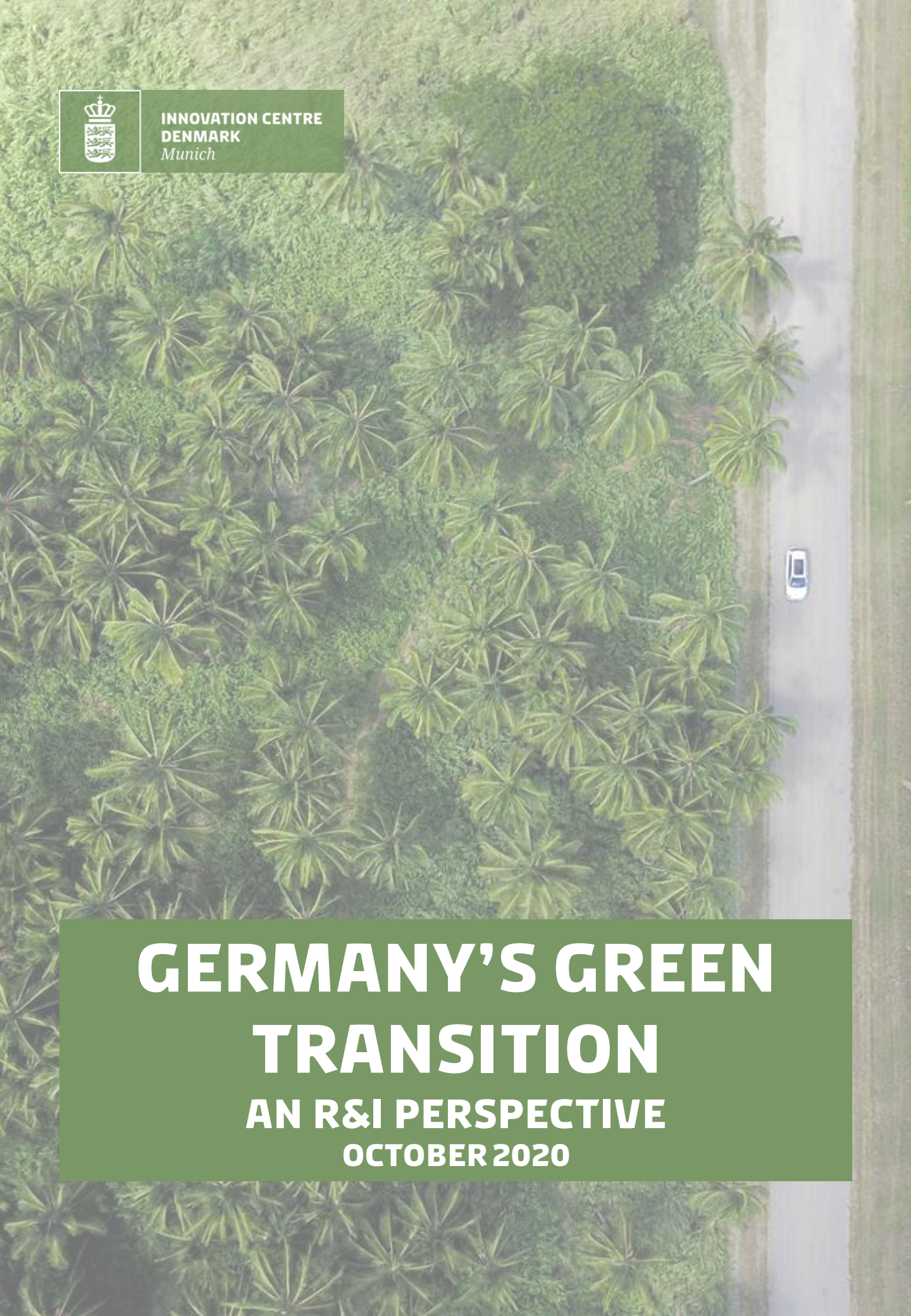

INNOVATION CENTRE
DENMARK
Munich

GERMANY'S GREEN TRANSITION

AN R&I PERSPECTIVE

OCTOBER 2020

INNOVATION CENTRE
DENMARK
Munich

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INNOVATION CENTRE DENMARK

Innovation Centre Denmark in Munich connects Danish companies, research organisations and higher education institutions with the Southern German innovation ecosystem and thereby provides access to one of the world's leading research and innovation environments.

Germany is one of the world's largest exporters and the biggest and most important export market for Denmark. Southern Germany, notably Bavaria and Baden-Württemberg, are research and innovation epicentres.

Both federal states have excellent framework conditions and are strong and active supporters of research, innovation and technology transfer, for example through research institutes like the Fraunhofer and Max Planck societies.

Munich is a hotspot for education, innovation, and technology. It is home to two of the best universities in Germany - Ludwig-Maximilian-Universität München (LMU) and the Technical University of Munich (TUM).

AUTHOR

ULRIK KJØLSEN OLSEN
Research & Innovation Attaché

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INNOVATION CENTRE DENMARK
Royal Danish Consulate General

Türkenstr. 7
D-80333 Munich
+49 (89) 5458 540 /
http://www.icdk.de

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CONTENTS

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EXECUTIVE SUMMARY

Germany has put a strong focus on research and innovation (R&I) to mitigate climate change. While Denmark remains a close partner of Germany in various international R&I projects, the present impetus on the environment, reflected in the recent strategies and policies, will open promising areas of collaboration in the future. This report provides an overview of the political goals towards the green transition, most recent research strategies, research programs, areas of strength, and regional focus areas from the south of Germany, with a special focus on Bavaria and Baden-Württemberg. Finally, the report highlights some relevant areas for future collaboration between Denmark and Germany in areas of R&I.

POLITICAL FRAMEWORK & GOALS

Germany has defined key policy goals towards green transition

- To phase out nuclear power plants by 2022, increase the share of renewables in the energy mix to 80% by 2050, phase out coal by 2038 and reduce greenhouse gas emissions to 40% of 1990 levels until 2030.
- The Climate Protection Law aims to foster innovation and investments in climate protection to achieve carbon neutrality by 2050. The focus being on new carbon pricing on traffic and heat from 2021, energy efficient technologies and Hydrogen.
- Cross-sectoral research strategies such as the Hightech-Strategy 2025 (2018), German Bioeconomy Strategy (2020) and the National Hydrogen Strategy (2020) are aimed to foster R&I for a green transition in Germany.

RESEARCH & INNOVATION STRATEGIES

The Industry accounts for two-thirds of R&D expenditure, the public sector accounts for the rest in Germany

- The Hightech-Strategy (HTS) 2025 is the main overarching research and innovation strategy, connecting public and private sectors with a focus on energy research, green economy, bioeconomy, city of the future, sustainable agriculture etc.
- The Bioeconomy Strategy (2020) focusses on the goal of achieving a circular economy by utilizing research and technological solutions to achieve renewable energy based economic models, alternative materials and reduction in consumption.
- The Hydrogen Strategy (2020) aims at fostering the research and innovation in the complete value chain of Hydrogen from generation, storage, infrastructure, logistics and quality assurance.

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KEY RESEARCH PROGRAMS

- Interdisciplinary research projects focussing on developing key technologies and energy efficiency form the basis of the R&I landscape in Germany.
- FONA*, Energy Research programme, Collaborative Research Centres, German Universities Excellence Strategy, German Research Foundation, Project Management Jülich are the key programs and institutions for climate focussed R&I.

