How “green” is E-Mobility really?

The field of “e-mobility” is highly complex and highlights one of the greatest issues of the future. The field challenges many research disciplines, the political world and many economic sectors. In June 2015, at the invitation of the University of Oldenburg and the Hanse Wissenschaftskolleg, a high-quality, international panel of experts was assembled to discuss the status of development in this field and the current problems faced.

According to the Federal Motor Transport Authority of Germany, in the start of 2015 44.4 million passenger cars were registered, of which almost 19,000 were electric cars. The federal government aims to reach its goal of having one million electric cars on the country’s roads by the year 2020. "Given the manifold problems, this is a very ambitious goal, which cannot be achieved with introducing sales incentives only," asserts Alexandra Pehlken, head of the junior research group Cascade Use of the University of Oldenburg regarding the development plans of the nation. “There is also still a long way to go until the concept of E-Mobility really becomes a green solution.”

Because of their batteries, E-cars are not only considerably more expensive than cars with internal combustion engines, they are also heavier while yielding a short range and being burdened by long charging time. Additionally, the current refuelling infrastructure is aimed at combustion engines and not at electrical charging points or hydrogen supply for fuel cell vehicles. The recycling of these vehicles is equally problematic, with batteries posing a particular challenge. “In addition, electric cars require the use of new, partly scarce and environmentally problematic materials, which also represents a major challenge in recycling,” says Pehlken. To find solutions, numerous disciplines are involved. For the electric car to succeed, diverse research engagement is required together with development of economic policies and stimulation and support of the federal government.

Interdisciplinary workshop with the full product life cycle of electric vehicles at a glance

Focusing on batteries, fuel cells, recycling technologies, energy efficiency, electricity networks, renewable energy and material cycles, there are long-standing research teams of scientists from the University of Oldenburg working in numerous areas relevant for e-mobility. Actively involved are mainly the energy research network ENERiO, the Cascade Use research group, the OFFIS institute and Next Energy.

On invitation, 50 researchers from Norway, Canada, South Africa and China, as well as numerous well-known German universities attended for three days in June at the Hanse Wissenschaftskolleg Institute in Delmenhorst to discuss the future of e-mobility. The conference was funded through the Program for International Doctoral Graduation in Germany for all (IPID4all), the German Academic Exchange Service (DAAD) and the Hanse Wissenschaftskolleg Institute through the Foundation Innovation Pool. Accompanying the experts’ conference was a one-week summer school for doctoral students from around the world.

Both events investigated the entire product life cycle of electric vehicles - from development and production through the use phase to the end-of-life recycling phase. Andreas Günther, a researcher at the University of Oldenburg and an IPID4all coordinator, initiated and organised the events. “For a successful change towards sustainable e-mobility, a technical, institutional and international cooperation is required,” said the expert on renewable energies. “At the University of Oldenburg, research

and teaching is done in many disciplines related to e-mobility. The university is very well positioned and not only maintains an intensive internal exchange, but also numerous, cooperative partnerships worldwide to promote the development," he explains.

Compellingly necessary: The integration of batteries as storage devices in smart grids

One focus of the events was the subject of energy management. Sustainable E-Mobility needs more than just renewable energy. Truly sustainable E-Mobility requires intelligent power networks (Smart Grids), i.e. the communicative networking and control of power generators, storage, electrical consumers and network resources in power transmission and distribution networks of the electricity supply. An important field is the demand-side management where the supply for network services is dynamically provisioned relative to the customers in industry, commerce and households.

Curran Crawford of the University of Victoria (Canada) presented an example of how to utilise electric vehicles integrated into smart grids. When considering larger fleets integrated into the network, fleets can effectively act as storage in the networks, which is particularly important for the use of renewable energies. The University of Victoria has developed models for these aspects, while the OFFIS institute at the University of Oldenburg also researches the integration of E-Mobility as network storage.

Taking concerns seriously and resolving them with attractive solutions

A phenomenon often accompanying E-Mobility is the so-called "Range Anxiety". Ideally fitted for urban transport but unsuitable for a spontaneous 500-kilometer trip, is the general assessment of motorists and drivers, who typically want to have permanently available vehicles without fear of restrictions on their mobility and flexibility. "These concerns must be taken seriously," says Associate Professor Sebastian Lehnhoff of OFFIS.

This is another problem for which researchers at the University of Victoria and OFFIS at the University of Oldenburg, among others, are trying to find solutions. New models for the availability of batteries may help: Instead of the time-consuming process of charging one's own battery to always remain in "loaded" status, an alternative lies in the rapid changing of an empty battery with a loaded one at an exchange stations. This would ideally afford the constant availability of the traditional vehicles to electric vehicles, so they would always be ready for the spontaneous, long journey. The battery would no longer be seen as an owned commodity in the vehicle, but rather as a deposit or lease-based property.

