



# Mobility Vision for Efficiency: 10kWh per 100km

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Infineon Technologies AG



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## Today's speakers:

### › **Dirk Geiger**

- › Senior Director, Infineon Technologies
  - › Automotive Application Marketing & Management
  - › Department: IFX ATV SYS SAE
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- › [Dirk.Geiger@infineon.com](mailto:Dirk.Geiger@infineon.com)

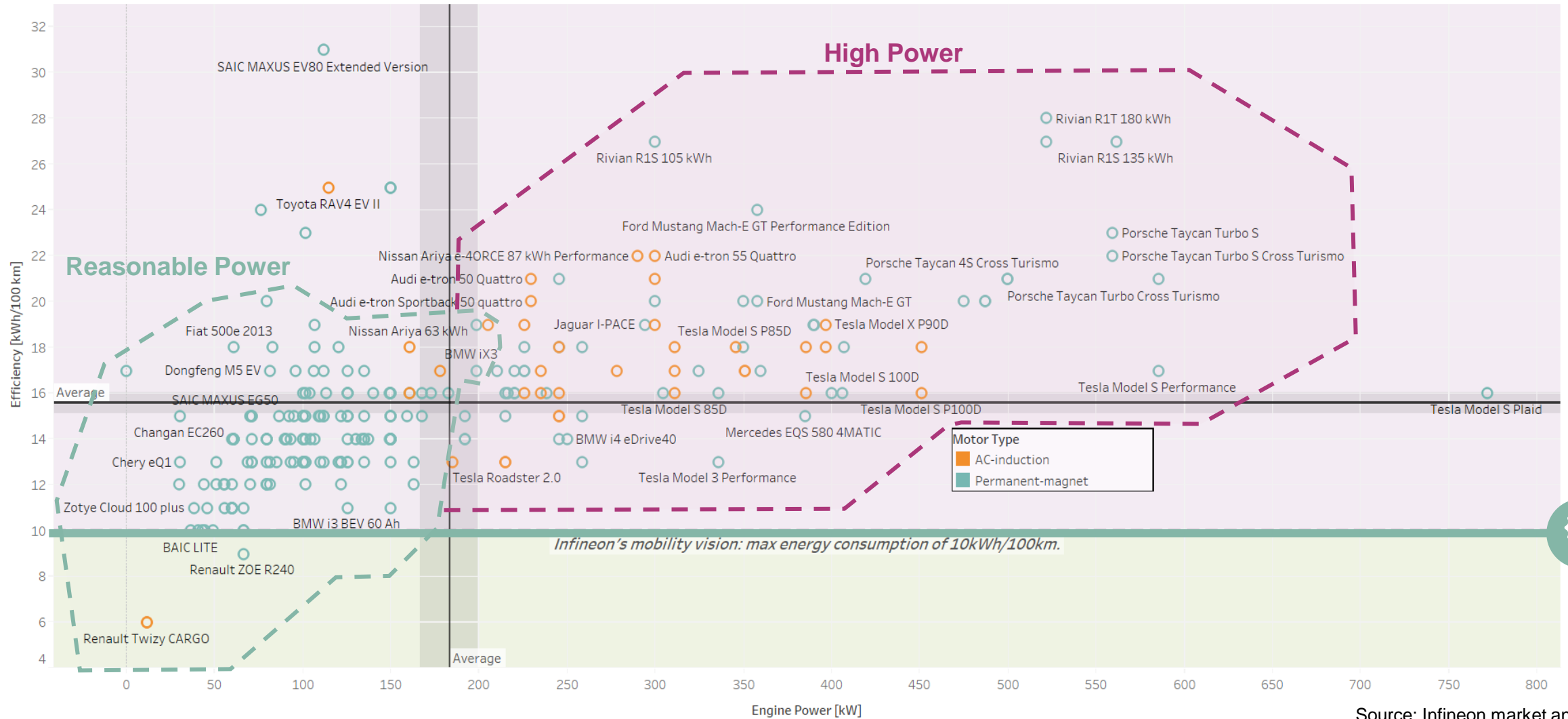


### › **Christoph Bauer**

- › System Architect, Infineon Technologies
  - › Traction Inverter and eMobility
  - › Department: IFX ATV SYS SAE
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- › [Christoph.Bauer@infineon.com](mailto:Christoph.Bauer@infineon.com)