RESEARCH & INNOVATION STRATEGIES

- Bavaria's Hightech-Agenda allocates €600 million for Artificial Intelligence, robotics, quantum computing, aerospace and CleanTech. The R&I focus includes synthetic fuels, batteries, hydrogen etc. the region is investing in Hydrogen infrastructure to boost Hydrogen in Transport and Industry sectors.
- Both states have ambitious research and technology policies and the level of investments in R&I is high: B-W (5.68% of GDP expenditure on R&D) and Bavaria (3.19% of GDP expenditure on R&D)**.

REGIONAL PERSPECTIVE – BADEN-WÜRTTEMBERG (BW) AND BAVARIA

- The Federal states have their regional R&I strategies and programs. The southern states of Bavaria and B-W have a predominant focus on Industry 4.0 and R&I for green transition
- B-W is home to Energy and Biotechnology innovation clusters. Their Innovation Strategy (2020) allocates €500 million in 2020/21 for R&I including the challenges of energy transition and biological transformation & industry. The Danish Energy Agency and Ministry of Climate, Energy and Environment of B-W entered into an agreement to collaborate on achieving energy neutrality by 2050.

INTERNATIONAL COLLABORATION ON GREEN R&I

- Within the Horizon 2020 framework, Germany performs strongly in the Industrial Leadership pillar with ICT, Nanotechnology, Biotechnology, Advanced Materials and Production with highest contribution to "smart, green and integrated transport".
- The automotive and aviation sector organizations lead the R&I in Germany. The German Aerospace Centre, Fraunhofer Society, Airbus, Technical University of Munich, Research Institute, Forschungszentrum Jülich are some of the top performing institutions.

*Forschung für Nachhaltige Entwicklung

** German Federal Statistics Office 2018 figures

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AVENUES OF FUTURE R&I COLLABORATION BETWEEN GERMANY AND DENMARK

Denmark and Germany have high potential for collaborative research and innovation for a green transition by building on existing strong bonds in research and innovation and exploring new areas together. The level of research and innovation collaboration between Denmark and Germany is high, also in areas relating to the green transition with EU Framework Programmes for Research and Innovation being the main platform for collaboration. Other key research areas revolving around green technologies also promise strong potential for collaboration.

1 Germany remains Denmark's number one and an indispensable partner in collaborative projects In the EU Framework Programmes for Research and Innovation (FP6 786 joint projects & FP7 1259 joint projects*).

Germany also remains the most frequent partner within the Horizon 2020 framework.

In the future EU Framework for Research and Innovation focused on green transition will certainly allow for collaboration between Denmark and Germany.

The R&I focus for green transition will be on the automotive, aviation and industrial sectors. The R&I focus on cross-cutting technologies will be on technologies such as robotics, materials and advanced manufacturing, and artificial intelligence.

2 The international/Transregional dimension of the Collaborative Research Centre scheme of the German Research Foundation promises a funding possibility to be further explored for Danish-German collaboration.

3 Batteries for electromobility is an area of significance with the German Federal Hightech-Strategy, the Bavarian Hightech-Agenda, as well as Horizon 2020 (and expectedly Horizon Europe) supporting R&I.

Germany along with the 7 members of the European Battery Alliance will provide €3.2 billion in funding for this project, which is expected to be supplemented by an additional €5 billion in private investments.

4 Alternative fuels such as Hydrogen as well as Power-to-X technologies have received further momentum. The Federal Ministry of Transport and Digital Infrastructure has earmarked €1.4 billion for the Phase 2 (2016-2026) of the National Innovation Programme Hydrogen and Fuel Cell Technology.

1. Framing Green Research & Innovation in Germany: Policy Framework, Strategies and Programmes towards Green Transition

1.1. Key Policy Goals Towards the Green Transition

In 2010, in response to the nuclear catastrophe in Fukushima, Germany set out a new "**Energiewende**" (Energy Transition) policy, which would phase out nuclear power plants in Germany by 2022. The Energiewende policy includes, among others, the objectives to increase the share of renewable energy for electricity to 80 per cent in 2050 and to reduce primary energy consumption by 50 per cent compared to 2008. In early 2020, the German Federal Government adopted a new **Coal Phase-out Act** (Kohleausstiegsgesetz) with the objective to phase out the last coal-fired power station in Germany by 2038.
As an EU Member State, Germany has ratified the Paris Agreement and thereby committed to the binding target of an at least 40 per cent domestic reduction in greenhouse gas emissions by 2030 compared to 1990 levels. In October 2019, the German Federal Government decided on a **Climate Protection Programme** (Klimaschutzprogramm 2030[1]) followed by a **Climate Protection Law** (Klimaschutzgesetz[2]) in December 2019, with the objective to foster innovation and investments in climate protection. The aim is to reach 55 per cent less greenhouse gas emissions compared to 1990 levels and achieve CO2 neutrality by 2050. Other elements include:

- New CO2 pricing on traffic and heat from 2021
- Phasing out coal as energy source
- Support scheme for the development of new energy efficient technologies
- More research in Hydrogen; battery production; and lowering CO2 emissions

The Climate Protections Programme's specific initiatives in the field of research and innovation can be found in section 3.5.3 Forschung und Innovation (pages 149-163) here.

1.2. Research Strategies Supporting the Green Transition in Germany

Germany does not have a research strategy for the green transition per se, but several strategies at federal level support sustainability and the green transition. The following will address the German research and technology strategy, the **Hightech-Strategy 2025** (2018), **German Bioeconomy Strategy** (2020) and the newly adopted **National Hydrogen Strategy** (2020).

1.2.1 The Hightech-Strategy 2025

The current level of Gross domestic expenditure on R&D (GERD) (public and private sector) is 3.13 per cent (2018)[3], which is an increase of around 60 per cent since 2007. Industry accounts for around two thirds of total R&D expenditure, while the public sector accounts for the other third. This balance has been relatively stable since 2007[4].

The Hightech-Strategy is the main and overarching research and innovation strategy of the German government. The first edition of the strategy was published in 2006, while the most

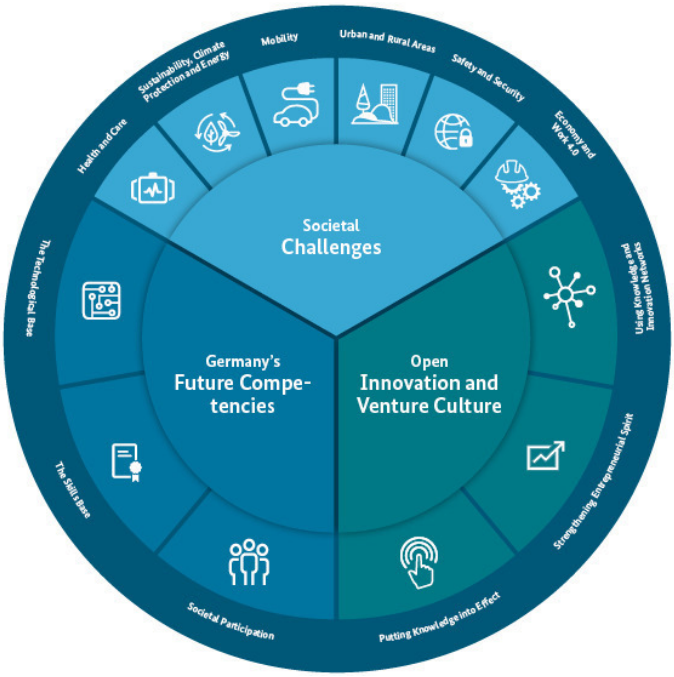
[1] https://www.bundesregierung.de/breg-de/themen/klimaschutz/klimaschutzprogramm-2030-1673578
[2] https://www.bundesregierung.de/breg-de/themen/klimaschutz/kimaschutzgesetz-beschlossen-1679886
[3] EFI Gutachten 2020: https://www.e-fi.de/fileadmin/Gutachten_2020/EFI_Gutachten_2020.pdf
[4] German public research investments towards objectives can be found here in "Bildung und Forschung in Zahlen 2019" (BMBF Datenportal)

recent version, the "Hightech-Strategy 2025" was published in 2018. The Hightech-Strategy is implemented by the German Federal Ministry of Education and Research (BMBF), is coordinated with several other ministries, including the Federal Ministry for Economic Affairs and Energy (BMWi). As a joint effort between mainly BMBF and BMWi, the HTS is also a key strategy for the collaboration between public universities and research institutes, and the private sector. With the **Hightech-Strategy 2025**, Germany has an objective to increase expenditure on research and development to 3.5 per cent by 2025.

