Green Car initiative

June 11, 2010
Brüssel, Belgium

The way to the full electric vehicle (FEV) E3CAR

Reiner John Infineon Technologies AG, Germany
Ovidiu Vermesan SINTEF, Norway
Marco Otella, Italy CRF
Piedro Perlo, Italy CRF

Outline

The way to the full electric vehicle (EV)

- Objectives of the project and participating partners
  E3Car project in general
  E3Car functional domains and research focus
- Major technological challenges and possible technological approach
  Component Efficiency based on Silicon technologies
  System integration based on Modul- and
  Functional Integration (Powertrain, Safety, Energy sources)
- Exploitation potential
  Examples in the project
  Electric vehicle outlook

- www.green-cars-initiative.eu/documents/Report_WS_EC-MS_Electric_Vehicle_R-D.pdf/view

Electrical and Hybrid Vehicles

Bluecar
Source: Pininfarina/Bolloré

Mila EV
Source: Magna Steyr

Renault Electric Concepts
Source: Renault

Think City
Source: Think

Peugeot BB1
Source: Peugeot

Porsche Cayenne Hybrid SUV
Source: Porsche/Audi

Phylla
Source: Fiat

i-MiEV
Source: Mitsubishi

Leaf
Source: Nissan

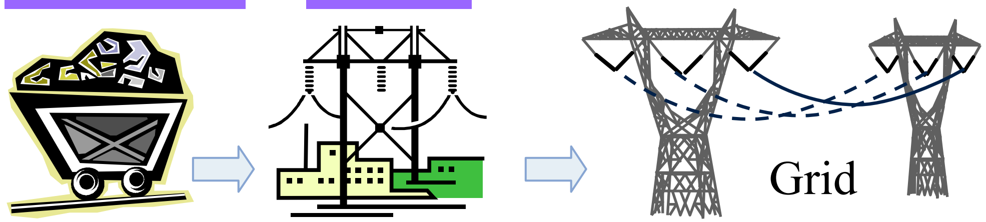
Tesla Roadster
Source: Tesla

Well to Wheel Conversion Efficiency

Oil Well	Refinery	Distribution	Combustion Engine Car		
			Engine (FUDS *)	Transmission	
96%	90%	93%	*28%	90%	
Oil supply 80%			Urban traffic Car 23%		18%


* Highly efficient Diesel

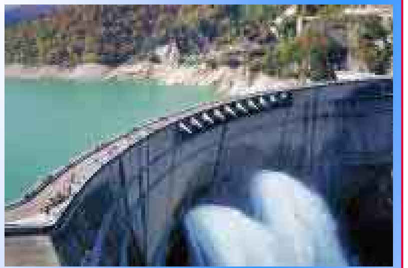
Coal Mine	Utility	Distribution	Electrical Vehicle (EV)					
			Charger	Battery	Power Control	Motor	Trans mission	
97%	45%	93%	91%	85%	88%	91%	97%	
Coal to electricity 40%			EV 60%					24%



Efficiency of themal conversion processes is limited at 40 -45%

Smart Power Electronics and Technologies enabling Regenerative Mobile Efficiency (RME)

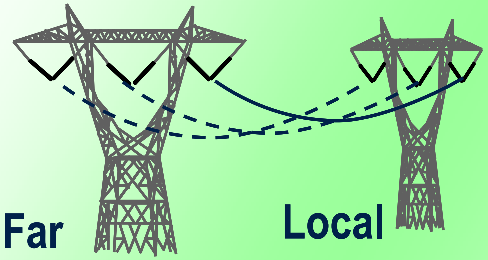
Power plant



100%

Generator-voltage
30KV

Grid = Energy transfer



93%

High-voltage
AC 380KV

Middle-voltage
AC 30KV

E-Mobility

Charger	Battery	Power Control	Motor	Trans mission
91%	85%	88%	91%	97%

AC 220/380V

Board net

IGBT Module

IGBT, Modules

IGBT, MOSFET, VHV CMOS, SiC, GaN

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Federal Ministry of Education and Research

100% x 60% = 60% Supply chain efficiency

* Efficency is set to 100% because primary energy is not wasted

Aeneas

EV as Strategic Option in the Multi Billion $ Energy Household

Opt 1	Oil supply (80%)	x ICE Car (23% eff. Diesel)	=	18%	High Emission
Opt 2	Burn Coal (40%)	x EV (60%)	=	24%	Low Emission
Opt 3	renewable (100%)	x EV (60%)	=	60%	Zero Emission

CHINA´s way to renewable energy

burning coal		renewable energy	
China	Germany	Norway	Canada
EV 危機	EV, Diesel	EV	EV, Diesel
weak automotive Industry	strong automotive Industry	urban	Non urban 80% life in 10% area

Countries will choose mobility based on efficiency and cost

China 機 + Replace Oil + Save Bill $ of coal by efficiency
+ enable path to highly competitive automotive industry

