Evaluation of EVs energy consumption influencing factors,

driving conditions, auxiliaries use, driver's aggressiveness

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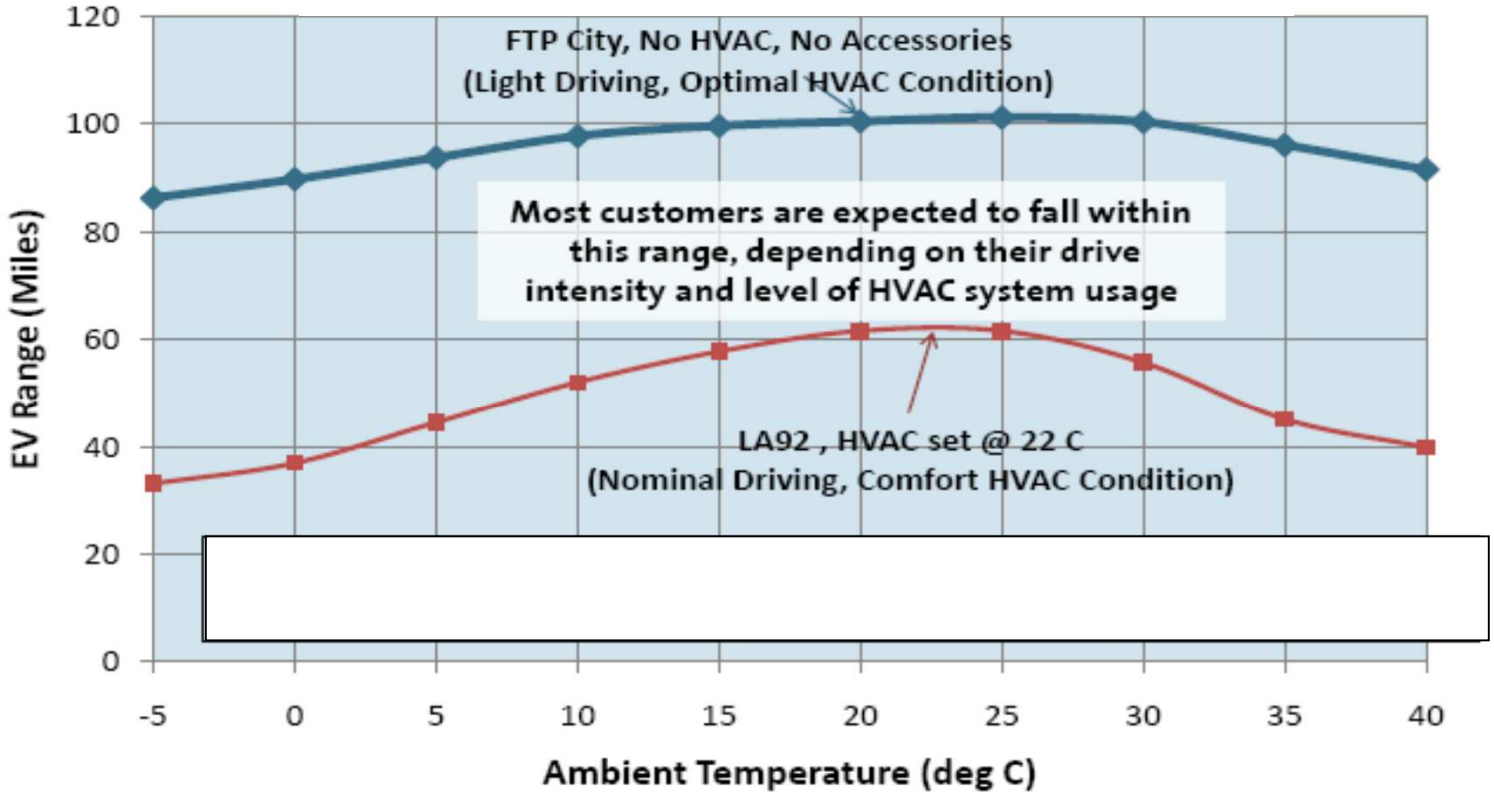
Problematic

- EV's enable to avoid local nuisances
- EV's energy consumption is very sensitive :
  - To the vehicle range (driver's anxiety)
  - To the evaluation of the Life Cycle emission values (GHG balance)
  - To the evaluation of TCO

Car manufacturers are very sensitive to that point (EVs)

