VDE Study

Drive Portfolio of the Future

A Thought Leaders Report from Politics and Economy

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Drive Portfolio of the Future

A Thought Leaders Report from Politics and Economy

Initiators:

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1. Panel of Thought Leaders

We would like to thank all the interview partners from the economic and political sectors for being available as thought leaders, providing their expertise in an open dialog and thus making it accessible to others.

The positions summarized in this study do not, of course, reflect the opinions of the persons specified here and their parties or companies in every respect.

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MdB = Member of the German Bundestag
BMVi = Federal Ministry of Transport and Digital Infrastructure
*© Photo Cem Özdemir: Sedat Mehder

2. Management Summary

This thought leader report compiles the assessments from multiple parties and sectors along the entire value creation chain. The most important findings and the resulting recommendations for action are:

1. **The declared, mutual goal is "zero emissions" and can only be achieved with a coordinated effort**
   Achieving the ambitious climate policy goals is a whole-of-society task that Germany and the European Union have taken on. It can only be achieved if policymakers, the economy and civil society work together. The greatest opportunity lies in combining interdisciplinary expertise and decision-making skills and coordinating based on common goals.

   Intensifying the dialog between policymakers and the economy and creating a forum for constructive exchanges.

2. **The structural change to locally zero-emission mobility must be open to all types of technology and supported in a user-oriented manner during the market ramp-up phase**
   This applies to the expansion of a needs-based charging system and the provision of adequate quantities of electricity for vehicles with battery-electric drives (BEV) which will constitute the largest part of the drive portfolio of the future after 2030 in the road vehicle sector. At the same time, the hydrogen infrastructure has to be expanded which will be needed, in particular, in the heavy load and long-haul goods transport sector. The availability of eFuels as a niche and bridging technology has to be ensured. The economy must simultaneously provide locally CO_2-neutral vehicles that are ready for series production, successively expand the range of models and drive innovation forward by making investments in the future and utilizing available grant funds.

   Synchronization of a needs-based expansion of infrastructure for the distribution of locally CO_2-neutral drive technologies by policymakers with an expansion of the range of models of locally zero-emission vehicles by the economy.

3. **Political framework conditions must be clearly defined in the long term so companies can invest in new technologies and innovations in a future-proof manner**
   The companies will successively expand the diversity of models of locally CO_2-neutral vehicles in the coming years. To accelerate the assertion of new drive technologies, it is important for policymakers to provide the economy planning and investment security so they can plan their business models accordingly. In addition, regulatory hurdles need to be reduced so the transformation of the infrastructure can be implemented.

   Reduction of regulatory hurdles and definition of the political framework conditions with respect to the 2030+ drive portfolio.

4. **The pressure to act is high: The groundwork for climate-friendly mobility "Made in Germany" is being laid now to strengthen the industrial location and secure jobs**
   Germany is in an intense international competition, in particular with the USA and China. Targeted economic policy must therefore strengthen the key sectors and secure the independence of research, technology and raw material imports long term. This includes the provision of grant funds as well as risk capital, and improved communication between policymakers and the economy to promote innovation growth in a needs-based manner here.

   Making access to capital for major innovation projects easier and coordination between policymakers and the economy to optimize the funding needs and programs.

5. **Creating a positive vision for the future drive portfolio among the general public**
   In order to successfully establish locally zero-emission mobility, increasing acceptance by consistently taking into account the users' needs is another crucial success factor. This includes suitable concepts for urban and rural areas, as well as solutions for heavy load and long-haul goods transports. What is important here, is creating a positive narrative that leads the general public to a change of consciousness, dismantles preconceptions and accompanies the transformation process. The use of locally zero-emission vehicle in federal and municipal fleets, in public transport and among the policymakers responsible for taking action, as role models, can also make a major contribution. Locally CO_2-neutral means that while operating the vehicle with the energy source, no local emissions are generated.

   A manufacturer-independent communication offensive is that creates a positive attitude toward getting started on changing to locally zero-emission mobility among the general public.

3. Study Design

In addition to technical innovations and modified user behavior, achieving the climate goals requires, in particular, a uniform understanding of the framework conditions for the future drive portfolio. For this study, thought leaders from the German economy and politics were surveyed regarding future developments, their assessments were analyzed and compressed into compiled findings.

