

Energy & Microelectronics

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Infineon Technologies AG

Brussels, September 4th, 2017

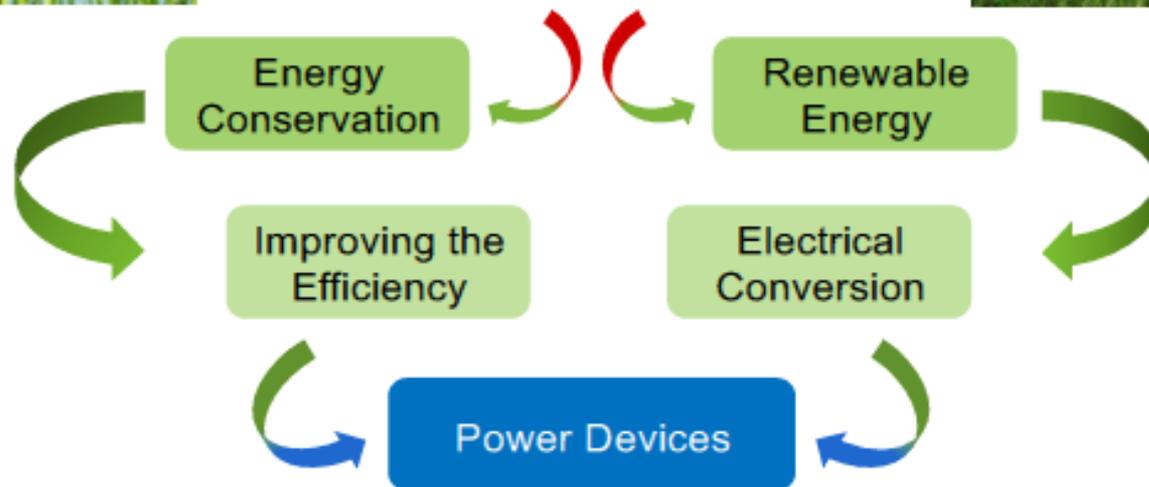
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The Story: Energy & Power Devices...



Global Warming

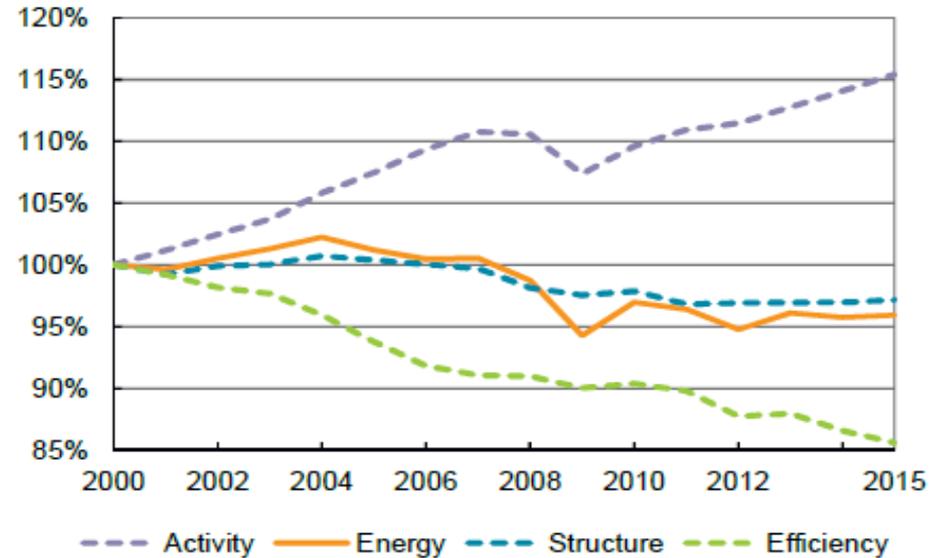
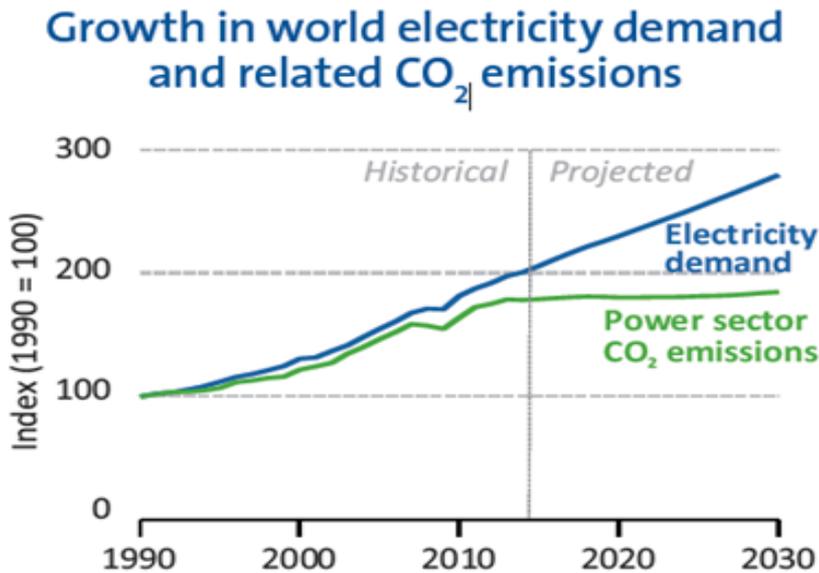


At least 50 % of the electricity used in the world is controlled by Power Devices.

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.

