

## **Measures Supporting the Transition to Efficient Mobility in the Free State of Saxony**

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### **Summary**

In the Free State of Saxony, with its experience as an official German “Model Region” and “Showcase” for electric mobility, there is a close cooperation between researchers, developers and users to support technological progress. This approach has been expanded to intelligent transport systems by the Saxon strategy “Synchronized Mobility 2023” and led to an urban test bed in the free state. This paper describes numerous examples of technology developments, the “Saxon way” for mobility transition and value creation, as well as the involvement of the public. One of the key aspects is an approach for a charging infrastructure-demand-analysis.

*Keywords: Policy, Intelligent, Electric Vehicle, Infrastructure, Demand*

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### **1 Initiating the Change of Mobility and Value Creation in the Free State of Saxony**

Observing climate change, air quality and dependency on fossil resources, as well as the potential of intelligent transport, a transition of mobility and corresponding value creation has begun in the Free State of Saxony. In 2017, the Saxon Cabinet decided to support electric mobility and intelligent transport by a “framework concept for automobility of the future” [1]. Manifold measures have been started, concentrated by the Saxon Energy Agency (SAENA), together with a comprehensive network (Figure 1).

SAENA has supported efficient mobility since 2009 as a coordinator for the “Model Region Electric Mobility Saxony” and since 2012 for the “Showcase Region” in cooperation with Bavaria. Since 2014, Additionally, SAENA has been pushing intelligent transport systems for automated and connected driving. A network with a variety of partners is available. See figure 2.

As the official Saxon center of competence for efficient mobility, SAENA acts as the first contact for consulting, project initiation and public relations. A selection of measures offered to the different target groups is described in the following sections, combined with implementation examples.

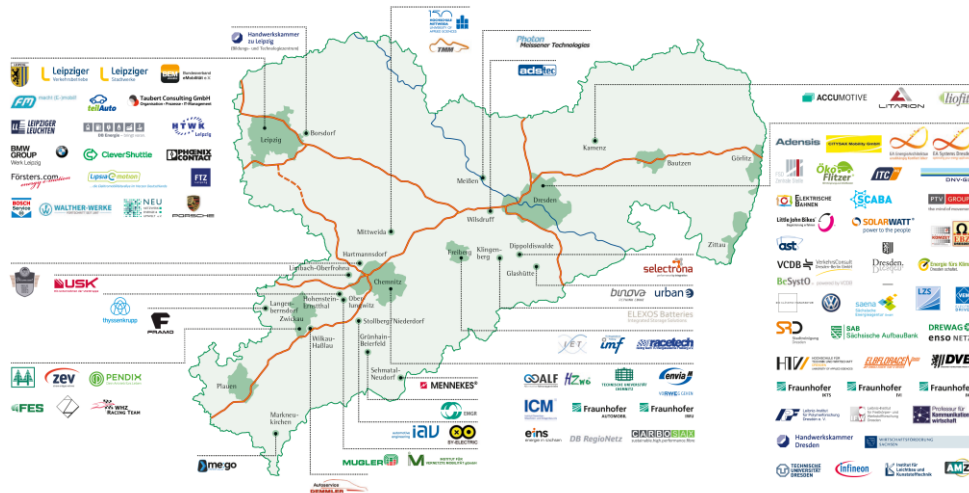


Figure 1: Network of about 100 Saxon partners related to electric mobility [2]



Figure 2: Network of about 80 Saxon partners related to intelligent transport systems [3]

## 2 Long-Term Technology Alignment

To shape the range of technologies available for low-emission, low-resource-consuming transport based on renewable energy, researchers and developers are supported. SAENA proposes and discusses project topics, helps with the partner search, supports the presentation to federal and Saxon funding authorities and helps to identify gaps in the funding environment. This support also extends to problem solving during the project duration and dissemination of results.

