Florian Wittmann, Florian Roth, Miriam Hufnagl

With contributions by: Ralf Lindner, Merve Yorulmaz, Tanja Bratan, Marlene Arens, Clemens Rohde, Katrin Ostertag, Matthias Pfaff, Thomas Stahlecker, Andrea Zenker, Dorothea Steinebrunner

First Mission Analysis Report of the Scientific Support Action to the German Hightech Strategy 2025

Setting the stage:
Positioning the missions in the socio-technical system.

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Abbreviations

AI	artificial intelligence
BAG SELBSTHILFE	Bundesarbeitsgemeinschaft Selbsthilfe von Menschen mit Behinderung und chronischer Erkrankung und ihren Angehörigen e.V. (Head organisation for patient selfhelp groups in Germany)
BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Federal Institute for Occupational Safety and Health)
BfArM	Bundesinstitut für Arzneimittel und Medizinprodukte (Federal Institute for Drugs and Medical Devices)
BfR	Bundesinstitut für Risikobewertung (German Federal Institute for Risk Assessment)
BfS	Bundesamt für Strahlenschutz (Federal Office for Radiation Protection)
BMAS	Bundesministerium für Arbeit und Soziales (Federal Ministry of Labour and Social Affairs)
BMBF	Bundesministerium für Bildung und Forschung German Ministry of Education and Research
BMEL	Bundesministerium für Ernährung und Landwirtschaft (Federal Ministry of Food and Agriculture)
BMFSFJ	Bundesministerium für Familie, Senioren, Frauen und Jugend (Federal Ministry for Family Affairs, Senior Citizens, Women and Youth)
BMG	Bundesministerium für Gesundheit (Federal Ministry of Health)
BMI	Bundesministerium des Innern, für Bau und Heimat (Federal Ministry of the Interior, Building and Community)
BMU	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur (Federal Ministry of Transport and Digital Infrastructure)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)
BNHO	Berufsverband der Niedergelassenen Hämatologen und Onkologen (Professional organization for physicians specialized in Hematology and Oncoloy)

BZgA	Bundeszentrale für gesundheitliche Aufklärung (Federal Centre for Health Education)
CE	Circular Economy
CEAP	Circular Economy Action Plan
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilization
Ci3	Cluster für individualisierte Immunintervention (Cluster for Individualized Immune Intervention)
CO2	carbon dioxide
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DGHO	Deutsche Gesellschaft für Hämatologie und Medizinische Onkologie (German Society of Hematology and Oncology)
DGNB	Deutsche Gesellschaft für nachhaltiges Bauen (German Sustainable Building Council)
DIFU	Deutsches Institut für Urbanistik (German Institute for Urban Studies)
DKG	Deutsche Krebsgesellschaft
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DKFZ	Deutsches Krebsforschungszentrum (German Cancer Research Center)
EAFRD	Europäischer Landwirtschaftsfonds für die Entwicklung des ländlichen Raums (European agricultural fund for rural development)
EMFF	Europäischer Meeres- und Fischereifonds (European maritime and fisheries fund)
EPAAC	European Partnership for Actions Against Cancer
ERA-Min-2	ERA-NET Cofund on Raw Materials
EraNET	European Research Area Networks
ERDF	Europäischer Fonds für regionale Entwicklung (European Regional Development Fund)
ESF	Europäischer Sozialfonds (European Social Fund)
ESIF	Europäischer Struktur- und Investitionsfonds (european structural and investment funds)
EU	European Union
EU ETS	European Union Emissions Trading System
EUROFER	European Steel association

Fona	Forschung für nachhaltige Entwicklung (Research for Sustainable Development)
Fona3	Forschung für Nachhaltigkeit (Research for Sustainable Development) 3
GAK	Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz (agriculture and costal protection)
G-BA	Gemeinsamer Bundesausschuss (Federal Joint Committee of health insurances and professional organizations of physicians)
GKV	Gesetzliche Krankenversicherung (Public health insurance)
GPP	green public procurement
GRW	Gemeinschaftsaufgabe Verbesserung der regionalen Wirtschaftsstruktur (improving the regional economic structure)
HPV	human papilloma virus
HTS 2025	Hightech Strategy 2025
ICGC	International Cancer Genome Consortium
ICT	Information and Communication Technology
IF	Innovation Fund
IMAG	Interdepartmental working group
ISI	Institute for Systems and Innovation Research
IQWiG	Institut für Qualität und Wirtschaftlichkeit im Gesundheitswesen (Institute for Quality and Efficiency in Health Care)
KEI	Kompetenzzentrum Klimaschutz in energieintensiven Industrien (Competence Centre on climate change mitigation in energy-intensive industries)
MAR	Mission Analyses Report
MAUP	modifiable areal unit problem
MBKW	Ministerium für Bildung, Wissenschaft und Kultur des Landes Schleswig-Holstein (Ministry of Education, Science and Cultural Affairs of Schleswig-Holstein)
MFT	Medizinischer Fakultätentag (Convent of medical faculties)
MIS	Mission-oriented Innovation System
MOIP	Mission-oriented innovation policies
MRT/MRI	Magnetresonanztomographie (Magnetic Resonance Imaging)
NDK	Nationale Dekade gegen Krebs (National Decade Against Cancer)
NGO	Non-governmental organization
NKP	Nationaler Krebsplan (national cancer plan)

NTC	Nationales Tumorzentrum (National Center for Tumor Diseases)
PEI	Paul-Ehrlich-Institut (Federal Institute for Vaccines and Biomedicines)
PET	Polyethylene terephthalate
Platform NaRess	National Platform for Resource Efficiency
ProgRess	German Resource Efficiency Programme
ReZiProk	„Ressourceneffiziente Kreislaufwirtschaft –Innovative Produktkreisläufe (Resource-efficient recycling management - Innovative product cycles)
RKI	Robert Koch Institut (Robert Koch Institute)
R&D	Research & Development
R&I	Research & Innovation
STI	science, technology and innovation
SPI	Sustainable Product Initiative
TRANSCAN	Translational Cancer Research
TRL	Technology Readiness Level
UBA	Umweltbundesamt (German Environment Agency)
VCI	Verband der Chemischen Industrie (Association of chemical industry in Germany)
vfa	Verband Forschender Arzneimittelhersteller (Association of Research-Based Pharmaceutical Companies in Germany)
VUD	Verband der Universitätsklinika Deutschlands (Association of German university hospitals)
WWF	World Wildlife Fund

1 Introduction

In 2010, the German government announced a reorientation of its Hightech Strategy from fostering "key technologies" to solving Grand Challenges. To this end, it applied a more systemic approach to design and implement mission-oriented innovation policies (MOIP). With the Hightech Strategy 2025 (HTS 2025), starting in 2018, the German federal government put even more emphasis on directing the country's research and innovation policy towards addressing some of the most urgent societal challenges of our time. By announcing twelve specific missions, the strategy draws on a MOIP approach to tackle pressing problems such as pollution, climate change or demographic change. There are high hopes that innovative ideas, processes and products will not only address but also solve these problems (directionality). This re-orientation towards societal goals requires conceptualizing policies in a broader and crosscutting way, understanding the potential impacts of these policies in different sectors and domains, and finally, developing new institutional arrangements that integrate a wide range of actor groups and stakeholders. In many ways, this new mission-orientation challenges established governance mechanisms and calls for new approaches for designing and implementing innovation policy.

1.1 Project goal

Mandated by the German Ministry of Education and Research (BMBF), the Fraunhofer Institute for Systems and Innovation Research (ISI) provides scientific support to the German HTS 2025.[1] The project has twofold goals: First, it provides evidence-based scientific policy consultation for the implementation of the current Hightech Strategy. Secondly, by offering in-depth insights into selected missions and their diverse instruments and approaches, the project supports the development of a framework for measuring the impacts of mission-oriented policy approaches.

As part of this project, Fraunhofer ISI generates consecutive Mission Analysis Reports (MARs) of selected HTS 2025 missions in order to assess the development of Germany's research and innovation policies and how these policies address different Grand Challenges. The reports draw on a series of expert workshops and interviews, as well as the analysis of official policy documents and academic literature. Each report has a specific topical focus to allow for an in-depth analysis of the entire policy cycle. The present report sums up the main results of the first analysis, conducted in spring to summer 2020. This

1 For more information on the project, see https://www.isi.fraunhofer.de/en/competence-center/politik-gesellschaft/projekte/htf2025.html

report specifically looks at the socio-technical systems in which the various HTS missions are located and how the missions' policies aim to influence the overall systems.

1.2 Structure of report

The document is structured as follows: Following this introduction, chapter 2 presents the conceptual and methodological foundations of the MAR approach. It describes the application of a comprehensive system mapping approach to integrate findings from expert workshops and document analysis to understand the technological, economic and political contexts in which selected HTS 2025 missions operate and situate the missions within their specific socio-technical system. Further, it introduces a novel typology of MOIP that is then used to inform the case selection process for the MAR. Finally, data sources used are discussed. After this conceptual part, chapters 3-6 present the results of the MAR 1 for four selected HTS 2025 missions: Combating cancer (chapter 3); achieving substantial greenhouse gas neutrality in industry (chapter 4); creating sustainable circular economies (chapter 5); and ensuring good living and working conditions throughout the country (chapter 6). For each mission, we first sketch out the socio-technical system, focusing specifically on the role of science, technology and innovation (STI) policies, as well as the international links of socio-technical system. Further, each mission's political context, its goals and its most important governance mechanisms and actors are discussed. Finally, we present a critical assessment of the mission's goals and its position within its socio-technical system. The last part of the report (chapter 7) synthesizes the key empirical insights derived from the MAR, providing both insights for the implementation of the HTS 2025 in general and for conceptual aspects related to the study of mission-oriented policies.

2 Research Design

The general aim of this report series is to examine selected missions of the HTS 2025 to provide insights into their specific institutional design, point to limitations and challenges during their implementation and identify lessons for the improvement of HTS 2025 and MOIP more generally. Therefore the reports exemplify different aspects of MOIP by analyzing these for four selected missions; the specific topical foci are:

- MAR1: *Setting the stage*: Focusing on a better understanding of the mission goals and the position of missions within the socio-technical system – public report
- MAR2: *Taking stock*: understanding the link between mission goals and activities – public report
- *Tracking interventions*: contribution focusing on early indicators for goal achievement and tracking development of mission activities and changes to the overall socio-technical system.

2.1 Focus of first Mission Analysis Report

The present analysis focuses on an in-depth understanding of the mission, its goals and the position of the mission in its socio-technical system. It constitutes a zooming out, requiring to embed the mission into a broader context. This is necessary because both the formulation and the implementation of missions can be considered as highly context-dependent. The formulation of mission goals (or the translation of challenges into policy goals) is embedded into a specific economic, social, political and institutional context that shapes the formulated goals. In consequence, missions within a single policy framework may reveal considerable variation with regard to the goals, priorities and understanding of goals (Wittmann et al. 2020). Consequently, it is pivotal to clarify the boundaries of the mission against the background of the envisaged impact assessment, as a mission might not address all aspects. Conducting an analysis of the mission can contribute to identify the main areas of activity and priority of a mission. To this end, the MAR1 builds on the following three steps:

- A system mapping of the overall socio-technical system including the main topics, context factors and actors identifying to scope a mission could potentially address and pinpointing possible interactions
- A brief description of the mission goals and the governance of a mission, enlisting the key actors relevant for its implementation
- Locating the mission within the overall socio-technical system. This analytical step provides the opportunity for a comprehensive review of mission goals and allows for an identification of mission boundaries.

In combination, these steps provide a comprehensive understanding of the missions and their respective context and a critical assessment of the achievements and challenges of the individual missions.

2.1.1 System mapping

Missions take place in a specific socio-technical system which they aim to transform or at least to influence. Each system is characterized by complex networks of technical innovations, but also by the societal functions these innovations provide, highlighting the importance of not only the production of technology, but also its diffusion and use (Geels 2004). Taking a systemic perspective on MOIPs allows assessing the level of ambition of individual missions, how comprehensive or partial their scope is and to what degree they have an impact on the larger system. For the purpose of the analysis, socio-technical systems are understood as the 'articulated ensembles of social and technical elements which interact with each other in distinct ways, are distinguishable from their environment, have developed specific forms of collective knowledge production, knowledge utilization and innovation, and which are oriented towards specific purposes in society and economy' (Borrás and Edler 2014, p.11).

Methodologically and practically, mapping a complex socio-technical system is a challenging task, especially if many elements and connections are to be included. By deliberately excluding certain factors from the analytical process, the scope and limitations of the system mapping are made transparent. The developed model of the system should be simple, but not simplistic (Magro and Wilson 2013, p.1649). For the purpose of the MAR1, we use a three-step process of mapping the mission-specific socio-technical systems:

1. System elements: Develop a basic conception of the main elements of each of the socio-technical systems under study. Possible elements of the socio-technical system are:
    - **Topics and subtopics:** subdomains, sectors or topical clusters within the larger socio-technical system. The understanding of sub-topics is particularly broad, including for example also relevant technological innovations and solutions.
    - **Actors:** important governmental, private sector, and civil society actors, regardless of their official involvement in the mission. 'Since a Mission-oriented Innovation System (MIS) emerges around problems rather than solutions, it is not clear from the outset which actors play a role in developing and diffusing innovative solutions during a mission's runtime' (Hekkert et al. 2020, p.77 own translation)
    - **Policies**: Key political instruments expected to have an impact on the system. The focus should be (a) on current measures (not past measures or planned

measures), (b) that have a clear connection to the overall system, (c) that are focused on Research and Innovation (R&I) and (d) that are at least partially related to public actors (Walz et al. 2019, p.62).

2. System boundaries: Due to the complexity of socio-technical processes and the limitations of analytical capabilities, not all factors and elements that could potentially influence a system can also be included in the mapping process. Setting the system boundaries is a theory-driven process, guided by the following considerations:
   - Relevance: Based on previous research, which elements are expected to be most important for understanding the socio-technical system under study?
   - Data: Which elements might be interesting to consider, but hard to assess empirically, either because data is not available or include intangible factors?
   - Policy leverage: To what degree can elements be influenced by R&I instruments?
3. Connections: Socio-technical systems are more than the sum of their parts, but defined by the complex interplay of hierarchies, feedback loops and self-organisation (Savaget et al. 2019). Identifying connections is particularly relevant for assessing the impact of policy instruments at a later stage of the project. To capture this complexity, the last step of the process involves structuring the socio-technical system and specifically to examine the linkages between the elements of the system.

2.1.2 Understanding the goals of missions

Once a basic understanding of the specific socio-technical system has been established, the focus of the MAR shifts to the HTS 2025 mission itself. As an intermediate step to assess the achievements and shortcomings of the mission in influencing the socio-technical system, a basic overview of the central goals and elements of the mission needs to be established. Establishing a detailed analysis of mission goals and mapping these in combination with the assumed pathways provides a starting point for situating the mission in the socio-technical system. Specifically, this step includes answering the following questions:

- What are the main goals of a mission, as stated in official documents?
- What are the political approaches to achieve these goals?
- Which actors are involved in the governance and implementing the instruments?

2.1.3 Situating the missions in the socio-technical systems

Once the mission goals and its main activities have been identified, we can assess the position of the mission within its related socio-technical system. This final analytical step allows to track priorities and ambitions of missions as well as blank spots, i.e. topics that

are beyond the scope of the mission. This approach does not aim to provide a rating, but aims to understand the empirical mission in its whole complexity. Ultimately, a critical review of the mission and its goals can reveal possible challenges that need to be taken into consideration for the impact assessment. Particularly important questions in this context are:

- Do the goals of the mission address most parts of the socio-technical system or only a few?
- How ambitious are the mission goals?
- Are there blank spots in the socio-technical system that the mission ignores?
- What kind of activities are envisaged to address the challenge? Are these suited to address the dynamics of the socio-technical system?
- Are the most important actors within the system involved or at least considered in the mission?

2.2 Case selection

The case selection of the MAR draws on a novel typology of MOIP, developed within the project scope (Wittmann et al. 2020). By focusing on both the anticipated solution and the internal governance structure, the typology provides a complex and comprehensive understanding of innovation policies. Building on these two main dimensions, the typology distinguishes between four types of missions, with two of them falling into the category of transformer and accelerator type each.

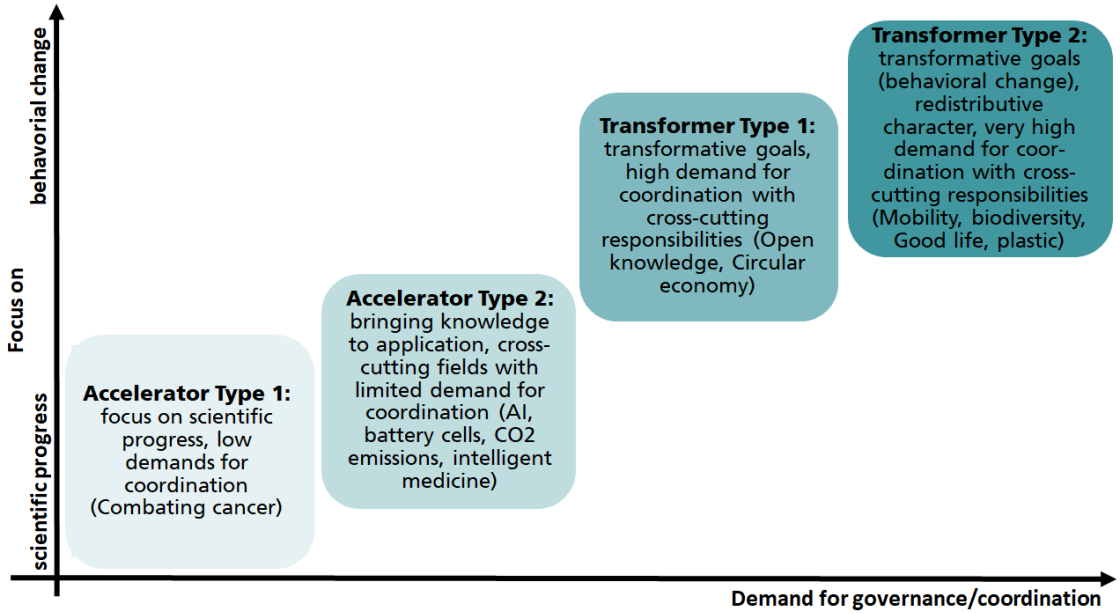
Applying the typology to the HTS 2025, considerable diversity [in challenges addressed, scope, aims and implementation approaches] among the twelve dedicated missions can be observed. Understanding this diversity can provide a first glimpse into the internal implementation logic of a mission and its specific challenges.

The MARs focus on four selected missions out of the twelve missions of the HTS 2025. An important selection criterion for this subset of four missions was their fit with the four identified mission types. The underlying strategy is to maximize variation when studying the implementation of different missions in order to provide generalizable conclusions that hold for MOIPs in general. To this end, we identified missions that exhibit highly diverse goals, approaches to challenges, governance constellations and level and scope of goals.

- **Accelerator Type 1 – Combating cancer:** A mission that builds upon the focus on healthcare in previous Hightech strategies. Given its emphasis on research activities as a means to combat cancer, it has been classified as an Accelerator Type 1, while exhibiting elements (strengthening of prevention) that aim for behavioral change.

- **Accelerator Type 2 – Achieving substantial greenhouse gas neutrality in industry**: Contributing to address the Grand Challenge of achieving sustainability and mitigating global climate change, the mission strives for bringing new solutions for CO_2 emissions in industry to application. Since the mission does not aim for a comprehensive transformation but focuses on incremental solutions, it can be considered as an Accelerator Type 2 mission:
- **Transformer Type 1 – Creating sustainable circular economies**: A second mission linked to the challenge of sustainability focusing on the re-use of materials and a significant increase of the raw material productivity. It entails considerable transformative elements, by aiming to alter existing structures of the socio-technical system and therefore qualifies as a Transformer Type 1 mission.
- **Transformer Type 2 – Ensuring good living and working conditions throughout the country**: While the question of equal living conditions has been deeply rooted in the German political discourse, a mission that aims to influence factors constituting good living conditions is a novelty in the German HTS 2025. Given its broad approach, the complexity of actor constellations and the anticipated changes to human behavior, it represents a particularly complex mission that falls into the category of a Transformer Type 2.

Figure 1: Mission types and empirical classification



Source: complemented version of Wittmann et al. 2020, p.11

In this context, however, it is important to keep several aspects in mind. Firstly, missions may contain elements from different approaches, deviating from the ideal types of the mission typology. Further missions are no static endeavor, but may evolve over time

(Janssen et al. 2020, p.10). Therefore, a classification of missions according to the outlined typology can only serve as a starting point for analysis, as mission goals may be specified, alternated or replaced over time. Secondly, the assessment of a mission is conditional on the availability of adequate empirical material, with different sources having their specific strengths and weaknesses. Aiming to understand the design of missions, our classification primarily relies on official documents such as the HTS 2025 and the progress report (BMBF 2018, 2019). However, as missions cannot be understood without the complex socio-technical system they are embedded in, this typology can only serve as a preliminary step that requires in-depth investigation of the mission.

2.3 Data sources

In order to provide a comprehensive assessment of the selected HTS 2025 missions, the MAR1 draws on multiple sources. This includes, first of all, official documents such as the HTS 2025 that was published in 2018 and the subsequent progress report from 2019 (BMBF 2018, 2019). Secondly, to get an in-depth understanding of the missions from a ministerial perspective, from May to October 2020, the research team conducted ten interviews with representatives from different departments and executing agencies involved in the design and implementation of the HTS missions. For a minority of cases in which the research team was unable to conduct interviews with the responsible staff, the analysis primarily relies on the review of official documents and the assessment of external experts.

The mapping process of the socio-technical system, moreover, requires extensive knowledge that reaches beyond the mission. In order to gain a comprehensive understanding of the socio-technical system, thematic experts from Fraunhofer ISI working on the chosen topics were actively involved in the system mapping and the MAR as a whole. This approach allowed combining technical expertise with knowledge about the mission-oriented innovation approach.

