

# Energy & Microelectronics

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Brussels, September 4<sup>th</sup>, 2017

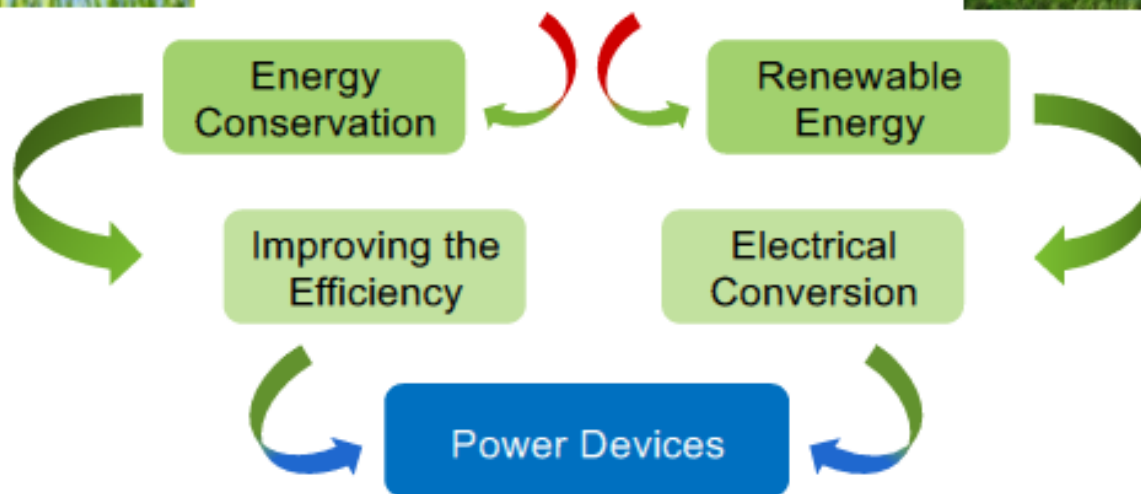
restricted



# The Story: Energy & Power Devices...



Global Warming

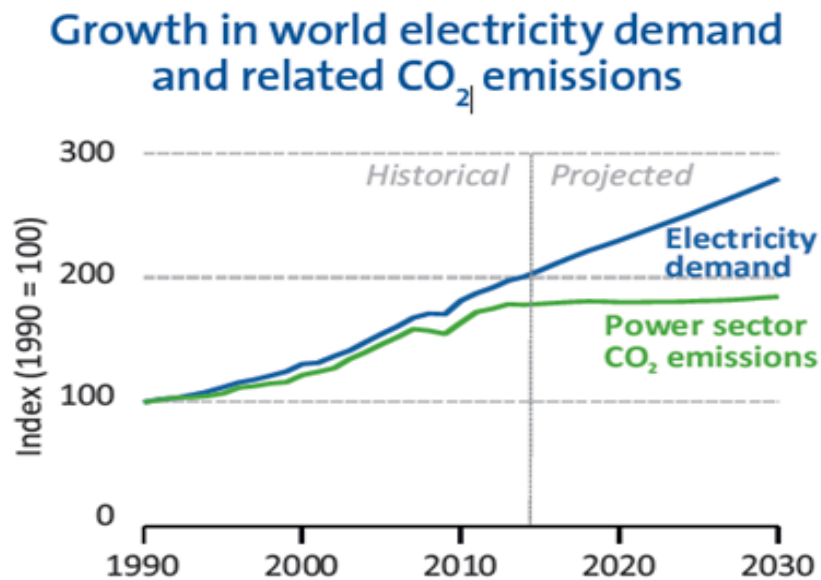


At least 50 % of the electricity used in the world is controlled by Power Devices.

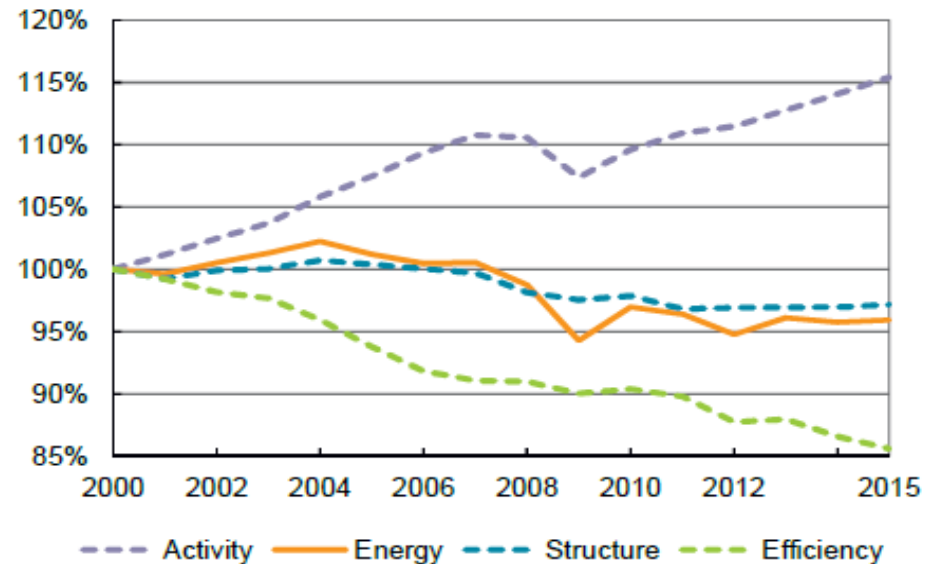
B.J. Ballga, Advanced High Voltage Power Device Concepts, Springer

# Efficiency Improvements are Key!

## → Chapter Energy in the ECS SRA\*



Source: World Energy Outlook Special Briefing for COP21 (2015).



Source: adapted from IEA Energy efficiency market report, 2016, based on IEA energy efficiency indicators database.

- According to the IEA the decomposition analysis of **factors driving energy consumption trends for IEA member countries indicates that in the IEA the decoupling was mainly due to efficiency improvements** (figure right above). Structural changes (mostly shift to less intensive industries and services) also assisted efficiency improvements to reduce the final energy consumption.
- Cumulative savings over the period 2000 – 2015 were 159 EJ or equivalent to more than one year of final energy consumption in Europe, China and India combined.

