Batteries

During the past decade, there has been a lot of progress, especially in the field of electrochemical storage devices and FCEVs. Beside durability and energy density, cost is one of the main areas where improvements are required to compete with conventional fossil fuels. Within the last years, costs have been falling rapidly and are expected to continue doing so for the next 10 years. The battery's durability is already expected to be sufficient for automotive use, giving ten years calendar life and 150,000 mi. Fuel cell stacks appear to still be falling short of the US DoE's 2009 target of 2,000 hours operation, corresponding to approximately 25,000 miles before a 10 % drop in power output. The next generation of lithium-based chemistries are expected to approach the perennial problem of 'range anxiety'. Currently, 80 % of the total amount of e-drive costs belongs to the battery (see Figure 1), while the 10 % attributable to the e-motor and further 10 % to the power electronics.

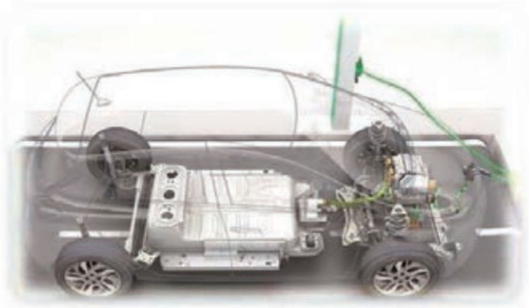

Figure 1 Battery module of Renault ZOE (image courtesy of Renault Austria[1])

Improvements by Thermal and Battery Management

Thermal and battery management is playing one of the most important roles, as it can increase the range and efficiency through optimized system configurations. Knowing the precise thermal interaction of components is necessary for an optimal design as it influences fatigue, energy consumption, noise, emissions, etc.

Workshops of this Task pointed out that:

- Driving at higher speeds, but also aggressive driving will increase the energy consumption in an EV,
- Cold start energy consumption is larger than the hot start energy consumption,
- The largest energy consumption increase for an EV occurs at -7°C (20°F) and for a conventional one at 35°C (95°F) (compare Figure 2),
- A conventional vehicle has the largest absolute energy consumption penalty on a cold start,
- Generally increased speeds and accelerations translate to higher energy consumption except for the conventional due to low efficiency in the city.

Simulation and Virtual Vehicles

With the introduction of EVs, the number of components that can populate a vehicle has increased considerably, and more components translate into more possible drive train configurations. In addition, building hardware is expensive. Traditional design paradigms in the automotive industry often delay control-system design until late in the process – in some cases requiring several costly hardware iterations. To reduce costs and improve time to market, it is imperative that greater

[1] Renault Austria, Available online at: www.renault.at accessed 11 November, 2015

emphasis has to be placed on modelling and simulation (see Figure 3). This only becomes truer as time goes on, because of the increasing complexity of vehicles and the greater number of vehicle configurations. Thus, the necessary expertise to perform the required sophisticated simulations and calculations becomes more and more complex. Especially predicted future driving information like route-based energy management, supported by a mixture between deterministic and stochastic information, will play a key role as they can help to optimize the energy consumption. Task 17 pointed out, that the demand for companies, focusing on simulation tools for EVs, is still increasing. These companies and R&D institutes will play an important role in the future.

Optimisation Through Lightweight

Vehicle weight and size reduction is one known strategy to improve fuel economy in vehicles and presents an opportunity to reduce fuel use from the transportation sector. By reducing the mass of the vehicle, the inertial forces that the engine has to overcome when accelerating are less, and the work or energy required to move the vehicle is thus lowered. A general rule of thumb is that for every 10 % reduction in vehicle weight, the fuel consumption of vehicles is reduced by 5-7 %. Vehicle weight reduction can be effective but is a challenging way to achieve significantly greater fuel economy gains. Especially light weighting the vehicle has a massive impact on the driving range (depending on the driving type cycle).

The light weighting benefits on fuel/energy consumption depends on the driving type.

- In city type driving and aggressive type driving with many and/or larger accelerations, light weighting any vehicle type will reduce the energy/fuel consumption.
- In highway type driving where a vehicle will cruise at relative steady speed light weighting vehicles does not significantly reduce the energy/fuel consumption.
- Light weighting a conventional vehicle will provide the largest improvement in fuel consumption due to the relative lower powertrain efficiency compared to a BEV.

