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Paris
Nov. 2011

MEGEVH
French network on HEV's

http://l2ep.univ-lille1.fr/megevh.htm

« GENERALITIES ON ELECTRIC VEHICLES (EVs) & HYBRID ELECTRIC VEHICLES (HEVs) »

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L2EP, University Lille1, LTE, IFSTTAR,

MEGEVH network,

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Université Lille1 Sciences et Technologies

based on MEGEVH tutorial
at IEEE-VPPC 2009

IFSTTAR

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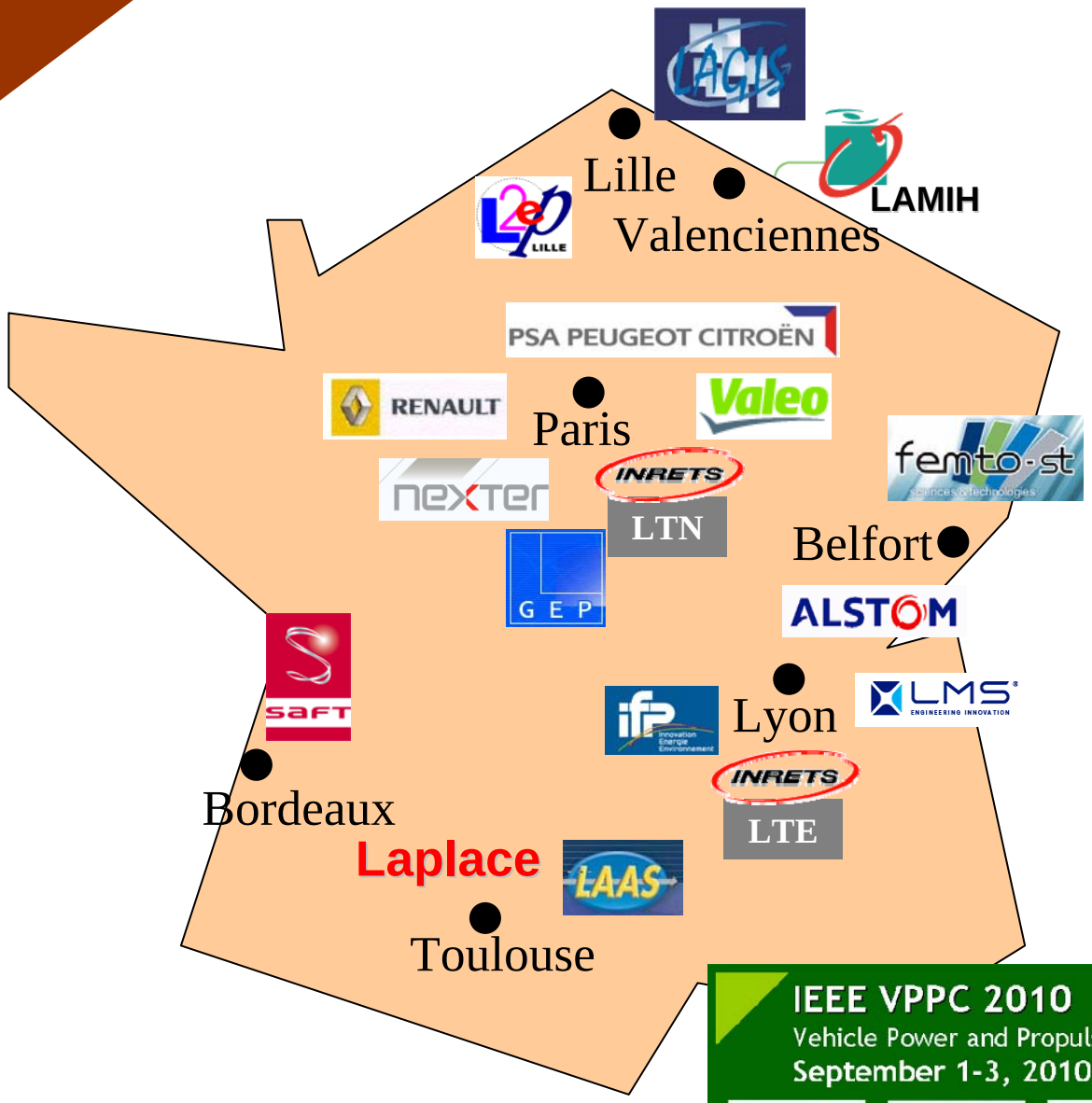
EVs &
HEVs

- MEGEVH network -



MEGEVH
French network on HEV's

(Energy management of Hybrid Electric Vehicles)

http://l2ep.univ-lille1.fr/megevh.htm

Coordination:
Prof.A. Bouscayrol

7 industrial partners
10 academic Labs

- MEGEVH philosophy -

Theoretical level

MEGEVH-macro

MEGEVH-strategy

MEGEVH-optim

MEGEVH-FC **MEGEVH-store**

HEV 1 – – – **HEV n**

Vehicle level

Development of methodologies
of modelling and
energy management

independently of
the kinds of vehicles

- **co-supersized PhD**
- **collaboration projects**

- **7 PhD Defended**
- **6 PhD in progress**
- **EMR as common tool**
- **generic model of HEV (Prize)**

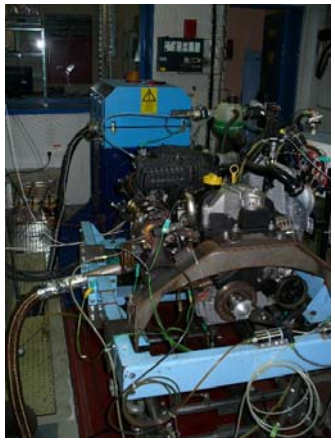
*Paper Prize Award of
IEEE-VPPC'08*

- Experimental platform, and vehicles -

platform « eV »
Real-time energy management

platform
« storage devices »

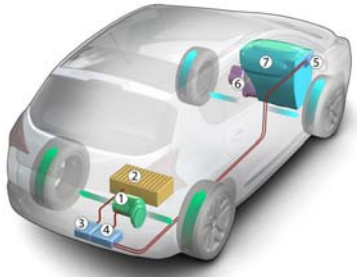
platform « propulsion »



Toyota Prius II

DPE 6x6

3008 HY4



- Outline -

1. CONTEXT OF EVS AND HEVS

2. DIFFERENT KINDS OF EVS AND HEVS

3. KEY ISSUES OF EVS AND HEVS

4. EXAMPLES OF RESAERCH PROJECTS

REFERENCES

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1. Context of EVs & HEVs

- Global warming
- Petroleum resources
- Thermal Vehicle

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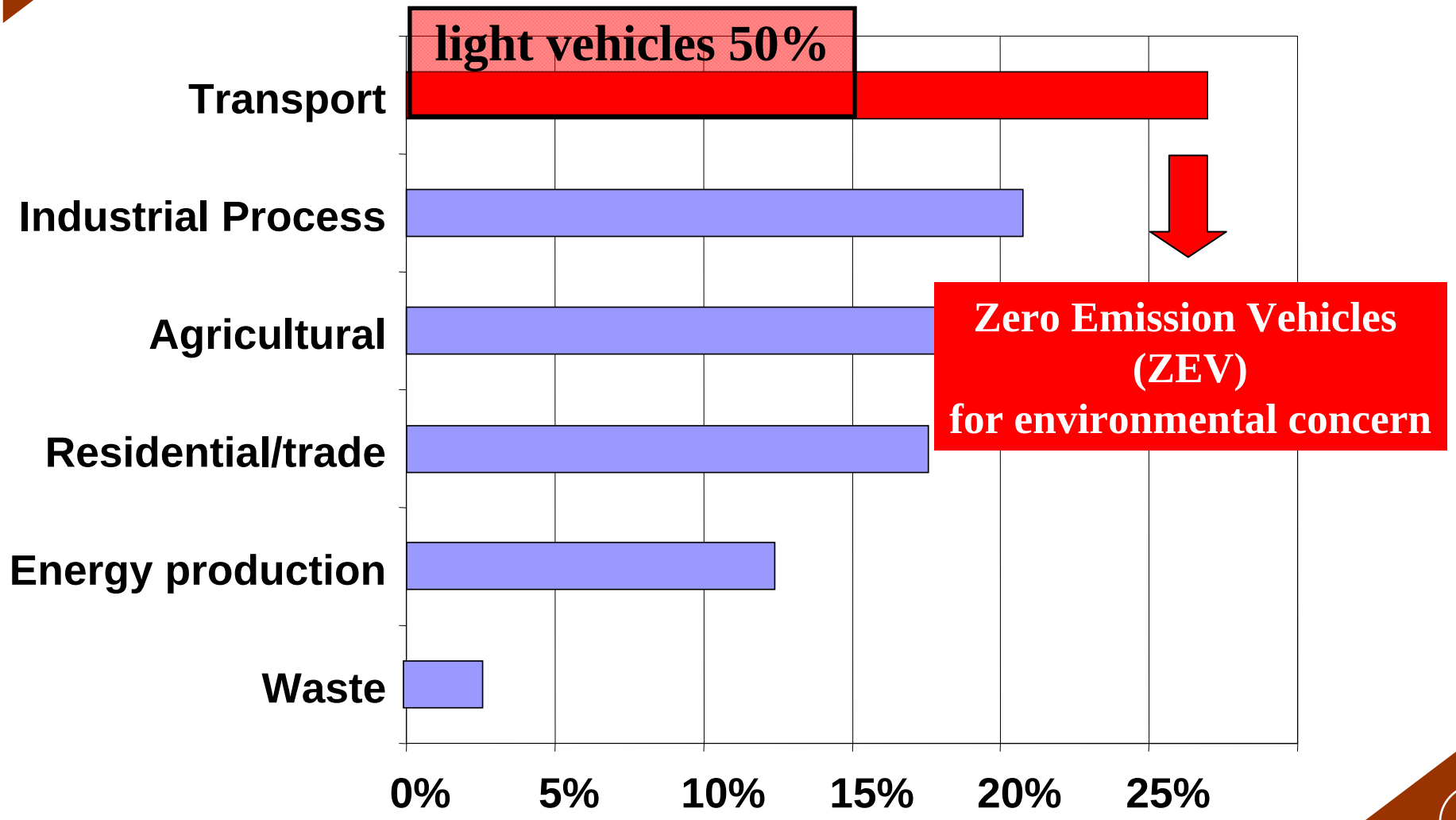
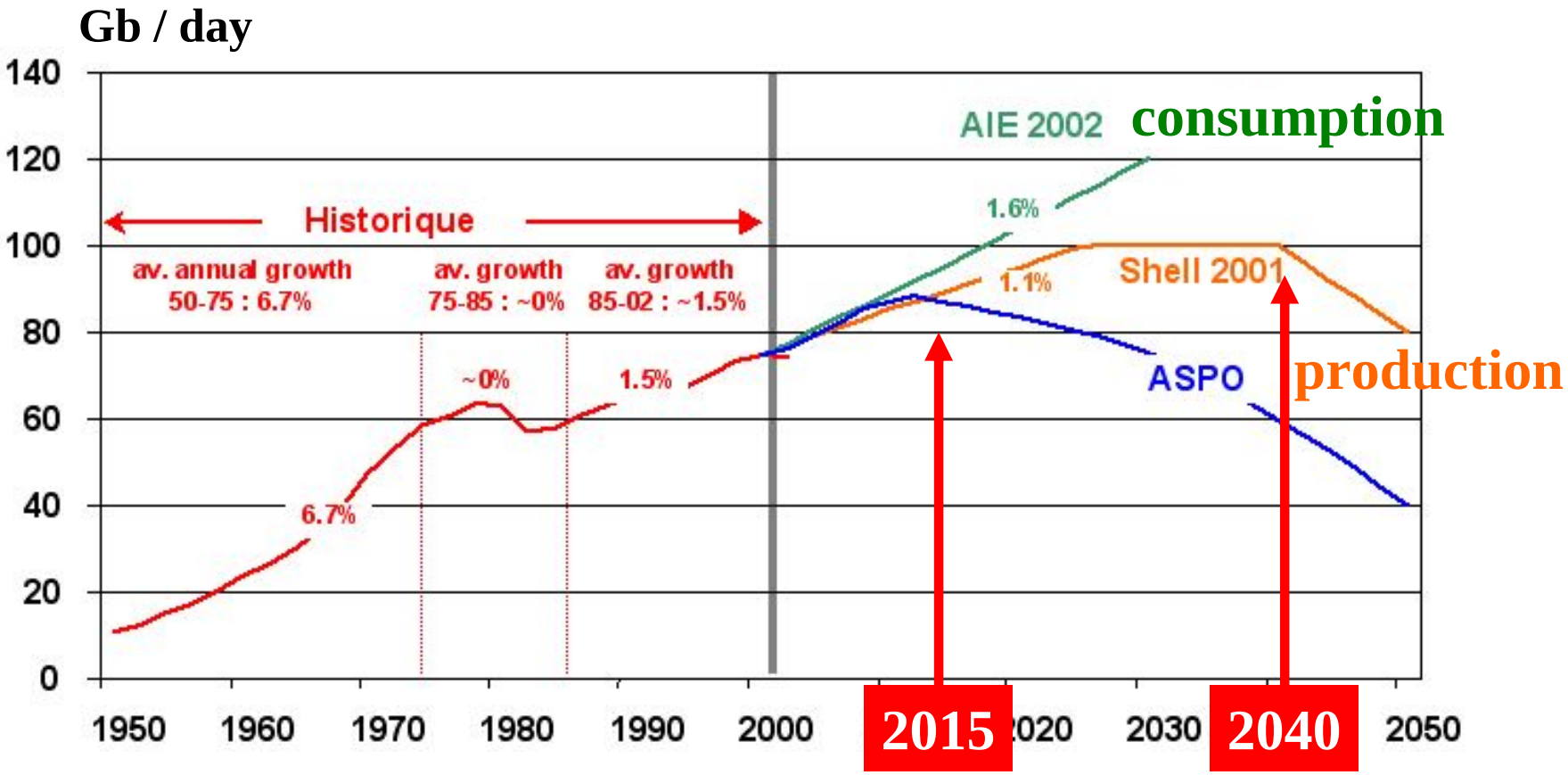
- Source of Green House Gases -



