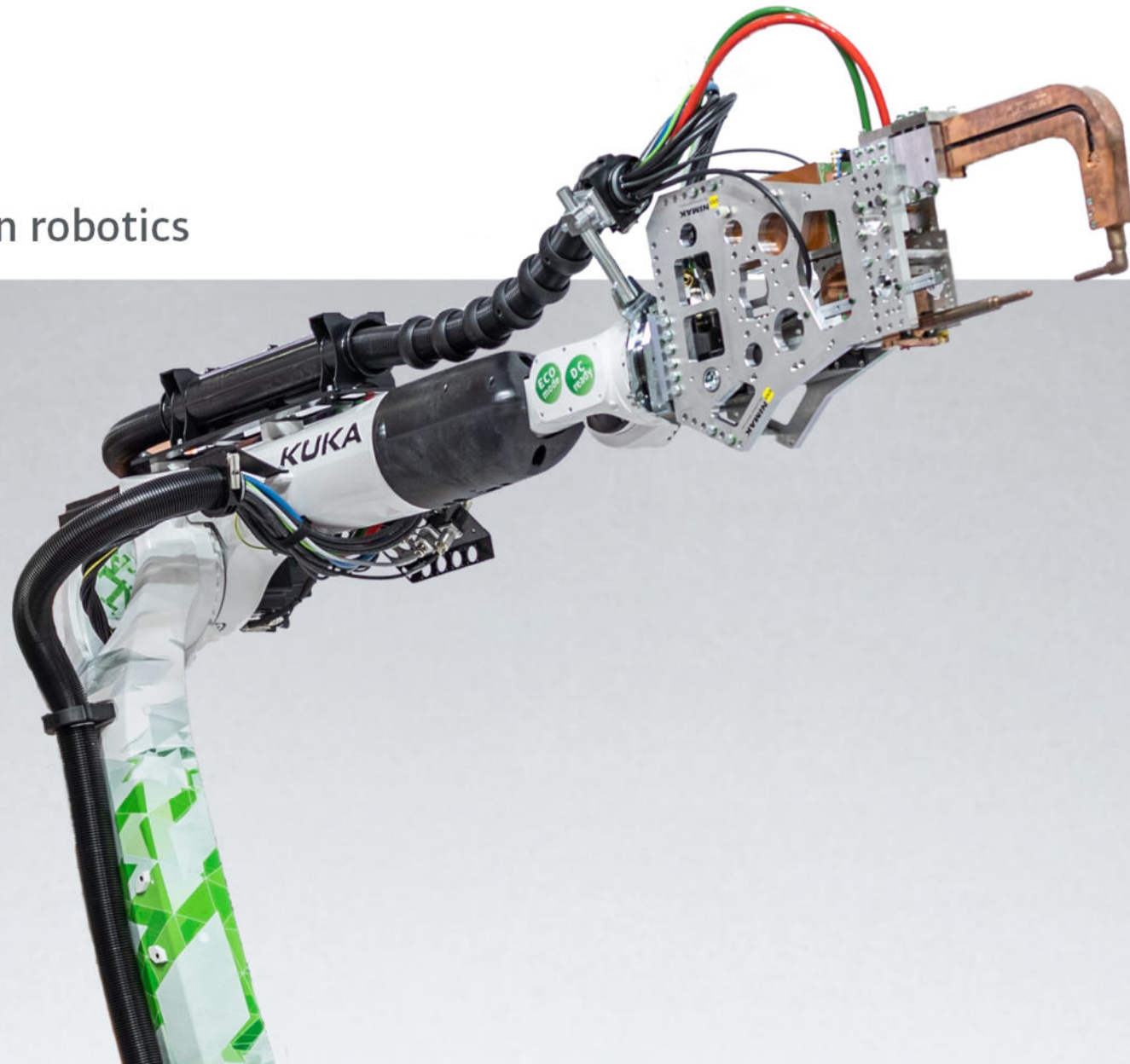
The potential for **cost reduction** by reducing energy consumption is enormous





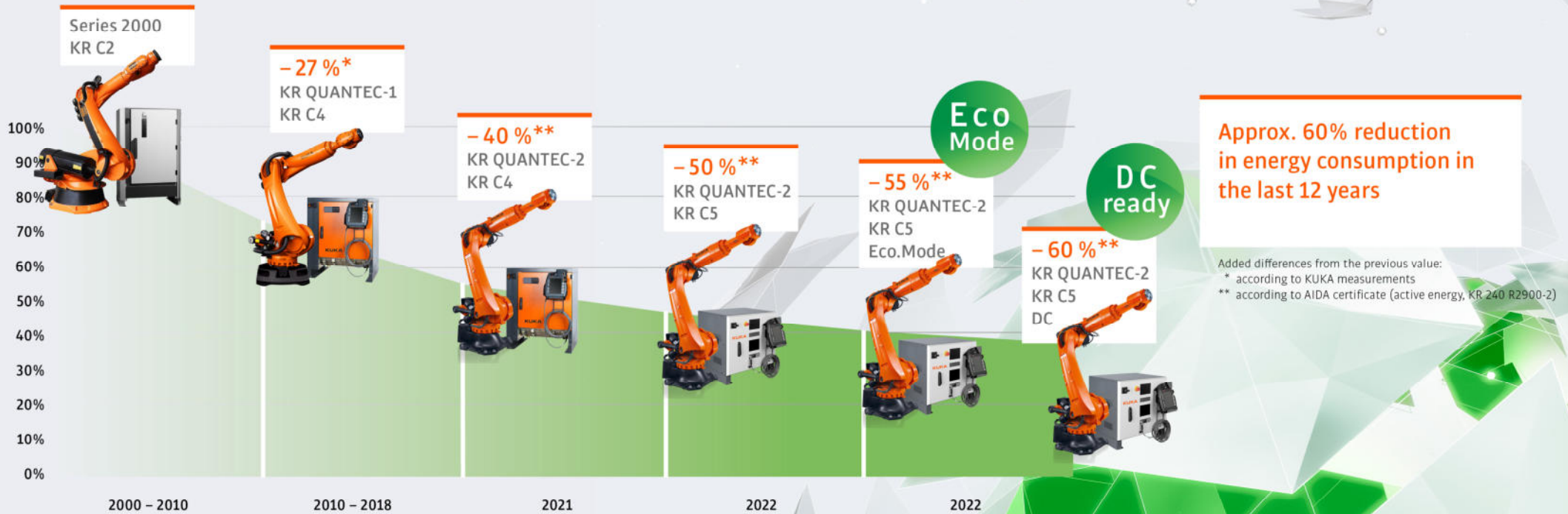
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Energy efficiency in robotics



