LES MOTEURS PSA EURO 6 DE DEUXIEME GENERATION ET LES PERSPECTIVES AU DELA DE 2020

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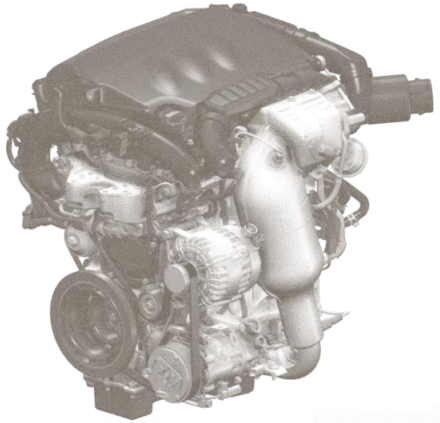
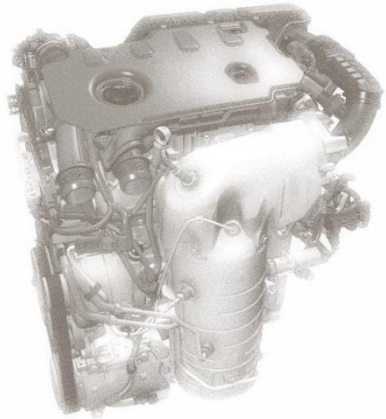
PLAN DE PRESENTATION

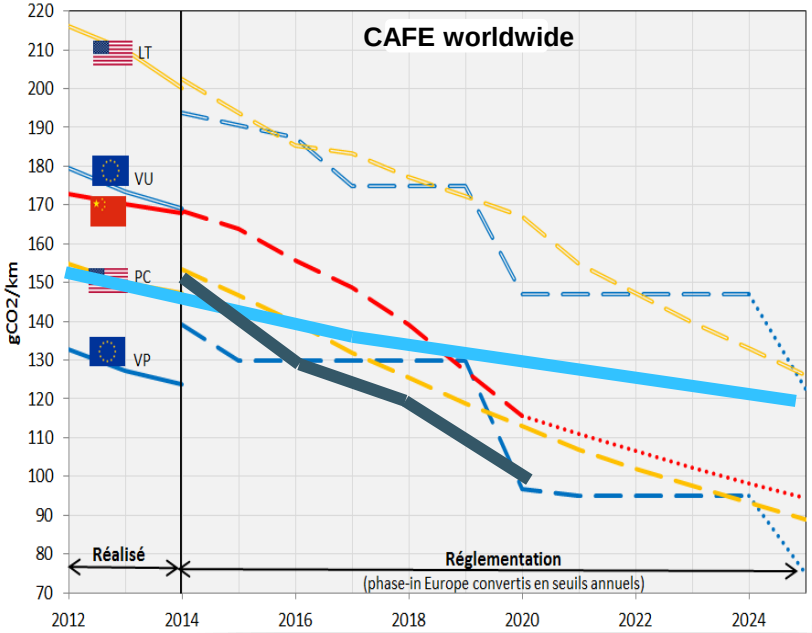


1. CHALLENGES PRINCIPAUX
2. NOUVELLES FAMILLES MOTEURS ESSENCE
3. NOUVELLES FAMILLES MOTEURS DIESEL
4. PERSPECTIVES AU DELA DE 2020



CO_2 REDUCTION

- Clean mobility is a major target for automotive industry
- CO_2 reduction drives important technical evolutions in vehicles and powertrains. Middle term roadmaps are still moving taking in account “reasonable” overcost
- Groupe PSA has developed for many years solutions to make consistent progress in fuel economy and emissions reduction



1 - CHALLENGES PRINCIPAUX

ELECTRIC VEHICLE

1995

DIESEL
HDI

1998

DPF

2000

STOP
& START

2004

GASOLINE
THP

2006

HYBRID4

2012

1 – CHALLENGES PRINCIPAUX

- For emissions, progress has been made in all major customer usages and RDE with new test cycles will contribute to measure progress
- For fuel consumption (and in next future, NOx emission) Groupe PSA, NGOs T&E and FNE, and Bureau Veritas set up a protocol for measuring real world fuel consumption. Until now, Groupe PSA has published results for more than 58 vehicles
- Challenge for “out of Europe”: to carry technical improvements with lower quality fuels and lubs with more difficult usage conditions

1 - CHALLENGES PRINCIPAUX

CO_2

- 2020 : CO_2 emissions target is, for Groupe PSA, less than 95 g/km
- Groupe PSA will release PHEV on mid / upper platform and BEV on future new small platform
- But in 2020, in Europe
  - *BEV : 4% to 5% of the market*
  - *MHEV and PHEV : 12 % of the market*

➔ Conventional thermal engine = more than 80 % of the sales

➔ More than 95% of the sold vehicles = at least one thermal engine

➡ Further improvement of conventional engines is necessary

2 - NOUVELLES FAMILLES MOTEURS ESSENCE

2.1 – Headlines of new PSA gasoline engine line up

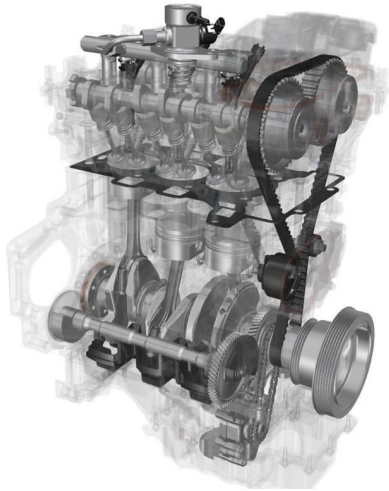
PURETECH 3 CYLINDERS 1,2l
PURETECH 82: 60kW /118 N.m (N.A.)
PURETECH 110: 81kW / 205 N.m
PURETECH 130: 96kW / 230 N.m

PURETECH 4 CYLINDERS 1,6l
PURETECH 180: 133kW / 250 N.m
PURETECH 225: 165kW/ 300 N.m

Variable Valve Lift generalized for all Puretech 4 cylinders

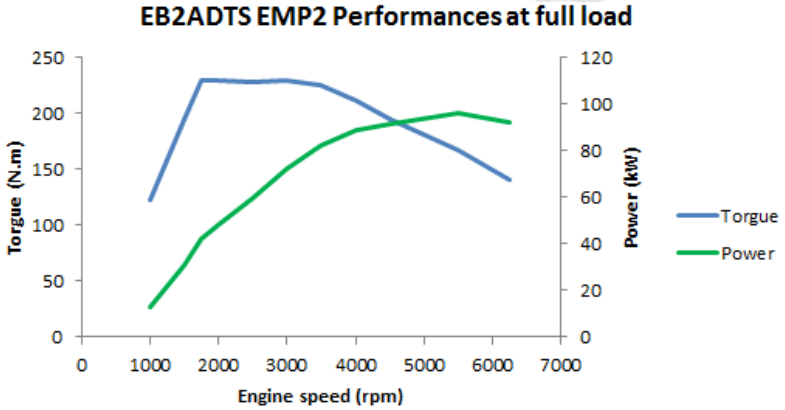
2.2 – New 1,2l Puretech engines

Launch date: 1st application in Europe: December 2017
Launch date: 1st application in China: March 2019



Main objectives

- Improve fuel consumption on the engine itself and on powertrain with new manual (6 speed) and new AT (8 speed) gearbox
- Improve packaging for installation in all existing and future vehicle platforms
- Meet most of worldwide emissions with in particular:
  - Euro 6d anticipated with RDE conformity factor of 1,5 (WLTP)
  - China 6b (and China 6a)
- Ability to be deployed worldwide
- Robustness to fuel quality