http://www.citepa.org/ http://www.ifen.fr/

- Petroleum consumption -



ASPO: Association for the Study of Peak Oil

AIE: International Agency of Energy

Peak Oil

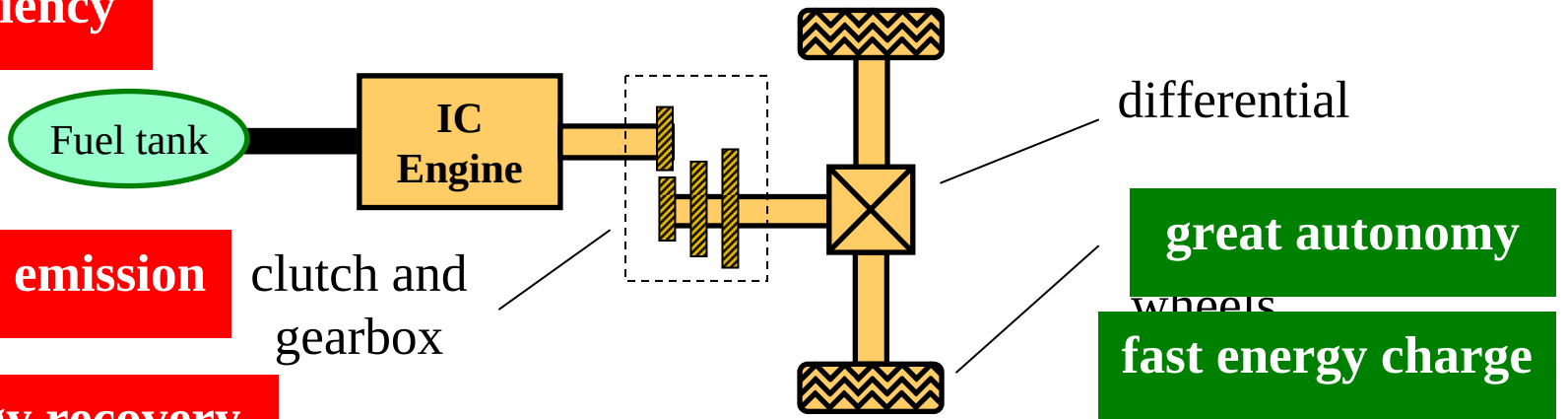
http://www.manicore.com/

- Thermal Vehicle -

low efficiency

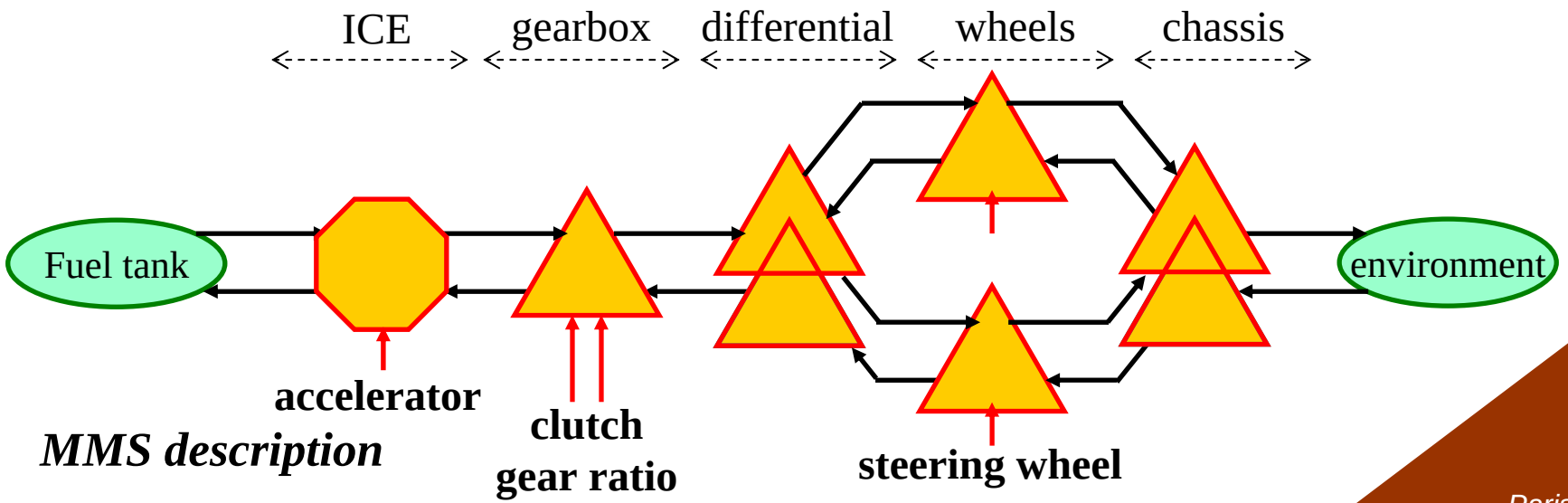
pollution emission

no energy recovery



great autonomy

fast energy charge



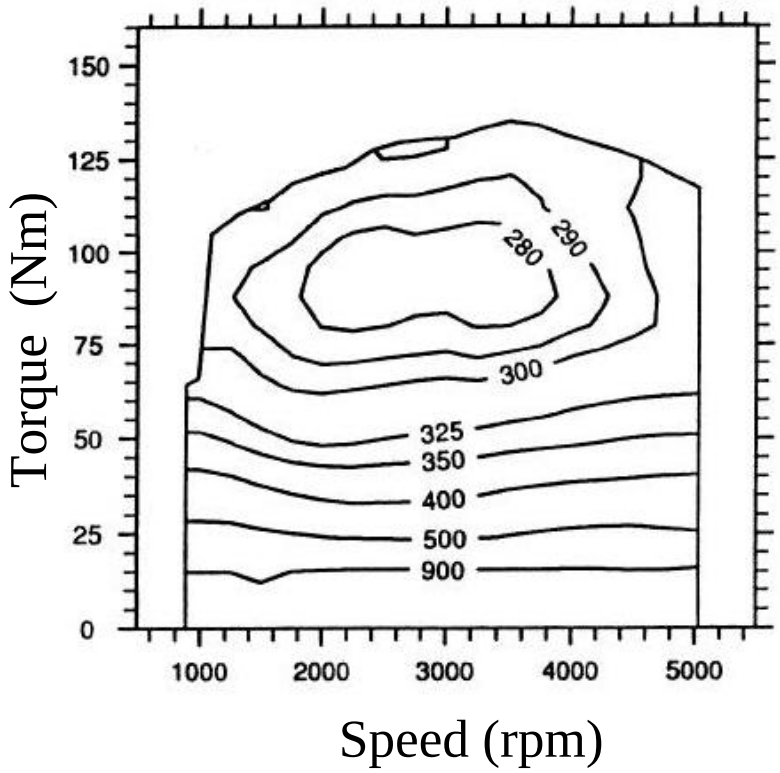
MMS description

- Gasoline engine -

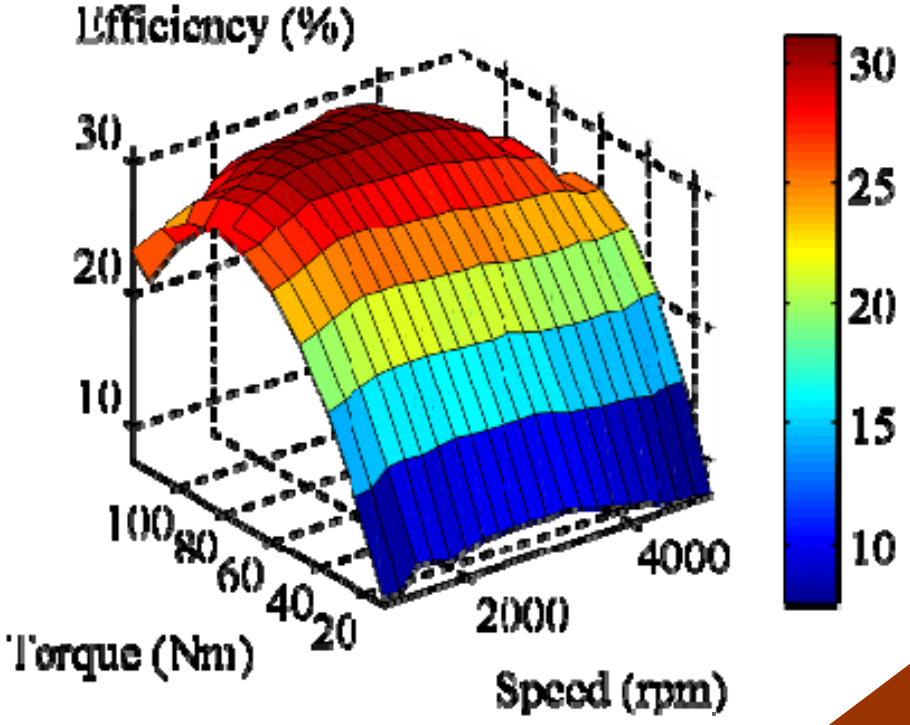
P_{max}=60 ch (45 kW) @ 3750 rpm T_{max}=119 Nm @ 3400 rpm

(1700 cm^3)

Iso specific consumption (g/kWh)



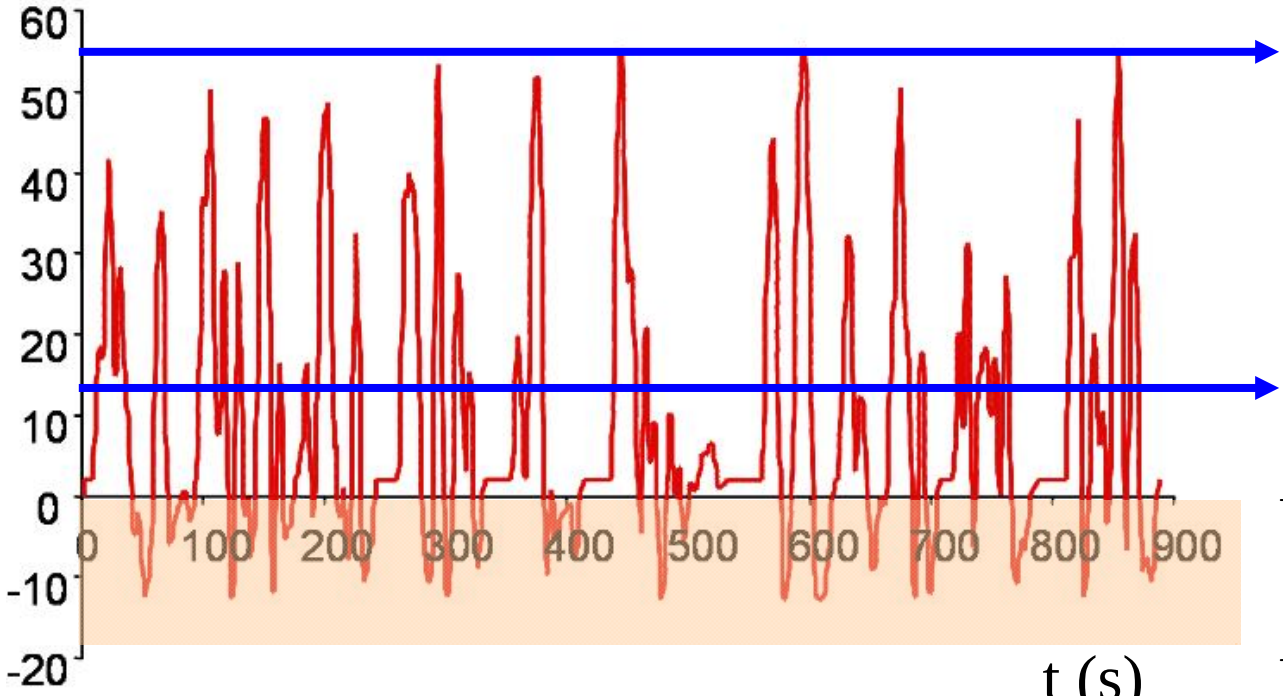
Efficiency map



- Power of a thermal vehicle -

ICE Power (kW)