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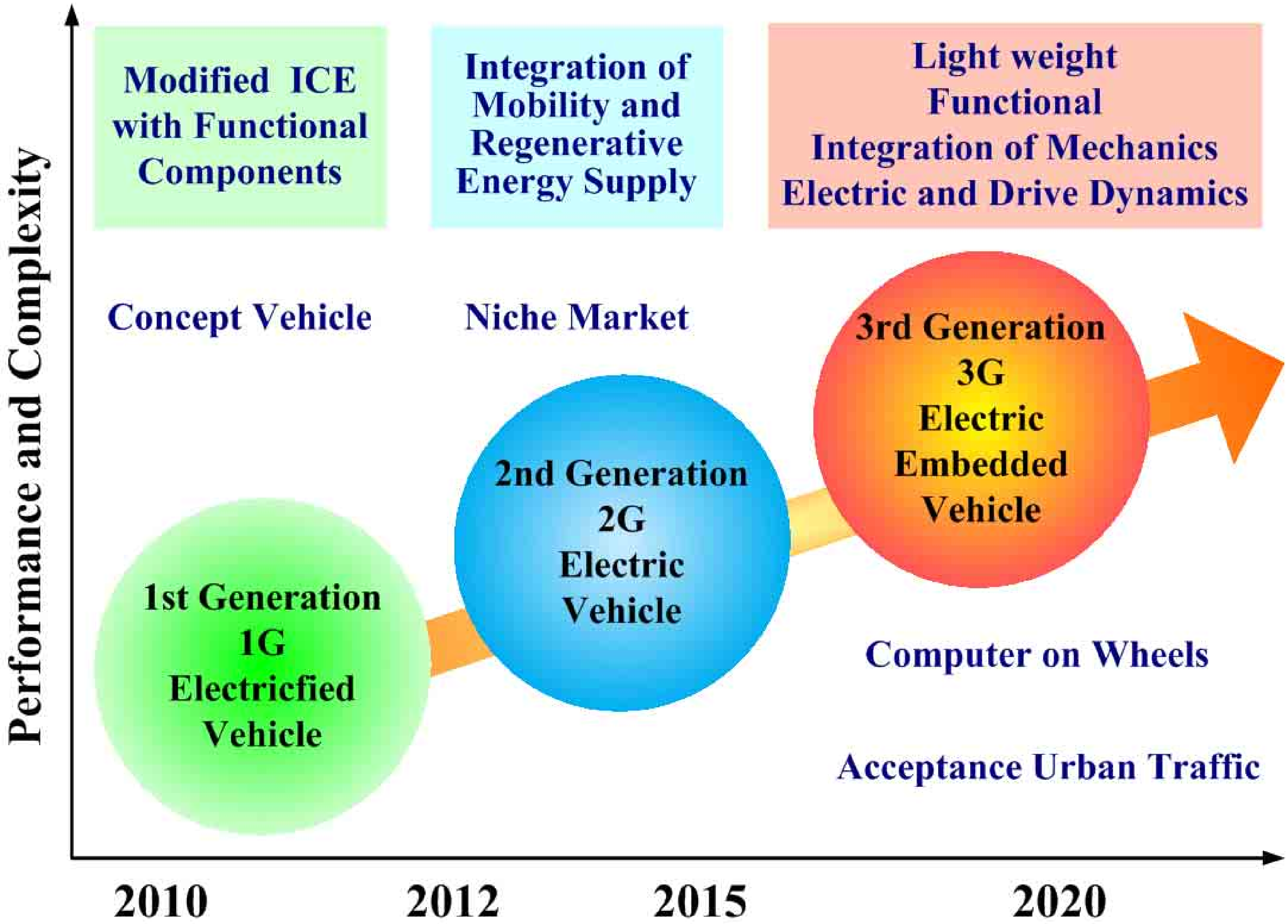
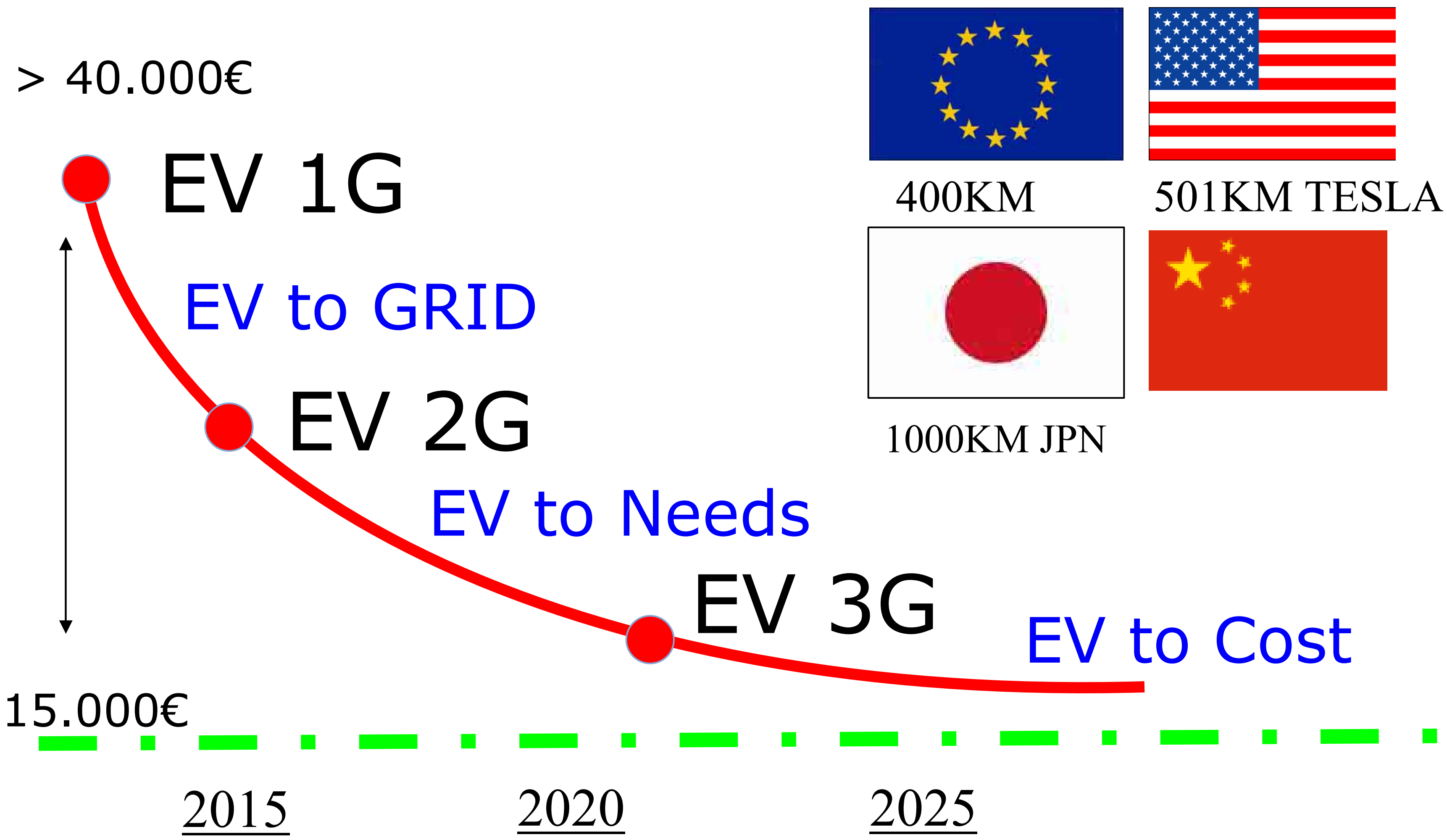
http://www.chinadaily.com.cn/bizchina/2009-08/10/content_8548057.htm
http://rutledgecapital.com/2009/05/30/china-energy-mix/

Aeneas

Evolution and Phases of EV´s in Europe



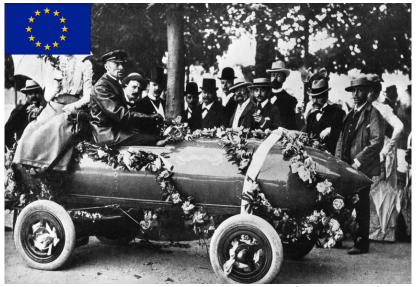
Generations, needs and volume markets



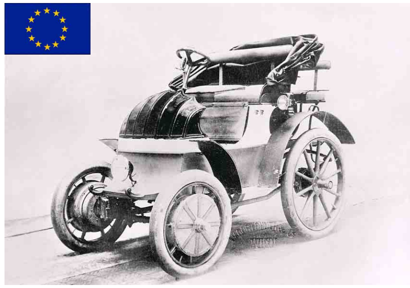
Volume market cost

Evolution and Phases of EV´s:

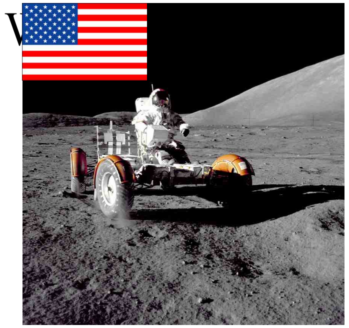
Market break troug after 100y?



1899 >100kmh



1900 50km



1971 92km

1941 ~80km

1945 ~65km

Missing
Fossil oil
resources

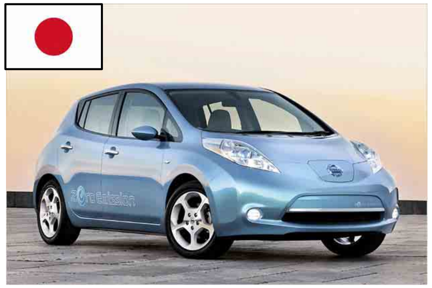
1992 70km

1991 250Km

1993

1996 220km

2008 300km

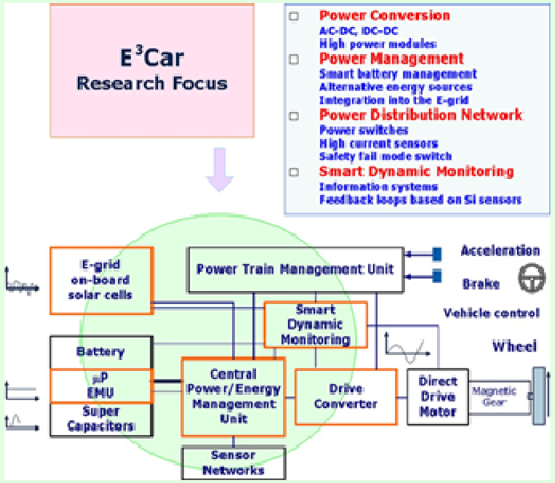


2010 160km

Research in E-Mobility: Think big, Think different, Think holistic

I. Generation

Efficient Components



- Smart power management architectures
- Conversion efficiency
- Power management efficiency
- Energy flow efficiency
- Smart power control
- Miniaturisation
- Low loss on device and module level
- High temperature operation/Thermal management
- Improved reliability
- Increased life time

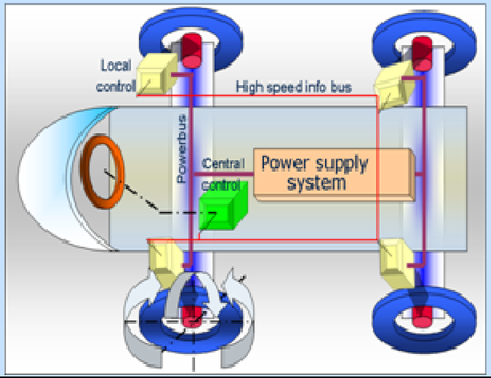
E3Car

PL R.John

ENIAC

II. Generation

Embedded Control



Embedded control architectures reflecting the major changes in the physical concept of EV I generation

