AKASHA RESEARCH

About Akasha Research

What we do: As part of the Akasha Research Network, people with a background in natural and political sciences, education, medicine, IT, law and economics do research on pressing topics of our time. These include public health and mobility, as well as environmental and climate protection.

In our papers, we approach these topics in an interdisciplinary, scientific and synergistic manner and from an independent, holistic perspective, highlighting essential aspects and presenting them in their relevant context. The aim of the Research Network is to create synergies, to encourage action and further research. The target groups are stakeholders and decision-makers, people with a scientific interest and the public.

Our motivation: Within an interconnected world, challenged by multiple existential crises and political-economic upheavals, complex issues cannot be solved when solely addressed in an isolated manner or when driven by self-interest. Inspired by the universal vision of the Akasha Academy of the Buddhist Master Tulku Khyungdor Rinpoche, the Akasha Research Network seeks practical answers that are based on facts and are of benefit for all. Our Buddhist background is based on the universal principles of our existence: We all live on this planet, we share the same elements and resources. We are all responsible for the whole.

„We all breathe the same air, we all drink the same water,
we all walk on the same earth.“ TK Rinpoche

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Brave new world: The green conscience of electromobility

About this paper

This paper focuses on electromobility, the great hope for climate-friendly transport of the future. Besides the well-known advantages, some aspects are being closer examined. Based on the life cycle of an electric vehicle, relevant aspects and implications are highlighted in section 2. The most important findings are summarized in the last section.

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1 E-Mobility as a green beacon of hope for the mobility revolution

The transportation sector is one of the main contributors to greenhouse gas emissions in the world (1). The International Energy Agency (IEA) states that transportation makes up 24 % of direct CO2 emissions from fuel combustion of which three quarters are due to road vehicles (1). For reaching the goal of net zero, which a rising number of countries vows to pursue in the next decades, the increase of the efficiency and the electrification of the transport system are seen as important parts of the solution (2).

Therefore, electromobility is at the very core of future mobility concepts aimed at protecting the environment, climate, and resources. In this regard, e-vehicles (EVs) are promoted by policymakers and the industry to be the key. The IAE Sustainable Development Scenario assumes an increase of the number of EVs from 10 million in 2020 to 230 million in 2030 (3).

EVs are characterized by the fact that they are electrically powered by a battery and generally draw their energy from the power grid. Unlike gasoline or diesel vehicles, EVs emit no CO2 while driving, run almost silently, and are supposed to be more energy-efficient than comparable models with combustion engines. Therefore, EVs are generally considered climate- and environment-friendly.

2 Theory and practice: prerequisites, manufacturing, utilization and disposal

The potential of e-mobility is often assessed only based on the aspects known and relevant for internal combustion engine (ICE) vehicles. For a more comprehensive picture, aspects specific to e-mobility must also be taken into account, such as the availability of electricity generated from renewable sources, the environmental footprint of battery production, the charging and disposal of batteries, battery safety, and the impact of electromagnetic fields (EMF) on people and nature. Furthermore, data protection issues also become more relevant. Referring to the "life cycle" of an EV, this paper will outline where further investigations are necessary for a realistic assessment of e-mobility.

2.1 Electricity as the foundation for e-mobility

The foundation of e-mobility is electricity. Especially electricity generated by renewable sources determine the positive climate footprint to which the concepts of e-mobility refer. Thus, for the ambitious plans on significantly expanding the use of EVs worldwide, enough electricity must be available. Based on the policies that are currently in place or being developed in the countries, the electricity demand is projected to grow by almost 30 % from 2020 to 2030. The share of renewable sources grows from below 30 % to over 40 % in the same time. To fulfil the climate and energy commitments announced so far, the electricity demand and share of renewables would be higher. The IEA speaks of an implementation gap which mainly occurs in advanced economies including United States, Canada, Australia and the European Union. Among the main reasons for the higher demand is the electrification of the transport in those countries. It is worth mentioning that the climate commitments made by the countries so far are not sufficient to achieve net zero emissions by 2050. (3)

The implementation gap also reflects in the situation of individual countries. In Germany for instance, the latest scientific forecasts show that both the actual total electricity demand as well as the resulting demand for renewable energies will be significantly higher by 2030 than estimated in the legal basis (Climate Protection Act and Renewable Energies Act). Many studies identify a “green power gap” of around 100 terawatt hours per year (4). It is unclear, how this gap is supposed to be covered.