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_Development of the energy efficiency of a KUKA robot system





CO₂-Footprint

Comparison with robots with 50% higher energy consumption

Average CO₂-Emission per kWh in Europa: **510 g [CO₂/kWh]**

QUANTEC-2, 14 years, 500 robots,

60 765 kWh * 500 = 30,38 GWh

50% higher energy consumption → approx 30 GWh difference

30 GWh * 510 g [CO₂/kWh]

→ approx. 15 300t more CO₂ emissions





CO₂-costs (Emissions Trading)

approx. 85€/t CO₂ (European Union Emissions Trading System, Jan. 2023)

according to the sample calculation

(**500** robots, **14** years,

approx. **15 300** t saved CO₂ emissions)

15 300 t CO₂ * €85/t CO₂

**= approx. EUR 1.3 million
reduced CO₂ costs**

Price development of EU certificate in EUR / t CO₂

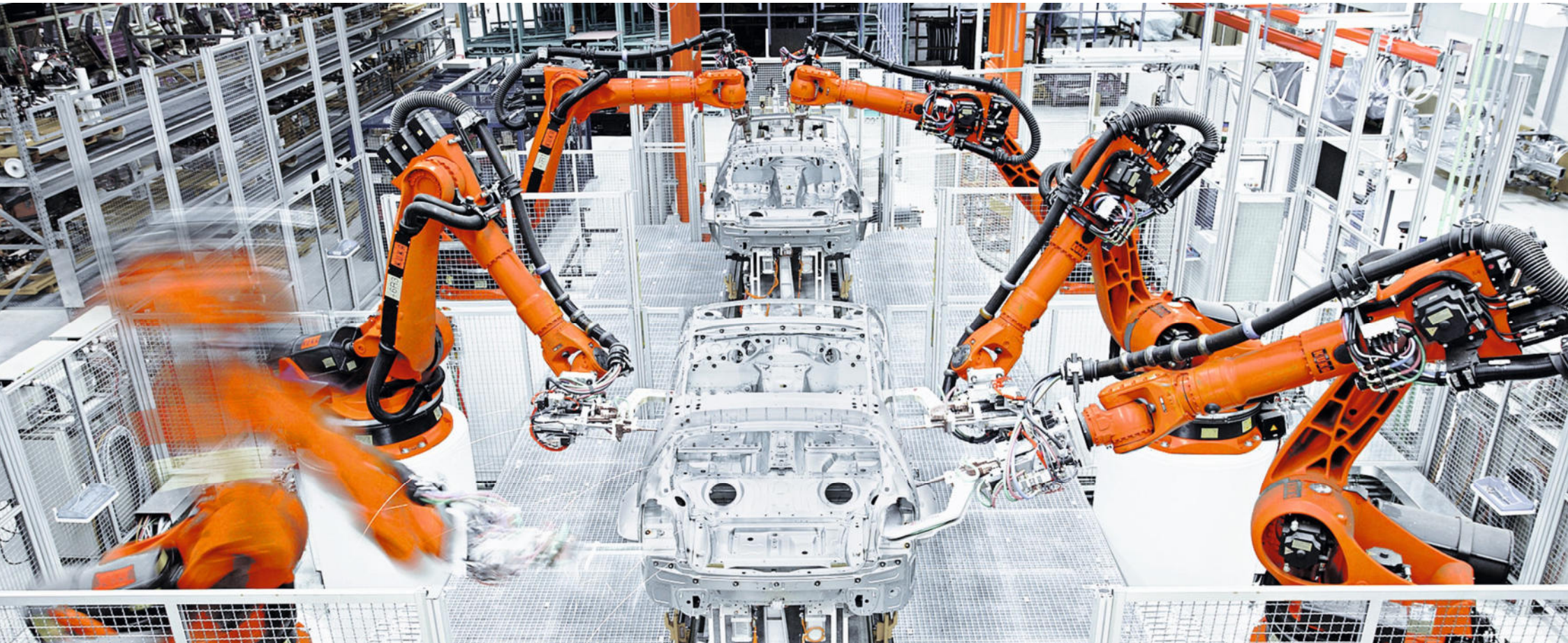


Quelle: Intercontinental Currency Exchange (ICE) / Ab 2021: Wattsight

→ Increase from €5 (2014) to €85 (2023) by a factor of 17

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Sustainability
_in production plants



