SEVENTH FRAMEWORK PROGRAMME

P MOB

Integrated Enabling Technologies for Efficient Electrical Personal Mobility

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CENTRO RICERCHE FIAT · MAZEL GROUP · IFEVS · The University Of Sheffield. · SIEMENS · POLI MODEL · Magnomatics

Aims and key innovations

P⚡MOB

- **Aims to break the link between the growth in transport capacity and increased demand on oil, increased fatalities, congestion and pollution**.
  - Develop **key enabling technologies for Light Electrical Vehicles with** embedded on-board photovoltaic (PV) capable of providing >**20 km/day solar energy** in southern EC countries
  - Implement **a fail-safe power train architecture** with high efficiency, **advanced energy management** and **V2G**
  - Address the needs of urban mobility whilst also encompassing characteristics suitable for extra urban mobility
  - Reduce system complexity with a focus on the key essentials
  - Apply advanced systems integration including
    - ✓ Thin film solar cells;
    - ✓ **Power dense, highly efficient e-motor and advance torque control**
    - ✓ Integrated power-energy management
    - ✓ Distributed battery packs
    - ✓ Technologies to facilitate ‘sell-buy electricity’ by adaptable vehicle to grid connections.

Classification of means per mass and energy consumption

Type	Light EVs (e-Bike)	Light EVs (other)	Micro Cars light-heavy Q-cycles	City Cars NEDC	Small Cars NEDC	Mid size Cars NEDC	Large Cars NEDC
Weight kg	15-50	50-350	350-650	650 -1000	1000-1300	1300-1500	1500-2000
Energy kWh/100km	1-2	2-4	4-8	9-12	12-15	15-18	18-25
kg/100km of Li-ion battery pack (180Wh/kg)	6 -11	11-17	23-50	50-67	67-85	85-100	100 -150

P-MOB

Currently 70kg of battery pack over a range of 150km

(near term < 60kg)

Toward Clean, Safe and efficient Electrical Mobility

Smart flexible monocrystal Silicon solar panels

Power dense, highly efficient motors & power converters

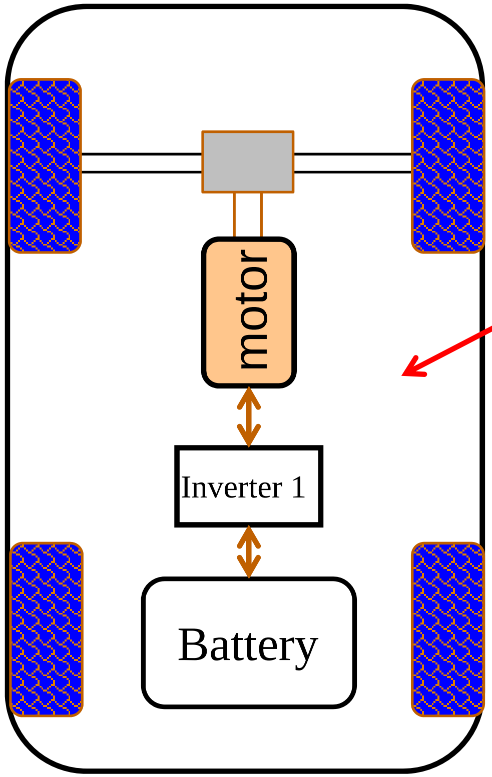
Lightweight and flexible lighting systems with integrated PV, Batteries, RF link and Photodiode.

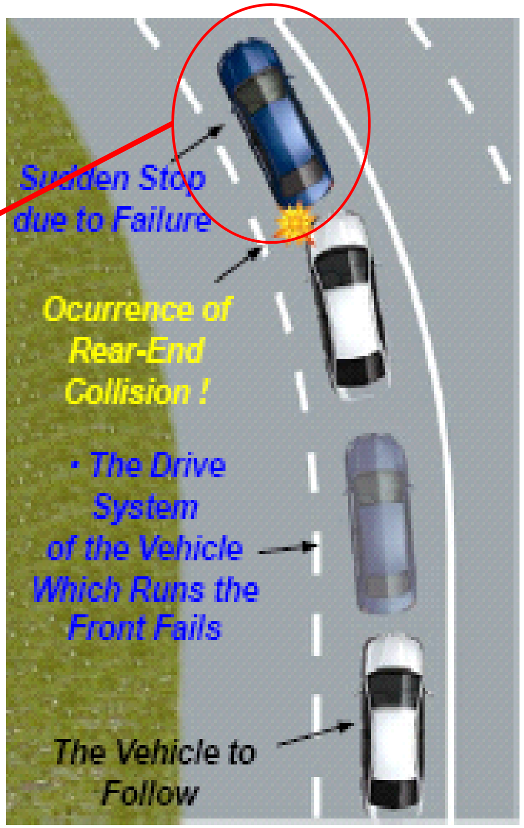
Fail-safe electrical power train architecture