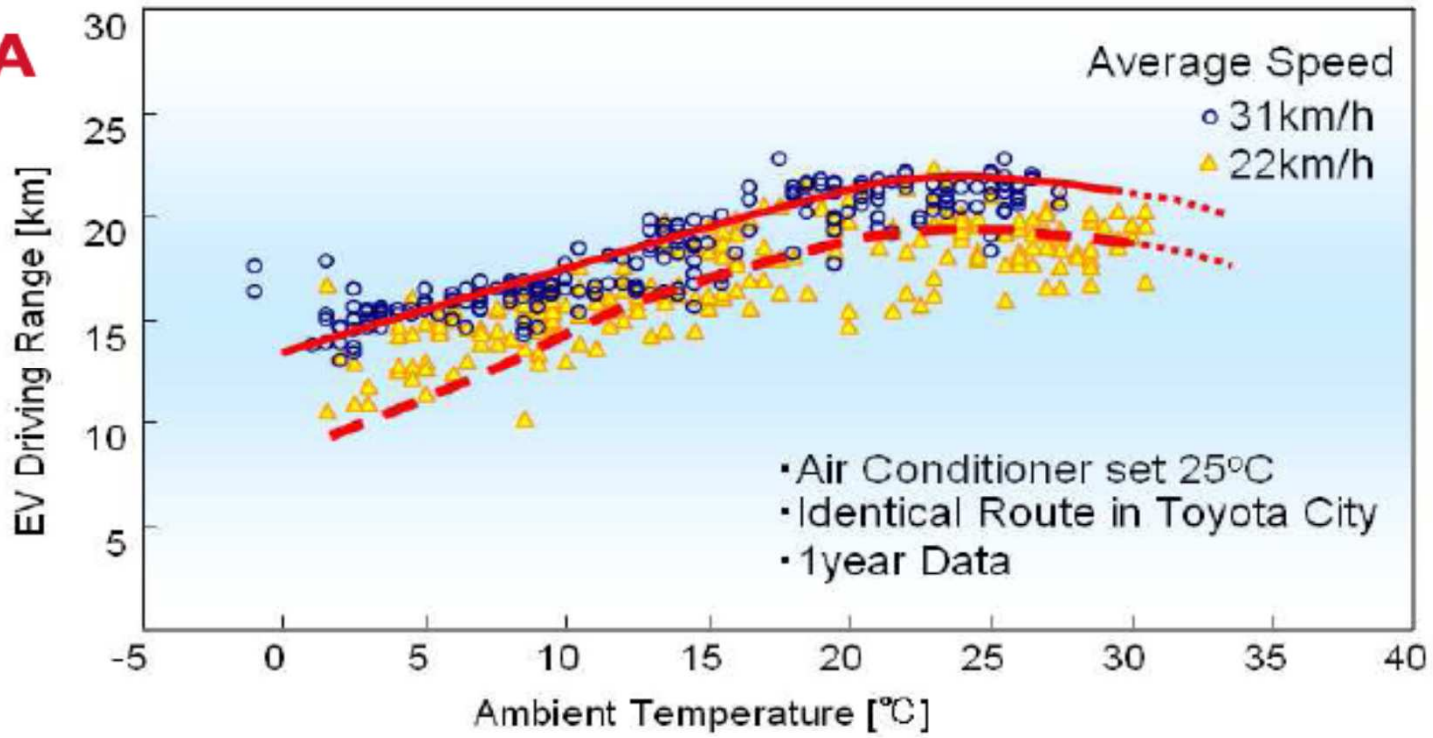


Driving schedule

A/C use

Car manufacturers are very sensitive to that point (PHEVs)

TOYOTA



Driving schedule

A/C use

Research program to evaluate the influence of driving conditions and ambient temperature

- IFPEN : Research center
- French ADEME : Financial support
- PSA, Renault and Tazzari : Technical support
- Three steps program :
  - Measurements on 4WD climatic chassis dyno
  - Validated EVs software
  - Analytic correlation of Evs consumption

Chassis dyno measurements

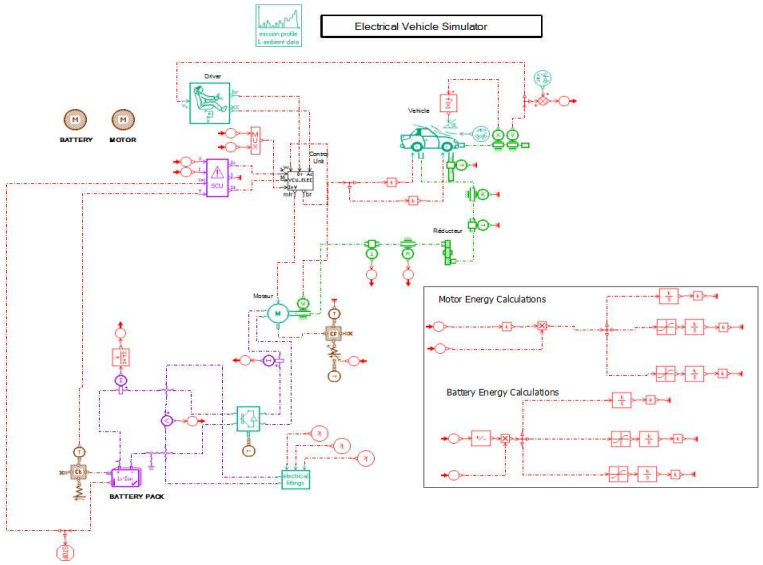
4WD climatic chassis dyno

- Expensive tool ;
- Limited number of tests cycles x 3 ambient cond.);
- Confidentiality setting, CAN...) ;
- Not a benchmarking (3 EVs tested);
- Limited to existing vehicles and technologies

Simulation software (1/2)

- Dedicated library ;
- Complete set of data ;
- Validations (component & vehi
- Great care on the results ;
- Fast and not expensive ;
- Exhaustive analysis

LMS Imagine Lab AMESim



IFPEN EM test bench

IFPEN BAT test bench

Simulation software (2/2)

- Battery simulation case :
  - Quasistatic model for short power solicitations (cycling)
  - Electrochemical model for long solicitations (charging)