Example of an urban drive cycle



P_{max} = 60 kW

oversizing

P_{mean} = 15 kW

P < 0

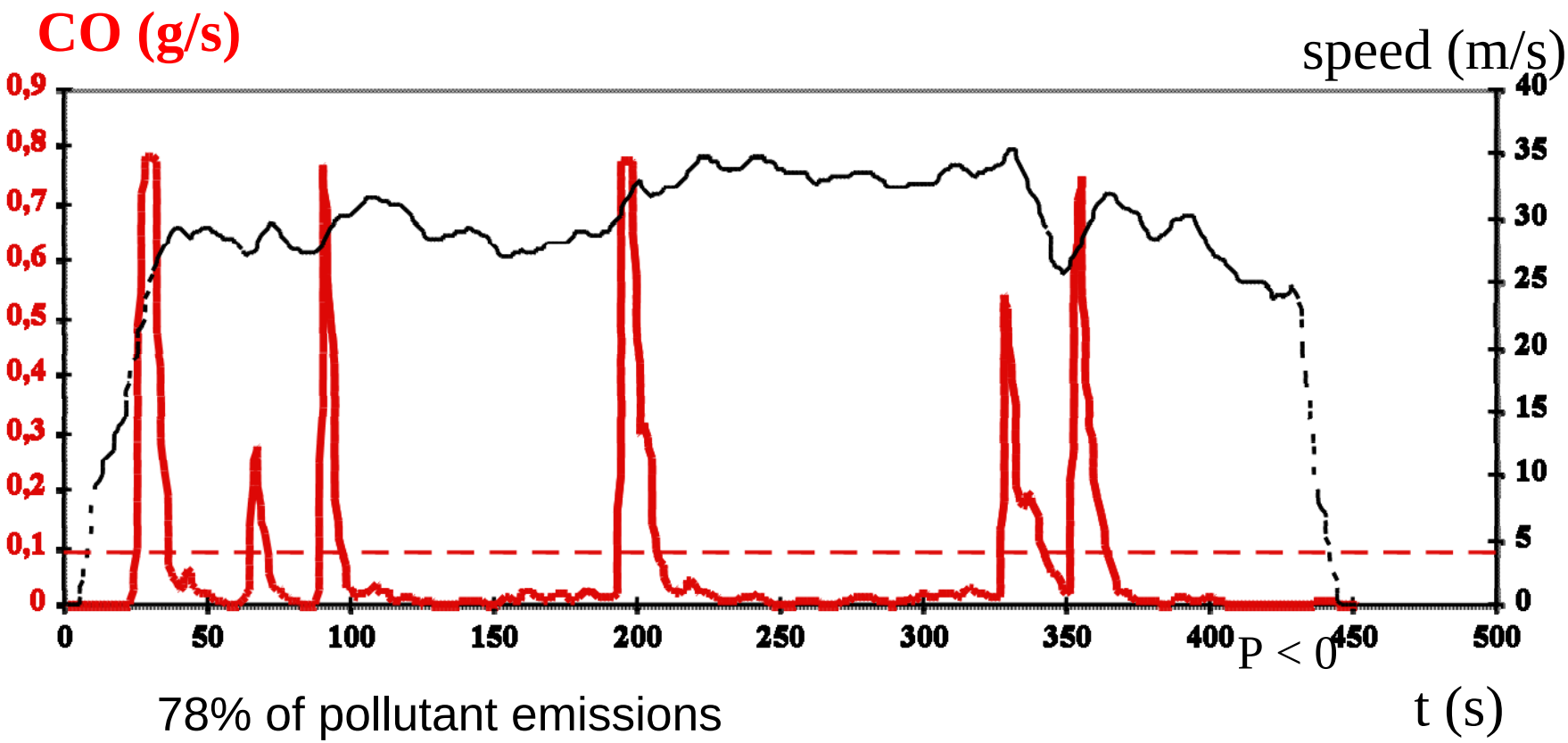
Energy loss

Interest of a system which:
- delivers peak power at high efficiency
- enables energy recovery

http://www.inrets.fr/

- Pollution of a thermal vehicle -

Example of a highway drive cycle



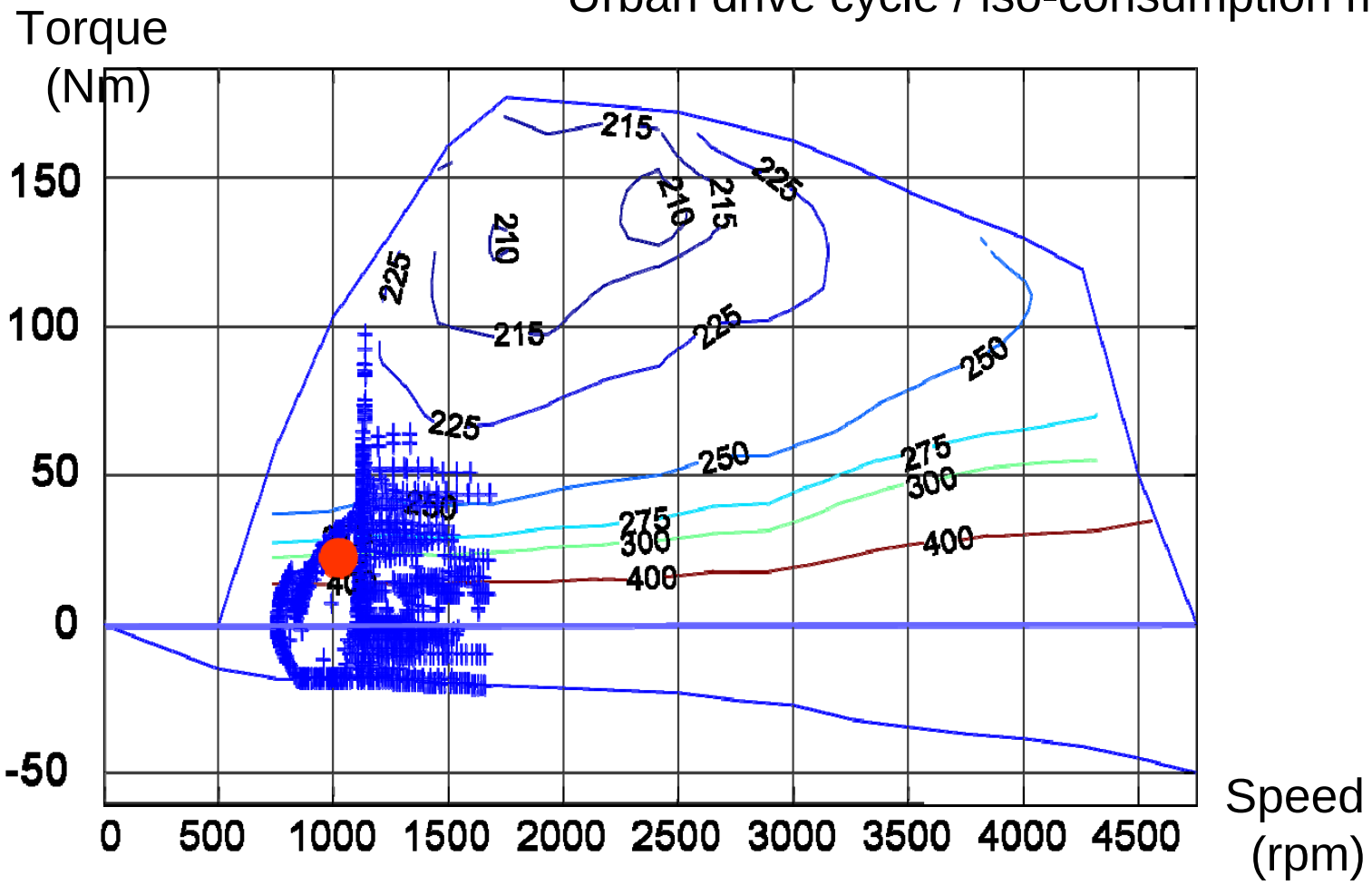
78% of pollutant emissions
during 14 % of the cycle

Interest of a system which:
• enables transients at high efficiency and low emission

http://www.inrets.fr/

- Operation of an ICE -

Urban drive cycle / iso-consumption map

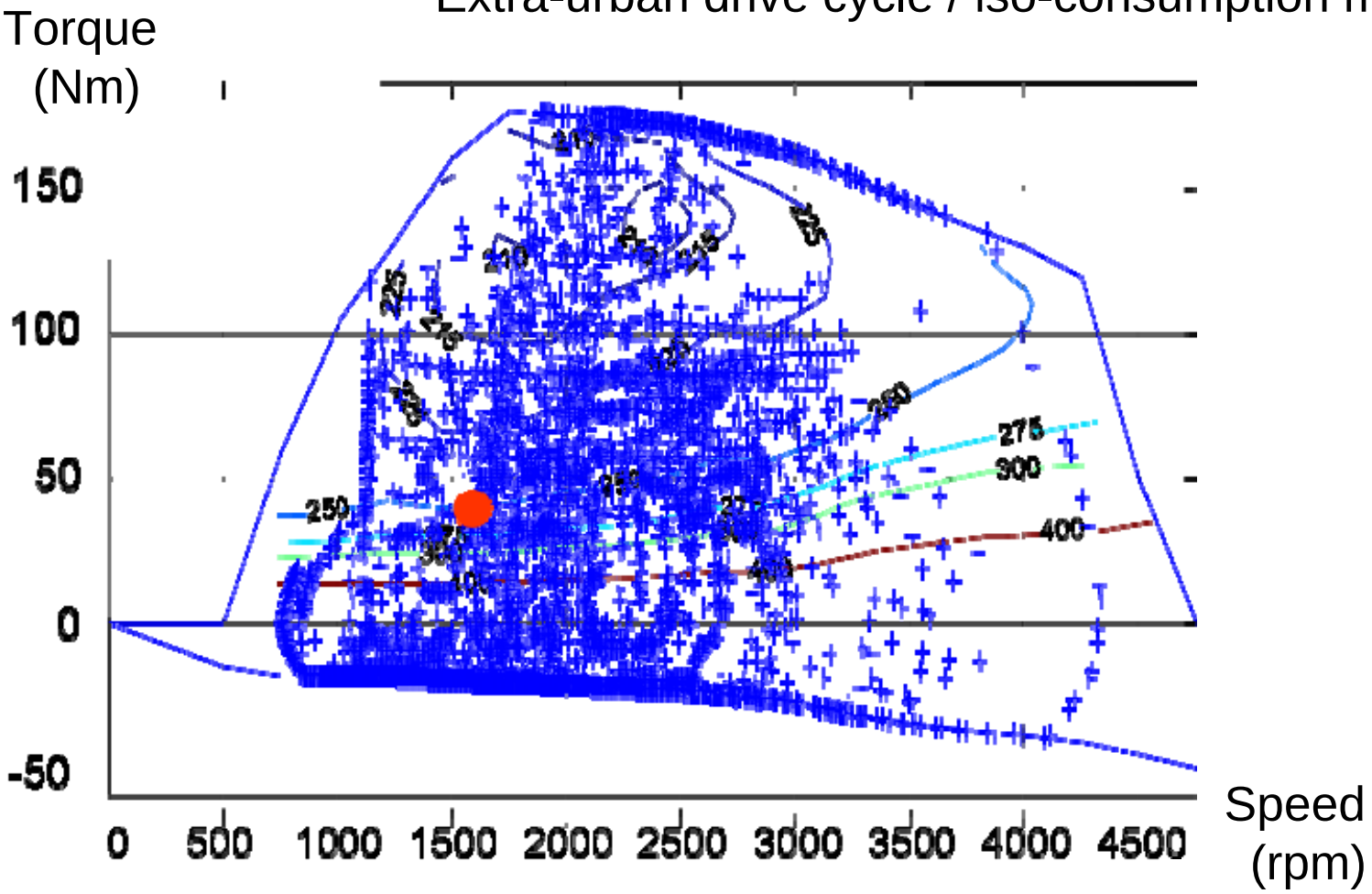


● mean efficiency ~12%
(88% of losses!!)

http://www.inrets.fr/

- Operation of an ICE -

Extra-urban drive cycle / iso-consumption map



● mean efficiency ~20%

http://www.inrets.fr/

- Future Vehicles? -

- Thermal vehicle with bio-fuels
  (coupling energy & food? water requirement? Etc)
- Electric Vehicles
  (production of electricity? autonomy reduction? Etc)
- Hybrid Electric vehicles
  (increase of prize? need of fossil fuel? Etc)
- Fuel Cell Vehicle
  (increase of prize? hydrogen production? Etc)
- Etc.

No ideal and unique solution

but also

- A more reasonable mobility!
  (reduction of travels? Increase of common transport? Etc.)

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2. Different kinds of EVs & HEVs

- Electric Vehicles
- Hybrid Electric Vehicles
- Fuel Cell Vehicles

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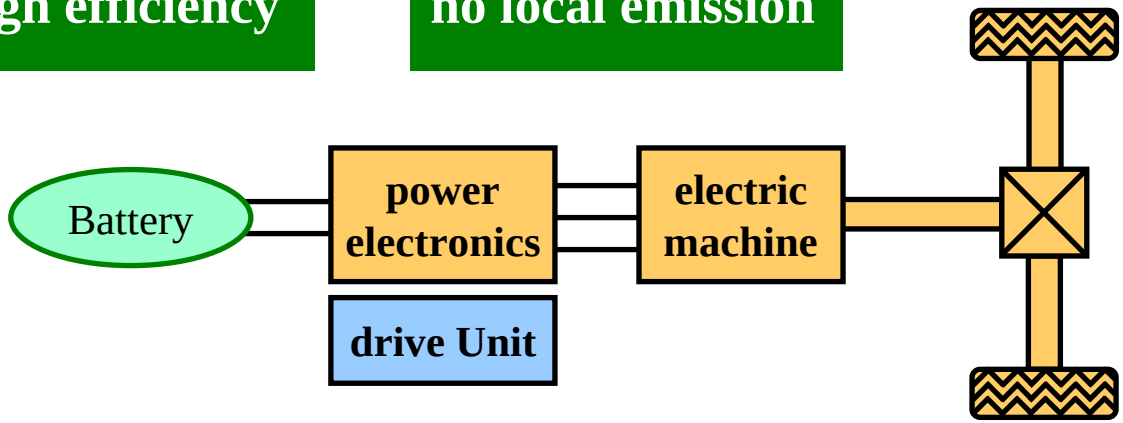
- Electric vehicle -

