

Technical challenges of hybrid and plug-in hybrid vehicles

Dr. François BADIN & AI.
IFP Energies nouvelles



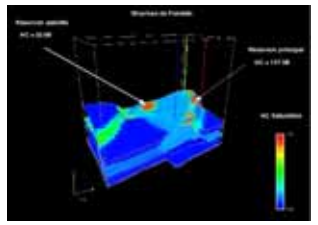


IFP strategic priorities

Preparing for the energy transition

EXTENDED RESERVES

Pushing back the boundaries in oil and gas exploration and production



CLEAN REFINING

Converting as much raw material as possible into transport energy



DIVERSIFIED FUELS

Diversifying fuel sources



FUEL-EFFICIENT VEHICLES

Developing clean, fuel-efficient vehicles



CONTROLLED CO₂

Capturing and storing CO₂ to combat greenhouse effect



Powertrain Engineering

Hybrid Vehicles Research & Development activities

A wide and coordinated approach

Vehicle and powertrain simulation

LMS AMESim



Real time simulation



Integrated powertrain control, optimized energy management



Component testing and optimization

Energy storage system test bench



BMS

Engine test benches



Vehicle testing

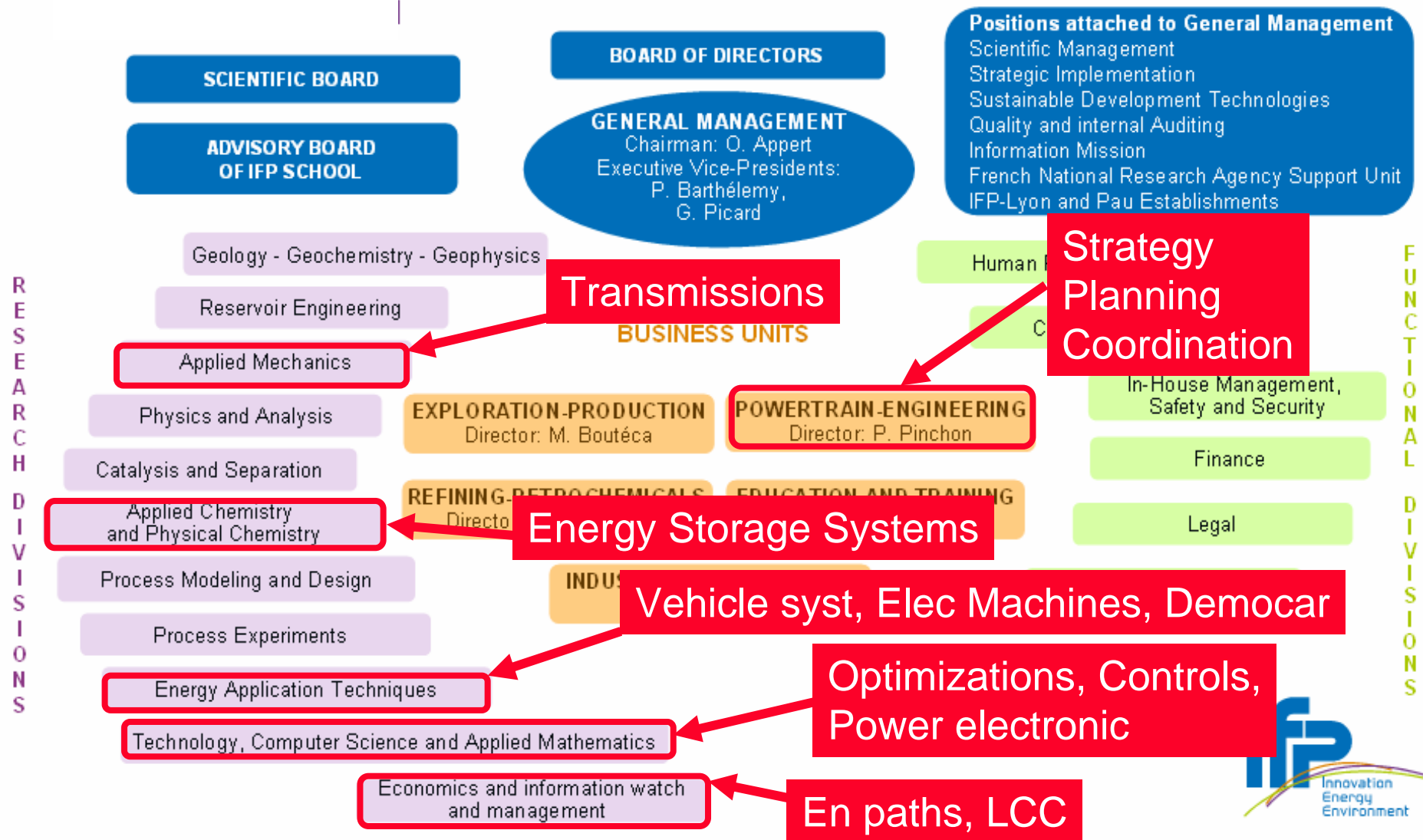


Demo cars design, realization and optimization



HEV R&D activities

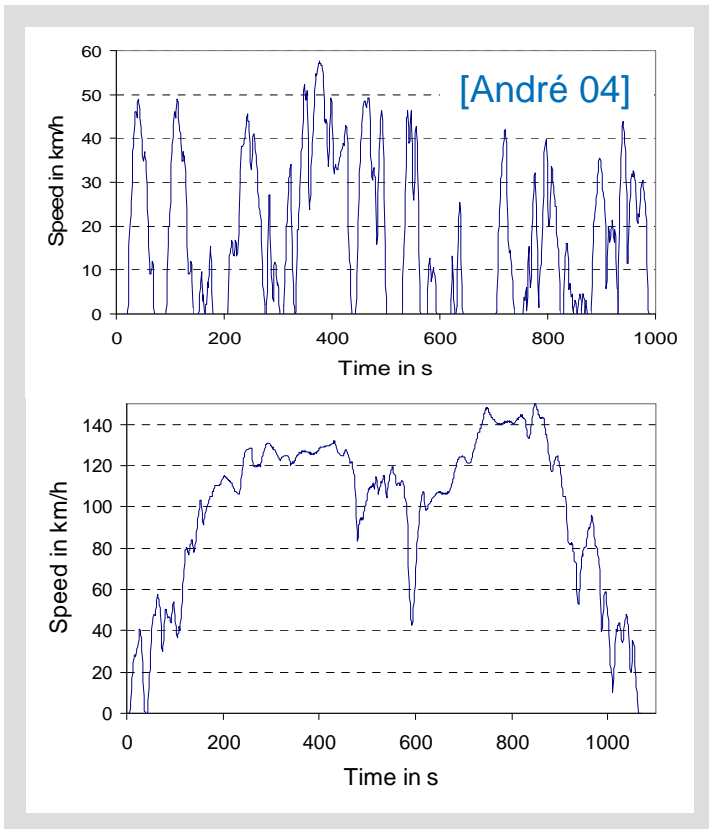
One Business Unit and five Research Divisions involved



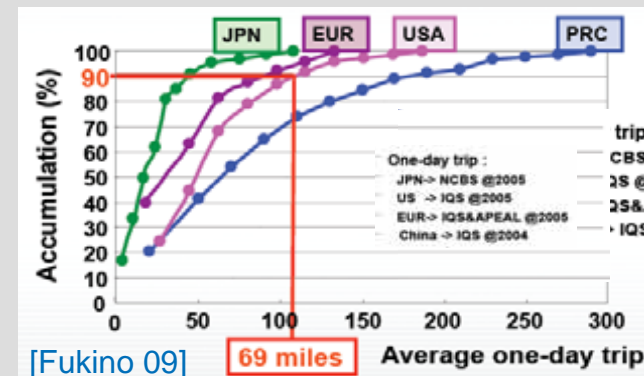
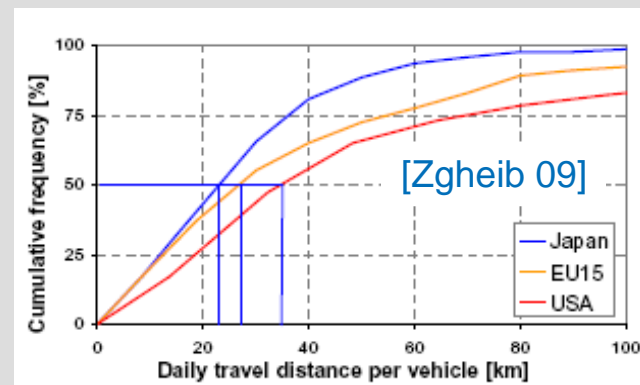


