FRANCO-GERMAN COLLABORATION POTENTIAL FOR GREEN HYDROGEN

1 Background: Comparison of French and German hydrogen ecosystems

Hydrogen is currently understood in national and international discussions as an important element of the energy transition and economic system. As a mean of local emission free energy carriers, significant feedstock for a carbon free industry and as a source for a variety of synthetic fuels, that can be efficiently stored over long periods and transported over long distances. Considering this important role, both France and Germany have placed hydrogen technologies on their political agenda and ministers of both countries stated their aim of becoming the major player in hydrogen technologies. According to the EU commission, hydrogen should also play a more important role in the next legislative package for gas and since the establishment of hydrogen as an energy carrier is a European joint project, it will become one of the priorities of the upcoming German EU Council presidency and Germany will use its presidency to promote framework conditions for sector coupling and the development of an EU internal hydrogen market. The hydrogen economy is seen as one of six strategic areas for which European value chains and ecosystems should be established. While there is growing competition from other parts of the world, Europe should take the window of opportunity and jointly develop technologies in the field of hydrogen. Both France and Germany have increased funding for research and development as well as market ramp-up of electrolysis and fuel cell technologies. However, political discussion and specific projects have focused on the deployment of hydrogen use-cases in their territories, resulting in a regional rather than national and European advance. Moreover, the strategy followed has led to both countries developing in different fields: whilst France is focusing on hydrogen mobility, Germany sets more focus on power to gas and the production of green hydrogen. This has, respectively and will subsequently influence the conditions of the legal framework of each country. Thus, a joint effort between France and Germany in this field will allow the sharing of the already required knowledge, the acceleration of research as well as a unification of the legal conditions and deployment objectives, which might drive the trends towards a strong international collaboration on hydrogen technologies in Europe.

1.1 French hydrogen plan and the German hydrogen strategy

The French Hydrogen Deployment Plan for the Energy Transition was published in June 2018 and is backed by 100M€ for first deployment of hydrogen technology. The funding is managed by the French environment and energy agency (ADEME). The French Hydrogen Plan has a strategic part and is backed by specific goals:

- 10% green hydrogen in the industry by 2023; 20 – 40% by 2028

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- 5000 light commercial hydrogen vehicles by 2023
- 200 heavy duty hydrogen vehicles by 2023

A German National Hydrogen Strategy was first announced by Chancellor Merkel in the course of the publication of the climate package. In November 2019 a major hydrogen stakeholder conference was held by four federal ministries (the Ministry of Economic Affairs and Energy, the Ministry of Transport and Digital Infrastructure, the Ministry of Economic Cooperation and Development, and the Ministry of Education and Research). Over 700 participants under-lined the strong interest of the German industry for hydrogen related topics. The stakeholder conference was held to generate input to the upcoming German National Hydrogen Strategy, which is meant to be published in early 2020. While the goals of the French Hydrogen Deployment Plan have legal liability (the goal, that climate-neutral and renewable hydrogen should make up to 40% of the industrial hydrogen demand and 20% of the overall hydrogen consumption in France is legally anchored).

1.2 Regional strategies for hydrogen deployment in France and Germany

Besides national hydrogen development plans on the federal level, also regions in both countries are taking action to foster hydrogen development. The five northern German states Bremen, Hamburg, Mecklenburg-Vorpommern, Niedersachsen and Schleswig Holstein agreed on pillars for a joint „Northern German Hydrogen Strategy", looking to have an installed electrolyser capacity of 500 MW by 2025 and 5.000 MW by 2030. Besides that, they also want to de-ploy an area-wide network of 250 hydrogen fueling stations.

A similar development can be seen in different French regions, especially in the East. The Auvergne-Rhône-Alpes Region has decided to make hydrogen a field of excellence, so the regional government has launched the Zero Emission Valley project to deploy 20 hydrogen stations and a fleet of 1,000 vehicles with the aim of offering hydrogen vehicles to the market at the same price as the equivalent diesel vehicle. A little further south, the Region Occitanie, after launching its global strategy and declaring the first operational hydrogen plan in France HyDéO, is accelerating with a "Green Hydrogen" plan with a vision until 2030. The region is planning to purchase three hydrogen-powered trains, started development of a hydrogen-powered aircraft, build several green hydrogen production and distribution stations, and construct hydrogen production plants with industry-scale electrolysers. The region Grand Est recently published its regional plan for development, sustainable development and equality of territories (SRADDT), where the region aims for a net surplus of energy while having a significantly lower carbon footprint by 2050. Furthermore, the SRADDT explicitly states the importance of hydrogen as energy storage technology and predicts the usage of 0,5 TWh hydrogen produced with surplus energy of renewable electricity production.