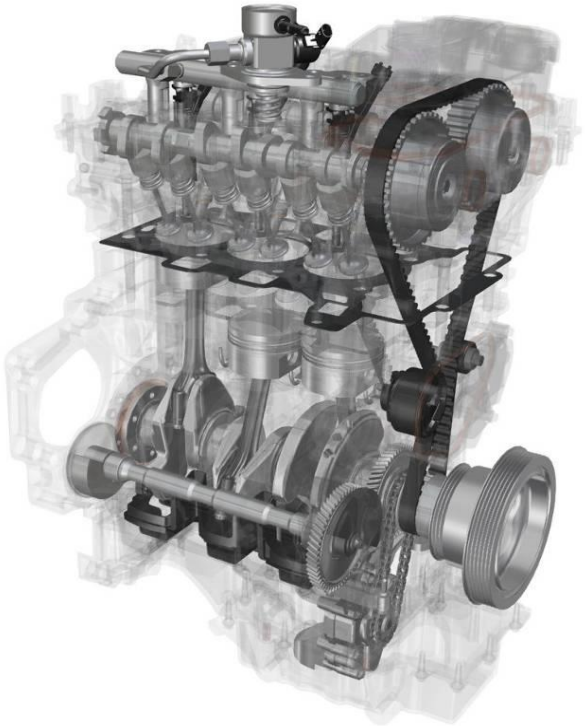
2.2 – New 1,2l Puretech engines

Main features

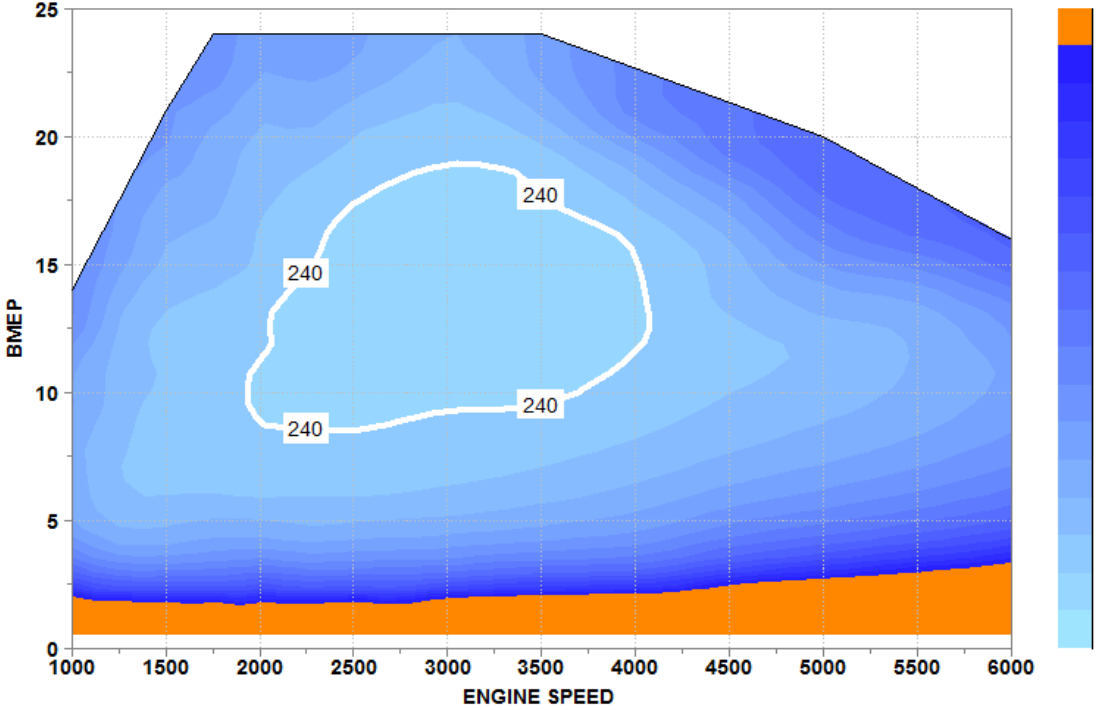
- Cylinder head evolution with compact packaging
- Combustion system upgrade with new turbocharger
- Improved protection strategies and mechanical reinforcement to cope with environmental requirements and improve robustness to abnormal combustion with low quality fuels and/or extreme usage conditions
- Gasoline particulate filter (GPF)
- Reduction of friction losses
- Proportional A/F sensor
- Volumetric ratio: 10,5 (same for Europe and China)
- Same core calibration settings for Europe and China

2 - NOUVELLES FAMILLES MOTEURS ESSENCE

Main characteristics of the new EB PureTech engine		
Number of cylinder	-	3
Displacement	cm^3	1199
Stroke	mm	90,4
Bore	mm	75
Cylinder spacing	mm	82
Main bearing diameter	mm	42
Conrod bearing diameter	mm	42
Conrod length	mm	143
Compression ratio	-	10,5
Power output	kW	96
Specific power output	kW/l	80
Max torque	Nm	230
Specific max torque	Nm/l	192
Fuel type (European version)	RON	91 - 98



NEW 1.2L PURE TECH PSA ENGINE: A CHAMPION IN FUEL CONSUMPTION !



Large range BSFC <240g/Kw/h

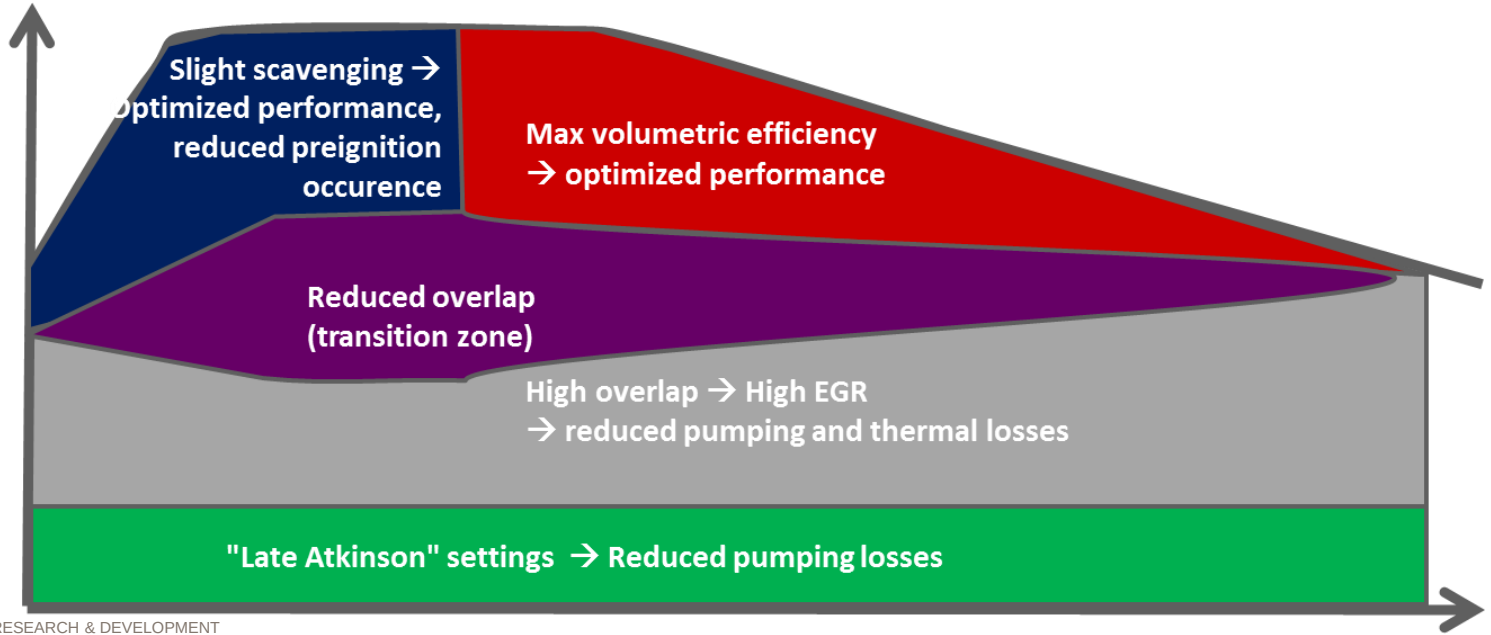
Minimal BSFC: 234g/kWh

Performance: 96kw / 230 mN

2.2 – New 1,2l Puretech engines

Combustion system upgrade

- Full use of double VVT to optimise BSFC, gaseous and PN emissions and comply with RDE requirements



2.2 – New 1,2l Puretech engines

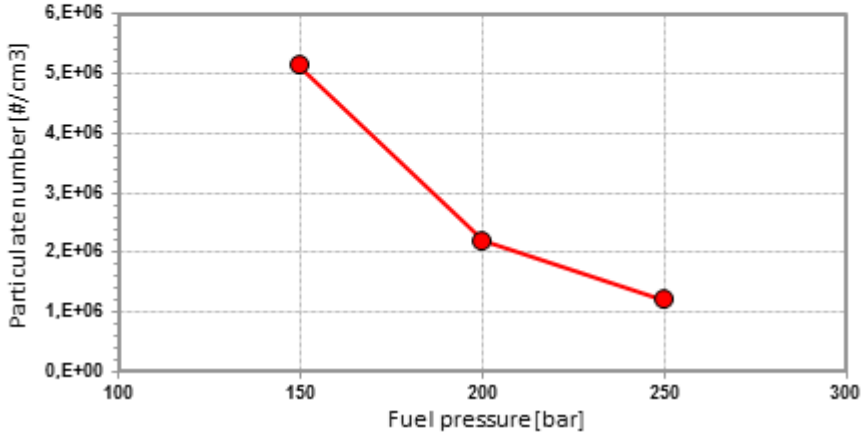
Combustion system upgrade

- Increase of injection pressure from 200 to 250 bars which gives 20 to 30% PN reduction (raw emissions upstream aftertreatment system)

Operating point : 3000 - 8bar BMEP

Fuel pressure	bar	250	200	150
Particulate Number	#/cm3	1,20E+06	2,19E+06	5,12E+06
Gap	%	-45%	0%	134%

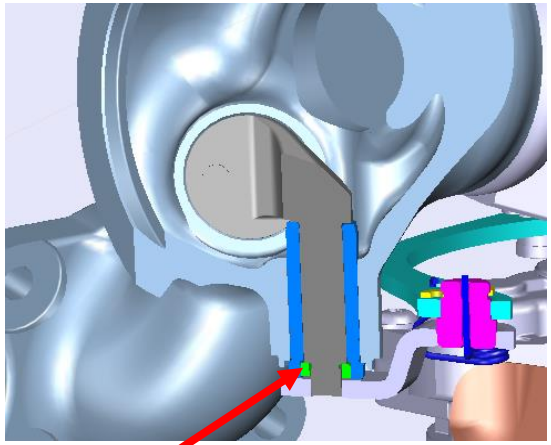
PN reduction with fuel pressure increase

