

HCSS GEO-ECONOMICS

Energy R&D Made in Germany

Strategic Lessons for the Netherlands





Energy Transition Program



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Energy R&D Made in Germany
Strategic Lessons for the Netherlands
HCSS Geo-Economics
The Hague Centre for Strategic Studies

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Netherlands Enterprise Agency



TOPSECTOR ENERGIE
Empowering the new economy



System-
integratie

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Table of Contents

Executive Summary	11
1. Introduction	12
1.1 The Netherlands and Germany	13
1.2 Aim of the Report	15
1.3 Structure of the Report	16
1.4 Limitations of the Report	16
2. German Federal Energy R&D Policy	17
2.1 Federal Energy Research Program	17
2.2 Energy R&D Framework	18
2.3 Institutional Set-Up of Energy Research Policy	20
2.3.1 Inter-Ministerial and Joint Programmatic	20
2.3.2 R&D Stakeholders	21
2.3.3 Transparency in Energy Research Policy	24
2.4 Challenges and Goals of Federal Energy Research Policy	25
2.4.1 Strategic Challenges & Criteria	26
2.4.2 Strategic Goals	28
2.5 Review of Federal Energy R&D Policy	31
2.6 Conclusion	34
3. German State-Level Energy R&D Policy	36
3.1 Overview of Energy R&D Funding	36
3.2 North Rhine-Westphalia (NRW)	41
3.2.1 Energy Landscape	41
3.2.2 Energy Research Stakeholders	43
3.2.3 Focus in Energy Research	45
3.2.4 Funding	47
3.3 Conclusion	50

4. Dutch-German Energy R&D Cooperation: Practices and Opportunities	51
4.1 Dutch-German Energy Relations	52
4.2 Themes of Common Interest	54
4.3 Cross-Border Energy R&D: the Netherlands and NRW	57
4.3.1 Introduction	57
4.3.2 Cross-Border Cooperation in Energy R&D: Practices and Barriers	58
4.3.3 NRW-NL Cross-Border Cooperation and EU INTERREG	62
4.4 Conclusion	65
5. Conclusions and Strategic Lessons	67
Strategic Lessons	69
6. Follow-Up Action Plan (2019-2020)	72
7. Bibliography	73

List of abbreviations

Acatech (German Academies of Science)
BDEW (Federal Association of Energy and Water Industries)
BDI (Federal Association of Industry)
BMBF (Federal Ministry of Education and Research)
BMEL (Federal Ministry of Food and Agriculture)
BMWi (Federal Ministry for Economic Affairs and Energy)
BW (Baden-Württemberg)
CDU NRW (Christian Democratic Union of Germany North Rhine-Westphalia)
CEF (Connecting Europe Facility)
CEF NRW (Cluster Energy Research North Rhine-Westphalia)
CGE (Coordination Group on Energy)
CHP (Combined heat and power)
DECHEMA (Society for Chemical Engineering and Biotechnology)
ECN (Energy Research Centre of the Netherlands)
EET (Energy and environmental technology)
Energieforschungsoffensive (Energy R&D strategy of NRW coalition government 2017-2022)
ERDF (European Regional Development Fund)
ERP (Energy Research Program)
ESI (European Structural and Investment Funds)
ESYS (Energy Systems of the Future)
ETN (Projektträger ETN Energie, Technologie, Nachhaltigkeit – Forschungszentrum Jülich)
EU (European Union)
FDP NRW (Free Democratic Party North Rhine-Westphalia)
GDP (Gross domestic product)
GHG (Greenhouse gas)
H2 (Hydrogen)
INTERREG (European Territorial Cooperation)
MKW (Ministry for Innovation, Science and Research of North Rhine-Westphalia)

MWIDE (Ministry of Economic Affairs, Innovation, Digitalisation and Energy of North Rhine-Westphalia)
NRW (North Rhine-Westphalia)
NL (The Netherlands)
Progress.nrw (Renewable energy R&D funding policy of North Rhine-Westphalia government)
PV (Photovoltaic)
R&D (Research and development)
R&I (Research and innovation)
R&I Platform (Energy Transition Research and Innovation Platform)
SINTEG (Funding program Smart energy showcases – Digital Agenda for the energy transition)
SMEs (Small and medium-sized enterprises)
SNG (Synthetic natural gas)
TRL (Technology Readiness Level)
TSO (Transmission system operator)
VI (Virtual Institute Transformation-Energy Transition NRW 2015-2017)

List of Figures and Tables

Figure 1a: German energy mix 2018 in PJ	13
Figure 1b: Breakdown of renewables in German energy mix 2018 in PJ	14
Figure 2: Composition of electricity generated in Germany in 2018	14
Figure 3: Overview of focus and financing of the energy research programs of the German Federal Government 2006-2017	18
Figure 4: TRL in project funding under the 7th Energy Research Program	19
Figure 5: Valley of Death between research funding and full commercial application	19
Figure 6: Responsibilities of the ministries in TRL-project funding under the 7th ERP	20
Figure 7: Institutional setup for scientific exchange, networking and input for German federal energy research	23
Figure 8: Categories of Stakeholders in Germany's climate and energy policy	23
Figure 9: Overview of top 25 institutional funding in German energy research funding between 2010 and 2019	24
Figure 10: Institutional setup for German federal energy research	25
Figure 11: Strategic evaluation criteria for energy R&D research	27
Figure 12: Ownership of renewable energy systems in Germany at the end of 2016	33
Figure 13: Main categories of research funding by the 16 federal states in 2016	37
Figure 14: State government expenditure for energy research funding in 2016, i.e. both project funding and institutional funding	38
Figure 15: State expenditure on R&D of renewable energies based on mean value of GDP (2014-2015) in millions of EUR	40
Figure 16: State R&D expenditure on system integration based on mean value of GDP (2014-2015) in millions of EUR	40
Figure 17: Map of power plants in NRW	42
Figure 18: NRW lignite-fired power plants and cross-border high-voltage power line with the Netherlands	42
Figure 19: Dutch-German electricity exchange 2018	52
Figure 20: Transnational energy cooperation between North Sea countries between 2009 and 2020	53

Figure 21: Government spending on R&D in Germany (Federal) and the Netherlands (national government) in 2017	54
Figure 22: Flexible Power System & sector coupling	55
Figure 23: Power-to-x applications	56
Figure 24: The Netherlands and North Rhine-Westphalia	58
Table 1: German energy and climate targets (2020-2050)	12
Table 2: TRL-categories in project funding under the 7th ERP	19
Table 3: Federal ministerial budgetary spending under the 7th Energy Research Program	21
Table 4: Overview of the focus in project funding in the 6th ERP and 7th ERP	29
Table 5: Overview of energy research spending on the state-level in 2016	39
Table 6: Company examples in NRW	44
Table 7: Universities in NRW (examples)	44
Table 8: Research institutions in NRW (examples)	45
Table 9: Electricity exchange between Germany and the Netherlands	52
Table 10: Energy R&D in the German ERP and Dutch climate agreement	55
Table 11: Strategic measures for the energy industry in the trilateral region	57
Table 12: Connecting Europe Facility	59
Table 13: Schematic overview of cultural differences between Dutch and German societies	61
Table 14: INTERREG	62
Table 15: NL-NRW INTERREG-projects Cleantech Energy Crossing and EnerPRO	63
Table 16: Summary of the pros and cons of German energy R&D policy	67

Executive Summary

Energy research and development (R&D) ‘made in Germany’ is geared towards the implementation of the country’s ambitious energy transition (or ‘Energiewende’) and climate targets. It is a key strategic element in Germany’s energy policy. Germany is the European leader in renewable energy patenting. Government programs for energy R&D are generally characterized by a long-term and coherent approach, a well-consulted and strategic vision, and large amounts of funding. These and other aspects make German energy R&D policy a highly relevant research object for Dutch policymakers. Additionally, Germany and the Netherlands are important partners in the field of climate and energy policy and share many strategic interests in terms of specific technologies and major socio-economic factors that go well beyond the energy sector. Despite increasing political ambitions to collaborate more closely on strategic energy issues, however, Dutch-German cooperation is largely limited to political declarations and a range of cross-border projects funded with subsidies from the European Union (EU). This is remarkable in the context of equally ambitious Dutch and German energy and climate targets, as well as the (growing) political necessity to carry out the energy transition in a more cost effective and cross-border manner.

This report offers an introduction into the German energy R&D approach and points out a range of practices and barriers in Dutch-German energy cooperation. The focus of this report is therefore threefold: (1) It provides an analysis of energy R&D projects that are financed by the German federal and state-level government, including actors, aims, and financial means. (2) It analyzes the German and Dutch approaches in energy R&D policy. (3) It formulates several issues that require follow-up research with the aim of strengthening Dutch-German cooperation in energy R&D.

Due to the economic and political relevance, as well as the geographical proximity to the Netherlands, this report pays particular attention to the political landscape, stakeholders, focus and funding of energy R&D in North Rhine-Westphalia (NRW).

The report aims to promote a strategic discussion between the Netherlands and Germany on long-term bilateral cooperation in energy R&D. In strengthening bilateral cooperation between the two countries, the report recommends the establishment of a bilateral ‘energy priority program’.

1. Introduction

The promotion of energy research is a strategic element in any country's energy policy.¹ In Germany, government-funded energy research and development (R&D) is geared towards the implementation of the country's energy transition (or 'Energiewende'). Energy R&D should also support the German Federal Government's energy and climate policy (see Table 1).

Targets		2020	2030	2040	2050
Energy efficiency	Reduction of primary energy consumption (base year: 2008)	20%			50%
	Reduction of electricity consumption (base year: 2008)	10%			25%
	Reduction of final energy consumption in the transport sector (base year: 2005)	10%			40%
Renewable energy	Share of renewable energies in electricity consumption	35%	50%	65%	80%
	Share of renewable energies in total final energy consumption	18%	30%	45%	60%
GHG	Reduction in GHG emissions (base year: 1990)	40%	55%	70%	80%-95%

Table 1: German energy and climate targets (2020-2050) (source: BMWi and BMU 2010).

Therefore, addressing the need to put more innovative ideas into practice and bring new technological and non-technological innovations successfully into the market is essential in this context.

In short, challenges and strategic goals for German energy policy are:

- Accelerating the commercial expansion of renewable energies.
- Raising the efficiency at all system levels.
- Making smart use of energy infrastructure.
- Securing energy supply.
- Taking account of social impacts and managing societal risks.

¹ Federal Ministry for Economic Affairs and Energy, '2018 Federal Government Report on Energy Research' (Federal Ministry for Economic Affairs and Energy (BMWi), 30 September 2018), https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/bundesbericht-energieforschung-2018.pdf?__blob=publicationFile&v=4.

However, German energy R&D policy, including funding, is a jungle. There exists a federal and state component to energy R&D, each with its own specific strategic focus and goals. There are many different programs carried out by different government actors, with a wide range of stakeholders. There is project-based funding and institutional funding. Additionally, there is an international component.

1.1 The Netherlands and Germany

Next to the complexities of energy research in Germany there is the multi-faceted economic and political relationship between the Netherlands and Germany. The Netherlands is one of the closest partners of Germany within the EU. Both countries have exceptionally large industrial and service sectors, are characterized by high population density (in specific regions) and a vocal civil society. Strong economic interdependence of the border regions and the largest trade volume within the EU—the second largest worldwide—characterizes the special Dutch-German relationship.²

The Netherlands is also a close partner of Germany in the field of energy, both bilaterally and in relevant fora for energy policy cooperation.

In Europe and globally, Germany is the country that leads the way in the use of sustainable energy technologies. The world's fourth largest economy generates 14% of all energy from renewable sources, such as: biomass, solar PV and wind (Figures 1a and 1b).

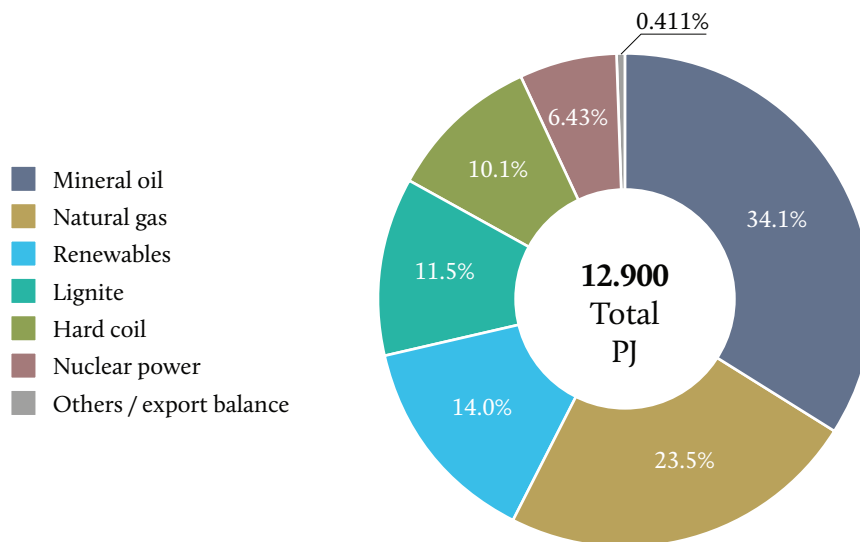


Figure 1a: German Energy Mix 2018 in PJ (source: HCSS based on AG Energiebilanzen 2018).

2 Deutscher Bundestag, „Antwort Der Bundesregierung Auf Die Kleine Anfrage Der Abgeordneten Otto Fricke, Christian Dürr, Dr. Stefan Ruppert, Weiterer Abgeordneter Und Der Fraktion Der FDP – Drucksache 19/2661 Die Deutsch-Niederländischen Beziehungen“ (Deutscher Bundestag - 19. Wahlperiode, 12 July 2018), <http://dipbt.bundestag.de/doc/btd/19/033/1903385.pdf>.

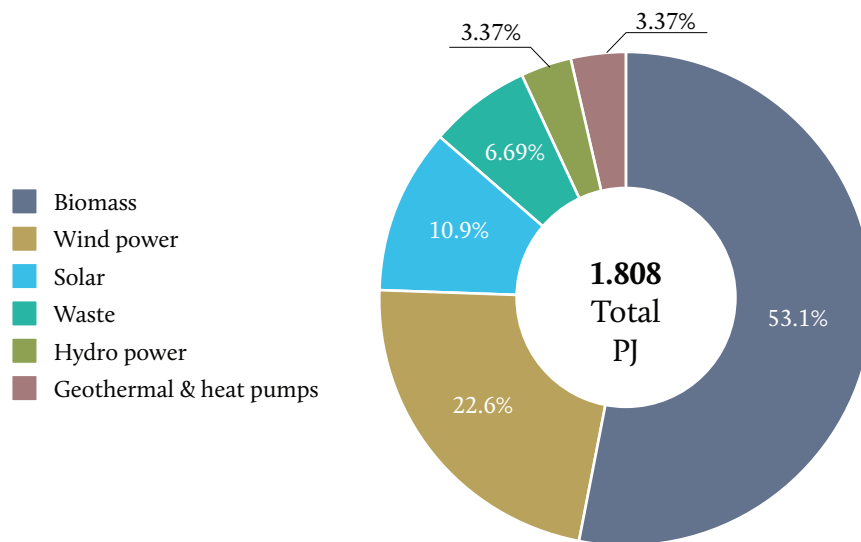


Figure 1b: Breakdown of renewables in German Energy Mix 2018 in PJ (source: HCSS based on AG Energiebilanzen 2018).

Germany’s power mix is almost 40% renewable-based (Figure 2). These efforts make many Dutch stakeholders view Germany as being at the forefront of the energy transition while offering interesting opportunities for cross-border collaboration on research and development.

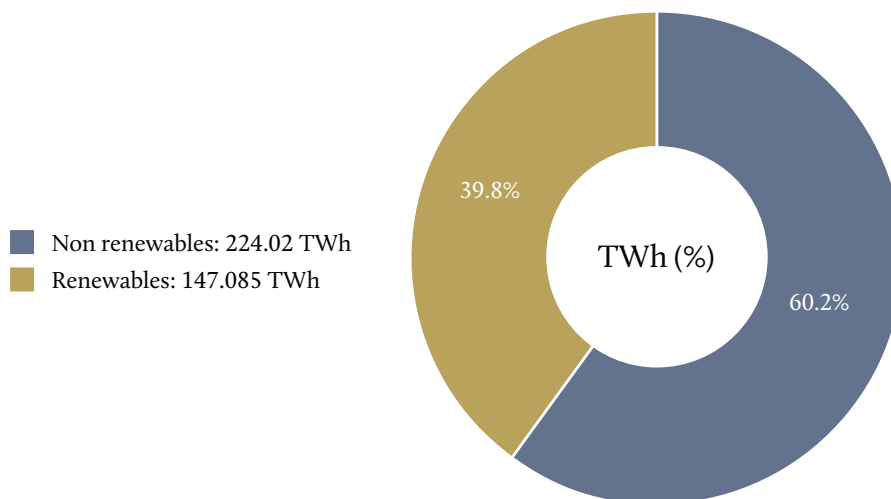


Figure 2: Composition of electricity generated in Germany in 2018 (source: HCSS based on Fraunhofer Energy Charts).

Even though the two countries share many common energy interests, in terms of both specific technologies and larger subject areas, cross-border cooperation in energy R&D is largely limited to political declarations and carrying out a range of common projects funded with EU-subsidies.

In the context of the highly ambitious Dutch climate policy (*Klimaatakkoord*) and the German *Energiewende*, an important condition for optimal, long-term energy relations

is to increase collaboration on major technological and societal challenges that are of common and strategic interest to both countries.

Common research interest in both countries are related to establishing an integrated energy infrastructure and improving the flexibility and exchange between the fields of application of electricity, heat, and transport. In the Netherlands, the latter is called 'hybrid energy supply.' In Germany, it is known as '*Sektorkopplung*.' Regarding societal challenges, and due to the obvious socio-economic similarities, stronger bilateral cooperation should be sought in examining the broader implications of the energy transformation. This report uses the term 'energy transition' to refer to the shift from fossil fuels to renewable energy sources. The term 'energy transformation' is used here to refer to the broader social-economic implications of this shift.³

Germany and the Netherlands have much to gain by cooperating more close in energy R&D. This includes joining forces in subject areas and technologies of common interest, coordinating financial means and learning from respective national experiences, for example, in regard to the socio-economic implications of the energy transformation.⁴

In the context of these complexities, the main research questions that this report will answer are as follows:

1. Which specific energy R&D projects are financed by the German government at the federal and state levels?
2. What is the institutional set-up of German energy R&D policy?
3. What are relevant projects and techniques for the Netherlands that are financed by the German government?
4. What is a prominent example of Dutch-German cross-border cooperation in energy R&D?
5. What are limitations in Dutch-German cross-border energy cooperation?
6. What are strategic lessons for the Dutch government?

1.2 Aim of the Report

The main aims of this report are the following:

- Provide an overview of the institutional structure of Germany's energy R&D, including actors, aims, and financial means.
- Analyze the German approach in managing energy R&D.

3 Global Commission on the Geopolitics of Energy Transformation, 'A New World: The Geopolitics of the Energy Transformation' (IRENA, 11 January 2019), http://geopoliticsofrenewables.org/assets/geopolitics/Reports/wp-content/uploads/2019/01/Global_commission_renewable_energy_2019.pdf.

4 Stephan Slingerland, Lisa Eichler, and Lucia van Geuns, 'Nederland en Duitsland: Groene Energie-Vrienden in de Toekomst? (Netherlands and Germany: Green energy partners in the future?)' (The Hague: TNO, April 2017).

- Formulate recommendations on Dutch-German energy R&D in terms of subject areas, financing, and institutions.
- Promote a strategic discussion between stakeholders involved in energy R&D from the Netherlands and Germany that leads to more coherent and better coordinated, bilateral collaboration.
- Propose the action plan Next Steps in German-Dutch Energy Relations (2019-2020).

1.3 Structure of the Report

Chapter 2 focuses on German federal energy R&D policy. Chapter 3 provides an overview of energy R&D on the state-level. This part gives particular attention to the state of North Rhine-Westphalia (NRW). This report zooms in on NRW based on the following criteria: 1) economic and political relevance for the Netherlands (NL) (main criteria) and; 2) geographical proximity (secondary criteria). Chapter 4 looks at practices, barriers and opportunities in Dutch-German energy R&D cooperation, especially between the NL and NRW. Chapter 5 summarizes the conclusions drawn in Chapters 1-4, and formulates a range of recommendations for strengthening Dutch-German energy R&D cooperation. The final part of this report formulates a concrete follow-up action plan for 2019-2020.