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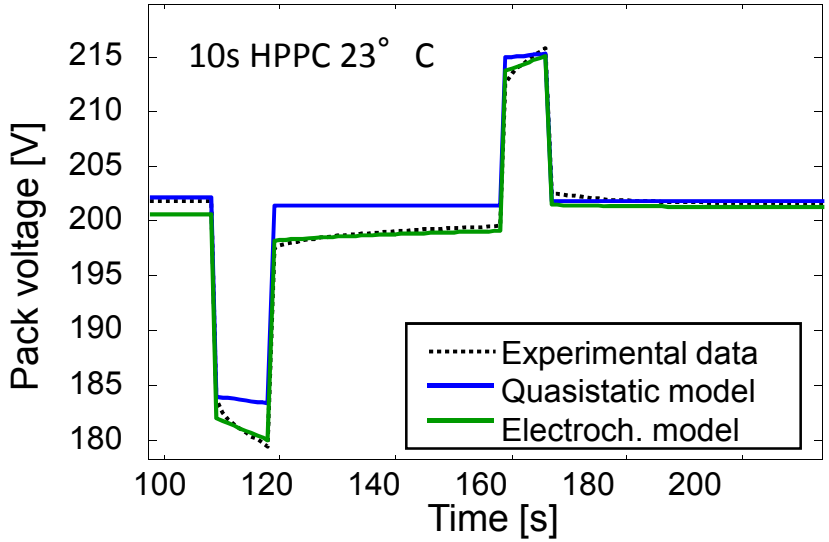
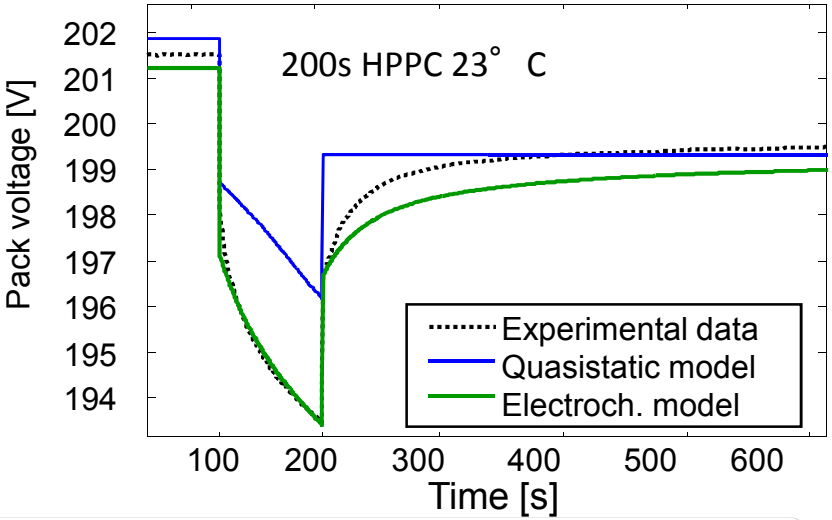
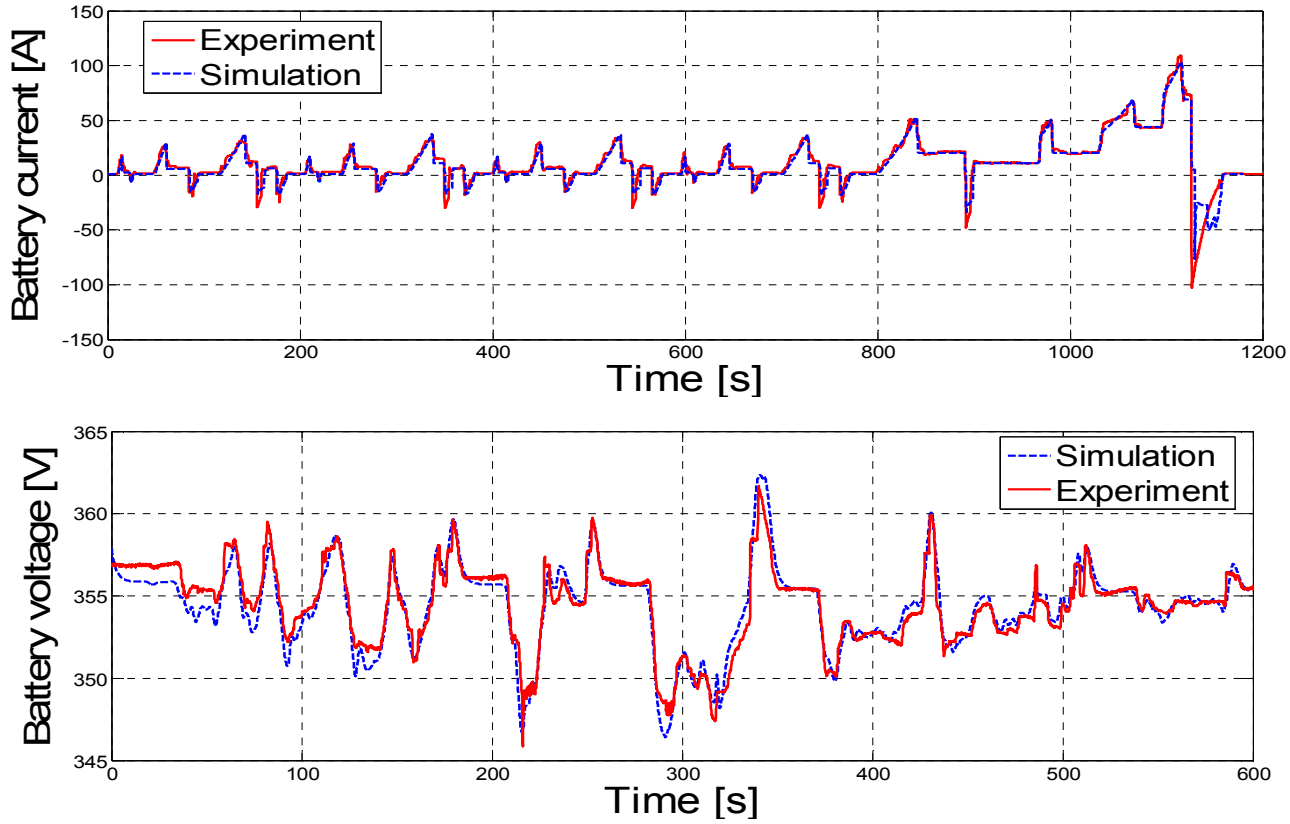
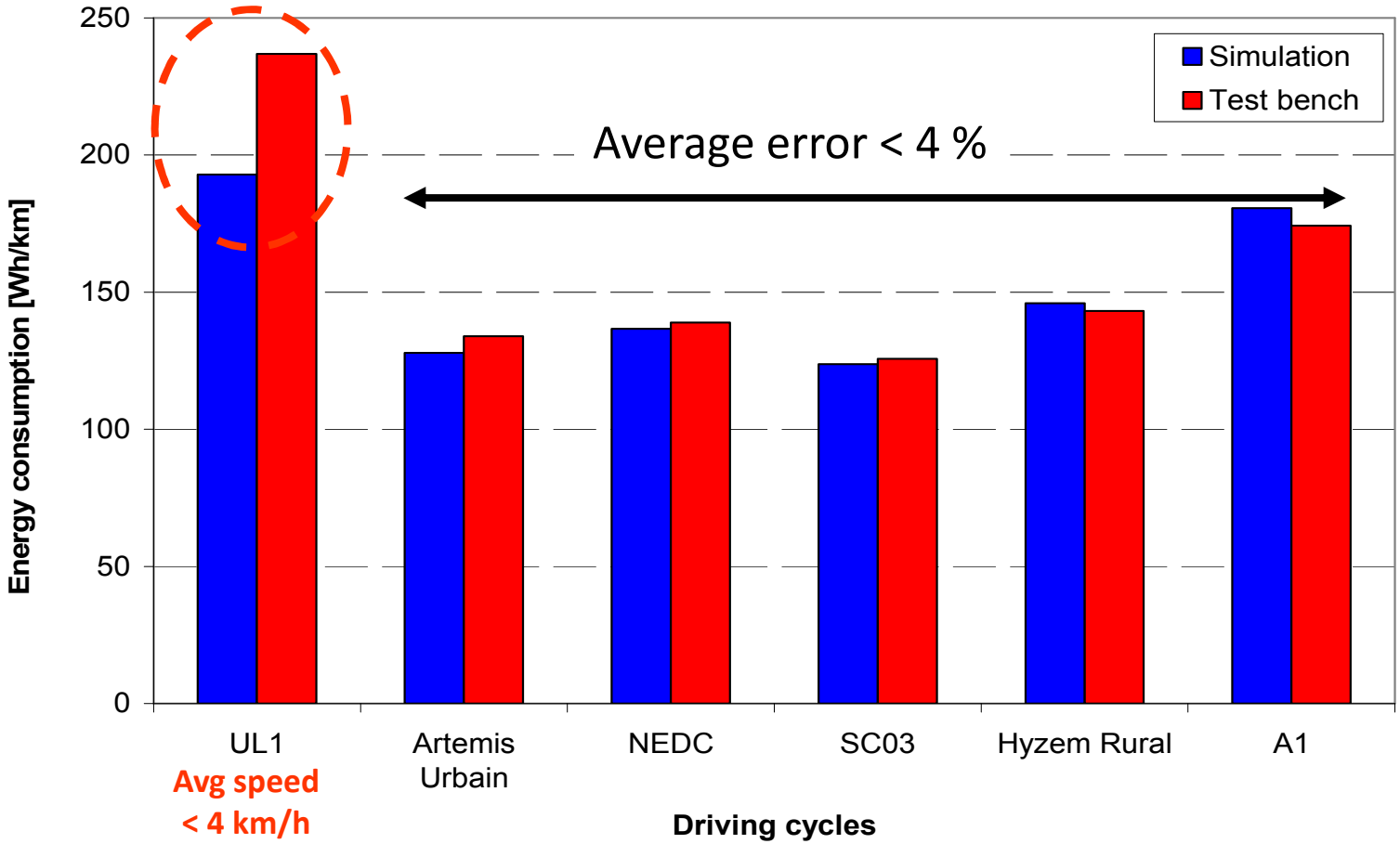