high efficiency

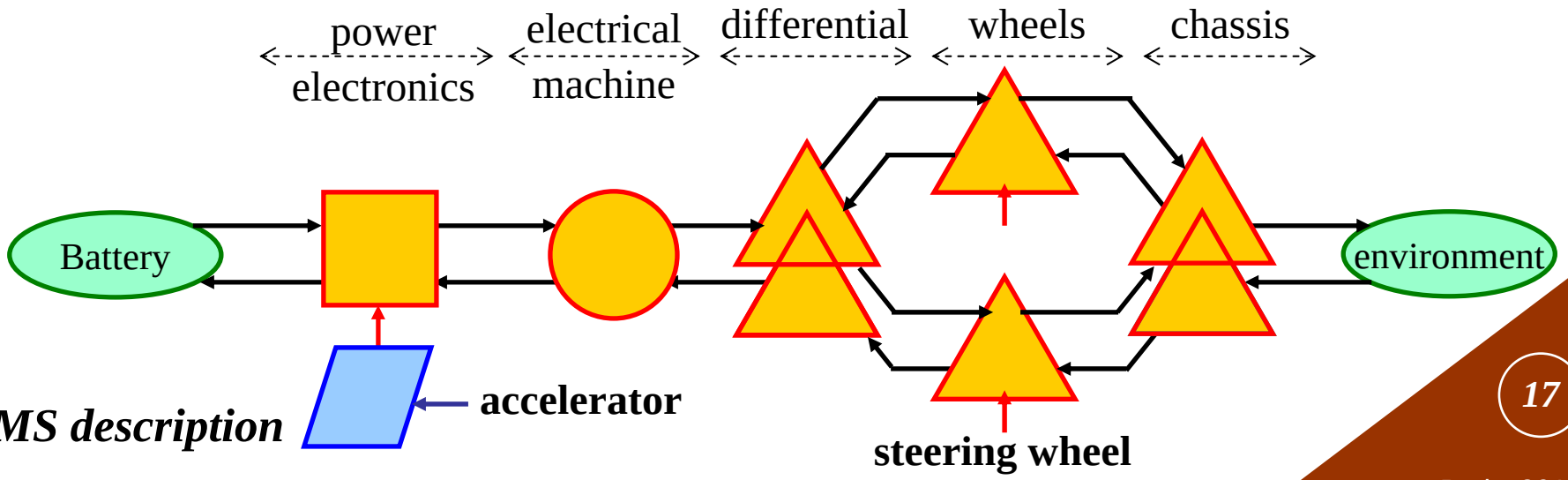
no local emission

energy recovery



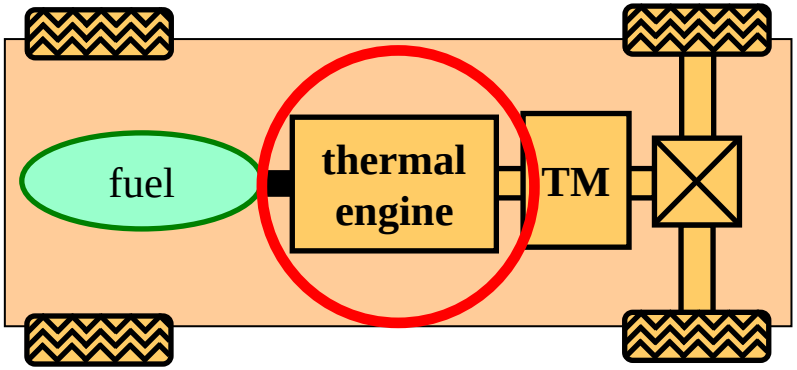
low autonomy

long energy charge

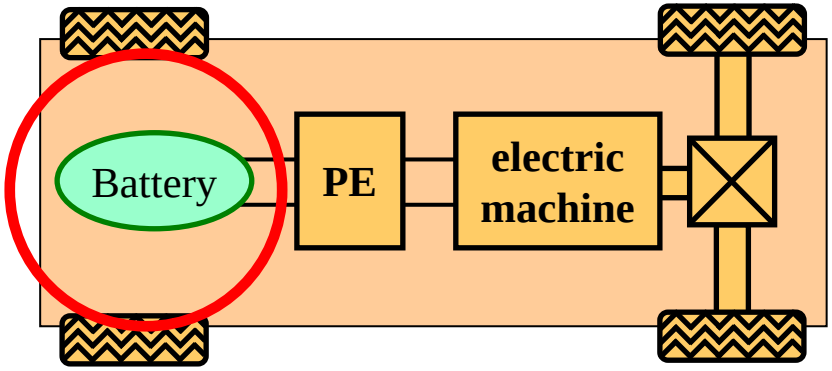


MMS description

- Thermal and Electric Vehicles -



Thermal Vehicle:
- pollution
- low efficiency

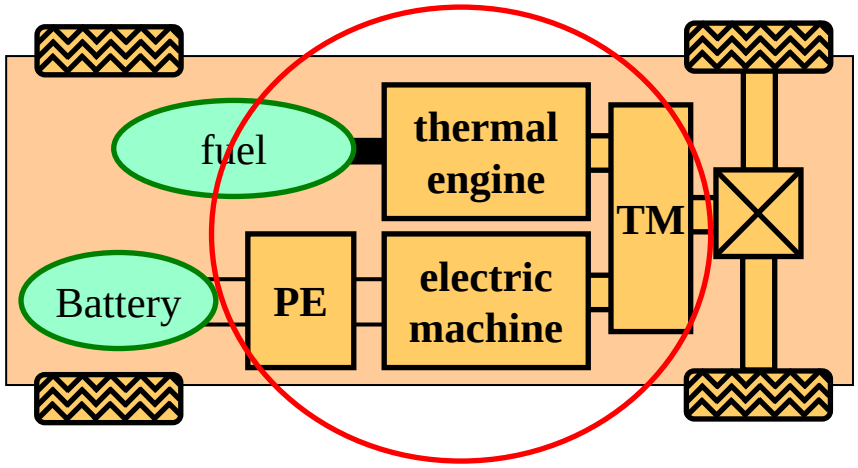


Electric Vehicle:
- long charge
- low autonomy

Think city

http://www.thinkev.com/

- Hybrid Electric Vehicles -



Hybrid vehicle:
- advantage of each technology
- higher cost
- complex control

Toyota Prius 3

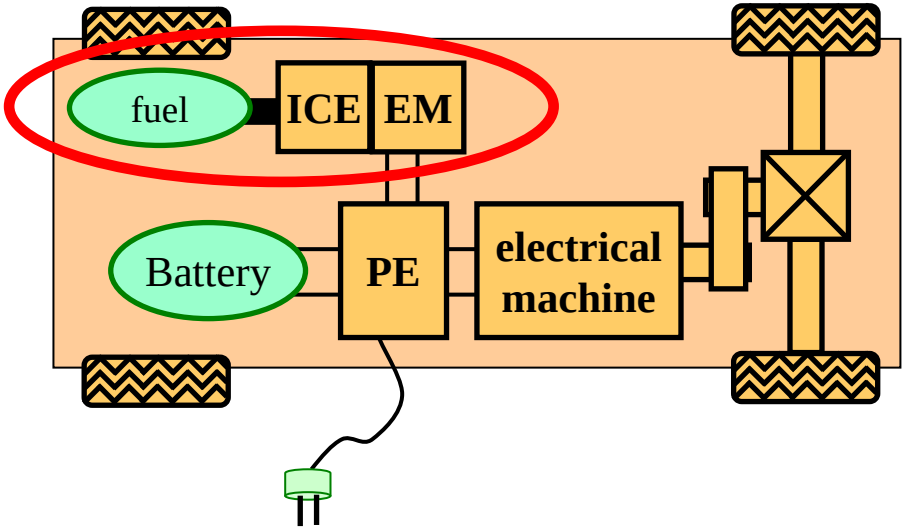
http://www.toyota.com/

Various configurations:
- Different power ratios P_{ICE}/P_{EM}
- Different component organization

Peugeot 3008 HY4

http://www.mpsa.com

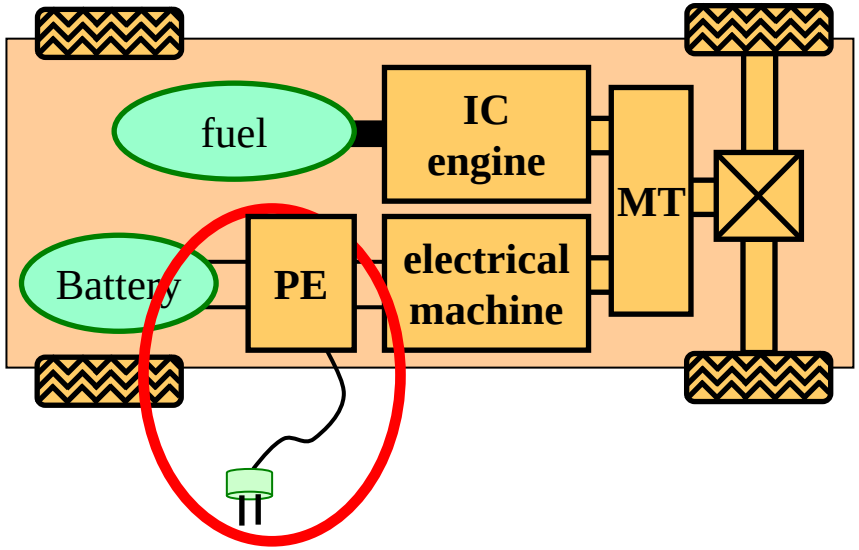
- HEVs or EVs? -



Kangoo electroroad RE

Range extender EV
= EV + ICE for higher mileage range

http://www.renault.fr

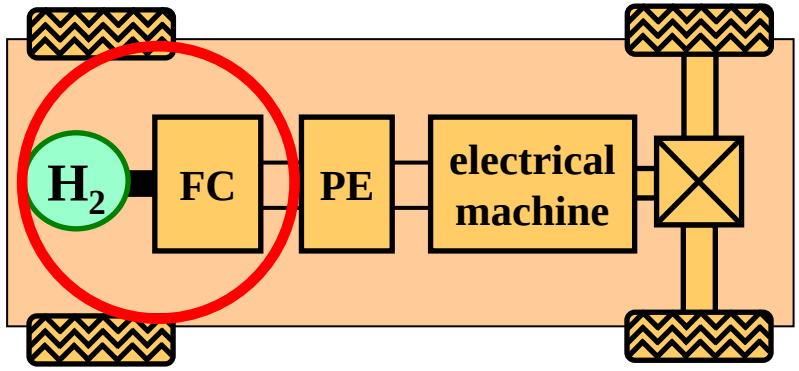


Chevrolet Volt

Plug-in HEV:
= HEV + charger + plug

http://www.chevrolet.com//

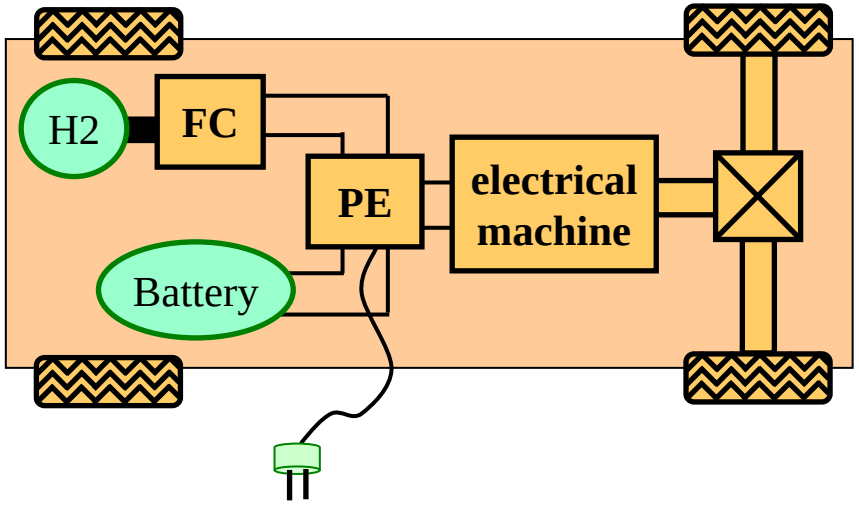
- Fuel Cell vehicles? -



Fuel cell vehicle :
= EV with battery replaced by
a fuel cell and a H2 tank

Honda Clarity FX

http://www.honda.com/

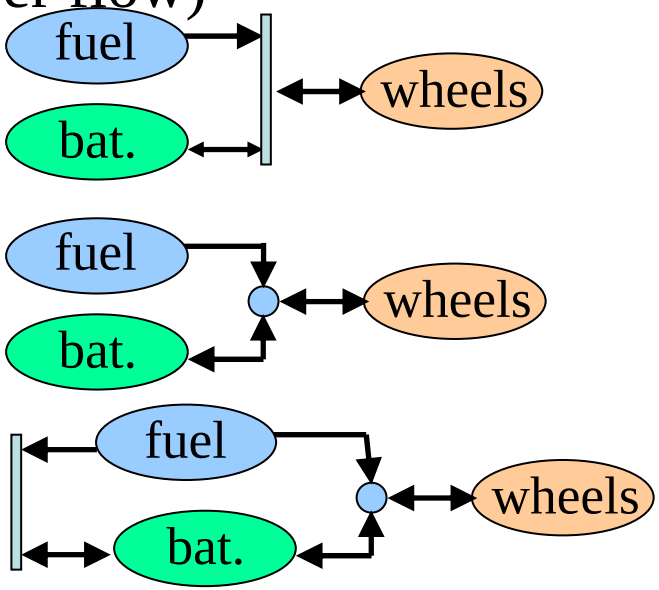


FC vehicle with hybrid storage
= another kind of RE-EV

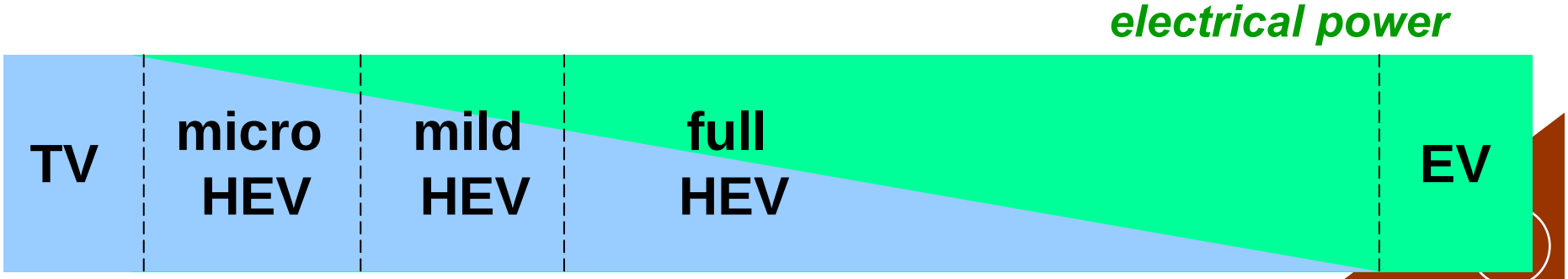
- HEV classifications -

- **Architecture classification** (power flow)