Low rolling resistance tyres

Light weight & resistant composites

- A single point failure of any key component in single drive EV power train may result in a serious accident

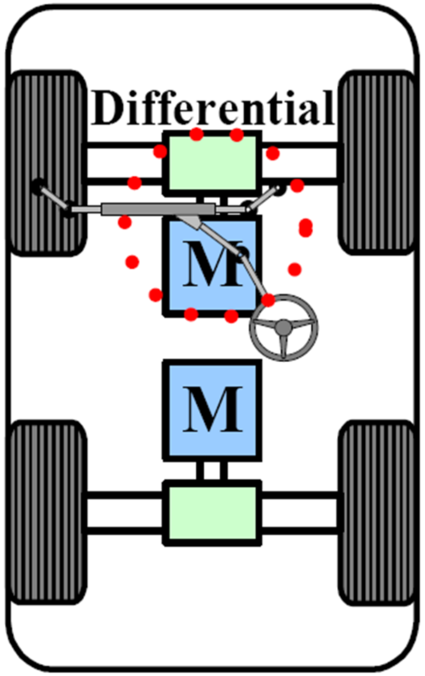




Fail-safe, distributed EV power trains

P-MOB

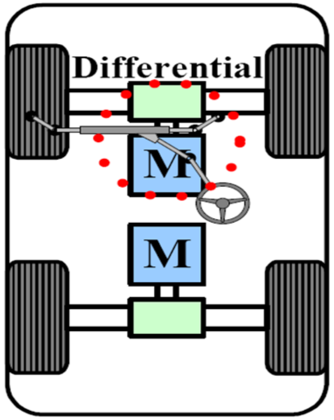
- Front and rear drives via two differentials adopted in **P-MOB**

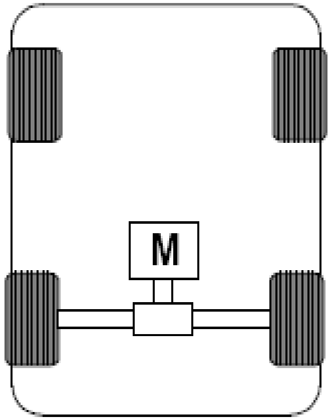


- Loss of power in any single drive will not lead to complete loss of propulsion, nor any steering difficulties
- 4-wheel drives with distributed traction enhance safety in adverse weather conditions and slippery roads

Efficiency gains of distributed drive

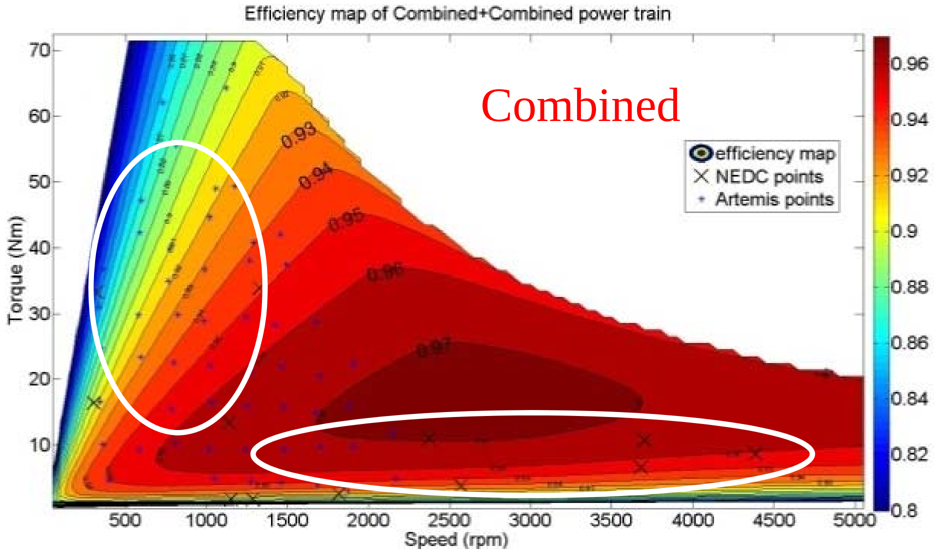
- The distributed power train reduces energy consumption in the tyre slip compared with the single motor drive scheme.