# Almost no passenger vehicles currently available are achieving our energy efficiency vision of 10 kWh / 100 km



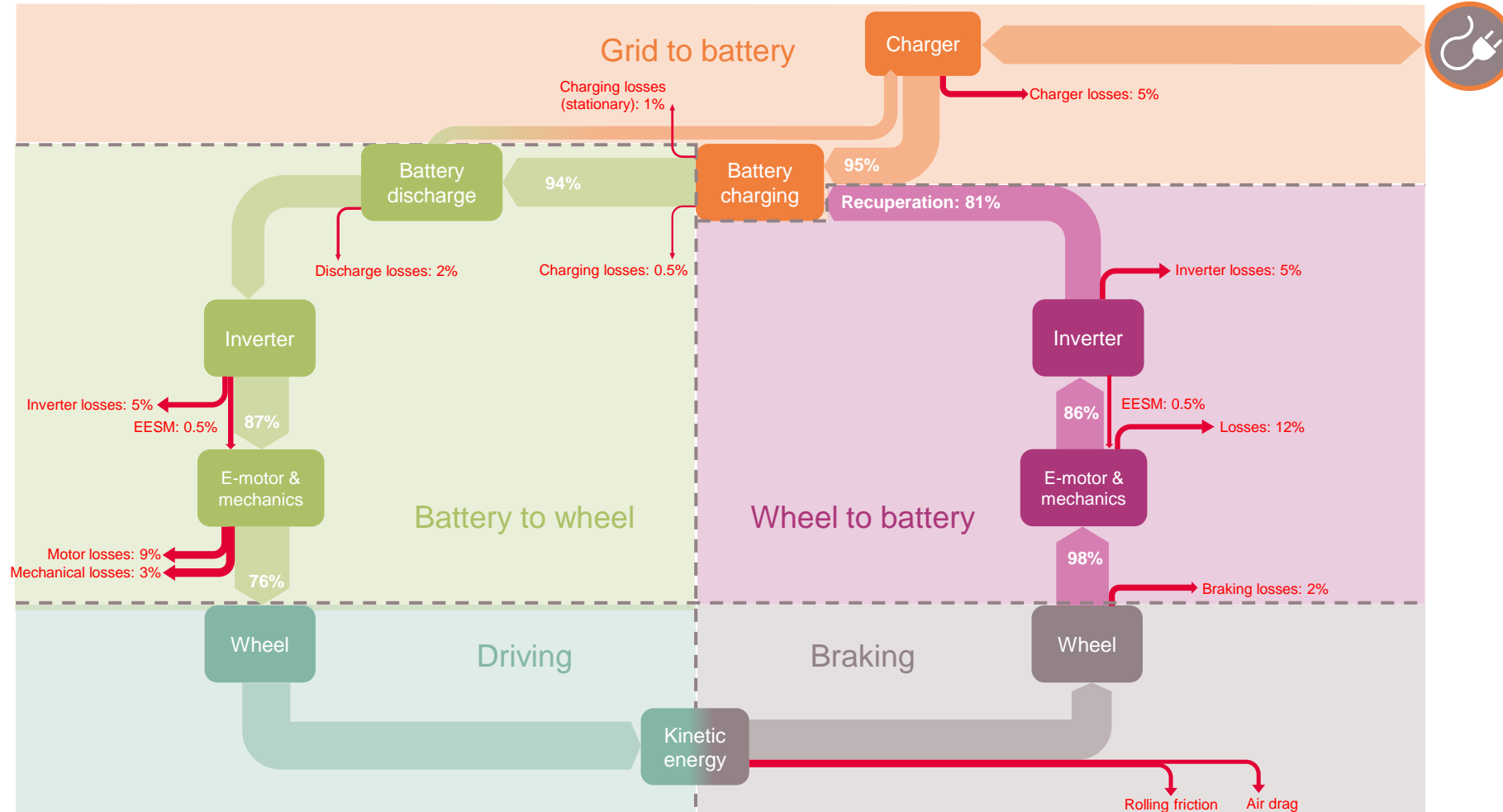
Source: Infineon market analysis

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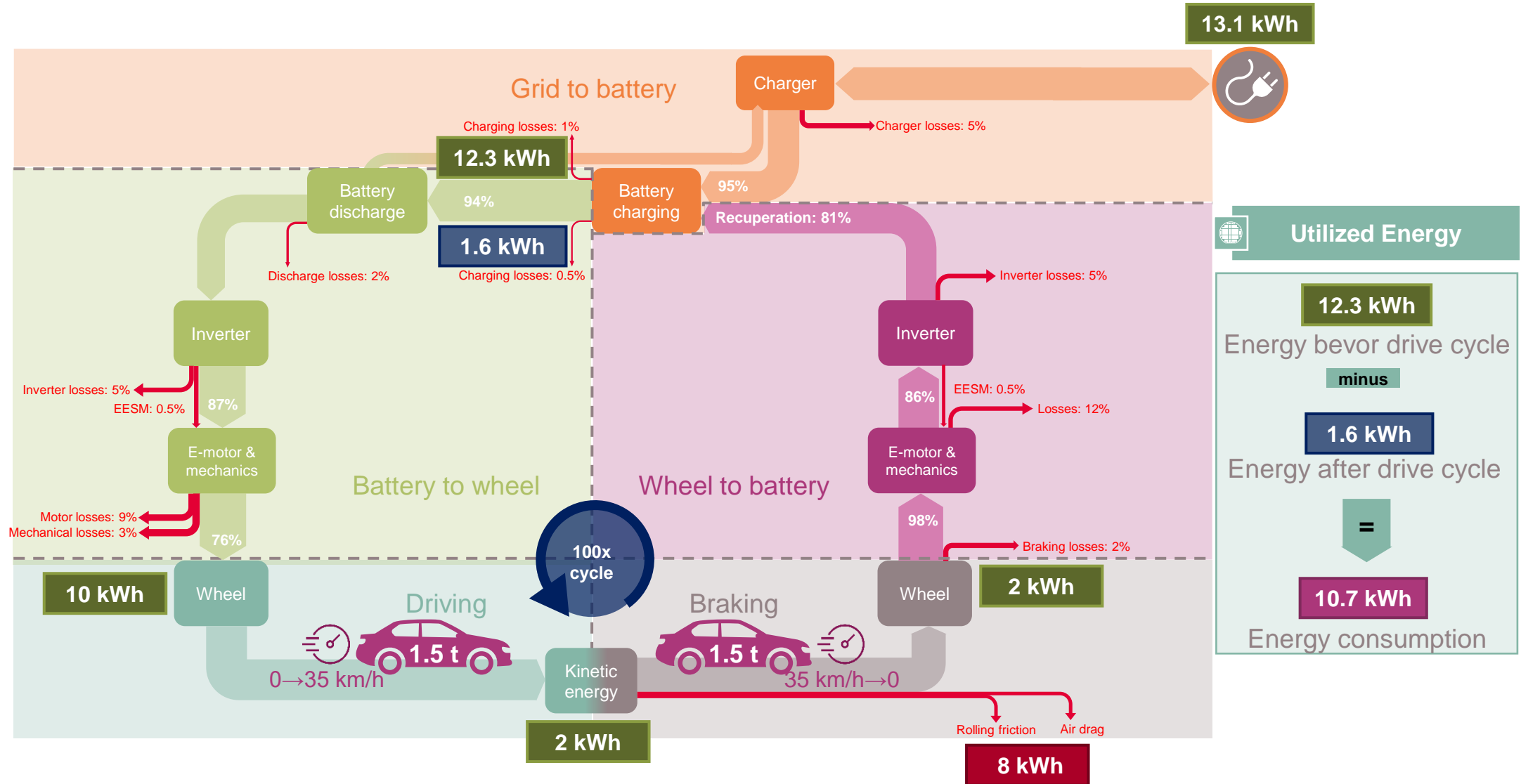
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# Energy flow diagram of a complete BEV driving cycle: Efficiency potential is clearly visible.