Background

The study was created in the framework of the research and development project ELSTA ("Promotion of Electromobility via Standardization and Specifications") and was sponsored by BMWi (Federal Ministry for Economic Affairs and Energy). In this project, comprehensive, coordinated measures and public relations work will be conducted and targeted support for the German economy and research institutions will be provided when setting standards and specifications to achieve the reduction of energy consumption in transport by around 40 percent in 2050 (in comparison to 2005) as specified in the energy concept.

Participating project partners include the German Institute for Standardisation (DIN), the Standardization Committee of the German Association of the Automotive Industry (VDA-NA Automobil) and the German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (DKE). The work is closely coordinated with the National Platform Future of Mobility (NPM) which was created to harmonize national activities.

This study was developed by VDE DKE in the framework of a sub-work package to ELSTA. The project work was comprised of the coordination and management of a dialog process between the stakeholders from politics and the economy as well as documenting, summarizing and publishing the results.

Objective

The objective of this study is to promote the dialog and understanding between policymakers and the economy to overcome the major challenges on the path toward locally, zero-emission mobility together and establish Germany as a pioneer in this sector. Incorporating the results and findings of the study into the further dialog process of the (technical) public is an important aspect. This study combines the two views of thought leaders in politics from the German Bundestag and the Federal Ministry of Transport and Infrastructure (BMVI) and the economy along the entire value creation chain (production of energy sources, extraction of raw materials, production, operation, recycling and infrastructure).

The study focuses on the following central points:

- Compatibility of or dichotomy between the approach on the policymaker side, as the issuers of calls for promotion with the challenges on the corporate side with respect to industrialization and the development of new technologies
- Policymakers' knowledge and understanding of the strategies and major challenges in the economy (portfolio, infrastructure, etc.)
- Knowledge and understanding on the economy's part with respect to the strategic plan and regulatory objectives of the policymakers (zero-emission mobility, setting up the hydrogen economy, etc.)
- Assessment of the 2030+ future drive portfolio

Methodology

The study was performed between April 2020 and March 2021. At the first kick-off meeting in April 2020, the study concept was developed and the detailed plan defined. In the first step, relevant interview partners from politics and the economy were identified and recruited as participants. At the same time, the interview guidelines were developed: The contents include fundamental questions regarding the requirements and potential of the various drive technologies, the drive portfolio of the future, the future mobility scenario and the expectations and contributions of policymakers and the economy.

In the months leading up to November 2020, thought leaders from politics and the economy were interviewed in a (telephone/video) meeting[1]. The politicians were also given the opportunity to answer the questions in writing. The responses were transscribed, analyzed in a workshop and compressed into the core statements as a basis for this study.

4. Key Findings

As varied as the perspectives of the politicians and representatives of the economy are, there is broad consensus with respect to the major aspects: The common goal is "zero emissions". This can be achieved with an intelligent mix of all available climate-neutral drive technologies. To this end, the joint efforts of policymakers and the economy must be increased in order to implement user-friendly mobility and strengthen Germany as an industrial location.

> "Drives must come closer and closer to meeting zero-emission requirements to be able to achieve the CO_2-reduction goals in the transport sector. Therefore, the greatest potential is in in changing drives and modifying user behavior."

Climate-neutral mobility is the common goal – politicians from all parties and the representatives from the economy along the entire value creation chain agree on that. Everyone is also aware that this goal can only be achieved with a concerted effort: in concert with innovative products, a needs-based infrastructure and new mobility services with a high level of acceptance among the public. It is important to take into account CO_2-emissions, the ecological footprint, social aspects and geopolitical matters across the entire product life cycle and along the supply chain.

> "Especially for motorized, individual transport, there are already indications today that the storage of electrical energy in the battery offers enormous efficiency advantages in comparison to hydrogen."

A clear majority expects that in the coming years, the battery-electric drive will make up the largest share of the portfolio in the road transport sector. On the one hand, because the current offers can meet the current user expectations and, on the other hand, because, in the near future, major improvements are expected in the field of battery technology. The biggest bottleneck here is seen as being in the infrastructure sector: Charging stations must be expanded and the provision of adequate quantities of electricity must be ensured (see "Focus: Batteries", p. 8).

> "Primarily fuel cells are establishing themselves in the long-haul, heavy-duty utility sector."

Fuel cell vehicles (FCEV) will also be attributed an important role in the 2030+ drive portfolio of the future if they are used in accordance with their specific strengths. The focus here is on applications in the heavy-load and long-haul goods transport sector. A prerequisite is the adequate provision of green hydrogen by means of sustainable electricity production, domestically or abroad. Due to the low efficiency in comparison to the battery-electric drive, a high demand for primary energy is also expected. Here too, the construction of a user-oriented infrastructure is crucial for the acceptance and success of fuel cells (see "Focus: Fuel Cells", p. 9).