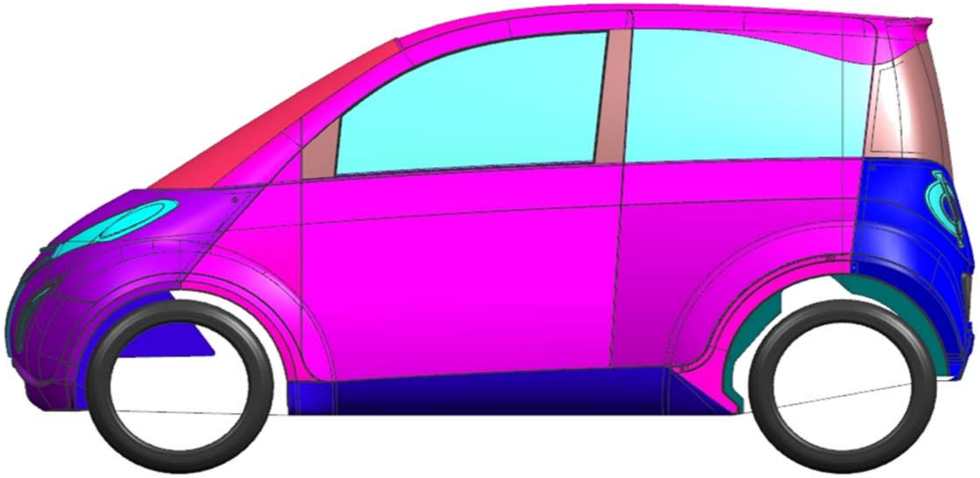


Energy consumption (NEDC)	Value	Unit
Concentrated drive	1643.3	kJ
Distributed drive	1630.1	kJ
Energy Saved (0.8%)	13.2	kJ

- Front motor optimised against NEDC, rear motor against Artemis Urban to achieve best overall efficiency
- Optimal torque distribution saves further ~ 4% energy over NEDC