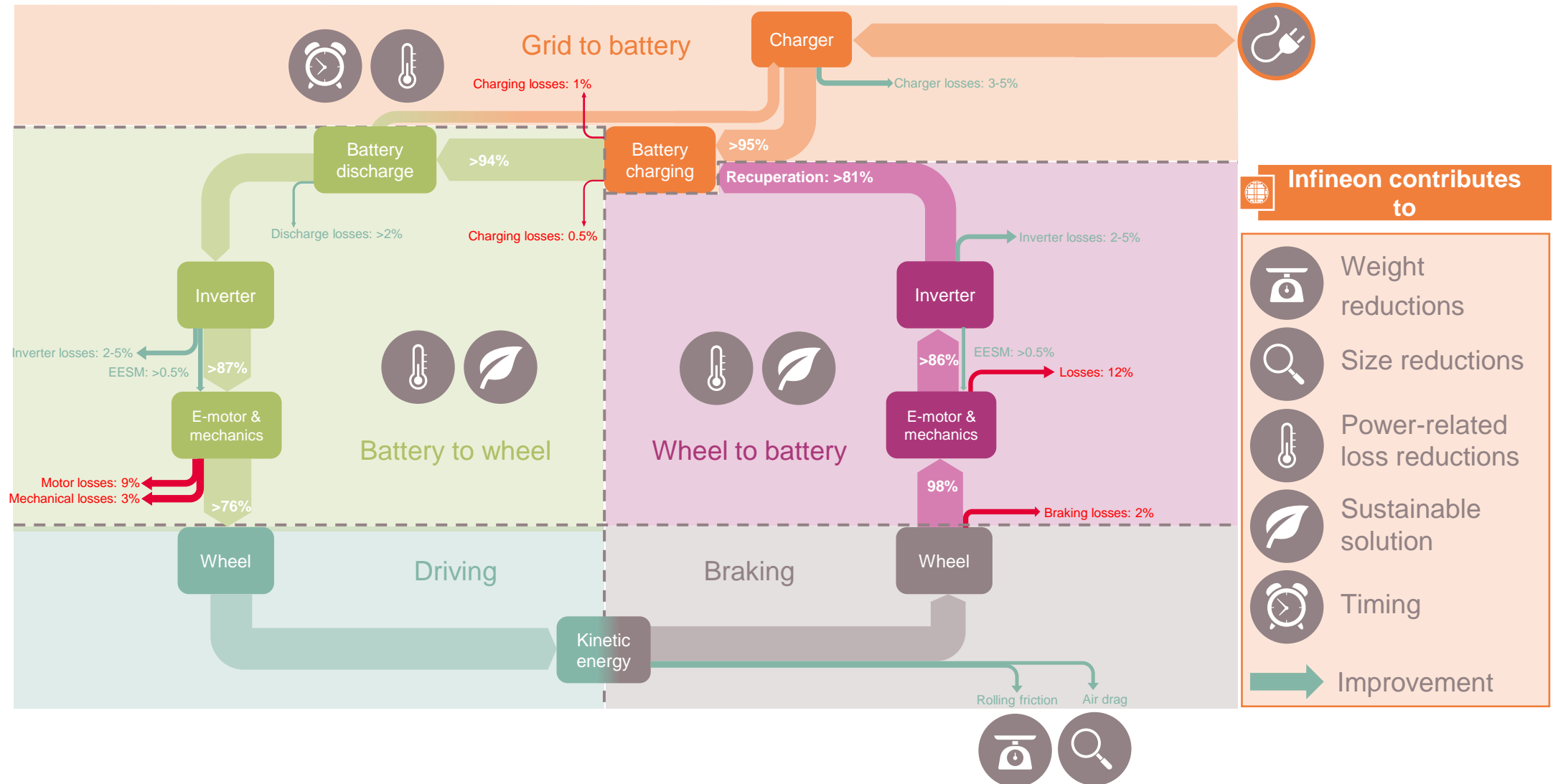


# Utilizing 12.3kWh from the battery for 100km driving and leaving a remaining charge of 1.6kWh in the battery: 10.7kWh/ 100km

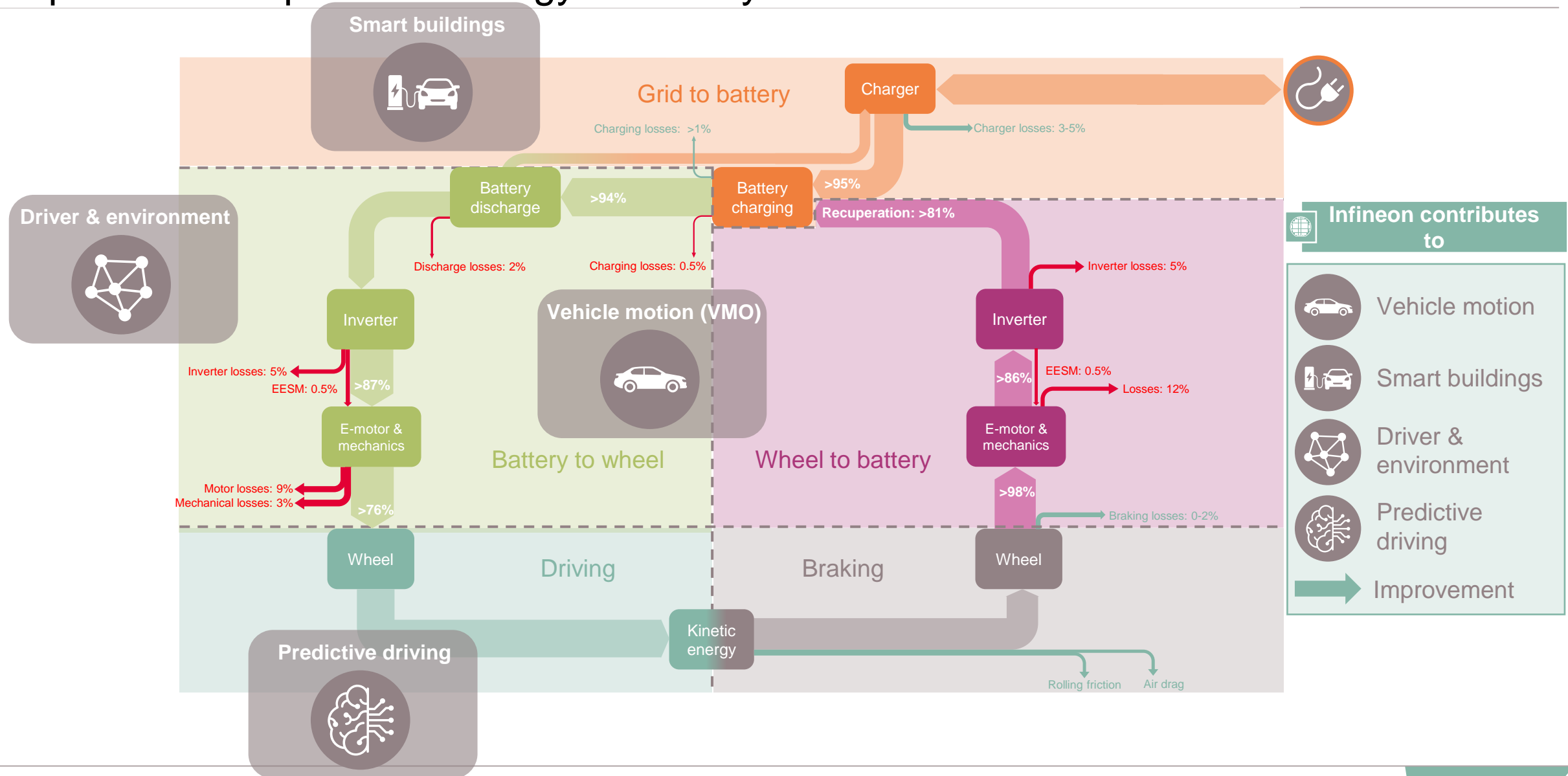




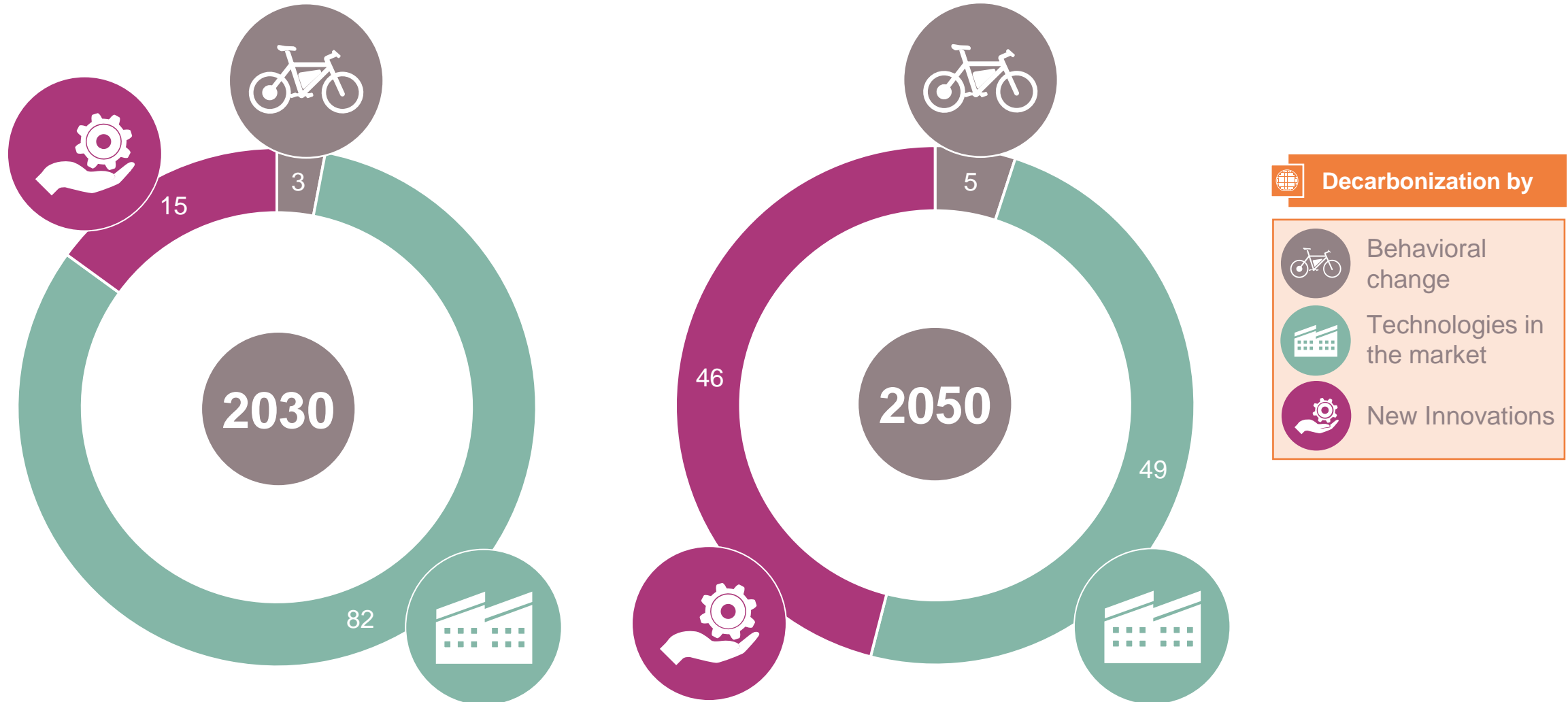
# Semiconductors contribute directly to improved energy efficiency, but also to size and weight reductions and enhanced vehicle dynamics.



