IAMF/EET-2008 – Highlights

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Foreword

This summary contains some highlights of the combined EET – IAMF conference held at Geneva Palexpo during the International Geneva Motor Show. It is first of all dedicated to the attendees of the conference as a reminder including links to the corresponding papers and sessions (see CD-ROM "iamf EET-2008" and www.iamf.ch for the plenary sessions). It may also serve to get an overview on the presentations, as some of the sessions were held in parallel what made it impossible to attend all of them.

In addition, it may help other experts such as researchers, policy makers and journalists, to get an overview on the presentations and the results of this conference.

The summary contains the main topics of the conference. At the beginning of each section a short statement of the author of this summary is given (italic).

Abbreviations

Li	Lithium (batteries)
NiMH	Nickel-Metal-Hydride (batteries)
EV	(Battery) Electric Vehicle
HEV	Hybrid Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
FC	Fuel Cell
USABC	US Advanced Battery Consortium
ALABC	Advanced Lead Acid Battery consortium
V2G	Vehicle to grid

Hybrid Vehicles (HEV)

Thanks to Toyota/Lexus and Honda, the hybrid technology is established on the world market today. Most of the other car manufacturers have announced to commercialize hybrid vehicles soon.

Max Mosley, president of the Fédération Internationale de l'Automobile (FIA), announced the implementation of the hybrid technology in the Formula 1 for 2009. Due to the importance of the vehicle weight and aerodynamics the requirements on race cars will be quite different than those for daily use cars. But the reporting in the media will improve the image of hybrid vehicles like no other campaign ever before. (Opening session)

In the long term Lithium batteries will be used for hybrid vehicles due to their energy density as well as to their power density. As they are not yet commercially competitive with NiMH batteries today, the latter technology will remain the standard for some more years (Pillot, 3B).

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Even the lead acid batteries might have a comeback, at least for mild and micro hybrids, were the requirements are quite modest. The Advanced Lead Acid Battery Consortium (ALABC) has implemented a new kind of these batteries in a Honda Insight and so far achieved more than 100’000 miles without any battery problems. The novelty lies in the design of the negative plate which is part asymmetric supercapacitor and part conventional plate. This gives the battery the ability to both deliver and receive charge at very high rates as required in an HEV battery. Cost – the main advantage of lead acid batteries – remains at a very low level. (Alan Cooper, 3B)

Plug-in Hybrids (PHEV)

For plug-in Hybrids with their higher requirements on both energy density and power density Lithium batteries seem to be imperative. Therefore mass production cannot be expected before 2015. The Chinese manufacturer BYD may be an exception.

According to the IEEE (USA’s Energy Policy Committee), a plug-in hybrid vehicle is defined as any HEV which contains at least:

(1) a battery storage system of 4 kWh or more,

(2) a means of recharging that battery from an external source of electricity, and

(3) at least a 10 miles all-electric range. (Schofield, R1)

The larger battery pack (compared to a HEV) can have a negative impact on the vehicle weight and consequently on the cost and the fuel economy of the vehicle. However, research studies have shown that battery packs offering an effective electric range of 20 miles will yield over 45 % reduction in petroleum consumption. (Schofield, R1)

Google has launched the RechargeIT program together with A 123 and Hymotion. It aims to convert Google’s growing corporate fleet of hybrid cars into PHEV, and allows collecting real-world performance data to demonstrate their efficiency as compared to hybrids and conventional vehicles. RechargeIT is also working with Pacific Gas and Electric to explore ways to develop and enable a vehicle-to-grid technology (V2G, see below). (Schofield, R1)

BYD, a Chinese company originally producing batteries, presents the F3DM, a PHEV with a Ferrum battery which allows an all electric range of 100 km. Mass production for the Chinese market is planned for autumn 2008. (Zhu, 1B)

Fuel Cell Vehicles

The state of the art in the fuel cell technology may be confusing: On the one side, there are a lot of questions regarding production, distribution and storage of hydrogen and regarding cost issues. On the other side, Honda announces the market introduction of its FCX Clarita for mid-2008 already.