Vehicle types of use

■ Driving pattern

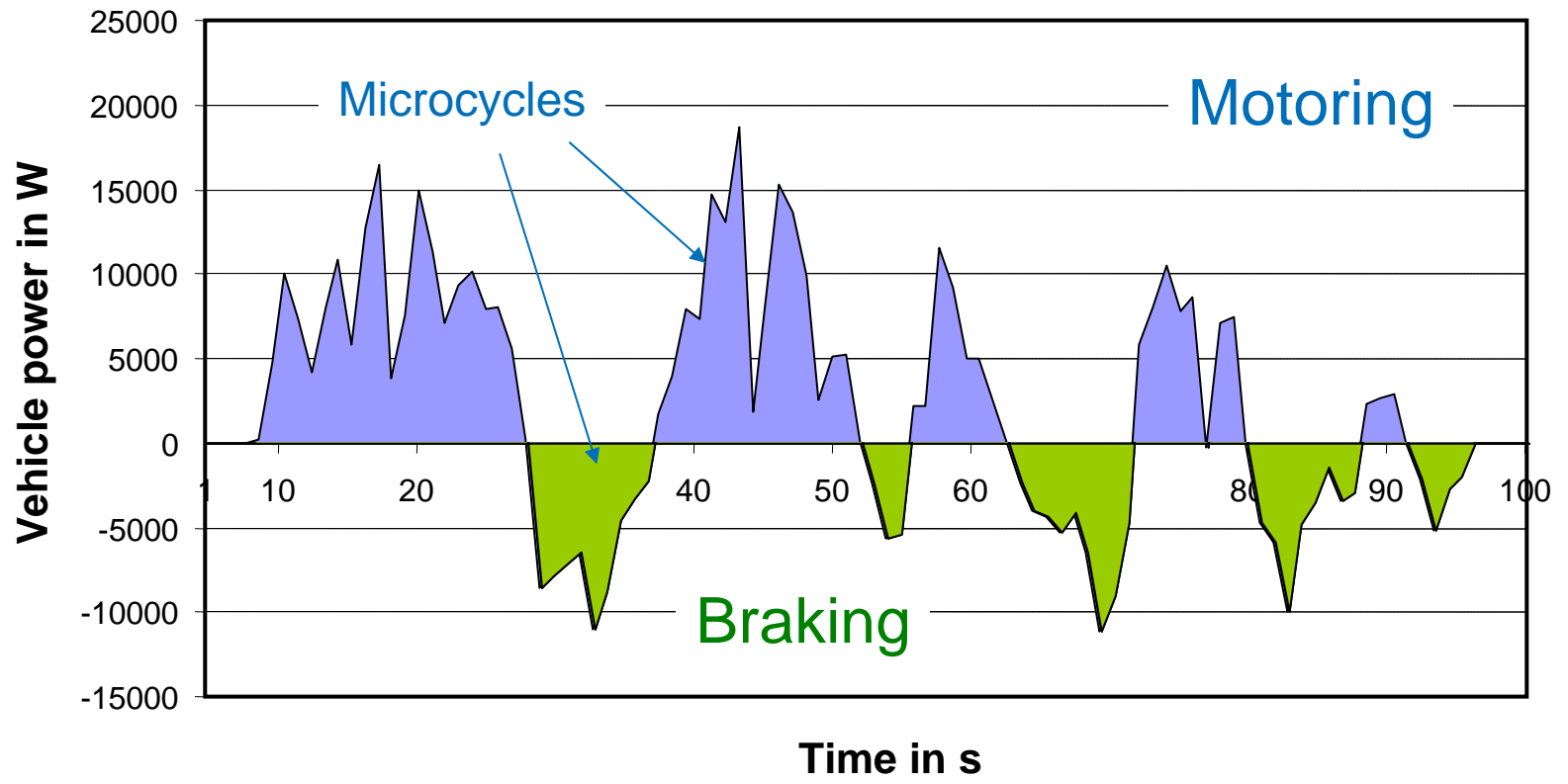


■ Distance between charge (PHEVs & EVs)





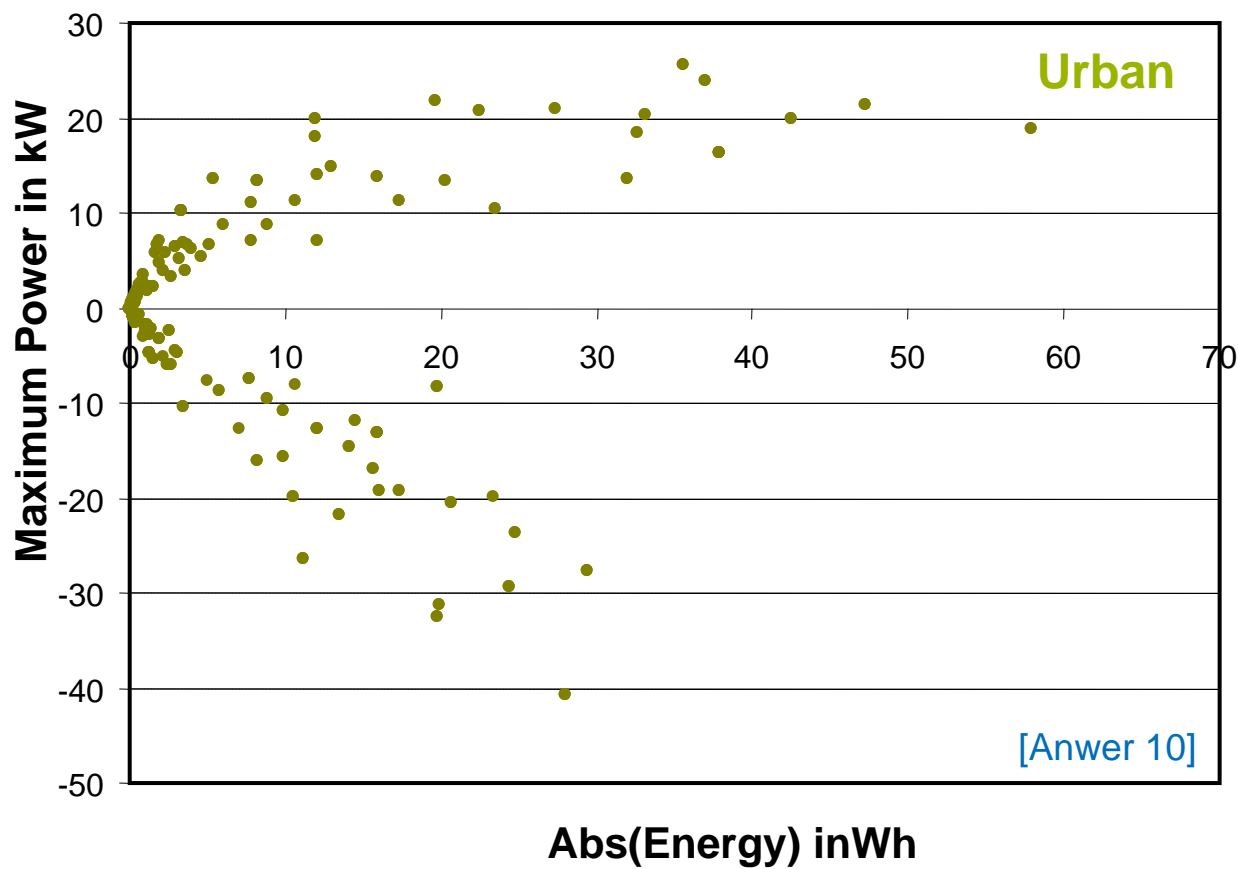
Vehicle required power for motion





Microcycles analysis (1/3)