Distributed real time embedded systems platform for the EV II Generation

Designs and embedded systems architectures for high efficiency innovative mechatronics systems

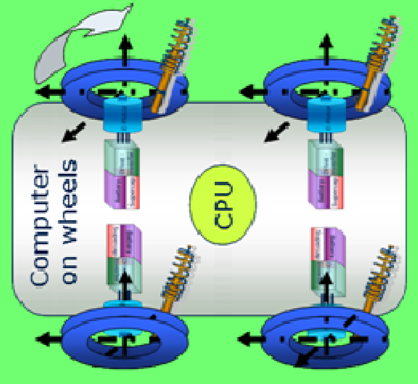
Initiated by R.John /O.Vermesan
Lead by Marco Ottella

Pollux

Artemis

II+. Generation

Integrated Powertrain



Multi phase engine approach to enable intrinsic safe power train
Highly integrated powertrain to enable also distributed propulsion

- High dynamics due low mass
- Shortest connection to power
- Elimination of central mass

New 03.11.09 Castor

PL R.John

Green Car
ICT 10.3

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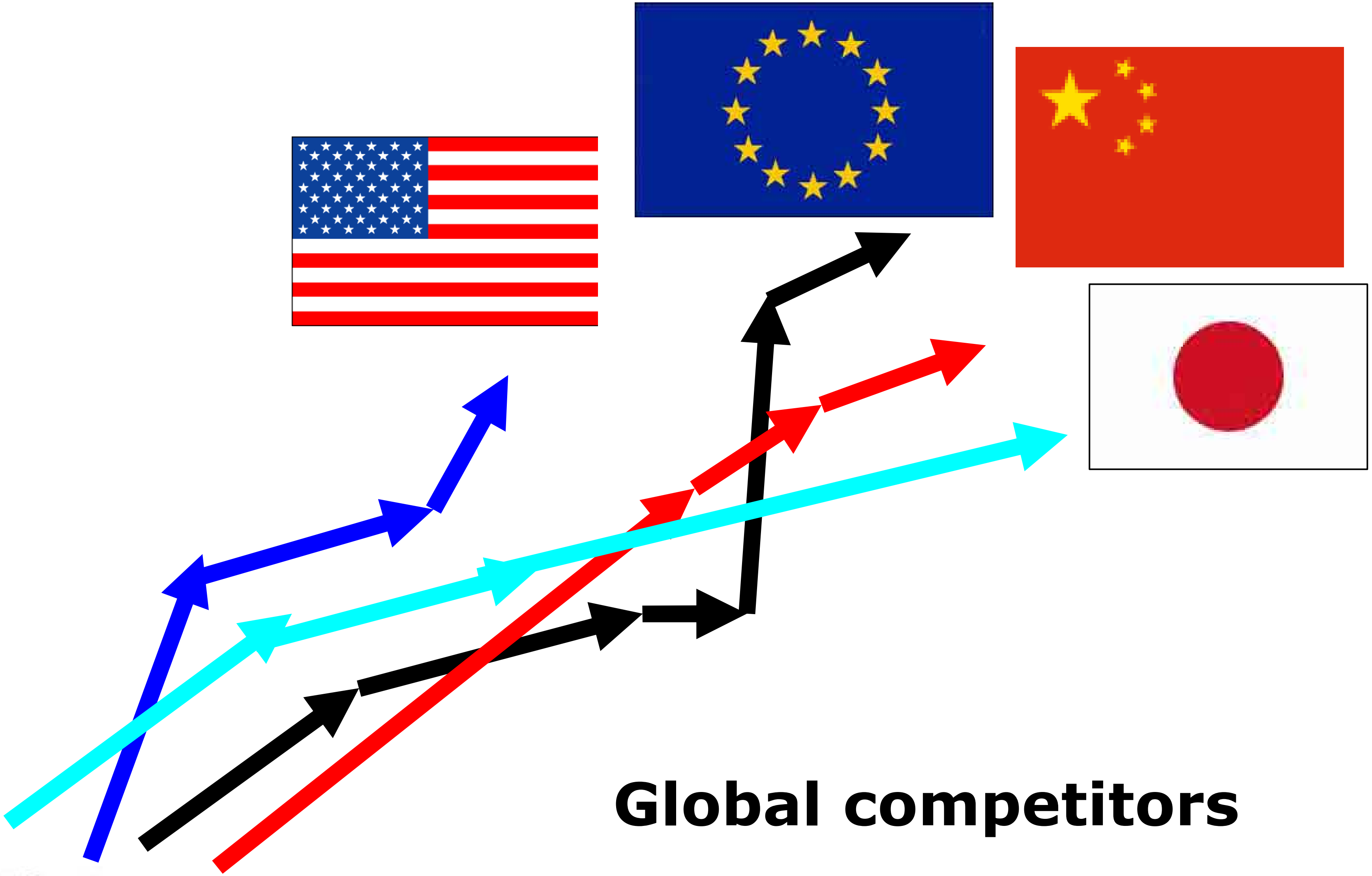
Renewable Mobility: The global challenge



Global competitors

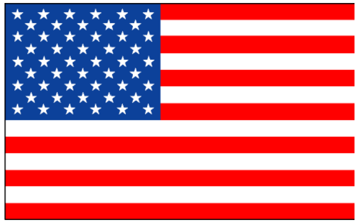
Europe and the Global competition

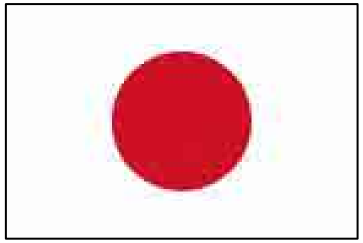
Team Blue

Standardization:
Grid, Car, Tax, rules, Infrastructure, networking among the national clusters and among the automotive manufacturer

Mobility needs
Population: 500 Mio
Distance: 2000 km

Energy basis: 25% Coal+25% NG





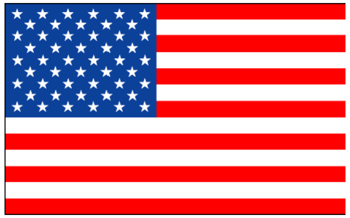
Team Red

Standardization
China practise since 3000y
US, J are one country

Mobility needs
US 300 Mio + China 1300 Mio + J 100 Mio
Distance: 4000 km

Advantages
- ✓ US +C ->Non competitive Automotive industry: J -> highly advanced AI
- ✓ Standardization,
- ✓ Early Mass market

Mobility : Distance records 500KM

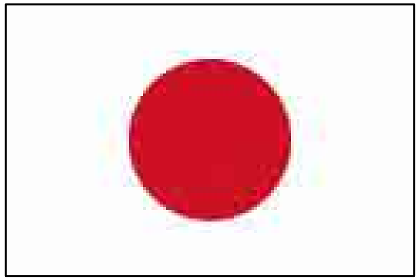


501 km @ TESLA
by Simon Hackett
27.10.2009

Leaders of the Eco class for production cars on the World Solar Challenge (now known as the Global Green Challenge) have set a new 'world record' for distance traveled on one charge in a standard production Tesla Roadster of 501 kms or 313 miles. The car had about 3 miles of range left when the drive was completed.