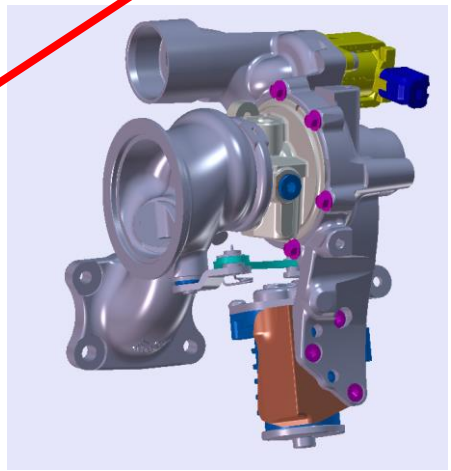


Combustion system with 5 holes injector with 50° spray angle offers best compromise between PN, oil dilution issues and pre-ignition occurrence

Engine dynamic performances improved by turbocharger evolutions

- Global evolution of the turbocharger performance through
  - ✓ Reduction by 20 % of the inertia with the use of a mix-flow technology for the turbine
  - ✓ Compressor stage was also redesigned for a significant step in terms of efficiency
  - ✓ Reduced shaft diameter (less friction losses)
  - ✓ Improvement of the sealing between wastegate valve and seat. An axial prepositioning was added by a ring welded in the bushing
  - ✓ Integration of the dump valve
  - ✓ Electric wastegate actuator instead of pneumatic

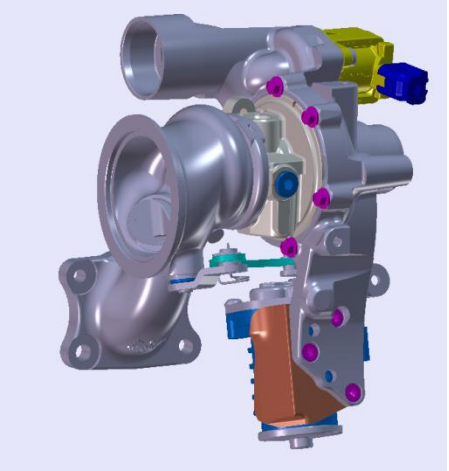


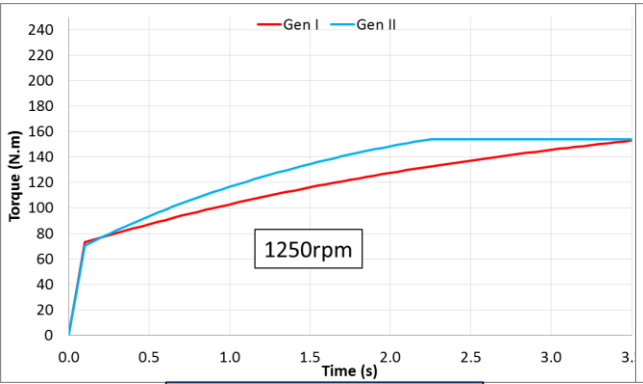


2.2 – New 1,2l Puretech engines

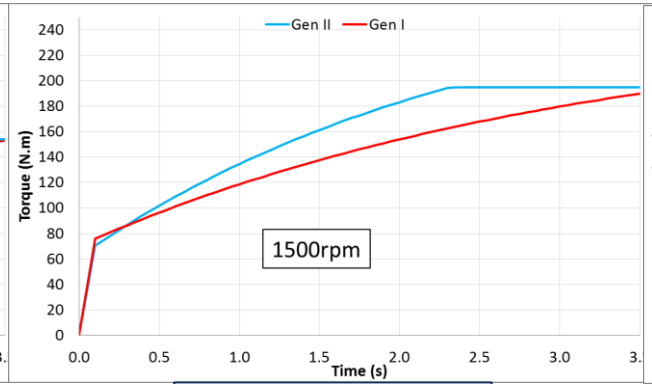
Engine dynamic performance improved by turbocharger evolutions

- Inertia benefit (- 20%) in comparison with previous turbocharger
- Turbine wheel efficiency increased at equal flow capacity
- Enhancement of the turbocharger bearing system

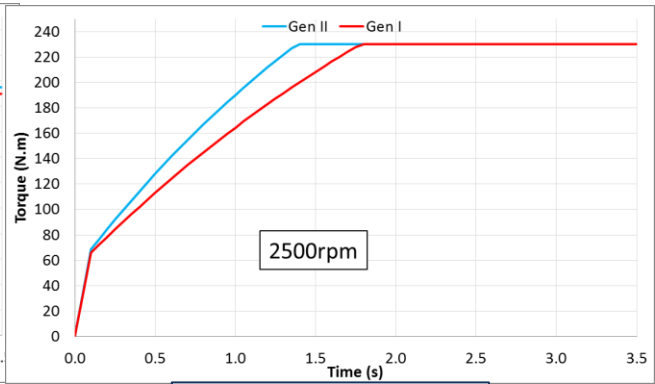




+65% of torque slope
+ 20 N.m @1.5 sec



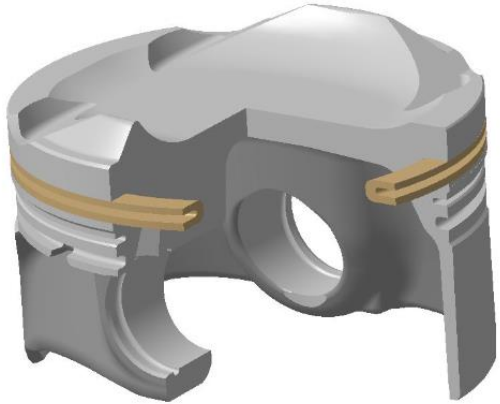
+54% of torque slope
+ 25 N.m @1.5 sec



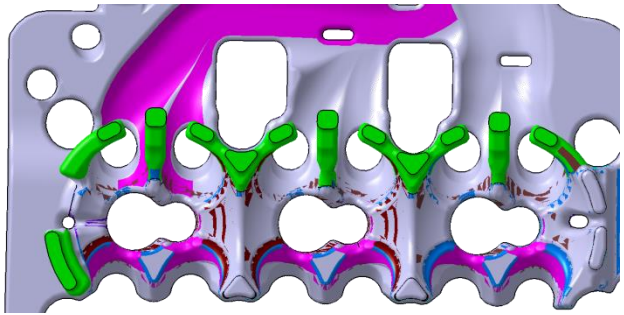
+33% of torque slope
+ 25 N.m @1 sec

2.2 – New 1,2l Puretech engines

- Improved protection strategies and mechanical reinforcement to cope with environmental requirements and improve robustness to abnormal combustion with low quality fuels and/or extreme usage conditions
- Several steps of improvement
  - Lube oil specification
  - Oil consumption limitation (most important improvement is in oil ring tuning)
  - Ring carrier on pistons
  - Pre ignition protection strategies
  - Cylinderhead cooling



Piston with ring carrier



Cylinderhead cooling improvement (in green) around exhaust valves and injector

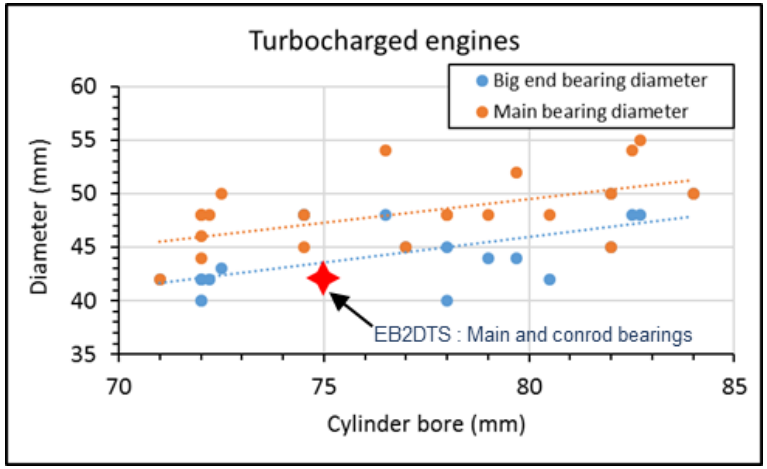
2.2 – New 1,2l Puretech engines

Catalyst and GPF system of GEN 2 Puretech engine

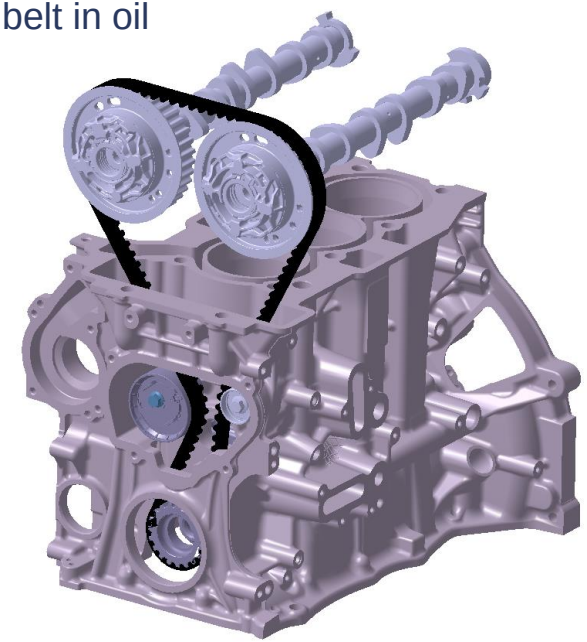
- Groupe PSA will generalize GPF in all TGDi PURETECH engines
- The « one-can » module with
  - a 3 ways catalyst (1,25l)
  - a cordierite GPF (1,16l)
- Filtering efficiency of 75%
- Specific strategies to manage all driving conditions which could generate GPF overload