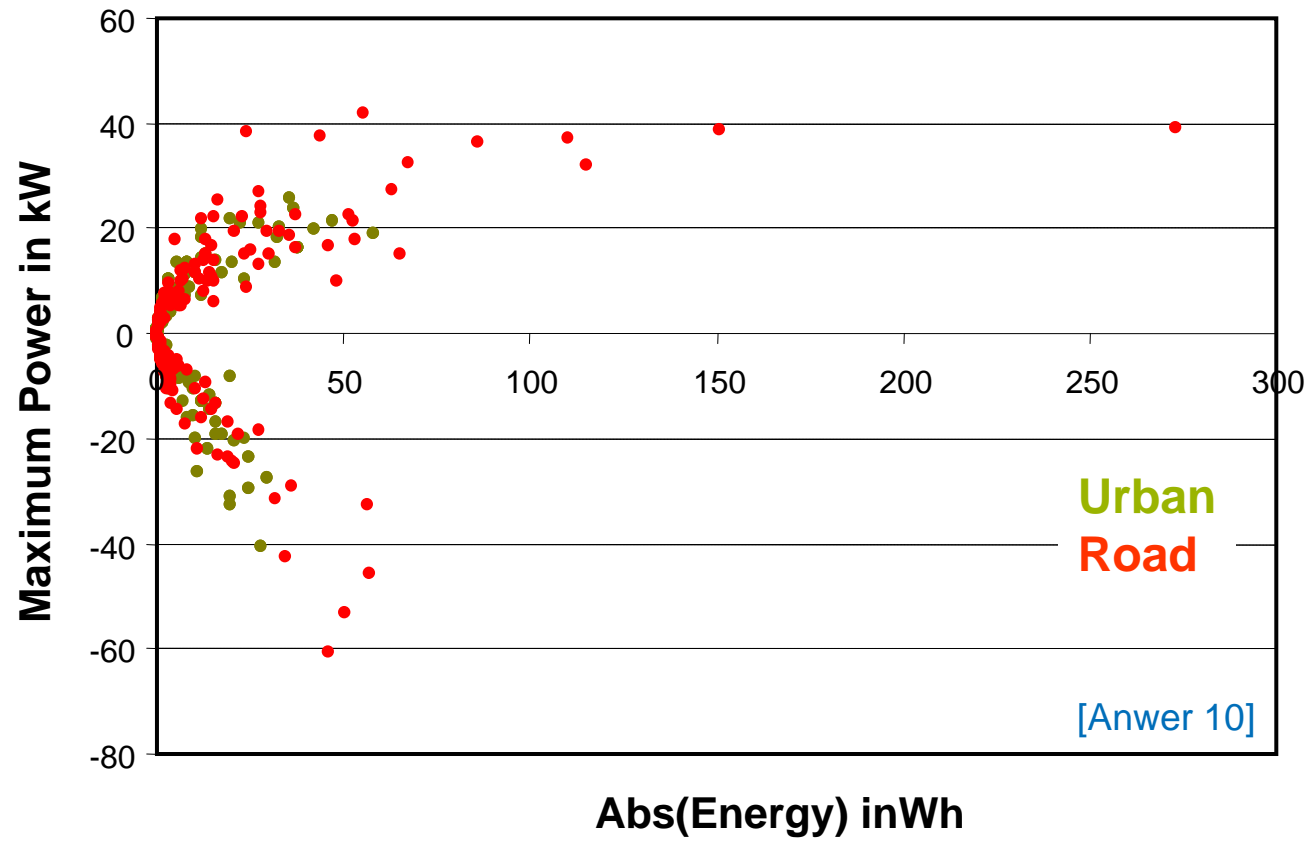
Vehicle level





Microcycles analysis (2/3)

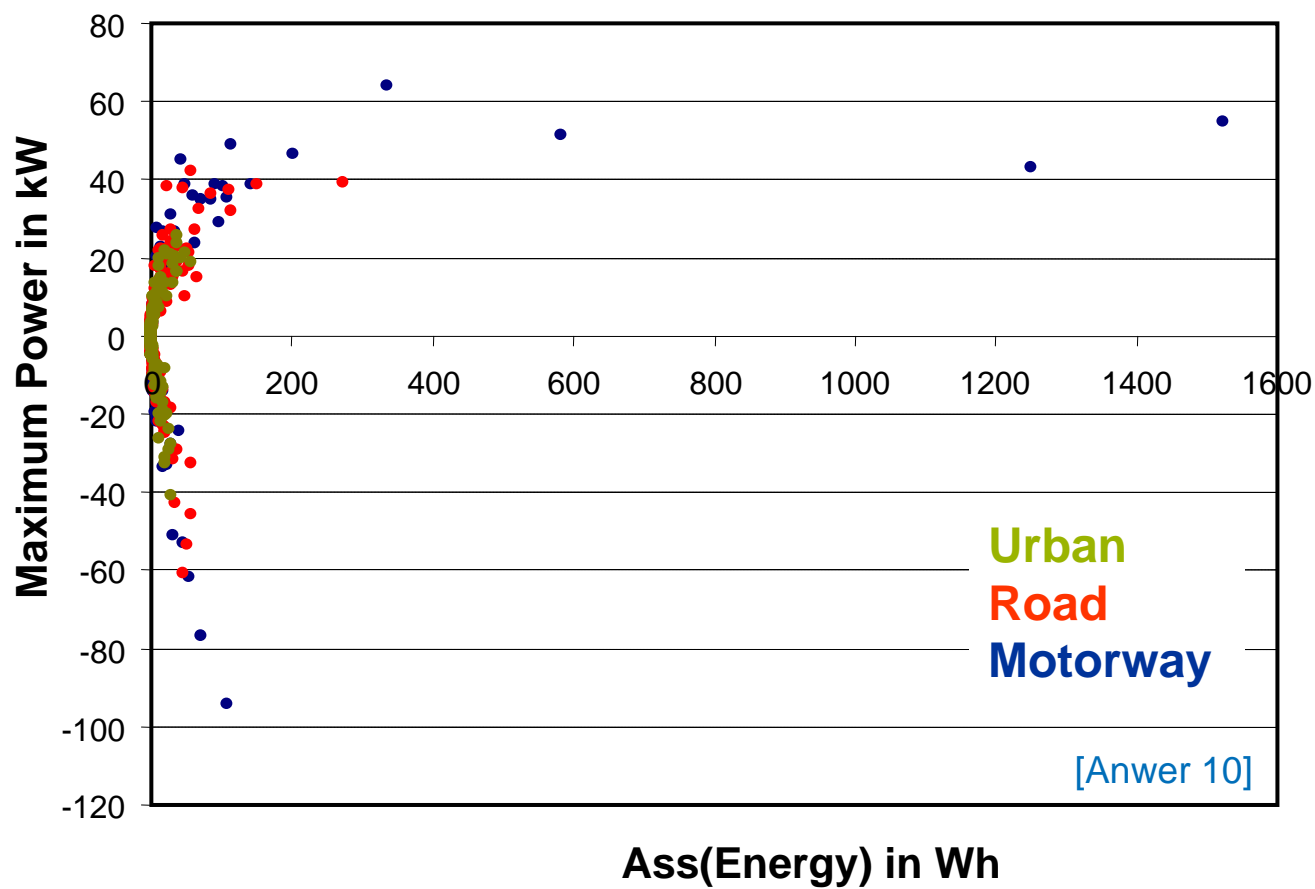
Vehicle level





Microcycles analysis (3/3)

