FRAUNHOFER SYSTEM RESEARCH FOR ELECTROMOBILITY

1 *3 kW stack on test stand.*

2 *5 kW stack on shaker unit with strobe flash.*

FUEL CELLS RANGE EXTENDER

Battery- and fuel-cell-powered systems represent two competing approaches that are currently being developed with the aim of reducing noise and pollution in urban areas and utilizing renewable energy sources for transport.

Battery-powered vehicles are characterized by a highly-efficient use of primary energy, and in the ideal case can be charged with excess electricity at a low cost. However, they are limited in terms of charging times and range.

Fuel-cell-powered vehicles offer ranges and refueling times comparable to today's vehicles, but their lower primary energy efficiency means that higher operating costs are expected. As a result, neither technology on its own can completely meet user requirements.

Solution

The integration of both systems can be used to develop a vehicle that is powered by cheap electricity during normal operation. This enables both the use of the fuel cell with a suitable fuel and environmentally-friendly long-distance journeys. There are also some further advantages, such as

- Protection of the battery against total discharge
- Preheating of the battery at low temperatures
- Utilization of waste heat to heat the passenger compartment

Challenges

The use of a fuel cell as a range extender is different from its use as part of a drive system, leading to several challenges in terms of design and operation.

Fraunhofer System Research for Electromobilyty

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Range Extender Design

Electrical output is the most important parameter when designing a range extender. Here it is necessary to differentiate between three application areas:

- APU systems up to approx. 5 kW relieve the traction battery by supplying other electrical applications with energy, for example the heating system, A/C unit or lighting
- Simple range extenders between 5 kW and approx. 15 kW recharge the battery during operation without directly supplying the engine, and can significantly increase the vehicle's range, which is especially advantageous during short-distance travel
- Larger range extenders with more than 15 kW power can directly supply the drive system and where necessary power the vehicle on their own.

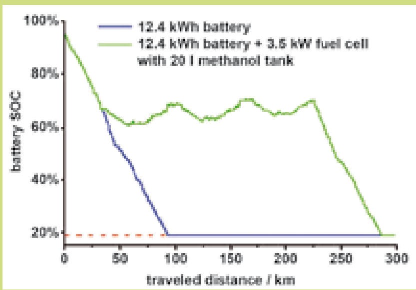
For the first two application areas solutions with liquid fuels such as methanol or gasoline are preferred, due to their high energy storage densities. To achieve more than 15 kW of electric power PEMFCs with hydrogen as fuel are the optimal choice. Within the framework of the FSEM II project the Fraunhofer ICT is developing a hydrogen-based range extender while also working on systems with smaller power outputs and other fuels.

Mode of operation

The operation parameters of a fuel cell used as a range extender differ in detail from those of a fuel cell in a drive unit. Examples of such differences include:

- More frequent and longer interruptions to operation, causing more air-air starts
- Greater number of start-stop cycles
- Higher probability of very short startstop cycles
- Lower load dynamics because the battery is usually charged with constant power
- Lower self-heating when performing cold starts, due to lower power output.

As some of these differences pose a challenge to the fuel cell, the operating strategy needs to include appropriate countermeasures. One important goal of the FSEM II project is therefore the development of an appropriate operating strategy. The basis for this is a detailed investigation of the operational behavior of the stack. Approaches pursued include



Range extender 3.5 kW – 12 kWh

Battery state of charge

- Protection of the cathode against electricalsurges
- Start-up processes for rapid humidification
- Optimized shut-down with regard to protection against freezing or drying out

Our offer

- Design of range extenders or APU systems for your vehicle application
- Selection of appropriate components
- Complete characterization of PEMFC, HT-PEMFC and DMFC fuel cell stacks
- Environmental simulation tests on stacks and systems, such as climate tests, effects of shock etc.
- Development of operating strategies
- Optimization of the interaction between fuel cell and battery
- Safety assessment using the FMEA method

3 *5 kW stack in climate chamber.*