P-MOB

Integrated Enabling Technologies for Efficient Electrical Personal Mobility

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7 Partners, 4 Member States:

CRF	Centro Ricerche Fiat (IT)
MAZEL	Mazel Ingegneros (ES)
Integra	Integrare (IT)
USFD	University of Sheffield (UK)
SIE	Siemens (DE)
Polimodel	Polimodel (IT)
MGM	Magnomatics (UK)

Instrument: STREP **Duration: 3 Years**

Problems and Objectives

Problem

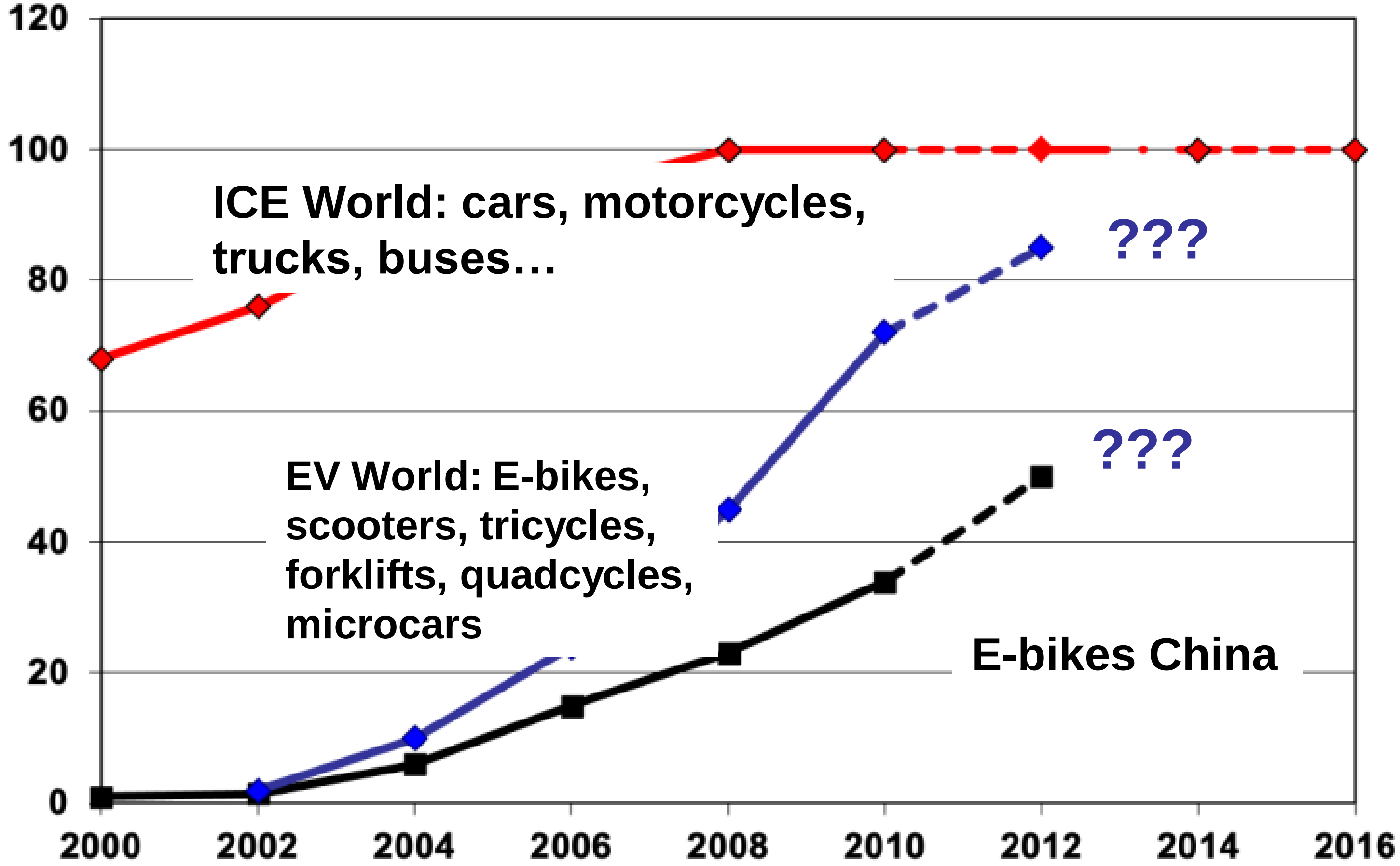
- ❑ EU: 80% of the population live in cities
- ❑ World:> 50%   living in megalopolis
- ❑ Urban congestion primarily due to large vehicles with a single occupant on board
- ❑ Cost - energy consume – noxious emissions – GHG – raw materials
- ❑ New competition of a world already moving electrically