The Hightech-Strategy 2025 includes several societal challenges to be addressed jointly by industry, research, and society. One of the 6 defined societal challenges is "Sustainability, Climate Protection and Energy", with the following underlying focus areas:

- Energy research (with the Energy Research Programme as a key component)
- Green economy
- Bioeconomy
- Sustainable agricultural production
- Assuring the supply of raw materials
- City of the future
- Future of Building
- Sustainable consumption

An overview of concrete initiatives under the "Sustainability, Climate Protection and Energy" challenge in the period from 2018-2021 can be found on page 23 of the Hightech-Strategy 2025 [link to English version].



Picture: The High-Tech Strategy 2025, BMBF

1.2.2 German Bioeconomy Strategy (2020)

In January 2020, the German Federal Government adopted a new **Bioeconomy Strategy**, which builds on the previous National Research Strategy Bioeconomy (2010) for which €2.4 billion was set aside for research and development from 2010-2016. That framework has since its inception in 2010 supported more than 2,000 research projects.

The National Bioeconomy Strategy (2020) includes a set of guidelines and objectives for bioeconomy research and implementation in Germany. Whereas the Federal Ministry for Food and Agriculture (BMEL) was the main ministry in charge of the 2010 strategy, the Federal Ministry of Education and Science (BMBF) coordinate the new Bioeconomy Strategy. The specific goals of the strategy is to use utilize research and technological solutions to implement the Sustainable Development Goals and the realisation of a circular economy. The strategy aims at achieving a biobased economic model based on renewable energy, alternative materials, and a reduction in consumption.

The international perspective of the Bioeconomy Strategy is to commit to a dialogue and information exchange in the working groups at EU level, notably the Standing Committee on Agricultural Research (SCAR) and the States Representative Group of the Bio-Based Industries Joint Undertaking (BBI JU). The framework offers no immediate funding for international partners but is open to international cooperation.

An overview of research programmes funded within Bioeconomy is available on the national platform Bioökonomie.de.

1.2.3. National Hydrogen Strategy (2020)

With the mission to mitigate climate change through decarbonization and promoting a sustainable economic recovery post COVID-19, the German Federal Government adopted the National Hydrogen Strategy in June, 2020 along with the establishment of a Hydrogen Council. Although Hydrogen and related technologies have remained in the focus since 2016 – as seen through various federal funding activities – the newfound impetus is being put on "Green Hydrogen"[5]. The focus is placed on the complete value chain right from the generation, storage, infrastructure, logistics as well as quality assurance.

The Federal Government sees Hydrogen essentially as a collaborative European Project. The justification for this claim lies in the Federal Ministry for Economic Affairs and Energy estimates, Germany expects to become a net importer of Hydrogen. The domestic generation capacity of green Hydrogen in Germany will not be sufficient to cover the new demand. The Government thus plans to work closely with the North and Baltic sea neighbours to establish a regulatory framework for offshore wind energy.

Further funds have been earmarked by both the Federal ministries, among others, for promoting basic research on green Hydrogen, building regulatory sandboxes for energy transition, speeding up market rollout of Hydrogen technology and for international

[5] Hydrogen based on renewables which is carbon free

partnerships. Green mobility through Hydrogen[6] remains a central focus of the green transition as part of the National Hydrogen Strategy.

1.3 Key Research and Innovation Programmes towards the Green Transition in Germany

The German Federal Ministry of Education and Science (BMBF) is responsible for several programmes supporting research and development relating to the green transition. At the federal level, BMBF cover most of the responsibilities for research policy. Other ministries are involved in research and innovation programmes supporting the green transition as well, e.g. the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry for Food and Agriculture (BMEL). This section will focus on a selection of research and programmes with BMBF as one of the responsible ministries.

Many research programmes supported by the federal level are open to many research themes and thus not targeted to a specific scientific discipline. Rather, they often have a focus on technological development. This is not least due to the importance of industrial production, including the automotive sector, for Germany. As highlighted in the German Sustainable Development Strategy (2018), p. 35:

"In the development of key technologies, ambitious resource and energy efficiency targets are enshrined in all of the BMBF's research programmes, for example in materials research or microelectronics. The BMBF is contributing to sustainable production and added value by promoting Industry 4.0 and new production technologies."

1.3.1 Research for Sustainable Development - FONA3 (2015-)

FONA is a framework program of the German Federal Ministry of Education and Research for financing sustainable development research. The goal of FONA is to fund research that explores the possibilities of a sustainable lifestyle and an economy build upon sustainable products, as well as providing input to decision-makers. The programme intends to broaden the systemic approach to other urgent fields of action such as mobility, digitization, and species diversity, including with new tools such as scalable "living labs".

The current third edition of the programme, FONA3, was launched in 2015 and includes three flagship initiatives for sustainability: Green Economy, City of the Future and The Energiewende.

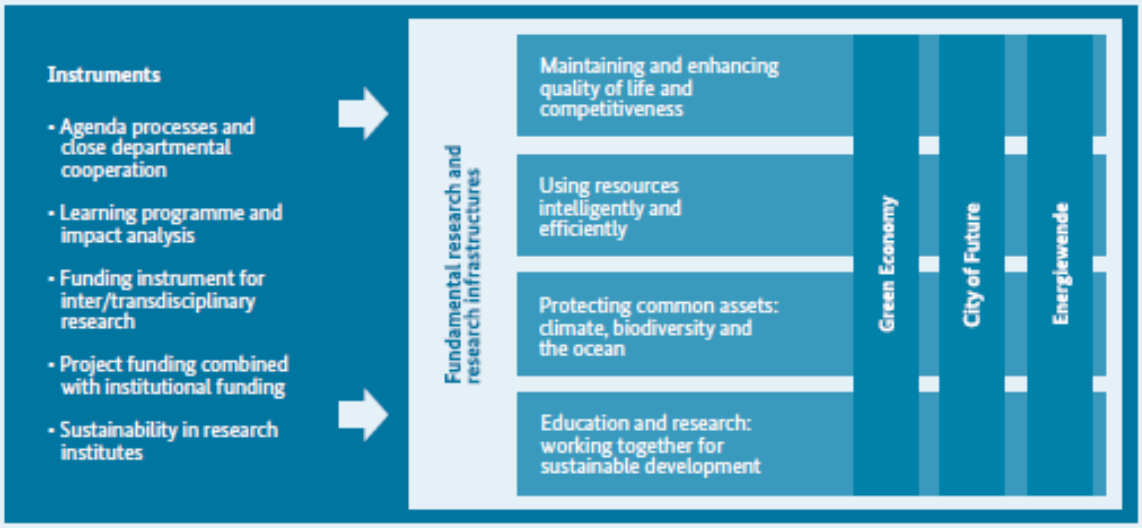
- **Green Economy** covers research on sustainable management tools and methods, sustainable business development and stakeholder process optimization. The goal is a collaboration between politics, research, business, and society on the creation of a sustainable and resource efficient economy.
- **City of the Future** covers research on sustainable cities, the interaction between urban and rural areas and the development of urban zones.
- **The Energiewende** covers research on renewable energy and Germany's shift from the current energy source to a new sustainable source, both from a technical and a social perspective.