Furthermore, the practical realization of the expansion of renewable sources with all its consequences has not been adequately discussed. According to the climate commitments announced so far, solar and wind energy will account for almost 27 % of the electricity supply in 2030 compared to below 10 % in 2020. However, considering the space required for these power plants, it becomes apparent that sufficient land must be available. Ecological consequences, such as an increased clearing of forest areas, are currently mostly discussed by environmental groups. The fact that particularly ancient forests contribute significantly to the compensation of CO2 should definitely be considered when planning additional wind and solar farms. For the transformation to renewable energies, all possible ways should be assessed in an integrated and holistic manner, while taking their respective consequences into account.

2.2 Manufacturing

Compared to ICE vehicles, the battery production is the main difference in the manufacturing of EVs. The production of the primarily utilized lithium-ion batteries requires large amounts of energy and resources throughout the entire process. The necessary raw materials like cobalt, nickel, graphite, and other expensive earth elements are scarce while facing a rapidly growing demand (5). Depending on the assumed scenario, the battery demand may increase twenty-fold by 2030 compared to today's demand (3).

A large proportion of batteries is currently being produced in China with the use of fossil fuels. This has a negative impact on the overall carbon footprint of EVs. The data of the exact share of fossil sources in China's electricity mix is inaccurate and ranges between 30 and 70 % (6). While the worldwide production capacity must be increased significantly to meet the demand (3), it is unclear if the major part of the production of batteries could be relocated to other countries to reduce the climate footprint. It is equally unclear how big the improvement on the footprint would be, due to sparse data available.

Only few reliable data are available on the greenhouse gas emissions caused by the production of batteries. The same applies to the projected reductions of the production in the future. Many studies are carried out by industrial stakeholders, who (for competitive reasons among others) rarely publish their data in detail. Existing studies also come to very different conclusions (7). For informed political decisions, transparency regarding data on the climate impact of batteries is urgently needed.

Questions also arise from the safety of lithium-ion batteries, due to their sensitivity to external conditions, their reactive ingredients, and their high energy density. Malfunctions can cause hardly extinguishable fires and even explosions (8; 9). Therefore, it is necessary to evaluate the safety of lithium-ion batteries realistically and to make this information transparent to the consumers.

2.3 Charging

2.3.1 Charging infrastructure

The transition to e-mobility requires a transformation from the current refuelling infrastructure to a charging infrastructure.

EVs can be charged at public e-charging stations, but also at home or at the workplace. For the latter two, charging via a standard household outlet is very slow and not convenient for driving longer distances. For faster charging, the installation of a wall charger is recommended. (10)

The option of charging at home or at the workplace may not be available for everyone. Also, for covering long distances, public charging is the only option. In Europe, there are currently seven EVs per public charging point. Privately owned chargers currently constitute two thirds of the vehicles' energy supply. In the next years, the demand for public charging options is expected to grow faster than the setup of public charging infrastructure. (11)

With a growing number of newly registered EVs, more cars will need to be charged at the same time, which may overwhelm the power grids for example in residential buildings or at the workplace. This requires smart charging strategies and the involvement of different players such as vehicle designer, utilities and city planners (12; 13). Moreover, load management systems (14) may consume a lot of data, especially the more advanced the algorithms are. This raises data protection concerns, see *section 2.7*.

2.3.2 Charging process

Extreme charging states (deep discharging or permanent full charge) should always be avoided to ensure the longevity of the battery. When parked, the battery steadily loses charge. This discharge means that the charge level must be permanently monitored, and that the battery must be continuously recharged (15). EMF are inevitably generated during charging. So far, there is hardly any scientific study on the effects of EMF on human beings and nature especially in terms of different frequencies.

A power loss must also be considered during the charging process (16; 17) which results in heat being released into the environment. The effect on the environment has not been sufficiently investigated in the context of the extensive use of EVs.

In connection with the release of heat and EMF, the possibility of electrochemical vapours leaking from the battery should also be investigated. A high concentration of pollutants is known to alter the electrical properties of air, which determine how EMF act on airborne particles. Combining this aspect with the high reactivity of the electrochemical substances of the batteries, the risk of fires and explosions must be evaluated, especially in heated spaces.

2.4 Driving

Studies show that the energy efficiency of EVs depends on the driving speed. While EVs are most efficient at lower speeds in urban traffic, ICE vehicles operate more efficiently at higher speeds (18; 19). This fact is rarely considered in the development of mobility concepts. These concepts should holistically take all available kinds of transportation into account.

Just like during the charging process, EMF are also generated while driving (20). This refers particularly to the area around the battery and the motor, against which the passenger compartment is not properly shielded, depending on the car model. The direct impact of the EMF on the passengers of an EV raises potential health issues. Besides, the battery's and motor’s EMF may interact with the EMF emitted by other equipment, such as the air-conditioning system, the fan, and the seat heating system. The biological effects of this interaction have not been investigated enough.