Objectives

Safe and ergonomic small vehicle addressing personal mobility needs having:

- ❑ Distributed powertrain solutions (optimisation of the drive train as a whole)
- ❑ Ultralight structure
- ❑ Advanced aerodynamic solutions
- ❑ V2G+I technologies
- ❑ On board solar cells
- ❑ state of the art ICT technology for energy flow management and connectivity.

A world already moving electrically!



The annual production of E-means will very soon approach and supersede that of ICE means. ICE cars continue to increase, ICE motorcycles already decreasing. By 2020 > 2 Billion motor vehicles (two-wheels, cars, trucks) on the roads. By 2020 the production of E-means is likely to reach 200 millions/year!

Renewable Energy and e-mobility as converging tech.

From 2000 to 2007 the installations of photovoltaic PV panels and wind turbines has always exceeded the most optimistic forecasts!!

- **2008/EU-27 new RE installations exceeded in power the new installations based on fossils!!** www.EWEA.org www.EPIA.org
- **2009/EU-27 new RE installations during peak hours have produced more energy than that of the new installations based on fossils!!**

- **2009-2013: PV-World still at 40% CAGR** www.greentechmedia.com
- **2009-2013: PV-USA largest market at 50% CAGR** www.spireCorp.com

- **2003-2009: EV world 50% CAGR !!**
- **2009-2014: EV World is very likely to continue at 40% CAGR**
- **2010-2011: World the production of E-means approaches- exceeds that of ICE means**

Needed Power to drive an ideal vehicle

$$P_{total} = \underbrace{P_{kin} + P_{grade}}_{\text{Partial Regeneration}} + P_{air-drag} + P_{friction}$$