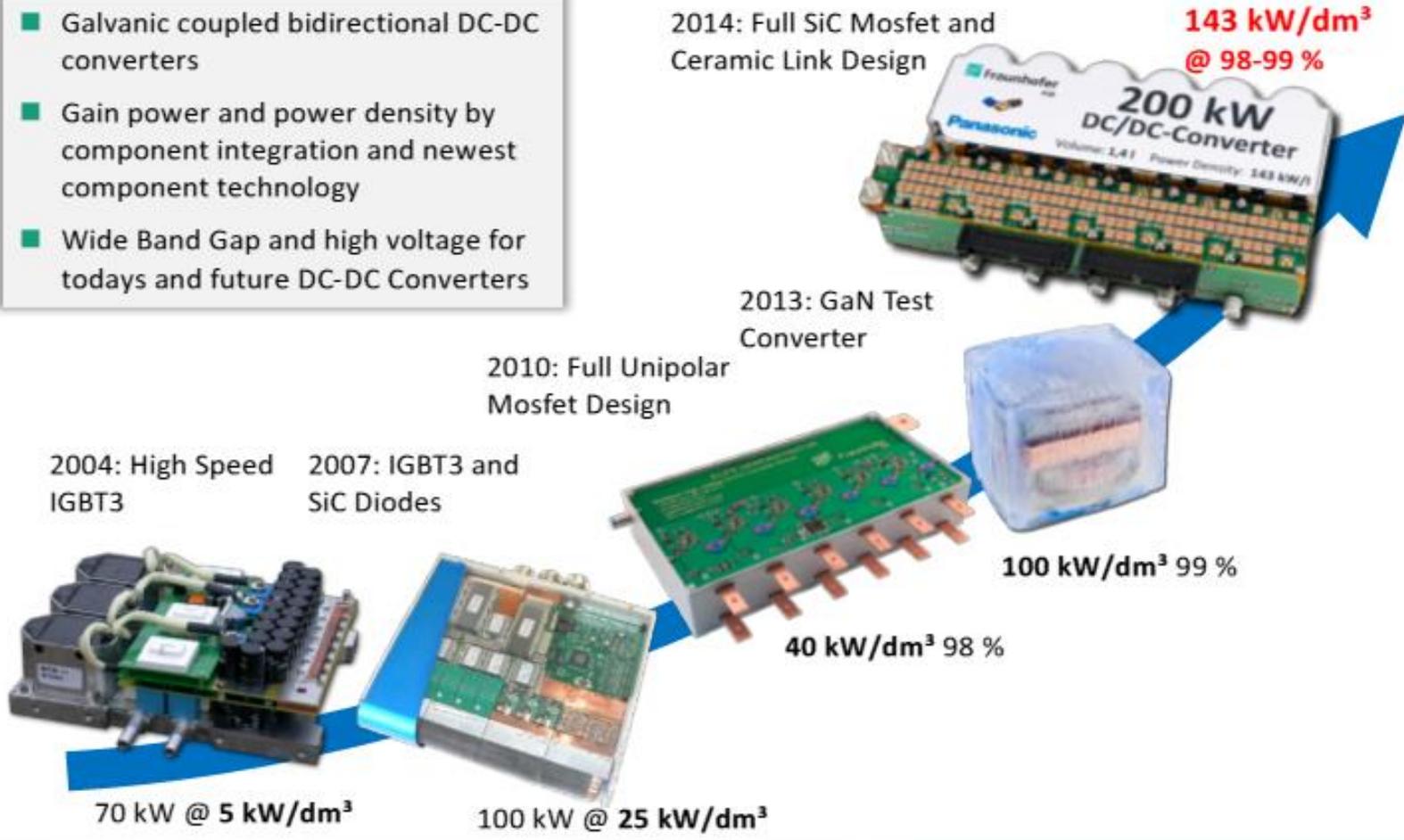
- › According to the IEA the decomposition analysis of **factors driving energy consumption trends for IEA member countries indicates that in the IEA the decoupling was mainly due to efficiency improvements** (figure right above). Structural changes (mostly shift to less intensive industries and services) 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

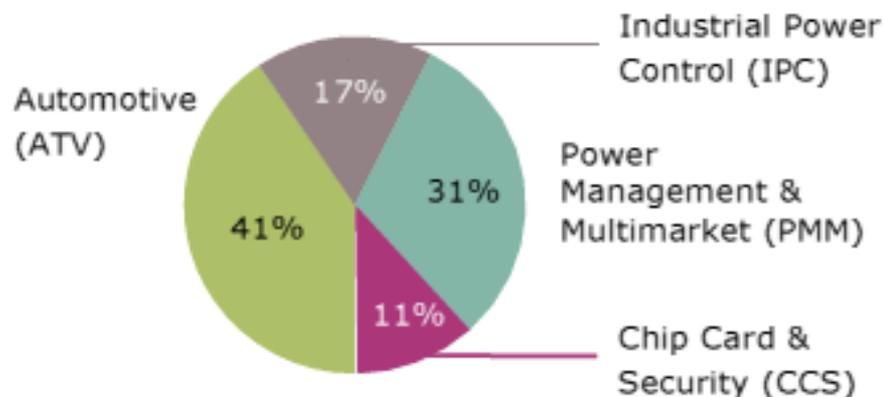
- Galvanic coupled bidirectional DC-DC converters
- Gain power and power density by component integration and newest component technology
- Wide Band Gap and high voltage for todays and future DC-DC Converters



Infineon at a glance (source Q3 report)



Business Segments



Revenue FY 2016

Employees

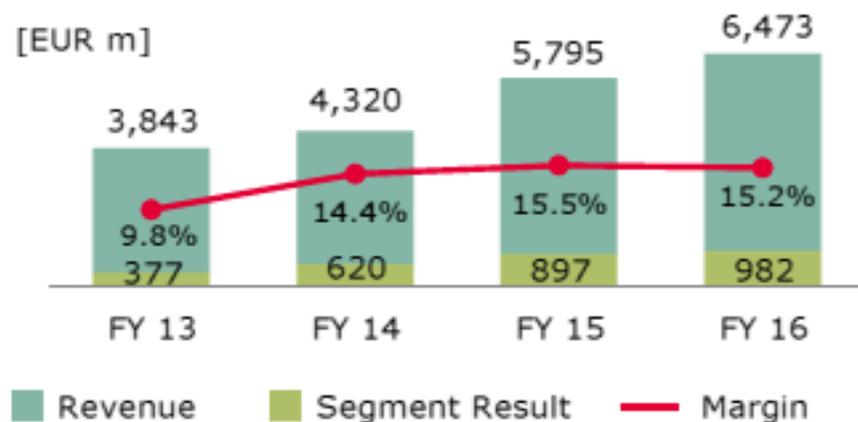
More than **36,000** employees worldwide
(as of Sep. 2016)



34 R&D locations
19 manufacturing locations

Financials

[EUR m]