\* Remark: ECS SRA will be the common Aeneas – ARTEMIS – EPoSS SRA

# The Potential and R&D&I

## Gain Power Density by WBG

- Galvanic coupled bidirectional DC-DC converters
- Gain power and power density by component integration and newest component technology
- Wide Band Gap and high voltage for todays and future DC-DC Converters

2014: Full SiC Mosfet and Ceramic Link Design

**143 kW/dm<sup>3</sup>  
@ 98-99 %**



2013: GaN Test Converter

2010: Full Unipolar Mosfet Design



**100 kW/dm<sup>3</sup> 99 %**

2004: High Speed IGBT3

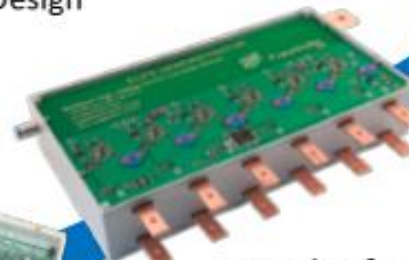
2007: IGBT3 and SiC Diodes



**70 kW @ 5 kW/dm<sup>3</sup>**



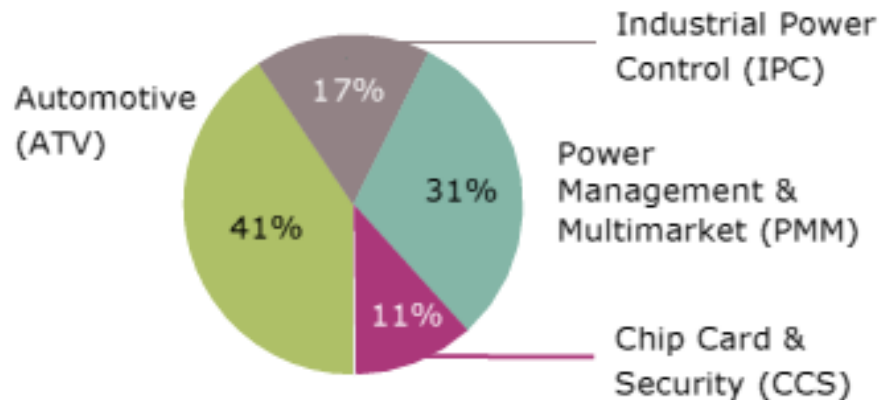
**100 kW @ 25 kW/dm<sup>3</sup>**



**40 kW/dm<sup>3</sup> 98 %**

# Infineon at a glance (source Q3 report)

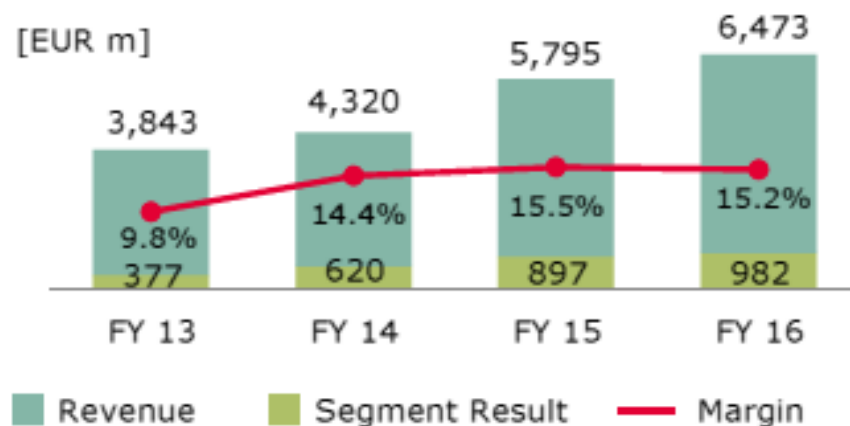
## Business Segments



Revenue FY 2016

## Financials

[EUR m]



## Employees

More than **36,000** employees worldwide  
(as of Sep. 2016)



## Market Position

Automotive



**# 2**

Strategy Analytics,  
April 2017

Power



**# 1**

IHS Markit,  
Technology Group,  
October 2016

Smart card ICs



**# 1**

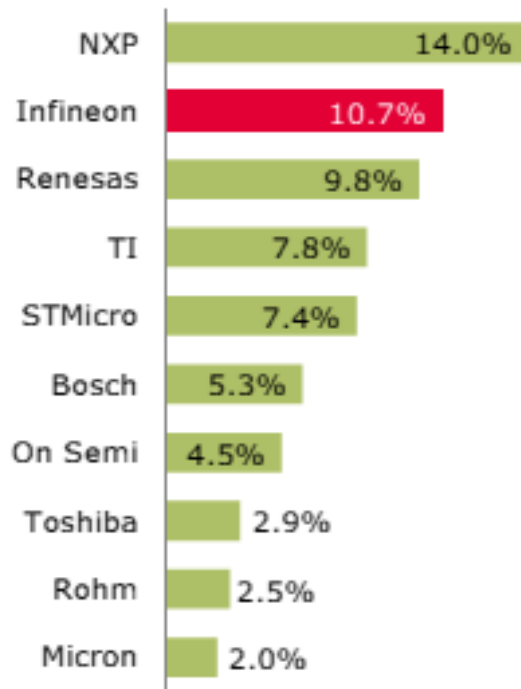
IHS Markit,  
Technology Group,  
July 2017

# Infineon: Top Positions in all major Product Categories (source Company Q3 2017 report)



## Automotive semiconductors

total market in CY 2016:  
\$30.2bn

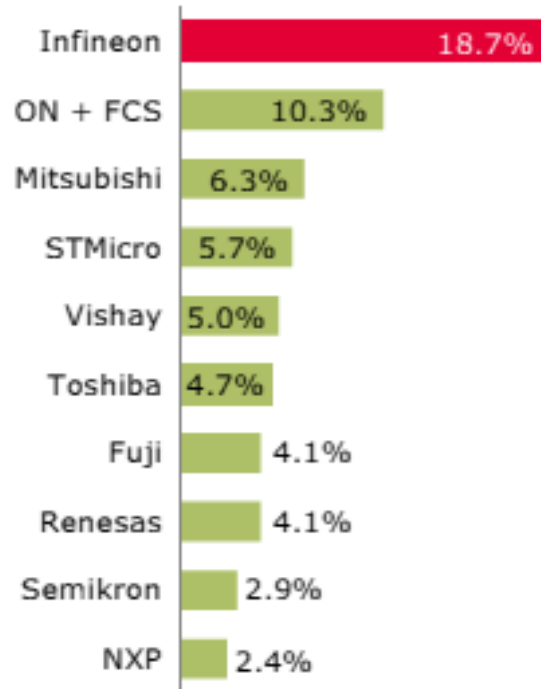


Automotive semiconductors incl.  
semiconductor sensors

Source: Strategy Analytics, "2016  
Automotive Semiconductor  
Vendor Share", April 2017