$$P_{kin} = d(KE)/dt = d(1/2Mv^2)/dt = Mav$$

M = mass of vehicle

$$P_{grade} = d(PE)/dt = Mgv \sin q$$

Sinq = inclination of road

$$P_{air-drag} = ½\, \rho\, C_x S v^3$$

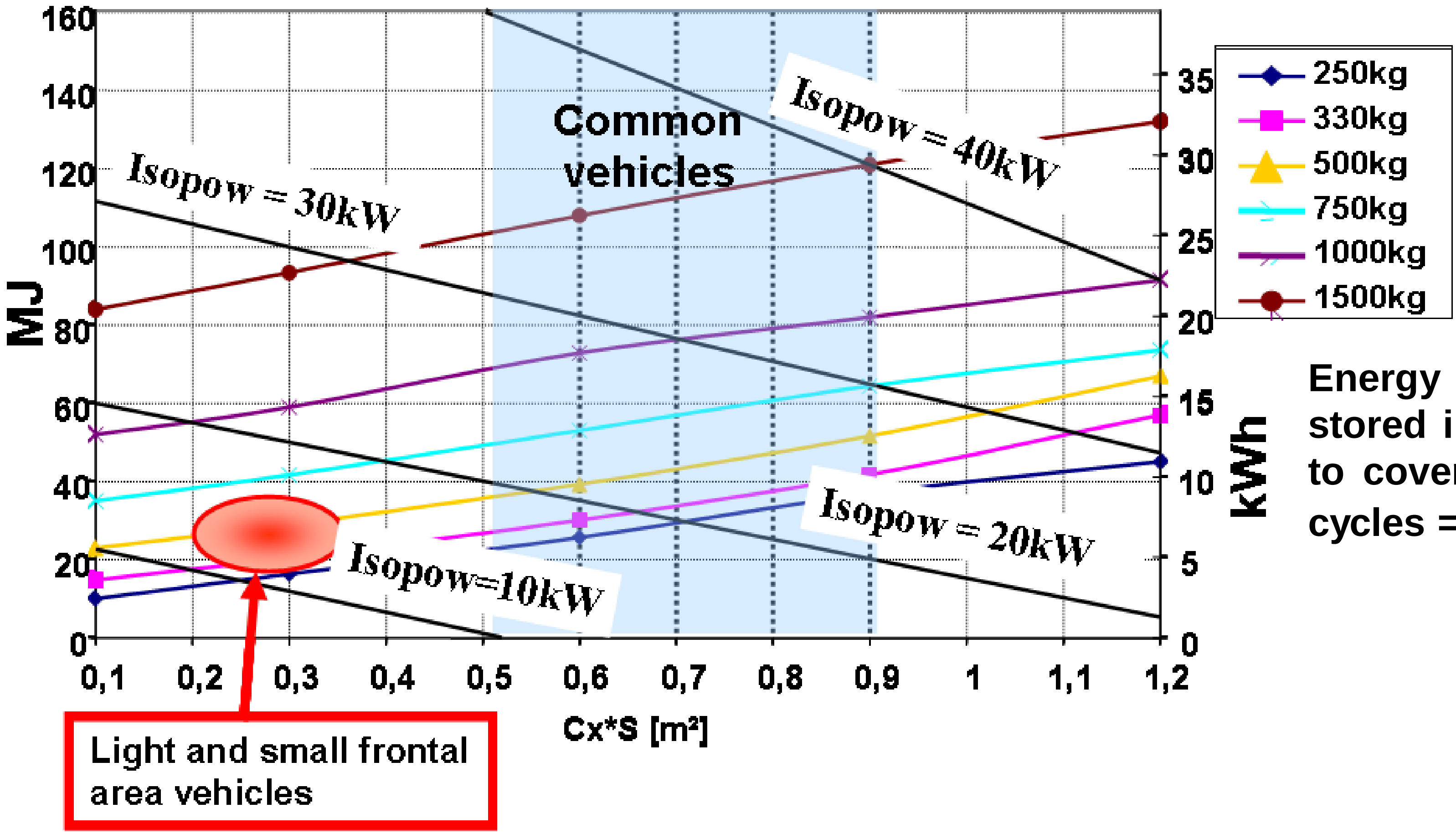
ρ=air density, **S = frontal area,**
Cx= aero resistance

$$P_{friction} = \mu Mgv$$

μ=Tyre Rolling Resistance,
ν =velocity, g = acc.gravity

Internal losses PWT + 4 parameters to control: Mass, frontal area, aero drag, TyreRR

Small frontal area and low aero-drag



Energy to be stored in batteries to cover 10 NEDC cycles = 100km

An Isopower line is the total nominal power required at the e-motors to reach 120km/h of the NEDC cycle (note: peak power is 2-3 times the nominal power).