FRICTION LOSSES

- Main features of current engine are unchanged :
  - ✓ Crankshaft offset
  - ✓ Main and conrod bearings diameter



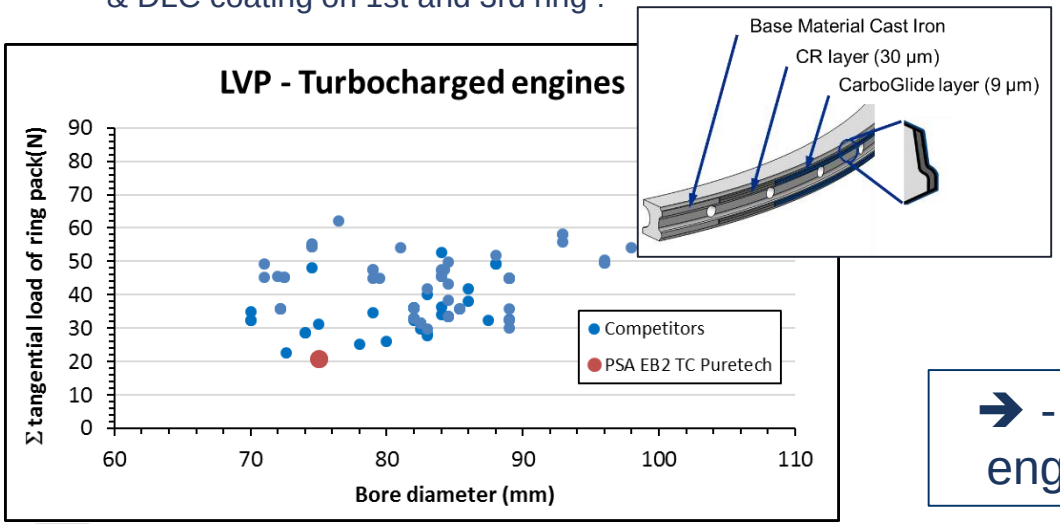
- ✓ Regulated oil pump
- ✓ DLC coating on tappets
- ✓ Timing belt in oil



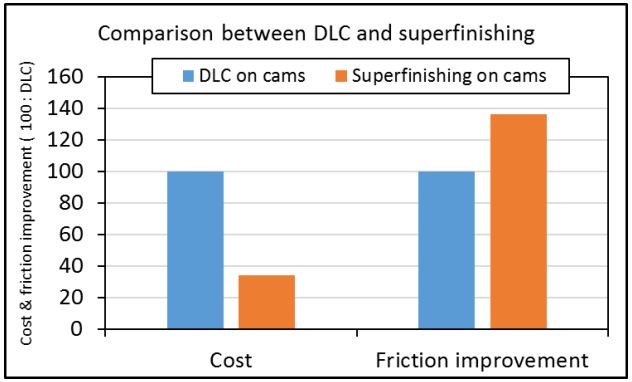
FRICTION LOSSES

- Introduction of new improvements regarding friction losses :
  - ✓ 0W20 oil : reduced viscosity and new additives
  - ✓ Optimized ring pack : very low tangential load

  & DLC coating on 1st and 3rd ring :



- ✓ Superfinishing on cams : better compromise cost / friction than DLC coating

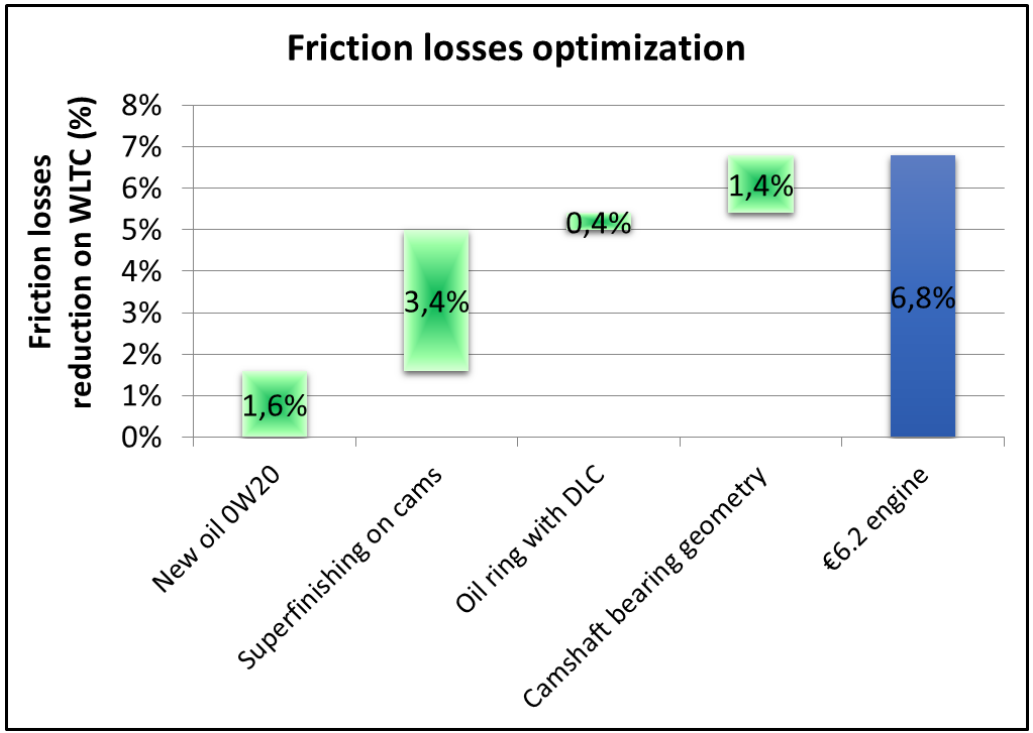


➔ - 6,8 % friction losses on new engine compared to the current

2.2 – New 1,2l Puretech engines

Frictions losses: Synthesis

- Friction improvement between previous and new generation Puretech engines: up to 6,8% gain in WLTC



2.3 – Global powertrain Puretech 3 cylinders attributes improvement with new transmission

- Steady state performances are unchanged :

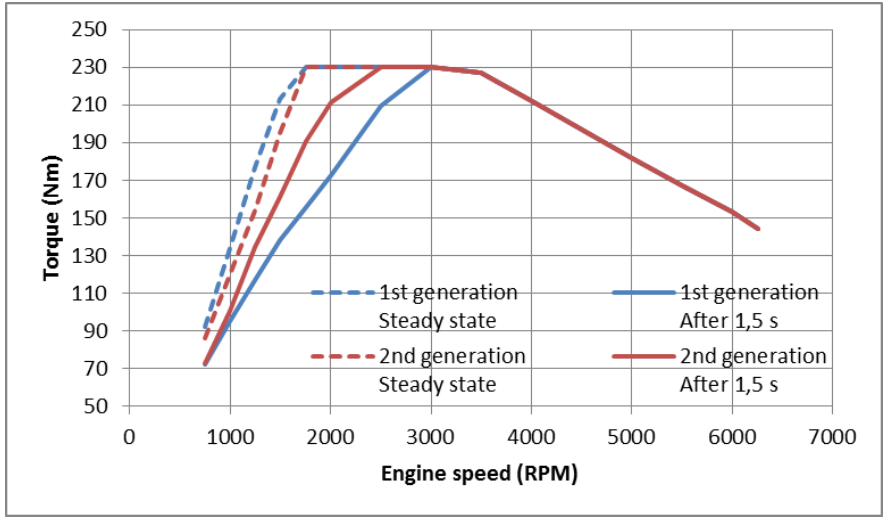
  230 N.m @ 1750 rpm and 96 kW

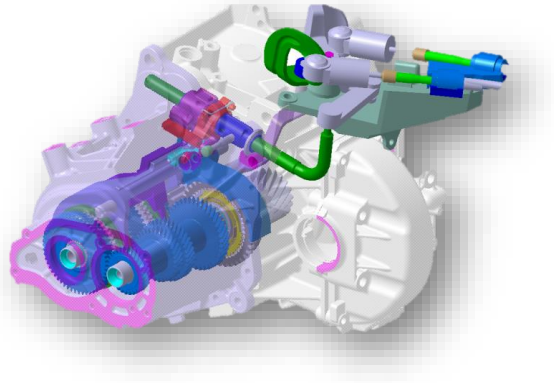
- Transient response improved

		Fuel consumption improvement
EUROPE (WLTP)	MT	4%
	AT	3 to 4%
CHINA (China 6b)	MT	2%
	AT(*)	Up to 9%