Prototype implementation in Hamburg promoted the use of electric vehicles

Great interest aroused the rather small project "Hamburg - economy on electricity": For businesses, the State takes the burden of half of the lease costs of electric vehicles. Currently there are more than 500 of these subsidised electric cars on the streets of Hamburg. Kerstin Kuchta, a researcher of the Technical University of Hamburg (TUHH)'s Institute for Environmental Technology and Energy for Waste Resources Economics reported on the commitment of the Hanseatic city to establish e-mobility.

"Hamburg is attempting to convince users to switch to electric vehicles and address concerns in order to make the city greener," says Kuchta, who has become an enthusiastic electric car user and has equipped her small engineering office entirely with electric vehicles. "It is such a comfortable ride, and never have we had any problems. Neither with the technology nor with the batteries. It is just great! When the development program is phased out, we want to continue to rely on e-vehicles. Certainly that's always a question of cost, because electric vehicles are still very expensive." While early on, range anxiety was an issue also for Kerstin Kuchta, this aspect has long been mitigated because of her positive experiences with E-mobility in practice.

On this topic, Alexandra Pehlken adds “Unfortunately, such convincing and practical measures are lacking in many cases. In my opinion, an imposed top-down revolution is not the answer. We should rather engage in projects such as the example in Hamburg to convince and inspire individuals – this also removes their fears, transforming them into ambassadors and multipliers for the new technologies”. This “grassroots” approach, agree Kuchta and Pehlken, would be both useful and helpful.

Despite her enthusiasm for electric vehicles, Kuchta also sees the fundamental and serious challenges - due to her research related to, among other aspects, the use of raw materials. “Economic and research funding programmes need to collaborate better and more target-oriented” she believes. The existing approaches show promise, but they are not yet sufficient. Relative to this background, intentions and lobbying activities of the economy were discussed at the workshop.

Mobility services should make the trip with an electric vehicle more comfortable and sustainable

More positive examples with very good approaches in the field of sustainable mobility were provided through current research activities in the program “showcase electric mobility”, an initiative of the federal government. Benjamin Wagner vom Berg and his team at the University of Oldenburg devote themselves to improve customer-oriented mobility. The team is particularly concerned with provisioning of E-Mobile users with user support services such as intermodal mobility services in the form of mobile applications for travel planning and assistance. With the technology developed, travellers are supported in fulfilling their mobility requirements in a sustainable way. The goal: saving energy and other resources and minimizing harmful emissions.

A real option is the fuel cell, however...

Largely because of the high weight and the limited capacity of batteries, fuel cells remain an important option in E-Mobility. This is verified by studies conducted in Canada, one of the world's leading nations in fuel cell research, as well as a current practical case study from Japan. These were presented by Pang-Chieh Sui from the University of Victoria (Canada).

Toyota already set new standards with the release of their “Prius” hybrid car. With the "Mirai" the Japanese carmaker has now released the first marketable fuel cell car and production is already lagging behind the very strong demand. The car has 152 horsepower and a range of 650 kilometres. The technology, suggested Pang-Chieh Sui, was far superior to competitors. The fuel cell vehicle can also be used as an external power source and brings enough power to supply a 4-person household for a week with energy. From autumn 2015 onwards the “Mirai” will also be available in the US and European markets.

A crucial condition for the commercialisation of fuel cell cars, according to the experts, is the identification of new recycling technologies - among others for the recovery of the platinum contained in the fuel cell. The share of this rare and precious metal required in fuel cells has fallen dramatically, but remains still significantly high. The need for new recycling concepts and technologies or possibly even fundamentally new technologies persists.

... the technology development is still lagging behind, and the infrastructure remains insufficient

Promising research in fuel cell technologies is also evident at the University of Oldenburg. The university deals with alternative materials for the proton exchange membrane (PEM) fuel cells. “These can extend the power range significantly,” says chemist Michael Wark. The scientists conducting research at the University of Oldenburg study, amongst related concepts, membranes for fuel cells. However, poor infrastructure remains a challenge: “There is still a lack of hydrogen filling stations. This is where both industry and government are called upon to act.” the researchers conclude. Current research successes, for example in generating hydrogen from methane, also favour the use of fuel cells in the domain of E-Mobility.

Despite the ongoing progress, Pehlken explained that in some aspects, the fuel cell powertrain technology is lagging behind. The biggest challenge is a lack of sufficient cost-effective ways for comprehensive production and provisioning of hydrogen. An example, discussed by Pang-Chieh Sui confirms the concerns of hydrogen availability: Following the Winter Olympics 2010, the initially well-received "Fuel Cell Bus Project" in Whistler (British Columbia, Canada) with 20 hydrogen buses for transportation in the ski areas was discontinued due to the high cost of supplying hydrogen.