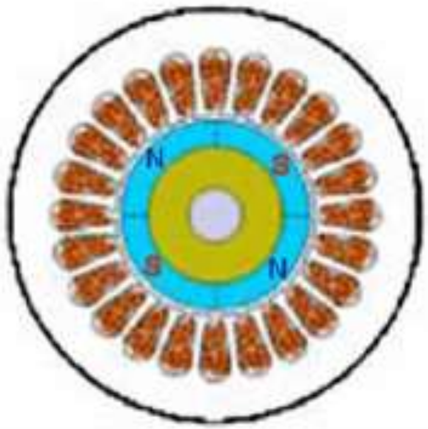
Energy per typology of EV

Type	LEVs (E-Bike) Speed limit	LEVs (other) Speed limit	Micro Cars NEDC	Small Cars NEDC	Mid size Cars NEDC	Large Cars NEDC
Weight kg	20-50	50-300	300 -700	700 -1100	1100-1500	1500-2000
Energy kWh/100km	1-2	2-3	4-9	9-12	12-18	18-25
Kg/100km of Li-ion battery pack level (180Wh/kg)	6 -11	11-17	23-50	50-67	67-100	100 -139

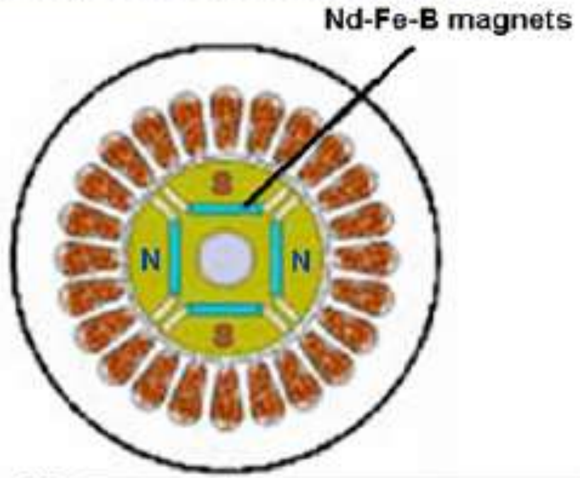
Sales of LEVs (e-bicycles, e-scooters and other two-wheelers) is already driven by lower purchase prices, low cost of operation and lack of harmful emissions. The new focus is on micro and small cars!!

PM for more efficient motors

Surface Permanent Magnet

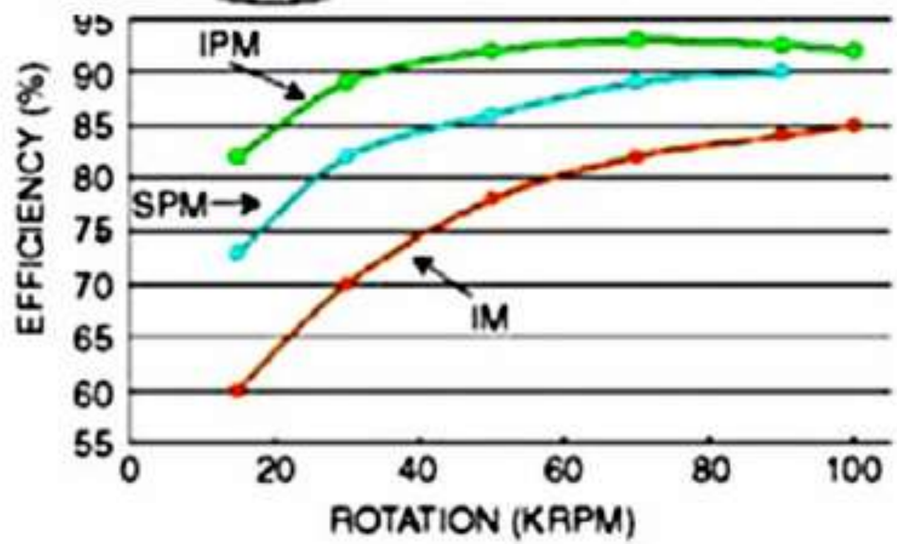


Interior Permanent Magnet



- High-performance Nd-Fe-B sintered magnets are playing an increasingly important role in automobile and electric appliances driven by the issues of energy saving and efficiency.

- In an *air-conditioner compressor motor* Inserted permanent magnet rotor has better efficiency than a surface mounted rotor.

