

How hydrogen & fuel cell technologies evolve Baden-Württemberg's' automotive sector

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Executive Summary

This paper aims to show how Baden-Württemberg, as an automotive region located in the southwest of Germany with existing combustion competences, can successfully manage the transformation process and why the existing competences are particularly well suited to fuel cell and hydrogen technologies. The future structure of Baden-Württemberg, opportunities and potentials are shown, and it is explained how these can be used optimally. Various strategies and instruments have been developed in Baden-Württemberg for this purpose, such as the Cluster Fuel Cell BW. These various support services and initiatives offer companies the opportunity to develop and manage the transformation. A look at the current players in the hydrogen and fuel cell sector will also show which competences are already available in Baden-Württemberg and which need to be specifically expanded.

Keywords: fuel cell, hydrogen, industrialization, strategy, state government

1 Future Structure of Baden-Württemberg

Worldwide, the automotive industry is facing an enormous change. Based on the three major trends of electrification, digitalisation and automation, the transformation of mobility itself is already in full swing. This brings challenges and potentials for the players in the automotive industry: Existing business models must be adapted to the changing requirements. New technologies and components are gaining importance.

The transformation towards electromobility is changing the automotive industry, as value creation shares, processes, and structures in vehicle development as well as in vehicle production are changing.

Baden-Württemberg, the south-western state of Germany and cradle of the modern automotive industry, has a complete automobile cluster, which is home to internationally important OEMs and global suppliers as well as many leading suppliers in the plant and mechanical engineering sectors. About 470,000 workers are part of the cluster, which relies on industrial innovation for its performance and competitiveness. The emerging transition process in the automobile industry – mainly driven by electric mobility and digitalisation – is thus not only a question of environmental necessity. A successful transition will enable Baden-Württemberg to further develop its industrial strength, but any failure to shift to new technologies could impact adversely on the industrial structure and prosperity of the State.[1]

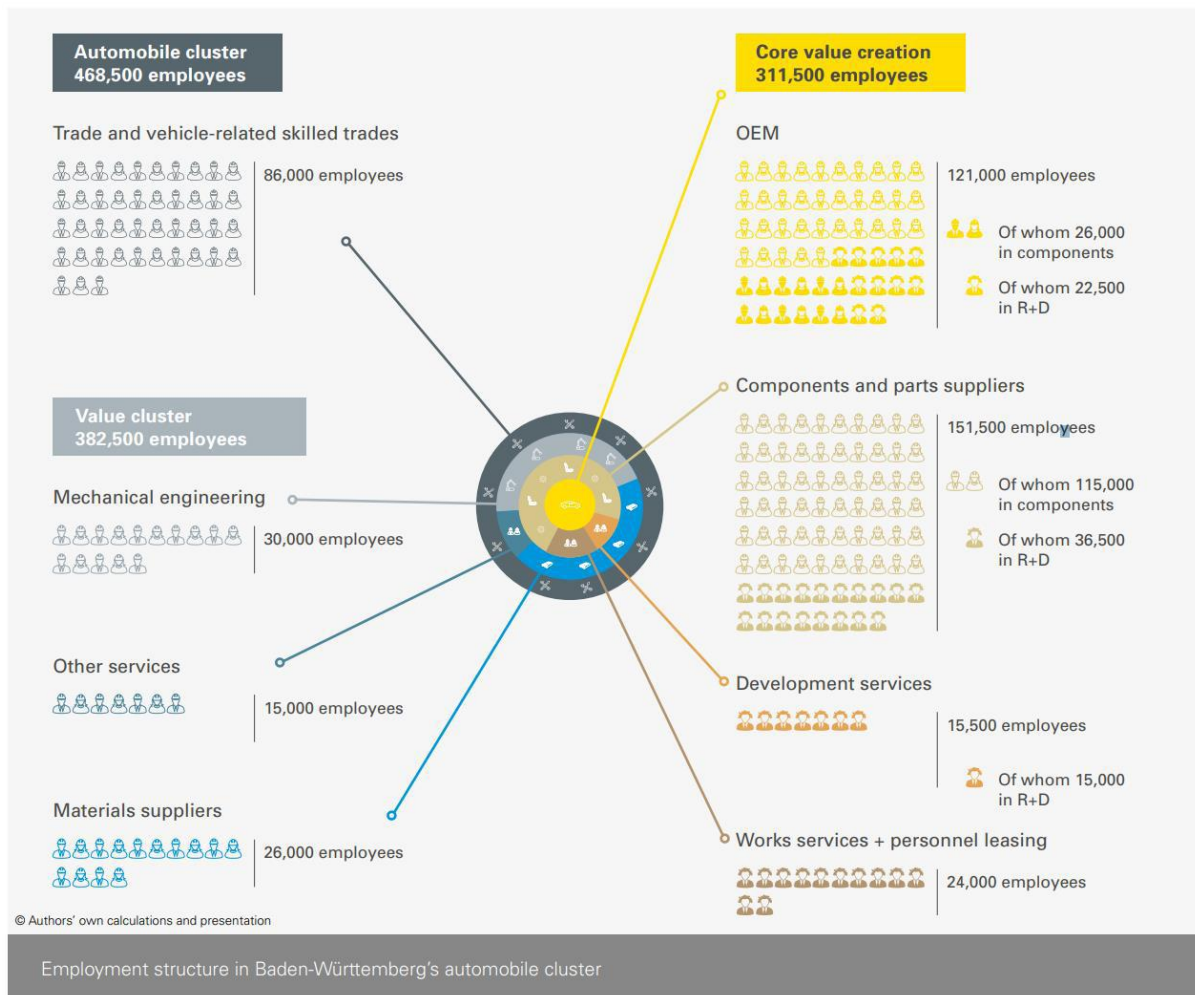


Figure 1: Employment structure in Baden-Württemberg's automobile cluster [1]