[6] https://www.bmvi.de/SharedDocs/EN/PressRelease/2019/079-scheuer-investment-Hydrogen-mobility.html

In addition to the flagship initiatives, FONA3 supports "prevention research for sustainability" under the following headlines: 1) Maintaining and enhancing the quality of life and effectiveness, 2) Using resources intelligently and efficiently (including the MARE:N (Marine and Polar Research for Sustainability) specialized programme)), 3) Protecting common assets: climate, biodiversity and the ocean, and 4) Education and research: working together for the sustainable development.

Within the FONA3 framework, bilateral and multilateral cooperation is encouraged, however with the general principle that each international partner funds its own national applicants (no common pot). Furthermore, a call can only be drafted after a scoping process. Through FONA3, Germany supports participation (German participants) in Joint Programming Initiatives under Horizon 2020, notably JPI Water, JPI Climate and JPI Oceans.

Figure: The programme structure of FONA[3]



Source: Research for Sustainable Development - FONA3 (BMBF), page 6.

1.3.2 7th Energy Research Programme (2018-2022)

The Energy Research Programme is a key research and innovation initiative to implement the energy transition (Energiewende) in Germany. The programme funds technological, economic and social innovations across the full TRL scale (basic research, research nearing application, and Living Labs). The aim is to transform our existing energy system in Germany and Europe into a sustainable energy system. Project funding from the 7th Energy Research Programmes is guided by five focus areas:

- **Energy transition in consumption sectors** (focusing on several areas. Battery research for electric mobility being an important part.)
- **Power generation** (addressing address the entire range of renewable energies and thermal power stations)
- **System integration: Grids, energy storage, sector coupling**

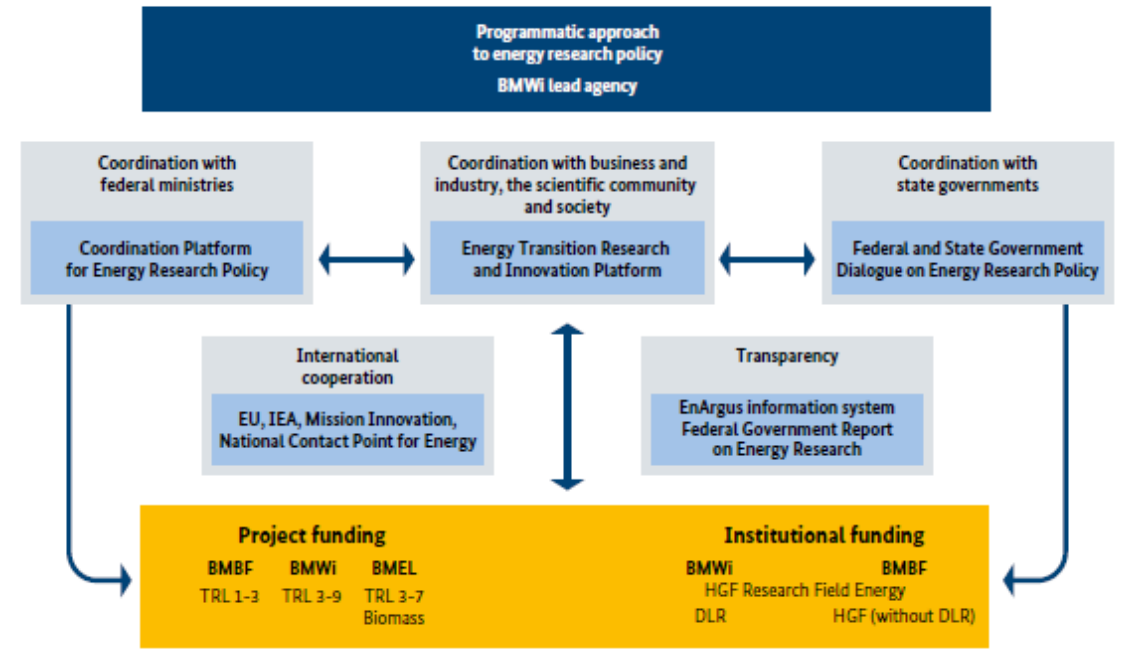
- **Cross-system research topics for the energy transition** (energy system analysis, energy-related aspects of digitization, resource efficiency, CO2 technologies for the energy transition, materials research, and societal aspects of the energy transition)
- **Nuclear safety research framework** (including ensuring safe out-phasing of nuclear power in Germany by 2022).

The 7th Energy Research Programme is implemented by the Federal Ministry of Education and Research, the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry for Food and Agriculture (BMEL). Around €7 billion is made available for projects in the current programming period (2018-2022)[7]. This amount is around 50 per cent more than in the 6th Energy Research Programme.

One of the selected scalable Living Labs (Reallabore), "ReWest100" in Heide in Northern Germany, which focuses on green Hydrogen, has the Danish company Ørsted as a partner. See here for an overview of Living Labs under the 7th Energy Research Programme.

The 7th Energy Research Program has an international perspective (supporting UN Sustainable Development Goal 7: Affordable and Clean Energy; The Strategic Energy Technology Plan (SET-Plan) and coordination with Horizon 2020 and Horizon Europe, as well as collaboration through the International Energy Agency) and European collaboration is highlighted as an opportunity for increased competitiveness within the energy research field.

Figure 6: Institutional setup for energy research



Source: 7th Energy Research Programme, page 16

[7] https://www.bmwi.de/Redaktion/EN/Artikel/Energy/research-for-an-ecological-reliable-and-affordable-power-supply.html

1.4 Further Non-Thematic Research and Innovation Programmes Supporting the Green Transition

Many publicly funded research and innovation programmes in Germany are open for proposals from different research themes and are thus not targeted to the green transition exclusively. In the following section, some of the key programmes, which can address (but are not limited to addressing) "green" aspects, are highlighted:

1.4.1 Collaborative Research Centres (CRC) (implemented by DFG)

Collaborative Research Centres (CRC), which is a funding scheme of the German Research Foundation (DFG), has existed since 1968. More than 1000 research centres have been funded in the lifetime of the CRC scheme. Among 275 active Collaborative Research Centres, 72 projects are within the "Natural Sciences" domain[8]. In 2020, a total of €797 million has been allocated to CRC.

Collaborative Research Centres are long-term university-based research institutions, established for up to 12 years, in which researchers work together within a multidisciplinary research programme. Collaboration with non-university research institutions are encouraged. CRCs consist of many projects. The number and scope of these projects depend on the research programme.

Funding is made available by the DFG to the Collaborative Research Centres for travel, colloquia and visiting professors for the purposes of maintaining international contacts and presenting findings to an international audience. Additional funding may be applied for to develop project-like cooperation structures. This funding can also be used to finance long-term cooperation projects with comparable centres of excellence abroad. Scientists and academics can also lead (either individually or jointly) their own projects abroad, although funding for these is to be received by one of the DFG's international partner organisations. More info on international collaboration through CRC can be found here. While international collaboration is a possibility in the programme, as of May 2019 there were no projects with Danish partners[9]. However, CRC can be a relevant tool for research collaboration between Denmark and Germany, which could be pursued further[10].

1.4.2 German Universities Excellence Strategy

The German Universities Excellence Strategy supports top-level research clusters and universities across thematic fields. The Excellence Strategy is implemented by the German Research Foundation together with the German Council of Science and Humanities. During the current phase of the Excellence Strategy, which started in 2018, funding has been awarded to 57 **Excellence Clusters** and 11 **Excellence Universities** and University Associations.