Software validation (1/2 component level)



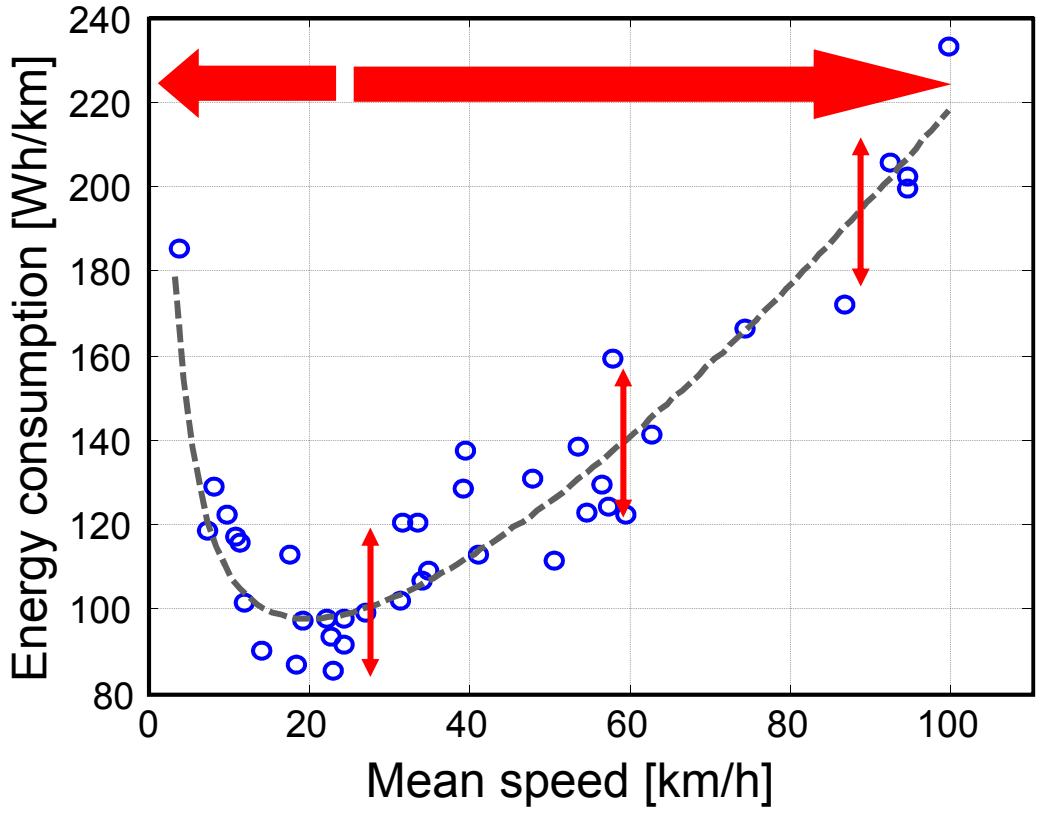
Software validation (2/2 vehicle level)



Software results

Vehicle energy consumption

- Large number of driving patterns (40*)
- Wide range of En Cons 90 to 240 Wh/km
- Disparities

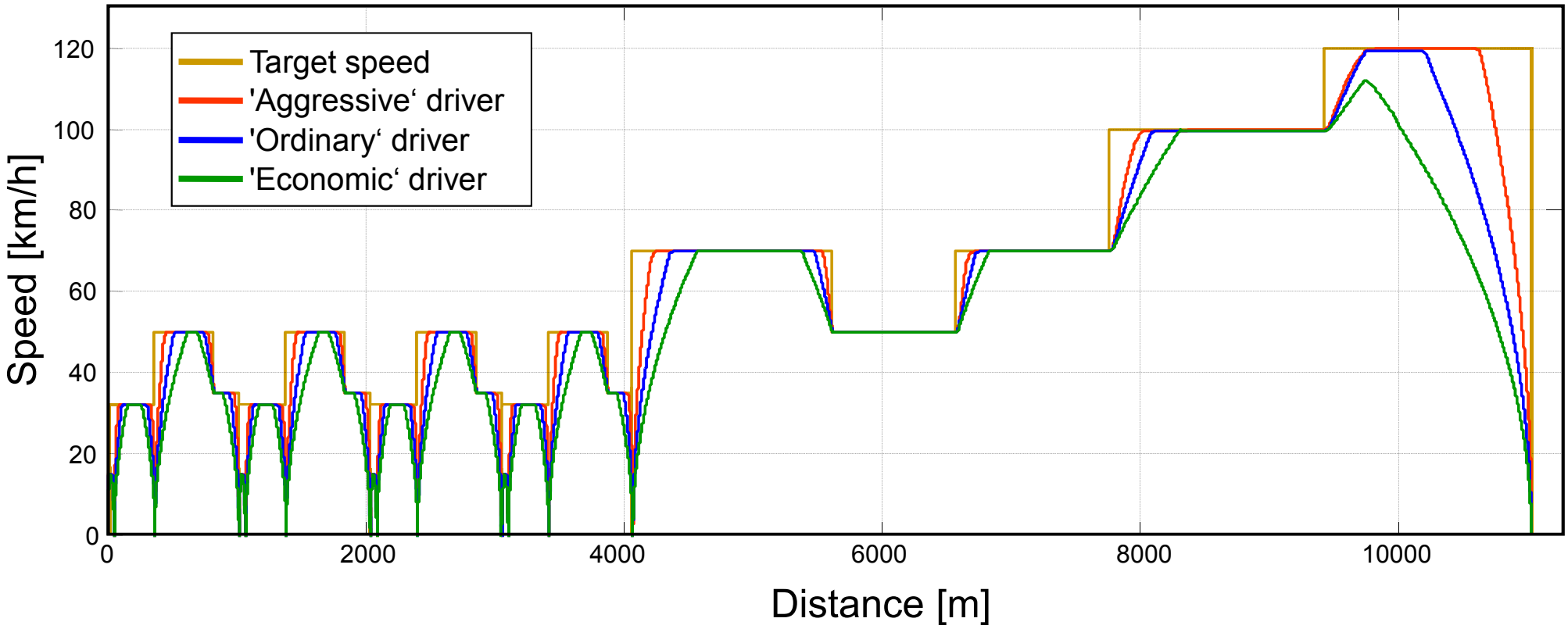


* Influence of slope not considered

Software results

Influence of driver's aggressiveness (1/3)