Market Position

Automotive



2

Strategy Analytics,
April 2017

Power



1

IHS Markit,
Technology Group,
October 2016

Smart card ICs



1

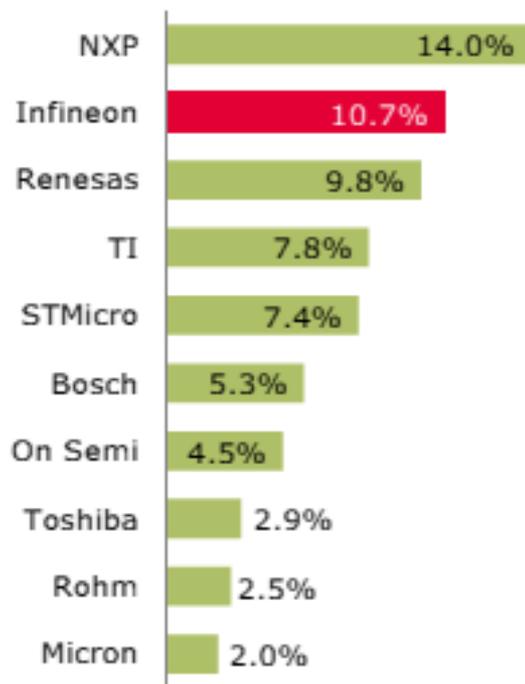
IHS Markit,
Technology Group,
July 2017

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



Automotive semiconductors

total market in CY 2016:
\$30.2bn

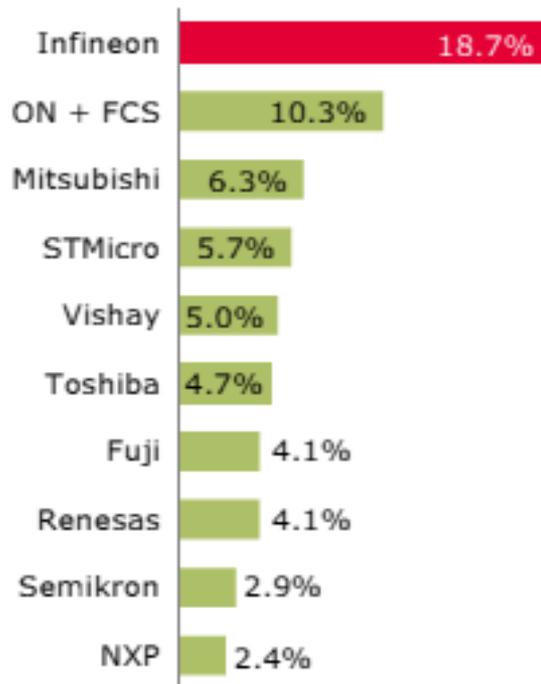


Automotive semiconductors incl. semiconductor sensors

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