[8] An overview of scientific domains and panels in DFG programmes is available here: https://www.dfg.de/dfg_profil/gremien/fachkollegien/faecher/.
[9] Own correspondence with the CRC secretariat at DFG.
[10] The possibilities are briefly outlined in this blog post: https://ufm.dk/blogs/ulrik-kjolsen-olsen/her-er-tysklands-nye-excellence-universiteter

The 57 new **Excellence Clusters** were awarded in 2018. The Clusters have each received between €3 and €7 million each year for a 7-year period. Among the 57 Excellence Clusters, the following have a clear focus on green transition and sustainability:

- **Climate, Climatic Change, and Society (CLICCS)** (Universität Hamburg)
- **PhenoRob - Robotik und Phänotypisierung für Nachhaltige Nutzpflanzenproduktion**, (Rheinische Friedrich-Wilhelms-Universität Bonn)
- **Sustainable and Energy-Efficient Aviation – SE²A** (Technische Universität Braunschweig)
- **Das Fuel Science Center – Adaptive Umwandlungssysteme für erneuerbare Energie- und Kohlenstoffquellen** (Rheinisch-Westfälische Technische Hochschule Aachen)
- **e-Conversion** (Technische Universität München)

Excellence Universities can be awarded between €10 and €28 million yearly for a 7-year period. While the aim of the Excellence Universities competition is to strengthen the profile and internationalization of the universities, and thus not necessarily a thematic/sectorial focus, only 1 of the funded projects have a (from the outset) clear focus on green transition and sustainability:

- **A Flagship University: Innovation and Cooperation for a Sustainable Future** (Universität Hamburg)

Even though the Excellence Strategy targets German universities only, it can be relevant for Danish knowledge institutions and companies to link with Excellence Strategy beneficiaries to look for international partners. Often these beneficiaries are leading in their field, and the projects can be seen (and are intended to work) as platforms to foster further international collaboration. Funding for joint projects can be sought through e.g. Horizon 2020 / Horizon Europe.

ICDK Munich blogposts about the German Universities Excellence Strategy (in Danish):

- Champions League for universiteter: Excellente forskningsmiljøer opnår hædersbevisning (28.10.18)
- Her er Tysklands nye excellenceuniversiteter (27.09.19)
- Med brint mod en grønnere fremtid (to be published)

1.4.3 Other Programmes

The **German Research Foundation** (Deutsche Forschungsgemeinschaft, DFG) complements institutional funding with project funding for basic research, based on calls for propsals. DFG has a number of research programmes, which allows for (but is not limited to) funding of programmes addressing the green transition. An overview of DFG programmes can be found here: https://www.dfg.de/en/research_funding/programmes/index.html.

Project Management Jülich (Projektträger Jülich) is responsible for the implementation of several publicly funded research and innovation programmes from various German ministries.

An overview of "green" programmes implemented by Projektträger Jülich can be found here: https://www.ptj.de/index.php?index=10&topic=60.

1.5. Further Initiatives

Two selected initiatives; the **Franco-German collaboration: Make Our Planet Great Again** fellowship programme (2018-2022) and the **German Year of Science**.

The Franco-German Fellowship Programme "**Make our Planet Great Again**" is an initiative running from 2017 to 2022, currently funding 13 research projects within the climate, energy and Earth Systems fields. Climate research is a complex process, and the integration of these different focus areas is a unique quality of this programme. The objective is to guide policy makers on climate change, provide research that enables Germany to meet the Paris climate targets and strengthening the German-French relations and cooperation. From the German side, the "Make our Planet Great Again" programme is funded by BMBF and implemented by the German Academic Exchange Service (DAAD) with €15 million. Funding is awarded to research projects and fellowships for both junior and senior researchers.

"**Wissenschaftsjahr**" is an initiative by the German Federal Ministry of Education and Research, which is similar to Forskningens Døgn in Denmark. Wissenschaftsjahr promotes a topic to the public, aiming at increased transparency, dialogue and interest. In 2020, the theme is Bioeconomy, signalling a focus on the green transition. The theme of the two previous years were "The Future of Work" (2018) and "Artificial Intelligence" (2019).

2. International Collaboration on Green R&I: Perspectives on Horizon 2020 and Southern Germany

The EU Framework Programmes for Research and Innovation are arguably the most important forum for international collaboration on R&I for Germany, as it is for Denmark, including on the green transition. This section provides an overview of German participation in Horizon 2020, as well as discusses the potential for further international collaboration. Germany has no bilateral research agreement with Denmark outside of the scope of Horizon 2020 / the European Research Area. Furthermore, this section includes a "Länder" perspective to highlight key initiatives of the two southernmost federal states, Baden-Württemberg and Bavaria.

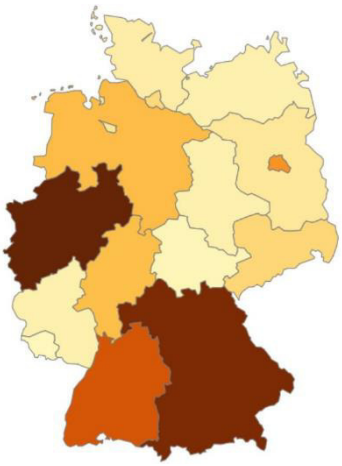
2.1 Germany in Horizon 2020: Status and collaboration with Denmark.

Germany in green areas of Horizon 2020

- From an overall perspective Germany performs relatively better in the Industrial Leadership pillar than EU average. The share of total EU contribution to Germany from the Industrial Leadership pillar is 16.31 per cent, whereas Germany's share of total EU contribution from Excellent Science (15.49 per cent) and Societal Challenges (14.10 per cent) is lower. The Industrial Leadership pillar includes programmes with a technology focus (ICT, Nanotechnology, Biotechnology, Advanced Materials and Production etc.). Germany's strong performance in the Industrial Leadership pillar is thus not surprising taking national strategies and positions of strength into account.

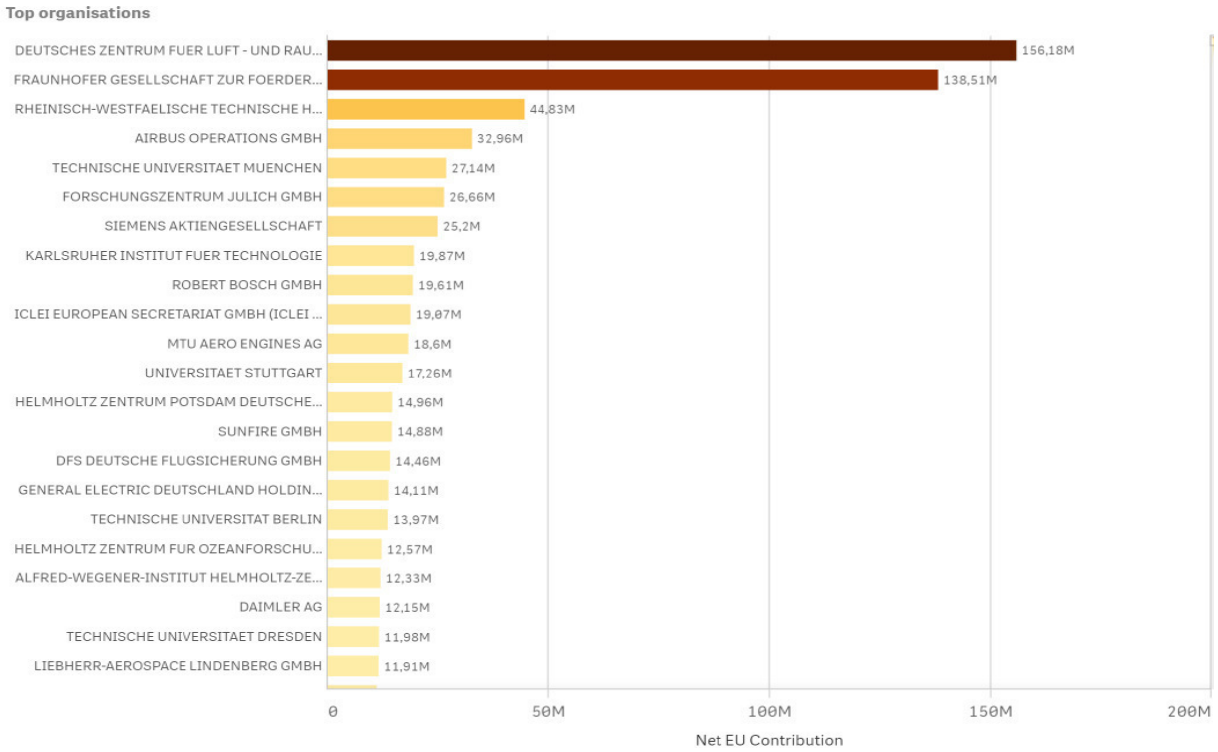
- Germany's highest share of total EU contribution is to be found in "SC4 - Smart, green and integrated transport" (18.41 per cent). This is an area with a number of strong German players in terms of both research institutions and industry (automotive and aviation).
- Among the green societal challenges Germany has the lowest share of total EU contribution in "SC2 - Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy", with 10.49 per cent.