Proton Exchange Membrane (PEM) fuel cells are the most common today. The critical issues remain cost, life time, cold start capability, durability and range. (Addock, 2B)

For hydrogen storage, metal hydride tanks are a promising approach. The main challenges remain the gravimetric density and the operating temperature range – and cost, of course. (Bakker, 2B)

Honda announces the market introduction of its FCX Clarity in June 2008 (in USA) resp. November 2009 (in Japan and Europe?) to selected private users. The vehicle is equipped with a 100 kW motor, which allows a top speed of 160 km/h. The hydrogen is stored at 350 bar. Thanks to a 171 litre tank volume, a range of 434 km could be achieved. The hydrogen is provided through Hydrogen Highways, a number of hydrogen stations along important highways, or via the Home Energy Station developed by Honda. This latter generates hydrogen from natural gas and is designed to provide heat and electricity for the home through fuel cell cogeneration and to supply fuel for a hydrogen-powered fuel cell vehicle. (Brachmann, Plenary Technology Overview)

Battery Electric Vehicles

The latest progresses in the battery technology as well as the emerging environmental problems could lead to a renaissance of the battery electric car soon. This assumption was supported by two announcements at the conference.

The Norwegian city car Think has started series production: 2'000 vehicles have been ordered already, the first vehicles will be delivered to customers in Mai 08 at a retail price of app. 20’000 Euros, excl. a monthly rental fee of 200 Euros. The production volumes are limited due to battery production (Zebra, later this year A 123 and Enerdel). Think is developing new models such as a 5 seated vehicle and a hybrid vehicle with fuel cells. (Waitz, Plenary Technology Overview).

Mercedes-Benz has started the development of commercialisation of a pure electric Smart. The driving forces for this decision were:

- The achievements in technology and cost of the electric drive-train incl. battery,
- The sociological development: More and more people live in urban areas, where the requirements on the vehicle range is lower,
- Legislation regarding clean city cars (congestion charge London etc.).

The extra weight of the electric Smart will be 50 kg. The electric Smart will be equipped with a 30 – 45 kW Motor and a Li-Battery of 17 kWh. At present 30 vehicles are running in a customer test in London. (Moos, Plenary Technology Overview)

Light Electric Vehicles

The advancements in Li-battery technology is the driving force for the market introduction of Light Electric Vehicles. After electric bicycles have been established on the market in several countries, electric scooters are expected to be the next vehicle category to develop rapidly.

The International Energy Agency IEA is leading a working group on electric cycles. Main issues for preparing the market introduction are standardisation, safety and infrastructure (charging stations). (IEA workshop on Electric Two Wheelers)

The use of off-road motor cycles is limited due to emissions, especially noise. The absence of noise, in combination with the high performance of the electric drive train, make electric off-road motor cycles an attractive alternative for motor sports. (Conte, 1B)

The University of Linköpping presented an electric drive-train for a motor cycle which can be implemented in different vehicle concepts. (Hallberg, 1B)

For developing countries such as India, clean vehicles with simple technology are needed immediately instead of high sophisticated concepts which might be still in the developing state for a longer time. (Chatterij, 2A)

Batteries and Supercapacitors

Following the demands for HEVs, PHEVs, FC and EVs, considerable technological improvements could be achieved for almost all types. Cost, however, will be reduced only with high volume productions.

The following table shows an overview over the relevant battery technologies for electric vehicles and compares them with the USABC goals for commercialisation.

Battery type	**specific energy [Wh / kg]**	**specific power [W / kg]**	**cycle life**	**efficiency [%]**
Lead-acid	25 - 30	80 - 300	500	82.5
NiCd	50 - 60	200 - 500	1350	72.5
NiMH	60 - 70	200 - 1500	1350	70
NaNiCl (ZEBRA)	125	150	1000	92 minus additional heating losses
Lithium	60 - 150	80 - 2000	>1000	90
USABC goals for commercialisation	*150*	*300*	*1000*	-

Lithium batteries are the only ones which seem to be able to reach the requirements for mass production as set in the USABC goals. Actually, there are three kinds of Li-Ion batteries under development. Their main characteristics are described in the following table.

Technology	**specific energy [Wh / kg]**	**remarks**
LiCo	150	poor thermal stability, relatively short cycle life
LiMnNiCo	120	good thermal stability, good cycle life
$LiFePo_4$	105	very good thermal stability, high cycle life

These performances are expected to get improved further. Using nanotechnology leads to structures with big surface areas and a superior fast charge ability. Charging times of less than 15 minutes are possible. (Eberleh, 3B)

Due to their high power density (compared to batteries), supercapacitors can be used to relieve the battery systems from peak loads. The battery unit can be dimensioned and optimized for regime load conditions, resulting in better energy management and longer battery cycle-life. (van Mulders, 2C; Härri, 2C; Burke, 2C)

Another application field for supercapacitors could be Tramways, due to their high number of stops and starts. Energy savings could achieve 20 % and more. (Barrero, D2)

Capacitiy of the Electricity Grid

One issue of the electrification of automotive drive-trains is the capacity of the grid. It was suggested to use, vehicles with batteries and chargers to serve as regulators of the grid by controlling the time of charging and even to be used for providing electricity to the grid in peak hours.

