

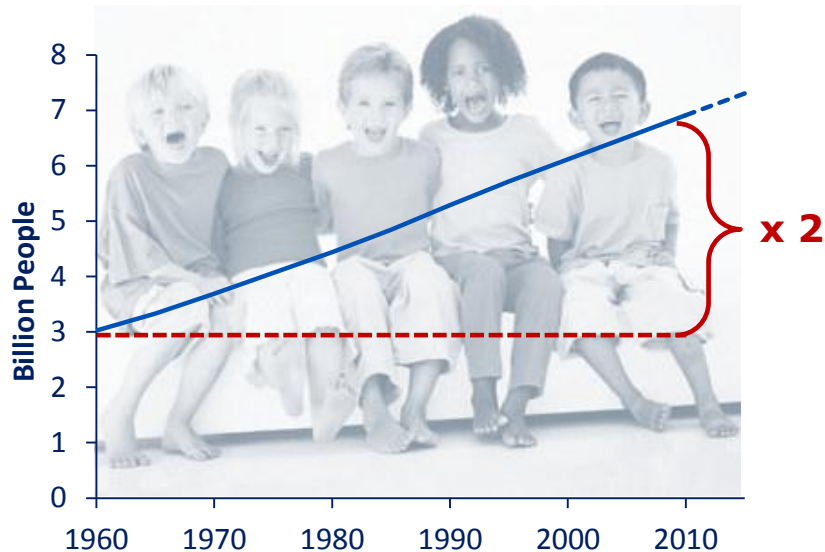
Semiconductors: Key Enablers For a More Efficient Future

Peter Bauer, CEO Infineon Technologies AG
IEEE Technology Time Machine



Growing Population and Increase in Wealth Continue to Drive Consumption ...

World population 1960-2010



Gross world product 1960-2010

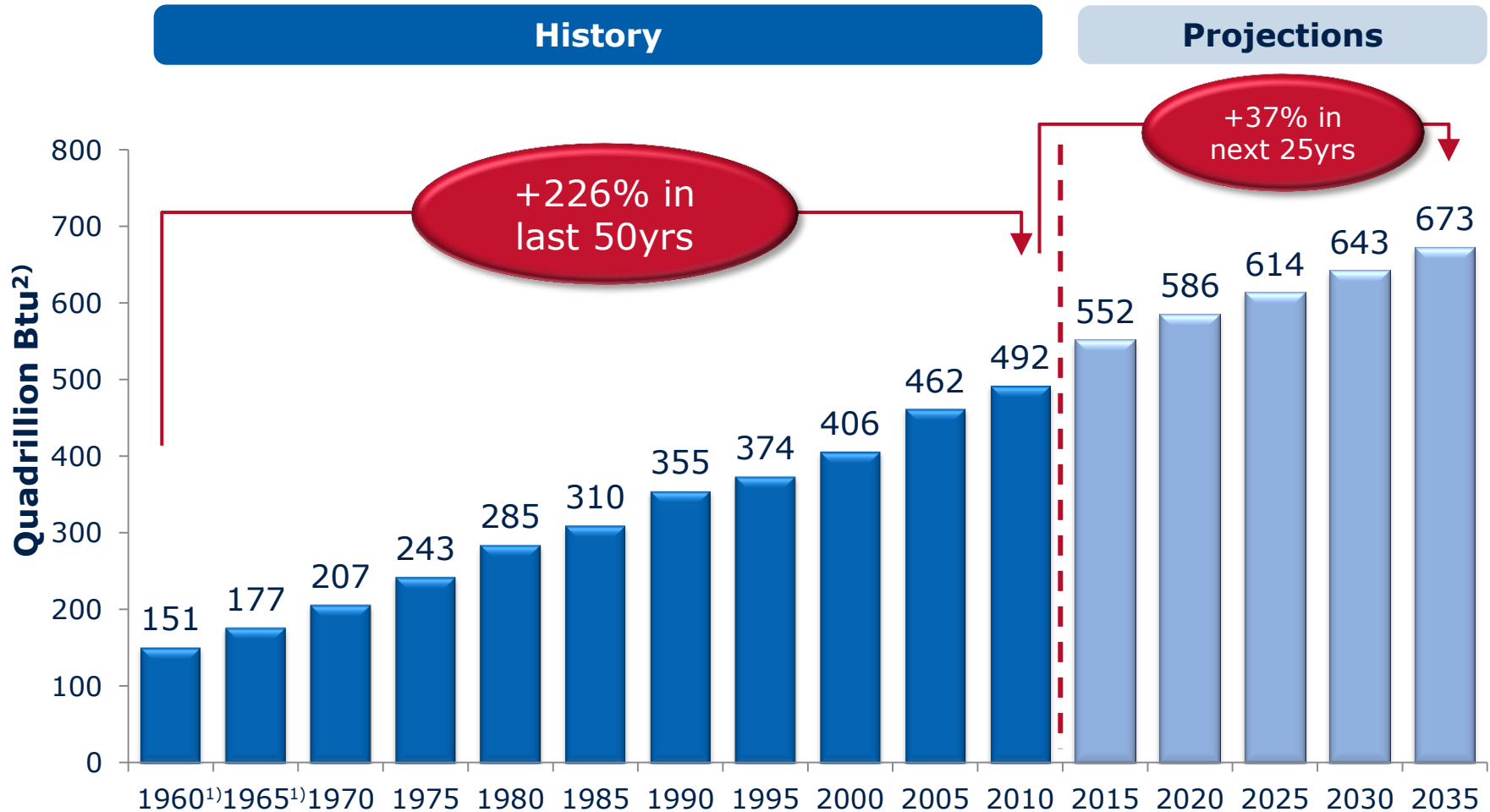


Source: UN Data, IMF, Worldbank

Gross World Product = the sum of all finished goods & services produced globally

... And Demand For Energy!