Energy consumption _influencing factors



Factors
influencing
energy
consumption

Payload

Speed

Temperature

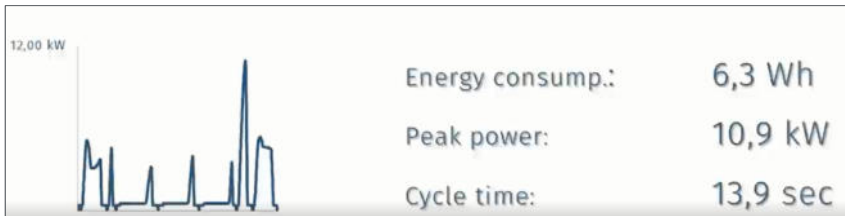
Path planning

Robot positioning

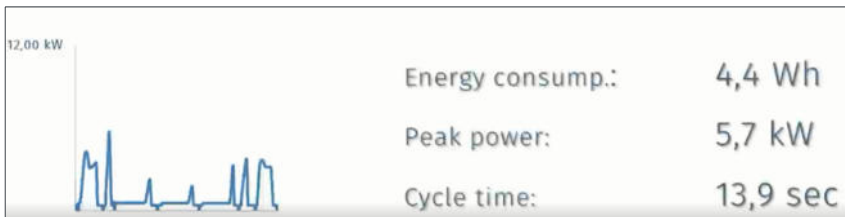




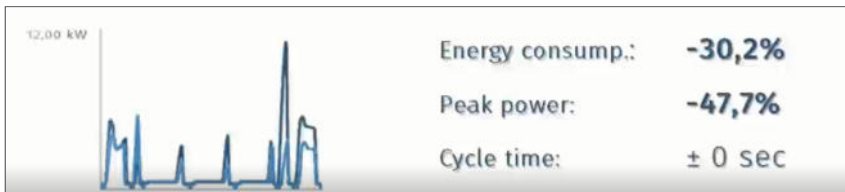
Robot positioning



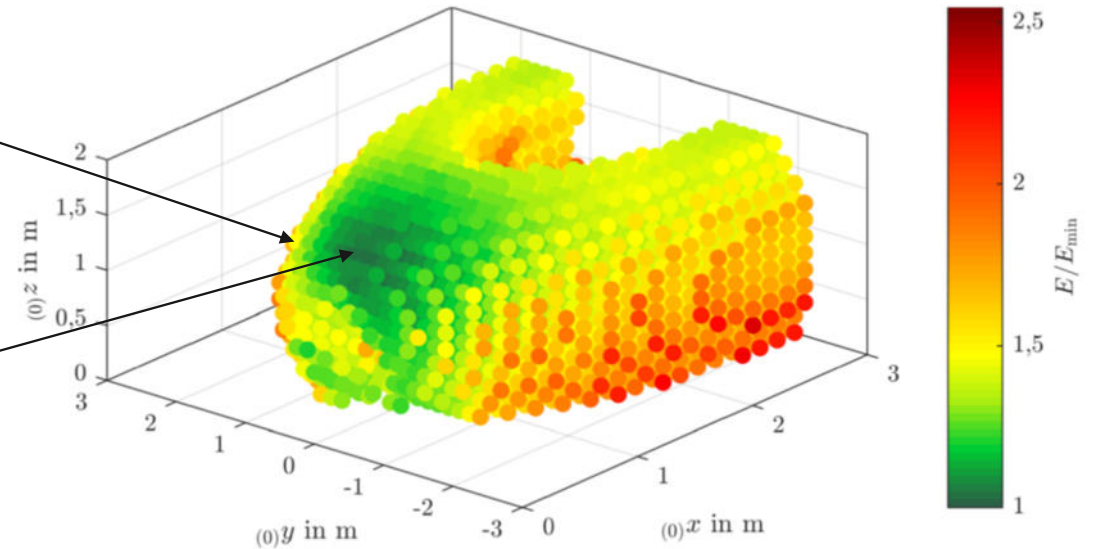
Bad positioning



Ideal positioning
(shift by 60cm to the side)



Delta



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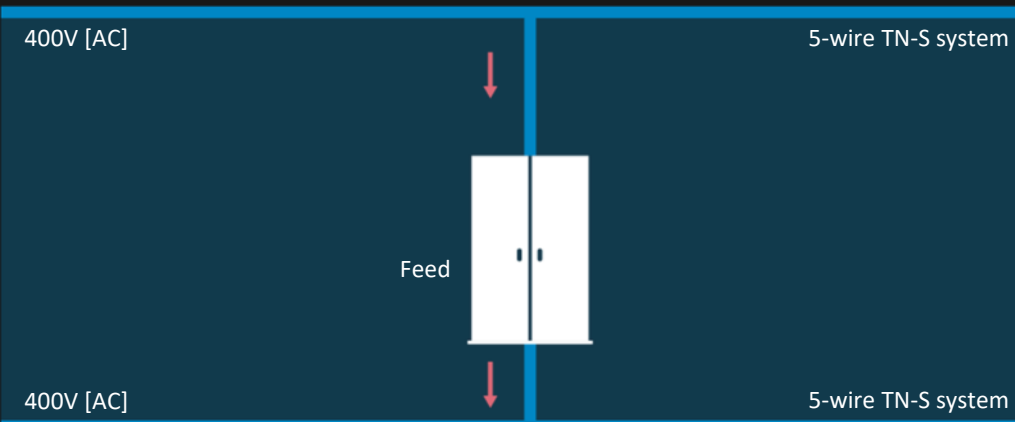
Industrial DC grids

_enormous potential for sustainability, material usage and grid stability





Conventional power distribution. Status quo since Nicola Tesla in 1888.