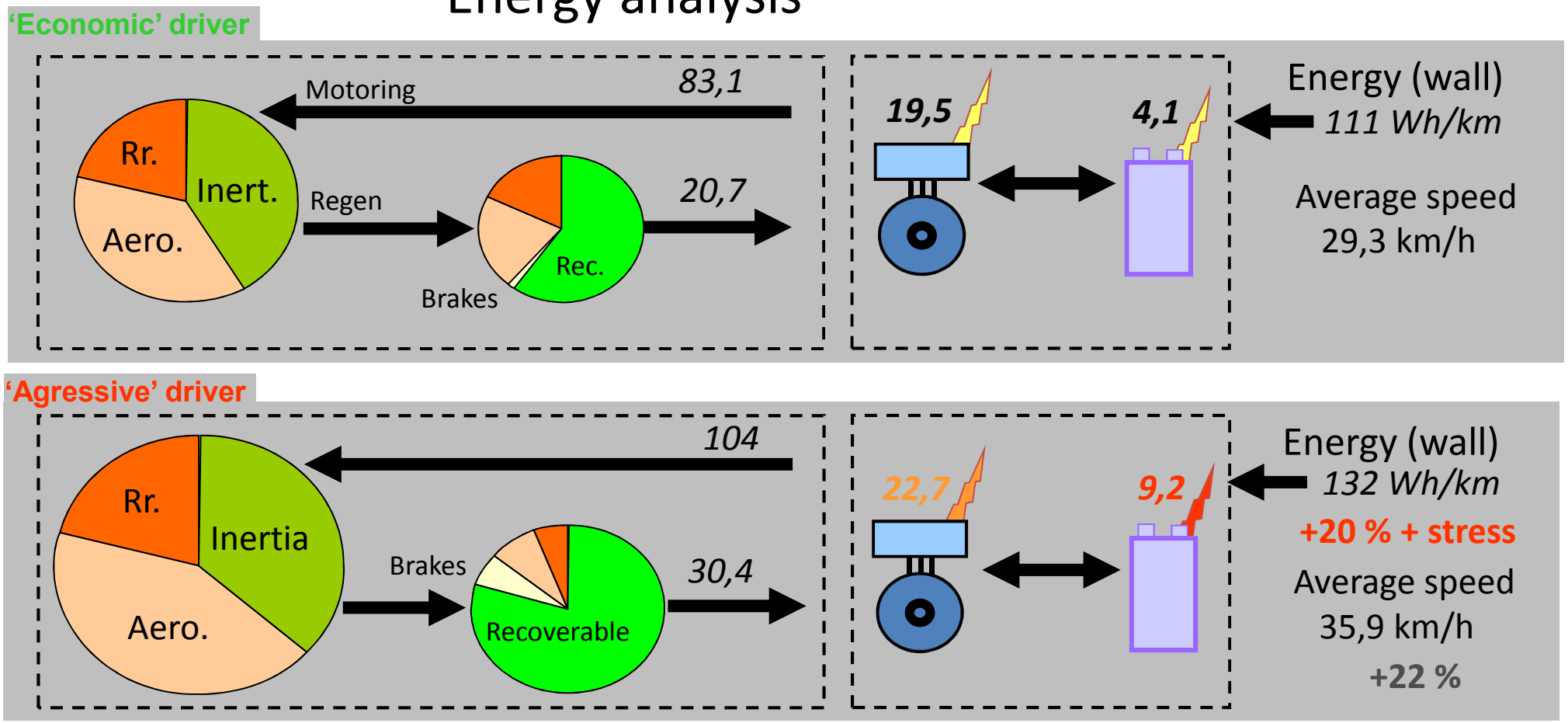
- Dynamic analysis (NEDC cycle base)



Software results

Influence of driver's aggressiveness (2/3)

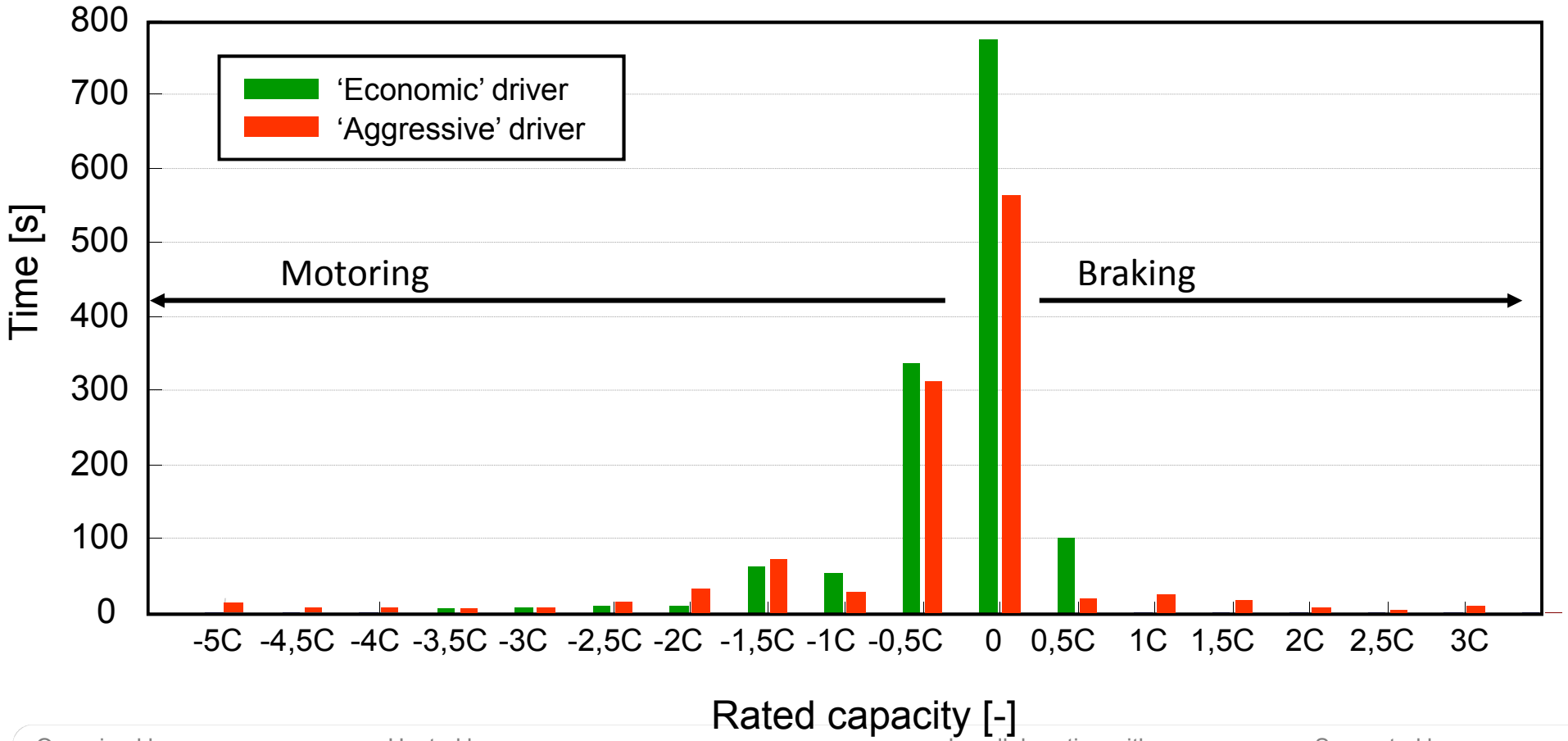
- Energy analysis



Software results

Influence of driver's aggressiveness (3/3)