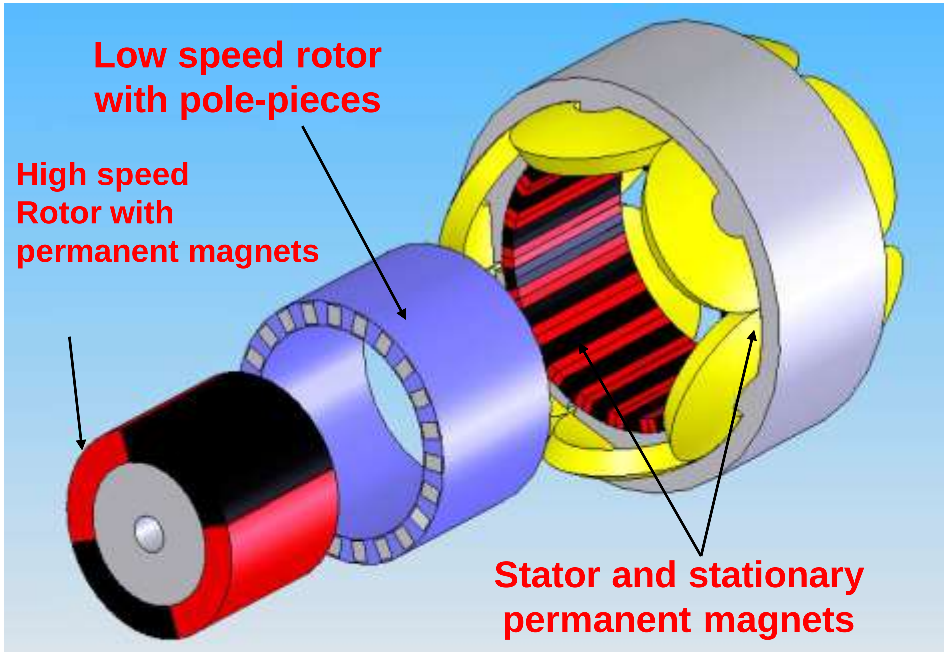


Y. Matsuura. *J. Magn. Magn. Mater.* 303 (2006).

P-MOB: Motor innovation

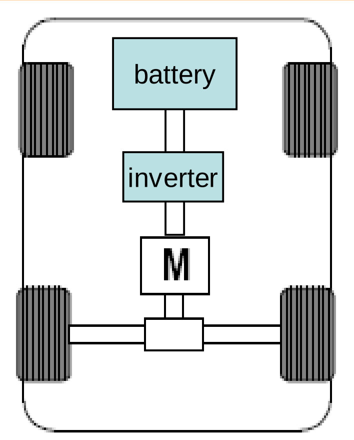
Electric drives based on PM design with integrated gearing and integrated electronic drive

High torque, low speed at wheel
To reduce gearing and improve drive train efficiency, torque density has to be significantly increased.
The novel pseudo direct-drive PM machine integrates a "magnetic gear" in the machine and hence increases torque density by a factor of (4~10)