**** DCT in China***

- Emissions results
  - Euro 6d with RDE ≤ 1,5 achieved
  - China 6b achieved





3.1 – Headlines of PSA Diesel engine line up

1,5 BLUE HDi

1,5 BLUE HDi 130: 96kW / 300 N.m

1,5 BLUE HDi 100: 75kW / 250 N.m

2,0 BLUE HDi

2,0 BLUE HDi 180: 130kW / 400 N.m

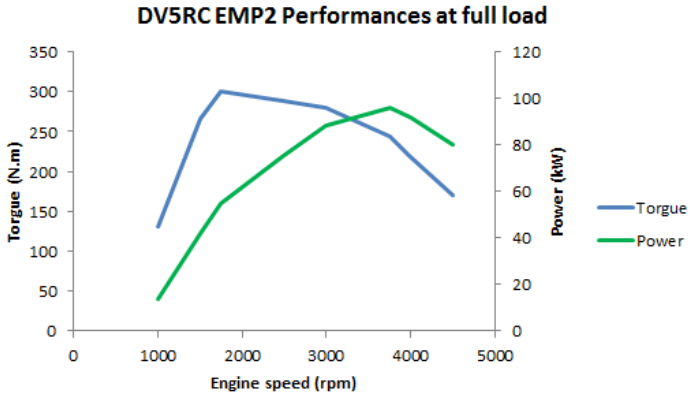
3.2 – New 1,5l Blue HDi engines

Launch date: 1st application in Europe: October 2017

Launch date: 1st application in Asia (Japan/Korea): Beginning 2018

Main objectives

- Improve fuel consumption on the engine itself and on powertrain with new gearboxes
- Improve packaging of the engine and aftertreatment system for installation in all existing and future vehicle plateforms
- Meet key emissions target
  - Euro 6d anticipated with RDE conformity factor of 1,5 (WLTP)
  - Japan and Korea
- Improve digital design (and reduce experimental phases)



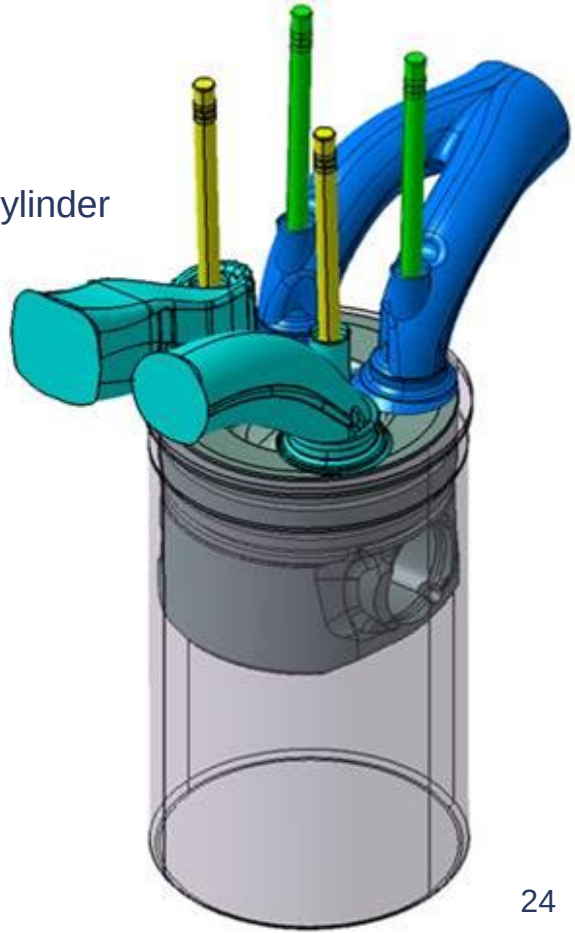
3.2 – New 1,5l Blue HDi engines

Main features

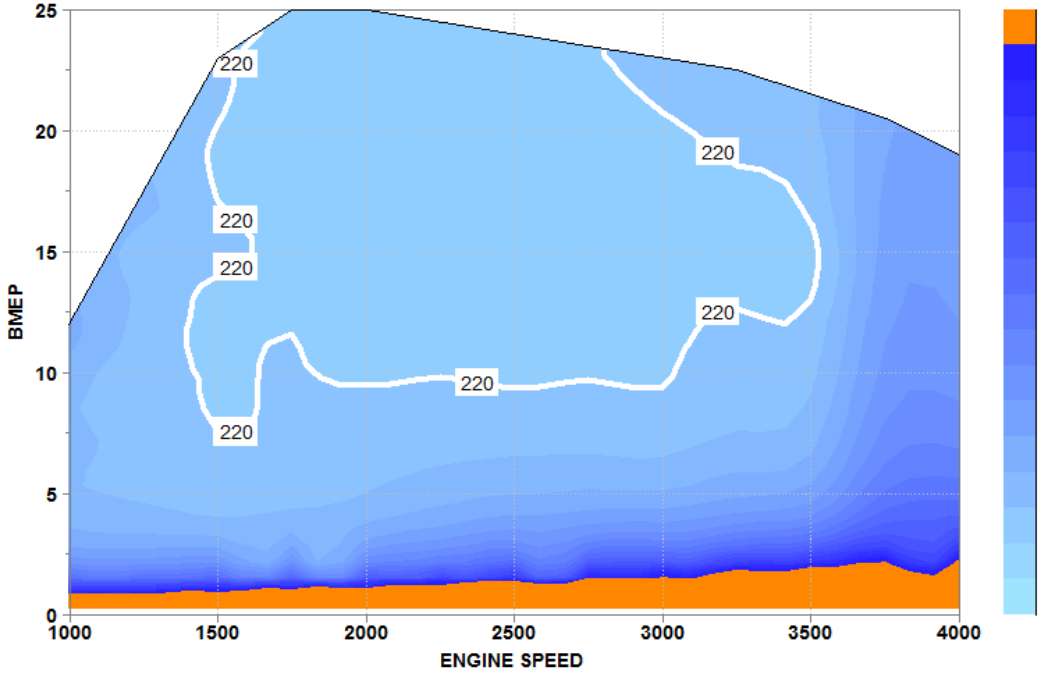
- New design of the cylinderhead with better packaging and 4 valves by cylinder
- New combustion system
- New EGR system
- New “one-can” aftertreatment system (with SCR on filter trap)
- Reduction of friction losses

Remarks

- Derived versions for commercial applications
- Development in collaboration with Ford



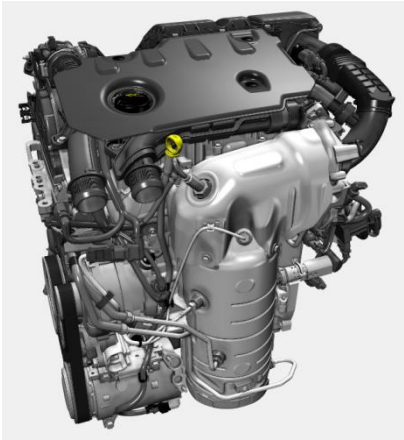
NEW 1,5L BLUE HDI PSA ENGINE: A CHAMPION IN FUEL CONSUMPTION!



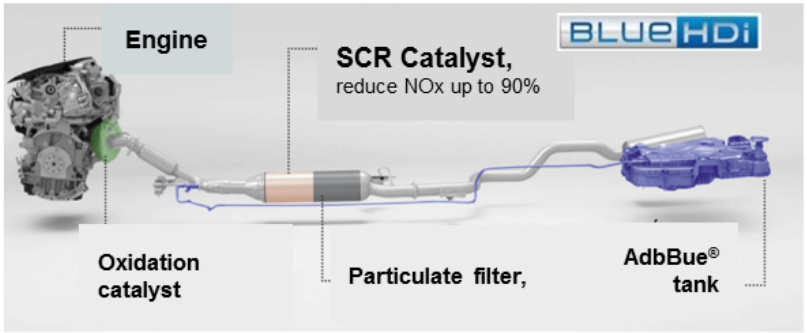
Large range BSFC <220g/Kw/h

Minimal BSFC: 210g/kWh

Performance: 96kw / 300 mN

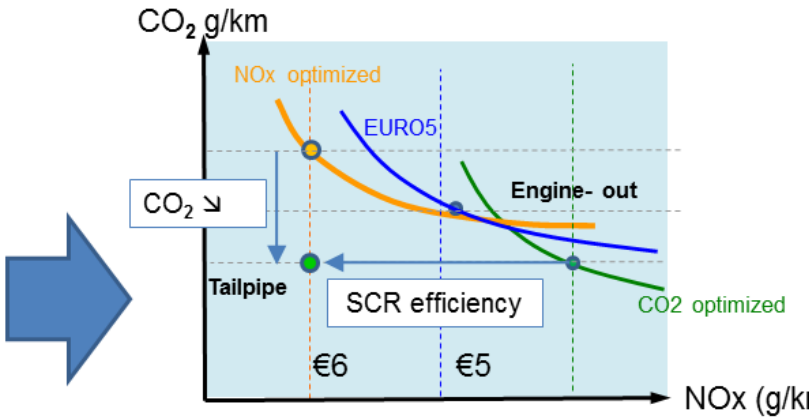


3.2 – New 1,5l Blue HDi engines



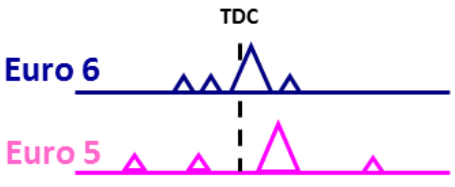
From 2013, PSA extended the SCR use on all its applications