3 Mission: Combating cancer

Section written by Florian Wittmann, Tanja Bratan

3.1 Description of the socio-technical system

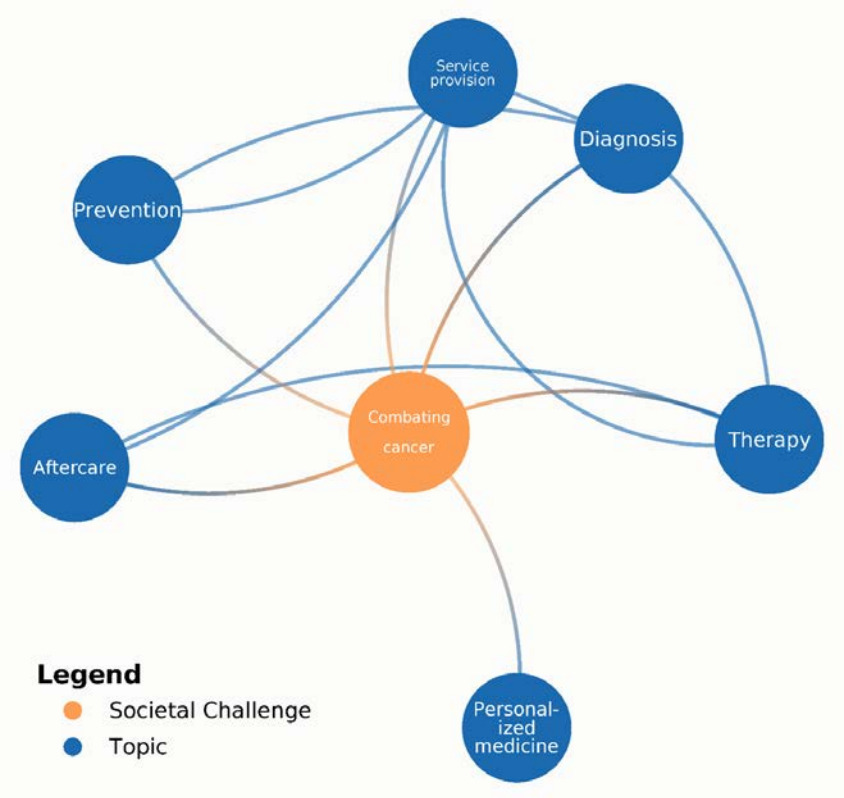
The challenge of combating cancer is embedded in the context of demographic change with an ageing society and a shift in lifestyles. In consequence, there is a growing prevalence of cancer, turning it into a vital problem of modern societies that affects both quality of life and health care systems. The topic receives increasing attention under the paradigm of mission-orientation, leading to the formulation of missions both at the domestic level (Germany) and EU-level (Horizon Europe).

Attempts to address the issue of cancer can be grouped around four main topics, i.e. prevention, diagnosis/early detection, treatment, and aftercare. Each of these topics can be further divided into multiple sub-topics, such as different ways of treatment (pharmacological, surgery, psycho-oncological treatment, etc.) and diagnosis (imaging, pathology, etc.). Two of the main topics (diagnosis/early detection and treatment) are primarily linked to curing and managing cancer, whereas the remaining address the challenge in different ways. Prevention aims to reduce the number of cancer incidents beforehand (primary prevention), detecting cancer at an early stage to increase the probability of treatment success (secondary prevention) or prevent affected people from a worsening of the situation (tertiary prevention). Aftercare focuses on the period after treatment aiming to improve the quality of life of people affected (care, rehabilitation, palliative).

The whole complex of combating cancer has received increasingly more attention under the newly emerging paradigm of personalized medicine. This means there has been a growing emphasis on the heterogeneity of cancer as well as diversity among patients and their specific conditions and requirements. A second cross-cutting topic within the different stages of fighting cancer is service provision. Ensuring sufficient access to the required services to address each of the individual topics. The ability to provide the required services covers multiple dimensions:

- functional (cooperation between entities such as resident doctors and hospitals)
- regulatory (reimbursement of treatments etc. by health insurances)
- infrastructural (existence of modern technical and infrastructure, sufficient number of doctors, etc.)
- spatial (ensuring access to treatment over the whole territory of Germany, regardless of the rural/urban place of living)
- educational (quality of treatment, intake of new developments).

Figure 2: Main topics for system of combating cancer (own elaboration)



The question of service provision also introduces a multi-level structure into this socio-technical system, as different services are provided and regulated by actors at different levels. This includes, for example:

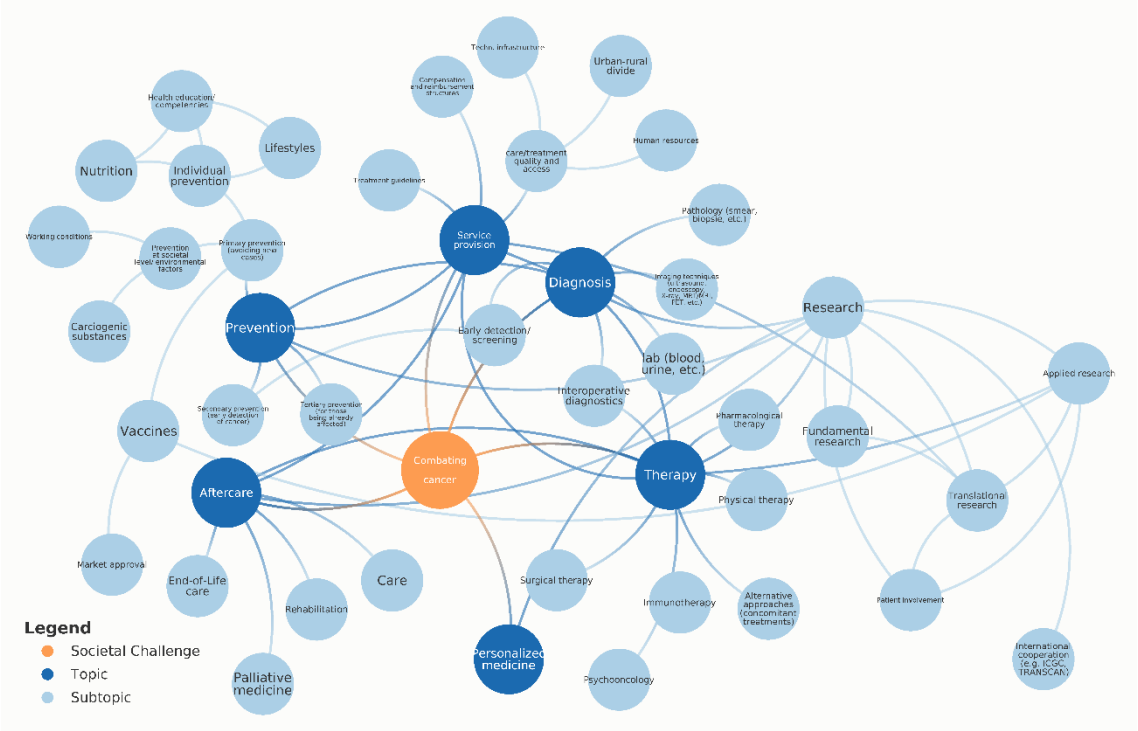
- agreement on reimbursements (health insurance), treatment guidelines (professional organizations), and research funding (federal government), and at the federal level
- regulation on university education and hospital financing at the regional level
- service provision by physicians and self-help organizations at the local level.

3.1.1 The role of science and technology

Especially two of the main topics are closely linked to STI policies, benefiting from new insights, research and development: diagnosis and therapy and their respective different approaches and techniques. In this domain, the approach of translational medicine has gained increasing importance, trying to accelerate the translation of research insights to the treatment of patients. Research activities are carried out both by public (universities, research institutes, German Cancer Research Center - DKFZ, National Center for Tumor Diseases - NTC) and private actors (enterprises from the field of pharmacology, medical

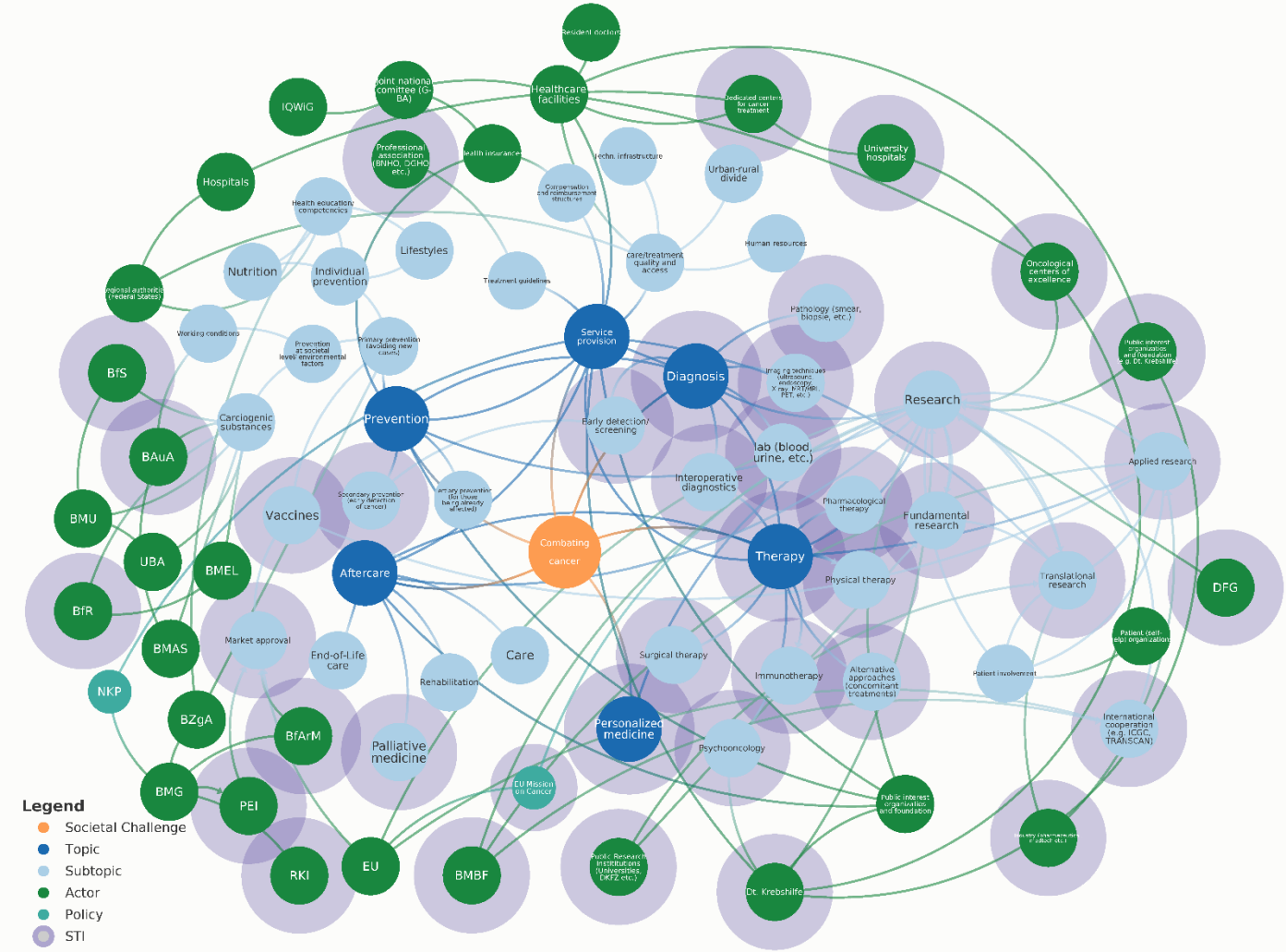
technology), however, with different priorities and a focus on different stages of the development process. Whereas fundamental research is primarily linked to public institutions, the cost-intensive clinical trials can often be found on the side of private enterprises. These domains are also supported by thematic organizations (Fachgesellschaften), above all the 'Deutsche Krebsgesellschaft' (DKG).

Figure 3: Topics for system of combating cancer (own elaboration)



In contrast, the remaining three topics (service provision, prevention, aftercare) have a different character that reaches clearly beyond the role of STI policies. While innovations and research can contribute to the development in these areas, they are strongly characterized by a multi-level and multi-actor setting, consisting of multiple interventions and activities. This is particularly well illustrated by the case of primary prevention, where there is a wide variety of areas of intervention ranging from health/life-style questions, to the development of vaccines for specific types of cancer caused by viruses such as human papilloma virus (HPV), and the question of carcinogenic substances. This diversity is also reflected in the variety of possibly involved actors (e.g. education, health insurances, ...) that link to these aspects on different institutional levels via different means (information, regulation, creating incentives, etc.), reflecting an area that ultimately requires to achieve a change of human behavior. From a federal point of view, the area of prevention is also characterized by the involvement by numerous ministries (BMU,

Figure 4: Topics and actors for system of combating cancer (own elaboration)[2]



2 Access to the full map is available under: https://embed.kumu.io/e323326c30db34997e3ed6e4f0a3fb9d.

BMAS, BMEL) and its subordinated institutes (BfS, BzGA, BfR, UBA, BAuA) that reach beyond the main federal players of Federal Ministry of Health (BMG) and Research/Education (BMBF). In case of service provision, the flagship policy of the federal level is the National cancer plan (NKP) that was initiated in 2008 and is led by the BMG.

Many actors focus on specific topic areas, especially patient organizations, foundations, and other organizations oriented towards social welfare. This particularly applies to the 'Deutsche Krebshilfe' a private organization supporting both research and supporting projects in the different topic areas addressing cancer.

3.1.2 Beyond the domestic context

The issue of combating cancer also has multiple links to the international sphere. Firstly, input for research might be an external influence. Instead of originating from the domestic innovation system, insights from international research, drug development, etc. may diffuse across space given the pressuring character of this challenge in many countries. However, such external impulses at the same time require a sufficient capacity to be absorbed and integrated in an appropriate way. Transnational cooperation at the same time appears as a tool for enhancing synergies and creating a critical mass for research activities. This can be observed in trans-national research projects, like in the framework of EraNET TransCan or the European Partnership for Actions Against Cancer (EPAAC).

The topic of combating cancer is also reflected at the European level within the newly emerging research strategy (Horizon Europe) for the next budget period (2021-2027). One of the five priority areas in this strategy will be the issue area of combating cancer, complementing domestic efforts. However, the temporal asynchrony might constitute a challenge here, as an alignment of priorities ex-post might appear difficult, so that the EU mission might rather serve as a source of input into the mission.

3.2 Mission goals and structure

3.2.1 Mission context

The mission on 'combating cancer' is led by the BMBF with support from the BMG. Further public, private and societal actors are primarily involved through the main policy platform in this field - the National Decade Against Cancer (NDK). The mission addresses a pivotal topic in German society, as cancer is among the main causes for death that also has received considerable attention in the political sphere. Therefore, one can assume wide consensus about the relevance and urgency of this challenge, giving the topic a high level of legitimacy.

In the context of the German HTS 2025 , this mission is rooted in the long-standing focus on health-related topics (BMBF 2006, 2010, 2014). However, in contrast to previous editions, it explicitly focuses on a certain type of illness, aiming to address specific problems related to cancer instead of approaching health aspects from a broader perspective. The mission exhibits multiple links to other missions of the HTS 2025. Firstly, besides the mission on 'combating cancer', there is a second mission falling into the field of health aspects: the mission on 'intelligent medicine' strives for the introduction of an electronic patient file as a way to enhance the flow of information and improve treatment quality in general. Secondly, at a more general level, the mission exhibits thematic links to two other missions. On the one hand, the mission on bringing knowledge in AI to application might serve as a means to provide novel treatment solutions. On the other hand, the mission on new sources of knowledge may serve as a cross-cutting mission, enhancing knowledge production and innovation activities in general.

3.2.2 Mission goals

The goals postulated in the HTS 2025 and its progress report encompass a variety of different aspects aimed at addressing the problem of cancer. These include the development of new therapies and early diagnosis measures (though additional financing, improvement of coordination mechanisms, patient involvement and framework conditions) and a focus on translational research activities to bring these innovations to patients. At this stage, there are no qualified or quantified goals.

> **Mission description:** We will declare a National Decade Against Cancer. We will work together with science, business, society and all stakeholders in the health system to make people with cancer live longer and better, while reducing the incidence of cancer. To this end, we will further strengthen cancer research in Germany, thereby advancing prevention, early detection, diagnosis and treatment. We want to enable the development and clinical validation of new preventive and therapeutic strategies. For example, risk-adjusted early detection measures are to be developed and tested for people with a significantly increased cancer risk. We want to improve the quality of life of those affected and also look at the long-term consequences of cancer disease and treatment (BMBF 2018, p. 17).

Below the overarching mission, especially the NDK can be considered as the main vehicle of the mission to bring together different stakeholders from public and private sector in a long-term research strategy. Its creation is part of the mission description in the HTS 2025 and its goals can therefore be considered as constitutive for the impacts the mission wants to achieve. The timeframe of the NDK exceeds the duration of the HTS 2025, encompassing the period from 2019 until 2029. The NDK joint declaration (NDK 2019)

enlists a total of five goals, with two of them being quantified and being supported by the remaining goals (see also figure 5):

- Until the end of the NDK (2029) 75% of diagnosed incidents of cancer are cured/manageable (while ensuring quality of life) by new approaches for early diagnoses and treatment
- The share of avoidable cancer incidents is reduced from 40% by 10% every ten years (effects visible from 2040).

The remaining three goals can be considered as a contribution to the aforementioned goals by addressing the framework conditions for improving research activities, treatment quality and public awareness:

- Ensuring access to high-level oncological treatment, through access to translational research and regional treatment facilities
- Creating awareness for prevention measures
- Supporting research/treatment activities by high levels of qualification of researchers/specialists.

Besides the NDK, a second flagship policy in this field is the NKP that was initiated in 2008. It contains a total of 13 non-quantified goals with 40 sub-goals and focuses on the improvement of service deliverable and the strengthening of secondary preventions, thus takes a different approach than the research-based NDK. There are multiple thematic links between NDK and NKP, particularly with regard to translation of research insights into practical use.

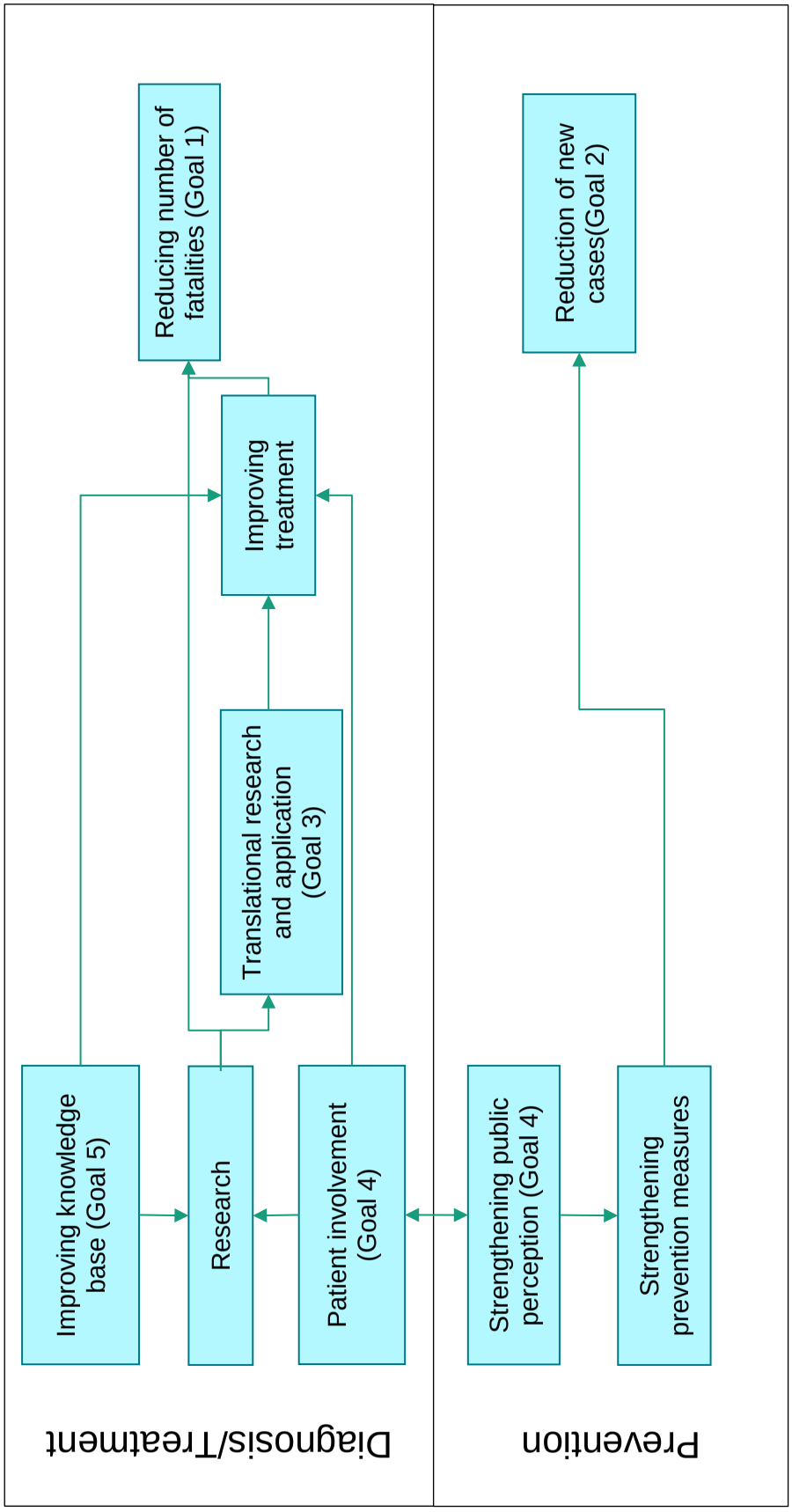


Figure 5: Anticipated pathways towards goals of mission on combating cancer (own elaboration)

3.2.1 Governance of the mission and actors

The NDK as the main vehicle of the mission whose creation was part of the Coalition Agreement (Bundesregierung 2018) was initiated in 2019. Its main body is the strategy council (Strategiekreis) providing guidelines for the implementation of the NDK. It is headed by parliamentary secretary Rachel (BMBF), indicating a high level of commitment from the top echelons of BMBF compared to other missions. Further members represent partners of the NDK, BMG is represented by parliamentary secretary Weiß. The NDK established three working groups focusing on unresolved questions of cancer research, prevention, and closer links between research and service provision. Especially, the latter constitutes the main interface between the research-driven agenda of the NDK and the focus on service provision of the NKP.

The main actors from federal government involved in the implementation of the mission are the BMBF and the BMG. In case of the BMBF, there is a project group NDK as the main hub for coordination of the NDK and totally four departmental units ('Fachreferate'). BMG is involved in all working groups of the NDK, heading the working group 3 on the translation of research insights into service provision by parliamentary secretary from BMG (Weiß). Other members of the NDK are research and professional associations, patient organizations, representatives from health insurance, foundations, a representative of German sub-national entities and private enterprises (see table 1).