Functional integration will play a major role in future vehicles in order to reduce the amount of total parts being used in a vehicle. Functional integration (e.g., CFRP wheel with integrated hub motor (see Figure 4) doesn’t only have an impact on reducing weight, it can also help to improve the driving abilities and can lead to a fundamental technology turnaround.

Especially the use of bionic concepts can help to reduce the number of materials needed. Bionic design can reduce development time, minimize development costs, identify new light weight solutions and help to find efficient concepts in product development. Also, the use of new materials as carbon or sandwich materials (combination of different materials in order to improve the total abilities) contributes to light weighting the car. But it should be kept in mind to have a look at the life cycle assessment too. For example, carbon has two main advantages: its low weight and its strength. But the increasing use of carbon in EVs (e.g., BMW i3) requires the need for new recycling processes. Comparing HSS vs. aluminium in lightweight vehicles: HSS is less costly and has lower production energy demands. However, aluminium remains competitive in select applications.

Future new vehicles are still expected to become steadily lighter, as automakers seek all means to achieve higher fuel economy. Further, the new fuel economy standards for 2016 on will require rapid rates of new and improved vehicle technology deployment. More fuel-efficient vehicles, like those with more sophisticated propulsion systems, tend to require more energy during their material processing and production phase. The material production energy demand for a current conventional gasoline car is 5 % of its life-cycle energy impact. The energy expended over its long use-phase in form of fuel use dominates its life-cycle impact at 76%.

Vehicle light weighting and vehicle downsizing coupled with efficiency gains in material processing over time can greatly reduce the production energy footprint of new vehicles.

Power Electronics and Drive Train Technologies Require New Software Concepts

The increasing demand for autonomous driving results in an increasing amount of software and electronics within the vehicles. Especially in terms of EVs the number of embedded systems and software within the powertrain is rapidly growing. This leads to a fundamental technology turnaround which requires adapted software solutions. Thus, the systems are becoming very complex, which results in required embedded systems and E/E-Architecture in order to process all the data and sources. Power Electronics and adaptive drive train technologies are thus playing an important role and will have a massive impact in the future. In today's conventional vehicles, the proportion of electrical, electronic and IT components is between 20 and 35%. In EVs, this share will increase to >70% – including around 70 main control units with more than 13,000 electronic devices.

In the future, every second euro/dollar is spent on the production for electronics. Currently, the share of electronic components to the manufacturing cost is around 30%, by 2017 it will grow to 35% and will still increase to 50% in 2030.

Task 17 pointed out, that today's manufacturers are focusing very intensely on that field of thematic which indicates the importance on that topic (see Figure 5). Modular drive train topologies could increase the chances for a market breakthrough of EVs by providing a better opportunity for high production volumes. Future generations of EVs require a layered, flexible, and scalable architecture addressing different system aspects such as uniform communication, scalable/flexible modules as well as hardware and software.

Further, this Task demonstrated that the automotive industry is dealing with two major trends: the electrification of the drivetrain and autonomous driving.

Change Within the Automotive Value Chain

The trend towards e-mobility leads to massive changes along the automotive sector's entire value chain. The new vehicles require a number of technically innovative components and systems to operate. This will impact key parts of the component and vehicle creation value chain, from R&D in specific components like batteries, all the way to integrating and assembling vehicles, down to new fields in the mobility value chain such as new infrastructure and new business models.

While the ICE was almost the component with the highest value within the value chain), the introduction of EVs are changing the hierarchy. Due to the fact that components like ICE, clutch, exhaust system, etc. won't be needed in EVs anymore, new and additional components as power electronics, e-motor, software will be necessary.

It can be foreseen that the power electronic unit and the e-motor will be on the top of the hierarchy and thus will replace the ICE. This key message has to be transferred to policy makers and representatives of industry in order to aware them of the upcoming change in value chain as well as guarantee qualification and education in that kind of business fields.

The Need to Change

The demand for EVs is still at a low level and far behind expectations (except in a few countries like Norway). However, in order to reach the various global consumption requirements, further hybridization and thus electrification is inevitable. For conventional cars there is still potential for optimization like through downsizing, use of alternative fuels, etc. Experts from Bosch Engineering are of the opinion that for conventional cars there are still further fuel savings possible (diesel: 10 % and for petrol up to 20%[2]). However, (partial) electrification is indispensable.

It is predictable that due global trends like interconnectivity, autonomous driving, limited resources and global consumption requirements, the electrified drive train – EVs – will sooner or later dominate.

[2] Source: CEA, 2014