1.4 Limitations of the Report

This report is limited to providing an overview of the main stakeholders, resources, and themes concerning energy R&D ‘made in Germany.’ Here we look at ongoing programs in ministries at the federal level and state level.

Due to the vast scope and complexity of the subject, the chapters of this report are non-exhaustive. Combined, they introduce and provide an overview of the institutional set-up of energy R&D policy, including programs and focus. Many issues of strategic importance to both Germany and the Netherlands that are briefly mentioned in this report require a much more comprehensive analysis in separate studies. These studies should go into depth on specific topics, e.g. the R&D governance of system integration, explaining funding institutions and processes on European, federal, and state-levels, and R&D efforts which encourage the societal aspects of the energy transition.

Research into the organization of energy innovation in all 16 federal states does not fit within the scope of this report. Not all federal states are equally relevant to the Netherlands. For these reasons we restrict our initial focus to providing an in-depth analysis of energy R&D in NRW. In recognition of these limitations this report concludes with a range of issues for further research.

2. German Federal Energy R&D Policy

This chapter provides an analysis of energy R&D projects that are financed by the German federal government. It explains the federal energy research program, challenges, and strategic goals of energy research funding, including the institutional set-up and the decision-making process.



2.1 Federal Energy Research Program

German Federal Government funding for energy research is carried out in the Energy Research Program (ERP). The ERP has three main objectives: *“to make a technological contribution to the components of the energy system of the future, to consolidate and expand the high level of German companies and research institutions in the field of modern energy technologies, and to secure technological options in the long term”*.⁵

Funding allocated under the ERP is used to support projects with a limited timeframe and to research institutions over long periods of time. In September 2018, the Federal Cabinet passed the 7th ERP entitled “Innovations for the Energy Transition.” The 7th ERP contains the guidelines for energy research funding as well as a total budget of EUR 6.4 billion for researching, developing, demonstrating and testing viable future technologies and concepts for the period 2018-2022. This amounts to an increase of about 45% increase in funding from the previous period, i.e. the years from 2013 to 2017 under the 6th ERP.⁶

In 2017, the Federal Government spent around EUR 1.01 billion on R&D of energy and efficiency technologies and applications for the energy transition. Figure 3 shows that this budget constitutes an increase of nearly 16% in spending compared to 2016.

⁵ Bundesministerium der Finanzen, “Haushaltaufstellung 2018”, April 27, 2018.

⁶ Federal Ministry of Economics and Technology, “Research for an Environmentally Sound, Reliable and Affordable Energy Supply - 6th Energy Research Programme of the Federal Government” (Federal Ministry of Economics and Technology (BMWi), November 2011), https://www.bmwi.de/Redaktion/EN/Publikationen/research-for-an-environmentally-sound-reliable-and-affordable-energy-supply.pdf?__blob=publicationFile&v=3.

The largest share of funds, about 80%, was invested in research into renewable energies and energy efficiency.

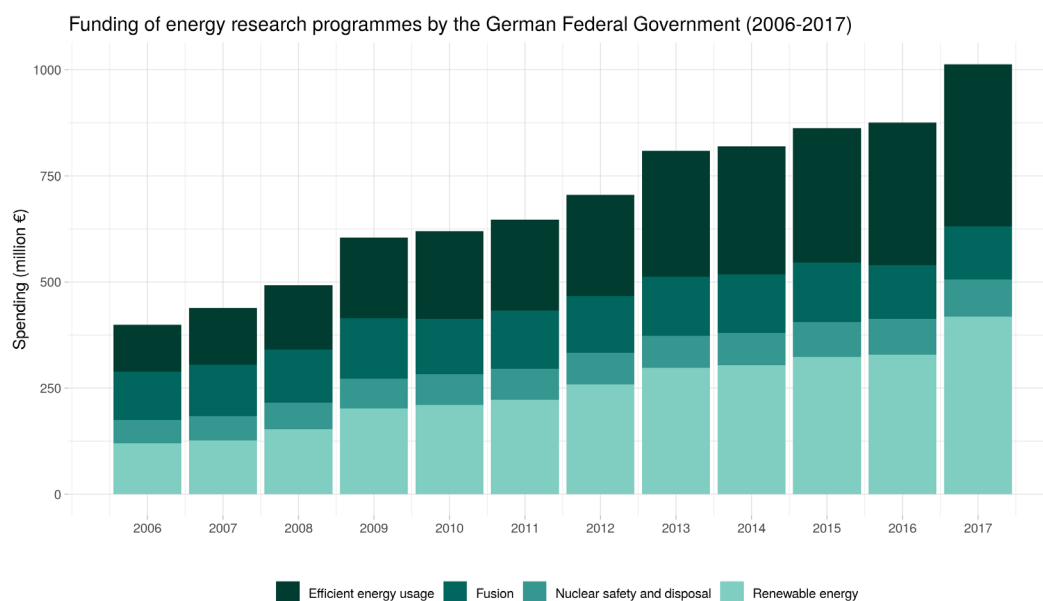


Figure 3: Overview of focus and financing of the energy research programs of the German Federal Government 2006-2017 (source: HCSS based on 2018 Federal Government Report on Energy Research).

Germany’s business R&D spending is among the highest in the EU, while its research and innovation also benefits from the highest performance in public-private cooperation in the EU.⁷ Germany’s economic impact through innovation is among the best in Europe, reflected in part through the activities of small and medium-sized enterprises (SMEs) and high patenting levels, particularly in the energy technology sector.⁸ In Europe, Germany leads the way with almost 31,000 renewable energy patents.⁹

2.2 Energy R&D Framework

Topics and technologies to be investigated under the Federal energy research policy and funding are categorized according to a Technology Readiness Level (TRL), which is also the basis for the EU Framework Program Horizon 2020 (Figure 4, Table 2).¹⁰

7 European Commission, “Research and Innovation Performance for Germany” (Brussels: European Commission, January 30, 2018), http://ec.europa.eu/research/horizon2020/pdf/country-performance/de_research_and_innovation_performance.pdf#zoom=125&pagemode=none.

8 European Commission, “Research and Innovation Performance in the EU” Research and Innovation (Brussels: European Commission, 2014), http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/iuc_progress_report_2014.pdf.

9 Global Commission on the Geopolitics of Energy Transformation, “A New World: The Geopolitics of the Energy Transformation” (IRENA, January 11, 2019), http://geopoliticsofrenewables.org/assets/geopolitics/Reports/wp-content/uploads/2019/01/Global_commission_renewable_energy_2019.pdf.

10 Federal Ministry for Economic Affairs and Energy, “7th Energy Research Program of the Federal Government” (Federal Ministry for Economic Affairs and Energy, September 19, 2018), https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/7th-energy-research-programme-of-the-federal-government.pdf?__blob=publicationFile&v=3.

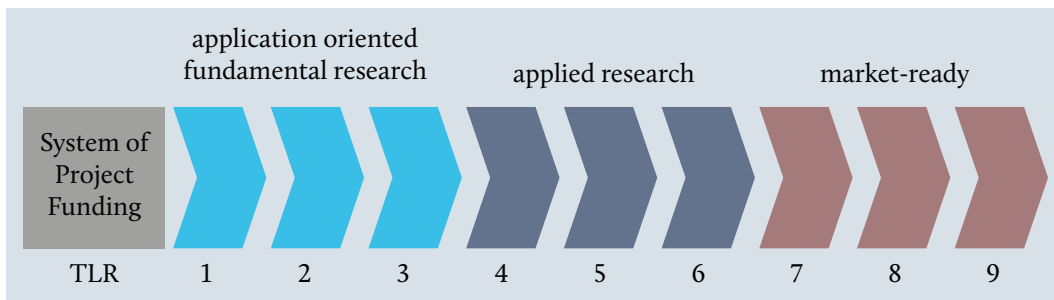


Figure 4: TRL in project funding under the 7th Energy Research Program (source: BMWi 2018).

Technology Readiness Levels	
TRL 0:	Idea. Unproven concept, no testing has been performed.
TRL 1:	Basic research. Principles postulated and observed but no experimental proof available.
TRL 2:	Technology formulation. Concept and application have been formulated.
TRL 3:	Applied research. First laboratory tests completed; proof of concept.
TRL 4:	Small scale prototype built in a laboratory environment ('ugly' prototype).
TRL 5:	Large scale prototype tested in intended environment.
TRL 6:	Prototype system tested in intended environment close to expected performance.
TRL 7:	Demonstration system operating in operational environment at pre-commercial scale.
TRL 8:	First of a kind commercial system. Manufacturing issues solved.
TRL 9:	Full commercial application. Technology available for consumers.

Table 2: TRL-categories in project funding under the 7th ERP (source: BMWi, September 2018).

The TRL categories are linked to overcoming the classic 'Valley of Death' in research, i.e. the innovation and/or funding gap for technologies that occurs between TRL levels 4-7 and 7-8 (Figure 5).

Project funding is funding for limited-term projects with a defined topic, which is aimed at businesses, research institutes and universities. Funding is provided in the form of grants for research, development, innovation and demonstration projects, pilot projects, and other formats. For projects obtaining funding under the 7th ERP the area of application-oriented basic research encompasses TRL 1-3 and TRL 3-7 applied energy research.

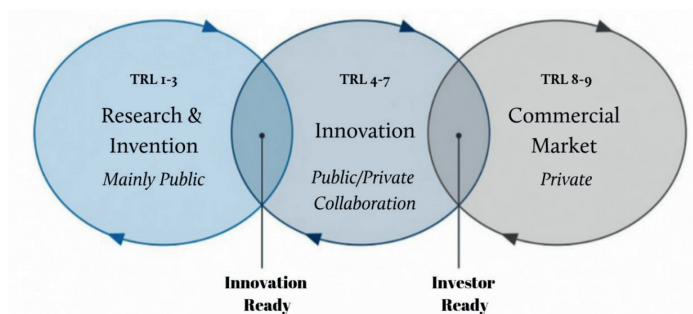


Figure 5: Valley of Death between research funding and full commercial application (source: Herbert 2016).¹¹

11 Matthew Herbert, "The Innovation Challenge and the Valley of Death," CPI, May 18, 2016, <https://www.uk-cpi.com/blog/the-innovation-challenge-and-the-valley-of-death>.

2.3 Institutional Set-Up of Energy Research Policy

The Federal Government has recognized that under previous ERPs notions of strict thematic demarcations and linear sequences of innovation processes fell short of the challenges posed by rapid developments in the energy sector. In the 7th ERP the Federal Government has therefore opted for an inter-ministerial and thematic programmatic setup for its project funding. This aims to underscore the coherence of research policy goals in the energy sector.

The 7th ERP is implemented by by three federal ministries, namely the Ministry for Economic Affairs and Energy (BMWi), Education and Research (BMBF), and Food and Agriculture (BMEL). Together, the three ministries cover the entire innovation chain, from basic energy research to application-oriented research, development and demonstration (Figure 6).¹²

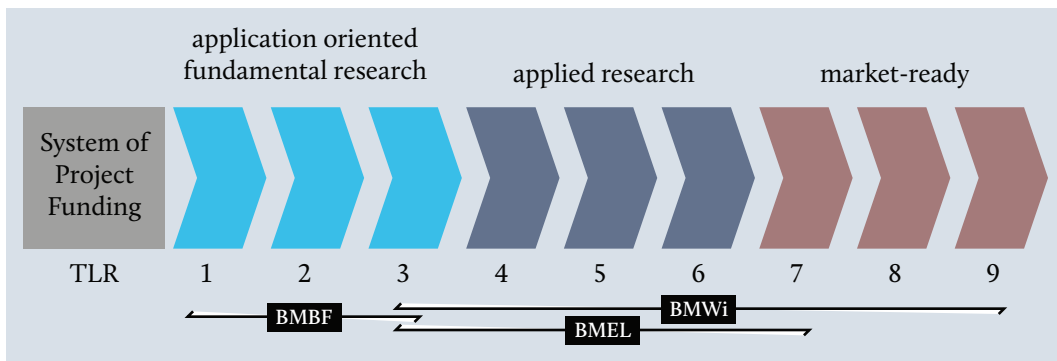


Figure 6: Responsibilities of the ministries in TRL-project funding under the 7th ERP (source: BMWi, September 2018).

2.3.1 Inter-Ministerial and Joint Programmatic

BMWi takes the lead in coordinating and managing the programmatic direction of the energy research policy of the Federal Government. In carrying out the 7th ERP, BMWi is responsible for the coordination, programmatic orientation, and the further development of energy research policy.

- **BMWi** oversees funding projects nearing the application stage, e.g. TRL 3-9, except for biomass. BMWi also represents the German Federal Government in international energy research cooperation.
- **BMBF** takes charge of project funding in basic applied research for the entire thematic spectrum of the program (TRL 1-3).
- **BMEL** is responsible for project funding with a thematic focus on energy production from biomass (TRL 3-7).

12 Bundesministerium für Wirtschaft und Energie, "Bundesbericht Energieforschung 2018," June 2018, https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/bundesbericht-energieforschung-2018.pdf?__blob=publicationFile&v=12.

Table 3 summarizes the ministerial and budget responsibilities in project and institutional funding under the 7th ERP.

Federal Government's 7 th Energy Research Program (2018-2022)					
In EUR (thousands)	Target	Government draft		Plan Data	
	2018	2019	2020	2021	2022
BMWi	639.700	725.205	725.798	723.800	723.745
Project Funding	595.596	682.980	682.980	682.980	682.980
Institutional Funding	44.104	42.225	42.798	40.820	40.765
BMEL					
Project Funding	46.803	46.803	46.803	46.803	46.803
BMBF	506.613	515.601	528,018	521.809	521.809
Project Funding	133.427	133.261	133.355	133.355	133.355
Institutional Funding	373.186	382.340	394.663	388.454	388.454
Total	1.193.116	1.287.609	1.300.599	1.292.412	1.292.357

Table 3: Federal ministerial budgetary spending under the 7th Energy Research Program (source: BMWi, September 2018).

Table 3 illustrates that BMWi's focus is on project funding, whereas most of BMBF's allocated budget is geared towards institutional spending.

2.3.2 R&D Stakeholders

The political decision-making by the responsible ministries (i.e. BMWi, BMEL, and BMBF) on the ERP is supported by scientific input from the scientific and business community, industry, and state-level government. This input, to a large extent, determines the strategic decisions and focus of federal energy R&D.

Decision-making on effective energy R&D spending depends on whether a balance of interests can be struck and a basic consensus reached in the competition among different stakeholders. This is also a major part of, or task for, energy research policy.¹³

In this context, and when developing and implementing funding strategies for energy research, the Federal Government attaches great importance to a transparent dialogue with all relevant actors in this sector. This assures the optimal coordination of research activities, guarantees the high practical relevance of research, and supports the transfer of innovations to the energy sector.¹⁴

13 Federal Ministry for Economic Affairs and Energy, "7th Energy Research Program of the Federal Government" (Federal Ministry for Economic Affairs and Energy, September 19, 2018), https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/7th-energy-research-programme-of-the-federal-government.pdf?__blob=publicationFile&v=3.

14 Interview with Dr. Jost Liebich (Grundlagenforschung Energie) and Dr. Gesine Arends (Grundlagenforschung Energieinfrastruktur, BMBF) from Project Management Organisation Jülich (PTJ), 21 September 2018.

The main actors involved in German energy R&D policy work together on so-called stakeholder platforms. The platforms listed below facilitate exchange and provide input for the strategic decision-making of German energy R&D policy.

- **Energy Transition Research and Innovation Platform (R&I Platform).** The R&I Platform is the advisory board for overarching issues of funding policy in energy research.
- **Energy Research Networks.** These provide the R&I Platform with expert assistance and enable actors from politics, business, science and the relevant ministries to participate directly in the further development of the ERP.¹⁵ Established in 2014 and hosting more than 3,500 experts, these permanent support the work of the federal ministries:
 1. Bioenergy.
 2. Energy System Analysis.
 3. Energy Transition Construction.
 4. Renewables.
 5. Flexible Energy Conversion.
 6. Industry and Commerce.
 7. Power Grids.
 8. Start Ups (new in the 7th ERP).¹⁶
- The basic applied science research academies' project, **Energy Systems for the Future (ESYS)**, also channels its findings into the R&I Platform. Through the ESYS project the German Academies of Sciences (acatech) seeks to provide systematic expertise to the German government, for example regarding strategic focus and impetus for the 7th ERP.¹⁷

The work of these research actors includes taking part in and contributing to proposals for planning energy research policy, such as delivering expert input into broad-based consultative procedures for the ERP.¹⁸ They also discuss and evaluate current developments and research strategies with a view toward facilitating the rapid market launch of new energy technologies and innovative procedures. The aim is to pinpoint how the various research activities in Germany can become better networked and used more effectively.¹⁹ The networks also contribute to the strengthening of cross-cutting issues such as digitalization, energy storage and sectoral interconnection.²⁰

15 For an overview of relevant actors engaged in strategic decision-making on energy research policy, see Federal Foreign Office, "Who Is Who der Energiewende in Deutschland Ansprechpartner in Politik, Wirtschaft und Gesellschaft" (Federal Foreign Office, July 2015), <https://www.auswaertiges-amt.de/blob/216910/7a1be4e46851e6912959e89bc9cd90ee/energiewendewhoiswho-data.pdf>.

16 Federal Ministry for Economic Affairs and Energy, "Forschungsnetzwerke Energie", <https://www.energieforschung.de/vernetzung/forschungsnetzwerke-energie>.

17 Ulrich Glotzbach, "Impulse für das 7. Energieforschungsprogramm der Bundesregierung" (acatech - National Academy of Science and Engineering, Januar 2018).

18 See Federal Ministry for Economic Affairs and Energy, "Konsultationsprozess", <https://www.energieforschung.de/energieforschungspolitik/energieforschungsprogramm/konsultationsprozess>.

19 Federal Ministry for Economic Affairs and Energy, "Research and Innovation Platform," 2018, <https://www.bmwi.de/Redaktion/EN/Artikel/Energy/research-and-innovation-platform.html>.

20 Project Management Jülich, "Forschungsnetzwerk Energie," 2018, <https://www.forschungsnetzwerke-energie.de/>.

Figure 7 summarizes the institutional set-up of scientific input and exchange into the energy research policy-making process.

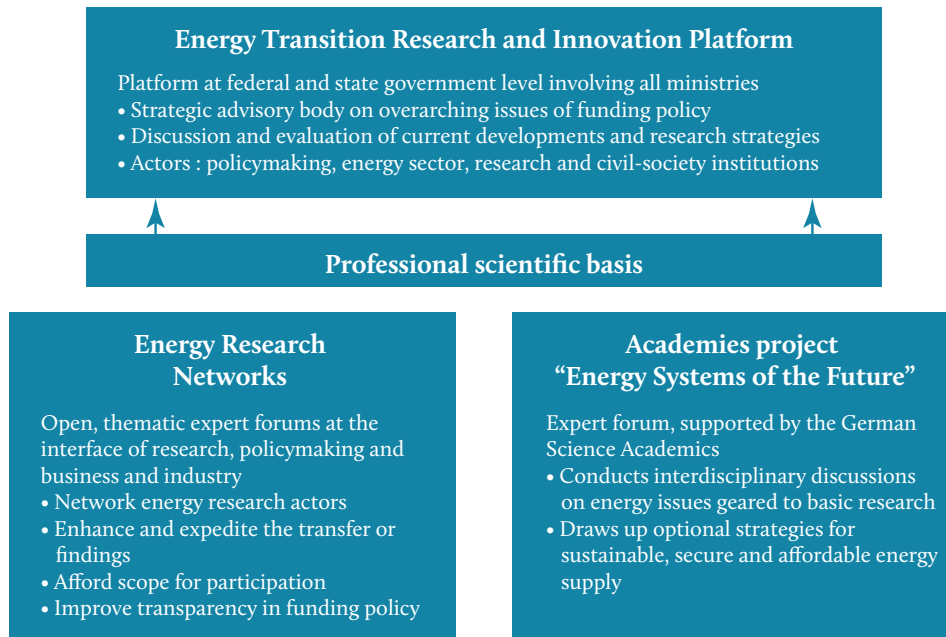


Figure 7: Institutional setup for scientific exchange, networking and input for German federal energy research (source: BMWi, September 2018).