## Power semiconductors

total market in CY 2015:  
\$14.8bn

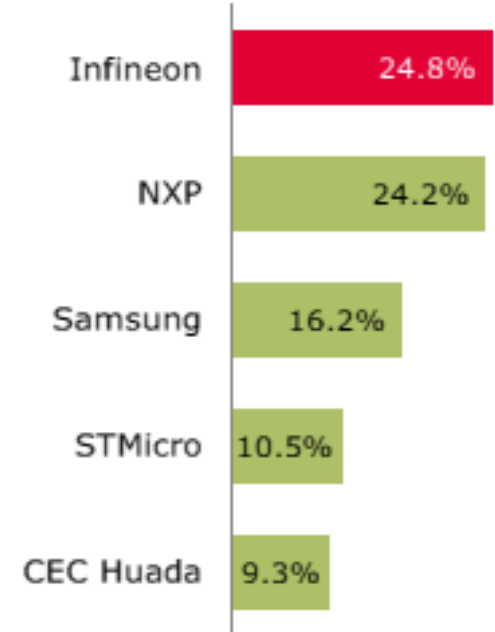


Discrete power semiconductors and power  
modules

Source: IHS Markit, Technology Group,  
"Power Semiconductor Annual  
Market Share Report",  
October 2016

## Smart card ICs

total market in CY 2016:  
\$2.79bn

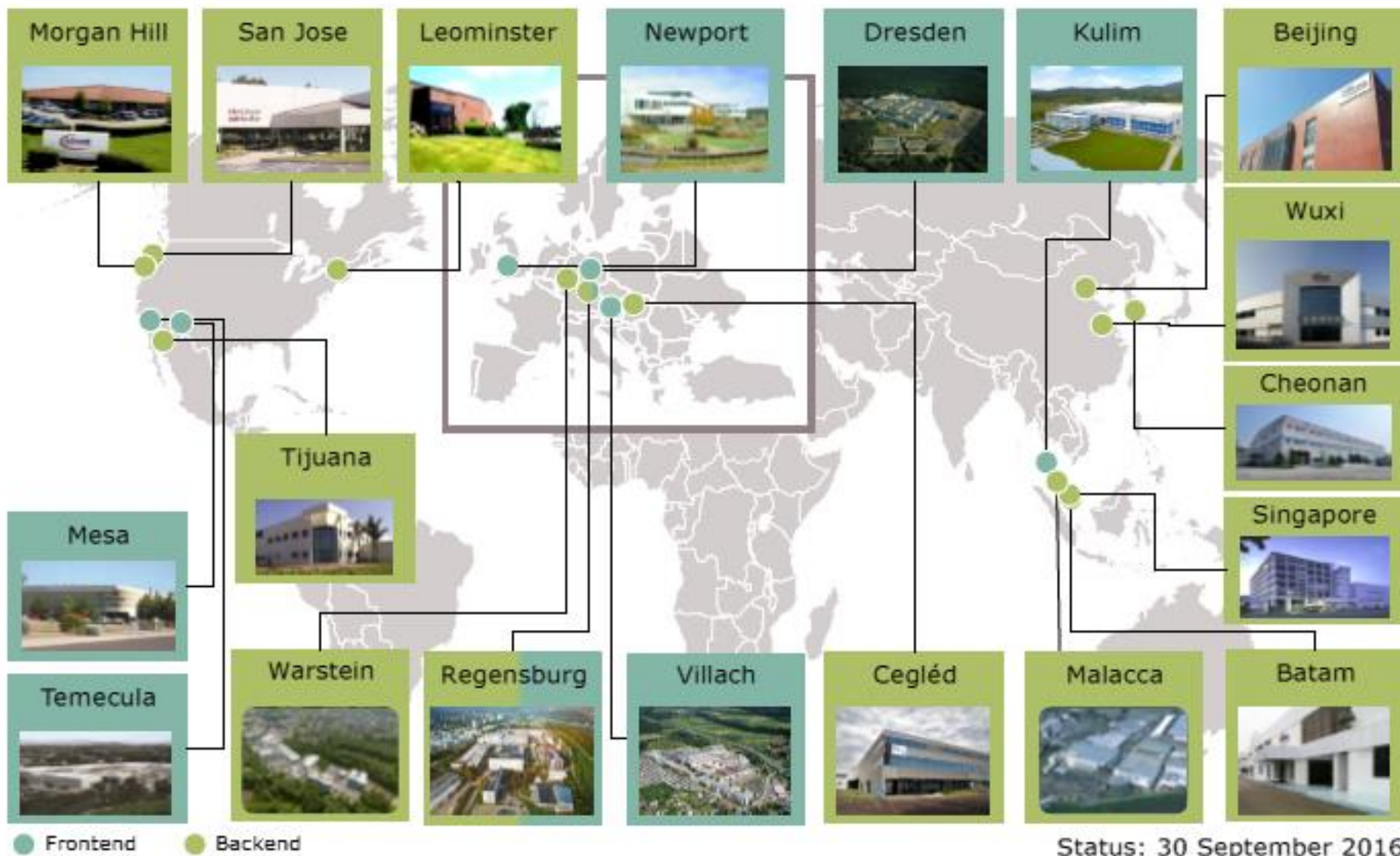


Microcontroller-based smart  
card ICs

Source: IHS Markit, Technology Group,  
"Smart Cards Semiconductors  
Report", July 2017