Power semiconductors

total market in CY 2015:
\$14.8bn

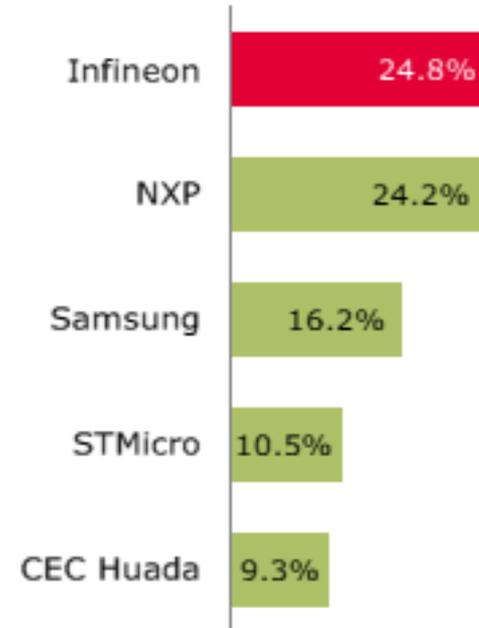


Discrete power semiconductors and power modules

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

Smart card ICs

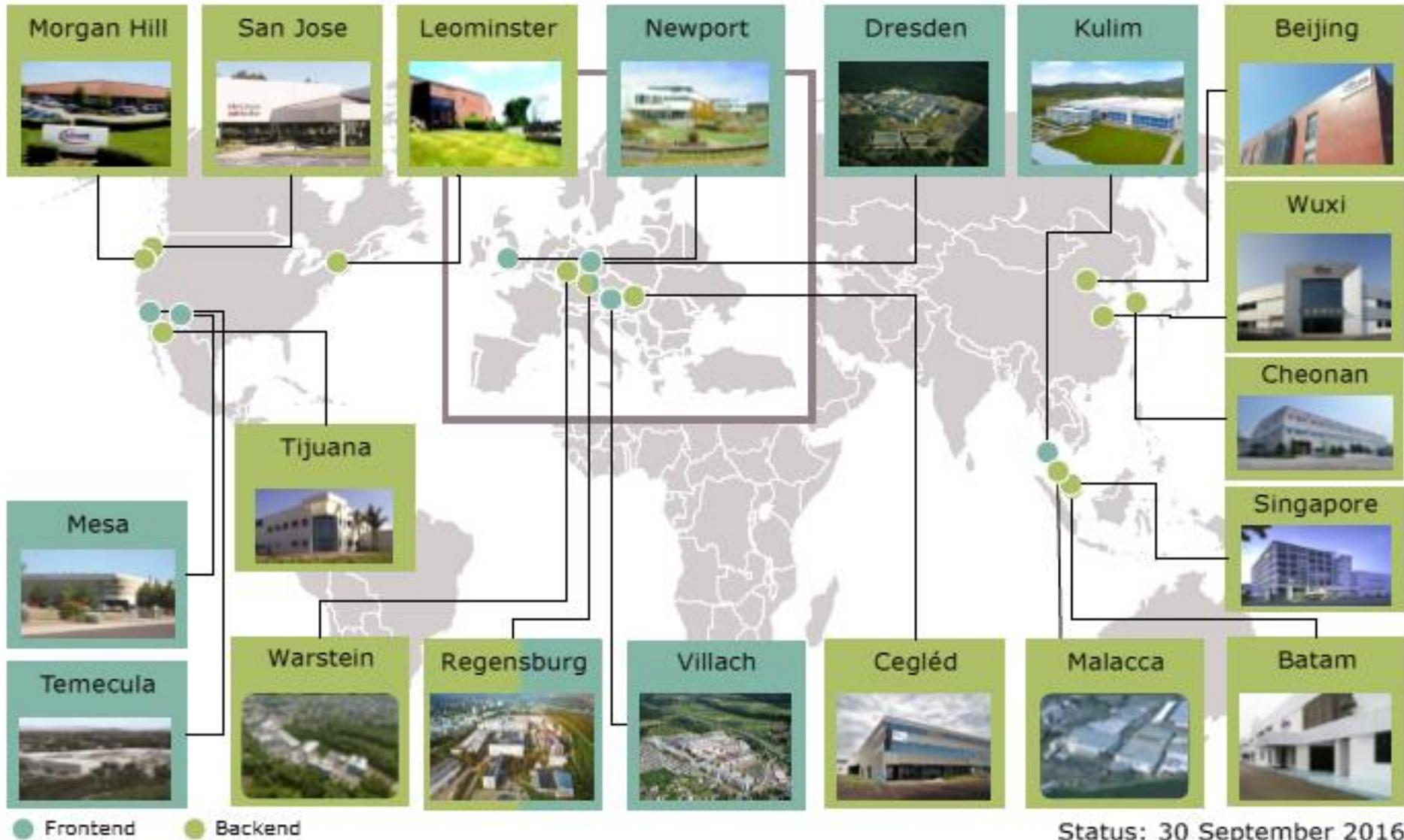
total market in CY 2016:
\$2.79bn



Microcontroller-based smart card ICs

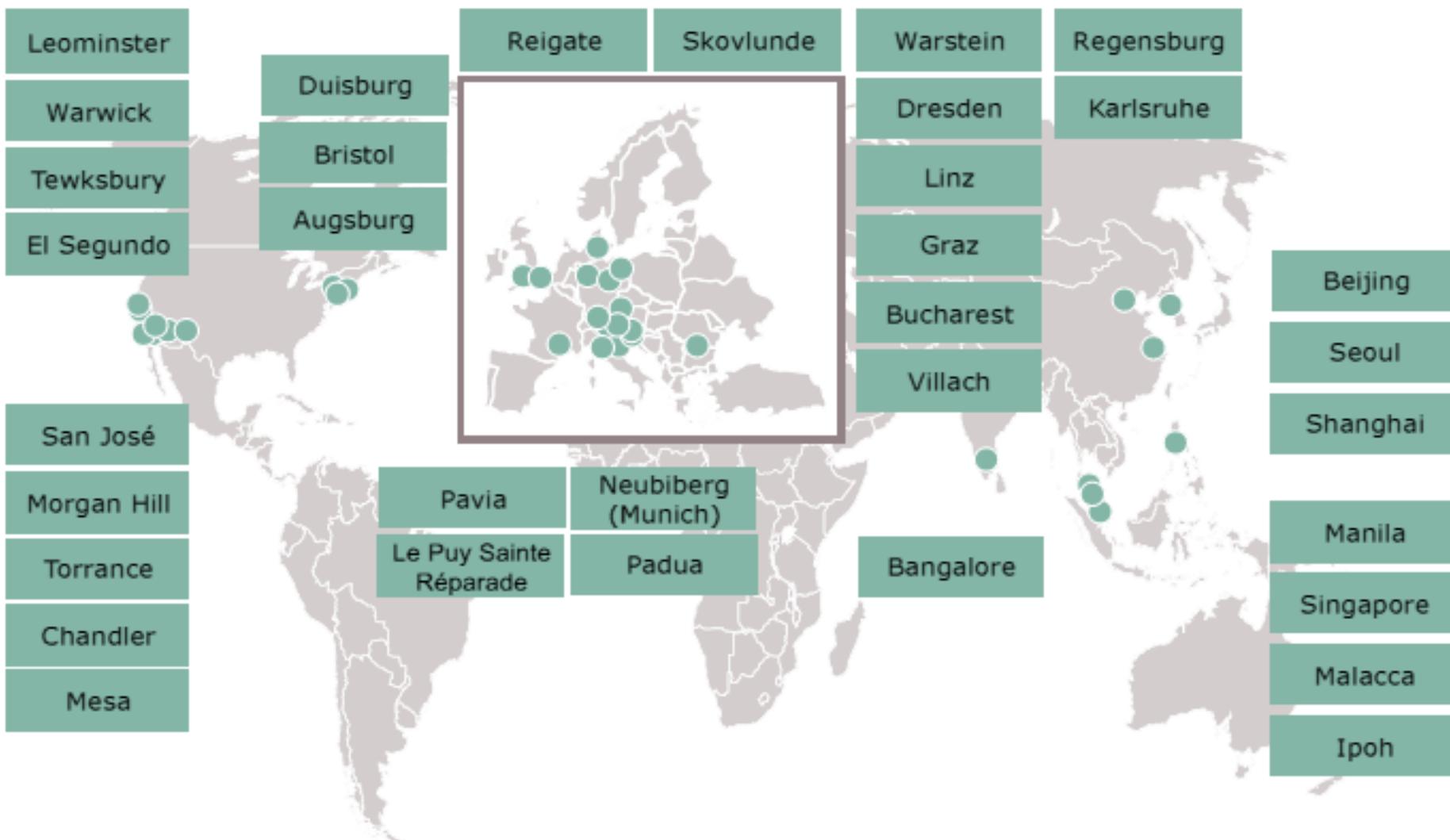
Source: IHS Markit, Technology Group, "Smart Cards Semiconductors Report", July 2017