Besides the membership in the NDK, there are more open forms of cooperation for CSOs/foundations/institutions/etc., by becoming a supporter of the NDK and thereby obtaining access to activities of the NDK (upon confirmation of the NDK strategy council). Currently there are eight organizations, foundations and enterprises registered as supporters of the mission.[3]

Table 1: Actors involved in the realization of the NDK (own elaboration)

Type	Organization
Public (federal)	BMBF • Ref. 612 (Einrichtungen der Lebenswissenschaften) • Ref. 614 (Medizinische Forschung; Medizintechnik) • Ref. 615 (Forschung für globale und öffentliche Gesundheit; Umwelt und Gesundheit) • Ref. 617 (Neue Methoden in den Lebenswissenschaften; Biotechnologie; Wirkstoffforschung • PG NDK (Projektgruppe „Nationale Dekade gegen Krebs')

3 Actors involved in the realization of the NDK.

Type	Organization
Public (federal)	BMG • Ref. 324 (Krebserkrankungen)
Public (federal)	Bundesinstitut für Arzneimittel und Medizinprodukte (BfArM)
Association (research/ treatment)	Berufsverband der Niedergelassenen Hämatologen und Onkologen (BNHO)
Association (research)	Deutsche Gesellschaft für Hämatologie und Medizinische Onkologie (DGHO)
Association (mixed)	Cluster für individualisierte Immunintervention (Ci3): Private and public actors from Rhine-Main region (https://ci-3.de/partners/)
Association (research)	Deutsche Hochschulmedizin e.V. • Verband der Universitätsklinika Deutschlands (VUD) • Medizinischer Fakultätentag (MFT)
Association (research)	DKG
Association	Deutsche Krebshilfe
Research institution (public)	DKFZ
Foundation	Felix Burda Stiftung
Association (health insurance)	Gesetzliche Krankenversicherung (GKV)-Spitzenverband
Public (regional)	Ministerium für Bildung, Wissenschaft und Kultur des Landes Schleswig-Holstein (MBWK) representing German Länder (regional level)
Patient organisation	Bundesarbeitsgemeinschaft Selbsthilfe von Menschen mit Behinderung und chronischer Erkrankung und ihren Angehörigen e.V. (BAG SELBSTHILFE)
Think tank/patient organisation	Patvocates GmbH
Private enterprise	Roche Pharma AG

3.3 Review of mission goals and position within the socio-technical system

3.3.1 Position of the mission in the socio-technical system

The mission exhibits a differentiated approach to the identified topics in the field of combating cancer, exhibiting a strong STI focus. One main priority is the improvement of diagnosis and treatment by bringing together relevant stakeholders and undertaking efforts to directly and indirectly generate new scientific insights. This closely matches with the research-orientation of the BMBF emphasizing the role of research and innovation, as these topics are most closely linked with research activities.

The topic of service provision, identified as a cross-cutting theme for addressing the different aspects for combating cancer is not explicitly part of the NDK, but falls into the domain of the NKP. Especially working group 3 in the NDK serves here as an interface to link translational efforts and bringing together the different priorities.

A second aspect that is reflected in the mission is prevention. While one goal directly targets the reduction of avoidable cancer incidences, another goal (of the NDK) indirectly seeks to support this by awareness creation. Especially the question of primary prevention, that appears as the main target of the NDK (avoidable cases), requires a wider set of activities reaching beyond a STI-driven approach.

The topic of aftercare does not receive particular attention in the NDK (but is covered by the activities of the NKP) . Focusing on the improvement of the quality and length of life of people affected by cancer, no additional goals are formulated with regard to those people that have survived cancer.

The mission takes a domestic perspective on fighting cancer not having defined a clear interface with the mission on cancer in Horizon Europe. Given the fact that the Hightech Strategy and the subsequently established NDK were formulated prior to the more detailed specification of Horizon Europe, there are limited possibilities for aligning these goals from the beginning (despite potential overlap of involved stakeholders).

3.3.2 Review of the mission

The mission postulates achievable and fairly realistic goals and with the NDK established a vehicle for achieving these goals. The mission (or more precisely the NDK) manages to mobilize a wide range of key actors in the field formulating a set of jointly shared goals – this can be considered as a key strength of the mission. At the same time, the strong focus on research activities might have implications for the involvement of actors (see below). There are established institutional forms of coordination between different federal ministries, ensuring an involvement of the BMG in the implementation of the NDK. The coordination manifests itself particularly in the responsibility of the BMG representative for the working group of translational efforts in the NDK.

The goals postulated in the NDK develop the mission further and provide a specification of the non-quantified goals of the overall mission, by introducing two quantified and three non-quantified goals that can be considered as descriptions of the anticipated pathways. In comparison to other initiatives, these goals are rather specific and therefore have the potential for mobilizing relevant actors around them, even though they need further specification during the implementation process. The process of goal formulation through the NDK from this perspective can be considered as a downstream process of consensus

building, once the overall goals have been spelled out in the mission goals. This approach might be considered as positive development, ensuring the ownership of involved partners. The supporter mechanism may allow mobilizing additional stakeholders besides the key partners of the mission, while ensuring the coherence of the goals. The flipside of the coin might be that the lacking ability to shape the agenda might be an obstacle for some potential supporters.

The drawback of this approach might be rooted in the complexity and nested structure of goals. Introducing a further specification of goals through the NDK entails the risk that multiple points of reference exist for actors and activities. Moreover, such a nested structure makes it difficult to follow the overall progress of the mission, as there is uncertainty about the relation between NDK and mission. This raises the question, whether the NDK is identical with the mission (or only highly congruent) and what the boundaries of the mission are. Interviews revealed moreover considerable uncertainty among stakeholders within the BMBF and BMG how to delineate the overall mission from the inputs and goals of the NDK and NKP. If the goals of the NKP were indeed part of the mission, this would result in additional difficulties given the question about hierarchies, interactions, the consequences of policy fragmentation, and the challenges arising from the different stages of implementation (NDK: started in 2019, NKP started in 2008).

Looking at the first main strand of activities in the NDK, the improvement of therapy and diagnosis in order to improve treatments requires several remarks. First of all, while introducing a quantified goal, the NDK does not specify how to understand a good quality of life, leaving ample room for interpretation, the more that there are substantial differences between a cured and a manageable case of cancer. Secondly, this rather classical focus on research has been complemented by additional elements (infrastructure improvements, patient involvement). While not being a paradigm shift, the emphasis of a more inclusive research approach incorporating patients at the different stages of the process might allow for increasing the efficiency of research activities and therefore has to be assessed positively. The assessment of the role industrial partners is difficult, given the different types of involvement that require further investigation. Whereas Roche is included as an industrial partner of the mission, other companies are represented indirectly via the Ci3 cluster or are listed as supporters of the mission (Novartis, Bayer Life Sciences, etc.).

The second set of goals relates to the topic of prevention, where the NDK emphasizes the role of prevention in order to decrease the number of avoidable incidents of cancer, creating a dedicated working group for strengthening research on prevention. The quantified goal (-10% per 10 years) is accompanied by the goal to increase greater awareness for the issue of cancer and by doing so strengthening existing prevention measures.

Emphasizing the 40% of avoidable incidents of cancer, strengthening relevant research may serve as a first step, but it will require further activities to achieve this goal of greater awareness on cancer prevention amongst the population. On the one hand, this would include measures within the realm of healthcare (dietary advice, exercise, stress reduction available on prescription to target risk factors), on the other hand it could require collaboration with other policy areas (environmental protection, labour law/ occupational health, etc.). Relevant actors in the field of prevention are only indirectly (representative of public health insurance providers as a link to 'Nationale Präventionskonferenz', Federal Centre for Health Education - BZgA, resident doctors) represented in the coordination of the NDK, indicating a limited attention to these aspects beyond the research-driven approach to this topic. In a similar vein, one could expect the involvement of departments beyond Life Sciences in BMBF, as well as the involvement of other ministries (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety - BMU, Federal Ministry of Labour and Social Affairs - BMAS) that deal with aspects that link to the topic of prevention.

From the perspective of evaluation, the focus on avoidable cases of cancer moreover raises the question of the baseline to assess the success of the mission. Not aiming to reduce to total prevalence of cancer, but only a subset thereof, it remains undefined what exactly are the criteria for 'avoidable' cases. As long as there is limited knowledge about the different causes driving different types of cancer, it will be difficult to provide reliable statistical foundation to this quantified goal.

4 Mission: Achieving substantial greenhouse gas neutrality in industry

Section written by Florian Roth, Marlene Ahrens, Clemens Rohde

4.1 Description of the socio-technical system

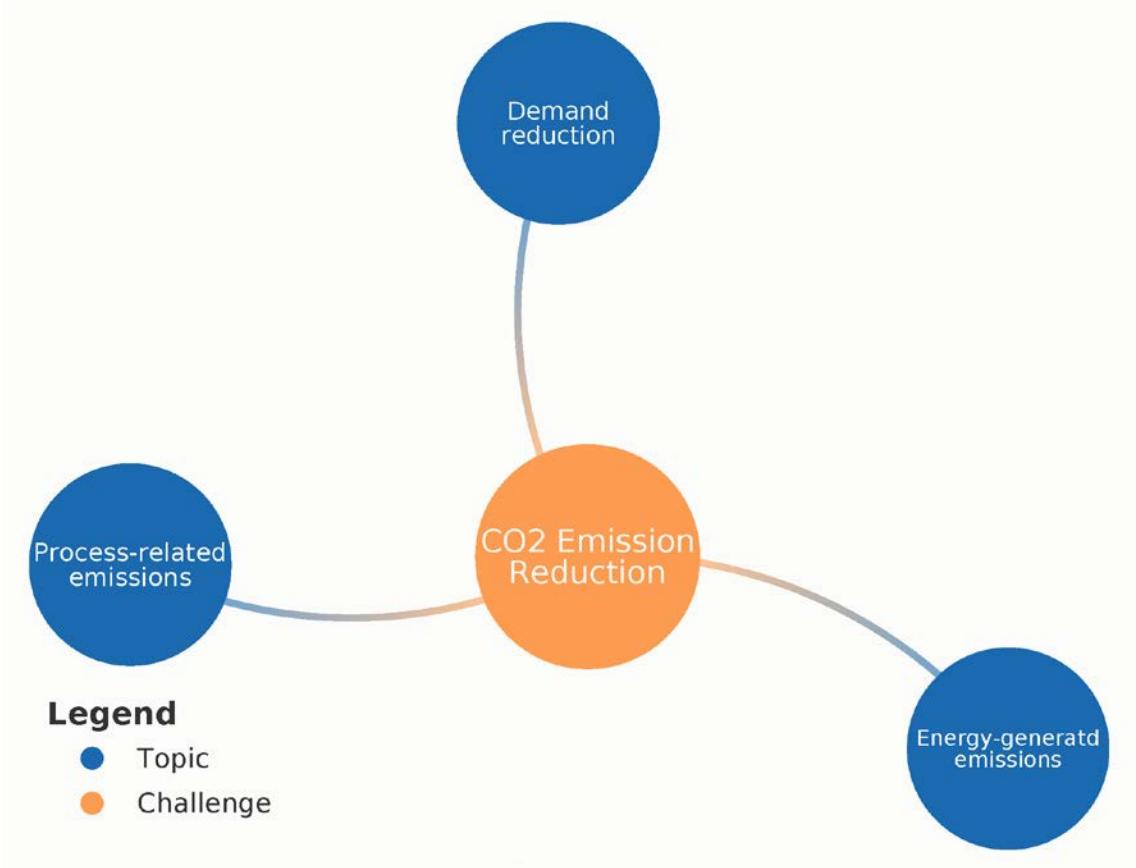
Looking at the main variables that influence the CO_2 emissions of Germany's industry sector, three aspects stand out. First, emissions naturally depend on the volume of industrial goods and materials produced. Today, particularly the large scale production of metals, like steel and aluminum, chemical products as well as building materials, such as cement and chalk, account for significant shares of industrial CO_2 emissions in Germany. Second, emissions are influenced by the energy consumption and the CO_2 emissions of the energy carrier used (energy-related emissions). Third, process-related emissions represent the final major factor influencing CO_2 emissions of the industry sector. Many industrial processes like the production of steel or cement involve chemical reactions that set free significant amounts of CO_2. These process-related industrial emissions are especially hard to abate.

A first main topic relates to the demand side of industrial products and materials. This encompasses several subtopics, including maintainability, obsolescence management and sustainable engineering. For example, designing long-lasting cars or buildings that do not have to be replaced after a short period of time, but can be refurbished instead, significantly reduces the demand for energy-intensive materials such as steel, aluminum, and concrete. Related to this, also circular economy and recycling concepts can contribute to reduce the demand for energy-intense materials, for example, of steel and aluminum, or plastic. Finally, the substitution of materials that involve high levels of CO_2 emissions with more sustainable materials is another subtopic that could make a significant contribution to achieving an overall reduction of industrial CO_2 emissions. For example, in the building industry, replacing steel with wood and other organic building materials whenever possible offers a great potential for reducing CO_2 emissions.

While at a first glance, reducing the need for energy-intensive materials and goods appears as a simple and effective way to reduce Germany's industrial CO_2 emissions, as will be discussed below, in reality, demand-focused strategies are facing different technical, economic and political challenges. Above all, hard-to-abate industries, like steel and cement companies, have little economic incentives to transform their production processes to replace current materials with alternative, less CO_2 intense materials or reduce their overall production volumes. Further, other key industrial players, such as Germa-

ny's powerful car manufacturers and construction companies have little economic interest in more durable and sustainable materials and goods. Related to this, also societal developments play an important role. For example, if more people demand goods that are repairable, recyclable or made of low-carbon materials or are willing and able to pay for more sustainable products, this could have a major impact on industrial production processes. In spite of the large external costs of energy-intensive materials in terms of their contribution to climate change and other negative environmental impacts, these materials are currently still cheap, because these external costs are not sufficiently factored in. Attempts to make sustainable materials and products more attractive through regulatory measures are only slowing making ground. For example, steel, concrete and many other energy-intense products have long been exempted from the European emission trading scheme (ETS). Only recently, with the revision of the ETS in 2018, a clear path has been set that from 2021 onwards, these companies have to pay more and more for their CO_2 emissions. Besides this, governments also play an important role as regulators, which need to adapt standards and norms, for instance, to oblige companies to include recycling in their business as well.

Figure 6: Main topics for system of CO_2 emission reductions (own elaboration)



A second topic are energy-generated emissions. One subtopic of this is energy efficiency, which can be improved for example through optimized industrial processes, or the utilization of waste heat in integrated energy systems. To note, while in some cases, an increased energy efficiency is connected with lower operating expenses, mainly through reduced energy costs, in other cases, the economic benefits of increasing energy efficiency are set-off by other costs, for example longer production times or a personal-intensive maintenance of installations. Therefore, an effective development and testing of new facilities is important, bringing together researchers and private actors, for example plant manufacturers and energy producers. In this context, to get these new technologies to the market, it is decisive to not only address the capital expenditures (CAPEX) needed for replacing old CO_2-intense facilities, but also to find ways to achieve competitive operating costs (OPEX).

Another important subtopic is the use of low-carbon energy sources for industrial production. Especially renewable energy sources, above all wind, solar, biogas and water power, have a much better CO_2 footprint compared to fossil energy sources, such as coal, oil and natural gas. To set up a renewable energy infrastructure, several challenges have to be overcome, for example finding suitable positions for wind turbines that comply with nature conservation and biodiversity, expanding solar PV, or dealing with high and low peaks in renewable energy supply. Finding solutions for these problems that can be regarded as bottlenecks in the larger efforts towards greenhouse gas neutrality requires the engagement of electricity providers and political actors on different administrative levels.

A final major topic are process-related emissions, which currently account for 38 per cent of the CO_2 emission of the German industry sector. One subtopic here are innovative production methods with lower emissions. For example, the transition of the steel industry from fossil fuels to renewable energy means a deep-reaching technological disruption that is only slowly becoming economically viable. As one of the first of its kind, the Swedish HYBRIT project aims to bring fossil-free steel to the markets at competitive prices by 2026.[4] In addition, there are only small windows of opportunity when old furnaces have to be replaced or retrofitted anyway. Today, using electric power from renewable sources for primary steel production would require an intermediate energy carrier, i.e. hydrogen. Generating hydrogen, however, is not a very energy-efficient process. Steel companies are currently unwilling to be first movers and to make substantial investment in green technologies without government support, as operating costs of conventional furnaces are far lower than for alternative solutions.

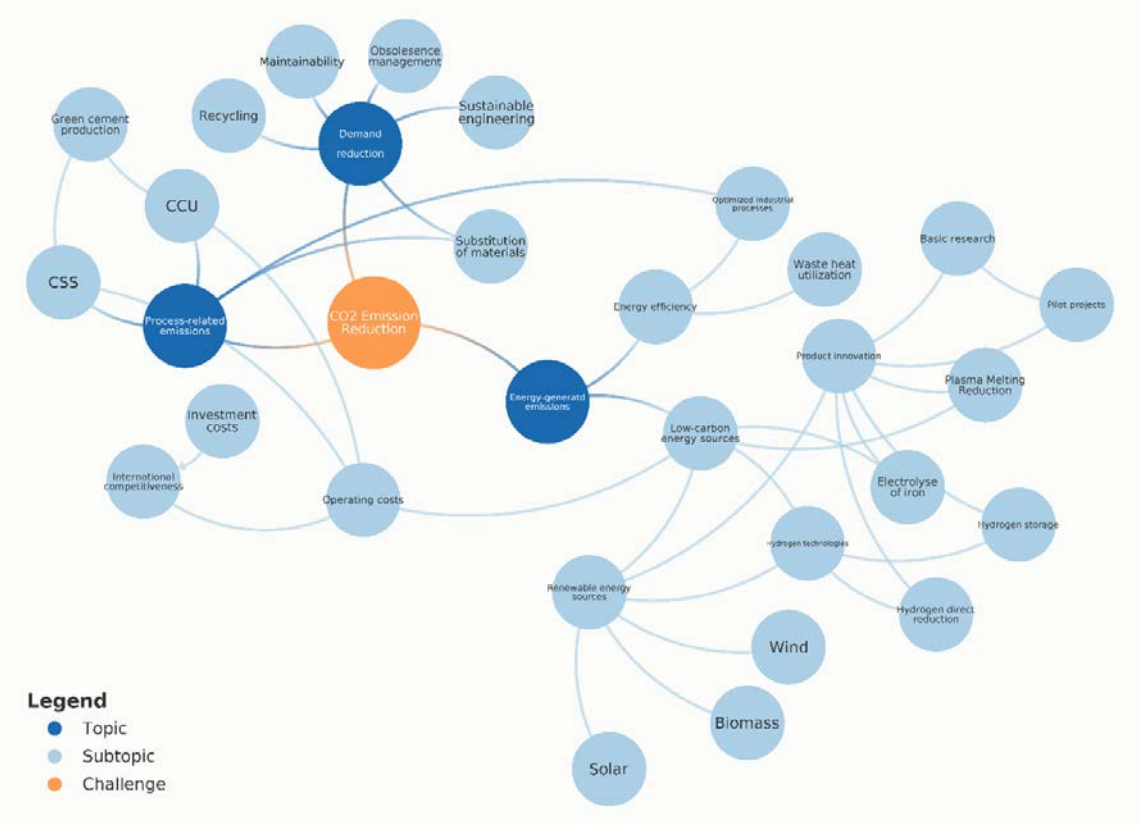
4 https://www.hybritdevelopment.com/

Further, for many industrial production processes that generate CO_2, few affordable and reliable substitution options are available today. For example, during cement production, CO_2 is released from raw material limestone and these CO_2 emissions could only be mitigated if an alternative to limestone was available. However, there is currently no alternative to limestone available that is that vastly abundant and cheap. Therefore, efforts focus on either capturing and utilizing (so-called CCU technologies) or capturing and long-term storing parts of the CO_2 emitted during the production process (CCS technologies). CCUis a promising approach for reducing emissions in hard-to-abate industries. However, CCU will be unable to enable greenhouse gas neutrality of the German industry sector alone, because the firing of CCU products still emits considerable amounts of CO_2 . On the other side, CCS technologies face political challenges foremost social acceptance. In recent years, there has been a growing public opposition against such storage sites, as CCS techniques bear the risk of inducing earthquakes and are criticized for other unintended ecological consequences. Finally, both CCU and CCS technologies increase the overall production costs considerably. As a result, getting these technologies to the markets and into broad application therefore would require a strong joint effort by energy-intensive industries, especially from the building sector, energy providers and political actors to demonstrate that these technologies can make an effective and at the same time safe contribution to the reduction of CO_2 emissions.

The public debate around CCS points to the important role of citizens in achieving Grand Challenges. As mentioned above, public opposition can block certain technological pathways, regardless if this opposition is based on environmental and health concerns or the fear to lose jobs in energy-intensive industries. Moreover, citizens can influence technological transformation processes through changed demands for consumer products. For example, if the demand for green products increases and consumers are able and willing to pay more for climate-friendly products, this could be a powerful incentive for private companies to switch to sustainable production processes. In some consumer products the extra costs for green materials are nearly negligible. For example, a car produced with green steel costs about 100-150 Euros more than a similar car made of conventional steel However, this requires that consumers are actually provided with the necessary information on materials and products, for example with trusted labels, in order to assess the specific carbon footprint.[5]

5 https://materialeconomics.com/publications/industrial-transformation-2050

Figure 7: Topics for system of CO_2 emission reductions (own elaboration)



4.1.1 The role of science and technology

The overview of the main factors of industrial CO_2 emissions shows that technological innovation is an important building stone across efforts to reduce these emissions, but also that in order to make an actual contribution, new technological solutions have to be adopted on a large scale. As discussed above, the demand for energy emissions could be reduced if industrial materials were developed and put into application that require little energy input during production, that are long-lasting, and that ultimately can be recycled. Further, also industrial goods have to be designed following the same principles. Different public and private actors play a role in this context. Sustainable materials and design solutions are mostly developed by universities and other public research institutes, in cooperation with industrial partners, such as car manufacturers, chemical companies, building companies, architects, and others.