  - series HEVs (electric power node)
  - parallel HEVs (mechanical power node)
  - series/parallel HEVs
    (electric and mechanical power node)

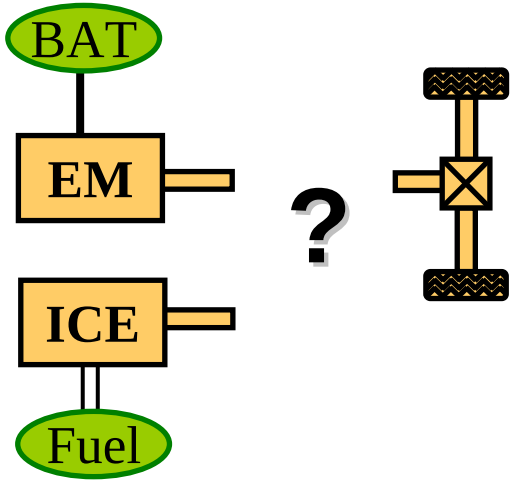


- **Power ratio classification** (thermal and electric power)

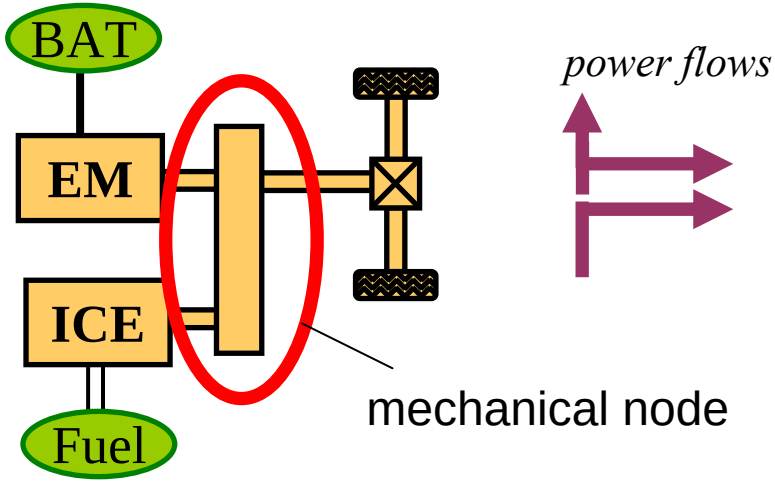


[Chan 07] [Emadi 07]

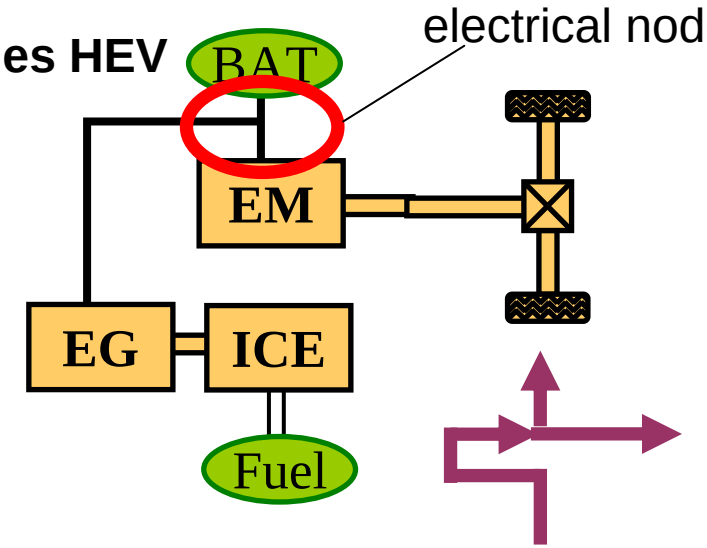
- Architecture bases -



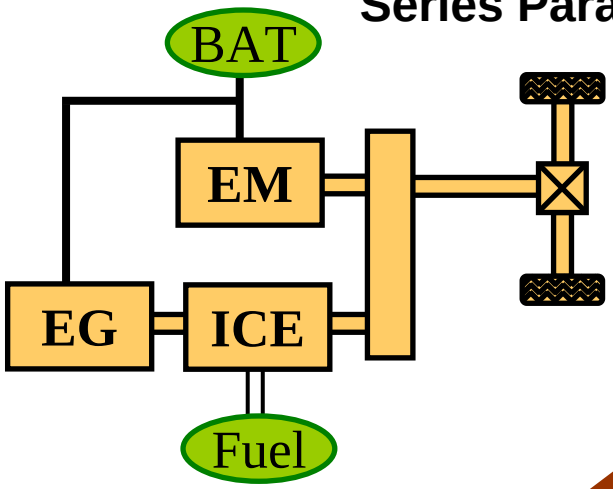
Parallel HEV



Series HEV

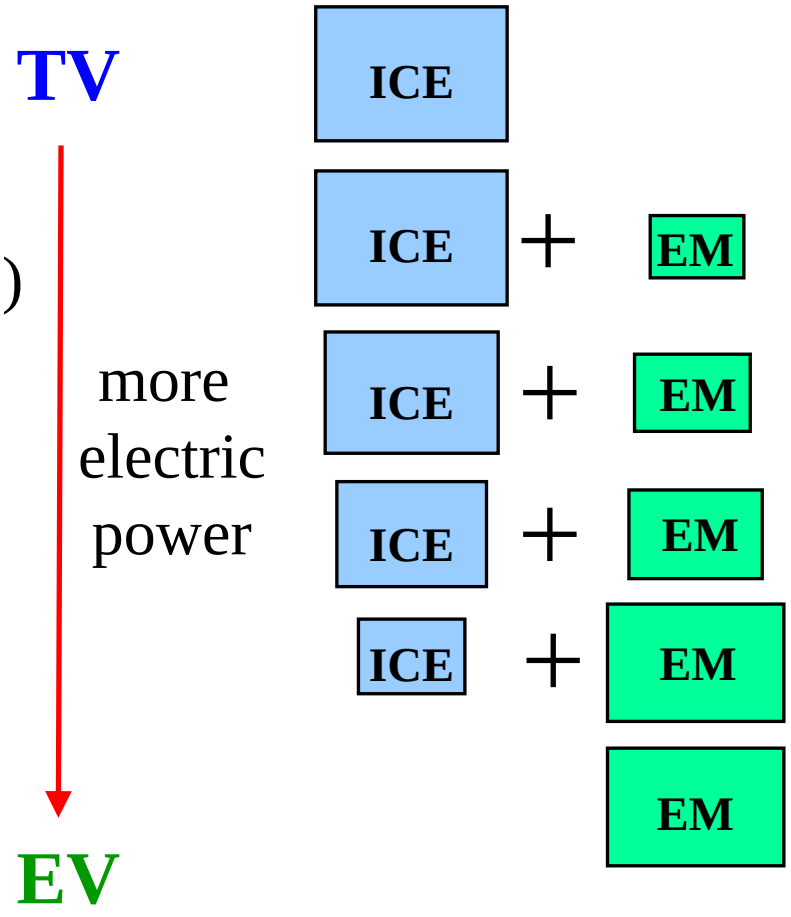


Series Parallel HEV



- Operation modes -

- Thermal traction
- Internal battery charge (from ICE)
- Stop and Go (electrical starter)
- Regenerative braking
- Boost (electric support)
- Electric traction (Zero Emission)



- External battery charge (Plug-in HEV)

- Consumption reduction -

source: VALEO (http://www.valeo.com/)

Hybridization functions

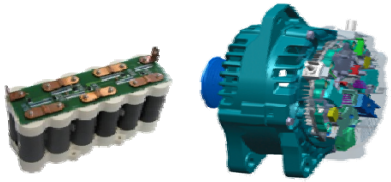
City - 25%

NEDC - 6%

MICRO-HYBRID

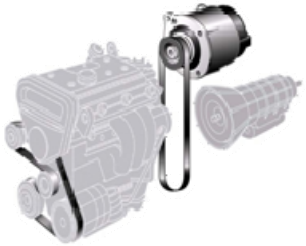
- 12%

MICRO - MILD HYBRID



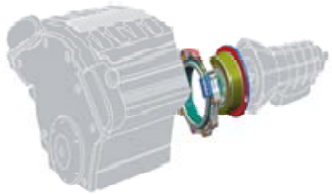
-15-20%

MILD HYBRID



-20-30%

FULL HYBRID and PLUG-INs



Electric Drive

Torque Assistance

Regenerative Braking

Stop & Start

Stop-Start: basis of hybridization for mass production affordable solutions

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3. Key issues of EVs & HEVs

- Energy Storage Subsystems
- Energy Management
- Societal changes

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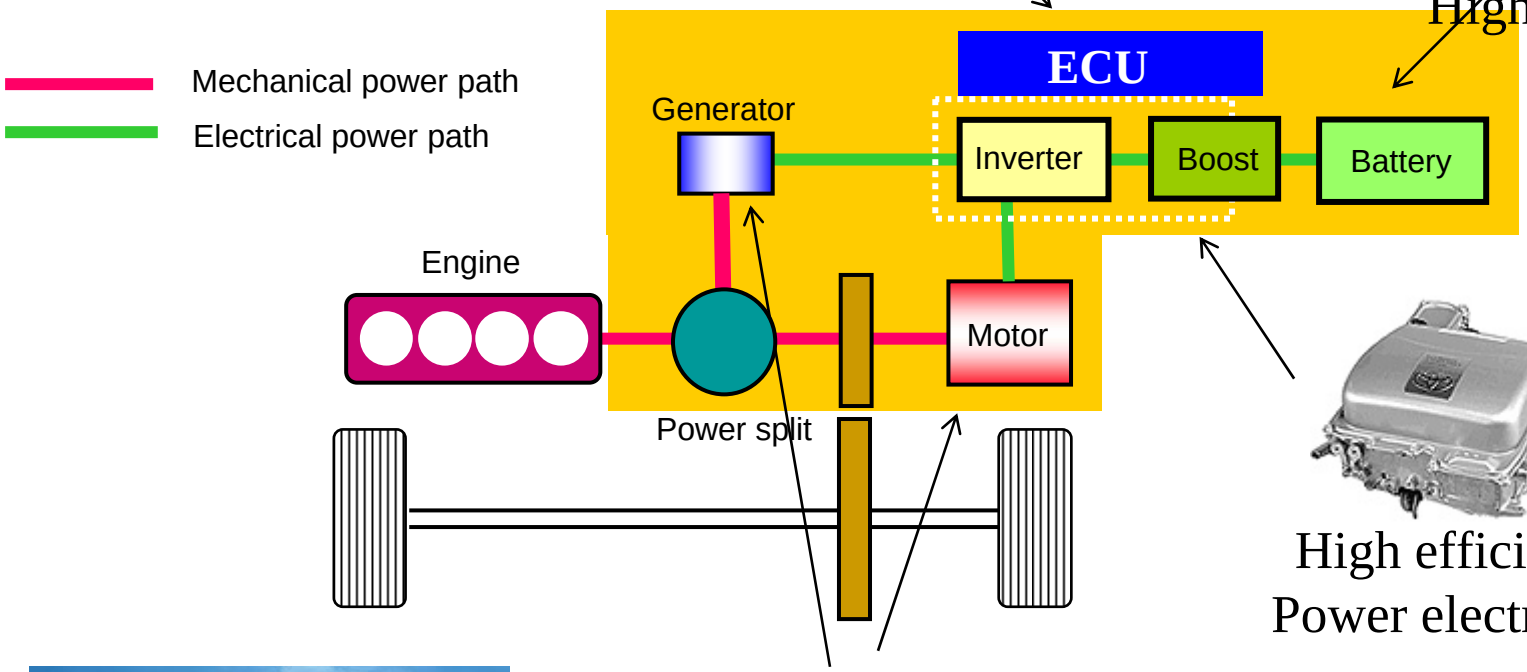
- Prius, success story -