World energy consumption, 1960-2035



Sources: Energy Information Administration (EIA), International Energy Outlook 2005, 2011

1) Infineon estimates based on EIA 2005

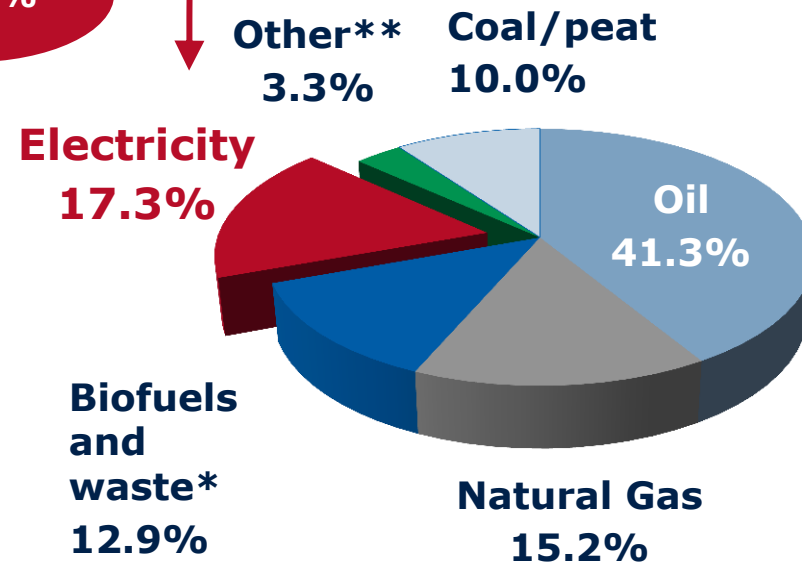
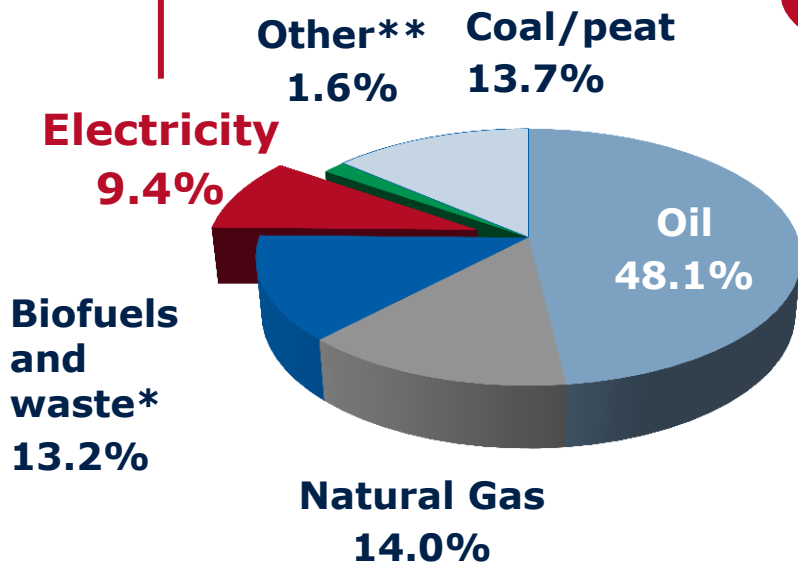
2) British thermal unit (Btu): 1 Btu = 1.05506 kJ