> "The mobility of the future will be networked, increasingly autonomous, payable and as close to zero-emission as possible and offer the requirements for equivalent living conditions in urban and rural areas."

To successfully transform mobility, the process must consistently be oriented on the needs of the users. Future mobility not only has to be zero-emission locally, it also has to be convenient and payable. This includes motorized individual transport and public passenger transport and a variety of solutions for goods transports. Mobility in the city will look different than the solutions for rural areas. The future drive portfolio will be supplemented by consistently taking advantage of the opportunities offered by digitalization: sharing offers, "mobility as a service", autonomous vehicles and smart, inter-modal solutions.

> "We will have very diverse drive technologies in the coming years: batteries, hydrogen and synthetic fuels (eFuels)."

Our study shows: There is not one single drive technology of the future. The climate policy goals can only be achieved with an intelligent mix and smart portfolio of climate-neutral drive technologies and intelligent mobility solutions. This requires a continuous and constructive dialog between policymakers and the economy in order to synchronize the expansion of a needs-based infrastructure and of the range of vehicle models.

> "We will only achieve our goals if all of the stakeholders come together and there is then a concentrated action and we start immediately."

4.1 Focus: Batteries

In the past few years, significant gains in efficiency with respect to increasing the energy density and reducing costs have been achieved in the development of batteries and further improvements are expected in the coming years. These developments make the battery-electric drive the most efficient drive technology. Its future role will be determined by the construction and expansion of an extensive charging infrastructure as well as by the ecological assessment of the entire life cycle, from the procurement of the raw materials to the production in Germany and Europe through to the second use ("second life") and recycling.

All of the interview partners are aware of the strengths of the battery-electric drive – also because it is currently the most widespread locally CO_2-neutral drive technology and a basic, extensive electricity grid infrastructure already exists. Another major strength is the efficiency, as it requires the least primary energy in comparison to other drive technologies (see Fig. 3, page 10).

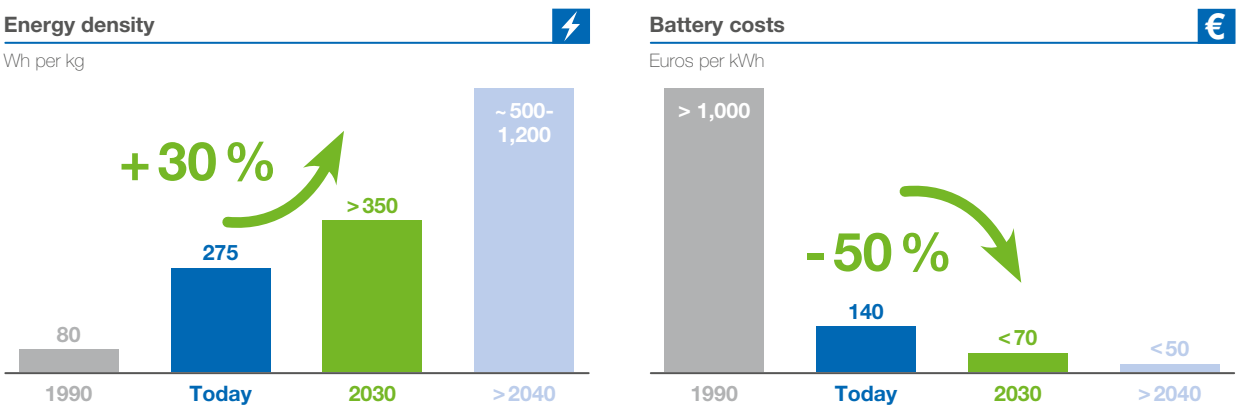
A major challenge for battery-electric individual transport is the construction and expansion of a needs-based charging infrastructure. On the one hand, the strength of the battery-electrical drive lies in the fact that the existing electrical grid can be used to feed in and distribute the energy. On the other hand, with an increasing number of battery-electric vehicles, capacity shortages are expected in the future[2] for which solutions must be found in the form of expanding the grid and intelligent demand response must be created.

In addition, the number and distribution of the charging stations in the public and private sector must be expanded in a user-oriented manner. A high range must be ensured for the technologies to be broadly accepted by the public. This can be achieved, on the one hand, by increasing the energy density of the batteries used in the vehicle. As a result, areas of application for further means of transport can be developed (heavy-load and long-haul goods transports and in rail transport, shipping and aeronautics). On the other hand, with an improved offer of rapid charging stations, high ranges and user convenience can also be ensured with smaller batteries in the future.