Not transferring to new technologies could have negative impact on the economic structure and prosperity of the country [1]. Electrification includes not only pure electric vehicles, but all forms of hybrids as well as fuel cell vehicles, especially in the commercial vehicle sector [2]. Therefore, fuel cell technologies, as one of several types of electric drive, will also make an important contribution to the ongoing transformation.

Not only well-known OEMs are in the state, but very many small and medium-sized suppliers are strongly represented in the region. Due to the future discontinuation of the classic internal combustion engine, these companies will be faced with major challenges to remain in existence and receive orders from OEMs. However, many companies can apply their expertise and manufacturing processes to both electromobility and hydrogen & fuel cell technology and exploit synergies from conventional technology.

2 Recognizing potential and addressing it in terms of industrial policy

Hydrogen and fuel cell technology has become an increasingly relevant topic during recent years. From an industrial policy point of view, it is therefore also necessary to put a stronger focus on this topic, in order to recognise potentials and to make the best possible use of them. The high potential for Baden-Württemberg in this field was analysed in the study "Potentials of the hydrogen and fuel cell industry in Baden-Württemberg" [3] by Roland Berger in cooperation with the Ministry for the Environment, Climate and Energy Sector Baden-Württemberg. 16,000 new jobs could be created, especially in producing components

or integrated fuel cell systems. The sales potential is estimated to €9 billion in 2030. Many actors in the region already have competencies in different areas of the hydrogen value chain, as Figure 2 shows. By the meantime a lot more companies are active in the fields of hydrogen and fuel cell technologies. Unfortunately there is no updated data available. In chapter three the development of the Cluster Fuel Cell BW will be shown. The extreme growth in the cluster suggests that significantly more players are bringing and using skills in this area.

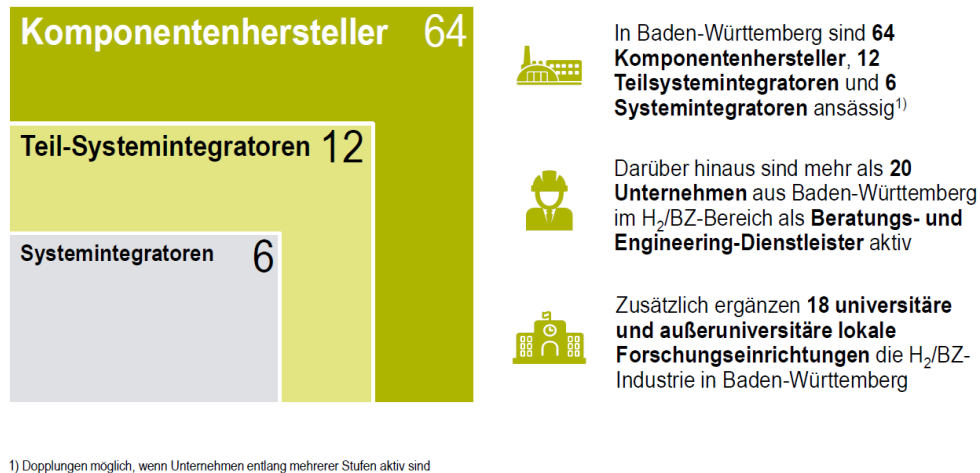


Figure 2: already active stakeholder in Baden-Württemberg in 2020 [3]

In order to exploit this potential, it is essential to address it politically. In addition to support programs and strategies, direct contact with companies must also be sought. This is done, for example, in the Strategic Dialogue for the Automotive Sector Baden-Württemberg as an intersectoral and holistic collaboration platform for stakeholders from business, science, society and politics [4].

In addition, SMEs are being strengthened in Baden-Württemberg and the shortage of skilled workers is being addressed at an early stage, for example through qualification initiatives. A short overview on existing initiatives focussing on skills and qualification will be shown in chapter three. The aim is to make hydrogen and fuel cell technology attractive, to enable employees to use and work on these new technologies and to retain existing jobs.

3 Initiatives for transformation

Different instruments and initiatives have been launched to make the best possible use of the potential mentioned above. These will be examined in more detail in the full paper, as they are highly relevant and transferable to other regions. These initiatives support their members through knowledge transfer, working groups on relevant topics, visibility also for small businesses, exchange and networking.

In the coalition agreement of the Baden-Württemberg state government for 2021, e-mobil BW was mentioned several times. Particularly important is the further development of the state agency as a "transformation agency" until 2030. On March 21, 2023 the Cabinet of the State of Baden-Württemberg decided to finance e-mobil BW as transformation agency until 2030 and to position the agency for the future. Especially in the fields of hydrogen, energy and digitalization new tasks will enlarge the portfolio of the agency.