Univ.Sheffield- Magnomatics

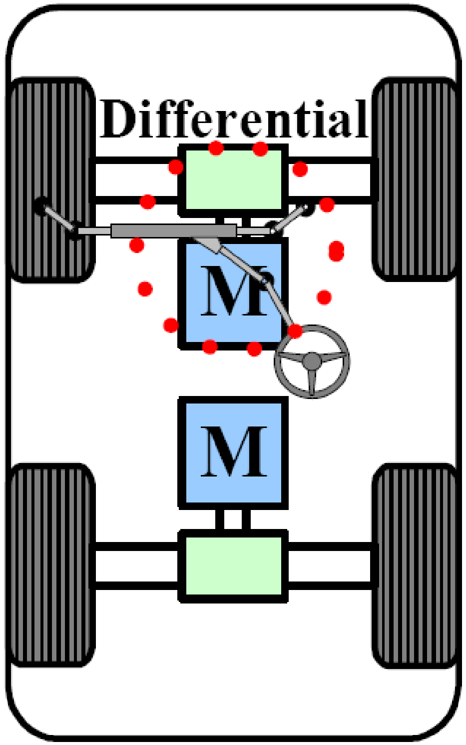
Problems of conventional EV Power train



- Centralised mass distribution affects vehicle dynamic performance and constitutes a safety concern.
- Transmission losses in cables and gear box reduce the system efficiency
- Cable weight increases the total vehicle mass which in turn increases power rating of the propulsion system.
- High EMI pulses due to dynamic peak current produce interference to control electronics and pose a serious threat to their operation.
- Unshielded low frequency electromagnetic field may cause health hazard to passengers.
- Single point failure will lead to complete loss of traction power, and potential accidents
- High DC-Link voltage increases the cost and complexity of the energy storage, reduces their efficiency and reliability and further deteriorate EMI as voltage stress and dv/dt increase

And Low efficiency, complex and costly cooling

Fail-safe power train architecture



The distributed traction system for next generation of EVs can be made fail-safe. The key features of the fail-safe scheme are:

Inherently fault-tolerant ---- failure in one drive will not significantly affect the vehicle performance

Fail-safe --- no spin or complete loss of power will take place

Freedom in distribution of traction torque according to weight shift, --- further improvement in traction efficiency

Moderate high efficiency in energy recovery

Improved traction control on low friction road and safety enhancement

P-MOB first selection

Ergonomic

Designed to be five stars on ergonomics, easy access for the driver…

but not only for humans

On-board "Smart" Photovoltaic

Conservative average daily energy produced by on-board solar cells in Torino* with existing technologies could be as much as 1.8 kWh/day (657 kWh/year).

Mid size EV 657kWh/(150Wh/km)= 4380 km/year

Small size EV 657kWh/(130Wh/km)= 5053 km/year

Micro EV 657kWh/(80Wh/km)= 8212 km/year

*Average annual insulation 3.8kWh/m^2/day

The Goal is to produce > 2kWh/day on the annual average insulation of South Europe 5kWh/m^2/day.

Low weight and low cost flexible materials for both Silicon crystalline and thin film PV technologies

