FEV Signature Solutions

Hybrid powertrain benchmarking

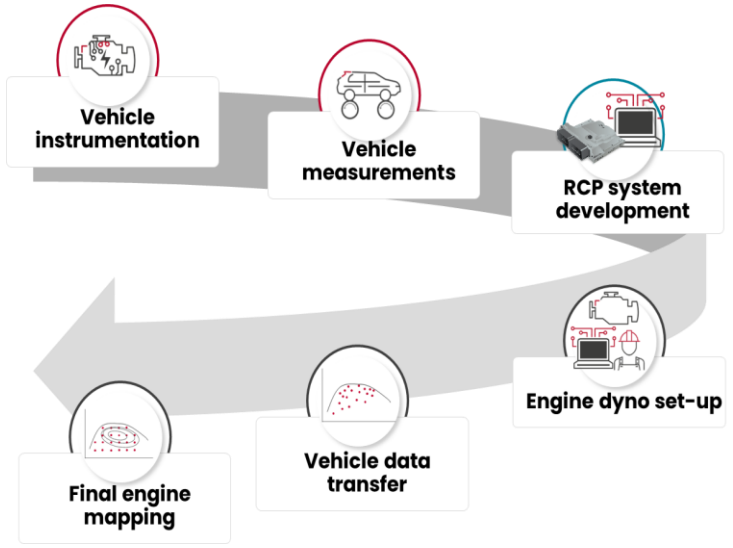
Profit from our inhouse rapid control prototyping (RCP) ECU giving us full control during the benchmarking

FEV offers the entire spectrum of benchmarking for hybrid vehicles

- Vehicle testing with comprehensive instrumentation
  - Hybrid operation strategy
  - Vehicle performance
  - Emissions and efficiency
- ICE investigation on thermodynamic test bench with our inhouse RCP ECU
  - Transfer of base calibration from vehicle to test bench
  - Base mapping with vehicle calibration
  - Parameter variations for evaluation of further BTE potential
- Component level testing
- Design- & cost analysis

Why FEV

- 45+ years of automotive engineering excellence, trusted by global OEMs and Tier-X suppliers to deliver innovative, production-ready solutions with deep domain expertise
- 35+ years of extensive experience in benchmarking
- Wide range of advanced test facilities



Reference project FEV propulsion
Hybrid Benchmarking

Background: Benchmarking of BYD Qin Plus DM-I

η_{bth} 43%[2)]

FEV involvement & key data

- **VEHICLE**
  - Chinese serial PHEV with 55 km[1)] electric range
  - HV Battery 8.32 kWh
- **ENGINE (BYD 472QA)**
  - Gasoline, 1.5L, 4-cylinder, dedicated hybrid
  - 78 kW & 135 Nm
  - 72 x 92 mm bore x stroke
  - 15.5 : 1 compression ratio
  - NA, PFI, Atkinson cycle, external EGR
- **ROLLER DYNO TESTING**
  - Driving cycles (Charge Depleting & Sustaining, WLTC, RTS95, US-Cycles)
  - Steady state to measure calibration mapping
- **ENGINE DYNO TESTING WITH RCP SYSTEM**
  - **RCP System** controls all actuators
  - Engine Mapping with **emulated series calibration** (BSFC, Indication, Emissions)
  - Parameter Variations (Lambda, EGR, VVT)

1) Electric range in NEDC is used for official claiming | 2) Certified by CATARC (China Automotive Technology and Research Center)