1.3 Expertise of French and German industries in hydrogen technologies

Both countries are well developed in hydrogen technologies, but as the whole the industry is still on the edge of growth and both countries must implement their findings from the laboratory and adapt their products to industrial scale. One could argue that the French side is more developed on the mobility application. Indeed, several French companies have taken the impetus, whether in the context of research or application for hydrogen mobility. Among them are Symbio, Faurecia and Michelin, which have launched and implemented projects in the use of fuel cells in light vehicles and trucks. In order to develop further in this field, Michelin and Faurecia have decided to create a joint venture by combining the existing and complementary assets of the two partners. This will enable the joint venture to immediately offer a unique range of hydrogen fuel cell systems for all applications. In the meantime, Alstom has become the world leader in the use of hydrogen trains while Air Liquide, Engie and GRDF, are playing a lead role in the development of the hydrogen value chain in France. working on increasing green hydrogen production for industry, electricity storage and feeding the gas circuit.

On the other hand, Germany has developed fundamental expertise with regard to a big range of hydrogen applications. With its large number of Power to Gas demonstration sites being built, companies like Sunfire, Enertrag or Siemens have acquired broad knowledge in the operation of electrolyzers. Recently, German industry is building up knowledge about hydrogen technologies as a decarbonisation option. Thyssenkrupp is testing the conversion from conventional steel production to direct-iron routes with the usage of hydrogen. Germany has started in 2018 the integration of hydrogen in mobility thanks to the large number of hydrogen stations installed by Shell, OMV and Total and recently, BMW and VW have stepped up their research efforts concerning fuel cells to launch their range of hydrogen-powered cars.

2 Potential collaboration projects on green hydrogen

Based on the comparisons made in the first chapter, the ideas for potential collaboration are presented below. As the project is in a rather early development phase, the following project ideas shall serve as a basis for further consultations with stakeholders from both countries (participants/invitees of the workshop held on December 6th 2019)

2.1 Coordination of national hydrogen infrastructure

Recommendations:

- Elaborate on the status- quo of current German and French gas infrastructure including franco-german border area
- Identify needed extension and retrofitting measures taking into account potential synergies in the border area

- Provide recommendations for sustainable gas infrastructure investments especially with regard to "Projects of common interest"

The Gas industry already sets the course for the nationwide use of hydrogen on a large scale. The gas transmission system operators in Germany have recently drawn up the plan for a 5,900 km hydrogen network. Gas transmission system operators, like Open Grid Europe see hydrogen as a future use case for their existing gas infrastructures and underline the importance of connecting the German network with hydrogen infrastructure in neighboring European countries, to ensure a Europe-wide exchange of hydrogen at an early stage. Coordination measures with regard to retrofitting and extension of the gas infrastructure in France and Germany are therefore to be considered. Steering mechanisms with regard to investments into the future gas infrastructure, on a national and European level, is deemed necessary.

2.2 Elaboration of key pillars for the deployment of a European hydrogen strategy

Recommendations:

- Comparison of the French and German hydrogen strategies and extract the most important and focused aspects for the two plans
- Set up a dialogue between stakeholders from the industry, politics and science to deduct the broad needs for a joint development and a growing market for hydrogen technologies.

As the European Commission put hydrogen as a strategic topic on the agenda of the following legislative period, it might be beneficial for France and Germany to provide best practice examples for the further elaboration process of a European strategy. This can be beneficial as France has already developed a hydrogen strategy, while Germany is supposed to publish its own hydrogen strategy soon. Therefore, a comparison of both approaches might be useful in order to derive the most important and target-oriented aspects of both plans. For this purpose, a stakeholder dialogue with participants from industry, politics and science needs to be established in order to develop a broad understanding of which steps are needed to foster a joint development/ market ramp- up of hydrogen technologies.

2.3 Guarantees of Origins for hydrogen and the calculation of the CO2 footprint of hydrogen production

Recommendations:

- Open a discussion between German and French stakeholders about the calculation of CO2-content of hydrogen in respect to the production pathway
- Standardize the Hydrogen Guarantees of origin with a global collaboration between dena, ADEME, IEA and EU representatives

Guarantees of Origin are an important factor in the development of a global hydrogen market as it enables the valuation of climate-friendly characteristics of energy carriers. Guarantees of Origin is no new concept

but already implemented to proof the renewable characteristics of electricity. A comparable mechanism is also needed to value the costlier generation of green hydrogen, as the composition of the molecules don't differ from the production pathways (likewise for electrons). Guarantees of origin are correlating with currently developed sustainability criteria for hydrogen and other synthetic energy carriers, in the course of this discussion an opinion building process between German and French stakeholders could be hold and might be further extended to the question on how the CO2-content of hydrogen should be calculated in respect to the production pathway.