During the duration of the “Model Region” and the “Showcase Region” electric mobility, a variety of technologies has been developed, demonstrated by the project partners in real-life. Saxony had a focus on hybrid and electric buses, public and private fleets, commuters, sharing, routing, cleaning and waste collection, hybrid trains, lightweight design, charging infrastructure, communication technologies, business models, regulation, battery production and recycling, as well as education. See Figure 3. The Figure shows electric buses in Dresden and Leipzig, an electric vehicle fleet at the Saxon police, electric mobility offered in a rural area in combination with renewable energy, storage and energy management, an electric street cleaner, everyday life demonstration, a street light with charging infrastructure and graduates of new commercial and technical education courses. A summary of the showcase’s results is available in [4].



Figure 3: Examples for the several evaluated electric mobility showcase's projects

After evaluating the showcase's results, SAENA now supports the network partners, in order to intensify the activities, especially in central challenging fields such as public transport, utility vehicles, charging infrastructure and battery. Meanwhile, the network pushes these topics in new projects, such as "SEEN-KV" and "iHub" which are related to logistics. These are based on electric vehicles or "heat2go", which is associated to the management of temperature in electric buses. The support SAENA offers in terms of project acquisition is independent of specific technologies. This means that the Free State of Saxony, for example, also funds the project "HZwo:BIP" in order to develop bipolar plates for passenger car fuel cells [5]. This initiative has led to further fuel cell projects with federal and EU funding.

Furthermore, Saxony is now a pilot region for intelligent transport and autonomous driving as a supplier of automotive and microelectronic components. As mentioned by the German federal government, the region of Dresden is one of the main test areas for urban automated driving. As coordinated by SAENA in the framework of "Synchronized Mobility 2023", working groups have been founded to focus research and demonstration on urban solutions. As an example, autonomous driving by a car of IAV has been presented to the public with SAENA. See Figure 4.



Figure 4: Demonstration of autonomous driving by the network "Intelligent Transport Systems Saxony"

The partner network has also started several accompanying projects, for example "eJIT" related to logistics. Electric 40t-delivery is tested by a truck, which was put into service at the Volkswagen plant in Zwickau and the Porsche plant in Leipzig in 2017 [6]. See Figure 5. One of the next steps in the project will be the integration of functions for automated driving – including public road passages.



Figure 5: Electric 40t-truck for automotive component delivery at Saxon plants of Volkswagen and Porsche

Another project related to automated driving in real road traffic is HarmonizeDD, which is coordinated by BMW and was recently started on the digital urban testbed in Dresden. New projects, such as REMAS (resource management for highly automated urban traffic), SYNCAR (synchronized automated urban driving) and IVS-KOM (communication module), are also embedded in the testbed of Dresden. The Fraunhofer Institute for Transportation and Infrastructure Systems IVI is one of the main supporters of the comprehensive initiative “Synchronized Mobility 2023”.

### 3 Specific Analysis, Planning and Implementation Activities

#### 3.1 Change of the Traffic System

In terms of electric mobility, the installation of charging stations is currently in progress by different partners. See Figure 6. The examples shown were installed by the German SLAM consortium, the European Fast-E consortium, the operator of German rest stops Tank&Rast and Volkswagen. SAENA is in dialogue with all of them regarding their activities. In order to support investors in placing charging infrastructure in economically promising manners, a study for public charging infrastructure demand in Saxony is under progress in collaboration with the Dresden University of Technology. Section 3.2 shows a summary of its method and gives an overview of the expected results. It will also be used to align activities with actors, such as municipalities or energy providers.



Figure 6: Examples of recently installed fast-charging infrastructure (Autobahn A14 near Nossen; Autobahn A4 near Bautzen; at “The Transparent Factory” of Volkswagen in Dresden (including solar panels and storage))

Furthermore, integrating electric vehicles into the state’s administration fleet is ongoing. A “blueprint” from the police delivers procedures for easy usage and acceptance, as well as for installing infrastructure and the education of personnel (see Figure 3). SAENA was involved in initiating this project and its experience will be applied to fulfil the cabinet’s decision, as described in section 1.