Energy Consumption – Electricity more than tripled since 1973

1973

2009

+228%



4,674 Mtoe***

8,353 Mtoe***

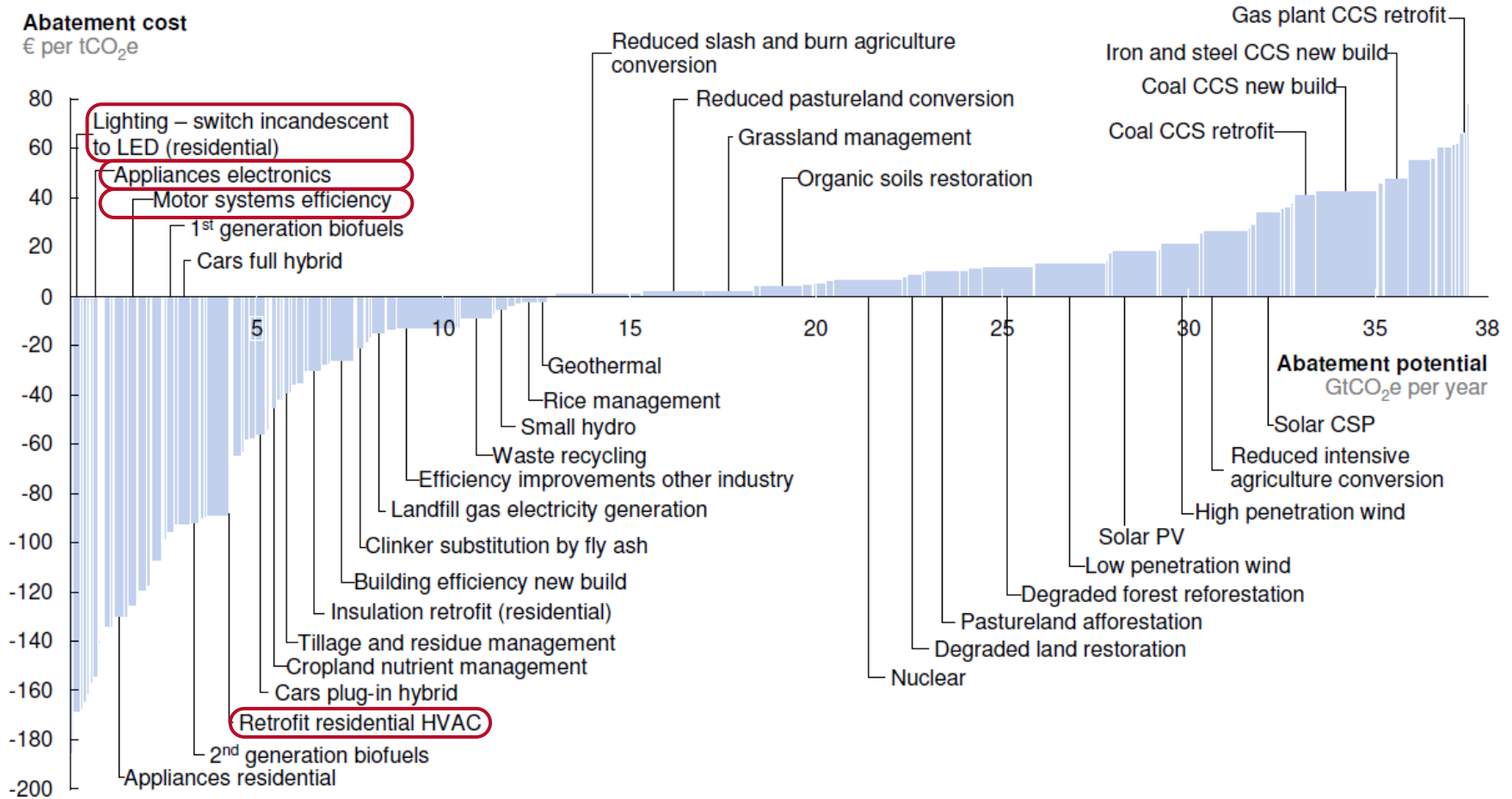
* Data prior to 1994 for biofuels and waste final consumption have been estimated.

** Other includes geothermal, solar, wind, heat, etc.

*** Mtoe means Million Tons Oil Equivalent

Source: IEA, Key World Energy Statistics 2011, P. 30, Total Final Consumption

Global GHG Abatement Cost Curve Beyond BAU - 2030



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO₂e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: McKinsey Global GHG Abatement Cost Curve v2.1

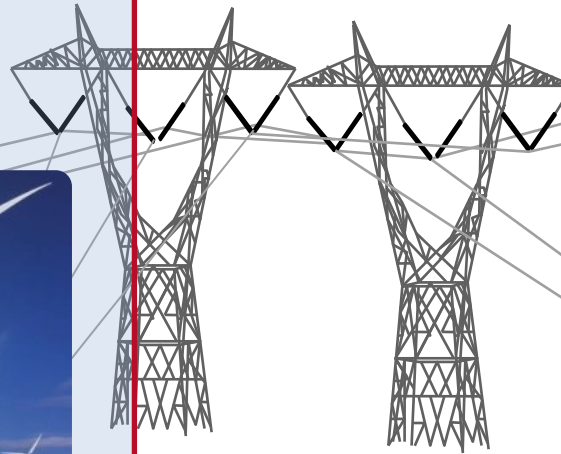
Semiconductors Play an Important Role in the Whole Electrical Energy Supply Chain