Conventional AC Architecture

- Unidirectional energy flow "from producer to consumer"
- - Rectifier in each component
- - Renewable energy is wasted

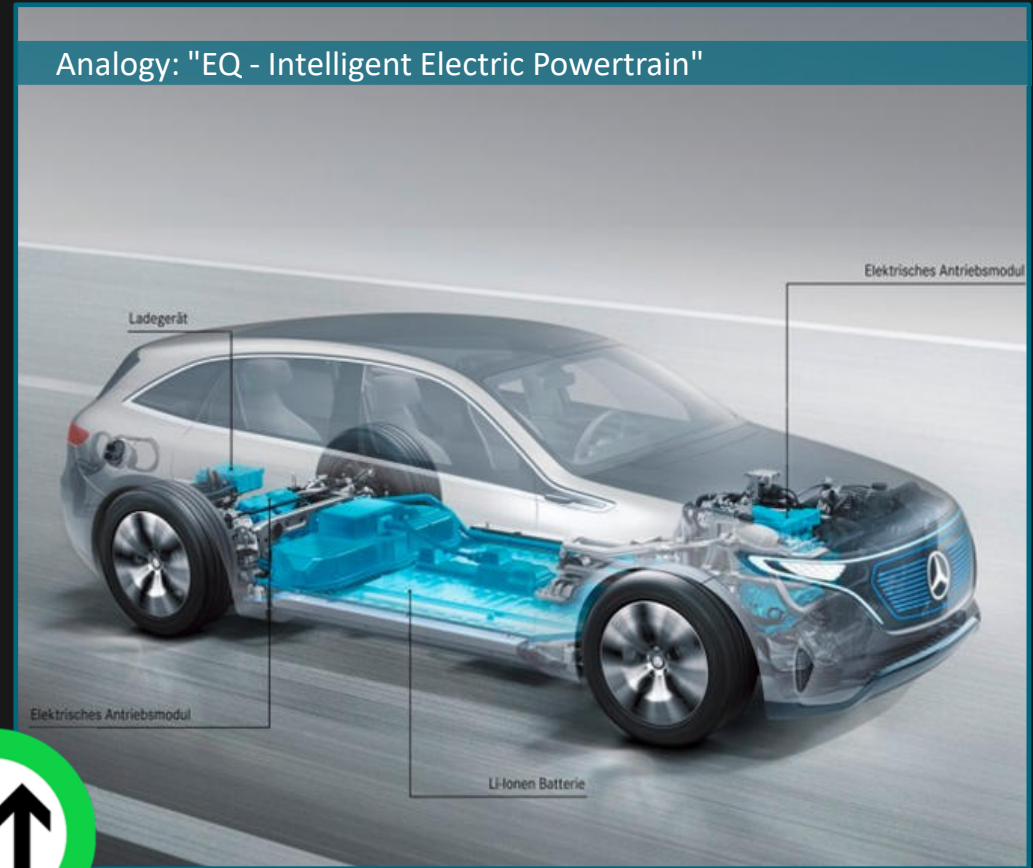
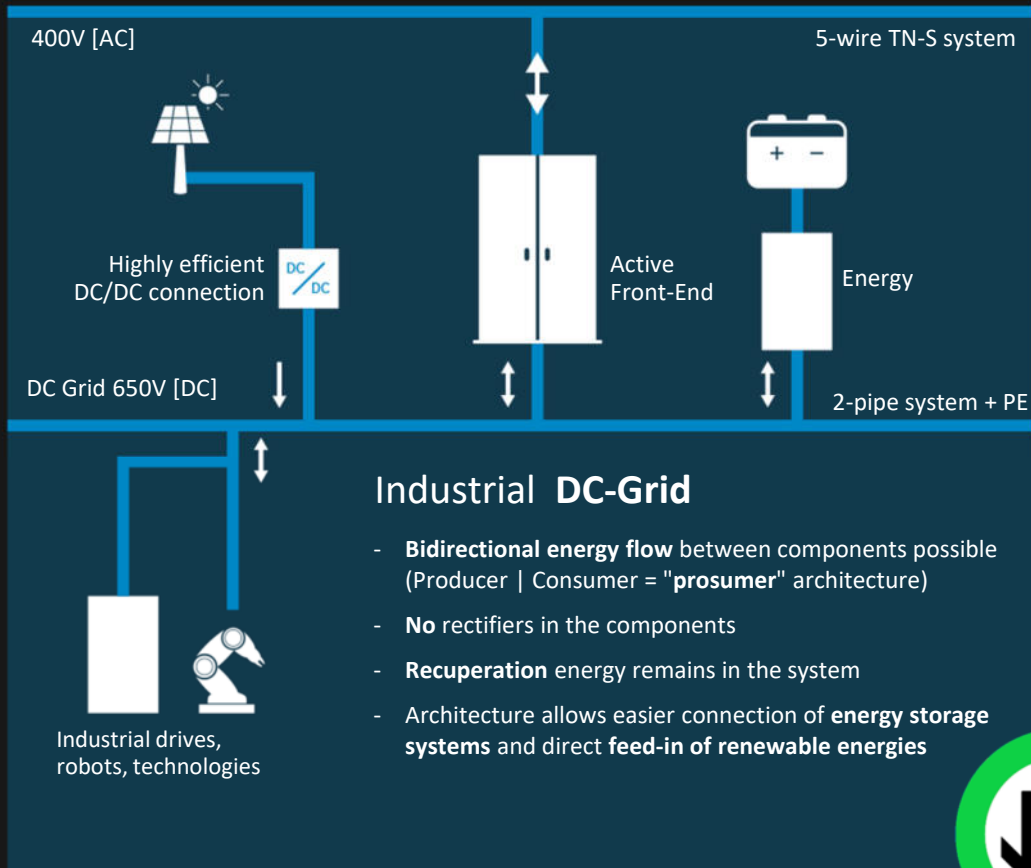
Industrial drives, robots, technologies