P-MOB: V2G+I

Wind Plant

PV Plant

PV House

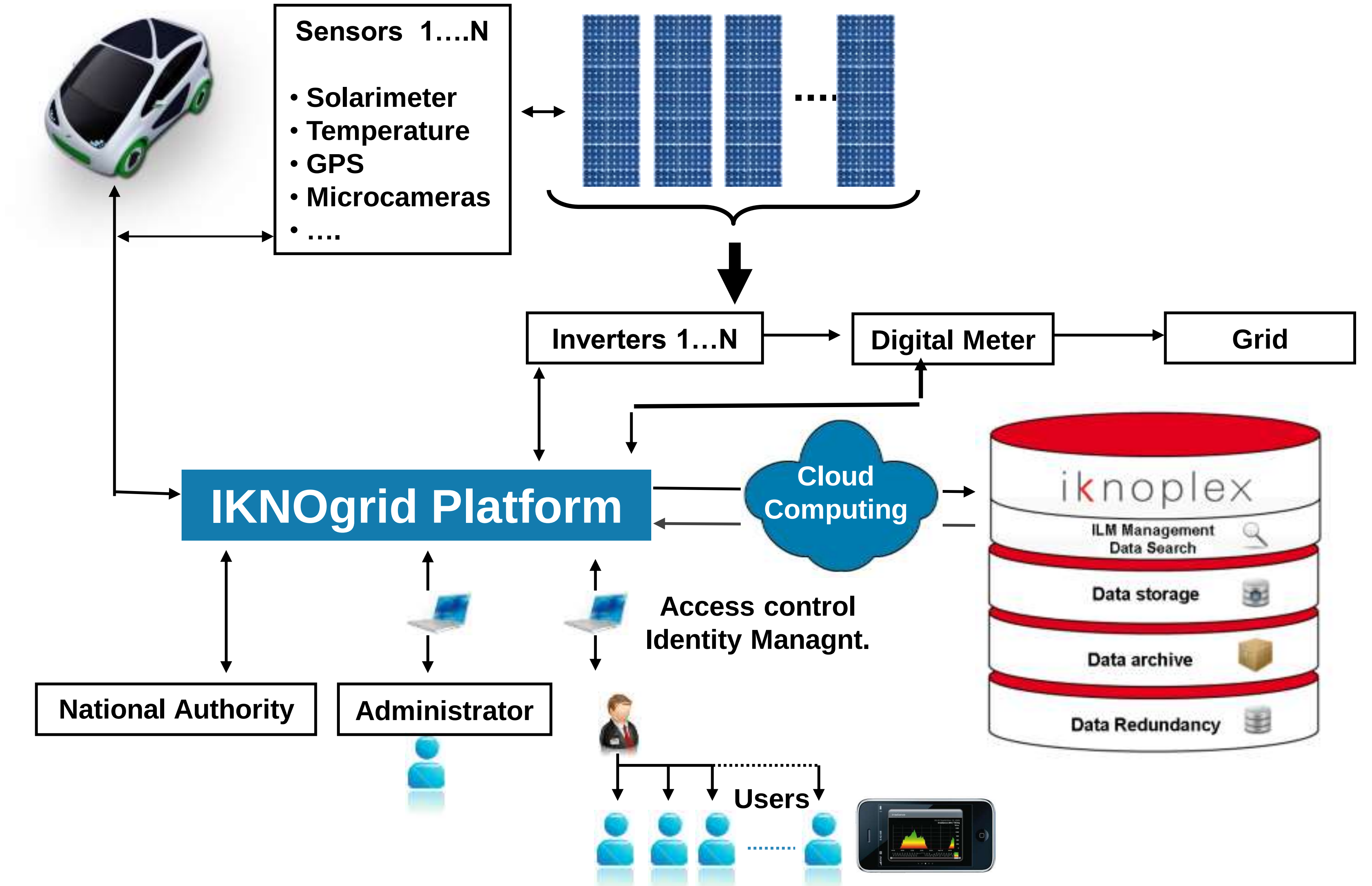
E-Car

Remote Control System

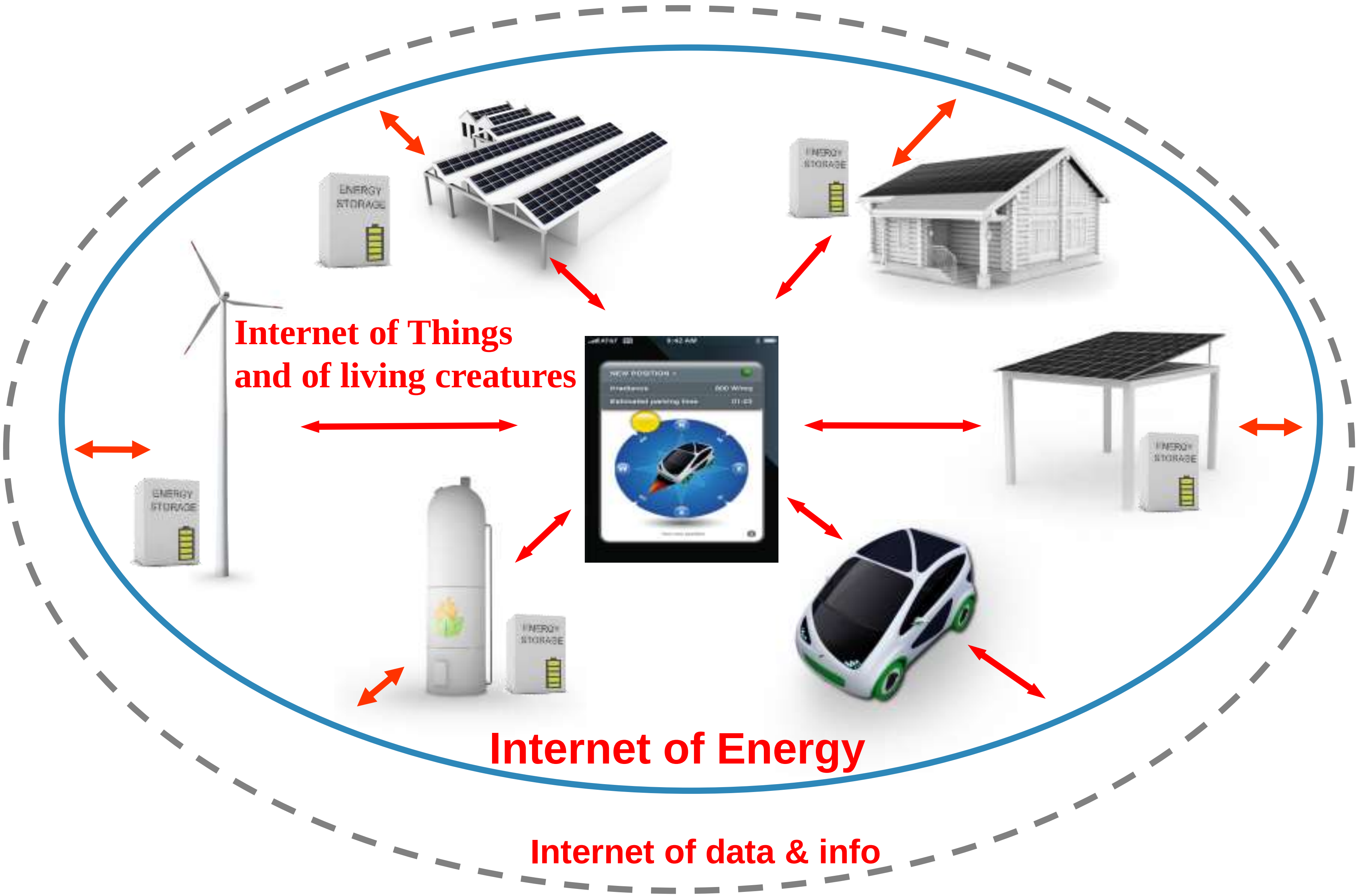
On computer

On a smart phone

Architecture



V2G+I: Web Centric Embedded Platform



P-MOB: V2G+I


AT&T 3G
9:42 AM
AUTONOMY >
Remaining charge 18,4 kWh
Autonomy NEDC Cycles 05:36
Remaining Km 50 Km
Urban autonomy 65 Km I 03:26
Extra-Urban autonomy 38 Km I 05:54
CLOSEST CHARGING STATIONS >


AT&T 3G
9:42 AM
Phylla Charging Station
Pho Cyclo
Map
Satellite
List


AT&T 3G
9:42 AM
POSITION >
SUGGEST PARKING ORIENTATION >
N
W
E
S
Your actual position


AT&T 3G
9:42 AM
RESUME
ENERGY TRADED
Purchased
Sold
Profit
ENERGY TRADED >
PROFIT >
FUEL SAVED >
CO2 SAVED >

P-MOB : Summary of expected outputs

The project addresses the design and development criteria of EVs basic building blocks such as:

- **Implementation of Advanced V2G+I**
- **On board V2G multifuctional charger for V2G**
- **Low weight and aerodrag** body,

- **Solar panels distributed on both horizontal and vertical surfaces** with smart adaptive electronic for a continuous optimization of the output under shadowing

- Overall system optimisation **based on two PM motors** for enhanced efficiency of the Drive train,

- **Finalisation** trough a demo vehicle for urban mobility integrating the proposed concepts.
- Guidelines, IPR and experience upon which to build a world-leading EU position to track and exploit the global uptake of FEV mobility.