# Smart energy management and trained neural networks are the next steps towards optimized energy efficiency.



Today's technologies main contributor to decarbonization by 2030.  
Innovations of today: Main contributor to decarbonization by 2050.



› Source: Net Zero by 2050, A Roadmap for the Global Energy Sector (p.16) (International Energy Agency)

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# The On-Board Charger's will be one of the first applications in automotive to leverage GaN benefits for best kW/Liter ratios

## Power Semiconductors

- › **GaN** in mass market designs by 2026+
- › But **SiC** and **Si** still dominating
- Infineon's offers the benchmark portfolio for Si as well as WBG in a variety of packages
- GaN is the solution for very high power densities designs at efficiencies difficult to achieve with SiC or Si



## Output - Power

- › **7.2 kW & 11 kW** are currently standard and 22kW will get more share in the next years
- › **Integrated solutions** for more kW/l
- › **Multi-phase** approach
- Infineon's broad and scalable product offering enables efficient solutions



## V2x

- › OBC becomes **bidirectional** due to V2x demands
- › Advance and more safe **communication** will be needed (ISO15118)
- Infineon power semiconductors, Microcontrollers, Wifi and Bluetooth products, safety and security expertise are the basis for V2x solutions



## Size and Weight

- › Higher **switching frequency** will be demanded to reduce size of magnetics
- › Optimized **thermal design** by new innovative SMD packages
- Infineon package solutions for SiC and GaN, like TSC, for optimized kW/Liter ratios

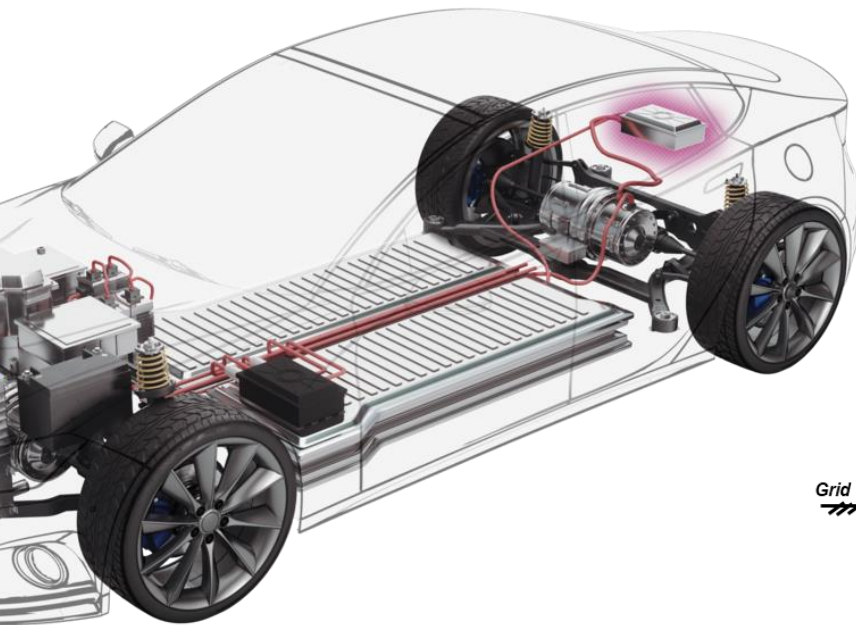


# All functions of the OBC & HV-LV DC/DC influence the energy efficiency

## 1 Primary Functions

### Charging Control

- Battery Charging (400 & 800V)
- Vehicle to grid / home / load (V2x)
- Power classes (3.6 / 7.2 / 11 / 22 kW)



## 2 Secondary Functions

### High availability

- Support trend to replace 12V battery
- X-by-Wire: Braking, Steering

### Power Density

- Same size with higher power (2kW/l → 6kW/l)

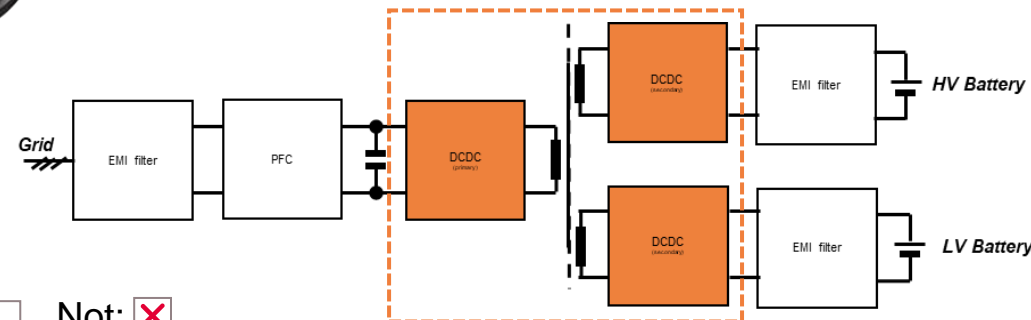
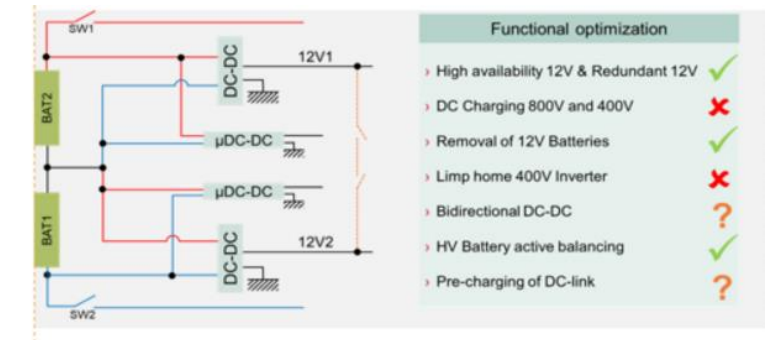
### Efficiency