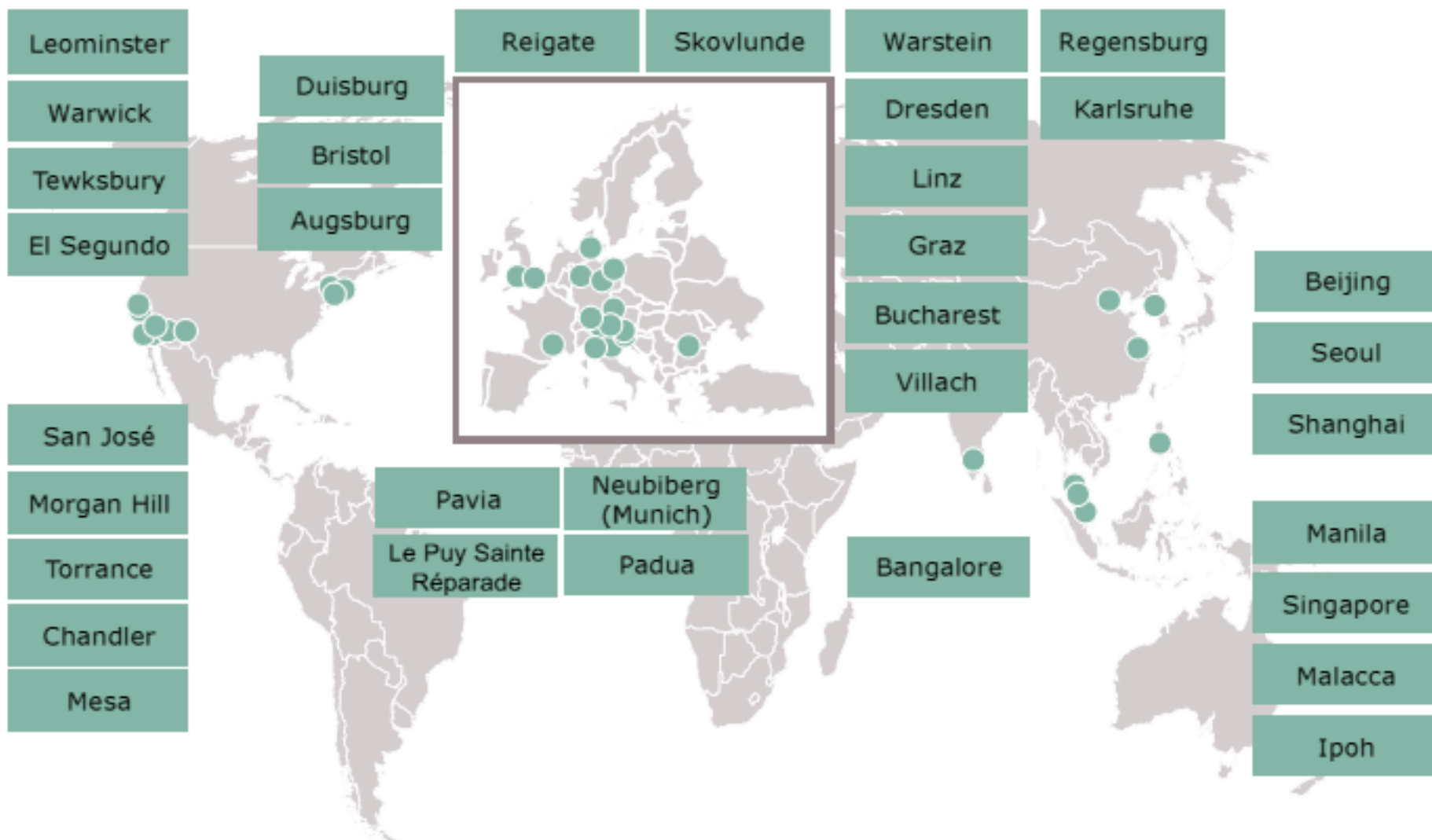


# Infineon – Worldwide Manufacturing Sides



Status: 30 September 2016

# Infineon – Worldwide R&D network



Status: 30 September 2016



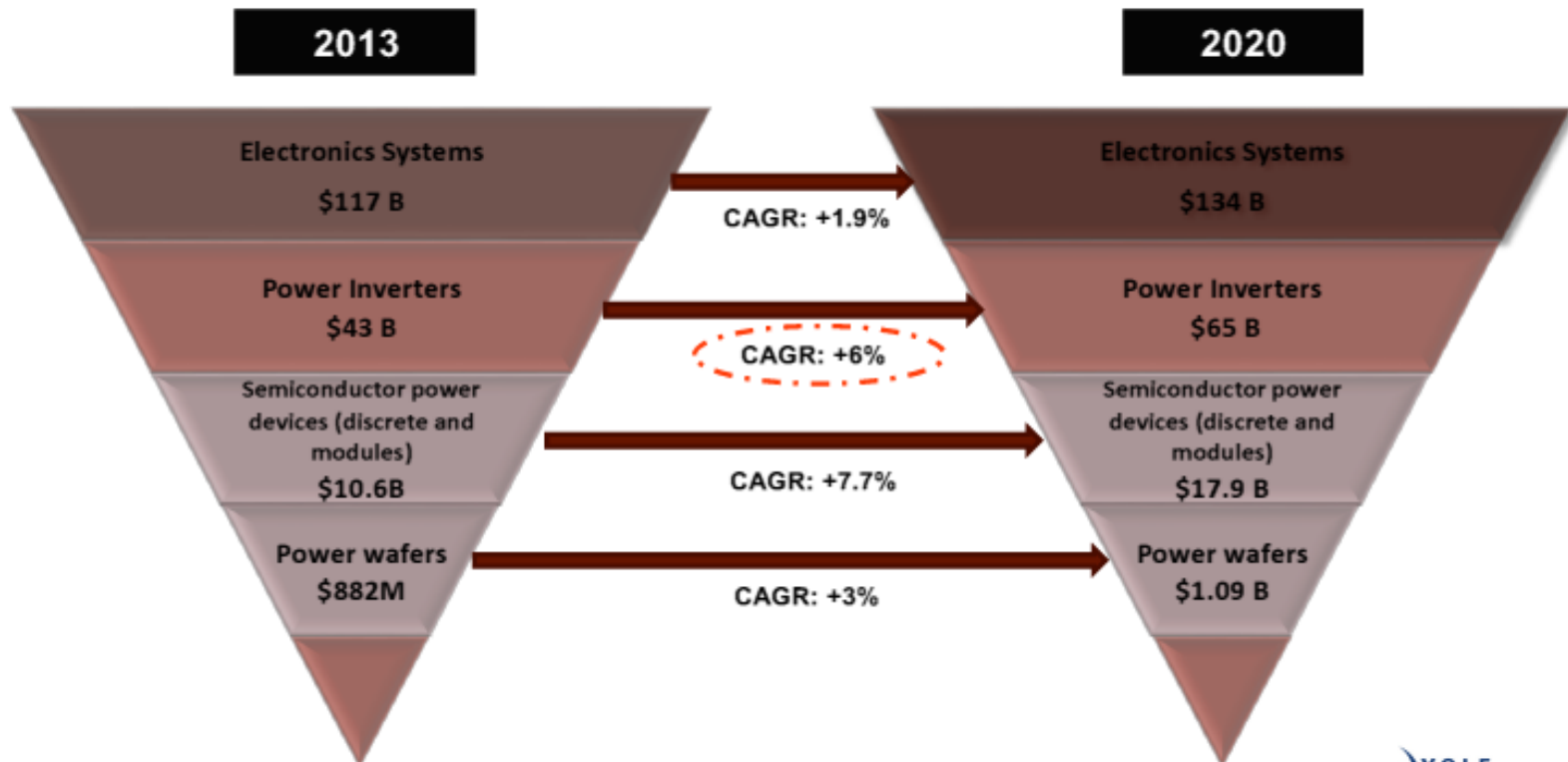
# The impact of power electronics – example inverters – source Yole report