At a regional level, cities such as Leipzig or Zwickau added electric vehicles to their municipal fleets. Further municipalities have been supported by SAENA in acquiring funding for local electric mobility concepts or vehicle procurement. Moreover, private network partners push activities, with two example partners supported by SAENA: Autoservice Demmler has intensified procurement of electric vehicles

following its showcase project – specifically for rural areas. DDV Mediengruppe is starting the often-discussed transition of logistics in urban and rural environments, by downsizing conventional vehicles for media delivery to lightweight electric vehicles [7]. See Figure 7.



Figure 7: Lightweight electric vehicle at DDV Mediengruppe (source: Andreas Krause / [2])

Project support by SAENA is not limited to road traffic. Figure 8 shows the hybrid EcoTrain, developed in Saxony by DB Regio / Erzgebirgsbahn.



Figure 8: Hybrid EcoTrain of DB Regio / Erzgebirgsbahn (source: DB RegioNetz Verkehrs GmbH / [2])

Related to intelligent transport, test corridors for autonomous driving within real traffic are currently being prepared. SAENA supports this by coordinating between research institutions, infrastructure component suppliers and responsible authorities for road integration in the Free state of Saxony and on a municipal level. Several activities connected to the implementation of intelligent urban traffic are concentrated around Dresden. This is based on the state-of-the-art traffic control “VAMOS”, see Figure 9. As an example, “VAMOS” allows traffic dependent automated traffic signal changes, based on the data from public transport or taxis.

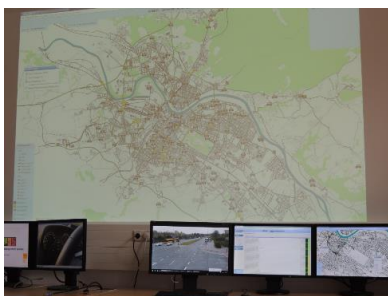


Figure 9: Traffic control “VAMOS” in Dresden (duplicate running on live traffic data at Dresden University of Technology)

To coordinate all activities with other regions, SAENA uses several platforms. The “Metropolregion Mitteldeutschland” initiative offers regular meetings for an exchange of information with neighboring federal states Thuringia, Saxony-Anhalt and Brandenburg. Further strategic meetings allow a form of discussions with other regions and federal ministries. Topics can include charging infrastructure roll-out or the testing of autonomous driving. With neighboring regions, such as the Czech Republic or Poland, joint meetings are used for exchange. For international activities SAENA and the Saxony Economic Development Corporation (WFS) agree on activities in close consultation.

## **3.2 Study on Public Charging Infrastructure Demand in the Free State of Saxony**

### **3.2.1 Targets of the Charging Infrastructure Demand Analysis**

Providing publicly accessible charging infrastructure is considered to be one of the essential prerequisites for the roll-out of automobile electric mobility. At the end of March 2017, there were about 849 normal (= up to and including 22 kW) and 20 fast-charging points in the Free State of Saxony. Currently further charging infrastructure is under construction. The charging points are not, however, heterogeneously spread. Also, the framework regarding population densities, use intensities, registered vehicles and economic indicators is not heterogenous in the Free State of Saxony. Due to these conditions, the roll-out is expected to develop differently in the regions. The specific situations in the different regions of Saxony are very important for the strategy of providing charging infrastructure. Future demand estimates must take this into account.

The content of the study described here, developed by the Institute of Transport and Economics of Dresden University of Technology on behalf of SAENA, is a comprehensive inventory of the existing and estimated future charging demand of publicly accessible charging infrastructure in the Free State of Saxony. Based on the current market situation, estimates and influencing factors on the development in the area of electric mobility, an estimate for the charging infrastructure necessary for this should be made. Therefore, a comparison with the already existing charging infrastructure should show gaps. Estimate horizons of different times were reviewed to identify possible dynamics.