The Energy Research Networks are among the high-power, high-interest stakeholders of German energy policy (Figure 8).

Stakeholder type mapping		
	High power	Low power
High interest	<ul style="list-style-type: none"> • Nuclear industry / energy supply companies (RWE, E.ON, Vattenfall, EnBW) • Transmission network operators (50Hertz, Amprion, TenneT, TransnetBW) • Utilities • Industry associations (Federal Association of Energy and Water Management – BDEW, Federal Association of Industry – BDI, Federal Association of Renewable Energies – BEE, Association of Municipal Enterprises – VKU) • Energy Research Networks • Scientific institution (Helmholtz Association of German Research Centers, Max Planck Society, Fraunhofer, Leibniz) 	<ul style="list-style-type: none"> • Farmers (German Farmer Association – DBV) • NGOs (Greenpeace, Naturschutzbund Deutschland – NABU, World Wide Fund for Nature – WWF) • Think Tanks (Agora Energiewende)
Low interest	<ul style="list-style-type: none"> • Labour organisations (German Trade Union Confederation – DGB) 	

Figure 8: Categories of Stakeholders in Germany’s climate and energy policy (source: Technopolis 2016).²¹

21 Technopolis Group, “International Comparison of Energy Transitions: Country Study Germany” (Topsector Energie, November 2016), <https://www.topsectorenergie.nl/sites/default/files/uploads/Systeemintegratie/ICET%20Country%20Study%20Germany.pdf>.

The same goes for Germany’s major scientific institutions. Figure 9 provides the top 25 scientific institutions that were awarded the largest sums for project funding between 2010 and 2019.

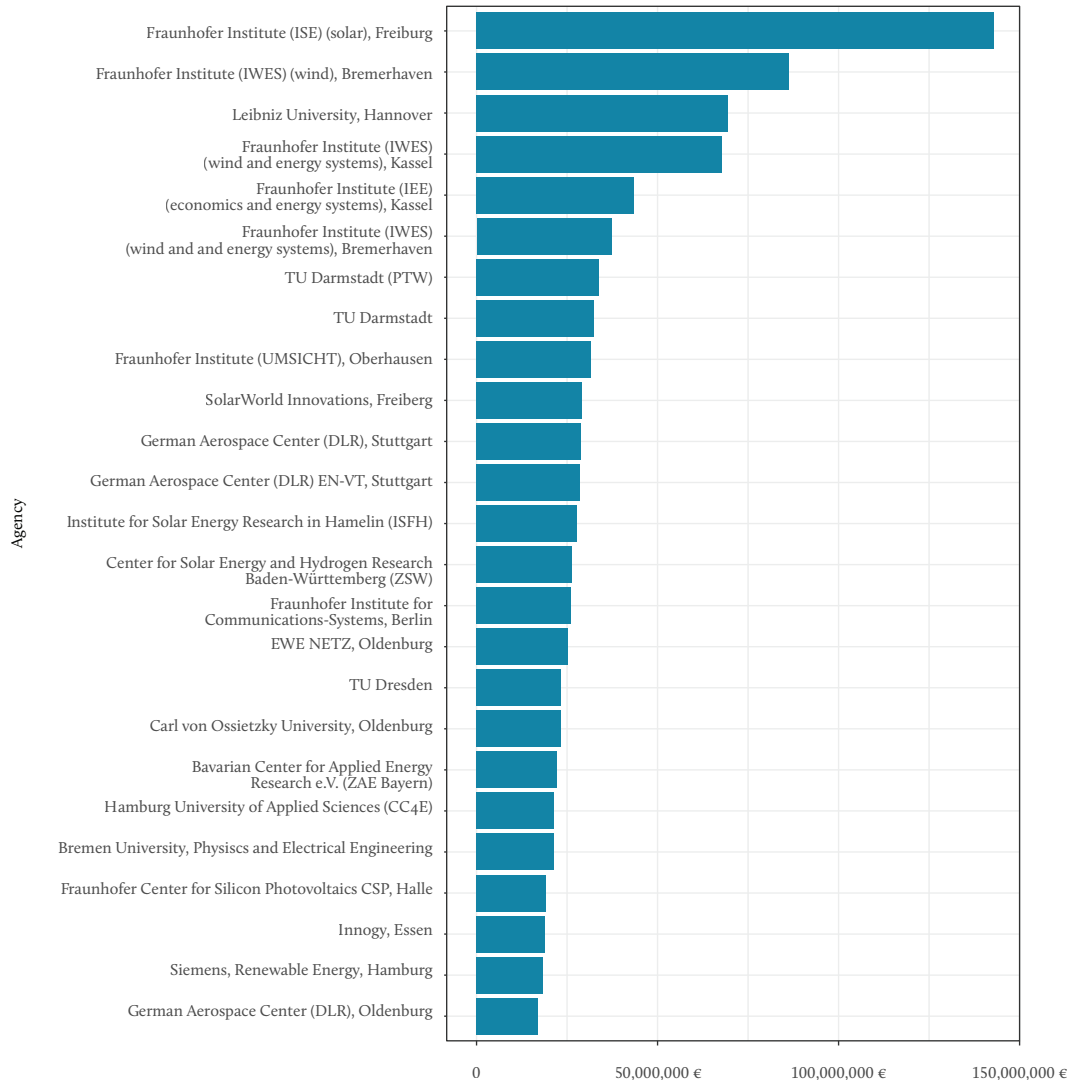


Figure 9: Overview of top 25 institutional funding in German energy research funding between 2010 and 2019 (source: HCSS 2019 based on EnArgus Database).

2.3.3 Transparency in Energy Research Policy

Another key task of the Federal Government is to provide transparency in energy R&D. This includes reporting on future trends and research contents, expediting the practical application of research findings, and ensuring transparency in the allocation of funds.

In order to achieve these aims, media output is made accessible to the public. This includes the EnArgus information system and publishing a Federal Energy Research Report.²² The EnArgus website documents over 24,000 energy R&D projects.

22 See www.enargus.de

EnArgus also accounts for the efficient application of funds in various projects and enables analyses to be made on the future direction of funding policy. Based on EnArgus, the Federal Government prepares its annual Federal Energy Research Report, which informs the public and parliament about its funding activities in energy research.²³

Figure 10 summarizes the overall structure and institutions involved in German Federal energy research policy.

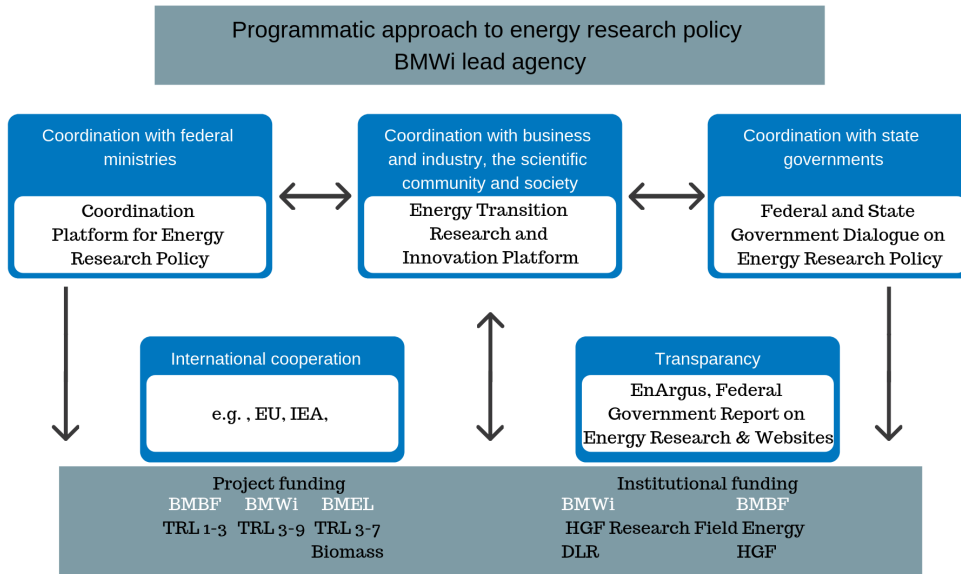


Figure 10: Institutional setup for German federal energy research (source: BMWi, September 2018).

2.4 Challenges and Goals of Federal Energy Research Policy

The development of the German energy sector will be dominated by four key trends in the coming years: decarbonization, continued decentralization, digitalization, and systemic integration. Therefore, next to the development of individual and sustainable energy technologies, an important focus of the new ERP is the optimization of the overall system of energy supply and intelligent sector coupling.²⁴

German society faces the enormous task of radically transforming the energy landscape of Europe's number one industrial powerhouse.

23 For 2018, see Federal Ministry for Economic Affairs and Energy, "2018 Federal Government Report on Energy Research - Funding research for the energy transition" (Federal Ministry for Economic Affairs and Energy September 2018) <https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/bundesbericht-energieforschung-2018.html> and for 2017 <https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/bundesbericht-energieforschung-2017.html>.

24 Bundesministerium für Wirtschaft und Energie, "Artikel 40 Jahre Energieforschung: Forschen für die Energiewende," [bmwi.de](https://www.bmwi.de/Redaktion/DE/Artikel/Energie/Energieforschung/40-jahre-energieforschungsprogramm.html), besucht December 30, 2018, <https://www.bmwi.de/Redaktion/DE/Artikel/Energie/Energieforschung/40-jahre-energieforschungsprogramm.html>.

2.4.1 Strategic Challenges & Criteria

In the context of these general developments, the 7th ERP lists a range of challenges.²⁵ The challenges of the 7th ERP are:

- **Accelerating the commercial expansion of renewable energies**
The use of renewables such as wind and solar power for electricity generation, as well as biomass and geothermal energy for heat supply and electro mobility, is currently progressing at multiple speeds. Tangible success has been achieved in the German power sector. Progress in the German heating and transport sectors has been slow. An integral approach of smart coupling of heating, mobility and the power sector, including storage, is required to reach the 60% share of renewable energies in the German gross final energy consumption by 2050.
- **Raising the efficiency at all system levels**
'Efficiency first' is a central leitmotif of German energy R&D policy and the basis for increasing the energy productivity of the Germany's industry-based economy. The Federal Government is drawing up an ambitious, inter-sectoral energy-efficiency strategy for this with the aim of halving primary energy consumption by 2050 compared with 2008.
- **Making smart use of energy infrastructure**
In speeding up the energy transition the modernization and expansion of power grids is of particular importance. Another concern is to make use of the synergies and flexibility options afforded by sector coupling, integrated storage technologies, and the scope for decentralization.
- **Securing energy supply**
A strategically important task with economic, security, and social policy relevance is ensuring a technologically robust and resilient supply system to cope with increasing volatile input and digital networking. The challenge here is to strike a necessary balance among digital progress, social acceptance, and risk minimization.
- **Advancing environmental and climate protection**
Besides the urgent tasks of reducing greenhouse gas emissions and local air pollution, issues of resource and material efficiency, environmental protection, and nature conservation are essential criteria for assessing the future viability of modern energy and efficiency technologies.

25 Federal Ministry for Economic Affairs and Energy, "7th Energy Research Program of the Federal Government" (Federal Ministry for Economic Affairs and Energy, September 19, 2018), https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/7th-energy-research-programme-of-the-federal-government.pdf?__blob=publicationFile&v=3.

- **Taking account of social impacts**

There is a strong need to create prospects for traditional energy regions. Here the repercussions of energy transition processes in terms of structural adjustments are more felt. This is due to the heavy geographical concentration of coal and lignite, for example in Germany’s three lignite mining regions in Saxony and Saxony-Anhalt, Brandenburg, and North Rhine-Westphalia.²⁶ Choices regarding particular energy research, such as funding of institutions and choices regarding location, bear a particular responsibility in this connection.

Energy R&D projects and technologies are assessed in the German institutional set-up according to a whole range of evaluation criteria. These criteria include funding relevance, national and international climate and energy policy targets, market potential, cost efficiency and social acceptance. Covering all technical, political, economic and social aspects of energy R&D, these criteria are essential in understanding the strategic focus in this field. Figure 11 provides a schematic overview of these evaluation criteria for German energy R&D.²⁷

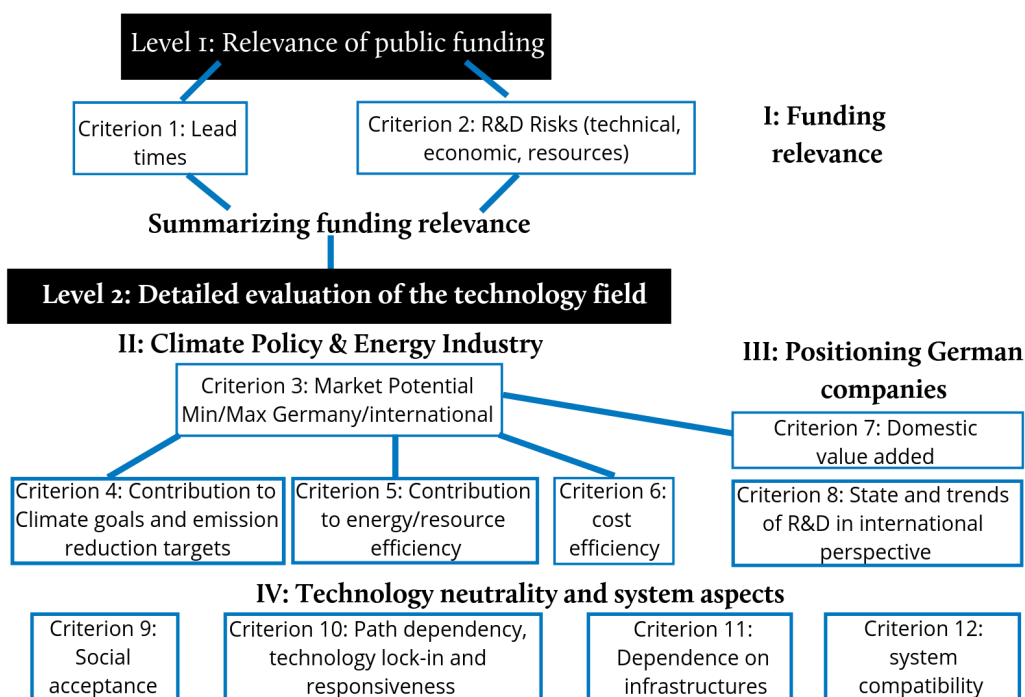


Figure 11: Strategic evaluation criteria for energy R&D research (source: Viebahn et al., April 2018).

26 Kerstine Appunn, “Germany’s three lignite mining regions,” Clean Energy Wire, July 30, 2018, <https://www.cleanenergywire.org/factsheets/germanys-three-lignite-mining-regions>.

27 Peter Viebahn et al., “Technologien für die Energiewende Politikbericht,” Wuppertal Report (Wuppertal Institut, Fraunhofer-Institut für System- und Innovationsforschung, Institut für ZukunftsEnergie- und Stoffstromsysteme GmbH, April 2018).

With these challenges and criteria in mind the next section looks at the strategic goals of the Federal energy R&D policy.

2.4.2 Strategic Goals

The strategic goals of the 7th ERP are:

- **Expediting the energy transition**
A key aim of funding research is developing innovative, integral solutions ready for successful market launch, supported by a broad funding approach along the entire energy supply chain (production/generation, transmission/distribution and/or retail services). Close attention is paid to technological aspects and non-technological factors in the energy transition, such as social processes.
- **Strengthening industrial research**
Funding energy research makes major contributions to keeping the German and European economies competitive. The concern of the Federal Government is to take up new trends such as digitalization where appropriate, maintain and upgrade technological competencies in the energy sector, and improve export opportunities for innovative energy technologies. Therefore, research funding is directed at technologies for world markets, especially in developing and newly industrialized countries.
- **Managing societal risks**
The objective is to promote a technologically-neutral programmatic approach through which the Federal Government aims to contribute to developing a broad range of technological options for international markets.²⁸ Government engagement is necessary in enabling energy research to move from the idea stage to technology available for consumers. This includes solving specific problems such as prolonged time horizons for technological innovations or associated high economic and technological risks.

Based on these strategic goals, Table 4 provides an overview of the focus in project funding in the 6th and 7th ERP.

28 Federal Ministry for Economic Affairs and Energy, “7th Energy Research Program of the Federal Government” (Federal Ministry for Economic Affairs and Energy, September 19, 2018), https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/7th-energy-research-programme-of-the-federal-government.pdf?__blob=publicationFile&v=3.

Overview of the focus in project funding in the 6 th ERP and 7 th ERP	
Project funding in the 6 th Energy Research Program	Project funding in the 7 th Energy Research Program
Energy conversion: Photovoltaics Wind power Bioenergy Deep geothermal energy Power plant and CO ₂ technologies Fuel cells and hydrogen Solar thermal power plants Hydropower and marine energy	Power generation: Photovoltaics Wind power Bioenergy ²⁹ Geothermal Hydropower and marine energy Thermal power plants
Efficient use of energy: Energy efficiency in industry and commerce, trade and services Energy in buildings and cities	Energy transition in consumption sectors: Buildings and neighborhoods Industry, commerce, trade and services Interfaces of energy research with mobility and transport
System-oriented energy research: Energy systems analysis Energy storage Electricity grids	System integration: Sector coupling and hydrogen Electricity grids Energy storage
Horizontal issues: Energy Transition Research Alliance of Industrial Community Research Kopernikus projects (<i>more on this below</i>) Carbon2Chem ³⁰ Transformation of the energy system in a socially acceptable manner Materials research for the energy transition Dissemination of information	Cross-system research topics for the energy transition: Energy system analysis Digitalization of the energy transition Resource efficiency for the energy transition CO ₂ technologies for the energy transition Energy transition and society Materials research for the energy transition

Table 4: Overview of the focus in project funding in the 6th ERP and 7th ERP (source: BMWi, September 2018).

The German Federal Government has only recently started broadening the focus of its R&D goals, i.e. from project funding centered on individual technologies to funding that encompasses systemic and inter-systemic issues of the energy transition. The Federal Government underlines that this systemic approach needs to be extended in the future with a cross-border approach, i.e. on a regional and European scale.

The acceleration of this systemic approach is supported by classic funding programs and new innovative solutions focused on regulatory learning. Both Smart Energy Showcases - Digital Agenda for the Energy Transition (SINTEG) and the Kopernikus

29 Strategic goals of R&D funding include biomass-based CHP solutions, the interplay of biomass and renewable electricity in power-to-x applications. The “x” can stand for “hydrogen”, “gas”, “liquids”, “fuels”, “chemicals” or “heat”. It refers to the conversion of renewable power into these substances and energy forms. This concept is an essential element of sector coupling.

30 In the Federal Ministry of Education and Research’s Carbon2Chem project, leading German companies from the chemical, steel, energy and automotive sectors are joining leading universities and research institutes to achieve significant cuts in greenhouse gas emissions in the steel industry for the first time.

projects are classic funding programs. Living labs (*Reallabore*) is a completely new and innovative solution.

- **Funding program “Smart Energy Showcases - Digital Agenda for the Energy Transition (SINTEG)” (2016-2020).** Financed by BMWi (230 million EUR) and the private sector (300 million EUR) in five showcase regions.³¹ Focused on funding market-ready research (TRL 7-9), SINTEG seeks to develop blueprints for a smart renewables-based electricity supply that can then be rolled out on a wider scale. “The showcase regions are to pool knowledge and experience, undertake joint activities, address the technical, economic and regulatory challenges posed by the energy transition over the coming decades, and deliver model solutions which have been tried out in practice.”³² This includes building smart networks linking up the energy supply and demand sides, and focusses on the use of innovative grid technology and operating strategies. To make it possible for the participants of the SINTEG program to test new technologies, procedures, and business models in practice without facing financial disadvantages, BMWi has developed a fixed-term SINTEG ordinance. This ordinance provides these participants with room for conducting experiments.³³
- **Kopernikus projects (2016-2026).** Funding program carried out by BMBF that is focused on four projects: new network structures, power-to-x, industrial processes, and system integration.³⁴ With a budget of 400 million EUR, these projects are carried out to develop technological and economic solutions for the energy transition in the next ten years. For the most part, Kopernikus is focused on application-oriented, fundamental research (TRL 1-3) dominated by science and engineering and with the close involvement of industry.³⁵ Other disciplines, such as the social sciences and a focus on society “to develop concepts consistent with the public’s expectations of the energy transition,”³⁶ are described as playing only a marginal role.