Energy Supply Chain

Energy Generation



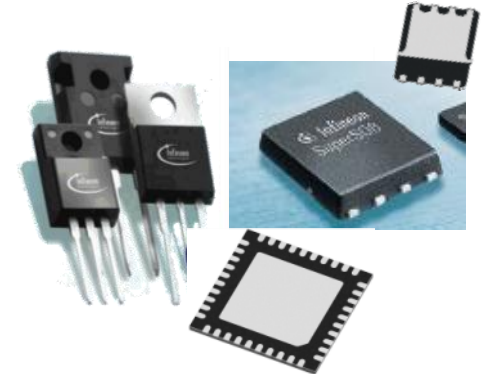
Energy Transmission



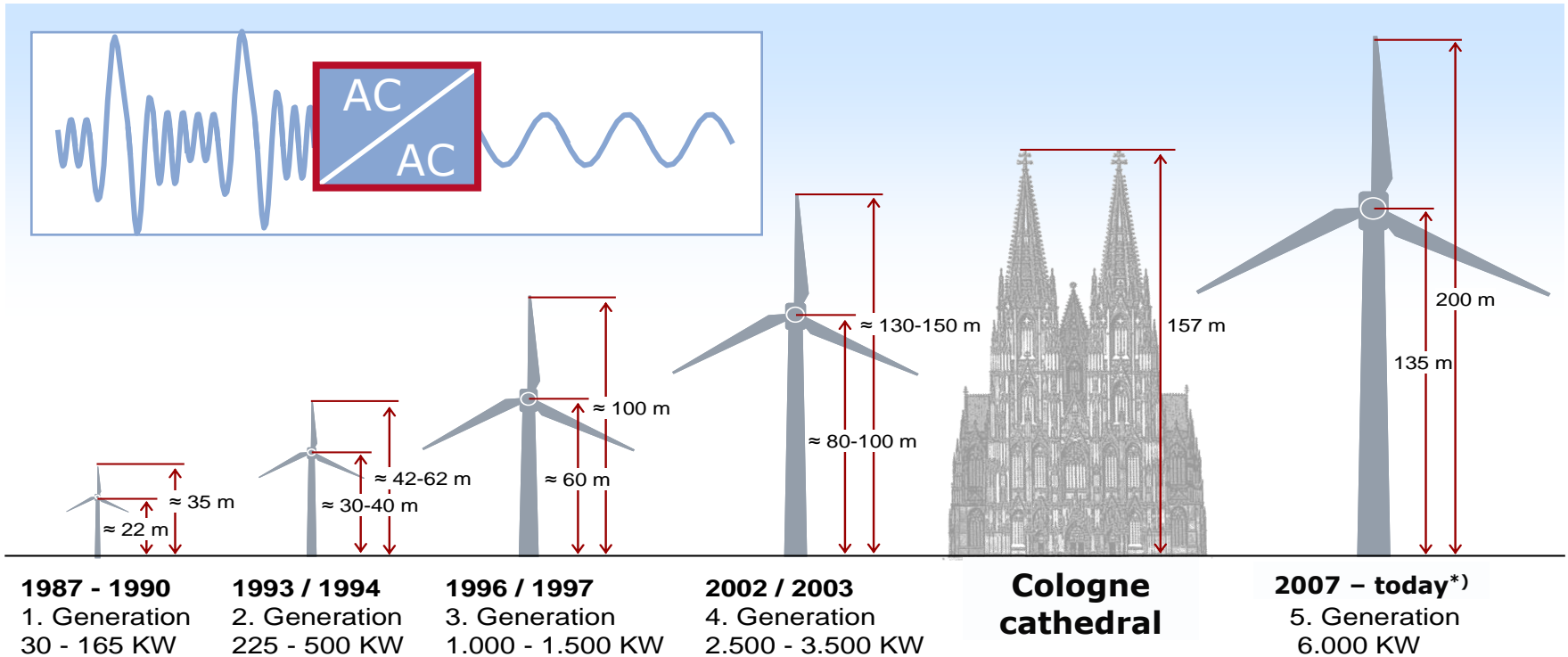
Energy Consumption



Semiconductors / Systems



As consciousness on renewable energy grows, so do the windmills & their output power!



BARD Offshore 1 (Germany's first off-shore wind park)

- Location: 90 km northwest of Borkum, North Sea, Germany
- Key data:
 - 80 wind turbines of 5 MW each
 - 400 MW total power generation
 - first turbines connected to the grid in Dec 2010
- Components: Power Modul IHM 1700V



*) Source: Siemens Renewable Energy Division, 2009

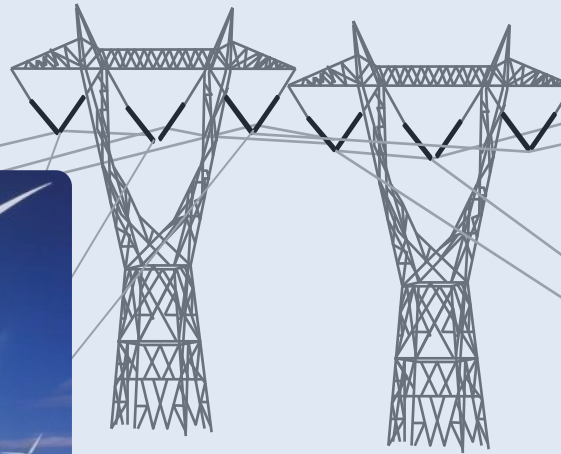
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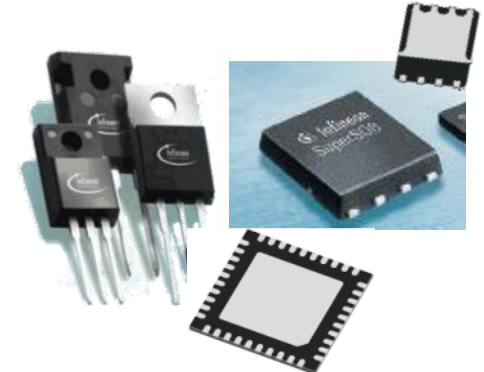
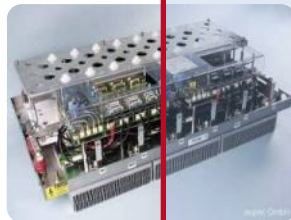
Energy Transmission