The idea of cluster initiatives as a form of pre-competitive research-oriented cooperation

Founded in 2007, the Cluster Electric Mobility South-West brings together around 200 partners from industry and science and represents cross-industry and cross-technology thinking and collaboration as a form of pre-

competitive cooperations in four fields of innovation: Vehicle, Energy, ICT and Production. It became apparent that other stakeholders and competences are relevant for fuel cell technologies and that the needs for further development of the technology are different and therefore must be supported in a different way. To make the best possible use of the competencies of Baden-Württemberg's companies and research institutions, the Cluster Fuel Cell BW was spun off in 2013 to accelerate the industrialisation of mobile and stationary fuel cell applications. The Cluster Fuel Cell BW [5] has experienced strong growth in the last two years and currently has over 200 partners from research, industry and associations who actively cooperate along the entire value chain.[6] Figure 1 shows the development of the number of partners of the Cluster Fuel Cell BW and thus underlines the increasingly important role of hydrogen and fuel cell technology in recent years.

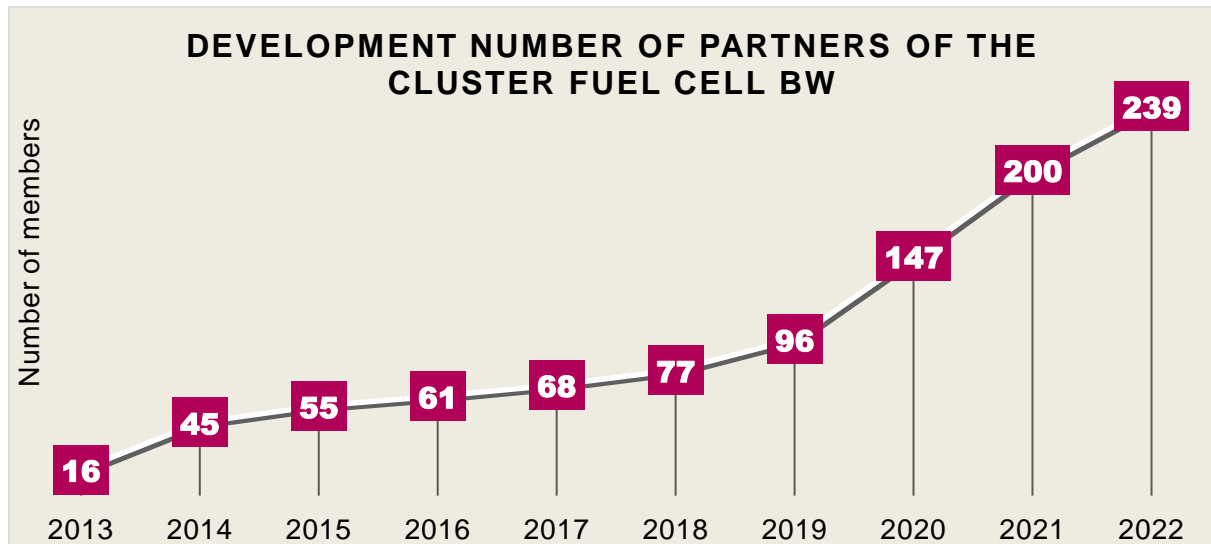


Figure 3: Development number of members Cluster Fuel Cell BW

Offerings of the cluster as an opportunity for skilled workforce and qualification

As mentioned earlier qualified and skilled workforce is a crucial point to achieve a successful transformation in the automotive industry. In the Cluster Fuel Cell BW, universities and further education centres are active in this topic within the framework of the "Skilled Workers and Qualification" working group. Together with companies, they develop strategies and show which instruments are needed. In this way, experienced cluster partners can contribute their expertise and the rest can benefit from it. Various activities are being planned, such as seminars and workshops.

Further initiatives for transformation

Beside the Fuel Cell Cluster BW, other support initiatives like the Plattform H2BW [7] as framework for the Hydrogen Roadmap of the state government [8] and the Information Centre for the Transformation of the Automotive Sector in Baden-Württemberg (Landeslotsenstelle Transformationswissen BW) [9] for companies have been established to support small and medium-sized companies in the automotive industry in their technological and strategic development.

The task of the **Plattform H2BW** is to implement and accompany the goals of the Hydrogen Roadmap of Baden-Württemberg. Therefore many activities has been initiated to get into the process. The activities are oriented towards the entire hydrogen value chain and can be subdivided into the various thematic areas of the roadmap. One of the application fields is mobility, which is good for the automotive sector in BW. However, other application areas such as stationary applications are also addressed. The overarching topic is technology - this is where the automotive players can contribute their expertise and create the transformation from classic mechanical and plant engineering to hydrogen and fuel cell technologies.