31 The five showcase regions were selected by means of a competition and are (1) C/sells: large showcase in the ‘solar arch’ in southern Germany’ (in Baden-Württemberg, Bavaria and Hesse); (2) Designnetz: a modular concept for the energy transition – from isolated solutions to an efficient energy system of the future (in North Rhine-Westphalia, Rhineland-Palatinate and Saarland); (3) enera (on changing the static and centralized energy system to a dynamic and decentralized one in the northwest of Lower Saxony); (4) NEW 4.0 on the efficient management of surplus (wind-generated) electricity in Hamburg and Schleswig-Holstein; (5) WindNODE (the five eastern German states plus Berlin): Showcase efficient integration of large volumes of renewable energy into an energy system which is optimized for all energy sources and combines the electricity, heat and mobility.

32 Federal Ministry for Economics Affairs and Energy, “Funding Programme SINTEG,” accessed December 12, 2018, <https://www.bmwi.de/Redaktion/EN/Artikel/Energy/sinteg-funding-programme.html>.

33 See: https://www.bmwi.de/Redaktion/DE/Downloads/E/entwurf-sinteg.pdf?__blob=publicationFile&v=4.

34 Regarding power-to-x, see for example: Florian Ausfelder and Hanna Ewa Dura, “Optionen für ein nachhaltiges Energiesystem mit Power-to-X Technologien” (DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V., August 31, 2018). <https://www.kopernikus-projekte.de/en/projects/system-integration>

35 An exception here is the System integration Kopernikus project: Energiewende navigation system (ENavi). ENavi sees the Energiewende as a society-wide transformation process and links scientific analyses with politico-social requirements. One organizational task of the ENavi project consists of combining the expertise from the various fields of science, the economy and civil society.

36 Interview Dr. Weert Canzler, Berlin Social Science Center, 8 and 21 January 2019.

- **Living Labs (2016-onwards).** This constitutes a regulatory instrument initiated by BMWi that can be used in a wide variety of subject areas.³⁷ As a funding format in the 7th ERP, Living Labs address the main systemic challenges for German energy policy in clearly demarcated and large-scale pilot projects. Although developed in parallel with the Kopernikus projects, the aim and approach of Living Labs are radically different. First, ‘regulatory learning’ and the subsequent promoting of innovation-friendly regulation are central to Living Labs. The latter includes temporary modifications of the legal framework through ‘experimentation clauses’, which create the necessary flexibility for the practical testing of innovations and quickly adapt regulation to new developments.³⁸ Second, Living Labs take the social impacts of the energy transition into strong consideration. This includes the strong involvement of a range of stakeholders and end-users, including startups, small and medium enterprises, prosumers³⁹, and local and regional utilities (*Stadtwerke*). Related to this, thirdly, Living Labs are carried out in real-life environments, such as cities, and consider different circumstances.

“The funding format for living labs will be designed to keep pace with local and social developments. The challenges in regions affected by structural adjustment and declining population numbers differ from those faced in growing, populous cities. The Living Labs for the energy transition will develop, try out and propagate integral solutions. They must be cross-cutting projects whose objectives are understood and endorsed by the local population to arrive at the necessary basic consensus for the successful transfer from research to application.”⁴⁰

2.5 Review of Federal Energy R&D Policy

Several considerations emerge when reviewing the focus of German federal energy research. This report mentions four considerations, from specific to more general.

Our first consideration relates to some of the specifics of systemic approaches described in the previous section. Experiences with research funding in long-

37 Bundesministerium für Wirtschaft und Energie, “Reallabore Als Testräume Für Innovation Und Regulierung: Innovation Ermöglichen Und Regulierung Weiterentwickeln,” BMWi-Strategie (Berlin: BMWi, December 10, 2018), https://www.bmw.de/Redaktion/DE/Downloads/S-T/strategiepapier-reallabore.pdf?__blob=publicationFile&v=10.

38 Bundesministerium für Wirtschaft und Energie.

39 The term prosumer refers to the shift to a distributed energy system, where consumers not only draw power from the grid but also feed it into the grid from home installations, such as rooftop photovoltaic panels. Source: https://www.cleanenergywire.org/glossary/letter_p.

40 Federal Ministry for Economic Affairs and Energy, “7th Energy Research Program of the Federal Government.”

term approaches like Kopernikus have proven to be rather rigid.⁴¹ A more dynamic interaction between evaluation and coordination would strengthen the ability to review and assess goals, targets, requirements, and desired outcomes, and adapt these in a timely manner.⁴²

Second, while Living Labs take a right step in pointing out the potentials for systemic optimization and the scope for the requisite legislative measures, they don't nullify the dissonance between regulation and market design on the one hand, and the quickly-changing needs of the power system on the other. The former is still very much focused on a centralized, inflexible and unidirectional power system. The real power system, meanwhile, is increasingly flexible, decentral and characterized by bi-directional energy flows due to prosumers.⁴³ Therefore, the question is whether indeed Living Labs lead to the establishment of proper regulatory conditions which incentivize businesses to rapidly introduce innovative energy technologies and schemes into the market.

An important factor here are the 'high-power, high-interest' stakeholders in Germany's energy sector. Mentioned in the stakeholder matrix (Figure 8), these include energy supply companies, utilities and associations such as the highly influential Federal Association of Industry (BDI) and the Federal Association of Energy and Water Industries (BDEW). These established and powerful actors are important in determining the scope and depth of public-private cooperation and R&D spending in energy research.

Third, Federal energy research has increasingly geared its orientation towards great societal challenges.

- *In addition to supporting basic research, research and innovation (R&I) policy must be able to focus on funding R&I activities that are relevant to the greater societal challenges, keeping the door open to all technologies.*
- *Innovations can lead to conflicts with specific sustainability goals, such as environmental quality or social justice. Such conflicts of objectives should be cushioned by coordinating with other policy areas such as environmental or social policy.*
- *The careful involvement of different societal groups to identify or confirm important societal challenges is a useful guideline for R&I policy. [This calls for] a further examination of the theoretical principles and practical implementation possibilities of research and innovation approach[es].⁴⁴*

41 Although the Copernicus projects have a formal duration of 10 years, they must be formally applied for in each of the 3 new phases. Currently, the decision is made as to whether the corresponding amount of money will be ready in the coming (2nd phase). The projects are currently submitting applications for the next phase. Interview Dr. Florian Ausfelder, DECHEMA, 18 January 2019.

42 Interview Dr. Florian Ausfelder, DECHEMA, 18 January 2019.

43 Interview Dr. Weert Canzler, Berlin Social Science Center, 8 January 2019.

44 EFI – Commission of Experts for Research and Innovation, "Research, Innovation and Technological Performance in Germany - Report 2018" (Berlin: Commission of Experts for Research and Innovation - EFI, January 2018), https://www.e-fi.de/fileadmin/Gutachten_2018/EFI_Report_2018.pdf.

Next to technological and economic incentives, the Federal Government has recognized socio-political challenges such as fighting energy poverty as essential in carrying out responsible R&D. The German energy transition can only be successfully shaped if the needs and expectations of the population are adequately reflected and attention is paid to both the need for environmental sustainability and the requirements of the social market economy.⁴⁵

On the other hand, largely public ownership in Germany goes a long way in explaining strong general support for the costs and consequences of the *Energiewende*. Figure 12 points out that in 2016 households owned 31.5% of installed renewable power capacity, making them the largest ‘bloc’ of investors in the sector.⁴⁶

Finally, startups are key actors in making energy research ready for the market and have only recently been recognized as such in the ERP.⁴⁷ Startups help to find novel technological solutions and develop new markets with innovative and sometimes unconventional products, services and business models. They are often engaged in cross-technology fields of research, such as sector coupling or digitalization, but also deal with socio-economic issues and pilot innovative developments and findings in a practical environment.

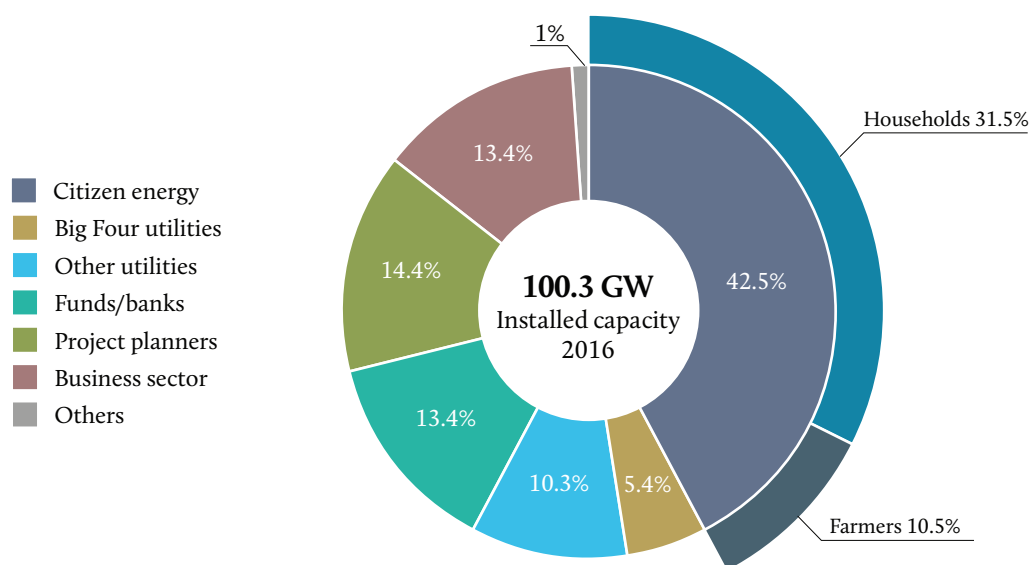


Figure 12: Ownership of renewable energy systems in Germany at the end of 2016 (source: Energy Transition, 7 February 2018).

45 Federal Ministry of Education and Research, “Kopernikus Projekte: Energy Research,” Kopernikus Projekte, January 18, 2019, <https://www.kopernikus-projekte.de/en/energy-research>.

46 Craig Morris, ‘Share of German Citizen Renewable Energy Shrinking’, *Energy Transition* (blog), 7 February 2018, <https://energytransition.org/2018/02/share-of-german-citizen-renewable-energy-shrinking/>.

47 Interview Dr. Weert Canzler, Berlin Social Science Center, 8 and 21 January 2019.

The Federal Government has started to support startups via new and more appropriate funding formats and strengthening their participation in all thematic clusters of energy research. The government aims to dismantle current barriers by (1) enlarging the content of the ERP to include non-technological innovations (business models, new services), with a bearing on technological innovation, and (2) reforming and speeding up administrative procedures.⁴⁸

2.6 Conclusion

The Federal Government's steady and strong commitment to energy R&D has greatly benefited both German and international energy transition efforts. Germany's R&D spending is among the highest in the EU and benefits from a solid performance in public-private cooperation in the EU.

This chapter has pointed out the Federal Government's focus is on the deeper transformation of Germany's energy system, i.e. "one that has major social, economic and political implications which go well beyond the energy sector"⁴⁹. The term energy transformation captures these broader implications and the core of the analysis in this chapter, i.e. a wider research spectrum of project funding that broadens from a focus on individual technologies to encompass systemic and inter-systemic energy issues.

New thematic priorities in this focus mentioned in this chapter are:

- Addressing the technology readiness level (TRL) of a technology across the entire innovation cycle in an inter-ministerial manner.
- Making funding available for overarching cross-sector issues such as energy efficiency, reduction of consumption, sector coupling and digitalization.
- Focusing on innovative funding formats such as the Living Labs, which allow regulatory testing of the energy system of the future.
- Managing societal risks.

The analysis provided here furthermore points out that Federal energy research policy under the 7thERP has been characterized by increased spending. In regard to systemic and inter-systemic energy issues, for example, the Federal Government is increasingly looking at cross-border approaches and collaborations, i.e. on a regional and European scale.

48 Federal Ministry for Economic Affairs and Energy, "7th Energy Research Program of the Federal Government" (Federal Ministry for Economic Affairs and Energy, September 19, 2018), https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/7th-energy-research-programme-of-the-federal-government.pdf?__blob=publicationFile&v=3.

49 Commission on the Geopolitics of Energy Transformation, "A New World: The Geopolitics of the Energy Transformation.", p. 76.

The review of the institutional set-up pointed out that the ministries (Economic Affairs and Energy, Education and Research, and Food and Agriculture) cover the entire innovation chain, i.e. from basic energy research to application-oriented research, development and demonstration. The Ministry for Economic Affairs and Energy (BMWi's) plays the leading role in coordinating and managing the programmatic direction of the energy research policy of the Federal Government.

The political decision-making by these ministries is, to a very large extent, determined by scientific input from a diverse range of actors from Germany's research and business communities, industry and state-level government. These Research Networks belong to the 'high-interest, high-power' stakeholder group of Germany's climate and energy (R&D) policy. Strategic evaluation criteria such as climate and energy policy, international competitiveness, technology neutrality, and social acceptance define and determine the funding relevance of a technology field and hence the broader spectrum and direction of Germany's energy R&D policy.

3. German State-Level Energy R&D Policy

First, this chapter provides a general overview of energy research policy in the 16 federal states (Bundesländer) of Germany. It answers the question of which specific technologies and subject areas are financed by the 16 state governments. Second, the chapter zooms in on the energy research policy of North Rhine-Westphalia (NRW), including focus, financing options, stakeholders, and coordination of energy research policy.



3.1 Overview of Energy R&D Funding

There is a consensus across state borders that Germany needs to reduce its CO₂ emissions to combat climate change and transform its energy supply to a system based on renewables. Although the energy policy orientation of the 16 federal states is fundamentally based on the goals and focus of the Federal Government's ERP, in practice, approaches in R&D funding diverge between these levels of government. This is due to different economic and policy interests of the state governments as well as strategic priorities and regional advantages, for example in terms of geography.

There are also differences regarding competencies of the federal and state-level governments in energy R&D policy. Germany's states have limited authority when it comes to climate and energy legislation. The privilege to make laws for the energy industry and transport sectors, for example, lies largely with the federal government. State governments enact planning laws on state level and below. This gives them, for example, the power to decide on a specific focus in state government-funded energy research as well as on education in this field.

However, with a volume of more than 248 million EUR in 2016, the 16 federal states contributed more than a quarter of general government expenditure in the field of (non-nuclear) energy research. Composing more than 27% of total non-nuclear energy

R&D funding in 2016 (913 million EUR), state government expenditure makes up a substantial part of Germany’s overall efforts in this area.⁵⁰

With the aim of supporting local and regional businesses and research organizations, state government funding focuses on industrial research and pilot projects from small-scale prototypes (TRL 4) to full commercial application (TRL 9).⁵¹ Application-oriented fundamental research (TLR 1-3) is exclusively carried out on the federal level by the BMBF.

Figure 13 below provides an overview of which technologies and subject areas were provided with most of the state government’s funding.

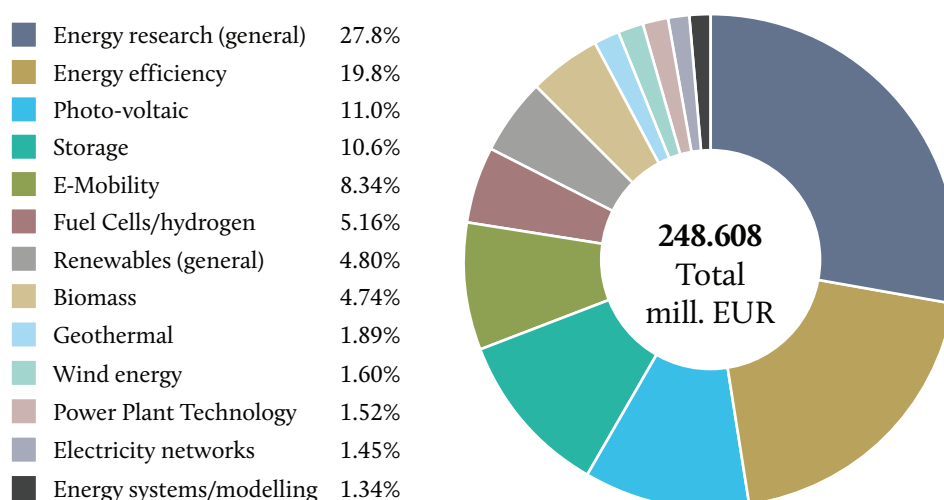


Figure 13: Main categories of research funding by the 16 federal states in 2016 (source: HCSS based on Jessen, 2016).

The category “energy research (general)” is assigned to those expenditures which cannot be further differentiated by the various state ministries according to individual technologies. Think of system integration or *Sektorkopplung* solutions.

Figure 14 below summarizes the categories listed in Figure 13 and shows state government spending on energy R&D (including institutional funding). Table 5 breaks down the numbers listed in Figure 14 per state in detail.

50 Christoph Jessen, “Förderung der nichtnuklearen Energieforschung durch die Länder im Jahre 2016”, Geschäftsbereich Energiesystem: Integration (Forschungszentrum Jülich GmbH, 2016), https://www.ptj.de/lw_resource/datapool/systemfiles/agent/ptjpublications/70CDEF8A959D470DE0539A695E86F0E0/live/document/L%C3%A4nderbericht_2016.pdf.

51 Interview with NRW-official, 18 January 2019.

Funding in millions of € by State in 2016

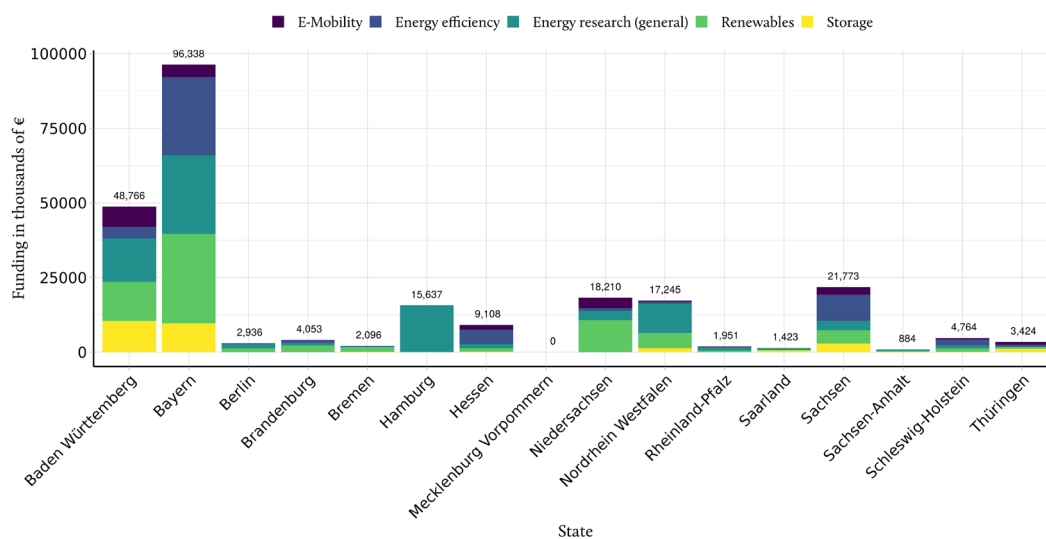


Figure 14: State government expenditure for energy research funding in 2016, i.e. both project funding and institutional funding (source: HCSS based on Jessen, 2016).

Figure 14 shows that Baden-Württemberg (BW) and Bavaria rank highest in absolute government R&D spending. Saarland and Sachsen-Anhalt rank the lowest. BW spends most on (1) energy research, (2) storage, (3) PV, and (4) fuel cells/hydrogen. Bavaria spends most on (1) efficiency, (2) energy research (general), (3) PV, and (4) storage.

Different from overall spending is calculating R&D expenditure as part of the gross domestic product (GDP) of a federal state. A study by the German Institute for Economic Research (DIW Berlin) prefers departing from the most recent mean value of GDP as a benchmark for overall research expenditure. This as not to favor those federal states that only marginally promote R&D.⁵² Based on this approach, Figure 15 shows state expenditure on R&D for renewables.