Tesla Goes 313 Miles on Single Charge By Tony Borroz _ October 27, 2009 | 6:18 pm |
Categories: EVs and Hybrids, Performance
Read More http://www.wired.com/autopia/2009/10/tesla-313-miles/#ixzz0qLRDT5KI

Mobility : Distance records

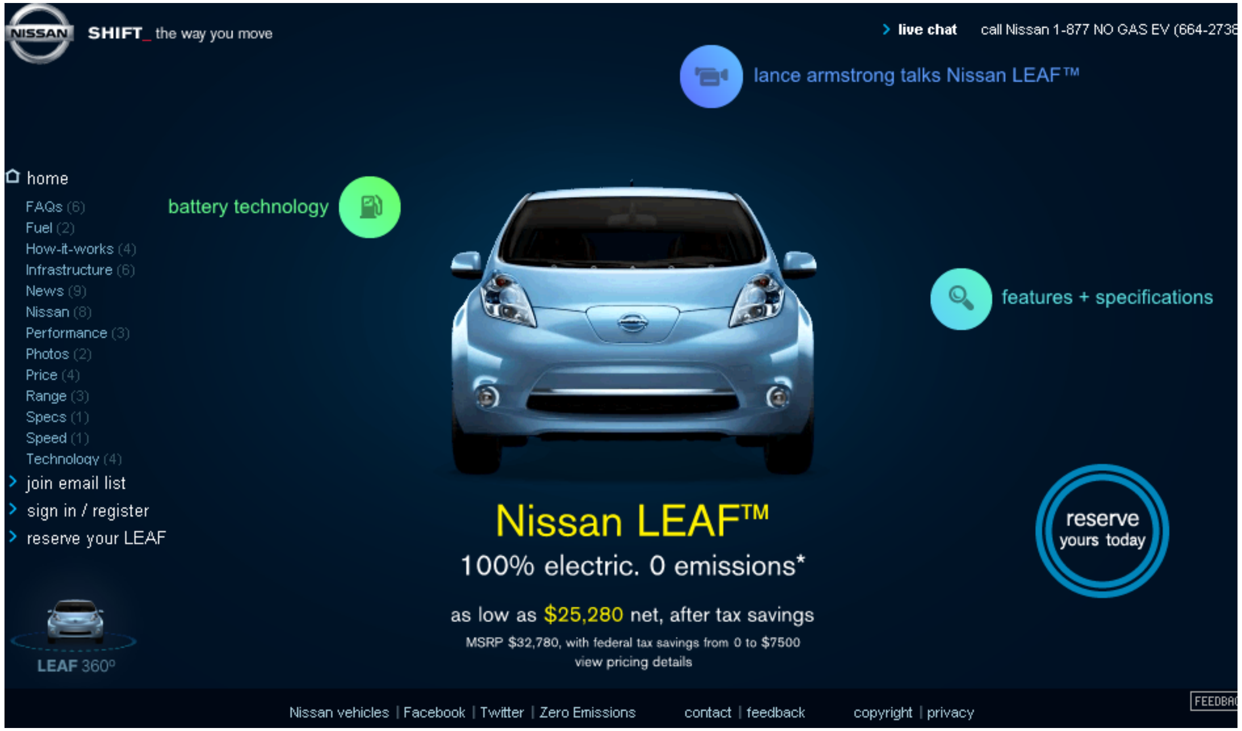


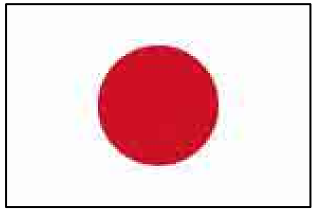
555.6 Km in Osaka
1003 KM @ 40Km/h on MIRA EV
by Japan Electric Vehicle Club 25.05.201

One of the biggest problems that stands between electric vehicles and becoming mainstream is limited battery life. But there has been some progress in that area lately: the Japan Electric Vehicle Club [JP], a civic group based in Tokyo, announced today a Mira EV customized by the group traveled exactly 1,003.184 kilometers without a recharge.
The club shattered its own record from last month when another electric vehicle drove 555.6km (345 miles) from Tokyo to Osaka on a single charge. The new record was made possible by driving the car at a driving course in Shimotsuma, Japan, which is apparently the world's longest.
Powered by a Sanyo lithium-ion battery (built by assembling 8,320 cylindrical lithium-ion batteries), the car ran for 27 and a half hours at around 40km/h on average.
The club had a team of 17 people at the course who took turns at the wheel. It will ask the Guinness World Records to officially recognize the drive soon.