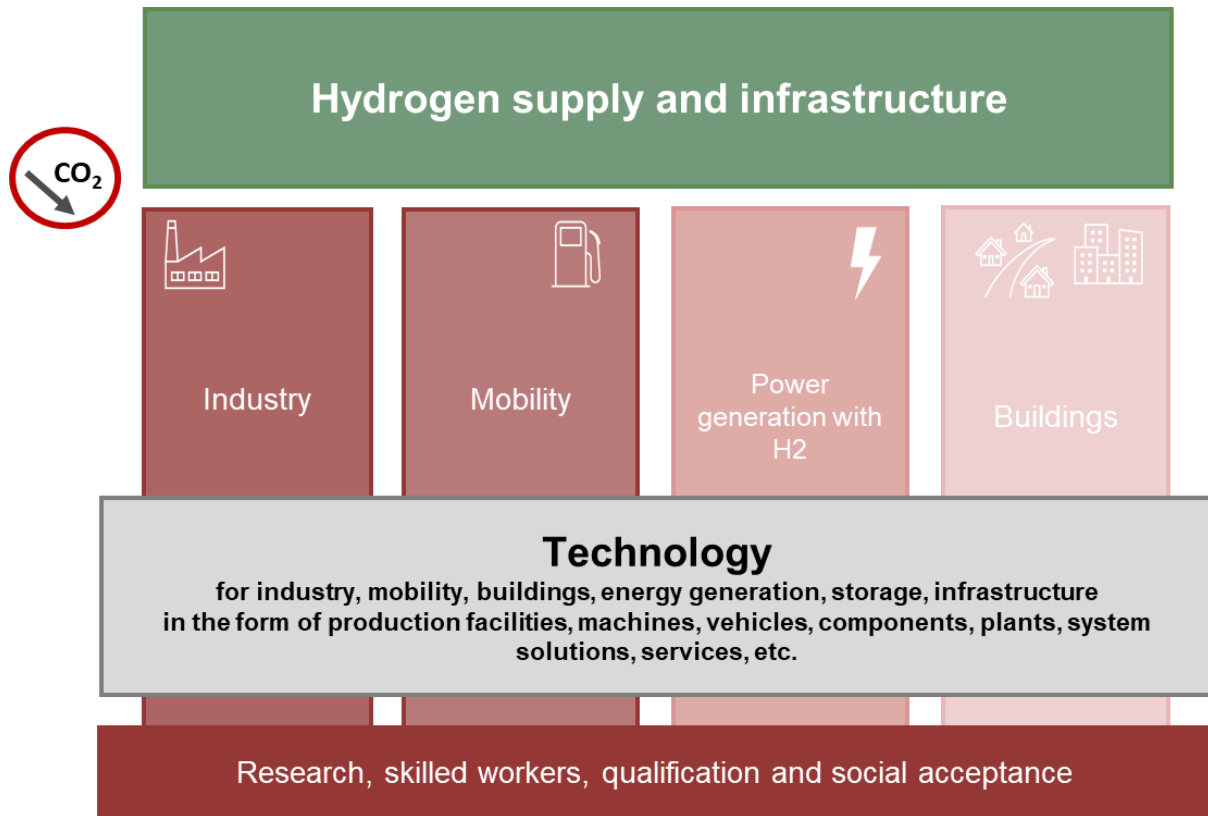


Figure 4: thematic areas of the hydrogen roadmap and the Platform H2BW [7]

Another important instrument of the Platform H2BW for the implementation of the Roadmap is the Baden-Württemberg Hydrogen Advisory Council. In November 2021, the Minister for the Environment, Climate and Energy BW appointed 25 experts from business, science, civil society and municipalities to the state's Hydrogen Advisory Council. The Hydrogen Advisory Council Baden-Württemberg assists the state government in an advisory and supportive capacity and meets around four times a year. The committee's task is to accompany the implementation of the Hydrogen Roadmap BW and to develop recommendations on how the measures contained therein can be further implemented in a demand-oriented and effective manner. The Platform H2BW acts as the office of the advisory board, supports it and takes up its recommendations for the implementation of the Hydrogen Roadmap BW. In December 2022, the Hydrogen Advisory Council BW formulated concrete recommendations for action to the state government on the further orientation of the upcoming update of the Hydrogen Roadmap Baden-Württemberg. In its so-called "Seven-Point Plan", the Advisory Council presents recommendations for setting priorities for the hydrogen strategy.