While EVs are known to solve the problem of exhaust particle emission, the OECD report (21) emphasizes that non-exhaust particle emissions still pose a problem. Compared to its ICE vehicle equivalent, the actually lower emission of a lightweight EV will be offset or even increased by the generally heavier weight of EVs due to their batteries and larger vehicles sizes preferred by customers. In contrast to exhaust particles, non-exhaust particle emissions are largely unregulated. (21)

2.5 Disposal

Compared to ICE vehicles, the composition of batteries in EVs raises the critical question of proper disposal or a suitable recycling process. The lithium-ion batteries are larger, heavier and consist of several hundred cells which must be disassembled individually. The substances are both highly toxic and easily explosive. Special requirements apply to transportation and storage. At present, presumably only 5 % of the batteries or less are being recycled. (22)

Standardizing the recycling process is proving difficult due to different battery models. A disposal infrastructure is practically non-existent to date.

2.6 Increased exposure of people and environment to electromagnetic fields

As already described, the use of e-mobility leads to an increased exposure of human beings and the environment to EMF (23). Inside the car, the EMF of the different systems are so strong that they need to be shielded from each other. In Europe, this is based on the laws relating to electromagnetic compatibility (24). At the same time, the effect of EMF on human beings and the environment is insufficiently investigated and understood. There are indications that EMF of this type have biological, even potentially carcinogenic effects. Based on evidence from some animal experiments and epidemiological studies, the International Agency for Research on Cancer (IARC) estimates both low-frequency and high-frequency EMF to be potentially carcinogenic for humans (25) . In the intermediate frequency range, there is evidence that EMF influence cardiac pacemakers (26). With the planned expansion of e-mobility ahead, scientific studies on this topic are required. Clear results and binding regulations on protection from radiation with maximum exposure levels are imperative (27).

2.7 Open questions on data protection

Modern ICE vehicles use data-intensive technologies. This fact is even more pronounced for EVs in the context of the charging load management for example (28). Therefore, data protection concerns arise.

Assistance systems in modern ICE vehicles collect data from the air conditioner, speedometer, lighting, etc[1]. Additionally, EVs are using a battery management system, which monitors the condition of the battery and stores or transmits these sensitive data directly to the manufacturer (29). Direct conclusions could thus be drawn about user behaviour, which is very problematic from a data protection perspective. The often-implemented video recordings of the vehicle interior and its surroundings are problematic, too. For Europe, TÜV Süd[2] recommends a standardized regulation at the European level (30).

[1] Guidelines on processing personal data in the context of connected vehicles have been released by the European Data Protection Board (32)
[2] Company testing and certifying technical systems to ensure their safety

3 Conclusion & recommendations

Energy generation as the key to e-mobility feasibility

The electricity demand will increase worldwide amid the transition of energy generation from fossil fuels to renewable sources.

A crucial factor for the assumed climate benefits is the amount of green energy available for e-mobility, both for the battery production and the charging of the car. So far, it remains unclear if enough green energy can be provided not only on a global but also local level. Therefore, it is imperative to reassess e-mobility in the overall context of the energy transition. This includes a critical assessment of ecological consequences of that energy transition, such as the increased clearing of forest areas for wind and solar farms. Consequently, the targets set out on a global scale and by each country need to be adapted to realistic scenarios.

Possible (health) impact on people & environment

The accelerated expansion of electromobility leads to an increased exposure to electromagnetic fields which result from charging and driving e-vehicles. A comprehensive risk assessment for the population using evidence-based, scientific studies is absolutely necessary. The main focus should be on the effects of high, intermediate and low-frequency electromagnetic fields, as well as on the interaction of electromagnetic fields from the battery with those from other equipment in the car. On that basis, a binding regulation on protection from radiation must be established, including the definition of maximum exposure values to electromagnetic fields.

Due to the power loss during battery charging, heat is constantly released into the environment. E-vehicles are seen as a beacon of hope tackling global warming. The impact of heat emitted into the environment in that way, should therefore be investigated under the assumption that e-mobility is greatly expanded. Additionally, investigations should include the possibility and impact of electrochemical vapor emissions in connection with power loss and electromagnetic fields.

Addressing data protection concerns

A variety of data-intensive technologies are installed in e-vehicles. Data on driving and charging are stored by e-vehicle manufacturers. Especially the battery management system and the camera recordings of the vehicle interior and surroundings raise data protection concerns. So far, this topic is largely unregulated.

Standardized regulations are therefore imperative in the interest of data protection. For future e-vehicle users to be able to make an informed purchase decision, civil society should have access to this information. So far, the topic has barely been discussed publicly.

Transparency of research data about battery production and safety

Political decisions on the expansion of e-mobility must be based on a broad data base with transparent findings on the production and safety of batteries. Studies, which are currently financed by the industry and kept confidential, should be made available to policymakers and the public.

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