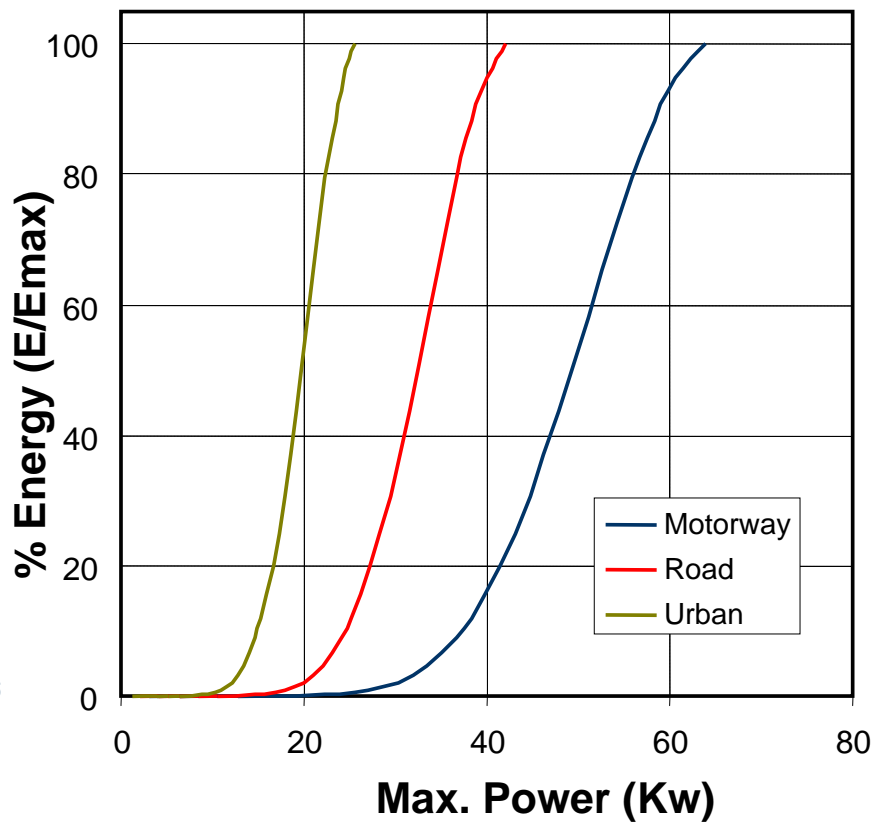
Vehicle level



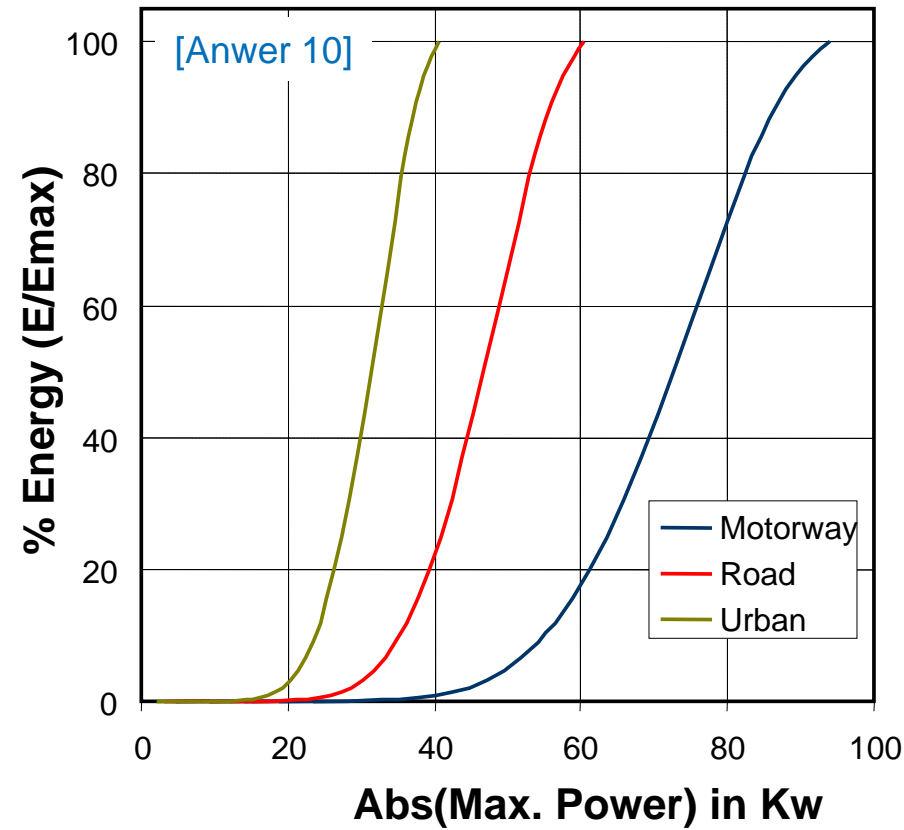


Energy vs power

■ Motoring



■ Regeneration



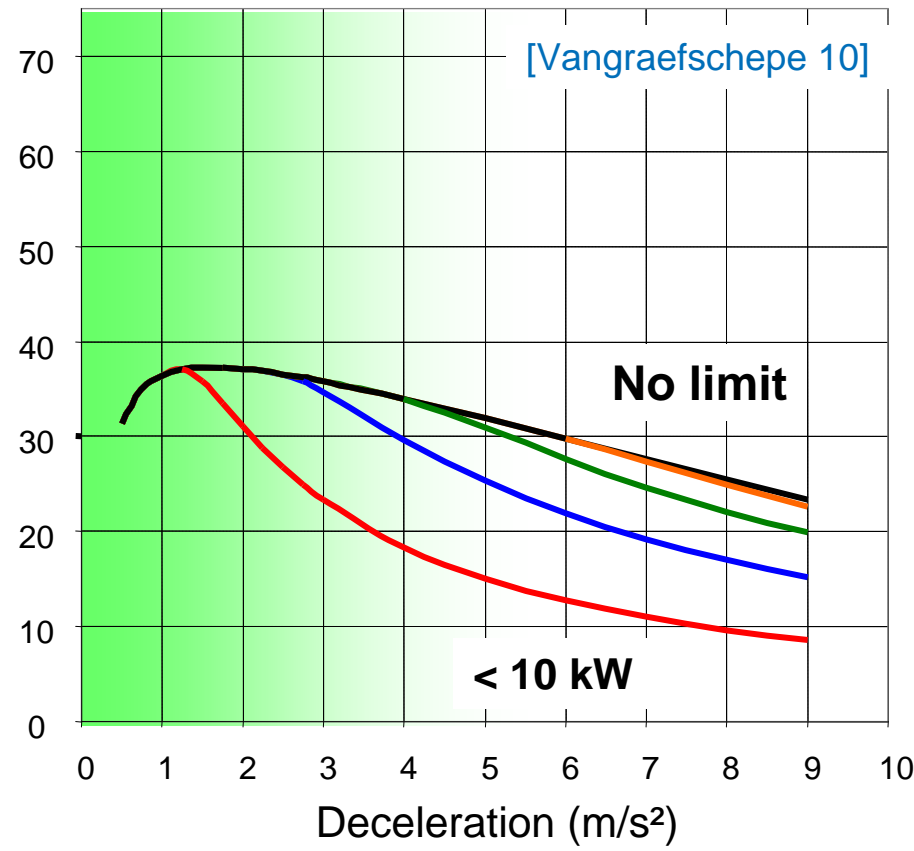
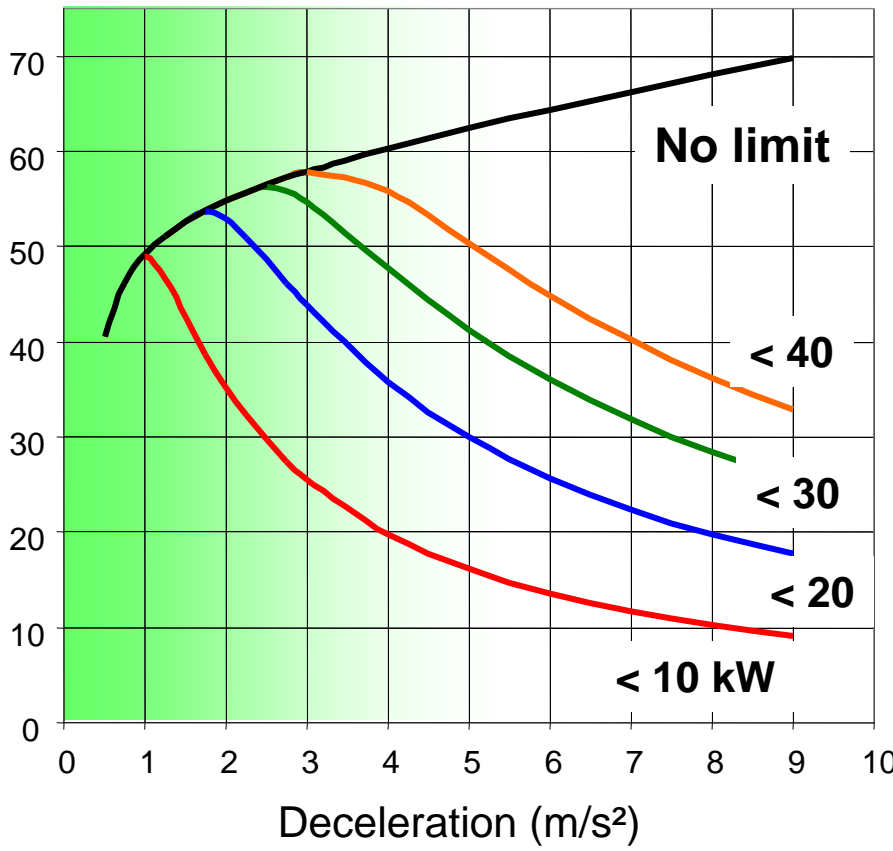
Energy recovery in deceleration