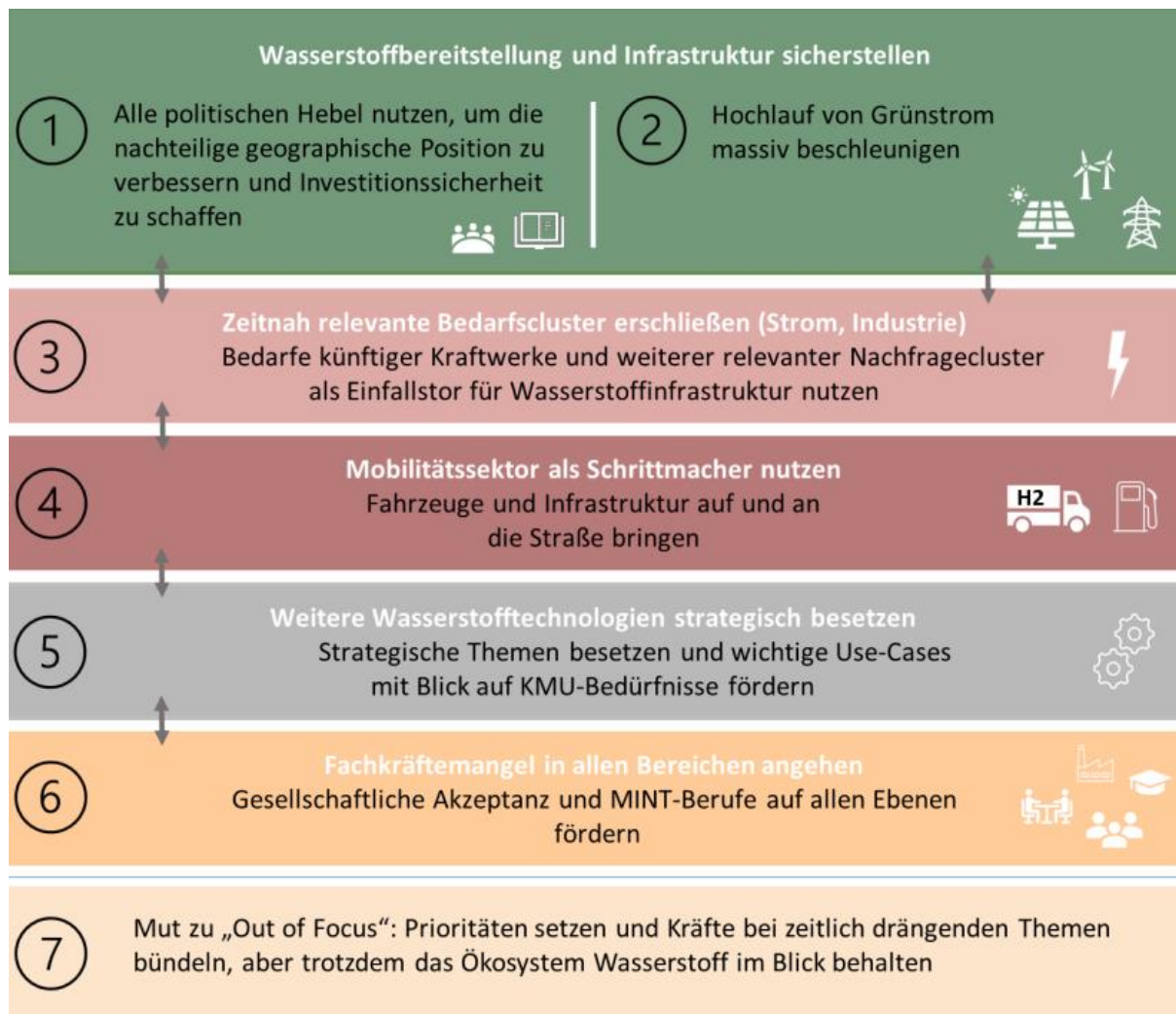


Figure 5: Seven-Point Plan" published by the Advisory Council [7]

The Seven-Point plan contains recommendations for action for the continuation of the Baden-Württemberg Hydrogen Roadmap, including:

- Use all political opportunities to improve Baden-Württemberg's unfavourable geographical location through suitable measures such as supply corridors and hubs and to create investment security.
- Massively accelerate the expansion of renewable power generation in Baden-Württemberg and create options for own hydrogen production.
- Tapping the demand of future power plants and relevant consumption clusters as a gateway for hydrogen connection.
- Forcing the mobility sector as a pacesetter for the use of hydrogen.
- Strategically position further hydrogen technologies and develop them along important use cases.
- The transition to a hydrogen economy requires broad social acceptance and sufficient skilled workers at all levels.
- Courage to "go out of focus" for hydrogen: set priorities, but keep an eye on the hydrogen ecosystem.

Funding is also an important area of work for the Platform H2BW. The transformation process is to be supported with the help of targeted funding programmes. The aim of these calls is to support the development

of a hydrogen economy and the transformation to a climate-neutral economy: In addition to R&D, the focus is also on investment funding.

This leads all to the creation of a platform for networking and knowledge transfer between the numerous actors in Baden-Württemberg. All the activities and promotional opportunities should contribute to strengthen Baden-Württemberg's companies and research institutions and promote them in their innovative strength and support them in maintaining their leading technological position in international competition.

Another cross-technology measure is the **Information Centre for the Transformation of the Automotive Sector in Baden-Württemberg** [9] with the aim to give orientation in the ongoing transformation process. Small and medium-sized companies in the automotive industry in particular receive support in their technological and strategic development. For this purpose, qualification offers, consulting services, networking offers and access to knowledge via scientifically sound publications are clearly listed and indexed in databases. With the "Transformation Automotive Industry" consulting vouchers, strategic consulting for small and medium-sized enterprises in the state is supported by financial funding in the complex structural change of the automotive industry. Whether new types of production, service and sales processes or shorter innovation cycles of the entire value creation system - business models and competences of supplier companies and the automotive industry must be further developed, adapted to the trends or fundamentally found and implemented.