Energy Consumption

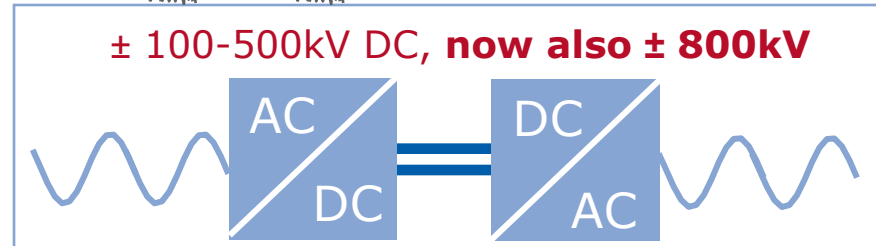


Power SC & Modules



The World's First UHVDC Transmission Line Went Into Full Operation Recently

HVDC Transmission: Efficient Grid coupling and energy transport



800kV HVDC line has been put into full operation in China:

- the Yunnan-Guangdong HVDC transmission system covers a distance of **>1400 km** with losses of $\sim 2\%$ per 1000 km
- transmission capacity is **5000 MW** produced by several hydro power plants
- reduction of annual CO_2 emissions by **>30 megatons** compared with equivalent fossil-fueled power plants

HVDC = High Voltage Direct Current

Source: Siemens Renewable Energy Division, 2009

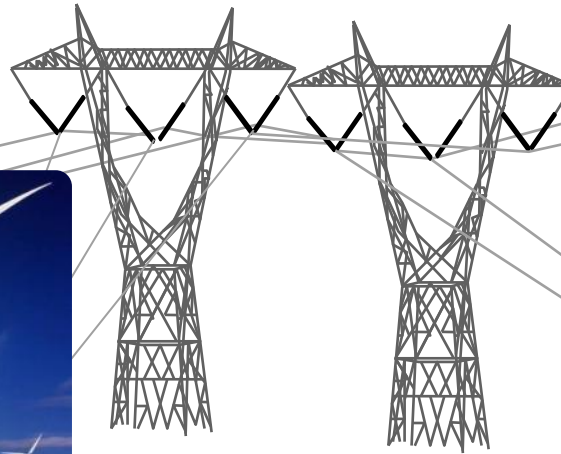
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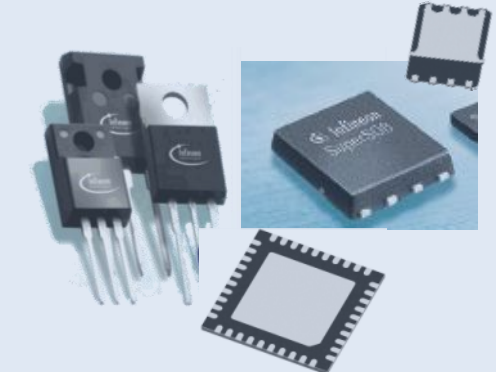
Energy Transmission