In the same vein, also the reduction of energy-generated emissions draws directly on effective research and innovation activities. Only a relatively small number of industrial facilities, mainly factories producing steel, aluminum and concrete, account for a large part of the energy consumed by the German industry, thereby providing a powerful lever for efforts to reduce CO_2 emissions of this sector. However, these facilities are highly

complex, expensive and often custom-made technical systems. Any attempt to make these facilities more sustainable requires the involvement of scientists, engineers, operators as well as regulators and legislation. At the same time, while only some markets are predominantly national (e.g. cement and steel), part of the above-mentioned products are traded internationally (e.g. chemical products). In addition, investment cycles for these facilities are typically very long. In consequence, any update of processes and facilities in these industries has to bear in mind the specific cost-sensitivity of the materials and goods produced over a long timeframe. To meet these requirements, researchers from various disciplines are working towards sustainable or at least less harmful and at the same time affordable technical solutions for all kinds of industrial applications. For example, some of Germany's largest ongoing industrial innovation projects aim to replace coal-fired furnaces with hydrogen-power furnaces. As of today, only pilot facilities have been built, operating at far higher costs than conventional furnaces. To get the new alternatives to the market stage, more basic and applied research is still needed. Further, the introduction of this new generation of furnaces also depends on the availability of affordable hydrogen on a large scale.

Finally, also the reduction of process-generated emissions is virtually impossible without significant advancements in scientific and technological know-how. Although CCS as the main available technological approach to reduce this type of CO_2emission has been employed in the energy sector in some countries today, there are significant doubts concerning the effectiveness and safety of the existing technologies. Although the German CO_2 storage law would allow an annual storage of up to four millions tons of CO_2, today, only one test site in Ketzing is operational.

While these examples illustrate the manifold technological challenges involved in the overall effort to transform the German industry sector to significantly reduce greenhouse gas emissions within the upcoming years, the analysis of the socio-technical system also shows the limits of technical innovations alone. For example, the demand for green industrial products is directly related to social factors, such as public environmental awareness. Also a strong political will is important in support of technological innovations. For instance, capturing and storing or utilizing industrial CO_2 emissions will most likely remain a complicated and costly endeavor in the foreseeable future. Unless industrial companies are not provided with clear incentives to invest in innovative technologies, just releasing greenhouse gas will remain the easier and cheaper way. In short, advancements in science and technology are an important precondition to enable a transformation of the industrial sector towards sustainability, but they alone are unlikely to create enough momentum to fundamentally change the ways in which industries are working today. Only a combination of technological innovation, enabling economic and political conditions as well a general societal change will be able to do so.

4.1.2 Beyond the domestic context

In search for possible solutions to achieve an effective CO_2 reduction of Germany's industrial sector, it is imperative to consider the international context, not just because climate change is a global challenge, but also because Germany's industry is competing internationally. Especially the European Union is relevant here, as it sets many of the regulatory conditions under which German companies operate. Above all, the European level is decisive for the cost-benefit analysis of competing technologies with different CO_2 footprints. Started in 2005, the European Union Emissions Trading System (EU ETS) uses a certificate system to regulate the maximum of CO_2 gases that installations can emit as well as the trade of unused certificates. In recent years, the price of certificates has increased sharply, from less than five Euros per ton in 2017 to around 25 Euros per ton in early 2020. As the certificate prices continue to climb, this should make energy-intensive production more expensive. However, allowances, designed to prevent possible disadvantages from EU climate legislation with international competitors, could in the end offset European greenhouse gas emission reduction (so-called carbon leakage). An alternative approach under discussion are so-called carbon border adjustments that would impose tariffs on goods and materials imported into the EU, based on their specific greenhouse gas footprint.

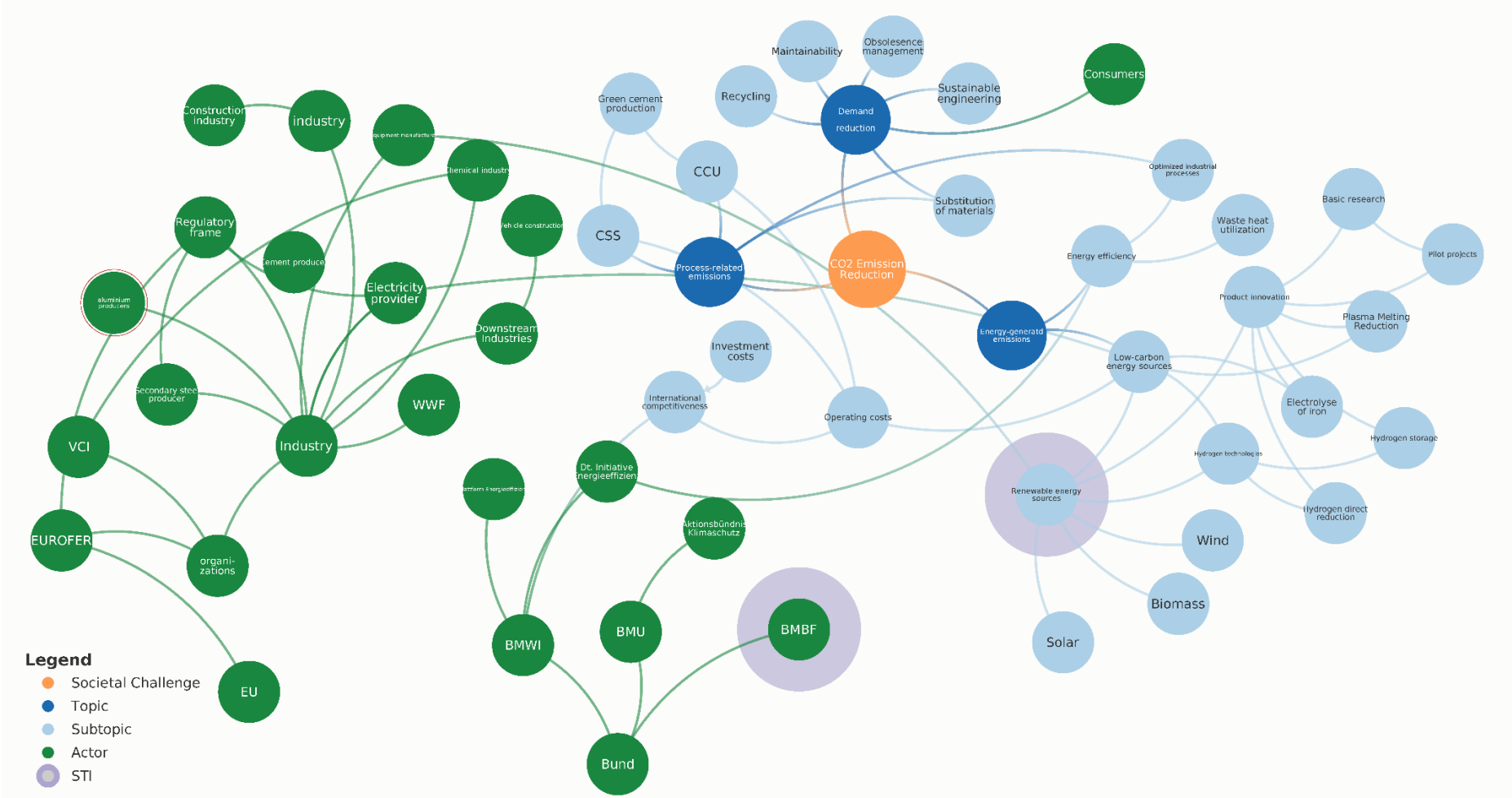
In addition, the European Union not only plays a key role as a regulator of energy-intensive industries, but also as a driver and financier of innovation processes. Above all, the EU Innovation Fund (IF) uses revenues from the EU ETS to support the demonstration of low-carbon technologies. For the period of 2020-2030 alone, the IF is planning to spend 10 billion Euros for innovation projects. Further, the EU also uses other instruments, such as the EU Horizon research program to advance scientific knowledge and accelerate Europe's decarbonisation process. To note, these innovation programs only address the capital expenses connected to replacing CO_2-intense facilities. Yet they are generally unable to set off the higher operating expanses of the new, low-carbon plants.

4.2 Mission goals and structure

4.2.1 Mission context

In Germany, the industry sector is responsible for a significant part of the country's current CO_2 emissions, currently around 20 per cent of all national greenhouse gas emissions. In consequence, an effective reduction of industrial CO_2 emissions plays a key role in Germany's efforts to mitigate climate change and fulfil its international obligations

Figure 8: Topics and actors for system of CO_2 emission reductions (own elaboration)[6]



6 Access to the full map is available under https://embed.kumu.io/cc5d8bed0461e8ee84ebce9ef103a3e2

under the 2015 Paris Agreement, which requires greenhouse gas neutrality by the year 2050.

The mission on 'substantial greenhouse gas neutrality in industry' is closely connected to the Federal Government's decarbonisation strategy for Germany of 2010, the Climate Action Plan 2050 and the more recent Climate Action Programme 2030, which came into effect in 2019. Following the Action Plan, Germany has to reduce its CO_2 emissions by 80 to 95 per cent, compared to 1990, effectively becoming greenhouse gas neutral by the year 2050. For the industry sector, the Climate Action Plan further defines as an intermediate goal the reduction of 49-51 per cent (equivalent to 40 mio. tons CO_2) by the year 2030. The Climate Action Programme aims to translate these goals into more precise measures, driving by the binding reduction goal of 55 percent of greenhouse gases by 2030. It entails several regulatory instruments, such as the Climate Action Act (Klimaschutzgesetz) and the extension of the carbon emission trade to transport and heating sectors.

4.2.2 Mission goals

The mission's target is to reduce industrial emissions in line with the requirements of the Climate Action Plan, while securing the competitiveness of Germany's industry as well as industrial jobs. Further, the enhancement of sustainable industrial solutions is hoped to open up new opportunities for exporting green German technology, ultimately strengthening the global market position of the German industry.

Mission description: In order to achieve its ambitious environmental and climate policy goals, the German Federal Government intends to launch a decarbonisation support program for industry in accordance with the Coalition Agreement. The Coalition Agreement also provides for the targeted provision of public funds within the framework of energy research for the development of low-CO_2 industrial processes and for the CO_2 circular economy. A research, development and market launch program aimed at reducing climate-impacting industrial process emissions is already included in the Climate Action Plan 2050. These measures are intended to serve the long-term climate action goal of being largely greenhouse gas-neutral, i.e. achieving a reduction of 80 to 95 per cent compared to 1990, to safeguard Germany as an industrial location, to strengthen the international competitiveness of German companies, and to create and maintain sustainable jobs in Germany. The long investment cycles must already be taken into account in this process. The development of the planned funding program requires comprehensive scientific groundwork, dialogue with the sectors concerned, and a time frame for the preparation and coordination of the funding directive and notification under EU State Aid Law (BMBF 2018, p.21).

In principle, the mission is designed in a technology-open fashion, meaning that it does not favor specific technological solutions over others. Rather, it unites research activities

in different fields, some aiming at 'easy wins', while others working towards long-term solutions. Specific focus is set on innovations in the following industries: steel and iron, chemical, cement and chalk, non-iron metals.

In terms of funding, the largest element of the mission is the 7th Energy Research Program, which supports basic and applied energy research with over one billion Euros per year. It is led by the Federal Ministry of Economic Affairs and Energy (BMWi), organized together with the Federal Ministry of Food and Agriculture (BMEL), and the BMBF. It supports innovation activities by large companies, but also by medium and small enterprises as well as start-ups. While the BMBF implements funding measures in all areas of basic research (Technology Readiness Level (TRL) 1-3), the BMWI promotes application-oriented research (TRL 3-7) and real laboratories along the entire energy chain (TRL 7-9). The BMEL is responsible for application-oriented biomass research (TRL 3-7). The 7th Energy Research program supports a variety of industry-related topics, including energy efficiency in the industry, system integration, and CO_2 capturing technologies.[7] For example, the project Carbon2Chem follows a CCU approach, aiming at using CO_2 from the steel industry as an input to the production of chemicals, e.g. fertilizers. Potentially, this could lead to a reduction of CO_2 emissions of 20 million tons per year. The research project MACOR analyzes the potential of direct reduction techniques for steel production using natural gas and green hydrogen. Also, several of the 10-year Kopernikus projects within the 7th Energy Research Program address industry-related questions. These projects aim to support research topics over the whole innovation cycle, from basic research to the application stage. Following this approach, for example, the SynErgie project, led by the Technical University Darmstadt, examines how industrial companies, for example in the aluminum, chemical and plastic industry, can balance out current fluctuations in the energy grid through flexible energy consumption. The project uses a demand-side management approach to synchronize demand and supply with an integrated IT platform. Since 2019, the research program also includes a new funding scheme that enables 'Reallabore' for energy transformation. In a first round, 20 projects with scientific and industrial partners were selected and provided an annual support of overall 100 million Euros. The focus of this funding scheme is on hydrogen technologies as well as on integrated energy systems.[8]

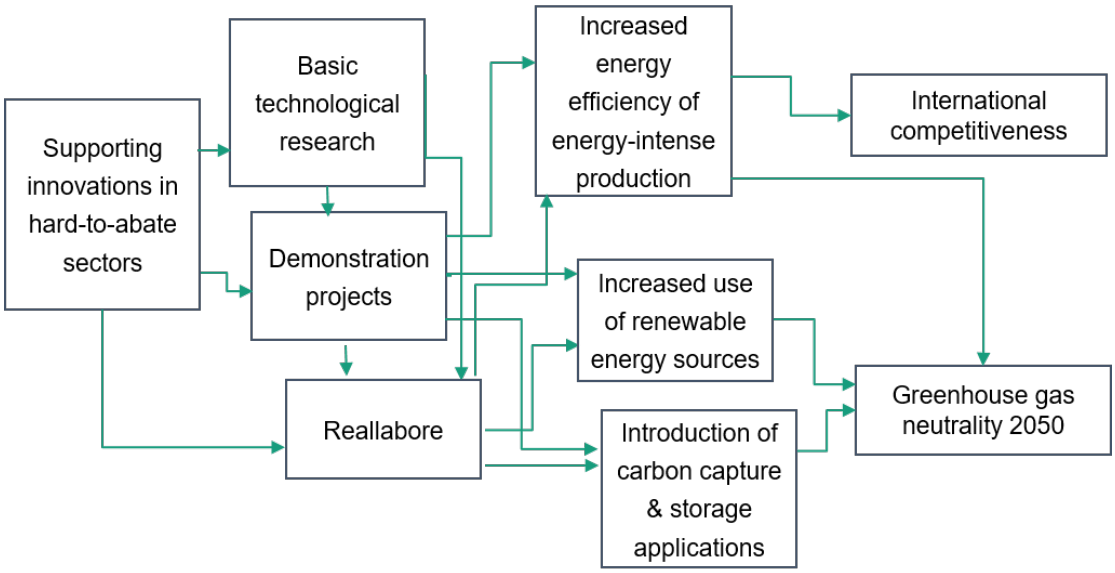
Another important pillar of the mission is the research framework Research for Sustainable Development - Fona3, led by the BMBF. Overall, it encompasses sustainability-

7 https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/bundesbericht-energieforschung-2020.html

8 https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2019/20190718-altmaier-verkuendet- gewinner-im-ideenwettbewerb-reallabore-der-energiewende.html

related project funding of around 500 million Euros per year. Since 2015, Fona3 supports technical and social innovations around several flagship initiatives, including one focused on green economy and another one on the transformation of the energy sector. It entails several Reallabore to test innovative approaches on a local or regional scale under realistic conditions. In 2019, as part of Fona3, a new funding scheme 'KlimPro-Industrie' for technologies of capturing and utilizing respectively storing CO_2 emission was started, aiming to reduce process-generated emissions.

Figure 9: Anticipated pathways towards goals of mission on the reduction of CO_2 emissions (own elaboration)



A new instrument within the mission is the research program 'Decarbonisation in the Industry Sector', that has started in 2020 and is financed by the BMU. It is part of the ministry's environmental innovation program and focuses on process-related emissions. It offers overall 45 million Euros of funding for the development and introduction of market-ready technologies to minimise greenhouse gas in German industries. The program supports demonstration projects for new industrial-scale applications of technologies and processes to reduce this type of emissions, mainly in the steel, cement, chalk, and chemical industries. Connected to the research program is the Competence Centre on climate change mitigation in energy-intensive industries (KEI) in Cottbus, which already opened in 2019. The KEI is a think tank for new research needs in the domain of energy-intensive industries, closely cooperating with the Federal Environment Agency (UBA). Further, the

KEI also functions as the executive agency of the 'Decarbonisation in the Industry Sector' research program.[9]

A final element of the mission is the Institute of Low-Carbon Industrial Processes, operated by the German Aerospace Center (DLR). It supports large applied research projects, among others on the provision of renewable high-temperature heat for energy-intensive processes in chemical, cement and other industries. The institute with locations in Cottbus and Görlitz/Zittau was established in 2019 as part of German government's efforts to guide structural transformation processes in former coal regions.[10]

4.2.3 Governance of the mission and actors

Most important actors for the governance of the mission are the three ministries that jointly organize the mission, i.e. BMWi, BMU and BMBF. Further public, private and societal actors are primarily involved through different policy platforms. To mention here the dialogue series 'decarbonisation in the industry', organized by the BMU and UBA. Further, the research network 'Energy in Industries und Trade', commissioned by BMWi, brings together representatives of the industry, science, society and politics.[11] on the political-strategic level, the ministries coordinate their activities through the Climate Cabinet Committee (the so-called Klimakabinett). The Climate Cabinet Committee particularly serves to set the legal and economic guidelines for the government's various activities. To ensure a close link between policy-making and academia, the Science Platform Climate Protection was established in 2019. The Platform is part of the Climate Action Plan 2050 and serves to underpin Germany's long-term climate change strategy with scientific expertise. Finally, there are governance arrangements for specific technologies and industries. To mention here is for example the "Handlungskonzept Stahl" (action plan steel) that aims to coordinate the actions of the BMWi, the BMU and the BMBF in support of a sustainable transformation of the steel production industry in Germany.[12]

9 https://www.klimaschutz-industrie.de/en/competence-centre/

10 https://www.dlr.de/di/en/desktopdefault.aspx/tabid-13342/23331_read-54008/

11 https://www.forschungsnetzwerke-energie.de/industrie-und-gewerbe

12 https://www.bmwi.de/Redaktion/DE/Publikationen/Wirtschaft/handlungskonzept-stahl.html

4.3 Review of mission goals and position within the socio-technical system

4.3.1 Position of the mission in the socio-technical system

The mission primarily addresses large-scale technological solutions for reducing energy-generated emissions in energy-intensive industries. To this end, different funding schemes provide governmental support for investments. Particular focus is put on steel and cement industries, where the mission aims to attract investments by private companies through generous funding for research and innovation activities. Several instruments within the mission further aim to find solutions for reducing process-related emissions. However, in relation to the great importance of process-related emissions for the goal of industrial greenhouse gas neutrality, these efforts appear rather limited, which may be due to the general unfavorable political climate for CO_2 capture and storage technologies in Germany. Downstream industries and secondary production (e.g. recycling steel) play a secondary role. While the mission offers considerable support to lower investment costs for the industry, operational costs are hardly addressed. However, the products produced with the new green technology will remain more expensive, as long as the external costs of industrial greenhouse gas emissions are not factored in. So far, as the mission is clearly focused on research and innovation activities, it does not include direct funding for operational costs. Rather it aims to set the regulatory framework to enhance the economic feasibility to implement green technologies on an industrial scale, for example through its action plan for the transformation of the German steel industry (Handlungskonzept Stahl), as well as advocacy for better enabling conditions for green technologies on the European level, e.g. related to border carbon adjustments, Carbon Contracts for Difference. Also, there are only few instruments within the mission that directly address the demand side of the industrial production equation. While, for example, the Fona3 research program provides funding for research projects on recycling technologies, it is not clear in how far these are part of the Hightech mission.

4.3.2 Review of the mission

In terms of CO_2 emissions, the targets of the mission are clearly defined, less so with regard to Germany's economic competitiveness. Further, the mission takes the European context into account. Especially, there are several links to European industrial regulations as well as European innovation activities. At the same time, there are only few instruments like the 7th Energy Research Program that bring together several ministries, creating extra momentum or synergies. In some instances, there appear to exist several instruments, commissioned by different ministries, aiming at similar objectives. It is not clear why some actors and instruments that could make a valuable contribution to the

mission are not considered. For example, there appears to be no connection to the newly established Fraunhofer IEG.

There are several forms and mechanisms to involve different stakeholders in the implementation of the mission. Especially the energy-intensive industries are involved in many instances. In comparison, downstream industries (e.g. car manufacturers, construction companies) or producers of secondary material (e.g. recycling steel), are rarely involved. A positive example in this context is the research project 'Eckpunkte für ein Roadmap zur Dekarbonisierung der Stahl- und Zementindustrie' by the German Environmental Agency, which also considers these actors. Inclusion of other stakeholders, such as environmental groups or the local population, could be observed for some, but not for all instruments. Product end users are usually not considered at all, although ultimately a major driver for change will be change in behavior (e.g. the acceptance of wood as a construction material and car sharing).

The instruments generally appear well-suited to advance technologies that could make an important contribution to lowering industrial CO_2 emissions and thereby reaching Germany's greenhouse gas reduction targets. The inclusion of several 'Reallabore' in the mission appears as a promising approach to bring new technological solutions into application and demonstrate their practical value. However, the measures are generally unable to overcome the central challenge of sustainable technologies in the industry sector, namely the high operating costs. Thus the regulatory framework (e.g. standards, norms, energy taxes and subsidies) would need to be considered as well.

There are some connections between the instruments of the CO_2 mission and instruments that are part of other missions of the German HTS 2025. For example, there are links to the mission on structural transformation. However, we could observe direct connections to other related missions, such as *'Creating Sustainable Circular Economies.'*

5 Mission: Creating sustainable circular economies

Section written by Miriam Hufnagl, Katrin Ostertag, Matthias Pfaff

5.1 Description of the socio-technical system

Against the background of a growing world population which relies on (limited) natural resources and the current experiences of climate change or the corona pandemic, a societal consensus is being established that different and more sustainable forms of 'doing business' need to be arranged. According to the Global Resources Outlook (2019) by UNEP: 'The use of natural resources has more than tripled from 1970 and continues to grow. Global population has doubled and global gross domestic product has grown fourfold since the 1970s. This has been fueled by an ever-increasing supply and extraction of materials, thereby intensifying pressure on land and water. From 1970 to 2017, the annual global extraction of materials grew from 27 billion tons to 92 billion tons, while the annual average material demand grew from 7 tons to over 12 tons per capita' (p.27). In order to transition to a sustainable future one essential point of action is therefore 'the decoupling of natural resource use and environmental impacts from economic activity and human well-being' (ibid. 28).