But not only initiatives with contribution of the state agency e-mobil BW are important. It also requires the commitment of the individual companies in Baden-Württemberg. For example, large companies such as Bosch are already actively training their own employees and thus giving them the opportunity to gain a foothold in new areas such as hydrogen and fuel cell technology and to continue to be employed in the company, even if the classic work area in the combustion engine is no longer available. [10]

In the same way, research institutions and further education centres such as KIT wbk have recognised the relevance. Further education and training in the field of hydrogen technologies is one of the most decisive steps on the path to transformation. Here, many parallels from battery technology can be used and thus no completely new programmes have to be created. KIT wbk had already gained good experience in the past with the **Fit4E** research project, which can now also be applied to hydrogen technology. In this project, the scientists developed a tool with which companies can check which manufacturing competences they already have that can be used to produce battery modules or electric motors. A workshop concept was central here in order to enter into the process chains and identify possible fields of action in a targeted manner. [11]

The **Fit4H2** programme aims to identify existing competencies in the company and bundle them with regard to fuel cell-electric drives. In this way, small and medium-sized enterprises will be shown the way to becoming suppliers of fuel cell production solutions. For this purpose, a knowledge base must be created in the company with regard to the entire fuel cell-electric drive train. In addition, the companies must be shown which current competences they can transfer to the manufacturing processes of the fuel cell-electric drive train and how they can use them. In addition, companies must be made to experience current challenges in the manufacturing of the powertrain components. [12]

In this way, it can be made easier for small and medium-sized companies in Baden-Württemberg to enter the field of fuel cell-electric drive trains.

4 How is the transformation proceeding?

For the mechanical engineering industry, fuel cell technology is a great opportunity in terms of value creation and jobs, as it can map the entire value chain in Germany and Europe. In order to tap the innovation potential of fuel cell drives, systemic know-how and very specific competences are required. This is a strength of the European automotive and supplier industry including mechanical engineering.[13] The region is particularly characterised by a high concentration of globally successful car manufacturers, globally leading system suppliers, numerous small and medium-sized automotive suppliers, highly specialised production equipment

and service providers as well as excellent universities and research institutions. This unique cooperation structure in an industrial innovation cluster is the basis for the innovative strength and global success of the development and production location in the German southwest.[14] This provides many competencies in Baden-Württemberg, as well as in other automotive regions worldwide, that are of high importance for the transition to electromobility and fuel cell technology.

As an important indication of how the transformation of the conventional combustion industry in Baden-Württemberg is progressing, the partners of the Fuel Cell Cluster BW can be looked at more closely. More and more companies are joining hydrogen and fuel cell technology, as shown in Figure 1. The analysis of the partners of the Cluster Fuel Cell BW, which can be seen in Figure 2, shows that nearly half of the partners are focused on components for hydrogen-applications, for example applications in mobility or energy supply. It is understandable that a large number of companies are active here, as this is the easiest way of transformation. The know-how, expertise and production techniques from the supplier landscape of the combustion engine can be applied to many components of fuel cell technology with relatively few adjustments.

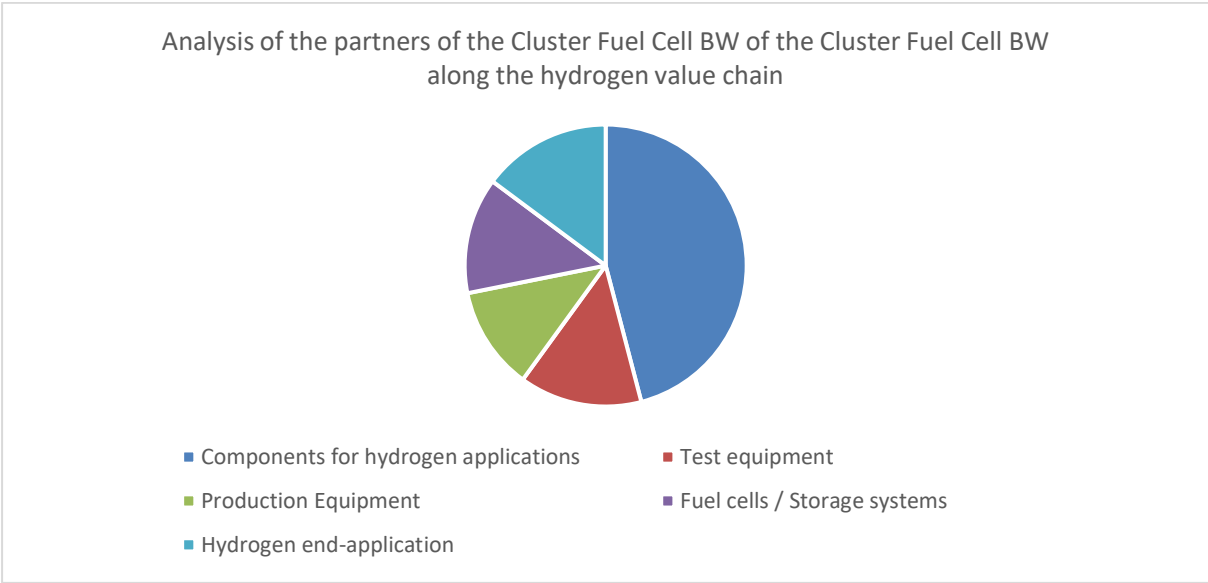


Figure 6: Analysis of the partners of the Cluster Fuel Cell BW along the hydrogen value chain

The next step is to analyse which competences are missing in Baden-Württemberg to complete the hydrogen value chain. As shown, components for mobility & application areas are well covered, the technology of electrolysis and refuelling stations is expandable, but more and more companies are entering this field. Further training opportunities also need to be expanded; recycling, as well as Second Life applications, need to be considered at an early stage. Currently, there are still relatively few competences in low-CO2 production in Baden-Württemberg (for example in the cement industry or in paper production). Further offerings, as well as funding programmes, are needed and some of the larger players in the region are already addressing this by creating appropriate in-house training programmes.