■ Front axle

■ Rear axle

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Charge sustaining HEVs

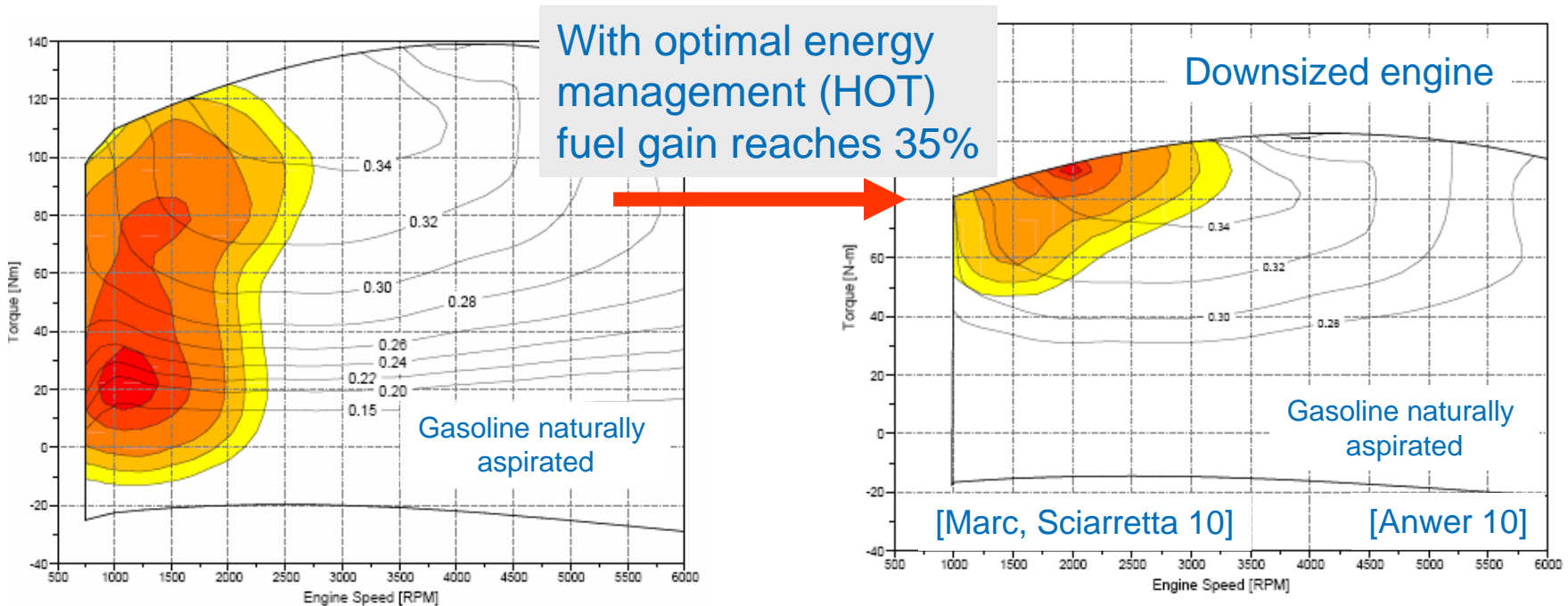
Influence of driving conditions : Urban case

Conventional drivetrain

- Average engine efficiency 19%

Parallel HEV drivetrain

- Average engine efficiency 35%
- More than 45% of motoring energy may be recovered



Charge sustaining HEVs

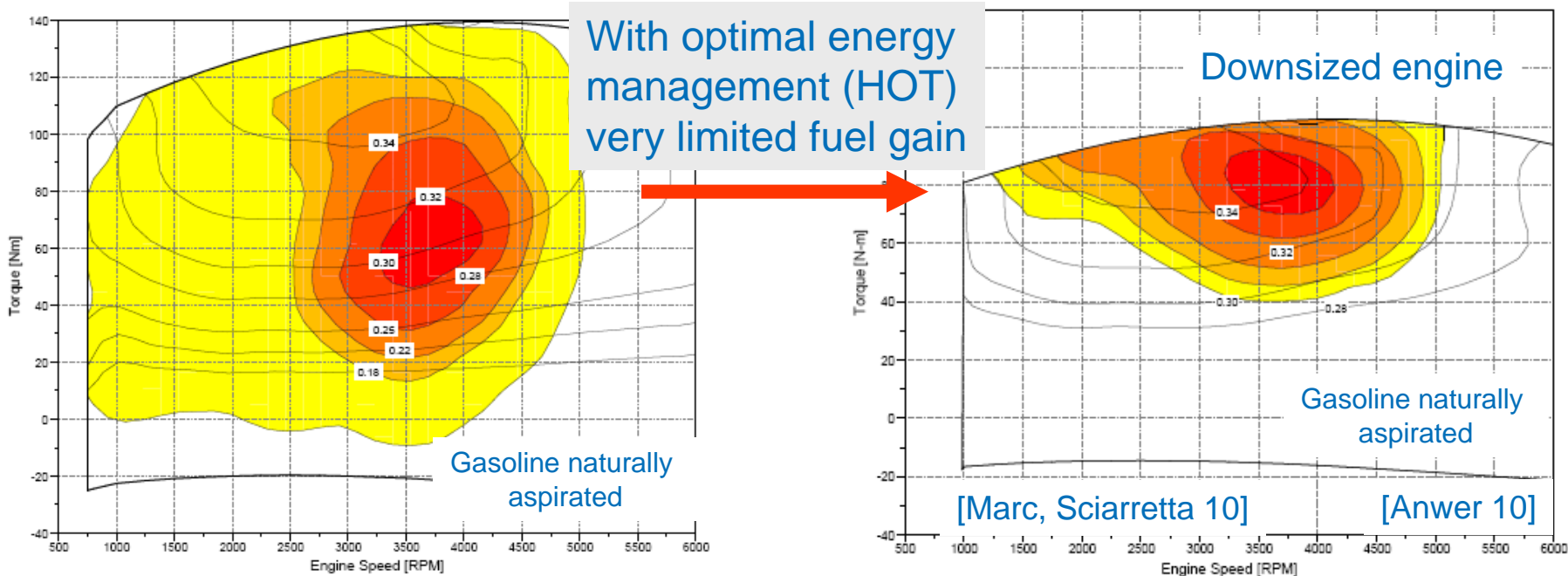
Influence of driving conditions : Motorway case