Infineon – Worldwide Manufacturing Sides



Status: 30 September 2016

Infineon – Worldwide R&D network



Status: 30 September 2016

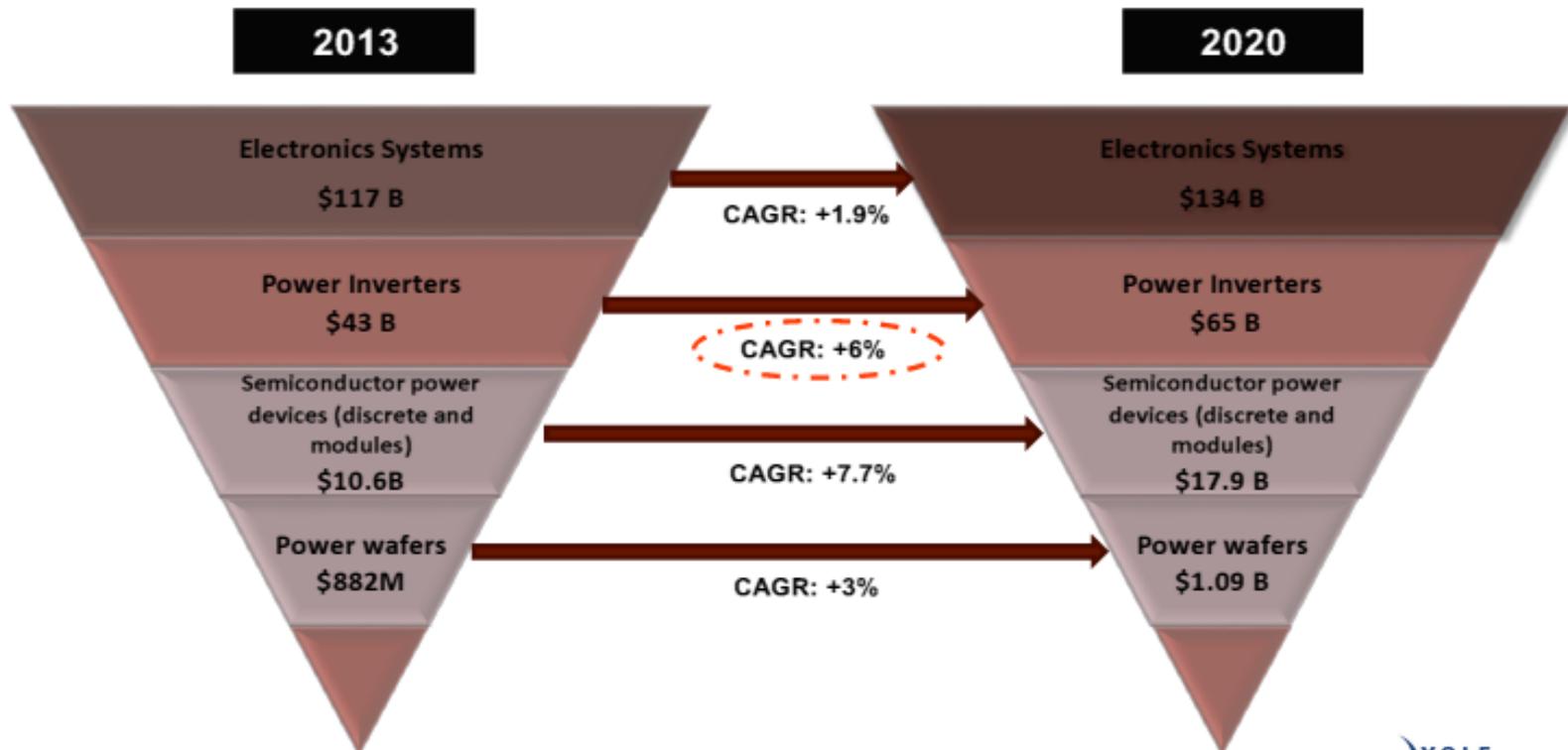
The impact of power electronics – example inverters – source Yole report