Energy Consumption

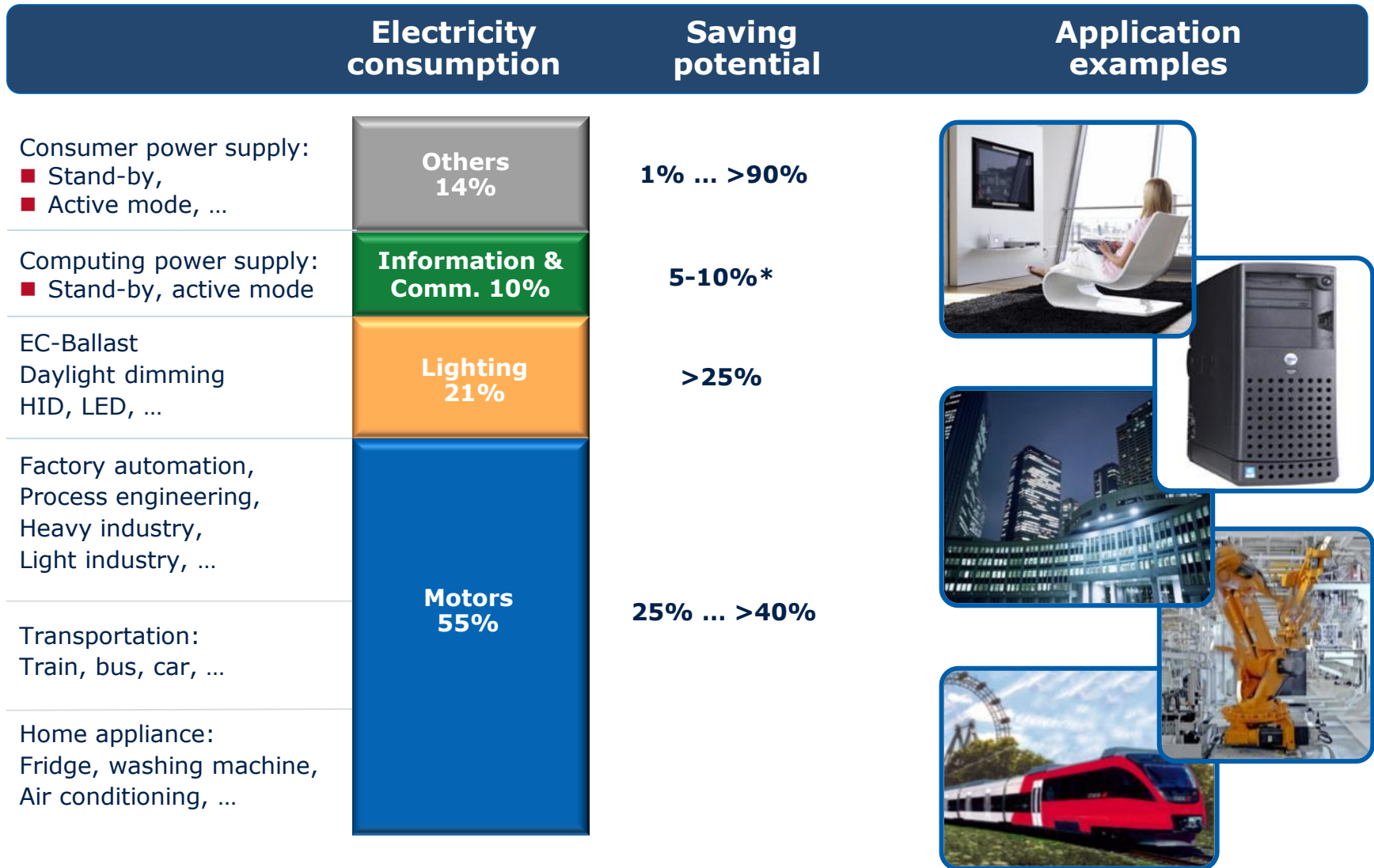


Power SC & Modules



In the Consumption Arena, Significant Savings are Possible Today!

Consumers electrical energy (ww)



Sources: ZVEI, Infineon, 2008 * Basis: "80 PLUS" Initiative

More (than) Moore: Examples

"More Moore"

vs.

"More than Moore"

Focus on scaling
digital performance

Focus on enhancing
power, analog / mixed
signal performance



Intel® Core™ i7 Processor*

- 32 nm node
- 2.3 bn transistors

Infineon EconoDual™ 3 power module

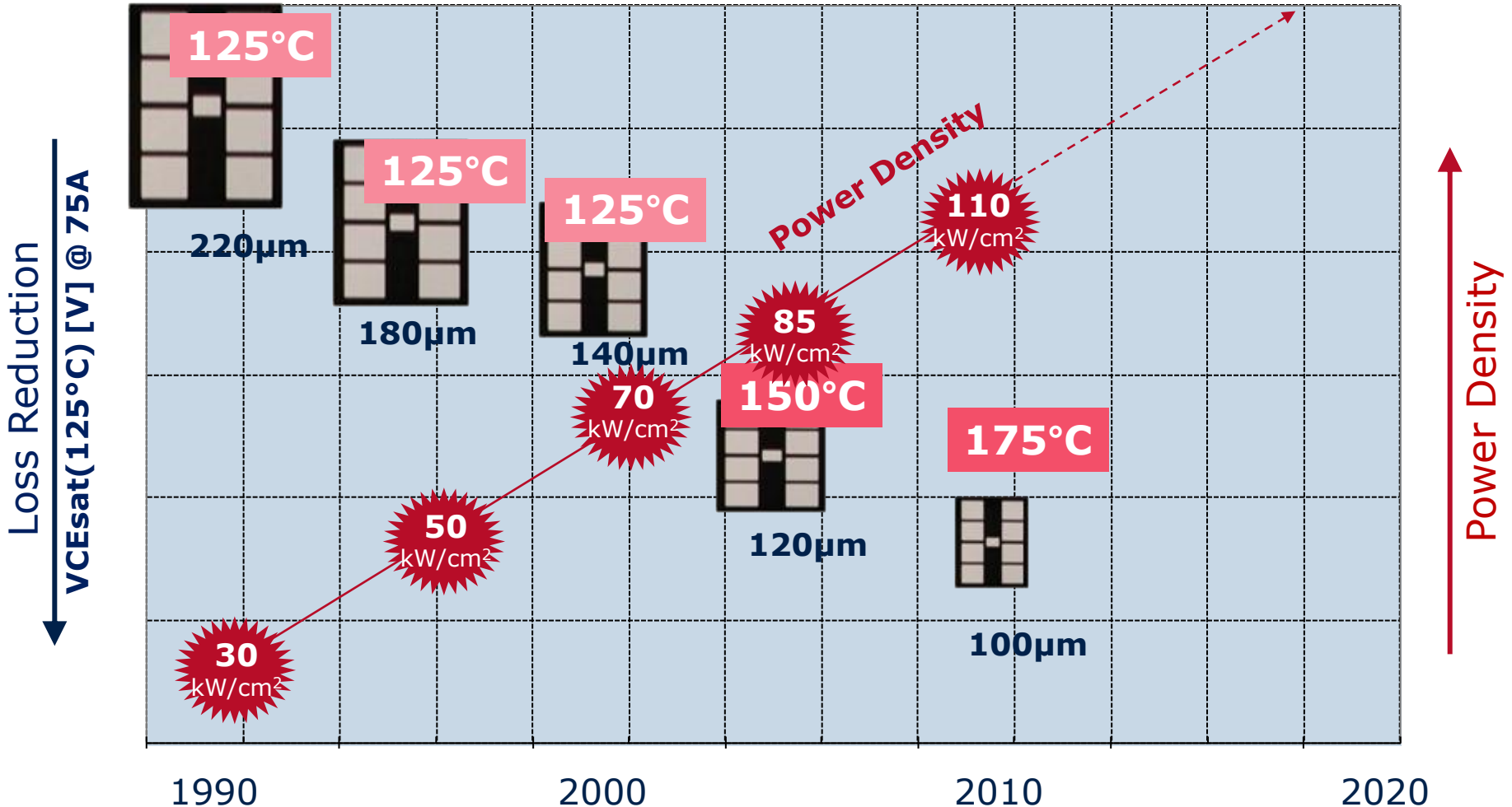
- 140 μm chip thickness
- 2 switches, each with x4 IGBT chips
- ≤500 kW power / 107 kW/cm² power density

*Source:http://en.wikipedia.org/wiki/Transistor_count (Intel Core i7: six-core Sandy Bridge-E variant)

Where do we go from here?