Source: Mercedes-Benz AG

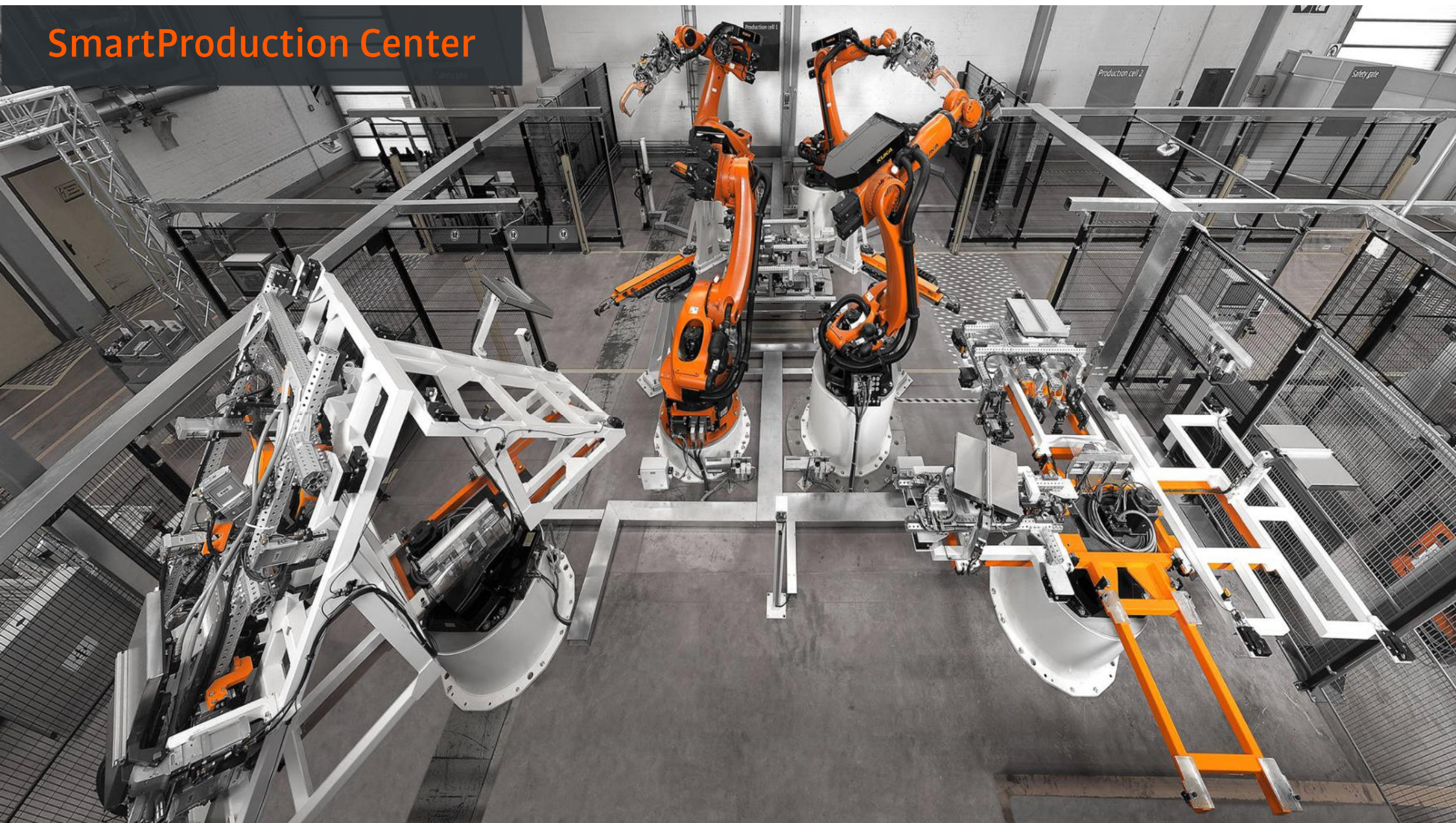


The future: Energy infrastructure with direct current. *Industrial Smart DC-Grid.*