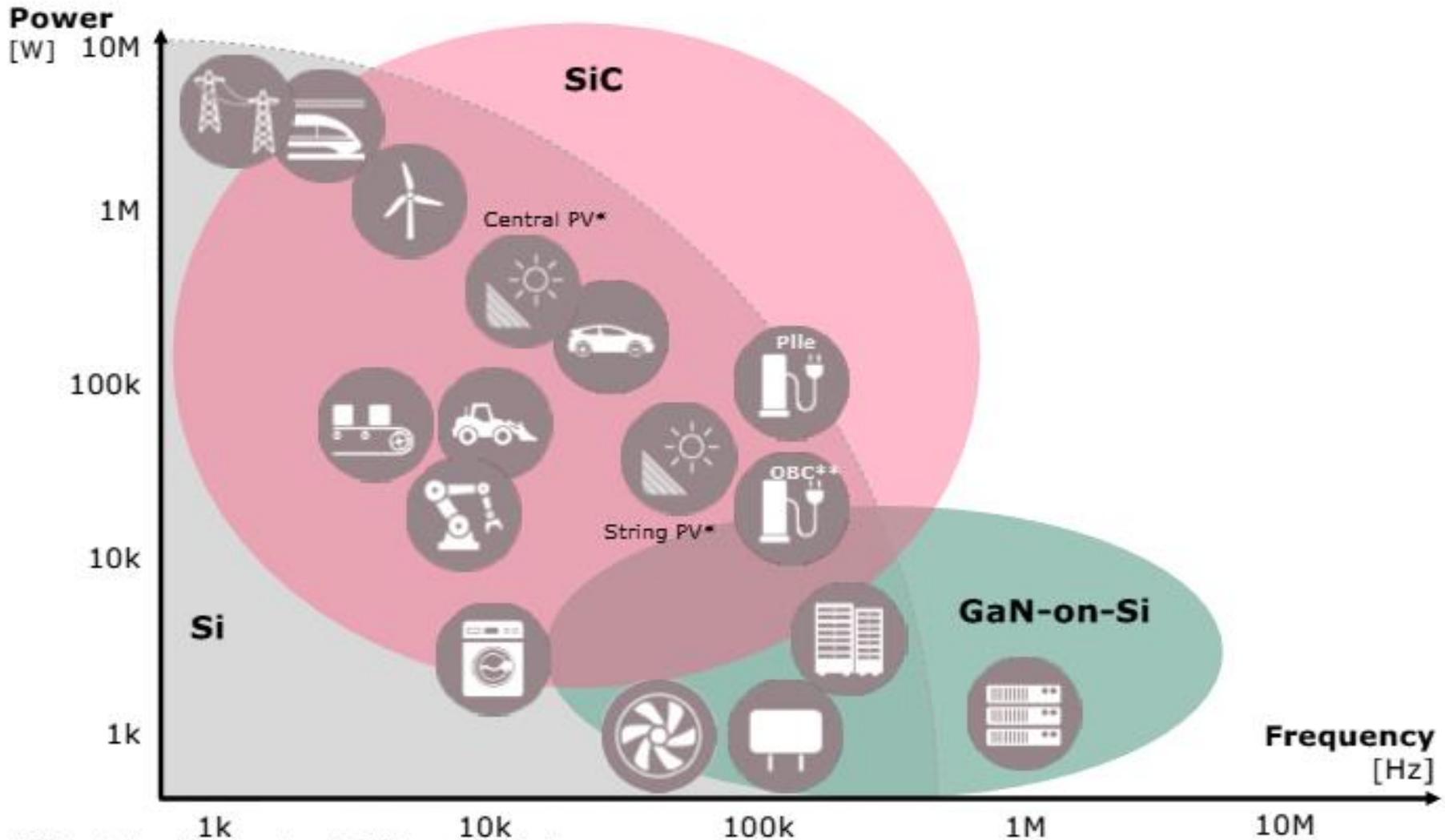
Overall Power Electronics markets

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



* PV - photovoltaic inverter; ** OBC - onboard charger

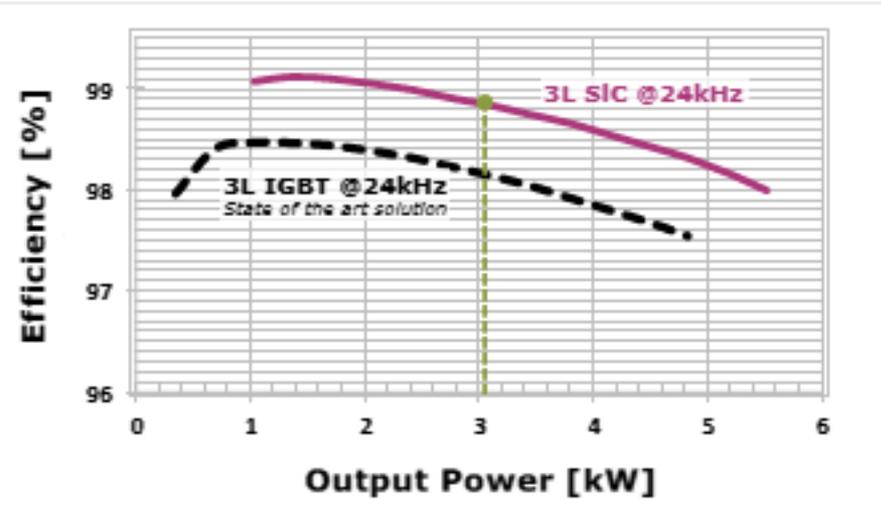
Source: Infineon @PCIM 2017

SiC MOSFET: higher conversion efficiency allows improvement of system costs

Higher conversion efficiency

Lower conduction and switching losses lead to

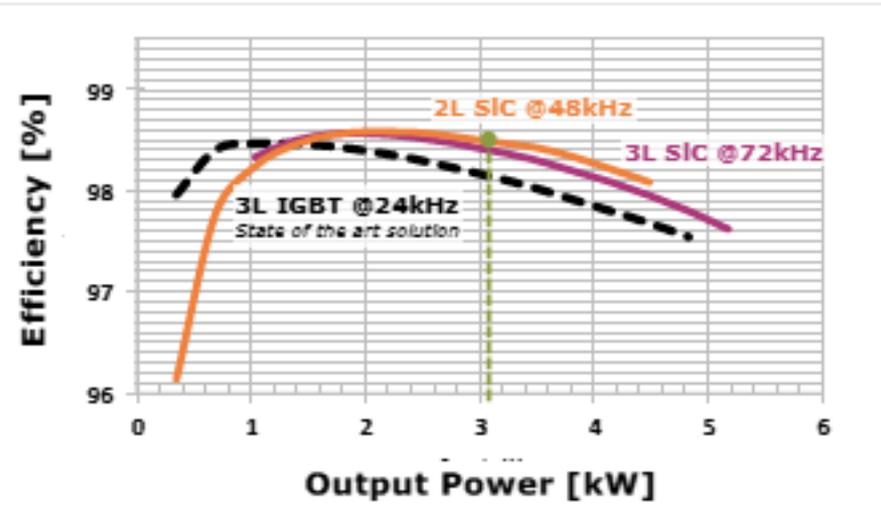
- › Higher conversion efficiency at same switching frequency
- › Higher output power for a given frame size



Effect on system costs

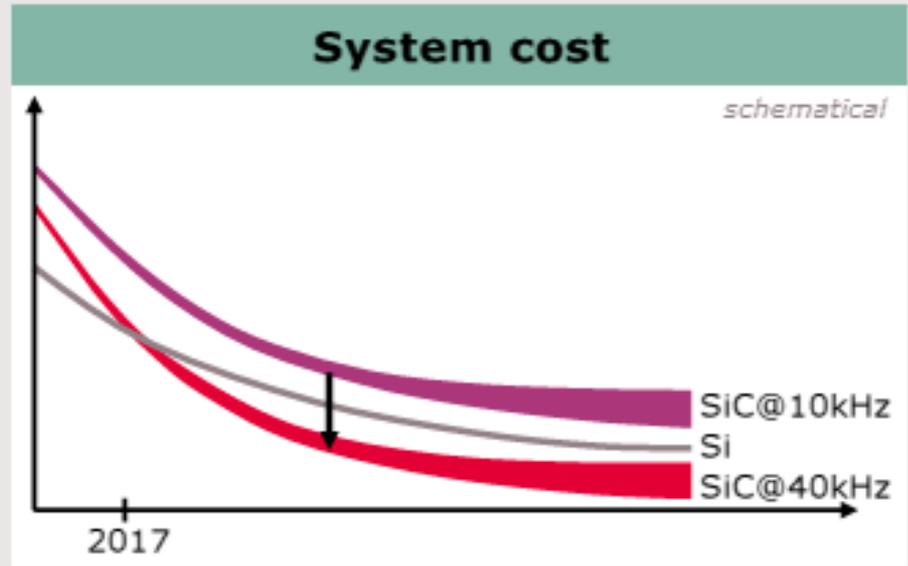
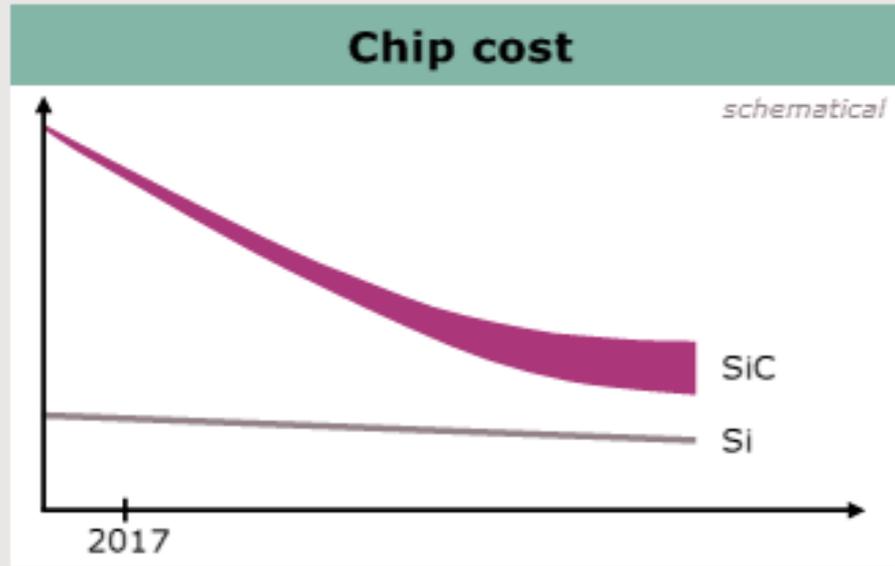
SiC devices enable