Conventional drivetrain

- Average engine efficiency 29%

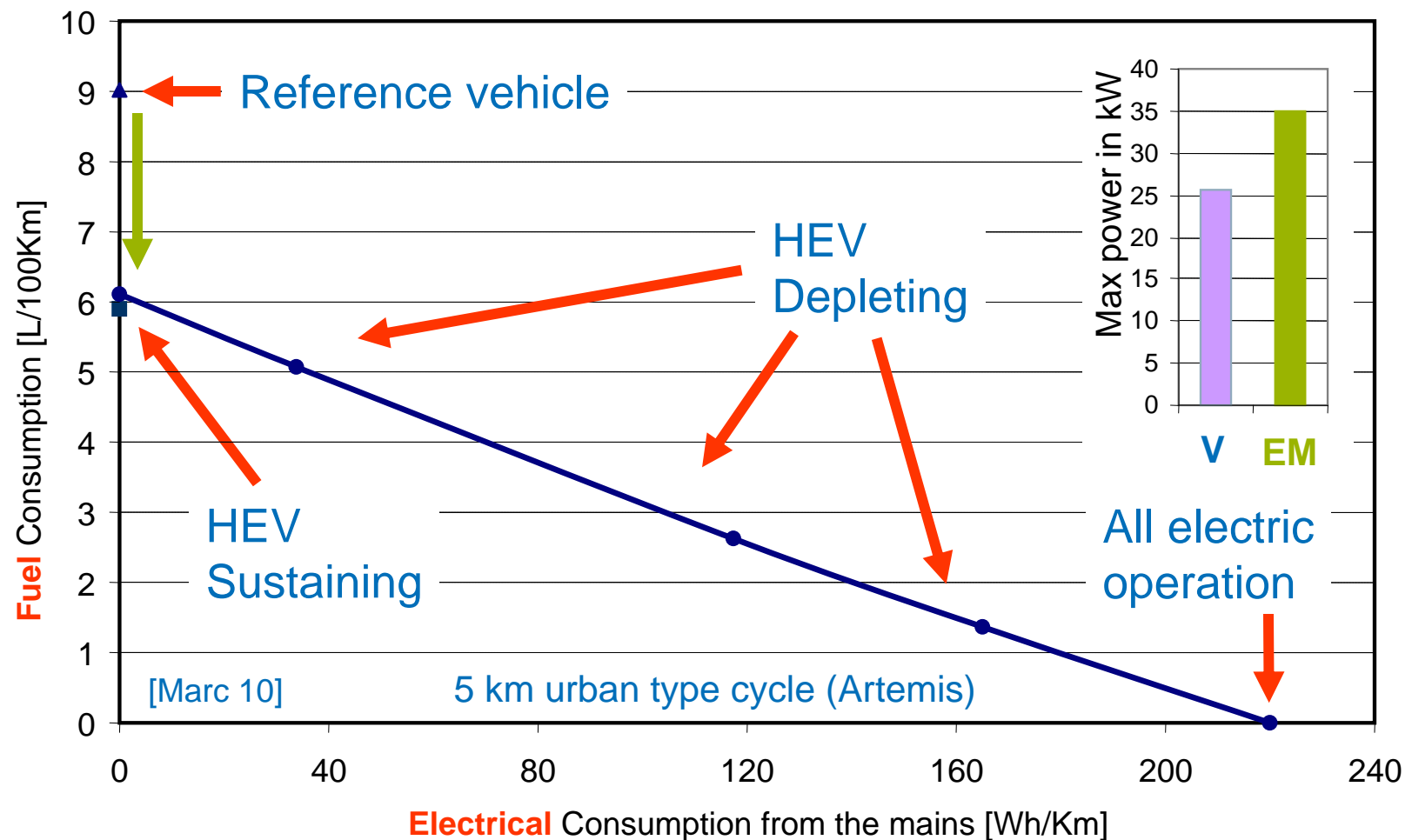
Parallel HEV drivetrain

- Average engine efficiency 34%
- Less than 6% of motoring energy may be recovered