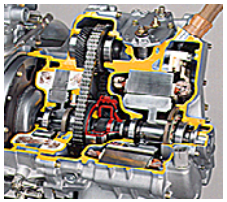
Complex control

Battery Ni-MH
High energy density



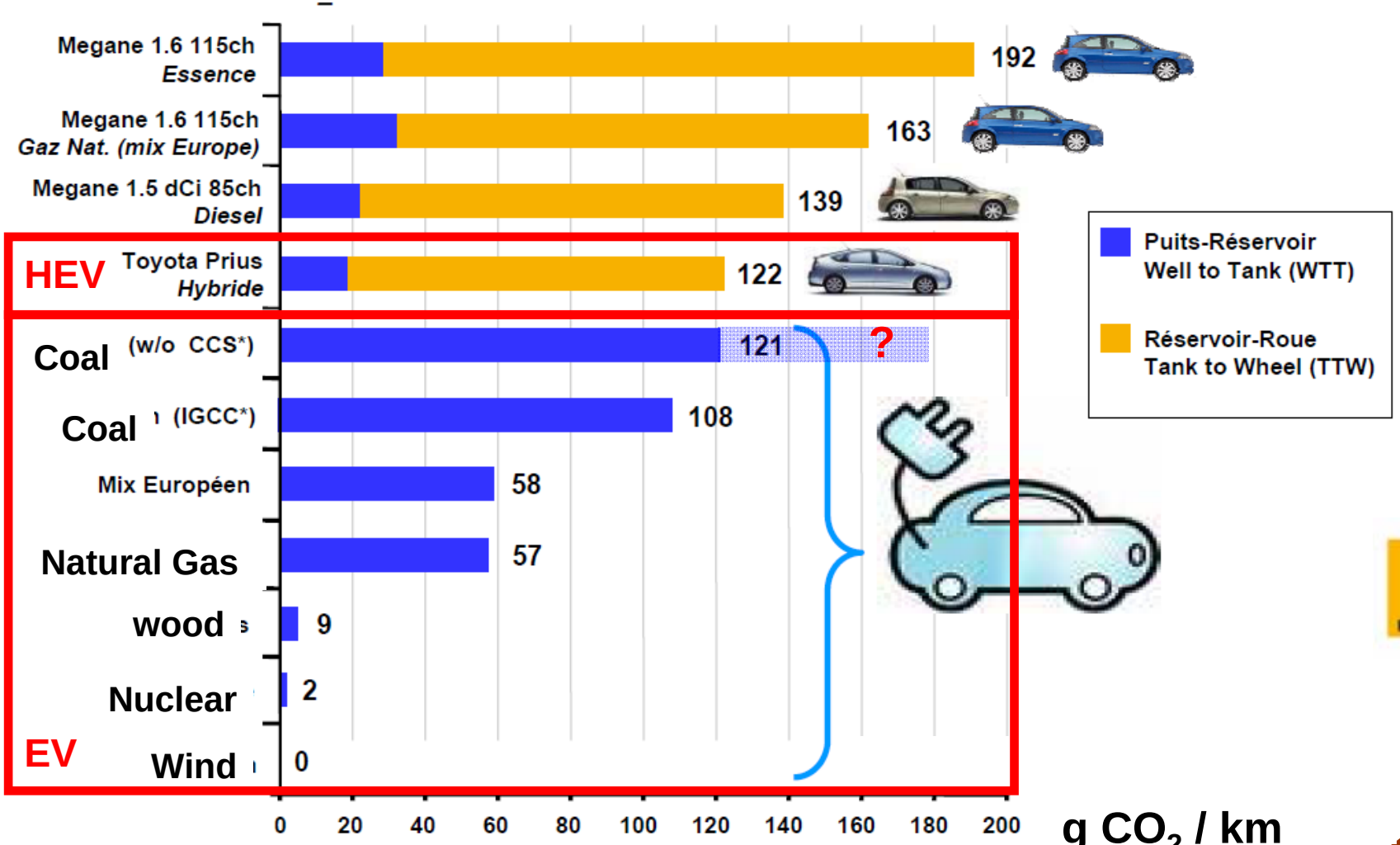
High efficiency
Power electronics

Véhicule PRIUS II
http://www.toyota.com/

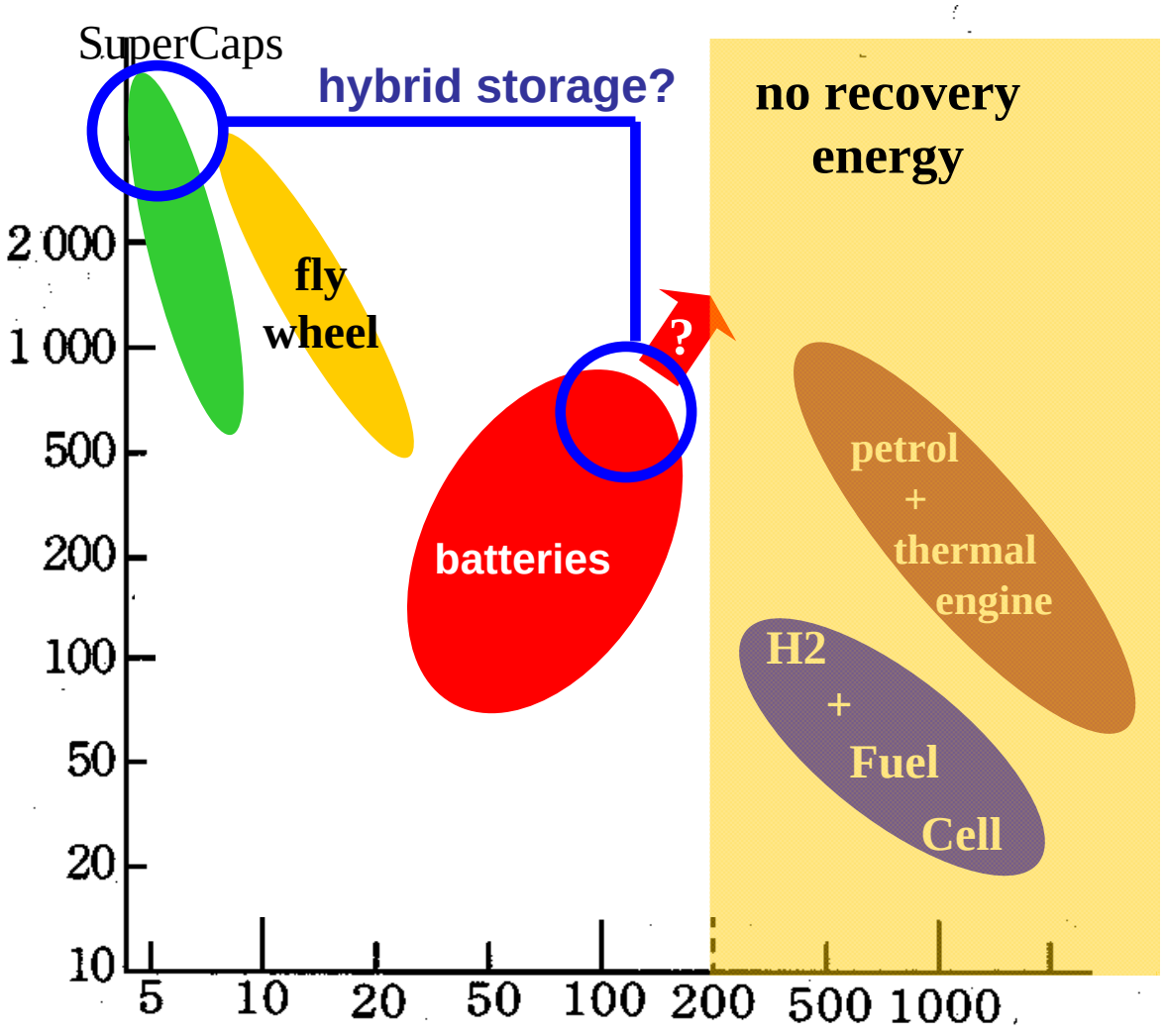


Permanent Magnet
Synchronous Machines

- Well to Wheel analysis -



- Energy sources -



Power density (W/kg)
~ acceleration, charge time

Energy density (Wh/kg)
~ mileage range

[Chan 2008]

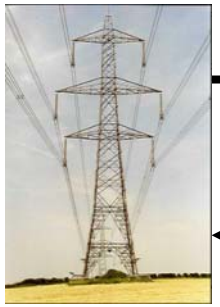
- Energy charge -

- slow charge at home
  / at work (4-8h?)
  (plug or induction)
- ultra-fast charge at specific station (1/2h?)
- battery swap station (5-10 min?)

http://france.betterplace.com/

New technologies and developments? “Smart” charge?
but also
A new way to manage our energy charge?

- Impact on the grid -

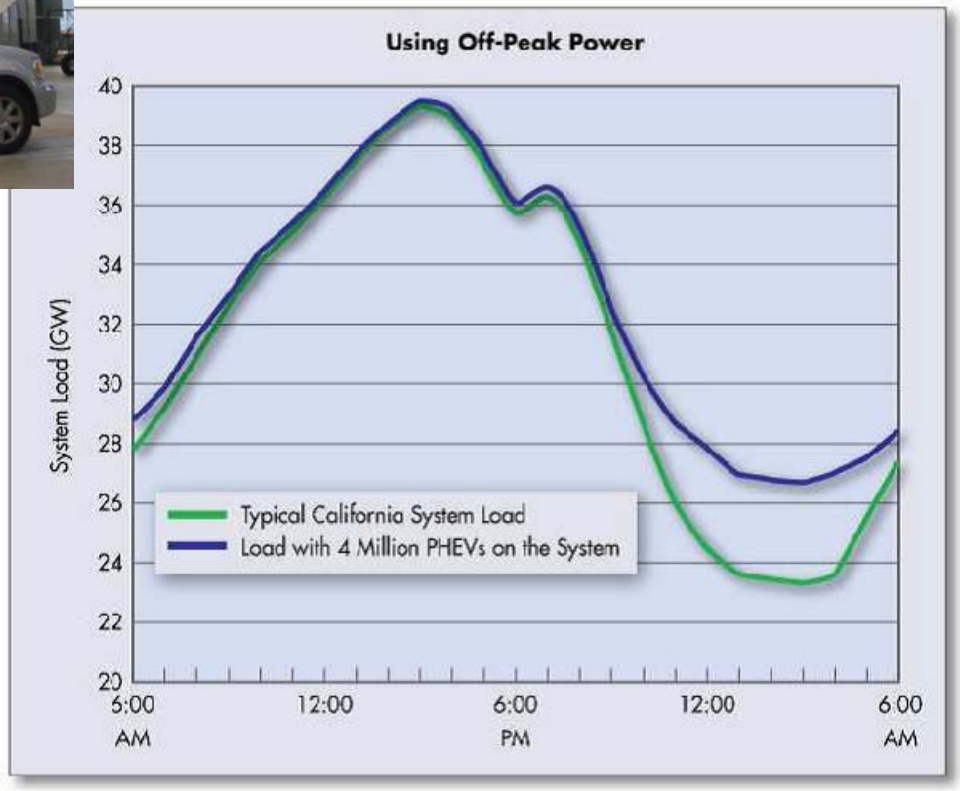


G2V

V2G

(Vehicle to Grid)

http://my.epri.com



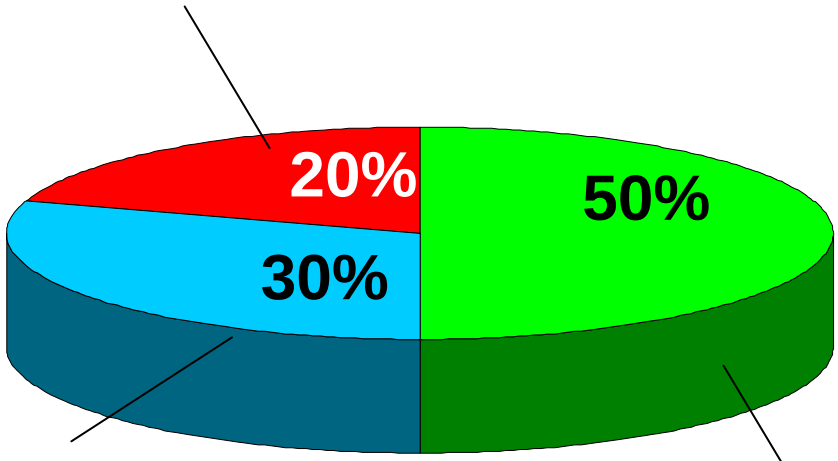
New concepts for grid management?

but also

A new way to manage our energy price?

- Day trip Analysis -

Average values of daily trips in Europe in 2007



Mileage range of a classical EV = 100 to 150 km

Possible uses of EVs?

but

A new way to manage our mobility?

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4. Examples of research projects

- Energy Storage Subsystems
- Energy Management
- Societal changes

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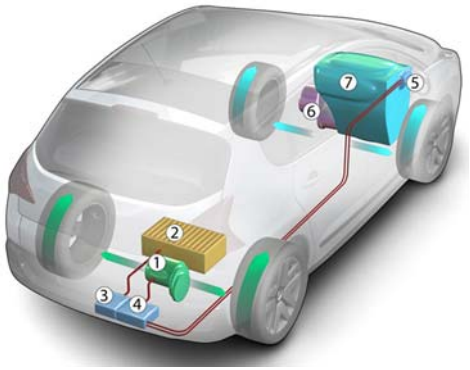
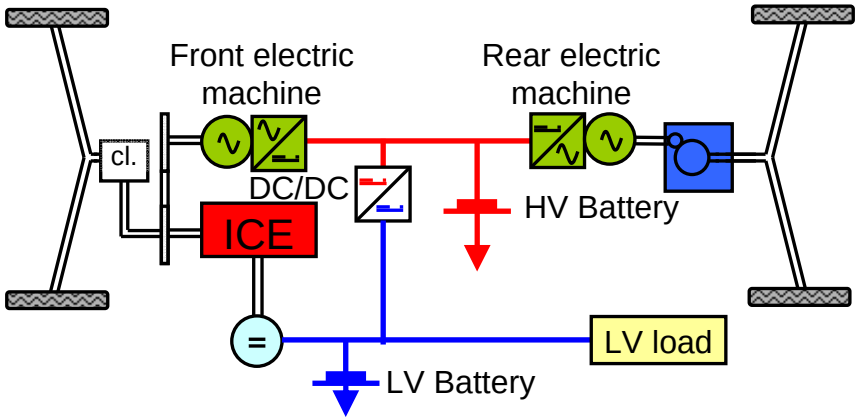
- Double parallel HEV -



new concept

energy management?