52 Jochen Diekmann e.a., “Vergleich der Bundesländer: Analyse der Erfolgsfaktoren für den Ausbau der Erneuerbaren Energien 2017: Indikatoren und Ranking; Endbericht”, Text (Berlin: Deutsches Institut für Wirtschaftsforschung, 3 januari 2007), https://www.diw.de/sixcms/detail.php?id=diw_01.c.569611.de.

In thousands of € / States	Biomass			Fuel		E- Mobility		Energy research (general)		Storage systems/modelling		Renewables (general)		Power Plant Technology		Photo-voltaic		Electricity networks		Wind energy		of which institutional funding (%)	
	Biomass	Cells/hydrogen	CCS	Mobility	Efficiency	Research (general)	Storage	Systems/modelling	Renewables (general)	Geothermal	Technology	Plant	Photo-voltaic	Electricity networks	Wind energy	Sum	of which institutional funding (%)						
Baden Württemberg	1,285	3,226	0	6,741	3,845	12,905	10,472	1,112	846	573	0	6,756	568	437	48,767	<u>43.3%</u>							
Bayern	6,596	5,338	0	4,200	26,207	22,836	9,621	0	1,550	1,524	1,909	13,682	1,575	1,300	96,339	<u>25.4%</u>							
Berlin	0	0	0	0	296	1,349	0	0	0	0	0	1,291	0	0	2,936	<u>99.4%</u>							
Brandenburg	2,171	0	0	115	805	877	2	0	0	0	0	13	0	70	4,053	<u>62.4%</u>							
Bremen	66	0	0	80	139	0	90	200	473	0	0	15	0	1,033	2,096	<u>21.5%</u>							
Hamburg	15	0	0	58	0	15,544	0	0	20	0	0	0	0	0	15,636	<u>97.8%</u>							
Hessen	294	752	0	1,621	4,815	992	114	332	44	0	0	56	44	44	9,111	<u>22.3%</u>							
Mecklenburg Vorpommern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<u>0%</u>							
Niedersachsen	440	0	0	3,475	888	2,979	0	103	5,385	2,233	0	2,707	0	0	18,210	<u>39.8%</u>							
Nordrhein Westfalen	152	1,706	0	283	723	7,797	1,325	47	2,635	94	1,190	495	798	0	17,245	<u>47.6%</u>							
Rheinland-Pfalz	0	500	0	195	170	471	0	601	14	0	0	0	0	0	1,951	<u>38.6%</u>							
Saarland	0	0	0	0	0	800	623	0	0	0	0	0	0	0	1,423	<u>56.2%</u>							
Sachsen	633	1,273	9	2,506	8,780	1,589	2,860	477	542	111	616	1,526	444	416	21,781	<u>68.2%</u>							
Sachsen-Anhalt	94	26	7	17	30	136	42	214	43	25	0	223	22	12	892	<u>53.9%</u>							
Schleswig-Holstein	35	5	0	513	1,944	745	68	241	364	136	60	26	12	615	4,763	<u>62.5%</u>							
Thüringen	0	0	0	925	631	1	1,121	0	21	0	0	547	138	40	3,425	<u>25.2%</u>							
Sum	11,782	12,826	16	20,730	49,272	69,020	26,339	3,328	11,937	4,697	3,776	27,336	3,601	3,969	248,628	42.2%							

Table 5: Overview of energy research spending on the state-level in 2016 (source: Jessen, 2016).

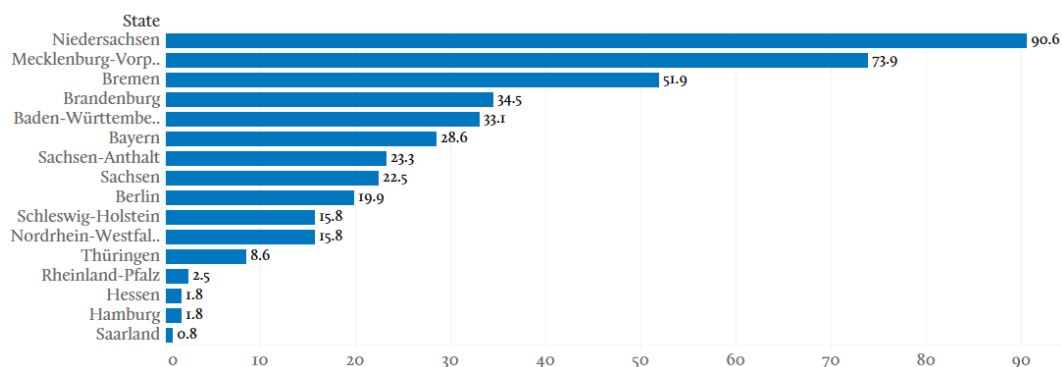


Figure 15: State expenditure on R&D of renewable energies based on mean value of GDP (2014-2015) in millions of EUR (source: DIW Berlin 2017).

According to these numbers, Niedersachsen (Lower Saxony) is by far the top spender on R&D for renewables, with an average of 90.6 EUR of GDP spent in 2014 and 2015. The main research areas here were wind and geothermal energy. In second place, Mecklenburg-Vorpommern follows with 73.9 million EUR. Research here focuses on wind energy. The city state of Bremen is in third place, with research also mainly focused on wind energy.

Another indicator used by DIW Berlin in analyzing the R&D activities of the federal states is the expenditure on system integration.⁵³ Figure 16 shows that by considering average R&D spending based on GDP in system integration in 2014 and 2015, Bavaria and Baden-Württemberg are the leading states.

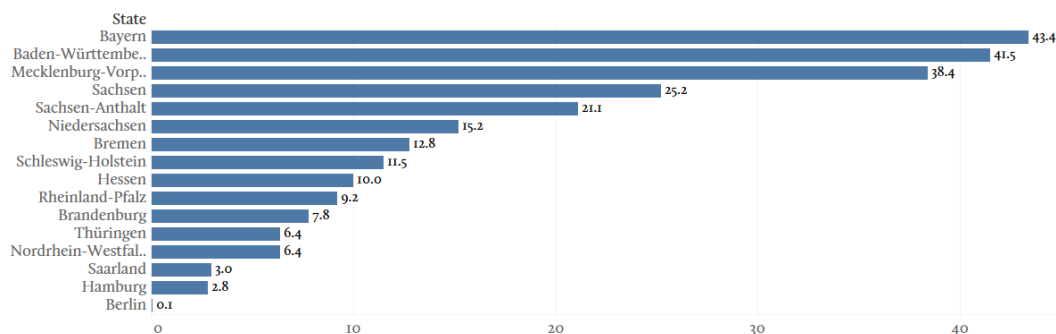


Figure 16: State R&D expenditure on system integration based on mean value of GDP (2014-2015) in millions of EUR (source: DIW Berlin 2017).

53 DIW Berlin considers the following categories as part of system integration: fuel cells and hydrogen, energy systems and modeling as well as electro mobility, electricity storage and networks.

3.2 North Rhine-Westphalia (NRW)

3.2.1 Energy Landscape

NRW is Germany's leading energy location and the most important energy region in Europe. Around 30% of Germany's electricity is produced and 32% consumed in NRW – more than in any other federal state.

One hundred % of German coal and 52% of German lignite are produced here, with coal accounting for 40% (2016) and 42% (2015) of electricity generated in Germany.⁵⁴ Germany's most densely populated and industrialized state is also one of the largest producers of wind and solar power. However, compared to its overall electricity output (mainly from coal), wind and solar make up only around 9% of its power generation.⁵⁵

To promote renewable energies and to achieve Germany's climate protection goals, NRW was also the first state to introduce a Climate Protection Law (2013). This law provides for a reduction of GHG emissions of at least 25% by the year 2020 and of at least 80% by the year 2050, compared to 1990.

NRW and the Renewable Energy Sector

Around 26,000 employees work on the development and utilization of renewable energy technologies in 3,600 companies, generating total sales of more than 6.6 billion EUR. With more work places in the maintenance area and in the operation of renewable energies, the total number of employees has risen to more than 50,000 (2013).⁵⁶

A map of NRW's conventional power plants shows coal plants northwest of Dortmund and lignite plants in the region west of Cologne (Figure 17). Gas plants dominate the power plant landscape from Bielefeld down to Cologne. The numbers on electricity trade are not made public, so we cannot give a precise estimation of the amount of electricity trade between the Netherlands and Germany that comes from NRW.⁵⁷

54 NRW. INVEST, "Energies in North Rhine-Westphalia: Facts, Figures." (Duesseldorf: NRW.INVEST Germany, maart 2017), http://www.energieregion.nrw.de/_database/_data/datainfopool/Energy_in_North_Rhine-Westphalia_Facts_Figures.pdf.

55 Appunn, "German Federalism".

56 NRW. INVEST, "Energies in North Rhine-Westphalia: Facts, Figures."

57 Interview Professor Dr. Bruno Burger, Fraunhofer Institute for Solar Energy Systems ISE, 5 May 2018.

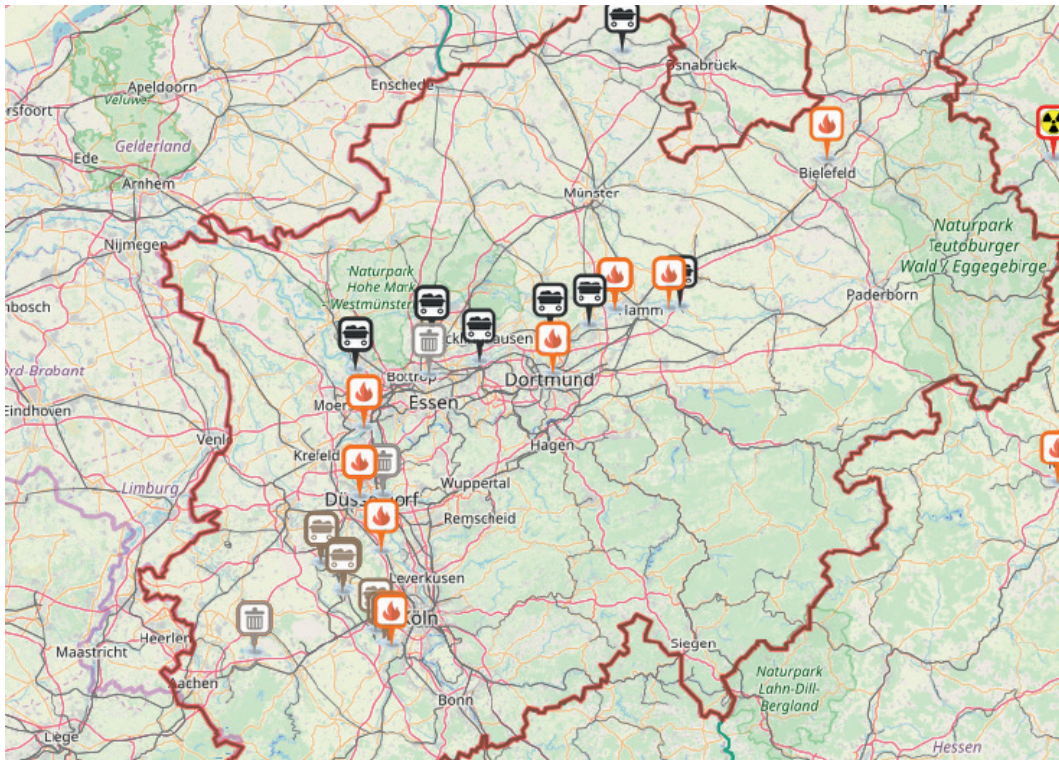


Figure 17: Map of power plants in NRW (source: EEX 06-02-2019, Fraunhofer Energy Charts).

The fact is that several lignite-fired power plants in NRW feed into lines that cross the Dutch border (Figure 18). Add to this that grid operators in Germany are obliged to give priority to electricity from renewable sources. It is therefore reasonable to assume that a substantial part of German electricity for the Dutch market is both ‘cheap’ and ‘dirty.’



Figure 18: NRW lignite-fired power plants and cross-border high-voltage power line with the Netherlands (source: EEX 02-05-2018, Fraunhofer Energy Charts).

With Germany’s coal exit commission announcing the phase-out of coal-fired power generation by 2038, with an option to end it by 2035, NRW’s power plant landscape

will vastly change in the coming decades. The changing energy landscape in NRW will certainly find a reflection in energy R&D and therefore constitutes a crucial and strategic issue for further research.

3.2.2 Energy Research Stakeholders

NRW's Ministry of Economic Affairs, Innovation, Digitalisation and Energy (**MWIDE**) oversees energy research policy. The Ministry of Culture and Science of North Rhine-Westphalia (**MKW**) formulates the energy economy and climate policy objectives of the state government in the field of energy research.

Organizations that support the work of the ministries:

- The **Cluster Energy Research NRW (CEF.NRW)** works on behalf of the MKW and acts as the contact body for all matters relating to energy research in NRW.⁵⁸ It works to ensure that new technological and socio-economic knowledge is applied as fast as possible. The cluster initiates R&D projects as part of a collaborative effort between research institutions and industry. The cluster's network and coalition-building activities focus on centralized and decentralized energy generation, conversion technologies, energy grids and storage systems.⁵⁹
- The **Energy Agency NRW** works on behalf of the state government as an operative platform with broad expertise in the field of energy: from energy research, to technical development, to demonstration, to market launch and energy consultancy, to continuous vocational training.⁶⁰ It receives funding partly from the European Union's ERDF (European Regional Development Fund).
- **Energy, Technology, Sustainability Project Management (Projektträger ETN)** works on behalf of the state government, including MKW, MWIDE and two other ministries and is partly funded through the ERDF⁶¹. ETN is the first point of contact for funding opportunities for a range of clients in the fields of energy use, renewable energy, and energy saving, and offers a range of services. These include application advice, application processing, approval, project controlling and project completion.

With roughly 120 institutes and more than 30 higher education locations and 20 non-university research institutions, plus the research departments of numerous companies, NRW is one of Germany's top energy research regions.

58 See: www.cef.nrw.de

59 Interview Georg Unger and Dr. Stefan Rabe, CEF.NRW, 19 December 2018.

60 See: <https://www.energieagentur.nrw>.

61 See: <http://www.fz-juelich.de/etn/DE>.

Next to government R&D funding, funds are spent Germany-wide for energy research at universities, of which around 168 million EUR is accounted for by NRW annually. This is about a quarter of the total spending and makes NRW the frontrunner among all federal states.⁶² NRW also hosts Germany's top energy companies such as E.ON and Innogy, a subsidiary of RWE. Tables 6-8 provide an overview of NRW's key stakeholders in energy R&D.

Companies (examples)	Est.	Sales	Description
E.ON SE, Düsseldorf	2016	EUR38 billion	E.ON is an international private energy company with a core focus on energy grids.
Innogy SE, Essen	2016	EUR44 billion	Launched in April 2016, Innogy's focus is on renewable power generation.
Vaillant Deutschland GmbH & Co. KG, Remscheid	1874	EUR2.4 billion	Vaillant is one of the market and technology leaders in the field of heating technology.
Winergy AG, Voerde	1981	EUR6 billion	Winergy is the world's leading component manufacturers for wind energy turbines with more than 125,000 MW of gearbox output.

Table 6: Company examples in NRW (source: NRW.INVEST 2017).

NRW universities (examples)	Est.	Subject areas
Aachen University of Applied Sciences	1971	e.g. renewables.
RWTH Aachen University	1870	e.g. renewables, power systems, networks, storage, energy economics and social aspects, nuclear safety, buildings.
Ruhr University Bochum	1962	e.g. power systems, networks, storage, energy economics and social aspects.
University of Cologne	1388	e.g. energy economics and social aspects.
Technical University (TU) Dortmund	1968	e.g. energy systems, networks, storage, efficiency.
University Duisburg-Essen	2003	e.g. power systems, networks, storage.
University of Münster	1780	Has the Chair of Microeconomics, concerned with the economic analysis of energy, climate and re-source policies regulation.
University of Wuppertal	1972	e.g. networks, storage, buildings.

Table 7: Universities in NRW (examples) (source: NRW.INVEST 2017 and MKW NRW).

62 NRW. INVEST, "Energies in North Rhine-Westphalia: Facts, Figures."

NRW research institutions (examples)	Est.	Description
Center for Wind Power Drives (CWD), Aachen	2013	The CWD controls and organizes the interdisciplinary research activities of RWTH Aachen University in the field of wind turbine power drive systems. In addition to basic scientific research, these research activities also include pre-competitive research and development projects.
E.ON Energy Research Center, Aachen	2006	Focuses on generation, conversion, distribution and storage of energy.
Hydrogen and Fuel Cell Center ZBT GmbH, Duisburg	2001	ZBT supports industrial enterprises with the aim of achieving the market penetration of fuel cells and innovative energy technologies.
Max Planck Institute for Coal Research, Mülheim a. d. Ruhr	1912	Activities focus on the exploration of energy-saving and resource-conserving chemical conversions.
Institute for Energy Economics at the University of Cologne (ewi)	1943	The institute is dedicated to energy economics research and teaching.
Wuppertal Institute for Climate, Environment and Energy	1990	Researches and develops models, strategies and instruments for transitions to sustainable development at regional, national and international level.
Institute for Advanced Study in the Humanities Essen	1989	Studies the socio-cultural effects of the energy transition. Together with the Wuppertal Institute, coordinates the Virtual Institute (VI) "Transformation- Energy Transition NRW" (see section below).

Table 8: Research institutions in NRW (examples) (source: NRW.INVEST 2017 and MKW NRW⁶³).

3.2.3 Focus in Energy Research

The focus of NRW-funded energy research is defined in the government coalition agreement. Regarding EU funding awarded to NRW under the ERDF, agreement is reached in coordination with the EU Commission.⁶⁴

In the coalition agreement between the Christian Democrats (CDU NRW) and the Liberals (FDP NRW) of June 2017, the parties have agreed to a technology-neutral energy research strategy that should realize NRW's ambitions in becoming a leading international energy research location.

63 <https://www.mkw.nrw/forschung/forschung-nrw/grosse-gesellschaftliche-herausforderungen-bewaeltigen/sichere-saubere-und-effiziente-energieversorgung/>.

64 Interview NRW-official, 18 January 2019.

[Die] Bedeutung der erneuerbaren Energien [renewables] und Speichertechnologien [storage] [werden] schrittweise zunehmen. Unser Ziel ist es, durch technologieneutrale Förderung von Forschung, Entwicklung und Verfahren insbesondere bei Energieumwandlung [energy conversion], Energiespeicherung [storage], alternativen Antrieben und Recycling Innovationen anzuregen, die auch zukünftig eine umweltverträgliche und jederzeit sichere Energieversorgung zu wettbewerbsfähigen Preisen ermöglichen. Wir werden sicherstellen, dass die Potenziale der Tiefengeothermie [geothermal] wieder ausgeschöpft werden können.⁶⁵

This report adds to this focus by mentioning that currently important research themes in NRW are sector coupling (including power-to-x), decentralized power solutions, fuel cells and hydrogen, biogas, thermal power plants, and mobility.⁶⁶ Aims are to support innovative measures and technologies to reduce CO₂-emissions and support demonstration and pilot projects, which allow for the increasing use of renewable energies, the stability of electricity grids, and an increase in energy efficiency.

Regarding R&D efforts in the energy transformation, the Virtual Institute (VI) “Transformation-Energy Transition NRW” (2015-2017) focused on the broader socio-economic and cultural implications of the shift from fossil fuels to renewable energy sources.⁶⁷

[The “VI Transformation-Energy Transition NRW”] nimmt sich der Herausforderung an und befasst sich mit den nichttechnischen Fragestellungen der Energiewende in NRW. Durch die Bündelung der Kompetenzen beteiligter nordrhein-westfälischer Forschungsinstitute werden diejenigen Themen adressiert, die über die technische Realisierung hinausgehen. Neben den ökonomischen Aspekten der Energiewende, die naturgemäß eng mit den technischen Fragestellungen verknüpft sind, werden im Virtuellen Institut weitere Themen erforscht. Zentral sind hier Fragen der demokratischen Mitgestaltung der Energiewende, des individuellen Umgangs mit der Energiewende sowie der Transformation industrieller Infrastrukturen.⁶⁸

65 “Koalitionsvertrag für Nordrhein-Westfalen 2017-2022” (Düsseldorf: CDU NRW & Freie Demokraten (FDP) NRW, 26 Juni 2017), https://www.cdu-nrw.de/sites/default/files/media/docs/nrwkoalition_koalitionsvertrag_fuer_nordrhein-westfalen_2017_-_2022.pdf.