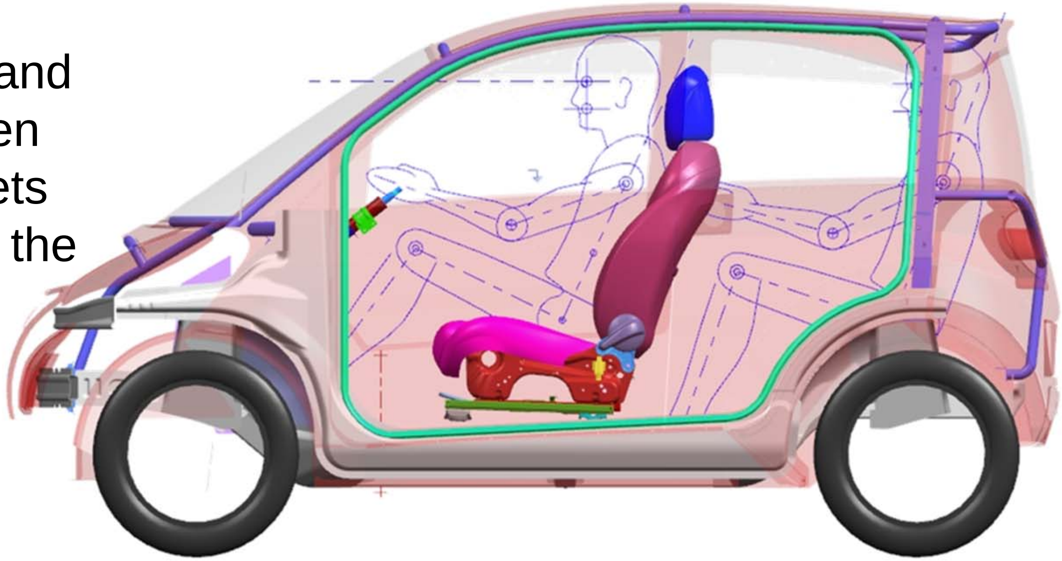


Vehicle Architecture



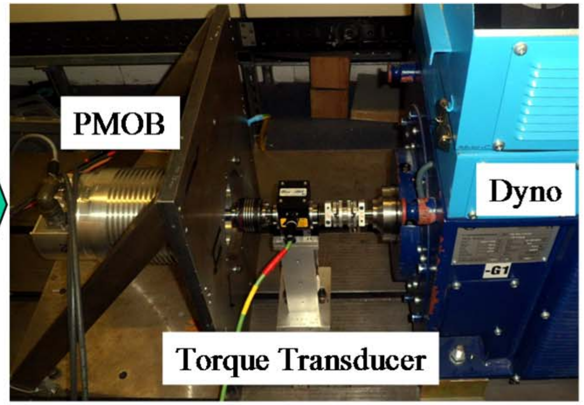
- The vehicle structure has been developed to allow good safety performance

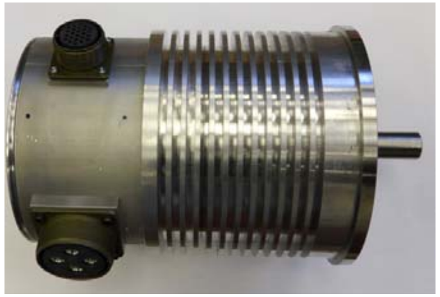
- Composite materials, low cost and volumes technologies have been considered to achieve the targets (safety and weight) and assure the economic affordability

