Electric Vehicles – Plug-Ins with and without Range-Extender

The electrification of cars is rapidly moving forward. At the end of this evolution seems to be all-electric vehicles, which eliminate the local vehicle exhaust emissions, and the prime power supply is through re-charge over the electricity grid (plug-ins).

Previous attempts to develop and market electric vehicles were not very successful. One of the reasons was the limited available range of those vehicles. However, new battery technology reduce this issue, and offer a substantial increase in electric range. But, even today's battery technology will not provide the same vehicle drive range than a conventional gasoline-fueled vehicle. In order to overcome this hurdle in a step towards the all-electric vehicle, a Range-Extender electric vehicle provides the benefits of partial local zero emissions, combined with the advantage of a "normal" vehicle driving range. In this combination, an internal combustion engine serves as additional power source, should the battery power not be sufficient to drive the vehicle (s. Fig. 1).

This push for pure electric or range-extender electric vehicles is particularly present in the US. Presently, tax incentives of up to US$ 7.000 per vehicle are being discussed.

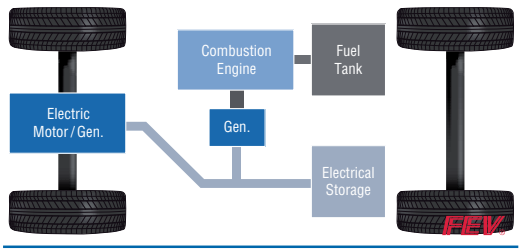

Fig. 1: Range-Extender PHEV Concept

Under these boundary conditions, the development of electric vehicles, either as pure electric or as range-extended vehicles with plug-in capability, has gained a tremendous momentum.
FEV has built and developed several such demonstrator vehicles for various customers. As this is new technology (batteries, electric motors, controls, etc.), no benchmark information exists, and no prior automotive experience can be utilized. Even completely new development processes and test equipment needs to be utilized. As an example, the electric traction motor needs to be tested and verified on a special test rig. In order to develop the traction motor system and its controls to the highest degree on such a test rig, it is necessary to include battery emulation capabilities, but also have the capability for the test rig to simulate regeneration. Based on the work done on such test rigs at FEV, the actual vehicle calibration time could be reduced to a few days, rather than weeks or months. Figure 2 shows one of FEV's electric motor test rigs.

With this new technology come completely new technical issues and challenges. For example, the complexity of the cooling system(s) increases significantly, the vehicle might now have up to 6 cooling circuits. Another technical challenge is the operating strategy of the combustion engine in case of the Range-Extended Electric Vehicle. As the engine has no mechanical connection to the wheels, only the generator demand determines the engine operating condition. The engine operating strategy is the subject of current optimization work, but depends on the actual vehicle and its customer drive cycle.

Based on experience with various vehicles at FEV, the plug-in capability has been demonstrated, with all-electric drive ranges in excess of 40 miles. Presently, several development programs with various

Fig. 2: FEV Electric Motor Test Rig

customers are on-going. The next few months will see a lot of valuable information coming from such demonstrator vehicles.

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