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



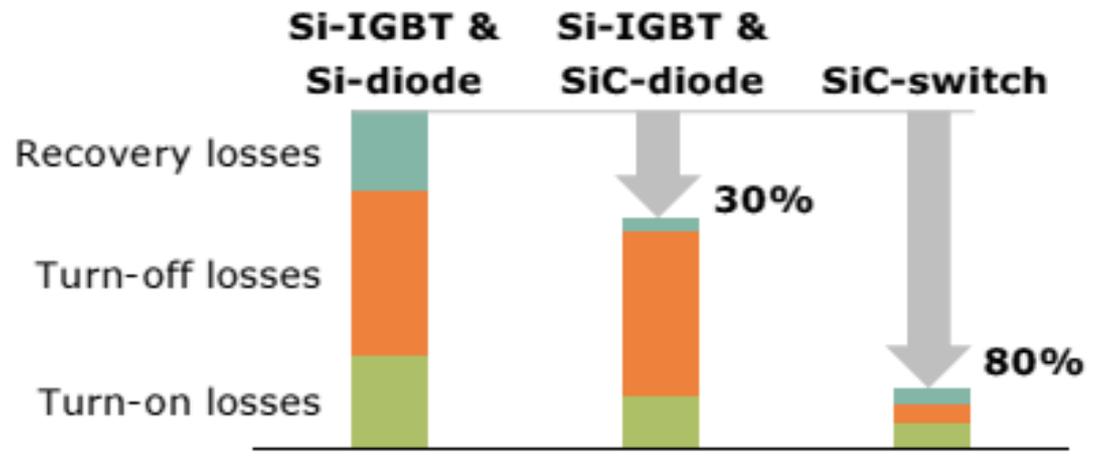
Source: Infineon @PCIM 2017

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



Cool SiC

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



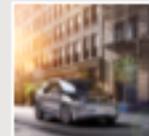
Reduction of system cost and size

Photovoltaics



Faster charging cycles

EV charging



Higher reach per charge and smaller systems

eMobility



Lower system cost and higher efficiency

Traction