- Increase efficiency by using SiC and/or GaN

## 3 Related Functions

### Further integration

- Battery bank balancing (2x 400V)
- Junction box along with E-fuses



Relevant for Efficiency? Strong:  Little:  Not:

# Key components for on-board charger and HV DCDC applications



- Communication MCU**
- › [AURIX™](#) TC36x / TC37x
- Control MCU**
- › [AURIX™](#) TC33x / TC32x
- Power Supply**
- › [OPTIREG™](#) PMIC  
SBC , Linear , DCDC
- Sensors (SC)**
- › [XENSIV™](#) current sensor
- Gate Driver**
- › [EiceDRIVER™](#)
- Power stage**
- › [CoolMOS™](#), [CoolSiC™](#)  
› [TRENCHSTOP™ 5](#)  
› [OptiMOS™](#)

- › Multi-core device w/ scalable portfolio
- › Safety & security
- › Ethernet capabilities

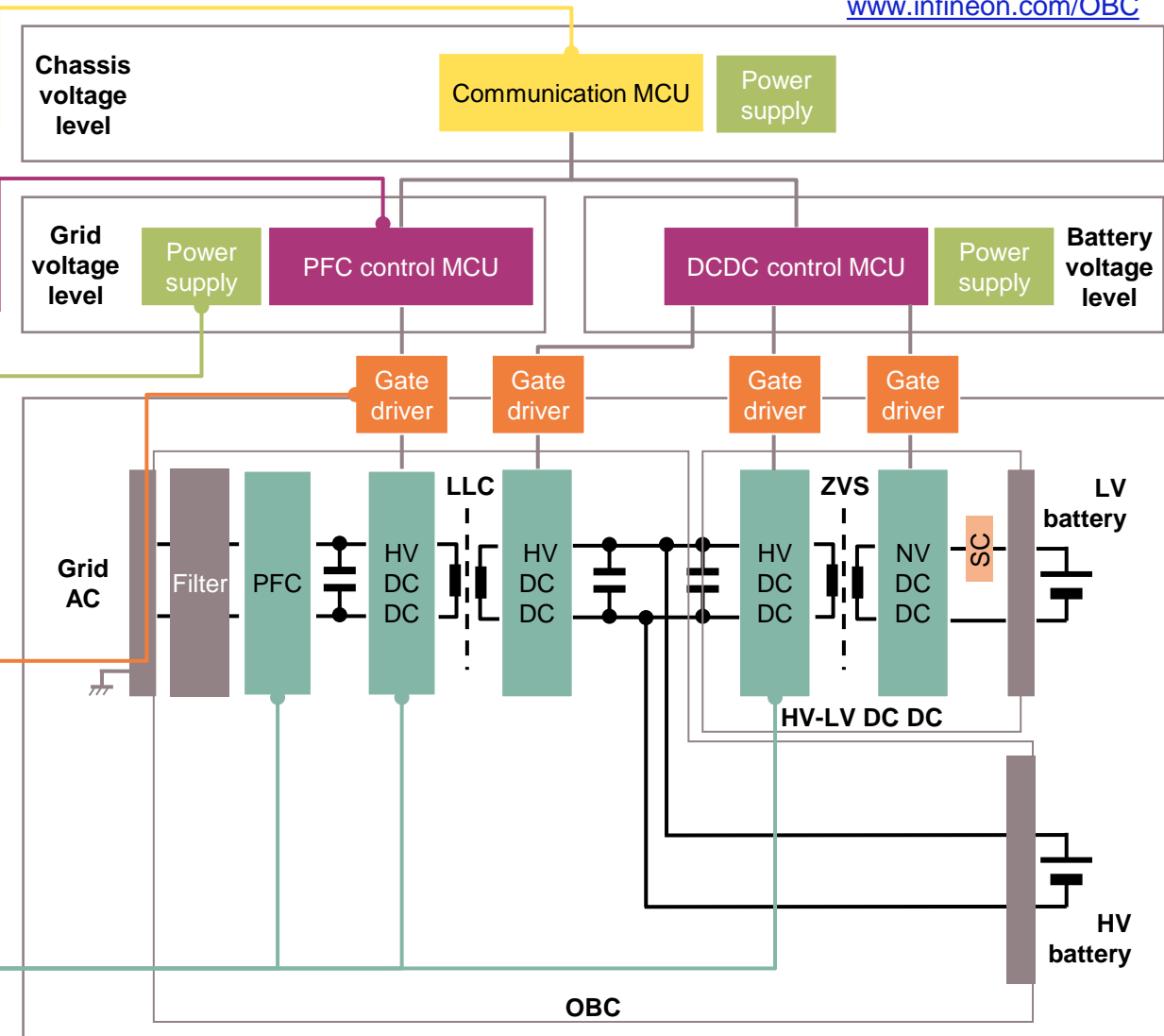
- › Single-core device w/ scalable portfolio
- › Safety & security
- › Improved mixed signal peripherals

- › Functional safety
- › Standby-mode
- › Improved EMC behavior

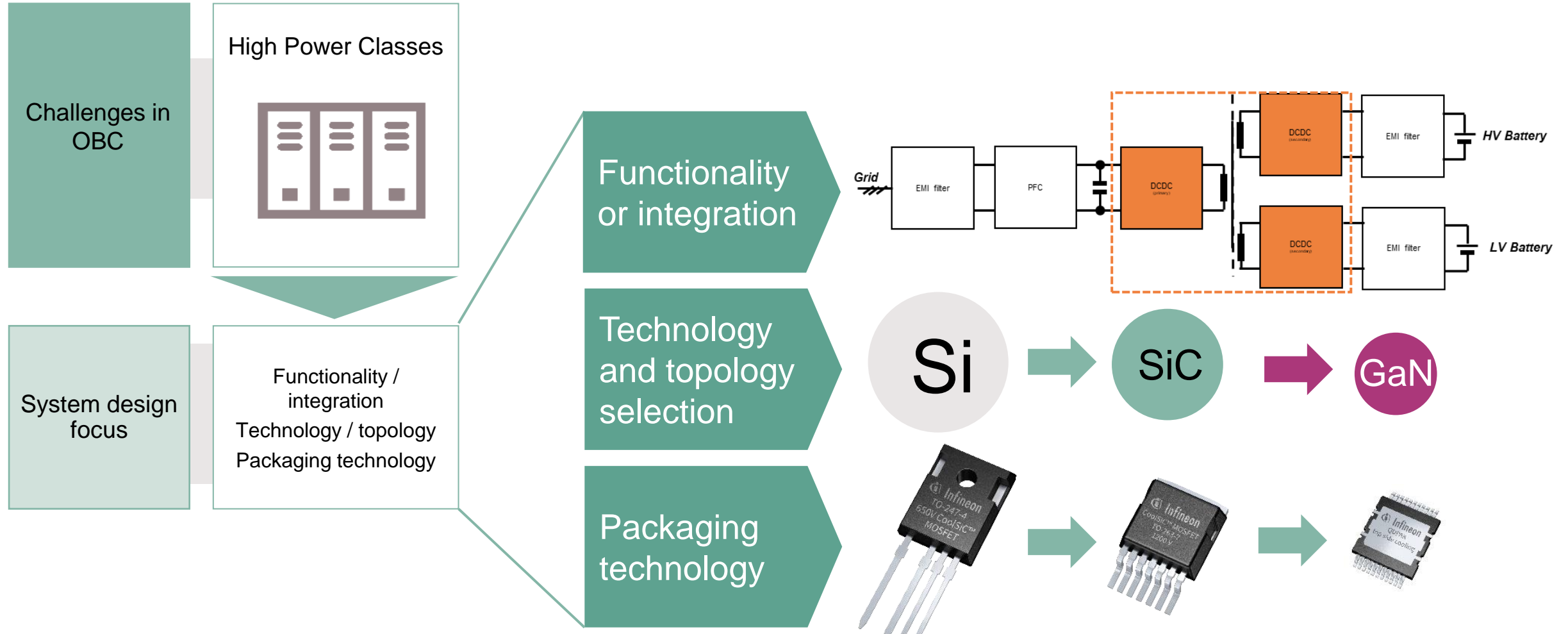
- › accurate and stable current measurement