66 Interview Dr. Michaela Krupp and Dr. Doris Thiemann, Unit Research & Funding for Energy and Climate, MWIDE, 18 December 2018. Interview NRW-official, 18 January 2019.

67 Under the banner of the CEF.NRW, the work of VI was coordinated by the Wuppertal Institute and the Institute for Advanced Study in the Humanities Essen. It was a collaborative and interdisciplinary effort with other universities and research institutions, including the RWTH Aachen, TU Dortmund, and the Institute for Energy Economics (ewi) at the University of Cologne. See website: <https://www.vi-transformation.de/>

68 Georg Unger, “Bisherige und künftige Arbeiten des Virtuellen Instituts “Transformation-Energiewende NRW” (EnergieAgentur.NRW GmbH, 2017).

The main task of the VI was to analyze the drivers and consequences of the energy transformation in NRW. Through innovative research designs and stakeholder meetings, as well as actively involving actors from politics, industry, and civil society, the VI was focused on:

- **Governance & participation.** Leading research questions were: Where and how can social innovations inspire the energy transition? What might be new forms of participation and what is their basis?
- **Mentalities and patterns of behavior.** Leading research questions here were: Which mentalities, patterns of behavior and social practices in the realm of resource and energy-use can be identified in NRW? Which drivers and barriers exist for the implementation of the energy transition in people's everyday lives? How can citizens play a role in the successful transition of the energy system?
- **Transformation of industrial infrastructures.** This cluster focused on the existing industrial infrastructure in NRW and examined how industry could shape the transformation process into a climate-friendly energy system. On the one hand, this cluster was about creating an understanding of the economic impact of the energy transition in NRW and its regions. On the other, its goal was to understand how industrial transformation processes in regions and companies could be organized and shaped as innovation processes.⁶⁹

The VI “Transformation-Energy Transition” points out that state governments like the one in NRW pay particular research attention to the drivers and consequences of the energy transformation.

3.2.4 Funding

In 2016, NRW-government funding on energy R&D was 17,24 million EUR.⁷⁰ The MWIDE has bundled the state government's R&D funding policy activities in the renewable energy program “progress.nrw”.⁷¹

Related to the ambitions of the new CDU and FDP coalition government NRW has initiated an ‘action strategy,’ or *Energieforschungsoffensive*.⁷² This action strategy should strengthen the strategic orientation of R&D efforts.

69 See: <https://www.vi-transformation.de>.

70 Bundesministerium für Wirtschaft und Energie, “Bundesbericht Energieforschung 2018”, June 2018, https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/bundesbericht-energieforschung-2018.pdf?__blob=publicationFile&v=12, p. 51. This sum includes 8,2 million EUR on institutional funding.

71 See: <https://www.energieagentur.nrw/foerderung/progres.nrw>.

72 See: <https://www.wirtschaft.nrw/pressemitteilung/erster-energieforschungsdialo-g-des-landes>.

Important building blocks of this *Energieforschungsoffensive* are:

- Boosting effective dialogue between actors from science, industry and government on strategic issues for energy research policy, for example in terms of needs, interest and themes.
- Optimizing cooperation in joint research projects and systemic approaches like Living Labs through the usage of funding opportunities on EU, federal and state-levels in a coherent manner.
- Creating custom-fit energy R&D funding instruments for NRW actors that supplement established support programs, including support programs from the federal government and the EU.
- Encouraging high public exposure of *Energieforschungsoffensive*-projects, including annual reporting from 2020 onwards.⁷³

The efforts of the NRW state government under the *Energieforschungsoffensive* point towards gearing the multi-level energy R&D funding activities to one another in a more coordinated and effective way and in terms of focus, (avoiding) overlap and better spending.

Most of energy R&D funding in NRW currently takes place through financial means in the EU's ERDF.⁷⁴ The funds for NRW are distributed under the following criteria:

- Priority 1: 40% goes to strengthening research, technological development and innovation.
- Priority 2: 15% is used to increase the competitiveness of small and medium-sized enterprises (SMEs).
- Priority 3: 25% is used to reduce CO₂ emissions.
- Priority 4: 20% benefits sustainable urban and district development.⁷⁵

Under the ERDF Program 2014-2020, 40 million EUR is made available for energy and climate R&D in NRW. The focus here is on:

- Sustainable energy conversion, energy transport and energy storage.
- Raw material, material and energy efficiency.
- Climate technologies.⁷⁶

73 Interview Dr. Michaela Krupp and Dr. Doris Thiemann, Unit Research & Funding for Energy and Climate, MWIDE, 18 December 2018.

74 Interview Dr. Michaela Krupp and Dr. Doris Thiemann, Unit Research & Funding for Energy and Climate, MWIDE, 18 December 2018. Interview NRW-official, 18 January 2019.

75 See: <https://www.efre.nrw.de/efre-programm/op-efre-nrw/>.

76 See: <https://www.leitmarktagentur.nrw/leitmarkt Wettbewerbe/energieumweltwirtschaft>.

As part of streamlining state-level and EU funding NRW has bundled its previous energy climate and research competitions into one overarching competition called “EnergieSystemWandel.NRW.” Funding is provided for projects ranging from implementation-oriented R&D to prototype testing in pilot and demonstration plants in the following priority areas:

- Expansion and increase of the use of renewable energies.
- Pilot and model projects to stabilize the electricity grids.
- Increase energy efficiency in companies.

The funding rules for co-financing R&D with EU means is that maximum 50% of project spending is covered by the ERDF. The remaining 50% is financed with state government means and contributions from the involved stakeholders, i.e. research institutions, companies and/or universities.

Although perhaps obvious, this report points out that federal and state funding means are available only for research organizations and businesses, especially SMEs, within national borders. “Energy R&D funding takes place according to national rules, i.e. the German government supports German companies and research organizations.”⁷⁷ Cross-border or transnational funding is only made possible with EU means.

A more general point of criticism made by stakeholders in NRW is that the administrative procedures related to R&D funding on the state and European level are “rigid” and “not user-friendly”.⁷⁸ Regarding national funding programs, the digitization of financial procedures, for example, related to making the request of refunding expenses for a project, would greatly reduce the administrative burden on the participating parties in a research consortium.

European funding processes related to R&D programs are also characterized by a lack of user-friendliness. EU administrative procedures for reimbursing project-funded expenses to participants, for example, is a cumbersome affair. For applicants it often takes many months, and sometimes more than a year, for large purchases (e.g. machinery) to be reimbursed by the European Commission. Beneficiaries of subsidies that participate in projects that are funded or co-funded with EU finances complain of “a disincentive” or even outright “discouragement” to advance awarded sums due to lengthy reimbursement procedures.⁷⁹

77 Interview NRW-official, 12 December 2018.

78 Interview NRW-official, 18 January 2019, Interview NRW-official, 12 December 2018, Interview German funding expert, 14 December 2018.

79 Dutch EU funding expert, 6 February 2019.

3.3 Conclusion

This chapter has provided an overview of the volume of funding and the subject areas that are supported by the federal state governments. State government energy R&D funding is aimed at supporting local and regional businesses and research organizations in carrying out applied and market-ready research.

State government funding contributed more than a quarter of general government expenditure in the field of non-nuclear energy R&D in 2016. General energy R&D, energy efficiency, PV, wind and storage are key subject areas for funding.

Due to economic and political relevance, as well as the geographical proximity to the Netherlands, the second part of this chapter focused on NRW's energy landscape, stakeholders, focus and funding of energy R&D.

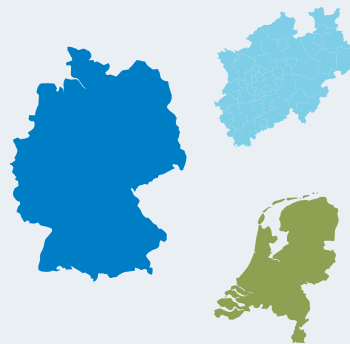
The section on focus pointed out energy-transition related technologies as well research efforts related to the broader cultural and economic aspects of the energy transformation. The latter includes democratic participation and individual acceptance of the vast changes related to the shift from fossil fuels to renewable energy sources.

In regard to funding, the EU's ERDF is a highly important financing instrument for NRW in combination with state and private sector means for energy R&D. Efforts are made by the current state government to further integrate or bundle funding opportunities on EU, federal and state-levels, as well as creating custom-fit energy R&D funding instruments for actors in NRW.

The chapter concludes that without EU means, NRW efforts in energy R&D stop at the border.

4. Dutch-German Energy R&D Cooperation: Practices and Opportunities

This chapter looks at the different facets of the energy relationship between the Netherlands and Germany. This includes common themes of R&D interest and a prominent example of cross-border energy cooperation between NRW and the Netherlands. The chapter includes a review of several barriers and opportunities for improving Dutch-German cooperation in energy R&D.



In the context of the Paris Agreement commitment of achieving a 95% CO₂ emission reduction by 2050 and the targets in the EU 2030 Climate and Energy Framework, there is a certain clarity about the overall direction of the European energy transition pathway in the coming decades. This direction is about decarbonization, energy efficiency and system integration through the interplay of renewable electricity production and the conversion of ‘green electrons’ into ‘green molecules.’ The latter occurs through “a strong growth of solar and wind power in combination with the development of power-to-gas (P2G) (hydrogen) conversion, the production of chemicals and liquid fuels, and the development of energy storage.”⁸⁰ All this needs to happen in bulk quantities for the power, heating, industry and mobility sectors.

In this context, the Dutch and German governments agreed in 2016 to step up their collaboration on energy R&D for the transition to a low-carbon energy supply. The official press statement of these high-level Dutch-German government talks stated that: “On both sides of the border, businesses, knowledge institutions and government bodies work closely together on developing innovative solutions. This has generated many cross-border partnerships.”⁸¹

80 Tennet and Gasunie, “Infrastructure Outlook 2050” (Tennet & Gasunie, February 15, 2019), https://www.tennet.eu/fileadmin/user_upload/Company/News/Dutch/2019/Infrastructure_Outlook_2050_appendices_190214.pdf.

81 Dutch Ministry of Foreign Affairs, “The Netherlands and Germany Strengthen Collaboration on Innovation” (Government.nl, April 26, 2016), <https://www.government.nl/latest/news/2016/04/26/the-netherlands-and-germany-strengthen-collaboration-on-innovation>.

This chapter analyzes important facets of the Dutch-German cross-border energy relationship. This includes energy themes of common interest and cross-border R&D cooperation practices. Due to the economic and political relevance for the Netherlands, as well as geographical proximity, particular attention is paid to Dutch cross-border energy relations with NRW.

4.1 Dutch-German Energy Relations

As neighboring countries, The Netherlands and Germany are close partners in the field of energy. Bilaterally, the German Federal Government is in close exchange with the Dutch Government on the decreasing availability of low calorific gas (L-gas) following seismic activity in the Dutch region of Groningen. This dialogue also includes measures to reduce the need for L-gas and L-gas production in the Netherlands as well as to increase large-scale and sustainable hydrogen as a successor to L-gas.⁸²

Second, the Dutch and German power markets are heavily interconnected as highlighted by the substantial electricity exchange between the two countries (Figure 19 and Table 9).

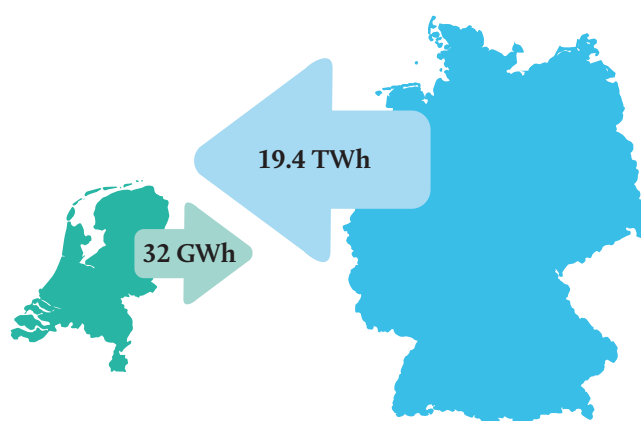


Figure 19: Dutch-German electricity exchange 2018 (source: HCSS based on ENTSO-E in Fraunhofer Energy Charts, 6 January 2019).

	2011	2012	2013	2014	2015	2016	2017	2018
Germany-Netherlands	9.6 TWh	20.5 TWh	24.6 TWh	24.3 TWh	24 TWh	15.8 TWh	14.2 TWh	19.4 TWh
Netherlands-Germany	3.2 TWh	1.6 TWh	340 GWh	348 GWh	338 GWh	189 GWh	422 GWh	32 GWh

Table 9: Electricity exchange between Germany and the Netherlands (source: ENTSO-E in Fraunhofer Energy Charts).

82 Deutscher Bundestag, "Antwort der Bundesregierung auf die kleine Anfrage der Abgeordneten Otto Fricke, Christian Dürr, Dr. Stefan Ruppert, Weiterer Abgeordneter und der Fraktion der FDP – Drucksache 19/2661 Die Deutsch-Niederländischen Beziehungen" (Deutscher Bundestag - 19. Wahlperiode, July 12, 2018), <http://dipbt.bundestag.de/doc/btd/19/033/1903385.pdf>.

In regard to multilateral initiatives, the Netherlands and Germany have cooperated within the framework of the Pentilateral Energy Forum since 2005. This Forum is the framework for regional cooperation in Central Western Europe (i.e. Austria, Belgium, Germany, France, Luxembourg, Netherlands and Switzerland) that works towards improved electricity market integration and security of supply.⁸³

Germany and the Netherlands are also engaged in a range of energy research projects in the North Sea Region (Figure 20).

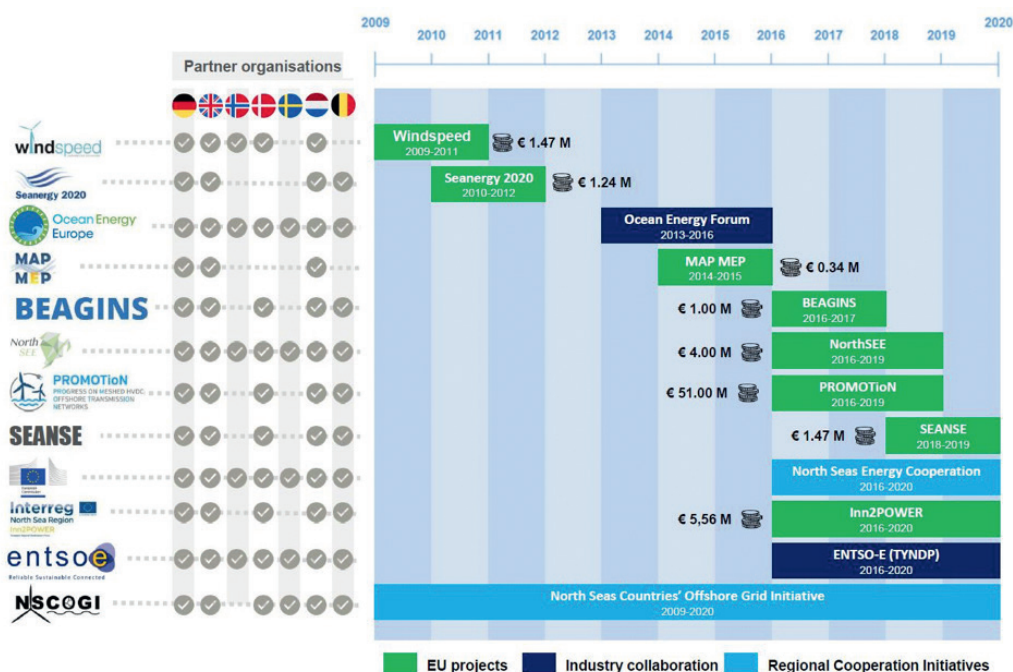


Figure 20: Transnational energy cooperation between North Sea countries between 2009 and 2020 (source: NorthSEE 2018).⁸⁴

Some of the projects mentioned in Figure 20, such as the North Seas Countries' Offshore Grid Initiative, are mentioned in the 2016 political declaration on energy cooperation between these countries. Germany, the Netherlands and seven other countries signed this non-binding agreement, which aims to further facilitate the cost-effective deployment of offshore renewable wind energy.

R&D issues mentioned in this declaration include exploring hybrid project options by linking offshore windfarms with interconnectors and potential synergies with the conventional offshore sector which include operational cooperation and the electrification of platforms.⁸⁵

83 See: <http://www.benelux.int/nl/kernthemas/holder/energie/pentilateral-energy-forum>.

84 <https://northsearegion.eu/northsee/e-energy/transnational-energy-cooperation-between-north-sea-countries/>

85 "Political Declaration Energy Cooperation between the North Seas Countries" (Luxembourg, June 6, 2016), http://www.benelux.int/files/9014/6519/7677/Political_Declaration_on_Energy_Cooperation_between_the_North_Seas_Countries.pdf.

4.2 Themes of Common Interest

The largest share of German and Dutch government expenditure in energy R&D was in renewable energies and energy efficiency. Figure 21 visualizes this focus in terms of absolute government spending.

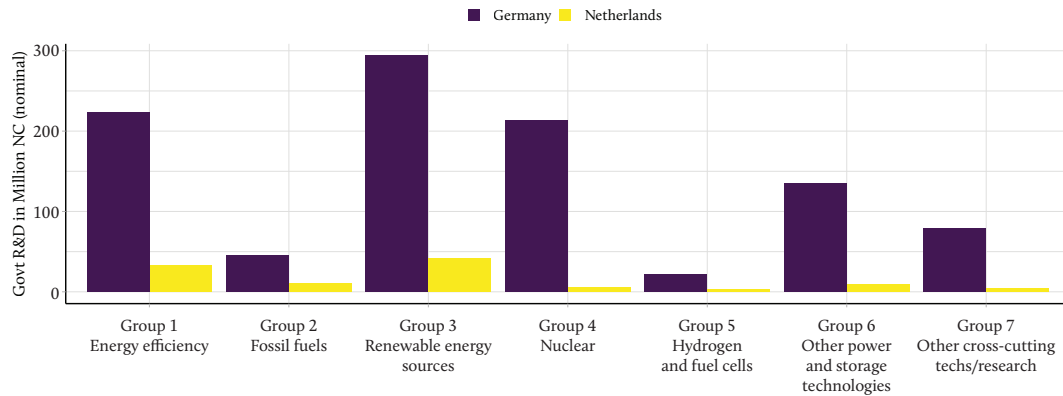


Figure 21: Government spending on R&D in Germany (Federal) and the Netherlands (national government) in 2017 (source: HCSS based on IEA Energy Data Services, 2019).

Due to the vast differences in terms of geographical size, population, and GDP, the comparison in absolute spending between the Netherlands and Germany is, of course, of limited relevance.

More relevant here is mentioning here some of the energy technologies and subject areas that are of cross-border interest to both Germany and the Netherlands. These include bioenergy, smart grids, mobility, storage, hydrogen and district heating.

To elaborate further on these general remarks, Table 10 makes a quantitative comparison of technologies and parts of the energy supply chain. This is based on the (preliminary) Dutch climate agreement and the 7th Federal Energy Research Program (ERP).

Energy R&D in the 7 th Federal ERP	Energy R&D in the Dutch Climate Agreement
Power generation: Photovoltaics Wind power Bioenergy (includes biomass-based CHP) Geothermal Hydropower and marine energy Thermal power plants	Photovoltaics Wind power (onshore but especially offshore) Bioenergy (including biogas) Geothermal
Energy transition in consumption sectors: Buildings and neighborhoods Industry, commerce, trade and services	Energy efficient buildings and neighborhoods Process efficiency, electrification /green hydrogen, power-2-heat CO ₂ technologies for industries

Energy R&D in the 7 th Federal ERP	Energy R&D in the Dutch Climate Agreement
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<p>System integration:</p> <ul style="list-style-type: none"> Sector coupling and hydrogen (incl. power-to-x) Electricity grids Energy storage 	<ul style="list-style-type: none"> Hybrid energy systems Sector coupling and hydrogen (incl. power-to-x) Demand side management, smart grids Energy storage and conversion (e.g. CO₂, electricity, gas, and hydrogen)
<p>Cross-system research topics for the energy transition:</p> <ul style="list-style-type: none"> Energy system analysis Digitization of the energy transition Resource efficiency for the energy transition CO₂ technologies for the energy transition Energy transition and society Materials research for the energy transition 	<ul style="list-style-type: none"> Energy systems analysis and multi-stakeholder decision making Digitalization of the energy transition and supply chain Transformation of the energy system in a socially acceptable manner

Table 10: Energy R&D in the German ERP and Dutch climate agreement.