Source: Mercedes-Benz AG

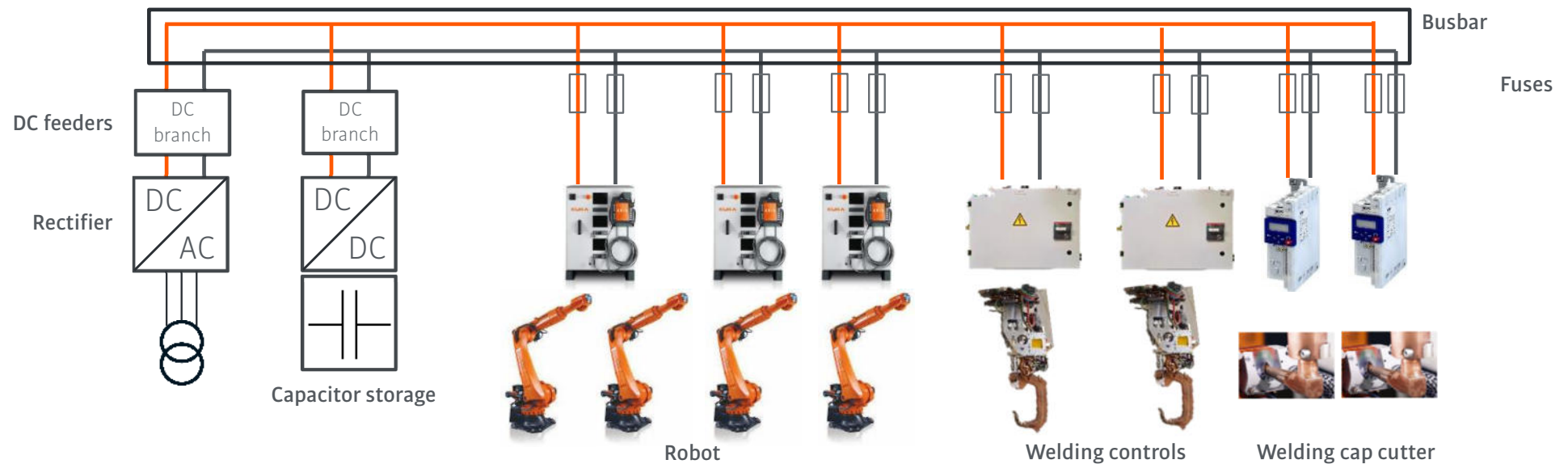
SmartProduction Center





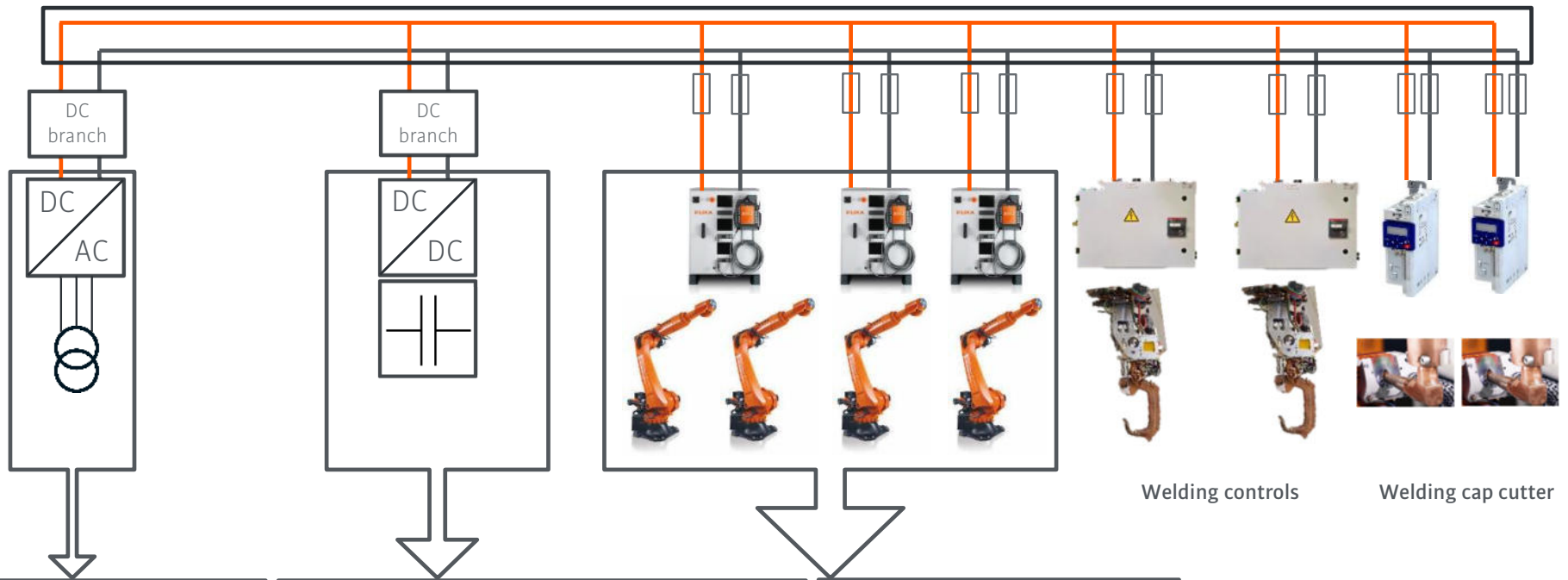
Structural design of the DC grid in the SmartProduction Center