For the future drive portfolio, thought leaders expect progress in battery technology as a result of the increase of the energy density while simultaneously reducing the battery costs (see. Fig. 1). New materials, optimized manufacturing processes, battery cell production in Germany and Europe as well as the realization of cost reduction potential will continue the economical and ecological success of the battery-electric drive.

> "We have to implement renewable energies everywhere as efficiently as possible. For the passenger vehicle sector, that means: battery-electric, wherever possible."

Fig. 1 – Development of energy density and the costs of battery technology
The development of battery technology will be dynamic in the future



4.2 Focus: Fuel Cells

The fuel cells differ from batteries in many respects: On the one hand, they are comparatively more expensive as energy storage media, which, in addition to the higher primary energy requirement, also pose major challenges with respect to the extraction of green hydrogen and the distribution infrastructure. On the other hand, hydrogen as a drive technology has a broadly positive connotation. In the heavy-load and long-haul goods transport sector, as well as in the rail transport sector, there are a wide variety of applications in which the high energy density of hydrogen can be used sensibly.

The fuel cell is a technology that is already well-developed and has been tested in practice. In contrast to batteries, hardly any technological jumps with respect to fuel cells are expected in the coming years. Economic progress with respect to the fuel cell are expected, in particular, due to scaling effects.

The major disadvantage, the high primary energy requirement and thus the low degree of efficiency, will not change significantly. In the opinion of the thought leaders, the fuel cell will therefore only make up a small share of the future drive portfolio with respect to individual passenger transport.

Fuel cells' strengths always play out when high density over long routes is required, meaning, in the heavy-load and long-haul goods transport sector and in the rail transport, shipping and aeronautics sectors[3].

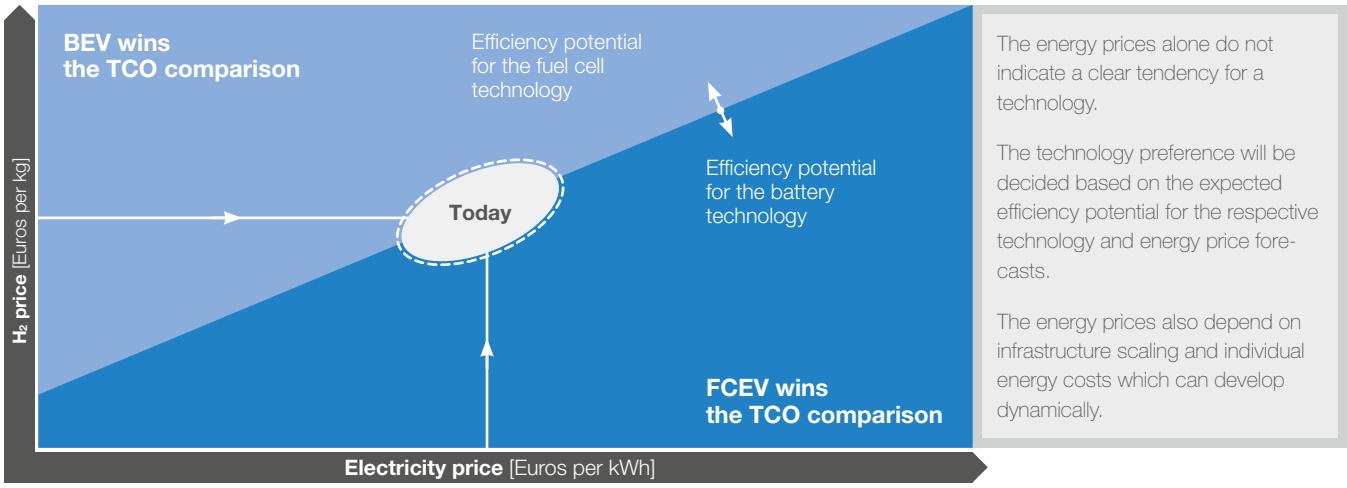
Our graphic shows, schematically and based on the example of the overall operating costs (TCO - Total Cost of Ownership) of a 40-ton truck, that there are different scenarios for the future with respect to which drive technology is less expensive, depending on the price of green electricity or green hydrogen (see Fig. 2).