"Infineon's Law": Double Power Density Every 10 Years!

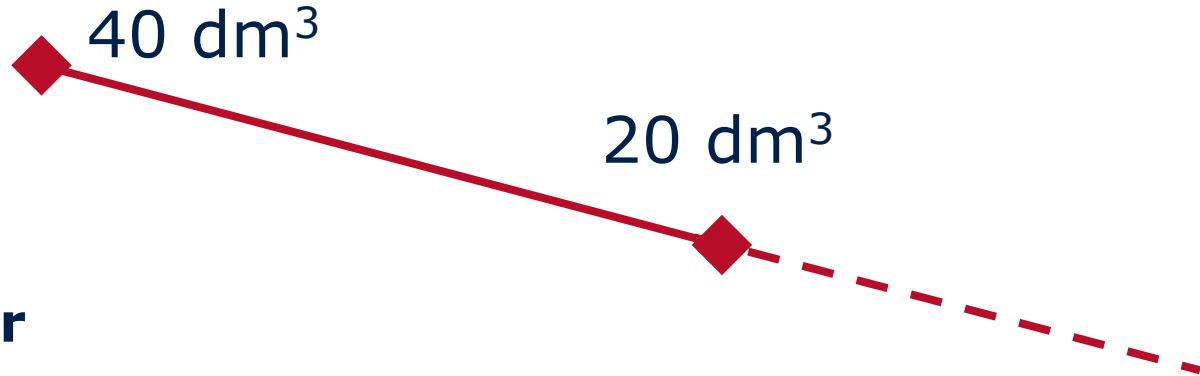
Development of power density for a device with 1200V breakdown voltage



Industrial Drives



Dimensions of 100 kW Converter:



Semiconductor Technology:

IGBT1 ... IGBT5,
IGBTx, WbG-Switches

Package Roadmap:

62mm, EconoDUAL™ 2, Easy2B,
High Temperature / Low Inductive Package



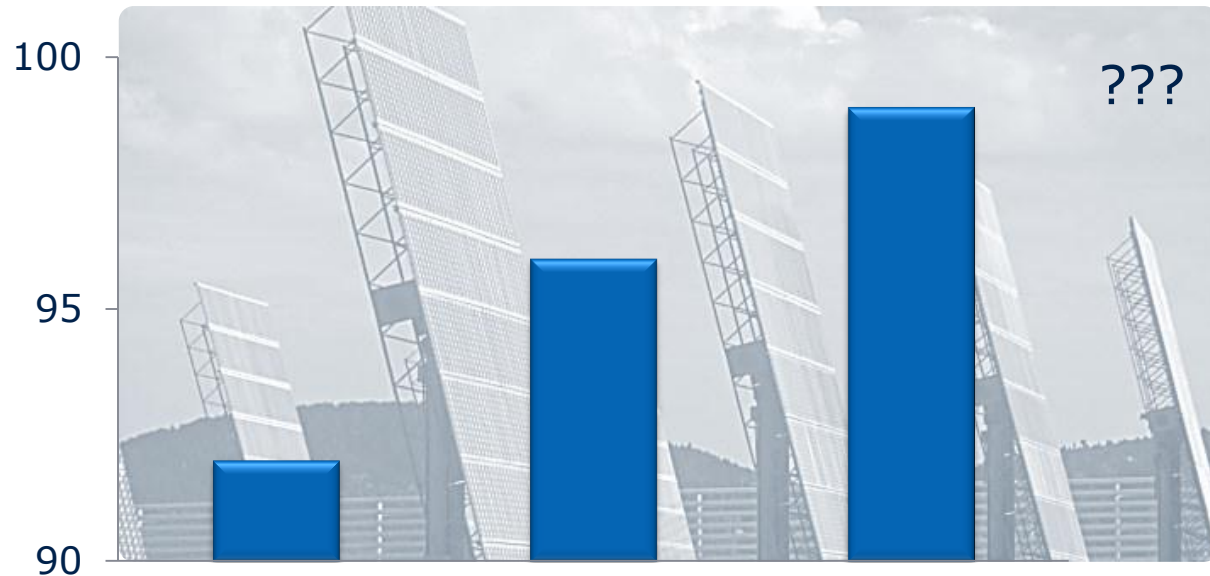
Solar Inverter



Efficiency:

1990 2000 2010 2020 2030

95% 98% >99% 99.??%
Cost Driven



Semiconductor Technology:

CoolMOS™
Si-IGBT Wide Band Gap (e.g. SiC) Future Technologies

Wind Power



Max power:

1.5 MW 6MW 8MW? 10MW?

Grid connection:

Medium Voltage
10kV~

Single Device 10kV~
Parks up to 100kV~ HVDC in development
20-100kV~ or HVDC

Expected lifetime:

10y 20y 30y? Contd.