Both topics need to be standardized to not further hinder the development of creating a global market for hydrogen. Germany and France are both seen as big players in a future hydrogen market, especially on the demand side of hydrogen and as technology-provider. Therefore, both countries might have similar requirements on how Guarantees of Origin and the calculation of the CO2 content for different hydrogen production pathways should look like, so that the balancing act between a fast market-ramp up whilst ensuring to lower greenhouse-gas emissions is ensured. dena has already established a comparable register for biogas and bio methane, while ADEME has this topic on the agenda as well and is planning an exchange on Guarantees of Origin together with dena, the IEA and EU- representatives.

2.4 Pilot project ideas

Besides consultation processes on certain important strategic questions on what a future hydrogen economy might look like and which instruments are needed for that, physical projects represent the other important pillar for the successful implementation of a broad hydrogen role out. Therefore, different project ideas might be considered which can play stimulating role towards a European hydrogen project which could evolve into a project for hydrogen comparable to what Airbus is for aviation. This might be pivotal for the industrial development of hydrogen technologies in Europe with respect to rising competition from Asia and North America.

2.4.1 Joint research infrastructure

Recommendations:

- Identify existing bottlenecks on both sides for the development of hydrogen research facilities
- Implement joint testing facilities in the border area
- Develop research exchange programs and joint university programs related to hydrogen development for a better cooperation between France and Germany in hydrogen technologies

Research for hydrogen technologies is crucial for the deployment of a hydrogen industry. Joining forces in research activities is a possibility to further intensify the knowledge of research activities in both countries. This should lead to a more efficient use of the existing infrastructure and expertise as well as an efficient roll-out of new research facilities with respect to existing bottlenecks on both sides. An example for an existing

bottleneck in the development of fuel cell technologies is the fuel cell testing facility with a waiting time of around one year. Further bottlenecks may be identified in order to actively take countermeasures and speed up the technology development. For those reasons and more, relevant research institutes of both countries are to be consulted on a regular basis. Based on their feedback, action should be taken by the respective governmental institutions. Joint testing facilities could be implemented in the border area.

As an accompanying measure, research exchange programs and joint university programs related to hydrogen development could be developed to deepen the exchange on university and student level and could be seen as a sustainable approach to develop the cooperation of both countries in hydrogen technologies.

2.4.2 Cross-border hydrogen mobility

Recommendations:

- Plan a franco-german cross border infrastructure for hydrogen fuel stations and open up a major European corridor for hydrogen mobility between France and Germany
- Design a cross-border project idea that includes all parts of the hydrogen value chain from the production of renewable electricity and hydrogen from electrolysis to the application in respond to the local electricity demand or development of clean public transportation
- Establish a consortium of interested partners from the industry and science along the value chain
- Study the feasibility of the project with respect to the existing funding options
- Provide a strong communication of the project benefits at regional, national and trans-national levels as well as the best practice examples for a better development of hydrogen projects

Up until now no cross-border infrastructure for hydrogen fuel stations has been planned or implemented. There are existing hydrogen projects and infrastructure on both sides of the border, e.g. in the municipality "Communauté de Communes Coeur du Pays-Haut" (CASC) in Sarreguemines (CASC) and another one planned in Saarbrücken. The future operation of the CASC charging station as of 2020 is currently unclear and a franco-german operation is being considered.

Since the two countries have worked independently on a national infrastructure for hydrogen refuelling stations, the approaches are different. A cross-border deployment and operation of hydrogen could therefore ensure an optimised planning for a hydrogen infrastructure in the cross-border area and then open up a major European corridor for hydrogen mobility between France and Germany. In order to raise public acceptance for renewable energy application, projects with immediate impact and benefits for the population are crucial. Hydrogen offers great potential in public local transportation, for example with emission-free fuel-cell driven busses and trains. These co-benefits are already in public discussions and governmental institutions are already trying to foster the development, as demonstrated by the announcement of the German federal parliament to provide financing for green cross-border mobility feasibility studies. Concrete project ideas should be designed with an integrated approach that spans from

the generation of renewable electricity, the hydrogen production by electrolysis, the distribution of the hydrogen and providing excess electricity to local demand sectors, as well as providing clean public transportation with low to no local emissions. This approach has also the possibility to be developed in a modular manner with accompaniment of institutes for applied science to support the evolution of hydrogen applications from laboratory to preindustrial scale.

The Grand Est region is a promising partner region for such a cross-border cooperation as they just published their regional program for sustainable planning with a prominent role for green hydrogen and the intention of an interconnected mobility concept with neighboring regions.