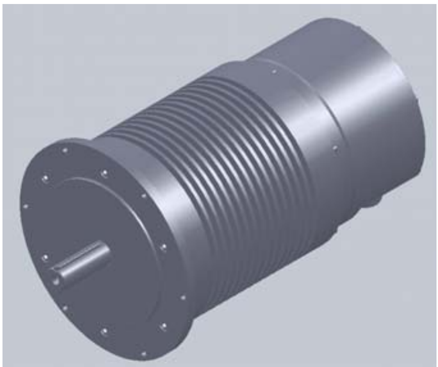


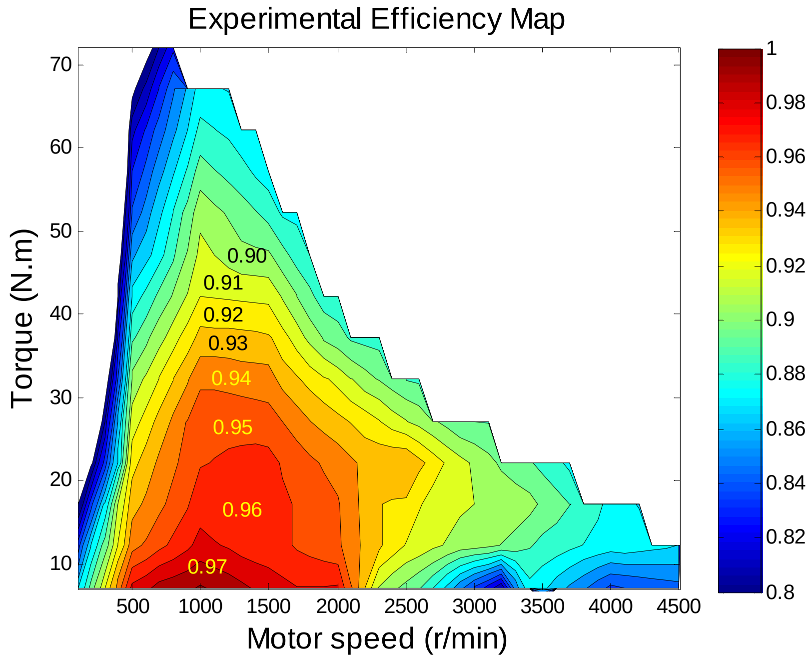
High efficiency drive train developed

P MOB



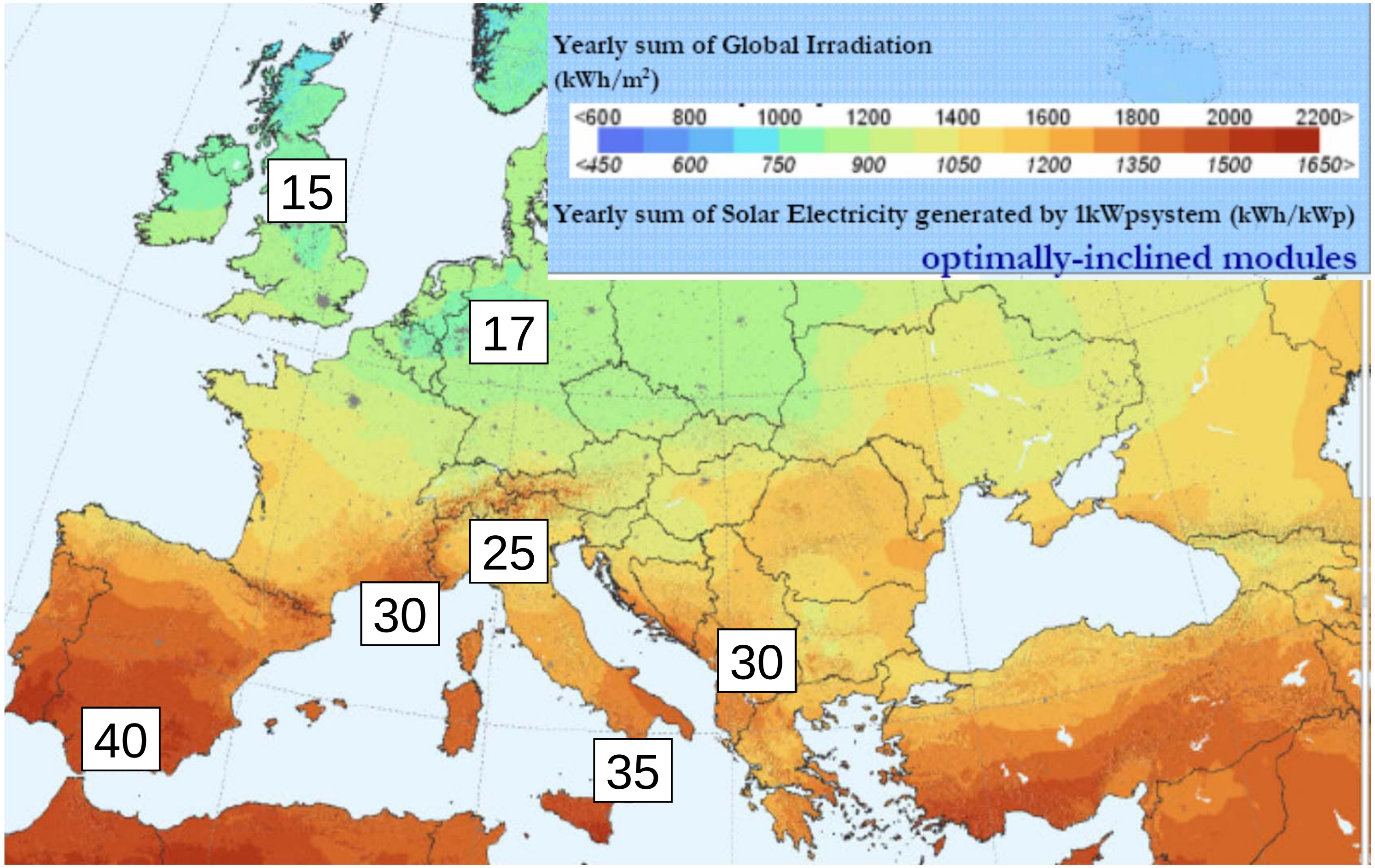






Potential of solar energy for mobility

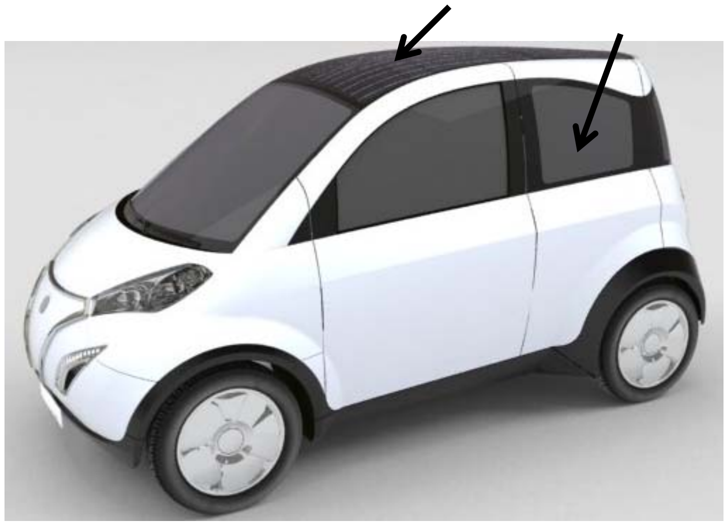
- Average daily mileage potentially provided by solar energy harvested by a small e-car



Solar energy harvesting