Many companies can contribute their know-how and manufacturing processes from conventional combustion technology and adapt them to both electromobility and hydrogen and fuel cell technology. For example, CFRP production and lightweight construction in general, but also metalworking processes such as stamping, bending and joining. The progressive transformation process of these companies can serve as a model for others around the world and the same hurdles and problems do not have to be encountered.

However, there is still a lot of work to be done in order to complete the transformation process in the best possible way and to support the companies in Baden-Württemberg in the process. To this end, a strategy process has been launched by the Fuel Cell Cluster BW to realign itself after 10 years and to discuss the

needs and hurdles of the cluster members. In this way, the work of the cluster should contribute to facilitating the transformation and to using adjusting screws where they are needed.

A survey for strategic orientation in the cluster shows that the majority of partners see strategic relevance in the area of hydrogen & fuel cell technology and that a new business field is being established. This corresponds to the previously mentioned transformation process of the automotive region of Baden-Württemberg. But a large number of partners are already established in this new business field. The rest are still in the middle of the transformation process and are reorienting themselves strategically.

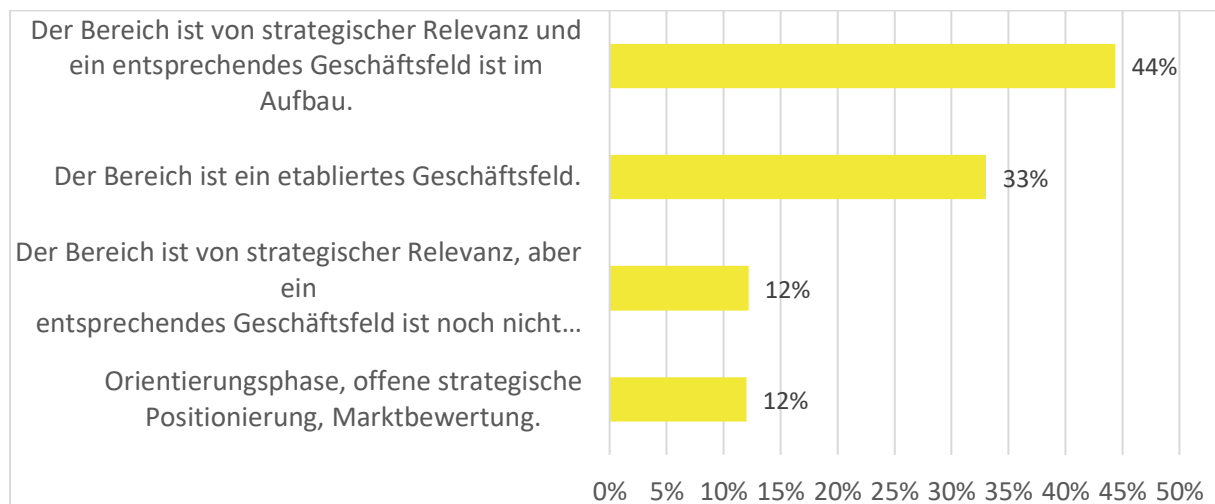


Figure 7: Business model relevance from survey - How do you rank your organisation in the field of hydrogen and fuel cell technology today? [15]

The survey also asked about the biggest challenges in the companies. This is intended to create a better understanding of where there are problems, hurdles and support needs and to address these in order to accompany the companies in their transformation in the best possible way. The biggest problem is the lack of skilled workers, followed by high costs in terms of investments and a lack of resources. All these challenges go hand in hand with the assessment of the Hydrogen Advisory Council and will be addressed to the state policy in the near future.