- › Increase system efficiency and lifetime

- › High efficiency, low design-in efforts
- › Various cost-performance ratios
- › Superior reliability and quality



# Newest Frontend- and Backend- Technology enables higher contributes to the energy efficiency



**Only complete system optimization will lead to cost-performant power density increase**



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# Optimizing size and weight of the Traction Inverter drives the market towards SiC solutions and 800V systems.

## Power Semiconductors

- › Market share of **SiC** increases
- › But **Si** remains still major
- › **400V and 800V** will share the market

→ Infineon best in class Si and SiC products

- › Blocking voltages of 750V and 1200V
- › 600V batteries are although supported



## Size and Weight

- › **Reduced size** for AC current sensing
- › **Integrated solutions** for smaller PCB size

› Integrated **safety concept**

→ Enabled by Infineon's complete product offering, complemented by deep system competency

## E- Motor

- › **PMSM** are dominant
- › **EESM** (externally excited synchronous m.) will start to increase their market shares

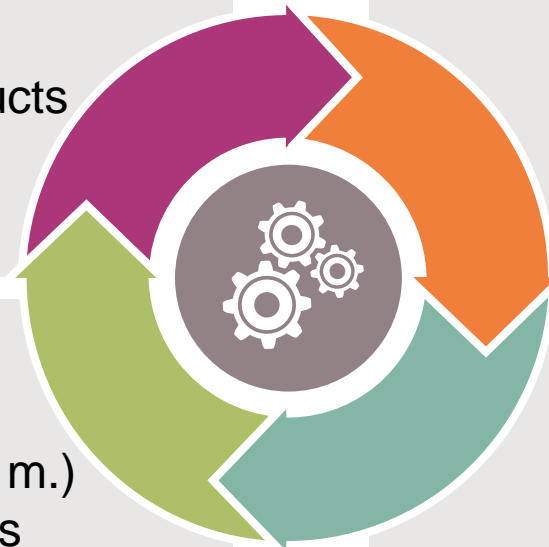
→ Infineon offers dedicated solutions for specific motor types



## Modulation

- › Higher **switching frequency** and higher **switching speed** will be demanded

→ Developments are made in accordance to the upcoming needs

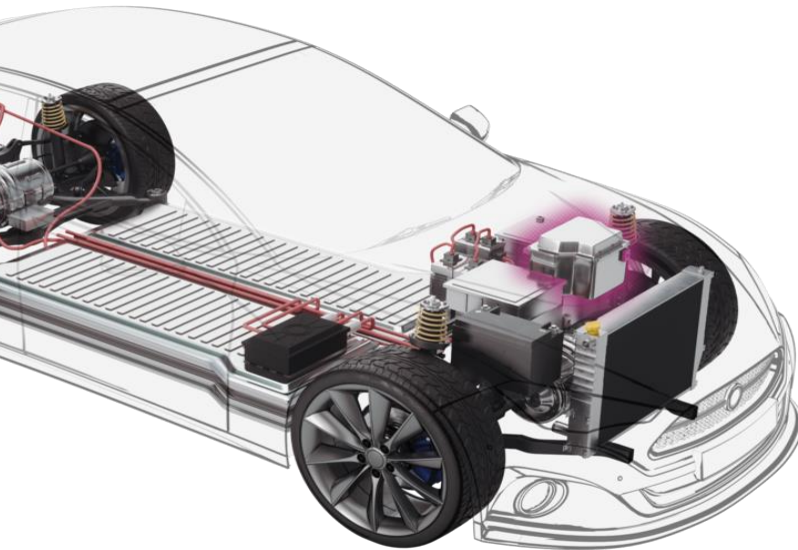


# The Traction Inverter is the important application in an EV to optimize energy efficiency

## 1 Primary Functions

### Motor control

- Forward/Backward
- Hill hold
- Generator (Regenerative braking)
- Ensure safe reaction of the car



## 2 Secondary Functions

### Battery warm-up / pre-conditioning

- startup at cold conditions
- Energy transfer inverter / battery

### Torque vectoring actuation

- Front/Rear & Right/Left (differential)