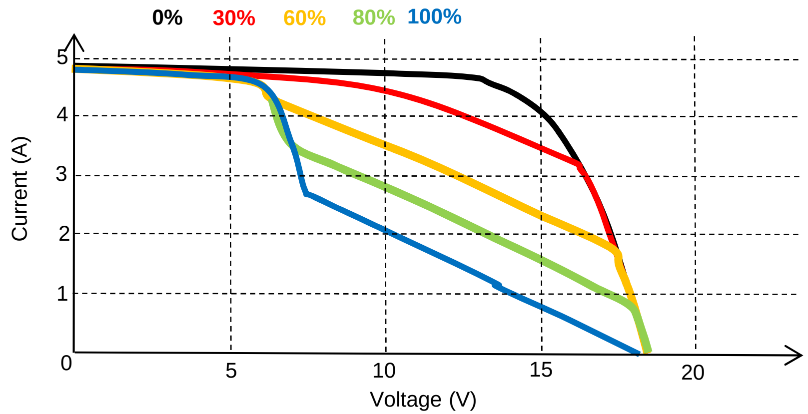
- Photovolatic panels allow to harvest the solar energy when both driving and parked.
- Crystalline silicone has been used due to high efficiency.
- Double curvature is achieved by separating solar cells to into small linear portions.
- High efficiency is achieved by connecting optimal number of cells in series with distributed electronic control