Efficient NOx aftertreatment technology allows combustion system optimization for global vehicle NOx and CO_2 reduction



CO_2 optimized combustion system

- Compression ratio increase
- Injector nozzle optimization
- Adapted and optimized injection pattern and calibration



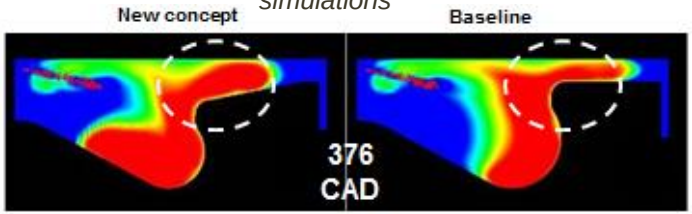
3.2 – New 1,5l Blue HDi engines

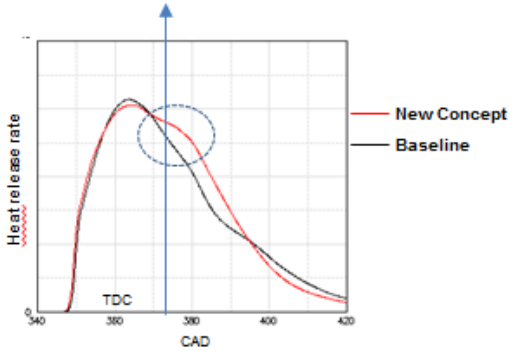
- Objectives for new engine generation
  - Further CO_2 and NOx emission reduction on the whole range of vehicle utilization
  - Improvement of specific performances and NVH
  - Keep downsizing benefits and fun to drive

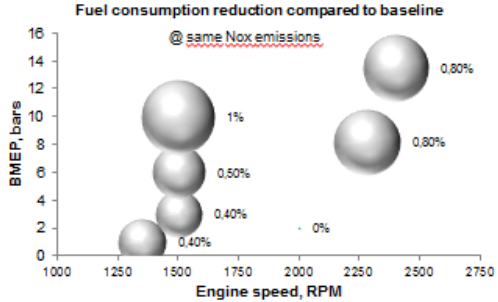
  → **New combustion system set up to fulfill these requirements**
- Full load combustion analysis
  - Increased heat release rate when combustion reaches squish area
  - Reduced combustion duration
  - Improved efficiency

  → **This new combustion system offers**
  - An Increased thermal efficiency without pollutants emissions penalties
  - Further CO_2 and NOx reduction combined with aftertreatment system

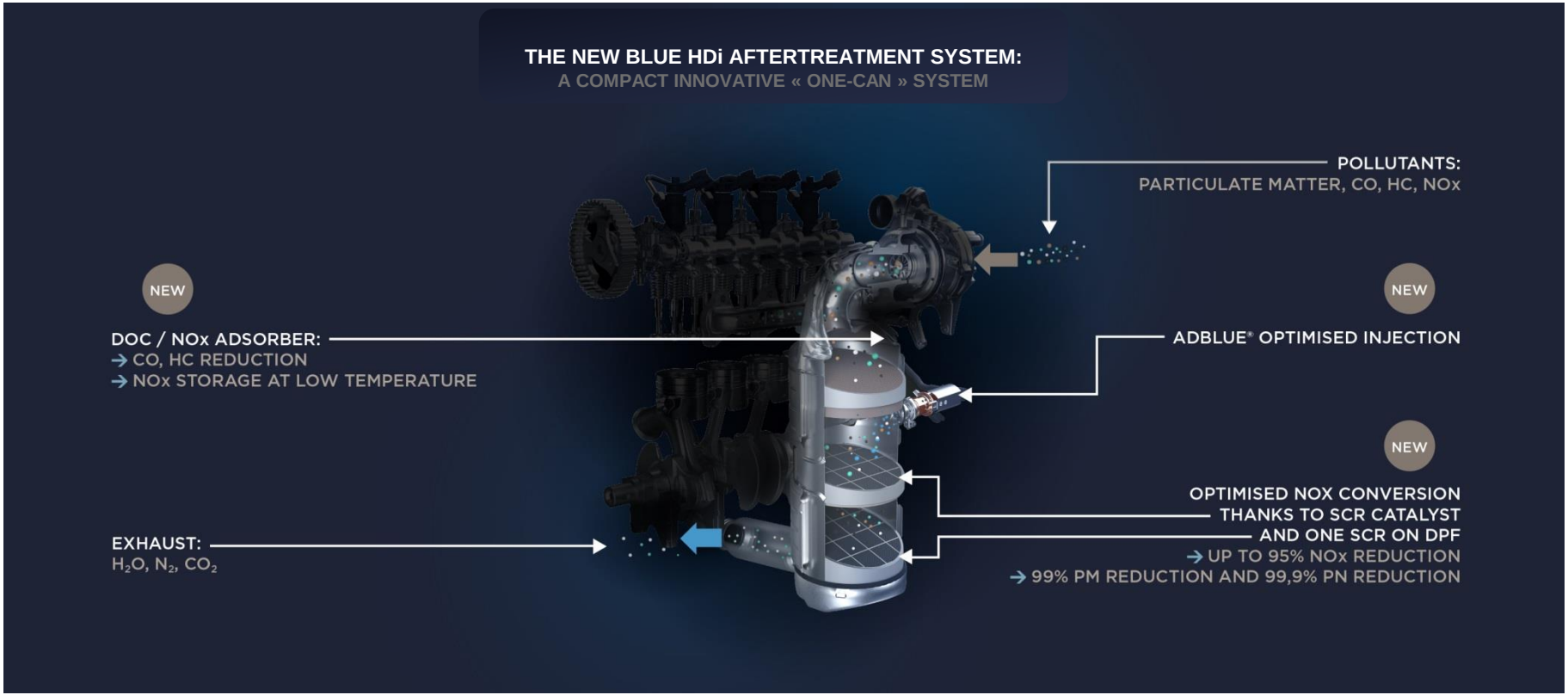
New combustion chamber fully designed by 3D CFD simulations







3.2 – New 1,5l Blue HDi engines



3.2 – New 1,5l Blue HDi engines

Fuel consumption reduction: main drivers

- **Combustion system** with new 16V cylinder head / 2000 bar injection pressure and high efficiency cooled EGR

- **Friction losses reduction**
  - Oil viscosity: 0W20 instead of 0W30
  - 1 ball bearing on inlet camshaft on timing belt side
  - Low friction coating on piston and rings
  - Ring pack tuning (dimension and tangential load)
  - Significant reduction of crankshaft's, connecting rod's and piston's masses
    - -15% for alternative mass
    - -35% for connecting rod's rotating mass

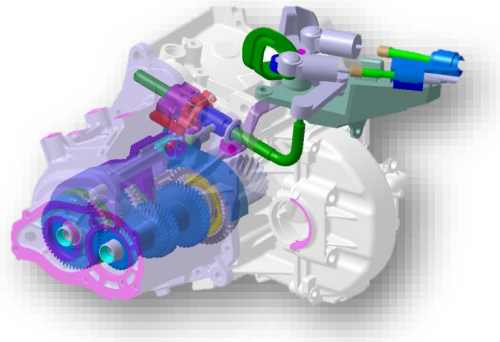
3.3 – Global 1,5 BLUE HDi powertrain attribute improvement with new transmission

- Emissions results
  - Euro 6d with RDE CF < 1,5 achieved

- Fuel consumption

			Fuel consumption improvement
EUROPE (WLTP)	1,5 Blue HDi 130	MT	5 to 6%
		AT	7 to 9 %
	1,5 Blue HDi 100	MT	4 to 6 %

New 6 speed MT



New 8 speed AT

REAL WORLD FUEL CONSUMPTION

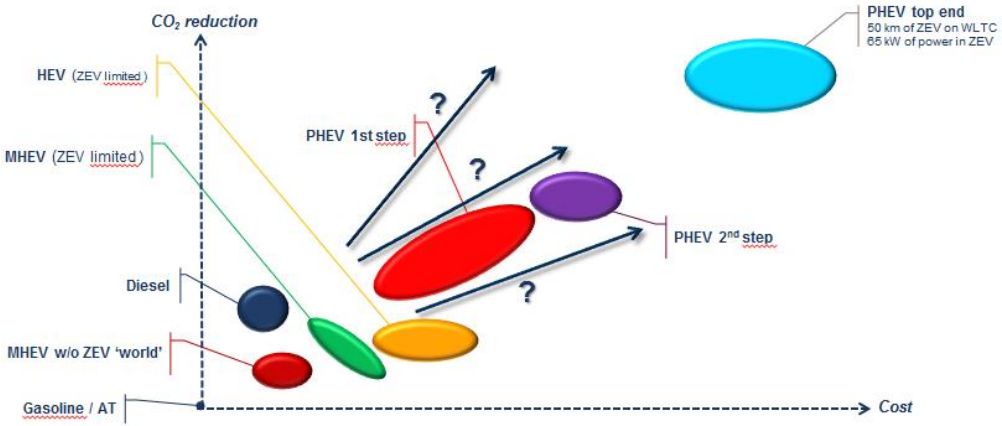
- Thanks to measurements handled with T&E FNE, it is now possible to evaluate the consumption in real world driving conditions for more than **1000 versions of Peugeot, Citroën and DS vehicles.** For each model, estimations have been made at same powertrain plus 3 variants : body type, trim level and tires dimensions