In summary, in all parts of the energy supply chain there are plenty of topics of common interest in Dutch-German energy R&D. These are summarized in Figure 22.

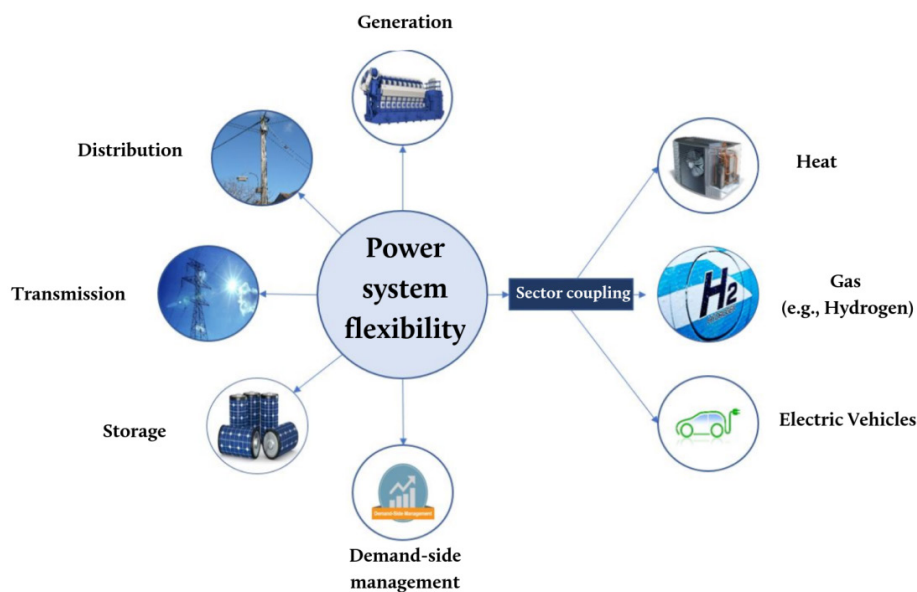


Figure 22: Flexible Power System & sector coupling (source: IRENA, 13 November 2018)⁸⁶.

Regarding energy transport and conversion, two electricity and gas TSOs in Germany and the Netherlands, i.e. Tennet and Gasunie, recently outlined an integrated energy infrastructure design for both countries. This is based on the assumption that electricity and gas are the main energy carriers by 2050 and that coupling power and gas grids gives the energy system valuable flexibility and transport capacity. “For the

⁸⁶ IRENA, “Making Power Systems More Flexible as Global Energy Transition Accelerates,” IRENA.org, November 13, 2018, /newsroom/articles/2018/Nov/Making-power-systems-more-flexible-as-global-energy-transition-accelerates.

Netherlands, this gas infrastructure is expected to transport hydrogen, bio-methane and imported natural gas. For Germany, it is expected to transport hydrogen, bio-methane and domestic or imported synthetic CO₂ neutral methane.”⁸⁷

Creating a connection between the power grid and the gas grid with its ample storage and transport capacity, power-to-gas (P2G) conversion is a key technology of common interest (see Figure 23). Essential for system integration and energy efficiency, P2G allows the conversion of volatile electricity into renewable, synthetic gases (H₂ or SNG) – with an unmatched low carbon footprint – which can be stored (large-scale), transported and commercialized for mobility (green, renewable synthetic fuels) and industrial markets (green chemistry).⁸⁸

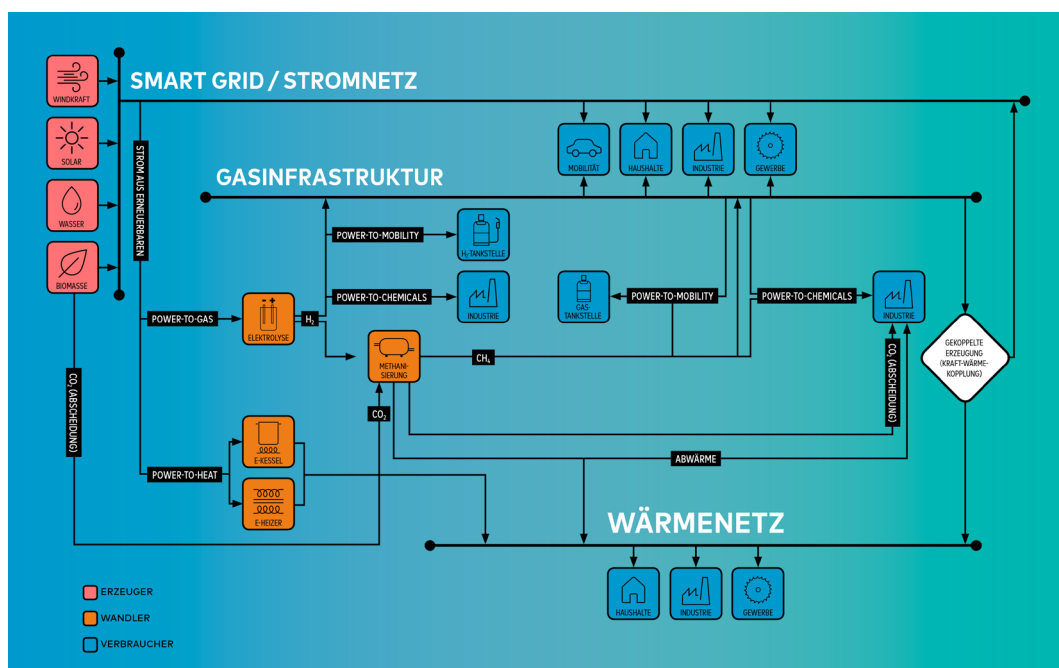


Figure 23: Power-to-x applications (source: BDEW 2017).

Another example constitutes cross-border energy R&D themes for the Dutch and German chemical industry. The first trilateral strategy for this flagship industry by the governments of NRW, the Netherlands and Flanders talks of combining efforts in energy R&D. This to allow for the connection of the renewable energy sector to the chemical industry and support the conversion of renewables to heat, hydrogen and chemicals.⁸⁹

87 Tettet and Gasunie, “Infrastructure Outlook 2050.”

88 Wolfgang Beez, “The Future of Power-to-Gas Couldn’t Be Brighter,” *Renewable Energy World*, February 20, 2018, <https://www.renewableenergyworld.com/articles/2018/02/the-future-of-power-to-gas-couldn-t-be-brighter.html>.

89 Dr. Jan-Philipp Kramer et al., “Trilateral Strategy for the Chemical Industry” (Ministry of Economic Affairs, Innovation, Digitalisation and Energy of the State of North Rhine-Westphalia, 2017), https://www.wirtschaft.nrw/sites/default/files/asset/document/trilateral_strategy_chemical_industry.pdf.

Key measures for collaboration include developing a common trilateral approach for a competitive energy cost position and expanding cross-border availability of alternative feedstocks. Table 11 mentions some key topics related to these measures.

Develop a common trilateral approach for a competitive energy cost position	Expand cross-border availability of alternative feedstocks
<p>Possible actions:</p> <ul style="list-style-type: none"> Adapting chemical processes to fluctuating energy supply and allow flexible demand-side management of the power grid. Invest in long-term storage possibilities to compensate for the volatile impact of renewable energies, incl. P2G and power-to-chemicals (see Figure 23). 	<p>Possible actions:</p> <p>Scale up technologies for the production of sustainable chemicals.</p>
<p>Region-wide demand-side management by the chemical industry. <i>Examples of existing projects mentioned here include 'Voltachem' (TNO and ECN) and 'Power-to-X' (RWTH Aachen, research centers of Jülich and Dechema).</i></p>	<p>Transport, handling and storage of sustainable raw materials flows (biomass, CO₂, agricultural food and waste). <i>Example: German-Dutch INTERREG-project 'Study on the biomass potential of the cities Krefeld and Venlo'.</i></p>

Table 11: Strategic measures for the energy industry in the trilateral region (source: Kramer et. al 2017).

4.3 Cross-Border Energy R&D: the Netherlands and NRW

4.3.1 Introduction

The Netherlands is NRW's most key trading partner.⁹⁰ With a volume of 1.271 billion EUR in 2016 the Netherlands is NRW's most important export market for sustainable and resource-efficient energy and environmental technology (EET).⁹¹ EET includes products and services in sectors such as renewables (bioenergy, solar, geothermal, wind), bio-based economy (materials, processes, techniques), sustainable transport (e-mobility, batteries, bio-fuels, hydrogen, charging infrastructure), grids, energy efficiency, storage and circular economy.⁹²

Conversely, NRW is the largest importer of Dutch products and services within Germany.⁹³ Regarding EET, the Netherlands distinguishes itself in the field of IT related to smart housing and smart driving. For example, many German car companies import 'smart equipment' from the Netherlands.⁹⁴

90 Stephanus Lintker et al., "Niederlande - International - EnergieAgentur.NRW" (EnergieAgentur.NRW GmbH, August 2017).

91 Oliver Lühr et al., "Umweltwirtschaftsbericht Nordrhein-Westfalen 2017" (Ministerium für Umwelt, Landwirtschaft, Natur- und), p. 14 accessed August 2, 2018, https://www.umwelt.nrw.de/fileadmin/redaktion/Broschueren/uwb_2017.pdf.

92 Lühr et al., p. 11.

93 Harry de Vries et al., "Grensoverschrijdend Samenwerken in de Energietransitie (Cross border cooperation in the energy transition)" (North Rhine Westphalia: Stichting kiEMT, 2015), pp. 5-6.

94 De Vries et al., p. 22.

Both regions are approximately the same size (Figure 24). Both NRW and the Netherlands share similarities in terms of large energy, industrial producing and supplying sectors, high population density and a vocal civil society.

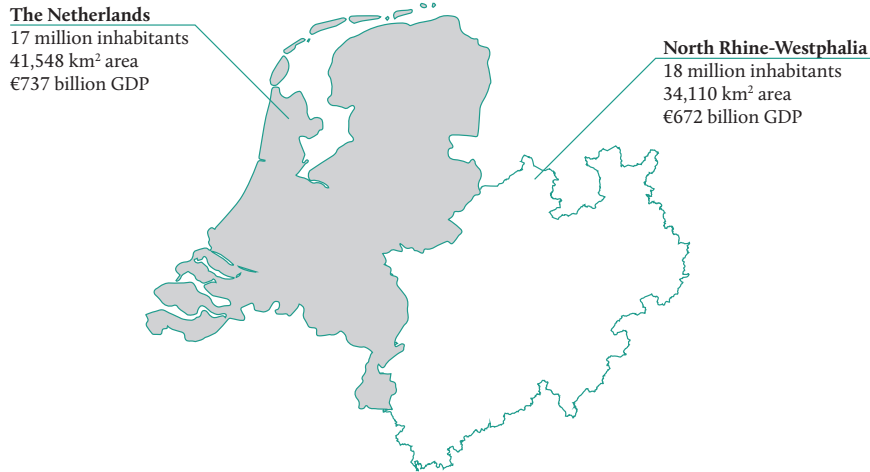


Figure 24: The Netherlands and North Rhine-Westphalia (source: HCSS 2018 and De Vries 2015).

4.3.2 Cross-Border Cooperation in Energy R&D: Practices and Barriers

Strong economic interdependency is one of the main drivers of the close political cooperation between the governments of the Netherlands and NRW. Joint Declarations of Intent between the two governments from 2003 and 2008 formulate several strategic objectives. These objectives include stimulating and facilitating cross-border cooperation in topics of strategic interest among partners throughout NRW and NL. The aim of cross-border cooperation is “to increase greater synergies and develop more coherent policies”⁹⁵, and improve “exploitation of R&D funding opportunities, particularly within the EU.”⁹⁶ The 2008 Declaration speaks of coordinated action between the NL and NRW in energy R&D via establishing a joint Coordination Group on Energy (CGE) with members from the Dutch and NRW Ministries of Economic Affairs and the NRW Energy Agency.⁹⁷ The tasks mentioned in energy R&D include strengthening cooperation in different technological fields such as buildings, hydrogen and fuel cells, smart electrical grids and storage, clean mobility and process intensification. Regarding shared funding, “CGE will investigate and when possible implement a first joint NL-NRW funding [set-up] in the field of photovoltaic

95 Landesregierung NRW and Regierung der Niederlande, “Gemeinsame Absichtserklärung zur Fortsetzung der Verstärkung der Strategischen Zusammenarbeit in den Bereichen Wissenschaft, Forschung, Technologie und Innovation zwischen der Regierung der Niederlande und der Landesregierung von Nordrhein-Westfalen” (Maastricht, March 2, 2005).

96 Landesregierung NRW and Regierung der Niederlande., p. 2, p. 9.

97 Landesregierung NRW and Regierung der Niederlande, “Appendix - Gemeinsame Absichtserklärung zur Fortsetzung der Verstärkung der Strategischen Zusammenarbeit in den Bereichen Wissenschaft, Forschung, Technologie und Innovation zwischen der Regierung der Niederlande und der Landesregierung von Nordrhein-Westfalen” (Maastricht, April 17, 2008).

R&D”⁹⁸, and “further joint funding on other themes (for long term research, short & medium term R&D or demonstration projects).”⁹⁹

Increasing cooperation in energy-related themes was also on the agenda during the first high-level dialogue between the two governments in November 2018. With the participation of the prime ministers from both NRW and NL, agreement was reached to continue, and in some cases intensify, cross-border efforts in promoting sustainable mobility and a sustainable hydrogen economy. The communiqué speaks of intensifying cross-border cooperation on hydrogen in terms of cross-border infrastructure projects financed with EU means, specifically the Connecting Europe Facility (CEF), joint EU initiatives and projects, bilateral coordination of future strategies, and roadmaps and exchange between companies on a joint activity (see Table 12).¹⁰⁰

Connecting Europe Facility (CEF – Energy): *Under the CEF, for the period 2014–2020, around 5.85 billion EUR is available for trans-European energy infrastructure projects, i.e. gas pipelines, transmission grids, LNG terminals, gas storage, and smart grids. For the period 2021–2027, with a proposed budget of 8.7 billion EUR, CEF further backs trans-European energy network infrastructures as well as fostering, for the first time, Member State cooperation on cross-border renewable energy technology projects.*

Table 12: Connecting Europe Facility (source: European Commission, 6 June 2018).

As proposed in the 2008 Declaration, a NL-NRW conference on energy R&D has been organized twice so far, in 2012 and 2016. These combined energy conferences informed participants about practices and policy developments while reviewing the impact and business opportunities of new technologies in the energy market.¹⁰¹ These conferences aimed to intensify cooperation between companies and scientific institutions from both sides and offer a platform for joint projects and activities. On the one hand, the 2016 conference pointed out major opportunities for cross-border collaboration in energy R&D issues such as smart grids, mobility, storage, hydrogen and geothermal. On the other, the conference turned out to be a gathering during which stakeholders from NRW and the Netherlands came to inform the audience about a specific energy project or approach in a city or region on either side of the

98 Landesregierung NRW and Regierung der Niederlande., p. 10.

99 Landesregierung NRW and Regierung der Niederlande., p. 10.

100 Die Landesregierung Nordrhein-Westfalen and Koninkrijk der Nederlanden, “Kommuniqué des ersten Regierungsdialogs zwischen den Niederlanden und Nordrhein-Westfalen” (Die Landesregierung Nordrhein-Westfalen, November 19, 2018).

101 Dr Frank-Michael Baumann and Barto Piersma, “Welcome to the 2nd Combined Energy: November 21st, 2016, in Neuss” (EnergieAgentur.NRW GmbH, November 21, 2016), https://www.energieagentur.nrw/content/anlagen/einladung_combined-energy_FINAL.PDF.

border. In addition to the national focus, what was lacking was a clear cross-border perspective and suggestions to extend or shape innovations with stakeholders. The ambition to offer a platform for joint projects and activities was limited to two presentations: one on a EU-funded “cross-border collaboration in the energy transition”¹⁰² project and one on “incentives and financing options for (joint) projects in NRW and NL.”¹⁰³

This points to the fact that, despite increased political support for closer cooperation in energy R&D, there are some substantial social-economic barriers in cross-border cooperation between stakeholders from NRW and NL.

Cross-border stakeholders such as SMEs and research organizations have pointed to the following barriers specifically:

- Difficulties in finding the right partners, establishing consortia and carrying out projects.
- Vast legal, subsidy and legislation differences.
- Attracting appropriate financing or funding.
- Cultural differences.
- The limited coordination of cross-border activities, which impede the effectiveness of the cooperation.

First, several research organizations and businesses have indicated that it is often difficult to find the right cooperation partner on the other side of the border. They point to the importance of an “experienced [cross-border] facilitator [or project manager] who can support consortia and project formations by connecting the right parties and mediating in agreements”.¹⁰⁴

Second, regarding subsidies, and in comparison to the long-term and more strategically focused German Energy Research Programs, the Dutch energy R&D approach is viewed as short-term focused and politically-biased. The long-term German approach offers businesses and research organizations more certainty towards the future.¹⁰⁵ Yet German subsidies are more characterized by bureaucratic rigidity and lack of user-friendliness. This is perceived as being less the case in the Netherlands.¹⁰⁶

Third, regarding attracting the appropriate financing, a clear difference with the Netherlands is that, in Germany, there is little policy for start-ups and entrepreneurship.

102 Maarten de Vries, “Cross-Border Collaboration in the Energy Transition” (November 21, 2016).

103 Benno Weissner, “Incentives and Financing Options for (Joint) Projects in NRW and NL” (November 21, 2016).

104 De Vries et al., “Grensoverschrijdend Samenwerken in de Energietransitie (Cross border cooperation in the energy transition).”, p. 34.

105 De Vries et al., p. 35.

106 Interview Maarten de Vries, former Project Manager at kiEMT, 13 December 2018. Interview NRW stakeholder, 19 December 2018.

Germany also has a lack of public pre-seed and proof-of-concept funds to help start-ups and innovative entrepreneurs take the first steps. The Netherlands, in contrast, has various instruments for early phase financing. Next to these differences, entrepreneurs on both sides of the border indicate that they have a financing gap and are looking for financial means. In both countries, the importance and share of alternative financing is growing. Both in the Netherlands and in Germany there is the challenge to break through a lack of funding.¹⁰⁷

Fourth, although there is no 100% ‘German’ or ‘Dutch’ culture, there are differences to indicate. When stakeholders are not aware of this it can lead to misunderstandings and ineffective cross-border cooperation (see Table 13).

Dutch culture	German Culture
Less hierarchical, less formal	More hierarchical, more formal
Greater focus on well-being, personal relationships, solidarity and consensus	Greater focus on success, status, ambitions and resoluteness
<ul style="list-style-type: none"> • Academic titles are usually omitted • Equality, status is of limited importance • Everyone needs to have their say, every opinion counts • You (informal pronoun) 	<ul style="list-style-type: none"> • Academic titles carry weight • Differences are natural, status is important • Decisions are left to higher levels of authority • You (formal pronoun)
<ul style="list-style-type: none"> • Higher tolerance for uncertainty, emphasis on trust • Dutch entrepreneurs want ‘to do business quickly’ • Less ‘bureaucratic’ or paper-driven processes, more digitized • Project collaboration: focus more on common trust, less on formalities 	<ul style="list-style-type: none"> • Lower tolerance for uncertainty, emphasis on control • German entrepreneurs are more reserved before engaging in a business venture • More ‘bureaucratic’ or paper-driven processes, focus on proof • Project collaboration: focus more on clearly defined goals and processes
Energy transition: primarily economic drivers (general public, industry, government)	Energy transition: economic and environmental drivers (general public, industry, government)
More short-term driven goals	Long term vision and planning, e.g. roadmaps
A decentralized and pragmatic approach <ul style="list-style-type: none"> • Government/politics more a facilitating role 	A more central, top-down approach <ul style="list-style-type: none"> • Government/politics stronger initiating role
Civil service (in general less technical background)	Civil service (in general more technical background)

Table 13: Schematic overview of cultural differences between Dutch and German societies (De Vries 2015).