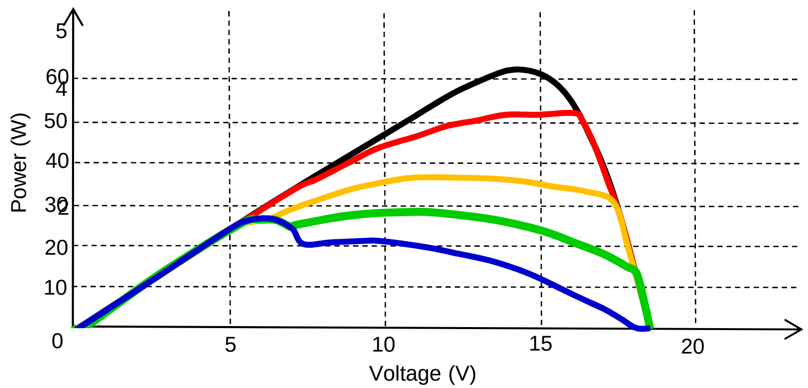
PV Surfaces

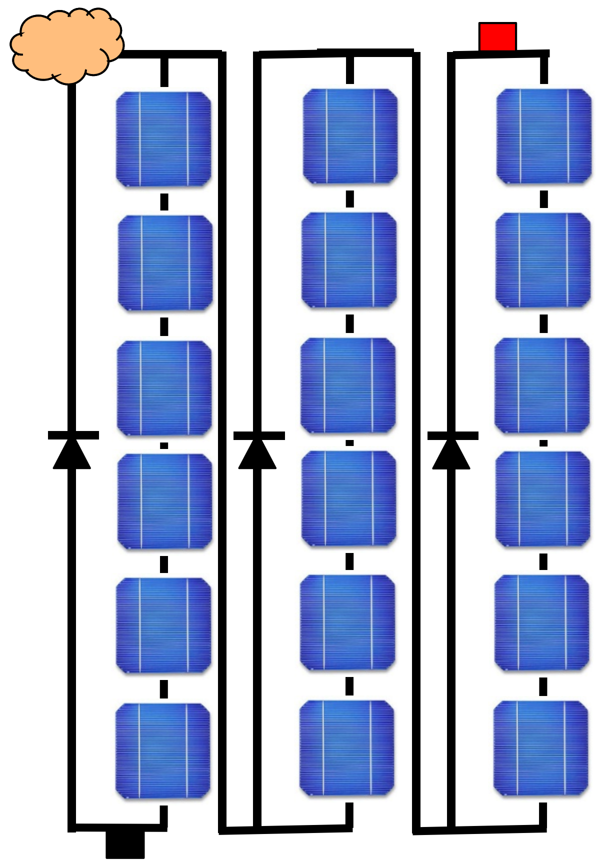


- At ambient temperature and with an irradiation of 1000 W/sqm average conversion efficiency measured at bench is about 20%
- Target surface: 2.5 sqm
- Target energy: 1,2kWh/day average