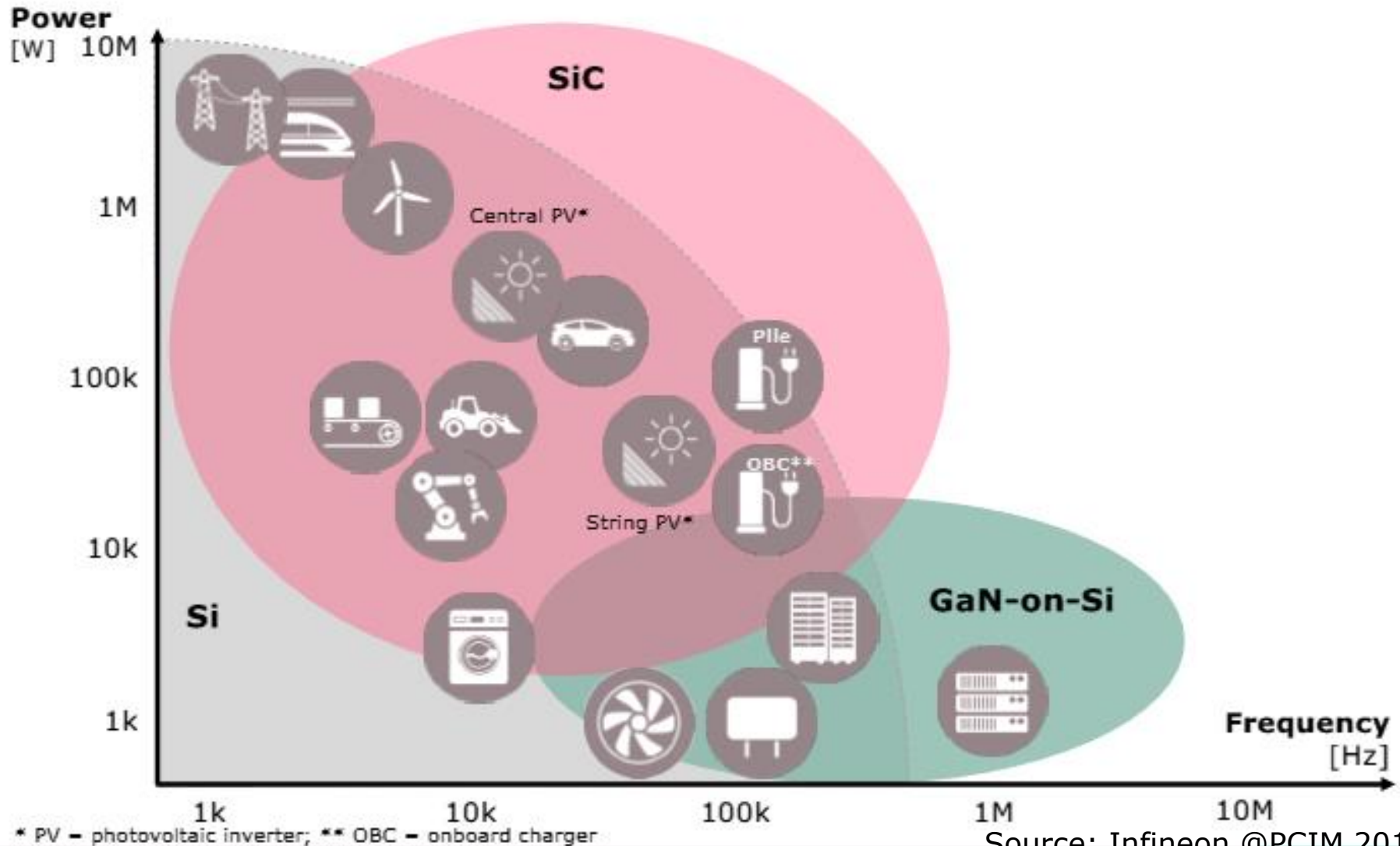
## Overall Power Electronics markets

2013 – 2020 value chain analysis: wafer, device, system

The overall inverter market size of applications considered in this report will reach about **\$65 billion in 2020**.



# SiC and GaN enable higher efficiency through faster switching with lower losses than Si



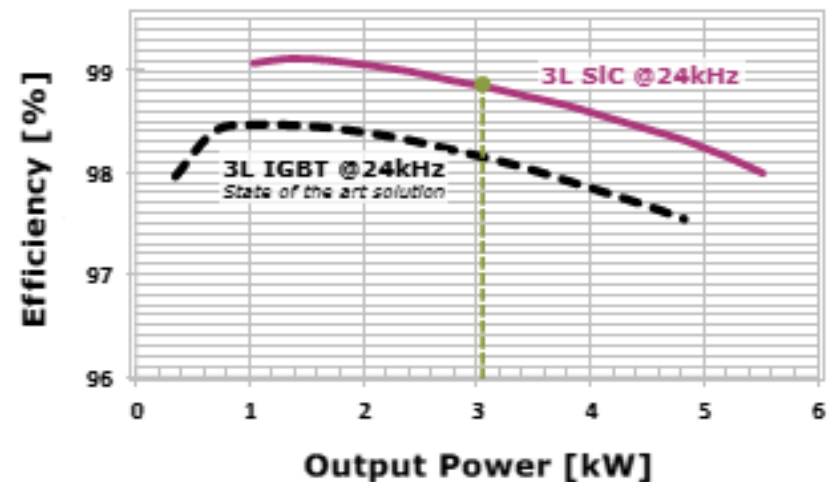
Source: Infineon @PCIM 2017

# SiC MOSFET: higher conversion efficiency allows improvement of system costs

## Higher conversion efficiency

Lower conduction and switching losses lead to

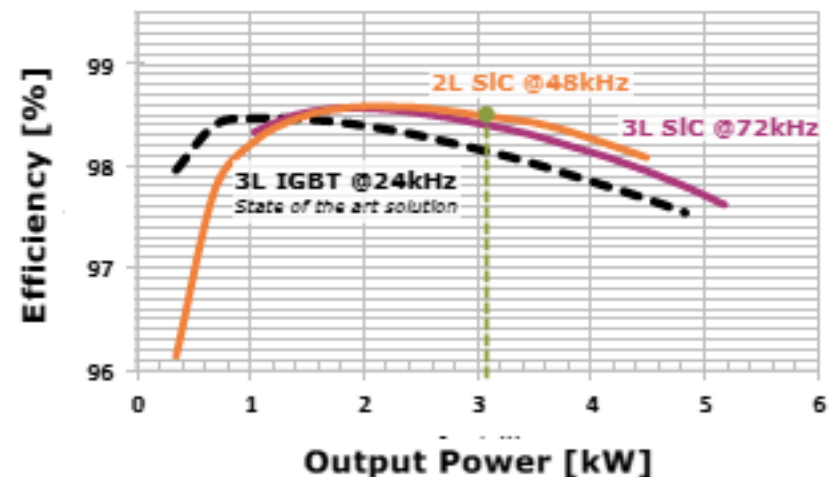
- › Higher conversion efficiency at same switching frequency
- › Higher output power for a given frame size