Danielle Demetriou in Tokyo Published: 6:50PM BST 25 May 2010

Mobility : Cost records

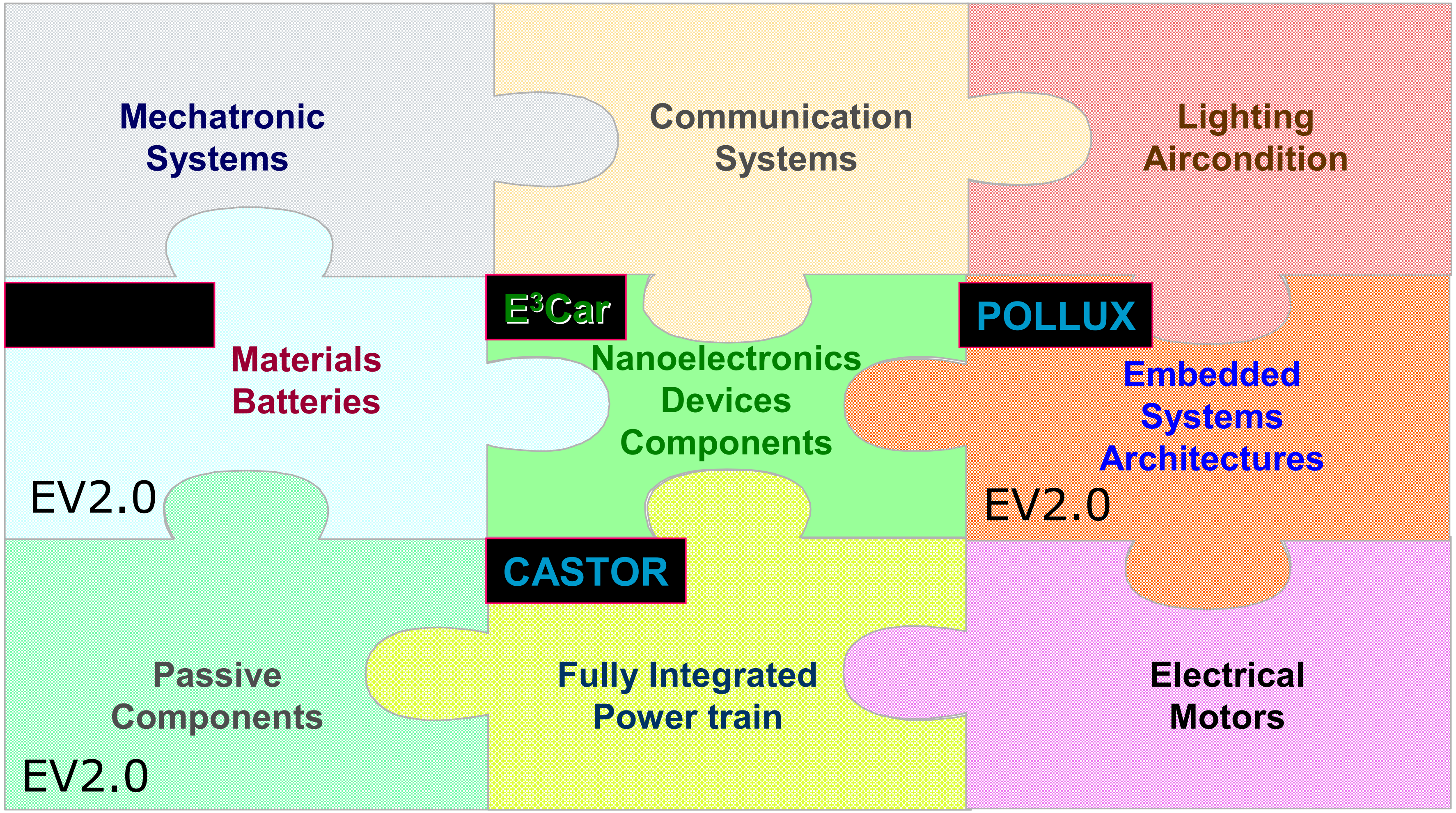




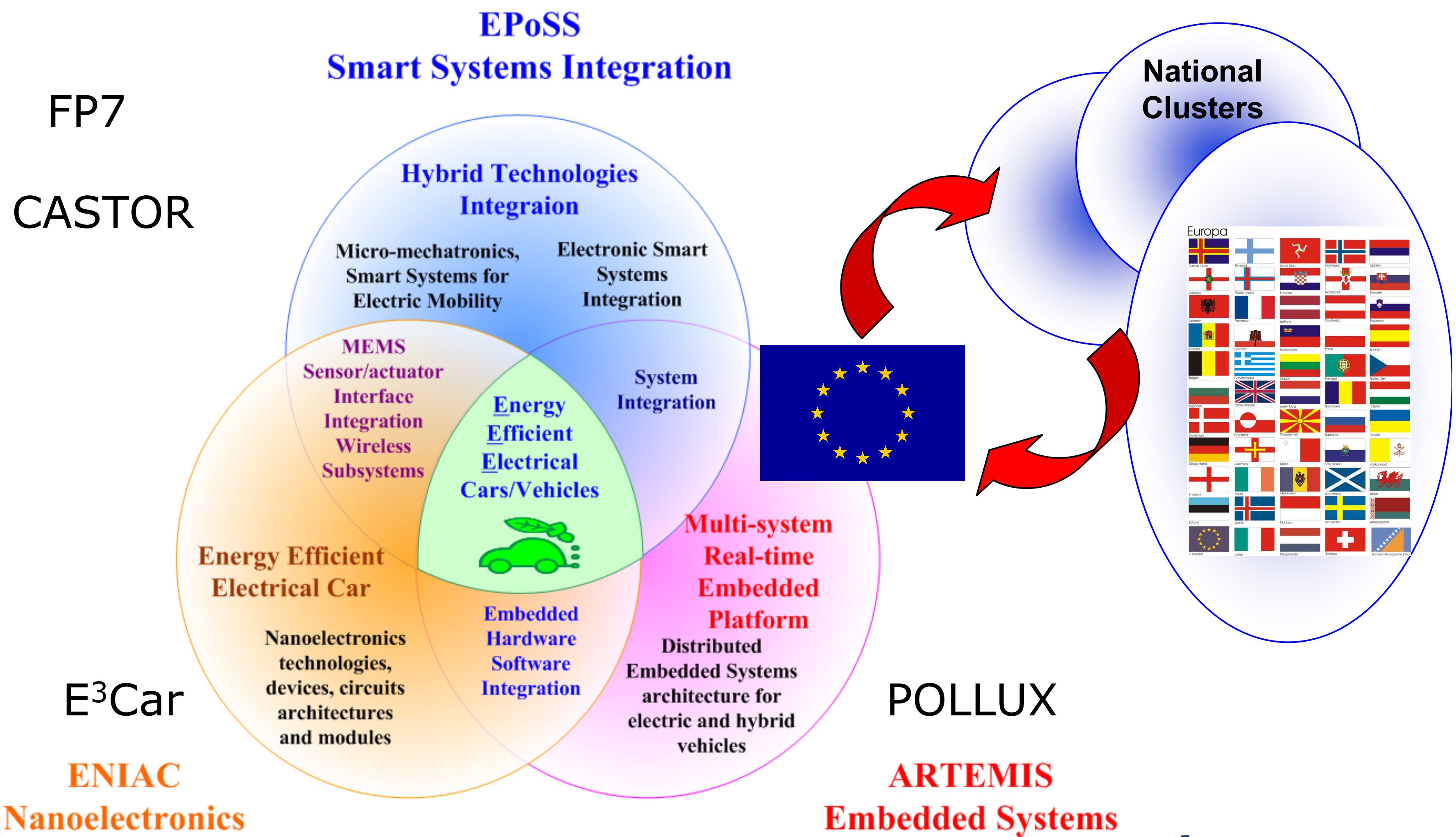
Batterie: 48 Module laminierte Lithium-Ionen-Batterie
Kapazität: 24 kWh -> 160 Km -> 15KW/100km
Leistung: über 90 kW
Energiedichte: 140 Wh/kg -> 171 Kg Battery
Leistungsdichte: 2.5 kW/kg
Ladezeit: Schnellader DC 50kW (0-80%): unter 30 Minuten
AC200V Aufladung: unter 8 Stunden

Brühl, 18. Mai 2010 – Anschaffungskosten unter 30.000 Euro anbieten, worin Fördermittel oder Gutschriften eingerechnet sind. Vorreservierungen sollen ab Juli 2010 entgegengenommen werden.

Synergy of research programs and plattform in Europe for electro mobility

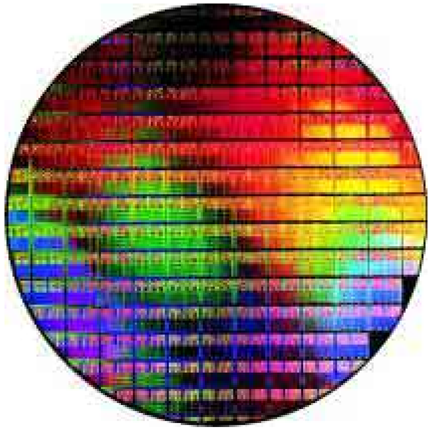
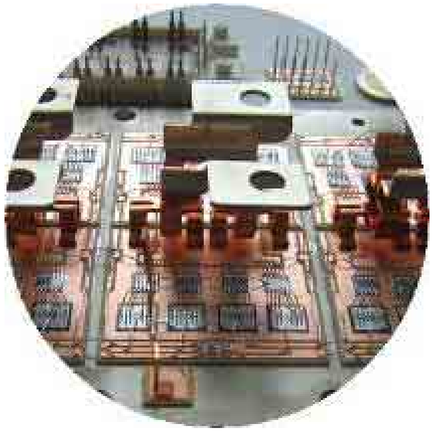


E3CAR Technology Platform Embedding



ENIAC E3Car Project Vision:

- Build **a solid nanoelectronics technology base** for Europe.
- Establish **standard designs and platforms for electrical/**hybrid vehicles **with a significant industrial, economic, innovation and societal impact** to enable the path to the **all electrical vehicle.**
- Development of efficient and smart semiconductor components for the **first industrial generation** of **energy efficient electrical** vehicles.

E^3Car covers 3 EVs functional domains

Energy (Batteries, super capacitors, range extender, grid connection)

Propulsion (Power converters and motor-generators)

Auxiliary systems (Power supply only)

E^3Car

Power and signal distribution
(Wiring, harnesses and intra vehicle communication)

Chassis (Steering, brake, suspensions and correlated functions)

Body and board control
(HMI, vehicle entertainment, navigation,
vehicle to vehicle (V2V and vehicle to infrastructure (V2I)
communication

E^3Car Project Targets

Top targets for energy savings by:

- Converter efficiency (9% potential)
- Mileage of battery set (11% potential)
- Weight by integration (10% potential)
- Power distribution net (5% potential)

Overall target: 35% Energy savings

ENIAC E^3Car Objectives / Key facts

Objectives:

Research and development of **nanoelectronics technologies**, **devices, circuit architectures and modules** to build **efficient components** for Electrical Vehicles **(EVs)** and demonstrations in the final systems.

Key facts:

11 European countries involved
22 Deliverables as Prototypes or Demonstrators
33 Project partners
44 M€ Budget -> 3500 PM

28 Design/Supply chains
36 Months duration

33 Project Partners cover the whole Value Chain

Research → Semiconductor → Tier1 → OEM

FhG	FH JOANNEUM	CISC semiconductor	OKMETIC	infineon Germany *WP Lead 8*	infineon Austria *WP Lead 3*	BOSCH *WP Lead 2*	Audi
TU Vienna	VTT	EPYON	CIDETEC	ST Italy	ST France	Valeo *WP Lead 4*	buddy *WP Lead 5*
Tyndall	CNR	III-V lab Alcatel-Thales	CNM	VTI Technologies	ATMEL France Germany	SIEMENS	THINK
	BRNO	cea leti	austriamicrosystems AMS	ON Semiconductor ON SEMI	SINTEF *WP Lead 7*	PHILIPS	Centro Ricerche Fiat FIAT *WP Lead 1,6*

Germany	**Austria**	**Belgium**	**Norway**	**Italy**	**France**	**Spain**	**Finland**	**Ireland**	**Czech Republic**	**Nederland**