### **3.2.2 Methodology of the Study**

At the beginning, the specific characteristics of the Free State of Saxony were examined, regarding vehicle registrations and economic parameters. For this, national statistical analyses were also analyzed. These led to the assumption that higher income groups and home owners, especially with solar power generation, show a higher affinity for buying an electric vehicle [8]. Therefore, a much higher buying quota can be assumed in these groups.

The existing charging infrastructure was examined regarding the satisfaction of the need for area and route coverage with the help of typical traffic movement. In addition, a nationwide and international comparison with the respective charging infrastructure coverage followed to showcase spreading systems of charging infrastructure. Conventional gas stations were also used as comparative figures and their area distribution analyzed.

Furthermore, the suitability of electric vehicles, available currently and in the future, for the different charging speeds and standards was examined. The goal of this study was to find out which charging speeds are demanded on the market. A meta-analysis on existing successful market estimates and the expected sales numbers of electric vehicles in the coming years was also carried out. [9, 10, 11, 12, 13, 14, 15] Influence factors on the expected sales were worked out and compared to the current market conditions.

The charging behavior of the current and future electric car drivers was also analyzed based on preliminary studies. Thereby, influencing factors on the price regarding the willingness to pay and price sensitivity were also considered. [8, 16] This has a relevant influence on the use, especially of charging infrastructure up to and including 22 kW.

The result was the realization that there are significantly different prerequisites for the distribution of electric mobility on a municipal level, which will remain until the year 2030. Regionally fluctuating registration figures of electric vehicles, traffic volume and movement lead to a different demand for charging processes at publicly accessible charging infrastructure.

It should be noted that a high charging amount at home and at work is expected. Therefore, only comparatively few charging processes are necessary in public. This especially goes for longer distances for which Ad-hoc opportunity charges are necessary most of the time or charges resulting from surprising need. These should preferably be provided through a fast-charging infrastructure with  $\geq 50$  kW power. Nevertheless, there is great potential for opportunity charging processes, which depends a lot on the context of the parking process and the pricing. Therefore, the power price in the near residential area is the reference price.

General estimates, which calculate the charging demand based on all estimated electrical vehicles and then divide these by the average utilization at each station, are not useful due to the stated spatial disparities. Existing approaches confirm this assumption. [17, 18]

The implemented model approach consisted of predicting the number of public charging processes. This was differentiated by the purpose of the trip and charging power for each municipality and independent town in Saxony, based on the predicted registration figures of electric vehicles.

The following input data was used for this:

- Inventory of cars regarding the number, new registrations, age and share of electric vehicles
- Statistical data on the municipalities/independent towns (income, housing structures, commuters, etc.)
- Traffic movement in the Free State of Saxony and beyond
- Findings on the mobility behavior with cars
- User surveys on charging behavior

Founded on an estimate of the purchase likeliness in the individual municipalities and independent towns, the number of predicted electric vehicles was assigned to the individual Saxon municipalities. External traffic was separately reviewed through the traffic volume recordings. Therefore, different times of the market roll-out were calculated as scenarios.

Based on typical distances, commuting movements, workplaces, points of interest and points of sale, the respective charging demand was calculated in a geo-based way. A matrix was created, which takes the trip purposes and the differentiation according to transit, as well as origin/destination traffic according to municipality, into account. With this, the demand for fast- and slower charging can be estimated separately. In the summary of the results, the willingness to take detours was taken into account and the summary of charging demands in neighboring municipalities was made. As a result, each municipality was assigned a charging demand. This demand was then compared to key figures on economically necessary utilizations.

### **3.2.3 Outlook on Results**

As a result, it becomes clear that the current charging infrastructure in the Free State of Saxony is not sufficient to provide a sufficient charging infrastructure for the market roll-out. Areas near the border have a clear disadvantage in regards to the catchment area for potential people charging, especially as long as there are few electric vehicles in the neighboring countries. At highly frequented locations (cities, highways, main roads), fast-charging infrastructure is an attractive business model. In less populated regions, there is also a demand for fast-charging stations that may, however, initially in the phase of market roll-out, hardly be run economically. Here, there is a necessity to support the phase of the market roll-out with funding programs (such as [19]) or vehicle producer's activities. From about two million electric vehicles in Germany, one can assume that the spatially necessary coverage of fast-charging infrastructure can be provided economically.