Overview of concentration of the participation of German federal states in "green" programmes under Horizon 2020 (SC2-5):



Source: European Commission, Horizon 2020 Dashboard, Projects and Grants, Published 18 February 2020[11]

Top 20 performing organisations (total EU contribution received) in SC2-5:



[11] Version P.PROJ.H2020.1911. Data retrieved on 15 April 2020

Germany's top 5 organisations (EU contribution received) in "green" Societal Challenges of Horizon 2020	**SC2 - Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy**	**SC3 - Secure, clean and efficient energy**	**SC4 - Smart, green and integrated transport**	**SC5 - Climate Action, Environment, Resource Efficiency and Raw Materials**
#1	Fraunhofer Society	Fraunhofer Society	German Aerospace Center	Fraunhofer Society
#2	Johann Heinrich von Thünen Institute	German Aerospace Center	Fraunhofer Society	German Aerospace Center
#3	University of Hohenheim	RWTH Aachen	Airbus GmbH	Potsdam Institute for Climate Impact Research
#4	Research Centre Jülich	Research Centre Jülich	Robert Bosch GmbH	Alfred Wegener Institute for Polar and Marine Research
#5	Clariant Produkte (Deutschland) GmbH	Sunfire GmbH	MTU Aero Engines	ICLEI - Local Governments for Sustainability

Source: European Commission, Horizon 2020 Dashboard, Projects, and Grants, Published 18 February 2020[12]

As seen from the figure and table, the largest concentration of EU contribution to Horizon 2020 projects is found in Nordrhein-Westfalen, Bavaria, and Baden-Württemberg. Part of the reason for the high EU contribution to Nordrhein-Westfalen can be ascribed to the fact that the German Aerospace Center (DLR) and Research Centre Jülich (Forschungszentrum Jülich) have their seat and are registered as legal entity in in NRW, even though the individual research institutions are based across Germany.

DLR is the national center for aerospace, energy, and transportation research of Germany; and Research Centre Jülich is performing interdisciplinary research in energy, information, and sustainable bioeconomy. Bavaria holds the seat and legal entity address of the Fraunhofer Society, which has more than 70 research institutes across Germany. Bavaria and Baden-Württemberg are home to strong industrial players, including Airbus GmbH, MTU Aero Engines (Bavaria) and Robert Bosch GmbH (Baden-Württemberg).

[12] Version P.PROJ.H2020.1911. Data retrieved on 15 April 2020

Successful proposals

- While the German population is more than 14 times that of Denmark, German institutions and companies participated in less than 3.5 times more successful proposals under Horizon 2020 than Denmark. The number of German partners (individual companies/institutions) in successful proposals is around 5 times higher than the number of Danish partners in successful proposals.
- The number is even lower when it comes to the green programmes (SC2-5) of H2020: Here, German organisations participate in roughly 3.15 times more projects than Denmark.

Submitted proposals and success rates

- Denmark has a higher success rate than Germany in all four selected "green societal challenges" (SC2, SC3, SC4 and SC5) in Horizon 2020. Not only is the success rate higher, but the relative number of submitted proposals, considering population size, is also considerably higher.
- "SC4 - Smart, green and integrated transport" is the programme in which both Denmark and Germany have the highest success rate (34.4 per cent and 31 per cent, respectively). However, when zooming in on the federal state perspective, it can be noted that both Baden-Württemberg (34.4 per cent) and Bavaria (40 per cent) have higher success rates than Denmark under SC4.

Joint projects (successful proposals)

- More than 80 per cent (406 of 498) of successful Horizon proposals with minimum one Danish partner also includes minimum one German partner. The amount of funding for joint Danish-German successful proposals amount to €429.9 million. The largest EU contribution in joint projects between Denmark and Germany has been obtained under SC3.
- 28 per cent of successful proposals with Denmark involved also include minimum one partner from Baden-Württemberg, while for Bavaria the number is 23 per cent. For both Baden-Württemberg and Bavaria, the number of joint projects with Denmark is highest in "SC3 - Secure, clean and efficient energy"[13] and "SC4 - Smart, green and integrated transport[14]".
- When looking at country level, "SC2 - Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy" and SC3 are the two pillars with most joint projects between Denmark and Germany[15].

[13] BW: 46 out of 162 projects (successful proposals), Bavaria: 52 out of 162 projects (successful proposals)
[14] BW: 29 out of 93 projects (successful proposals), Bavaria: 38 out of 93 projects (successful proposals)
[15] SC2: 125 projects, SC3: 135 projects

	Successful DK proposals (success rate %)	Successful DE proposals (success rate %)	Successful joint DK-DE proposals	EU contribution total (€ million)
SC2 - Bioeconomy	162 (25.3%)	314 (22.3%)	125	88,1
SC3 - Energy	162 (20.1%)	468 (18.9%)	135	127,3
SC4 - Transport	93 (34.4%)	554 (31%)	79	137
SC5 - Climate	81 (25.2%)	244 (22.3%)	67	77,5

Source: CORDA (European Commission Research Data Warehouse), Horizon 2020 Proposals and Partners, 14.10.2019

Germany is participating in 254 active public-public partnerships under the EU Framework Programmes for Research and Innovation. Link to overview on the ERA-LEARN platform[16].

2.2 A Federal State Perspective: Bavaria and Baden-Württemberg

Technology policy in Germany is organised at both federal and federal state level. It is important to understand that federal states have their own research and innovation strategies and programmes, which support the development at the level of the individual federal state. In the following, we focus on relevant policies and programmes in Southern Germany, namely the federal states of Bavaria and Baden-Württemberg. Both federal states have very ambitious research and technology policies and the levels of investments in research and innovation is high. According to the German Federal Statistics Office (Destatis), the level of expenditure on research and development (public and private sector) of Baden-Württemberg is 5,68 per cent of GDP, whereas the level of expenditure on R&D (public and private sector) for Bavaria was 3.19 per cent (2018)[17]. It should be that while both federal states have a predominant focus on Industry 4.0, research and innovation linked to a green transition should be seen in this perspective.