## Effect on system costs

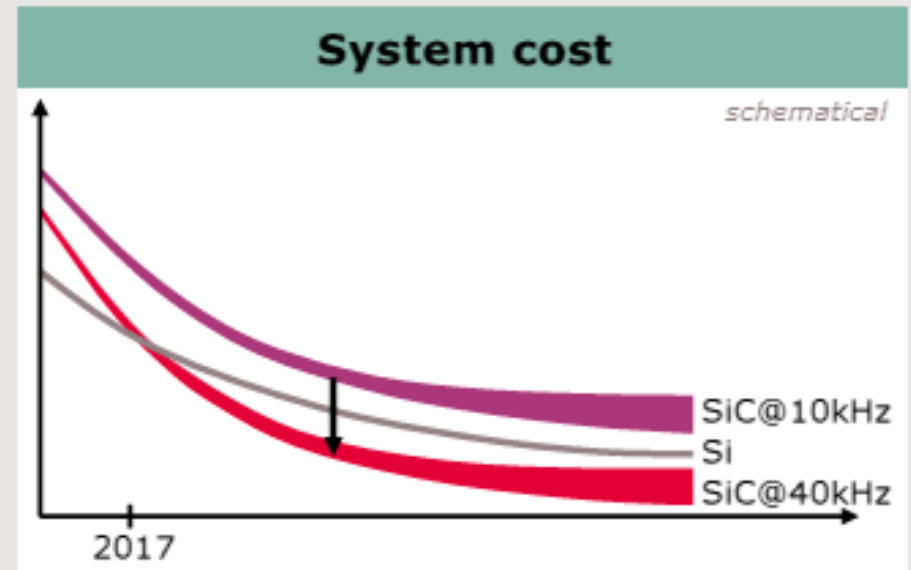
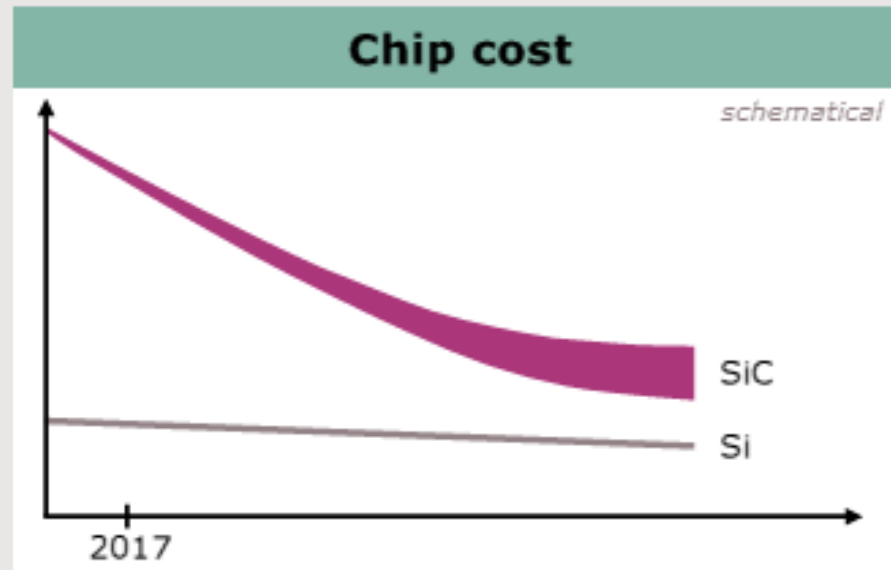
SiC devices enable

- › Increased switching frequencies to shrink magnetic components
- › Reduced power circuit complexity by using simpler topologies, e.g. 2L instead of 3L