- **Rectifier:** Active Infeed Converter (AIC)
- **Battery:** Capacitor with DC/DC converter
- **Distribution:** Busbar system with fuse outlets
- **Protection:** DC feeders and fuses





Measurement results 400 V AC vs. 650 V DC



Active Infeed Converter

- Reduction of AC mains perturbation
- Characteristic curve control of the DC voltage

Battery

- 80% reduction in peak load
- Possibility of self-sufficient operation
- Function according to control characteristic curve

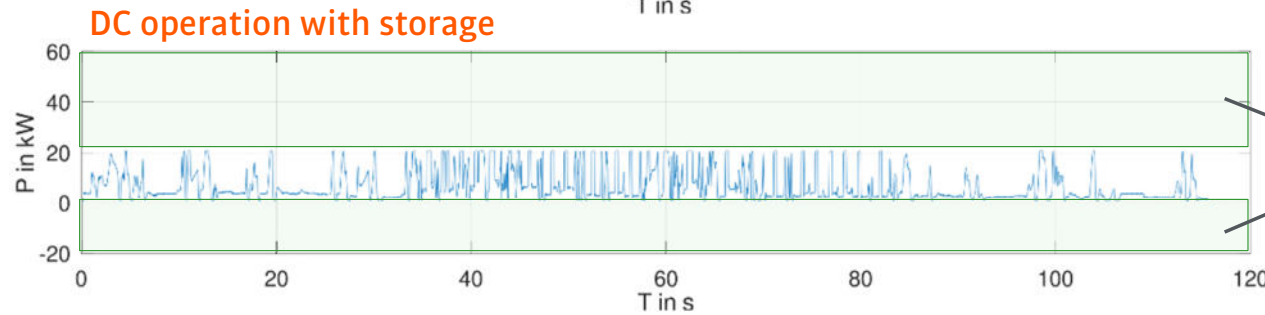
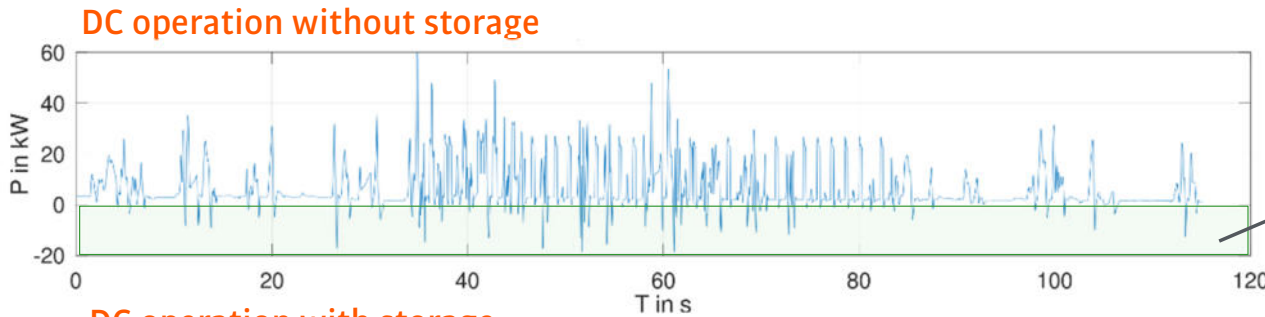
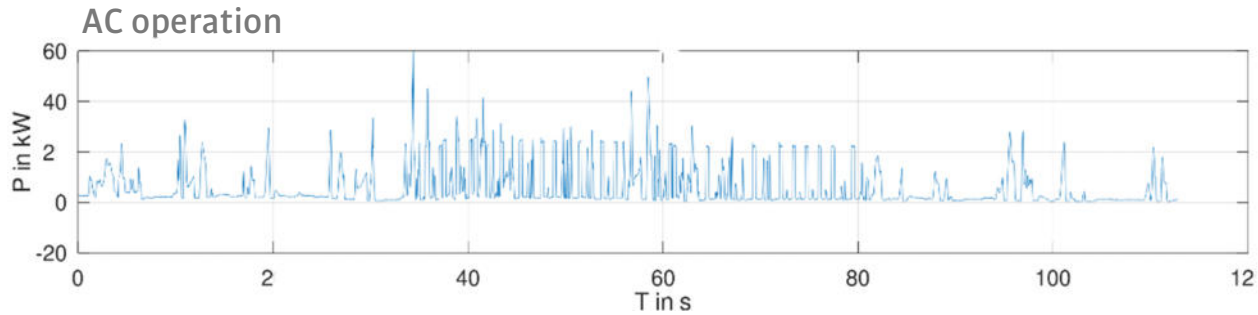
Robot