As a first step, a consortium of interested partners from the industry and science along the value chain (RE-generation, hydrogen generation, supply of hydrogen and hydrogen mobility) as well as regional stakeholders shall be established. In a second step, a feasibility study needs to be conducted with respect to possible funding options, like Important Projects of Common European Interests (IPCEI). The whole process shall be accompanied by a strong communication concept underlining benefits for the region as well as national and transnational levels, positioning such as a lighthouse project and best practice examples for a further rollout of hydrogen projects.

2.4.3 Projects of common interest with no regional link

Recommendations:

- Develop decarbonizing options for steel industry, refineries and chemical industry in both countries
- Create a franco-german regional partnerships to exchange about the hydrogen successful applications and experiences

Besides regional project ideas in the cross border area, Germany and France might have common interests in other hydrogen applications, such as the substitution of hydrogen used in industry applications with green hydrogen. One common interest is the transformation of the steel industry from traditional furnace production to direct reduced iron as both Germany and France are amongst the biggest steel producers in the European Union and are in the need of reducing their carbon emissions. Other industrial demand sectors could be refineries and the chemical industry where hydrogen is already used and on which both countries are having an unneglectable share of the global market. The development of decarbonizing options for these key industries might not only help both countries to maintain their positions in a low carbon future, but also gets them in a position for future export markets.

Another possible project might be the establishment of hydrogen partnerships between regions or cities, e.g. the “HyStarter” regions on the German side and Grand Est or Bourgogne Franche comté on the French

side. With this network, regions who are willing to implement hydrogen as a key pillar of their local future energy system, can exchange on their most successful applications and general experiences.

2.5 Project financing and possible funding options

In order to accelerate the deployment of hydrogen technologies on the market at both national and European level, several partnerships supporting research, technological development and demonstration activities have been created which are offering, in addition to the national public sectors in France and Germany, funding programs as an instrument to turn project ideas into reality and thus to achieve a clean carbon energy system and a further connected Europe. There are a whole range of different funding programs offered, but most suitable from today's perspective might be the funding option of the European Union for Important Projects of Common European Interest (IPCEI). The IPCEI has identified hydrogen technology as a key area for the future European technology development and therefore, added it to its funding possibilities. The IPCEI offers funding for a variety of project costs and is viable for bilateral project consortia. Under certain project constellations, IPCEI funding can furthermore be complemented with other funding mechanisms. The following table shows possible existing funding programs offered by France, Germany and the European Union that can support the pilot projects presented above.

	Program	General Description
Europe	Important Projects of Common European Interest (IPCEI)	IPCEI are about disruptive and ambitious research and innovation, followed by the industrial deployment and is a specific possibility to find aid compatible with the internal market. Important Aspects include: ▪ Contribution to EU objective ▪ Involvement of more than one Member State ▪ Positive spill-over effects on internal market/union society ▪ Co-financing by the beneficiary ▪ Major innovations and added value to the sector in sight ▪ Development of a new product with high R&D&I content IPCEI have the advantage of presuming market failure and up to 100% financial aid for the project, while the costs of first industrial deployment are considered eligible.

	Connecting Europe Facility (CEF)	The CEF supports the development of high performing, sustainable and efficiently interconnected trans-European networks in the fields of transport, energy and digital services. CEF investments fill the missing links in Europe's energy, transport and digital backbone.
	European Regional Development Fund (ERDF)	The ERDF aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. It promotes balanced development in the different regions of the EU. One key priority of ERDF is the low carbon economy, including hydrogen technologies.
	Fuel Cells and Hydrogen Joint Undertaking (FCH JU)	The FCH JU is a unique public private partnership supporting research, technological development and demonstration (RTD) activities in fuel cell and hydrogen energy technologies in Europe. Its aim is to accelerate the market introduction of these technologies, realizing their potential as an instrument in achieving a carbon-clean energy system.
Germany	National Innovation Programme Hydrogen and Fuel Cell Technology Phase II (NIP)	Within the framework of the NIP, the Federal Ministry of Transport and Digital Infrastructure (BMVI) supports projects in the field of hydrogen and fuel cell technology, in particular in road, rail, water and air transport as well as in special applications. The BMVI pursues a technology-open approach.
France	Grand-Est Region: Climaxion	Through Climaxion, the Region Grand Est supports public actors or companies who want to deploy H2 charging infrastructures by giving them a financial aid to buy H2 vehicles which will be charged mainly at this station. In addition, within the framework of the SRADDET, the Grand Est region offers a scheme in the form of a financial contribution to carry out an opportunity study and then a contribution to the purchase of vehicle(s), depending on the socio-economic viability of the project, of up to 55% for an electric or hydrogen-powered vehicle.

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