Heavy-load transport currently generates around a third of the CO_2-emissions in the entire transport sector. For this reason, the fuel cell is an important component on the path to locally CO_2-neutral mobility (see also: the Nationale Wasserstoffstrategie 2020 der Bundesregierung (federal government's national hydrogen strategy[4]).

What is crucial is that it is "green" hydrogen gained from renewable energies. Here too, there are major challenges with respect to the expansion of the infrastructure. To what extent existing natural gas grids can be used to distributed hydrogen is equally as uncertain as the option to import green hydrogen from suitable regions and thus diversify geopolitical dependencies.

> "The fuel cell has opportunities where hydrogen, with its high energy density, has an advantage, e.g. in truck transport and trains on little-frequented routes without overhead lines."

Fig. 2 – Energy costs determine economic efficiency
The efficiency of the drive technologies depends on the price of electricity and hydrogen



4.3 Focus: eFuels

eFuels are assuming an important niche position in the drive portfolio of the future with respect to existing vehicles. Due to their long value-creation chain, they require the highest primary energy use in comparison to batteries and fuel cells. Their greatest strength: Once they have been generated, they can be stored comparatively easily, distributed via the existing infrastructure and installed in vehicles with combustion engines (ICE).

eFuels are electricity-based fuels that are gained on the basis of renewable energies and are thus locally zero-emission ("power-to-fuel"). In addition to solar fuels, they can be extracted from ammonia, methane or from green hydrogen using electrolysis.

The generation of these eFuels requires, on average, six to eight times the amount of primary energy in comparison to the battery-electric drive for a small vehicle with a mileage of 20,000 km p.a. (see Fig. 3.) Accordingly, eFuels can only be used for very limited applications in which the alternative drive technologies, batteries and fuel cells, cannot be used sensibly.

Their greatest advantage is that eFuels are very easy to handle because they can be fed into the existing infrastructure of pipelines, transport cars, gas stations, fuel dispensers and conventional combustion engines and used without complications. Accordingly, process eFuels can allow for passenger vehicles with combustion engines to operate locally in a CO_2-neutral manner, which is considered a luxury due to the expected high price, for instance, to operate historical vehicles ("old timers") or motor sports cars for enthusiasts' purposes.

In addition, applications in the aeronautics industry are being tested at various development stages.

(*The research initiative "Energiewende im Verkehr" (Energy Transformation in Transport)*[5], funded by the Federal Ministry for Economic Affairs and Energy (BMWi), offers further information about the production and use of electricity-based fuels.)

> "It is imaginable that eFuels will remain relevant for a niche market with combustion engines – namely, where there is also a willingness to pay high prices."

Fig. 3 – Comparison of the supply capacity of a wind turbine for various drive technologies
The electric car with a battery is the most efficient

Energy source	Energy carrier	Drive	Locally zero-emission	A 3-MW wind turbine supplies...
Electricity	Electricity	BEV	✔	1,600 Vehicles
e.g. Wind turbine 3 MW, 2,000 h full capacity p.a.	H_2	FCEV	✔	600 Vehicles
	eFuels	ICE	✗	250 Vehicles

5. The Drive Portfolio of the Future

Long-term openness to all available climate-neutral drive technologies, ideology-free discussions and the economic competition of a wide variety of innovations constitute the mutual, basic understanding of policymakers and the economy. The groundwork for the future success of locally zero-emission mobility must be laid now with the highest priority. This requires: A broad, user-oriented range of vehicle models from the economy and funding of the expansion of a needs-based infrastructure by policymakers.

Passenger vehicles: battery-electric drive as a basis technology

In the coming years, a significant increase in battery-electric mobility is expected with respect to passenger vehicles. Continuous innovations will differentiate into a variety of solution concepts which will ensure a high level of user-friendliness and everyday usefulness. The diversity of models will serve the variety of customer needs from the compact to the premium class as well as for city and rural transport, for private and business use.

Trucks: Mix of fuel cell and battery-electric drive

With respect to commercial goods transport on roads, a mix of various solutions are expected, whereby, in principle, the following priorities are expected to be set:

- Use for short distances, in the city, light vehicle classes: more likely battery
- Use for long distances, cross-country trips, heavier vehicle classes: more likely fuel cell

As a locally zero-emission bridging technology, biomethane is already being used in selected sectors.