- 7.2% energy savings

*Depending on the application, energy savings of up to 20% can be achieved



Measurements



Recovery of braking energy
7.2%* energy savings of robots

*Depending on the application, energy savings of up to 20% can be achieved

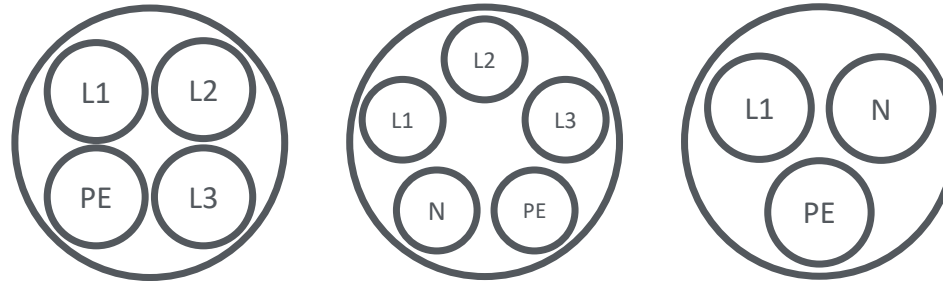
70% reduction in peak load

Absorption and release of braking energy



Copper savings: 650 V DC vs 400 V AC

400 V AC system



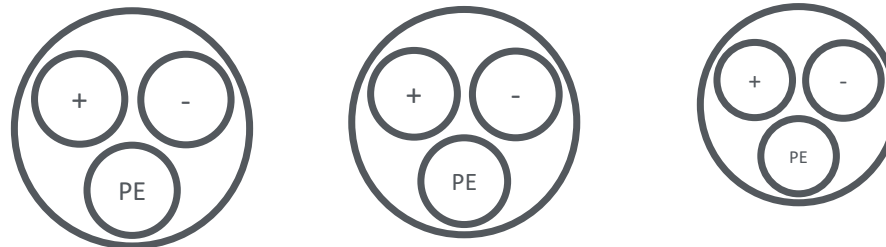
Copper savings
with the same power
transmission

↓ - 29 %

↓ - 47 %

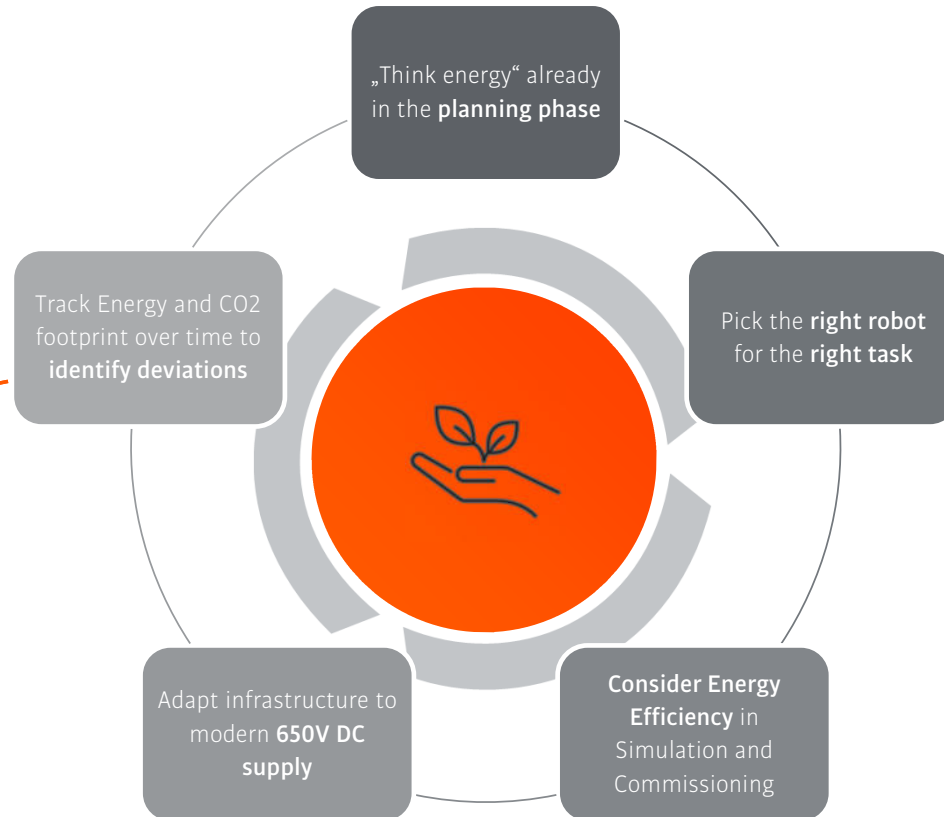
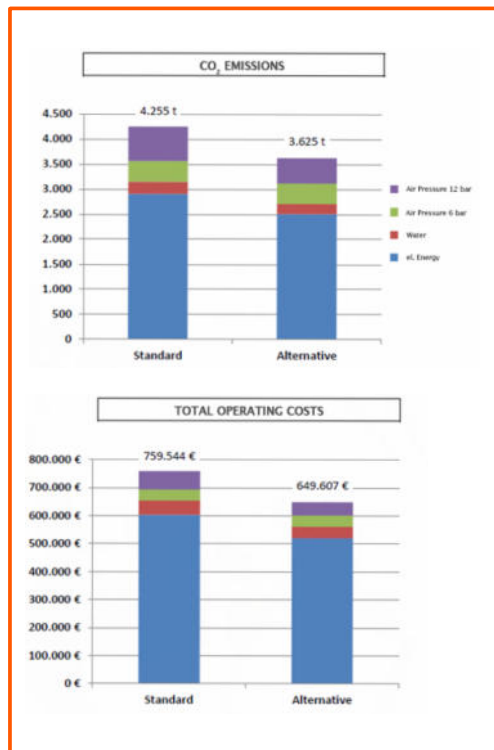
↓ - 65 %

650 V DC system





Energy efficiency _Summary



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