The need for smart PV electronics

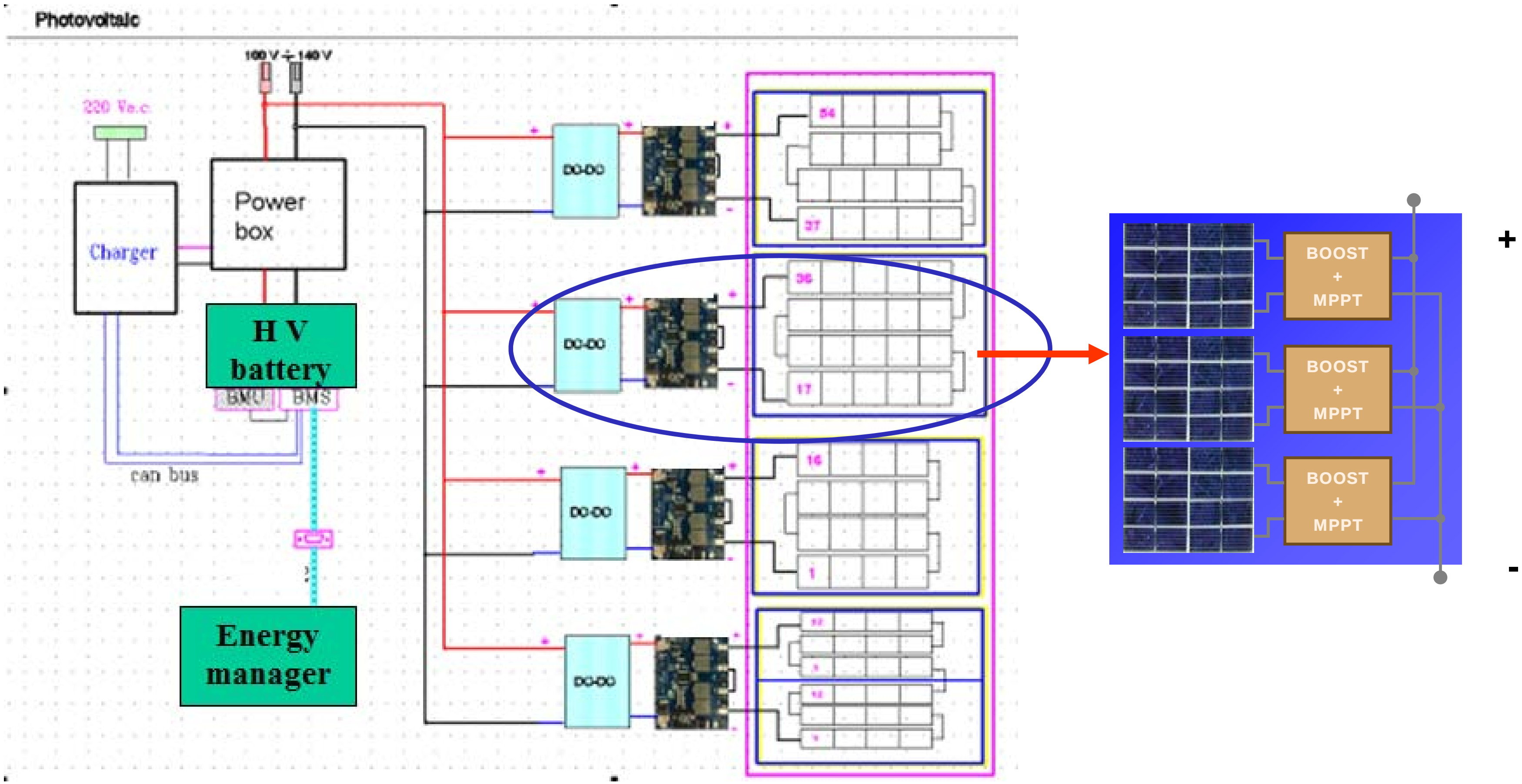






- 70W panel of 36 cells with three bypass diodes.
- 35 cells are irradiated with 1000W/m^2, one cell is partially shaded from 0% to 100% with 10W/m^2 remaining irradiation (diffused). Covering 100% **one cell only**, the peak power of the 36 cells is **less than half**.

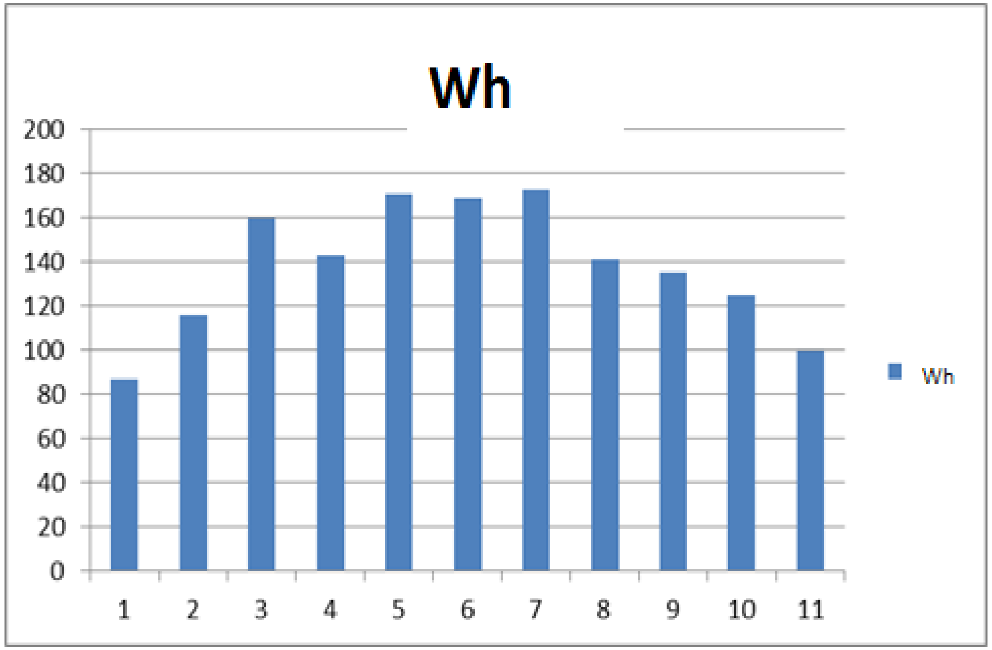
Solution: P-MOB Smart Photovoltaic



- Smart Photovoltaic employing system partition, lamination of cold diodes, distributed MPPT with adaptable boost electronics, second stage boost convertion wiht smart charging into the high voltage battery.

P-MOB: On-board "Smart" Photovoltaic

Measurements confirm that the P-MOB vehicle can run the targeted 20km a day at a constant speed of 50kmh (speed at which the vehicle consumes less than 50Wh/km).



1600/75=21km/day

NEDC cycle

Measured power comsumption
With full weight 800kg

- **Constant speed**
  - **50km/h: 48.37 Wh/km**
  - **100km/h: 107.30 Wh/km**
- **NEDC**
  - **No energy recovery: 80 Wh/km**
  - **Energy recovery 100%: 70 Wh/km**

Torino June 2012: Stored energy in the high voltage battery pack
1.6kWh/day month average

Prototype vehicle and milestones

Milestones set on:

- **First Fail-safe and efficient two motor powertrain**
- **First Smart photovoltaic capable of 20km/day on solar energy**

Thank you

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