Niche vehicles: eFuels

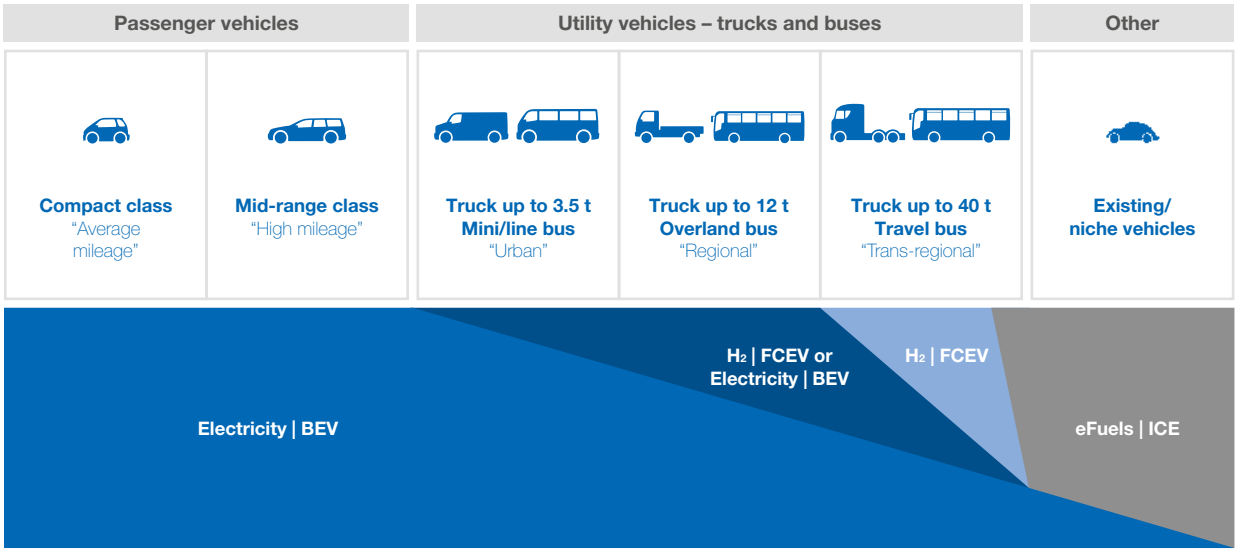
For the use in existing/niche vehicles, for instance sports cars and historical vehicles ("old timers"), eFuels will offer a suitable climate-neutral drive solution due to the lower price sensitivity.

Other transport routes

This study focuses on the observation of road traffic as the most important transport route and a major economic sector. Interactions with the development of the drive portfolio in aviation, water-borne transport and rail transport should therefore also be taken into account in future examinations.

Fig. 4 – 2030+ drive portfolio with a focus on road traffic

All available climate-neutral drive technologies are used based on their specific strengths



6. Challenges from a Policy Perspective

Across the political parties, policymakers have recognized the need to establish locally zero-emission drive solutions and see a suitable infrastructure as a whole-of-society task. The economy's ability to innovate must be supported by funding programs that are designed to be open to all types of technology, targeted and needs-based. By working together, the public can be convinced to switch to alternative drive technologies. If this succeeds, there are major opportunities for Germany as an economic location.

Supporting the conversion to locally zero-emission mobility in a manner open to all types of technology

The conversion of the entire drive portfolio is a whole-of-society task that can only be achieved if policymakers, the economy and civil society work together. Only then can the climate goals in the ambitious target corridors be achieved. It is important that the paths to achieving the goals can be chosen in a manner that is open to all types of technology and free of ideology. The successive replacement of entire fleets on roads, rails and in the air and the conversion of charging and supply infrastructures built over decades to new drive technologies demands high investment sums and intensive communication work by the economy and policymakers to ensure acceptance among the public.

Utilizing the strengths of the battery-electric drive and systematically increasing optimization potential

The surveyed politicians also see the strengths. It is expected that there will be significant development leaps in the coming years with respect to batteries which will ultimately result in higher performance capacities, more user-friendliness and thus a higher level of acceptance, in particular, in the individual mobility segment.

Hydrogen as an opportunity for Germany as an industrial and technological location

The positive developments in the past few years in the hydrogen segment are welcomed by policymakers. The majority of policymakers are endorsing the objective of having a very high share of climate-neutral, or "green" hydrogen, whereby the use of other forms, like "gray" or "purple" is imaginable during the transition phases. Due to the diversity of applications of hydrogen, even beyond the use as a drive for means of transport, e.g. in steel production, its significance for Germany as an industrial and technological location is also estimated as very high. That is why the expansion of the corresponding expertise and the execution of a variety of hydrogen pilot projects are being welcomed and supported. In addition to the opportunity to secure existing sectors and jobs, there is also additional export potential, for instance in mechanical engineering and plant construction.