6 DS MODELS	Protocole l/100km	Homologation l/100km	Ecart l/100km
DS 3 PureTech 110 S&S BVM pneu 16" TBRR	6	4,3	1,7
DS 3 BlueHDi 120 S&S pneu 17" TBRR	5	3,6	1,4
DS3 cabrio BlueHDi 100 S&S BVM pneu 16" TBRR	5	3,5	1,5
DS4 PureTech 130 S&S BVM6 pneu 17" TBRR	6,8	4,9	1,9
DS4 BlueHDi 120 S&S BVM6 pneu 17" TBRR	5,4	3,8	1,6
DS5 BlueHDi 180 S&S EAT6 pneu 18" STD	6,7	4,5	2,2

REAL WORLD FUEL CONSUMPTION

- Vehicles equipped with Diesel powertrains are in better position compared to gasoline engines with less deviation
- Diesel is still a strong way to secure the CO2 route but there is a need to offer, complementary to Diesel, new alternative and reasonable solutions
- **Gasoline engines and electrification have still wide ways of improvements to be explored**

Challenge: How to proceed keeping reasonable overcost?

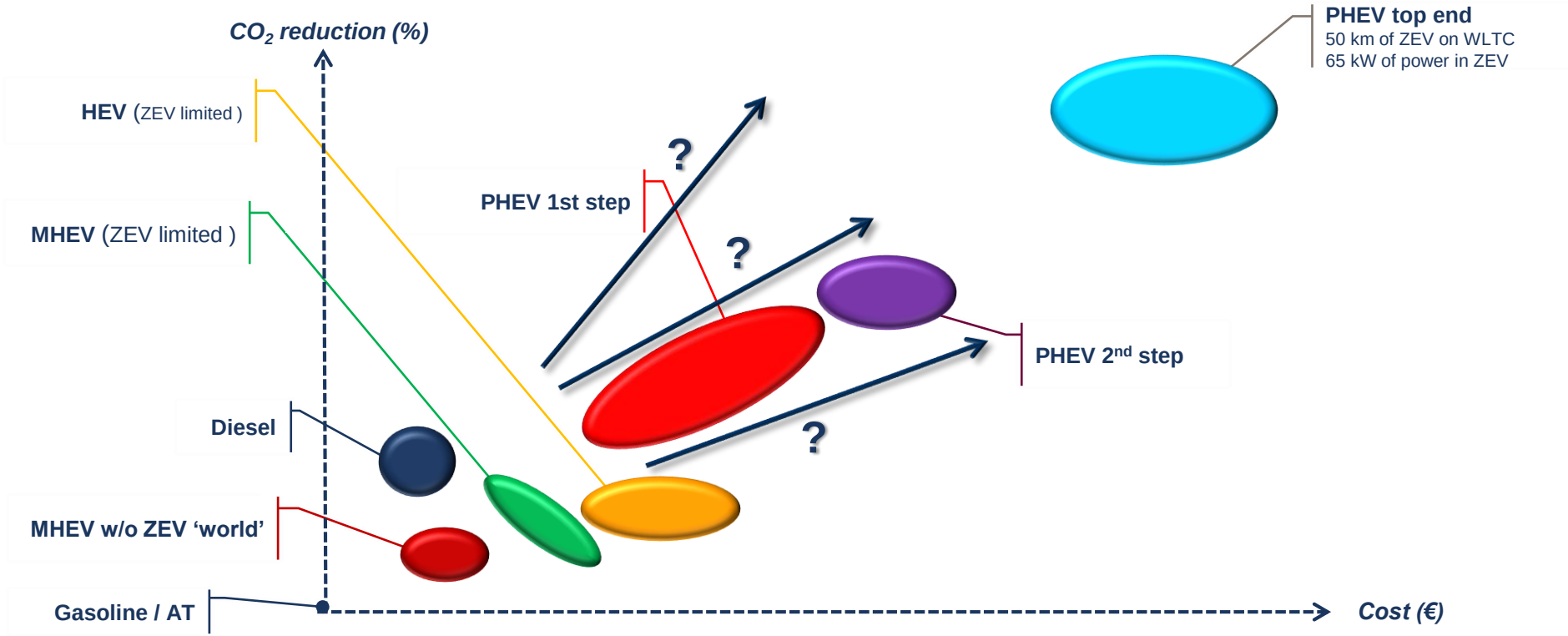


→ **Need to consider other attributes**

- CO_2 / Tank to wheel
- CO_2 / Well to wheel
- Refueling, charging time
- Weight

- Low speed performance
- Impact of fuel quality
- TCO
- …

Challenge: How to proceed keeping reasonable overcost?



→ SEVERAL POSSIBLE ROUTES

→ INTERESTING CHALLENGE FOR CAR MAKER COMMUNITY

Future for thermal engines

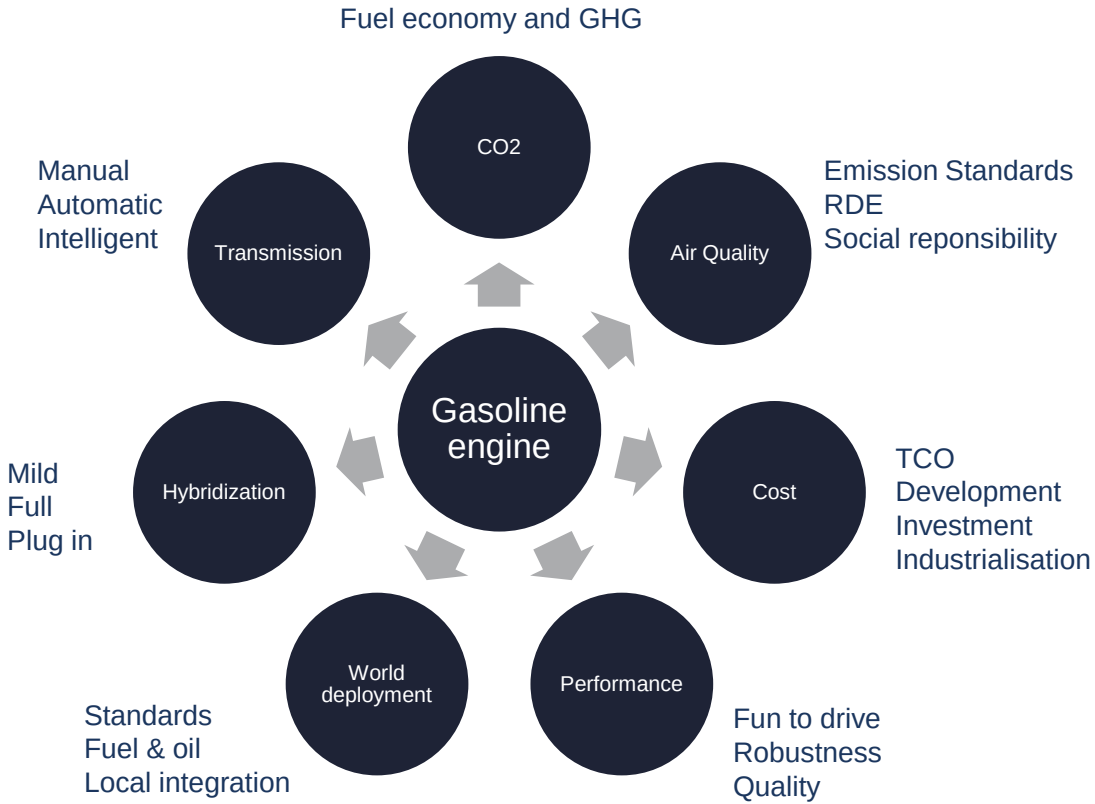
- **Diesel**
  - Strong emissions pressure
  - Still a good solutions for CO_2 and fuel consumption
  - Cost?
  - Solution for LCV, MDT and HDT

- **Gasoline**
  - Progress made recently with downsized TGDi engines
  - What reasonable technology to secure CO_2 route?