Charging infrastructure with lower power will be largely available at the beginning of the market roll-out. However, this means there will not be a business model in the sense of electricity sales, apart from a few exceptions. Trade, service providers and tourism will provide charging infrastructure in significantly larger numbers and can profit through customer acquisition, loyalty or cross-selling.

The final major result of the study, the municipality based estimated public charging demand for an example number of vehicles during market roll-out, will support investors to identify the most attractive locations. Furthermore a support is expected for estimating regional funding demand.

## **3.3 Change of Value Creation**

For Saxony, with its automotive manufacturing and supply, adapting value creation to mobility trends is important. BMW and Volkswagen are producing electric vehicles in Leipzig and Dresden. See Figure 10. Furthermore, Porsche is producing hybrid vehicles in Leipzig. As presented in the Figure, SAENA integrates these manufacturing activities in public relations and demonstration to professionals e.g. by respective booth design at trade fairs or demonstration vehicle design.



Figure 10: Electric vehicles Volkswagen e-Golf and BMW i3 produced in Saxony

Related to further manufacturing activities, Daimler expands its battery production plant of Deutsche ACCUMOTIVE in Kamenz. Figure 11 shows a battery example integrated in SAENA's traveling exhibition, hence also applied to addressing the public. Hoppecke is a further example for battery production and SCABA an example for battery start-ups. The specialist for production systems Thyssenkrupp System Engineering has focused its Saxon site on battery production equipment [20], demonstrated to press in a tour organized by SAENA.

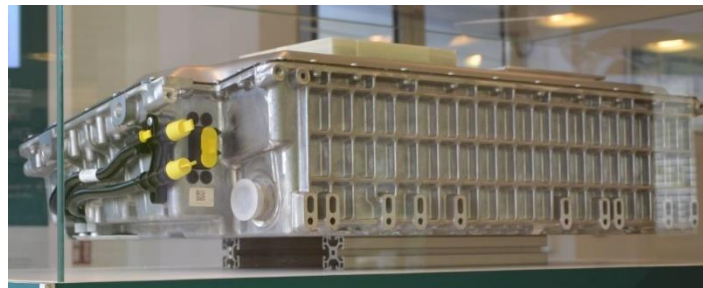


Figure 11: Vehicle Battery produced by Deutsche ACCUMOTIVE in Saxony for Daimler

As a further key area, several companies produce lightweight components - the Showcase's resulting lightweight rim also shows potential for production [21]. The network for intelligent transport systems in Saxony contains several actors, which are being prepared for the relevant product delivery, such as Preh Car Connect.

SAENA supports the transition of value creation by consulting and organizing events for the exchange of knowledge between the traditional automotive industry and the community of electric mobility, as well as connected and automated driving.

## 4 Public Involvement

Convincing the public of a fundamental change in mobility behavior – and shaping this change, in order for it to become permanent, requires targeted and continuous efforts of persuasion. Inspiring personnel to support changes in manufacturing will also be required. Several approaches of SAENA help this development. Research results are presented by SAENA's conference formats such as the Electric Bus Conference or a joint international cooperation forum, related to autonomous and connected driving technologies. This is in cooperation with the Association for Standardization of Automation and Measuring Systems (ASAM) in December 2017 in Dresden. Mutual knowledge of findings and avoidance of duplication is supported by formats such as "Innovation Workshop". Encouraging development of education programs has helped to simplify the growing introduction of electric vehicles, e.g. related to development or service. Electric vehicle test events, such as the traditional Saxon day for Road Safety at Sachsenring near Chemnitz or interactive traveling exhibitions, address a variety of target groups. See Figure 12.



Figure 12: New traveling exhibition addressing electric mobility and intelligent transport systems in Saxony; booth and vehicle test event at the Saxon day for road safety at Sachsenring near Chemnitz

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