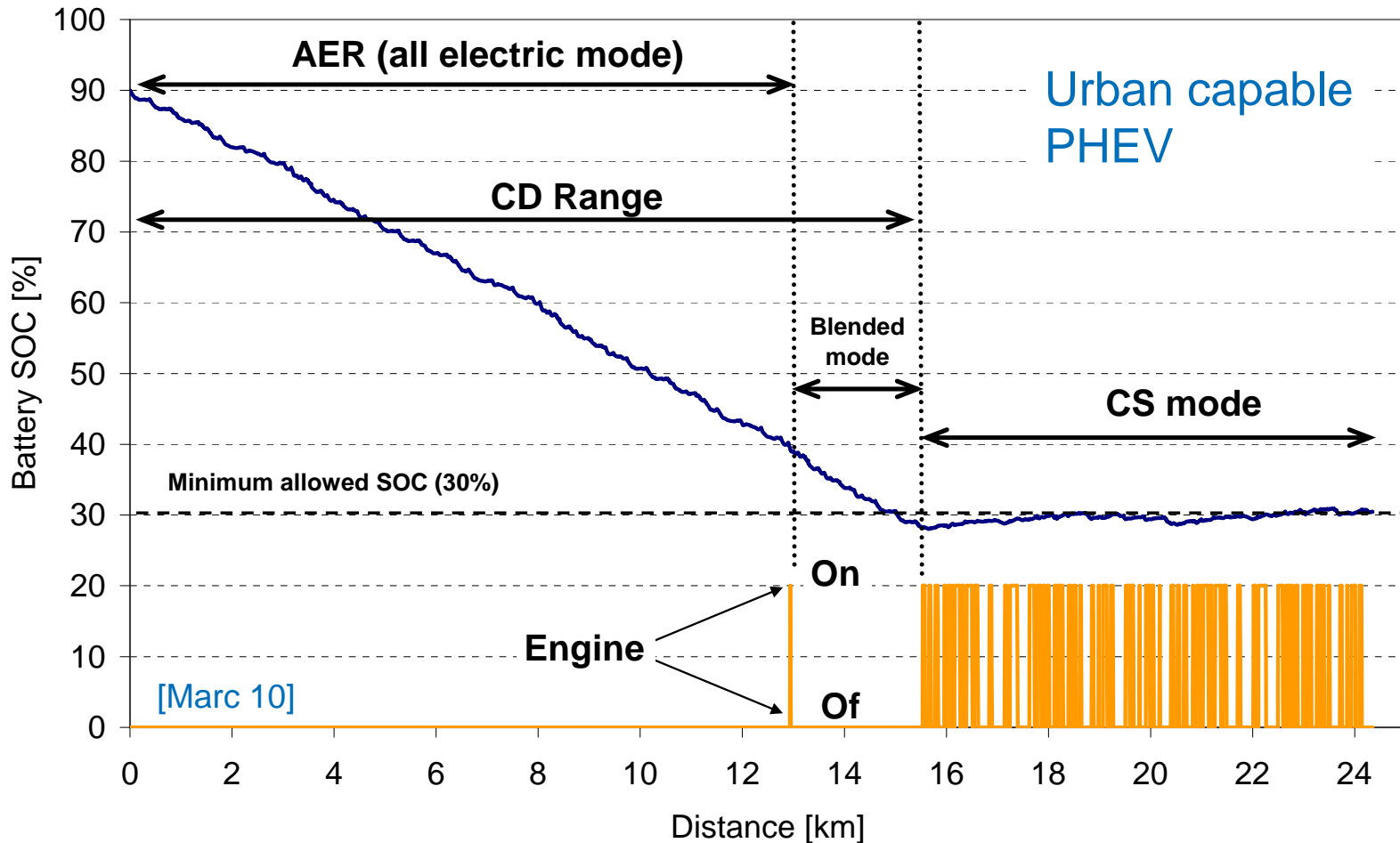
Charge depleting HEVs

Influence of energy management : Urban case



Charge depleting HEVs

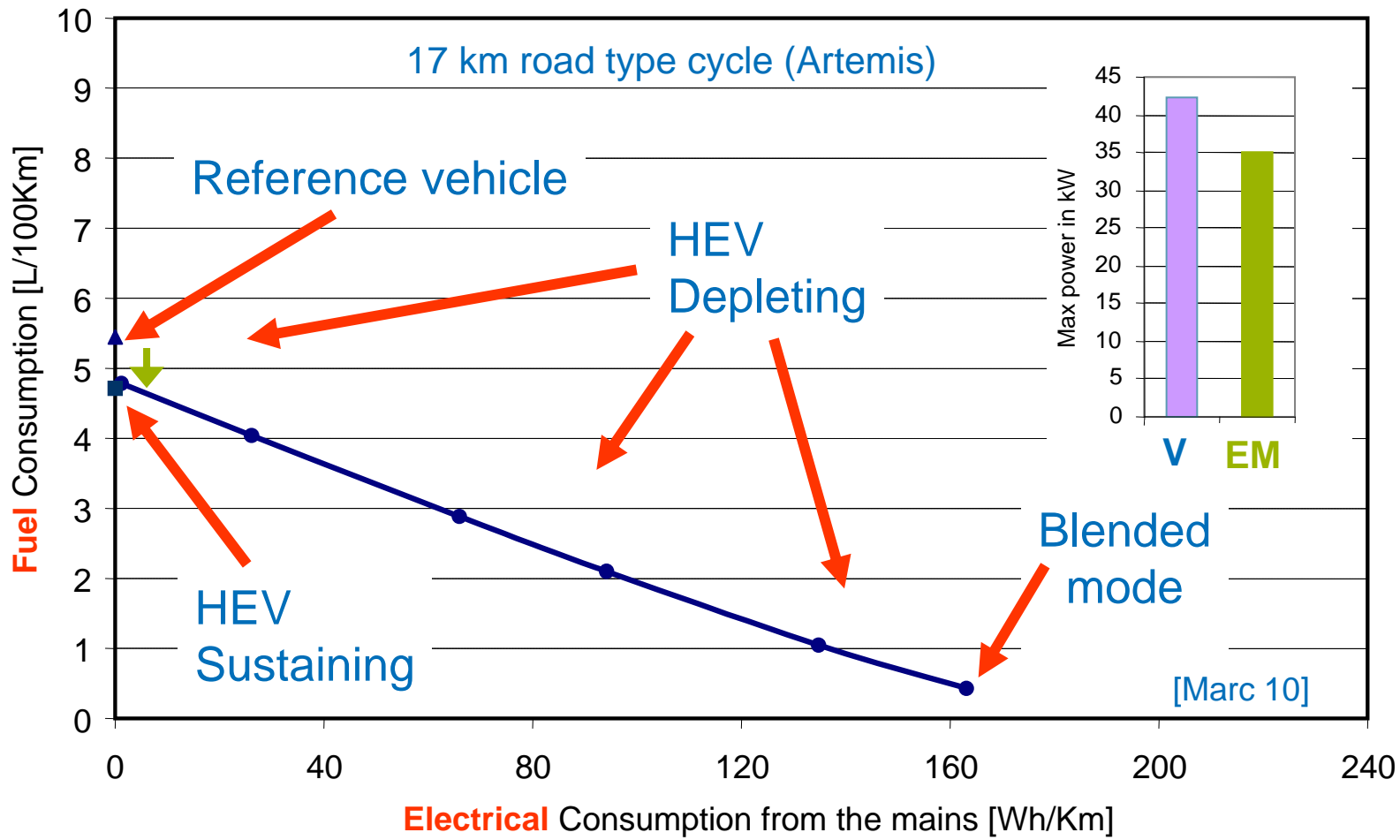
Different operating modes : Urban case





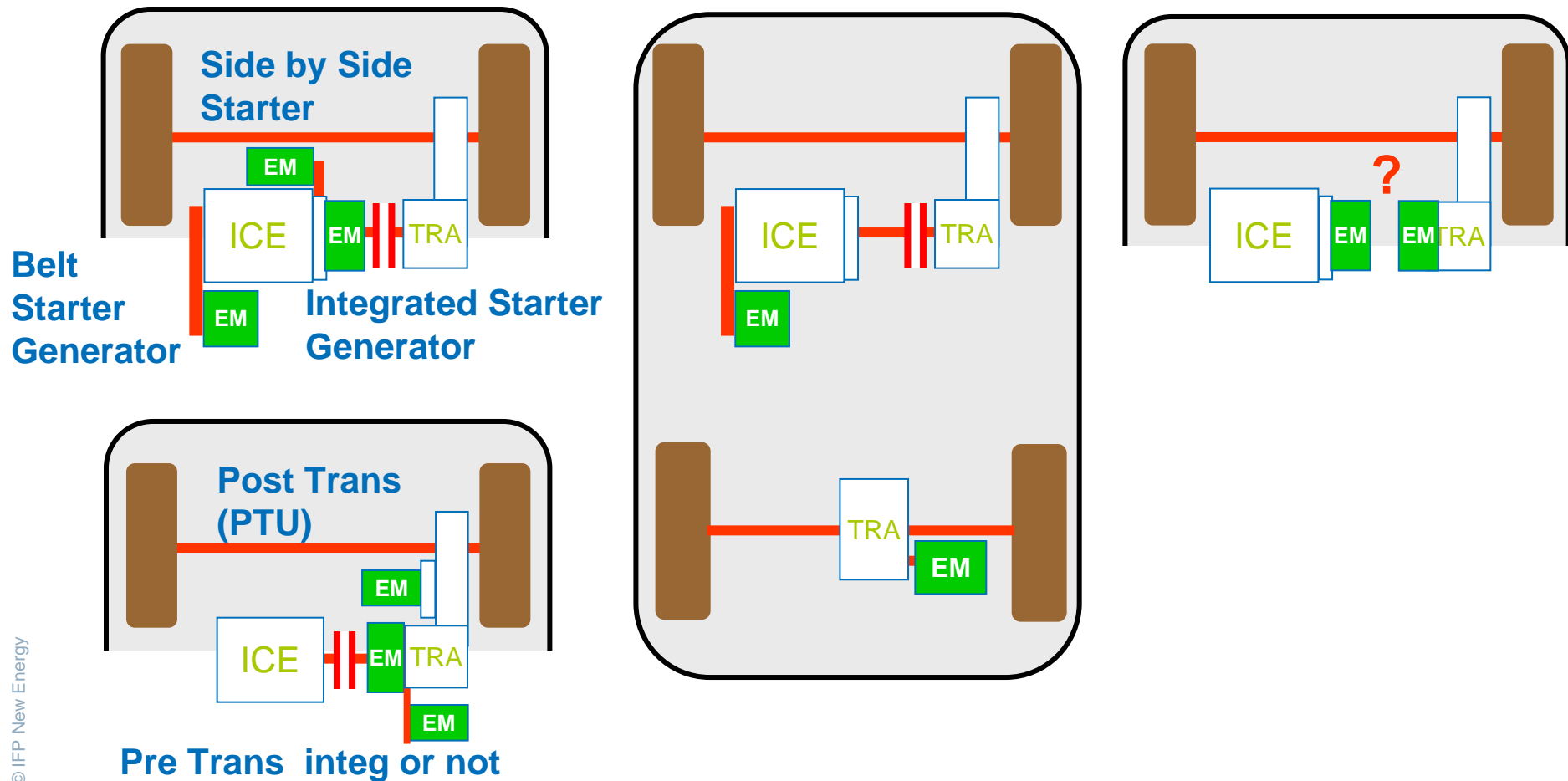
Charge depleting HEVs

Influence of energy management : Road case



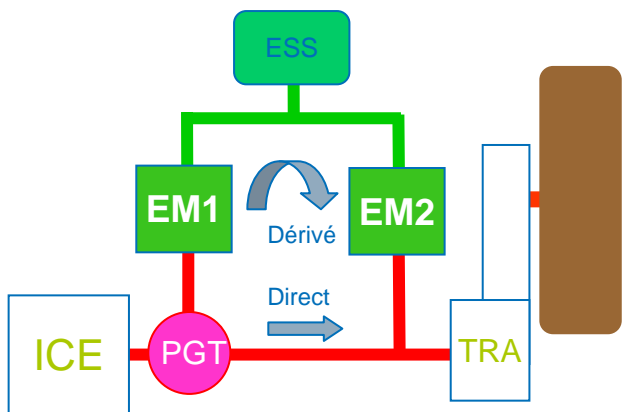
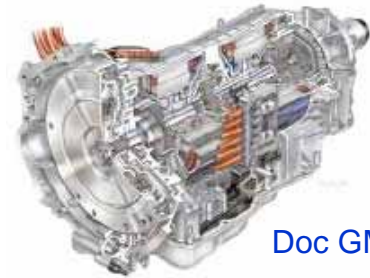
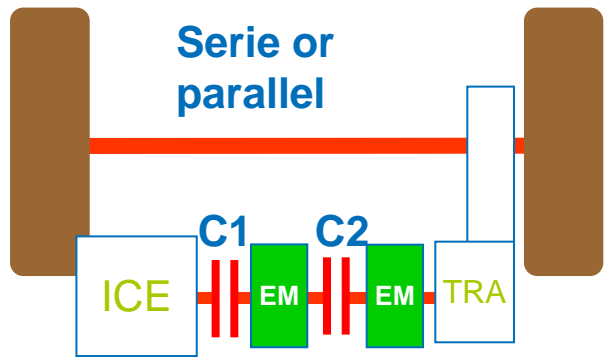


Multitude of architectures (1/3)