Higher efficiency, reducing TCO

UPS/ SMPS¹



System size and TCO reduction

Drives

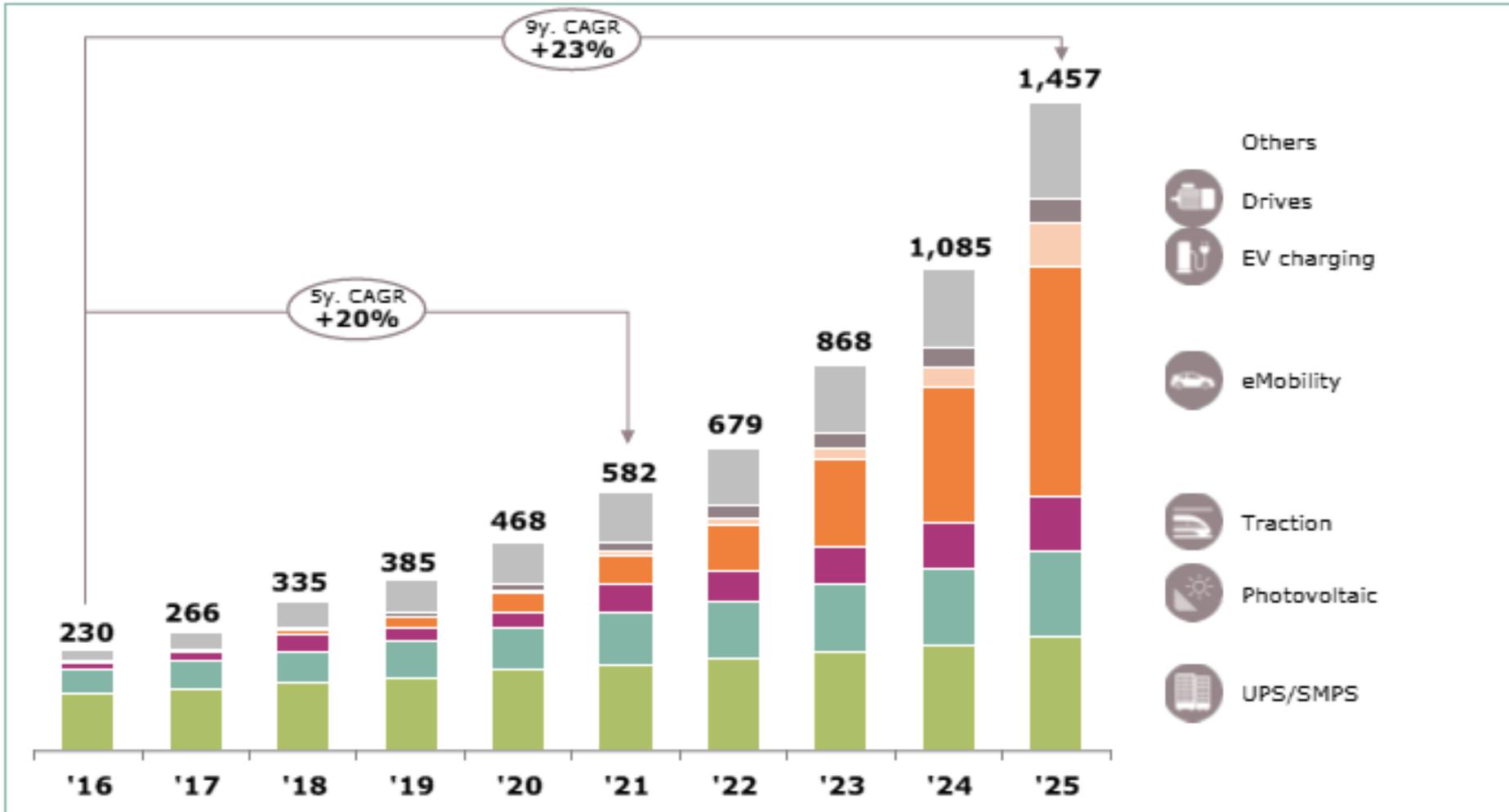
Time

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

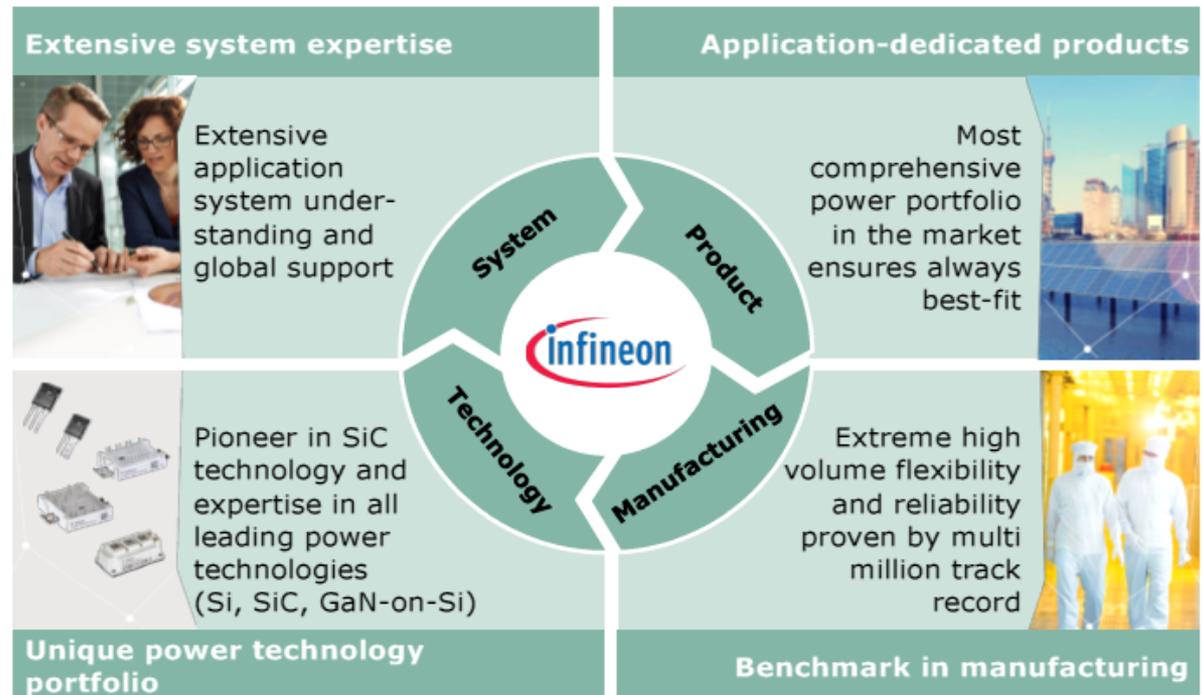
Source: Infineon @PCIM 2017

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:

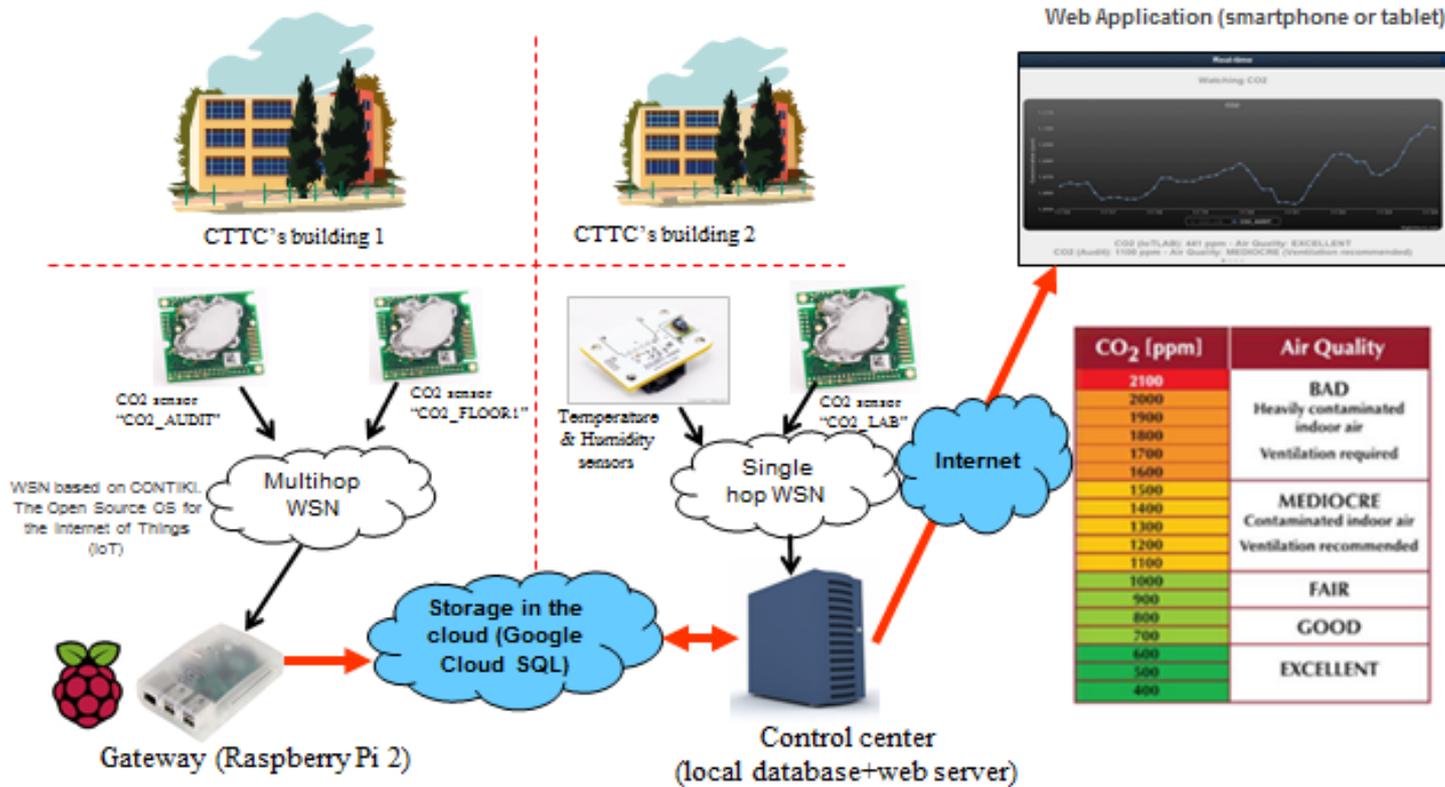


Example for System Application

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**



- › "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.