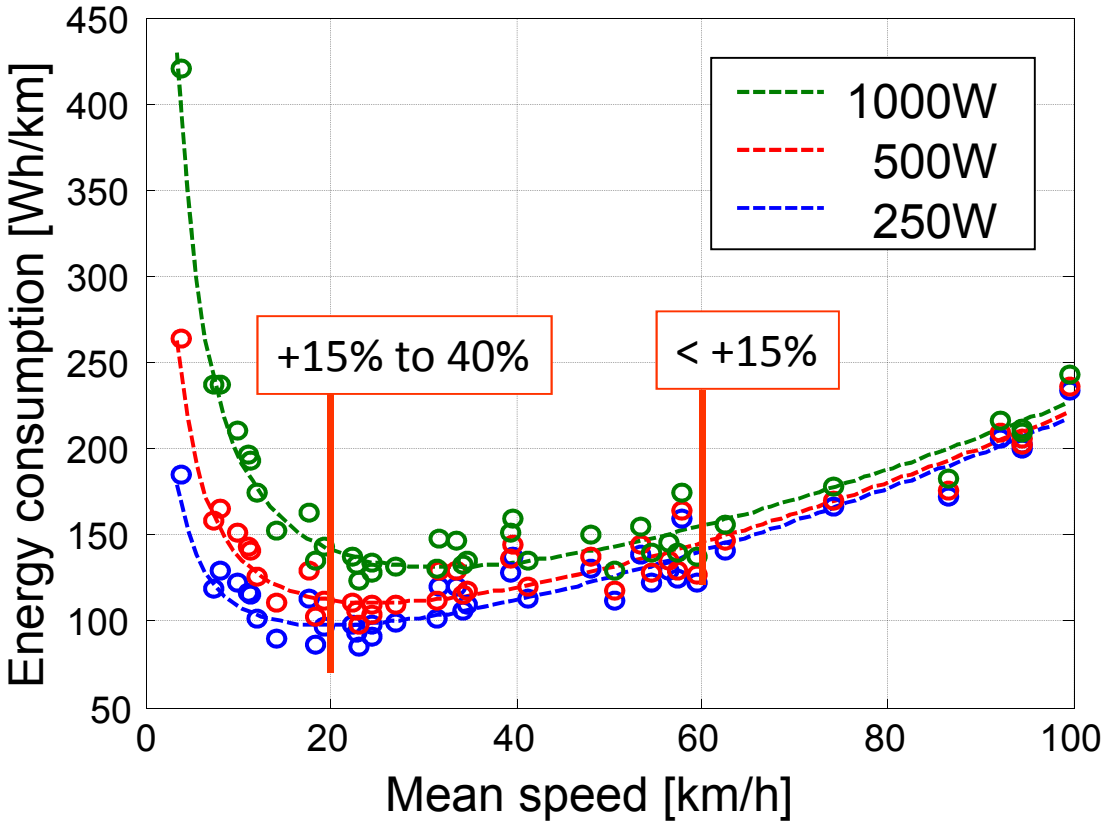
- Component stress analysis (battery)



Software results

Influence of auxiliary power

- Three cases tested, 250, 500 and 1000 W



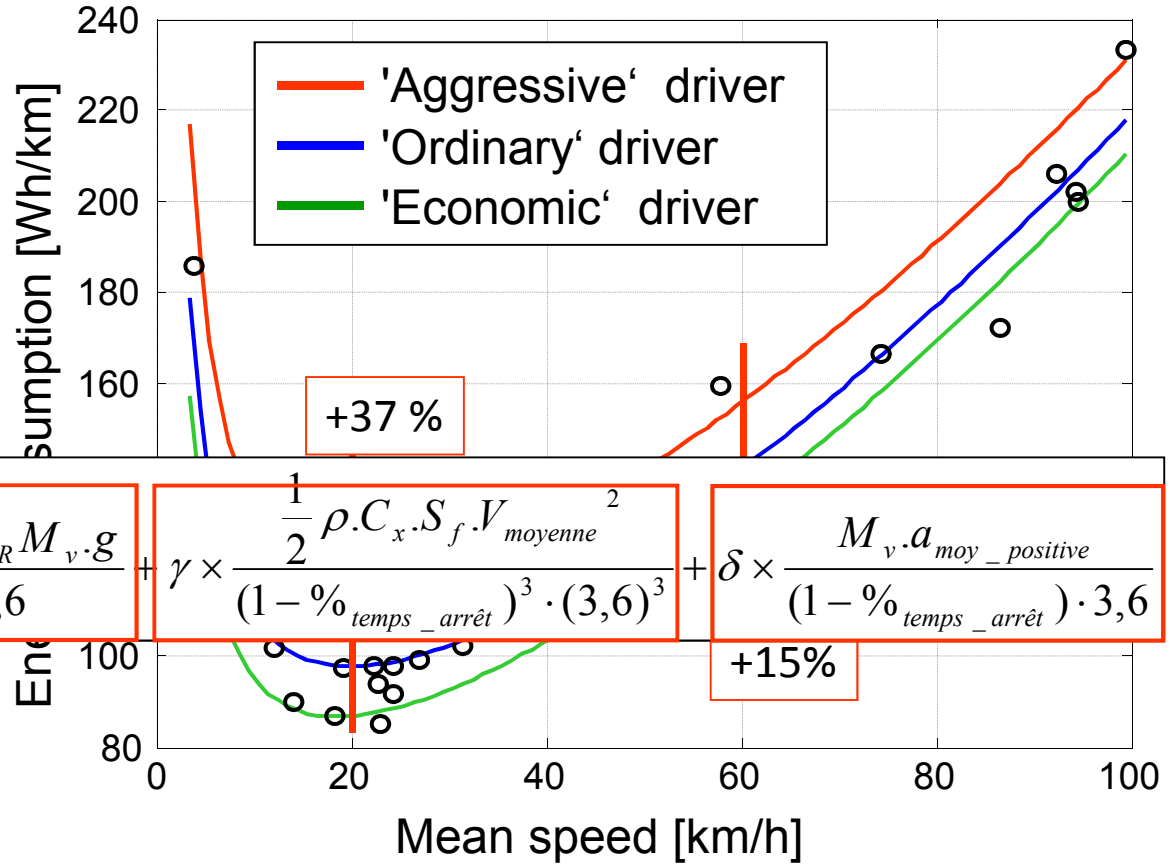
Analytical method

Evaluation of EV energy consumption

- Cons [Wh/km] =

  $K_{1aux} + K_{2rolling} + K_{3aero}$

  $+ K_{4acceleration}$



$$Conso_{moyenne}[W.h/km] = \alpha \times \frac{P_{accessoire\ s}}{V_{moyenne}} + \frac{\beta \times C_{RR} M_v . g}{3,6} + \gamma \times \frac{\frac{1}{2}\rho . C_x . S_f . V_{moyenne}^{\ 2}}{(1 - \%_{temps_arrêt})^3 \cdot (3,6)^3} + \delta \times \frac{M_v . a_{moy_positive}}{(1 - \%_{temps_arrêt}) \cdot 3,6}$$