### Battery charging

- DC-DC charging 400 V - 800 V

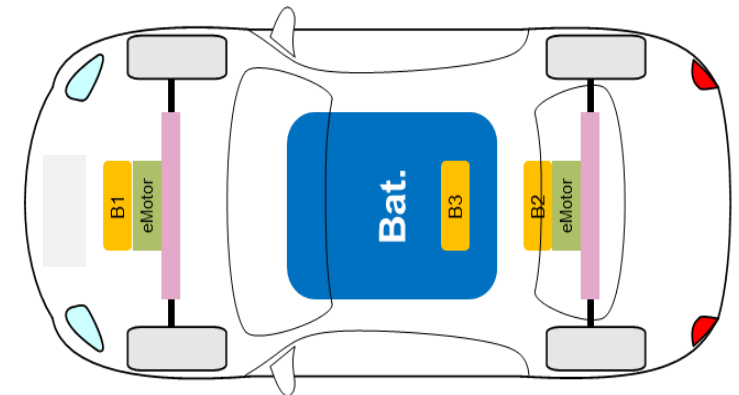
### Discharging the DC Link

- After battery turn off

## 3 Related Functions

### Vehicle stability system

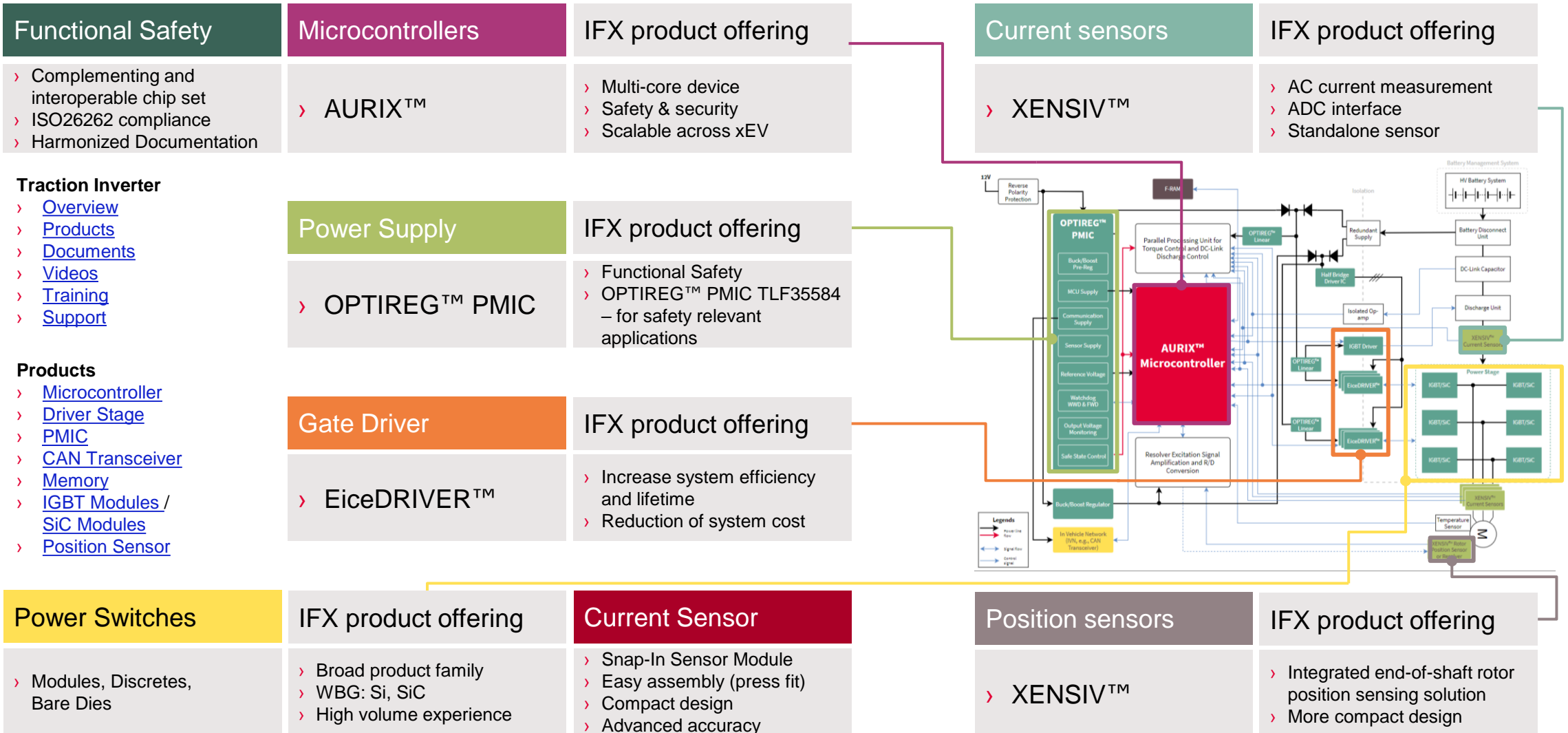
- Motion control (VCU)
- Synergies:
  - > Motors
  - > Braking
  - > Steering
  - > Suspension



Relevant for Efficiency? Strong:  Little:  Not:

# Infineon offers all components for Traction Inverters

## The one-stop shop for optimized application solutions

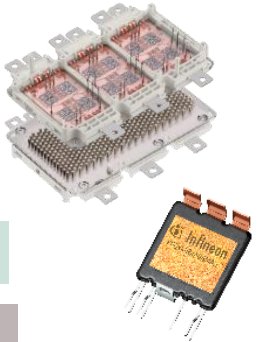


# Optimizing vehicle motion with combined SiC and Si for best efficiency

### HybridPACK™ Drive CoolSiC™ MOSFET for rear axle

Focus on

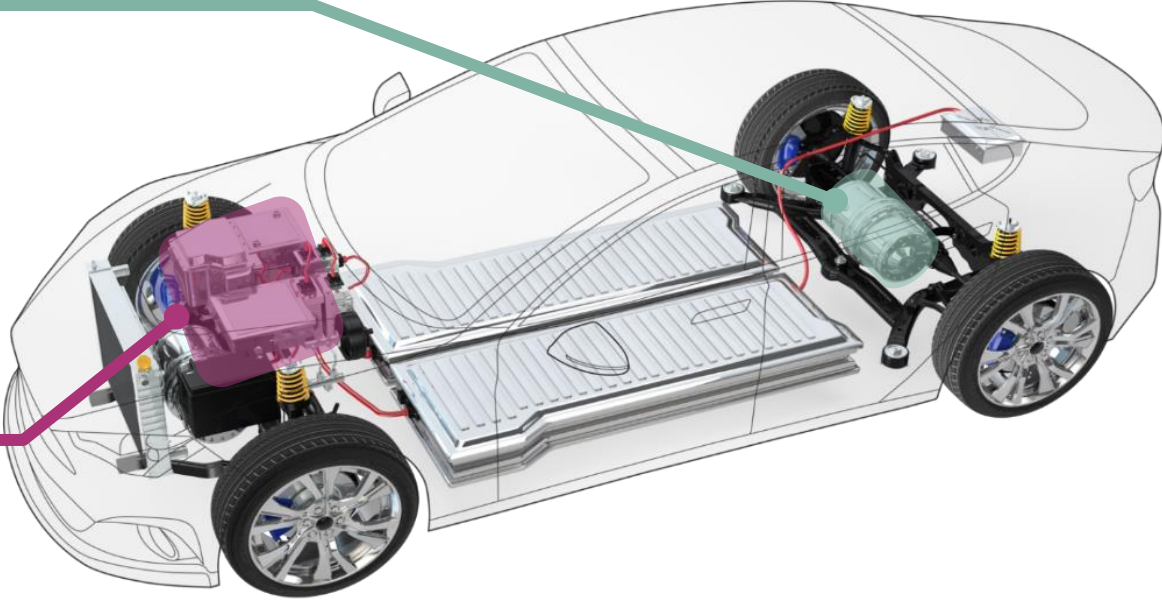
- Range: SiC
- Cost
  - Large battery: SiC
  - Small battery: Si



- Longer range ✓
- Compact size ✓
- System cost ✓

### HybridPACK™ Drive IGBT for front axle

Focus on cost : Si



# Battery size reduction & range are two major CoolSiC™ benefits

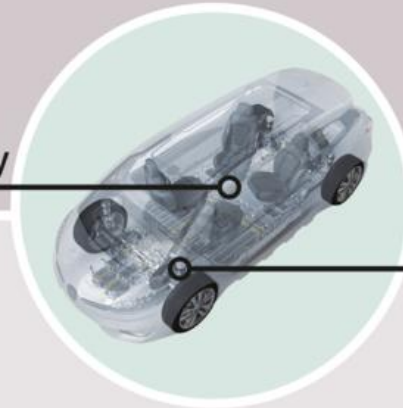
Shrink battery size and cost – by up to 10% – thanks to improved efficiency

Smaller battery

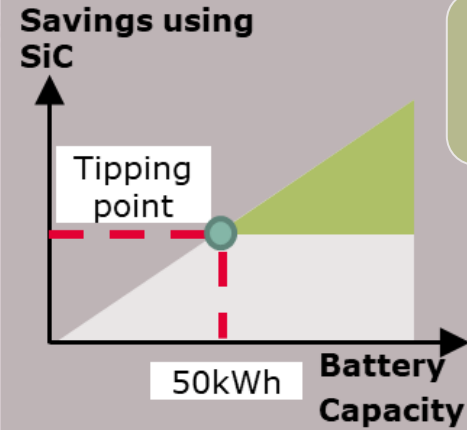
Up to 10% times smaller  
Up to 800 euros cheaper <sup>1)</sup>