2.2.1 The Innovation Strategy of Baden-Württemberg

The newest edition of the Innovation Strategy (2020) of the federal state of Baden-Württemberg includes €500 million for research and innovation for the financial year 2020/21[18]. The 2020 strategy addresses challenges of climate change to a larger degree than the first edition of the Innovation Strategy from 2012/2013. Among the five key innovation policy challenges highlighted in the Innovation Strategy are the "Energiewende" (energy transition) and "Biologisieriung der Wirtschaft" (biological transformation of industry). Furthermore, the Ministry of Environment (Umweltministerium) was among the ministries drafting the 2020 Innovation Strategy.

Already in 2013, the Government of Baden-Württemberg decided on a Climate Protection Law for the federal state, with the main objective to reduce emissions by 90 per cent by 2050. The

[16] As of 10 March 2020.
[17] Overview at Destatis: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bildung-Forschung-Kultur/Forschung-Entwicklung/Tabellen/bip-bundeslaender-sektoren.html
[18] https://wm.baden-wuerttemberg.de/de/innovation/innovationsstrategie-des-landes

so-called "50-80-90" campaign was launched to highlight the Baden-Württemberg goals of increasing energy efficiency by 50 per cent compared to 2010, achieving 80 per cent of energy from sustainable sources, as well as the aforementioned 90 per cent reduction of CO2 emissions.

Climate protection is seen as a "driver" for innovation. The Innovation Strategy builds on the Climate Protection Law of Baden-Württemberg from 2013, which stipulates that CO2 emissions should be reduced by 42 per cent until 2030[19]. In 2017, the Danish Energy Agency and the Ministry of Climate, Energy and Environment of Baden-Württemberg entered an agreement (MoU) on collaboration regarding achieving energy neutrality by 2050. In May 2019, the government decided on cornerstones for the continuation of the objectives of the Law, which includes specific goals for individual emission sectors. The Energiewende Platform of the Government of Baden-Württemberg also provides an overview of research and education initiatives taken towards reaching the 50-80-90 goals.

Furthermore, in June 2019 the Government of Baden-Württemberg launched a Strategy for Sustainable Bioeconomy of the state, with a key focus on technological innovation. In addition, Baden-Württemberg has individual strategies for Sustainable Development and Energy Efficiency.

2.2.2 The Hightech-Agenda of the Government of Bavaria

In October 2019, the Government of Bavaria decided in a new strategy for research and innovation, **Hightech-Agenda Bayern**. Hightech-Agenda Bayern includes a €2 billion investment into research, education, and innovation initiatives towards 2025. Key objectives of the strategy include:

- 1,000 new professorships
- 10,000 new student places at university
- More than 20 cutting-edge research centres across Bavaria
- Advancing and accelerating regional higher education initiatives

The €2 billion investment covers the following areas:

- €600 million for artificial intelligence and "SuperTech" (robotics, quantum technology, aerospace, and CleanTech)
- €600 million for redevelopment and acceleration programmes
- €400 million for a higher education reform
- €400 million for Bavarian SMEs and start-ups.

The focus on ***CleanTech*** includes the following concrete initiatives:

- €80 million set aside for making Bavaria a leading region for innovative climate protection.
- Strengthening research in synthetic fuels, including developing a synthetic aviation fuel.
- New Hydrogen Centre in Nuremberg and installing 50 Hydrogen filling stations across Bavaria by 2023.

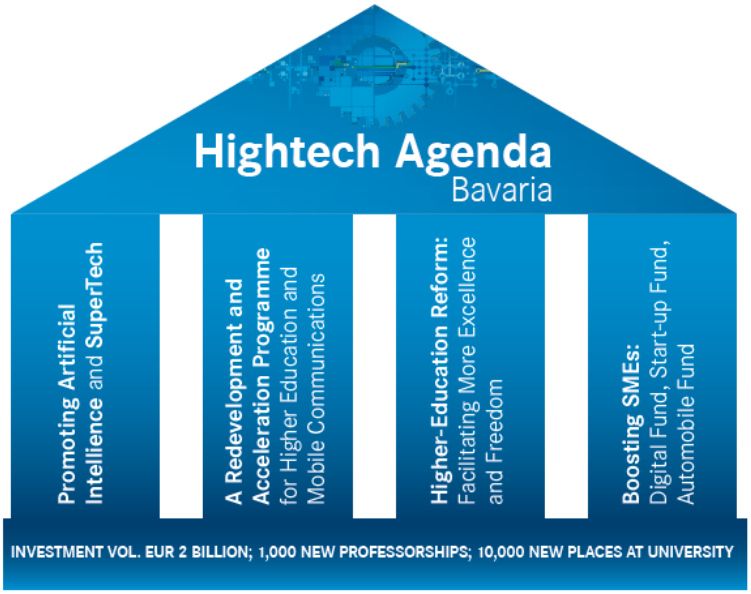
[19] BW Innovation Strategy 2020 (page 59)

- Establishing a new Bavarian battery network, "BayBatt", and developing a new generation of climate-friendly and more efficient batteries for electromobility.
- Launching a new battery production project with the industry, together with Baden-Württemberg.

All in all, the Bavarian Hightech-Agenda will open new collaboration opportunities with Danish research and innovation environments. This is due to the new investments, but also to the fact that the success of the plan stands and falls with international input and cooperation.

The Bavarian Hydrogen Strategy, a predecessor to the Federal Hydrogen Strategy, aims to establish the Southern German state of Bavaria under "H2 Hightech Bavaria" as the technology and Innovation leader and aims to trade this technology with the Green Hydrogen producing states as well as other EU countries. The H2B Centre in Nurnberg will lay down the Hydrogen Roadmap until 2025 for Bavaria. The TUM+FAU collaboration[20] is an effort in this direction.

The regional strategy also aims to promote cooperation between the strong industry in the region and research organizations to boost industrial scaling and profitability of Hydrogen technologies by creating space for development, testing, and forming use cases for Hydrogen. Apart from this, the region is investing in Hydrogen infrastructure to boost Hydrogen in Transport and Industry sector.



Source: Hightech-Agenda Bavaria, Bavarian State Government, 10 October 2019

ICDK Munich blogposts on the Bavarian Hightech-Agenda (in Danish):

- Bayern sætter milliarder af til robotteknologi og kunstig intelligens (Altinget Digital, 06.11.19)
- Bayern søger 1.000 nye professorer og 10.000 nye studerende (Danish Ministry of Higher Education and Science, 05.05.20)

[20] https://www.tum.de/nc/die-tum/aktuelles/pressemitteilungen/details/36052/

Collaboration with innovative clusters in Southern Germany
The ICDK Outlook "Danish collaboration with innovative clusters in Southern Germany" (2019) presents an overview of innovation clusters in Bavaria and Baden-Württemberg, describes the activities of the clusters, and evaluates their collaboration potential. Furthermore, the report addresses the following questions:

- What is the best way for Danish R&I actors to approach innovation clusters in Bavaria and Baden-Württemberg?
- What are the main opportunities and barriers for collaboration?

Among the 17 cluster platforms in Bavaria, 2 are within the Energy area (Energy Technology and Environmental Technology), while other "green" clusters are the Food Cluster and the Forestry and Wood Cluster.

With regards to green clusters in Baden-Württemberg, the Energy Cluster and Biotechnology Cluster platforms (which both include several individual cluster initiatives) can be highlighted.

3. Avenues for Future R&I Collaboration Between Germany and Denmark

The level of research and innovation collaboration between Denmark and Germany is high, also in areas relating to the green transition. As highlighted, the main platform for collaboration is the EU Framework Programmes for Research and Innovation. Germany was Denmark's number one partner in collaborative projects in both FP6 (786 joint projects) and FP7 (1259 joint projects) and so far, the most frequent partner for Danish organisations in Horizon 2020[21]. In the case of both FP6 and FP7, the United Kingdom was Denmark's second most frequent partner. However, considering Brexit this might change for the future. Furthermore, the new and increasingly green priorities set for the next EU Framework for Research and Innovation will certainly allow for collaboration between Denmark and Germany, e.g. linked to the greening of European industry (automotive and aviation as important sectors), as well as research and innovation on cross-cutting technologies such as robotics, materials and advanced manufacturing, and artificial intelligence.