PSA PEUGEOT CITROËN

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1 EMR and control

Simulation of various cases and energy management

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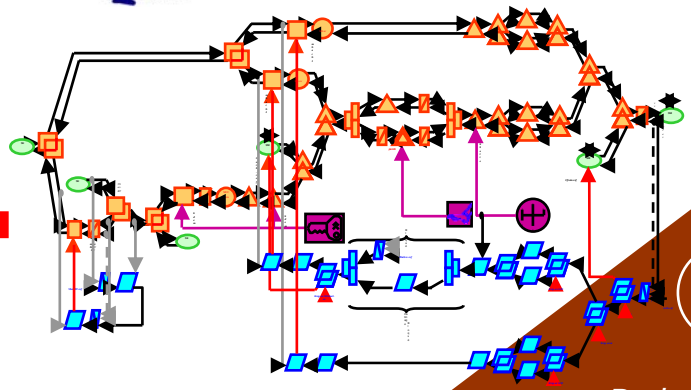

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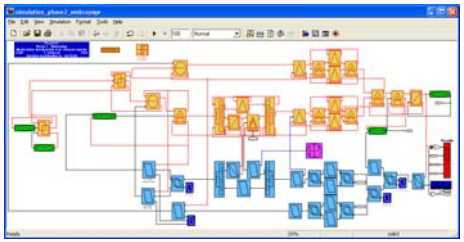
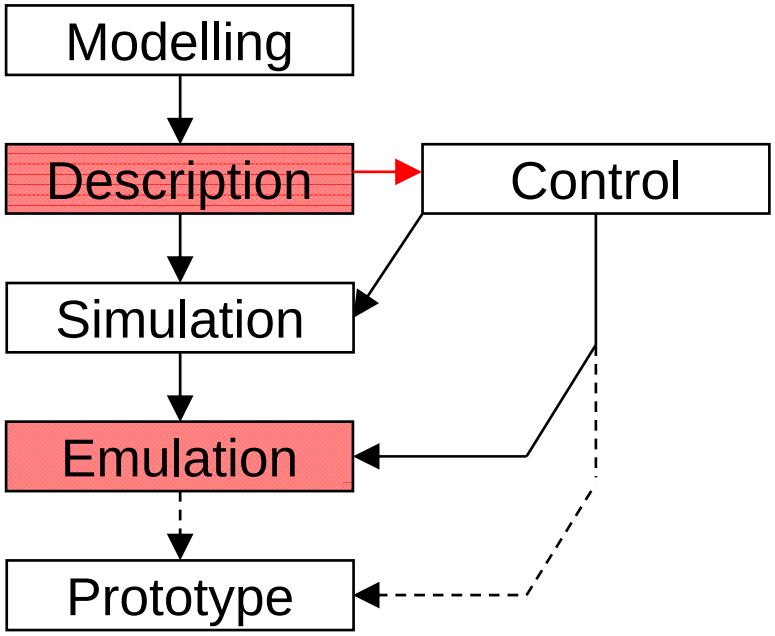
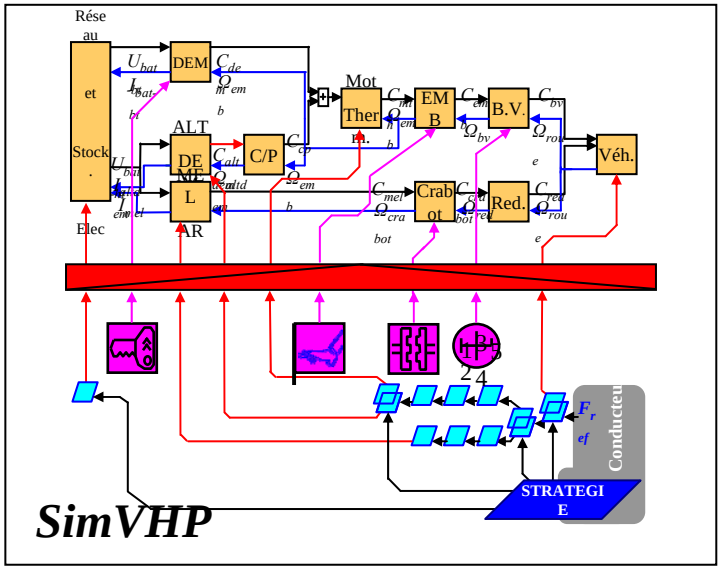


3 implementation on prototypes

[Letrouvé & al. 2011]

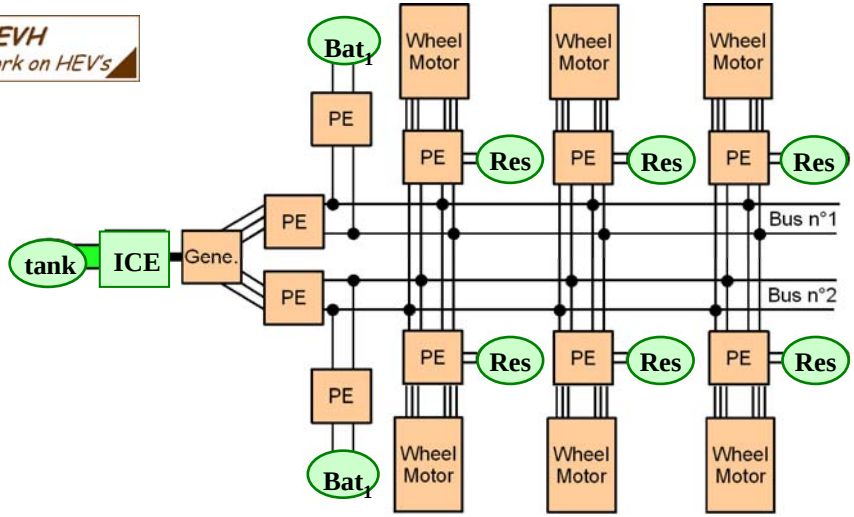
- Double parallel HEV -

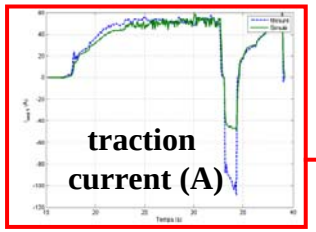


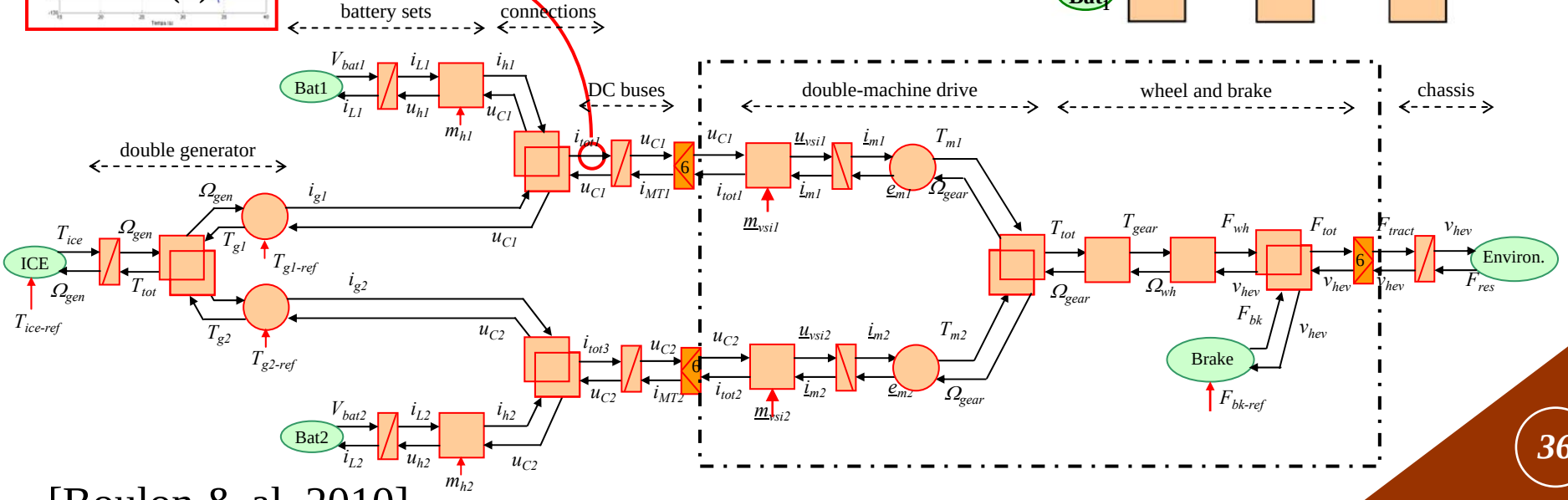


HIL simulation

- High-redundancy HEV -

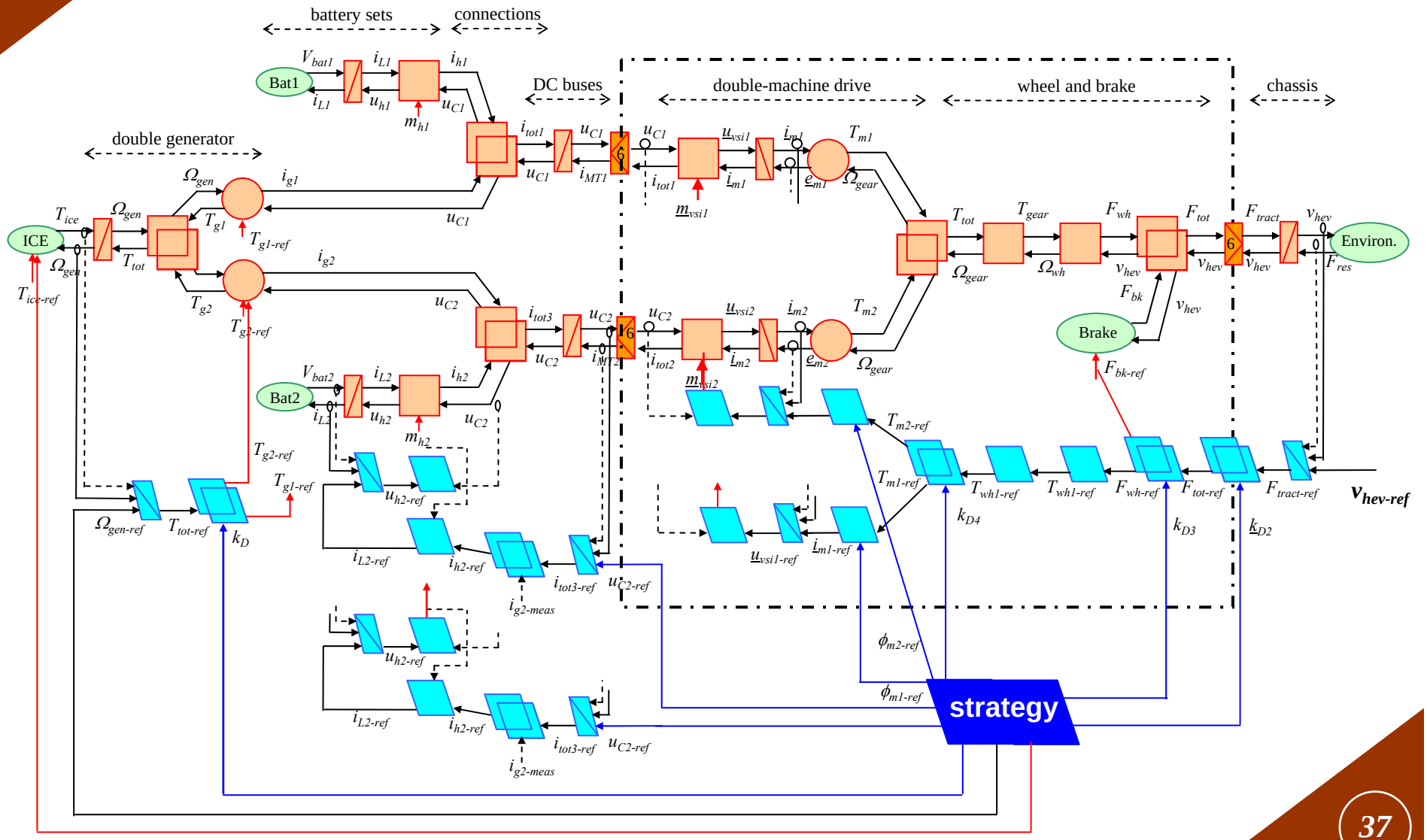






[Boulon & al. 2010]