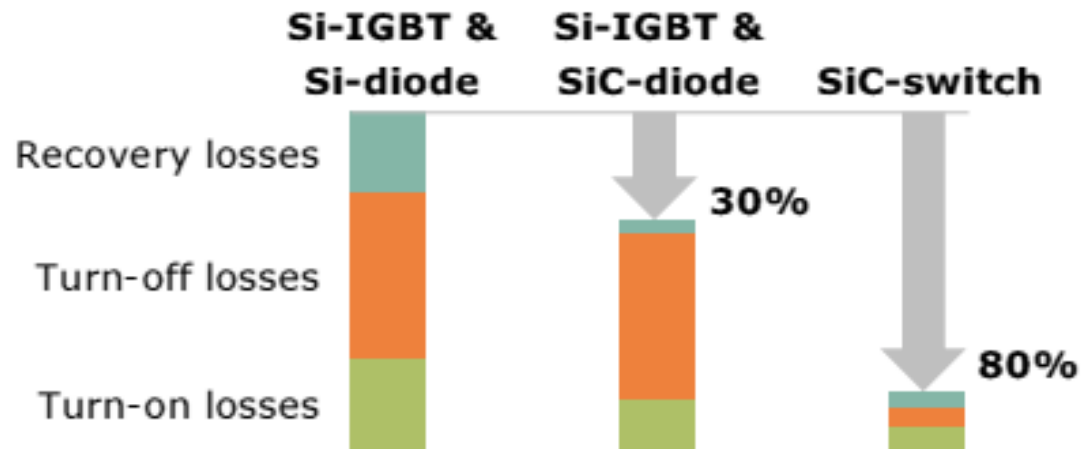


Source: Infineon @PCIM 2017

# System integration and energy savings will be a key lever for power electronics



**best in class  
switching frequency,  
conduction losses  
and radically improved  
efficiency**



Source: Infineon @PCIM 2017

# SiC and GaN on Si will add significant value to a broad variety of systems across many applications



## Industry Drivers



**Photovoltaics**

Reduction of system cost and size



**EV charging**

Faster charging cycles



**eMobility**

Higher reach per charge and smaller systems



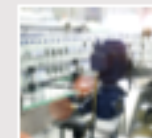
**Traction**

Lower system cost and higher efficiency



**UPS/ SMPS<sup>1</sup>**

Higher efficiency, reducing TCO



**Drives**

System size and TCO reduction

**Time**

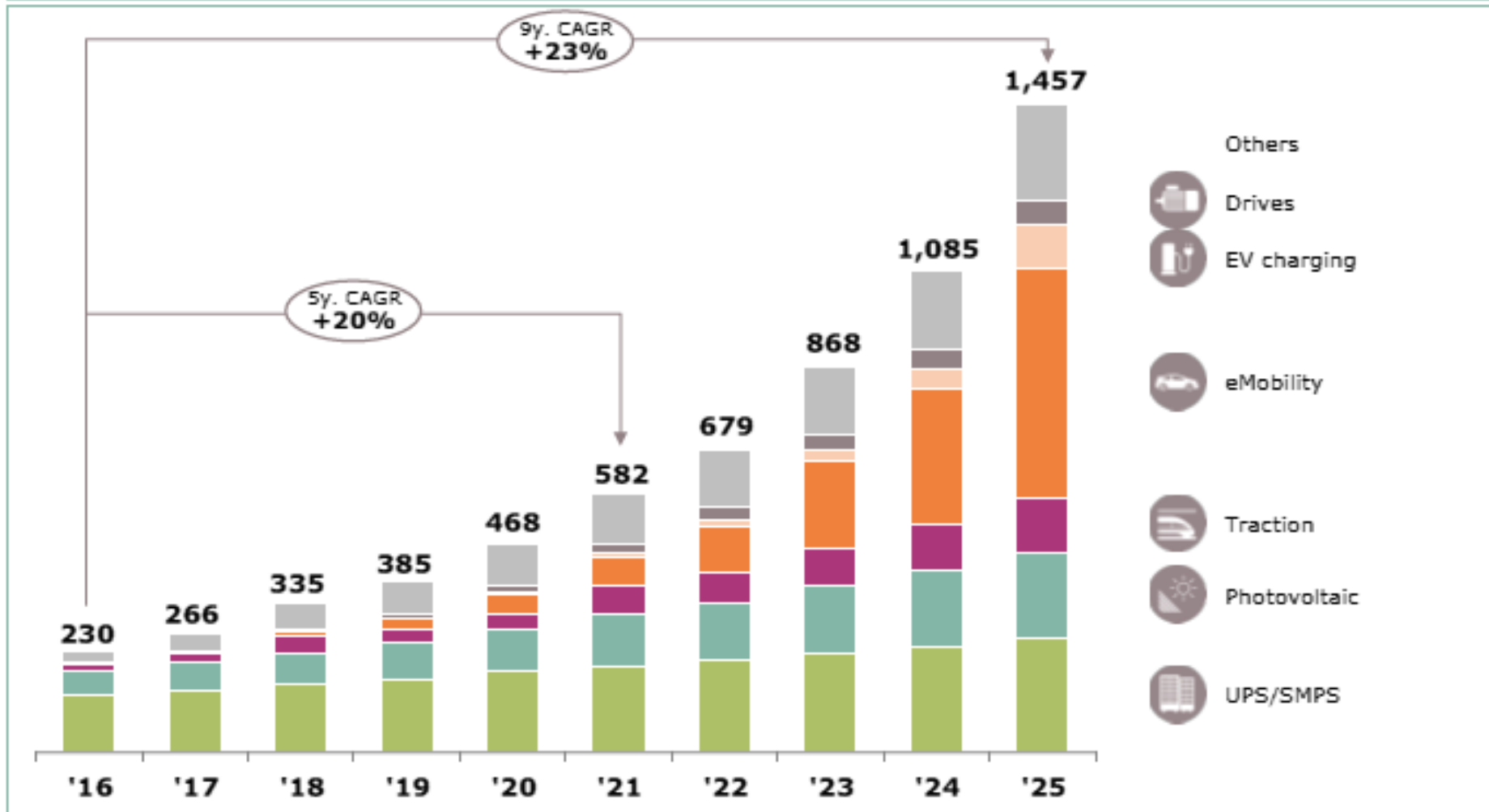
Note: 1) UPS = uninterruptible power supply; SMPS = Switched-mode power supply; TCO = total cost of ownership

Source: Infineon @PCIM 2017



# Over time, more and more applications will adopt SiC solutions

## SiC Power market development [m USD]



Sources: IHS Markit, "World Market for SiC and GaN Power Semiconductors", Feb 2016, Infineon. SiC JFET and SiC BJT not included in market overview