Utilizing synergies between state funding policy and business investment capital

Policymakers are aware of the necessary parallelism between the construction of the infrastructure and the expansion of the range of vehicle models. They advocate for state funding which is "necessary and sensible" in order to ensure a synchronous ramp-up of vehicle offers and charging infrastructure. The political instrument can include: easing of tolls, financial purchase incentives, funding projects for the charging infrastructure, tax exemptions, reduction of energy prices, e.g. by reducing the EEG-surcharge (EEG-Umlage) the national production of green hydrogen. It is important that the economy fully utilizes the provided funds so the necessary transformation can be implemented. Requirements and prohibitions should only be used if the financial incentives do not achieve the desired effects.

Taking geopolitical and tax-related challenges into account

Each drive technology must always be seen in the context of the global economy. This applies in the competition for leadership in technology as well as the development of new sales markets. The balance between the preservation of national interests, the strengthening of key German sectors and the avoidance of dependencies in international competition must be maintained. Policymakers consider the establishment and expansion of international alliances in order to ensure access to the necessary raw materials (e.g. for batteries) and acquiring new suppliers (e.g. green hydrogen from Africa), to be particularly within the economy's scope of responsibility.

Another challenge: If the electrification of the vehicle fleet progresses, the current income from the mineral oil tax, in the millions of euros, will be eliminated. To compensate for these tax losses, new concepts must be developed and coordinated early on to ensure planning and investment certainty.

7. Challenges from an Economic Perspective

The German economy supports the political and whole-of-society objective of achieving locally CO_2-neutral mobility with a high level of innovative capacity and investments. It also considers the acceleration of the market ramp-up of all locally CO_2-neutral drive technologies as a crucial success factor in order for Germany to be a contender in international competition as an economic location. What is important is that the political framework conditions be defined long-term so the investments made today are future-proof.

Infrastructure expansion and the expansion of the vehicles offered with alternative drive technologies must go hand-in-hand

Today, the economy is at a point at which it can provide locally zero-emission vehicles in all classes and for a wide variety of applications – and this portfolio is constantly being expanded. The funding programs from the political side benefit the market ramp-up of locally zero-emission mobility. It is clear, however, that the lack of an expansion of the infrastructure for electricity and hydrogen constitutes a bottleneck which is inhibiting even stronger growth. On the one hand, because skeptical consumers are still waiting for the switch to low-emission vehicles and, on the other hand, because, for instance, there is the possibility of an unsatisfying user experience with electric vehicles due to a lack of charging stations. The prioritization and acceleration of the expansion of the infrastructure is therefore one of the most important levers for increasing user acceptance of vehicles with locally zero-emission drives.

Accelerating the expansion of the electrical grid and the provision of renewable energies

With an increasing number of battery-powered vehicles on the market and a higher supply and demand of rapid charging technologies, the required quantity of energy is also increasing rapidly. In addition to intelligent demand response, an accelerated expansion of the grid and new electrical lines is required. This must be simplified by means of corresponding regulatory intervention and quickly driven forward. In particular, the municipalities must receive support for the expansion by means of simplified processes and statutory framework conditions. This is the only way the required energy can be provided to the customers on a need basis while simultaneously ensuring grid stability.

Define long-term, clear framework conditions for investment certainty

The need to make major investments within a very short period of time in order to transform one of the most im--portant economic sectors in the country is an unprecedented challenge. Rapid action is important in order to secure German and European providers' position in the highly competitive international competition. Therefore, planning and investment certainty are of central importance for the economy. Investments are already being made for the technological conversion, which have to amortize over a period of 20-30 years. These investments are only worth it, however, if policymakers create binding and reliable framework conditions that also apply long-term.

Continue and intensify the dialog between policymakers and the economy

Even today, with respect to the goal of locally CO_2-neutral mobility, there is an unprecedented cross-segment and cross-sector cooperation in the economy and a broad, cross-party consensus among policymakers. This study also confirms that. Only by bundling all of those powers and with optimally coordinated measures, can this challenge be overcome. The targeted bundling of investments and incentives, long-term planning ability and an optimal coordination of the timing of all these measures between policymakers and the economy are therefore vital. Therefore, the existing dialog forums should be further utilized and expanded so losses due to friction can be avoided, mutual understanding can be deepened and prompt decisions can be made.