The uncontrolled power consumption by charging millions of EVs or PHEVs at the same time could lead to grid problems. This can be avoided by varying the power of the charger between zero and maximum output throughout a specific period of time. (Kristien, 1C)

EVs and PHEVs dispose of a reversible battery charger and are thus able to draw energy from the grid for traction, and – on the other hand – could feed it on demand back to the electric grid as regulating energy (Vehicle to grid, “V2G”). However, there are some concerns regarding the requirements on the batteries and their lifetime. (Horbaty, R1; de Breucker, D1; Ursin, R2; Schofield, R1)

Alternative Fuels

Regarding primary energy sources for fuels, there is a high and urgent demand for alternatives to (non renewable) fossil fuels. Today it seems that there will be a large diversity of products.

The adaptation of a gasoline engine to natural gas contains an electronic control module, pressure regulator and a CNG injector. In future a mixture of natural gas and hydrogen could further reduce the emissions of CNG vehicles. (Miletto, 4A)

The compression of natural gas (200 bar) requires app. 10 % of the energy content. Liquefying gas to BTL (biomass to liquid), GTL (gas to liquid) or CTL (coal to liquid) consumes app. 40 % of the energy content. (Wiedemann, 4A)

The EU Directive on biofuels (2003/30/EC) sets the target of substituting 5.75 of fossil fuels for the road transport in 2010. The Green Paper on security of energy supply (COM/2000/769) suggests a use of 20 % of alternative fuels (incl. natural gas, biofuels and hydrogen) by 2020 and 5.75 % fossil fuels to be replaced by biofuels until 2010 (EU directive). Biogasmax is a research and demonstration project supported by the European Commission. In 6 cities biogas is generated by local waste and used for transport. (Hirtzberger, 4A)

Vehicles running on Bioethanol (E85) have a significant reduction potential on greenhouse gases. However the fuel consumption in litres is 20 – 30 % higher. (Stockar, Plenary Techology Overview)

A vision for the future is to harvest sun power by decentralized photovoltaic installation on roofs in order to produce hydrogen and oxygen to power fuel cell vehicles. Excess electricity could be used locally or be fed to the power grid. (Dietrich, Closing)

Hydrogen could become important as energy carrier for renewable energies which are not easy to store or to distribute, such as solar power or the heat of the earth. In fact, these two primary energy sources are the only ones to have the potential to cover the future demand. (Fatio, 4A)

Vehicle Concepts

All the approaches described above allow for a large variety of vehicle concepts and, even more so, the development in parallel leads to a lot of synergies.

Matt van Wieringen and Mark Bernacki of the University of Ontario (Canada) showed how a future dirve-train could look like: It is based on hub motors in all four wheels. The electricity is stored in batteries. Supercapacitors are used for short-term storage of the breaking energy. A hydrogen internal combustion engine serves as range extender. Furthermore, the implementation of by-wire technology for steering, shifting, breaking etc., weight, efficiency, reliability, maintenance and cost can be reduced. (van Wieringen, 5D)

The Co-evolution of PHEV and FC-HEV leads to synergies, as some challenges are equal for both technologies: weight reduction, efficiency improvement, battery technology and refinement of control strategies. (Wilhelm, 1C)

Conclusions

In the years to come, there will be not just one new propulsion technology but certainly many new ones which will complete the existing ones. Furthermore, an optimized use of road vehicles is needed.

Generally the trend is clearly towards diversification of energy sources used in the automotive field. Several of the speakers believe in the development and hybridization of today's engines with a tendency, in the long term, to use electric motors for propulsion and eventually achieving zero emission. (Bautz, Closing)

Some speakers showed an expectation of governments and local authorities to better integrate vehicles in new concepts of urban traffic. Therefore, the optimization of the use of road vehicles in cities in particular most likely will be on the agenda of governments and local authorities in the future. (Bautz, Closing)

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