Finally, the coordination of cross-border activities is limited. “There is little synergy and coordination between different initiatives. A lot of information – for example in the area of regional subsidies – is only available in one language and is difficult to access for parties on the other side of the border.”¹⁰⁸ Another aspect is that many

107 De Vries et al., p. 37.

108 De Vries et al., p. 46.

cross-border partnerships are project-based, which means that collaborations are mostly finite. This means that accumulated knowledge is not followed-up on in a structured manner and is hence often lost. Project managers indicate that they are struggling to ‘institutionalize’ accumulated knowledge so that a more long-term effect can be brought about.¹⁰⁹

4.3.3 NRW-NL Cross-Border Cooperation and EU INTERREG

Despite the governments of the Netherlands and NRW pronouncing the ambition in 2008 to establish a joint NL-NRW funding program for energy R&D, this initiative has not yet materialized. Since then, however, the ambition hasn’t waned. In 2013, Dr. Frank-Michael Baumann, Director of the Energy Agency NRW, expressed the wish to achieve closer cooperation in energy between North Rhine-Westphalia and the Netherlands. A subsequent report from 2015 proposed a cross-border program in terms of closer cooperation between existing organizations from NL and NRW. This closer cooperation was to be carried out with organizations experienced in energy transition issues such the Kiemt Foundation in the Netherlands and the Energy Agency in NRW, and through projects financed with European means under INTERREG Germany-Netherlands (see Table 14).

INTERREG, officially “European territorial cooperation,” is part of the European Structural and Investment Funds (ESI funds) of the EU. ESI funds support transnational cooperation between regions, towns and cities, for example in the fields of transport and energy.

INTERREG is realized within three key areas (so-called strands):

- **Cross-border cooperation** (Strand A): Advancing economic and social cooperation in adjacent border regions.
- **Transnational cooperation** (Strand B): Promoting cooperation between national, regional and local partners in transnational program areas in order to increase the territorial integration of these areas.
- **Interregional cooperation** (Strand C): Promoting cooperation networks and exchange of experiences in order to improve the efficiency of existing regional development and cohesion instruments.

For the Dutch-German cross-border region, during the period **2014-2020**, there is a budget available of approximately **440 million EUR**.

Set-up: Funding of projects always consists of a personal contribution of the partners, EU-grant funding, and often national and regional grant funding (e.g. ministries and provinces).

Table 14: INTERREG (sources: interreg.de and deutschland-nederland.de).

109 Interview Maarten de Vries, former Project Manager at kiEMT, 13 December 2018,

The result was that closer cross-border cooperation with these and other actors was carried out with the use of EU funds and via two specific projects, i.e. Clean Energy Crossing and EnerPRO (Table 15).

Cleantech Energy Crossing ¹¹⁰

Strand: INTERREG V A.

Period: 2017-2020.

Budget: 4,8 mill. EUR.

Lead Partners: Energy Agency NRW and Kiemt Foundation.

Description: Cleantech aims to drive product innovations in the field of battery technology and heating and cooling technology. The focus on these themes is due to the fact that the built environment is responsible for 30-40% of total energy consumption in Germany and the Netherlands. The energy transition in the built environment is not easy: New and renewable technologies have to compete against existing (and often cheaper) fossil alternatives and present new challenges to the existing energy infrastructure. To achieve the climate goals of both countries there is a need for the development of market-oriented customer products which reduce the energy consumption and/or make it more sustainable. The geographic focus of this project is aimed at the border of NRW with the Dutch provinces of Overijssel, Gelderland, Brabant and Limburg.

Funding: Next to EU funding, contributors include the Dutch provinces of Gelderland, Limburg, North Brabant, NRW and the Dutch Ministry of Economic Affairs.

EnerPRO ¹¹¹

Strand: INTERREG V A.

Period: 2018-2021.

Budget: 4,23 mill. EUR.

Lead Partner: Center for Innovative Energy Systems of the University of Applied Sciences, Düsseldorf.

Description: EnerPRO focuses on cross-border cooperation processes for SMEs with the purpose to develop innovative products in the field of decentralized renewable energy production and storage as well as energy efficiency technologies. The project is targeted at technology developments in the fields of low energy consumption and CO₂-emission savings. This encompasses solar technologies, PV, fuel cell and hydrogen technologies, energy storage, system integration of renewables and e-mobility. The developed technology innovations will contribute to an increased share of renewables in the energy mix of the region, which will add mutual cross-border value. Therefore, the EnerPRO-project will have a significant impact on fulfilling the climate protection goals of the NL and NRW.

Funding: Next to EU funding, contributors include the Dutch provinces of Gelderland, Limburg, North Brabant, the NRW Ministry of Economic Affairs and a group of more than 50 SMEs from NL and NRW.

Table 15: NL-NRW INTERREG-projects Cleantech Energy Crossing and EnerPRO.

110 See: <https://www.kiemt.nl/programmas/cleantech-energy-crossing/>.

111 See: <https://www.deutschland-nederland.eu/nl/project/enerpro-2/>

INTERREG is a widely-used subsidy instrument by SMEs and research institutions in NRW and the NL in support of cross-border energy R&D consortia. Nonetheless, INTERREG is criticized by stakeholders as “too much of a political instrument.”¹¹² Resonating with the description of Dutch subsidy policy as short-term and politically-biased, criticism from Dutch stakeholders is that regional and local governments use INTERREG as an extension of their own political ambitions. Governments from provinces benefit local research organizations and SMEs within their respective constituencies, independent of whether this organization is most suited or has the best expertise in the specific field of energy R&D.¹¹³

A solution could be to make Dutch subsidy policy less politically-biased. One suggestion is to establish a joint funding scheme consisting of all the energy R&D means of the Dutch provinces. An independent expert committee could evaluate and award research proposals from SMEs and research organizations with means from this scheme; based on quality rather than on short-term political preferences of local governments.¹¹⁴

Another suggestion is to establish a Dutch equivalent of the long-term and strategically more focused German Energy Research Programs. A more long-term and programmatic set-up could include systemic approaches such as Kopernikus, Living Labs and the Smart energy showcases SINTEG program. This long-term oriented and programmatic set-up stands in contrast to the currently “small-scale and fragmented approach of the energy programs of the Dutch government.”¹¹⁵ Instead of a long-term and strategic-focused energy R&D program, newly elected Dutch governments usually start with drafting their own approaches. As a result, the first year of each cabinet period is usually spent with drawing up new programs which undermines the focus and stability of an energy R&D framework.¹¹⁶

In the same vein as making national funding less politically-biased, an INTERREG program or similar subsidy program for which all program partners release funds for the entire period would make the implementation of this much less susceptible to political ‘winds of change’ or ‘change of the guards’.¹¹⁷ The latter refers to the fact that there are usually several elections during the implementation of a joint program, all of which influence the optimal execution of a joint research program.

112 Interview Maarten de Vries, former Project Manager at kiEMT, 13 December 2018. Interview with NRW-stakeholder, 14 December 2018.

113 Interview Maarten de Vries, former Project Manager at kiEMT, 13 December 2018. Interview with NRW-stakeholder, 14 December 2018.

114 Interview Maarten de Vries, former Project Manager at kiEMT, 13 December 2018.

115 Interview Dutch senior stakeholder from the gas industry, 20 January 2019.

116 Interview Piet Boomsma, Regional Program Manager, INTERREG Germany-Netherlands, Rhine-Waal Euroregion, 20 December 2018.

117 Interview Piet Boomsma, Regional Program Manager, INTERREG Germany-Netherlands, Rhine-Waal Euroregion, 20 December 2018.

4.4 Conclusion

Germany and the Netherlands are important energy partners on the bilateral level as well as in multilateral initiatives. By identifying a wide range of technologies and subject areas, this chapter has identified multiple opportunities for cross-border cooperation between Dutch and German stakeholders in energy R&D. In other words, in areas all along the energy supply chain there are clear opportunities to strengthen the common Dutch-German approach.

In addition, this chapter has pointed out some generic themes that one country can specifically learn from the neighboring country. Germany can learn from the wider availability of financial means for early-stage energy R&D; the Netherlands from the long-term, more structured and strategically-focused German policy approach in this field.

With focus on the Netherlands and NRW this chapter recognized various stumbling blocks or barriers in (entering into) cross-border cooperation in energy R&D. These barriers include difficulties in finding the right partners, as well as cultural, legal and subsidy differences. Furthermore, a lack of financial resources can impede R&D innovation and realization. Particularly noted here is the political 'fickleness' of the Dutch energy subsidy system. In comparison to the German approach, this is furthermore characterized by a short-term focus. Also, coordination of cross-border energy R&D activities are described here as being limited to 'stopgap' project-based cooperation and lacking institutional continuity.

A call for closer cooperation between the governments of the Netherlands and NRW in 2008 was not matched by practical implementation. Instead of a truly combined and institutionalized approach, bilateral cooperation between existing organizations across borders is 'patched together' with EU funds, in this case the INTEREG Germany-Netherlands program.

Concerning the financing of research programs in the areas of the energy sector or the extension of energy-related infrastructure, the EU provides several funding programs and lending schemes to help companies, regions, and countries successfully implement energy projects. Nevertheless, and in the context of the need to speed-up the energy transition in a more cost-effective manner, it may be required to supplement EU-funded, cross-border projects with a more permanent and institutionalized collaboration between the Netherlands and Germany on both the federal and state-level.

In the context of securing and continuing energy R&D in the long term, this chapter pointed out the importance of starting a program that can take on these tasks for many years. By establishing a program for five to ten years, such as the ERP or

Kopernikus in Germany, one can realize continuity and, moreover, guarantee the institutionalization of gained research knowledge. This makes it possible to arrive at a more constructive cross-border energy R&D cooperation. By building on existing structures and organizations, this continuity is only partly guaranteed but needs to be expanded and institutionalized further. As a starting point for a much more consistent bilateral approach, EU-funded projects could be complemented with a common and permanent 'energy priority program'. This program would be funded with national means from both countries and would award funding based on merit, independent of nationality.

5. Conclusions and Strategic Lessons

Germany is the European leader in renewable energy patenting. Its government programs for energy R&D are generally characterized by a long-term and coherent approach, a well-consulted and strategic vision, and large amounts of funding. Germany's government-funded energy R&D is geared towards the implementation of the countries' energy transition goals. With this aim in mind, the government's multi-annual energy R&D policy is characterized by a programmatic approach and is hence a strategic element of Germany's energy policy. Table 16 lists the main pros and cons of 'energy R&D made in Germany'.

Energy R&D Made in Germany
<p>Pros:</p> <ul style="list-style-type: none">• Germany is the European leader in renewable energy patenting.• Germany is the European top performer in public-private R&D cooperation.• German energy programs are generally characterized by a long-term approach, a well-consulted and strategic vision, and a provision of sufficient funding.• Germany has a strong R&D focus on energy transformation, i.e. the major social, economic and political implications of the transformation of the energy system which go well beyond the energy sector. This includes systemic and societal approaches in energy research. <p>Cons:</p> <ul style="list-style-type: none">• Startups are key actors in making energy R&D market-ready yet have only recently been recognized in German government policy.• There is a lack of financing means for early-stage energy R&D.• Experiences with research funding in long-term programs such as Kopernikus have proven to be rather bureaucratic.

Table 16: Summary of the pros and cons of German energy R&D policy.

On the federal level, the Ministries for Economic Affairs, Education and Research, and Food and Agriculture cover the entire energy R&D policy chain, i.e. from fundamental research to market-ready-applications. This closely coordinated, inter-ministerial and joint programmatic approach for project funding aims to underscore the coherence of the Federal Government's energy R&D efforts. The decision-making by these ministries is to a large extent determined by strategic input from a diverse group of 'knowledge stakeholders' from the scientific and business communities. Next to utilities and transmission system operators, scientific institutions and the so-called Energy Research Networks, which are mentioned in Chapter 2, are among the 'high-power, high-interest' stakeholders of German energy R&D policy.

Key strategic goals of government R&D policy on both the federal and state-level is to accelerate the expansion of renewables, increase efficiency, expand the usage of smart infrastructure, and secure energy supply. Particular attention is paid by the German government to the energy transformation, i.e. in terms of social impact, acceptance and participation by the general public.

This wide range of strategic aims connects with the fact that the German government has recently broadened its R&D focus, i.e. from project funding centered on individual technologies towards a systemic, energy transition approach. This includes regulatory instruments such as Living Labs.

Regarding the strategic decision-making process in Germany's publicly-funded energy R&D, Chapter 2 paid particular attention to 12 key evaluation criteria. Covering all technical, political, economic and social aspects of energy R&D, this criteria-framework is essential to understanding which specific energy technologies and innovations and/or projects are financed by the German government.

Chapter 3 pointed out that state-level funding makes up a substantial part of the overall German government expenditure in energy R&D. State-level spending is aimed at supporting local and regional businesses and research organizations in carrying out applied and market-ready research. Key subject areas for funding on the state level are general energy R&D, energy efficiency, PV, wind and storage.

Due to NRW's economic and political relevance, as well as its geographical proximity to the Netherlands, Chapter 3 looked at the energy landscape, stakeholders, focus and funding of energy R&D in North Rhine-Westphalia (NRW).

Chapter 3 pointed out energy transition-related technologies as well as research efforts of NRW's government in the broader cultural and economic aspects of the energy transformation. The latter includes democratic participation and individual acceptance of the vast social-cultural changes related to the shift from fossil fuels to renewable energy sources.

EU programs are a highly important financing instrument for NRW, this in combination with state and private sector means for energy R&D. Regarding funding, efforts are made by the current state government to further integrate or bundle funding opportunities on EU, federal, and state levels, as well as to create custom-fit energy R&D funding instruments for NRW actors.

Chapter 4 provided an analysis of bilateral energy relations, R&D themes of common interest, and practices and barriers in cross-border energy cooperation between the Netherlands and NRW. Barriers in cross-border cooperation include limited

coordination and institutionalization of activities, legal and cultural differences, as well as contrasting funding approaches.

A general conclusion drawn in Chapter 4 is that the political ambitions of the governments of NL and NRW are not matched by practical means. For example, ambitions to establish a joint NL-NRW funding scheme for energy R&D never materialized, and a ‘cross-border energy program’ was watered down to carrying out two projects with EU funds. All existing cross-border energy R&D projects are exclusively made possible with the involvement of EU funding, through which governments support their respective national stakeholders. The chapter pointed out some of the political objections attached to cross-border energy cooperation with EU funds. For the sake of guaranteeing the continuity of cross-border energy R&D, the chapter suggested that EU-funded projects should be complemented with a common ‘bilateral energy priority program’.

Strategic Lessons

All sections in this report are non-exhaustive and raise several issues that (1) are highly relevant from a Dutch perspective and (2) require more elaborate research. **Seven strategic lessons for the Netherlands that require follow-up include:**

1. **Need to step up cross-border collaboration with Germany in energy topics of strategic interest.** This report has listed a wide range of energy R&D topics that are of strategic importance to both Germany and the Netherlands. These include hydrogen, storage, mobility, geothermal, biomass, system integration, and hybrid energy (or ‘sector coupling’). Other topics that were not mentioned in this report but also fall into this category include the expansion of European electricity and gas networks and the development of a EU carbon floor price.¹¹⁸ The German government has recently expressed the desire to collaborate across ‘borders’, i.e. on a regional or European scale and in subject areas such as hydrogen and system integration. This point should be taken up by the Dutch government in terms of exploring options and best-suited approaches for engaging in cross-border cooperation.
2. **Need to step up cross-border coordination with Germany in energy R&D.** In the context of equally ambitious Dutch and German energy and climate targets, as well as the political necessity to carry out the energy transition in a more cost effective manner, this report advises to invest in political capital and financial means that would allow for more optimal coordination of national approaches in energy R&D. This includes using funding opportunities on European and national

118 Christian Flachslund et al., “Five Myths about an EU ETS Carbon Price Floor” (Brussels: Centre for European Policy Studies, December 2018).

levels in a more coherent manner and applying these to key strategic areas of the economy such as industrial research and innovation. R&D objectives of such cooperation should also be better synchronized and used in parallel with energy R&D in the EU.¹¹⁹ These efforts could form the basis for establishing a **common and permanent German-Dutch ‘bilateral energy priority program’**.

3. **Need for the Dutch government to learn from Germany’s R&D efforts in energy transformation.** As mentioned throughout this report, the term ‘energy transformation’ refers to the major social-cultural, economic and political implications of the energy transition. The ability to anticipate and understand the broader societal implications of the energy transition has been recognized as an issue of high importance by German policy-makers. The current national discussion (and falsehoods) on the Dutch climate agreement point out that the ‘energy transformation’ is a crucial field of research for translating social acceptance and public participation into effective policy proposals. So far, research outcomes in Germany contain many valuable lessons for Dutch policy-makers and stakeholders. These need to be explored further and used as input for policy decisions.
4. **Explore the possibilities of establishing a Dutch equivalent of Germany’s long-term approach in energy R&D.** Current Dutch energy R&D programs are described in this report as short-term oriented, politically-biased and provided with insufficient funding. In contrast, German energy programs are much more long-term focused and less prone to outside political influences. Further research on German energy research programs should explore more in-depth strategic lessons for Dutch policy makers.
5. **Explore participatory processes in the German energy transition.** The Netherlands can learn from the more active role of the German government in involving citizens in the energy transition in terms of participation and ownership. Improving the ease with which end users can ‘co-own’ the energy transition has not been explored in-depth in this report, but is highly relevant for strengthening broad-based, public acceptance. What this refers to is policy that promotes the public participation in renewable projects such as wind farms, allowing end users to benefit from cheap solar power and providing them with attractive financing models. German examples in this context are, for example, Federal funding programs such as the ‘landlord-to-tenant electricity supply’ or *Mieterstrom*.¹²⁰
6. **Acquire more in-depth knowledge of German state-level energy R&D.** This report has merely provided an overview of R&D funding across the 16 federal states, while briefly zooming in on energy R&D in NRW. Based on economic and political relevance as well geographical proximity to the Netherlands, further insight into

119 Glotzbach, Sauer, and Huezl, “Impulse für das 7. Energieforschungsprogramm der Bundesregierung.”, p. 7.

120 See: <http://www.buildup.eu/en/news/green-light-brussels-landlord-tenant-electricity-supply-0>.

the energy R&D practices of states such as **Lower-Saxony, Baden-Württemberg** and **Bavaria** is of strategic importance to Dutch energy R&D efforts.¹²¹

7. **Explore the multi-level, energy landscape of Germany.** This includes obtaining in-depth knowledge on issues of ownership of DSOs and TSOs (gas and power), (alternative) financing options, relationship(s) between banks, businesses, and (local/regional) governments, the R&D governance of system integration or storage, and R&D efforts in encouraging the societal aspects of the energy transition.

¹²¹ With practices we mean in terms of funding, focus, actors, regional and existing and possible cross-border collaborations and opportunities.

6. Follow-Up Action Plan (2019-2020)

2019

March:

- Publication and distribution of report “Energy R&D Made in Germany”.
- Review of the findings with Topsector Energy and Dutch Enterprise Agency.
- Plan meetings with Dutch-German stakeholders to review findings and recommendations for follow-up.

April-July:

- Attend “**Berlin Energy Transition Dialogue 2019**” (April 2019).
- Present at event related to **North Rhine Westphalia Government “Year of the Benelux 2019”**.
- Attend/host (HCSS and possibly German Embassy to the Netherlands) **Energy Dialogue Meeting** in the Hague.
- Attend meeting with stakeholders in Germany (e.g. Düsseldorf and/or Berlin).
- Establish final focus and themes for follow-up and project-consortium for follow-up policy research on Dutch-German cross-border energy cooperation.

September-December:

- Start work with consortium.
- Present (TBC) at **3rd Netherlands-North Rhine Westphalia Energy-Conference “Combined Energy”** (Arnhem, November 2019).

2020

January-March:

- First findings of consortium.
- Meeting/workshop with stakeholders.
- Present and collect information at conferences.
- Drafting and presenting of findings

April-June:

TBD

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