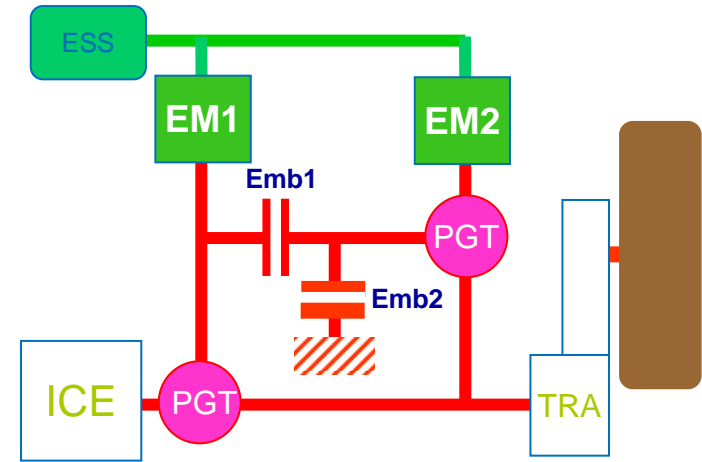




Multitude of architectures (2/3)



**Input split (one mode)
+ reduction gear
+ rear axle drive**

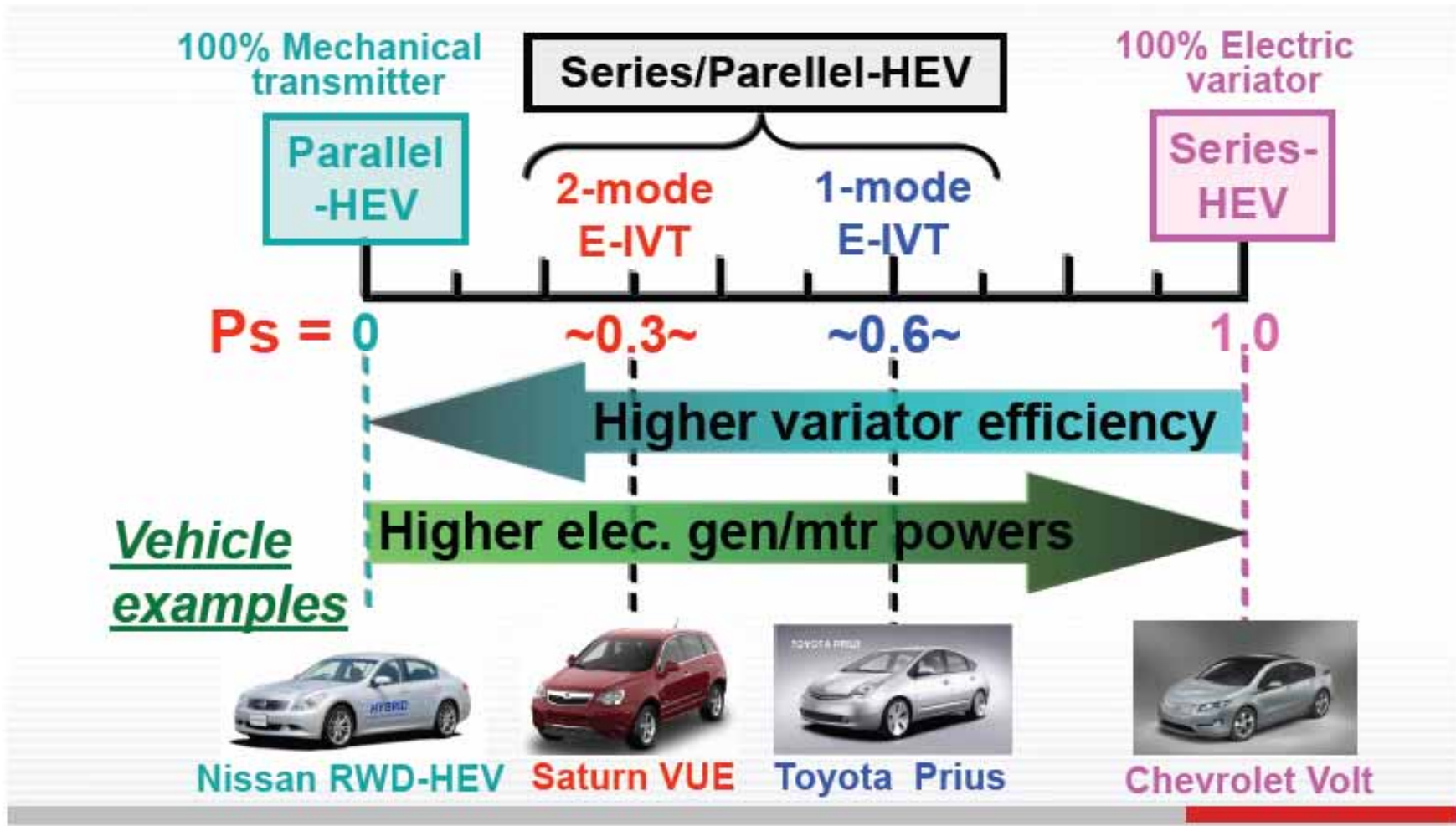


**Input/comound (two modes)
+ fixed gears (multi modes)**



Multitude of architectures (3/3)

[Fukino 09]





Elements of conclusion

- Concerning vehicle powertrain engineering

Program of Demand
Actual use
Trips distances
ZEV mandate
Charging opportunity



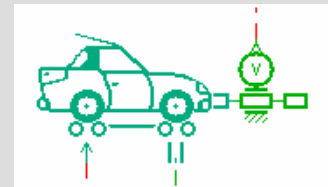
HOT



xMOD



AMESim

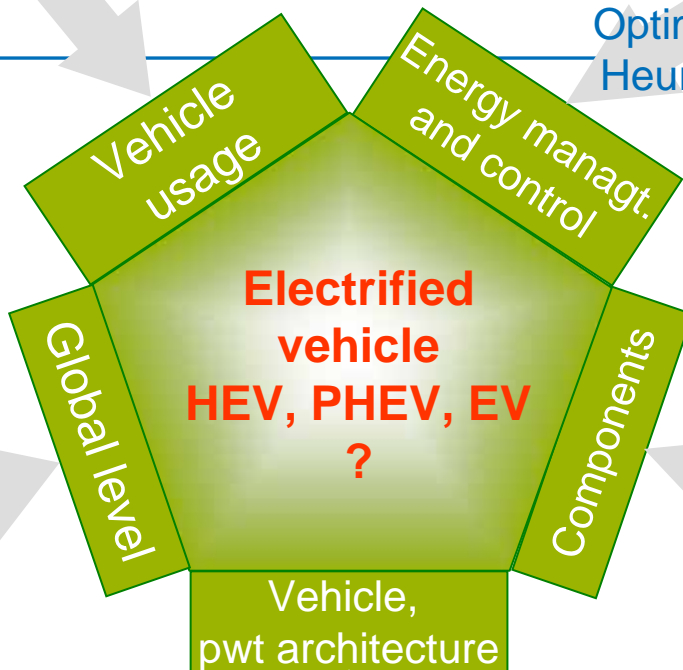
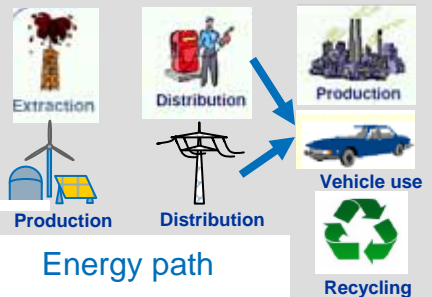


Optimized
Heuristic

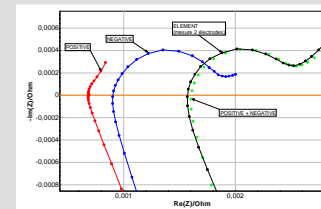
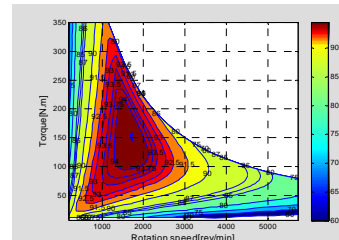
WtW analysis

- electricity vector
- fuel vector

Raw material
availability



Simulations
• quasistatic
• dynamic
Testing
Ageing

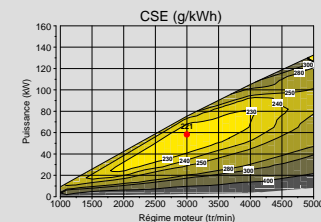


System integration, NVH, testing...

FlexHybrid IFP
Energies Nouvelles
Demo Car drivetrain



D2T 4WD climatic
Chassis dno
Dynamic engine
test bench





Thank you for your attention