Battery



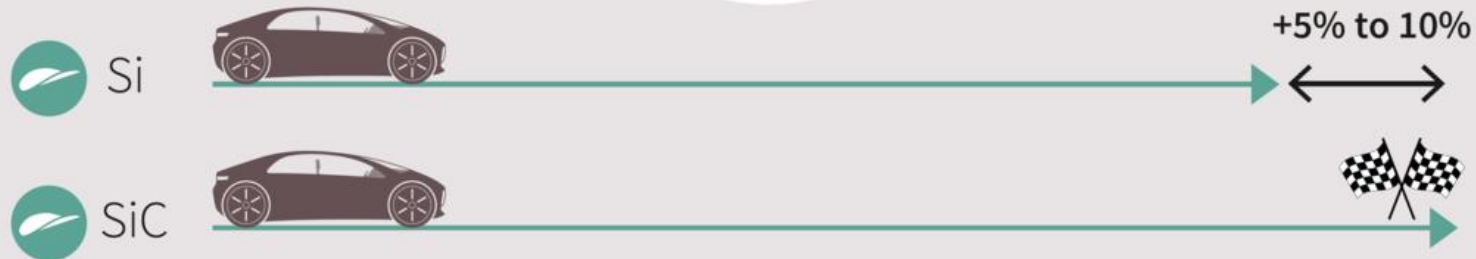
Inverter



SiC enables system cost savings for batteries >50kWh

Higher autonomy

Up to 600 hrs saved in charging <sup>2)</sup>  
Up to 1864 kg CO<sub>2</sub> saved per vehicle <sup>3)</sup>



1) For a 80kWh battery, assuming 100 € / kWh

2) Example based on 15000 km/year, 40kWh battery and on a 7kW charging point, 15years usage

3) Source [Environmental Progress](#)

# The engineer's preferred choice, the AURIX™ TC3xx, for efficient and performant traction inverter applications



## Supports Automotive standards

- › 1<sup>st</sup> MCU with ISO 26262:2018 **certification by TÜV**
- › <4 FIT for MCU at ASIL D (D)
- › AURIX™ supplemented by **iPMIC** and **GateDriver** for ASIL D inverter

## Robust, optimized ADCs & timers

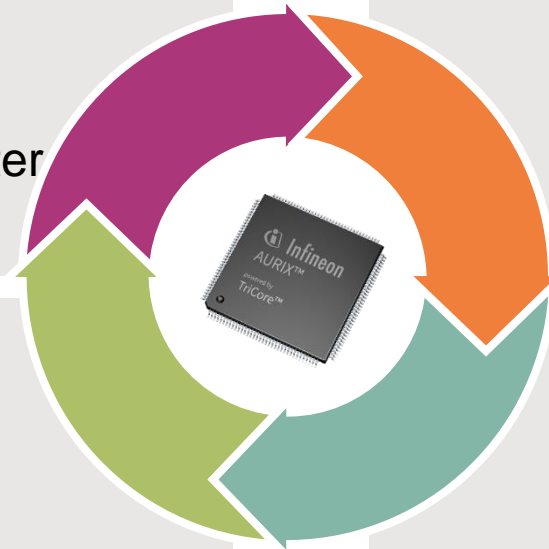
- › **Space saving:** replace of resolver IC
- › **Performance:** Improved equidistant and parallel sampling
- › **Scalable GTM:** improved peripheral access latency

## Multicore: Sub system integration

- › Enables **separation and parallel development** of functions
- › **More performance** for complex observers (e.g. Kalman) to differentiate system
- › Redundant supervision via iPMIC

## Scalable MCU portfolio

- › **Pin and SW compatibility** between AURIX™ TC2x & TC3x
- › Pin compatible in same package, Pin Superset in high pin count packages
- › SW compatible across the family
- › **Newest TC4xx upcoming**



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# Vehicle level: Visions and Reality

## Lifetime diagnostic

- › The demand for availability increases due to e.g. commercially used robot- taxis
- › Predictive maintenance could get a monetary benefit for fleet owners
- › AURIX™ is supporting such features

## Big Data approach

- › Generating data for different optimization processes like life time
- › Infineon products can gather, store and compute this data

## V2x Communication

- › V2Load
- › V2Vehicle
- › V2Grid
- › V2Home
- › Infineon offers different solutions for V2x

## Adoptive Cooling

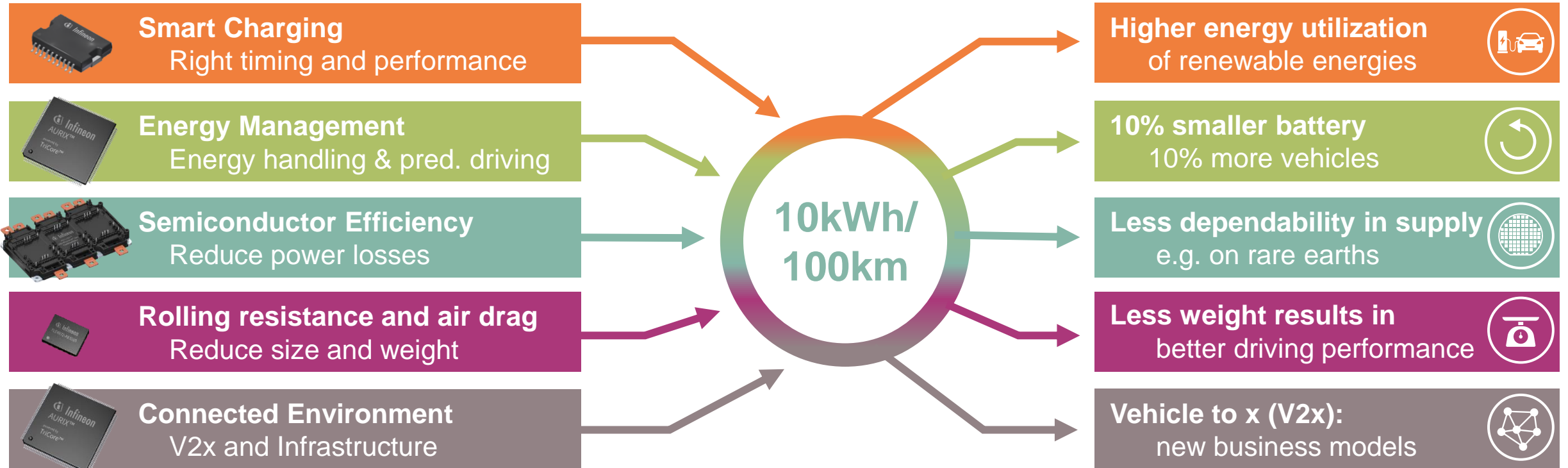
- › Regulating the coolant flow rate dynamically gains different potentials
- › The PPU- (AI-) section of the new AURIX™ TC4xx could support this
- › Predictive driving leverages many benefits



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# By leveraging **all dimensions** to improved efficiency, our vision for a holistic, green and sustainable mobility future comes to reality



 **10kWh/ 100km – enabling a greener and sustainable future** 

# Making eMobility Work! - Efficiently



## Efficiency is a "holistically" approach

Direct and indirect impacts, including the infrastructure



## Efficiency enables a sustainable life cycle

Reducing dependencies and material consumption



## Semiconductors are the basis for efficient and smart solutions

Thanks for listening!





Part of your life. Part of tomorrow.