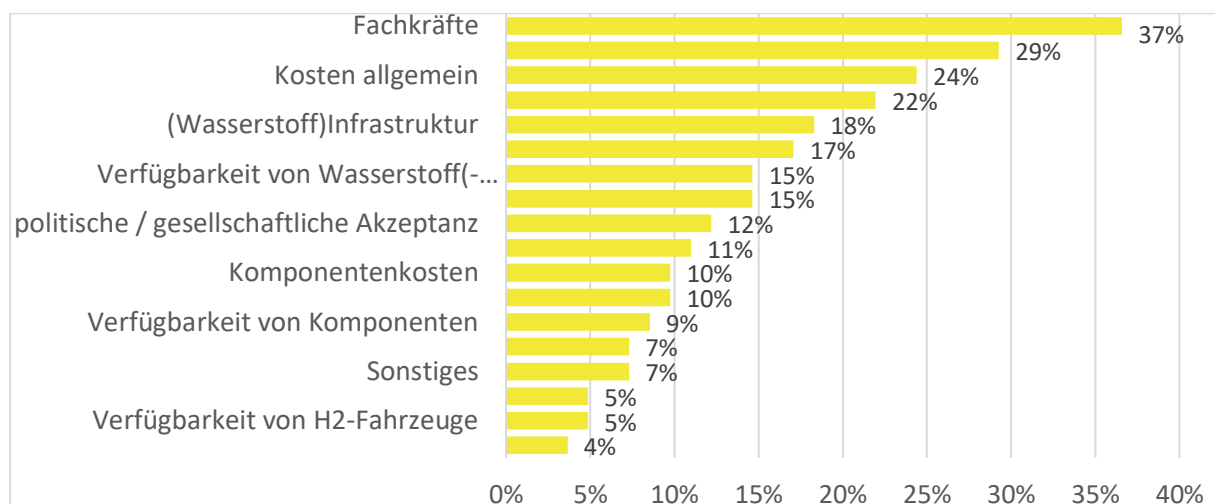


Figure 8: Challenges from survey - What are currently your five biggest challenges? [15]

In order to address the challenges identified and to help the companies in their transformation and to open up new business models, the participants were then asked about their desire for support offers from the cluster. In addition to market observation and evaluation, there is a clear need for cooperation and funding opportunities. Here, the cluster can make an enormous contribution and network companies in order to bring them into an exchange of experience.

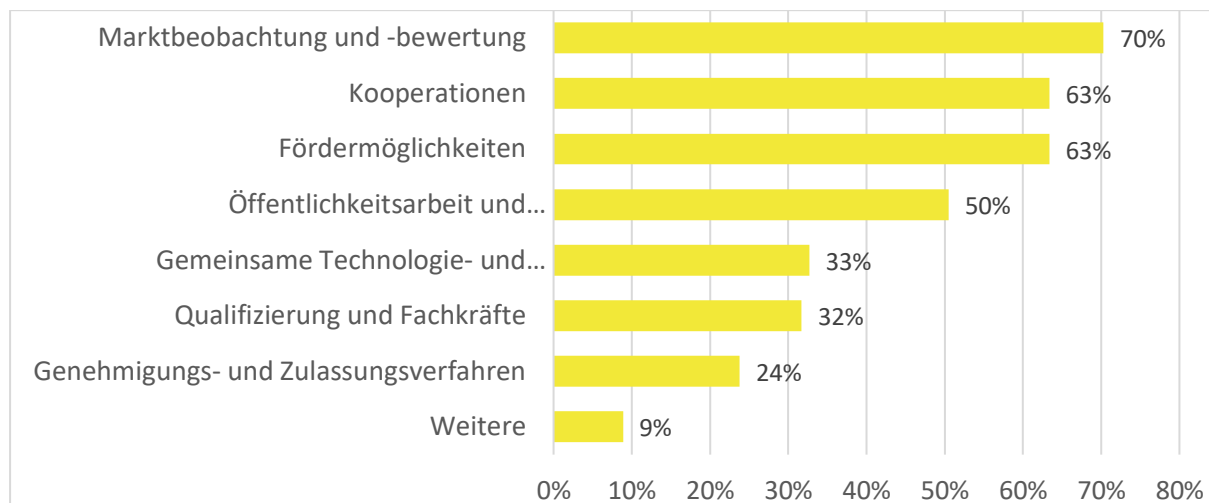


Figure 9: Need for support & activities of the Cluster from survey - In which areas would you like support from the Fuel Cell Cluster BW? [15]

5 Outlook

In the near future, there will be an update of the structural study [1], which, in addition to the passenger car industry, will also analyse the area of commercial vehicles in the fuel cell sector in more detail.

The energy sector has been subject to dynamic development, not least since the start of the war in Ukraine. The changed framework conditions and requirements call for further development and sharpening of the fields of action of the Hydrogen Roadmap. Likewise, new calls for proposals must continue to create opportunities to support companies in Baden-Württemberg in their transformation in the best possible way. This can be done through new calls for proposals or support measures for SMEs. e-mobil BW is in the planning stages to support them in the area of qualification.

There are still a few hurdles to overcome in order to ultimately successfully master the transformation in the automotive region of Baden-Württemberg. Nevertheless, the region is currently on a very good path and many regions with similar conditions can learn from Baden-Württemberg's experiences and initiatives.

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Presenter Biography



Alina Richter studied Aerospace Engineering at the University of Stuttgart with specialization in materials, manufacturing processes and space applications. As a student, she gained experience at STIHL and the German Aerospace Center (DLR). Since 2021 she is in charge of the coordination and initiation of projects in the field of hydrogen and fuel cell technologies also on European level at e-mobil BW GmbH - State Agency for New Mobility Solutions and Automotive Baden-Württemberg, an innovation agency and competence center for the transition towards automated, connected and electric mobility in a sustainable energy system.



Dr Wolfgang Fischer holds a doctorate in history and a degree in business administration. After various professional positions, including at the State Ministry of Baden-Württemberg, he has been working at the State Agency for New Mobility Solutions and Automotive Baden-Württemberg e-mobil BW GmbH since 2011. He is an authorised signatory and heads the area of project and cluster activities. His work focuses on electromobility, fuel cell technology, automated and connected driving as well as the transformation of the automotive industry, especially the support of small and medium-sized enterprises.