Remark: total power semiconductor market in 2015 \$14,8 bn

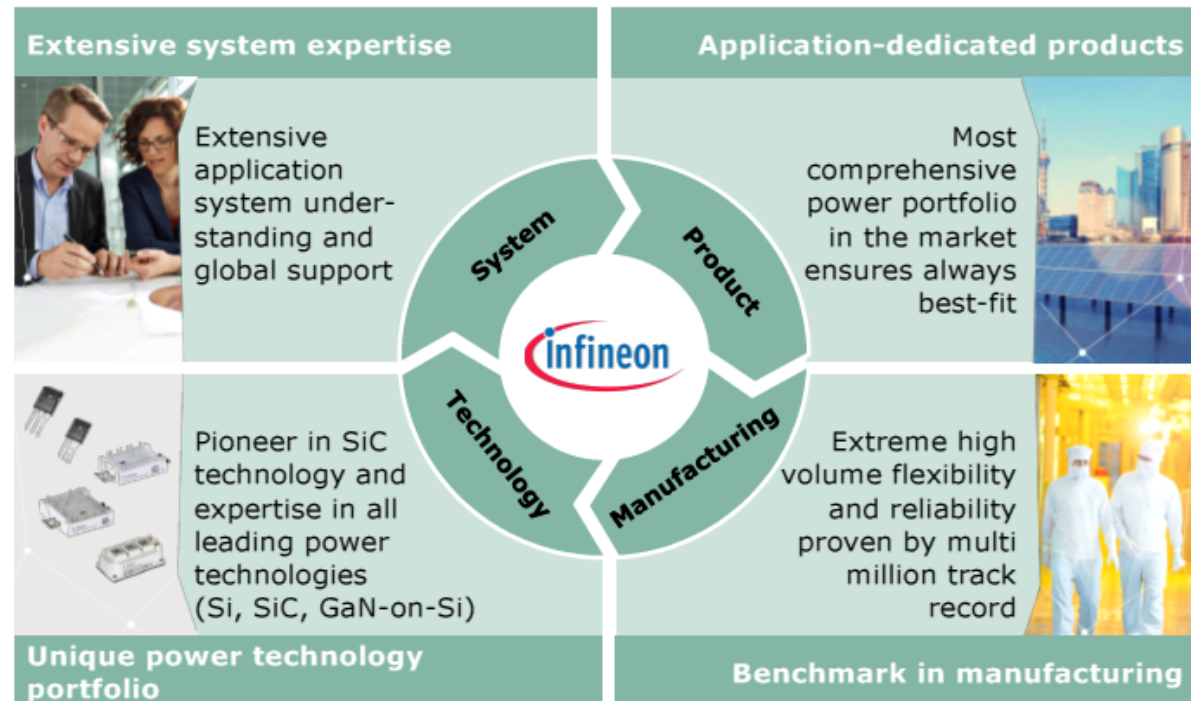
Source: Infineon @PCIM 2017

# EU and national programs – facilitators for speed up of the transition and to be in the driver seat



- › Several research areas with core competencies in Europe!!!!
  - Technologies itself (devices, architectures, ...)
  - Design, verification, validation, reliability
  - Manufacturing - Power semiconductors leading edge technology is in Europe!!!
  - Application – extended system view is key!

- Right side:  
Example Infineon  
Presentation  
at the PCIM 2017:

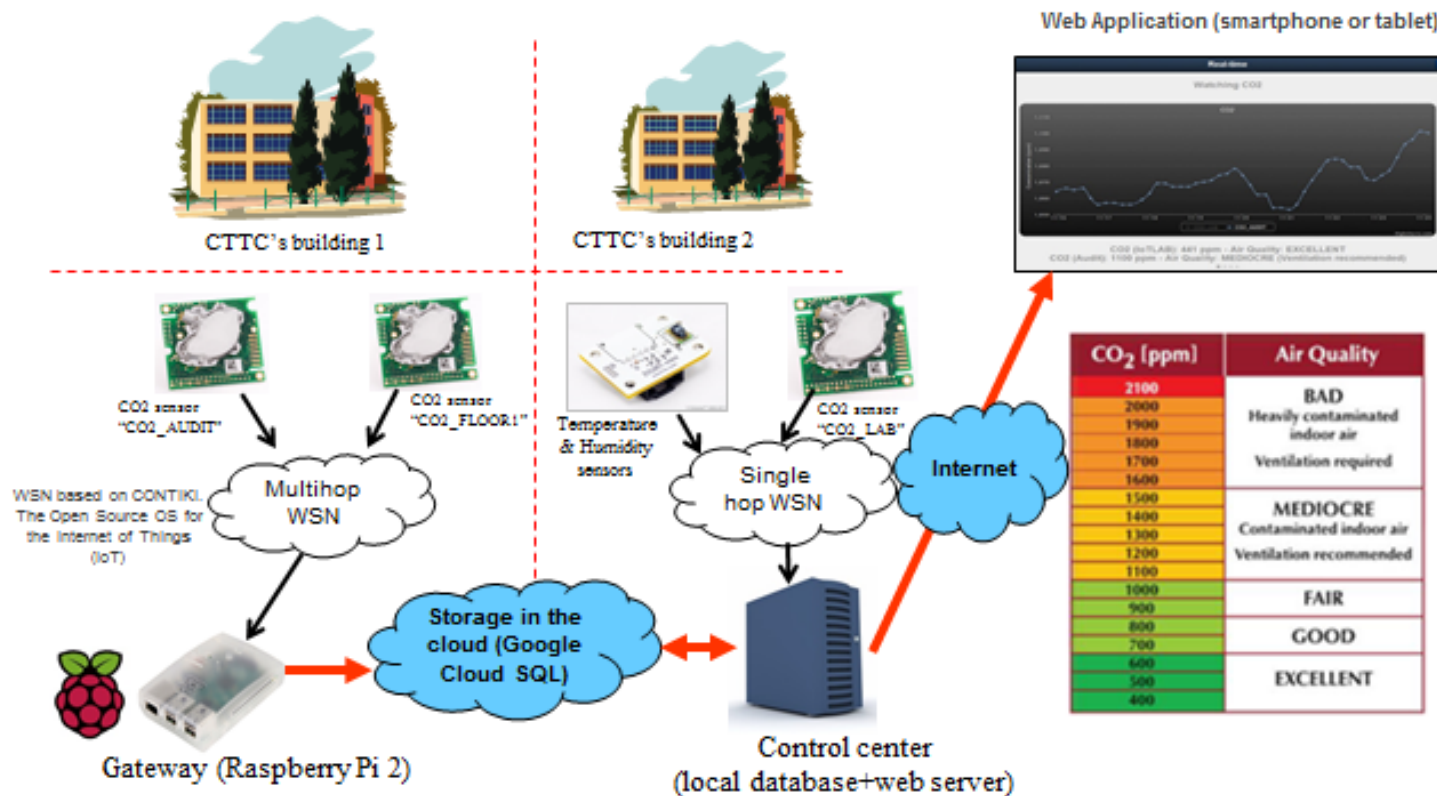


# Example for System Application

## Energy Efficiency in Buildings – ENIAC ESEE project

### ESEE WP4 Sensor Networks

*Air Quality monitoring in buildings based  
on a hybrid and robust multihop WSN  
(IoT testbed)*



# Example for Manufacturing – Project eRamp:

## Excellence in Speed and Reliability for More than Moore Technologies

### Project description / charter:

- Strengthen and enhance European key competencies in power electronics
- Providing a base to come up with innovative solutions to better and faster meet the needs of society
- Innovation in successful European industries depends highly on new electronic components and power electronics in particular → shown by demonstrators
- **R&D on enhanced methodologies for design, reliability and productivity to leverage power pilot lines in Europe**
- Duration: March 2014 – May 2017 (36 +2 months)
- **26 partners** from **6 countries**, total elig. costs 55,2 Mio. €, 70% non-funded, 15% JU, 15% nat.
- **Expert rating** after final review: **EXCELLENT**



# Sense – Act – Control ...

## Preplanned adopted energy use



- › "Total energy efficiency" – extension from the building example to communities....
  - From a single use perspective to connected systems with preplanning and scheduling
  - Need for energy profiles, user profiles, weather forecasts, traffic, ....
- › Microelectronic for Power to „electrical or other energy forms“ (P2X)
  - Microelectronics as key for efficiency increase
  - extension from the pure Power to Power application as in AC-DC or DC-DC converters
- › Microelectronic for Emission less cities support infrastructure
  - Transition of all infrastructure vehicles to electric drives (CAV - commercial construction and agricultural vehicles, e.g. buses, city trucks, cleaning trucks, waste trucks, ...)





Part of your life. Part of tomorrow.