Reliability (power cycling):



Automotive Car CO₂ Reduction Roadmap

1990 2000 2010 2020 2030

Targets
gCO₂/km



Measures:

Improved combustion

Engine accessories

**Energy management /
efficiency / on demand**

Transmission

Hybridization
Stop/start, Mild,
Full Hybrid

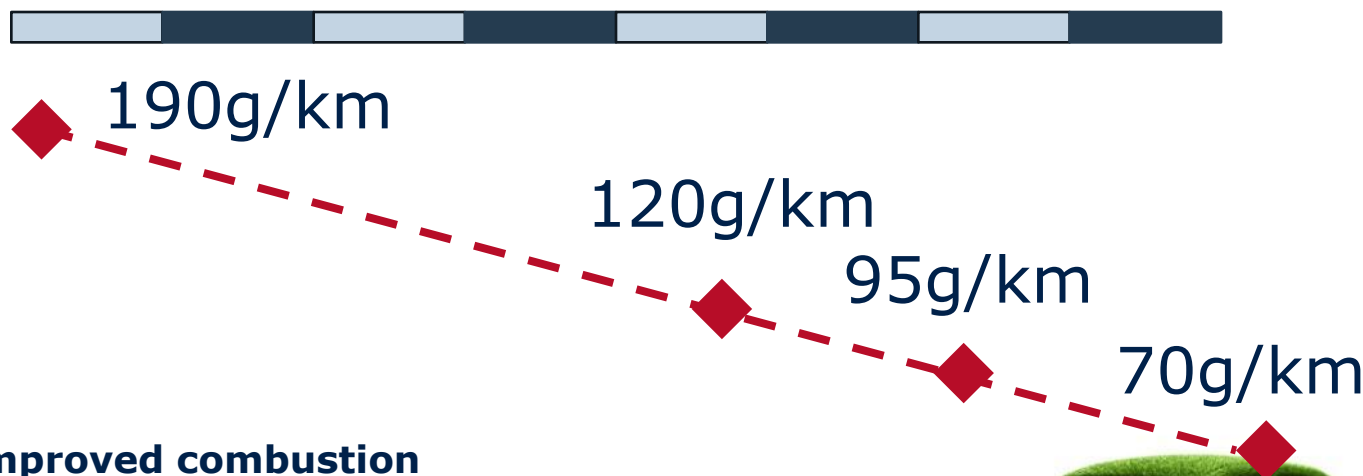
E-Mobility

**Semiconductor
Roadmap:**

IGBT

SiC

GaN?



Automotive Radar

1990 2000 2010 2020 2030



Radar:

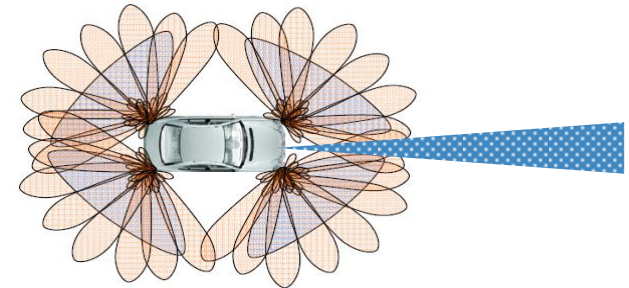
Single beam



Multi beam



Electronic Beam Forming



Semiconductor Technology:

GaAs Transmitters
Si diode

Bare die

SiGe transceivers
■ integration on single chips

Packaged RF components

SiGe transceivers
■ Integration of analog functionalities
■ Power optimisation
■ ISO26262

Antenna In Package

Internet of Things and Security



Single ECU



Many ECU



ECUs & Portable Devices



Internet of Things



Security Technology:

SW	HW Security	Common Criteria	Secure Element
Crypto Algorithms	HITAG	AES-128	ECC-256
	PKI Infrastructure		

Global challenges Fields of action

Climate
Energy

Health
Nutrition

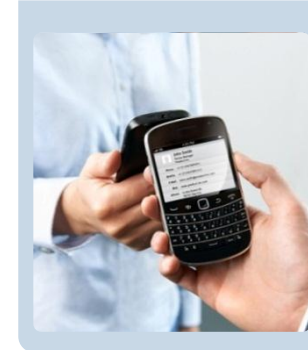
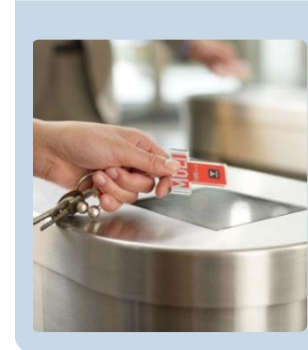
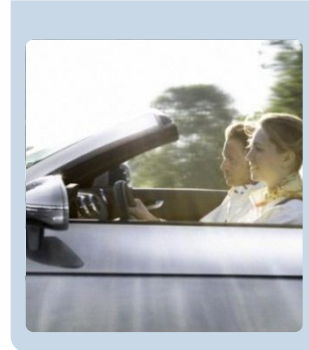
Mobility

Security

Communi-
cation

Key technologies

Cross-cutting issues / general conditions





ENERGY EFFICIENCY MOBILITY SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.