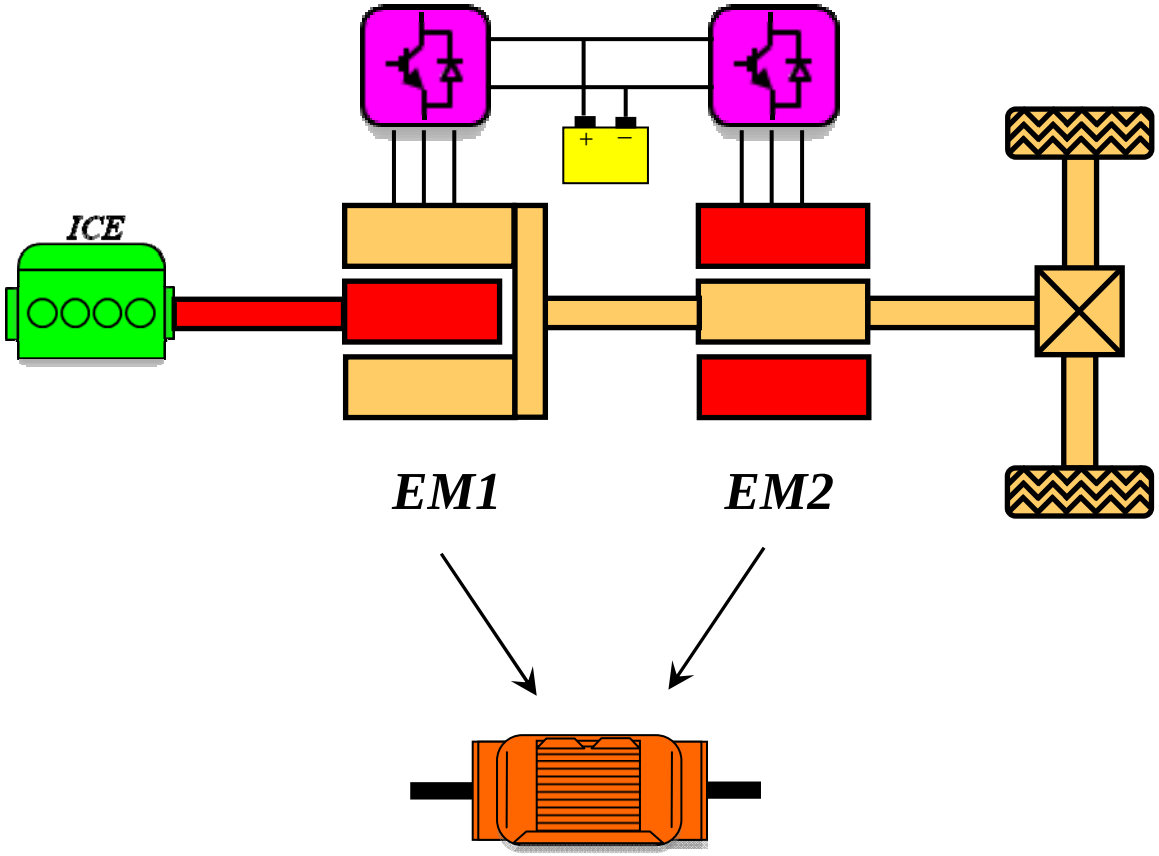
- High-redundancy HEV -



[Boulon & al. 2010]

Strategy = coordination of subsystems

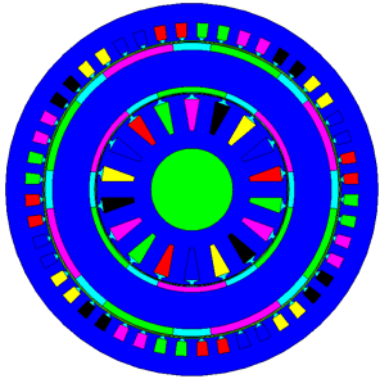
- Electric Variable Transmission -



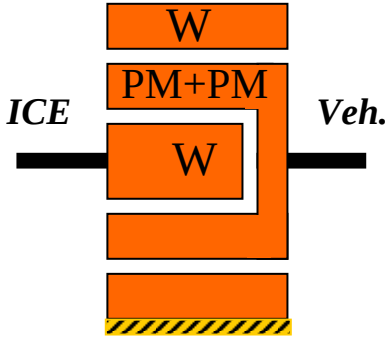
Enable a continuous variation of rotation speeds and torques ⇨ Optimization of ICE speed and torque

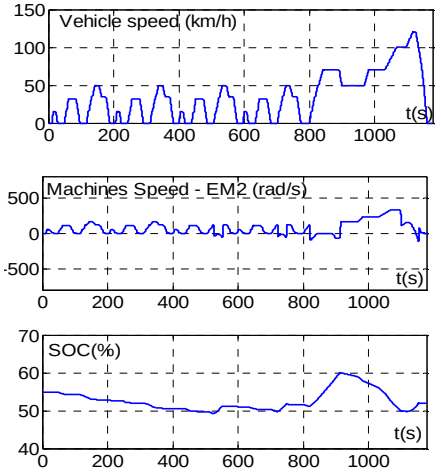
- HEVs using EVT -

- Design of an PM-SM EVT for Toyota Prius II
- Control of the EVT-HEV
- Comparison with Toyota Prius II

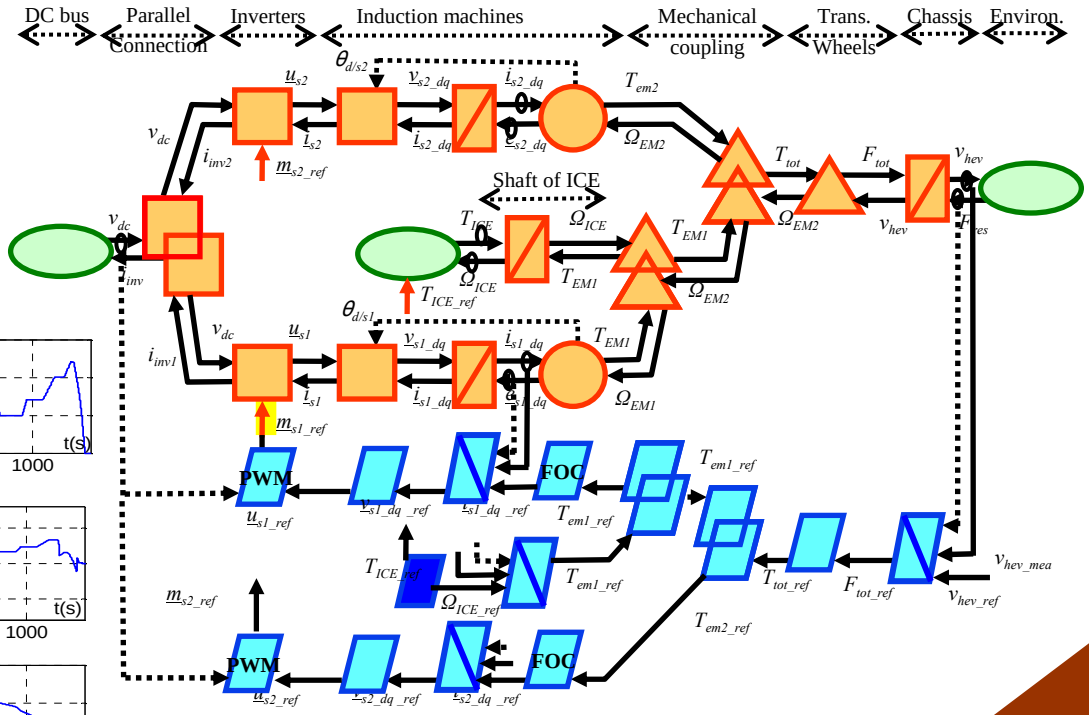


PM-SM EVT





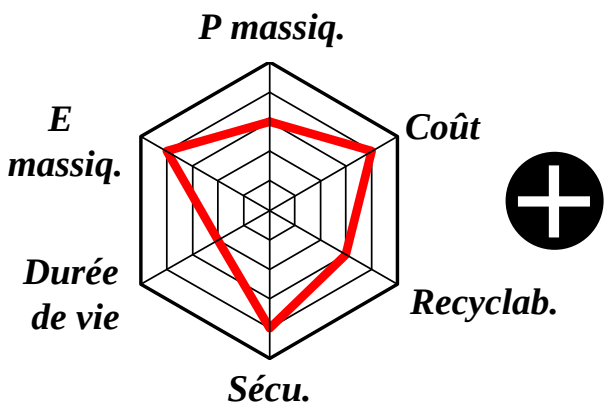
[Cheng & al. 2011]



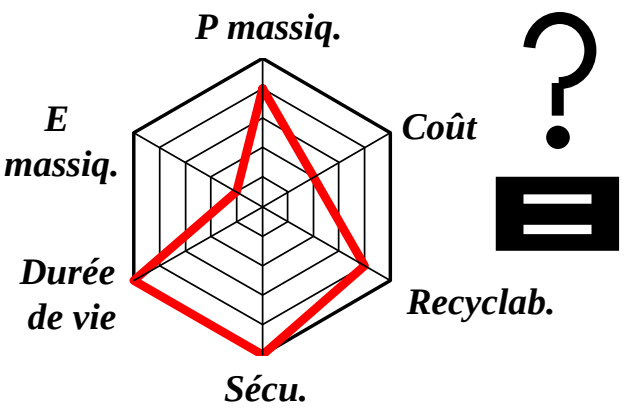
Energetic Macroscopic Representation and control of the EVT-HEV

- EVs using hybrid ESS -

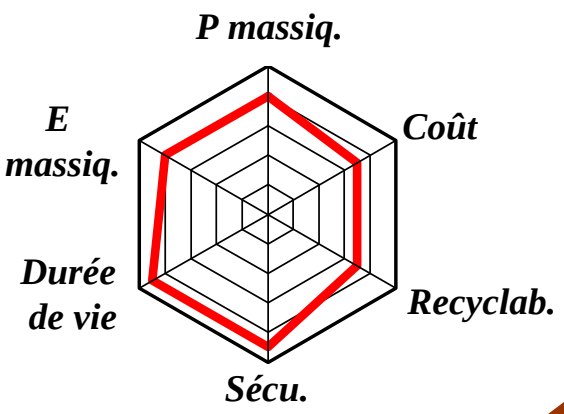
EV suing batteries



EV using Scaps.

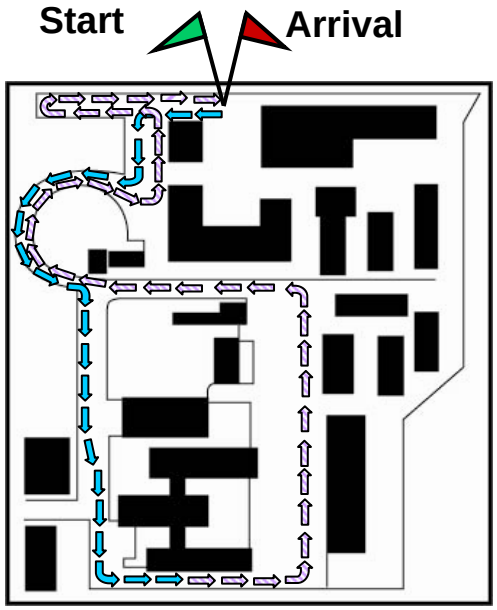


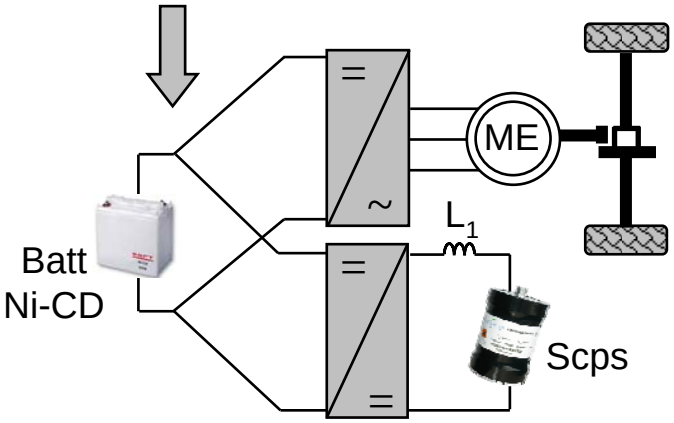
EV using batteries and Scaps.



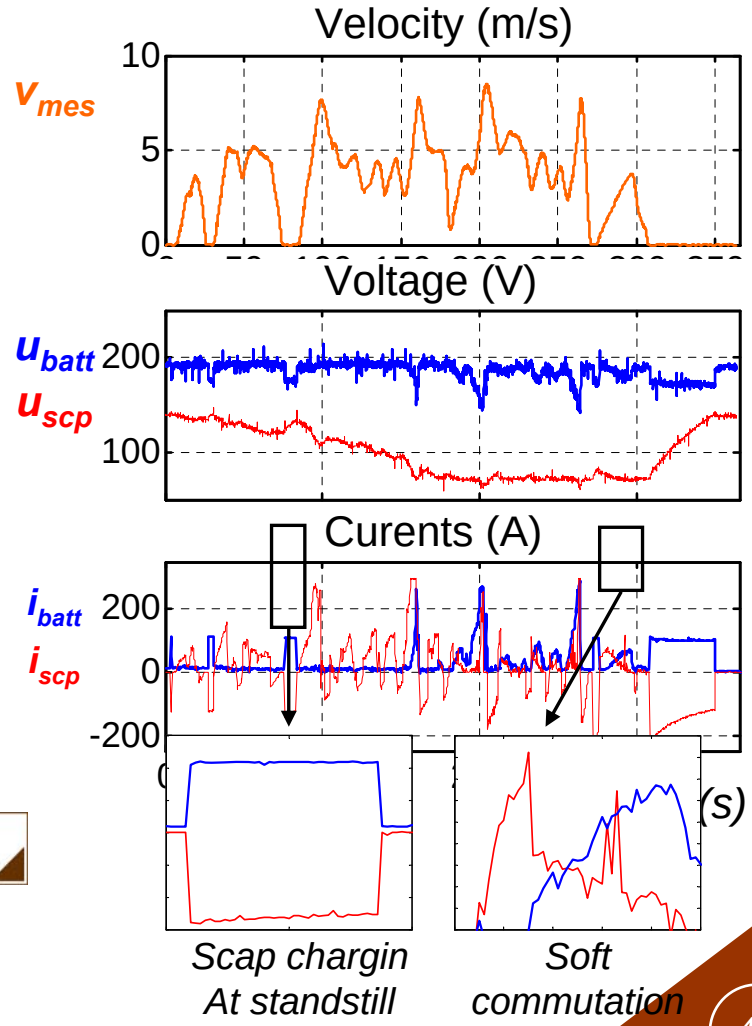
[Allègre 2010]

- EVs using hybrid ESS -





Test only for ZEV mode



Scap chargin At standstill

Soft commutation

The simplest strategy

Séminaire ASPROM
Paris
Nov. 2011

Conclusion

MEGEVH
French network on HEV's

Technology will not save Automotive industry!
The mobility concepts have to be changed!

HEVs and EVs could be valuable complementary vehicles

a limited mileage range could be…
a chance…
… forward a more reasonable use of our mobility!




MEGEVH
French network on HEV's

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