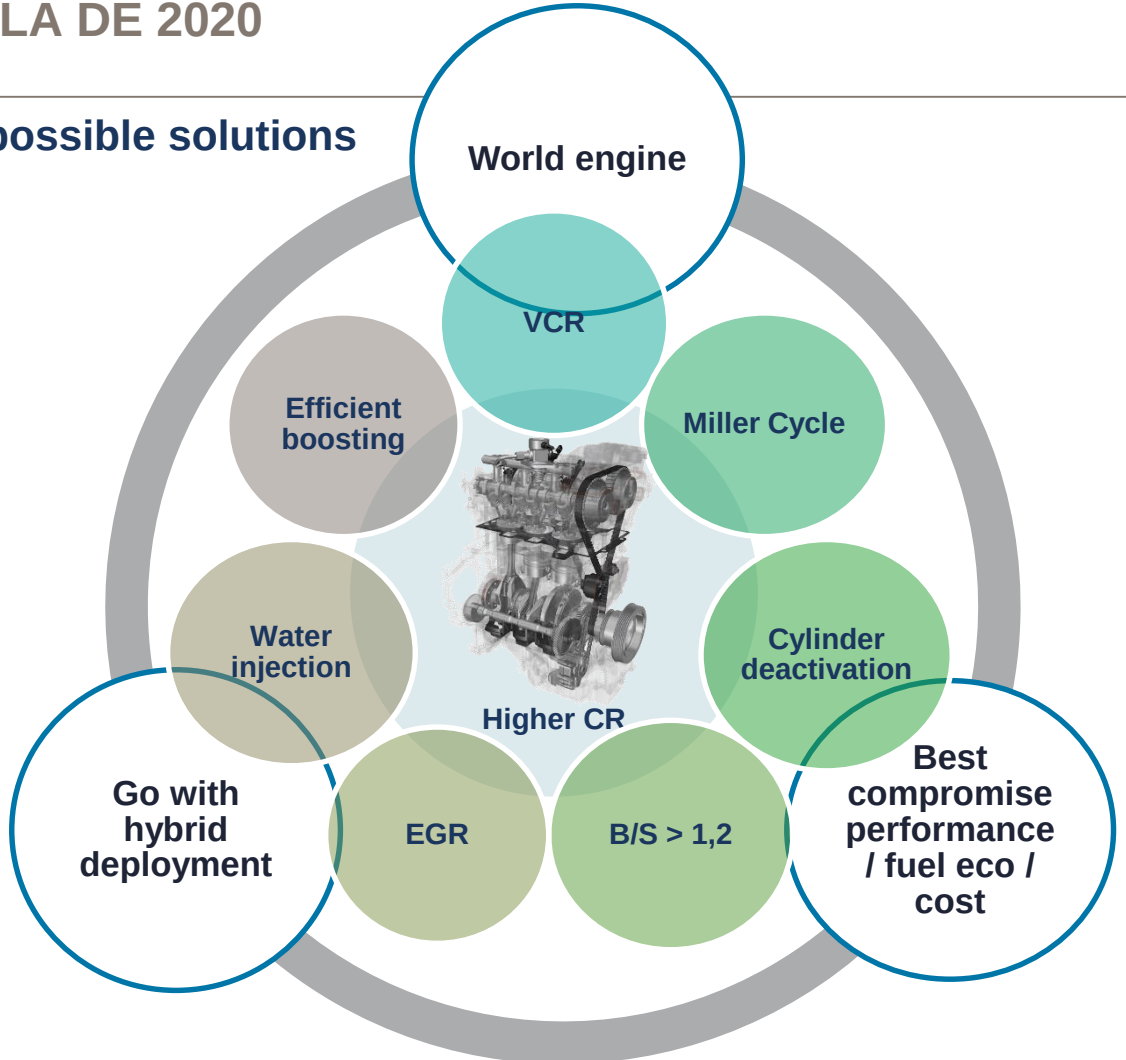
    → Electrification ?

    → Electrification + new features ?

Gasoline engines challenges: fuel consumption



Gasoline engine challenges: possible solutions



4 – PERSPECTIVES AU DELÀ DE 2020

Gasoline engine challenges: tentative technical portfolio

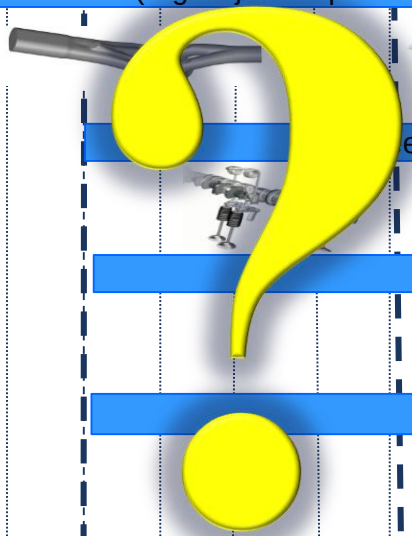
Emissions CAFE

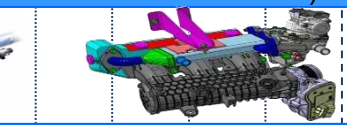
€ 6.1 | € 6.2 | € 6.3 – > € 6.3

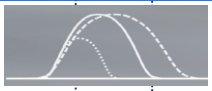
130 | 95 | 75 | < 75

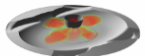
Combustion concepts & technologies

- Optimised Homogeneous GDI (High injection pressure / increased tumble /EGR …) — ~ 1-2% CO2
- ep Miller-Atkinson Cycle (Higher CR incl.) — ~ 1-2% CO2
- Long stroke (Higher CR incl.) — ~ 1-2% CO2
- Water injection (Higher CR incl.) — ~ 2-4% CO2
- Variable Compression Ratio / 2-stage — ~ 2-5% CO2
- Lean Burn / Advanced ignition — ~ 5-7% CO2









Approx CO2 values given for TGDI engines

Solutions for Groupe PSA

- « Clean car » is a strategical axis in the global R&D Groupe PSA program
- For 10 years, Groupe PSA is leading or among “top 3” carmakers with lowest CO_2 emissions in Europe
- New generation Diesel and gasoline powertrains will contribute to maintain this position
- To perform further progress, in addition to theses new powertrain families, Groupe PSA will launch from 2019 to 2021
  - 7 gasoline PHEV for C/D class cars on mid / upper platform
  - 4 BEV for B/C class cars on our future new small platform
- Groupe PSA will deliver a large “efficient and clean” offer for all customers

3 CYL PURETECH

BLUEHDI (SCR TECHNOLOGY)

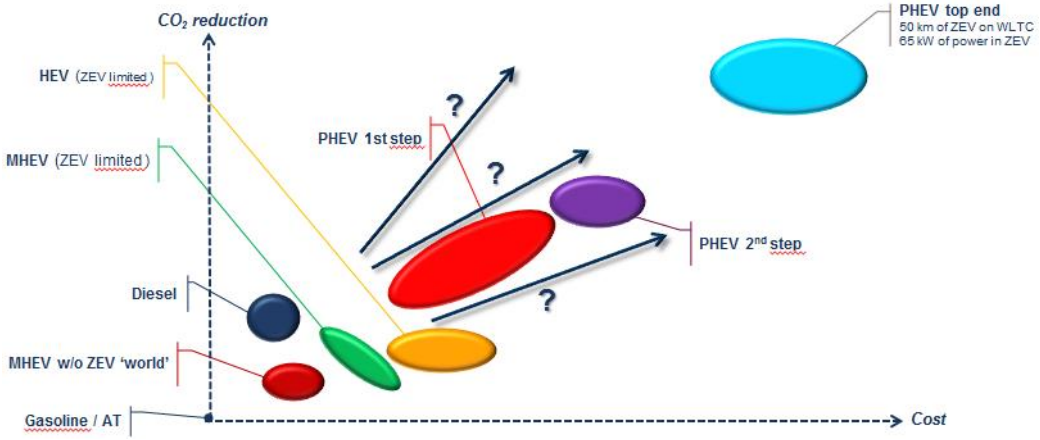
PHEV EMP2

BEV ON NEW PLATFORM CMP

CONCLUSION

- **Lot of possible combination to progress on CO_2 route**
- Lot of features have to be considered: well to wheel, tank to wheel, TCO, …
- Reasonable overcost is a strategical key

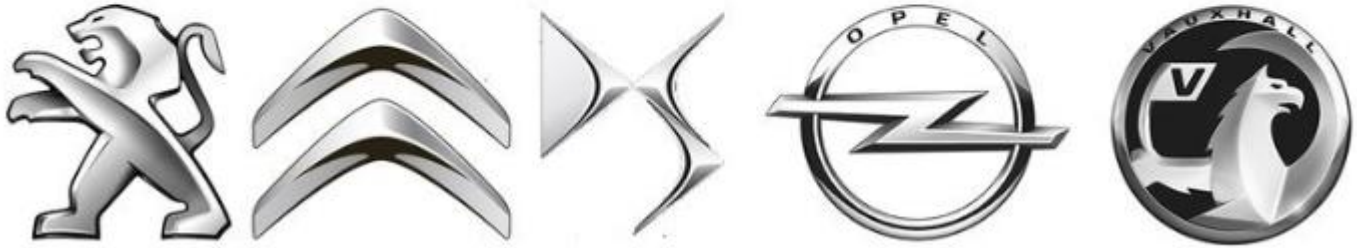
  (€ / g CO_2)
- Potential good synergy between combustion engine and electrification



A fantastic coming period for engineers !

MERCI DE VOTRE ATTENTION !

PSA GROUPE



- Car-sharing services
- Smart services
- Leasing
- B2B services for business fleets
- B2B Fleet management

FREE2MOVE