Funded by EU and 11 national countries

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E3CAR our Funding Partner

Germany	Austria	Belgium	Norway	Italy	France	Spain	Finland	Ireland	Czech Republic	Nederland
The German Federal Ministry of Education and Research (BMBF)	The Austrian Research Promotion Agency (FFG)	The Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT-Flanders)	The Research Council of Norway	The Italian Ministero Istruzione Università Ricerca; APRE Agenzia per la Promozione della Ricerca Europea	The French Ministère de l'Économie, de l'industrie et de l'emploi; Direction générale de la compétitivité, de l'industrie et des services (DGCIS)	The Spanish DGI-Ministerio de Educación y Ciencia	The Finnish Funding Agency for Technology and Innovation (TEKES)	Enterprise Ireland	The Research and Development Council in cooperation with the Ministry of Education, Youth and Sports (R&D)	The Dutch SenterNovem

Major technological challenges and possible technological approach

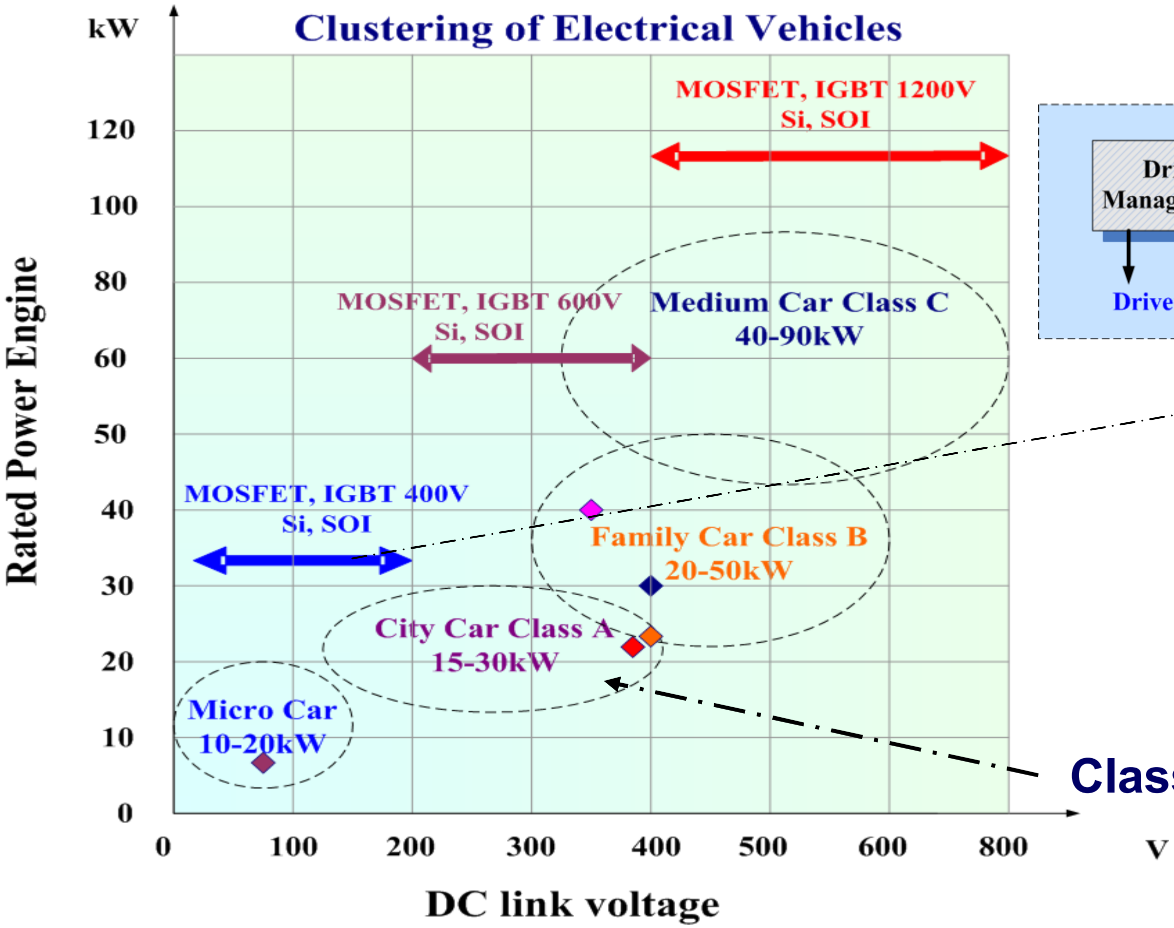
- Conversion of the drive train system
  - modular and scalable electronic control systems
  - intergrated and networking energy source in terms of power dissimination and usage
- Conversion of mobility and regenerative energy
  - Offboard grid operation
  - Onboard energy harvesting (high efficient cells)
- Conversion of Urban traffic and mobility needs
  - Energy harvesting -> charging stations
- Mass market volume to drive the price

EV needs and HV silicon technologies

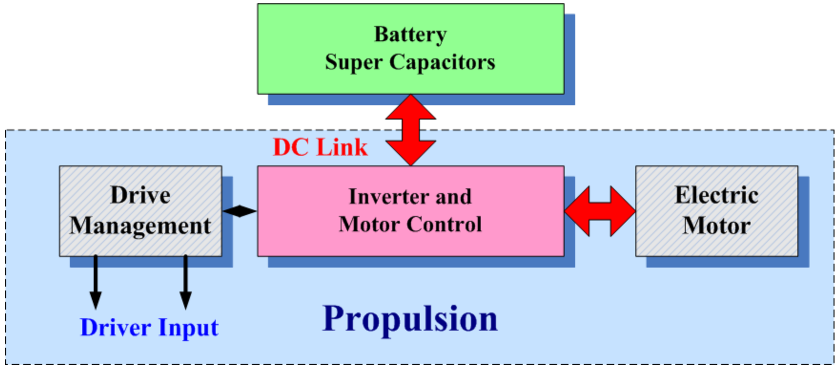
HV process technologies

- Requirements of EV functional units mapped to Semiconductor Technology
- Match strengths and limitations of available or new manufacturing technologies
  - High Voltage CMOS
  - IGBT (Insulated Gate Bipolar Transistor)
  - BCD (Bipolar/CMOS/DMOS)
  - SOI (Silicon on Insulator)
  - SiC (Silicon Carbide)
  - GaN (Gallium Nitride)
- Submicron lithography is necessary to combine complex logic with high voltage driver devices