Disrupting this connection between economic growth and use of resources is the centering philosophy of circular economy practices that introduce a fundamentally new way of producing and consuming. Three principles, that have been suggested by one of the leading think tanks in the field, the EllenMacArthur foundation[13], illustrate major aspects that need to change in the socio-technological systems underlying different branches and consumer goods:

1. Design out waste and pollution [n.b. avoiding both when creating new materials and technologies]
2. Keep products and materials in use
3. Regenerate natural systems

These principles also point to the fact that an orchestrated interplay of policy (in the role of a regulatory force but also as a powerful purchaser with a view to public procurement (green public purchasing) and initiator of stakeholder dialogues), industry (e.g. as obeying suppliers of goods or engineers for construction reacting to regulation) and society (e.g. pushing for behavioral change in consumers) is needed for this fundamental change

13 https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy, online last visited 30.09.2020

towards circularity. Political targets like national and international reliable framework conditions and non-discriminatory market access for innovative sustainable solutions regarding for instance new materials and their usage in housing or mobility devices could be put forward. To achieve the desired transformation of the way the economy is run today, solutions based on scientific insights and research activities are also necessary. Accordingly, a transfer of these solutions and the implementation and dissemination of new technologies, services and business models together with industry and consumers is key to achieve circularity.

A straightforward description for the motivational challenges of reconfiguring the linear economy towards circularity is the following: 'The 'circular' in circular economy is a cipher for feedback, for closing the loop, but revealed in the light of the economy being part of an open system [...] and where decay and disorder are every bit a reality as regeneration and restoration. It's a contrast to the analogy of economy as machine – extract-make-and-dispose. [Where] The only feedback is monetary' (Webster 2017, p.15)

There is consensus that 'loops' are at the heart of every CE concept. With a view to gaining more circularity though, the complex interconnection of topics, institutions and actors have to be analyzed separately for each economic sector (e.g. construction textiles or ICT) involved and targeted solutions need to be formulated and implemented in order to really affect the corresponding different diverse value chains. This also calls for a sensitive consideration of the geographical scope of associate policies considering the possibilities for communal, regional, national as well as international actions.

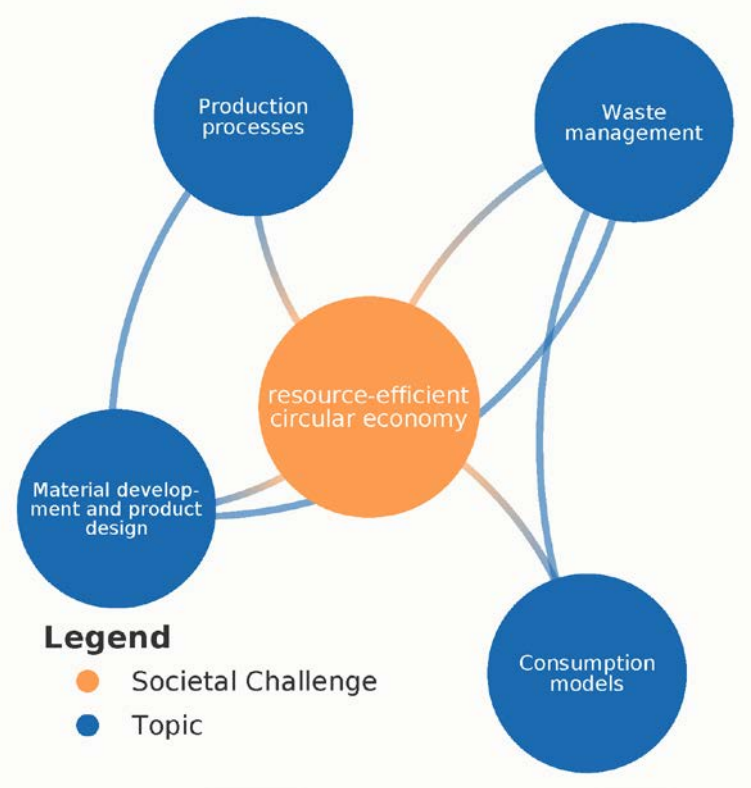
Introducing circularity as a general principle of product life-cycles though, needs awareness to similar meta-categories for each sector to ultimately affect the corresponding socio-technical systems. To grasp the complexity and variety of aspects that need to be addressed to reach circularity we highlighted the main topics that interconnect as displayed in figure 10 and will describe these hereafter. The attribution of a strong role of STI-policy is indicated by a grey circle, pointing to the fact that 'production processes' as well as 'material development and product design' have already been addressed by research funding for quite a while.

Material development and product design

Given the fact that the paradigm of circularity is targeting a fundamental shift in creating and distributing goods as diverse as electronics, vehicles or textiles as well as building components for houses for instance, different industries need fit-for-purpose regulatory guidance and sufficient incentives have to be implemented for producers to design goods that leave the linear paths of 'produce-use-dispose' in order to get reused or recycled and enter the material circle. The way products are designed and materials are

selected (see principle one above) will more than ever need to take into consideration aspects like durability, dismantleablity, updateablity, multi-functionality, re-purposability, valency and also the use of energy connected to the production process.

Figure 10: Main topics for system of circular economy (own elaboration)



Production processes

It is self-evident that a very complex policy mix is required to guide and direct modern processing routines of many different resources and substances that are needed for the production of different goods and the associated logistics. Producing with 'the end' or better 'reuse' in mind is absolutely vital to achieve circularity but quite a new obligation to many manifacturers particularly in supplier companies in third countries outside the EU for instance. The avoidance of hazardous substances during production processes has obviously been an important aspect for quite a while but also needs careful attention with a view to CE: the concept adds to this challenge because hazardous substances embodied in a product may hamper future reusability and recyclability. Producers are furthermore forced through the concept of CE to think about the after use phase of their product, the associated reverse logistics and also reconsider the way how their production is set up in the first place (e.g. engage in pay per use models with a view to facilities). Evidently the subject of mandatory (or in exceptional cases voluntary self-)

regulation of production processes is also covered by another mission, namely 'Achieving substantial greenhouse gas neutrality in industry' with its core aspects of addressing energy-intensive production processes and process-related emissions.

Waste management

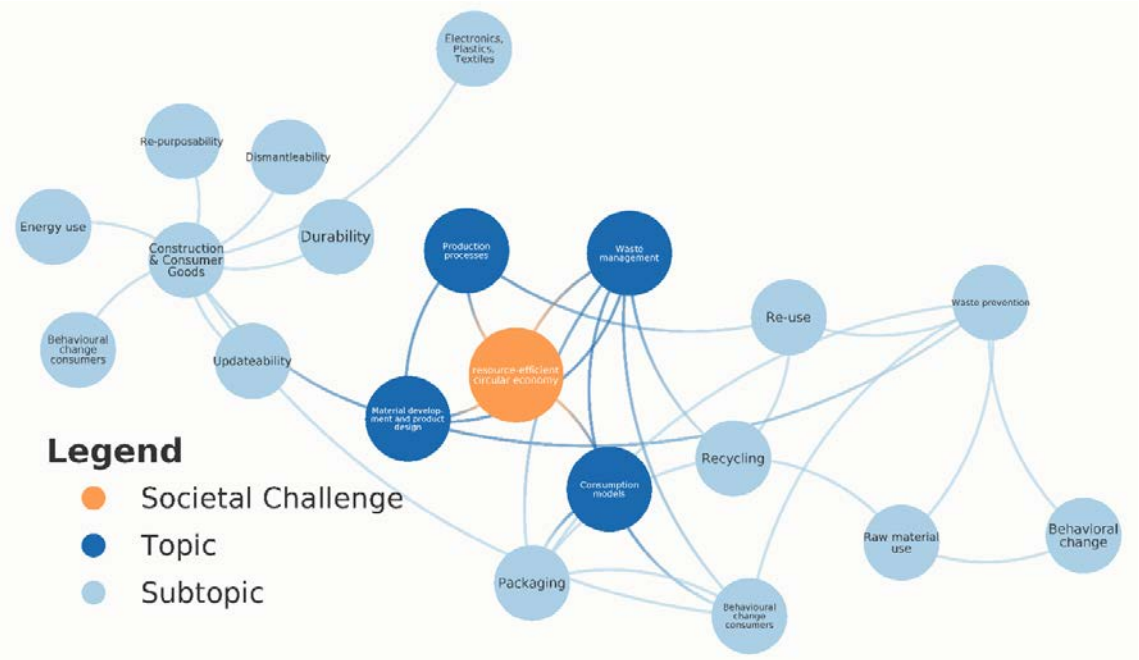
Public authorities traditionally approach the concept of CE by addressing the goal of 'avoidance of waste disposal' considering the provision of municipal public services. Keeping substances and materials in the loop ultimately restructures the waste hierarchy of avoidance, reuse, recycling, other forms of recovery and landfilling/disposal while abandoning the latter. In Germany the starting point for circularity can be associated with the introduction of the Recycling Management Act (Kreislaufwirtschaftsgesetz) in 2012. The purpose of the law was to promote recycling management to conserve natural resources and to ensure the environmentally compatible management of waste. In 2018 the EU introduced amendments to the main waste management regulations which in 2020 resulted in a draft amendment of the Recycling Management Act of the BMU (under Social-democratic leadership) with three focal points: recycled products are to be given priority in public procurement by federal authorities; financial liability of producers and distributers of waste intensive goods (e.g. disposable cups or cigarettes) will be introduced; the destruction of returned goods in e-commerce should be avoided.

Consumption model

The common model of the consumer society needs a fundamental shift if circularity is to be achieved. All above mentioned domains will need to feed into changing the mindsets of producers of goods and individual consumers. Keywords like sharing economy, shops with unpackaged goods and self-supplying lifestyles (prosumer) represent the vast variety of individual and collective societal engagement that is gaining momentum momentarily. However, as mentioned above the complete the paradigm shift 'full circle' targeted bottom up initiatives can be observed, though strong regulatory measures and the support of social innovation are at the heart of consumer adjustment. The latter focuses on bringing about a sustainable shift of social practices in general as well as individual behavior.

Considering different stages in product life cycles and the fact that a real paradigm shift towards circularity has to address many industrial subsystems and take into consideration consumer as well as producer routines and portfolios, one cannot single out concrete socio-technological systems that need to transform, but rather a systemic shift on how 'business is done' and 'waste gets handled' needs to happen. Accordingly, the complexity of the subject is also reflected in the distributed responsibilities between the different public authorities with strong topical fragmentation.

Figure 11: Topics for system of circular economy (own elaboration)



5.1.1 The role of science and technology

Each of the four topics exhibits potential for research and innovation support and activities. Transferring results from e.g. material sciences and engineering into product design will heavily contribute to solving the underlying challenge of avoiding or reusing waste. Furthermore, when assessing the individual material footprint when using and circulating raw materials as different as fossils fuels, metals and non-metallic minerals, wood (or even water and land), indicators derived from STI practices are important (see below for more details on STI policies). Evidently, with a view to waste handling processes, research in ICT and artificial intelligence (AI) plays an important role. Since *circularity* is also asking for changing routines of industry and individual consumers socio-scientific insights are also required to accompany the roll out of CE practice and investigate modes of acceptance and change management.

5.1.2 Beyond the domestic context

As outlined above, the matter of circularity is a cross-sectoral and cross-national issue that has already gained worldwide attention by policy makers, NGOs and industrial federations.

The urge to reconsider the way economical dynamics are structured today is considered in many different settings ranging from communal or regional initiatives[14] to national efforts and supra- as well as international initiatives. Many elaborate attempts of 'circular economy' initiatives that try to connect societal initiatives as well as governmental actions can be found among EU member states such as: France, Greece, Denmark, Portugal, Slovenia, Italy and Finland.

Considering globalized production and consumption chains, however, effective circularity can only be reached if all levels of policy making and more importantly, the manufacturing industry which is embedded in a wider network of supplier and service industries like logistics or even the finance sector reach common and reliable agreements on certain standard values and perform active and shared responsibility.

Accordingly it is imperative to pay attention to the EU Commission's current activities targeted at forging a 'sustainable industry' within the European Green Deal[15]. Taking into account the ambition and budget involved in this strategic framework that is currently taking shape in the transitioning phase between the two research framework programs Horizon 2020 (2014 to 2020) and Horizon Europe (starting in 2021), there are high expectations on changing policy accordingly.

Striving for circularity is a guiding principle of the Green Deal, 'that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.' (ibid. p. 1) To meet these ultimate goals, the Commission announced the formulation and implementation of novel transformative policy instruments. Accordingly consultation processes are currently underway among stakeholders to propose sound and senseful impact assessment schemes, which might fit to monitor and improve this new strategy and its instruments. In this context, however, it remains to be seen how the Commission will proceed with defining and fine tuning the concrete procedures of the Green Deal missions in exchange and cooperation with respective experts in the fields and ultimately the member states. As for every level of STI-policy making and already stated above: besides the consensus on the urge to 'rethink policies' by developing a transformative impetus by a given budget and within a certain timeframe the concept of mission-orientation is still underdeveloped as a guiding

14 like the Amsterdam Circular Strategy or the Belgian partnership 'Circular Flanders'

15 as announced in the Communication of the EU Commission COM/2019/640 final as of 11.12.2019: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1596443911913&uri=CELEX:52019DC0640#document2

principle and particularly contested when it comes to complex and interconnected topics like circular economy.

Nonetheless, with the formulation of the 'Circular Economy Action Plan' (CEAP) [16] the EU Commission took a bold step by acknowledging the biggest challenges when trying to tackle current stream of produce-use-dispose. The Action plan namely outlines a sustainable product policy framework considering three aspects:

- designing sustainable products
- [introducing] circularity in production processes
- Empowering consumers and public buyers

Above all, particularly a focus on the latter point of ultimately changing consumer behavior has to be acknowledged. This decisive aspect is neglected in many national initiatives with the HTS mission being no exception in the field. One possible explanation for this might be the fact that implementing public policies that aim at changing citizens' behavior with regard to consumption is a sensitive and contested topic for policy makers particularly at ministerial level. However, changing social routines of consumption has had a fundamental impact in recent years with regards to certain products or niches and there are high hopes that 'social innovation' will gain more momentum and the near future. Furthermore, with a view to the HTS at least, the main areas of action are within the field of securing raw materials and science-technology-innovation policy and right to this point there is no guideline or cross-sectoral agreement established on how to properly connect STI topics to mission's inherent ambitions for systemic change altogether (see review of mission).

To further acknowledge the EU Commission's efforts though, several instruments that might directly *contribute to* achieving more circularity in Germany as well, have to be stated like the Ecodesign Directive[17]or the EU Ecolabel[18] and the EU green public procurement (GPP) criteria[19]. Nonetheless, the current policy mix of EU initiaves and legislation is not sufficient since 'there is no comprehensive set of requirements to ensure that all products placed on the EU market become increasingly sustainable and stand the test of circularity' as stated in the Circular Economy Action Plan (CEAP, ibid, p.3).

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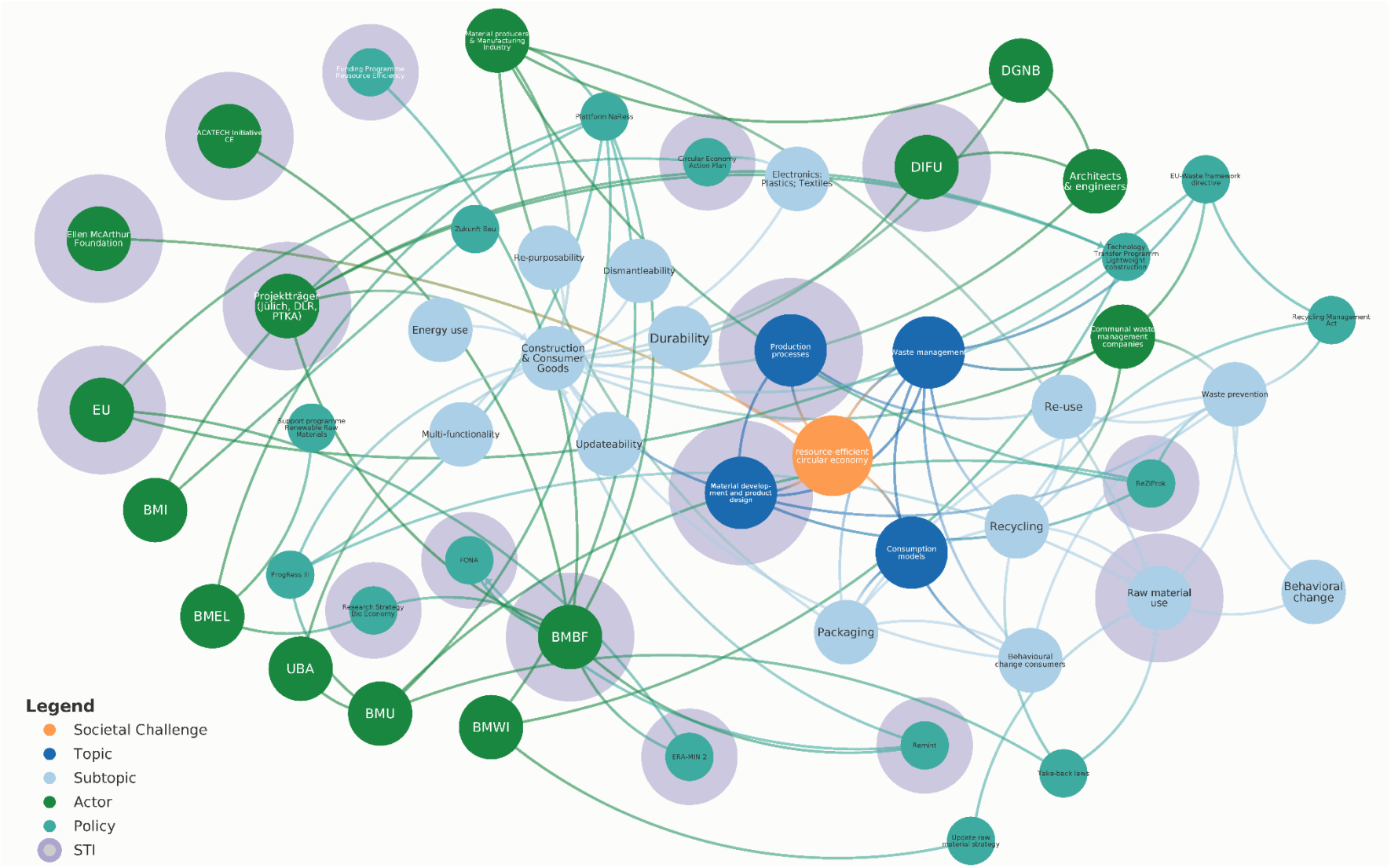
16 https://ec.europa.eu/environment/circular-economy/index_en.htm

17 Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, OJ L 285, 31.10.2009, p. 10.

18 Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel, OJ L 27, 30.1.2010, p. 1.

19 https://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm

Figure 12: Topics and actors for system of circular economy[20]



20 Access to the full map is available under https://embed.kumu.io/57afdaf0f4de4adad8e7ab21afdcb315

Therefore the proposal of 'a sustainable product policy legislative initiative' (Sustainable Product Initiative SPI) is announced by the Commission. The first selected resource intense sectors that will be addressed by the SPI are electronics, ICT and textiles but also furniture and high impact intermediary products of construction and consumption such as steel, cement, plastics and chemicals.

5.2 Mission goals and structure

5.2.1 Mission context

As outlined in the HTS so far, 91 per cent of the global economy is linear (produce- use-dispose) and only 9 per cent of the resources used are kept in circulation. The central challenge is therefore to facilitate the transformation of the predominant model of 'linear economy' to a resource-efficient and ecologically sound circular economy. This requires new business models and forms of cooperation to extend and intensify the utilization phase of products and to keep the raw materials involved in low-emission cycles, as well as change (long-term) consumer behavior and acceptance by all relevant stakeholders.' (HTS Progress Report, p.33)

Even though this holistic view on CE is put forward, the instruments introduced reflect that the perception on how to tackle the task of *creating sustainable circular economies* is rooted in the *Recycling Management Act* from 2012 (Kreislaufwirtschaftsgesetz). Accordingly the underlying principle for formulating the targets and possible levers of the mission, mainly revolves around solving the problem of waste disposal, guided by monitoring and managing the waste hierarchy in a rather classic sense (avoidance, reuse, recycle, other forms of recovery, landfilling). Therefore, the target values momentarily exhibit a strong focus on recycling and the reuse of recycled materials.

Mission description: We will work with industry, science and consumers to link economic growth to sustainability goals and achieve a 30 per cent increase in overall raw material productivity by 2030 compared to 2010. Material efficiency will be given priority in the manufacture of products. Together with all those involved, we want to press ahead intensively with the transformation of the traditionally linear economy into a resource-efficient circular economy. The focus will be on innovative business models in connection with digitalisation. (BMBF 2018, p.22)

Furthermore, the BMBF outlines the role of research and innovation to foster circularity as follows: 'At the heart of a resource-efficient circular economy is the circulation of products, components and raw materials. Their value or function should be preserved as long as possible and as little waste as possible should be generated. To this end, resource-efficient cycles, cross-sectoral value-added networks or cascade systems for products,

components and materials are to be established with the help of research and innovation.' (BMBF 2018, p.5, own translation)

Since the societal and political debate on the threats and consequences of climate change currently gained a new and dynamic impetus, a serious push for the sub-topics of circular economy in connection with conservation of resource and the avoidance of CO_2 emissions is apparent. Accordingly, connections to two other missions can be drawn:

namely, 'Substantially reduce plastic discharges to the environment' (effective recycling of plastics, reusable and less packaging, material substitution are important approaches towards that goal) and 'Achieving substantial greenhouse gas neutrality in industry' (avoidance of CO_2 emissions through increased resource efficiency and circular economy, material use of CO_2 in terms of a carbon cycle economy). Furthermore, the mission 'Putting artificial intelligence into practical application' has many systemically relevant overlapping features with a view to CE like use of AI for the detection of contaminants and intelligent sorting processes in recycling, for condition monitoring and extending the service life of products. Also the mission on 'Good life in the whole country' could develop some strong links. Even though the connection to the HTS in general is drawn, it has not been made explicit so far how to connect the policies in a meaningful way with a view to the missions themselves. Parts of the new initiative on 'innovation and structural change' will possibly feed into the CE mission and support the same goals[21], however, the connection has not been made in official documents so far.