Communicate a positive vision of climate-friendly mobility to end customers

Customer acceptance is another central success factor for the successful establishment of locally zero-emission mobility. A manufacturer-independent and comprehensive communications offensive by policymakers that accompanies the transformation process, dismantles preconceptions and creates a positive attitude toward getting started is desirable. The increased use of locally zero-emission vehicle in federal and municipal fleets, in public transport and among public officials, as role models, can also make a major contribution. This way, a positive vision of locally zero-emission drive technologies, "Made in Germany" can be developed.

8. Next Steps

This study is another important step toward establishing a mutual understanding between policymakers and the economy with respect to the drive portfolio of the future. This process of dialog and consensus building must be consistently continued due to the dynamic innovative developments in the highly competitive international environment, as well as due to the changing framework conditions.

To achieve the mutual goals, the following areas of action can be derived:

1. Expand and institutionalize the dialog between policymakers and the economy

Our interviews showed how important regular dialog is to ensure the rapid exchange of knowledge and, simultaneously, equally understand the requirements and expectations of policymakers and the economy. Existing forums can be used for this. These include:

- National Platform Future of Mobility
- National Centre for Charging Infrastructure
- National Hydrogen Council
- Utility Vehicle Task Force
- Communications platforms in the framework of the development projects, e.g. ELSTA

New dialog options for the exchange between thought leaders across sectors, the economy and parties with mobility expertise offer the potential to further accelerate the transformation process.

2. Targeted infrastructure funding with a focus on generating, distributing and providing sustainably produced electricity and hydrogen

The experts agree that, in the long term, the best drive technology will assert itself by means of economic mechanisms. To achieve the climate policy objectives, in addition to the investments from the economy, a clear plan from the policymakers is necessary to promote and accelerate the expansion of the infrastructure. This applies to the generation and distribution of electricity produced in a climate-neutral manner, the expansion of the battery charging infrastructure and the hydrogen infrastructure.

3. Reduction of regulatory hurdles

To fully deploy the innovative potential and implement the transformation within the temporal target corridor, the reduction of regulatory hurdles is an important success factor. In addition to legislation, support of corresponding standardization projects must be taken into account. This is important in the following sectors, among others:

- Acceleration and simplification of the expansion of new electricity lines
- Simplified expansion of the charging infrastructure and support of the municipalities[6]
- More electromobility in public vehicle fleets[7]
- Uniform standards when charging and paying at charging stations[8]
- Bundling and strengthening all activities for the technological competence of the battery cell in Germany[9]
- Researching new value creation chains[10]
- Interoperability of the infrastructure for alternative fuels[11]

4. Improve access to capital for major innovation projects

In the competition with China and the USA, Germany and Europe have a strategic interest in finding independent solutions when developing and producing the most important future drive technologies. Access to capital is a major success factor as demonstrated in the discussion regarding domestic battery production. Funding innovative companies is an important starting point, whereby its accompaniment from a hidden to a global champion requires improved access to higher investment sums. This requires risk capital which strengthens innovation in Germany early on and allows for sustainable growth domestically.

5. Optimize end customer communication and the state's function as a role model

To generate acceptance for future drive technologies and thus the required change in behavior among the public, a manufacturer-independent and technology-neutral communications offensive is required. The mutual goal of achieving locally zero-emission mobility must be emphasized. The fact that policymakers and the economy will solve these challenges in a joint feat of strength must also be highlighted. It is important to convey that, in addition to ecological and economic considerations, the wide variety of the needs of the general public for customer-oriented, convenient and payable mobility, in rural areas and in cities, are the objective of the joint activities conducted by policymakers and the economy.

Index of Figures/References

[1] See complete list of all interview partners, p. 4

[2] See National Platform Future of Mobility, Whitepaper AG 6 09/19, VDE|FNN, p. 20

[3] See VDE study “Assessment of climate-neutral alternatives to diesel train sets” 2020

[4] See “Hydrogen and PtX-based mobility is an alternative for applications in which the direct use of electricity is not sensible or is technically impossible”, p. 11

[5] https://www.energiesystem-forschung.de/foerdern/energiewende_im_verkehr

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[7] https://www.bmwi.de/Redaktion/DE/Artikel/Industrie/rahmenbedingungen-und-anreize-fuer-elektrofahrzeuge.html

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[11] https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2020/10/20201020-NPM-Bericht-AG6-RoadmapNachhaltigeMobilitaet-V2-wrz.pdf

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