Conclusion

- Evaluation of EVs energy consumption thanks to a validated software, on 40 driving patterns;
- Consumption ranges from 90 to 240 Wh/km (B segment);
- Influence of driver's aggressiveness, up to 40% at 20 km/h and up to 15 % at 60 km/h;
- Influence of auxiliaries, 15 to 40 % at 20 km/h and 5 to 15% at 60 km/h (resp. +250 and +750 W);
- Setting up of an analytic method to quickly evaluate EV consumption with a reasonable error level;
- Work still in progress

Thank you for your attention

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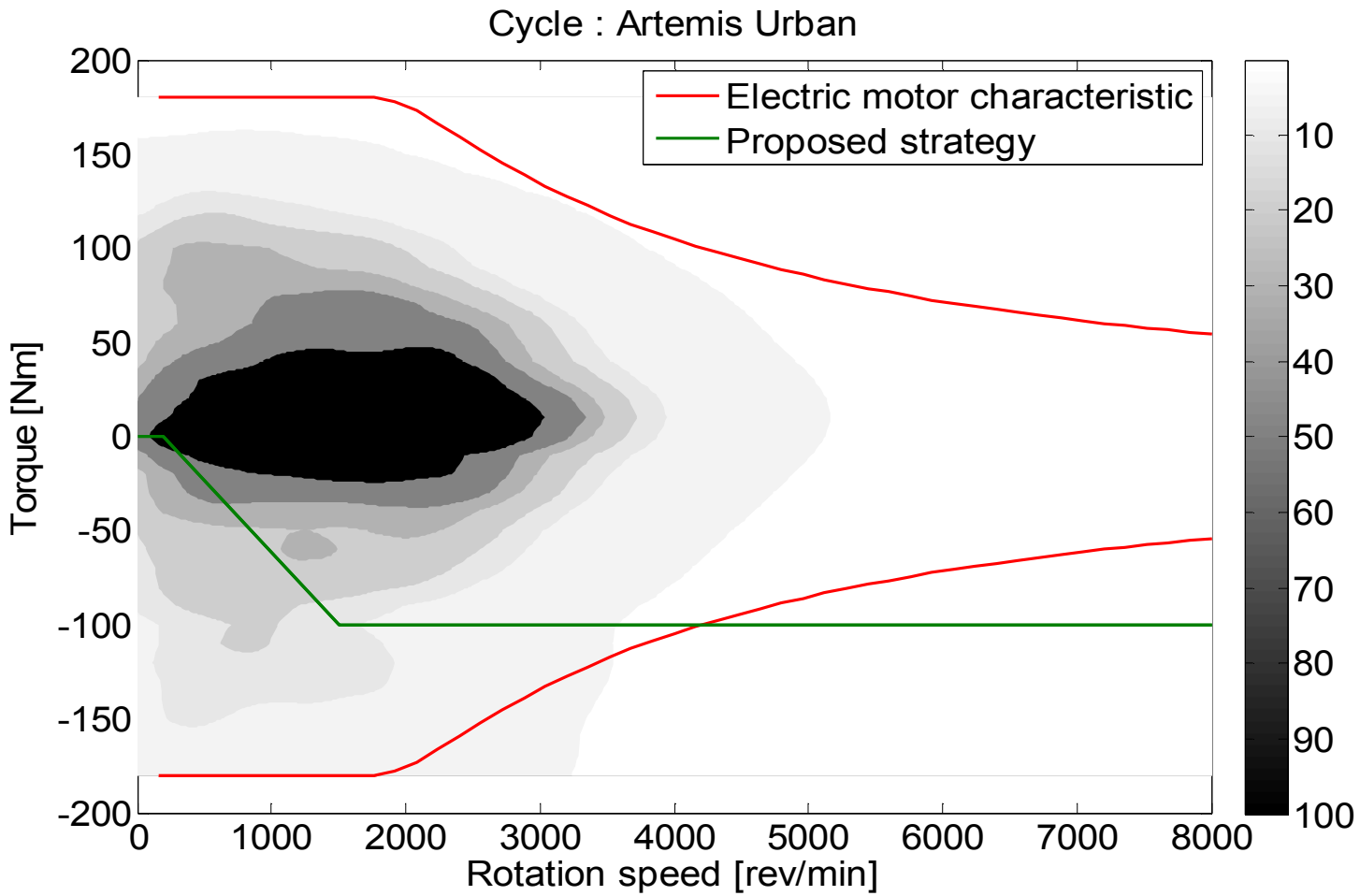
Cycle : Artemis Urban
Electric motor characteristic
Proposed strategy
Torque [Nm]
Rotation speed [rev/min]
200