Reference project FEV propulsion
Hybrid Benchmarking

Background: Benchmarking of Renault Grand Koleos E-Tech hybrid

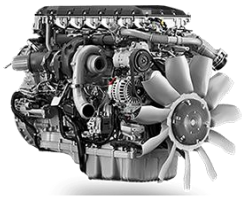
FEV involvement & key data

- **VEHICLE**
  - Korean market SUV with Geely hybrid powertrain
  - HV battery 1.65 kWh
- **ENGINE (GEELY BHE15-BFZ)**
  - Gasoline, 1.5L, 4-cylinder, dedicated hybrid
  - 106 kW & 230 Nm
  - 73.4 x 88.6 mm bore x stroke
  - 13.4 : 1 compression ratio
  - T/C, DI, Miller cycle, external EGR
- **COMBINED NVH AND THERMODYNAMIC BENCHMARK APPROACH**
  - In depth investigation with high amount of sensors at P/T and vehicle body/chassis and interior comfort points
  - Subjective assessments as well as objective measurements on road / test track and chassis dyno
  - Investigation and analysis of hybrid and ICE operation strategies with focus on NVH in combination with efficiency
  - Summary of revealed vehicle NVH hardware & design measures
  - Evaluation of emissions and efficiencies in legislative cycles
  - Engine mapping on chassis dyno

Reference projects

FEV BENCHMARKING OF ICE & HYBRID POWERTRAINS

- Commercial engine
- Hybrid electric vehicle
- Fuel cell vehicle
- Conventional vehicle

Commercial vehicles and engines	Hybrid electric vehicles	Mild hybrid vehicles	Fuel cell vehicles	Conventional powertrains
 Scania CBE	 BYD Qin Plus DM-i	 Alfa Romeo Tonale 1.5 VGT	 Hyundai Nexo	 VW T-Roc / EA211 EVO2
 MAN D15	 Mercedes E300de	 Mercedes CLA 220	 Toyota Mirai 2	 Toyota Hilux 2.8 D

FEV offers the complete benchmarking service - from entire vehicle down to component level

Vehicle & engine instrumentation

- Installation of a comprehensive intrusive sensor instrumentation including indication

Vehicle testing

- Chassis dyno testing in legislative and customer specific driving cycles under different ambient conditions
- On-road testing on test track or public roads

ICE investigation

- Engine testing on thermodynamic test bench w/ RCP ECU
  - Engine mapping with serial calibration
  - Evaluation of BTE potential by parameter variations

Friction analysis

- Evaluation of ICE friction with FEV strip method on a dedicated friction test bench

Component testing

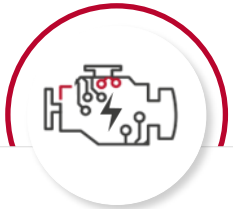
- T/C benchmarking
- Cylinder head port flow performance
- Battery testing
- Electric motor efficiency

Design analysis and cost benchmarking

- Design benchmark of ICE, hybrid system, HV battery
- Cost benchmarking and benchmarking workshop

FEV's in-house method to investigate hybrids on a thermodynamic engine dyno test bench

PROCESS DETAILS

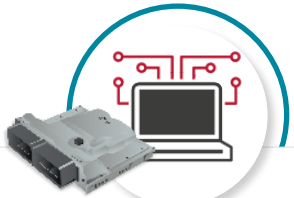


Vehicle instrumentation

Every actuator needs to get tapped. Cylinder indication already necessary for vehicle testing

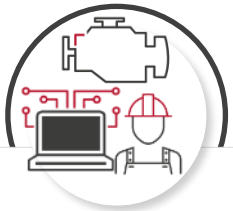
Vehicle measurements

Steady state engine operation points, depending on vehicle architecture



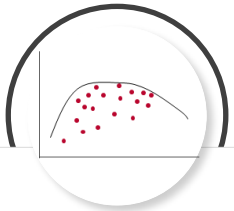
RCP system development

Control for every actuator is developed with spare parts hardware (as in a HiL approach)



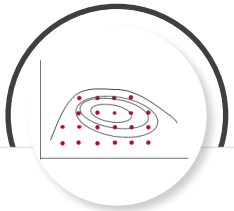
Engine dyno set-up

Step by step the actuators are controlled by RCP system while monitoring the proper running of the engine



Vehicle data transfer

A pre-engine map is necessary to harmonize parameters and erase outliers from the input data



Final engine mapping

Input parameters are calculated from the pre-engine map

fev propulsion

ADVANTAGES

Engine dyno testing of hybrid powertrains (DHE / REX)

- Acceptable risk compared to engine operation with production ECU on engine dyno

High flexibility

- Possibility of variation of calibration parameters
- Evaluation of hardware potential

Get in touch with us for further information

www.fev.com/en/signature-solutions