Efficiency and Power technology



Power Conversion -> +8% efficiency



Inverter Module

Class A

Fiat

Think

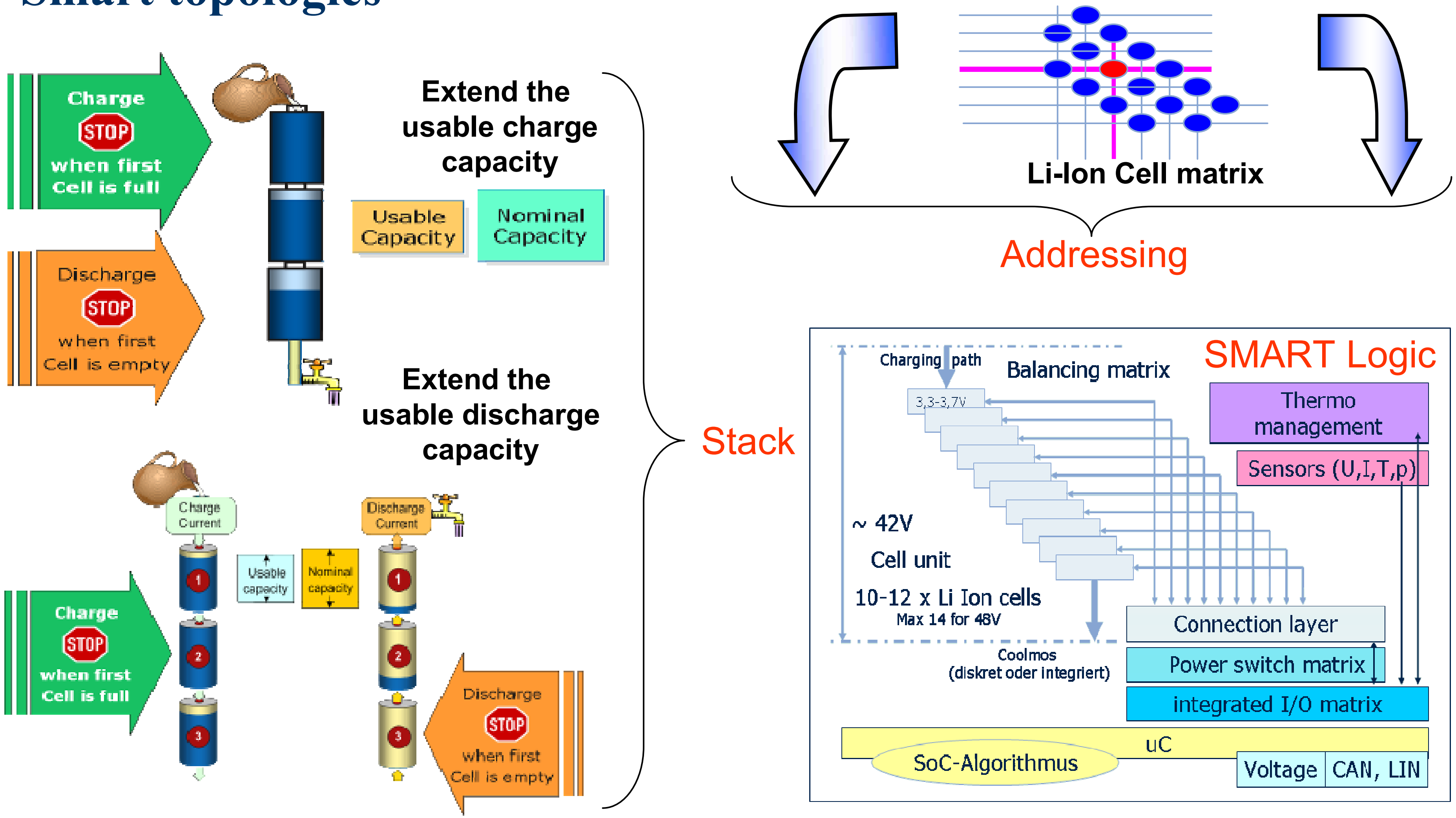
Structured in **clusters** of **car classes** based on **rated power** and **DC-link voltage**

Power Management

- Topologies - stack structures of Batteries (Li-Ion) or super capacitors
- Functional structures of battery management systems translated in semiconductor technologies:
  - Addressing of battery cell
  - Monitoring of battery cell
  - Redundancy concepts for defect battery cells
  - Sizing of Battery cell balancing currents driving
  - Scalability of stack structures
  - Scalability of addressing structures to enabling redundancy
  - digital/analog and analog/digital conversion
- Potential:
  - HV CMOS Technologies will enable modular and scalable battery managements system

Power Management Efficiency by smart stack topologies

Smart topologies



Mileage of Battery set -> +11% efficiency

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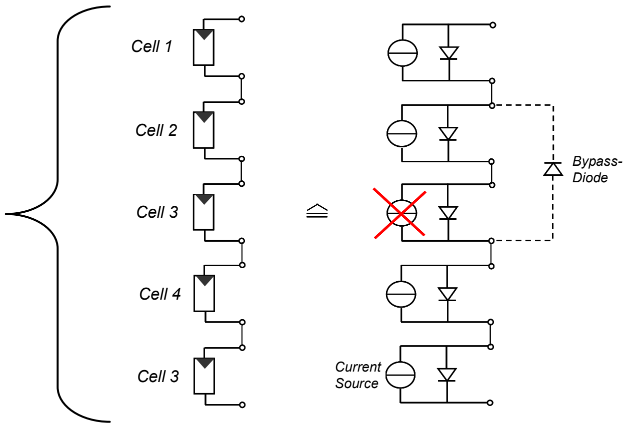
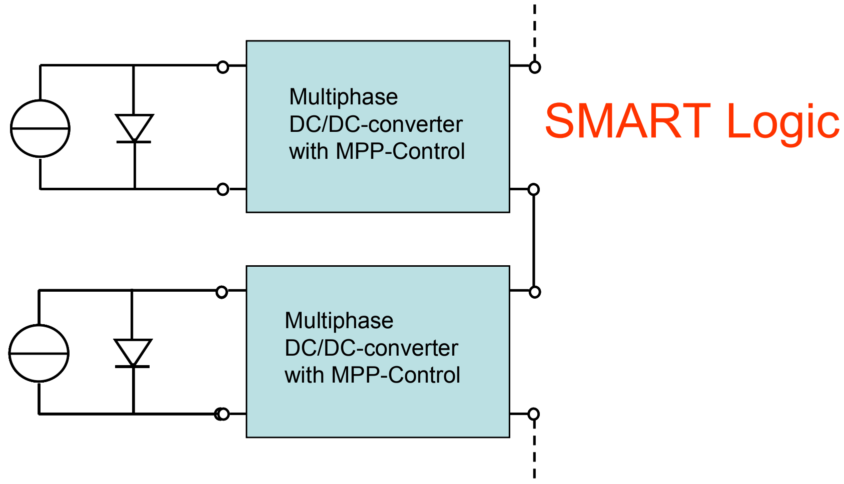
Power Management - Solar Energy

Automotive photo voltaic panels
for urban daily usage

Cell mismatch as a result of
divergent angles of incidence:

Stack





Simple : Bypass

SMART: Impedance conversion

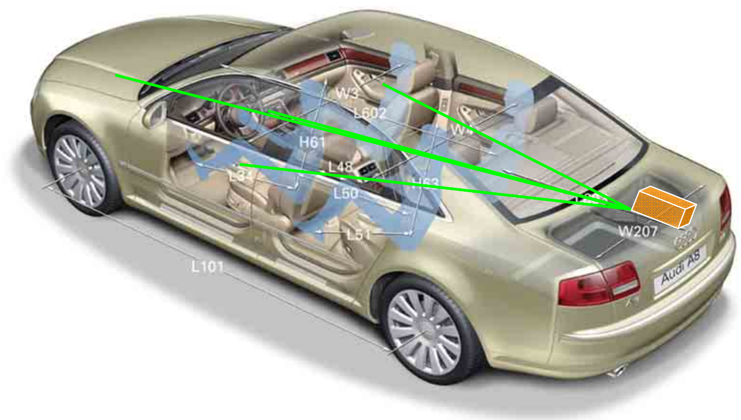
Demonstrator 12 V Starter Accumulator

- Development of a near-series starter accumulator (Li-Ion)
- Operation strategies for complete system
- Optimization of ⇔

  - Conductor rails (weight - form - heat build-up)
  - SOC/SOH algorithms
  - Strategies for charging and charge balance
  - Thermo management
  - µElectronic devices, sensors and power electronic
  - Communication between accumulator and automobile