150
100
50
0
-50
-100
-150
-200
0
1000
2000
3000
4000
5000
6000
7000
8000
10
20
30
40
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90
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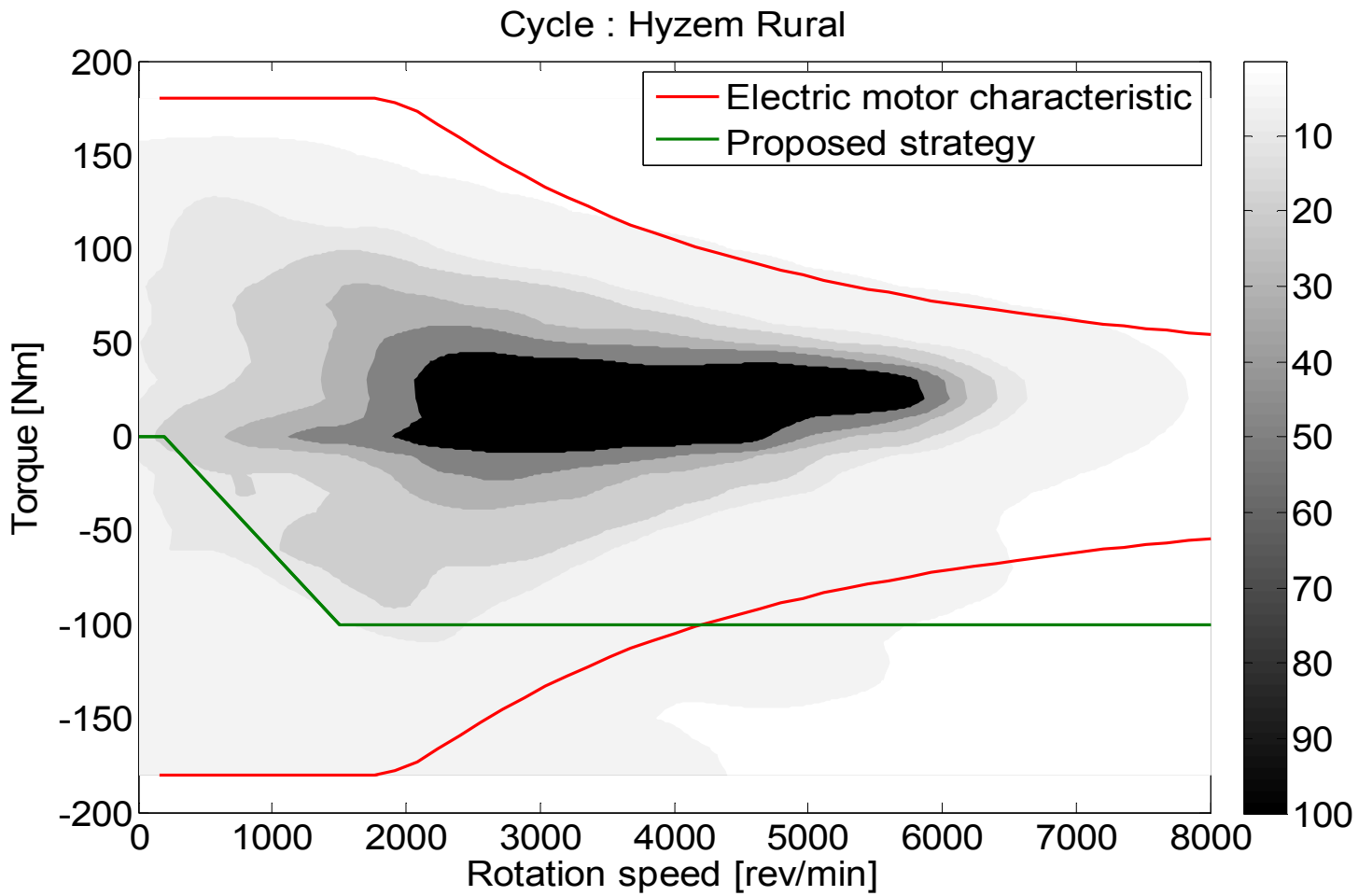
Cycle : Hyzem Rural
Electric motor characteristic
Proposed strategy
Torque [Nm]
Rotation speed [rev/min]
200
150
100
50
0
-50
-100
-150
-200
0
1000
2000
3000
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40
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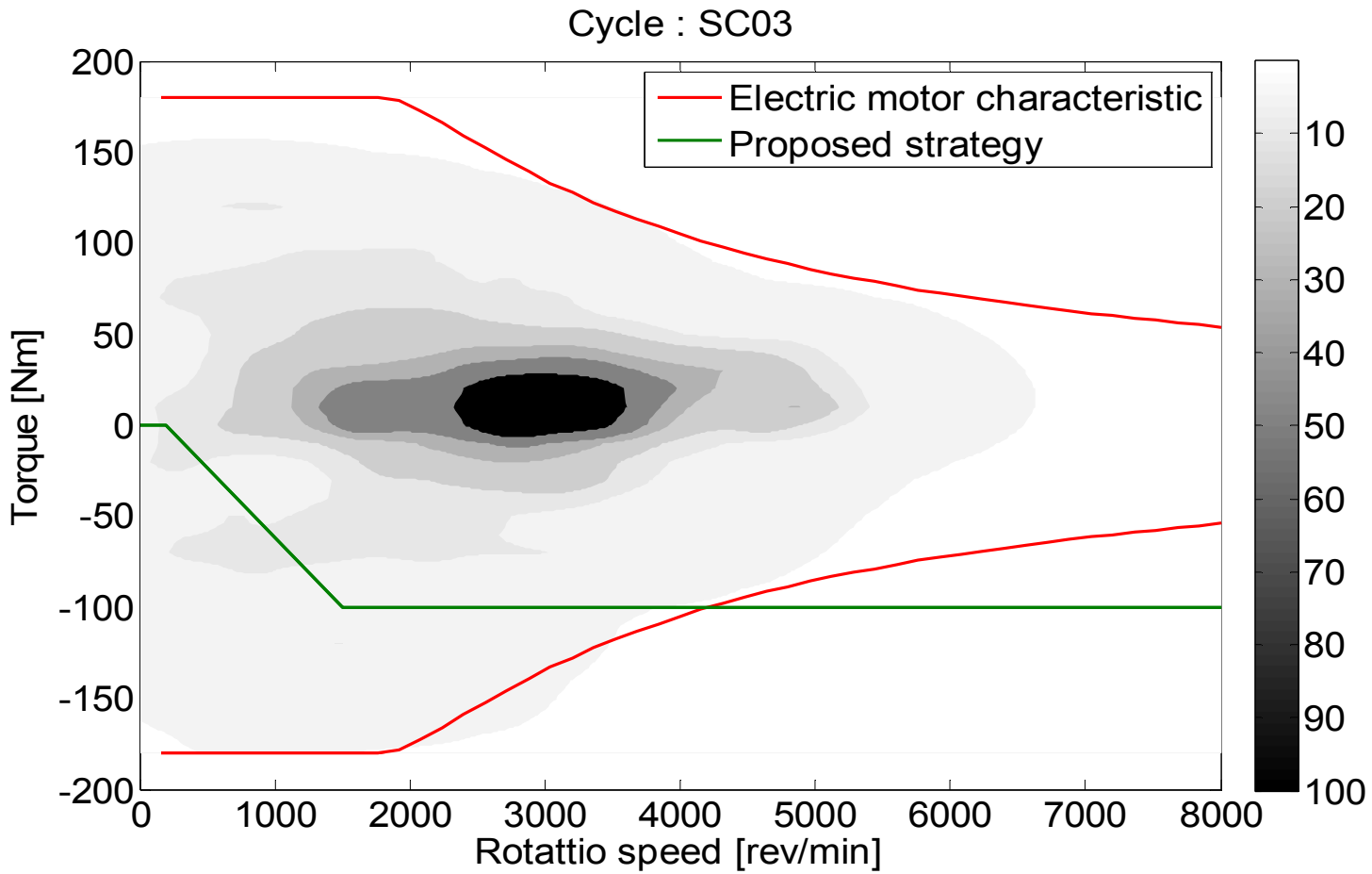
80
90
100


Cycle : SC03
Electric motor characteristic
Proposed strategy
Torque [Nm]
Rotattio speed [rev/min]
200
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