There are number of relevant areas of collaboration in relation to the green transition, especially concerning research and innovation on new technologies. This, even if German federal research and innovation programmes only allow for funding of international partners in limited cases. One of these cases being the international/Transregio dimension of the Collaborative Research Centre scheme of the German Research Foundation, which is a funding possibility to be further explored for Danish-German collaboration.

A few specific promising areas for research and innovation collaboration between Denmark and Germany going forward can be highlighted:

[21] Source: European Commission Research Data Warehouse (eCORDA) & Danish Agency for Science and Higher Education, October 2018

3.1. Batteries for Electromobility

BMBF has since 2007 funded battery research. The focus is to support research in battery materials and process technologies from battery cells. Furthermore, the purpose going forward is to support technologies post the "lithium-ion era". An overview of battery research in Germany can be found on the BMBF website.

One initiative of the so-called "Dachkonzept Forschungsfabrik Batterie", which was approved by BMBF in December 2018. The initiative focuses on technology transfer. A main activity is to establish a research facility for battery production in Münster. The facility is to be set up and run by the Fraunhofer-Gesellschaft and is planned to be ready for business in mid-2022. The goal of the Münster facility is to independently validate new production technologies and thus accelerate the transfer of new battery concepts and production processes into practice. BMBF is supporting the establishment of the facility with €500 million.

Through the "Dachkonzept Forschungsfabrik Batterie", German positions of strength and key players have been mapped:

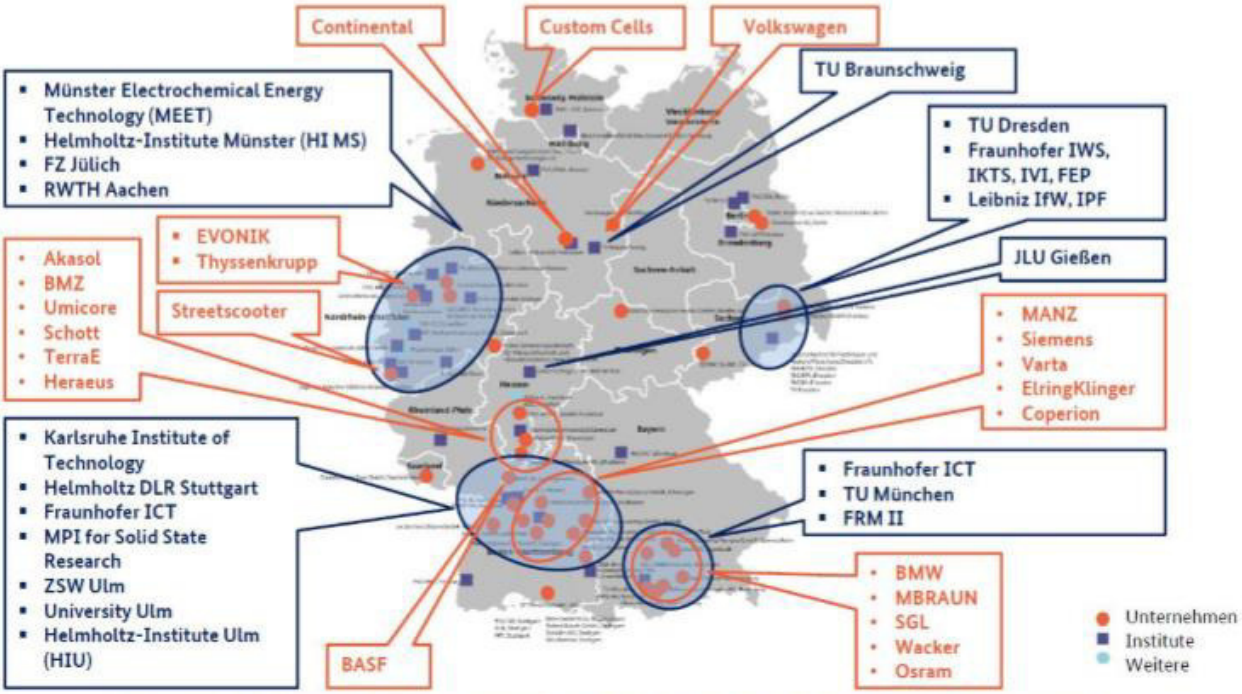


Abbildung 1: Schematische Darstellung der „hot spots" der Batterieforschung in Deutschland.

Source: Dachkonzept Forschungsfabrik Batterie, BMBF, 2019

As part of Batterieforum Deutschland and the support initiative "Batterie 2020" of BMBF, which was launched in 2008, a database of battery projects funded in Germany has been developed. The competence cluster, ProZell, gathers research institutions focusing on research and innovation towards battery cell production.

Germany is one of 7 EU Member States[22] active in the European Battery Alliance and supports research and innovation in the common European priority area of batteries. The seven Member States will provide up to approximately €3.2 billion in funding for this project, which is expected to be supplemented by an additional €5 billion in private investments.

The German federal Hightech-Strategy, the Bavarian Hightech-Agenda, as well as Horizon 2020 (and expectedly Horizon Europe) is supporting research and innovation in batteries.

3.2. Hydrogen ("Wasserstoff") and Alternative Fuels

The National Hydrogen Strategy builds on the Energy Research Programme (described in section 1.3.2) to develop technologies for green Hydrogen as well as Power-to-X/synthetic fuels (not least for the automotive and aviation sectors) and to combine climate, energy, industrial and innovation policy. As part of the strategy, Germany will enter new Hydrogen partnerships with other countries in Europe and the world.

In lines with the above, the Federal Ministry plans to launch an investment and innovation campaign to promote establishment of production capacity/production sites, supply chains, relevant technologies and thereby boosting employment in cooperation with the EU countries that can produce green Hydrogen. Apart from this trade stimulus, the research and innovation will focus on the Hydrogen value chain with the aim of Germany playing a key role within development and export of hydrogen and Power-to-X technologies.

The research and innovation focus is further on fostering key enabling technologies enabling technologies such as electrolysis-based or bio-based processes of hydrogen production, methane pyrolysis ('turquoise' hydrogen), artificial photosynthesis, and fuel cells integrating basic and applied research.

To bridge the gap between research and practice, collaboration between business and science communities will be fostered. This includes cross-border Business-Science collaboration in the realm of applied basic research. Some existing examples of this collaboration are Bon2Chem*and Kopernikus. The key sectors which will gain from the spill-over effects from such collaborations have been identified as being Air transport, Maritime transport, and Industry.

Since 2016, BMBF has funded research projects related to Hydrogen, through the federal Kopernikus Programme. The objective of the programme is to contribute to the achievement of the goal of climate neutrality by 2050. An overview of projects supported in the current second funding phase of the programme (2019-2021) is available here. In 2018, BMBF, as part of the federal Climate Protection Programme 2030 set aside €300 million for research in green Hydrogen until 2023. With the latest strategy the More info on the BMBF website here.

An overview of further BMBF funded Power-to-X projects is available here. The Federal Ministry of Transport and Digital Infrastructure has earmarked €1.4 billion for the Phase 2 (2016-2026) of the National Innovation Programme. An overview of projects funded under the National Innovation Program for Hydrogen and Fuel Cell Technology can be found here.

[22] The other member states are Finland, Belgium, Poland, France, Italy and Sweden.