5.2.2 Mission goals

Prominently featured in the HTS and the progress report, the German Resource Efficiency Programme (ProgRess) can be identified as the center piece of the mission apart from STI-related initiatives. The German Federal government has set itself the goal of increasing total raw material productivity by 1.5 per cent per annum by 2030 and through this support the principle of circular economy. This corresponds with the objectives of the sustainability strategy and contributes to the implementation of the European Circular Economy Strategy (Europäisches Paket zur Kreislaufwirtschaft von 2015) and the Climate Protection Plan 2050. Furthermore the new edition of the Raw Materials Strategy of January 2020 (lead BMWi), highlights circularity as a contribution to securing the raw material supply for the German industry. Increasing total raw material productivity means

21 The topic of single policy instruments and the interconnections between them will be raised in the SQA II. The new funding scheme 'REGION.innovativ: Circular Economy' will then probably be discussed in more detail: https://www.bmbf.de/upload_filestore/pub/REGION.innovativ_Kreislaufwirtschaft.pdf.

decoupling economic growth from resource consumption, significantly reducing greenhouse gases, waste and environmental pollution and reducing dependence on imports. These aspects interrelate with current challenges like changes in demand due to disruptive technologies, trade disputes, high market power of individual players, and increased requirements to guarantee socially and environmentally sound supply chains and respect for human rights[22], that indirectly might be mitigated by striving towards circularity. Focusing on the need of industry (particularly SME and higher TRL then BMBF schemes) the *Environmental Innovation Program* by the BMU finances projects that are 'well suited for demonstration purposes and hence for replication. The projects also lead to further refinement both of the technologies involved and of the environmental regulatory framework'[23].

Beyond this, the framework program FONA (research for sustainable development, third edition) is the most important initiative with dedicated funding schemes for STI related aspects of CE. A sub-program of FONA is the research concept on resource-efficient CE[24], which set the content framework identifying further R&D desiderate and outlines several funding policy initiatives like:

- Innovative Product Cycles (ReziProK)[25]
- Construction and Mineral Material Cycles (ReMin)[26]
- Transnational cooperation ERA-NET ERA-MIN 2[27]
- Resource-efficient Circular Economy - Plastic recycling technologies KuRT[28]

Material science is further supported by additional programs and institutional funding by Division 5 within the BMBF.

With a view to anticipating pathways towards (possible) mission goals figure 13 is one attempt to single out several paths towards 'closing the loop of production and consumption'.

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22 as stated in the BMWi (2020): Raw Material Strategy, p. 2.

23 https://www.umweltinnovationsprogramm.de/?en=1

24 Running from 2018-2023, with a total budget of 150 Mio. €, https://www.fona.de/medien/pdf/Ressourceneffiziente_Kreislaufwirtschaft.pdf

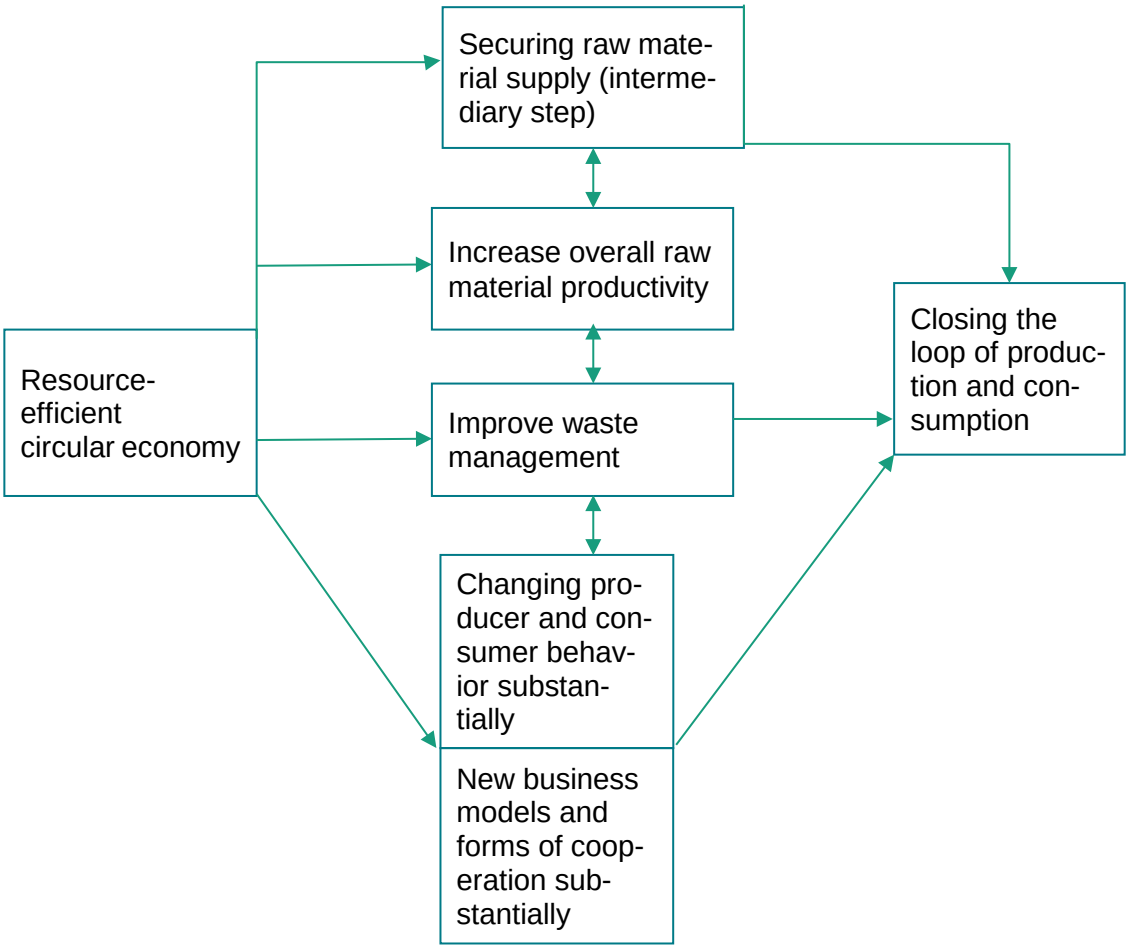
25 https://innovative-produktkreislaeufe.de

26 https://www.bmbf.de/foerderungen/bekanntmachung-2199.html

27 https://www.bmbf.de/foerderungen/bekanntmachung-2199.html

28 https://www.fona.de/de/massnahmen/foerdermassnahmen/recycling-kunststoffe.php

Figure 13: Anticipated pathways towards goals of mission on circular economy (own elaboration)



5.2.3 Governance of the mission and actors

The most important actors for the governance of the mission are four ministries, namely the Federal Ministry for the Environment, Nature Conversation and Nuclear Safety (BMU), the Federal Ministry of Research and Education (BMBF), the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry of Food and Agriculture (BMEL). Empirical observation and official publications document that there is a strict division of labor between ministries (following the Ressortprinzip) and there is room for more strategic and positive coordination/cooperation with a view to the policy instruments in place:

BMU: lead management of ProgRess (German Resource Efficiency Program), funding in the environmental innovation program and other measures (e.g. VDI Centre for Resource Efficiency), shaping the framework conditions (e.g. waste prevention program)

BMBF: Support for research and development (FONA, Bio-economy Research Strategy and other specialist program), lead management for planned research and innovation strategy

BMWi: Support measures for resource efficiency and lightweight construction, innovation in SMEs, market development program, involvement of industry, shaping the framework conditions for industrial stakeholders (e.g. securing the raw material supply through the raw material strategy)

BMEL: 'Renewable Resources' funding program, recycling management and cascade use of biogenic raw materials, interface with bio-economy (also a BMBF topic)

Three more joint initiatives have to be mentioned in this respect:

BMU and BMWi set up the 'National Platform for Resource Efficiency' (NaRess[29]) in 2015 to coordinate and discuss the needs of different industrial branches and ensure a structured dialog with regular meetings. In addition to industry associations, the platform has been extended to include organizations such as environmental and consumer protection associations, trade unions as well as representatives of local public services.

NaRess will actively contribute to the development of a 'national research and innovation strategy for resource conservation technology' as announced in the current coalition treaty (2018-2021). First steps on how to formulate a sound strategy that complements the mission are underway.

Furthermore, Acatech initiated a CE initiative[30] which is set out to propose a meaningful conceptual framework on how to foster the different aspects of circularity with a view to Germany. Industrial as well as societal stakeholders are engaged in this forum which is also supported by the BMBF.

5.3 Review of mission goals and position within the socio-technical system

5.3.1 Position of the mission in the socio-technical system

Since the mission asks for a sound balance of regulatory measures (waste management) and transfer of research insights into more sustainable products and packaging solutions

29 https://www.bmu.de/themen/wirtschaft-produkte-ressourcen-tourismus/ressourceneffizienz/naress-nationale-plattform-ressourceneffizienz/

30 https://www.circular-economy-initiative.de/

(product design) the socio-scientific perspective with regards to consumption models and behavioral changes is not yet very strongly established in the mission. With a view to engaging industrial partners the NaRess platform can be a strong forum to overcome this shortcoming partly. Currently though, the narrative emphasizes the role of raw material supply and security, as well as regulatory measures with a view to waste management. Apart from these two aspects with direct strategic relevance for the German industry, the funding schemes towards resource-efficiency are very prominent. But if and how the transfer of research insights into industrial practice is ensured has not been made explicit. Generally, a strategic stance on how the different foci arenas are linked together in order to accelerate the aspired transformation cannot be identified.

Broadening the perspective though, the mission does reveal considerable links towards EU policy making and the associated aspirations towards cutting down on material use and improving efficiency of production processes (see EU Circular Economy Action Plan).

5.3.2 Review of the mission

The mission was developed and formulated top-down, rooted in national and international sustainability policy. In this respect, it derives its legitimacy from an assumed broad societal consensus that, in view of increasing environmental problems (e.g. climate change) and, in particular, resource scarcity, there is a need to fundamentally change established economic practices, especially production and consumption. While this consensus may exist at a higher, abstract level, it is by no means uncontroversial whether economic growth is still desirable for society as a whole if it is only decoupled from the consumption of raw materials (and can be realised in a CO_2-neutral way). The reference to the potential of the bio-economy in this context is also critically discussed for various reasons (e.g. high biomass demand and competition with the use of biomass for energy). For the new edition of ProgRess as an essential instrument of the mission, a consultation process with stakeholders and a process with citizen dialogues took place in 2019 to raise awareness and legitimacy.

To increase total raw material productivity by 30 per cent by 2030 compared to 2010 is set out to be the major goal within the mission. So indeed, a certain direction can be identified; however this goal can only be seen as a milestone towards 'closing the loop' with a view to economy 'as a whole system'. For the mission to be successful and reach the overarching target it is fundamental to address different industrial branches, material suppliers and product designers, producers and consumers alike (socio-technological systems). So far it cannot be assessed if the policy actions taken contribute sufficiently and can impose a certain directionality towards reaching circularity in the long run: the

wording in official documents hints at a topical rather than holistic view on CE, with individual measures standing side by side, instead of being integrated into a systemic concept. Therefore, one has to question the decisiveness and commitment regarding CE in Germany by simultaneously acknowledging the fact that achieving circularity is a very difficult task that needs to be supported and fostered by all governmental areas at the same time (regional, national, EU-level).

There is no evidence of the way in which leadership at the operational level is supported and complemented by strategic leadership at the highest level of government. However, the division of tasks between the ministries listed above shows a clear demarcation of responsibilities with regard to thematically relevant research, setting framework conditions (e.g. waste management act) and raw material security (with diverse sub topics like fostering agriculture or supporting raw material intensive industries by securing scares materials needed for production purposes like rare-earth elements.

With a view to intentionality of this mission there are expectations that the first concrete industrial implementations with fundamental shifts towards circularity will occur by 2025. The target set for increasing overall raw material productivity refers to the year 2030 as mentioned about. Within the framework of ProgRess, as one of the main instruments of the mission, objectives and indicators are to be further developed in order to even track advances in the field beyond waste management and energy efficiency parameters. Strategic frameworks by the BMBF towards several subtopics are to be expected with regard to 'Increase raw material productivity, secure and broaden the raw material base, for example by replacing fossil fuels, support SMEs, accelerate implementation and cooperate internationally'[31].

With a view to the fundamental change this mission is aiming at participatory processes (like round tables, online consultations, green and white papers) can possibly be beneficial to foster consensus building. To solve the controversies on how to reach circularity these processes should involve all relevant actors to foster this systemic change, including civil stakeholders, representing e.g. the nature conservation movement and consumers, but also partners from industry and policy makers representing all levels of governmental authorities (communal, regional, the German states as well as the Federal Government and the EU). The results of the participatory processes should be tested for feasibility and implemented where suitable.

31 https://www.bmbf.de/de/ressourcen-forschung-fuer-mehr-effizienz-338.html

6 Mission: Ensuring good living and working conditions throughout the country

Section written by Florian Wittmann, Andrea Zenker, Thomas Stahlecker

6.1 Description of the socio-technical system

The question of equal living conditions and quality of life is enshrined in the German Basic Law, postulating equivalent living conditions throughout the whole country.[32] The question of equal living conditions, however, is not a challenge specific to Germany. Throughout Western democracies one can observe increasing popular discontent and challenges to the overall political system that are rooted in the decline of territories and growing territorial economic disparities(see Rodríguez-Pose 2018). The question of good living conditions is located in a socio-technical system that is driven by a variety of context factors, creating a highly complex and interdependent system. Among these context factors, there are trends like globalization, regionalization, urbanization, depopulation of rural areas, demographic change and technological developments shaping the living conditions in urban and rural, in highly and weakly developed regions in Germany.

To grasp the multi-faceted character of living conditions we focus on six main topics that are constitutive for the socio-technical system: mobility, social infrastructure, social cohesion, digitalization and communication, labor, and economy/innovation. Consequently, the issue of good living conditions reaches beyond the question of economic activity and infrastructure, but also takes into consideration questions of human well-being, living conditions, and social infrastructure.[33]

Being different dimensions affecting living conditions, these topics can be considered as closely interrelated. In rather rural and comparatively less densely populated areas, for instance, public transport and digital infrastructure (broadband) is provided to a less intense degree than in agglomeration areas. This constitutes one hampering factor for economic activities, thus for creating jobs. In a similar vein, social infrastructure, such as quality of schooling in rural areas or access to health infrastructure is often lagging behind more urbanized areas. On the other hand, living conditions in these areas - in the

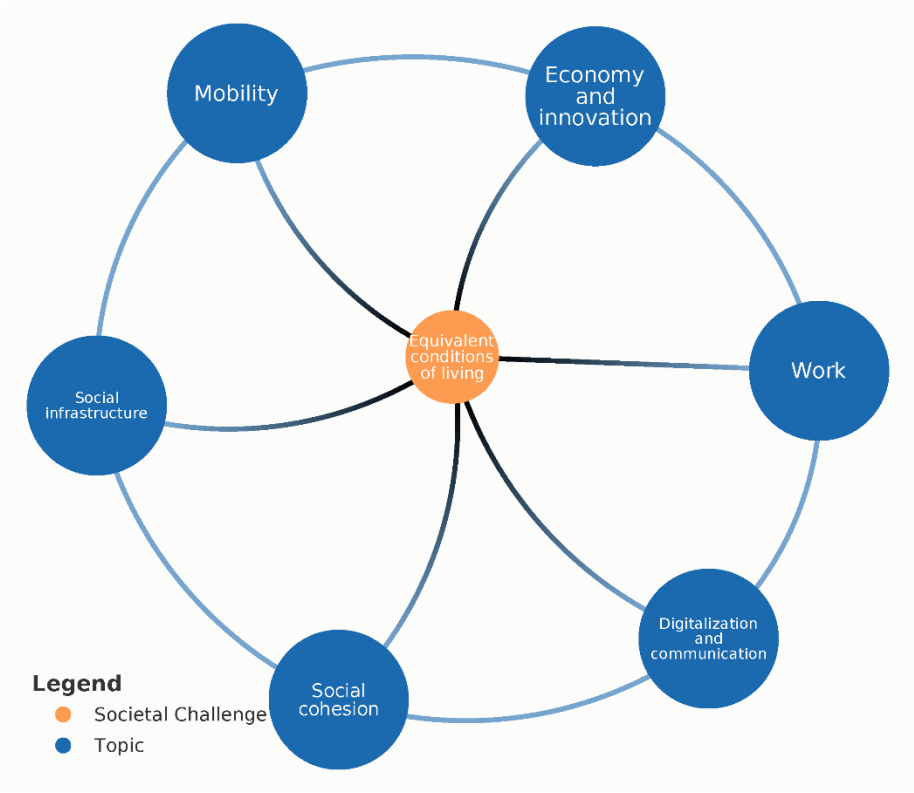
32 Also note the current understanding in the strategic document 'Our plan for Germany' (BMI, BMEL, BMFSFJ 2019, p. 8) that builds on the work of the Commission for Equal conditions of living (Kommission für gleichwertige Lebensverhältnisse) that defines equal conditions as good and fair opportunities for development and participation for all, regardless of the place of residence

33 We thereby draw on the main pillars of the report by the Commission for Equal Living Conditions Living, complementing it with additional sub-topics and interactions.

sense of negative agglomeration factors such as pollution, traffic jams, costs for living and housing - are often better than in larger cities.

Furthermore, the aspects are not only affecting each other, but can also reinforce possible positive or negative effects. In consequence, territories may end up in a vicious circle, continuously aggravating the overall quality of life in different areas. The lack of employment opportunities, pushes people to commute to distant working places and/or to leave the place in search for qualification and employment opportunities and in turn decreases the availability of skilled work force. Moreover, such developments can be accompanied by a rupture of existing social networks, a loss of social cohesion and an increasing dissatisfaction with the political system.

Figure 14: Main topics for system of equivalent living conditions (own elaboration)

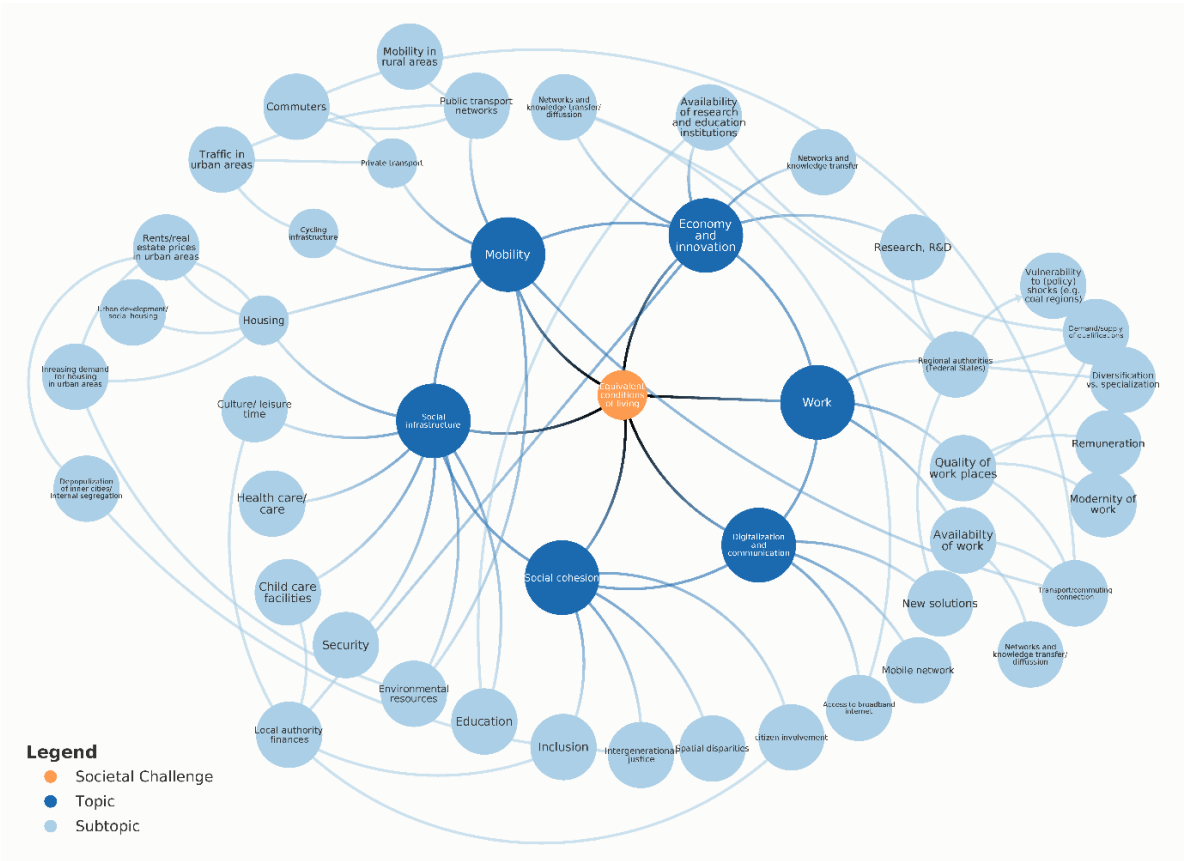


Additional complexity arises from the fact that the perspectives on living conditions can vary depending on the spatial and ideational perspective, cross-cutting the previously mentioned topics. Firstly, different types of areas like rural and urban areas, border regions, etc. might have highly divergent needs. Therefore, the 'set' of activities (policy mix) required to address the primary challenges in one type of areas might not be suitable in another. Whereas rural areas may suffer from depopulation and increasing difficulties to provide basic social infrastructure in the areas of culture, leisure/entertainment, health,

child care etc., booming regions might face a shortage of space of living, increasing rents, growing demands for service provision. The issue of good living conditions may therefore reveal highly different requirements, depending on the spatial focus.

Secondly, from an analytical perspective, the topic of good living conditions raises the question about the granularity of the perspective that may have profound implications for the level of intervention. Whereas the traditional focus is on disparities of regions, disparities might also be found within smaller spatial units. This has been described as MAUP – the 'modifiable areal unit problem' (cf. e.g. Openshaw and Taylor 1979) that describes the risk of overlooking internal heterogeneity depending on the level of aggregation. Quality of living conditions may not only vary considerably across regions, but also within regions or even within municipalities. Whereas social infrastructure and social cohesion may be well developed in some parts of a city, the opposite might be true for other parts, masking the needs when relying on an aggregated perspective.

Figure 15: Topics for system of equivalent living conditions (own elaboration)



Finally, there might be different ideational approaches how to address the identified problems. The German Basic Law establishes the baseline by postulating equivalent living conditions throughout the whole country, i.e. not requiring similar conditions everywhere,

but ensuring basic conditions to achieve these aspects. However, this does not entail an answer about the most appropriate strategy to achieve these outcomes and the main focus of interventions. Should interventions seek to focus on reducing the weaknesses or rather focus on strengthening strengths? Should activities target those with the biggest needs or instead be driven by efficiency considerations that focus on stronger areas, expecting spill-over effects to the remaining areas?

6.1.1 The role of science and technology

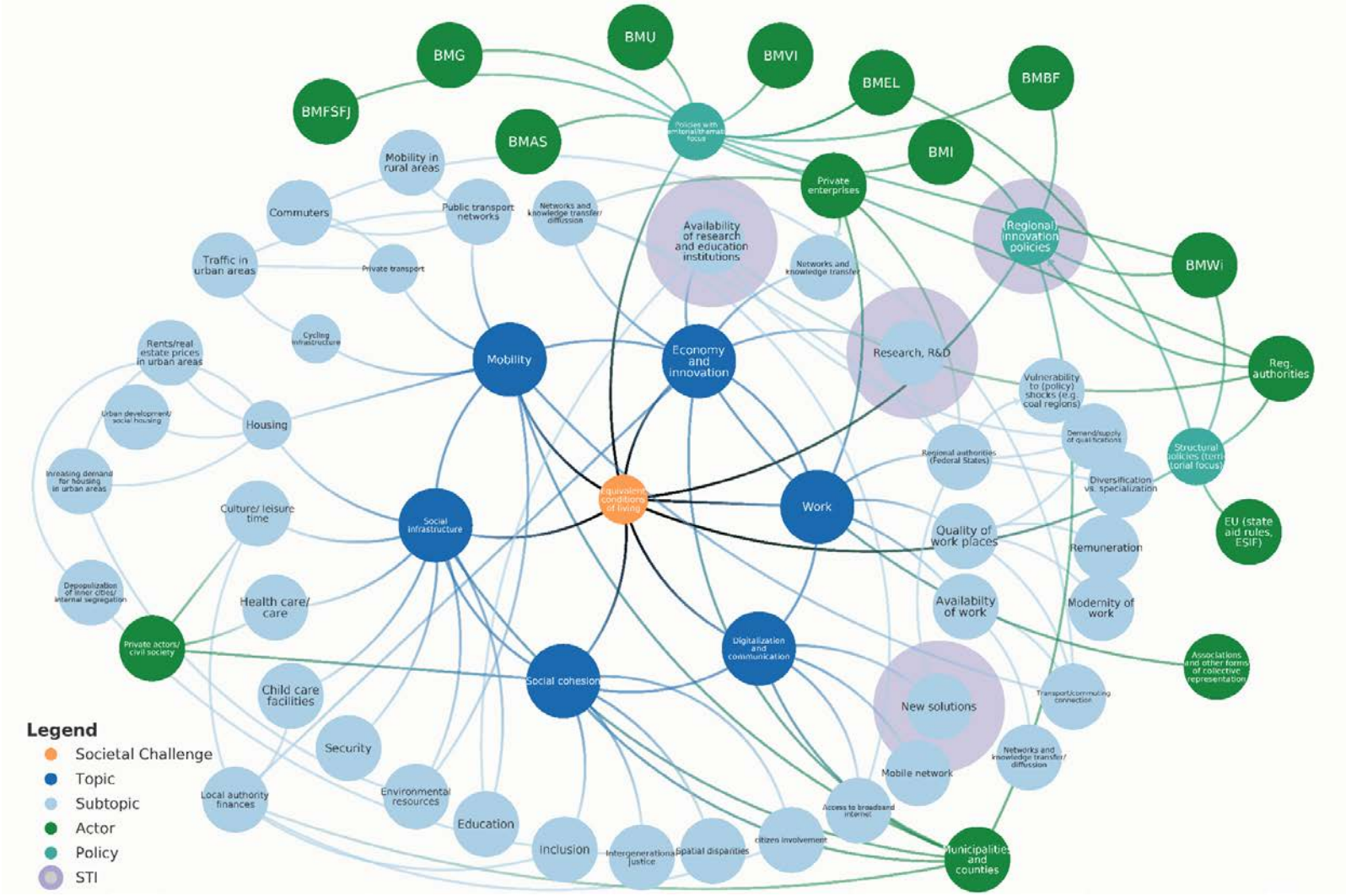
The diversity of topics has also profound implications for the structure of policies and actors in the socio-technical system. First of all, the different types of topics are addressed by different types of policies and combinations thereof. Among the main policies addressing the question of 'good life' one can list structural policies (at different levels) aimed at overcoming structural deficiencies, STI/innovation policies, and departmental policies and activities focusing on individual topics that are relevant for the quality of life (housing, environment, mobility, labor, etc.).[34] All of these policies are shaped by actors at different levels (EU, federal government, regional authorities, local authorities), making it difficult in many cases to delineate activities, as has been argued for the case of STI policies (Alecke et al.,p.13ff).

For policies beyond STI/innovation and structural policies, moreover, it is difficult in many instances to establish a borderline for policies belonging to the complex of 'good life'. Besides policies that intentionally address (sub-)topics in this complex, many other policies and activities can have side-effects on regional development that are beyond the main focus. For example, this could include decisions about the position of ministries or military bases or changes in the regulatory framework for certain economic branches, creating considerable economic effects in selected regions despite a non-spatial focus of the policy.
These different types of policies also vary with regard to their approach. Whereas research policies tend to rely on an approach of building upon existing strengths, (infra-) structural policies emphasize the weaknesses that are addressed. STI/innovation policies from this perspective are located between these poles. In consequence, the 'mix' of these policies and activities can vary considerably across different topics, prioritizing some activities over others.

Similar to infrastructural and departmental policies, the role of STI is cross-cutting the identified topics of 'good life' that were identified in this section. The interrelationship with

34 Cf. also the work by Karl and Untiedt (2018) distinguishing three layers/types of policies.

Figure 16: Topics and actors for system of equivalent living conditions (own elaboration)[35]



35 Access to the full map is available under https://embed.kumu.io/63b023ac6a31867e9dac95b1521a53c5

innovation-related activities with remaining policies can vary, however, depending on the topics, creating different kinds of dynamics in the socio-technical system:

- Topics that are fundamentally linked to STI policies, such as econom-ic/innovation and labor. Research and innovation complement structural policies by creating additional job opportunities and supporting economic activity through strengthening specific promising areas of activity. Key players at the federal level in this context are the BMBF, BMWi, however, there are also new initiatives such as from the Federal Ministry of the Interior, Building and Community (BMI).
- Topics where innovation can provide novel solutions, alongside departmental and structural policies. This applies particularly for the topics of social cohesion, social infrastructure and mobility, where (social) innovations may provide new solutions and avenue that help to overcome problems that cannot be addressed by other means. These developments can be additionality strengthened by polices focusing on questions of digitalization and communication. While entailing a focus on infrastructure building on the one hand, innovation in the area of digitalization/communication primarily serves as an enabling factor for (social) innovations and research in the remaining fields. These topics might be also addressed by other federal ministries (Federal Ministry of Transport and Digital Infrastructure - BMVI, Federal Ministry for Family Affairs, Senior Citizens, Women and Youth - BMFSFJ, BMG, etc.)

Finally, the diverse character of topics and instruments also implies a multifaceted multi-level actor structure, incorporating a wide variety of trans-national (EU) and domestic actors (federal government, regional government, municipalities, enterprises, counties, associations, private actors/civil society). Within Germany, the responsibilities and competencies of the federal and federal state levels are defined in art. 72 to 74 of the Constitution. Generally, the 16 Federal states have large competencies, but the Federal Government is in charge for overseeing equivalent living conditions in all parts of Germany. In this sense, art 91 of the German Constitutions defines so-called 'Joint Tasks' (Gemeinschaftsaufgaben) where Federal and Federal State Government cooperate. This is the case for issues like agriculture and coastal protection (GAK), and also for improving the regional economic structure (GRW) Both levels can also interact in supporting science, research and education, if the considered topics are of supra-regional importance. Joint tasks are coordinated and financed by both federal and federal state levels, and are implemented by the federal states (considering their specific conditions)

In many instances, local (sub-regional) actors such as municipalities, counties, enterprises, civil society organizations etc. are a target of policy interventions from higher levels, e.g. by receiving support in from of financial resources through funding schemes.

6.1.2 Beyond the domestic context

The whole topic of regional disparities and quality of life is also embedded into a broader domestic and trans-national context. Within the domestic context, the socio-technical system in the following years will be influenced by the decision of the coal phase-out until 2038. The process of abandoning the usage and mining of coal causes a loss of the predominant economic structures in selected regions that need to come up with novel solutions, the more that many of them are already considered as economically weak (and coal mining was subsidized in the past). Managing this transformation process runs in parallel to existing efforts of ensuring equal conditions of living and might thus partly overlap.[36] This in particular applies to the suggested activities based on the report of the so-called 'Coal Commission' (Kommission für Wachstum, Strukturwandel und Beschäftigung) and the legislative actions that have been undertaken since then (Strukturstärkungsgesetz Kohleregionen).

At the same time, the EU-level plays a profound role in shaping the playing field, by defining subsidies rules (state aid rules, EU-Beihilferecht) that implement the EU Competition Law and define conditions for grants as a framework for the domestic socio-technical system. Besides rule setting, the EU has its own resources that are supposed to complement domestic activities and require a domestic co-financing. In particular these are the funds for regional development (ERDF), European Social Fund (ESF), the, European agricultural fund for rural development (EAFRD), and the European maritime and fisheries fund (EMFF). Those programs have all distinct geographical and thematic foci, often being driven by a focus on overcoming existing weaknesses. In contrast, programs such as the research/innovation framework (Horizon 2020/Horizon Europe) that have a non-spatial focus, focusing on areas with already established structures and competencies.

6.2 Mission goals and structure

6.2.1 Mission context

The issue of 'good living conditions throughout the country' has been deeply rooted in the German political discourse for a long time. Depending on the temporal context (reunification, debate about 'lost places') the debate and activities have resulted in different priorities and thematic orientations, shifting from a strengthening of former territories of

36 Cf.https://www.bmwi.de/Redaktion/DE/Publikationen/Wirtschaft/abschlussbericht-kommission-wachstum-strukturwandel-und-beschaeftigung.pdf?__blob=publicationFile&v=4

the German Democratic Republic to a perspective that takes into consideration weak and declining areas throughout whole Germany. Therefore, the issue of good living conditions can be considered as highly urgent and a highly political issue that receives considerable attention. Given this background, the mission is embedded into a vivid political and societal context that is influenced by current political dynamics. This in particular applies to the process of abandoning coal usage that gained momentum in the past years and the planned steps to support the transformation process of affected regions and the emergence of a new support system for underdeveloped regions.

The mission in its current form does not have any direct predecessors in the previous Hightech Strategies (BMBF 2006, 2010, 2014). Whereas the cross-cutting character of the issue is the driving factor that certain aspects have been already taken up by earlier editions of the HTS 2025, the newly formulated mission in its comprehensiveness constitutes a novel development that has little resemblance with earlier activities. It introduces a spatially oriented approach that seeks to support the development of selected regions instead of facilitating dynamics in the whole territory of the Federal Republic of Germany.

Given its cross-cutting character, the mission is linked to most of the remaining mission of the HTS 2025. This can be achieved either by affecting economic and innovation capabilities (battery cell production, bringing AI to application, new sources for new knowledge), the quality of life and sustainability (biological diversity, circular economy, CO_2 emissions in industry, reduction of plastic waste, technology for humans), or an improvement public service provision (combating cancer, intelligent medicine). For example, the mission on combating cancer postulates that it seeks to improve access to good medical treatment (in terms of therapies) throughout the whole country. What sets the mission apart from the remaining missions, however, is its territorial focus, thus a prioritization of certain spatial entities that stands in contrast to the thematic approach of other missions.

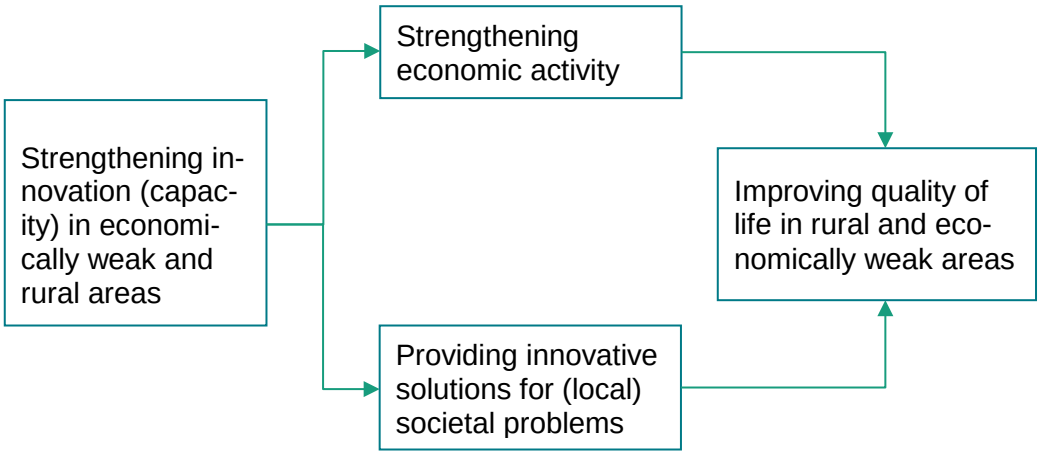
6.2.2 Missions goals

The mission goal has developed over time, going beyond the initial description in the HTS 2025. Whereas the theme of innovation has been present in both the HTS 2025 and the later published progress report (BMBF 2018, 2019), a certain narrowing of the goals has occurred. Whilst the mission had been initially placed within the context of structural and innovation policies, the focus on innovation as the mission's main leverage point has been strengthened over time.

Mission description: Economic structural change and demographic upheavals lead to spatially and socially unequal development. Ecological risks such as climate change often exacerbate these imbalances even further. We accept the challenge of creating equivalent living conditions for all. The opportunities offered by digitalisation are to be used specifically to secure and strengthen the attractiveness of peripheral and structurally weak regions as places to work and live. In order to successfully shape the future of our country and of structural change, we want to draw on local regional expertise and creativity, because regional know-how and experience are important for success. With new funding initiatives, we are actively working towards structural change that is innovation-based, sustainable and socially just. In this way, we are helping to ensure that innovations in 2025 are the most important drivers of growth, employment and prosperity – in all regions of Germany (BMBF 2018, p. 27)

The mission from this perspective is cross-cutting key policies in this field like the successor of the GRW (the newly established Gesamtdeutsches Fördersystem) and activities related to the coal phase-out. While not setting up a clearly delineated set of instruments aside these policies, it approaches the topic from a thematic perspective that assembles policies from different programs under the umbrella of the mission. The uniting theme of activities being subsumed is a strengthening of innovation activities as a means to overcome the specific challenges of weakly developed and rural areas. The understanding of innovation in this context is – according to interviewees – broad and comprises social innovations. At the same time, this implies that the mission does not focus on other activities within these larger programs, such as infrastructural investments, but rather introduces a kind of meta-coordination of thematically connected topics across different platforms and ministries.

Figure 17: Anticipated pathways towards goals of mission on good living and working conditions throughout the country (own elaboration)



The mission rests primarily on an understanding of the anticipated impacts, without providing a further specification. Whereas the time horizon of the mission is until 2025, the mission does not entail a detailed description of (qualified or quantified) goals. Taking the innovation perspective as a starting point, one can nonetheless assume to main strands of the missions aimed at improving living conditions (see figure 17). On the one hand, the support of economic development through innovation by creating new economic opportunities and strengthening the institutional framework (education, qualification). On the other hand, (social) innovations can contribute to overcoming existing (local) societal problems in a wide range of area (social infrastructure, mobility etc.).

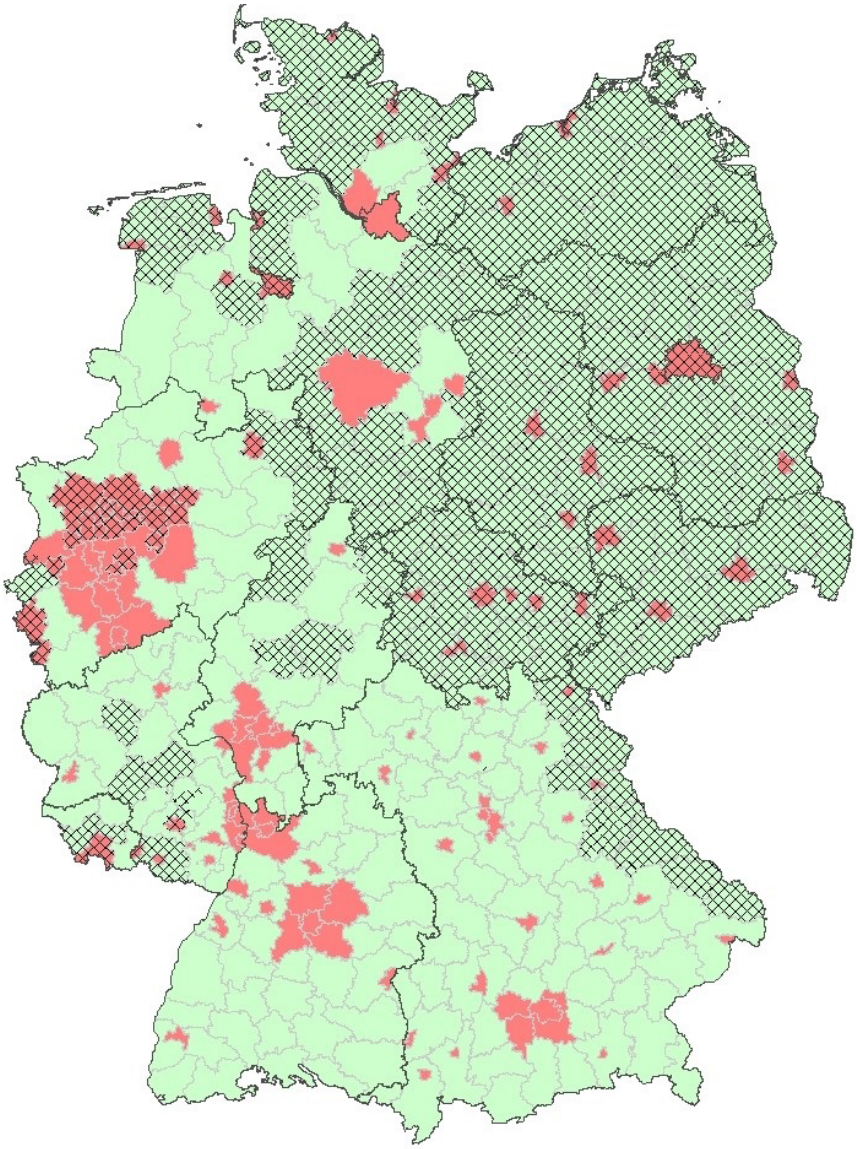
The territorial focus of the mission is limited to activities in two types of areas: economically weak areas and rural areas. While these two categories in many cases overlap, this has mainly two implications. Firstly, it follows the existing GRW criteria for defining the main areas of intervention (unemployment rates, income for work, prediction of employees, indicators for infrastructure). Areas that are beyond considerations are, for example, areas that are at the beginning of economic transformation and therefore are still performing comparatively well with regard to these indicators. Secondly, it includes rural areas regardless of their level of development. While many rural areas also qualify as GRW areas, there might exist variation with rural areas with regard to their levels of economic development (e.g. the economically rather strong counties of Ost- und Unterallgäu). Figure 18 displays the different spatial foci that are embedded in the understanding of the mission.

6.2.3 Governance of the mission and actors

The mission is headed by BMBF, unit 721 (Nachhaltige regionale Innovationsinitiativen), reflecting the high prioritization of innovation as the main mission theme. Among the other partners of the mission are BMWi, BMI, BMEL, BMU. Other ministries have taken an observer role (BMU, BMG). Besides this horizontal coordination within Federal ministries, there is no direct vertical coordination taking place within the mission, as regional and local actors are not directly involved in mission implementation (see table 2).

Being embedded into a context with multiple large key policies (Gesamtdeutsches Fördersystem, Coal-phase out), the mission does not only require internal coordination within the mission, but also ensuring the alignment with these overarching policies. This has been visible, e.g. by the fact that the process of specifying mission goals has been influenced by development of these core policies, such as the activities of the Commission for equal living conditions and its working group on 'Economy and innovation' At the

Figure 18: Rural and economically weak areas in Germany



Legend:

- Eligible areas in the model project 'Smarte LandRegionen' as part of program BULE (Bundesprogramm Ländliche Entwicklung)
- Non-rural areas and district-free cities that are not eligible for funding in Smarte LandRegionen
- Area eligible for Joint Federal Government/Länder scheme for 'Improving regional economic structures' (GRW)

Source: Own elaboration, based on project call for model project 'Smarte LandRegionen' as part of BULE (Bundesprogramms Ländliche Entwicklung) that makes use of classification scheme for rural areas by the Thünen Institute for Rural Studies 2016, GRW-Coordination scheme from 01.01.2020. Geodaten: © GeoBasis-DE / BKG (2020). Map created by ArcMap 10.4

same time, activities of the mission cannot be seen independently from the interdepartmental working group (IMAG) that is in charge of supervising and monitoring of the national support scheme for underdeveloped regions (Gesamtdeutsches Fördersystem).

Table 2: Actors involved in the governance of the mission on good living and working conditions throughout the country (own elaboration)

Type of actor	Actor
Public (federal)	BMBF • Ref. 721: Nachhaltige regionale Innovationsinitiativen (lead) • Ref. 726: Ressourcen, Kreislaufwirtschaft; Geoforschung • Ref. 521: Zukunft von Arbeit und Wertschöpfung; Innovationsförderung; Industrie 4.0 • Ref. 113: Grundsatzfragen von Innovation und Transfer; Koordinierung
Public (federal)	BMI • Ref.H II 2: Fördersysteme; Analysen; Heimatberichterstattung
Public (federal)	BMWi • Ref. I B 7: Strukturwandel in den Kohleregionen • Ref.I B 3: Regionale Wirtschaftspolitik
Public (federal)	BMEL • Ref. 816: Strategie und Koordinierung der Abteilung 8, Gleichwertigkeit der Lebensverhältnisse in ländlichen Räumen • Unterabteilung 81: Ländliche Entwicklung
Public (federal)	BMAS
Public (federal)	BMU (observatory role) • Ref. G II 3: Umweltangelegenheiten der Raumordnung, Flächenverbrauch, Ländliche Entwicklung
Public	BMG (observatory role)

6.3 Review of mission goals and position within the socio-technical system

6.3.1 Position of the mission in the socio-technical system

The mission exhibits a broad understanding of quality of life going beyond the scope of traditional structural policies and incorporating the social, non-economic dimension of quality of living. The cross-cutting approach focusing on innovation policies implies that the mission strives for a comprehensive approach that does not selectively focus on some of the key topics of the socio-technical system (economy/innovation, social cohesion, social infrastructure etc.), but aims to contribute to the whole range of these topics by a specific type of policies. Following the characterization from figure 17, there are two possible avenues how the activities within the mission affect the socio-technical system.

On the one hand, innovations can strengthen economic activity by enhancing the competitiveness of firms and creating new work places, i.e. also affecting the quality of working places and their robustness to transformation processes, thus primarily linking to the topics of economy/innovation and labor. On the other hand, especially social innovations can provide solutions alongside infrastructural investments and other topic-specific policies. Thereby they can additionally contribute to the areas of mobility, social cohesion and social infrastructure. Digitalization and communication in this context is a cross-cutting theme, supporting the development of activities in the remaining topic areas.

Considering innovation in a territorial perspective is not a new approach and has a long tradition both in theory and in policy, as shown by concepts such as 'Regional innovation policy', 'Innovation-oriented regional policy', 'Place-based development policies' etc. They are rooted in positive effects of interactions between different actors located in similar context conditions, thus have a certain degree of proximity. In Germany, programs like for instance InnoRegio and succeeding supporting measures reflect the implementation of these approaches (cf. Dohse 2000).

The mission takes a rather narrow approach with regard to the multi-level and multi-actor setting that characterizes the socio-technical system. Focusing on federal ministries and their main policies, the activities at EU- and sub-national level (regional, local) appears to be beyond the scope of the mission, serving as a framework condition and additional governance level. The complexity of interaction is therefore reduced, by focusing on the horizontal coordination of different policy activities of one level instead of a vertical integration and a broader mobilization of actors as stakeholders in the implementation process.

6.3.2 Review of the mission

In the absence of clearly defined goals, the mission is primarily characterized by the cross-cutting theme of innovation as a tool to promote equal living conditions across regions with particular needs (structural weaknesses, rural character). While the time frame for this issue (2025) is rather short and might not reveal impacts yet, there are no qualified quantified goals that allow for an understanding of the expected key impacts of the mission. Given the complexity of the issue and the multidimensionality, involved actors hardly see distinct and quantifiable goals for this mission. This applies in particular when looking at desired impacts instead of policy outputs, as observable dynamics are not only exclusively driven by innovation-related activities. In fact, there are multiple dynamics contributing to the evolution of the socio-technical system. Therefore, it is hardly possible to assign individual innovation policy measures to impacts in an unambiguous way.

Whereas the overarching goal of good living conditions indicates an orientation towards a grand societal challenge, the subordinate levels lack a similar level of directionality that could provide orientation in policy-making and designing appropriate instruments. The definition of more clearly specified sub-goals could have contributed to specify a hierarchy of goals and thereby more clearly delineating different impact pathways that contribute to the overarching mission goal and supporting monitoring of mission implementation. This in particular applies to the strand of activity on fostering economic development. While innovation can serve as a pivotal factor to ensure good conditions for economic framework, the absence of a more precisely defined goal raises the question whether this allows to unleash the full potential of new mission-oriented approaches in a way that provides an added value ('delta') compared to earlier approaches of innovation policy.

The cross-cutting character of the mission has the asset of a uniting theme that may enhance the ability for internal policy coherence, bringing together activities with relatively similar logics. Thereby the mission approaches the problem from a broad perspective, including innovations in different fields, thus allowing to address the topic of quality of living conditions in a comprehensive way/perspective. If implemented properly, the mission has the potential in the medium to long term to provide the opportunity deliver clarity, guidance and a coherent policy framework towards a 'multi-governance and multi-measure' approach for strengthening one driver and enabling factor of better living conditions**.** The flipside of the coin is the question to what extent the mission enjoys the ability for coordination across activities, by introducing a kind of cross-cutting layer of coordination: if activities are simultaneously embedded into vertical (federal-regional funding) and a horizontal (mission) system of coordination. Therefore, it remains to be seen to what extent the mission is able to provide independent inputs besides the key policies for regional development and structural change.

Focusing on the coordination of federal activities, the mission reveals the reluctance to touch upon areas that may into the responsibilities of other actors within the federal multi-level systems. As outlined in Section 6.2.3, the governance of the mission is limited to federal ministries and their respective instruments, taking lower levels of territorial governance primarily as beneficiaries into considerations. While this decision reduces the complexity of coordination, it may hamper the coherence of policy interventions across different levels and reduce effectiveness due to a limited mobilization of key players in the socio-technical system. While this negative aspect might be limited by the fact that regional governments – with their limited budget – often adjust to support of the Federal government (Alecke et al. 2011, 13ff), the EU level appears to be beyond the scope. This aspect might be particularly relevant for the Eastern German regions that besides being a main target of the mission as rather economically weakly developed areas are also the

main focus of EU Cohesion Policy within Germany. Of the 4.4 bln EUR foreseen for research and innovation of the European Regional Development Fund (ERDF), more than 60 per cent are allocated to the Eastern German regions (including Berlin).[37]

The territorial focus is inherent in improving the (preconditions for) good and decent living conditions throughout the country, and the overlap between living conditions and innovation represents the novelty of this mission. As explained above, this refers to its broad approach of innovation, but also to the core question of how to define territories to be addressed. The mission includes different policies, thus various (existing) funding schemes with specific objectives and territories that are eligible for support. Generally, those territories are defined on the base of certain indicators and their characteristics in (administrative) territories. The characteristics of those indicators define 'territorial eligibility' for the support schemes. Structural policy (Joint Scheme for improving regional economic structure) and supporting structural change (WIR! program for Innovation and structural change) for instance rely on unemployment, annual wages, labour force and infrastructure with highest weights for unemployment rate (45%) and annual wages (40%). In contrast to an established set of indicators for the GRW the delineation is more difficult for rural areas, as there exist approaches emphasizing different aspects (functional centers, population density, etc.), so that even different programs in a ministry may rely of varying eligibility criteria (e.g. for the BMEL).

What these approaches – regardless of the presence or absence of an established set of indicators for determining interventions – have in common is their 'macro-level' perspective that focuses on differences between units (mostly counties), but does not take into consideration heterogeneity within units (such as differences in quality of life within municipalities or cities). Following the logic of federal support and the division of tasks between the federal and federal state levels, these small-scale aspects remain beyond the scope of this mission.

37 Own calculations based on https://ec.europa.eu/regional_policy/en/atlas/programmes/ and https://cohesiondata.ec.europa.eu/countries/DE#

7 Summary of conceptual and empirical insights

Section written by Florian Wittmann, Miriam Hufnagl, Florian Roth, Ralf Lindner

This final section summarizes the key findings of the MAR1 for the selected missions as well as the broader insights gathered during the research process. Focusing on the position of each mission in its respective socio-technical system and a detailed review of the mission, the MAR1 constitutes the first of three analyses on the current state of the German HTS 2025 that are part of this research project.

In the following, we distinguish between three groups of insights:

- insights with regard to the empirical case of the HTS 2025 and the missions under study,
- a reflection on the methodological approach and its implications for the next steps in the scientific support action,
- and finally, insights that are relevant beyond the case of the HTS 2025 and can inspire research on MOIP in general.

Missions in the German HTS 2025

Our analysis of the four selected missions shows that the HTS 2025 only partially fulfills the basic characteristics that are commonly associated with MOIP at a strategic level, including legitimacy, directionality, intentionality, and leadership (Larrue 2019, 2020)[38]:

The overall legitimacy of the HTS 2025 appears to be high, as the analyzed missions all relate to some of the most pressing challenges of our time, such as demographic change and diseases, decarbonisation and environmental degradation, and regional disparities. In addressing these challenges, the HTS 2025 often builds on earlier editions of the HTS. Yet remarkably, it has been able to broaden the narrow technological focus of its early predecessors to some degree by also considering other aspects, for example regulation and citizen behavior. **However, the crosscutting aspirations of systemic transformation, which correspond to mission-orientation per se, pose two problems with regard to legitimacy**. Firstly, there is a risk of setting up duplicated or even contradictory policy actions targeted at similar outcomes. In some missions one could observe that newly formulated missions and long-standing existing policies run parallel to each other, instead of explicitly integrating them as part of the mission.

38 Note that we exclude flexibility, as the focus of the MAR does not provide any insights for this question.

Secondly, if the alignment with other policy areas beyond STI is not actively addressed and strategically orchestrated, there is the risk of overburdening the field of STI policy making. Without critically reflecting the potentials and limitations of STI policies with regard to its transformative contributions, the general legitimacy of this policy field might possibly be jeopardized, thus requiring careful expectation management (see discussion below).

All missions under study imply some kind of directionality, framing mission activities as (at least part of) solutions for specific societal challenges. At the same time, missions rely on a clear institutional lead by the BMBF (in fact all missions are led by the BMBF). **Although official mission documents emphasize the importance of horizontal coordination between ministries, the case studies revealed that cross-ministerial cooperation has so far reached rather low levels of institutionalisation. While the German political system assigns general responsibility for public policies to specific ministries (Ressortprinzip), our findings suggest that a recalibration of existing practices of inner- and cross-departmental cooperation is indicated to translate a mission-oriented innovation approach into ministerial policy practice more effectively.**

Particularly in those instances in which mission goals require systemic and behavioral change, and include boundary spanning components across ministerial domains, ensuring the alignment of activities is a highly challenging task. To overcome bureaucratic silos for coherent policy action, setting up reliable, practicable and sufficiently equipped coordinative structures and processes is a key element to a successful mission-oriented policy strategy. In most instances, a narrow focus on STI seems insufficient to unleash the full potential of a mission-oriented approach in the long-run (e.g. prevention in cancer might benefit from research, but is strongly driven by non STI-instruments). **Subsequently, there might be a need to strengthen the orientation of missions towards one of the two poles in order to clarify their directionality and facilitate policy implementation:** either choosing rather narrowly defined goals that can be achieved by STI alone (in effect, accelerator missions), or a broader and more comprehensive approach that most likely requires alternative institutional arrangements including extensive cross-ministerial cooperation (transformer missions).

Moreover, **the MAR1 delivered a rather mixed picture with regard to the intentionality of the missions under study. Even though in some cases clear and ambitious mission goals were formulated, the translation of these goals into policies capable of achieving real systemic transformation remains unclear and offers room for improvement**. Further, from an external perspective, in some cases it is difficult to clearly

identify the driving motivation behind the missions and the criteria defined to assess completed missions.

Likewise, in several cases it was difficult to determine whether or not a mission can be considered as successful, and whether or not a running mission is on a good path and its effects (and later impacts) can be traced. Empirical insights suggest that future missions will benefit from a strategic and systematic approach to the formulation of the missions, the setting of clear targets and milestones, and the development of approaches to assess progress. We observed the existence of multiple parallel goals, or a nesting of goals in other initiatives and documents, hinting at the need for more coherence. **Therefore, we conclude that inclusive strategic processes, prior to the formulation and implementation phase of MOIP, are an additional key for sound policy making and a prerequisite to trace the dynamics and impacts of mission policies at a later stage. Clearly defined targets are pivotal to ensure the mobilization of different actors and to facilitate effective cooperation and coordination.** Goals that are open to different interpretations hamper real agency and reinforce a lack of responsibility and accountability.

Furthermore, strong political leadership has profound implications for the implementation of a mission. Whereas the mission on combating cancer enjoys a high level of political leadership through the NDK being anchored in the coalition agreement and the involvement of secretaries of state in the mission governance, a similar constellation was not observed among other missions. With a view to 'Good Life', 'Circular Economy' and 'Reducing CO_2 emissions', the tentative descriptions of possible points for action mainly hint at thematic clusters without directly addressing the actors in charge. With a view to the CO_2 mission, for example, obvious actors and areas of action, such as the building industry and regulatory measures associated to building materials, were not listed in official mission documents.

Taking these insights together, the ownership with regard to missions needs to be strengthened in future mission policies. To this end, the respective ministries as well as the relevant stakeholders need to be actively and continuously involved from the early stages of problem definition and mission formulation right through to the implementation phase. Adequate processes of deliberation, negotiation, co-design and joint implementation are likely to generate the required levels of "buy-in" of the responsible ministries and stakeholders needed to unite behind a mission.

Table 3: Summary of key mission characteristics (own elaboration based on classification of Larrue 2019)

Mission	Legitimacy	Directionality	Intentionality	Leadership
Combating Cancer	Visible societal challenge, mission building on earlier activities of HTS; broad involvement of actors in NDK	Research-oriented goals specified in NDK instead of mission (nested structure), serving as a tool for mobilization of actors around shared goals	Two of five goals in NDK are quantified, but suffer from definitional problems, medium level of ambition, time horizon beyond HTS (2029<->2025)	High levels of involvement (NDK as part of coalition agreement), involvement of parliamentary state secretary; creation of initiative (NDK) that is partly outside ministerial structures
C02 emissions	Central political challenge, acknowledged on national, European and global level (Paris Agreement), mission in accordance with the national decarbonisation strategy	Instruments clearly aimed at tackling the challenge (CO2 emission reduction), but mainly focus on technological pilots, less on getting technology to the markets	High level goals quantified, intermediate and lower level goals less precisely formulated	Considerable involvement of several ministries, however little interdepartmental processes or projects
Circular economy	Rooted in national and international sustainability policy following a (assumed) broad societal consensus on the topical facts of CE addressing waste management and material use.	Ambitious systemic key goal is set; milestones on how to achieve this goal are rather weak though. An overall concept for a targeted, reasonable and complementary action is missing, which weakens directionality.	Clear objectives, indicators are to be further developed to track advances beyond waste management and energy efficiency. First major quantifiable milestones beyond 2025	Due to variance of topics; clear division of labor between ministries with different leading roles. No evidence if complemented by strategic leadership at the highest level of government
Good life	Long-standing and pivotal topics in Germany; no predecessors in HTS 2025	Adding complementary perspective aside of other key policies with a cross-cutting character; and broad perspective; directionality unclear in case of economic activity	No quantified or qualified goal; strands of activities instead of goals (not thinking mission from goal but from process)	Leadership limited, as mission located in-between/across several large-scale policies (coal-phase out, GRW and structural funding)

Based on our findings so far, the following elements of mission policy appear to be crucial:

- **Create strong and encompassing participatory processes,** bringing in the views and expertise of those actors that are affected by and in charge of enacting the goals set by policy in defining clear, ambitious, but realistic and measurable mission goals,
- **increase capacity for strategic processes** to "take stock" of existing instruments and the socio-technical system in focus, and to align activities by allowing conceptual debates (inner ministerial and across domains) that lead to a common understanding, agenda and the advancement of policies,
- **increase attention to the translation of mission goals and workable concepts**. As highlighted above, ambitious missions need a clear vision and a convincing narrative as well as a realistic 'to do list' to be accomplished after all,
- **improve the opportunities to showcase advances of missions** and receive positive public attention as rewards in order to overcome the problem that mission goals exceed electoral terms.

The increased coordinative needs of mission-orientation that are potentially cutting across different ministries and levels of responsibility do not come at zero cost. In effect, sufficient capacities to bring together and ensure real beneficial coordination and even cooperation between different actors and stakeholders are essential. This is a very challenging undertaking and would entail significant changes of the administrative culture of the federal governmental bureaucracy or even evoke ideas about a relocation of mission competencies all together (e.g., empowering an agency to depoliticize rivalries between ministries as other countries have done). Anticipating intentionality is crucial as a lack of strategic planning with regard to linking mission goals with subsequent activities is hard to compensate later on.

Therefore, a sound strategic process translating the formulated goals into a comprehensive concept and workable plan of activities and priorities is pivotal to strengthening the missions and ensuring the commitment of all actors towards a common goal. Achieving a common understanding of the goals and scope of a mission and its governance structure is a key step towards aligning activities with the goals of a mission and delineating responsibilities. The use of specific platforms, such as the NDK in the case of the mission 'combating cancer', might serve as such a vehicle for uniting different stakeholders with a joint declaration, just to pick one illustrative example.

Looking beyond individual missions, the MAR1 has revealed that multiple interactions and interdependencies between different missions exist, at least according to official documents. Whereas synergies between missions are to be welcomed, problems may arise if there is no overarching strategy of systematizing these interactions.

Thus, future mission-oriented strategies should **establish meta-governance processes which actively address such interactions at the level of mission-related policy formulation and implementation of specific measures**. While not all interactions between missions will necessarily be mutually reinforcing, it is also possible that certain interaction trade-offs might impede the success of a mission. This observation again points to possible beneficial effects of having strategic processes before adjusting or reconfiguring the missions. For example, while research on combating cancer might benefit from a concentration of activities following the paradigm of scientific excellence, this might have detrimental effects with regard to equal living conditions.

Methodological approach

MAR1 rests on a combined approach of a mapping of the relevant socio-technical systems (system mapping) and the attempt to review the missions, their goals and priorities in a more detailed way, linking the insights back to the system mapping. This section reflects upon the usability of this approach and the implications arising from challenges and difficulties that have been encountered during the process.

The process of system mapping has proven to be a helpful tool to better understand the scope of diverse missions and their underlying societal challenges and potentially explain decisions that shape the priorities. The mapping process itself, however, was shaped by two factors. Firstly, while focusing on the overall socio-technical system, the mission definition shapes the level of abstraction of the system mapping. The broader and less clear the main priorities of a mission are defined, the larger and more complex the system mapping becomes in order to cover all potential problems, actors and activities of a mission. Secondly, the underlying challenges are driven by different constellations between the different types of problems. Whereas in the majority of missions it was possible to map the system in a way that decomposes the challenge into sequential/hierarchical order of different issues (CO_2 emissions, Combating cancer, Circular Economy), what provided considerable analytical advances. In contrast, this was not possible for the question of living conditions (with multiple factors being interwoven with each other).

From this perspective, a problem-centered approach as pursued in this MAR might provide an easier access to understanding the overall system. The drawback of this approach is the lacking process perspective that needs to be integrated in later steps when zooming into the activities of a mission (MAR2). Thus, the approach of mapping systems along the key issues instead of processes can only serve as a starting point. Only with a detailed understanding of the dynamics and activities, it is possible to explore the impact of a mission on the socio-technical system.

The focus on the domestic context for missions did not prove to be a problem for the mapping process. Being able to incorporate the interface with other activities (such as European policies), the focus of the mapping process from this perspective appears to be adequate. The mapping tool and the possibility for tagging STI relevant activities appeared as highly helpful for better understanding the role of STI policies in the overall system in an analytical way. Thereby, the mapping process can shed light on the constraints and boundaries of certain policy approaches. What has proven to be more challenging from this perspective is the question of delineating the overall boundaries of the socio-technical context.

Whereas the process of the system mapping through the involvement of experts allows developing a comprehensive perspective, the analysis of the actual missions requires the access to relevant information from ministries and actors in charge. In many cases, we could observe deviations between statements in official documents and the actual status quo of the mission. While it is not surprising that missions develop over time and may experience a re-orientation of goals as they progress, the unequal access and availability of information has been a constraint for the analysis, creating difficulties to trace the goals of missions and relevant developments in an equal way.

Moreover, the activity of system mapping appears to have significant potential as a useful tool in processes of formulating and specifying mission goals, as has already been performed in other countries (see Hufnagl et al. 2019). Such activities might be carried out either by the implementing actors themselves, by or jointly with scientific support actions. From the perspective of a formative evaluation approach, it would also be beneficial to uncover and explore the implications of the missions' goals, and make explicit their intended scope in order to support policy design and implementation.

Research on MOIP

This first MAR supports the earlier findings by Daimer et al.(2012) that a new label does not necessarily result in major shifts in the underlying design and implementation of a policy. With achieving mission-orientation being a goal in its own right, there appear to be multiple obstacles already at the strategic level. **In reality, many policies resemble a mixture of elements from different paradigms of research and innovation activities (Arnold 2019, p.53). For research accompanying the implementation of MOIPs, this implies the need to avoid an implicit assumption that all missions necessarily fulfil the conceptual requirements of MOIP. Instead, the study of these policies needs to take a perspective that is flexible enough to deal with the layering of different types of paradigms, policies, governance practices etc**.

The question about the complexity of mission formulation and the arising challenges for bringing this into a workable concept has been largely neglected by policy analysis so far. The upcoming analysis report, MAR2, will devote more attention to this shortcoming[39]. **The critique by some policy makers that the concept of MOIP is under-conceptualized itself – with an overwhelming focus on the overarching and generic principles while neglecting conceptual practical guidance on how to achieve the roll out of MOIP – has to be taken serious**.

While having outlined basic characteristics of goals – the above mentioned guiding principles of 'bold, ambitious, significant and addressing pressing societal problems (Mazzucato 2018, 2016) – the process of goal formulation and its subsequent translation into an implementation strategy is more than a technical process (Edler, Salas Gironés 2020). This ranges from questions of stakeholder involvement during the process of goal definition to questions about agency and capacity. Mission goals as a reference point for stakeholders should be the starting point of a strategic planning process preparing the formulation of corresponding instruments and implementation as a follow up. While mission goals might be formulated in a top-down way, implementation requires translation into workable concepts by involved stakeholders, delineating responsibilities and activities. **The problem of a poor mission definition in turn can affect the whole cascade of mission implementation and negatively affect the ability to trace any impacts of a mission as a whole (and its building blocks).**

The analysis of selected missions did not reveal a systematic fit with the anticipated key characteristics described by Wittmann et al. (2020). While focusing on ideal types, real-world missions may evolve over time (Janssen et al. 2020) and show considerable divergence between formulated goals and the understanding of involved actors. At the same time, the limited fit might also be an indication that the studied missions do not yet fully utilize the potential of mission orientation. This applies, for example, if missions initially described as a transformer mission reveal a rather narrow focus on STI activities in the actual implementation, thereby following the classic canon of research funding without an overarching systemic and transformative impetus.

Overall, the first MAR has highlighted that the strategic level of MOIPs comes along with a number of challenges that so far have only been partially reflected in the existing literature. **The analysis revealed that further efforts for conceptualizing are necessary to understand MOIP from the very beginning. Thereby, it particularly shifts attention to the role of mission goals and their formulation process, suggesting that**

39 Since the MAR2 will be dedicated to '*Taking stock*: understanding the link between mission goals and activities and tracking changes of missions'.

this process itself and not defined mission goals as an outcome should constitute the starting point for the study of MOIP.

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