Audi

Audi Electronics Venture GmbH



Silicon Semiconductor Technologies

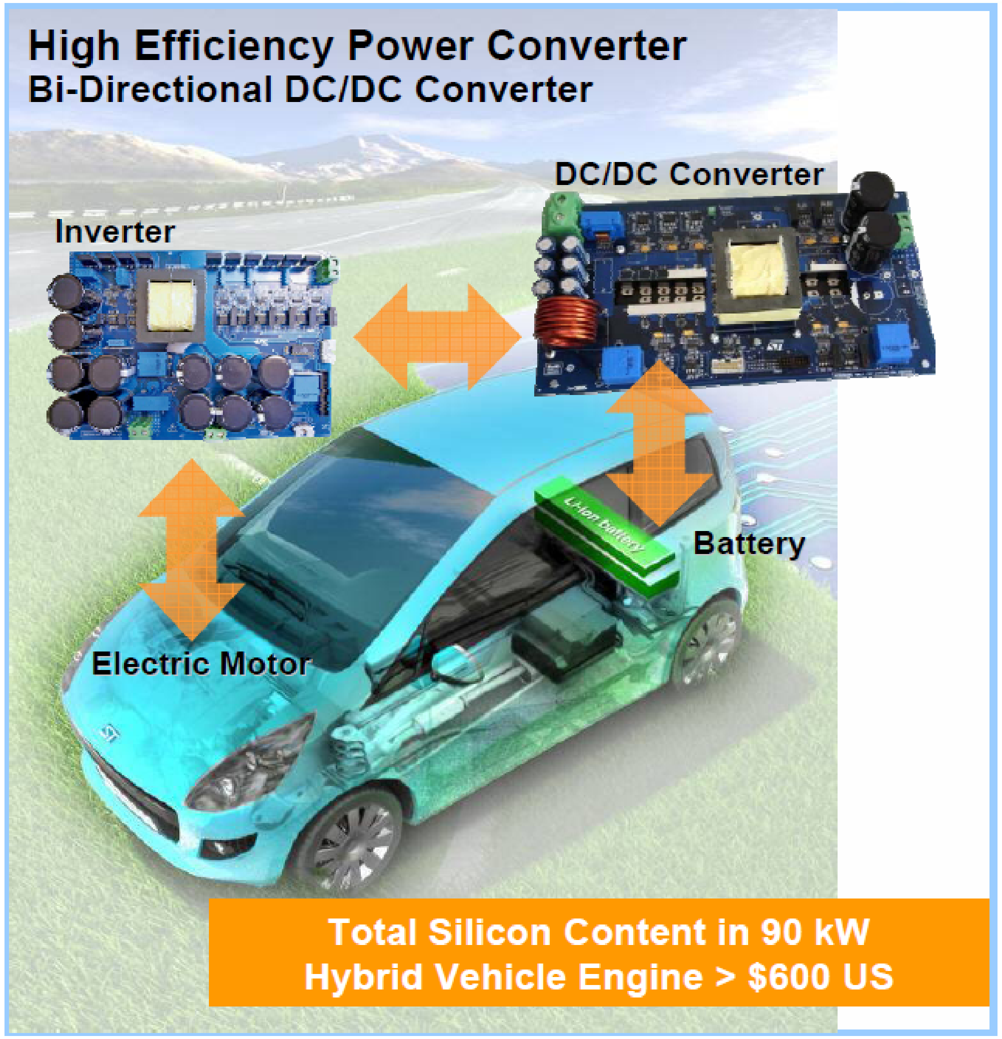
STMicroelectronics

Technology
- Innovative Wire Bonding
- Advanced Planar Punch-Through IGBT
- BCD < 0.18um

Products
- ST A1 Power Module

…and more

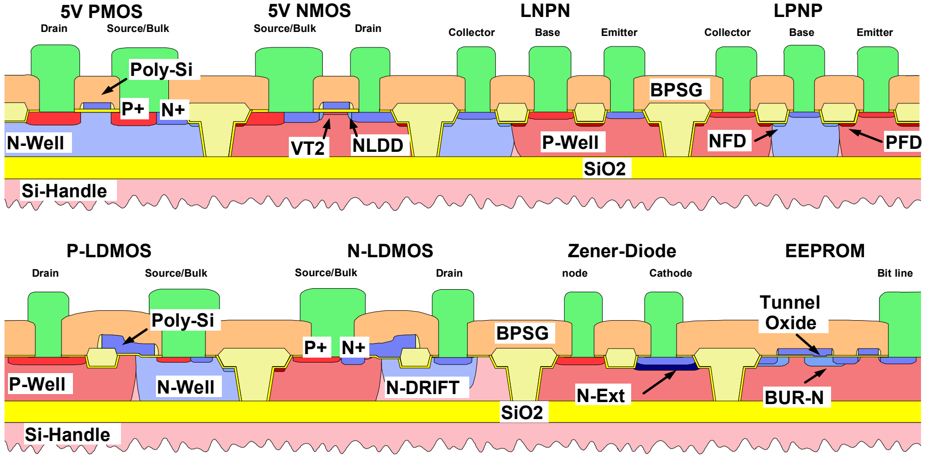
Solutions
- High Efficiency Power Converter



Source: STMicroelectronics

BCD-on-SOI Technology

- Fully dielectric isolation
- A high-performance 0.15 µm CMOS process with embedded options for automotive, aerospace and power management SoC (System-on-Chip) applications
- Less parasitics for robust design and high EMI performance
- Very low leakage current even at high temperatures
- Latch-up-free operation over complete temperature range
- $T_{Junction}$=175°C

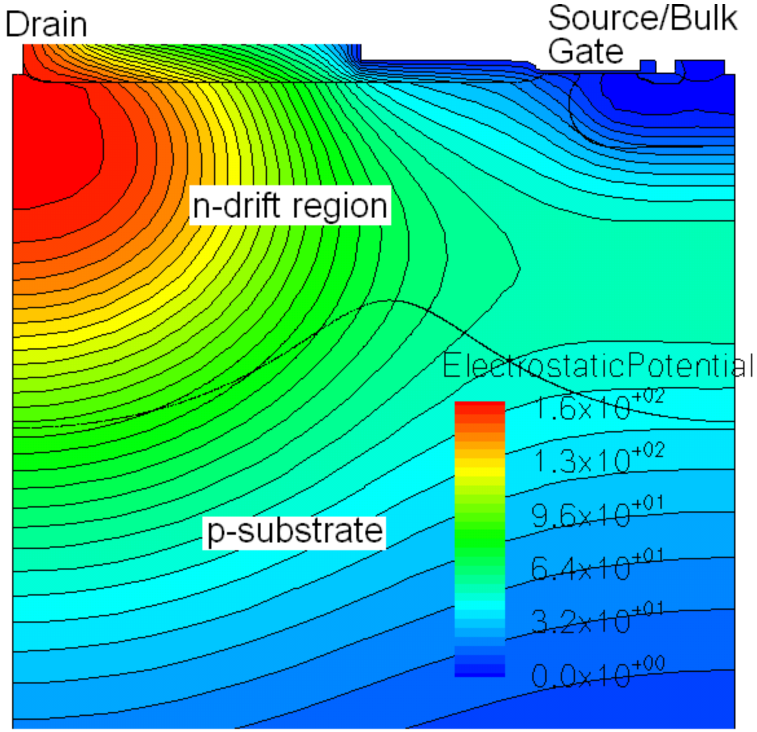


(through 1st metal layer)

Source: Atmel

CMOS High Voltage Process

- 120V n-channel LDMOSFET: Potential distribution at 160V

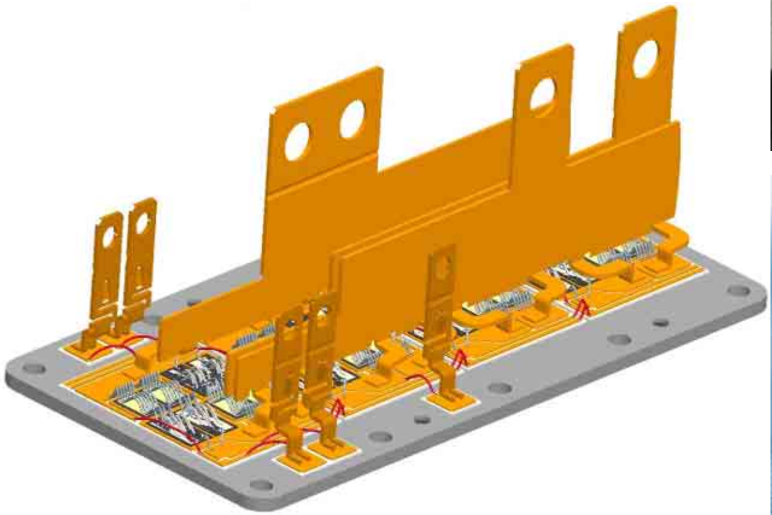


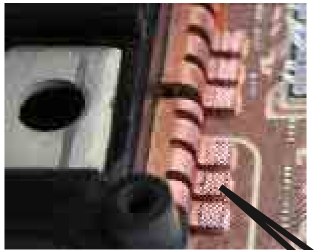
Source: austriamicrosystems

- 0.35 µm technology
- 120V n-channel LDMOS Lateral Diffused MOS transistor
- Thick Gox (Vgmax=20V)
- Blocking voltage over 150 V
- Low HC degradation
- Low Ron by non-uniform NWELL

Reliability

- Solder replaced at terminal joints- direct copper bonded
- Roll out of direct copper bonded terminals





- TST (-40 / +150) up to 1000 Cycles tested

PIN-FIN base plate for direct water cooling

Source: Infineon

EVs - A Way of Life - A New Lifestyle

Emissions -> **Electrical vehicle vs. combustion vehicle:**

CO: -99%, **HC**: -97%, **NOx**: -92%, **CO_2**: -50%