In contrast, the refuelling station infrastructure for electric vehicles has improved significantly, but open challenges include, amongst other issues, the question of standards. E-Vehicle manufacturer Tesla, for example, is pushing for its own standards in charging stations and is investing in its own charging infrastructure. Roswitha Zeis from Ulm Helmholtz Institute reported on the Tesla Supercharger. The supercharger shortens the battery charging time enormously, but can be only be used in conjunction with Tesla vehicles due to their standards.

Also a great and crucial problem: Recycling & Co.

With a view to the entire product lifecycle and material flows, recycling and resource efficiency have moved more into focus. “Again, we still have a lot of catching up to do. We urgently need new concepts and technologies and also more information about the materials used,” states Alexandra Pehlken, whose research group is concerned with exactly these problems. “As it is not yet clear which type of battery will prevail, the recycling industry remains hesitant,” she explains. “To date, no recycling technology has matured industrially, but there are very good national research projects such as LithoRec 1 and 2 and LiBRi that show promising approaches. What we now need is a sufficient supply of end-of-life batteries to make these processes economical.”

"Urgent action with regard to resource efficiency"

Pehlken identifies another example of the need for urgent action: The recycling of lithium-ion batteries has still not been industrially implemented. First solutions to the automated disassembly of these batteries currently exist only prototypical in laboratories.

Susanne Rotter from the Technical University of Berlin referred to difficulties and questions to be addressed that are well-known to her from her current research on batteries and electronic components: “Moreover, recycling poses problems with regards to data availability, as manufacturers on the one hand hesitate to disclose their manufacturing data while on the other hand also only having fragmented information on components, in particularly those with long supply chains. Exact mass fractions of lithium, cobalt and iron phosphate are often only learnt when recycling actually takes place. Due to the uncertainty concerning which battery chemistry is going to prevail, industries are hesitant to develop larger capacity.”

Without new technologies and a comprehensive infrastructure for material recovery, a breakthrough is not possible in E-Mobility. This matter requires not only the input of research and politics, but automobile and battery manufacturers must also cooperate with the recycling industry, discuss Pehlken and Rotter. It also became clear in the expert panel discussion that in the evaluation of alternative drive concepts, raw material efficiency should be highlighted as a perspective in addition to economic efficiency.

Workshop co-organizer Stephen B. Young of the University of Waterloo (Canada) agrees and adds: “The amounts and proportions of critical and strategically important materials in the car are increasing. This also raises the pressure on the manufacturers. Among other things, a take-back system for batteries or even a leasing system are increasingly discussed.”

A closer look: Frequently mentioned and exemplary "China" has flaws

In China, E-Mobility is also politically desired and actively pushed forward in the form of New Energy Vehicles (NEV). These are pure electric vehicles, fuel cell and hybrid vehicles. The Chinese put primary focus on plug-in hybrids, which are vehicles that can also be charged via the mains. They are more practical, cheaper and easier to produce than pure electric vehicles, and the acceptance of the technology is relatively high. In the years 2014/2015, their share has grown considerably. According to E-Mobility expert Jinsheng Xiao from Wuhan (China), approximately one in 300 cars in China is now a New Energy Vehicle. For comparison: In Germany, in early 2015 only one in 412 vehicles was a hybrid, and only one in every 2 343 a pure electric vehicle.

“These figures, however, say relatively little about sustainability,” Alexandra Pehlken points out. “In China, for example, the energy for E-Mobility is still almost exclusively supplied by coal power stations and thus involves high environmental impacts.” Even with the recycling that China does, it is still considered demanding on materials. Chen Ming of the Shanghai Jiao Tong University, co-organizer of the workshop and expert on the Chinese market as well as the local research community concerned with reprocessing explains: “In China, for example, engines must be scrapped. For safety reasons or because of legal conditions, a further processing is not allowed.” Chen Ming still researches recycling and opportunities for making better use of resources and returning raw materials to the economic cycle.

Is "E-mobility" still just a popular buzzword with no lasting impact?

“Simply developing and establishing electric vehicles is therefore not enough” concludes Alexandra Pehlken. The use of renewable energies, the development of smart grids and further research on the usage of raw materials and recycling must be promoted more intensively at the same time, she believes. “Without these, E-Mobility remains just a popular, media-effective slogan with no lasting impact.”

(Sabine Nollmann)

Contact Partner

Dr.-Ing. Alexandra Pehlken (Carl von Ossietzky University Oldenburg)
Telephone: +49 (0) 441 798 47 96
E-Mail: alexandra.pehlken@uni-oldenburg.de
www.uni-oldenburg.de/cascadeuse

Selected Pictures of the event: